R. B. TODD

RUDIMENTS

OF

PHYSIOLOGY,

R. B. Todd.

IN THREE PARTS.

PART I. ON ORGANISM.

PART II. ON LIFE, AS MANIFESTED IN IRRITATION.

PART III. ON LIFE, AS MANIFESTED IN SENSATION AND IN THOUGHT.

BY THE LATE

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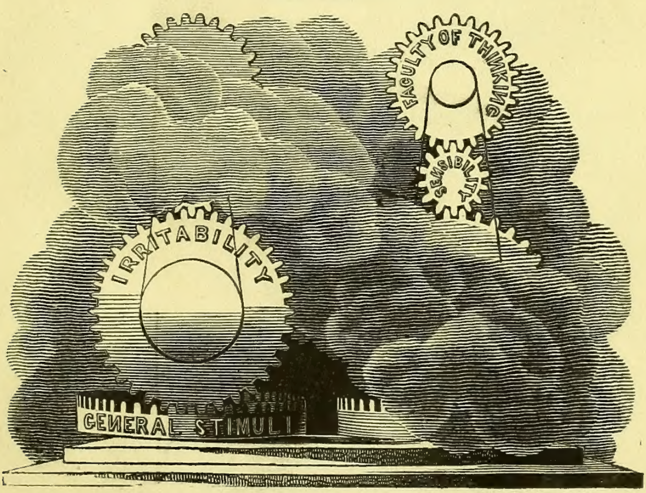
WITH A BIOGRAPHICAL MEMOIR OF THE AUTHOR.



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TO

HIS PUPILS

THIS WORK

IS,

WITH SINCERE WISHES FOR THEIR PROSPERITY,

DEDICATED

BY

THE AUTHOR.

CONTENTS OF PART I.

ON ORGANISM.

CONTENTS OF PART II. *a*.

ON LIFE, AS MANIFESTED IN IRRITATION.

CONTENTS OF PART II. *b*.

ON LIFE, AS MANIFESTED IN IRRITATION.

CONTENTS OF PART III.

ON LIFE, AS MANIFESTED IN SENSATION AND IN THOUGHT.

PREFACE.

The following Work will contain, in a somewhat amplified form, the matter of the earlier part of a six months' Course of Lectures on Physiology, which the Author has for some years been engaged in delivering annually; and it is published principally for the purpose of obviating an inconvenience which he has every year experienced—the necessity either of treating in too cursory a manner of certain general subjects, a knowledge of which is quite essential to a full comprehension of any particular point of Physiology, or of occupying a longer time with questions belonging equally to all the functions, than could be well spared from the detail of each. The ordinary works on Physiology in our language commonly plunge almost immediately *in medias res*, dispatching the consideration of these general subjects in some eight or ten pages—a space which is quite inadequate to communicate any available information; and of those works which treat expressly of these subjects—admirable as many of these are, and unwilling as the Author of the following pages would be that his production should be compared with even the least meritorious of them, each in its own particular department—he still knows of no one which gives such a grasp of the whole, and that so continuously, and with such a direct reference to the business of particular Physiology, as can be of any considerable service to the student.

Authors always succeed in proving to their own satisfaction, if not to that of the public, that their lucubrations are a desideratum ; and he may therefore be excused if he entertain this opinion with respect to the present undertaking, particularly after the repeated solicitations of his pupils that he would engage in it. That his book will be of material use to *them* he does not hesitate to believe, and he hopes that it may not be quite useless to others.

It has been the uniform practice of the Author, in treating in his Lectures of each of the individual functions, to begin with a short description of the apparatus by which this function is performed in all tribes of organized beings, and afterwards to state the vital conditions necessary to its performance. Now it is impossible to speak of the structure of any individual apparatus or organ without referring frequently to the subject of Organism in general, including the considerations of the general Classification of organized beings, the character of their several Organs, the properties and general distribution of their Tissues and Fluids, and the nature of the Chemical Principles entering, or supposed to enter into their composition ; and it is equally impossible to treat of the vital conditions necessary to the performance of any individual function without making frequent allusions to the subject of Life in general, including the considerations of the Mutual Relations of the functions, the nature and sources of Irritability or Vitality, of Sensibility or of the Faculty of Thinking, and the character and mode of action of the Various Agents by which these vital susceptibilities are excited. It is of these general subjects then that the following Work will treat, more or less fully according as they appertain more or less directly to the proper business of Physiology. It will be divided into Three Parts : the First treating of Organism in general, the consideration of which, as belonging to the proper business rather of Phytology and Zoology, of Anatomy, descriptive and general, and of Organic Chemistry, than of Physiology, will be comparatively summary, and in many parts little more than commemorative; the Second treating of Life as manifested in Irritation, the consideration of which, as proper to Physiology, will be considerably more full; and the Third treating of Life as manifested in Sensation and in Thought, the consideration of which, involving, as it does, the business partly of Physiology, and partly of Moral Philosophy, will be in the former relation ample, while in the latter it is more concise. The First and Second Parts are intended as introductory to a detailed description of what are called the Organic Functions alone, including Respiration, Circulation, Deposition, Absorption, Assimilation and Generation; and the Third as introductory to that of what are called the Animal Functions, including Sensation, Thought and Voluntary Motion; and care will be taken that the order in which every fact is stated, and every allusion made, directly correspond with that in which these several functions will fall subsequently to be treated of. This must be the Author's apology for adopting frequently a less lucid arrangement, and one perhaps less illustrative of the subject immediately in hand, than might have been followed had he had no ulterior object in view; and the same prospective purpose must also plead his excuse for introducing occasionally an apparent superfluity of examples, and these not always perhaps the best that could have been selected, had the point directly at issue been the only thing to be considered. In choosing such examples, while he has always brought forward as many as possible of those which he will have occasion afterwards to introduce in other associations, he has confined himself almost exclusively to these ; so that the present Work, although perhaps, considered *per se*, less perfect than it might have been without these encumbrances, will be, he hopes and believes, more conducive to his main object of rendering the general subservient to the particular. Students for the most part do not readily take up mere didactic precepts, nor long retain abstract conclusions which have been drawn for them by others ; but if frequently presented with numerous facts, from which such precepts and conclusions necessarily flow, and these in various relations to each other, the wished-for deductions are gradually forced upon them, and, so implanted, are retained with all the pertinacity of real or fancied discoveries of their own : they cannot be successfully led to the goal, but by the same road by which their instructors have reached it. The numerous references to delineations of the organs alluded to in the First Part are intended principally as a guide to such Students as may wish to consult the originals of the large diagrams in oil, which the Author has for many years been in the habit of exhibiting in his Lectures—a plan which he is proud to find so many other public teachers have since adopted.

In entering upon the composition of the following pages the Author imposed upon himself two rules which he has never infringed—the one, to confine the text to facts and arguments, without any interlarding of authorities or *ipsissima verba* of Authors, all which will be found in the foot notes—the other, never to speak directly or indirectly of himself. By attention to the former of these rules, the Philosophy of the Science has been kept quite distinct from what may be called the Literature of it—a plan in his opinion highly conducive to perspicuity ; while by attention to the latter, the be-setting sin of egotism, into which he might have been occasionally betrayed, from finding that not a few doctrines which he conscientiously believes were taught for the first time by himself have been since appropriated by others, has been effectually avoided.

9. Windsor Street, Edinburgh.
30th October 1835.

BIOGRAPHICAL MEMOIR

OF

DR FLETCHER.

The Life of a Scholar, which Dr Fletcher undoubtedly was, in the highest sense of the term, seldom affords much *materiel* for historical detail. There were, however, incidents in the history of his brief career worthy of commemoration, and of being impressed on the minds of the rising medical generation. To speak elaborately of these might be subservient to the cause of literature and science; but called, as I unexpectedly was, to perform the onerous duty of editing his unfinished work on Physiology, and fully occupied with other urgent avocations, I have had little leisure to enlarge the Biographical Sketch written immediately after the lamented death of my amiable and accomplished friend, which appeared in the British and Foreign Medical Review, when his demise was announced in that respectable periodical. That Biographical Sketch, somewhat amplified, will, I trust, be acceptable to the readers of his Rudiments of Physiology.

Dr Fletcher was the eldest son of the late Mr Thomas Fletcher, a respectable London merchant. It was the intention of his father to bring up his son to his own profession; and after having enjoyed the benefit of a liberal education, he was actually placed in the counting-house for some time.

But to a mind like his, a mercantile life was intolerable, and no prospect of ultimate advantage was considered sufficient to induce him to forego the gratification he promised himself in the cultivation of science and literature. To these he by degrees entirely devoted himself, and at an early period gave abundant promise that, in due time, he would gain for himself a name and a fame amongst the learned of the age.

Attracted by the superior advantages which the Medical School of Edinburgh presented, he repaired thither in the Autumn of 1813, and commenced the Study of Medicine, having previously attended, but not regularly, the lectures of the late Mr Abernethy, and Sir Charles Bell, in London. When Dr Fletcher first came to Scotland he was an utter stranger in this country, and brought only a single introductory letter, addressed to myself, by a mutual friend in London. Dr Fletcher resided under the same roof with me for some months, and, during the earlier part of his residence in Scotland, although rather my senior, did me the honour to consider himself my pupil. Even after the lapse of twenty-three years, I remember well the impression which was at once made on my mind by his genius, and especially by his unwearied perseverance in the acquisition of knowledge. My intercourse with him, whilst a student, was frequent and intimate, and from it resulted consequences which exercised an important influence over my future life.

In 1816, he obtained the degree of Doctor of Medicine, after writing and publicly defending an inaugural dissertation, "De Rei Medicæ Vicissitudinibus," which, from the uncommon purity of its Latinity, attracted the notice, and I believe obtained the marked approbation of the late distinguished Dr Gregory, then Professor of the Practice of Medicine in the University of Edinburgh.

Dr Fletcher intended to settle in London, as a physician; but an event occurred, soon after he finished his studies, which not only frustrated his intentions in regard to his proposed place of residence, but entirely changed his future prospects. This event, to which it is unnecessary to advert more particularly, deprived him of all his patrimony, and rendered it necessary that he should call his talents into operation to provide for his immediate wants,—wants which, although nurtured in affluence, he could, to his credit, make few, when prudence or necessity required such a sacrifice.

After abandoning his intention of settling in London, he, at the request of his mother, I believe, entertained the idea of practising medicine at Henley on Thames, where he resided for some time with her and his two sisters; but the life of a medical practitioner in a provincial town was utterly repugnant to his liberal and classical mind. It was during this period (1817) that he often sojourned at Oxford, and associated with Members of the University. He never, however, kept regular terms at that renowned seat of learning.

The System of teaching Medicine at Edinburgh, and the Mode of granting Medical Degrees, at the period to which I allude, were in many respects faulty and imperfect. The practice of conducting all the examinations in the Latin language made it necessary for the Candidates to employ a class of men known by the name of *Grinders*, who generally enabled their pupils to do little more than to answer questions by rote in bad Latin. Dr Fletcher's knowledge of this discreditable practice induced him to return to Edinburgh, with the view of establishing a System of Tuition akin to that which is practised at Oxford, in the way of private tutorship; a mode of life more congenial to his habits than the drudgery of general medical practice; and I hesitate not to assert, that by executing this plan, he materially, although silently, contributed to support the then declining reputation of our celebrated University.

As soon as it was known that Dr Fletcher had arrived in Edinburgh with the intention alluded to, the most respectable

Medical Students flocked to him for instruction; and he was at once enabled to render his superior medical and classical attainments available, and, for all immediate purposes, to supply his loss of fortune.

The labours which devolved upon him soon became very considerable. His pupils were usually divided into classes of four, and each class had an hour's examination. His occupation began at eight o'clock in the morning, and sometimes lasted twelve hours. To those enabled by their previous education fully to profit by his instruction, his critical commentaries on Celsus were invaluable. His care was not confined to imbuing the Student with a love of the classical beauties of that elegant medical writer, or to supplying him with an abundant and expressive vocabulary of Latin conversation, although in this he had perhaps no equal: His pupils felt that under his tuition all their previous knowledge became arranged and available. They learnt both the degree of their acquirements, and the extent of their deficiencies. He required correct thoughts in correct words; and whilst the taste was improved, the memory and understanding were vigorously exercised. He was systematic in every thing. His time was accurately divided, and he never wasted any portion of it. It was a maxim with him, that whatever was said, written, or done, might be said, written, or done in a certain assigned space; (*a*) and that all waste of space and time was an abandonment of power that any one might exercise,—a maxim which I would

(*a*) This was strikingly and affectingly exemplified by a memorandum which was found appended to his Manuscript Notes of Lectures on Sensation and Thought, and evidently written immediately before his last illness, as the first step, and the only one that he was allowed to take in the way of preparing for publication. He had prescribed to himself a *certain time*, in which he resolved to write and arrange the work for the press; and, intending to devote three hours a-day to that particular occupation, with all his knowledge of the subject, well-concocted plans, and command of time, he calculated on finishing his task in thirty-two days. An idea may thus be formed of what another person had to encounter in performing the same duty.

most earnestly impress on the youthful mind, as one of inestimable value.

In the course of two years from the period of Dr Fletcher's return to Edinburgh, he was so independent in his circumstances, as to enable him to make a proposal of marriage to Miss Agnes Seton, the daughter of an East Lothian gentleman of good family. The lady alluded to is the grand-daughter of the late Mr Somners, who was a most respectable surgeon at Haddington, and for a long period possessed, in a high degree, the confidence of the intelligent and influential inhabitants of the county. Dr Fletcher became acquainted with Mr Seton's family, when performing my professional duty during a season that I was in England. He was united to Miss Seton in 1821; a union from which he derived, for fifteen years, in the enjoyment of elegant and enlightened domestic society, as much happiness as usually falls to the lot of man. He left a widow, but no family, to deplore his premature decease.

In the society of those possessed of minds congenial with his own, he was cheerful and animated. He was fond of music, possessed considerable knowledge of the fine arts, and his literary attainments were of a superior order.

The Epistles of Rubus, (Rubi Epistolæ Edinburgenses,) written by him when a Student, sufficiently attest his vivacity and wit, as well as his unlimited command of Latin and Greek. Their composition would have done honour to a University in which classical acquirement was held in higher esteem; and with the exception of some occasional satire, the remarks they contain on the life and manners of the Students, and the merits of the Professors, will render them ever valuable to every lover of Edinburgh. I have the honour to be one of his correspondents, to whom letters are addressed in the Epistolæ Rubi. His satire, it must be remarked, was not that of a Cynic or Misanthropist, but the reverse. Indeed I have always thought that the touching and elegant panegyric on the late Professor Playfair, attributed to the pen of Lord Jeffrey, might with great truth be applied to Dr Fletcher. "It was wonderful, indeed, considering the measure of his own intellect, and the rigid and undeviating propriety of his own conduct, how tolerant he was of the errors and defects of other men; and whilst his friends enjoyed the free and unstudied conversation of an easy and intelligent associate, they had at all times the proud and inward assurance that he was a being upon whose perfect honour and generosity they might rely with the most implicit confidence in life and death,—and of whom it was equally impossible that, under any circumstances, he should ever perform a mean, a selfish, or a questionable action, as that his body should cease to gravitate, or his soul to live."

In the year 1822 Dr Fletcher embodied several of his critical observations on the employment of the Latin language, in a very useful little book, entitled Horæ Subsecivæ. This publication, and the Epistles of Rubus, are now somewhat scarce. Those who desire something more correct than the ordinary language of prescription would do well to place these little works on the shelves of their library.

With the view of removing a prejudice, founded on the incompetency of the public to judge, that the acquittal of a man tried for the murder of his wife was undeserved, Dr Fletcher published Remarks on the Trial of Robert Reid, for the Murder of his Wife, before the High Court of Justiciary, at Edinburgh, on the 29th of June 1835,—a Pamphlet which well deserves to be carefully perused by lawyers and jurors, as well as by medical practitioners. Reid had the good fortune to have Dr Fletcher for his Medical Counsel at the trial, and to that circumstance may perhaps be attributed the preservation of the wretched man's life. The interest which my humane friend was thus induced to take in the fate of Reid was prompted by the purest feeling of Christian philanthropy.

I cannot omit here to advert to Dr Fletcher's published Introductory Discourse to a Popular Course of Lectures on Physiology, which was cut short by his untimely death,—a production of great talent, and truly characteristic of an original, an independent, and a pious mind. This Lecture was printed at the special request of several gentlemen well qualified to judge of its merits, who were of opinion that its publication, in such a form as to render it easily accessible to all "classes of the community, would greatly subserve the cause of popular enlightenment:" they might with justice have added, of religious truth. I cannot at present enter into an analysis of this luminous discourse; but to prove how forcibly and eloquently the objections are refuted which prudery and bigotry have sometimes made to the general study of the Science of which he was the zealous advocate, I shall make an extract from this Lecture, satisfied that it will be the means of inducing the reader to furnish himself with the original, which contains more that is calculated to delight and edify than is often found within the same compass.

"And with respect to the alleged indelicate and repulsive nature of physiological studies, the time is fortunately past—although not long past—when it was necessary to refute the calumnious charge. For my own part, although in teaching this science as a branch of a medical education, I have never withheld from my hearers any fact with which it was incumbent on them as medical men to be acquainted, nor refrained from any illustration which I considered calculated, either to arrest the attention, or make an impression on the memory, I hope and trust I shall never forget that while in this place I am not in a theatre of medicine, nor addressing those whose business it is to know *every thing* relating to the physiological department of that profession. The privilege of selection is here allowed me; and I must very much fail in my object if I shall have occasion to see a single cheek for a moment suffused, or a single eye cast down or averted from any thing that I shall utter or exhibit within these walls. There is no manner of necessity for using one word that can infringe, in the slightest degree, on the fine enamel, as it has been beautifully called, of the purest mind—for displaying one object which the most sensitive may not contemplate without offence —and Heaven forbid that I should wantonly seek occasion for doing either. I hope also that I can make every allowance even for the natural weaknesses of the uninitiated; and as many such persons would perhaps shudder at the exhibition of any actual part taken from the human frame, I shall scrupulously abstain from introducing such parts; the organs of the lower animals, assisted occasionally by casts or delineations of the corresponding parts in man, being for the most part quite sufficient for the purpose of explaining any function of the human economy. The goddess of Purity and the god of Prejudice (if there happen to be such a personage) may look every day with equal boldness on my walls and tables.

" And while the objections to the study of Physiology are so unfair and untenable, how great and numerous, on the other hand, are the inducements to engage in it!

" Is it not, in the first place, a tribute that we owe to the Great Author of Nature, who has made all his works so admirable, and endowed us with faculties for admiring them, to pay attention to these works, and thus to rise through Nature up to Nature's God? Were we given our faculties in vain, or that we should employ them in praise of his power, wisdom and goodness? and how can we praise what we do not appreciate? We may use, like parrots, the words of praise, as a man ignorant of painting or of sculpture may repeat what he has heard others say in praise of the author of a picture or a statue, but we cannot be actuated by the soul which should inspire these words, unless we know and feel how infinite are the merits of those works on which alone our admiration can be founded. The blindest savage may be instructed to mumble lip-service to the Creator of the Universe, but it is the man of intelligence alone whose mouth can speak his praises from the fulness of his heart. We may say, "How manifold are thy works, O Lord," but it is almost scornful to say so, if we have taken no pains to know these works: We may add, "in wisdom hast thou made them all;" but the addition is mere mockery, if we have neglected to search for the evidences of this wisdom. A wilfully ignorant man may be superstitious, but he can hardly be religious. He may believe that he reverences his Creator, but he cannot reverence him as a thinking and a rational being, and one liable to give an account of the talents entrusted to his keeping, and at the same time remain indifferent to his works. And which of these works is so well adapted to inspire admiration of their omnipotent Author, as the structure and actions of animals in general, and of man in particular? It is on the evidences afforded by Physiology, of the wisdom, the power and the goodness of God, that the greatest men of every age have principally relied for inculcating a belief in the existence and attributes of a Deity; and can we without reproach neglect to avail ourselves of this assistance to the faith inspired by Holy Writ, of this means of illustrating and corroborating the sublime truths of Scripture?

"Most unwilling should I be to appear to lend myself, in the remotest manner, to any attempt to make what is called Natural religion a substitute for Revealed. Natural theology may tend to make a religious man more so, by strengthening the hope that is within him; but natural theology can never make an irreligious, a religious man, for it can never teach him the immortality of his soul and his moral responsibility. To attempt, therefore, to render the writings of any class of philosophers a *substitute* for the Bible, is to attempt to annihilate all the noblest and best aspirations of man. But I am totally unconscious of the existence, in any class of persons, of a desire to do so; and I cannot help thinking that rather more jealousy than is calculated to benefit their cause, has been lately displayed by some well-meaning people, of any interference by lay teachers with the business of religion. The same God who gave us the Bible as the mandate of his will, gave us the objects of nature as the testimonials of his wisdom, power and goodness; and I am at a loss to perceive by what train of fair reasoning any one who insists on the latter as bearing evidence of the highest attributes of the Creator, can be construed into an opposer of the former as inculcating the sublime truths of revelation. Why should facts which might be rendered mutually illustrative of each other, and made to act as allies strengthening and receiving strength, be adduced only, or supposed to be adduced, in opposition? Can it be believed that the writings of a Boyle, or a Swammerdam, of Roget, of Kirby, or of Bell—men whose attainments in science make us proud of the species to which we belong—have tended to shake in the slightest degree the religious faith of a single individual; and that the fervour of the piety which they every where breathe has not rather roused thousands from their withering and fatal apathy? The pestilential precepts of infidelity have emanated, not indeed exclusively, but principally, from benighted visionaries, alike blind to the beautiful harmony of nature, and from illiterate, cowardly and base fools, who have dared to "rush in where angels fear to tread," and whose lives and conversations have furnished in general the best refutation of their poisonous doctrines, and made all good men blush for being formed in the same image. A want of religion, revealed as well as natural, is not a mark of profound philosophy, for the deepest philosophers have bowed before that Being in whose sight their utmost wisdom is as foolishness; not of extensive erudition, for the most universal scholars have left behind them imperishable monuments of their devotion; not of superior spirit, for the greatest heroes have been as renowned for their religion as for their courage; not of high fashion, for persons of the most exalted rank have been no less conspicuous for unaffected piety; but, on the contrary, it *is* a mark, and, as far as my experience goes, a never-failing one, of a half-witted and half-educated — a dastardly and vulgar creature, not valiant, (as he perhaps tries to persuade himself,) since his wretchedly contracted views of things render him unconscious of what he braves, and the farthest possible from well-bred, since good manners would have taught him to treat with deference even the errors, if they be such, of the great and the good of all ages and of all nations."

Our Author's claim to professional distinction may safely be founded upon his Work on Physiology alone. But besides it, and those already mentioned, there are others, I suspect, which have been foisted on the world by certain literary and scientific jack-daws, who have plumed themselves with his feathers, and published opinions, if not books, as their own, for which Dr Fletcher ought to have got credit had the *suum cuique* maxim been observed.

He joined the Argyle Square Medical School in 1828-29, as Lecturer on Physiology, and latterly also lectured there on Medical Jurisprudence. He taught both of these branches of Medical Science in a manner which has seldom been equalled, never surpassed in Britain.

The rapid extension of his fame in the medical and scientific world affords unquestionable evidence of his superior attainments; whilst the steady increase of the number of his pupils proved how highly his talents as a public teacher were appreciated and valued.

In the beginning of last year, at the urgent solicitation of several individuals, who knew the extent of his attainments, he announced his intention of delivering a course of popular lectures on Physiology, (the introductory discourse to which has been already noticed,) which he did to a numerous and intelligent audience, amongst whom were some of the most talented members of the Scottish bar and of the English church, besides many other gentlemen distinguished for their intellectual endowments. There were upwards of three hundred ladies and gentlemen present at the first lecture, and many had to depart without being able to gain admittance. Dr Fletcher, therefore, repeated the lecture gratuitously some days afterwards. The variety and extent of interesting information which he communicated, the vast store of scientific knowledge which he brought to bear on the subject, and the beautiful preparations and diagrams, (all the work of his own hands, and which would have done credit to a first-rate artist,) by which he illustrated his subject, delighted and astonished his audience. When listening to his graphic description of the wondrous structure of organised bodies, and his luminous but delicate exposition of the functions of their various complicated organs, so illustrative, as he justly expressed it, of the wisdom and goodness of God, little, alas! did they think that his sun was to set so suddenly, whilst it was yet day, and before he had finished the Work, so energetically and auspiciously begun.

His health for some time past had been in a delicate state, but he did not consider it necessary to confine himself to the house until within a few days of his death. So insidiously did the disease make its attack, and continue its fatal progress, that no alarm was excited in his own mind, or on that of his affectionate wife, until Dr John Argyle Robertson having accidentally called, discovered the alarming condition of his valued friend. Dr Fletcher was afterwards seen by other highly talented members of the medical profession, who most anxiously and perseveringly rendered all the assistance which the healing art was capable of affording, but in vain. He was aware of his actual situation for about twenty-four hours before death, and submitted to the fate which he knew to be inevitable, with the rational fortitude of a Philosopher, as well as with the calm resignation of a Christian. He expired early on the morning of May 10, 1836, in the 45th year of his age, after not more than a week's confinement to the house, and scarcely an entire day to his bed.

His remains were deposited in the Edinburgh Episcopal Burial-ground of St John's.

An inflammatory affection of the lungs was the immediate cause of Dr Fletcher's death. Subsequent investigation, however, discovered that the state of these vital organs was such as to preclude the probability, if not possibility, of longevity; but it is too true, that his intense and unremitting application to study was the means of shortening his valuable life. By his decease, science lost a most industrious and successful cultivator, and the Medical School of Edinburgh was deprived of one of its brightest ornaments.

R. L.

RUDIMENTS

OF

PHYSIOLOGY.

PART I.

ON ORGANISM.

THE term Physiology signifies etymologically the History of Nature; and it was in this comprehensive sense that it was employed by the ancients in general. By the earlier moderns it was restricted to signify the History of that branch of medicine which relates to the nature and functions of Man; but it has more recently been again extended to include the nature and functions, not only of other Animals, but of Plants also. In this acceptation of the term Physiology may be defined to be the Science of those actions of Organized beings in which Life consists; (*a*) in other words, the Science of

(*a*) It appears to be of essential importance that the meanings attached in the following pages to the words "Organized" and "Life," as well as to some others more or less allied to, and therefore liable to be confounded with them, should be from the first precisely defined. How frequently do we find authors, with whom we agree perhaps in fact, perplexing us with propositions to which we cannot assent, from having attached to the words which they employ meanings totally different from those in which they use them. Nothing, for example, is more common than the proposition, "Life results from organization," and nothing perhaps is less exceptionable than the *fact* intended to be conveyed; but the principal *words* are entirely misapplied—the sentence should have stood, Life. (*a*) It has been proposed by some late authors to supersede the term Physiology by the terms Organonomy, Phyto-

" Vitality results from Organism." The following short glossary will, it is hoped, obviate all ambiguity and misunderstanding on this score in the present instance.

Organ—A part of a plant or animal more or less distinct from the rest, and destined to perform, either alone or in conjunction with others, some specific function.

Organization—The *process* by which a being possessed of organs is formed. (*v. g.* the formation of a germ)

Organism, or Organic Structure—The *structure* of a being so formed. [Dr Barclay is among the very few who have, with great propriety, made this distinction between organization and organism. The title of his Essay therefore, " On Life and Organization," has a very different meaning from that of the present Treatise, " On Organism and Life;" the former implying that life is the cause of the process by which an organized being is formed; the latter, that organic structure is a condition necessary to the manifestation of life]

Organized—Possessed of such a structure.

Organogenesy—The process by which the several organs become perfectly distinct from each other. (*v. g.* the development of a germ)

Organic—Appertaining to organized beings.

Vitality or Irritability—The property which characterizes organized beings of being acted on by certain powers otherwise than either strictly mechanically or strictly chemically.

Life—The sum of the actions of organized beings, resulting directly from their vitality so acted on.

It is constantly in these acceptations that the foregoing words will each be used in the text of the following work; and where a different meaning seems to be attached to them by authors cited in the notes, the sense apparently understood will be at the same time expressed in a parenthesis.

(*a*) By Rudolphi and others Physiology has been defined to be the Science of Organism. An organized being without life is, according to Rudolphi, a thing which cannot be conceived, since organism and life always begin and terminate at the same instant, and exist together in the same degree: the term life then signifies, he says, the same thing as organism. (*Grund. der Physiol.* 1821, I. § 2. and § 209) And indeed if he employ the term organism to signify something, not merely co-existent, but identical with life, the proposition is a mere truism, and the alteration in the definition was only superfluous; but if he employ it, as appears to be the case, to signify organic structure, the proposition is mistaken, and the alteration was vicious. It is not the case, as assumed by Rudolphi and so many others, and among the rest by Adelon, that " le mode de structure, appelé organisation, (organisme) et le mode d'activité, appelé vie, existent toujours ensemble;" (*Physiol. de l'Homme*, 1823, I. 31) the error having originated in confounding life with vitality or irritability, a constant attendant indeed on organism, and a necessary condition of life, but still not life itself—not " la vie," but " l'aptitude à vivre." Indeed Rudolphi himself appears elsewhere to be aware of the distinction; and describes, not life, but vitality only as co-existent with organism, admitting that there can nomy, Zoonomy, Bionomy or some other more precisely indicative of the scope and bearings of the science; but this endless introduction, on every frivolous pretence, of new technical terms seems adapted, much less to benefit, than to injure the cause of philosophy.

Organized beings then, the characteristic actions of which it is the province of Physiology to investigate, are distinguished from Inorganized matters by certain peculiarities, *in the first* place in their Structure, and *secondly* in their Actions. With respect to their Structure the following may be said to be the principal distinctive marks respectively

Of Inorganized Matters.	Of Organized Beings.
1. A body of an indefinite form, or of one presenting flat surfaces, and bounded by straight lines; of an indeterminate bulk, and without any general envelope.	1. A body of a definite form, (*Individual*) presenting convex or concave surfaces, and bounded by curved lines; of a determinate bulk; and invested by a general envelope.
2. An aggregation of homogeneous parts, no one of which bears any certain relation to the rest.	2. An aggregation of heterogeneous parts, (*Organs*) each of which bears a certain relation to the rest.
3. A substance exclusively either solid, liquid or aëriform; the particles of which are merely either superimposed upon, or intermingled with each other.	3. A substance conjointly solid, liquid and aëriform; (*Tissues and Fluids*) the solid particles being, as it were, interlaced or interwoven together, and traversed by the fluid.
4. A composition each of but few elements, associated into binary compounds; which, as formed by common chemical attraction, are easily imitated artificially, and which are not prone to spontaneous decomposition.	4. A composition each of several elements, associated, at least after the cessation of their vitality, into ternary or quaternary compounds; (*Proximate Principles*) which, as formed by secretion, are not capable of being imitated by art, and which are prone to spontaneous decomposition.

The characteristic differences between the two great kingdoms of nature are of course the more pronounced, the higher

be no excitement—that is to say no life—without the requisite stimuli to excite, as well as the requisite susceptibility of being excited; (§ 214) An asphyxized man is not disorganized, but he manifests no life; and the Eel of blighted corn —*Vibrio* 1—may continue organized, and retain its vitality for twenty or thirty years; nay the seeds and bulbs of some plants may do so perhaps for a hundred times that period, but without in all that time exercising any one of the functions in the sum of which life consists. Vitality or irritability, resulting as it does from organism, can never fail otherwise than from the destruction of this organism, and the return of the organized being to the state of inorganized matter; but life may fail without any such conditions. It is Anatomy which, as observed long ago by Richerand, is the Science of Organism, while Physiology is the Science of Life.

is the rank of any individual organized being, between which and inorganized matter the comparison is made; but even between the lowest tribes of the former and mere *bruta tellus*, the distinctions, as well in structure as in actions, are still too broad, to allow of our assenting to the speculations of those who represent the two as fundamentally the same. (*a*)

(*a*) It has nevertheless been frequently made a question whether there be really any precise line of demarcation between inorganised matters and organised beings, and whether the former do not, in fact, slide by insensible degrees into the latter. To say nothing of the alleged identity of their molecular construction,—a doctrine, not only of many of the ancients, but of Leibnitz, (*Essai de Théodicée, &c.* 1720) of Fray (*Sur l'Origine des Corps Org. et Inorg.* 1817) and of some others in modern times—it has been assumed as an axiom by some philosophers that, in the sensible characters of her works, " La Nature ne va point par sauts;" that the law of continuity is maintained from the lowest to the highest of created beings, every thing that exists constituting an essential link between something immediately below, and something immediately above itself in the great chain of creation; and that consequently, all nature being made up of individuals distinguished from each other only by a greater or less degree of advancement, every attempt to arrange them into genera, orders, classes and kingdoms, with certain definite lines of demarcation, must be as unphilosophical as it is futile. Leibnitz accordingly beautifully describes the universe as consisting in " L'unité dans la variété;" but the idea has been inculcated principally by Robinet, who, besides adopting this doctrine, or rather the necessary inference from it, that " tout la matière est organique, vivante, animale," expressly describes every object in existence, mineral, vegetable and animal, as resulting from the repeated efforts of nature, which became only progressively successful, to form man. (*De la Gradation Naturelle des Formes de l'Etre*, 1768.) In the course of her progressive improvement however she may be easily supposed to have gradually deserted her original plan, and to have left out some materials while she introduced others; so that this wild idea, involving thus the inorganic kingdom of nature in these supposed efforts, is not to be confounded with the more popular recent speculations, either on the progressive formation of the higher tribes of organized beings from the lower at the creation, or on the progressive development of each embryo in its generation, as connected with the subject of the supposed identity of all the tribes of such beings, or with that of the supposed unity of their organic structure, of which we shall speak in future. All those fantastic minerals accordingly which have been called Encephalites, Ophthalmolites, Podolites, Chirites &c. from their rude resemblance to certain parts of the human structure, furnish Robinet with proofs of this long and bungling apprenticeship of nature to the art of man-making; in the course of which the reputedly inorganic kingdom of nature is represented by him as having passed into the organic through the medium of mica, talc and other fibrous minerals, as it has been more recently by Schweigger, (*Handbuch der Naturgeschichte, &c.* 1820) through that of some kinds of corals: but in either case ~~it~~ is quite impossible, it is said, to determine where the one ends and the other begins. Whatever may be thought however of the difficulty of discriminating between one form of organized being

The four distinctive marks then above proposed will constitute the subjects of the four Chapters into which this first Part will be divided.

and another, that of distinguishing any such being from inorganized matter seems to be altogether imaginary. There may be "in this universe a stair, or manifest scale of creatures, rising, not disorderly, or in confusion, but with a comely method and proportion;" *(Religio Medici*, § 33) but in this stair or scale, as beautifully shewn by Dr Johnson, "wherever it begins or ends, are *infinite* vacuities;" *(On the Nature and Origin of Evil)* and however insensible we may sometimes be to these vacuities, as occurring between different forms of organized beings, the gap between the inorganic and organic kingdoms of nature is, at least in general, sufficiently perceptible. Even Bonnet accordingly, one of the most powerful advocates of the doctrine of a graduated scale of bodies, and who does not hesitate to inculcate that

—— "each moss,
Each shell, each crawling insect, holds a rank
Important in the plan of Him who framed
This scale of beings—holds a rank which, lost,
Would break the chain, and leave behind a gap
Which Nature's self would rue,"

admits, that in passing from inorganized matters to organized beings, "la nature semble faire un saut;" *(Sur les Corps Organ.* 1762) and, as remarked by Prichard, "no analogy can here be traced except what is vague and chimerical." (*On the Vital Principle*, 1829)

CHAPTER I.

ON THE FORM AND CLASSIFICATION OF ORGANIZED BEINGS.

The first of the above proposed distinguishing features in the structure of organized beings furnishes the foundation for Phytology and Zoology, or those Sciences which specify individuals, whether plants or animals, and refer each to its proper place in the system of nature.

Inorganized matters have no individuality, except in their integrant molecule. They may have a tendency, as is the case with crystals, stalactites and petrifactions, to assume a regular form and size; but the operation of this is in a great measure accidental, and they are susceptible of division in any direction, and to any degree, without prejudice to their properties: they cannot consequently have any fixed and certain shape, extent or covering, and their character therefore and situation in the system of nature must be taken from some other peculiarities. On the contrary organized beings have each collectively an individual existence, and proportions and dimensions more or less established; and upon being divided either acquire, in each portion, such new parts as are necessary to maintain their individuality, or cease to exist: the shape therefore, as well as the bulk and covering of each, is more or less decided, and affords sufficient grounds for determining and arranging them.

Plants are however somewhat less distinguished from minerals in these respects than the majority of animals are, since they are in general capable of being multiplied by division, while the latter are not. (*a*) Further they do not equally affect the globular or cylindrical form—which appears to be the basis, as it were, of the animal configuration—nor is their form so generally symmetrical, that is to say they are not so com-

(*a*) Hence by Darwin, Decandolle and others a plant has been represented to be not so much a single individual, as a collection of several; and if this be admitted, it may be said perhaps summarily that minerals are individual only in each molecule, while plants are so in each member, and animals in the sum of all.

monly divisible into two equal halves; they are capable in general of attaining a much greater size; the number of their members is commonly less determinate; and they have, unlike animals, a tendency to increase rather from their surface than from their centre. Plants however are not necessarily less highly organized than animals. It has indeed been maintained by some naturalists, and is a common opinion with the uninformed, that the vegetable constitutes a kind of intermediate kingdom between the mineral and the animal; and that the highest tribes of the former are still one step lower, in this respect, than the lowest tribes of the latter. (*a*) So far however is this from being the case, that it is not the highest, but the lowest tribes of plants which are most intimately related to the lowest tribes of animals—both being, in fact, only one remove from minerals, and perhaps, if not identical with each other, at least mutually convertible; (*b*) and it is from this point, or the common foundation of both, that Nature seems to advance by two different roads, till she arrive, by the one at the highest point of the vegetable, and by the

(*a*) This view of the matter was taken for example by Bonnet, (*Sur les Corps Organ.* 1762) and by Buffon, (*Hist. Nat.* 1768) the latter of whom speaks of the fresh-water polype as the first of plants, or the last of animals. But who can for a moment regard a coralline or a sponge as more highly organized than "the Cedar Tree that is in Lebanon," or even than "the Hyssop that springeth out of the wall?" The notion would imply a very inadequate knowledge of the circumstances which alone can establish a claim to precedence in this respect.

(*b*) It was this amalgamation, as it were, of the rudimental forms of plants and animals, which gave occasion to Pallas, Brisseau-Mirbel and others, to deny that there is any real distinction between them; but Nitzch and G. R. Treviranus are perhaps more correct in regarding many of the so called acotyledonous plants and zoophytes, which are perhaps essentially the same, as neither plants nor animals, properly so called, but a kind of chaos from which both take their rise. And accordingly some kinds of algæ and infusoria have been described as mutually convertible by Ingenhouz, Edwards and many other naturalists; and so ambiguous are at best the marks of these tribes, that, while some kinds of reputed algæ have been identified with polypi by Fontana, Saussure and Girod-Chantran, the sponges, so commonly regarded as of an animal nature, have been referred to the vegetable kingdom by John Bauhin, Ray, Tournefort and Spallanzani. There appears to be no way of reconciling these discrepancies, but that of establishing a tribe of organized beings inferior in rank to either plants or animals, in the strict acceptation of these terms, and constituting a class equally distinct from the mineral kingdom on the one hand, and from the proper vegetable and animal kingdoms on the other.

other at the highest point of the animal kingdom (*a*). Beginning then with the most abject forms of each—which we may, if we please, identify—we seem to ascend almost in the following order to the most exalted; assuming in the mean time, as the criterion of advancement in the scale, an increase in the number and extent of the manifestations of life, or of the relations which an organized being bears to the external world. It is hardly necessary to say that the question, in these cases, is one of *relative* perfection only; since every organized being is of course *absolutely* perfect, that is to say accurately adapted *per se* to the offices which it performs. (*b*)

Cryptogamic Plants.		Avertebrated Animals.	
Acotyledones. (Aphyllæ)	1. Fungi.	*Zoophyta.*	1. Infusoria.
	2. Lichenes.		2. Polypi.
	3. Algæ.		3. Acalephæ.
(Phylloideæ)	4. Characeæ.		4. Entozoa.
	5. Hepaticæ.		5. Echinodermata.
	6. Musci.	*Mollusca.*	6. Cirrhopoda.
	7. Marsileaceæ.		7. Brachiopoda.
	8. Lycopodiaceæ.		8. Acephala.
	9. Filices.		9. Gasteropoda.
	10. Equisetæ.		10. Pteropoda.
			11. Cephalopoda.

(*a*) " Ils forment," says Brisseau-Mirbel, " deux séries graduées, deux chaînes ascendantes, qui partent d'un point commun, mais qui s'écartent l'une de l'autre à mesure qu'elles s'élèvent."

(*b*) The commiseration expressed by Buffon and other naturalists for the abject condition in which nature appears to have placed some animals, as resulting from what they choose to regard the imperfection of their organism, is altogether misplaced. If the tardigrade quadrupeds, for example, with respect to which in a particular manner their tender sympathies have been manifested, move with difficulty and apparent pain when exposed to conditions under which other animals range about with freedom and delight, the circumstance is not such as to call forth our pity, or to warrant us in ascribing to them " a bungled and faulty composition." The happiness of each individual depends on the satisfying of its natural instincts, which instincts being the results of its organism, that organism can never be otherwise than perfect, nor are the means of happiness ever wanting. The toad under its cold stone has all the happiness of which it can form any conception: it is not the happiness of man, but it is the perfection of the happiness of a toad, and the organism of the toad is perfect with relation to that happiness. " The compassion," as remarked by Sir Charles Bell, " expressed by these philosophers for animals which they consider imperfectly organized is uncalled for; as well might they pity the larva of the summer fly which creeps in the bottom of a pool because it cannot yet rise upon the wing." (*On the Hand*, 1834, p. 31)

Articulata. (Annelida)	12. Abranchia.
	13. Dorsibranchia.
	14. Tubicola.
(Crustacea)	15. Isopoda.
	16. Læmodipoda.
	17. Amphipoda.
	18. Stomapoda.
	19. Decapoda.
	20. Entomostraca.
(Arachnida)	21. Trachealia.
	22. Pulmonalia.
(Insecta)	23. Diptera.
	24. Rhipiptera.
	25. Lepidoptera.
	26. Hymenoptera.
	27. Neuroptera.
	28. Hemiptera.
	29. Orthoptera.
	30. Coleoptera.
	31. Aptera.

PHANEROGAMIC PLANTS.

Monocotyledones.	
(With Perianth inferior or wanting)	13 orders.
(With Perianth superior)	5 orders.
Dicotyledones.	
(With Perianth single or wanting)	15 orders.
(With Perianth double, and Corolla monopetalous)	25 orders.
(With Perianth double, and Corolla polypetalous)	38 orders.

VERTEBRATED ANIMALS.

Vertebrata. (Pisces)	32. Chondropterygii.
	33. Plectognathi.
	34. Lophobranchi.
	35. Malacopterygii.
	36. Acanthopterygii.
(Reptilia)	37. Batrachia.
	38. Ophidia.
	39. Sauria.
	40. Chelonia.
(Aves)	41. Palmipedes.
	42. Grallæ.
	43. Gallinæ.
	44. Scansores.
	45. Passeres.
	46. Accipitres.
(Mammalia)	47. Cetacea.
	48. Ruminantia.
	49. Pachydermata.
	50. Edentata.
	51. Rodentia.
	52. Marsupialia.
	53. Amphibia.
	54. Digitigrada.
	55. Plantigrada.
	56. Insectivora.
	57. Cheiroptera.
	58. Quadrumana.
	59. Bimana. (*a*)

(*a*) Of the two tables given above the one corresponds very nearly with the natural arrangement of Jussieu, the other with that of Cuvier, both so far preferable to those of Linnaeus and other previous naturalists. The classification of animals upon the principles, not of their general similarities of form and function, but of the fundamental structure of their organs, as proposed by Geoffroy St Hilaire, De

It was computed several years ago that we were acquainted with about 56000 species of plants, and about 51700 species of animals: (*a*) but many more have been discovered since that time. The latter alone are said at present to amount to about 125000. (*b*) Of these about 4000 belong to the Division of Zoophyta, 8000 belong to that of Mollusca and the Classes of Annelida and Crustacea, 100000 belong to the Classes of Arachnida and Insecta, 6000 belong to the Class of Pisces, 600 belong to that of Reptilia, 5000 belong to that of Aves, 1200 belong to that of Mammalia. To some one or other however of the above 106 orders of plants, and 59 orders of animals, every species in nature must be referable; and accordingly, as often as any animal—for with plants we have comparatively little to do—is mentioned in the following work, its place in the scale will be indicated by the figure attached, in the above table, to the order to which it belongs. In this manner a rough idea of its relative rank will be inculcated; but it will be proper to keep constantly in mind that it is only a very rough idea that can be conveyed by any schedule of this description. For we are not to imagine that each individual tribe, whether of plants or animals, in these ascending scales, is in a certain and definite degree superior in rank to the one which immediately precedes it, or indeed that it is always superior to it at all; since, while on the one hand many tribes are often comprehended in a very slight advancement in the gradation, the transition on the other hand from one tribe to that next to it carries with it sometimes an advancement of almost infinite extent. In how insignificant a degree, for example, do the manifestations of life become more numerous or more extensive as we proceed through all the various steps which lead from the lowest to the highest orders of the avertebrated animals, while on the contrary how vast is the improvement in all the relations to the external world effected in the one short step from Apes to Man—

Simia quam similis, turpissima bestia, nobis!

Blainville and others, is unquestionably much more profound and scientific than that of Cuvier, but it appears to be less adapted—in as far as it is less natural and obvious—to our present purpose.

(*a*) Humboldt. (*Ann. de Chim.* tom. xvi)

(*b*) (*The Menageries*, 1829, vol. i. p. 129)

Further it is not always easy to determine the superiority, with respect to its rank as an organized being, of one tribe, whether of plants or of animals, compared with another; since, while the one certainly excels the other perhaps in some particulars, it may in an equal degree fall short of it in others, so that the balance, in any individual instance of comparison, is not always easily settled. (*a*) Upon the whole therefore we must continually remember, not only that the steps in the ascending stair of animated nature are of very unequal heights, but that, as expressed in this general way, it may be doubted whether they do not occasionally, at least with respect to individuals, lead rather downwards than upwards; and consequently that tables of this kind are at best only a very rude and imperfect indication of the ascent in question. (*b*)

It is a point which involves much curious and interesting speculation, not whether the inorganic and organic kingdoms of nature on the one hand, nor the vegetable and animal on the other, be essentially distinct or the same, but whether the various tribes respectively of plants and animals be fundamentally different from each other, or have been all formed upon the same plan, the sensible differences between them arising only from the circumstances of some having receded less, and others more, from the characters of the primitive nucleus on which all were originally constructed. It seems at first sight that there can be nothing in common, except in the accident of both being organized, with the abject Fungus and the stately Pine on the one hand, or with the base Polype and majestic Man on the other; but it has been a favourite hypothesis with some physiologists that the vilest species of

(*a*) Even in man "it is not," says Dr Roget, "on a pre-eminence in any single physical quality or function that the title to superiority can be founded, for in each of these endowments man is excelled in turn by particular races of the lower animals; but the chief perfection of his frame consists in its general adaptation to an incomparably greater variety of objects, and an infinitely more expanded sphere of action;" (*An. and Veg. Physiol.* 1834)

(*b*) It is remarked by Dr Roget, that this reputed chain is rather "a complicated net-work, where several parallel series are joined by transverse or oblique lines of connection;" or, according to Mr M'Leay, it is "more correctly represented by circular or recurring arrangements." (*An. and Veg. Physiol.* 1834, vol. i. p. 54) both the vegetable and animal kingdom pass by imperceptible degrees into the most elevated—and this, not by the acquisition, however insensibly effected, of essentially different rudiments, but merely by the development of such as are in all radically the same—the Fungus and the Polype being a coarse epitome, as it were, of the Pine and Man. (*a*) Nor is this prototype on which each plant and animal, however elevated, is supposed to be based, conceived to be merely traceable in imagination through all the adventitious forms of the less perfect fabric; but to have actually existed, first preparatory to the general creation successively of the various tribes of organized beings, and again preparatory to the development of the embryo of each individual in its generation.

It has been conjectured that, in the infancy of the organic

(*a*) The doctrine of the fundamental identity of the various tribes of organized beings would appear to have been a fortiori that, not only of Leibnitz, Fray, Robinet and the rest of those who identified all the three kingdoms of nature, but also of Pallas, Brisseau-Mirbel and all those who regarded at least the vegetable and animal kingdoms as one and the same; but it has been expressly promulgated principally, on the one hand by those who conceive that every form of organized matter consists of a congeries of monads or organic molecules of precisely the same nature, and competent therefore to enter into the composition of any organized being, and on the other by those who imagine that, if not all plants, certainly all animals consist of the same number of organs, and these all fundamentally the same. Among the former of these may be enumerated Turberville Needham, Buffon, Lamarck, G. R. Treviranus, Tiedemann and many more, while of the latter the chief is Geoffroy St Hilaire. Every body knows that it was the doctrine of Pascal, that " animated beings were, in their commencement, nothing but formless and ambiguous individuals, whose constitution was originally decided by the permanent circumstances in the midst of which they lived;" and the same is the principle of Lamarck, who traces all tribes of animals to the lowest zoophyte, and ascribes all the differences which they now display entirely to the different instincts which they experienced, and the different efforts which they severally made to gratify them—as if instinct were not determined by structure, and not structure by instinct. On the contrary Geoffroy St Hilaire attributes all these differences to the greater or less degree of original development of a certain primitive type common to all, and explicitly states " Il n'est plus d'animaux divers, un seul fait les domine, c'est comme un seul être qui apparait." (*Philosophie Zoologique*, 1830) " According to this system," says Dr Prichard, " men and toads are descended from the same original parents." But he might have gone much further than that, toads being more than half way up in the chain extending between the lowest tribes of organized beings and the lords of the creation—" il est si grand cet intervalle entre ses termes extrêmes, si imposant l'hiatus entre les familles du bas, et celles du haut de l'échelle zoologique."

kingdom of nature, and long after the establishment of the inorganic, none but the simplest possible tribes of plants and animals, as the fungi and polypi, existed. Many of these, it is supposed, continued to be propagated by either simple division or germs; while some of them on the contrary, under the influence of different external circumstances connected with the changes to which the globe itself was gradually subjected, underwent, on the progressive supply with their aliment of fresh materials, in the form of monads or organic molecules—the supposed nature of which will be elsewhere explained—a greater development than was consistent with the retention of their original characters, and hence resulted perhaps some higher tribes of acotyledonous plants, and among animals, the mollusca and the articulata. The propagation of many of these is believed to have continued to be effected without confusion from generation to generation, under the influence of the genital organs with which they were furnished, and which perpetuated only definite associations of the monads or organic molecules; but in the mean time improvement proceeded with some of them, upon which—external circumstances still varying—were built in succession, by the help of new molecules continually entering with their food, among plants the monocotyledones and dicotyledones, and among animals fishes, reptiles, birds and mammals, the last step of the process being the formation of man. The alleged evidences in favour of this hypothesis are that, as in the primary or first-created rocks no traces whatever of organized beings are to be met with, so of the secondary strata the lower layers are found to contain those only of the simplest acotyledonous plants, and of the lowest zoophytes, while the upper present traces of the monocotyledonous plants, as the palms, and of the lowest kinds of vertebrated animals, as fishes, reptiles and other oviparous tribes. It is not however till we come to the tertiary strata that we meet with any vestiges of the dicotyledonous plants, as the coniferæ, or of the highest tribes of vertebrated animals, as the viviparous; those of man in the mean time, who is presumed to have been last created, and whom alone nature made erect as the last and greatest of her works,

Cœlumque tueri
Jussit, et erectos ad sidera tollere vultus,

having never been found in these situations otherwise than quite superficially. (*a*) There actually existed then, it is supposed, one common nucleus of all the various tribes of plants and animals in the beginning of time, and it is further from one common nucleus that each individual of every tribe is imagined to be developed in its generation. There is indeed the best reason for believing that the germ of every plant and animal is in fact a kind of chaos, like that which has been above described as constituting, in the scale of organized beings, the common origin of either kingdom; and it is supposed that it assumes progressively, during its development, by the continual accession of new monads or organic molecules received by absorption, the characters of each tribe of that kingdom of organized beings of which it is to be a member, from the lowest upwards, till it stops at that to which it is destined to belong. In support of this doctrine is brought forward the general resemblance of the human embryo—taking this as the one which is to undergo the longest series of improvements—during its progressive development, to almost every tribe of animals in succession; (*b*) which is ascribed to its taking on the more and more advanced characters of each in the ascending scale, till it at length reaches, as a climax, the perfection of those of its own.

With respect to this hypothesis however, in its application to the progressive creation of the various tribes of organized beings, as built each upon the one below it, it may be said that, while it has nothing but the most vague and rambling presumptions in its favour, it is quite inconsistent with the generally immutable character of each tribe from the earliest periods of which we have any records; nor does the fact of many tribes being known to have formerly existed which have now perished from off the face of the earth, (*c*) any more than

(*a*) The anthropolithoi or fossil human bones found at Fahlun in 1785 were imbedded in iron-pyrites; those in a cavern on the Mendip Hills in stalactite; those at Trinidad in 1804 in a chalk-bank; those at Guadaloupe in 1814 in limestone; and those lastly at Köstritz in 1820 in cliffs of gypsum and loam.

(*b*) This general resemblance of the human embryo, at one time to the larva of a reptile, at another to the fetus of a quadruped, and so on, has been noticed by Harvey, Grew, Lister, Meckel and many others: we shall find however that it is, and must be, but a very coarse one.

(*c*) It might perhaps have been reasonably expected that, when all the orgathat of many others now inheriting the earth which probably at one time had no existence, afford any proof of their mutual convertibility, or indicate any thing more than that the character of its inhabitants has, at different times, varied with that of the globe. Moreover the most amply developed avertebrated animal could never have become a fish, nor the most perfectly developed fish a reptile, and so on, so long as the form and mutual relations of their parts were maintained; and if this form and these relations were altered, it cannot be said to be merely in their general development that the several tribes of animals differ from each other. Nor, in its application to the elaboration of each individual in its generation, is this hypothesis more happy, in as far as it would establish an identity of the several tribes of organized beings, upon the presumption that the human fetus belongs in turn to each inferior tribe of animals before it arrives at its own. The human fetus never belongs to any tribe but man. Its several organs may, in their different phases, be formed in succession upon the model of those of many inferior tribes, but the fetus collectively is never formed upon any model but its own. That the corresponding *organs* of the different tribes of animals are fundamentally the same, and that the organs of the human fetus represent in turn those of many of the lower animals,

nized beings on the face of the earth consisted of cryptogamic plants and avertebrated animals, not only many species would be in being which became afterwards swallowed up upon a different balance of power being set up in the organic kingdom, but also that they would be in general of gigantic size; and such appears to have been the case with many of the fuci and algæ and many of the zoophyta of the primitive world. Of the fishes and reptiles also, which seem to have inhabited the globe before birds and mammals were in existence, not only was the number of species apparently much greater than we are at present acquainted with, but their size in general seems to have been such as is in our times fortunately unheard of. Of these enormous creatures we have examples in the Hylæosaurus discovered by Mr Mantell, which measured about thirty feet, in the Iguanodon, likewise discovered by Mr Mantell, and in the Megalosaurus, discovered by Mr Buckland, each of which measured from seventy to eighty feet; and as instances of the ambiguous nature of some of them may be mentioned, the Plesiosaurus of Conybeare, something between a fish and a crocodile, and the Pterodactyle of Cuvier, a kind of mixture of fish, reptile, bird and quadruped. Among quadrupeds also the Megatherium of Paraguay, and the Mastodon of the Ohio and the Irawadi, are good illustrations of the immensity of the antediluvian species, and the Megalonix of President Jefferson, of their equivocal nature.

is a truth which will in future fall to be particularly insisted on; but the fundamental identity of such organs by no means implies an actual identity, either of the different *tribes* of animals which consist of an assemblage of these organs, or of the human fetus at any period with any one of the inferior tribes. In order that this should be the case with respect to the different tribes, as compared with each other, it would be necessary, as just observed, that the form and mutual relations of the several organs should be at every step in the ascending scale maintained; whereas it is sufficiently well known, not only that any development may be, with respect to the elements of each organ, quite irregular, so that its general aspect may become entirely changed, but also that some organs do not at any given step advance at all, perhaps even recede, while the rest undergo, some a slight, and others a vast degree of development. And the same want of correspondence takes place in the progressive advancement of the organs of the human fetus, as compared with those of any one of the inferior tribes. Its individual organs may represent, at different periods of their elaboration, those of an avertebrated animal, of a fish, a reptile, a bird, a quadruped; but if, while the respiratory organs are like those of one tribe, the circulating organs represent those of another, and the assimilating organs, the genital organs, and those of sensation, thought and voluntary motion, those of numerous others, it is impossible that, akin as it may be in its several parts to many, it should be collectively akin to, and still less identical with any one. (*a*)

(*a*) The system then which would establish it that " men and toads" differ only in their greater or less development is not tenable; for, admitting that during the development of the human fetus, it rests at each step of its progress upon a basis inferior to that to which it is about to be raised, it is not true that this inferior basis is identical with any other established form of organized existence: and still more certainly do the various tribes of mature animals essentially differ from each other. For the phrase then " *Les Animaux* sont tous créés sur le même plan," we should read rather " *Les Organes des Animaux*" —since in the different associations of organs constituting the various species of animals the plan is decidedly different. The established distinctions therefore between beasts and birds and creeping things and fishes may be allowed still to remain; and it may be conceded to Weber, that, however similar certain animals may be to one another in some respects, they are still more dissimilar in others, (*Hildebrandt's Anatomy*, I. 125) and to Rudolphi, that the human embryo is

It is not then on one common nucleus, but on several, that the various tribes of plants and animals appear to have been constructed; and the different character and mutual relations of these nuclei in the various tribes seem to be quite sufficient to justify us in regarding them as decidedly different from each other.

still a human embryo, distinct from all other animals and animal embryos, and that it never was a worm." (*Grund. der Physiol.* 1821, § 129) All the races of animated beings may be, as Dr Roget remarks, " members of one family," but no one of these members has ever been identical with any other; and " whatever may be the apparent similarity between one animal and another during different periods of their respective developments, there still exist specific differences establishing between them an impassable barrier of separation." (*An. and Veg. Physiol.* 1834)

CHAPTER II.

ON THE AGGREGATION OF ORGANIZED BEINGS.

SECTION I.

On the Organs of Plants and Animals in general.

The second of the above proposed distinguishing features in the structure of organized beings furnishes the foundation for Descriptive Anatomy, or that Science which describes the organs of plants and animals, and their mutual relations and dependencies.

Inorganized matters, as indeed their name implies, have no organs. Each part of such a substance is an epitome of the whole, from which it may be removed without any bad consequence; for, as it is itself independent of the other parts, so it contributes nothing to their integrity. On the other hand organized beings are composed each of certain organs, every one of which is a necessary part of the whole; for, while it is itself more or less dependent on the rest, it conduces in a greater or less degree to the perfection of all. (*a*) It is true that in plants in general, as well as in quite the lowest tribes of animals, this subserviency of each part to the existence or welfare of the whole, is much less remarkable than in animals in general; and hence they are generally, as has been already stated, capable of being multiplied by division. In the latter we meet with always a distinct pair of lungs, or some corresponding organ, a distinct heart and blood-vessels, or something which answers the same purpose, and so forth; and we know by experience that each of these organs is reciprocally dependent on the others, as the whole body is upon them all: but in quite the lowest tribes of animals, and in plants in general, these organs are not met

(*a*) "The reason," says Kant, "of the existence of each part of an unorganized being is to be found in itself, while, in organized beings, the reason of the existence of each part resides in the whole;" or, as it is expressed by Richerand, "Chaque partie d'une masse brute ou inorganique est independante des autres parties—au contraire toutes les parties d'un corps vivant, soit végétal, soit animal, tendent et concourent à un but commun."

with, at least in a concentrated and obvious state; so that, as no single part contains any one of these or other vital organs, no single part is quite essential either to any other part or to the whole. Nevertheless to all forms of organized beings it seems to be requisite that organs corresponding to lungs, heart and blood-vessels, and so forth, should be present in every individual which is capable of an independent existence; and the only difference in this respect between plants and the lowest tribes of animals on the one hand, and the rest of the animal creation on the other, appears to consist in this, that in the two former these organs are scattered and intermixed, while in the latter they are collected and individualized.

It seems indeed that the great diffusion of the several organs is a chief characteristic of the lowest forms of organized beings; and that the tendency to concentration or centralization in this respect is in general in the direct ratio, in each, of the advancement of its organism, or its rank in the scale of organized beings, to be determined, as already stated, by the number and extent of its relations with the external world.

Thus the Respiratory Organs in the acotyledonous plants and the zoophytes are so diffuse as to be quite indistinguishable from the general surface; but as we advance through the other vegetable tribes, as well as the other tribes of avertebrated animals, we find it assuming the appearance, first of numerous but distinct vesicles, opening in plants by stomata of various forms on the surface of their leaves, and in animals by different kinds of apertures on the surface of various parts of their body. Such is the case, among the annelida, in the Earth-worm — *Lumbricus* 12 (*a*) — and Leech — *Hirudo* 13 (*b*)—and, among the arachnida, in the Scorpion — *Scorpio* 22 (*c*)—while in insects the numerous stigmata opening on the surface of their body are prolonged into tubes which ramify throughout every part of their substance. Of this we have examples in the Silk-worm — *Phalæna* 25 (*d*) — the Moth—*Sphinx* 25 (*e*) — the Bee —

(*a*) Carus. (*Comp. Anat.* pl. v. fig. 3)

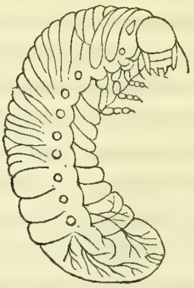
(*b*) Home. (*Comp. Anat.* vol. iv. p. 39)

(*c*) Treviranus; Roget. (*An. and Veg. Phys.* vol. ii. p. 315)

(*d*) Malpighi.

(*e*) Swammerdam; Carus. (pl. vii. fig. 19)

Apis 26 (*a*) — the Hornet-fly — *Asilus* 26 (*b*) — the Grasshopper — *Gryllus* 29 (*c*)—the Beetle—*Scarabæus* 30 (*d*) — the Stag-beetle —*Lucanus* 30 (*e*) — the Cerambyx—*Cerambyx* 30 (*f*)—the Louse—*Pediculus* 31 (*g*)—and numerous others. Much less diffuse in general are the respiratory organs of the vertebrated tribes: but among fishes the Rays and Sharks, as well as the Lamprey —*Petromyzon* 32 (*h*)—and the Myxine—*Gastrobranchus* 32 (*i*)—still breathe by numerous vesicles, called internal gills, the entrance to which is from their gullet, while the exit is in general by corresponding apertures on the sides of their neck; and even those fishes which breathe by external and more concentrated gills still conduct the water over them from their pharynx by numerous apertures. The latter seem to employ further their air-bladder, connected as it is in general with some part of the alimentary canal, as an additional respiratory organ, in the same manner as some reptiles, for example the Proteus and Siren—*Proteus* and *Siren* 37 (*j*)—use both gills and lungs, while others have both lungs and a reputedly urinary, although perhaps really respiratory bladder; and it is not till we arrive at the highest of the vertebrated tribes that we find the respiratory organs settling into one compact pair of lungs. The same is the case also with the Circulating Organs, those parts which, in the more advanced tribes, are to become distinct blood-vessels and a heart, being in quite the lowest plants and animals merely scattered cells, which by their subsequent union form tubes. These tubes are at first still diffuse but distinct, as in plants in general, and in the Sea-blubber—*Medusa* 3 (*k*)—but in the course of them dilatations subsequent-

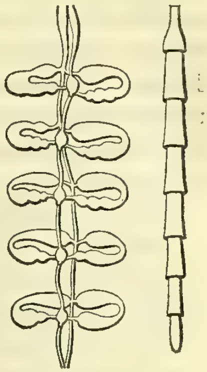


Bee-worm.

Shark.

(*a*) Swammerdam. (pl. xvii)
(*b*) Swammerdam. (pl. xxxix. and xl)
(*c*) Carus. (pl. vii. fig. 21)
(*d*) Malpighi.
(*e*) Swammerdam. (pl. xxvii)
(*f*) Fabricius; Roget. (vol. ii. p. 311)
(*g*) Swammerdam.
(*h*) Home; (vol. iv. pl. 46) Roget. (vol. ii. p. 302)
(*i*) Home. (vol. iv. pl. 47)
(*j*) Home. (vol. vi. pl. 58)
(*k*) Gaede; Carus; (pl. i. fig. 9) Forskall; Roget. (vol. ii. p. 88)

ly occur, constituting, for example, the numerous little hollow beads in the vascular semicircles which surround a portion of the intestinal canal of the Earth-worm—*Lumbricus* 12 (*a*)—and some of the crustacea, (*b*) and the valvular pouches in the dorsal vessel of the arachnida, as the Spider—*Aranea* 22 (*c*)—and in that of insects in general, as the Silk-worm—*Phalæna* 25 (*d*)—Moth—*Sphinx* 25 (*e*)—Bee—*Apis* 26 (*f*)—and Cock-chafer—*Melolontha* 30 (*g*)—Similar dilatations take in the Cuttle—*Sepia* 11 (*h*)—the form of three distinct hearts, and in the Ship-worm—*Teredo* 8 (*i*)—that of two, till at last we arrive at the one compact heart of the vertebrated tribes. Nor are the large trunks of the arterial, venous and lymphiferous and chyliferous systems at first individualized, almost all those vessels which in the higher tribes are single, as the aorta, vena cava and thoracic duct, being in the lower double or even still more diffuse; and the same want of concentration prevails even among organs composed chiefly of blood-vessels, the thyroid gland, for example, having its two lobes quite unconnected in birds, and among mammals in the Elephant, the Horse, the Dog and the Cat. With respect to the ORGANS OF ASSIMILATION also, the stomach and intestines are much less concentrated in the lower, than in the higher tribes of animals; witness the diffuse cells, which, in quite the lowest orders, stand in the place of these organs, and their ramifications and repetitions when first met with. Of the former we have examples, among the avertebrated animals, in the numerous blind pouches connected with the stomach even of some in-



Earth-worm. Insect.

(*a*) Home; (vol. iv. pl. 40) Morren; Grant; Roget. (vol. ii. p. 255)

(*b*) Audouin; Grant.

(*c*) Treviranus; Carus. (pl. vii. fig. 7)

(*d*) Malpighi.

(*e*) Carus. (pl. vii. fig. 13)

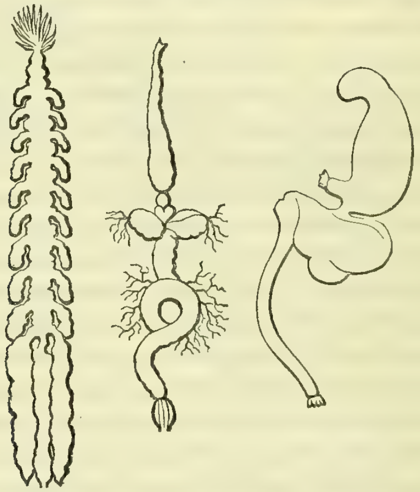
(*f*) Swammerdam. (pl. xix)

(*g*) Straus Durkheim; Roget. (vol. ii. p. 237)

(*h*) Swammerdam; Home. (vol. iv. pl. 45) Audouin; Roget. (vol. ii. p. 271)

(*i*) Home; Carus. (pl. ii. fig. 15)

fusory animals, as the *Leucophra* 1 (*a*)—but much more obviously with that of the Sea-blubber — *Medusa* 3 (*b*)—the Star-fish—*Asterias* 5 (*c*)—and the Leech—*Hirudo* 12 (*d*)—and with the whole course of the intestinal canal of the Cuttle —*Sepia* 11 (*e*)—the Sea-worm — *Nereis* 13 (*f*) — the Sea-mouse—*Aphrodita* 13 (*g*)—the Crab—*Cancer* 19 (*h*)—and the Louse—*Pediculus* 31 (*i*)—as well as in the bundles of scattered tubes, which in most insects seem to serve the purpose of a liver, as in the Cock-chafer—*Melolontha* 30 (*j*) — Of



Leech. *Insect.* *Hamster.*

the latter we have examples in the plurality of stomachs of the Blatta—*Blatta* 29 (*k*)—the Grasshopper—*Gryllus* 29 (*l*) —and many other insects. Subdivisions of the stomach are

(*a*) Ehrenberg; Roget. (vol. ii. p. 97)

(*b*) Gaede; Carus; (pl. i. fig. 10) Forskall; Roget. (vol. ii. p. 88)

(*c*) Tiedemann; Roget. (vol. ii. p. 100)

(*d*) Carus; (pl. v. fig. 8) Newport; Roget. (vol. ii. p. 103)

(*e*) Home; (vol. ii. pl. 83) Carus. (pl. iv. fig. 2)

(*f*) Home; (vol. ii. pl. 79) Carus. (pl. v. fig. 13)

(*g*) Pallas; (*Misc. Zool.* pl. vii.) Home. (vol. iv. pl. 39)

(*h*) Tyson; Colins. (*Anaty.* pl. xxxix. fig. 1)

(*i*) Swammerdam. (pl. ii. fig. 3)

(*j*) Léon Dufour; Roget. (vol. ii. p. 213)

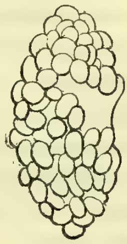
(*k*) Marcel des Serres; Carus. (pl. vii. fig. 20)

(*l*) Home. (vol. ii. pl. 84)

very common also among the vertebrated tribes, as in the Sea-devil—*Lophius* 32 (*a*)—and Shark—*Squalus* 32 (*b*)—among fishes; the Surinam toad—*Rana* 37—Viper—*Coluber* 38 (*c*)—and Crocodile—*Crocodilus* 39—among reptiles; the Pelican—*Pelicanus* 46—among birds; and the Hare and Rabbit—*Lepus* 51—the Dormouse—*Glis* 51 — the Hamster—*Mus* 51 (*d*)—the Beaver—*Castor* 51—the Kanguroo —*Kangurus* 52 (*e*)—and the Bat—*Vespertilio* 56 (*f*)—among mammals: and ramifications similar to those found in the avertebrated tribes are met with in the Dugong—*Manatus* 47 (*g*)—the Elephant — *Elephantus* 49 — the Hippopotamus — *Hippopotamus* 49—the Peccari—*Sus* 49—the Sloth—*Bradypus* 50—and the Rat—*Mus* 51—Lastly a similar plurality of stomachs, besides the craw or crop in their gullet, occurs in the Pigeon—*Columba* 43 (*h*)—and other Gallinaceous Birds; and, among mammals, in the Porpoise—*Delphinus* 47 (*i*)—Camel—*Camelus* 48 (*l*)—Sheep—*Ovis* 48 (*j*)—Ox—*Bos* 48 (*k*)—and ruminantia in general. The cœcum again is in most of the lower vertebrated animals very long and frequently double; the liver is divided into numerous lobes by deep fissures; and the pancreas occurs either in the form of innumerable cœcal appendages to various parts of the intestinal canal, as in the Burbot—*Gadus* 35 (*m*)—and most osseous fishes, or at least in two distinct portions; so that upon the whole it is only in quite the higher tribes that any thing like a concentration of these organs is to be met with. Of the Urinary Organs again, the kidneys, in the avertebrated tribes, are so little centralized as to appear to be wanting; while in fishes in general, as the Gurnard—*Trigla* 34 (*n*)—and in reptiles, as the Proteus — *Proteus* 37 (*o*) — and Salamander — *Salamandra* 37 (*p*)—they constitute a diffused, spongy, beaded mass, extending along the greater part of the spine. And indeed in almost

(*a*) Home. (vol. ii. pl. 94)
(*b*) Home. (vol. ii. pl. 69)
(*c*) Home. (vol. ii. pl. 64)
(*d*) Daubenton; Carus. (pl. xix. fig. 18)
(*e*) Home; (vol. ii. pl. 19) Cuvier; Roget. (vol. ii. p. 191)
(*f*) Home. (vol. ii. pl. 20)
(*g*) Home. (vol. iv. pl. 25)
(*h*) Carus. (pl. xv. fig. 12)
(*i*) Cuvier.
(*j*) Home. (vol. ii. pl. 24)
(*k*) Bell.
(*l*) Home. (vol. ii. pl. 21)
(*m*) Carus. (pl. ix. fig. 20)
(*n*) Colins. (pl. xxxviii)
(*o*) Home. (vol. vi. pl. 58)
(*p*) Carus. (pl. xiii. fig. 3)

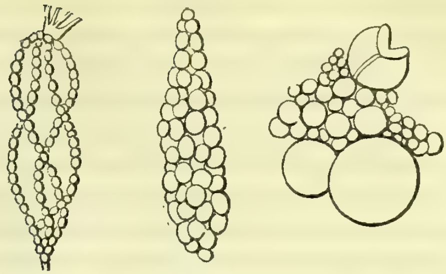
all the lower animals these organs are lobulated, sometimes to such a degree as to represent, as in the Ostrich—*Struthio* 43 (*a*)—among birds, and the Porpoise—*Delphinus* 47 (*b*)—and Seal—*Phoca* 53 (*c*)—among mammals, a bunch of grapes. The same rule holds likewise with the Genital Organs, which may be described as almost universally diffused throughout the substance of such of the inferior tribes of both plants and animals as propagate by shoots. And even when distinct female and male organs are first met with, they are often, as in most plants,



Seal.

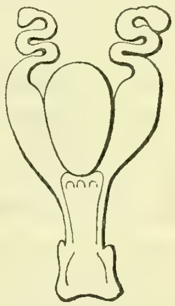
and, among animals, in the Ascidia—*Ascidia* 8 (*d*)—the Sea-hare—*Aplysia* 9 (*e*)—the Garden-snail—*Helix* 9 (*f*)—the Earth-worm—*Lumbricus* 12 (*g*)—and the Leech—*Hirudo* 12 (*h*)—combined together in the same individual, besides being in plants very generally scattered over each. In animals also which are female and male the sexual organs become only progressively concentrated. Thus the ovaries of the female Round intestinal worm—*Ascaris* 12 (*i*)—and the testicles of the male, (*j*) present an appearance like that of the liver of insects and the pancreas of all animals below the cartilaginous fishes, being of a tubular form, and constituting, not indeed a series of several tubes, but one enormously long and convoluted; and a more or less similar appearance is displayed by the same organs in the crustacea, as the Cray-fish—*Cancer* 19 (*k*)—the arachnida, as the Spider—*Aranea* 22 (*l*)—and insects in general, as the Silk-worm—*Phalæna* 25 (*m*)—and Horned-beetle—*Scarabæus* 30 (*n*)—The same diffusion also may be traced long after these tubes have become condensed into solid organs; witness the large and deeply lobulated ovaries of fishes

(*a*) Colins. (pl. lxxv)
(*b*) Colins. (pl. xliv)
(*c*) Carus. (pl. xix. fig. 22)
(*d*) Carus. (pl. ii. fig. 2)
(*e*) Cuvier; Carus. (pl. iii. fig. 7)
(*f*) Cuvier; Carus. (pl. iii. fig. 3)
(*g*) Home; Carus. (pl. v. fig. 3)
(*h*) Home; (vol. iv. pl. 39) Carus. (pl. v. fig. 11)
(*i*) J. Cloquet. (*Vers. Intest.* pl. iv. fig. 1)
(*j*) J. Cloquet. (*Vers. Intest.* pl. ii. fig. 8)
(*k*) Carus. (pl. vi. fig. 4, and 10)
(*l*) Carus. (pl. vii. fig. 8)
(*m*) Malpighi.
(*n*) Swammerdam. (pl. xxx)



Silk-worm. *Reptile.* *Bird.*

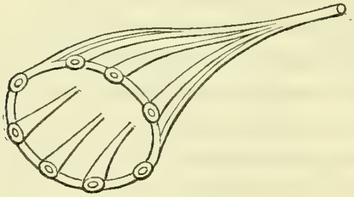
in general, as the Dog-fish — *Squalus* 32 (*a*) — of reptiles, as the Proteus — *Proteus* 37 (*b*)—of birds, as the common Fowl—*Phasianus* 43 (*c*) — and even of some mammals, as the Hog — *Sus* 49 (*d*) — and in the testicles of almost all vertebrated animals, except man, the epididymis is quite distinct from the body of the gland. The progressive advancement also from a diffuse to a concentrated uterus is beautifully shewn in the various tribes of mammals, from the decidedly double uterus of the Duck-billed animal — *Ornythorrynchus* 50 (*e*) — through the doubly-arched uterus of the Kanguroo — *Kangurus* 52 (*f*) — and Opossum — *Didelphis* 52 — the distinctly horned, but not arched uterus of the Dugong — *Manatus* 47 (*g*) — and most quadrupeds; the slightly bifid uterus of the Makis, and the merely triangular uterus of the Anteater — *Mermecophaga* 50 — and Armadillo—*Dasypus* 50 — to the compact pear-shaped uterus of the human female. How much more concentrated also are the mammæ of the last than those of almost any other mammal is sufficiently well known. The same tendency to centralization, as we advance in the scale of beings, is equally obvious in parts the duration of which is only temporary; the human placenta, for example, being only a concentration of the glan-



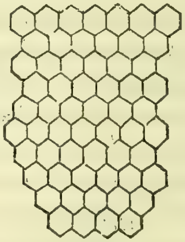
Duck-billed animal.

(*a*) Home. (vol. vi. pl. 52)
(*b*) Home. (vol. vi. pl. 56)
(*c*) Carus. (pl. xv. fig. 12)
(*d*) Carus. (pl. xx. fig. 9)
(*e*) Home. (vol. iv)
(*f*) Home. (vol. iv. pl. 125)
(*g*) Home. (vol. iv. pl. 116)

dulæ and cotyledons of quadrupeds, as these again are of the still more diffuse corresponding organs of the oviparous tribes. The double penis again of many avertebrated animals, as the Cray-fish—*Cancer* 19 (*a*)—and Spider—*Aranea* 22 (*b*) —as well as of several vertebrated, as many reptiles and birds, and, among mammals, the Duck-billed animal—*Ornithorrynchus* 50 (*c*)—and the bifid glans penis of the Opossum—*Didelphis* 52—are further illustrations of the proposition in question. With respect to the ORGANS OF SENSATION, it is probable that quite the lowest tribes of animals, as the polypes, smell, see and hear by their whole surface; and even in the mollusca and articulata these organs are certainly much less individualized and compact than in the higher tribes of animals. The organ of smell is in general very obscure in them all; but that of sight is often sufficiently obvious from the infusoria upwards, although it is in general very diffuse. Such are the numerous stemmata of some of the annelida and of caterpillars in general, (*d*) as well as of the arachnida,



Caterpillar.



Insect.

as the Spider—*Aranea* 22—and Scorpion—*Scorpio* 22—which have these stemmata alone; and such are the compound eyes of insects, which consist of from fifty to twenty-five thousand distinct eyes, as in the Butterfly—*Papilio* 25—and Beetle—*Scarabæus* 30—which have these compound eyes alone, and the Bee—*Apis* 26 (*e*)—and Dragon-fly—*Libellula* 27 (*f*)—which have both stemmata and compound eyes. The lacrymal gland also is more compact in Apes and Man than in any

(*a*) Swammerdam; (pl. xi. fig. 9) Carus. (pl. vii. fig. 4. and 10)

(*b*) Treviranus; Carus. (pl. vii. fig. 8)

(*c*) Home. (vol. iv. p. 131)

(*d*) Muller; Roget. (vol. ii. p. 484)

(*e*) Swammerdam. (pl. xx. fig. 5)

(*f*) Dugès; Roget. (vol. ii. p. 481)

other animal possessed of that organ. The organ of hearing in most of the avertebrated tribes is again very ambiguous; but the tubular or otherwise prolonged lips of so many of them is in favour of the presumption that the organ of taste is in them very diffuse. The almost double tongue of serpents, and the slightly cloven tongue of the Frog—*Rana* 37 (*a*)—of rapacious birds in general, and, among mammals, of the Dromedary—*Camelus* 48—and Seal—*Phoca* 53 (*b*)—all tend to the same conclusion, that a want of concentration is characteristic of a low degree of advancement. But perhaps no organ, or set of organs, so well displays this diffusion in the ruder tribes of organized beings as the NERVOUS SYSTEM. Few plants offer any traces of it; and in those which appear to do so, it presents itself in the form, not of masses, nor even of cords, but of minute, scattered globules. Among the avertebrated animals likewise many tribes, as the zoophytes in general, including even the Sea-blubber—*Medusa* 3—the Tape-worm—*Tænia* 4—and the Sea-hedgehog—*Echinus* 5—are quite destitute, to all appearance, of such a system; and when it does manifest itself, it is always in the form of diffuse cords and knots, loosely connected indeed together, but nowhere so incorporated as to present any appearance like that of the concentrated spinal cord and brain of the superior tribes. These knots, in quite the lowest animals which display a nervous system at all, are in general so disposed as to constitute, with their connecting medium, a kind of circle sending out rays, but in the greater number of avertebrated animals they form a line running down the body. The connecting medium of these knots also, which is double in some, as the Leech—*Hirudo* 12 (*c*)—is single in others, as the Earth-worm—*Lumbricus* 12 (*d*)—an argument of a somewhat higher advancement in the scale; and when the animal is considerably further advanced, the main part of the nervous system is no longer in diffuse knots, but in one large knot called the thoracic ganglion, in the centre of the body, as in the Spider-crab—*Maia* 19 (*e*)—It is equally in favour also of the doctrine now under consideration, that, in such of the lower

(*a*) Carus. (pl. xii. fig. 18)
(*b*) Daubenton; Carus. (pl. xx. fig. 5)
(*c*) Home. (vol. iv. p. 39)
(*d*) Home. (vol. iv. p. 147)
(*e*) Audouin; Roget. (vol. ii. p. 545)

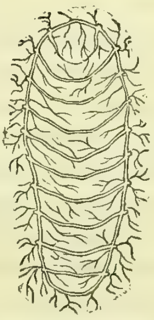
tribes as have a distinct spinal cord, as fishes, reptiles, birds and mammals, it extends generally to their os coccygis, whereas in Man it terminates about his second lumbar vertebra. There remain only the ORGANS OF LOCOMOTION; and proper as the skeleton and the muscles by which its several bones are moved appear to be to the vertebrated animals, it is not improbable—as will be shown more fully in future—that they exist also in the avertebrated, although in so rudimental and diffuse a state that they cannot be recognised. The jaw-bone certainly of the Sea-hedgehog — *Echinus* 5 (*a*)—commonly called Aristotle's lantern, consists of not fewer than five pieces, each of which is a kind of epitome of that of some of the higher classes of animals; and the teeth likewise, although they are, strictly speaking, no part of the skeleton, are far less centralized in the lower than in the higher tribes, being met with in the Sea-nettle—*Actinia* 3—and Star-fish—*Asterias* 5 — on the membrane which surrounds the mouth, in the Whelk — *Buccinum* 9 — on the tongue, in the Sea-mouse—*Aphrodita* 13—and many insects on the proboscis, and in the Sea-hare—*Aplysia* 9—Sea-worm—*Nereis* 13—and Cray-fish—*Cancer* 19—in the gullet, stomach and elsewhere, while, among the vertebrated animals, a similar diffusion of these organs is met with only in fishes.

It may appear at first sight to be an objection to the doctrine in question, that, the more perfect is any animal, the more complicated are in general its heart, eye, ear, brain and some other organs: but it must be remembered that it is not the simplicity of an organ as opposed to complexity, but its concentration, as opposed to diffusion—its constituting within a space more or less definite and circumscribed, the whole or principal instrument of the function to which it is subservient—which is here assumed as in general proportioned to the advancement of the organism of the being to which it belongs, and, so that this is maintained, its simplicity or complexity is, in this respect, a matter of indifference. Perhaps it may be said summarily that, as we ascend in the scale of organized beings, the tide, as it were, of the component parts of the several organs sets first from the periphery

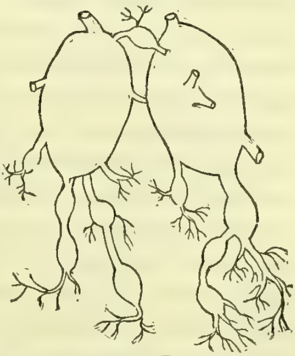
(*a*) Carus. (pl. i. fig. 19)

of each to its centre, so that in proportion as its rays, formed at first of distinct points, are shortened, and the lobules thus resulting are obliterated, the central portion becomes at once more individualized, larger and more simple; but now another tide sometimes sets in an opposite direction, namely from the centre of the organ to its periphery, so that, without losing any thing of its compactness and centralization, it gains once more in extent, and *now* in complexity. It is of the former tide alone that we are at present speaking. The latter will fall to be considered, in conjunction with it, under the head of unity of organic structure; since that unity can be established only by forming a just estimate of the changes which both processes are calculated to effect.

And it is a strong corroboration of the doctrine now under consideration, that almost all the organs of animals in a state of immaturity are less concentrated than they afterwards become. The respiratory apparatus in insects in general, for example in the Bee—*Apis* 26 (*a*)—is much more diffuse in the imperfect than in the perfect state of the animal; and the same thing occurs in reptiles, the larva of the Frog for instance—*Rana* 37 (*b*)—possessing both gills and lungs, but losing the former in proportion as the animal approaches maturity. But this fact is perhaps still more remarkable with respect to the assimilating organs. In the larva of insects, as the Moth—*Sphinx* 25 (*c*)—the stomach and its appendages are much more ample and diffused than in the pupa, and in this again than in the imago, the degree of concentration being



Bee-worm.

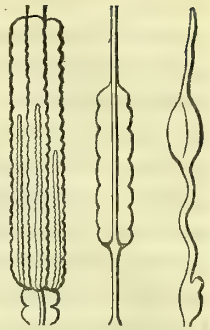


Bee.

(*a*) Swammerdam. (pl. xxiv. fig. 1. and xvii. fig. 9)

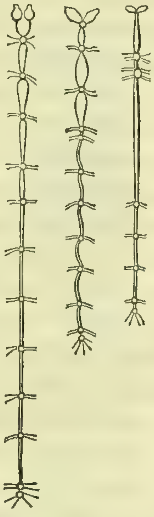
(*b*) Swammerdam; (pl. xlix) Home; (vol. vi. p. 55 and 56) Carus.

(*c*) Carus; (pl. vii. fig. 11, 12, 15 and 16) Newport; Roget. (vol. ii. p. 217)



Larva. Pupa. Imago.

proportioned in each to the step made towards perfection; and the same thing is met with in reptiles, the intestinal canal becoming sometimes so much less voluminous on the animal attaining a perfect state, that that of the mature Frog—*Rana* 37 (*a*)—does not exceed one quarter of the length which it had in the tadpole. A similar concentration takes place also in the nervous system, in those animals which undergo metamorphoses, on their arriving at a higher grade of organism; the chain of knots in insects, for example, as the Moth—*Sphinx* 25 (*b*) — and Hornet-fly—*Asilus* 26 (*c*)—becoming considerably shorter by the coalition, in certain places, of three or four separate knots into one, as if nature made an attempt, by this means, to give them a kind of distinct spinal cord and brain. The connecting cords also, which were at first double, frequently become almost or entirely single in the progress of development, as in the Sandhopper—*Talitrus* 19 (*d*) — Further the part corresponding, in these animals, to a vertebral column,—although it is, strictly speaking, a portion of their integuments—undergoes a similar concentration under the same circumstances, the numerous segments which existed in the larva coalescing into fewer in the pupa, and still fewer in the imago. But it is in tracing the progressive development of the human embryo, as that destined to undergo the most remarkable, and the longest series of transformations, that we are most struck with these gradual changes from diffusion to centralization, as its organ-



Larva. Pupa. Imago.

(*a*) Grant.
(*b*) Newport; Roget. (vol. ii. p. 546)
(*c*) Swammerdam. (pl. xxxix. and xl)
(*d*) Audouin; Roget. (vol. ii. p. 543)

ism verges towards maturity. In all probability the minute germ of the human being, or primary germinal membrane, is in structure strictly analogous to the simplest zoophyte, containing, not indeed any where the rudiments of any organ as it is in future to appear, but in every point rude structures performing the offices of these organs, while each distinct organ is subsequently formed by the concentration, as it were, of these structures in certain parts, in proportion to the advancement of its organism. It would hence follow that, in the systems which are to be afterwards universally diffused, as the vascular and the nervous, every point of their area would co-exist from the first; and it has accordingly been pretty well established that it is not, as was for a long time supposed, by the shooting forth of any pre-existing central organs that the extreme parts are constituted, but by the coalition of these central organs, when formed, with the primordial extreme parts, that each system is at length perfected. Thus it is not from the heart and brain that the large vessels and nerves, and from these again that the smaller grow, but each minute vessel and nerve has from the first a kind of independent existence, and is developed *per se*; (*a*) and it is at least as much from these extreme parts towards the common centres, as in the opposite direction, that the junction of the two proceeds. It seems that the primary germinal membrane, at first an apparently uniform mass, soon undergoes the first step to concentration, or splits into certain distinct portions, which have been called respectively its mucous, its vascular and its serous layers; and that of the first of these—the process of concentration still going on—are subsequently formed the stomach and intestines and other organs consisting essentially of mucous tissue, of the second the heart and large vessels, and of the last the spinal cord and brain, the bones and muscles, and the common integuments, till at length, the union of the

(*a*) Harvey, Wolff and Pander are among those who have most successfully established this fact, with respect to the origin of the blood-vessels in the vascular area of the yelk of the incubated egg; and Doëllinger, (*Journ. de Prog.* 1828) Kaltenbrunner (*Ibid.*) and Baumgartner (*Isis* 1830) with respect to that of new blood-vessels in general. Dr Allen Thomson's Inaugural Essay (*On the Formation of New Blood-vessels*, 1832) is an extremely valuable summary of the observations and opinions of these and other physiologists on this subject.

centre with the extreme parts of each general system being effected, the proper instrument of each function becomes entirely isolated. This degree of perfection however is only very gradually attained; and one point it is of great interest to be acquainted with, particularly as bearing on the subject now under consideration, that each of those organs which are afterwards to be single—the stomach and intestines, the heart, the brain, and the bones and other parts in the mesial line—is said to be at first double, as formed in two halves on the opposite sides of the body, and that it is only after some time that these unite into one, (*a*) so that one grand step in concentration is certainly an attendant on the progress of organization. But this is not all; for the proper instrument of each function has in the early human embryo very much of the diffuse character which it presents in the lower animals. Thus there was a time, during its progress to maturity, when the human embryo had a kind of gills as well as lungs—to say nothing of the employment at once of a yelk-bag, an allantoïs and a placenta in the capacity of a respiratory organ; when all the large blood-vessels which are afterwards to become single were double; when the intestinal canal was enormously long and sinuated, the liver double, with each portion deeply indented, and the kidneys long and lobulated; when the ovaries of the female were likewise lobulated, while in the male the epididymis and body of the testicle were quite distinct from each other; and when the uterus of the female was at first distinctly double, and afterwards bifid. All the conglomerate glands moreover were at one time merely distinct mucous tubes, shooting into gelatinous masses, by which at length they became concentrated. How diffuse also was at first the spinal cord—which, originally a double thread, extends at the third month as low as the coccyx, whence it gradually creeps upwards, till at the seventh it terminates

(*a*) The law by which the two halves of the body are separately developed is called by Serres—one of the most active prosecutors of these speculations—" la loi de symétrie," and that by which they at length coalesce in the mesial line, " la loi de conjugaison." (*Anat. Comp. du Cerveau*, 1824) It is denied however by Mayo (*Outlines of Physiology*, 1833, p. 385) that these laws are so constant as they have been represented, the spinal cord and brain for example being, according to him, from the first single, and only appearing double from becoming opaque first at the sides.

about the fifth, and at the ninth about the second lumbar vertebra—it is superfluous to say ; and how innumerable were at first the bones is equally well known.

Every view of the matter then seems to furnish evidence that the tendency to concentration or centralization of its several organs is in general in the direct ratio of the rank of an organized being; but, in whatever state they may exist, the parts in question are not less decidedly organs, nor less certainly essential, collectively taken, to the well-being both of each other and of the individual to which they belong, when most diffuse and ambiguous, than when most concentrated and unequivocal. Nor must we quit this subject without remarking that a knowledge of the chief laws which regulate the development of the embryo, in as far at least as regards the junction of the extreme and central parts of the general systems on the one hand, and the primary separation and subsequent union of the single organs on the other, is often available in explaining certain kinds of monstrosity. It is to the defective operation of the former of these laws that we must refer a normal extreme with an anormal central organ, or the reverse, as a retina without an optic nerve, or *vice versa*; and to that of the latter that we must ascribe the hare-lip, the divided palate and uvula, the cleft sternum with exposed heart, the congenital exomphalos, the denuded and imperfect urinary bladder, the open perineum, the spina bifida and other similar monstrosities. On the contrary too energetic an operation of the latter law may tend to incorporate two organs naturally separate into one, as in the case of Monophthalmia —the eyes being at first in the human embryo, as in most of the lower animals, on the sides of the head, and verging to the mesial line only in proportion to the advancement of its organization—or to effect the closure of parts which should have remained open, as in the case of an imperforate vagina. A person ignorant of this law would probably feel a good deal surprised on being told that the possession of two organs in the place of one may arise from defective development, and of one organ instead of two from the development being excessive; but such is nevertheless often the case.

An Organ then is an assemblage, more or less concentrated, of certain tissues, ministering, either alone or with others, to some definite function.

The organs of plants differ from those of animals in general principally in being at once more diffuse and more simple, and in not being contained in specific cavities, like the viscera of animals, but tending all towards their surface. (*a*) From this great diffusion they are of course much more numerous, those ministering to respiration and generation for example being not only distributed indefinitely over the whole plant, instead of being confined to a single spot, but also of an indefinite number; and hence there is an equal want of symmetry in the structure as in the external form of plants. Further some of the organs of plants seem to be mutually convertible, and many of them are periodically deciduous, neither of which is the case, at least in an equal degree, with animals. Finally plants appear to want altogether a proper assimilating apparatus, with which perhaps all animals are furnished, as well as that very important class of organs which is subservient to what have been called, by way of distinction, the animal functions — sensation, thought and voluntary motion — organs which, under one modification or other, are generally, if not universally, met with in the animal kingdom.

The following are the principal Organs respectively

Of plants in general.	Of animals in general.
The vesicles within the substance of the leaves, with their appendages, or some corresponding organs, constituting *the Respiratory apparatus.*	The lungs, with their appendages, or some corresponding organs, constituting *the Respiratory apparatus.*
The entire vessels, principally in the bark, and the spiral vessels, with their modifications the reticulated, annular, punctuated, beaded and other vessels, principally in the wood, or some corresponding organs, constituting *the Depositing and Absorbing apparatus.*	The heart, with its appendages the arteries, veins and lymphiferous and chyliferous vessels, with the parenchyma and erectile structure, or some corresponding organs, constituting the *Circulating, Depositing and Absorbing apparatus.*
	The gullet, stomach and intestinal canal, with their appendages the liver and pancreas, or some corresponding organs, constituting *the Assimilating apparatus.*

(*a*) Hence the trite remark that either a plant is an animal turned inside out, or an animal a plant turned outside in.

The pistil, with its appendages, and the stamen, with its appendages, in the flower, or some corresponding organs, constituting *the Generative apparatus.*

The ovaries, with their appendages, in the female, and the testicles, with their appendages, in the male, or some corresponding organs, constituting *the Generative apparatus.*

The nostrils, eyes, ears, mouth and common integuments, with the appendages of each, or some corresponding organs, constituting *the apparatus of Sensation.*

The brain, with its appendages, or some corresponding organs, constituting *the apparatus of Thought.*

The bones and muscles, with their appendages, or some corresponding organs, constituting *the apparatus of Voluntary Motion.*

The principal organs of animals which are in general without fellows are the heart, the gullet, stomach and intestinal canal, with their appendages the liver and pancreas, and of course all those which are situated in the mesial line of the body, as the spinal cord and brain, the bones of the vertebral column, of the sternum and of the base of the skull, and, among the muscles, the diaphragm and the several sphincters. It is worthy of being impressed however that all these organs were, at one period of fetal existence, in two distinct halves, and had therefore their fellows as well as the rest. The other organs again, as the lungs or corresponding organ, the kidneys, the ovaries or testicles, the nostrils, eyes, ears and salivary glands, the jaws and teeth on each side, and all the lateral bones and muscles of the trunk, head and extremities, have permanently, in most animals, each a fellow on the opposite side. It is important to remember also that while, of those organs which minister to what has been called organic life, some, as the lungs and the rest of those which have fellows, are to a certain degree symmetrical, and others, as the heart and the rest of those which want fellows, are not so, there is no organ which ministers to animal life, whether with or without a fellow, but is perfectly symmetrical, the organs of the senses and the opposite limbs being not more so on the one hand, than the spinal cord and brain and the bones and muscles situated in the mesial line are on the other.

SECTION II.

On the Unity of the Organic Structure of Animals.

Subsection I.

On the Unity of Organic Structure, as manifested in the different Tribes of Animals.

Allusion has been already made, when on the subject of the gradations of the various tribes of plants and animals, to the supposed prototypes of their several organs, and, when on that of the indispensability of parts to the integrity of the whole in organized beings, to the presence, in every such being, of certain essential organs; but it remains still to state a little more explicitly what is meant by these prototypes of organs, as well as to endeavour to show that not only every essential organ, but perhaps every possible organ, is present, or has been present, in every such being, those of the lowest being fundamentally identical with those of the highest, which may be presumed to include all that are capable of existing. It is an important fact, and one which has only recently received all the attention which it deserves, that, however different may seem, both in their anatomical and physiological relations, the organs of the higher and those of the lower tribes, if not of plants, certainly of animals, they are in both essentially the same, the nucleus or structural elements of each organ in the former, not only existing, but being in fact in all their essential characters identical with those of the corresponding organ in the latter; so that the history of the advancement of each organ towards perfection is merely the history of the progressive development of an imaginary unity. And as the more elevated tribes of animals embrace generally, in a greater or less degree, every improvement successively made on the moulds of the several organs of the tribes below them, the splendid human organism itself consists merely of the same organs, regarded fundamentally, as exist in the polype, the differences consisting chiefly in their different degrees of elaboration. (*a*) Not only then do the vesicles and cells already alluded to perform the office, in the economy of the

(*a*) The doctrine of the Unity of Organic Structure, or the theory of Analogies of Organs, in this application of it, is as ancient as the study of natural history, such having been Aristotle's persuasion of its truth, that his classification of animals, which presents, as observed by Mr Lawrence, " a vast and luminous plan, to which none of his successors has approached," is founded very much upon the data which it affords. Unfortunately however from his having made an analogy of form and of function, as well as of rudimental structure, a necessary condition of his system, and thus attempted to reconcile circumstances which have no manner of connection with each other, his theory is in many places entirely false, and even where it is least objectionable, presents a strange mixture of truth and error. He neglected to observe that many organs, originally cast, as it were, in the same mould, as composed of the same structural elements, changed their form and function almost infinitely in their transition from one tribe of animals to another, according to the relative development of these elements ; and that it was not therefore as individuals that such organs were to be contemplated, and this with respect only to their appearance and office, but as composed each of various essential parts associated together, under different circumstances, so differently, as to give to organs strictly analogous almost every possible aspect, and to render them subservient to almost every possible use. What analogy, for example, is there in these respects between the gills and bivalve shells of the mollusca and the wings and elytra of insects ; between the opercular bones of fishes and the auditory bones of the higher tribes ; or between the proboscis of the Elephant and the nose of Man ; and yet all the parts may be proved to be formed respectively upon the same plan ? And with respect to the possession by every tribe of animals of the same organs, where shall we find in any creature parts corresponding in general appearance with those of the Cuttle—(*Sepia* 11) —with its anus in its neck, and its arms and legs sprouting around its mouth ; and yet, admitting the fundamental identity of the organs, it requires little more than to fancy many mammals reflected backwards at the naval so as to bring their pelvis even with their neck, to make their parts almost correspond with those of the Cuttle in these accidental respects ? Again, to confine ourselves to the analogous organs of tribes more nearly allied to each other, what similarity of either form or function is there in the ribs, for example, confessedly identical as they are in all, as occurring in the four tribes of reptiles ; the same organ which in the batrachia serves merely for supporting the gills of the larva, and disappears with these, being in the ophidia without any sternal attachment, and ministering rather to locomotion than to respiration, in the sauria with such an attachment, and a respiratory organ, and in the chelonia lastly beaten out into an immoveable dorsal shield, and serving as a covering and defence for the whole body ? Or, to take the termination of the anterior extremity in mammals, what correspondence of appearance or office is observable in the pectoral fin of the Whale, the flipper of the Walruss, the hoof of the Horse, the paw of the Lion, the wing of the Bat, and the hand of the Ape ; and yet few, it is believed, will dispute their fundamental identity ? In modern times, the idea of a general unity in the animal structure, distinct from those gradations in the chain of created beings which have been already alluded to, but in the course of which all unity of structure may be easily supposed to have sooner lower tribes, of lungs, of heart and blood-vessels or of stomach and intestines, but they constitute in fact the rude models upon which, in the higher tribes, these organs are actually constructed. For what are lungs, but either one large cell, or a concentrated congeries of such cells; what are

or later entirely disappeared, seems to have flashed upon Newton in a moment of inspiration. " Similiter posita omnia," says he, " in omnibus fere animalibus;" (*Optic. qu.* 31) and this unity was by him referred to laws similar to those which regulate the economy of the universe. But it was in the hands of Geoffroy St Hilaire that the theory of Analogies—the idea that to certain corresponding organs of all animals there is a

Facies non omnibus una,
Nec diversa tamen,

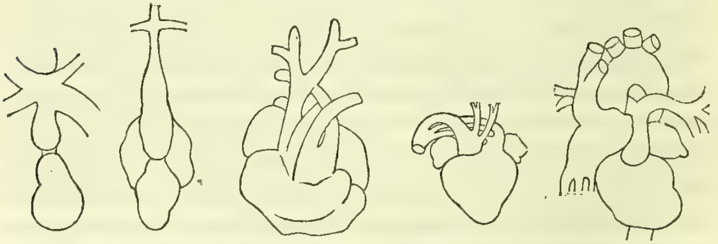
acquired for the first time any thing of a scientific character. It was he who first perceived that to attempt any alliance of similarity of elementary structure with that of form and function was not only to confuse the question, but to neutralize the whole pursuit; and who, having avoided the radical error of confounding the anatomical and physiological relations of organs with their fundamental structure, has suggested a system of associations, as applied at least to the vertebrated tribes of animals, which promises to be an honour to the age in which it originated, (*Philosophie Anatomique*, 1818) and " the conception of which," ironically as this remark has been made by Sir Charles Bell, deserves to be " marked as the commencement of a new æra." (*On the Hand*, 1834, p. 154) The basis of the system of St Hilaire, which he appears to have adopted so early as the year 1796, as opposed to that of Baron Cuvier, who followed in a great measure the ancient plan, is that of the essential analogies of organs, as deduced *a posteriori* by the profound zootomist, from a general contemplation of their rudimental parts in all tribes of animals; not that of their superficial similarities, obvious for the little way that they go *a priori*, and equally so to the most ignorant and the most profound. " S'en tenir," says St Hilaire, " aux faits observables, ne les vouloir comparer que dans le cercle de quelques groupes ou petites familles à parts, c'est rénoncer à de hautes révélations, qu'une étude plus générale et plus philosophique de la constitution des organes peut amener." (*Philosophie Zoologique*, 1830) The views of St Hilaire have been embraced, to a greater or less degree, almost from the first by Serres and De Blainville—the latter of whom was one of the first to apply them to " des animaux plus différens—plus éloignés dans la série—" (*De l' Organisation des Animaux*, 1822) and more recently by Latreille, Flourens, F. Cuvier, Savigny, Milne Edwards, Dubreuil, Duvernoy, and in fact by almost all the enlightened naturalists of the continent. It is gratifying to find such a man as Professor Grant of London speaking every where with approbation of " the ingenuity and boldness of the speculations of St Hilaire," at the same time that he confesses that, from our being " a century behind our continental neighbours in this department of science," his views are very inadequately appreciated among us. (*Lectures in Lancet*, 1833–34) They are gradually making way however in this uncongenial soil, and even in Edinburgh a student does not *now* look quite aghast, as he was wont to do, when they are cautiously alluded to.

blood-vessels or an intestinal canal, but continued strings of such cells, between which communications, the original sites of which are still indicated by their valves, rugæ &c. have been opened; and what lastly is a heart or stomach, but amplifications in certain places of these vessels or this canal? But it is not by taking such sweeping views of the subject as this, that the doctrine of the unity of organic structure could ever have become established; but by selecting in turn each individual organ in every tribe of animals, observing well what are its essential parts or structural elements, taking these as given points of reference, and afterwards patiently tracing them, as they become almost infinitely modified in the corresponding organs of other tribes. In doing this we shall find that, if we prosecute this scrutiny from the lowest to the highest, we advance by such insidious steps, that we never lose sight for a moment of the nucleus, as it were, of our crystal, however varied it may become in form and office; and are at length surprised, on arriving at its extreme development, to perceive that the organ from which we started, and that with which we finish, and which do not perhaps, when placed abruptly in juxtaposition, present a single point of resemblance, anatomical or physiological, are in fact rude copies of each other.

Thus the Air Vesicles of the Earth-worm, Leech and Scorpion already mentioned, as well as the respiratory bag of the Garden-snail—*Helix* 9 (*a*)—and the air-tubes of insects in general, expanded as they are in many of them, and in particular in some hymenopterous tribes, as the Scholia—*Scholia* 26 (*b*)—into large pouches, may be easily traced through the internal gills of the cartilaginous fishes and the air-bladder of fishes in general, the respiratory bag of serpents, the membranous lungs of other reptiles, and the parenchymatous lungs of birds and mammals in general, up to those of Man. It requires in fact little more than that the branched tubes sprouting from the exterior of the respiratory pouches of insects, as delineated in a previous diagram, should be curtailed, and their cavity minutely subdivided, in order to turn them into proper lungs; and indeed some proper lungs, as those of the

(*a*) Cuvier; Carus. (pl. iii. fig. 21) (*b*) Fabricius; Roget, (vol. ii. p. 311)

Chameleon, have somewhat of this ramified appearance. There can be little doubt also but that the contractile aperture of the respiratory bag of the Garden-snail, the equally contractile stigmata of some insects, as the Silk-worm—*Phalæna* 25 (*a*) — the Grasshopper — *Gryllus* 29 (*b*) — and the Cerambyx—*Cerambyx* 30 (*c*)—and the mouths of the passages leading from the gullet or other parts to the internal gills or air-bladder of fishes, are repeated in the glottis of the superior tribes. In like manner, to say nothing of the BEADED SEMICIRCULAR TUBES which surround a part of the intestinal canal of the Earth-worm and some of the crustacea, the knotted dorsal vessel of the arachnida and insects, the three hearts of the Cuttle, or the two hearts of the Ship-worm, it is easy to follow the proper heart of the Ascidia—*Ascidia* 8 (*d*) —the Mussel—*Mya* 8 (*e*) — the Sea-hare — *Aplysia* 9 (*f*)— the Garden-snail—*Helix* 9 (*g*)—the Cray-fish—*Cancer* 19 (*h*) —or the Soldier's crab—*Cancer* 19 (*i*) — allowing for the change in the relative situation of the auricular and ventricular portions, which will fall presently to be described—through the single heart of fishes and batrachian reptiles, the partially double heart of the higher tribes of reptiles, and the strictly double hearts of birds and mammals in general, up to that of Man. The prototype also even of his principal blood-ves-



Sea-hare. Fish. Reptile. Bird. Mammal.

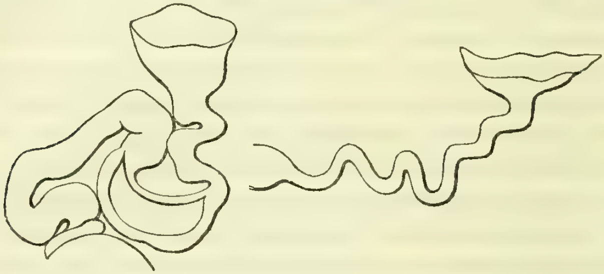
sels may be detected, perhaps in the avertebrated, but certainly in the lowest tribes of the vertebrated animals. The GULLET, STOMACH and INTESTINAL CANAL of the lowest ani-

(*a*) Malpighi.
(*b*) Carus. (pl. vii. fig. 21)
(*c*) Fabricius; Roget. (vol. ii. p. 311)
(*d*) Carus. (pl. ii. fig. 1)
(*e*) Carus. (pl. ii. fig. 11. and 13)
(*f*) Carus (pl. iii. fig. 7)
(*g*) Cuvier; Carus. (pl. iii. fig. 4)
(*h*) Carus. (pl. vi. fig. 4. and 9)
(*i*) Swammerdam. (pl. xi. fig. 2. and 8)

mals from the Polypi — *Hydra, Corallium, Gorgonia, Pennatula*, &c. (*a*)—Sponges—*Alcyonium* 3 (*b*)—and Sea-nettles — *Actinia* 3 (*c*) — upwards, are so manifestly a pattern of the same parts in the highest, that it is unnecessary to insist upon the fact. A well-developed liver also, the original of that of Man, is met with in the Sea-hedgehog—*Echinus* 5 (*d*)—Oyster—*Ostrea* 8 (*e*)—Cuttle—*Sepia* 11 (*f*) — and most of the mollusca, while in insects its place is supplied, as elsewhere observed, by collections of ducts, the primary and distinctive part of every conglomerate gland. Nor can it be questioned but that the numerous other blind tubes, which open into the stomach of some infusory animals, and of the Sea-blubber, Star-fish and Leech, and into various parts of the intestinal canal of several other avertebrated animals already specified, as the Cuttle, Sea-mouse, Sea-worm, Crab, Louse &c. and of the osseous fishes in general, as the Burbot, are the rudiments of the pancreas of the more elevated tribes; this organ assuming the appearance of a solid gland for the first time in the cartilaginous fishes, as the Sturgeon —*Acipenser* 32 (*g*)—and Shark—*Squalus* 32 (*h*)—From the simplest structure also of well-marked Genital Organs, female and male, as those of the Ascidia, the Sea-hare, the Garden-snail, the Earth-worm and the Leech, in all which both are combined in each individual, and those of the Viviparous snail—*Helix* 9 (*i*)—among the mollusca, as well as of the various individuals already enumerated belonging to the annelida, crustacea, arachnida and insecta, in which the sexes are distinct, the transition is obvious, through the corresponding organs of fishes, reptiles, birds and mammals, up to those of Man. Nor does the occurrence of the ovary and testicle in so many of the avertebrated animals in the form of long convoluted tubes, any more than their high situation in all tribes of animals below mammals, and in many of these also, constitute any essential distinction. Of the fundamental identity also of

(*a*) Ellis; Trembley; Roget. (vol. i. p. 162, &c)
(*b*) Spix; Carus; (pl. i. fig. 8) Grant; Roget. (vol. i. p. 149)
(*c*) Spix; Carus; (pl. i. fig. 9) Roget. (vol. i. p. 198)
(*d*) Home; (vol. ii. pl. 76) Carus. (pl. i. fig. 12)
(*e*) Home. (vol. ii. pl. 77)
(*f*) Home. (vol. ii. pl. 83)
(*g*) Home. (vol. ii. pl. 96)
(*h*) Home. (vol. ii. pl. 69)
(*i*) Cuvier; Carus. (pl. iii. fig. 10, 11 and 12)

the lower part of the oviducts of the inferior tribes of animals with the uterus of the superior, and of the upper part, or infundibulum, with the fallopian tubes, it is unnecessary to speak. It is well seen by comparing the parts of the Fowl—*Phasianus* 43 (*a*)—the essential structure of which is quite the same as that of the corresponding parts of all the inferior tribes of oviparous animals, with those of the Hog—*Sus* 49 (*b*)—which may be taken as a sample of those of such as are viviparous; and even

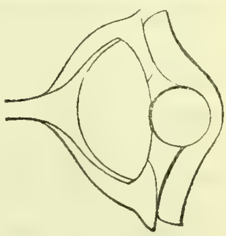


Fowl. *Hog.*

the mammæ of mammals are not perhaps without their representative in the avertebrated animals. We know at least that the young of the Sea-blubber—*Medusa* 3—of the Ascidia—*Ascidia* 8—of the Mussel—*Mya* 8—of the Cray-fish—*Cancer* 19—of the Spider—*Aranea* 22—and of many others are, after their expulsion from the uterus or analogous organ, received respectively into the arms, the respiratory sac, the gills, a fold of the tail or an enveloping web, in the same way as those of the Surinam toad—*Rana* 37 (*c*)—are received into vesicles on the back, and those of the Opossum—*Didelphis* 52—and Kanguroo—*Kangurus* 52 (*d*)—into their marsupia, where they undergo the requisite subsequent development; and as, in the last case, this development is certainly owing to the mammæ, the nipples of which open within the marsupia, (*e*) so it is not improbable that some analogous organs may be instrumental to it in the rest. It needs hardly be remarked that the circumstance of oviparous or viviparous generation constitutes no radical distinction between the different tribes of animals; and accordingly, though the former is the more common in all but quite the highest tribes, we have not a few

(*a*) Carus. (pl. xvi. fig. 16)
(*b*) Carus. (pl. xx. fig. 9)
(*c*) Ruysch ; Shaw. (*Zoology*, vol. iii. p. 168)
(*d*) Shaw. (vol. i. p. 476)
(*e*) Home. (vol. iv. p. 124)

examples of the latter even in the avertebrated animals, as the Viviparous snail—*Helix* 9 (*a*)—and in many fishes and reptiles. That there is the strictest analogy also in the structure of the simplest egg, and that of the most complicated contents of a gravid uterus—both containing the same deciduæ, chorion, general envelope of yelk and germinal membrane, the last of which in both at length splits into its three layers, the rudiments severally of all the parts of the embryo—recent investigations have abundantly demonstrated. (*b*) With respect likewise to the Organs of Sensation, the nostrils of Man may be traced from the nasal fossæ at the root of the small antennæ of the Lobster—*Cancer* 19 (*c*)—through the blind canals on the sides of the snout of most fishes, as the Burbot—*Gadus* 35 (*d*)—and those with an internal opening also, either in the palate, as in the batrachian and chelonian reptiles, (*e*) or in the pharynx, as in all the superior tribes of animals. The situation of the external openings of the nostrils on the top of their heads in the cetaceous tribes, as the Porpoise—*Delphinus* 47 (*f*) — is of course a merely accidental difference ; nor does the tubular and more or less elongated snout of the Hog, the Peccari and the Tapir, or even the proboscis of the Elephant, present any thing more than an inordinate evolution of the same structural elements as compose the cartilages of the nose of Man. All the parts again of the eye of Man exist in a rudimental state as well in the single pair of the Garden-snail—*Helix* 9 (*g*) — and the Cuttle—*Sepia* 11 (*h*)—as in the numerous stemmata of some of the annelida, of caterpillars in general, and of Spiders and Scorpions. (*i*) Nor are they less obvious in the compound



Scorpion.

(*a*) Cuvier; Carus. (pl. iii. fig. 10, 11 and 12)

(*b*) See Dr Allen Thomson's admirable Essay on the Development of the Vascular System of the Fetus. (*Edin. Philosoph. Journ.* 1829 and 1830)

(*c*) Rosenthal; Carus. (pl. vi. fig. 2)

(*d*) Geoffroy; Carus. (pl. viii. fig. 1)

(*e*) Carus. (pl. xii. fig. 10 and 18)

(*f*) Carus. (pl. xviii. fig. 1)

(*g*) Muller; Roget. (vol. ii. p. 481)

(*h*) Carus. (pl. iv. fig. 3)

(*i*) Muller; Roget. (vol. ii. p. 484)

eyes of those insects which have these alone, or in both the compound and simple eyes of those which possess both, whence they may be easily followed through the eyes of fishes, reptiles, birds and mammals in general. And the same graduated deposition, as it were, on a primary nucleus, is still more obvious in tracing the ear of the Cuttle—*Sepia* 11 (*a*)—or Cray-fish—*Cancer* 19 (*b*)—in which it consists merely of an auditory nerve distributed upon a sac of fluid, through that of fishes, as the Sea-devil—*Lophius* 32 (*c*)—where semi-circular canals are added, that of frogs (*d*) and tortoises, where a tympanum with an eustachian tube and a bone or bones are first met with, that of lizards and serpents, (*e*) which have the rudiments of a cochlea, that of birds, as the Turkey—*Meleagris* 43 (*f*)—where an external meatus, and lastly that of mammals in general, where at length a pinna and its appendages first display themselves, up to that of Man. Nothing can be more beautiful than this insidious progress to perfection of the whole ear, nor is that of its several parts less so; the transition for instance of the essential bone of the tympanum, the columella of reptiles and birds, through the stapes in succession of the Duck-billed animal—*Ornithorrynchus* 50—the Walruss—*Trichecus* 53—the Kanguroo—*Kangurus* 52—and the Cat—*Felis* 54—till it arrive at that of Man, (*g*) being among the best illustrations of the universal law

Crocodile. Bird. Duck-billed Animal. Walruss. Kanguroo. Cat. *

in question. From the lips also of the Garden-snail—*Helix* 9 (*h*)—the Whelk—*Buccinum* 9 (*i*)—the Cuttle—*Sepia* 11 (*j*)

(*a*) Scarpa; Carus. (pl. iv. fig. 13)
(*b*) Scarpa; Carus. (pl. vi. fig. 3)
(*c*) Scarpa; Carus. (pl. viii. fig. 3)
(*d*) Bell; Roget. (vol. ii. p. 439)
(*e*) Carus. (pl. x. fig. 7)
(*f*) Carus. (pl. xv. fig. 6)
(*g*) Carlisle; Carus. (pl. xii. fig. 12, pl. xv. fig. 6, and pl. xix. fig. 8. and 9)
(*h*) Cuvier; Carus. (pl. iii. fig. 5)
(*i*) Cuvier; Carus. (pl. iii. fig. 9)
(*j*) Carus. (pl. iv. fig. 10)

* *Some of the figures have been, by mistake, inverted in this diagram; but the relation of the bones is sufficiently manifest.*

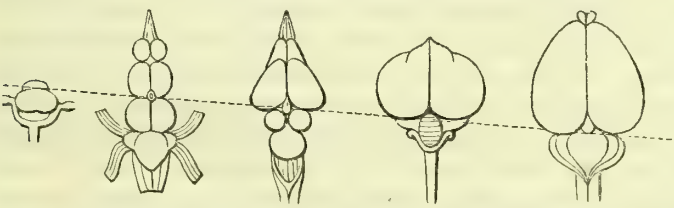
—the Leech—*Hirudo* 12 (*a*)—the Cray-fish—*Cancer* 19 (*b*)—and insects in general, through those of fishes and the rest of the vertebrated tribes; from the tongue of the Snail—*Helix* 9—the Whelk—*Buccinum* 9—the Cuttle—*Sepia* 11—and the Bee—*Apis* 23—and other insects, and from the salivary glands lastly of the Snail—*Helix* 9—the Cuttle—*Sepia* 11—and insects, through those of reptiles, including their venom organs, (*c*) of birds and of mammals in general, the progress towards perfection is equally gradual and remarkable. But can the same thing be said of the common integuments of various animals, which frequently present no apparent analogy whatever? It is not the less true however that the same structural elements which in Man constitute respectively the true skin, the corpus mucosum and the cuticle, are found under certain modifications in all. To the first of these belong the cloak of the Oyster—*Ostrea* 8—the pellicle of the Cray-fish—*Cancer* 19—and the proper dermoid covering of all the superior tribes of animals. In like manner it is of corpus mucosum, cornified, if we may so express it, as it is in forming the hairs and nails of Man, that are constituted the prickly case of the Sea-hedgehog—*Echinus* 5—the horny segments of the rays of the Star-fish—*Asterias* 5—the horny sheaths of insects, corresponding to a vertebral column, the scales of fishes and certain reptiles, and the coverings of the shields of tortoises; and it is superfluous to notice the strict analogy which subsists between the hairs and nails of Man, and the prickles of the Sea-hedgehog—*Echinus* 5—the small bristles of the Earth-worm—*Lumbricus* 12—and the large ones of the Sea-mouse—*Aphrodita* 13—the hairs, or rather minute feathers of insects, the claws of some reptiles, the proper feathers, claws and bills of birds, and the hair, fur, wool, bristles, quills &c., with the claws, hooves and horns of quadrupeds. Finally the cuticle of Man is only a repetition of the calcareous covering of the corallines, the mucilaginous coat of the Sea-blubber—*Medusa* 3—and of the Slug—*Limax* 9—and other mollusca, the leathery envelope of the Ascidia—*Ascidia* 8—and the flaky membrane which invests the

(*a*) Carus. (pl. v. fig. 8)
(*b*) Carus. (pl. vi. fig. 1)
(*c*) Home. (vol. iv. pl. 96)

horny covering of insects, the scales of fishes, serpents and lizards, the covering of the shields of tortoises, and the soft corpus mucosum of birds and mammals in general. There remain only the nervous system and the bones and muscles; nor is the progressive general advancement of our model, as we approach Man, less decided in these than in the preceding organs. The prototype of the Spinal Cord of Man may be considered to be the lines of nervous knots, connected by a double or single cord running down the body of most avertebrated animals, and that of the Brain, the large knot almost constantly found on the upper part of the nervous collar which surrounds their gullet. This is well seen in the Leech and Earth-worm already spoken of, as well as in the Mussel—*Mya* 8 (*a*)—the Sea-hare—*Aplysia* 9 (*b*)—the Garden-snail—*Helix* 9 (*c*)—the Cuttle—*Sepia* 11 (*d*)—the Sea-mouse — *Aphrodita* 13 (*e*) — the Cray-fish — *Cancer* 19 (*f*) — the Soldier's crab — *Cancer* 19 (*g*) — the Tick—*Acarus* 21 (*h*) — the Spider — *Aranea* 22 (*i*) — the Silk-worm — *Phalæna* 25 (*j*) — the Hornet-fly—*Asilus* 26 (*k*) — the Bee — *Apis* 26 (*l*) — the May-fly — *Ephemera* 27 (*m*)—the Louse —*Pediculus* 31 (*n*)—and insects in general; but it is not till we arrive at the vertebrated animals that any distinction of parts is very perceptible. The spinal cord of the lower vertebrated tribes differs from that of Man principally in being much larger in proportion to the brain, and in being in general traversed by a deep longitudinal fissure on its posterior aspect; but the brain of the former is at first very imperfect. It consists, in the osseous fishes, as the Conger—*Muræna* 35 (*o*)—the Burbot—*Gadus* 35 (*p*)—and the Perch—*Perca* 35 (*q*)—principally of the mesial parts of the cerebellum, with the corpora

(*a*) Spix; Carus. (pl. i. fig. 10)
(*b*) Cuvier; Carus; Roget. (vol. ii. p. 548)
(*c*) Swammerdam. (pl. iv. and vi)
(*d*) Swammerdam; Cuvier; Roget. (vol. ii. p. 548)
(*e*) Pallas. (pl. vii)
(*f*) Home; Carus. (pl. vi. fig. 1)
(*g*) Swammerdam. (pl. xi)
(*h*) Swammerdam. (pl. xliii)
(*i*) Treviranus; Carus. (pl. vii. fig. 5)
(*j*) Malpighi.
(*k*) Swammerdam. (pl. xxxix. and xl)
(*l*) Swammerdam. (pl. xli)
(*m*) Swammerdam. (pl. xiv. and xv)
(*n*) Swammerdam. (pl. i. and ii)
(*o*) Serres; Roget. (vol. ii. p. 552)
(*p*) Carus. (pl. ix. fig. 1)
(*q*) Cuvier; Roget. (vol. ii. p. 552)

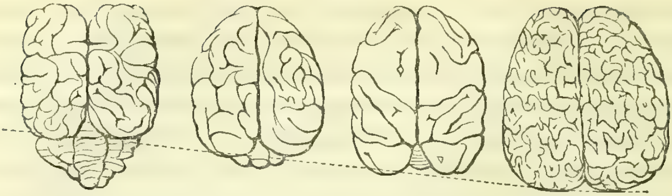
quadrigemina, the thalami optici, the rudiments of the hemispheres of the cerebrum above these, and anteriorly the corpora striata. In the cartilaginous fishes, as the Shark—*Squalus* 32 (*a*) —and Dog-fish —*Squalus* 32 (*b*)—and in frogs and chelonian reptiles, as the Toad—*Rana* 37 (*c*)—and Turtle —*Testudo* 40 (*d*)—the hemispheres of the cerebrum become considerably larger, and rudiments of the lobes or lateral parts of the cerebrum display themselves. In serpents and lizards again, as the Iguana—*Iguana* 39 (*e*)—and Crocodile—*Crocodilus* 39 (*f*)—and in birds, as the Pigeon—*Columba* 43 (*g*)—and Buzzard—*Falco* 46 (*h*)—besides the hemispheres becoming larger, there are met with rudiments of the fornix and of the corpus callosum and septum lucidum. Lastly in mammals, the tuber annulare and lateral parts of the cerebellum manifest themselves, and all the parts become progressively more perfect, particularly the hemispheres of the cerebrum, through the rodentia, as the Rat—*Mus* 51 (*i*)—the Agouti—*Aguti* 49 (*j*)—and the Marmot—*Arctomys* 49 (*k*)—the ruminantia, as the Sheep—*Ovis* 48 (*l*)—and the Deer—*Cervus* 48 (*m*)—the digitigrada, as the Cat—*Felis* 54 (*n*)—the Lion —*Felis* 54 (*o*)—and the Otter—*Lutra* 54 (*p*)—and the quadrumana, as the Orang-otang—*Simia* 59 (*q*)—so that in the elaboration of the latter from before to behind, they cover, first



Cuttle. *Conger.* *Turtle.* *Buzzard.* *Marmot.*

[The dotted line marks the posterior boundary of the hemispheres.]

(*a*) Home. (vol. iv. pl. 13)
(*b*) Home. (vol. iv. pl. 15)
(*c*) Mayo. (3d ed. p. 227)
(*d*) Serres; Carus; Roget. (vol. ii. p. 552)
(*e*) Carus. (pl. xii. fig. 9)
(*f*) Carus; Roget. (vol. ii. p. 552)
(*g*) Cuvier; Carus; Roget. (vol. ii. p. 552)
(*h*) Serres. (pl. iv. fig. 89)
(*i*) Carus. (pl. xix. fig. 1)
(*j*) Serres; Tiedemann.
(*k*) Serres. (pl. ix. fig. 207)
(*l*) Serres. (pl. x. fig. 221)
(*m*) Serres. (pl. xv. fig. 269)
(*n*) Carus. (pl. xix)
(*o*) Serres; Gall; Tiedemann; Roget. (vol. ii. p. 552)
(*p*) Serres.
(*q*) Gall; Tiedemann.



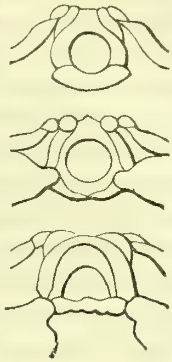
Sheep. *Otter.* *Orang-otang.* *Man.*

[The dotted line marks the posterior boundary of the hemispheres.]

the thalami optici, then the corpora quadrigemina, and afterwards the anterior portions of the cerebellum, no animal besides Man, with the exception of the Porpoise and some quadrumana, having the whole of this organ so covered. How admirable then is this example also of unity in variety; and how instrumental has the study of analogies been in pointing out what is really the character of certain organs in the lower animals; the parts, for example, now known to correspond in some of them to corpora quadrigemina having been long mistaken, while nothing but the coarser resemblances between the parts of different animals, and not their more abstract relations, were recognised, sometimes for thalami optici, at others for the hemispheres of the cerebrum, at others for corpora striata! With respect to the SKELETON and EXTERNAL MUSCLES of Man, it would appear, at first sight, that here at least we must admit a want of analogy with the avertebrated tribes, a fundamental distinction having been generally made between animals possessed of a skeleton, and those destitute of one; but perhaps the distinction is rather an artificial than a natural one. We are perhaps hardly justified in bringing in here the various parts of the integuments recently mentioned, which perform in many of the avertebrated animals the office of a skeleton, since they have probably no structural analogy with proper bones, but are rather perhaps a rival, than an analogous organ. At the same time it is very remarkable how closely this modification of the corpus mucosum sometimes corresponds in its several pieces with the vertebræ of the spinal column of the proper vertebrated animals, the rings down the back, which in the annelida are very numerous and without any appearance of legs (*a*) becoming less numerous in the crustacea, arachnida and insecta, and

(*a*) Roget. (vol. i. p. 271)

some of them supporting each a pair of legs precisely as some proper vertebræ support each a pair of ribs, (*a*) which, as we shall in future find, are formed upon exactly the same model. Nay in some of the crustacea, as the Cray-fish—*Cancer* 19 — and in some insects, as certain species of Grasshopper — *Gryllus* 29 — they form a partial canal within the large one for the reception of the part corresponding to the spinal cord. (*b*) Without having recourse to this part however, in order to establish the analogy in question, there are not a few internal parts of avertebrated animals which appear strictly to correspond with the bones of the vertebrated tribes in a rudimental state; and when we reflect on the very small number of the elementary forms of such bones in the latter — all being resolvable in fact, as we shall see presently, into those of a vertebra and a rib—we shall find no good reason for deserting our proposition on this score. The transition indeed, in this respect, from the cephalopoda, as the Cuttle—*Sepia* 11—to the lowest orders of cartilaginous fishes, as the Myxine—*Gastrobranchus* 32—and the Lamprey—*Petromyzon* 32—which have little appearance of a skeleton except a rude vertebral column, is hardly perceptible; and from these again up to Man the progressive steps are almost insensible. In this view of the matter the vertebral column of the vertebrated animals, with its muscles,



Segments of Insect.

(*a*) Carus; Grant. (vol. ii. p. 329)

(*b*) It is the opinion of St Hilaire, followed by Professor Grant, that this part of the avertebrated animals is strictly analogous to a true skeleton, while De Blainville regards it rather as a vicarious organ, and belonging to the integuments. By Carus it is called a Dermo-skeleton, in contradistinction to a true or Neuro-skeleton; and many facts—in particular the soft cartilaginous bones with the hard tuberculated integuments of the cartilaginous fishes—seem to show that the development of the one is frequently inversely as that of the other. It is not improbable that the woody fibre of the endogenous and exogenous plants stands in the same relation respectively to their external and internal parts, as the earthy matter of the avertebrated and vertebrated animals does with respect to their Dermo and Neuro-skeleton.

D

may be traced to the "os sepiæ" on the posterior part of the fleshy cloak of the Cuttle—*Sepia* 11—and their skull, in the form of the rudiments of an occipital bone, to the cartilaginous canal containing the nervous collar round the gullet of the same animal; thence to the internal shell, as it is called, of the Slug—*Limax* 9—the Sea-hare—*Aplysia* 9—and other gasteropoda; and thence again down to the internal oval cartilage within some of the acalephæ, as a kind of Sea-blubber—*Velella* 3. The lower jaw again of Man, with its muscles, has pretty obviously a pattern not only, as before remarked, in the bony frame-work of the Sea-hedgehog, but also in the horny jaw of the Snail—*Helix* 9 (*a*)—the beak of the Cuttle—*Sepia* 11 (*b*)—and the jaws of the Scorpion—*Scorpio* 22—and Spider—*Aranea* 22, (*c*) and of the larvæ of insects in general; and his teeth—not that these are mentioned as any part of the skeleton—are merely repetitions of those of the Sea-hedgehog—*Echinus* 5—the Snail—*Helix* 9—the Cray-fish *Cancer* 19—the Spider—*Aranea* 22—and numerous other avertebrated animals. But it is principally between the individual bones and muscles of the other vertebrated animals and Man that such analogies are striking; and it is indeed to this point that the doctrine of a unity of organic structure has been chiefly applied, and from this that it has derived its principal illustrations. Into this subject it would be out of place, at present, to enter at any length; suffice it to say, that the correspondence is found to be perfect in every particular, and that the structural elements or essential parts of each bone in Man, however differently combined, and to whatever degree developed, are always met with, while again none but these are met with, in all other vertebrated animals. (*d*) Of the different combination of these elements we have a good example in the hyoid bone, which, simple as it is in Man, becomes so only by giving two of its elements to the temporal bones, under the name of the styloid processes, and others to

(*a*) Cuvier; Carus. (pl. i. fig. 6) (*b*) Carus. (pl. iv. fig. 10)
(*c*) Treviranus; Carus. (pl. vii. fig. 2)
(*d*) "We are deceived," says Professor Grant, "in every case where we imagine we have got elements that do not exist in other animals, but only in the particular species we are examining—they exist, under another form, in Man." (*Lectures*, 1833-34)

other contiguous parts, so as to lose at length all appearance of the complicated pharyngeal bone of fishes and reptiles ; (*a*) and of the different degrees of development, equally good examples in the small bones within the tympanum, and the coracoid processes of the scapulæ, which, insignificant as they are in the human skeleton, are nevertheless all that remain respectively of the large opercular bones, (*b*) and the large coracoid arch of fishes, the latter becoming the furcula of reptiles and birds. (*c*) On the other hand, the individual bones of Man as often borrow elements from the neighbouring parts as impart such elements to them—witness, for example, the lower jaw, which in Man associates with itself the distinct intermaxillary bone of so many of the lower tribes (*d*)—and they are as frequently more developed than the corresponding bones of other vertebrated animals, as less so—witness again the several bones composing his skull. In this way a kind of balance, as it were, is everywhere struck between the sum of them all ; and what any individual tribe wants in the evolution of one bone is always made up to it in that of others. (*e*) It is to the hyoid bone and sternum, which is immediately continued from behind its centre, that in fishes the thoracic ribs with their muscles are attached, so that these animals carry

(*a*) Geoffroy St Hilaire. (*Phil. Anat.* p. 3 and 4)

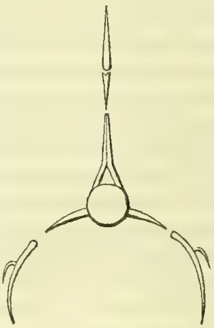
(*b*) G. St Hilaire ; (pl. 1) Grant. (*Lectures,* 1833-34)

(*c*) G. St Hilaire ; (pl. 2 and 9) Grant.

(*d*) Carus. (pl. viii. fig. 1 and 12 ; pl. xi. fig. 10 ; pl. xiv. fig. 1 &c.)

(*e*) This is what is meant by St Hilaire, by the phrase " Balancement des organes," any one being the more developed in proportion as any other is the less so, and *vice versâ ;* or, as he expresses it, " L'atrophie d'un organe tourne toujours au profit d'un autre." (*Philosophie Anatomique,* 1818) M. Serres has very well illustrated this law in the relative development of the cerebellum, corpora quadrigemina, thalami optici, hemispheres of the cerebrum and corpora striata in the four classes of vertebrated animals. (*Anat. Comp. du Cerveau,* 1824) Hence it is perhaps more judicious to speak of the presumed unity as rather that of certain structural elements or primitive types—as is the practice of Dr Knox, than of whole organs ; since it is obvious that it is frequently the former alone, and not the latter, which can with propriety be said to be repeated. Such interchanges of elements however are by no means so common as to justify Sir Charles Bell in asserting that the whole of the " New Theory" consists " essentially in this—that when a part which belongs to one animal is missed in another, we are to seek for it in some neighbouring organ." (*On the Hand,* 1834, p. 154) This is so far from being the whole, that it is a very inconsiderable part of the " New Theory" in question ; and consequently much of the ridicule which, on this misconception, he attempts to cast upon it falls quite harmless.

their chests, as it were, in their mouths, (*a*) and a freer motion is thus allowed to the posterior parts of the body; but this constitutes no essential difference between these parts of fishes and the corresponding parts of Man. Nor are the entire want of ribs in the adult batrachian reptiles (*b*)—since they disappear only with the gills, which, in the larva, had been attached to them—nor the prodigious number of ribs, without any apparent sternum, in the ophidian reptiles, (*c*) in which in fact they serve the purpose of legs, nor their expansion into the dorsal shield, or carapace, like that of the sternum into the ventral shield, or plastron, in the chelonian reptiles, (*d*) any other than accidental differences. Of the general correspondence of the vertebræ with their muscles in all vertebrated animals it is superfluous to speak. Nothing can be, it is true, apparently more unlike than an abdominal or caudal vertebra of a fish and the corresponding organ of a Man; but if we choose to investigate the matter, we shall find that it requires nothing more than a somewhat greater development of the spinous process of the latter to constitute the upper spinous process, with its interspinous bone and ray of the dorsal fin, of either of the former, and a somewhat greater development of the two transverse processes of the latter, to constitute on the one hand the so called abdominal ribs, and on the other the lower spinous process, with its interspinous bone and ray of the anal fin, respectively of the two former. The abdominal ribs of the fish are not in fact ribs in the proper acceptation of the term, any more than the processes from the vertebræ of the neck, by which some kinds of serpents, as the Cobra-da-capello — (*Coluber* 38) — raise their hoods, or those from the vertebræ of the back by which some kinds of lizard, as the Flying lizard — (*Draco* 39) — suspend themselves for a time in the air. The bones of the skull again, unlike as is its general aspect in the



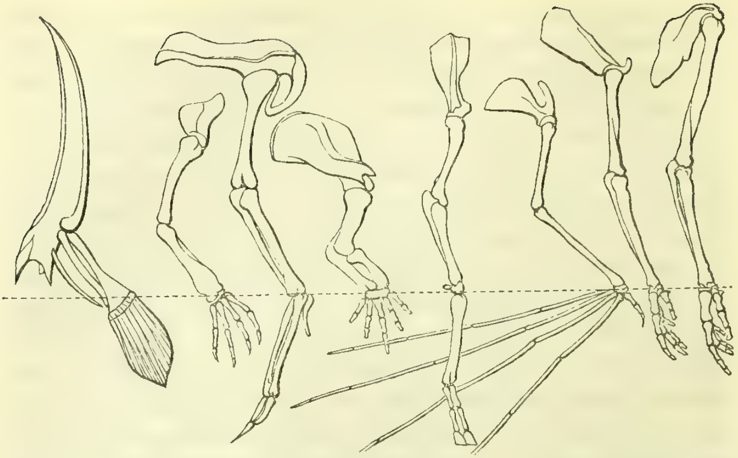
Abdominal Vertebra of Fish.

Caudal Vertebra of Fish.

(*a*) Carus. (pl. viii. fig. 5)
(*b*) Carus; Grant.
(*c*) Carus; Grant.
(*d*) Carus; Grant.

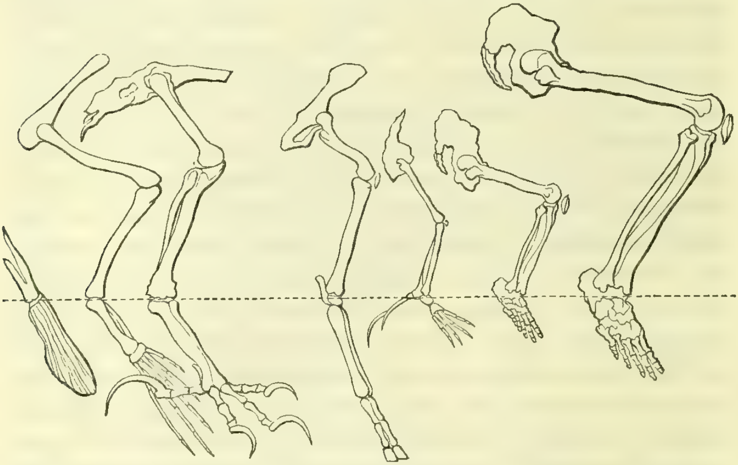
different vertebrated tribes, are essentially the same in all; the differences consisting only in the various associations or degrees of development of the same structural elements, or points, as they are called, of original ossification. (*a*) Even the large lateral hollows over the proper skull of the chelonian and some saurian reptiles, which appear at first sight entirely *sui generis*, are merely arches stretching outwards and downwards towards the zygomata from the spine of the parietal bones, in general so prominent in the inferior vertebrated tribes, and bearing nearly the same relation to these bones, as the dorsal and ventral shields bear, in the former of these orders, to the bones of the spine and sternum. The bones of the face likewise, and the lower jaw with their muscles, are in all fundamentally the same; and from the rudimental scapulæ and clavicles of fishes on the one hand, and the bones of the pelvis on the other, as well as from the bones of their pectoral and ventral fins, with their several muscles, the transition is easy and almost insensible through the corresponding parts, hard and soft, of reptiles, birds and mammals in general, to the bones and muscles of the shoulders and hips, and of the arms and legs of Man. Even serpents are not destitute, for the most part, of rudiments of proper anterior and posterior extremities, the former sometimes concealed by the integuments, but at others projecting in the form of claws, and the latter manifesting themselves in at least a rudimentary pelvis; and from these the transition to the Snake-lizard—*Chalcides* 39—and other similar tribes, in which the legs are hardly worthy of the name, is easy and natural. (*b*) And still less do the cetaceous tribes among mammals afford any exception to the general rule, the anterior extremities being in them in general remarkably perfect, (*c*) and most of them also presenting rudiments of at least a pelvis. In all these tribes then the prototype of the several bones is the same—it is the form and size alone that differ. The subjoined diagrams from pencil sketches (*d*) sufficiently display the structural identity of the bones of the extremities in vertebrated animals.

(*a*) Grant.
(*b*) Mayer; Roget. (vol. i. p. 447)
(*c*) Pander and D'Alton; Roget. (vol. i. p. 486)
(*d*) Bushnan.



Fish. *Frog.* *Bird.* *Dolphin.* *Deer.* *Bat.* *Ape.* *Man.*

[The dotted line passes through the wrist joint of each—all below this is the hand.]



Fish. *Frog.* *Bird.* *Deer.* *Bat.* *Ape.* *Man.*

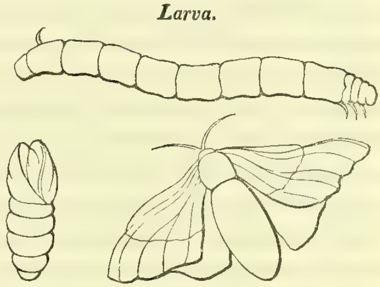
[The dotted line passes through the ankle joint of each—all below this is the foot.]

Such then is a rough sketch of the correspondence between the several organs of the different tribes of animals in their mature state—a correspondence strikingly illustrative of the hackneyed precept that nature, in all her works,

acts not by partial, but by general laws.

But it remains to be particularly noticed, and it is a strong presumptive proof of the alleged unity of their organic structure, that each individual of every tribe of animals, as has been already incidentally remarked, appears to pass, in the course of its organogenesy, through every gradation in this respect between the lowest tribe of all and that to which it is ultimately to belong; and consequently, that the human embryo—at first, like the rest, a kind of zoophyte, must have passed through every possible gradation, in order to arrive at the perfection of Man. (*a*) Of these transitions made by the various tribes of animals from a lower to a higher grade of existence, with the qualifications specified when it was denied that an immature animal of one tribe is ever quite identical with a perfect animal of any lower grade, we have examples in some of the metamorphoses which are continually going on before our eyes. Thus an immature molluscous animal corresponds *very nearly* with a zoophyte, an immature animal of the family of annelida with a molluscous animal, an immature crustaceous animal with one of the annelida, and an immature insect, in the state of larva with one of the annelida, and in the state of pupa with one of the crustacea. The same thing occurs also in the vertebrated tribes, an immature frog or salamander for example being *very nearly* a fish, and so forth; but it is in tracing the individual organs in their progressive evolution during their fetal state that this transition becomes most remarkable. Thus, to say nothing of the development, in the embryo of each superior tribe, of its proper lungs, from the prototype already mentioned, it is a remarkable fact, that even the gills of the molluscous animals — which are supposed in insects to become wings, as the bivalve shells become elytra

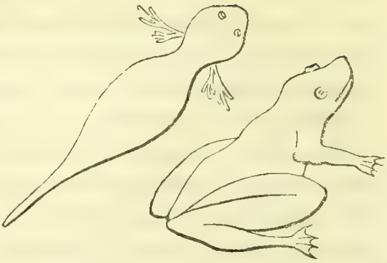
Larva.



Pupa. *Imago.*

(*a*) "Ce que ces formes embryonaires ont de tres remarquable dans les classes supérieures," says M. Serres, "c'est qu'elles répètent souvent les formes permanentes des classes inférieures;" (*Anat. Comp. du Cerveau*, 1824) and it is well remarked by Professor Grant, "that we pass through the same stages of development, by tracing it through the highest animal in the course of its progressive elaboration, as by tracing it through the great body of the animal kingdom." (*Lectures*, 1833-34) The knowledge of these changes is what is understood by Transcendental Anatomy—a Science of the deepest interest and importance.

—and those of the osseous fishes, which have no corresponding organ in the superior tribes of animals when mature, are met with in all at one period of their progress to maturity. The larvæ of the batrachian reptiles have been long known, as already remarked, to possess external gills, which they only gradually lose in proportion as their lungs become elaborated; but it has been only recently ascertained that similar gills exist, in a rudimental state, in the fetusses also of the higher orders of reptiles, of birds, and even of mammals, when they have passed through each about one-sixth part of their period of incubation or utero-gestation. These rudimental gills, which present the appearance of little projections or plates, bordering transverse clefts on each side of the pharynx, are connected together anteriorly, and traversed by arterial loops precisely in the manner of the external gills of fishes. They have been particularly noticed in the fetusses of many serpents and lizards—*Coluber* 38, *Lacerta* 39 &c.—in that of the Fowl—*Phasianus* 43 — and in those of the Ox—*Bos* 48—Sheep—*Ovis* 48 — Hog — *Sus* 49 — Rabbit — *Lepus* 56—Dog—*Canis* 54 — and Man; (*a*) and furnish certainly one of the most beautiful illustrations of the essentially identical structure of fishes, and perhaps even of molluscous animals, and of all the superior tribes, the only difference appearing to consist in this, that where the animal is to turn out an aquatic one, the organ corresponding to gills is evolved at the expense of that corresponding to lungs, while the opposite change takes place when the animal is destined to be terrestrial. The fact just stated also appears opposed to the opinion of some naturalists, that the thoracic ribs of fishes correspond rather to sections of the tracheal cartilages of the superior tribes, than to the proper ribs of the latter; since it is not easy to conceive that an essential part of a proper lung should ever have been



Tadpole. *Frog.*

(*a*) This interesting fact has been established by the researches principally of Baer, (*Meckel's Arch.* vol. ii. No. 4) and Rathke. (*Breschet's Répert. Gén. d'Anat.* &c. tom. vii) instrumental in supporting a different, and, as it were, a rival organ. In this respect then the gills and lungs seem to stand nearly in the same relation to each other as the corpus mucosum and proper skeleton, the development of the one being almost inversely as that of the other. Further the heart of the fetusses of fishes—moulded, as it is on that of the avertebrated animals—and that of those of reptiles, is in every respect fundamentally alike, being, when first observable, a simple tube, which becomes gradually contracted in the middle, and is afterwards reflected backwards on itself, so as to bring the auricular above the ventricular portion ; in addition to which, in the higher orders of the latter, a partial division of the two sides ultimately takes place. (*a*) Exactly similar is at first the heart of the chick—*Phasianus* 43—which about the thirtieth hour of incubation is also a simple tube, and situated, as it is permanently in the fish, in the neck. It becomes about the forty-fifth hour contracted in the middle and reflected on itself, but is without any appearance of a division into a right and left heart till about the sixty-fifth hour, when the ventricular portion begins to be so divided, as does the auricular portion about the eighty-fifth, till about the sixth or seventh day no vestige of any communication, except at the foramen ovale, is perceptible. (*b*) Among mammals also the nucleus of the heart is still the same. That of the fetus of the Dog—*Canis* 54—about the twenty-first day of utero-gestation is likewise a mere tube, contracted and reflected on itself, (*c*) and situated in the neck ; and that of the human embryo about the fourth week is precisely similar to that of the mature fish or lower reptile, or to that of the chick before it has begun to be divided into a right and left portion. This division commences in the human heart soon after this time, first, as in that of the chick, in its ventricular portion, which begins by splitting, as it were, from its apex upwards, and about the ninth week in its auricular portion also, till about the end of the third month, the foramen ovale is the only remnant of the original communication between the two sides. (*d*)

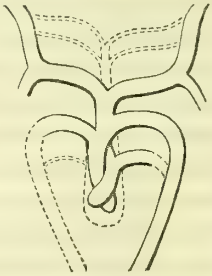
(*a*) Rathke ; (*Die Erzeugung der hartgrätigen Fische,* 1792) Rusconi. (*Amours des Salamand. Aquat.* 1821) &c.

(*b*) Prevost and Dumas ; (*Ann. des Sc. Nat.*, tom. iii) Dr Allen Thomson. (*Edinb. Phil. Journ.* 1829) &c.

(*c*) Baer. (*De Ovi Mam. et Hom. genesi,* 1827) &c.

(*d*) Meckel ; (*Archiv.* B. ii. p. 402 &c.) Owen, cited by Dr A. Thomson.

Nothing can be more admirable than this example of unity in the primeval structure of parts ultimately so dissimilar; but that afforded by the development of the great blood-vessels is not less so. The five branchial loops arising on each side from the single vessel which proceeds from the heart of the osseous fishes, are repeated, almost without change, in the fetusses of the batrachian reptiles; and it is only in proportion as their gills disappear, that those branches which previously went to these organs become obliterated, while of those which remain are formed, on the one hand the two aortæ, and on the other the two pulmonary arteries, which are, in these animals, merely branches of the former. (*a*) In the embryo of both serpents and lizards also the same primary trunk and its looped branches—to become afterwards the carotid and subclavian arteries, and the aortæ and pulmonary arteries—are met with. (*b*) And even in the chick and the fetusses of mammals, including Man, the identical five loops, running, as already observed, along the borders of the clefts in their pharynx, at first present themselves; and it is only gradually that, by the obliteration of some and the amplification of others, the carotid and subclavian arteries and the single aorta and pulmonary artery of these tribes become established. In the subjoined diagram the vessels indicated by the continued lines are those which alone remain, in the mature mammal, of all which it possessed in the early period of its development, when its vessels corresponded to those of the fish, such as have become obliterated being indicated, together with the original bulb of the aorta, by the dotted lines in the back. In order to form the single aorta and pulmonary artery, with its two branches, the bulb of the single vessel which originally proceeds from the heart, about the time of the division of this organ, becomes first contracted longitudinally, and at length splits into two tubes, one of which—the aorta—remains connected with the left side, and the other—the pulmonary artery—with the right side of the



Fetus of Mammal.

(*a*) Rusconi &c. (*b*) Baer, Rathke &c.

already divided heart; (*a*) furnishing, in conjunction with the separation of the heart, a beautiful illustration of the remark elsewhere made, that, as organs in general become concentrated in proportion to the advancement in rank of the animal to which they belong, so once concentrated organs in the same proportion often become complex, from the freedom with which their structural elements once accumulated, are afterwards employed. The various parts of the intestinal canal and its appendages, and of the genital organs, in the lower and higher tribes, are in general so similar, that, as examined in their fetal and mature state, they present less remarkable differences than the preceding organs. It may be remarked however that, as in the lower tribes the chylopoietic viscera are generally more voluminous and diffused than in the higher, so the fetusses of the latter have in general relatively longer and more sinuated intestinal canals, and larger and more complicated livers than the mature animals: those of mammals also have always at first a cloaca like birds and reptiles. The kidneys again of the fetusses of the higher tribes are, as in most of the lower animals, long and deeply lobulated; and, with respect to the genital organs, it is only necessary to refer to the diffused and lobulated structure and high situation of the ovaries and testicles, the double or bifurcated uterus, and the comparatively large size of the clitoris and of the penis of the human embryo, in proof of the identity of their original mould with that of the same organs in the lower animals. Of the progressive evolution of the organs of the senses, as tending to the same conclusion, it is unnecessary to say any thing, further than to remark that, in the ear for example, the vestibule is the part first developed, then the semicircular canals and cochlea, and afterwards the tympanum and the remaining parts, almost precisely in the order that they severally present themselves as we rise in the scale of creation; but on that of the nervous system a few words must be subjoined, since of all the organs of the body, none affords stronger evidence in favour of the doctrine of unity of organic structure. The spinal cord of the human embryo, at first composed of two distinct threads,

(*a*) Burdach. (*Physiologie als Ehrfahrungsgesweschenshaft*) is relatively long, large and deeply cleft on its posterior aspect, in proportion to the low degree of general development, thus corresponding precisely to its condition in the inferior animals as they are further and further removed from Man; but it is in the brain chiefly that this correspondence between the human embryo, in the different stages of its elaboration, and the lower tribes of animals displays itself. It has been already stated to what part this organ corresponds in the avertebrated tribes, and of what parts principally it consists respectively in the osseous fishes, in the cartilaginous fishes, frogs and chelonian reptiles, in serpents, lizards and birds, and, among mammals, in the several orders, rodentia, ruminantia, digitigrada and quadrumana; and it is a fact of the highest interest and moment that, as the brain of every tribe of animals appears to pass, during its development, in succession through the types of those of all below it, so the brain of Man passes through the types of those of every tribe in the creation. It represents accordingly before the second month of utero-gestation that of an avertebrated animal, at the second month that of an osseous fish, at the third that of a turtle, at the fourth that of a bird, at the fifth that of one of the rodentia, at the sixth that of one of the ruminantia, at the seventh that of one of the digitigrada, at the eighth that of one of the quadrumana, till at length, at the ninth, it compasses the brain of Man! It is hardly necessary to say that all this is only an approximation to the truth; since neither is the brain of all osseous fishes, of all turtles, of all birds, nor of all the species of any one of the above-mentioned orders of mammals, by any means precisely the same, nor does the brain of the human fetus at any time precisely resemble perhaps that of any individual whatever among the lower animals. Nevertheless it may be said to represent, at each of the above-mentioned periods, the aggregate as it were of the brains of each of the tribes stated; consisting, as it does, about the second month, chiefly of the mesial parts of the cerebellum, the corpora quadrigemina, thalami optici, rudiments of the hemispheres of the cerebrum and corpora striata; and receiving in succession, at the third, the rudiments of the lobes of the cerebrum, at the fourth, those of the fornix, corpus callosum and septum lucidum, at the fifth the tuber annulare, and so forth, the posterior lobes of the cerebrum increasing from before to behind, so as to cover the thalami optici about the fourth month, the corpora quadrigemina about the sixth, and the cerebellum about the seventh. (*a*) This then is another, and an equally striking example as that lately adduced, of an increase in the complexity of an organ succeeding its centralization; as if nature, having first piled up her materials in one spot, delighted afterwards to employ her abundance, not so much in enlarging old parts as in forming new ones upon the old foundations, and thus adding to the complexity of a fabric, the rudimental structure of which is in all animals equally simple. There remain only the bones and muscles; and respecting these it is sufficient to notice the total want apparently of these organs in the early embryos of the highest animals, and their correspondence, when they do appear, with the same organs in the lowest of those animals which are possessed of them—the contracted chest for example of the human fetus, the straight vertebral column, the minute pelvis, the lower jaw in two pieces, and almost without either a chin or an ascending ramus, the comparatively insignificant lower limbs &c.—to be satisfied that, with respect to these also, the embryo of Man is at one period analogous in structure to the inferior tribes, not merely of the vertebrated, but even of the avertebrated animals.

Do we not then appear to be justified in presuming, as before said, that all tribes of animated nature, with respect to their several organs, start, as it were together, that the germ of each of their organs is in all the same, and that they subsequently differ from each other only or chiefly in their arriving at their appointed goal sooner or later; those of the zoophyte—the zero of animal existence—reaching it almost instantly, those of the molluscous and articulated animals — annelida, crustacea and insecta — successively later, those of the fish, reptile, bird and quadruped each more tardily than the preceding, and those of Man—the maximum of such existence—" the Paragon of Animals"—the last of

(*a*) Tiedemann. (*Anat. du Cerveau, par Jourdan,* 1823) The appearance of the original of this admirable work constituted an era in the history of the science of this important organ.

all? (*a*) But it must be constantly kept in mind that this is true only with respect to each individual organ—not with respect to the sum of them all; so that it is no objection to this

(*a*) Independently of the wild speculations already alluded to respecting the long and unsuccessful apprenticeship of nature to the art of making Man, regarded en masse, an idea seems to have been for a long time prevalent, that it is only progressively that Man attains the general perfection of his several organs, and that nature had at the creation, as she still has in every successive generation, to build each of these upon a mould derived from the lower animals, at first the simplest possible, but becoming more complicated in proportion as she approaches the end of her labour. Perhaps a hint of this fact is suggested by Willis, who ascribes the greater perfection of the brain of quadrupeds and Man to the circumstance of their having been created on the sixth day, whereas "every winged fowl, and every thing which moveth, which the waters bring forth," were formed on the fifth, when, as seems to be implied, the hand of the Creator was less skilful! The law however which determines that the attainment of perfection by the parts of Man is possible only by means of their transition through the corresponding parts of brutes, was insisted on more particularly by Daubenton and Vicq d'Azyr, who described the anatomy of several of the lower animals, in illustration, as De Blainville expresses it, "De la même marche, adoptée aux différentes phases de perfectionnement de celle de l'Homme;" (*De l'Organ. des An.*, 1822) and indeed the term Comparative Anatomy, which was invented by Vicq d'Azyr, sufficiently indicates his persuasion of its universality. Blumenbach again describes the formation of the various organs of the human frame as the grandest effort of his "nisus formativus," at which it arrives only by gradual changes; and the immortal Göethe everywhere inculcates the idea that Man is only a more perfect specimen of the same fabric as the lowest animals, and insists that when nature made the several parts of the latter, she was "full of the thought" of those of the former, although she only very slowly realized it. In like manner Carus speaks of the gradations in the organs of animals as resulting only from the greater or less "development of an imaginary unity, attaining its utmost perfection in the human organization;" (organism) (*Comp. Anat. by Gore,* 1827) and according to Geoffroy St Hilaire, "Il n'est qu'un même mode de formation, pour engendrer les faits organiques, soit que son action, s'arrêtant de bonne heure, donne les animaux les plus simples, soit que cette action persévérant jusqu'au terme de toute sa capacité possible, amène la plus grand complication des organes." (*Philosoph. Zool.* 1830) To the same effect says Mr Bushnan, "The foundation stones, as it were, of all animals are of the self-same number and form, and upon these is reared a superstructure of the same character, but higher or lower, according to the rank which each individual being is to hold in the scale of creation. To each has the Creator said 'Thus far shalt thou go, and no farther.' Of some the progress has been very soon arrested, to others a greater advancement has been allowed, while in Man, to so towering a height has it been permitted to proceed, that he is tempted to deny his affinity with the rest, and to lose sight of the humble beginnings on which all equally rest." (*Study of Nature,* 1834) Finally Dr Roget (*Bridgewater Treatise,* 1834) and numerous other recent authors inculcate similar views. On the supposed Συνέχεια of Aristotle, or the regular gradation of doctrine, that the human embryo at no period of its organogenesy so far resembles a lower animal, that it can easily be mistaken for one. To this effect it would be necessary, as already remarked, that the development of each organ should bear the same relation to that of every other in the former as in the latter, which is sufficiently well known not to occur; and this circumstance furnishes additional proof of a fact which is only just beginning to be understood, that each organ, during its elaboration, is in a great measure independent of every other, and grows, as it were, *per se*. Had this not been the case, it is obvious that the pace of all the organs must have been the same, and had the human embryo been at any given time a fish in one part, it must have been at that time every inch a fish, and so on. As the matter stands however it is not at any period, with respect to the sum of its organs, like any other created thing; but being—like the celebrated fossil skeleton of the Pterodactyle Longirostris—a kind of fish in one part, a kind of reptile in a second, a kind of bird in a third, and a kind of quadruped in a fourth, it cannot well be mistaken for any thing but what it is. (*a*) The alleged unity therefore is strictly of the isolated organs alone—not of those collections of them which go to form the various tribes of animals; and consequently the admission of this doctrine to its fullest extent has no tendency, as before explained, to confound any of the established distinctions in Natural History. At the same time it must be remembered that there is in all animals, at every period, a certain relation between their several organs, with which the greater or less specific development of each is not incompatible, and which is still

all created things from the lowest to the highest, and the constant tendency throughout all nature

——————— to ascend
From small beginnings to a glorious end,

Mr Coleridge has some splendid remarks in his *Aids to Reflection*.

(*a*) Such mistakes however appear to have occurred; and it is to these that we must probably refer most of the idle stories, related by Schenk and others, in which women are represented as having been delivered of "polypi, echini, musculi, sanguisugæ, astaci, tenchæ, ranæ, bufones, serpentes, lacerti, porcelli, elephanti, lepusculi, talpæ, canes, feles, leones!" Upon these principles a few women, in the habit of aborting, at different periods of pregnancy, could soon get up specimens of the different tribes of animals, sufficient to stock the finest Museum of Natural History in the world.

not referable to the circumstance of such organs as display this general relation being themselves formed on the same plan—a modification of unity of organic structure to be in future alluded to. Thus we do not find organs which minister to one function associated with organs the office of which is inconsistent with, or even otherwise than to a greater or less degree subservient to this function : (*a*) but no such anomalies of relation are involved in the disproportionate specific development of the corresponding organs of different tribes, upon which the distinction, not only of these tribes from each other, but of any one of them from the fetusses of superior tribes mainly depends.

And it may be here remarked in passing that this constant relation of the various organs to each other, as ministering collectively to the general functions of an animal, furnishes an evidence of Divine power, wisdom and goodness in their construction, which the advocates of the doctrine of unity of organic structure are sometimes vaguely and ignorantly supposed to have lost sight of. (*b*) It may be

(*a*) —— neque centauri fuerunt, neque tempore in ullo
Esse queat duplici natura, et corpore bino
Ex alienegenis membris compacta potestas.
(*Lucretius*, V. 876)

(*b*) It is perhaps the most singular circumstance in the history of Science in general, and of Physiological Science in particular, since the time of Lord Bacon and the introduction of inductive philosophy, that almost every discovery and every new doctrine has given rise to an outcry, more or less loud, among a certain set of people, against the authors and promulgators thereof, as persons hostile to religion; as if a knowledge of the laws regulating the immediate means by which the Almighty operates in his works, could by any possibility, in a well-regulated mind, lead to any thing but a firmer impression of his power, a clearer perception of his wisdom, and a more grateful sense of his goodness. That ignorance should occasionally make men atheists is sufficiently intelligible, since if we know nothing of the works, it is reasonable to suppose that we shall be careless of their Creator; but how the continued contemplation of these works, and of the admirable harmony which every where pervades them, should ever have this effect on any body but a maniac, is as inconceivable as how the study of a beautiful and apposite piece of mechanism should lead to the denial of the existence of the mechanic. Attention to the works of nature has accordingly, in all ages, been principally relied on, by all but fanatics, as a means of establishing, not spurned as calculated to undermine religious faith. The study of nature is the study of nature's God; and it is they only who have stopped on the threshold of this study, and have let in only light enough to render darkness visible, or who are evidently wrong-headed—and such men have existed from Epicurus to Lamarck—that have ever indulged in those flippant and irreverent true, and is unquestionably true, that the hand of the Ape is formed on the same model as the wing of the Bat, the paw of the Lion, the hoof of the Horse, the flipper of the Walruss and the pectoral fin of the Whale; and that the development of each of these parts is immediately effected by certain inherent powers, of a different nature indeed, but not less definite in their operation, than those which determine the crystallization of a mineral. Nor is it perhaps a very conclusive argument of design—taking these organs *individually*—that we find the hand of the Ape well adapted for feeling, the

remarks, the object of which is to shake our faith in truths which it must distress us to doubt, and wither us to disbelieve. The greatest natural philosophers have in every age been the most devout men; and in exact proportion to the degree of intelligence with which we assent to the exclamation of the Royal Psalmist, "How *manifold* are thy works, O Lord," will be the fervour with which we add, "in *wisdom* hast thou made them all." Is the veneration of him who is acquainted with the laws of electricity for the Creator of the thunder, a less intense, because a more elevated feeling than the stupid awe of the savage, who listens to it in idiot wonder; or the love of him who knows "how fearfully and wonderfully he is made" for the Author of his being, a less ardent, because a more rational sentiment than the blind superstition of the rustic, who contemplates the penetralia of his fellow-creatures with disgust and abhorrence? It was remarked by the sublime Plato, "The world is God's epistle to mankind;" and it is sufficiently well known that Cicero, in his work *De Natura Deorum*, dwells more upon the fabric and functions of the human body than on any thing else, when he wishes to prove the existence of a Supreme Cause; that Seneca and Pliny were almost as much preachers as philosophers; and that Galen's work *De Usu Partium* may be regarded almost as a prose hymn to the Creator of the universe. Nor is this remark to be confined to pagans. Was Newton a pagan? Was Boyle, the founder of modern Natural Theology, and whose two works, *On the First Causes of Natural Things*, and *The Christian Virtuoso*, were the bases on which almost all the more recent works on the subject have been constructed, a less humble and sincere christian than the most gloomy puritan who would make religion synonymous with ignorance? What was Ray? What were Derham, Paley, Dugald Stewart—and should our conclusions respecting the tendency of the contemplation of nature be drawn from men like these, or from the few and obscure pseudo-philosophers who have made an illegitimate use of it, and by their ribald sneers have drawn down the anathemas of the well-meaning, but the weak and unenlightened, upon the study in general? It is to be hoped that the recent admirable *Bridgewater Treatises* will do much towards removing once and for ever this unfounded prejudice, and rescue, not only the pursuits of physiology from the imputation of irreligion, but religion from that worst of reproaches with which the ill-judged zeal of its false friends would load it—that it can thrive only in proportion to the darkness in which it is enveloped, and that, nurtured in the blindness and obscurity of cells and cloisters, it is unable to bear the broad light of day, and to go hand in hand with the progress of intelligence.

wing of the Bat for flying, the paw of the Lion for grasping its prey, the hoof of the Horse for standing, the flipper of the Walruss for clinging to rocks and ice-bergs, and the pectoral fin of the Whale for balancing the body; since it may be alleged that each of these circumstances indicates rather the mere concatenation of cause and effect, than the adaptation of means to end, and that it is not because these animals were intended severally to touch, to fly, to grasp, to stand, to cling and to balance themselves by these means, that such is the structure of their respective organs, but because such is the structure of their organs, that they put them to these uses. Function, it may be said, is the result of structure—not structure of function, or of any view to function; and it may be regarded as equally in conformity with one vast plan of the Almighty, that certain organs, abstractedly considered, should exist, as that certain functions should be performed. When an organ, it may be argued, is adapted to any particular function, it performs that function; but that it was not with a view to this that it was constructed, is obvious from the facts, that the corresponding organs in different animals often perform functions of a totally different character, and that many organs—such as the rudimentary legs of serpents, and the branchial apparatus of terrestrial fetusses, as well as the cremaster muscles and tunicæ vaginales of the female, the mammillæ of the male, and numerous others—seem to perform no function at all. (*a*) It is no great theme for admiration then,

(*a*) Although the arguments above stated are in their general application quite untenable, perhaps it would be better if we could divest ourselves of the tendency to inquire *on every occasion*, " What is the use of this or that organ ?" at least with reference to the being possessed of it; since, although the great majority of organs undoubtedly do contribute in every animal to some useful end in the economy of that animal, it is more than probable that many do not, but exist only in obedience to certain laws of harmony of structure which nature has imposed upon herself, and to maintain which is as much a part of her general scheme, as it can possibly be to minister to any display of function by individual animals. Not a few organs, for example, are in brutes merely rudimentary and seem to perform no office whatever, which, on attaining their fullest development in Man, are eminently serviceable to him ; while on the contrary not a few others are in Man merely vestiges of what they have been, and apparently useless, which, evolved as they were in brutes, performed some important function. The tendency in question has originated in a kind of intuitive notion that the Creator has *always* willed first that a certain function should be performed, it may be said, to find that any individual end in the animal economy is fulfilled by appropriate means, when the fulfilment of that end was the direct consequence of the means being appropriate. But to omit the evidences of design afforded by the express appropriation of not a few individual organs to certain precise purposes, which cannot be performed by any other—that of the eye or ear for example, the exquisite adaptation of which to their respective functions no speculations on the unity of organic structure, though they may illustrate, can in any degree obscure—*the association of the various organs* in every animal is such as to furnish, to all but the voluntarily blind, the most irresistible proof of the operation of a Divine hand in controlling and modifying those powers by which each is immediately constructed. It was not perhaps essential that the Ape should be furnished with a hand as an organ of touch, since it might have employed in this capacity either ciliæ and tentacula, like many mollusca, or antennæ and palpi like many articulata, or cirrhi like many fishes, or a bill like some birds, or its snout like the Hog and Elephant, or whiskers like the Lion and Cat, or a tail like some Monkeys; and each of the other animals above mentioned might have used many other organs besides the end of their anterior extremity as instruments respectively of flying, grasping, standing, clinging and balancing themselves. We may perhaps admit then that no very obvious design is manifested in the adaptation of the hand of the Ape to the particular function which it performs, looking at this hand *per se;* since it is only because it is of all its organs the best adapted to this par-

and afterwards that a certain organ should exist for performing it; but what good reason have we for believing that this was always the order of succession in the operations of the Supreme Mind, and that no organ can exist otherwise than as the result of this process. The functions performed by any creature are perhaps, strictly speaking, no more an end in the great plan of creation than the structure of that creature; and if the structure in performing these functions may be regarded rather as a means than an end, the end of many of the functions is in like manner the formation and preservation of that structure, and they must therefore in so far be looked upon as a means also. It may nevertheless be conceded that a view to function has *in general* preceded every modification of structure; but in cases where every function has been otherwise provided for, it does not appear that nature has departed from her uniform plan, but has continued to construct organs, the only use of which—if we must still find a use for them—is to manifest the harmony and consistency of her operaions.

ticular function that it so employs it, and were it deprived of this organ, it would use the one next best adapted to the purpose in the same capacity, which vicarious organ, had we seen it from the first so employed, we might perhaps have discovered was equally admirably calculated for its office. But contemplating the hand of the Ape *in its relations to the other organs of the body*, who can fail to be struck with admiration at the nice balance with which the inherent powers of organization, taking effect as they do in every point of the body independently of every other, constantly operate, and to recognise the work of the Divinity in their collective coaptation? What blind laws of organization, acting independently of a Presiding Mind, could have prevented the heterogeneous association of the hand of the Ape, with various other organs calculated in like manner to minister to touch, while they were incompetent to perform some other important function, which it became their office to perform upon the hand being appropriated to this, or could have insured such a structure of the other organs of the body as to render the hand at once available and almost indispensable in this capacity? "The eye cannot say unto the hand I have no need of thee, nor again the head to the feet I have no need of you." Taking any given number of functions to be performed by animals, it would be an exercise of science to observe by what very different organs each is in different tribes effected; but it would be an exercise of theosophy to notice with what harmony each organ in every tribe performs the part assigned to it, alike uninterfering and uninterfered with, otherwise than in cooperation, and adapted always to do more in one capacity in proportion as it does less in another. And what has been said with respect to the end of the anterior extremity might be repeated with respect to almost every other organ of the body, not indeed that the function of each is equally accidental—for this cannot be said of the respiratory organ, the stomach and numerous others, any more than of the eye and ear—but that the particular modification of the structure of each, as adapted to the particular character of the function which it performs, is less conclusive evidence of design, than the general association of all, with reference to this particular structure of each. Thus it may be said perhaps with equal justice that an aquatic animal inhabits the water, and a terrestrial animal the atmosphere, because their respiratory organs are respectively adapted to these media, as that the former is provided with gills, and the latter with lungs, in order that they may do so; and again perhaps with an equal show of reason that a herbivorous animal feeds on vegetables, and a carnivorous animal on flesh, because their assimilating organs are severally calculated to digest these substances, as that the one has a long and complicated, and the other a short and simple intestinal canal for the purpose of so doing. But when we find that so many other organs of an aquatic and terrestrial animal respectively, besides their gills and lungs, are equally adapted to a habitat below the water or in the atmosphere—their eyes, their ears, their integuments, their members, every point of their body—when we find combined with the ample and complicated intestinal canal of the vegetable feeder, the long and narrow jaw with its arthrodial joint, the powerful pteregoid muscles, the flat grinding teeth, the rigid spine and the stiff and hoofed extremities, and with the small and simple assimilating apparatus of the beast of prey, the broad and short jaw with its ginglimus joint, the powerful temporal and masseter muscles, the pointed teeth, the supple spine, and the flexible and clawed extremities—when we find in short that the old adage "ex ungue leonem" is strictly applicable, not only with respect to the size, but with respect to almost every other characteristic of an animal, and that an accomplished anatomist, from the inspection of almost any one part, can predicate something of all the rest, as well as of the habits of the animal which will result from them—it is surely no cant to acknowledge here the finger of God, or to say that an undevout anatomist must be a maniac. Had the association of the organs of animals been the result of a reckless chance, what should have prevented the realization of the fancies of the poets in the production of dragons and griffins, with the wings of birds added respectively to the trunk and extremities of reptiles and quadrupeds, or of mermaids and sirens, of centaurs and satyrs or fawns, with the upper parts human and the lower those of fishes and birds, of horses and goats; and not only of these, but of thousands of other unearthly beings which it never entered into the heart of man to conceive? But nature acknowledges no such monstrosities. She might have constructed, and no doubt did at one time construct many other forms of living beings besides those with which we are now familiar; but she never constructed, or could have constructed any being so incongruous as many which man has fancied, and the parts of which were at once structurally inconsistent with the general unity of her plan, and functionally incompatible with each other. Even the Pterodactyle above alluded to furnishes no exception to this remark.

Nor is it merely as a matter of curiosity that speculations on the unity of structure in the corresponding parts of different animals are interesting; since, if they do nothing else, they at least afford a satisfactory solution of many cases of monstrosity, which in former times were absurdly referred to a lusus naturæ. (*a*) If it be admitted that each organ of the human embryo passes, during its gradual elaboration, through so many inferior types, and that certain causes may arrest this elaboration in any stage of its progress, it will be easy to

(*a*) It was long ago observed by Blumenbach, that while he had often met with human monsters strongly resembling, in some of their organs, various kinds of brutes, owing to the *nisus formativus*, from some cause or other, not having reached the highest pitch of the human form, but having rested at a lower point, he had never once found among brutes an example of monstrosity which bore any analogy to the parts of the human body. (*Instit. Physiol.* 1786) M. Serres also makes a similar remark. " Dans les déformations variées," says he, " que peuvent éprouver les êtres organisés, jamais ils ne dépassent les limites de leur classe pour revêtir les formes de la classe supérieure." (*Anat. Comp. du Cerveau*, 1824, p. lxiii) It is a mistake however to imagine that this never occurs; for the lower animals are in some respects perhaps hardly less liable to monstrosities by excess than Man is to monstrosities by defect, and the two may thus approach each other in structure by either road. A man for example with fewer than five fingers, approximates in structure to the Hog, the Sheep or the Horse, but a Hog with more than four, a Sheep with more than two, or a Horse with more than one—and such monstrosities are not very uncommon—approximates equally in structure to Man. The investigation of this subject of " l'ordre dans le désordre" has been fully prosecuted principally by Tiedemann, Meckel, Geoffroy St Hilaire and Serres. " Ce que nous appellons monstres," says St Hilaire, " ne le sont pas à Dieu, qui voit, dans l'immensité de son ouvrage, l'infinité des formes qu'il-y-a comprises;" (*Philosophie Zool.* 1818) and, according to Serres, " L'ordre est toujours dans la nature, le désordre et les incohérences, que nous lui supposons, n'existe que dans notre manière de l'interpreter." (*Anat. Comp. du Cerveau*, 1824) The most perfect treatise on the subject of Thaumatology, or rather that which promises to be so, is the one now in progress by Isidore G. St Hilaire, son of the enlightened author above mentioned.

understand those numerous cases in which the human heart, for example, has been found with an open foramen ovale, and those, progressively more and more rare, of a defective septum auricularum, (*a*) of only one auricle, (*b*) of a bifid apex, (*c*) of a defective septum ventriculorum, (*d*) of only one ventricle, (*e*) and lastly of a heart altogether single, (*f*) the order of the frequency of such malformations being almost exactly proportioned to the near approach which each implies of the organ towards perfection; since, regarding as the most common circumstance of all the full development of this organ, it is of course more likely that such development will be arrested at a late period, when it is receiving its last touches, than at an early period, when its broader characteristics are being imposed. Upon similar principles are to be explained the instances of a double aorta, (*g*) or vena cava, upper (*h*) or lower, (*i*) of a sinuated stomach, (*j*) of a branched or double uterus, (*k*) of a non-descent of the testicles, of a spinal cord still traversed by a groove or ventricle, (*l*) of a brain deficient in either a portion of its posterior lobes, or a septum lucidum, corpus callosum or other commissures, (*m*) those parts being here, as well as in the heart, most frequently defective, which are naturally the last to be added. The same explanation may be applied to the various recorded instances of a want of extremities upper or lower—in place of which there is commonly a rudimentary finger or toe, reminding us of the first attempt at such an extremity in the serpent (*n*)—as well as to numerous other analogous mon-

(*a*) Lawrence, Farre, Walter &c.

(*b*) Haller, Ring &c.

(*c*) Bartholin, De Torres &c.

(*d*) Corvisart, Baillie, Meckel, Louis &c.

(*e*) Wolff, Farre, Breschet &c.

(*f*) Wilson, Ramsbotham &c.

(*g*) Malacarne, Homellius, Serres &c.

(*h*) Ring, Meckel, Bœhner, Murray, Breschet &c.

(*i*) Kerkring, Meckel, Breschet &c. Dr Paget has published an excellent essay on these and other malformations of the heart and great blood-vessels, in which most of these and many other authorities are cited. (*Edin. Med. and Surg. Journ.* 1831)

(*j*) Riolan, Cowper, Ludwig, Vanderholk, Sir E. Home, Soemmering &c.

(*k*) Valisnieri, Littre, Bauhin, Grauel, Eisenmann, Purcell, Ræderer, Lobstein, Cassan, Bérard, Cruveilhier, Cloquet, Lee &c.

(*l*) Columbo, Piccolomini, Bauhin &c.

(*m*) Greding, Meckel, Reil, Wenzel &c.

(*n*) Hastings, Isenflamm, Tiedeman, Harvey &c.

strosities. And if it be considered that the development of each organ is in a great measure independent of that of all the rest, we shall have no difficulty in explaining why monstrosities by defect are so often confined to individual organs; and in fact the circumstance that they are often, although by no means constantly so, is a proof of the independence in question.

Subsection II.

On the Unity of Organic Structure, as manifested in the different Sexes of the same Species.

It is not only the organs of individuals of different tribes of animals that have each its counterpart in individuals of other tribes—a principle which, however difficult may be its detailed application, is so obviously founded in nature, that every child, on being shown for the first time an animal a little more obscure than ordinary in its structure, asks where are its eyes—its legs and so forth? as actuated by an instinctive persuasion that it *must have* organs corresponding to those which itself possesses. But a similar unity of organic structure displays itself also in other ways. Thus both the genital organs of individuals of different sexes of the same tribe, and also many different organs even of the same individual, appear to be, as it were, rude copies of each other—facts which seem to lead to the conclusion that there is not only a certain number of types, apparently primary, of different organs, as met with in the bodies of different races of animals, but that several of these are further resolvable into types of still greater simplicity. It has been noticed that certain organs of the human male are formed on precisely the same moulds as other organs of the female; (*a*) the nucleus being the same, for instance, in

(*a*) This application also of the doctrine of unity of organic structure was made by Aristotle, who, after describing the construction by nature of the genital organs of the male, expressly adds, *τὸν αὔτον δὲ τρόπον καὶ ἐν τῶ θήλει πάντα πέφυκε·* (*Hist. Anim.* i. 17) and Galen equally explicitly states that the only or chief difference between the male and female organs is, that, while the one are pushed outwards by the excess of internal heat, the other are retained within, owing to a deficiency thereof—in all other respects, he says, *παντ᾽ ἀλληλοις εὐσησεις τα αὐτα·* (*De Semine*, ii. &c.) Nor has this idea ever been lost sight of, running, as it does, through Avicenna, Fallopia, Paré, and innumerable the testicle as in the ovary, in the vasa deferentia as in the fallopian tubes, in the prostate gland as in the uterus, in the scrotum as in the labia, in the penis as in the clitoris, in the prepuce as in the nymphæ. Nay even other organs, which do not appear to exist at all except in one sex, have really their rudiments in the other. Such are the tunicæ vaginales and cremaster muscles, which are rudimental in the female, and the mammæ, which are equally so in the male; as if the law of elective affinities, as it has been called, of the organic elements, determining a unity of organic structure in the two sexes, were indefeasible, and quite independent of any functional necessity. It furnishes further a strong support to this doctrine that, in all races of animals, when any peculiarity manifests itself in any one of these organs in the one sex, a similar peculiarity characterizes the corresponding organ in the other. Of this fact numerous illustrations might be given, from the filamentous structure of the ovary and testicle of the Round intestinal worm—*Ascaris* 12 (*a*)—through their lobulated structure and generally high situation in most of the lower vertebrated tribes, to their compact form and low site in the human species; and again from the membranous conformation of the uterus and postrate gland—if they deserve these names—in the lower animals in general, to the parenchymatous structure of these organs in Man. The glans clitoridis again of the female Opossum—*Didelphis* 52—is bifid like the glans penis of the male, and even a bone is found in the clitoris of the female of all tribes the penis of the male of which, like the Dog—*Canis* 54—is possessed of it; nay —what is more remarkable—the male of the marsupial tribes has an additional bone attached to his os pubis, corresponding to that by which the female supports her marsupium, (*b*)

other authors, down to the times of Sir Everard Home, (*Phil. Trans.* 1799) Rosenmuller (*De Ovariis Embryonum*, 1802) and Ackermann. (*Infantis Androg. Hist.* 1805) It was even one of the vagaries ascribed by Dean Swift to the celebrated Martinus Scriblerus; but had nevertheless attracted so little of the attention of British physiologists, that when Sir Everard Home published his remarks on the subject, they were received by many as something altogether unheard of. Modern physiologists are proud of many things, and of nothing more than of their ignorance of the writings of the ancients; and truly they have in general a great deal to be proud of, and, if ignorance be bliss, a great deal to be thankful for, in this particular.

(*a*) J. Cloquet. (*Vers Intest.* plate iv. fig. 1, and plate ii. fig. 8)

(*b*) Home. (vol. ii. plate 5)

although in him it is of no conceivable use. And even in some tribes of our own species certain peculiarities which display themselves in the organs of one sex are equally remarkably repeated in those of the other: witness the enormous nymphæ, and equally enormous prepuce of the Boschismans, Abyssinians, Moors, Copts, Mandingos and other African tribes—the former constituting the celebrated tablier of the Hottentots, (*a*) and the latter the old "reproach of Egypt"—and the strong tendency equally in the labia and scrotum of these tribes to become hypertrophic. (*b*) It is nevertheless not quite correct to say, as is sometimes done, that we are all females to begin with, and that males differ from females only in the greater development of their sexual organs. Strictly speaking we are neither females nor males originally, since we possess only the rudiments of the proper organs of either; and we become the one or the other, not from all these rudiments being equally, whether more or less evolved, but from some of them being more, and others less developed, in a certain definite relation to each other. Thus the collection of organic elements, which may go to form either a uterus or a prostate gland, is more elaborated in the female than in the male, while, on the contrary, that which may form the basis of either a clitoris or a penis, undergoes greater development in the male than in the female; and it is on a proper balance being struck in these respects that the collective integrity of the genital organs in either sex depends.

As then the first-mentioned application of the doctrine of

(*a*) Strabo, Aëtius, Ten Rhyne, Niebhur, Bruce, Brown, Barrow, Burkhardt &c. The best delineation of this organ is by J. H. Cloquet.

(*b*) Sir Everard Home (*Phil. Trans.* 1799) assumes it as a further argument in favour of the original identity of certain organs in the male and female, that twins are usually of the same sex, or, if otherwise, the female is barren, perhaps—like a free martin, or those apparently female animals which are sometimes produced, among black cattle, at a birth with a perfect male—from some monstrosity in her organs of generation. It would have been better however to have established this as a fact, before it was thus advanced as an argument; the twin sister of a male being so far from always barren, that she is sometimes remarkably fertile. (*London Med. Repository,* 1823 and 1827) It is altogether improper that such nonsense as this should be propagated by persons who ought to know better; since the mischief to which it might give rise, in causing a poor girl to be rejected as a wife for a defect, or taken for an excellence — according as sterility might be regarded—which she did not possess, is incalculable.

unity of organic structure furnishes a solution of many cases of monstrosity in general, so this application of the same doctrine explains most of those particular cases of monstrosity called hermaphroditism. (*a*) In quite the lower tribes of animals indeed, as the Ascidia—*Ascidia* 9—the Sea-hare—*Aplysia* 9—the Garden-snail—*Helix* 9—the Earth-worm—*Lumbricus* 12—and the Leech—*Hirudo* 12—there appear to exist, in each individual, certain primitive nuclei sufficient to form both the proper female and the corresponding male sexual organs; and it is a common belief, that, among fishes, the Sturgeon—*Acipenser* 32—has roe on one side of its body, and milt on the other, and that the Lamprey—*Petromyzon* 32—and Sea-perch—*Perca* 35—are likewise hermaphrodite. But however this may be, we have very few accredited instances where there have existed in the same individual of the higher tribes—and least of all of Man—both ovaries and testicles, both a clitoris and a penis, or indeed any proper female and the corresponding proper male organ; consequently we have very few accredited instances of hermaphroditism, properly so called. A commonly reputed hermaphrodite is not a being of both sexes, but a being of neither sex—at least in perfection. Man is at best an imperfect animal—he is at best only one-half of his species—but a so-called human hermaphrodite is not even that; the malformation commonly originating either in certain structural elements having been too little developed to form proper male organs, as the testicles, while at the same time others are too much developed to constitute proper female organs, as the clitoris; or on the other hand, in the former structural elements having been too much evolved to constitute ovaries, while, at the same time, the latter are too little evolved to form a penis.

(*a*) The origin of the ancient notion of hermaphroditism in the fable of the union of the bodies of the nymph Salmacis and the son of Mercury,

—nec fæmina dici
Nec puer ut posset,

as well as the voluptuous representations of supposed real hermaphrodites in the ancient statues, and on cameos, is sufficiently well known. Such beings however do not, and perhaps cannot exist, although a belief in their existence was for a long time prevalent; and accordingly we hear of an unfortunate monk who was executed in France, so lately as the year 1478, for getting himself with child!

In the latter case also, which is perhaps the most common kind of alleged hermaphroditism, the orifice of the urethra is in general, not at the extremity, but under some part of the course of the rudimental penis, constituting what is called hypospadias, and the primitive cleft in the perineum is at the same time too much closed for a female, and too little for a male. (*a*) It is indeed no more impossible that a being should be formed with both ovaries and testicles, both a uterus and a prostate gland, both a clitoris and a penis, and so forth, than that one should exist with more than two ovaries or testicles, (*b*) or that it should be provided with a preternatural multiplicity of any other organ of the body; but the recorded cases of this are certainly so few, as fully to warrant our explaining by far the greater number of the cases of reputed hermaphroditism upon the principles above proposed. (*c*)

(*a*) Persons with a preternaturally large clitoris, the other sexual organs being those of a perfect female, have been sometimes called females of the sapphic habit—from Sappho, the poetess, whose penchant for female as well as male paramours was so notorious—at others τριβαδες, or fricatrices—from those unnatural feats over which the ancient poets so delighted to gloat. These abominations are alluded to by Aristophanes, Plautus, Phædrus, Ovid, Martial, Lucian and numerous other profane writers; and, in terms of reprobation, by Paul, who speaks of "the woman changing the natural use into that which is against nature," (*Romans* i. 26) as well as by Tertullian and many of the fathers. Such a malformation is by no means uncommon; nor have the tendencies formerly ascribed to it wanted examples in modern times—witness the case of Mary Hamilton, who was tried at Taunton, in 1746, for marrying fourteen wives! It is hardly necessary to say however that such cases are not examples of true hermaphroditism. Of this description appear to have been the cases related by Sir Everard Home, (*Phil. Trans.* 1799) and by Dr Granville, (*Lon. Med. Rep.* 1815) The ordinarily alleged instances of hermaphroditism however, such as those of Androgynæ, or persons in whom the female characteristics are most conspicuous, related by Maret, (*Mem. de l'Acad. de Dijon*, 1767) Ferrein, (*Mem. de l'Acad. Roy. des Sciences*, 1757) Baillie, (*Morbid Anat.* 1793) and others, and those of Androgyni, or persons with the male organs preponderating, related by Cheselden, (*Anat.* 1778) Giraud, (*Journ. de Méd. par Sédillot*, 1796) Ackermann, (*Infant. Androg. Hist.* 1805) Soden, (*Ed. Med. and Surg. Journ.* 1808) Ring, (*Lon. Med. Rep.* 1820) and numerous others, are usually somewhat more complicated than this, but still such as to be easily explicable on the principle of disproportionate development. Of the latter character also were the remarkable cases of Marie Rosina alias Gottlieb Gottlich, recently exhibiting *itself* in this country, (see Dr Handyside's account, 1834) and of the Chevalier X., whose wife's suit for a divorce so unaccountably failed lately in France. Sometimes however a complete juste-milieu seems to be preserved.

(*b*) Fernel, Van Forest, Borelli, De Graaf, Dionis, Lealis, Blumener &c.

(*c*) Among these few cases is one related by Rudolphi, in which one ovary and

Subsection III.

On the Unity of Organic Structure, as manifested in the different Organs of the same Animal.

It remains still to be observed that many of the organs of animals appear to be, as it were, repeated, not only in individuals of different species, and in individuals of different sexes of the same species, but in the same individual. (*a*) To one who had not reflected on the subject, it would appear perhaps

fallopian tube with two testicles and vasa deferentia, as well as both a uterus and prostate gland presented themselves; and a second recently occurred to Bouillaud, in which likewise there was both a uterus and prostate gland: (*Mem. de l'Acad. Roy. des Sc.* 1833) so that Ackermann's assertion that the corresponding organs of the two sexes are *never* found in the same individual is not accurately true. (*Infantis Androg. Hist.* 1805) It is so nearly so however, that we are quite justified in regarding a reputed hermaphrodite as in general merely

> " Concretus sexu, sed non perfectus utroque,
> Ambiguo Venere, neutro potiundus amore."

M. Isidore Geoffroy St Hilaire has lately attempted to arrange hermaphrodites into those with only a loss of balance of the parts, and those with some excess; making four species of the former—the feminine, masculine, neutral and mixed, and three of the latter—the complex feminine, complex masculine and bisexual—but the present is not the place to enter minutely into the subject.

(*a*) This third and last application of the theory of Analogies of Organs seems to be almost exclusively a modern one—any further, at least, than it regards the correspondence of the two sides of the body; and as that which relates to the unity of corresponding parts in various tribes of animals was distinctly propagated for the first time in France by Geoffroy St Hilaire, so this appears to have originated in Germany with J. P. Frank. It was primarily deduced from the analogy which he was the first to remark, about the beginning of the present century, between the bones of the vertebræ and those of the skull; and the notion was subsequently taken up, and gradually applied also to the soft parts, by Oken, (*Ueber die Bedentung* &c. 1807) A. Meckel, (*De Genit. et Intest. Anal.* 1810) Spix, (*Cephalogenesis.* 1815) Carus, (*Lehrbuch der Zootomie*, 1818) Bojanus, (*Isis*, 1818) Burdach, (*Vienter Bericht* &c. 1822) J. F. Meckel, (*Handbuch* &c. 1825) and others in Germany, while in France it met with the support of Burdin, (*Cours d'Etudes* &c. 1803) of Dumeril, (*Consid. Gén.* &c. 1808) and many more. The idea was at first ridiculed, as all new ideas are; but, as M. Serres said of it in 1824, " quelques lustres se sont à peine écoulés, et déjà cette idée, devenue classique, a changé la face de la science, et a fait naître une partie toute nouvelle, celle des *homologues*." (*Anat. Comp. du Cerveau*, 1824, p. 21) It is a reproach, and unhappily not an uncommon one, to British authors, that they have been among the last to take up a subject of so much interest and importance; and, contented to immerge all questions of this kind in the single word nature, with nevertheless the hackneyed quotation continually on their tongues—

a very visionary project to attempt to prove that his lungs furnished the model on which his urinary organs were constructed, and his intestinal canal that on which were formed his genitals, that the vertebræ of his spine are repeated in the bones of his skull and face, and that his vertebræ and ribs are in fact the prototypes of all the other bones of his body; but all this, and much more than this, appears to be nevertheless strictly true. In order however to be convinced of it, it is not sufficient to contemplate these parts, as is generally done, in the human organism alone—on the contrary, this is the very last which we should approach in a question of this nature, as the one in which the parts recede most from their primitive simplicity—but we should begin with some one of the least elevated links in the chain of animated nature, and whenever such analogies present themselves between any two organs, as found in either the lower races of animals, or in the fetusses of the higher, endeavour to trace these analogies through the corresponding organs of the more and more perfect tribes, till we rise progressively to Man. If this be patiently done by one who is capable of seeing the facts of anatomy, as one of its most talented cultivators admirably expresses it, (*a*) alternately with the body's eye and the mind's eye, and who, penetrating with the latter a little deeper than the former could have led him, can thus mentally construct an aggregate of the many, where a common-place observer sees only this many individually, the smile of conviction will soon insensibly supersede the incredulous simper of self-conceit, or the unmeaning grin of buffoonery with which the proposition was at first perhaps received. The swim-bladder, for example, of fishes, (*b*) and the membranous lungs of reptiles, (*c*) are very little removed, in rudimental structure, from their kidneys, (*d*) the

"All nature is but *art* unknown to thee,
All chance *direction*, which thou canst not see,"

have neither made any attempt themselves, nor even acknowledged the attempts of others to attain the least knowledge of this art, or the least insight into this direction.

(*a*) De Blainville.

(*b*) Carus. (pl. v. fig. 20) Blasius; Roget. (vol. i. p. 429)

(*c*) Townson. (*De Resp. Amphib.* 1794)

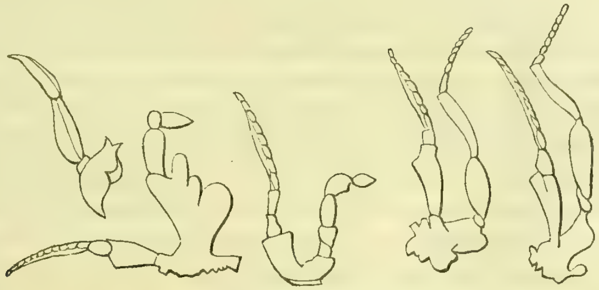
(*d*) Colins; (pl. xxxviii) Home; (vol. vi. pl. 58) Carus. (pl. xiii. fig. 3) tubes extending to the gullet or stomach in the former case, and the bronchi in the latter, corresponding to ureters, and the trachea, where it exists, to a urinary bladder, which is likewise often wanting. But the analogy is still more striking, in most of the lower animals, between the stomach and intestines, with their pyloric sphincter and valve of the colon, and the lower part of the oviducts—corresponding to the uterus, with its neck and os tincæ; and between the liver with its ducts, and the ovaries with the upper part of the oviducts—corresponding to the fallopian tubes. The oviducts indeed, in their impregnated state, can hardly be distinguished in the avertebrated animals, or even in fishes, (*a*) reptiles (*b*) and birds, (*c*) any more than the membranous uterus of most mammals, (*d*) from a portion of their intestinal canal; and the ovaries are in insects equally filamentous, and in most other lower animals equally lobulated as the liver. Further the gullet might be shown, and has been shown, (*e*) to correspond to the vagina, the soft palate to the hymen, the tongue to the clitoris, and the lips to the labia—both so large and prominent in the negress; and if they thus correspond to the female genital organs, it is superfluous to say that they do so also to the male, since the male and female organs have been already shown to correspond to each other. The bifid tongue of serpents and of many birds supports the analogy with their double penis, and the erectile structure of the tongue of the chameleon, (*f*) and many other animals, is a further corroboration of the analogy in question. That some of the most apparently dissimilar parts of the cerebro-spinal axis also are in fact repetitions of each other is equally susceptible of demonstration; (*g*) but perhaps the most satisfactory illustrations of this doctrine may be derived from the skeleton. At first sight there seems to be, in Man, no relation whatever between the structure of the vertebræ of the spine, and that of the bones of the skull, the former constituting a rough column,

(*a*) Home. (vol. vi. pl. 58)
(*b*) Home. (vol. vi. pl. 56)
(*c*) Carus. (pl. xv. fig. 12)
(*d*) Home. (vol. iv. pl. 116,125, &c.)
(*e*) A. Meckel. (*De Genit. et Intest. Anal.* 1810)
(*f*) Shekleton and Houston. (*Dublin Hospital Reports*, 1831)
(*g*) Serres. (*Anat. Comp. du Cerveau*, 1824)

with a narrow cylindrical canal, standing almost perpendicularly, the latter a smooth mass, with an ample oval space, placed horizontally, and almost at right angles with the former; but in the osseous fishes the surface of the skull is as rough, and its canal as narrow and cylindrical as those of the vertebræ, and it is fixed, not at right angles, but in a line with them. All the *prima facie* objections therefore are at once removed if we begin with these animals; and the more closely we examine, in them, the two sets of bones under consideration, the more we shall be satisfied that there is between them the analogy which has been supposed, and that their structural elements are in fact the same. Thus the occipital bone, with its cuneiform process, its hole and its spine, is the image almost of the atlas, with its body, its ring and its processes, while the posterior part of the sphenoid bone, with the two parietal bones, and the anterior part of the sphenoid, with the frontal, are little more than repetitions of the occipital bone; (*a*) and so insensible are the gradations in the character of the bones of the skull, from the osseous fishes through the cartilaginous fishes, reptiles, birds and quadrupeds, up to Man, that any analogy which we admit in the first link of the chain must be conceded in the last also, although it is, by this time, so obscured, that, had we begun with this, it could never have been recognised. In fact the character of a vertebra is not less distinct in its *maximum* state of development, as in the skull, than it is in its *minimum* state of development, as in the last bone of the tail of a reptile, a bird or a quadruped, when its structural identity with the rest is universally admitted. Nor is this analogy of structure in the solid parts of the trunk and head confined to the vertebrated animals, the cranium even of insects, if it may be so called, being in fact formed by the union of more or fewer of the segments of their trunk, corresponding to vertebræ, although a part, not of a neuro-skeleton, but of a dermo-skeleton, as before explained. In the mean time the bones of the upper jaw appear to stand in the relation of transverse processes to these cranial vertebræ, while the lower jaw, supported by the interposed temporal bones, is in the relation to them of a pair

(*a*) Carus. (pl. viii. fig. 7)

of ribs; as is also the hyoid bone. A third pair of ribs occurs in the united coracoid bones of fishes, and in the furculæ of some reptiles and of birds; a fourth and fifth pair in the clavicles and scapulæ on the one hand, and in the ossa innominata on the other; and lastly a fifth and sixth pair in the bones of the two upper, and in those of the two lower limbs, the prototype of each of which also is said to be a pair of ribs. All the bones of the highest animal are consequently resolvable, as elsewhere remarked, into a vertebra with a rib attached to it, as their primary nuclei. The least perfect skeleton of a vertebrated animal—that of some cartilaginous fishes and serpents—has these, and the most perfect has no more than these, although presented under such very different aspects; so that if we can display any appearances of either a vertebra or rib, in any one of their respective phases, in the reputedly avertebrated races, such as, on the one hand, the cartilaginous collar round the gullet of the Cuttle—*Sepia* 11—which is virtually its occipital bone, and the "os sepiæ" and internal skeleton of the Slug—*Limax* 9—the Sea-hare—*Aplysia* 9—and other gasteropoda and acalephæ, and, on the other, the jaw of so many avertebrated tribes as have been elsewhere alluded to, we in fact establish the existence in them, as already observed, of all the essential parts of a skeleton. Now the jaws and the legs of the Cray-fish—*Cancer* 19 (*a*)—and other crustacea (*b*) are almost indistinguishable from each other—so much so that some of the more central pairs are called leg-jaws, from



Crustaceous Animal.

(*a*) Carus. (pl. vi. fig. 7) (*b*) Bruquiere; Roget. (vol. i. p. 287) the difficulty of pronouncing which they are; and the same is more or less obviously the case with many of the annelida, the arachnida and the insecta. (*a*) But the legs of the avertebrated tribes in general, in their relations to the segments of their trunk, are rather like ribs than legs, as has been before noticed, so that here again we find jaws, legs and ribs all, as it were, identified. This is not the place for entering fully into the merits of a speculation of this kind, nor for attempting to answer any of the would-be-wit which has been opposed by the puny self-sufficiency of persons who have not studied, and who are perhaps incapable of comprehending the stupendous bearings of a question like this, to the depth of research and extent of intelligence of those who have studied and mastered the subject. It is they only who are competent to take, and have taken a full survey of the animal kingdom in all its organs, and in all the relations of these organs to each other, and who have employed in this survey sometimes the eye of the body, and at others that of the mind, who excel equally in detail and in abstraction, and who unite with the industry of the mechanic the soul of the philosopher and of the poet, who are qualified to pronounce any opinion with respect to the analogies which have been pointed out; and *they* have almost uniformly determined in favour of their existence. Nor is their decision in this instance opposed to, but on the contrary strictly in conformity with what might have been expected from long-established facts. We know at least that all the organs on one side of the body, with the exception of the heart and intestinal canal and their appendages in most tribes of animals, and some isolated examples of a want of symmetry in the external organs, such as in the Snail—*Helix* 9—with respect to its respiratory aperture, in many bivalve mollusca, with respect to their shell, in the Genus *Pleuronectes* 35—among fishes, with respect to their eyes, and in some cetaceous tribes, with respect to the two sides of their skull, are a counterpart of those of the other, and that some of those in the upper part of the body—the arms for example—are repeated in those of the lower; and it might therefore have been fairly presumed that the same laws—the same

(*a*) Savigny, Audouin, Latreille &c.

elective affinities which produced this correspondence, should produce also others, although it might require somewhat more trouble to detect, and somewhat more ingenuity to determine and arrange them. Let us hope that a little further well-directed assiduity may teach us in future to regard anatomy, not, as has hitherto been the case, and as was the case also formerly with chemistry, as a series of ultimate facts, insulated and detached, as has been beautifully said, (*a*) like the pyramids in the Egyptian deserts, and of which all that we could know was that they were so; but, like chemistry since the establishment of the atomic theory, as a consistent and rational science, each fact of which has a direct and obvious relation to every other, and all are such as at once to manifest the beautiful harmony—the τέχνη ποιητικὴ of nature, and to enable us to predicate with confidence, not only *what* they are, but *why* they are so, and why they could not, in obedience to certain established laws, have been otherwise. (*b*)

(*a*) Treviranus.

(*b*) "Suivez," says Serres, "l'esprit humain et la nature dans l'ordre physique et morale: partout vous verrez l'homme qui divise dans sa pensée, et la nature qui réunit dans son action. Plus les sciences se perfectionnent, plus elles se concentrent, plus elles se rapprochent de la nature." (*Anat. Comp. du Cerveau*, 1824, p. xviii) The force which under some modification or other determines the association of the component parts of organs, during the development of each, according to the laws above alluded to, was called by the Aristotelians the δυναμις διαπλαστικη or *plastic power*, by Lucretius the *vénus génétrix*, by Bacon the *motus generationis simplex*, by Van Helmont the blas alterativum, by Maupertuis the *vénus physique*, by Buffon the *puissance du moule intérieur*, by Darwin the *formative appetency* or *propensity*, by Wolff the *vis essentialis*, by Vander Kemp the *nisus formatrix*, and by Blumenbach the *bildungstrieb* or *nisus formativus*, the term which has been adopted by Geoffroy St Hilaire and Serres; and a similar force has been supposed to be in operation whenever an old part is to be repaired, or a new part to be formed in after life. It is hardly necessary to remark however, that merely giving a name to this force amounts to nothing more than admitting its existence; and perhaps it is no better entitled to a specific name than any other of the innumerable modifications of the vital forces to be in future spoken of.

CHAPTER III.

ON THE SUBSTANCE OF ORGANIZED BEINGS.

SECTION I.

On the Tissues and Fluids in general.

The third of the formerly proposed distinguishing features in the structure of organized beings furnishes the foundation for General Anatomy and Hygrology, or those sciences which describe the Tissues and Fluids of which plants and animals respectively consist.

Inorganized matters have nothing which can with propriety be called structure, their substance being exclusively of one form of matter, which is generally—if otherwise than either liquid or aëriform—of a uniformly hard and rigid consistence, and composed of particles merely superadded to, or intermingled with each other; nor does the water which is essential to the crystallization of some minerals, or that which is mechanically contained between the plates of others, furnish any exception to these remarks, since, in the former case, it is as a solid that it is present, and, in the latter, its presence is accidental. Organized beings, on the contrary, always present a more or less complicated structure, not only in their numerous organs, but also in the numerous distinct tissues of which these organs are composed, and the numerous distinct fluids which pervade them; and their consistence is accordingly in every part somewhat soft and flexible, although not equally so. (*a*)

A Tissue may be defined to be an anatomical element, composed in general of fibres more or less obvious, (*b*) and dis-

(*a*) Hence the old divisions of the parts of organized beings into ἰσχοντα and ἰσχομενα, στερεα and ὑγρα, nutrienda and nutrientia, stabilia and vaga—all which amount to nearly the same thing—are strictly characteristic of such beings, as distinguished from inorganized matters.

(*b*) It is not worth while to renew, at present, the effete and nonsensical subtleties, formerly so much in vogue, respecting the nature of the ultimate fibre, of tinguished by certain physical characters, which are recognisable by the unassisted senses, and capable of determining its identity in whatever organ it is found. (*a*) A Fluid requires no definition.

which every tissue of the organized body was supposed to be composed—whether it have dimensions, whether it be solid, whether it be organized, and so forth. According to Haller, " invisibilis ea Fibra est—sola mentis acie attingimus ;" and again, " Fibra physiologo id est quod Linea geometræ"—that is to say, nothing whatever. This is truly, as has been well remarked, " faire de l'Anatomie par la seule force de Génie." We may form some idea however of the minuteness of some of the fibres actually found in the animal structure, when we are told that there are no fewer than 62,500,000,000 of teeth serving to connect together the coarser cords composing the crystalline lens of a Cod, the whole of which is about the size of a pea !

(*a*) It is a very common error to imagine that the credit of having first divided the organs of the animal body into their several Tissues, " et d'avoir créé," as his countrymen say, " l'Anatomie Générale" is due to Bichât—" ce Bichât que l'Europe envie à la France ;" but the science is as old as the times—if not of Plato, with his Πρωτογονα, at least of Aristotle and Galen, with their 'Ομοιομερῆ, or parts composed of only one tissue, and similar in structure wherever they were found. These parts were so called because, as the latter observes, ταυτα δ'οὐκέτ' ἐκχωρεῖ τέμειν εἰς ἕτερον εἶδος· (*De Inæquali Temperie*) and because, directly formed, as they were supposed to be, ἐκ τῶν τεσσάρων στοιχείων, ἀλλήλοις κεραννυμένων, (*De Constit. Artis. Med.*) they constituted ἡ πρώτη σύνθεσις τῶν γεννητῶν σωμάτων. (*Comm. in Hipp. de Nat. Hom.*) It is impossible to give a clearer definition of a tissue than these words—pedantic as their quotation may perhaps appear to persons who undervalue the old writers only because they are ignorant of them—are calculated to convey ; nor was the doctrine confined to animals, since Aristotle expressly states, καθώς εἰσι καὶ ἐν τοις ζώοις μέρη ὁμοιομερῆ, οὑτω καὶ ἐν τοις φυτοις. (*De Plantis*, lib. i. cap. 3) Rudolphi then and others are mistaken, when they say that the term 'Ομοιομερῆ referred to either homogeneous or heterogeneous parts, provided every section was like every other section, and similar parts were found elsewhere. It is true the term was often applied to parts now known to be heterogeneous in their structure, such as the several viscera, but they were at that time supposed to be homogeneous—

> Ossa videlicet e pauxillis atque minutis
> Ossibu' ; sic et de pauxillis atque minutis
> Visceribus viscus gigni ;

and indeed the same thing has happened with respect to the term tissue, a distinct Glandular Tissue, for example, having been not unfrequently admitted. It is further true however that the term 'Ομοιομερῆ is not by any means synonymous with the term tissues ; since it was applied exclusively to whole organs, such as were both repeated elsewhere and could be divided into parts each of which was like every other, οἷον σάρκες εἰς σάρκας, as opposed to 'Ανομοιομερῆ, or organs which did not occur elsewhere, and which could not be so divided, οἷον χειρ οὐκ εἰς χειρας. (*Galeni Hist. Anat.*) but this use of the term clearly implied a knowledge of the fact, that either only one or several distinct tissues, which were common to

The proportion of the Tissues to the Fluids is in general much greater in plants than in animals, the weight of the solids of the human body, for example, not exceeding perhaps one-tenth of the whole, (*a*) while in many plants it is equal to one-third. It is to be observed however, that, since much fluid enters into the composition of every tissue, although the proportion of the solids to the fluids in plants and animals may be taken as a rough measure of the relative proportion of the tissues to the fluids in the two, it can furnish no criterion of

many organs, might enter into the composition of any one, and consequently a knowledge of the tissues in the strictest acceptation of the word. The Ὁμοιομερῆ of Galen were the Partes Similares of the earlier modern physiologists—of Berenger, Vesalius, Fallopia, Du Bois, Coiter, Spiegel, C. and T. Bartholin, and Glisson—by the last of whom such a part is defined to be a "mixtum uniforme," and said to constitute, as it were, the raw material—the "corpus aptum fingi et formari" of the several compound organs, which, in their turn, are described as the wrought fabric—the "modificatio quædam in materiam introducta, quâ usui destinato commodè inservit." (*Proleg. Anat.*) This doctrine of the tissues appears indeed to have afterwards sunk unto some neglect: but it was revived in 1757 by the great Haller, and once more in 1763 by Bonn; (*De Continuationibus Membranarum*) and it was applied for the first time to pathology in 1774 by John Hunter, (*On Inflammation*) as it was in 1790 by Dr Carmichael Smyth, (*Med. Commen.*) and again, much more extensively, in 1798 by Pinel. (*Nosographie Philosophique*) In the path thus chalked out for him followed, in 1801, Bichât; (*Anatomie Générale*) not indeed as a mere imitator of his predecessors, nor even as a rival; but as a master-spirit, with talent enough to embrace and embody into a whole their disjointed labours, and with genius enough so to improve upon them as to cause them to be almost forgotten in the scope and brilliancy of his own associations. "Personne," says Corvisart, speaking of this idol of the French, and most truly speaking of him, "personne, en si peu de temps, n'a fait tant de choses, et aussi bien."

(*a*) This is supposed to have been established by an experiment of Chaussier, who reduced the weight of a corpse, by desiccation in an oven, from a hundred and twenty to twelve pounds; as well as by the still greater reduction in weight which human bodies, left to dry on the burning deserts of Arabia and Africa, are found to undergo. The weight of mummies also, even with all their viscera preserved, is in general very inconsiderable. Blumenbach has one of Guanche, or aboriginal inhabitant of Teneriffe, the weight of which does not exceed seven pounds and a half. It is not improbable however that, in these cases, much of the solid parts is also dissipated in the form of the vapour of water, carbonic acid and other aëriform matters, resulting from their decomposition; while, on the other hand, it is certain that the body, in proportion to the desiccation which it has undergone, will afterwards absorb moisture from the surrounding atmosphere, so that a mummy, dry as it is, is still, as observed by Dr Milligan, a kind of hydrate of humanity. There are no known means of so obviating these sources of fallacy, as to arrive at any precise conclusions on the subject.

their absolute proportion in either. In general also the tissues, as estimated by the amount of the solids, are in greater proportion to the fluids in the terrestrial, than in the aquatic races of both plants and animals.

The ultimate particles of which the various Tissues and Fluids of organized beings essentially consist have been said to be minute globules, of a definite form and size, which have been detected, it appears, by the aid of the microscope, in almost all the tissues both of plants and animals—the rudest equally with the most perfect—as well as in most of the proper fluids of each. The fungi, lichenes and algæ on the one hand, and the infusoria and polypi on the other, are all represented as containing them; (*a*) and in the tissues and fluids of the more advanced species they are said to be still more manifest. It is indeed of such globules, arranged in lines, and cemented together by an amorphous substance, that the ultimate fibres, of a union of which the several tissues consist, are said to be immediately formed; and they are accordingly met with apparently, as well in the distinct tissues of the higher tribes of plants, (*b*) as in the Cellular Tissue, both simple, and in all its numerous modifications, (*c*) the Nervous (*d*) and the Muscular Tissues (*e*) of the more elevated species of animals. Again it is of similar globules, floating in a thin liquid, that all the proper fluids of organized beings are represented as consisting; and they therefore appear to present themselves equally in the Sap and Cambium, and in the secreted fluids in general of plants, (*f*) as in the Blood, Venous and Arterial, (*g*) the Lymph and the Chyle, as well as in the Fat, Pancreatic Fluid, Semen, Milk, Saliva and other fluid secretions of animals. It has been found more-

(*a*) Trembley, Schœffer &c.

(*b*) Rafn, G. R. Treviranus &c.

(*c*) H. M. Edwards &c.

(*d*) Leeuwenhoek, Delatorre, Prochaska, Barba, J. & C. Wenzell, Home and Bauer, Couerbe, Ehrenberg &c.

(*e*) Leeuwenhoek, Hooke, J. & C. Wenzell, Home and Bauer, Dumas and Prevost, Béclard, Dutrochet &c.

(*f*) Rafn &c.

(*g*) Home and Bauer, Hodgkin and Lister, Babington &c. These have no relation whatever to the red particles, as will be in future explained.

over that when any one of the reputed proximate principles of organized beings—of which mention will be made in future—when sodo-albumen, gelatin or fibrin, for example, is made to pass from a fluid to its naturally solid state, it always takes first the appearance of globules; and that it is from the subsequent aggregation of these to form fibres, that the solidity of the said proximate principle results, as it was from these globules continuing still moveable upon each other that it maintained the fluid state. (*a*) Hence it has been conjectured that these globules of sodo-albumen, gelatin, fibrin and so forth, are identical with those said to be found in the several tissues and fluids of plants and animals; and that these globules are, in fact, what have been called monads or organic elements, as constituting fundamentally the proper substance, solid and fluid, of which organized beings are essentially composed. But, however true this may be with respect to those tissues called inorganized, as well as with respect to all the fluids, it is more than questionable with respect to any one of the proper organized tissues. These have seldom or never appeared to display this globular structure till they had lost their irritability or vitality—in other words, had ceased to be organized; and the alleged presence of such globules at all times in the fluids—which are manifestly from the first inorganized, furnishes a strong presumption that they do not exist in the organized tissues so long as they continue such. (*b*) It is not improbable indeed that such is the composition of the latter, that, instantly upon the cessation of their vitality, they assume this globular structure, which is proper from the first to the fluids, and that it is of sodo-albumen, gelatin, fibrin and the other reputed proximate principles of organized beings that these globules are composed; but it will, in a future chapter, be rendered probable that organized tissues really contain no such proximate prin-

(*a*) Prevost and Dumas, G. R. Treviranus &c.

(*b*) The old argument of the Empirics, "Non quicquam esse stultius quam quale quidque vivo homine est, tale existimare esse moriente, imo jam mortuo," seems very applicable to this, as well as to numerous other conclusions of modern observers—perhaps to every thing relating to the ultimate mechanical, as well as the chemical composition of the organized tissues.

ciples, and, if this be the case, it is obvious that they cannot contain any of the globules which consist of them. It would be improper to dismiss this subject without observing that the whole doctrine of the globular structure of the tissues and fluids in general of organized beings has been represented, on very respectable authority, as founded on a microscopical illusion, only the blood and one or two analogous fluids really containing, it is said, any such globules as have been described, *in addition to* their red globules to be spoken of in future. (*a*) But to this subject it will be necessary to revert elsewhere.

SECTION II.

On the Individual Tissues.

The following are the principal Organized Tissues respectively

OF PLANTS IN GENERAL.

The Cellular Tissue, which there is reason to believe is the only primary tissue; it being apparently of some modification of this that every variety of the *Dermoid*, the *Vascular*, the *Ligneous*, the *Medullary* and all the other tissues of plants consist.

OF ANIMALS IN GENERAL.

The Cellular Tissue; of various modifications of which—as a primary tissue—are formed the several membranous tissues—*Dermoid*, *Mucous*, *Serous* and *Fibrous*—the *Vascular* tissue in all its varieties, and the *Osseous* and *Cartilaginous* tissues.

The Nervous Tissue; of which there are two varieties.

The Muscular Tissue; of which the varieties are likewise two.

The chief or only Inorganized Tissues are

IN PLANTS.

The *Epidermoid*.

IN ANIMALS.

The *Ungular*, the *Pilous*, the *Epidermoid*, and perhaps the *Dental*. (*b*)

(*a*) Hodgkin and Lister, (*Phil. Mag. and Ann. of Phily.* 1827) supported by Granger, (*El. of Gen. Anat.* 1829) King, (*Int. Lecture*, 1834) and many others.

(*b*) The enumeration and classification of the Tissues of plants, which, unlike those of animals, are almost identical with their organs, have been undertaken principally by Malpighi, (1675) Grew, (1682) Hedwig, (1798) Brisseau-Mirbel, (1802) Treviranus, (1806) Rudolphi, (1807) Sprengel, (1808) Dutrochet, (1824) Decandolle, (1827) and Dr A. T. Thomson; (1832) but hitherto with

The *Cellular Tissue* of plants is, in the acotyledonous tribes in general, the fungi, lichenes, algæ, musci &c. merely a fibrous, shapeless mass ; but in the monocotyledonous, and still more in the dicotyledonous tribes, it assumes the form of an opaque, rigid membrane, somewhat differently arranged in different parts, but every where constituting cells, which affect in general an hexagonal shape, and open freely into each other. It is by means of this tissue that all the other parts of the plant are united together, and it is of this that is immediately formed the support for the entire vessels, situated chiefly in the bark, and for the spiral vessels, in all their modifications, situated chiefly in the wood ; while in every part it constitutes sacs or utricles of various forms and sizes, at once for the reception of air, and for the accommodation of the several secreted fluids. In like manner the Cellular Tissue of animals (*a*) is, in quite the lowest tribes—the polypi and acalephæ for example—a semisolid, amorphous mass ; but, in the higher, it presents the appearance of a net-work

very little success, the number of their distinct tissues being still very doubtful, and the best arrangement of them, of course, therefore undetermined. The Tissues of animals have been investigated principally as they manifest themselves in Man ; and it is remarkable how many of those now commonly admitted are met with among the Ὁμοιομερῆ, or Partes Similares of Galen and his followers. Among these we find the Fibrous, the Arterial and Venous—varieties of the Vascular—the Osseous, the Cartilaginous and the Nervous ; the chief improvements made by the moderns having been the introduction of the Cellular, the other Membranous and the Muscular Tissues. The enumeration of the reputedly distinct tissues, in recent times, has been most various ; Bichât (1801) having admitted twenty-two, Chaussier (1807) only twelve, H. Cloquet (1815) fifteen, Lenhossek (1816) only eight, Rudolphi (1821) again twelve, and J. Cloquet (1821) again fifteen, Heusinger (1822) and Béclard (1823) each eleven, De Blainville (1823) sixteen, and so forth ; but there seems to be no advantage in multiplying these artificial schedules, particularly as the differences between them are rather apparent than real, and depend more on the greater or less generalization of the several tissues, than on the admission of a smaller or greater number of individuals. The general classification of them has been sometimes, as by Bichât, into universal and partial ; at others as by Richerand, Chaussier and Mayer, into primary or elementary, and secondary or compound—an arrangement which, as best suited to our present purpose, has been followed above.

(*a*) The Cellular Tissue, as found in certain parts, was described by Vesalius, and again by Spiegel ; but it was not understood as a generally distributed tissue till the time of Winslow and Kaau Boerhaave. The first good collective account of it is in the essay of Augustus de Bergen, published in 1732. (*Halleri Disp. Anat.* iii. 78) of colourless, semitransparent, elastic cords, more or less attenuated, and very differently disposed in different parts, but every where leaving interstices—rather than constituting cells—of a round, square or hexagonal shape, and communicating freely with each other. Hence it is with greater propriety perhaps called the Reticulated or Filamentous, than the Cellular Tissue. (*a*) This tissue is more delicate and more ductile in Man than in any other mammal; (*b*) and it is so universally distributed as a cement, throughout all the organized tissues of the body, that, were every other tissue withdrawn, each part would still retain the precise form and proportions which it previously possessed. It is in the interstices of those portions of this tissue which contain fat or marrow, that the *Adipose* and *Medullary Tissues* are situated, consisting each of extremely minute vesicles, which, unlike the interstices of the so-called Cellular Tissue, have no communication with each other, and which are attached to the latter by a kind of peduncles. It is hence easy to understand why the fat and marrow, which, in the living body, are quite liquid, do not, like the water in anasarca, gravitate on any change of position.

The only membranous tissue formed from the Cellular in plants is the Dermoid; whereas in animals we have besides this the Mucous, Serous and Fibrous. (*c*) The Dermoid Tissue

(*a*) It is questionable whether it be even entitled to this appellation, and whether it be not, as well in the highest as in the lowest animals, rather a viscid, amorphous mass, assuming a filamentous appearance only when the parts are cold and forcibly drawn from each other, than a proper solid tissue of any kind. Such is the opinion of Wolff, Meckel, Autenreith, Prochaska, Rudolphi, Blumenbach, Treviranus, and other German writers, as well as of Bordeu and some few more among the French; by whom it is accordingly called the mucous web or tissue, the shapeless or gelatinous substance &c. rather than the Cellular Tissue—the Mucous Tissue of British authors being in the mean time called the Internal Dermoid.

(*b*) Zinn, Haller, Blumenbach &c. It is to this peculiarity principally that the latter ascribes the comparative facility with which Man adapts himself to change of climate and other circumstances.

(*c*) The essay of De Bergen, lately alluded to, on the Cellular Tissue, led the way to an accurate knowledge of the Membranous Tissues in general, the first good collective account of which was given in 1763 by Bonn; (*De Continuationibus Membranarum*) and it is to this admirable work that much of the precision of modern anatomy and pathology is distinctly to be traced. It was the key-stone of the arch constructed afterwards by Bichât, (*Traité des Membranes*, 1800) and it presents in plants, as well as in animals, the utmost variety; but it will be sufficient for our present purpose to state the general characteristics of this tissue, as well as of the other membranous tissues, as presenting themselves in Man.

The Dermoid Membrane then, is	*The Mucous Membranes* are	*The Serous Membranes* are	*The Fibrous Membranes* are
Red;	Red;	Colourless;	Glistening;
Opaque;	Semitransparent;	Transparent;	Opaque;
Of moderate density and elasticity;	Spongy and inelastic;	Dense and elastic;	Of moderate density and elasticity;
Fibrous;	Slightly fibrous;	Without obvious fibres;	Fibrous;
Not plaited, nor reflected on itself.	Generally plaited, but not reflected on themselves.	Not plaited, but always reflected on themselves.	Not plaited, nor reflected on themselves.
Its smooth surface is furnished with papillæ, arranged in rows, and covered with a corpus mucosum and cuticle;	Their smooth surface is furnished with papillæ, villi, &c., lubricated by mucilage, and sometimes covered with an epithelium;	Their smooth surface is without papillæ, and lubricated by watery halitus;	Both surfaces are rough, and without any proper secretion. Their form is sometimes cylindrical.
Its rough surface is furnished with sebaceous follicles, bulbs of the hairs, adipose tissue and fat.	Their rough surface is furnished with mucous follicles, but without any adipose tissue and fat.	Their rough surface is without follicles, but often with much adipose tissue and fat.	

The *Dermoid Membrane* covers the whole external surface of the body, with the exception of the anterior part of the eyeballs, and insensibly terminates in the beginning of the Mucous Membranes, at the several apertures of the body: its whole area, in a moderately-sized Man, is about fifteen square feet. It is to the proper Dermoid Tissue that corresponds the cloak of the mollusca, as the Oyster—*Ostrea* 8—the pellicle of the crustacea, as the Cray-fish—*Cancer* 19—and the true skin of all the superior tribes of animals. To this tissue the proper *Corpus mucosum* with its numerous modifications, the calcareous case of the Sea-hedgehog—*Echinus* 5—the horny segments of the rays of the Star-fish—*Asterias* 5—the horny sheaths of insects, the scales of fishes, serpents and lizards, and the covering of the shields of tortoises; as well as its continuations the *Hair* and *Nails* with their modifications, the prickles of the Sea-hedgehog, the bristles of the Earthworm—*Lumbricus* 12—and Sea-mouse—*Aphrodita* 13—the minute feathers of insects, the claws of reptiles, the feathers and claws of birds, and the hair, fur,

is well remarked by Dr Craigie, "as an example of the capricious nature of scientific reputation, that while the work of Bichât, though little more than the thesis of Bonn expanded, has given its author an imperishable name, the small treatise of Bonn is equally unknown and unregarded, and has scarcely served to rescue his name from utter oblivion." (*Genl. and Pathl. Anaty.* 1828) wool, bristles, quills, &c. with the claws, hoofs and horns of quadrupeds, are merely inorganized appendages. The same is the case with the *Cuticle* and its modifications, the calcareous covering of the corallines, the mucilaginous coat of the Sea-blubber — *Medusa* 3 — the Slug — *Limax* 9—and other mollusca, the leathery membrane of the Ascidia — *Ascidia* 8 —and the flaky membrane which invests the corpus mucosum, whatever be its modification, of insects, fishes, reptiles, birds and mammals in general. (*a*) It has been supposed that a variegated, or in any way coloured corpus mucosum, the former of which is met with, not only in so many of the inferior tribes of animals—in insects, fishes and birds in particular, which are so dazzling frequently from this cause—but also very remarkably in the face of some of the quadrumana, and the latter, not only in the Ethiopian, but in every variety of the human race except the Caucasian, is an evidence, in proportion to its intensity, of the remoteness from perfection of the being which displays it; (*b*) and consequently that, as Man was barbarous before he was civilized, the first parents of the human race were in all probability black, and that it is from the black that the olive-coloured, the red-brown, the yellow and the white varieties of the race have gradually sprung up. (*c*) We may admit the premises how-

(*a*) It was the practice in the times of Glisson and Malpighi, to liken all these parts to ἐπιφυτα or parasitical plants, as attached to, and nourished by the Dermoid Tissue; but such a comparison is inappropriate, since parasitical plants are no less perfectly organized than those which sustain them. And that such is really the case with these tissues has been explicitly maintained by Fontana, Mascagni, Mojon, Gaultier, and others, but apparently without any good grounds. Rudolphi indeed asserts with strict truth, that no parts of living bodies are inorganic—that is to say, not appertaining to organized beings—(*Grund. der Physiol.* 1821, i. § 212) but this is not to be regarded as equivalent to asserting that no parts of such bodies are inorganized—that is to say, not possessed of organic structure—the necessary result of which is the development of irritability or vitality, no indications of which have ever been afforded by the tissues in question.

(*b*) This was a favourite speculation of the celebrated Goëthe, who conceived—rather fancifully perhaps—that all such "local and specific distinctions" as a variegated or coloured corpus mucosum constituted, were incompatible with that intimate relation between the surface and the interior which distinguished the more perfect creatures, and which was at once a result and an evidence of their perfection.

(*c*) A suspicion of this kind had been entertained by John Hunter, by Pallas, by Jarrold, by Doornik and by many others, before it met with so strong an ad-ever without admitting the conclusion which has been deduced from them : since this assumes in addition what is very far from having been established, that all mankind, amounting at present to about five hundred millions of individuals, originated from a single pair, or even from a single stock. (*a*)

The *Mucous Membranes* again constitute, as it were, the internal skin of the body, lining every canal which opens directly or indirectly upon the surface. One department of these membranes, called *the Gastro-pulmonary*, enters, in Man, by the nostrils and mouth, extending from the former to the various sinuses and cells communicating with them, and, by the nasal ducts, over the anterior part of the eye-balls, and thence into the substance of the lacrymal glands, and from the latter, first into the substance of the three pairs of salivary glands, and then into the tympana of the ears : it afterwards proceeds, on the one hand, by the air-passages into the substance of the lungs, and on the other, by the gullet through the stomach and small intestines—whence it passes, partly into the gall-bladder, and partly into the substance of the liver and pancreas—and lastly, through the large intestines, to terminate at the anus. Another division of these membranes, called *the Genito-urinary*, enters, in both sexes, by the urethra, whence it passes to line the urinary bladder and ureters, terminating at length in the substance of the kidneys. In the female, a portion of this membrane is continued from

vocate in Dr Prichard. (*On the Physical History of Man*, 1813) It is melancholy to think how much the beautiful descriptions and delineations of Eve " in naked majesty" in the flower garden must be qualified, if this notion, in addition to that of Rousseau, that Man originally had not his vaunted " os sublime," but went on all fours—that of Lord Monboddo, that he had a tail—and that of Dr Cross, that he was covered from head to foot with hair—be admitted. She could have been little better than a black baboon !

(*a*) See, on one side of the question, Rudolphi, (*Grund. der Physiologie*, 1821, i. § 50, et seq.) and, on the other, Kirby. (*Bridgewater Treatise*, 1835, vol. i. p. 73, et seq.) At any rate the black and the red-brown varieties must have existed from the most remote ages, since we find them distinctly delineated on the walls of the most ancient of the Egyptian temples ; and that the olive-coloured was at least coeval with them may be inferred from the received tradition, that all the learning and arts of the Egyptians came to them through the Brahmins of India. That the yellow variety moreover was not behind hand the legends of China abundantly prove ; and that the white is of at least very remote antiquity may be collected from the annals of the Persians, Jews and Greeks.

the pudendum along the vagina, to line the uterus and fallopian tubes; while in the male, a portion of it proceeds from the urethra, through the prostate gland, partly into the vesiculæ seminales, and partly along the vasa deferentia, into the substance of the testicles. There is likewise, in both sexes, a third comparatively inconsiderable department of these membranes, called *the Mammary*, which, entering by the ducts of each nipple, extends into the substance of the mammæ or mammillæ. (*a*) Of course in all tribes of animals, except mammals, the Gastro-pulmonary is commonly the only mucous membrane; since the Genito-urinary is either wanting, or falls in general into the former by means of a cloaca, and the Mammary does not exist. The collective area of the Mucous Tissue is probably greater than that of any other partially distributed tissue, or perhaps of all the other partially distributed tissues, in the body. This will be readily admitted when it is considered that—to say nothing of the numerous papillæ, villi &c. which it invests, and the numerous plaits into which it is in most places puckered—the extent of the internal surface of the lungs alone, which constitutes a fraction only of but one department of these membranes, has been estimated to exceed that of the external surface of the body from thirty to one hundred times, (*b*) and that the ducts of each of the several proper conglomerate glands—the lacrymal and salivary glands, liver, pancreas, kidneys, testicles, mammæ—all which consist essentially of mucous tubes, may be drawn out, it is said, many thousand feet. (*c*) This tissue has in some parts, as

(*a*) It is denied by some authors that the continuity of the Mucous membranes is so unbroken as it has been represented by Bonn and his followers; Gordon and Ribes, for example, questioning whether any such membrane be continued over the cornea; and Chaussier, Ribes, Madame Boivin and others, whether the uterus have any such lining. The opinion of Bonn is however much more generally adopted. At the same time it is proper to keep constantly in mind that the Mucous Tissue, in its several ramifications, is similar only—not the same; and that the general axiom of Milligan, that "no reasoning from similarity of tissue is ever correct, except when that similarity extends to vital and functionary properties," is here particularly applicable.

(*b*) The former was the estimate of the second Dr Monro, the latter more lately that of Lieberkuhn.

(*c*) Thus by Monro the ducts of the testicle are said to be five thousand feet long, while by Ferrein those of the kidney are represented as not less than sixty thousand feet in length! We have only to multiply the most moderate of such the interior of the mouth, a proper *Corpus Mucosum*, like that of the Dermoid Tissue, assuming frequently a modification analogous to *Hair* and *Nails*. It is accordingly to this that the prickles on the tongue of the Snail—*Helix* 9—the Welk—*Buccinum* 9—and the Cuttle—*Sepia* 11—as well as of many fishes and birds, and of most of the feræ, the rough horny plates, like the hoofs of some quadrupeds, investing the jaws of tortoises, the proper feathers on the tongues of some birds, as the Toucan—*Rhamphostos* 44—the baleen of whales, attached to their jaws, and consisting of a series of smooth, horny plates terminating in fringes like unravelled horn or horse-hair, and the scales investing the tongue of the Bat—*Vespertilio* 57—and other animals, are to be referred. In fact the proper *Teeth* of animals in general seem to be merely a modification of the corpus mucosum of the Mucous Tissue; and it is accordingly often difficult to detect any structural difference between the teeth or tusks of various animals, and a proper claw, a proper quill, a proper horn or any other proper modification of the corpus mucosum of the Dermoid Tissue. (*a*) The beak of the Cuttle—

estimates, for a gland of any given size, by the collective size of all the conglomerate glands of the body, to be satisfied that the surface of the Mucous Tissue must be stupendous; and that, whether the view of some pathologists, who habitually refer all diseases to these membranes, be true or false, it is certainly not, as it has been sometimes represented, a circumscribed one.

(*a*) This analogy, and the essential differences between teeth and bones—with which they had always previously been confounded—were pointed out first by Coiter, and have been successively insisted upon since by Bonn, Walther, Lavagna, Geoffroy St Hilaire, Serres, Mayer, Heusinger, and many others. It is sufficient to notice here, as distinguishing the teeth of Man from proper bones, their mode of formation, their renewal once and sometimes twice, their heterogeneous structure, their great density, their want of periosteum, and their total immunity from the general diseases of bones, such as rachitis and mollities ossium. The reputed caries of teeth is no argument for their organic structure, since false teeth not unfrequently undergo a similar change, which, in fact, is rather a kind of chemical decomposition than ulceration; and that the teeth are not the seat of the pain which we experience in odontalgia is sufficiently obvious. The apparent blood-vessels and nerves of the teeth also seem to belong rather to the membranes on which they are built than to the teeth themselves—at any rate they are not so subdivided within the substance of the teeth as to form parenchyma, without which no part can be organized. Mr Mayo observes, " Teeth, though not sensibly vascular, have some kind of Life," and instances in support of this doctrine the fact that only recently drawn teeth if inserted into living tissues contract adhesions. It is hardly necessary to state that it is by means

Sepia 11—the teeth of the Saw-fish—*Squalus* 32—the bill of birds in general, and the tusks of the Narwhal—*Monodon* 47—may indeed be referred with almost equal propriety to either. It is remarkable also that, while the teeth in general are periodically shed, like the calcareous covering of the crustacea, as the animal increases in size—these inorganic masses being incapable of keeping pace with the growth of the rest of the body—they are in some cases, like the hair and nails, undergoing perpetual renewal, as occurs with the teeth of sharks and serpents, as well as with the grinders of some mammals, as the Wild-boar—*Sus* 49—the Elephant—*Elephantus* 49—and several of the pecora, in proportion as they are worn away. Nay the same membrane seems capable of producing, at one time teeth, and at another some other modification of the corpus mucosum of the Mucous membrane of the mouth, the fetal Whale, for example, having rudimental teeth in its jaws till the baleen is perfected, when they disappear. (*a*) The bill of many birds also, while they are yet in the egg, assumes the form of teeth, and the vestiges of these are in some birds, as the Duck—*Anas* 42—obvious ever afterwards in the serrated margin of the bill. The teeth then may be said to bear the same relation to the Mucous Tissue as the nails and hairs bear to the Dermoid; while the *Epithelium*, in the meantime, with which the Mucous membranes are in many places invested, seems to be strictly analogous, in like manner, to the *Cuticle* or *Epidermis*.

With respect to the *Serous Membranes*, they occur each in the form of an isolated shut sac; one only, and that in the female alone—namely, the peritoneum, at the two points where the fallopian tubes terminate upon it—being indirectly open in Man, while in Rays and Sharks and some other fishes this membrane opens externally by two apertures on the sides of the anus. The Serous sacs are interposed between con-

of the membranes enveloping the teeth, and not by their own substance that these adhesions are effected. It is a singular fact moreover, and one that serves to strengthen in some measure the analogy between the teeth and hairs, that in most of the cases in which the former have been deposited in unnatural situations, as the stomach, urinary bladder, kidneys, ovaries and testicles, a mass of hair has been found to accompany, and often to envelop them.

(*a*) St Hilaire.

taining and contained parts, whenever a sliding motion is to be carried on. Of such sacs are constituted the right and left pleuræ, the pericardium, the peritoneum, the two tunicæ vaginales, the arachnoid coat of the spinal cord and brain, the sinovial membranes, corresponding in number to the moveable joints of the body, and the several bursæ mucosæ, as they are called, whether about the joints, or under the integuments, the whole number of which is between two and three hundred. The collective area of this Tissue appears to be considerably more ample than that of the Dermoid, but in a much greater degree perhaps falls short of that of the Mucous. (*a*)

Lastly the *Fibrous Membranes* do not line either open canals, like the Mucous, nor shut cavities, like the Serous; but, on the contrary, are connected on both surfaces, by cellular tissue, to the contiguous organs. They constitute, in Man, the inner covering—that below the Serous, when this is present—of all the solid viscera, lungs, liver, pancreas, ovaries, testicles and so forth. They form the outer coat of all the air-passages and ducts of glands, as well as of all arteries, veins and lymphiferous and chyliferous vessels. It is of these that all the membranes of the ovum are composed. They constitute all the coats of the eyes, with the exception of the conjunctivæ, irides and retinæ, as well as the membranes of the labyrinths of the ears. (*b*) Finally it is of them

(*a*) It is proper to observe, that by some modern physiologists—Rudolphi among the rest—the Serous Tissue is described as inorganized, like the Epidermis or Epithelium, and whatever vitality it appears to possess, is attributed to the parts which it immediately invests, and which, from its tenuity, have been identified with it. If this doctrine become established, we must of course cease, as indeed many of the continental pathologists have already done, to speak of these membranes as the immediate seat of disease.

(*b*) It is not unusual to call the membranes of the ovum, the hyaloid membrane, and the membrane lining the labyrinths of the ears Serous, rather than Fibrous membranes, probably for no better reason than because they contain serum, which, by the way, serous membranes in a state of health never do; while the dura mater, a truly Fibrous membrane, and the pericardium, a truly Serous one, are each in general called Sero-fibrous, the former from its being invested by the arachnoid, and the latter from its being covered by a fibrous expansion interposed between its rough surface and the contiguous parts. It is to confound all distinctions, after having established them, so to denominate the parts in question.

that the dura mater, the pia mater and the neurilema of the several nerves, the periosteum, external and internal, the perichondrium, the ligaments, the tendons, the fasciæ and the aponeuroses all over the body are composed. The extent of the area of the Fibrous membranes, insensibly sliding as they do into the common cellular tissue of the body, cannot be estimated with any thing like precision, but it is certainly very considerable.

The *Vascular Tissue* is not met with in quite the lowest tribes of either plants or animals, the substance of the bodies of which is in general a uniform gelatinous mass; and even in those in which a motion of fluid is first perceptible, it is rather through tubular excavations in this substance, than through a proper Vascular Tissue, that this takes place. In the higher orders of plants however a regular Vascular Tissue presents itself; but, formed as it is, like the membranous tissues, exclusively from the cellular, it is of nearly the same character in whatever description of vessels it is found. In most of the higher tribes of animals, on the contrary, it is distinctly divisible into the three varieties of Arterial, Venous and Lymphiferous and Chyliferous, to which may be added the Parenchymatous and the Erectile. (*a*) Of the three former, each consists of two distinct layers, which constitute the middle and internal coats of the vessel; its external coat, when it exists, being always formed, as has been just observed, of fibrous membrane; so that, though an artery, a vein and a lymphiferous or chyliferous vessel is correctly described as consisting in general of three coats, the proper Arterial Tissue, Venous Tissue and Lymphiferous and Chyliferous Tissue comprises only two.

(*a*) The arteries and veins were among the Ὁμοιομερῆ of Galen. The chyliferous vessels were long confounded, as by Erasistratus and Galen, with arteries—ἀρτηρίαι γάλακτος πλήρεις—and the lymphiferous, as by their reputed discoverer, T. Bartholin, (1653) with veins—"venæ aquosæ;" but their pretensions to be regarded as formed of a distinct tissue were at length established by the Hunters, (1762) Cruikshank, Hewson and Mascagni. The Parenchymatous or Capillary Tissue—a very different thing from the παρέγχυμα or sponge of Erasistratus, as well as from the parenchyma, or fancied folliculi, cryptæ, loculi, cotylæ, utriculi &c. of Malpighi—was regarded as a separate tissue first by Bichât; and the Erectile lastly—for a long time mistaken for cells in which arteries in some parts of the body were represented as terminating—was constituted a proper tissue first by Dupuytren, Richerand and Béclard.

The following then are the principal characteristics respectively

	Of an Artery.	*Of a Vein.*	*Of a Lymphiferous or Chyliferous Vessel.*
Of the Middle Coat.	Composed of dun-coloured, opaque, thick and somewhat spongy, but tough and very elastic fibres, a little flattened, and placed like rings round the bore of the vessel. (*a*)	Composed of flesh-coloured semi-transparent, thin, very dense, but almost inelastic fibres, nearly cylindrical, and running longitudinally with respect to the vessel.	Not easily separated, but similar, at least in its thickness, relatively to the bore of the vessel, to that of an artery. (*c*)
Of the Internal Coat.	Transparent, dense, elastic and without fibres or folds. (*b*)	Semi-transparent, spongy, inelastic, slightly fibrous and often laid in folds, constituting valves.	Not easily separated, but similar, at least in the structure of its valves, to that of a vein.

The Arterial and Lymphiferous and Chyliferous Tissues become gradually more rigid and unyielding as age advances, and are naturally more so in males than in females, while, on the other hand, the Venous Tissue becomes gradually less so in the progress of life, and is at all times less so in males than in females; so that the proportion of arterial blood and

(*a*) This is the coat of an artery concerning which so long and tiresome a controversy has been maintained, some physiologists confidently asserting, while others as confidently deny its muscularity. The arguments on either side hinge more on the vital, than on the physical evidences of this property, and will fall therefore to be considered more at length in future. In the meantime however it may be observed that every physical evidence seems to be against the presumption of their muscularity; the Muscular Tissue being in general red, yielding, inelastic and composed of cylindrical fibres, whereas the coat in question is dun-coloured, tough, very elastic and composed of fibres more or less flattened. By some physiologists it is represented as a variety of the tissue, described for the first time in 1822 by Hauff, under the name of Tela Elastica or Flava—the Tissue Elastique or Jaune of the French zoologists—other examples of which occur in the ligamentum nuchæ, the ligamentum flavum, the immediate envelope of the spleen and other erectile organs and elsewhere; but there appears hitherto to be no good reason for regarding it otherwise than entirely sui generis.

(*b*) This coat of an artery is often, but very incorrectly, called its serous coat; and it is amusing to hear persons who admit that the external coat of an artery is fibrous, and describe its middle coat as muscular, and its internal coat as serous, gravely at the same time talking of an Arterial Tissue. The internal coat of an artery is allied, not only in its physical characters, but in its liability to certain diseases, to a serous membrane, as the inner coat of a vein is to a mucous membrane; but they are merely allied to, not identical with these structures.

(*c*) This coat of a Lymphiferous or Chyliferous Vessel is by some authors reputed muscular; and experiments, supposed to substantiate this doctrine, have been made by Schreger, Haller, Tiedemann and Gmelin and others.

of lymph and chyle is greatest in children and females, and that of venous blood in old persons and males. The proper Arterial system may be said to begin, in Man, at the radicles of the pulmonary veins, to extend through the left heart, and to terminate at the extremities of the arteries of the system of the aorta; the proper Venous system to begin at the radicles of the veins of the system of the venæ cavæ, to extend through the right heart, and to terminate at the extremities of the pulmonary arteries; (*a*) and the Lymphiferous and Chyliferous system lastly to begin, like the Venous, at their radicles in the parenchyma, and to terminate by two mouths—one on each side—in the system of the upper vena cava, near the point where it reaches the right heart. The collective capacity of the proper Arterial system is computed to be equal, in an adult human being, to about one quarter of that of the Venous, and about one half of that of the Lymphiferous and Chyliferous; so that, estimating the quantity of the blood in the body, at any given time, as thirty pounds, the Arterial system will contain about six, and the Venous system about twenty-four—while there will be, at the same time, about twelve pounds of lymph and chyle in the Lymphiferous and Chyliferous system. The whole extent of these Tissues then, exclusively of the Parenchymatous and Erectile, must be very great. The *Parenchymatous* or *Capillary Tissue* comprises the net-work of minute vessels in which the proper arteries—or, in the lungs, veins—terminate on the one hand, and from which the proper veins and lymphiferous or chyliferous vessels—or, in the lungs, arteries—begin on the other. It may be defined to consist of that system of vessels which no longer subdivides in the manner of most arteries, and has

(*a*) The former is the *Système à Sang rouge*, the latter the *Système à Sang noir* of Bichât. Before the time of Harvey the pulmonary veins were always called arteries—the " arteriæ venosæ"—and the pulmonary arteries veins—" the venæ arteriosæ"—and the change of names, which he introduced, was certainly any thing but judicious. The properties of its contents, the nature of its tissue and the character of its diseases are surely better foundations for the name of a vessel than the accidental circumstance of the blood flowing through it either from branches to trunks, or from trunks to branches; and in all these respects the so called pulmonary veins are strictly arteries, and the so called pulmonary arteries, veins. If the opposite principle be adopted, what, it may be asked, is the vena portæ? It is a vein at one extremity, and an artery at the other.

not yet begun to coalesce in the manner of most veins and lymphiferous and chyliferous vessels. It is known rather by its actions than by its structure to be distinct from the proper tissue of any one of these systems of vessels; since the vessels of which it consists are too minute to present any distinct physical characters. (*a*) Its actions however are such as pretty obviously indicate in these vessels a co-existent muscular coat; (*b*) although, as it is impossible to believe that they consist exclusively of this, the admission of a pro-

(*a*) Although the existence of "real vessels," through which a part of the blood passes from the arteries into the veins, is not denied, it has become a somewhat prevalent opinion in the present day, and is maintained by Doellinger, Wedermeyer, Marshall Hall, J. W. Earle and many others, that a great part of this blood proceeds from the former to the latter through "membraneless canals, formed in the substance of the tissues;" thus bringing us back to the times of Harvey, with his "carnium meatus" and "carnium porositates," through which alone—the direct termination of arteries in veins not having been yet established by Malpighi and Leeuwenhoek—he could contrive to convey the blood in the course of the circulation. In the meantime however, as there do exist, it is admitted, such vessels of communication, we may speak of them as the Capillary Tissue in question, whatever we may think of any other means by which this communication is maintained. It cannot but be noticed moreover as somewhat singular, that, while in Man what was till lately admitted as effected exclusively by vessels, is now conceived to be effected at least partly by pores, in insects what was till lately admitted as effected exclusively by pores, is now found to be effected at least partly by vessels.

(*b*) The peculiar property of which these vessels appear to be possessed—the insensible contractility of Bichât—has been distinguished, apparently very superfluously, from that displayed during their sensible contractions by the more obvious muscles, by Stahl and his followers, Whytt, Cullen and others, by the name of tonicity, and by Blumenbach and Chaussier, by that of contractility, as contrasted, by the former with irritability, and by the latter with myotility. If this property however be not—as it certainly is not—elasticity, it must be that which is characteristic of Muscular fibre; for we have no valid evidence of the existence, in the living body, of any third source of motion, the muscularity of the parenchyma, if admitted, being quite adequate to explain all the alleged contractions of the cellular, the dermoid and other tissues, not *per se* possessed of Muscular fibres—nay even perhaps of the middle coat of the larger arteries themselves. It is true the conditions under which these contractions occur are often very different from those which call the sensible muscles into action; but this may be easily explained, without the admission of any difference of tissue. The heart, the stomach and the urinary bladder all owe their property of contracting to their Muscular fibres; but these fibres are called into action, in the different instances, by stimuli of a very different character. It is proper to be aware, in the meantime, that the possession of any such independent property whatever by the Capillary Tissue is expressly denied by some authors; but this subject will be considered more fully in future.

per Parenchymatous Tissue was not improper. It is hardly necessary to remark that the extreme minuteness of these vessels furnishes no fair objection to the presumption of their muscularity; since the least of them must be large enough to admit the red particles of the blood, the diameter of which seems very considerably to exceed that of the ultimate muscular fibril, and even the microscopic animalcules, hundreds of millions of which can be contained in a drop of water, in all probability possess a perfectly formed muscular apparatus. (*a*) The Parenchymatous or Capillary Tissue—as the seat of all the molecular actions of the body—is of course universally distributed, and indeed so copiously interwoven probably with all the organized tissues, that it constitutes a great part of their bulk and weight. The *Erectile Tissue*, lastly, is little more than dilatable parenchyma, that is to say, a net-work of extreme arteries, and incipient veins and lymphiferous vessels—chiefly however veins — which are susceptible of sudden dilatation from certain causes, but, on these causes ceasing to operate, immediately return to their original size. (*b*) Of this tissue are said to be composed all the papillæ of the Dermoid and Mucous membranes, the thyroid and thymus glands, the spleen and supra-renal capsules, the corpus spongiosum urethræ, the corpora cavernosa clitoridis, the fimbriated extremities of the fallopian tubes, the papillæ of the mammæ and the corpora cavernosa penis: its

(*a*) " Mere size," says Dr Roget, " is of all the circumstances attendant on organized beings that which should least be assumed as the criterion of complication or refinement of structure;" (*Bridgewater Treatise*, 1834, vol. i. p. 191) and if there may exist

> The shapely limb, the lubricated joint,
> Within the small dimensions of a point,

what objection to the muscularity of the capillary vessels of Man, founded upon their diminutive size, can be for a moment sustained ?

(*b*) Of all the five formerly reputed terminations of arteries then—in veins, in lymphiferous vessels, in the follicles of glands, in the cells of erectile organs, and in exhalents—the two first only can be retained: the folliculi &c. of Malpighi having been proved by Ruysch to be nothing more than pensils of radiating arteries, coalescing with corresponding pensils of veins &c.; the cells of Ruysch having been proved by Duvernoy, Cuvier, Tiedemann, Ribes, Morreschi, Dupuytren and others to be nothing more than dilated parenchyma; and the exhalents of Leeuwenhoek having never been seen by any body who did not require them in order to support an hypothesis.

extent therefore must be pretty considerable. It is not improbable that the several conglobate or lymphiferous and chyliferous glands consist also of a kind of Erectile Tissue—the principal vessels of which however are not, as in the proper Erectile Tissue, extreme arteries and dilatable incipient veins, but extreme lymphiferous or chyliferous vessels meeting dilatable incipient vessels of the same description—and that these glands are thus a kind of diverticula of lymph and chyle, as the organs before enumerated are of blood.

The *Osseous Tissue* (*a*)—for of the *Ligneous* and *Medullary Tissues* of plants no particular notice needs at present be taken—it is hardly necessary to observe is almost proper to the vertebrated tribes of animals, and in some even of these, as the cartilaginous fishes, the Cartilaginous Tissue supplies its place. It is, in Man, of a blue-grey colour, opaque and inflexible, consisting of hard plates, which are composed of fibres united together by cellular tissue, the latter, as it approaches the surface of the bone, becoming gradually condensed into its external periosteum, and forming, in like manner, its internal periosteum, if the bone be cancellated or hollow. It constitutes the whole of the proper skeleton, the number of bones of which is, in the adult human being, about two hundred and fifteen, exclusive of the ossa triquetra and sesamoidea; and all, except the hyoid bone, are more or less directly connected together. The average weight of the entire human skeleton, including of course a great proportion of water, is thirty pounds, or about one-fifth of that of the body.

The *Cartilaginous Tissue* again, the last of those derived from the Cellular, is of an opaline colour, semi-transparent, extremely pliable and elastic and of a homogeneous structure, without any appearance of fibres in its undecomposed state. This tissue is sometimes inextricably interwoven with the proper Fibrous, when it constitutes what is called the *Fibro-cartilaginous Tissue.* Of one or other of these are composed 1. The obducent cartilages, or those which directly cover the extremities of bones at the moveable joints; 2. The inter-articular, or those which are sometimes indirectly inter-

(*a*) Both bones and cartilages were among the Ὁμοιομερῆ of the older authors.

posed between such bones in these situations; 3. The ligamentous, or those which perform the office of ligaments, as in all the synchondrosial joints; and finally, the vicarious, or those which stand in the place of bone, as at the sternal ends of the ribs, in the larynx, trachea and bronchi, and about the nostrils, eye-lids and external ears, giving to these organs at once security and pliability. The distribution of this tissue is not however very extensive.

Such then is the first Elementary Tissue—the Cellular—with its compounds, the Membranous, Vascular, Osseous and Cartilaginous. Of the two other Elementary Tissues—the Nervous and Muscular—each presents two varieties, but neither ministers to the formation of any compounds.

A proper *Nervous Tissue* is certainly not met with in the lower tribes of plants, and the existence of any such tissue, even in the highest, is very problematical, although by some authors the Medullary Tissue, (*a*) and by others the modification of the Vascular Tissue constituting the spiral vessels (*b*) has been so reputed. By other physiologists some small globules, similar in appearance to those of which the ultimate fibrils of the proper Nervous Tissue of animals have been supposed to consist, and answering in a similar way to chemical re-agents, have been detected about the base of the petiole of the Humble plant (*c*)—*Mimosa*—and regarded as its Nervous system; but if these constitute a proper Nervous Tissue, it is certainly in a very rudimental state. In quite the lowest races of animals also it seems to be equally wanting, no appearance of it having been hitherto met with in the zoophytes in general, including the Sea-blubber—*Medusa* 3—Sea-hedgehog—*Echinus* 5—and some others, the degree of organism of which is certainly such as would have led us to expect it; and in those animals in which Nervous matter first manifests itself, it consists merely of isolated nodules, and cannot be said to constitute a proper Nervous Tissue. (*d*) In

(*a*) Linnæus, Haller, Brâchet.

(*b*) Oken.

(*c*) Dutrochet.

(*d*) Very recently the indefatigable Ehrenberg, among other discoveries made with the microscope, has announced that of the existence of a Nervous system in all the infusoria: further observations however are required to establish this as a fact. (See *Archives Générales* for December 1834) all the higher orders of animals however such a tissue is uniformly found; and it is divisible, in quite the highest, into two varieties—the Ganglionic, or that constituting the system of the great sympathetic nerve, and the Cerebro-spinal, or that constituting the spinal cord and brain, and the nerves immediately connected with them: (*a*) the two however become more or less incorporated together, as they proceed each from their central parts. Both consist partly of a grey, and partly of a white substance, opaque, pulpy and inelastic, the grey matter being always apparently homogeneous in its structure, the white sometimes apparently homogeneous, at others obviously fibrous, (*b*) and both supported by a fibrous membrane, called neurilema, which in the apparently homogeneous nervous substance is plexiform in its structure, and in the fibrous tubular. Between the two varieties of the Nervous Tissue the principal distinctions are that,

In the *Ganglionic Nervous Tissue,*	In the *Cerebro-spinal Nervous Tissue,*
The grey and white substances are every where—as well in the minutest nervous filament, as in the largest ganglion—inextricably interwoven together;	The grey and white substances are always separated by a decided line of demarcation, and the former is found only in the central parts of the system;

(*a*) The nerves were the last of the above-named Ὁμοιομερῆ of Galen, who was moreover the first to restrict the word Νεῦρος to the sense which it now bears, instead of extending it, as before his time was the custom, to signify also a tendon or a ligament, or even a blood-vessel or a muscle. The separate existence of the Ganglionic Nervous system, although known to Galen, was not generally recognised till the time of Willis; and it was not till that of Bichât, that the tissue of which it consists was distinguished from that of the Cerebro-spinal system, by the name of the Nervous Tissue of organic life, as opposed to the Nervous Tissue of animal life. The above terms however, as founded on physical, and not vital distinctions, and as not implying any hypothesis, have been considered preferable.

(*b*) From the recent microscopic investigations of Ehrenberg, (*Poggendorff's Annalen*, 1833) it appears that both the grey matter and every department of the white matter are in fact in some degree fibrous, the chief difference consisting in this, that in the grey matter the fibres are composed of strings of globules—or are what he calls articulated—their course is reticulated, and they are invested by a dense net-work of blood-vessels, whereas one part of the white matter, while it contains these articulated and reticulated fibres, is without this dense net-work, while the other contains not only these fibres, but also others which are cylindrical in their form, more or less parallel in their course, and formed probably by the junction of some of the preceding.

The white matter is always apparently homogeneous; and	The white matter is in some nerves — as those belonging to the Respiratory and Motiferous systems—obviously fibrous; and
There is found, upon analysis, very little oleaginous matter, but some fibrin.	There is found, upon analysis, much oleaginous matter, but no fibrin.

The form of the primitive Nervous fibre, when very obvious, is said to be cylindrical, and its size about twelve times greater than that of the primitive Muscular fibre. It is questionable whether it be tubular; and perhaps it is from the circumstance of the tubular neurilema, which immediately invests it, having been sometimes injected with mercury, that nerves have been by some authors represented as hollow. (*a*) It has been lately again asserted however, as the result of microscopic observation, that at least the larger of these cylindrical fibres are certainly tubular. (*b*) The primitive Nervous fibre is commonly described as somewhat tortuous in its course, to compensate for its want of elasticity. The collective bulk of the larger portions of the Ganglionic Nervous System is comparatively inconsiderable, but that of the Cerebro-spinal is much greater, the spinal cord of an adult man weighing about an ounce and a half, the brain between forty and fifty ounces, and the nerves immediately proceeding from them being also of considerable size. But it is perhaps chiefly of the minuter ramifications of these two systems that the bulk of the Nervous Tissue is composed, universally as these are distributed, and copiously as, like the Parenchymatous Tissue, they are interwoven probably with every organized tissue of the body, so that they constitute a great part of the volume and weight of each.

As a proper Nervous, so a proper *Muscular Tissue* does not, in all probability, occur in any plants; and many of the lowest tribes of animals likewise seem to be destitute of it. This appears to be the case with all the Zoophytes; and indeed in any of the avertebrated tribes of animals this tissue is not easily recognisable from the cellular—so difficultly, that by some authors (*c*) a proper Muscular Tissue has been denied

(*a*) M. Bogròs, (*Rév. Méd.* 1825) corrected by M. Amussat. (*Rév. Méd.* 1827)

(*b*) Ehrenberg.

(*c*) Oken &c.

to them all. On the other hand the number of distinct organs performing the office of muscles, and therefore to be looked upon as composed of a colourless and jelly-like Muscular Tissue proper to these animals, is, in some avertebrated animals, almost incalculable. (*a*) And in the lower orders of even the vertebrated animals the Muscular Tissue presents a very different aspect from what it has in the higher; being, in most fishes, white, flaky and without tendons, and in reptiles in general, although of a deeper colour and more rounded, still without tendons, and very dissimilar in its general characters to that of birds and mammals. In the latter, and particularly in Man, it is more or less distinctly divisible, like the Nervous Tissue, into two varieties. Of these one is unconnected with the skeleton, and generally in contact with the Mucous membranes, as in the air-passages, the gullet, stomach and intestinal canal, the ducts of all the proper conglomerate glands of the body, the gall-bladder, urinary-bladder and urethra, the fallopian tubes and the vesiculæ seminales, and over the muscles moving the small bones of the ears —the only exception to the latter condition being in the heart, the Parenchymatous and Erectile Tissues and the irides. The other is attached, directly or indirectly, to the skeleton, whether connected or not with the Mucous membranes, as in the muscles which dilate and contract the chest, those by which the voice and speech are effected, those by which the aliments are taken, and the voiding of the stools and urine assisted, those by which the organs of the senses are directed to their objects, and those lastly by which the various positions and motions of the head, trunk and extremities are performed. The former then may be called the Internal Muscular Tissue, as appertaining chiefly to the contained, the latter the External, as appertaining chiefly to the containing parts of the body. (*b*) Both are characterized by

(*a*) Lyonnet, many years ago, enumerated upwards of four thousand muscles in the caterpillar, many of which he described and delineated; and similar descriptions and delineations of the muscular apparatus of other avertebrated animals have been given lately by Straus Durckheim, Newport and others.

(*b*) The muscles were not enumerated by the ancients among their Ὁμοιομερῆ, because they were considered to be a mere mixture of the Fibrous and Nervous Tissues; and even so lately as the time of Stenon, no difference was presumed to exist between a tendon and a muscle, except that in the former the fibres were a red colour, opacity, a spongy inelastic consistence and a fibrous structure, and both have their fibres connected together by a fibrous membrane, which, becoming condensed on the surface, or at the extremity of a muscle, constitutes, where these are met with, its tendons, fasciæ, aponeuroses &c. The chief distinctions between the two varieties of the Muscular Tissue are that,

In the *Internal Muscular Tissue,*	In the *External Muscular Tissue,*
The colour, with few exceptions, is faint ;	The colour is commonly deep ;
The consistence is comparatively firm ;	The consistence is comparatively soft ;
The apparent fibres are small, and rather interwoven together, than placed parallel with each other ;	The apparent fibres are larger, and in general run parallel with each other ;
The fibrous membrane connecting these is seldom condensed into a tendon ;	The fibrous membrane connecting these commonly forms a tendon ;
The blood-vessels and nerves are comparatively numerous, but small.	The blood-vessels and nerves are comparatively few, but large.

The primitive Muscular fibre has been successively represented as composed of strings of vesicles—quite distinct from the solid globules already alluded to (*a*)—as tubular, (*b*) as solid and cylindrical, (*c*) and as flattened or prismatic ; (*d*) and its diameter, while it is by some writers stated to be con-

" arctè," and in the latter " laxè inter se conjunctæ." (*De Musc. et Gland.* 1683) The Muscular Tissue was regarded by Vieussens, Quesnay, Mascagni and others as directly composed of blood-vessels ; and a vague hypothesis—which appears to have originated in the observation of the effects of certain stimulants applied to all appearance directly to the Muscular fibre—that muscles were merely expansions of nerves, the two together constituting what was called the *solidum vivum* of the body, was for a long time prevalent in the schools of medicine. This hypothesis the second Dr Monro thought it necessary, so lately as the year 1783, formally to refute ; (*On the Nervous System*) and certainly, if distinct anatomical, chemical and vital properties can entitle any Tissue to be regarded sui generis, the Muscular has a better right than most others to be so reputed. The division of this Tissue into two varieties was proposed by Bichât, under the names however of Muscular Tissue of organic, and Muscular Tissue of animal life ; for which the names Internal and External have been above substituted, for reasons already mentioned when on the subject of a similar division of the Nervous Tissue.

(*a*) Croone, 1664 ; Willis, 1674 ; Borelli, 1679 ; Cowper, 1710 ; Keill, 1717 ; Stuart, 1734 ; K. Boerhaave, 1754 ; D'Hamberger, 1757 ; Heister, 1758 &c.

(*b*) Baglivi, 1703 ; Bernouilli, 1710 ; Santorini, 1739 ; Senac, 1749 &c.

(*c*) H. Boerhaave, 1727 ; Fontana, 1781 ; Carlisle, 1805 ; Rudolphi, 1825 &c.

(*d*) Prochaska, 1778 ; Meckel, 1816 &c.

siderably greater than that of the red particles of the blood, (*a*) is by others described as not exceeding one-third, (*b*) one-fifth, (*c*) or even one-eighth (*d*) of their diameter. We must remember however that the size of these red particles themselves is by no means established. The primitive Muscular fibre is in general said to be somewhat tortuous in its course, perhaps, as in the case of the Nervous fibre, to compensate for its want of elasticity: by some physiologists, however, it is represented, on the contrary, as quite straight. (*e*) The collective Muscular Tissue of the human body, constituting, as it does, not fewer perhaps than between four and five hundred muscles attached to the skeleton alone, and—if we admit its co-existence with the Parenchymatous Tissue—entering, as it must do, into every other organized tissue, is to be regarded as by far the most abundant of all, and as constituting a very great proportion of the weight, and a still greater proportion of the bulk of the whole body, although it is impossible of course to estimate this proportion with any thing like precision.

Of the Inorganised Tissues, whether of plants or animals, it is unnecessary to speak in this place, since they have all been alluded to incidentally, each after those organized tissues with which it appears to be most immediately connected.

SECTION III.

On the Individual Fluids.

The other component parts of an organized being are its Fluids. The following are the principal Fluids

OF PLANTS IN GENERAL.	OF ANIMALS IN GENERAL.
The Crude Fluids, or those which ascend by the spiral vessels and their numerous modifications to the vesicles of the leaves, or corresponding organ; called collectively the *Sap*.	The Crude Fluids, or those which are returned by the veins and lymphiferous or chyliferous vessels to the lungs, or corresponding organ; namely the *Venous Blood, Lymph* and *Chyle*.

(*a*) Sprengel.
(*b*) Autenreith.
(*c*) Prochaska.
(*d*) Muys.
(*e*) H. M. Edwards. Dr Hodgkin and Mr Lister speak of those of the External Muscular Tissue as every where intersected by transverse striæ—an appearance which they regard as characteristic of this Tissue.

The MATURE FLUID, or that which descends by the entire vessels from the vesicles of the leaves, or corresponding organ; namely the *Cambium.*

That SECRETED FROM SAP, and deposited, in plants which breathe by the vesicles of the leaves, in these vesicles, namely the *Carbonic Acid.*

Those SECRETED FROM CAMBIUM, all which appear to be deposited directly in proper utricles composed of cellular tissue, and consist of the *Oils,* fixed and volatile, the *Turpentines,* the *Balsams,* the *Gum-resins* &c. each of which contain two or more of the reputed proximate principles of vegetables, such as Stearin, Elain, Resin, Acid, Extractive &c. while there are numerous others, which, as consisting of only one such proximate principle, will fall to be specified elsewhere.

The MATURE FLUID, or that which proceeds by the arteries from the lungs, or corresponding organ; namely the *Arterial Blood.*

Those SECRETED FROM VENOUS BLOOD, either mixed with LYMPH and CHYLE or alone, and deposited, in animals which breathe by lungs, in the air passages, namely the *Carbonic Acid,* or in the ducts of the liver, namely the *Hepatic Bile.*

Those SECRETED FROM ARTERIAL BLOOD, and deposited—

1. Directly on expanded surfaces, when they are called Perspired Secretions, as the *Halitus from the Lungs,* the *Halitus of the Serous Sacs,* the *Gastric Fluid,* the *Intestinal Gases,* the *Menstrual Fluid,* the *Humours of the Eyes,* the *Fluid of Cotugno,* the *Fat,* the *Sweat,* the *Marrow,* the *Sinovia* and the *Bursal Fluid.*

2. Directly in follicles, when they are called Follicular Secretions, as the *Mucilage,* the bitter portion of the *Cystic Bile,* the *Stools,* the thick portion of the *Semen,* the *Fluid of Meibom,* the *Cerumen* and the *Sebaceous matter.*

3. Directly in the ducts of glands, when they are called Glandular Secretions, as—besides those already mentioned as secreted from Venous Blood—the *Pancreatic Fluid,* the *Urine,* the *Milk,* the thin portion of the *Semen,* the *Tears* and the *Saliva* (*a*).

(*a*) To say nothing of the Fluids of plants, the origin of the study of the Fluids of animals, and particularly of Man, preceded by many ages that of the study of the Tissues, ancient as this was; but it is of no interest at present to know the crude speculations, upon this subject, of the ancient philosophers and physicians, any further than as it furnishes us with a key to that system of Pathology, which, under the name of Humoral, maintained undisputed possession of the medical world for upwards of two thousand years, and the vestiges of which are still obvious in many of our most familiar phrases and allusions. It is sufficient at present to observe that they admitted only four primary or essential fluids—to wit the Blood, the Mucilage or Phlegm, the Yellow Bile and a supposed Black Bile. Τὸ δὲ σῶμα τοῦ ἀνθρώπου, says Hippocrates, ἔχει ἐν ἑωυτῷ Αἷμα, καὶ Φλέγμα, καὶ Χολὴν, διττὴν ἤγουν, Ζανθήν τε καὶ Μέλαιναν· (*De Nat. Hom.*) and it was from some loss of balance of these in certain parts of the body, and not, as is commonly believed, from any vitiation of them, that diseases in general

The *Sap* of plants is of course confined to those tribes which have a proper Vascular Tissue; and the same thing may be said of the *Venous Blood, Lymph and Chyle* of animals. In the former case the great bulk of the fluid at any time in the ascending vessels, is derived immediately from the soil, plants having no circulation, properly so called; but in the latter, the great bulk of the Venous Blood, Lymph and Chyle is derived immediately from the Arterial Blood, to which more or less has been added from the other parts of the body, solid and fluid, by means of absorption, so that most of these fluids are considerably different, as taken from different vessels. (*a*) And so rapid and incessant are these

were supposed to arise. All the other fluids, in the mean time, were looked upon as little more than accidental, and the purgings, as it were, of these four. Since however the subversion of these visionary notions, and the establishment of so many real and tangible fluids in the human body, the classification of them has become a matter of some importance. Accordingly by Pitcairn and Michelot they have been arranged, with reference to their mechanical properties, into thick and thin; by Haller and others, with reference to their preponderating proximate principles, into aqueous, mucilaginous, oleaginous, albuminous, gelatinous, fibrinous and so forth: and by others, with reference to their supposed physiological properties, into living and dead. The classification followed above is founded on those of Blumenbach and Chaussier respectively; the former of whom speaks of the fluids in general as crude, mature and secreted, while the latter subdivides the last into perspired, follicular and glandular. It is hardly necessary to say however that, in a subject of this kind, every body is at liberty to follow whatever arrangement he considers calculated to inculcate the most useful associations—the only legitimate object, at any time, of classification, which is not the mistress of science, but her handmaid—" Egregia illius ancilla, non alia pejor domina."

(*a*) It was the Venous Blood alone which the immediate followers of Thales and Pythagoras included among the four primary fluids lately alluded to; the existence of Arterial Blood not having been generally admitted till the time of Galen; the arteries—as indeed the name implies—having been previously represented as containing air only. The Chyle has been known as a distinct fluid since the time of Aselli, (1622) the discoverer, not indeed of the existence, but of the functions of the chyliferous vessels; and the Lymph, since that of the two Hunters (1762) and their immediate disciples. Le Gallois, Flandrin and Thackrah principally have been instrumental in shewing that the Venous Blood is of a different character, as taken from different veins; and Reuss, Emmert, Vauquelin and Brande, in establishing the same fact with respect to the Lymph. The Chyle, on the other hand, is always of very nearly the same character, and that equally after almost every kind of food, as proved by Macaire, Marcet and others—a circumstance not calculated to excite much surprise, when we reflect that the chyliferous vessels, unlike the veins and lymphiferous vessels, arise all from the same tissue, and that, different as may *perhaps* be the matters derived from the aliment at different times, conversions, on the one hand, of Arterial Blood into the fluids under consideration, and, on the other, of these again into Arterial Blood, that none of them, while circulating in their vessels, ever retain their identity beyond a very few minutes. (*a*) With respect to their physical properties, the following are, in Man, the

	Of Venous Blood.	*Of Lymph.*	*Of Chyle.*
Colour	Modena red ;	Rose red ;	White ;
Aspect	Semitransparent ;	Transparent ;	Opaque ;
Consistence	Viscid ;	Viscid ;	Viscid & oleaginous.
Specific gravity	1051 ; (*b*)	1025.	?
Temperature	102° ; (*c*)	?	?
Capacity for caloric	903. (*d*)	?	?

With respect to the intimate composition of the Blood, it appears from recent investigations (*e*) that Venous Blood, while in the course of circulation, consists entirely of a colour-

these bear a very inconsiderable proportion to the whole bulk of fluid which these vessels contain, and which is derived immediately from the Arterial Blood and from the products of general absorption. And it is on this account that Respiration, Circulation, Deposition and General Absorption are always spoken of, in the present work, before Assimilation ; the bulk of the circulating fluids being at any given time—at least in the higher tribes of animals—so little dependent on the supply which they receive from the latter, in comparison with that which they derive from the incessant decompositions and recompositions effected by the former processes.

(*a*) A very rough estimate will be sufficient to demonstrate this. Thus if the left heart of Man send two ounces of Blood into the arteries at each beat, and beat eighty times in a minute, it will renew every drop of Arterial Blood, at any given time in the body—say six pounds—in little more than half a minute ; and as these six pounds must pass, in this time, into the veins and lymphiferous or chyliferous vessels, it follows that every drop of Venous Blood, Lymph and Chyle at any given time in the body—say thirty-six pounds—must be renewed in about three minutes and a half. But every particle of Arterial Blood is decomposed in the parenchyma of the body, and every particle of Venous Blood, Lymph and Chyle is decomposed in the parenchyma of the lungs. The above therefore are the extreme periods of the retention, by any one of these fluids, of its identity.

(*b*) The specific gravity may vary, it is said, according to the state of the body, from 1022 to 1126. Dr Davy takes as the extremes 1038 and 1059. The Blood is generally of a less specific gravity in the lower animals than in Man.

(*c*) The temperature above stated is that of the Blood in the right cavity of the heart. It is hardly necessary to say that it varies very much in different animals, and in the same animal at different times.

(*d*) This is the estimate of Dr Davy. According to Crawford it is 893, taking that of water as 1000.

(*e*) Babington ; (*Med. Chir. Trans.* 1831) Müller. (*Burdach's Physiol. &c.* 1834) &c.

less, transparent, viscid fluid, strictly sui generis, and called Liquor Sanguinis, in which float the Red Particles constituting from 68 to 148 parts in 1000 of the whole mass; (*a*) and that it does not yet contain, in a state of permanence, any one of the proximate principles which it afterwards manifests. When drawn from its vessels, this Liquor Sanguinis soon coagulates, and subsequently separates into what are called the serum and crassamentum, in the former of which become now fully developed the *osmazom*, *sodo-albumen*, *oil*, *extractive* and *salts*, and in the latter the *fibrin*—constituting from about $1\frac{1}{2}$ to $2\frac{1}{4}$ parts in 1000 of the whole mass, (*b*) while the Red Particles—which the latter has involved, together with a large proportion of the serum also—contain the *hematosin* and the *oxyd of iron*. If this be the case, the rapid coagulation of the Venous Blood, when out of the course of circulation, or rather its non-coagulation while still circulating, is no longer a problem, since it is obviously to be ascribed to the perpetual molecular changes which in the latter case it is undergoing, and which are incompatible with the full development of that principle on which its coagulation depends. (*c*) And the same thing may be said probably of

(*a*) Lecanu.

(*b*) Fourcroy estimates the average quantity of fibrin as 29, Lassaigne as 12, Denis as $2\frac{3}{4}$, and Berzelius as $\frac{3}{4}$ in 1000. The above is the estimate of Lecanu.

(*c*) The spontaneous changes which the Blood undergoes when out of the course of circulation, and particularly its coagulation and separation, have been a favourite subject of investigation since the times of Harvey, Lower, Malpighi and Borelli; by whom and their successors the last-mentioned changes have been ascribed in general either to the contact of the air, or to the loss, sometimes of heat, sometimes of motion, sometimes of vitality. But the Blood coagulates and separates equally well in various gases, and even in vacuo, as in the atmosphere, equally well when agitated as when at rest, and equally well, or better, when heated than when exposed to cold; and to attribute these changes to a loss of vitality, is to impose upon ourselves the onus of proving that it ever possessed this property—a task—as will be in future shown—of no little difficulty. The Blood spontaneously coagulates and separates under any circumstances in which it is allowed fully to develop its fibrin, even though within the body, as in an ecchymosis—nay even though within its own proper vessels, provided it do not pass at rapid intervals through the parenchyma, as in an aneurismal sac; and the opinion that it is by the repeated decompositions which it undergoes in the parenchyma that these changes are obviated, is supported, among other things, by the fact that the Blood of the vena cava, which has been for the longest time identical, generally coagulates more quickly than that of other veins, and that the same quickness of coagulation occurs in most diseases of debility—in which, from the slowness of the cir-

Lymph and Chyle also, which appear to differ from Venous Blood, principally in both containing fewer Red Particles, while the latter again has more *oil*, on which its opacity depends, as well as some *sugar:* it is derived only very partially, as already stated, from the alimentary matters. (*a*) The

culation, the Blood retains its identity for a longer time—as well as during venesection, with respect to the portion of Blood last withdrawn. Again in all inflammatory diseases, which are seated principally in the capillary arteries, the healthy office of which seems to be to *decompose* the Blood, this office being now imperfectly performed, the quantity of fibrin, as well as of sodo-albumen and hematosin —as proved by Gendrin and Traill—is increased, and hence the greater firmness of the clot; whereas in most cases of sudden death, as when an animal has been killed by electricity, by violent exercise, by an intense emotion of the mind, by hanging or drowning, by certain poisons, or by a blow on the head, in all which cases there is congestion extending to the radicles of the veins, the healthy office of which seems to be to *recompose* this Blood, this office being now imperfectly exercised, the quantity of fibrin, sodo-albumen and hematosin is diminished, and the tendency to coagulation is more or less counteracted. The effects of heat and of acids, oxygen &c. in promoting, as well as of cold, various compound salts, hydrogen and nitrogen &c. in retarding the coagulation of the Blood, seem to be altogether chemical: but this subject will be resumed when the question of the vitality of the Blood falls to be considered. The statement of Dr Prout that the Blood does not coagulate during Life, because the particles of the fibrin are in a state of "extreme self-repulsion," (*Bridgewater Treatise*, 1804, p. 525) it is hardly necessary to observe, is an indirect admission that it contains no fibrin at all, or at least that the fibrin in it is not sufficiently long identical to admit of this process, since we recognise fibrin only by the tendency which its particles have within a certain period to cohere.

(*a*) From the rough estimate lately made, it will appear that the left heart of Man sends out nearly fifteen thousand pounds of Blood in the course of the day; and of this, supposing the veins and lymphiferous and chyliferous vessels to bring back each in proportion to their respective capacities as already stated, the former will return about ten thousand pounds, and the latter about five thousand. Now we can hardly estimate the capacity of the chyliferous vessels at less than one-fiftieth of that of the whole lymphiferous and chyliferous system; so that they would transmit, say one hundred pounds of fluid in the four-and-twenty hours, although they received nothing whatever from the aliment. The average amount of aliment taken in the day is a hundred ounces, of which at least two-thirds are liquid to begin with, and perhaps not less than three quarters of the reputedly solid aliment are liquid also; so that the utmost that this can add to such a mass—presuming the greater part of the watery and alcoholic portions to be taken up by the veins—does not exceed a very few ounces, the principal elements of which moreover are precisely the same, whether the food have been vegetable or animal! It is a common-place and erroneous view of the matter to regard the lymphiferous and chyliferous vessels otherwise than as instrumental, *essentially* to circulation, and *adventitiously* only to absorption. They are in every respect analogous to veins, and are equally continuous with the arteries, as ori-

Red Particles—(*a*) which however are not red individually, but only en masse — have been very generally described as consisting of a central, colourless nucleus, surrounded by a red vesicle, either loosely (*b*) or compactly; (*c*) and it was till very lately supposed that the globules, recently alluded to as found in the several tissues and other fluids, were merely these nuclei, but without their red envelopes, as it was, that the coagulation of the Venous Blood, Lymph and Chyle took place from the coalition into fibres of the same nuclei, which had previously shuffled off their red envelopes. (*d*) It has been for some time however known that these fluids, when drawn from their vessels, soon display globules quite distinct from their red particles—and they are in fact the only fluids, it is said, which really contain any such globules—and that it is upon the coalition of these, which have been called lymph globules, that their coagulation principally depends. (*e*) Moreover the recent observations, on the one hand, that these red particles really contain no such nuclei, (*f*) and, on the other, that it is from the liquor sanguinis, and not from the red particles, that the clot is formed, (*g*) are sufficient to establish it that the coagulation of these fluids is quite independent of the red particles which they contain. With respect to the number, size and form of the proper red particles of these fluids, there has been the utmost discrepancy. The prevailing impression is that they are less numerous and larger in fishes and reptiles than in other vertebrated animals, while they are most numerous and smallest in birds, and that in all the lower animals they are more or less oval or elliptical. In Man their size has been

ginally assumed by Bartholin, and proved by Nuck, Cowper and Ruysch, as veins are; and the Hunters and their school have done an irreparable injury to science by diverting the minds of physiologists from this relation.

(*a*) The discovery of these Red Particles of the Blood was one of the first results of the application of the microscope to philosophy, and was made almost simultaneously by Malpighi and Leeuwenhoek, about the year 1675.

(*b*) Hewson, Home and Bauer, Prevost and Dumas.

(*c*) Young, Müller, C. Williams &c.

(*d*) Dumas and Prevost, Dutrochet &c.

(*e*) Home and Bauer. (*Phil. Trans.* 1811)

(*f*) Hodgkin and Lister, (*Phil. Mag. and Ann. of Philosophy,* 1827) Raspail &c.

(*g*) Babington, Müller &c.

represented at different times as between the 6060th and 1700th of an inch in diameter; (*a*) while their form has been described sometimes as spherical, (*b*) and at others as oval, (*c*) lenticular, (*d*) annular, (*e*) flat with rounded edges, (*f*) or altogether irregular: (*g*) the general opinion seems to be that they are spherical—but fortunately the determination of the question does not appear to be of much importance. The average quantity of Venous Blood, Lymph and Chyle in the body of an adult human being, at any given time, is probably thirty-six pounds—twenty-four of the first, and twelve of the two last—assuming that the average quantity of the whole Blood is thirty pounds, but upon this subject also there is great discordance of opinion. (*h*) It is pretty well established however that the relative quantity of Venous Blood is greatest in old persons and males, and that of Lymph and Chyle in young persons and females, for reasons already assigned.

As the great bulk of the Venous Blood, Lymph and Chyle is derived immediately from the Arterial Blood, to which some additions are made by absorption from various parts, so the great bulk of the *Arterial Blood* is derived immediately from

(*a*) Young represents them as the 6060th, Kater as from the 6000th to the 4000th, Jurine as from the 5240th to the 1940th, Haller and Wollaston as the 5000th, Prevost and Dumas as the 4076th, Blumenbach as the 3300th, Rudolphi, Sprengel, Hodgkin and Lister as the 3000th, and Home and Bauer as the 1700th.

(*b*) Leeuwenhoek, Haller, Fontana, Blumenbach, Cavallo, Home and Bauer, Rudolphi &c.

(*c*) Sprengel &c.

(*d*) Hewson, Falconer, Wells &c.

(*e*) Delatorre.

(*f*) Hodgkin, Lister &c.

(*g*) Amici &c. As Dr Milligan expresses it, they have been compared "to a globe, to a bladder with a pea in it, to a piece of money, to a drum, to a candlestick, to a hexaedron, and I know not what;" and according to Magendie, they may be made to present almost any form—"suivant qu'elles soient placées exactement, ou inexactement, au foyer du microscope." (*Précis de Physiol.* 1816)

(*h*) By Harvey, Allen Mullen, Abildgard and Blumenbach, the whole quantity of Blood is computed at only 8 lbs.; by Lower at 10; by Sprengel at from 10 to 15; by Borelli at 20; by Quesnay at 28; by Haller—whose estimate is followed above—at 30; by Young at 40; by D'Hamberger at 80; by Keill at 100.

the former fluids, to which perhaps something is added in the way of absorption by the pulmonary veins (*a*) from the lungs; but nevertheless the Arterial Blood, as formed in one definite organ only, is, unlike the fluids just mentioned, precisely of the same character, from whatever artery it be taken. (*b*) With respect to its physical properties, the following are the

Of Arterial Blood.

Colour . . .	Bright Scarlet;
Aspect . . .	Semitransparent;
Consistence . .	Viscid;
Specific gravity . .	1049;
Temperature . .	104°; (*c*)
Capacity for caloric .	913. (*d*)

Its nature, while circulating, appears to be the same as that of Venous Blood, and the spontaneous changes which it undergoes when drawn are likewise similar to those sustained by Venous Blood, Lymph and Chyle, and to be explained in the same manner. Its general composition also is very nearly the same as that of Venous Blood, although there are specific differences sufficient to prove that there is, as above assumed, a decomposition and recomposition of the whole mass as often as the one passes into the other. Into a consideration of these differences however, and of the causes of them, as involving many of the most abstruse points of particular physiology, it would be improper to enter at present. The average quantity of Arterial Blood, at any given time in the body of an adult human being, has been represented, on the premises already assumed, as six pounds; but the relative quantity is greatest in children and females.

Of *Carbonic Acid*, as a secretion from the Sap of plants and from the Venous Blood, mixed with the Lymph and Chyle of animals, it is unnecessary to take notice in this place, further than to show that its insertion here was not unadvised. That it is not formed by the direct combination of the oxygen of the air with the carbon of the Venous Blood in the respira-

(*a*) See the experiments of Autenreith, Mayer, Magendie and others, in proof of the great absorbing power of these vessels.

(*b*) Le Gallois, in opposition to Nesbitt and Dumas.

(*c*) This is the temperature of the Blood in the left cavity of the heart.

(*d*) Davy. According to Crawford it is 1031.

tory organs, appears to be proved by the numerous arguments brought forward to prove that the whole or greater part of the oxygen which disappears in respiration is absorbed into the Arterial Blood ; (*a*) and that it does not nevertheless reach the respiratory organ ready-made with the Venous Blood, seems to be established by the fact that no such Carbonic Acid is contained in this fluid. (*b*) Its ingredients are there, as sufficiently demonstrated by the excess of carbon contained in Venous Blood, (*c*) but not Carbonic Acid already formed. On the other hand, the eminently philosophical views that have lately been taken, as well of the general structure of the lungs—which are now properly described as a large conglomerate gland (*d*)—as of the particular relation which subsists between this organ and the liver—direct, as to structure and function, and inverse, in all tribes of animals, under all circumstances, as to size and importance, (*e*) are decidedly in favour of the opinion that the Carbonic Acid voided in respiration, is not only a secretion, but one of which Hepatic Bile is in some measure vicarious. Whether the quantity of oxygen which has been absorbed determine that of Carbonic Acid to be secreted, or the quantity of Carbonic Acid which has been secreted determine that of oxygen to be absorbed—the two being found very nearly to correspond—will also fall to be considered elsewhere : in the meantime, upon the presumption that the latter is the case, the function of expiration will always be spoken of before that of inspiration. The average amount of Carbonic Acid excreted daily is, in Man,

(*a*) Spallanzani, Vogel, Coutanceau, Nysten, Lagrange, Hassenfratz, W. F. Edwards, C. Williams &c. *versus* Black, Priestley, Lavoisier, Crawford and Ellis.

(*b*) Davy, Duncan, Christison, Tiedemann and Gmelin, Stromeyer &c. *versus* Macbride, Vogel, Hunter, Vauquelin, Brande, Home, Bauer and Scudamore.

(*c*) Arterial Blood is stated by Thackrah, after Macaire and Marcet, to contain about 26 *per cent.* of oxygen and 50 *per cent.* of carbon ; while Venous Blood is represented to contain only about 22 *per cent.* of oxygen, and as much as 56 *per cent.* of carbon. (*On the Blood,* 1834) It is fair to observe however that the analysis of Michaelis (*Poggendorff's Annalen,* 1832) makes the difference much less considerable ; and when we remember that not less than fifteen thousand pounds of Venous Blood are employed in furnishing only about forty-three ounces of carbonic acid containing not more than twelve ounces of carbon, we should not anticipate any thing like the difference above stated.

(*d*) Jourdan and Breschet &c.

(*e*) Tiedemann &c.

about forty-six thousand cubic inches, the weight of which is about forty-three ounces. (*a*)

Hepatic Bile is still more certainly a secretion from the Blood of the vena portæ than Carbonic Acid is from that of the pulmonary artery, since the former fact may be proved by direct experiment; (*b*) nor do the cases on record in which this vessel did not go to the liver, while nevertheless Bile was found in the gall bladder, (*c*) tend at all to invalidate this conclusion, since a great proportion of the Cystic Bile is always a secretion of the hepatic artery, no branches of the vena portæ being distributed upon the gall bladder. Further that Hepatic Bile may be secreted, under extraordinary circumstances, by the hepatic artery is no more improbable than that Carbonic Acid should be secreted by the arteries of the skin and other parts. Hepatic Bile differs in its physical properties from Cystic Bile, principally in being free from all bitterness; and such is the Bile of course in all animals destitute of a gall bladder. It is in all probability, like Carbonic Acid, formed only to be evacuated, when it passes directly into the intestines; but that portion of it which reaches the cystic duct and gall bladder, and is mixed with the bitter secretion of these organs, perhaps performs some obscure end in the animal economy. The diurnal amount excreted, since it is only with the Stools that it can pass out of the body, is not easily estimated; but it is probably very small. (*d*)

With the fluids above enumerated, as secreted from the Cambium of plants, we have no immediate concern; and of those secreted from the Arterial Blood of animals, it is not necessary to speak particularly. They are commonly described as either secretions or excretions; but the distinction is not precise, and, what is worse, it is illogical, since all excretions are secretions to begin with. Of these fluids some are passing out of the body more or less continually; others at re-

(*a*) Davy says 45,504 cubic inches, Lavoisier 46,037, Menzies 51,840.

(*b*) See *Annali Univ.* 1825, and *Ed. Med. and Surg. Journ.* 1827. See also Mr Kiernan's late elaborate work on the liver. In several of the lower animals the Urine likewise is a secretion from Venous Blood.

(*c*) Abernethy, (*Phil. Trans.* 1793) Powell, (*On the Bile &c.* 1800) Lawrence. (*Med. Chir. Trans.* 1814)

(*d*) By Glisson the diurnal amount of the *whole* Bile was computed at two ounces only, and by Haller at twenty. Magendie thinks it probable that it is about two pounds.

gular or irregular intervals; others only accidentally, being in general re-absorbed; and others never under any circumstances, being always so re-absorbed, or otherwise disposed of within the body.

As an example of the first, in addition to the Carbonic Acid and Hepatic Bile already spoken of, are the *Halitus from the Lungs*, amounting on an average perhaps to ten ounces in the day; *the Sweat*, insensible and sensible, amounting to about forty ounces; (*a*) the *Intestinal Gases*, which are not, as is generally believed, the product of fermentation &c. but a proper perspired secretion, the amount of which is variable; the *Stools*, which are not, as is commonly supposed, merely the residual parts of the aliment, but a proper secretion from the follicles of the large intestines, analogous to the ambergris of the white Whale—*Physeter* 47—the civet of the Polecat—*Viverra* 51—&c. and which in conjunction with the Bile do not on an average exceed five ounces; (*b*) and the *Urine*, amounting perhaps to about thirty-two ounces. (*c*) The quantity of the Urine is in general inversely as that of the Sweat, as the quantity of the Hepatic Bile is in general inversely as that of the Carbonic Acid. On the whole then the human body voids day by day about one hundred and thirty ounces in this way; which, estimating the quantity of absorbed oxygen to weigh the odd thirty ounces, leaves about one hundred to be supplied by the aliment.

To the second head of fluids belong the *Menstrual Fluid*, the *Milk* and the *Semen*. The quantity of the first passed by the women of this country at each menstrual period, is perhaps from three to six ounces; (*d*) that of the others has not been, and can hardly be estimated.

To the third head belong the *Mucilage*, the *Tears* and the

(*a*) The results of calculations by Sanctorius, Dodart, Keill, De Gorter, Robinson, Rye, Lining, Lavoisier, Séguin, Abernethy, Cruikshank and others of the diurnal amount of transpired Halitus are most discordant: perhaps however that above stated is an approach to the average in temperate climates and weather.

(*b*) Sanctorius says four ounces; Keill five.

(*c*) Sanctorius estimates it at 16 ounces; Keill at 30; Prout, who is followed above, at 32; Bostock at 40; Haller at 49.

(*d*) According to Leroy, Baudeloque, De Haen and Smellie, the average quantity is 3 ounces; according to Haller, Astruc and Burns it is 6; according to Rousset and Freind it is 18; and according to Hippocrates it is 20.

Saliva, each of which, at least as occurring in Man, are intended by nature to be re-absorbed in proportion as they are deposited, a certain quantity being always present for a specific purpose; and it is only from the catarrh more or less constantly prevalent in cold climates, or from the practice of snuff-taking, that an overflow of the Mucilage of the nostrils ever takes place, as it is only from certain mental emotions, or other accidental causes, that the Tears are ever in excess, and from other mental emotions, or from smoking, chewing tobacco and so forth, that spitting is ever necessary. (*a*) In some animals however, as the Java swallow—*Hirundo* 45—the Mucilage of the gullet and stomach is said to be periodically voided in large quantities, in order to furnish the materials from which it constructs its nest; (*b*) and it is of a similar fluid, drawn from a specific apparatus, and inspissated by its absorption of the oxygen of the air, that the Cockle—*Cardium* 8—forms its byssus, the Spider—*Aranea* 22—its web, and the Silk-worm—*Phalæna* 25—its cocoon. The venom of serpents is, in like manner, analogous to Saliva. The quantity of Mucilage, Tears and Saliva at any given time present in the human body is not easily ascertained; but when we take into consideration the immense extent of the mucous surfaces, it will be obvious that that of the Mucilage at least must be very considerable. (*c*)

(*a*) The countenance extended in this and other hyperborean countries to the filthy and unnatural practice of blowing the nose is an excellent example of the adaptation of the tastes of man to his necessities. In ancient Rome a man might divorce his wife for this offence. The ancient Romans used pocket handkerchiefs or sudaria, and some of the finest statues of their orators represent them flourishing these conveniences; but they employed them for wiping their foreheads—a much more offensive practice among us—not for blowing their noses. In Persia also, and other warm regions, the latter practice is hardly less abominated at present. It is no more intended by nature that the nose should require wiping, than that the urethra, or any other mucous passage should stand in need of the same operation.

(*b*) That this is the material of which the celebrated esculent nests of the east are constructed is questioned by Rudolphi and others. The investigations of Sir E. Home however into the structure of the mucous follicles of the gullet and stomach of the Java swallow and other birds, seem to corroborate the prevalent opinion. (*Comp. Anat.* vol. ii. pl. 56; vol. iv. p. 29, &c.)

(*c*) By Haller the quantity of Mucilage secreted every day by the intestines alone is computed at eight pounds; but this affords no criterion for judging of the quantity at any given time present in this or any other mucous canal or cavity; and the same may be said of the estimates of the quantity of secreted Saliva, which

The remaining fluids, or those which are constantly so re-absorbed, or otherwise disposed of within the body, are the *Halitus of the Serous Sacs*, the *Gastric Fluid*, the *Humours of the Eyes*, the *Fluid of Cotugno*, the *Fat*, the *Marrow*, the *Sinovia*, the *Bursal Fluid*, probably the *Cystic Bile*, the *Fluid of Meibom*, the *Sebaceous Matter* and the *Pancreatic Fluid*. They are all present in very small quantities perhaps at any given time, with the exception of the Fat, which, upon an average, amounts to about one-twentieth of the weight of the body, or between seven and eight pounds in a middle-aged man of moderate size and obesity; its relative quantity however is generally greater in the two extremes of life, and in females. (*a*) Fishes frequently abound in Fat; but of all animals, the cetacea have in general the greatest quantity, the northern Whale—*Balæna* 47—frequently affording no less than one-twelfth of its enormous weight of blubber, or subcutaneous Fat alone.

according to Nuck is eight or ten ounces in the day, according to Cruikshank a pound, according to Paris from five to eight ounces every meal.

(*a*) Bright of Maldon weighed 728 lbs., Lambert of Leicester 739, and Haller speaks of a "huge hill of flesh," bearing the impress of humanity, which weighed 800 lbs. Allowing about 140 lb. for the other solids and fluids, this would leave about 660 lbs. for Fat, or a fair proportion for about ninety individuals! On the other hand Edson the American, and Seurât the Frenchman, who exhibited himself in this country a few years ago, under the name of the Living Skeleton, weighed only between 50 and 60 lbs. both being not only quite destitute of Fat, but very deficient in most of the other solids and fluids of the body.

CHAPTER IV.

ON THE COMPOSITION OF ORGANIZED BEINGS.

SECTION I.

On the Principles of Plants and Animals in general.

The fourth of the formerly proposed distinguishing features in the structure of organized beings, furnishes the foundation for what is called Organic Chemistry, or that Science which professes to describe the Proximate Principles of the tissues and fluids of plants and animals.

Inorganized matters may be either elementary or compound, and the latter may contain indiscriminately any of the fifty-four ponderable elements of all things: any single compound however has often only two such elements, and the combination, even when it has three or four, is always indirectly binary, being first one with one, and the compound thus formed afterwards uniting with either another element or another binary substance. An organized being, on the contrary, is always an aggregation of compounds, each of which, while it can contain only certain definite elements—the chief of which are oxygen, hydrogen, carbon and nitrogen, to which are added, in much smaller quantities, iodine, fluorine, chlorine, phosphorus, sulphur, aluminum, calcium, potassium, sodium and some others, in all nineteen—has very rarely fewer than three or four, which are, at least after the cessation of its vitality, combined together directly into a ternary or quaternary substance. Again an inorganic compound, the chemical nature of which has been once ascertained, may be in general easily imitated artificially; since its elements are not only associated and held together, but originally combined, by common chemical affinity. An organic compound, on the other hand, however easily—at least after the cessation of its vitality—it may be analysed, cannot, if ternary or quaternary, be formed by art; since its elements, although after their combination associated and held together by common chemical affinity, are always combined by the process of secretion. (*a*) Lastly in an organic compound, the combination of the elements is too energetic to admit of any tendency to spontaneous separation; whereas in an organic compound, such is commonly—after the cessation of its vitality—the weakness of this combination, if it be ternary or quaternary, that it generally tends rapidly, under favourable circumstances, to decomposition.

By the term Proximate Principle then is to be understood

(*a*) It is true some few vegetable and animal compounds—ternary, as Stearin, or at least a fatty substance resembling it, and even quaternary, as Urea, or at least something like it—are said to have been formed artificially, the former by Bérard, and the latter by Wœhler; but the accounts are rather apocryphal—at any rate, so rare at best have been such manufactures, that they cannot invalidate the general proposition advanced above. We know indeed that binary organic compounds, such as Carbonic Acid and Water, may result equally well from common chemical affinity as from secretion; and there is nothing therefore irrational in the idea that ternary and quaternary compounds might do so likewise; but such combinations are certainly not commonly nor easily effected in a chemical laboratory. It has nevertheless been considered not improbable that we shall, in future, be able to form artificially, not only organic proximate principles, such as Sodo-albumen, Gelatin and Fibrin, but proper tissues and fluids also, and even whole organs, such as bones and muscles. (*Edinb. Review*, vol. xxxi. p. 389) Dr Prout has lately conceived that the chief cause of the peculiarity in the products of secretion is that the " organic agent" employs together with the essential elements, such as oxygen, hydrogen and carbon, a small sprinkling of some of the incidental elements, such as iodine, fluorine, chlorine, phosphorus and the rest, which " apparently furnish to the organic agent some powers utterly beyond our comprehension " (*Bridgewater Essay*, 1834, p. 431) If this be all, the difficulty of forming Sodo-albumen, Gelatin, Fibrin &c. may probably be very soon overcome; and if we can once get these, the process of converting them into the proper tissues and fluids of the body appears to be a mere bagatelle, Dutrochet, for example, having not long ago succeeded in forming marvellous proper muscular fibre by galvanizing a drop of serum! (*Ann. des Sciences Nat.* 1831) It may therefore be confidently hoped that it will not much longer remain a secret

> What med'cine 'twas that Paracelsus
> Could make a man with, as he tells us;

and that we shall shortly be able to imitate the philosopher mentioned by Amatus Lusitanus, and compound a child outright, " marrow, bones and all," by the help of a pestle and mortar! The ancient fable of Prometheus, and the modern one of Frankenstein, are destined perhaps still to be realized. A plant or an animal is nothing but a mixture of charcoal and water, with a few " incidental elements;" and there can be no reasonable doubt that we shall soon be able to turn such a mixture—now that we know so well not only the ingredients, but the powers, which nature employs in her operations—into the " quintessence of dust" constituting an Alexander or an " Imperial Cæsar!"

a vegetable or animal compound, formed directly by the union of certain elements, characterized by distinct chemical properties, and, by its union again with others, contributing to form the several tissues and fluids of organized beings. (*a*)

The Proximate Principles of vegetables contain in general a great proportion of carbon, while they are commonly destitute of nitrogen, and they are for the most part ternary; (*b*) whereas those of animals contain usually much nitrogen, while they are in general comparatively deficient in carbon, and they are for the most part quaternary. The former again contain, among the less abundant principles, more frequently potassium, whereas the latter contain more frequently phosphorus, sulphur, calcium and sodium; and while it is in

(*a*) Organic chemistry is a Science of comparatively recent date. The ancients made nothing intermediate between their Στοιχεῖα or elements, on the one hand, and their Ὁμοιομερῆ or simple organs, and Ὑγρὰ or fluids on the other; and the earlier modern chemists are either quite silent on the subject of Proximate Principles, or speak of them with the utmost indecision and vagueness. The two Rouelles in France, Scheele in Sweden and Neumann in Prussia, made some slight advances in the science about sixty years ago; but it is hardly thirty years since Dr Bostock drew, for the first time, any thing like an accurate distinction between some of the leading Proximate Principles of organized beings, (*Nicholson's Journal*, 1805) and it is since that time that the subject has been taken up by Gay Lussac and Thénard, Berzelius, Marcet, Brande, Prout, Chevreul, Gmelin, John and so many other savans, that perhaps no branch of science at present offers, as M. Virey observes, a more " brillante carrière de nouveautés." It is true that many of these " nouveautés" are but the naked results of analysis undertaken apparently without motive, and of which one at present sees neither the immediate advantage nor the ultimate aim; but perhaps when some powerful and comprehensive mind shall have arisen to do for organic chemistry what Haller did for physiology, what Bichât did for general anatomy, and what the cultivators of the science of unity of organic structure are now doing for descriptive anatomy, we may be able more fully to appreciate the value of many facts, of which it seems at present that, in the words of Seneca, " Hic unus inventorum fructus est—invenisse." In every branch of science little men multiply, and great men reduce; and perhaps in organic chemistry, more than in any other, there is at present, as observed by Raspail, " more need for clearing away rubbish than for accumulating new matter—more necessity to pull down than to build up. We cannot now," he continues, " pretend to the honour of enriching science except by reducing its scope—it scarcely ought to advance now but by retreating." (*Nouv. Syst. de Chem. Organique*, translated by Henderson, 1834)

(*b*) It is from the fungous and cruciferous orders of plants that some of the vegetable compounds which contain nitrogen are obtained in the greatest abundance; but there are few orders which do not afford, in greater or less quantity, compounds containing this principle.

vegetable compounds only that aluminum has hitherto been detected, animal compounds alone have afforded fluorine. Of course, from their deficiency of nitrogen, vegetable compounds in general are less prone than animal to that modification of spontaneous decomposition called putrefaction.

SECTION II.

On the Proximate Principles.

THE following are the chief Proximate Principles, as composed at least of the four chief elements above alluded to,

OF PLANTS.		OF ANIMALS.
	I. *Binary.*	
	(Of oxygen and hydrogen)	
Water.		Water.
	(Of oxygen and carbon)	
Oxalic acid.		
	(Of carbon and hydrogen)	
Caoutchouc.		
	II. *Ternary.*	

(Of oxygen, hydrogen and carbon, the two former in the same proportions as in water)

Sugar Sarcocoll Glycyrrhizin Olivile Piperin Gum	Tannin Fecula Inulin Hordein Lignin	Sugar.

(Of the same principles, but with the oxygen in excess, with respect to the hydrogen)

Acetic, Strychnic, Kinic, Tartaric, Benzoic, Malic, Meconic, Sinapic } Acids.	Citric, Moroxylic, Gallic, Ellagic, Pectic, Fungic, Boletic } Acids.	Acetic, Formic } Acids.

(Of the same principles, but with the hydrogen in excess, with respect to the oxygen)

Resin	Camphor	Resin	Cetin
Stearin	Cerin	Stearin	Ambrein
Elain	Myricin	Elain	Butyrin
		Cholesterin	&c. (*a*)
		Erythogen	

(Of hydrogen, carbon and nitrogen)

Hydrocyanic acid.

III. *Quaternary.*

(Of oxygen, hydrogen, carbon and nitrogen)

Osmazom	Atropia	Osmazom	Fibrin
Sodo-albumen (*b*)	Hyoscyamia	Sodo-albumen	Casein
Colouring matter	Daturia	Colouring matter	Salivary matter
Extractive	Strychnia	Picromel	Hematosin
Cathartin	Emetia	Urea	Lithic } Acids
Colocyntin	Cinchonia	Gelatin	Allantoic } Acids
Asparagin	Quinia	Mucus	Cantharidia. (*c*)
Gliadin	Brucia		
Narcotin	Morphia		
Zymom	Delphia		
Fungin	Picrotoxia		
Solania	Veratria.		

(*a*) This is a very " simple coming in," in comparison of the number of fatty matters lately admitted as Principles of the animal kingdom; M. Courbe for example having described no fewer than five in the brain alone—to wit Stearacomote, Eleancephol, Cholescerote, Cerebrote and Cerancepholote !

(*b*) It has been considered expedient to designate by this name Albumen in its uncoagulated state, since it is to the possession of soda, as shown by Dr T. Thomson, Dumas and Prevost and others, that it owes all the properties by which it is recognised. The term Albumen strictly means coagulated Albumen, since it is only upon the principle of abstracting its soda that all the agents by which the coagulation of this substance is effected, operate. Dr C. Williams calls Albumen, as it occurs native, an albuminate of soda ; but this nomenclature is not very happy, if pure Albumen, as supposed by Dumas and Prevost, be alkaline rather than acid in its properties.

(*c*) In the above table those compounds only are mentioned which result directly from the process of secretion, and are found native in the several tissues and fluids of organized beings ; since with those into which they may be subsequently converted by various chemical manipulations, we have at present nothing whatever to do. The leading principles of the arrangement followed above are those suggested by MM. Gay-Lussac and Thénard. Dr Prout has lately attempted an arrangement of such compounds, upon the principle of their being either crystallizable or uncrystallizable, (*Bridgewater Essay*, 1834) and M. Raspail upon that of their being either already organized—tending to become organized — undergoing organization, or organic. (*Nouv. Syst. de Chem. Organique*, trans. by Henderson, 1834) The former principle however seems to be altogether inadequate, and the latter altogether hypothetical, if not—as we shall probably find in future—altogether false and unfounded.

Of the foregoing Proximate Principles but very few comparatively are described as entering into the composition of the tissues of either plants or animals, the greater number being found in the fluids alone. Among the former however are Lignin, Osmazom, Sodo-albumen and Fungin, which are said to constitute, with much Water, and a small proportion of certain salts, the principal tissues of plants; and Osmazom, Sodo-albumen, Gelatin and Fibrin, of which, with a still greater quantity of Water, and a similar proportion of certain salts, the chief tissues of animals are represented as consisting. Thus it is of Sodo-albumen and Gelatin principally that the cellular tissue, as well as the several membranous tissues, and the vascular tissue in all its modifications, is described as consisting, as it is of Osmazom and Sodo-albumen chiefly that the nervous tissue, and of Osmazom, Sodo-albumen, Gelatin and Fibrin for the most part that the muscular tissues are said respectively to be composed.

The following are some of the characteristic chemical properties

OF OSMAZOM.	OF SODO-ALBUMEN.	OF GELATIN.	OF FIBRIN.
Sol. in both water and alcohol, cold and hot. Coag. by tannin.	Sol. in cold water. Coag. by alcohol; ——— by heat; ——— by tannin; ——— by salts of tin, lead, mercury and silver.	Sol. in hot water. Insol. in alcohol. Coag. by cold; ——— by tannin; ——— by salts of tin and silver.	Insol. in either water or alcohol, cold or hot. Coag. spontaneously.

Now the question arises, What claim have the animal compounds just enumerated—to say nothing, for the present, of those of vegetables—to be regarded as really organic elements, or the Proximate Principles of the organized animal body? The substance of such a body has been elsewhere represented as consisting of certain tissues, organized and inorganized—or anatomical elements—and of certain fluids; and it is commonly believed that such tissues and fluids are all immediately composed of more or fewer of these animal compounds, the simple or primary elements of which have been associated by secretion. It has however been already stated incidentally that, *however true this doctrine may be with respect to the inorganized tissues and fluids*, it is more than doubtful with respect to the organized tissues, the chemical nature of which appears to be entirely *sui generis*, but nevertheless such as, immediately upon the cessation of their vitality, to resolve them into some of the compounds under consideration. The organized tissues have seldom or never—as was at the same time remarked—even appeared to manifest, while still possessed of their vitality, that globular structure which is said to be proper to Sodo-albumen, Gelatin, Fibrin and so forth; and it has been noticed from a very early period as characteristic of such tissues, that they resist, so long as their vitality lasts, the action of all those ordinary chemical agents which operate with the greatest energy on their reputed Proximate Principles. Does water, either cold or hot, act in dissolving, or alcohol in coagulating an organized membrane, which is nevertheless said to consist principally of Sodo-albumen and Gelatin; or does either water or alcohol display any solvent action on an organized nerve or muscle, which is still represented as containing Osmazom? (*a*) It is a distinguishing property of Fibrin to undergo spontaneous coagulation; but no such coagulation takes place in muscles—which are still described as containing this principle—till they are deprived of their vitality, when they rapidly become stiff; and it is to this cause, and not to the contraction of the muscles, that the rigidity of the limbs, which soon succeeds death, and continues till the putrefactive process has commenced, is to be attributed. It is a process very similar to that of the coagulation of the blood; the only difference consisting in this, that the blood stiffens, owing to the retention by its Fibrin for a sufficiently long time of its identity, while the muscles stiffen, owing to the development in them of Fibrin which they did not previously contain. (*b*) Again

(*a*) Notwithstanding all this, we find chemists, in the accounts of their operations on organic matters, continually using the terms membrane, nerve, muscle and so forth, as entirely synonymous with Gelatin, Sodo-albumen, Fibrin and the rest. Dr Bostock, for example, says habitually, "*membrane* is soluble" in this or that; "*membrane* has a strong affinity for the tanning principle," &c.; "the action of nitric acid on *nerve*" is so and so; "pure potash dissolves *nerve*," &c.; "the *muscular fibre* is readily acted on—" and so forth. The grave-digger in Hamlet spoke more "by the rule" in these matters—"One that was a woman," says he, "but, rest her soul, she's dead."

(*b*) That the seat of this rigidity is the muscles is obvious, since it ceases immediately upon their being divided; but Hunter, Nysten and most late physiovarious agents which are most active in corroding certain animal tissues when they have become disorganized, as the hydrochlorate of mercury and the nitrate of silver, with respect to those which contain Sodo-albumen, oxalic acid, with respect to those which contain Gelatin, and nitric acid, with respect to those which contain Fibrin, have no action whatever on them so long as they retain their vitality; and even the

logists have been mistaken in ascribing it to muscular contraction, excited by what Hunter calls " the stimulus of death," with as little precision as he speaks of " the stimulus of necessity," " the stimulus of cessation," &c. That such is not the case is clear from the facts, that it does not take place till some time after death, whereas such contractions should be most powerful immediately on its occurrence, and that it takes place—and that even more quickly and remarkably—as well in weak subjects as in strong ones. That it is not obviated by palsy, or by the division of the spinal cord, although apparently a very strong argument against the notion of Hunter, is not really so; since the supposed contractions may be conceived to be quite independent of any stimulus naturally conveyed by the nerves. It has indeed been suggested by some chemical physiologists, that the contractions of muscles during life may be, to a certain degree, dependent on the coagulation of their Fibrin; and Humboldt, Cuvier and others have supported the notion that the increased cohesion of muscles, under these circumstances, is attributable to this cause. Rudolphi accordingly endeavours to unite the opposed doctrines, and ascribes the rigidity of the limbs after death to muscular contractions, " excited by a chemical operation." The " chemical operation" however, unfortunately for this *juste milieu* hypothesis, does not take place till the susceptibility of contraction has ceased—to say nothing of the probability that such a coagulation of their Fibrin, far from effecting, would be incompatible with the contraction of muscles, or of the absolute superfluity of the presumption of any such contraction in explaining the phenomenon in question. It is remarkable that this rigidity is prevented, as already remarked, by most of the causes which prevent the coagulation of the blood; a circumstance which, while it favours the presumption that it depends on a strictly chemical cause, is not at first sight easily reconcileable with the hypothesis that the latter is prevented, in these cases, by the Fibrin being inadequately recomposed, after its decomposition, owing to the congested state of the radicles of the veins, since this cannot apparently have any effect in preventing the development of Fibrin in the muscular tissue upon the cessation of its irritability. It will appear however in future that the total want of muscular contraction, which likewise in general occurs after death under these circumstances, can be referred only to a deterioration, owing to excessive irritation—such as that produced by electricity, violent exercise and the other causes already enumerated, as producing venous congestion—of that tissue on which the irritability of the muscles immediately depends; and if we are thus compelled to admit the deterioration of one tissue to explain this phenomenon, it is surely allowable to suppose that of another to explain the one under consideration, and to presume that the want of subsequent rigidity under these circumstances results from the deterioration of the muscular tissue, which is resolved into Fibrin after death, only when in a state of integrity.

gastric fluid, which so rapidly decomposes every kind of disorganized organic matters, and not unfrequently, after death, even the very surface by which itself was secreted, (*a*) is totally inert with respect to such matters while still possessed of vitality. Hence seeds and small animals such as leeches, tadpoles &c. are well known to pass sometimes through the stomach and intestines of larger animals, and parasites even to harbour there for an unlimited time, without sustaining the least injury—nay some small fishes, as the Myxine—*Gastrobranchus* 32—are said even to make larger fishes their prey by going down their throats ; whereas, had their vitality once deserted them, they would have been immediately digested. (*b*) Lastly what membrane, nerve or muscle, under any circumstances of heat and moisture, ever, while it continues organized, runs on to putrefaction ; and which of the compounds, said to enter severally into their composition, under the same circumstances is capable of resisting it ? (*c*)

Have we not then a right to conclude that there is in reality no ready-made Osmazom, no Sodo-albumen, no Gelatin, no Fibrin in the organized tissues of animals, but only the same elements as these compounds contain, and even brought together—although not, chemically speaking, combined—as they are in them, by secretion, associated and held together by a power quite distinct from common chemical affinity, in a state of combination peculiar to living matter ; and that it is only at the instant of the cessation of the vitality of each organized tissue, that these compounds, or reputed Proximate

(*a*) This action of the gastric fluid on the stomach was noticed first by J. Hunter, (*Phil. Trans.* 1767) and has been since treated of principally by Baillie, Adams, Home, Burns, Meckel, Haviland, Gairdner, Want, Pascalis, Cheeseman, Ségalas, Beck, Travers, Crampton, Davis and Carsewell.

(*b*) It is superfluous to illustrate this fact by the legend of Jonah and the "Great Fish ;" or that of Hercules, surnamed Trinoctes, from having remained embowelled, it is said, three nights in the stomach of a shark.

(*c*) So striking is the attribute of organized tissues of resisting putrefaction, that it has been regarded by some physiologists, for example, Stahl, Junker and J. Hunter, as furnishing one of the best means of defining Life. Such is not the case ; but it is nevertheless a necessary result of the composition of a living being. Life is certainly "putredini contraria ;" but we cannot with propriety regard it, as Junker does, as consisting in "illud putredini contrarium." The resistance of common chemical re-agents is coincident with Life, but not identical with it.

Principles, are formed—at that instant when the power called chemical affinity succeeds another power, which may be called vital affinity, and by which it had been previously supersersed, and common chemical compounds are all that is left of that organized mass into which the elements had been before associated? It is contrary to every principle, not only of philosophy, but of common sense, to admit the presence, in any substance, of a property which is never displayed by common chemical compounds, and at the same time the absence of all those properties by which alone such compounds are known, and still affirm that the chemical nature of this substance and of these compounds is identical. Upon what circumstance, if not upon a difference in their properties, can we at any time establish a difference in the nature of bodies? We know nothing of their Ὕλη πρώτη—nothing of any one of them abstractedly; and if asked what is Osmazom, Sodo-albumen, Gelatin, Fibrin and so forth, what can we say but that each is something which has such and such characteristics, and which, when acted on by certain re-agents, manifests such and such phenomena? It is a mere truism then to say that organized tissues, which have other characteristics, and which do not exhibit, under the same circumstances, the same phenomena, cannot be of the same nature as they are. And, if this be admitted, it will be evident how mistaken must be the doctrine which regards the globules said to be found —at least after the cessation of their vitality—in the several organized tissues, and which, if they exist at all, are merely particles of Sodo-albumen, Gelatin &c. as organic elements or molecules, and inculcates that it is directly in them that the aptitude for life or vitality resides. The really organic elements or molecules are probably, under ordinary circumstances—that is to say, while the organized being not only possesses the aptitude for life, but manifests life itself—never for one instant the same, and are certainly such as to have entirely eluded hitherto all our attempts to overtake them. (*a*) There has nevertheless been generally evinced the utmost unwillingness to admit that organized matter is, in its chemical nature, distinct from such as is inorganized, and that

(*a*) Ehrenberg. (*Arch. Gén.* 1834)

it is held together by a power distinct from common chemical affinity. Any compromise seems to have been commonly preferred to this: and endless modifications, by the supposed vital principle, of a chemical nature presumed to be common to all kinds of matter, and of a power presumed to be in universal operation, have been accordingly proposed by chemists to account for the peculiarities of such as is organized, without their having perceived that the proposed modifications are such as, not merely to qualify this supposed common nature, but to exclude it, and establish a proper one in its place, and not merely to temporize with this common power, but to admit a proper one to counteract and supersede it. (*a*) Organized

(*a*) Thus, to cite the expressions on this subject of only a few of the most celebrated chemists of the present century, Chaptal describes living bodies as all subject to the influence of common chemical powers, but the effect of these, he says, " is modified by the reaction of the Vital Principle." (*El. of Chemistry*, 1800, vol. iii. p. 1) Dr Prout remarks that the elements in organized beings are not combined " in such a manner that the result or compound differs in its properties from those which it would possess if its elements were combined by any other agent;" *only* the existence of such compound " depends upon the immediate agency of a power or principle, superior to that which governs and determines the properties of inorganic compounds, and which is called the Principle of Organization," (*An. of Med. and Surgery*, 1817) or, as he has lately named it, " the Organic Agent," and described as " possessing the power of controlling and directing all inferior agents." (*Bridgewater Essay*, 1834) Dr Thomson again speaks of common chemical powers as being, in the living body, not superseded by, but " the servants of a Superior Agent, which directs them so as to accomplish always one particular end." (*System of Chemistry*, 1817, vol. iv. p. 642) By Dr Murray the parts of the living body are described as common chemical compounds, the result of common chemical affinities, " which have been exerted merely under Peculiar Circumstances." (*System of Chemistry*. 1819) Dr Dewar observes that the materials of which living bodies consist are not in the least withdrawn from the influence of the chemical laws which belong to other matter, but " New Laws are superadded by which the effects of these common laws are in the most important manner changed." (*Ed. Med. and Surg. Journ.* 1821) Lastly Dr Henry, while he admits that there is, in the living body, " a Directing Principle superior to, and differing from the cause which has been termed chemical affinity," with singular inconsistency at the same time presumes that " the processes of chemistry, performed on dead animal matter, exhibit its proximate principles in a state identical with that in which they exist in the animal structure." (*El. of Exp. Chemistry*, 1823) It is needless to multiply examples of this attempt to reconcile the simultaneous existence and action of contradictory forces. This " vital principle," this " principle of organization" or " organic agent," this " superior agent," these " peculiar circumstances," these " new laws," this " directing principle," are only other words to express a new power, which not only restrains and controls, but opposes and dispenses with commatter, as, on the one hand, possessed of properties which have no parallel in such as is inorganized, and, on the other, destitute of those by which the latter is characterized, must be regarded as quite distinct from it: and chemical analyses accordingly must be considered as useful in shewing us, not what such matter *was* composed of while it possessed vitality, but what it *is* composed of afterwards. (*a*)

mon chemical affinity; and which, as supporting forms of matter quite distinct from all others, is justly entitled to be regarded as entirely *sui generis*. Is it conceivable that a power confessedly *different* from common chemical affinity should, while it continues to exercise a paramount influence on any substance, maintain it in a state *identical* with that of a common chemical compound? It is quite true, as observed by Dr Prout, that no power can be conceived capable of combining the elements of Sodo-albumen, Gelatin and so forth, in the same proportions as they exist in these substances, so as to form any thing else of them; but he misrepresents physiologists when he states, that "a vague notion has prevailed among them that organic agents have the power of causing the results of their combination to be altogether different from the results which are produced, under exactly similar circumstances, by inorganic agency." (*Bridgewater Essay*, 1834, p. 436) Physiologists have no such vague notion. They do not imagine that the organic agent combines the said elements, in the same proportions, into different compounds; but they venture to believe that it does not combine them at all, in the chemical sense of the word, but merely holds them associated together in an ever varying form of existence, of which the chemists seem to have no idea, but which, as indicated by its properties, is as distinct from that of a mere chemical compound as one thing can be from another. But, observes Dr Prout in a previous essay, "if the vital principle"—that is to say some power proper to the living body—"were the only agent that operated in organic beings, the moment it ceased to act, the *vinculum* that kept the whole together would necessarily be removed, and an immediate dissolution"—that is to say some change of character—"would be the consequence, which," he says, "is not the case." (*Ann of Med. and Surg.* 1817) The fact however that such *is* the case is the burden of all the remarks made above; and this fact is the chief argument in favour of the opinion against which he contends. Mr Mayo considers it as "highly probable that the laws of chemistry, and the property which controls the affinity of matter in living bodies, will prove eventually to be identical." (*Outlines of Human Physiology*, 1827, p. 15, and 1833, p. 8.) Perhaps they may: but in the meantime we must be allowed to consider them as perfectly different from each other, since it is by their fruits only that we know either, and the fruits of the two are certainly—as far as they have been hitherto ascertained—as different as can well be imagined.

(*a*) Berzelius is among the few chemists who have admitted this almost self-evident fact. "Les élémens," says he, "paraissent obéir dans les corps vivans à d'autres lois que dans les corps morts"—(*Traité de Chemie, par Jourdan*, 1829, tom. v)—not merely modified, but other laws—but among physiologists, the admission has been almost universal. Thus Rudolphi expressly states that chemistry is able to investigate only the lifeless remains of organized beings.

SECTION III.

On the Ultimate Principles.

In the remarks which have preceded it has been throughout presumed that, however distinct may be the chemical nature of the several organized tissues from that of the inorganized tissues and fluids, all the vegetable and animal compounds, above enumerated as proximate principles, are the results of the combinations of certain Elements effected by secretion, as a process, although not identical with, still analogous to common chemical affinity; but it would be improper to dismiss the subject without remarking that it is by no means certain, on the one hand, that these alleged Elements are really so, or, on the other, that secretion is not a process essentially different from common chemical affinity, as well in the immediate *matériel*, as in the manner of its operation. The ave-

(*Grund. der Physiol.* 1821) Dr Barclay—one of the strongest advocates for the existence of a vital principle—concedes to it with respect to chemical affinity, not only, like Chaptal, a modifying, but a subversive influence; and remarks that the combinations of organized matter "not only indicate a species of chemistry unknown to man, but evidently imply a species of chemistry whose modes of operation are equally beyond his powers to imitate, and his powers to comprehend." (*On Life and Organization*, 1822, Pref. p. 5.) Adelon again speaks of vital affinity, contrasted with common chemical affinity, as "une force toute opposée;" and very justly demands, "les molecules qui forment les solides du corps humain, étant associées en vertu d'une affinité spéciale, dite vitale, et que les chemistes n'ont pas en main, comment ces chemistes pourraient-ils prétendre faire une analyse de ces solides? Ils ne font que les detruire." (*Physiol. de l'Homme*, 1823, tom. i. p. 104) It may be noticed as singular also, that Dr Prichard—one of the most successful opponents of the vital principle doctrine—still quite coincides in opinion with Dr Barclay on the subject in question, and maintains that "the component materials of the dead and living body are not existing under the same chemical circumstances." (*On the Vital Principle*, 1829, p. 117) Finally—for the list needs not be prolonged—Tiedemann describes the combinations of organized solids as depending on forces proper to these bodies, and admits that it is not till after death that chemical affinities enter into play; (*Physiologie*, 1831) and Lepelletier de la Sarthe remarks that it is reasonable to conclude that the composition of living or organized bodies is not the result of mere chemical affinity or union, but dependent on the power peculiar to such bodies—the vital power. (*Physiol. Med. et Philosophique*, 1835) And a similar opinion is now entertained by almost all who are capable of forming an opinion upon the subject.

nues by which all the Oxygen and Hydrogen, which these compounds contain, enter the organized system, are supposed to be sufficiently obvious: but with respect to the Carbon, it has been rendered probable by ample experiments that plants and animals in general excrete constantly from their respiratory organs alone—to say nothing of its consumption in other ways—much more of this principle than has any evident ingress into the system; (*a*) and the source of such an abundance of Nitrogen as many plants and all animals, herbivorous as well as carnivorous, not only contain, but continually give off, is a subject involved in much obscurity. It is known to be abundantly evolved from some of the fungi and cruciferæ, as the Mushroom and Mustard, when nourished by apparently perfectly pure water; (*b*) it exists in zoophytes, which remain permanently attached to rocks at the bottom of the sea; and it has been found that fishes, (*c*) which of all animals most abound in this principle, and in the air bladders of some of which it is found almost pure, as well as some reptiles, (*d*) live and grow though kept for years in water alone. Again plants which grow in sand, or upon granite, are found to contain as much lime—the chief element of which is Calcium—as those which grow in a calcareous soil; (*e*) the bones of the native animals of some districts of New South Wales, in which not a particle of lime, it is said, is to be detected in either the soil or the vegetable productions, contain this substance, in the state of phosphate

(*a*) That plants evolve in this way more Carbon than can be satisfactorily accounted for, was proved long again by Dr Crell; and, with respect to animals, of the forty-three ounces of carbonic acid lately mentioned as voided day by day from the lungs of man, about twelve ounces are pure Carbon, the only obvious source of which is the aliment. Now it has been computed that about one-eighth only of their weight of ordinary vegetable or animal food, such as potatoes and beef, is Carbon, so that to furnish only this quantity, a man must consume at the rate of at least six pounds, or ninety-six ounces of solid food *per* day. But the average daily quantity of aliment, solid and fluid together, does not exceed a hundred ounces, and of this at least two-thirds may be estimated as drink, so that not more than from thirty to forty ounces of reputedly solid food are left to furnish the twelve ounces of Carbon voided by the lungs alone, to say nothing of the very considerable quantity of the same principle which passes off likewise by the other outlets.

(*b*) Wallerius &c.

(*c*) Rondelet. (*Opera Omnia*, 1628)

(*d*) Redi; (*Experimenta* &c. 1685) Mead &c.

(*e*) Decandolle and Sprengel. (*Philosophy of Plants*, 1821) of lime, in the usual quantities; and the same has been found excreted, in the state of carbonate, with the egg-shells of hens, in quantities for which the food taken was quite inadequate to account (*a*). The enormous masses also of carbonate of lime, sometimes laid down in the form of coral-rocks &c. by minute animals, without any manifest supply of its principal ingredient, are sufficiently well known. Similar to these anomalies is that of the abundant excretion of Sodium, in the form of carbonate of soda, by plants—the Salsola Soda for example—when growing in a soil which does not contain an atom of it; (*b*) as well as that of the occasional presence, it is said, of Copper in some shell-fish, and of Gold in bezoards, or the intestinal concretions of certain herbivorous quadrupeds, the sources of both which are equally obscure. It is true that attempts have been made to explain, on ordinary principles, the evolution by plants of the great quantity of Carbon above alluded to, (*c*) as well as that of the Nitrogen, (*d*) of the Calcium, (*e*) and of the Sodium; (*f*) and similar attempts have been made to account for the appearance of some of those elements in animal compounds, the source of which is equally ambiguous—in particular of the Carbon, a considerably greater quantity of which principle has been stated to be received with the aliment, than is voided by respiration, (*g*) and of the Nitrogen, which has been confidently traced, as well in herbivorous as in carnivorous animals, to the food on which they subsist. (*h*) Of most of these attempts however it is sufficient to say that they are by no means satisfactory; and the source of

(*a*) Vauquelin. (*Ann. de Chim.* 1798)

(*b*) Schrader, Braconnot &c.

(*c*) Saussure, Goëppert &c.

(*d*) Kirwan &c.

(*e*) Bergmann &c.

(*f*) Saussure, Davy &c.

(*g*) Mr Dalton has calculated that as much as eleven ounces and a half of Carbon are, on an average, taken into the stomach daily, while only ten ounces and a half, and, according to a recent estimate by Dr Thomson, (*Records of General Science*, 1835) not more than nine ounces are excreted from the lungs. Whatever may be thought however of the quantity voided by this channel, that of the quantity received with the aliment is unquestionably very considerably overrated.

(*h*) This conclusion has been drawn by Magendie, who found that animals soon died when fed exclusively on pure gum, sugar, oil or any other substance quite destitute of Nitrogen, with distilled water. Similar experiments however have many of the presumed Elements in the reputed proximate principles of both plants and animals is still very problematical.

May we not then hazard a conjecture that these alleged Elements, or at least many of them, are not really elementary, but composed of ulterior atoms, for which we have no names, but which, united together in various proportions, constitute the substances in question? We call the latter Elements only because we are incapable of either decomposing or composing them in a common chemical laboratory; (*a*) but it is not certain that the powers brought into operation in the laboratory of the organized body—the powers of secretion—cannot first decompose, say Oxygen or Hydrogen, into certain ulterior atoms, and afterwards recombine some of the latter into Carbon or Nitrogen—the elementary nature of which has been so long a matter of doubt—or other reputedly simple substances, the source of which has just been represented as so mysterious. (*b*) However this may be, we seem at least justi-

been since made by Londe, Leuret and Lassaigne and others without establishing the indispensability of Nitrogen; and it is extremely unfavourable to the conclusion of Magendie, that the chyle collected after a vegetable meal, as proved by Macaire and Marcet, contains precisely as much Nitrogen as that collected after one of animal food. On the other hand the results of the unfortunate experiments made many years ago upon himself, by Stark of Vienna, sufficiently display the inadequacy of *any* kind of aliment, if too long persevered in, to support the vital powers; and it has been well shown by Paris, Prout, Raspail and others, that highly concentrated aliment is very ill adapted to this end, as not affording a sufficient stimulus to the digestive organs, and consequently that it was not for lack of Nitrogen, but for lack of food—abundant and, abstractedly considered, nutritious as their food was—that the subjects of the experiments of Magendie perished. The most highly azotised aliment, under the same circumstances of want of change and excessive concentration, would have had precisely the same effect.

(*a*) "The number of substances admitted as elementary," says Sir Charles Morgan, "is liable to perpetual variations; for the epithet referring to our own powers of operation, and not to qualities inherent in the subject, it becomes applicable or otherwise, as the species in question is affected by the progress of chemical research. The term Element must not therefore be taken as conveying a positive assertion respecting the intimate nature of the body to which it applies. It does not signify undecompoundable, but undecompounded." (*On the Philosophy of Life*, 1818, p. 29)

(*b*) The possibility of this is allowed by many, among the chemists, who are loudest in deprecating the admission of any creative or transmutive powers in organized beings; Dr Prout, for example, conceding, not only that "the Elements entering into their composition are generally in states of combination different from those of mineral substances," but that "they (the supposed Elements) fied in concluding, not only that the immediate chemical nature of organized matter is very different from that of such as is inorganized, but also that its alleged elements are somewhat questionable; that the process of secretion, by which the ultimate ingredients of all vegetable and animal compounds, whatever they may be, are brought together, is perhaps an infinitely more subtle and searching power than that of common chemical affinity; and that there exists between the two only a very faint and remote analogy.

Taking then all these circumstances into consideration, we need be at no loss probably to account for the very little advancement which either physiology, pathology or therapeutics have hitherto derived from the study of organic chemistry—an advancement certainly very disproportionate to the expectations which were at one time entertained of it, and to the ardour with which it has been so long prosecuted. (*a*) We indeed tacitly acknowledge that the composition of an organized being, whether in health or in disease, is out of the pale of common chemical doctrines, by in general instinctively, as it were, abandoning such doctrines, whenever we come to speak of the proper business of these sciences. Is there any thing, for example, in the history of the properties of Osmazom, of Sodo-albumen, of Gelatin or of Fibrin—pompously and circumstantially as these are sometimes set forth, under a vague impression of their importance—which assists us one jot in explaining any one of the physiological properties of a membrane, a nerve or a muscle? Is it from any change in their

probably *consist of ultimate and refined forms of matter*, which do not naturally, and perhaps cannot exist separately." (*Ann. of Med. and Surg.* 1817) And the same doctrine is continually inculcated in his recent work. (*Bridgewater Essay*, 1834)

(*a*) It was long ago perceived by Sprengel that organic chemistry could never afford any principles of physiology; and it was sagaciously remarked by one of our best medical journalists, soon after it began to be fashionable to apply this study to physiology and pathology, " We are not even certain that we are in the right path, and that we shall not be obliged to retrace our steps." (*Edinburgh Medical and Surgical Journal*, 1816) How prophetic was this observation! Dr Bostock ridicules the false estimate made formerly by the Iatro-Mathematicians of the value of " problems and theorems, corollaries and lemmas," as applied to physiology. (*System of Physiology*, 1824, vol. i. p. 169) Why does not he perceive that that made by the Iatro-Chemists of the importance of their hobby is equally extravagant?

reputed proximate principles that membranes contract adhesions, nerves become softened and muscles indurated; or do we seek to remove the first by dissolving their Sodo-albumen or Gelatin, to harden the second by coagulating their Osmazom or Sodo-albumen, or to soften the last by acting in any way on their Osmazom, Sodo-albumen, Gelatin or Fibrin? The idea is palpably absurd. We *feel* that organized tissues, whether sound or diseased, are not amenable to common chemical laws, nor within the reach of common chemical agents, as having, in fact, none of these so called proximate principles in their composition. Nor has the application of organic chemistry to the inorganized tissues and fluids, as connected with certain conditions of the organized parts, been hitherto so happy, as at all to invalidate the conclusion above adopted. We know indeed that the chemical character of the mucilage, for example, of the bile, of the stools, of the urine and of several other secreted fluids is variously affected in numerous diseases, and we have established about four distinct kinds of biliary concretions, double that number of intestinal, and almost double that number again of urinary; but what real light, it may be asked, has the knowledge of these facts thrown either on the processes by which such matters are produced, or on the means by which such processes may be either counteracted or subverted?

On the other hand most of the hypotheses—when such have been broached—whether physiological, pathological or therapeutical, which rest on a chemical foundation, involving either the supposed Proximate, or the supposed Ultimate Principles of the body, have been eminently unfortunate. Witness the notion lately alluded to, (*Note*, p. 131) that the contractions of the muscles depend on the coagulation of their supposed Fibrin; and that, still more absurd, which assumes that these contractions are effected directly by the motions of the Fibrin of muscles already coagulated, and represents accordingly the crassamentum of the blood as susceptible of the same, on the application of a stimulus. (*a*) Witness again the doctrine which has been so long prevalent, and is not yet obsolete, that the

(*a*) Tourdes and Circaud, contradicted by Heidmann. (*Reil's Archiv. VI., S.* 417 &c.)

natural nutrition of the body is effected in like manner by means of the coagulation of the Fibrin of the blood, previously deposited in a liquid state; (*a*) and that still so generally clung to, that the raw material of every new growth is merely, if not pure blood, coagulable lymph or Fibrin, effused by the arteries, and organized as it were mechanically, (*b*) instead of a proper germ or matter, secreted by these vessels, and containing within itself the rudiments of its own organism. And with respect to any primary changes in the above-mentioned proximate principles of the body, real or supposed, as causes of disease, how vaguely and inconsequentially has it been frequently assumed that, because this or that compound may abound in the matters deposited as the result of such disease, such compound previously existed in excess in the blood, and was at the bottom of the whole. Thus how idly has diabetes, in which the urine contains Sugar, been ascribed to the presence of ready-made Sugar in the blood, (*c*) and ready-made Urea, a principle in which the urine in this disease is comparatively deficient, been recommended as a remedy. (*d*) How vaguely has scrofula, or a tendency to deposit tubercular matter in various parts of the body, been referred to a superabundance of Sodo-albumen in the blood, (*e*) and abstinence from the white of eggs therefore gravely inculcated; (*f*) and with how little show of rea-

(*a*) Hunter; Burrows. (*Gulstonian Lectures*, 1835)

(*b*) See Home and Bauer's ingenious suggestions, borrowed from Borelli, Tabor and Hales, respecting the squirting out of carbonic acid from the reputed Fibrin, at the instant of its supposed coagulation, leaving channels into which the blood from the contiguous parts was squirted in, and thus the organization was effected. (*Phil. Trans.* 1818 *and* 1820)

(*c*) Dobson and Rollo, contradicted by Wollaston, Marcet, Thénard and Vauquelin.

(*d*) Ségalas.

(*e*) Dr Parr. (*Medical Dictionary*, 1809)

(*f*) M. Ségalas goes even further than this, and condemns cow's milk in scrofula, not only because it contains albumen, but because cows, as shown by M. Huzard, are very liable to tubercular accretions. By what process, or series of processes, these are to pass *en masse* out of the body of the cow with her milk, and again into the body of the drinker thereof, does not immediately appear. But, granting that the secreting vessels are thus easily influenced with respect to the nature of the organized matters which they deposit, we need be at no loss, at any time, for a new pleura or peritoneum, a new nervous system, or a new set of muscles, as occasion may require; since, without trying to manufacture them in son has it been lately supposed that the albuminous urine in dropsy indicates a similar excess of this principle in the blood, and that neutral salts are therefore useful by dissolving it. (*a*) Again how rambling is the hypothesis which would establish a connection between the liability to croup, and the consequent deposition of a false membrane in the trachea, with an excess of Fibrin in the blood, (*b*) and which would persuade us to try to obviate this effect by copious dilution; (*c*) and how injudiciously has it been lately presumed that the acknowledged excess of Fibrin in inflammatory blood is for the purpose of furnishing the false membranes &c. in which inflammation so frequently terminates. (*d*) All this however is quite of a piece with the conceit so long entertained, and still by some persons so fondly cherished, that numerous diseases, such as scrofula, (*e*) urinary calculi of uric acid, (*f*) gout (*g*) and rickets, (*h*) have their origin in too Acid a state

a laboratory—as it has been presumed that we shall in no long time be competent to do—they may easily be got by feeding for a reasonable time on isinglass or carpenter's glue, on the white of eggs, or on the clot of the blood of bulls or of goats. M. Bonhomme's suggestion of taking crude phosphate of lime in rickets, for the purpose of getting new bones, was a mere nothing to what may be done in this way.

(*a*) Burrows. (*Gulstonian Lectures*, 1835)

(*b*) Dr Mason Good, (*Study of Medicine*, 1822) the early fellow-labourer of Dr Parr, has the credit of having first directed "the prying eye of philosophy" into this promising field.

(*c*) Piorry.

(*d*) Thackrah.

(*e*) This doctrine is as old as the times of Arabian physicians, who were the first to substitute a supposed vitiation of the humours as the cause of diseases in general, for the supposed loss of balance in their distribution, as maintained by the first humoral pathologists.

(*f*) Wollaston, Magendie &c.

(*g*) Mazuyer &c. The "spécificité" *in toto* of gout has been denied by the Broussaists, and lately by Dr Leese; but we may admit the "spécificité" of the inflammation without attributing it to the cause above alluded to Dr Prout seems to believe that the chief mischief in gout is a tendency to form crystallized deposits; and he seriously advises gouty patients to avoid crystallized food, for "with so little control over their own fluids, how can they expect to assimilate extraneous crystallizations?" (*Bridgewater Essay*, 1834, p. 513) It is certainly very unreasonable of them.

(*h*) The notion that rickets arose from this cause originated in an absurd hypothesis to explain ossification, invented by the earlier chemical pathologists, but renewed lately by Dr G. H. Weatherhead, (*Treatise on Rickets*, 1835) and of the blood—and indeed pus has been lately found out to be nothing but the Sodo-albumen of the blood, coagulated by an acid formed in inflammation—(*a*) while others, on the contrary, as diabetes, (*b*) urinary calculi of the phosphates, (*c*) exostoses (*d*) and sea-scurvy, (*e*) arise from too Alkaline a state of this fluid; and that either an alkaline or some other morbid condition of the blood prevails also in most of the diseases of the skin, (*f*) and in all the so-called putrid diseases, (*g*) and is the cause of all the peculiarities which they severally display.

Nor is it only with respect to the supposed Proximate Principles of the blood—which has been thus ingeniously inferred to be saccharine, or too albuminous or fibrinous, when the secreting vessels have formed from it *de novo* compounds, which are found to contain these matters, or too acid or alkaline, when these vessels have deposited in the same manner a calculus or a gouty concretion unfortunately containing an acid, or matters of which the ingredients either are, or are supposed to be, too alkaline—that such doctrines have been adventured, but a loss of balance in the presumed Elements of the organized body has been frequently, and in general equally unhappily, put in requisition to explain various phe-

called by one of his reviewers "an exceedingly ingenious idea;" the said idea being that the process of ossification is quite analogous to petrifaction, or the deposition of tufa, the matter being first deposited by a fluid in the state of a soluble super-salt, and afterwards reduced to that of an insoluble neutral salt by the removal of its superfluous acid. This, in the former case, is of course to be effected by the absorbent vessels; but these vessels, if already overcharged with acid, refuse to do so, and hence the earth of bones is left in a soluble state. The blood in rickets was accordingly found by M. Vienac to effervesce in a most distressing manner with the carbonates of alkalies.

(*a*) Donne. (*Journ. Univ.* 1834)

(*b*) That diabetes depends on too little phosphoric acid in the blood is the conclusion to which Dr Latham arrived after several years spent, as he expresses it, "in weaving hypotheses" to explain this disease.

(*c* & *d*) These two diseases are directly opposed to rickets upon the principles above stated; while their immediate cause is the same as that of diabetes, as might indeed have been anticipated from the great similarity of the symptoms.

(*e*) This idea respecting sea-scurvy has been prevalent from the earliest writers on the disease down to the time of Cullen. It has been shown to be false by Deyeux and Parmentier, by Lind and by Parry.

(*f* & *g*) Lorry, Cullen, Mason Good &c.

nomena both of health and disease. And, in the first place, in whatever way these elements may be conceived to enter the animal body, it has been very generally inculcated that to the subsequent expulsion of each, except the oxygen, which goes off indiscriminately by every avenue, a specific organ is appropriated, the Hydrogen, for example, escaping with the bile from the liver, the Carbon with the carbonic acid from the lungs, the Nitrogen with the urine from the kidneys, and so forth ; (*a*) consequently, when any one of these organs performs less or more than its assigned part—to say nothing of the probability that more or less of these principles may at the same time be taken in—there must arise either an abundance or a deficiency of some one of them, and from each its own train of consequences. Moreover males, it is said, under ordinary circumstances, always abound more in Oxygen, and females in Hydrogen, so that the embryo derives almost the whole of the former principle from its father, and almost the whole of the latter from its mother ; (*b*) but from each of them thus in excess in the respective sexes certain peculiarities and liabilities to disease will of course arise. Thus a superfluity of Oxygen has been confidently represented as giving rise to phthisis, as a deficiency of it has to sea-scurvy ; (*c*) and it is on these grounds that the inhalation of hydrogenous gases in the former, and the employment of acids and ascescent fruits and salads, as containing Oxygen, in the latter, have been supposed to be beneficial. Again an excess of Hydrogen, produced by dram-drinking, has been supposed to give rise to catacausis or spontaneous combustion ; (*d*) and an excess of

(*a*) Fourcroy.

(*b*) This is the hypothesis of Ackermann, differing from that of Galen, lately renewed by Rolando, with respect to the communication to the embryo of certain *tissues* from each parent, only in being much less tenable. We smile in our wise moments at the reveries of our predecessors ; but how often do we, in our foolish moments, imitate, or even surpass them ! Which of the ancients could have said, as Sprengel has done, that man on account of his excess of Oxygen is positively electric, while woman on account of her excess of Hydrogen is negatively so ?

(*c*) Beddoes. On the other hand M. Baudelocque has lately, with equal probability, represented scrofula—of which phthisis is merely a mode—as arising from too little Oxygen, or, at any rate, as depending on too rare a renewal of the air.

(*d*) Le Cat, Marc, Kopp &c. It is perhaps on this account that drunken old women, who may be presumed to be excessively hydrogenous in their composition, are the chief victims of this disaster.

Carbon, occasioned by the undue admixture of venous with arterial blood, to give rise to all the bad symptoms of cyania or morbus cæruleus. Further it has been imagined that it is from a superabundance of Nitrogen that urinary calculi of uric acid and gout take their rise—the uric acid unluckily containing Nitrogen as one of its ingredients—and it is on this account, it is supposed, that, besides the use of alkalies, vegetable food agrees best with persons troubled with these diseases; whereas it is from too little Nitrogen, on the contrary, that diabetes has been conceived to arise, (*a*) and hence the advantage experienced from exclusively animal food in this disorder. But it is not only these chief Elements which either in excess or deficiency may be, it has been imagined, at the bottom of so many diseases, but others of less importance, as Sulphur, Arsenic &c. when superabundant, may act in a similar way, and such has been conceived to be the cause of cancer (*b*) and certain other affections.

And the application of chemical hypotheses to therapeutics has been equally woful. What shall we say to the doctrine which teaches that it is by a kind of tanning of the Gelatin of the several tissues that astringent medicines take effect in the various diseases in which they are used? What to that which inculcates that it is by combining with the Oil of a bronchocele, and thus converting it into a soluble soap, that soda is of service in this disease; or to that which would persuade us that it is by its affinity for the Ammoniacal salts of the blood, (*c*) or by its forming with the Hydrochloric acid of the saliva a soluble hydrochlorate—whereas with the urine it could have formed only an insoluble phosphate—(*d*) that mercury acts as a sialagogue? What shall we say to the presumption that the advantage of the cold affusion in fever depends upon the decomposition of the water, and the entrance of the Oxygen into the system; (*e*) what to that which represents yeast as of service in the reputedly putrid diseases, upon the same principle as Carbonic acid prevents meat from

(*a*) Rollo.

(*b*) Peyrilhe, Ewart &c.

(*c*) Cullen. (*Lect. on Mat. Med.* 1773)

(*d*) Murray. (*Materia Medica,* 1828)

(*e*) Mason Good. It is fair to observe however that the learned writer only "throws out this hypothesis as a hint to be prosecuted by" those who have nothing better to do.

putrifying; (*a*) or to that which assumes that Hydrochloric acid is beneficial in the same disease, because putrid gases are thereby decomposed? (*b*)

But it is superfluous dwelling any longer on such rambling fancies as these. That the blood may become changed in regard to its Proximate, and perhaps also its Ultimate Principles in the course of disease, owing to certain peculiarities in the circulation, or the reception into it by absorption of various deposited matters—in the same manner as the bile enters it in jaundice, or the urine in ischuria—or even that it may be the *vehicle* of numerous morbid agents accidentally thrown upon it, is unquestionable; but there is no good reason for believing that any primary and spontaneous change in the Principles of the blood constitutes any part of any disease whatever. If doctrines like these were applicable at all—that is to say, if the living body were to be regarded at any time as a merely chemical machine—they must obviously be so much more frequently than has ever been presumed. The proportion of the Principles of the blood, Proximate or Ultimate, if liable to be ever spontaneously disturbed, could hardly, under any slight variation of circumstances, escape disturbance; and such disturbance, if it produced the few diseases which have been stated, must have produced innumerable others. The operation of medicines also, if ever determined by chemical affinities, must have been always more or less under their influence. But the human body is regarded as a merely chemical machine only as often as it is convenient so to consider it—and, while in discussing the nature of some few diseases, and the action of some few remedies, chemical doctrines are all in all, in speaking of the great majority of both, it seems to be forgotten that there are such things as Sodo-albumen or Fibrin, Acids or Alkalies, Oxygen or Hydrogen in existence. Such partial hypotheses are primâ facie suspicious; and were this the place for discussing the subject, the greater number of those which have been just alluded to might easily be shown to be fanciful and erroneous. At present however it is sufficient to observe, in conclusion, that, as formerly a false estimate was made of the

(*a*) Cartwright. (*b*) Guyton-Morveau.

scope of mathematical science, in applying it to explain the *actions* of organized beings, so in recent times a similarly false estimate seems to have been made of that of chemistry, in applying it to explain their *composition*; and that the doctrine of angles and logarithms and algebraical equations is not in general more foreign from the one, than that of definite proportions and solubilities and chemical re-agents is from the other.

The more or less rapid spontaneous decomposition of organic matters, if ternary or quaternary, when deprived of their irritability or vitality, arises from the complexity of their combination being such as rarely to allow of the affinities of any of their elements being fully satisfied. The Oxygen in them, for example, is not in sufficient quantity to saturate their Hydrogen and Carbon—therefore they are all inflammable; and the constant tendency of all their elements to run into binary, instead of ternary or quaternary compounds, is such as to effect, under favourable circumstances, their speedy separation. The most remarkable kind of spontaneous decomposition of quaternary organic compounds is Putrefaction. In this case, if the substance which is about to undergo it, whether vegetable, as Extractive, or animal, as Sodo-albumen or Gelatin, be exposed to the atmosphere, it first acquires from it more Oxygen, and thus are formed, with a portion of the Hydrogen and Carbon, water and carbonic acid. In the mean time other portions of each of the latter, uniting together, form carburetted hydrogen; while the remainder of the Hydrogen, uniting with the Nitrogen, forms ammonia—the distinctive product of this kind of decomposition. This process is commonly very rapid in animals suddenly deprived of their irritability, as by electricity &c. and is favoured by any means which either diminishes the cohesion of the particles of the substance, or exerts an affinity for any one of the resulting binary compounds, the free access of the atmosphere being of course essential to it. It is accordingly in the former of these ways that a moderate temperature, such as that between 60° and 80°, and a moderate supply of moisture, promoted of course by the contact of deliquescent salts, seem to operate; while it is in the latter way that lime and other matters generally called septic, which predispose to the formation of carbonic acid &c. appear to act. (*a*) On the other hand the process is retarded by any means which either increases the cohesion of the particles of the substance, exerts an affinity for the quaternary compound as it is, or excludes the air. It is accordingly upon the first of these principles that either great heat or great cold seems to operate, the former by drying up, and the latter by congealing the moisture; (*b*) it is partly upon the first and partly upon the second principle that numerous matters, commonly called antiseptic, such as alum, nitre, sea salt and corrosive sublimate, appear to act; while it is upon the third principle chiefly that keeping the substance in full and well-stopped bottles, or in carbonic acid or other gases, or smoking it, or imbuing it with wax, honey, sugar, gum, resin, balsam, pitch, paint, varnish, oil of turpentine, alcohol, vinegar and so forth, seems to produce the effect in question. (*c*) If again a substance susceptible of putrefaction be kept in water, it undergoes these changes more slowly; and, provided there be present at the same time any acidifiable matters, such as stearin or elain, the results are different from those just stated. In this case the water, if not retained undecomposed by a mixture with it of alcohol, or any other substance having a strong affinity for it, first affords the requisite Oxygen, and the same, or nearly the same results as in

(*a*) Hence the common practice of putting lime into the coffins of persons who have died of really or reputedly contagious diseases—a practice somewhat superfluous perhaps, since such diseases pretty certainly cease to be contagious long before decomposition, however accelerated, can take place.

(*b*) It is sufficiently well known that dead bodies, left either on burning deserts, or in the glaciers of Alpine districts, do not undergo this change.

(*c*) It is remarkable how soon the practice of embalming, which is supposed to have originated in a belief in the celebrated doctrine of the metempsychosis, led to a knowledge of the influence of all these solid and liquid substances in preventing the decomposition of the dead, with the exception of corrosive sublimate, oil of turpentine and alcohol, with which mankind were not acquainted till the age of the Arabian physicians, who introduced, for the first time, the art of sublimation and distillation. The word mummy is said to be derived from the Egyptian *mum*, or wax, as embalming is from the *balm* employed in the process. (See Dr Granville's and Mr Pettigrew's recent Essays) The ancient Jews, Greeks and Romans commonly burnt their dead; but were accustomed to preserve their organic rarities in honey, as we do in alcohol. Savages often, in the present day, smoke-dry their dead by way of preserving them; but in some places, as Nova Scotia and Otaheite, as well as among the Guanches, an aboriginal tribe of Teneriffe, embalming seems to have been in use from time immemorial.

the former case are at first produced. But now the ammonia, instead of being dissipated, seems to remain in contact with the substance, and to predispose the acidifiable matters to absorb oxygen and to become acid, which acid, subsequently uniting with the ammonia, gives rise to a kind of salt or soap, called adipocere. (*a*) It was till lately believed that none but the fibrinous parts of animals, when interspersed with fat, were capable, under favourable circumstances, of undergoing this change; but it has been recently established that the albuminous and gelatinous parts are equally liable to it. (*b*) Lastly quaternary organic compounds when below ground undergo changes, according as the soil is either dry or moist, similar to those which they undergo in either air or water, but generally speaking, more slowly than in either, particularly if they have been well inclosed and buried deep: if however such changes have begun to take place previously to burial, it is important to know that they are not retarded by this measure. The decomposition of interred human bodies has been said to be, under ordinary circumstances, perfect at the expiration of about three years, if the grave be four feet deep; and of about four years, if it be six. (*c*) Upon what principle it is to be explained that such spontaneous decomposition of the animal body does not always take place, even when no extraordinary means have been employed to prevent it, or certainly not within the usual period, is quite unknown. Such however is said to have been the case in not a few very remarkable instances, (*d*) but the

(*a*) This singular effect of water, as " a sore decayer of your whoreson dead body," was noticed for the first time during the extensive exhumations which took place at the Cimetière des Innocens, at Paris, about fifty years ago, and was most remarkable in those bodies which had been buried about three years. It was proposed to turn the discovery to useful purposes first by Dr Smith Gibbs, (*Phil. Trans.* 1794 and 1795) while the first satisfactory explanation of the *rationale* of the process was given by Chevreul.

(*b*) This fact has been established by Dévergie, by whom the spontaneous changes which the several parts of the human body undergo in water have been particularly investigated. (*Ann. d'Hygiène Publique,* 1829)

(*c*) Petit.

(*d*) It is related that the body of Tullia, the daughter of Cicero, was discovered perfectly sound in the pontificate of Paul III. after having lain in the ground fifteen hundred years; and the same was the case, according to Lactantius, with the body of Maximianus, which was disinterred at Marseilles, after authenticity of the majority of these is somewhat questionable.

During all the above, and other similar decompositions of organic matters, myriads of minute plants, called mould &c. and of animalcules, according to the nature of the matters so decomposed, usually manifest themselves. This phenomenon was, till lately, in general attributed to the development, in the matters undergoing decomposition, of minute germs, which were presumed to be universally disseminated, but to become developed only when they met with a congenial soil, such as that afforded by the products of decomposition. (*a*) Of late however this hypothesis has been in a great measure superseded by another, which ascribes these plants and animalcules to the retention, by a portion of the Extractive, Sodo-albumen, Gelatin and so forth—the globules of which, it must be remembered, are regarded as monads or organic elements or molecules—of their supposed aptitude for life, so that certain globules of these matters take on, more or fewer of them together, the form of distinct organized beings. (*b*) It has been already mentioned that the highest tribes of plants and

eight hundred years' interment. It is said also by Jones that the body of Vladimir, who first introduced Christianity into Russia, is still to be seen quite entire, with that of his mother likewise, in the church of St Sophia, at Novogorod; as is that of the Duc de Croz, covered by a glass case, in the church of St Nicholas, at Revel. A similar story is related of the corpse of a man of the name of Bancroft, interred in St Helen's church, Bishopsgate, London, which was annually exposed for many years, in conformity with his will, and constantly found unchanged. Numerous other accounts of this kind are on record; but they are for the most part so ill authenticated, that it would be idle to speculate upon them.

(*a*) Harvey—the author of the celebrated axiom, "Omnia ab ovo"—Leeuwenhoek, Redi, Valisnieri, Swammerdam, Spallanzani, Bonnet, Linnæus, Ehrenberg &c.

(*b*) This "bold and fanciful hypothesis," as it is called by Roget, originated with Turberville Needham and Buffon, and has been adopted by Priestley, Ingenhouz, Lamarck, G. R. Treviranus, O. F. Müller, Tiedemann, H. M. Edwards, Dutrochet, Dumas and Prevost and many more. The doctrine, although allied to the ancient hypothesis of "Equivocal Generation," is not identical with it; since, while by the latter certain matters were supposed to be vivified *de novo* by the heat, either evolved during putrefaction, or communicated by the sun—"being a god, kissing carrion"—and thus to assume the form of distinct animalcules, by the former these matters are believed to be possessed of innate vitality, and to acquire merely each an independent existence by separation.

animals have been supposed to differ from the lowest, as well as the perfect plant and animal of every tribe from its earliest germ, only in the circumstance of more monads or organic molecules—the primary, as well as continual source of which is the aliment—entering into their composition. Hence it is easy to conceive that, as a progressive coalition of these molecules might, at the creation, form in succession each higher species of organized beings from those below it, as well as, during the development of each individual in its generation, carry it successively through all the inferior types till it finished with its own, so a separation of the same monads or molecules might, either as passed off with the excretions, or on the final decomposition of each individual of a higher species, again give rise to innumerable individuals of a lower grade; the same being ready subsequently to contribute, either by receiving into themselves new monads or organic molecules, or furnishing the same to other organized beings, to the formation again of any mode of organized existence superior to themselves. (*a*) And that such is the origin of the mould and animalcules in question has been inferred from the globules of such organic matters having been observed to be, in all such cases of spontaneous decomposition in con-

(*a*) Haud igitur penitus pereunt quæquomque videntur,
Quando aliud ex alio reficit natura; nec ullam
Rem gigni patitur, nisi morte adjecta aliena.

Well might the ancients say, if this be true, Death is the mother of Life—*Nascimur ad mortem, morimur ad vitam*—since what is called the death of a tree or a man is nothing more than the separation of a vast bag of mould or animalcules, which, as Dr Prichard expresses it, "had been tied up together, and obliged to subsist within one bark or skin," into fragments, which may either coalesce together into some higher tribes, indiscriminately of plants or animals—"de même," says Edwards, "que les sels affectent en crystallisant"—or go to form a future tree of the same kind, or a future man, by entering with their food. "Here's fine revolution, an we had the trick to see it." It had been long known that "we fat all creatures else to fat us, and we fat ourselves for maggots"—it had been long known that "a man may fish with a worm that hath eat of a king; and eat of the fish that hath fed of that worm:"—but it is only lately that it has been suspected that the said maggots and the said worms were *ab origine* part and parcel of this lord of the creation, as he was a compound of millions of their fraternity; and that, as when a man has been devoured by maggots, it is only that his individuality is multiplied, so every time he takes a meal, it is only that the individuality of myriads of other organized beings is destroyed. "Il n'y a point," says Cabanis, "la mort pour la nature."

stant agitation; and from such mould and animalcules having been detected in infusions of organic substances, during their decomposition, even when these substances have been previously exposed to a heat sufficient, it is presumed, to destroy all germs, when only distilled water has been used, and when the infusion has been kept constantly *in vacuo.* (*a*) But that the doctrine of the perpetual transmigration of any supposed organic molecules, whether well or ill founded, cannot apply to the globules of Extractive, Sodo-albumen, Gelatin &c. which are pretty certainly not identical with them, and have not the aptitude for life alluded to, is obvious; and it is equally so that it cannot be true of the really organic molecules, if we believe that it is into Extractive, Sodo-albumen and so forth that these molecules, or the organized tissues composed of them, are, on the cessation of their vitality, converted. It is a fair objection likewise to the hypothesis in question, or rather to an immediate corollary from it—namely that the whole of organized nature consists at all times, and has at all times consisted of the same definite number of organic molecules—(*b*)

(*a*) G. R. Treviranus &c.

(*b*) It would be a curious speculation to enquire, upon the principles of the advocates of this doctrine, in what way the determinate complement of the organic molecules on the surface of our planet has been, at any given time, disposed of—that is to say, what proportion has been appropriated, first respectively to the vegetable and animal kingdoms, and afterwards to each individual species of plants and of animals. It would appear that some of them must be very considerably minus what they were in "the mysterious week—the teeming work-days of the Creator," when the whole human race consisted of only a single pair, now that it numbers, at the lowest estimate, five hundred millions of individuals! In order to maintain any given balance of power in the organic kingdom, it is obvious that, upon these principles, each organized creature must furnish at its death precisely as many organic molecules as it appropriated to itself during its growth, besides continually supplying by its excretions, as many as it receives with its aliment; and all these must of course be distributed again, directly or indirectly, over exactly the same tribes of organized beings as originally provided them. If then in any tribe of such creatures there should be in a given time a greater number of growths than of deaths, as happened among the patriarchs of old, it follows that these tribes would soon be in excess, but in exactly the same proportion other tribes must fail. But the failure of a tribe of Iguanodons or Plesiosauri, of Megatheria or Mastodons, which were perhaps, as Mr Kirby suggests, too large to enter the ark, (*Bridgewater Essay*, 1835, p. 18) would go further to maintain this excess, than that of thousands of tribes of smaller organized beings; and this was, it may be said, the final cause why these unwieldy monsters are no longer met with. They were merely vast masses in reserve, to be cut down afterwards, among other things, into human beings!

that a very considerable proportion at least of Extractive, Sodo-albumen &c. is certainly resolved into merely mineral substances in every instance of the decomposition of organic matters—else whence the carbonic acid, carburetted hydrogen, and ammonia which they evolve? and as these substances must—unless the organic kingdoms of nature are gradually failing from off the face of the earth—be continually renewed, in the same proportion, by combinations of mineral substances, there seems to be no good reason why the whole of such substances should not be capable of being so resolved and so renewed. (*a*) It would be premature in this place to expatiate on the obscure subject of generation, involving as it does the important question of the nature of Life, which is so soon to occupy our attention; but it may be allowable to state here that nothing hitherto adduced, in support of the hypothesis now under consideration, seems to be at all less easily explicable on the old doctrine of universally diffused germs, than on the new one of perpetually transmigrating organic molecules. With respect to the constant agitation of globules said to be observed in the infusions of organic

(*a*) Raspail accordingly, although he believes in the ultimate molecular or vesicular structure of organized beings, still does not regard these as unchangeable, but represents them as continually decomposed on the one hand and recomposed, out of Oxygen, Hydrogen and Carbon on the other; (*Nouv. Syst. de Chem. Organique, translated by Dr Henderson,* 1834) and the same is the opinion of Dr Prout, who conceives, after Paley, that the " organic agent" in its simplest form constructs out of inorganic matters the simplest order of organic molecules, that in a more complicated form it constructs a second and higher order of such molecules and so on, till, becoming progressively more and more complex, it constructs at length those of which the highest tribes of organized beings consist. (*Bridgewater Essay,* 1834) It is well known that plants, and perhaps also animals, can feed on carbonic acid, and the fact also already mentioned of certain plants and animals appearing to thrive on other purely inorganic substances, such as water, as well as that of wolves and rein-deer, and even human beings, as the Ottomacs and other people, subsisting for months together upon a kind of earth, which, according to Humboldt, is " destitute of all organic substance, oily or farinaceous," is decidedly favourable to the idea that the supposed organic molecules, as they are decompoundable, so they are capable of being recompounded; and perhaps it is only, as Dr Prout says, by " saving them the labour of forming the proximate principles"—in other words the supposed organic molecules—" from their elements," or by affording these elements of the precise character and in the exact proportions required for the purpose, that organic matters constitute the most appropriate aliment for organized beings.

matters during their spontaneous decomposition, a similar phenomenon has been noticed during the mechanical separation of particles of sulphur, flint, glass, manganese and other mineral substances, in which the existence of organic molecules was out of the question; (*a*) and with respect to the development, in the former, of mould and animalcules, when they have been exposed to heat, immersed in distilled water, and kept *in vacuo*, it is easy to conceive that minute germs may have been as competent to resist heat without destruction as organic molecules, and that such minute germs may as well have been contained from the first in and about the matters undergoing decomposition, as that they could find access to them only during their decomposition with the water or the atmosphere. (*b*) Nor will the countless myriads of new beings frequently so developed appear to be any objection to this explanation, when we reflect on the incalculable rapidity with which, once evolved, they perpetuate their species. (*c*) Upon the whole the difficulty of accounting, upon commonly received principles, for the phenomena in question, does not appear to be so great, as to warrant our adopting so overwhelming an hypothesis, as that proposed as an alternative, in order to explain it.

(*a*) Fray; (*Sur l'Origine des Corps Org. et Inorg.* 1817) R. Brown; Brewster. (*Edinb. Journ. of Science*, 1829)

(*b*) It is not less likely that insects, prompted by instinct, should deposit their eggs in substances susceptible of such spontaneous decomposition as may afford a congenial soil to the young animal, than that they should do so in substances already undergoing such decomposition; and that they do the latter is universally admitted—nay that, deceived by the putrescent odour of certain plants, as some species of *Phallus* and *Agaricus*, they sometimes choose these inappropriate receptacles for the purpose. That at least *some* of the larvæ then which are developed during putrefaction result from ova cannot be questioned; and it seems *a priori* very improbable that there should be any second origin for the rest.

(*c*) It has been computed by Linnæus that three flesh-flies and their immediate progeny will devour the carcase of a horse in less time than a lion could have done it, the female not unfrequently giving birth to 20,000 larvæ at a time, and a few days being sufficient for the production of a third generation.

RUDIMENTS

OF

PHYSIOLOGY.

PART II.

ON LIFE, AS MANIFESTED IN IRRITATION.

The contents of the preceding Part appertain only to the differences in their Structure between Inorganized matters and Organized beings, involving the consideration of their form, aggregation, substance and composition: the next subject to be treated of is the differences in their Actions. The following then are the chief characteristic Actions respectively

Of Inorganized Matters.

Those only by which their particles are held together, and by which they retain the same composition, substance, aggregation and form, unalterably for ever, unless these are changed by some external agent.

Of Organized Beings.

1. Those by which they continually secrete and give off from their fluids, into the medium by which they are surrounded, certain gaseous substances, while they absorb from it others, for the purpose of effecting some necessary changes in the composition of these fluids. *(Respiration)*

2. Those by which they continually propel these fluids through the solid parts of their structure, for the

purposes, on the one hand of forming and depositing new solids and fluids, and on the other of breaking down and carrying away old ones, such of the latter as are useless being thrown entirely out of the system. *(Circulation, Deposition and Absorption)*

3. Those by which they at intervals receive from without certain solid and liquid substances which they assimilate to the nature of the fluids so employed, for the purpose of renewing them in proportion as they become wasted. *(Assimilation)*

4. Those by which they at intervals form and throw off certain organized parts, for the purpose of continuing their species. *(Generation)*

[The duration of these matters therefore may be said to depend on their being allowed to remain unchanged—in other words, on their apparent repose. (*a*)]

[All these actions are, under ordinary circumstances, (*b*) essential, first to the continued existence of organized beings as individuals, and secondly to their perpetuation as species; consequently the duration of these beings may be said in general to depend on their being continually decomposed and recomposed—in other words, on the obvious actions which are constantly going on within them. (*c*)]

(*a*) The repose is here merely *apparent*, and the term is used therefore as opposed only to *obvious* action, since it is by a constant insensible action—namely by attraction or repulsion, in one or other of their modifications—that repose itself is maintained. Even the *vis inertiæ*, in every thing but the ultimate atom of matter, depends upon their exercise.

(*b*) The expression "under ordinary circumstances" is added for the purpose of meeting those extraordinary cases, some of which have been already alluded to, in which organism survives for a longer or shorter period the display of any obvious action whatever.

(*c*) Organized beings are accordingly compared by Cuvier—and well compared, notwithstanding the protest of Dr. Barclay—" à des espèces de foyers, dans lesquels les substances mortes sont portées successivement pour s'y combiner entre elles de diverses manières, et pour s'en échapper un jour, afin de rentrer sous les lois de la matière morte;" *(Leçons d'Anat. Comp.*, 1799, *Tom.* i. p. 5) and again, " La vie," says he, " est un mouvement de tourbillon, plus ou moins rapide, plus ou moins compliqué." (p. 6)

In addition to these actions of organized beings in general, are some others, commonly presumed to be proper to animals, and certainly requiring other conditions besides those which alone are necessary to the foregoing; such as

5. Those by which they become conscious of impressions made upon them. *(Sensation)*

6. Those by which, in virtue of this consciousness, they reason and will. *(Thought)*

7. Those by which, in virtue of this will, they effect various movements. (*a*) *(Voluntary motion)*

(*a*) It is usual to enumerate, among the characteristic actions of organized beings, those by which they evolve heat; and if this be done, we should specify also others by which many such beings evolve likewise light and electricity. But none of these phenomena are in fact proper vital actions, but the necessary physical results of some of those actions which have been above mentioned; and indeed the evolution of cold—if the expression may be allowed—is often not less remarkable, as the result of such actions, than that of heat, the balance on either side depending, in any given instance, on the comparative energy of those vital actions from which heat and cold respectively result. If it be admitted that the carbonic acid which appears in respiration is not produced by the immediate combination of the carbon of the venous blood either with the oxygen of the air in the lungs, as we are taught by Mayow, Priestley, Black, Lavoisier, Crawford, Ellis and others, or with the oxygen of the arterial blood in the parenchyma of the body, as supposed by Lagrange, Hassenfratz, W. F. Edwards, C. Williams and the rest, but secreted from the venous blood in its passage through the lungs, while the oxygen which disappears is absorbed into the nascent arterial blood in the same passage, as has been already assumed, and as may be proved to be the case by all but conclusive evidence; if it be conceded, as it universally is, that, while there is very little difference in the density of venous and arterial blood, the density of carbonic acid considerably exceeds that of oxygen; and lastly if it be admitted that there is little or no difference in the bulk of the secreted and absorbed gases, as has been abundantly established; the extrication of animal heat involves no new vital action, but is a necessary physical result of others, and the theory of this process—so long regarded as one of the most inexplicable problems—becomes one of the most simple and satisfactory in all physiology. The conversion of a liquid into a gas *must* by rarifaction produce cold, whilst the opposite conversion of a gas into a liquid *must* by condensation produce heat; and—the density of the two liquids being nearly the same—had the density of the two gases been so too, keeping in mind that their bulk is equal, the one process would have neutralized the other, and neither sensible cold nor sensible heat would have resulted. But the density of the two gases is not equal: the transition therefore of the liquid into the denser gas produces less cold than that of the rarer gas into the liquid produces heat, and what is called animal heat is thus merely the result of the absorption of oxygen into arterial blood, *minus* that of the secretion from venous blood of carbonic acid. And when we reflect that in the human being the temperature of not less perhaps than ten pounds of arterial blood is sensibly raised by this means about 2 deg. every minute, as first insisted on by Dr. Holland of Sheffield, (*Experimental Inquiry &c.* 1829) and that he has, not continually to extricate *de novo* a quantity of caloric sufficient to constitute the whole difference between the temperature of his body and that of the atmosphere, but merely to keep up what is in any given time passing from him, we shall not require any aid from the latent heat doctrine, nor from any other, easily and satisfactorily to explain the whole process. Perhaps indeed the theory above proposed may be, as Magendie says, "trouvée trop simple;" but in the mean time, were the present the place for entering in detail into the subject, it would be easy to show that, simple as it is, while it is supported by every fact which was at one time supposed so strongly to corroborate that of Black and Crawford, it is amenable to none of the objections which must be fatal to the latter, and at the same time explains many circumstances which neither this nor any other theory has approached. At all events Calorification is no more a vital action *per se* than Frigorification, which has long by general consent been allowed to be the natural and necessary result of transpiration, the inconsistency in the mean time of attributing heat to one gaseous exhalation, and cold to another having been overlooked. The secretion of carbonic acid is, and must be directly a source of cold, but, the absorption of oxygen always corresponding with it, it becomes thus indirectly a source of heat; whereas the secretion of halitus—so much rarer as it is, to begin with, than carbonic acid—is a source of unqualified cold, there being in this instance no counteracting power in operation.

CHAPTER I.

ON THE FUNCTIONS OF ORGANIZED BEINGS, AND THEIR ARRANGEMENT.

THE foregoing are the chief distinguishing features in the actions of organized beings, and it is in the investigation of these that the Science of PHYSIOLOGY properly consists. The several series of actions above enumerated are their functions, the term Function differing from the term Action, as applied to such beings, only as being more comprehensive, and as having a reference always to some general end; the function of Respiration, for example, including the actions of many different organs, all which however co-operate in effecting some necessary changes in the composition of the fluids. (*a*) In this view of the matter then a function may be defined to be the action, not of an *Organ*, but of an *Apparatus*, destined to some specific purpose in the general economy of an organized being; and it is only in this view of the matter that the functions of such beings are susceptible of any definite enumeration or classification. (*b*) Of the several series of actions however or

(*a*) It is very important to keep constantly in mind the physiological distinctions between a Property, faculty, quality or capability, a Power, stimulus or agent, and an Action or function; the first, like irritability, sensibility and so forth, signifying only a susceptibility of excitement, the second, like caloric, light, sympathy, &c. only a means by which this susceptibility may be called into action, while the last, like irritation and sensation, signifies the phenomena resulting from the two in co-operation. It would have appeared almost superfluous to notice these distinctions, had they not been so frequently lost sight of, not only by the οἱ πολλοι, but even by authors of merited celebrity, Barclay, for instance, speaking continually of the *property* of sympathy, Bostock of the *power* of sensation, and Adelon of the *function* of sensibility. Life is a property with some authors, a power with others, and an action, or series of actions, with a third set; and the expression is in all these cases correct, if in the first instance the term be used as synonymous with vitality, in the second as signifying a substantial Vital Principle, and in the last as indicating the sum of the functions—but not otherwise.

(*b*) The enumeration of the functions has been from the most ancient periods almost the same as at present, the co-operation of the actions of several organs, if not the specific end in view, having from the first furnished certain broad principles upon which each might be distinguished from the rest; but the classification of them has been very various. By Aristotle, the first to attempt any regular arrangement of the functions of animals, they were classed under the three heads of Vital, Natural and Animal; the two former including those which were common to plants functions specified above the four first are those by which principally organized beings are distinguished from inorgan-

and animals—the first however not allowing of interruption for an instant without danger of death, while the second allowed of a considerable interruption with impunity—and the latter including those which were regarded as proper to animals. This classification, adopted as it was by Galen, became that of most physiologists almost down to our own times; nor have indeed many years elapsed since the addition which Galen made to this system of classification, that over each of the heads of functions which it includes certain specific πνευματα or spirits, called respectively Vital, Natural and Animal, presided, was abolished. By Paracelsus, one of the first original thinkers in after times, the Vital and Natural functions of Galen were spoken of as constituting one Life—that which acted within an animal, and the Animal functions as constituting another—that which acted upon surrounding bodies; and this was the basis of the arrangement of the functions proposed by Harvey under the names of Vegetative and Sensitive, the former of which were supposed to be actuated by the ψυχη θρεπτικη, and the latter by the ψυχη αἰσθητικη of the ancients, or, as Harvey himself called them, the anima vegetativa and the anima sensitiva. Almost precisely similar to this, except in words, is the popular twofold arrangement of the functions followed by Bichât, his Organic functions almost entirely corresponding to the Vegetative, and his Animal to the Sensitive of Harvey; but he differed essentially from the latter in denying that they were the results of the operation of any ψυχη or anima, contenting himself with representing one general department of the nervous system—the ganglionic—as subservient to the former of these heads of functions, and the other—the cerebro-spinal—to the latter. Still more recently the functions have been commonly classified, as by Cuvier, according rather to the general purposes to which they minister in the animal economy than to any other condition; and upon these principles, which have been followed above, three heads of functions have been generally admitted, the Nutritive, or those which are subservient to maintaining the well-being of the individual, the Sexual, Generative or Reproductive, or those which serve to perpetuate the species, and the Relative, or those by which an intercourse or relation is kept up with the external world. Admitting then on all hands the same number of functions, the following is their classification by the above-mentioned authors.

	Aristotle and Galen.	Harvey, Bichat.	Cuvier.
Respiration Circulation	Vital.	Vegetative or Organic.	Nutritive.
Deposition Absorption Assimilation	Natural.		
Generation			Sexual, Generative or Reproductive.
Sensation Thought Voluntary Motion	Animal.	Sensitive or Animal.	Relative.

It seems superfluous to notice certain other classifications of the functions proposed by Vicq d'Azyr, Dumas, Buisson, Richerand, Cuvier and others, in the attempt to attain absolute precision on a subject on which, from its very nature, absolute precision is not attainable, and on which therefore any great solicitude about it is vain and frivolous. It is enough that any arrangement inculcates useful associations, and is conducive to perspicuity, to make it a good one; and that is the best, however logically defective, which conduces most to these ends. "Divisions," says Lord Bacon, "only give us the husks and outer parts of a science, while they allow the juice and kernel to escape in the splitting."

ized matters; while the three last, on the other hand, serve chiefly to distinguish some kinds of organized beings from others.

Inorganized matters then have no reciprocal action with the medium in which they exist; whereas there is no plant nor animal the crude fluids of which do not maintain a continual interchange of gaseous matters with the atmosphere or water in which it dwells, and such an interchange is essential to the conversion of these crude fluids into the mature fluid which is to minister to deposition in general. This is effected generally by means of some proper organ, as the vesicles within the substance of the leaves of plants, and the lungs and their appendages, or some corresponding organs in animals; but sometimes, on the other hand, it is brought about by the surface in general.

Again the substance of inorganized matters being exclusively either solid, liquid or aëriform, it is evident that there can take place in them nothing analogous to a circulation of fluid through solid parts; and, if this be wanting, there can of course be nothing similar to organic deposition on the one hand, or to absorption on the other. New particles may indeed be accidentally formed and deposited within or upon them, and this even after certain definite laws, as in the formation of stalactites, petrifactions &c., and their old particles may be accidentally broken down and carried away; but the former occurs only when such new particles have been conveyed to them by a fluid which is afterwards removed, and the latter only when some chemical or mechanical power has been in operation. On the other hand in every plant and animal, as the mature fluid is constantly moving in the interstices of the solids, for the purpose of being formed into various new solids and fluids —the former in proportion as they are absorbed, the latter either that they may effect some useful purpose in the system, or be carried out of it as useless or deleterious—so the crude fluids are equally constantly in motion, in some parts indeed as instrumental to deposition, but in most for the purpose of receiving again into themselves such solids and fluids as have already fulfilled their respective offices; and, having arrived with them again at the respiratory organ, are there once more converted into the mature fluid, to go through the same course as before. It is to these actions that the entire and spiral vessels of plants in general, and the heart, arteries and veins, and lymphiferous and chyliferous vessels, with the parenchyma and erectile parts of animals in general are subservient; but in quite the lowest tribes of organized beings it is not through proper vessels, but through their generally spongy texture that the fluids are moved, and it is in this that all the offices which they perform are effected.

Further, inorganized matters, as they waste no part of their substance by any processes similar to the foregoing, so they do not renew it by receiving into themselves and assimilating foreign matters. But, while plants in general repair their loss by selecting from the soil, by means of their absorbing vessels, such matters as with little or no assimilation become at once their crude fluids, all animals take occasionally from the external world certain solid and liquid matters which they assimilate, by a series of processes called collectively assimilation, each to the nature of its own crude fluids, and thus compensate for what has been consumed. It has been proposed as a general ground of distinction between plants and animals, that the alimentary matters of the former are always inorganic; (*a*) and the vegetable kingdom has been thus represented as a kind of laboratory in which mineral matters become adapted for the aliment of the herbivorous tribes of animals, as these last are a kind of laboratory in which vegetable matters are rendered fit for the aliment of such as are carnivorous. (*b*) If the recent speculations however respecting the indefeasible nature and perpetual transmigrations of monads or organic molecules be well founded, it follows that these proposed distinctions are imaginary, and that not only do plants, as well as animals in general, subsist in fact on organic matters absorbed from the soil—using the water and salts, precisely as animals do, merely as diluents and condiments—but all animals indiscriminately are capable of subsisting on any kind of organic matters, whether vegetable or animal, always provided that they afford a sufficient stimulus to the digestive organs. (*c*) It may be made a question

(*a*) Brisseau-Mirbel &c.

(*b*) See Prout. (*Bridgewater Treatise*, 1834, p. 474)

(*c*) It is an axiom as old as Hippocrates, that there are many species of food, but only one aliment; but whether he intended to imply by this that the essence, as it however whether the above distinction between plants and animals be not objectionable, not so much because *neither* are capable of subsisting on inorganic matters, as because *both*, as elsewhere stated, are competent to do so ; and whether that between different kinds of animals be not equally so, not so much because either vegetable or animal food will do equally well for *both*, as because any such aliment is essentially requisite to *neither*. Numerous instances are on record, and to some of them allusion has been already made, in which not only plants, but animals also, and these as well naturally carnivorous as herbivorous, have lived and increased in size when fed apparently on strictly inorganic matters—even on such as appeared to be quite destitute of certain elements in which their bodies abounded ; and, however conducive ready-made organic matters may be to these ends, there seems to be no good reason for doubting that every organized being is quite competent so to separate and recombine, by the consecutive processes of assimilation and deposition, the elements of many inorganic matters—at any rate when these inorganic matters contain all those elements which are presumed to be in requisition—as to form the immediate materials of its own tissues. Nay there is some reason to believe that even organic matters are entirely decomposed and recomposed by this double process ; so that it is perhaps only by affording the precise elements, and those in the precise proportions required, that such matters are best adapted to the purpose. The principal organs which minister to the process of assimilation in animals—for plants have no specific apparatus for the purpose (*a*)—are the gullet, stomach and intestines, with their appendages ; but in quite the lowest tribes, the alimentary matters are received and assi-

were, of every kind of food was primarily the same, or that it only became so when acted on by the assimilating powers, is a question. The supporters of the molecular doctrines however choose to take the axiom in the former sense. " La matière," says Buffon, " qui sert à la nutrition et à la reproduction de tous les Animaux et de tous les Végétaux est la même ;" (*Hist. Nat.* 1750) thus abolishing, at a word, all the above proposed distinctions.

(*a*) Saussure. (*Rech. Chim. sur la Végétation*, 1804, p. 264) Hence we may say, with Hippocrates, that the soil is the stomach and intestines of plants—" Ventriculus sicut humus"—or, with Aristotle and Boerhaave, that the vessels of their roots are analagous to the chyliferous vessels, a part of the circulating system, of animals, which comes to precisely the same thing, both propositions serving equally to withhold from plants any proper assimilating apparatus. They *select* rather than assimilate.

milated, as well as when assimilated turned to their proper account, by the indiscriminate spongy mass of which they are composed.

Between all the above-mentioned actions of organized beings, which minister exclusively to the preservation of the individual, there is a fixed and determinate relation, nor is it severally and after each other, but, as far as possible, all together, and with and through each other that they should be contemplated; the remark already made that "while each organ is itself more or less dependent on the rest, it conduces in a greater or less degree to the perfection of all," being applicable to the fullest possible extent to all those which are concerned in the functions now under consideration, (*a*) and this quite independently of the healthy action of each contributing by sympathy, as it also does, to the healthy action of all the others. Thus unless the respiratory organs were continually supplied with the crude fluids from those of circulation, absorption and assimilation, they could not act reciprocally with the surrounding medium, and thus prepare the mature fluid; unless the organs of circulation and deposition were equally constantly supplied with the mature fluid from those of respiration these processes must stand still; and, if such were the case, neither could absorption go on, and whatever alimentary matters were received could never be assimilated, so that the supply of crude fluids would in consequence be cut off from the organs of respiration.

Such however is the economy of organized beings that those very actions which are directly subservient to their preservation, besides entailing upon them many gradual changes by their continuance, and many accidental maladies, indirectly tend to exhaust and destroy them; and it is a law therefore of this economy that every individual plant and animal, having, in a period more or less definite for each, attained its acme of perfection, begins to decay, and each at length—from the insect which perishes within the hour, to the tree which survives the revolutions of centuries—ceases to exist. (*b*) To die then is as

(*a*) It is to this circle of actions alone that the well-known beautiful saying of Hippocrates, with respect to the functions in general—Πάντα ὁμόιως ʼΑρχη, κὰι παντα Τελευτή—(*De Locis in Homine*)—is strictly applicable.

(*b*) The age which animals in general attain is commonly estimated as between characteristic of organized beings as to live; and, paradoxical as it may appear, it is in fact from a distinct vital process that death in all cases immediately results, and in all forms of such beings, in proportion as the other vital actions are sluggish, the supervention of death is tardy and gradual. (*a*) Inorganized matters, sustaining no changes of this kind by any inherent actions, and incapable of becoming extinct, are of course unprovided with any inherent means of perpetuating their kinds, and the existence of each is quite independent of the pre-existence of any other. On the other hand organized beings, certain as they are to become individually annihilated, are provided with the means of forming and separating from themselves at definite periods certain organized parts, which, becoming at length new beings of the same species, constitute another and another generation, so that, while individuals perish, the race is perpetual. (*b*) The principal organs which minister to the process of generation are, in plants in general, the pistils and stamens, and, in animals in general, both oviparous and viviparous, the ovaries and testicles with their respective appendages; but in quite the lowest tribes of organized beings, which are without sexual organs, no equally specific parts are appropriated to this function, their propagation being effected, sometimes by a spontaneous division of themselves into distinct beings, when they are called fissiparous, and at others, as in the gemmiparous tribes, by the detachment from some part of their bodies of shoots, which become ultimately possessed each of an independent existence. What is properly called

seven and eight times the period which they take to arrive at puberty; consequently Man is one of the longest livers, at least of mammals, the Whale being among the few which surpass him in this respect, as sometimes reaching, it is said, the age of 300 or 400 years. Aquatic animals indeed perhaps in general live longer than terrestrial; the Carp—*Cyprinus* 35—for example, often attaining, it is said, the age of 100, and the Pike—*Esox* 34—sometimes that of between 200 and 300. Among trees the Lime is computed to have arrived at the age of 580 years, the Cypress of 900, the Oak of 1600, the Yew of 3000, and the celebrated Baobab tree of Africa of 5150; so that it is not improbable that "some individuals now existing may have been silent witnesses of the Noachian deluge."

(*a*) A late Professor of the Institutions of Medicine in the University of Edinburgh, no less estimable in every other capacity than tiresome as a teacher, was accustomed to incur a great deal of unmerited ridicule by prefacing his Lecture on Dissolution, with the remark that he had now to treat of "the last function—Death." He was perfectly correct in his definition.

(*b*) "We love," as is beautifully remarked by M. Virey, "because we do not live for ever. We purchase Love at the expense of our Life."

generation then is the formation or deposition by organized beings of other organized beings capable of assuming the likeness of themselves, whether thousands of millions, as in many fishes, or one only, as in Man, be at once so formed; but it is not certain that they have not the power also of forming in a similar way many other organized beings distinct, as well from themselves, as from each other. Of this nature are probably parasites: and when we consider that not only every animal, but almost every organ of every animal has its own proper parasites and no other; (*a*) that other, if not living animals, at least living tissues, such as tubercles, encephaloid tumours, melanoses and scirrhi, are certainly the products of a specific deposition, and that it is more than probable that all these were at first a kind of parasites, (*b*) possessing each its own rudiments of organic structure, and only by an ulterior process establishing an imperfect connection with the contiguous parts; (*c*) and that at least one kind of parasites, namely hydatids, are often found in parts which are known to have suffered contusions, and have even been artificially produced by this means, (*d*) we may be excused if we feel disposed to entertain the belief that the parasites of animals *may be* as much the product of secretion as their own proper progeny. And this belief may be still further strengthened perhaps by observing how totally untenable are the various other hypotheses which have been at different times advanced to explain the production of parasites. Of these one is that they are received into the body with the aliment &c. in the form of ova, deposited either by animals the natural habitat of

(*a*) Thus Man is liable to twelve proper entozoa—one in the lungs, six in the intestinal canal and its appendages, one in the urinary organs, one in the ovaries, one in the integuments, one in the eye, the brain and the muscles, and one lastly in any organ except the intestinal canal—all quite distinct from numerous other animals which are reported to have been passed sometimes from the stomach, urinary bladder, uterus, skin and other organs, and the source of all which was in all probability really received ova. Again the Sheep—*Ovis* 48—in its several organs is liable to nine proper parasites; the Ox—*Bos* 48—to eleven; the Horse—*Equus* 49—and Hog—*Sus* 49—again to nine; the Hare—*Lepus* 51—to eight; and the Fox—*Canis* 54—once more to nine. Birds in general have about seven. Among reptiles, the Frog—*Rana* 37—is liable to eight; and among fishes, the Salmon—*Salmo* 35—is liable to eight; and the Perch—*Perca* 36—to seven. Almost every organ also of every avertebrated animal seems to be distinguished, in like manner, by its own proper parasites.

(*b*) Justamond, Adams, Carmichael, Baron, Fosbroke &c.

(*c*) J. Hunter, Doëllinger, Gruithuisen, Meckel, Béclard, Lobstein, Hastings &c.

(*d*) Bremser.

which is without, (*a*) or by the proper entozoa of other animals previously passed from their bodies; (*b*) another, that such ova are conveyed directly from parent to offspring, either while in utero along the umbilical cord, or after birth with the milk, having been at all times a proper constituent part of the body of the former; (*c*) a third, that the said ova are evolved simultaneously with the proper ovum of the being which is to contain them, the former having from the first existed within the latter (*d*)—but not one of these hypotheses will bear a rigid examination. On the other hand if we admit that the proper progeny of an animal is formed in the ovaries or corresponding organs, of which it constitutes the natural and proper secretion, there seems to be nothing irrational in the idea that these parasitical beings may be laid down in numerous organs, differing in each like the various other secretions of these parts; and the fact that they do so differ according to the organs in which they are found seems to furnish a strong support to the doctrine in question. (*e*) It is indeed difficult to understand how persons who believe that living animals have the power of constantly renewing by secretion their own natural organized tissues, or even whole organs, as well as of depositing such as are altogether preternatural, which, at first isolated, become united with the parent tissues only subsequently, can be startled at the idea of their secreting either their own proper progeny, or their own proper parasites. But it is only one of the innumerable evils into which the want of a proper idea of the nature of Life has led physiologists,

(*a*) Leeuwenhoek, Linnæus, Andry, Boerhaave, Hoffmann &c.

(*b*) Pallas, Reinlein, Brera, Rhind &c.

(*c*) Valisnieri, Goëze, Bloch, Werner &c.

(*d*) Haller, Bonnet &c.

(*e*) This hypothesis, although stupidly regarded by some people, as Bremser says, "presque comme un blasphème," is adopted by him, as well as by Rudolphi and other celebrated helminthologists. It is proper to remark however that, although it is *de novo* that entozoa are formed, according to these authors, in the animals which contain them, and they therefore result from secretion, still this secretion is not, they imagine, that of substances organized from the first in the manner of newly deposited tissues, but of an inorganized mass, which, upon its spontaneous separation, gives rise to new living beings upon the principle of organic molecules lately spoken of. To the objections to these doctrines it is unnecessary to recur at present. Every view of the matter seems to favour the presumption that every new animal, as well as every new part of every animal, is laid down first as a kind of organized germ formed by secretion; and that the axiom "Omnia ab ovo," in this extended sense of the word, is still unshaken. Respecting the first creation of parasites consult Mr. Kirby. (*Bridgewater Treatise*, 1835, vol. i. p. 12) that the doctrines respecting generation in all its forms have been more vague and visionary than those respecting almost any other function of the body. They think they can comprehend the expansion of a living Principle over a larger or a smaller area; but they cannot understand the creation by one living being of a new living Principle, such as is presumed to be necessary to vivify another. The difficulty however is an imaginary one. There is no creation of a living Principle in the case, nor is there any "Univocal generation," or communication of such living Principle from one being to another; but only such a new combination of matter by secretion, as necessarily developes one of the conditions of Life, namely vitality, and this, when acted on by the necessary stimuli, gives rise to those phenomena in which Life consists. (*a*) Whatever opinion however we adopt with respect to the source of parasitical animals it must lead equally to the conclusion that the existence of every organized being implies the pre-existence of some other, either of the same or of a different species, and thus to the establishment of a broad line of distinction between them and inorganized matters.

The several functions then thus summarily run over may be represented as primary and essential, and said to constitute the main revolving wheel, as it were, of the Organized machine; and however numerous may be, in the more perfect kinds of this machine, the minor wheels which are called at second hand and incidentally into play, it is upon the movements of this that those of all the rest are dependent. *Accordingly in the Diagrams in the Title, which are intended to illustrate the mutual relations of the functions of the higher tribes of organized beings, these characteristic actions of all such beings are represented as constituting the lowest of the erect wheels, to signify their fundamental nature, and at once their independence of all other actions, and their instrumentality in supporting those additional actions which the higher tribes alone of such beings display. These additional actions are those in which sensation, thought and voluntary motion*

(*a*) "It is absurd," says Mr. Bushnan, in a very succinct and clear account of the various hypotheses which have been advanced to explain the origin of parasites, "it is absurd to talk of finite beings creating any thing, but it is worse than absurd to talk of their creating that which has no existence." (*Account of Worms found in the Vein of a Boy*, 1833) *consist, and which are represented in these Diagrams as constituting the three other erect wheels; but into a consider ation of these adventitious functions, it is inexpedient to enter at present, since, as before observed, they appear to require some other conditions besides those which alone are essential to the foregoing, and which it is our business now to investigate.*

CHAPTER II.

ON THE NATURE OF LIFE.

It is in the sum of those actions of organized beings which have been above described as fundamental, whether any others be added to them or not, that Life appears essentially to consist. Organism and Life are, under ordinary circumstances—in other words, under the application of the requisite stimuli—coincident, the commencement of the former producing generally that of the latter, while the cessation of the former gives rise always to that of the latter also; and if we retrace all that has been said respecting each particular feature in the Structure of organized beings—their individuality and definite form and volume, the multiplicity of their distinct organs, the co-existence in them of solid and fluid parts each in a constant state of mutual conversion, and their specific chemical nature—we shall find that every thing relating to their Organism or Structure has a direct relation to their Life, or the Actions which they are to perform. Organism and Life then, in this sense of the latter term, may be described as standing in the relation indirectly of cause and effect to each other, the former giving rise essentially to the development of a certain property called Irritability or Vitality, which, when acted on by certain Stimuli, generally in more or less constant operation, produces those Actions in the sum of which Life consists. This relation then of the two may be represented by the following plan.

Organism.

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Irrritability or Vitality. Certain Stimuli.

Life = Living Action.

This view of the matter however has not always, nor even till of late generally been taken; the Structure of organized beings having been admitted indeed to be identical with their Organism, but not their Actions with Life; and while it has been allowed that this Organism and these Actions are commonly coincident, it has been denied that they stand, either directly or indirectly, in the relation of cause and effect to each other, both being described as dependent on Life as a substantial Principle. The following plan may represent this relation of Organism and Life.

LIFE = Vital Principle.

Organization. (producing Organism) Living Action.

It is hence obvious that the word Life is employed in two very different acceptations, signifying sometimes merely that chain of peculiar actions above-described as characteristic of organized beings, the immediate conditions of which are to be sought for, partially at least, in a necessary result of organism; and sometimes a substantial Principle—an Entity, whether material or immaterial (*a*)—which, entering certain aggregations of matter, regulates as well their organization—whence results their organism—as all the other phenomena which they exhibit. (*b*) The questions then arise, 1st. What evidence have we

(*a*) It would not have been considered necessary to remind the student that the existence of an immaterial substance—of an οὐσια ἀΰλος, as well as a ὕλη—has never been regarded as an impossibility, had not some recent writers seemed to imply the reverse. Dr. Bostock, for example, accuses Mr. Mayo, to the correctness of whose general phraseology he at the same time pays a merited compliment, with having controverted his own proposition in the very statement of it, where he says, "Mind and matter are logically distinct substances." (*El. of Physiology*, 1825, vol. i. p. 301) Whether they be so or not may be questioned; but it is at least certain that they may be so.

(*b*) In ancient times Life in the former of these senses was called by the Greeks Ζωή, and by the Romans *Vita;* in the latter, by the Greeks Ψυχή, and by the Romans *Anima.* We have unfortunately no single term by which to designate the supposed substantial Principle, if we employ the word Life to signify merely the chain of actions, and no one by which to designate the chain of actions, if we apply the word Life to the supposed substantial Principle. We can do better however without a name for a Principle which pretty certainly has no existence, than for actions which certainly occur. In these two acceptations then the word Life, not only has two totally different meanings, but implies two totally different views of the subject at issue; but there is still a third acceptation in which the term is sometimes employed, distinct from both these meanings, but nevertheless quite consistent with the former of these views, the only difference consisting in this, that whereas the term, as used above, signifies Living action, it is employed in this new meaning to signify irritability or vitality—one of the conditions of this action. Such is the meaning attached to the word Life by Dr. Elliotson, who says of it that "it is used sometimes properly for the power, (property) sometimes improperly for the result." (*Human Physiology*, 1834, p. 31) In the mere application of a term however where the proposition sigof the existence of any such substantial Principle? and 2ndly. How far is it adequate, admitting its existence, to explain vital phenomena? (*a*) If we fail in establishing, both its existence, and its adequacy to produce the effects which have been ascribed to it, we must acquiesce in the proposition first advanced, that Life is a mere abstract term used to denote the characteristic actions of organized beings resulting more or less immediately from their organism.

First then with respect to the *Existence* of a Vital Principle, or of Life as a substance. The evidences commonly adduced in favour of this hypothesis hinge principally upon the presumed impossibility of explaining either the original organization of a living being, or its characteristic actions when organized, without this admission, and the incompatibility of the opposite opinion with a belief in a future state of existence: (*b*) on the degree of validity therefore of each of these

nified is the same, that must surely be the best which is the most usual; and as the term Vitality is by general consent appropriated to one of the conditions of living action, and the term Life to this living action itself, the employment of the term Life to signify vitality has only the effect of giving us two terms for the property, while it deprives us of any term at all for the result of it, and is calculated to give rise to a great deal of logomachia which might very well have been avoided. Let it not be imagined however that because in this instance the whole point in dispute hinges on the definition of a word, the same is the case in the two acceptations of the word Life previously proposed; for, while no difference of doctrine exists whether the term Life be used to signify living action or vitality, since both are parts of one doctrine, a fundamental difference of doctrine is conveyed by the acceptation of the word Life in the sense of Vital Principle, no such substance as this being in the former case admitted.

(*a*) It is a rule of the immortal Newton, of which we are aptly reminded by Dr. Prichard, in entering upon the present discussion, (*On the Vital Principle*, 1829) "Causas rerum naturalium non plures admitti debere, quam quæ et *veræ sint*, et earum *phænomenis explicandis sufficiant.*" (*Principia*, lib. iii)

(*b*) That Life is an Ουσια, an Entity or a Substance, material or immaterial, resident in certain aggregations of matter, and the cause both of its organization, and of the characteristic actions which it afterwards performs, is the oldest opinion on the subject, having been entertained by almost all the ancient sects of philosophers. The notion of the existence of an Elementary Fire—the Soul of the world, the formative and conservative Power of all nature—descended from the Brahmins of India, through the renowned Hermes Trismegistus, or Tot of glorious memory, and the Pastophori of ancient Egypt to Thales and Pythagoras, the former of whom studied at Memphis, and subsequently taught philosophy at Miletus, while the latter studied at Thebes, and taught afterwards at Crotona. It thus became the tenet of the numerous schools which, in later times, flourished in Greece and Italy—the Academic under Plato, the Peripatetic under Aristotle, the Stoic under Chrysippus, and so forth. By the "learned Theban" indeed this Πῦρ καθάρσιον of the Egyptians had its name changed to Φύσις, while by Plato it was called for the first time Ψὴχὴ, by Aristotle Εντελέχεια, and by Chrysippus Πνεῦμα. Nor were the opinions of alleged evidences it will now be necessary to say a few words.

these and other celebrated philosophers, respecting the nature of this imaginary substance, less discordant than the names which they imposed upon it; some looking upon it, like the original propagators of the doctrine, as a kind of Fire, others as a kind of Air, or Ether, or Spirit—the Breath of life &c.—and others again as merely a kind of Water. (*Ciceronis Tusc. Quæst.* lib. i, § 9, 10) But, whatever were its nature, this supposed substance actuating, as was believed, the Macrocosm or universe, of which it regulated all the motions in the capacity of Life or Soul of the world, was capable of being split or divided into innumerable portions, so that each individual Microcosm or organized being got a chip of it—a *Divinæ particula auræ* —and this, in quality of its proper Life, in like manner actuated and directed all its proceedings. This idea of the Vital Principle, in its character of Fire, has been immortalized by the story of Prometheus, who is said by the poets to have vivified his clay statues by a fragment of it stolen from the chariot of the sun; and a similar notion was embraced by all the early physicians. Thus by Hippocrates the human body is described as consisting, not merely of ἰσχοντα and ἰσχομενα, of which notice has been taken already, but of ἐνορμοῦντα also, which seems to signify nearly the same thing, or the same nothing, as any one of the terms above specified—so much so, that Galen subsequently again employed, instead of it, the term πνευματα, from Chrysippus. These πνευματα, he split, as lately mentioned, into three families, under the names respectively of Vital, Natural and Animal Spirits, to each of which he gave, as well as a "name," a "local habitation"—the first being placed in the heart, the second in the liver, and the last in the brain; and thus conferred a most essential favour on the subsequent physiologists of the Vital Principle school, by supplying them with a most convenient Θεὸν ἀπὸ μηχανῆς, to be always conjured up when any difficulty was to be explained, or at least disposed of. In this way then Life came to be regarded as a substantial Existence, like that coarser kind of Fire which was one of the four reputed elements of all things; and as the latter, when it entered into bodies, was represented as the cause, as well of their general physical properties, as of the peculiar phenomena which they displayed during combustion, so the former, on becoming a denizen thereof, was described as the cause, first of their organization, and afterwards of the peculiar actions by which, when so organized, they were distinguished. And this view of the matter was perhaps the most natural to Man in the infancy of Philosophy, impressed as he was, from the first, with the idea that all matter—at least all the grosser forms of it—were essentially inert, and of course disposed therefore as he was, to ascribe all spontaneous motion to a union with the thing moved of some substantial moving cause. It was not easy even for the most exalted geniuses, with so limited a knowledge as they then possessed of the essentially different properties resulting from differences in the composition, substance and aggregation of different forms of matter, to do otherwise than attribute the distinctive actions of organized beings to some hidden Principle operating within them, of which inorganized matters were destitute; but it might have been expected that such vague surmises as this would long before this time have sunk under a more enlightened Philosophy, and that Life as a substance would long since have shared the same fate as Fire as an element. Such however has not been the case, the notion that Life and living action are quite distinct, the former being the substantial cause of the latter, having descended from the authors above enumerated, through Van Helmont, Harvey, Borelli, Perrault, Stahl, Carl, Coschwitz, Swammerdam, Whytt, Sauvages, Bordeu and Barthez, to Plenck, Platner, Hufeland, Sprengel, Schmidt, and other writers of the close of the last century. From these it has been transmitted unadulterated by Abernethy, Lamarck, Pring, Barclay, Good, Davies, Bell, Prout, Kirby and others, down to our own times; and we are still condemned to hear the terms Vital Spark, Vital Spirit, Vital Principle and so

If organism, it is confidently asked by most of the supporters of the Vital Principle doctrine be, either directly or indirectly,

forth continually used, not only by the vulgar, but by philosophers of eminence, as referring to something which has confessedly a real and substantial existence, and the human body is still sometimes described as consisting of solids, fluids and a Vital Principle, almost in the same words as were employed between two and three thousand years ago by Hippocrates. Of course the said Principle has acquired in its progress some new names, as in the hands of Van Helmont, who, as he could not of course use any term which had been employed by Galen, called it Archæus, a term borrowed from Paracelsus; and, instead of being shorn of any of its blushing honours, has even been invested with higher attributes than of yore, as in the hands of Stahl, who very much extended the powers of the ancient Ψυχὴ or Anima, to which term he had, after Harvey, returned. The term Vital Principle originated with Barthez, and was invented to signify something distinct from either mind or body, but nevertheless in all probability subsisting by itself, although he confessed that he could not determine "whether it were a substance, or only a mode of the living body." Whytt has been called a semi-animist—a half-stahlian. Barthez may perhaps with equal propriety be called a semi-substantialist—a kind of stepping stone between the Entity and Non-entity schools. John Hunter was perhaps the first to identify the Vital Principle with Electricity or Galvanism. It has been denied by some that John Hunter was really one of the Subtle fluid persuasion, (*Ann. of Med. and Surg.* 1817—*Lawrence's Lect. on the Physiology of Man*, 1819) and it is quite certain that his "Materia Vitæ," which was the solid nervous substance, was nothing of this etherial nature. But this was with him only the material domicile of Life, not Life itself, which, in as far as he identified or associated with Galvanism, he certainly made a fluid of the nature above described. With respect to the modifications of the doctrine which maintains the existence of Life as a substance by those who have most recently written on the subject—and it seems quite superfluous to go further back than the present century—Mr Abernethy, who treads everywhere so closely in the footsteps of John Hunter, believes of course that Life is, if not identical with, certainly analogous to Electricity or Galvanism; (*On Mr. Hunter's Theory of Life*, 1814) but the refutation of this unfortunate hypothesis may be advantageously deferred till the subject of Electricity or Galvanism, as a stimulus to irritability, falls to be considered: in the mean time it is sufficient to say of it, that any thing more vague and visionary has never hitherto obstructed the progress of physiological science. Of the same stamp is the hypothesis of Lamarck, that Life is a compound of Electricity and Light. By Dr. Pring on the contrary the Vital Principle is represented as a substance quite sui generis, and he speaks of a "sum and quantum of Life," with as much confidence as if it could be meted out by the help of a pair of scales, or a glass measure; while it is an inference from his hypothesis, that, as Life is on the one hand a cause of organization, so organism is on the other a cause of Life, since the substance of Life is continually renewed, he assures us, "by the assimilation of its identity from the blood." (*On the Laws of Organic Life*, 1819) But if the substance of Life be renewed from the blood, it must either have entered the blood in propriâ personâ with the food, in which case the said food ought to be alive, or it must have been formed by the blood, in the manner of a secretion: and from what ingredient of the blood secretion can produce *de novo* a simple substance, material or immaterial, remains to be explained. But perhaps the substance of Life is not simple—and indeed we are told that "the influence of Life is to separate from the blood those elements which constitute its own identity;" and elsewhere, that "animal heat is a part of the Principle of Life." *Elements* and *parts* of a *Principle—material ingredients* of that which even those who look upon it as substantial still generally consider as *immaterial!* But it is mere waste of time discussing such "verba et voces prætereaque nihil" as these. Dr. Barclay's work, the cause or one of the causes of Life, what is the cause of organization, or that process from which organism itself

(*On Life and Organization*, 1822) extolled, as it has of course been, by those who advocate similar opinions, consists, not so much of a statement of arguments in favour of the existence of Life as a substance, as of a parade of authorities on the question whether Life be the result of organism, or organization be the result of Life —a question only indirectly connected with the one at issue, since, although most of those who contend for the existence of Life as an entity adopt the latter opinion, there are of them, as elsewhere observed, who still imagine, like all those who deny this existence, that organization is independent thereof, and believe that Life does not enter the being till its organization has been effected. Dr. Barclay is not one of these; but presuming on the existence from the first of a substantial Principle, which may be called indiscriminately Vital, Sensitive, Rational or Immortal—a most unfortunate, but not very unusual jumble—he indulges in a tirade of somewhat captious abuse of the head and heart of every body—in particular of Blumenbach, Cuvier, Cabanis and Lawrence—who presume to differ from him, and whose tenets he vaguely conceives likely to interfere with "the raptures of Moses and the Lamb." (p. 399) Dr. Barclay was an excellent anatomist and an excellent man; but as good anatomists and as good men as he have entertained, and still entertain very different sentiments on these matters. In the same track follows Dr. Mason Good—a name hardly less notorious in physiology, than eminent in literature—who, in ridicule of the doctrine that Life has no real existence, which had become by this time rather inconveniently prevalent, facetiously remarks, "the human frame is hence a barrel organ, possessing a systematic arrangement of parts, played upon by peculiar powers, and executing particular pieces or purposes, and Life is the music produced by the general assemblage or result of the harmonious action." (*Study of Medicine*, 1825, vol. iv. p. 44) He could not possibly have illustrated the nature of Life, consisting as it does in the proper actions of *organ*-ized beings, more happily—"We thank thee, Jew, for teaching us that word." Dr. Pring instructs us only how the substance of Life is continually renewed; but Mr. Davies in some otherwise excellent papers in a medical journal teaches us how it is subsequently disposed of, assuring us that "it combines with the structure by means of affinity, as well as forms that structure by the same power," (*London Medical Repository*, 1827) a circumstance which it must be extremely gratifying to every body to be aware of, particularly as it is so satisfactorily demonstrated. Dr. Alison in his recent work avoids, perhaps judiciously, entering into any discussion respecting the nature of Life; a word which "does not," he inadvertently observes, "denote a simple idea, and therefore cannot be defined," (*Outlines of Physiology*, 1831, p. 1) a diametrically opposite reason being offered with more propriety a little further on (p. 151) for not attempting a definition of sensation or thought. He is obviously inclined however to regard Life, not indeed as any thing material, but still as an entity, since he describes organization as one of its effects; and accordingly we find his reviewer stating, in opposition to the more modern opinions concerning the nature of Life, that "it is a sad confusion of all etiological relations, which ascribes to the passive and naked effect the very existence of the agent to which this effect owes its being." (*Medico. Chir. Review*, 1831) Still more recently also Mr. Thomas, in allusion to the same doctrines, has observed, "We have first the effect, and secondly the sum total of the effect entering into an unnatural conspiracy to produce, by an ex-post-facto operation, a cause for an antecedent operation." (*Liverpool Med. Gazette*, 1833) Now this is precisely what we *have* in the entity view, and what we *have not* in the non-entity view of the matter in question; for in the former we have first Life (Ψυχὴ) represented as forming the structure, and then the structure represented as forming Life (Ψυχὴ), whereas in the latter Life is admitted as an effect alone—as a Ζωὴ; and it is only therefore upon the unjustifiable petitio principii that life exits as a Ψυχὴ—the q. e. d.—the very point resulted? Can any known chemical or mechanical forces give rise to so specific a composition, so complicated a substance, so heterogeneous an aggregation, and so determinate a body, as those which characterize an organized being? It has been conceived indeed even by some of the supporters, on other grounds, of the doctrine in question, that such may be the case, and that the substantial Life may not perhaps enter such a being till it has become organized by other means; (*a*) but it may be safely conceded to the most unqualified substantialist that no chemical or mechanical powers are competent to produce such an effect. It has been already shown at some

at issue—that these objections are founded. here needs no ghost come from the dead to tell us that an effect cannot be the cause by which that effect was produced; but had the opponents of the latter view of the matter understood the doctrine which they impugn, they would have known that Life is regarded by the advocates of this doctrine, not as a cause of vital action, but as identical with it, the cause being the co-operation of a certain property and certain powers, both quite distinct from Life in either sense of the word. Sir Charles Bell, Dr. Prout and Mr. Kirby (*Bridgewater Treatises*, 1834) are among the latest authors who have contended for the existence of a substantial Life, but they have adduced none but the usual arguments in its favour; and the last is more than usually mystical upon the subject. Upon the whole, that there is any evidence whatever of the existence of Life as an Entity, those who maintain the opposite opinion are satisfied with denying, the onus probandi resting of course with those who support the proposition. It might otherwise be shown that the admission of this hypothesis brings with it many more difficulties than it removes; and that innumerable phenomena, which are easily explained without it, become quite inexplicable if it be admitted: but it is idle making giants merely for the purpose of killing them. It may appear, and indeed it has been lately remarked by Dr. Clark (*Report on Animal Physiology, read to the British Association at Edinburgh*, 1834) that the views of most of the authors above cited from Aristotle downwards are in fact nearly the same as those at present generally entertained, and that if we substitute the word Property for Principle, and the word Vitality for Life, there is no essential difference between the two. It must be remembered however that in the more modern view of the matter this property is never regarded as *substantial*, nor ever as *per se sufficient* for the display of vital phenomena—points, which appear quite sufficient to constitute a fundamental difference between the two. The acrimony with which the contest has been sometimes maintained might be supposed to furnish of itself sufficient proof that the opinions entertained were not at all reconcileable, did we not know that the most acrimonious disputes have frequently been those in which the question was *de verbo*, and not *de re*—but this is not the case in the present instance.

(*a*) This appears to have been the opinion of not a few of the authors lately enumerated as advocates of the Vital Principle doctrine, and the list might have been swelled with the names of Descartes, Needham, Darwin, Priestley, Fray and many more; who, while they in general ascribe the proper actions of an organized being, when formed, to the presence of such a Principle, still consider its formation to depend upon certain chemical affinities, formative appetencies and so forth, quite independently of its operation. The general question however at present is—not whether Life, considered as a substance, perform *all* that has been attributed to it—but whether it be a substance at all.

length that the chemical composition of organized tissues is quite distinct from that of inorganized compounds; and consequently the first step towards organism must require powers different from those by which inorganized matters are formed. It requires Life, but not a Living Principle. It requires the Life, or living action (Ζωη) of the thing *organizing;* not any Living Principle (Ψυχη) in the thing *to be organized.* It has been expressly stated lately that organized beings can be formed only by such as are already organized, the existence of any one implying always the pre-existence of some other; and that the forming and separating from themselves, each in its generation, such new beings is one of the characteristic actions —that is to say a part of the Life—of plants and animals in general. The organization then of the embryo, or the process by which a new being is formed, possessed of organs however rude, and in virtue of its organism indued with irritability or vitality, is the work of the parent. Nor does there appear to be any greater difficulty, as at the same time observed, in conceiving this particular application of the process of secretion, than in understanding that by which every organized being, not only continually renews, in proportion as they are removed by absorption or other means, its own natural organized tissues, and sometimes whole organs, but also frequently deposits new ones, each of which is equally indued with irritability or vitality, as those germs which are the rudiments of beings of a future generation. Nay the difficulty is, in fact, less in the case of such germs, than in that of what are called new growths in general; since in the former case we have to comprehend only the organization, or the formation by secretion of the rudimental structure in question, whereas in the latter we have to comprehend further the mode by which, at first distinct, as already stated, from the parent animal, it subsequently becomes a part of it. The germ then so formed by a vital action of the parent, and possessed in virtue of its primordial organism of the property of irritability or vitality, maintains from the first, by the co-operation of this property and the natural stimuli by which it is excited, a series of actions constituting its Life; and it is by one modification of these actions, effected by a supposed specific force, which has been signalized by the name of plastic power and so many others elsewhere specified, and not by any substantial Vital Principle, that its full elaboration is effected. It is by this that in animals are formed, by means of the parenchyma laid down from a very early period in the apparently homogeneous germinal membrane, first the three principal layers of the latter, and subsequently all the tissues and organs of the body in a certain definite series; so that, though the organization of the embryo was the work of its parent, its organogenesy is its own, and parts which it received from the former in a state of diffusion and ambiguity, itself renders concentrated and determinate. But if the embryo be thus organized by its parent, how, it may be asked, was the first parent organized? If the first egg were the product of a bird, how was the first bird produced? With this problem the physiologist, in the strict sense of the word, has nothing whatever to do. The Almighty Creator—the first and the last—willed that, not only the inorganic, but the organic kingdom of nature should exist; but how either the one or the other was originally called into being He alone knows who said "Let there be light—and THERE WAS LIGHT"—

> "Whose word leaps forth at once to its effect—
> Who calls for things that are not—and THEY COME."

Any attempt, by a finite being, to comprehend the process of creation, even in the least of its manifestations, seems to be vain and presumptuous in the extreme. But it may be observed that the solution of the problem, how the first organized being of every species was formed, founded on the presumption that certain aggregations of matter, however effected, became indued in virtue of this aggregation with a distinct property, giving rise under fit circumstances to the phenomena of Life, is at least as simple and satisfactory as that which assumes that it was by Life, as a distinct substance, entering into matter, that these aggregations of it were effected; and that the latter implies a greater infringement of the law *οὐδεν ἐξ οὐδενος* than the former is sufficiently obvious.

But a monad, it is alleged, that is to say, a globule of organic matter or presumed organic molecule, which cannot have even so rude a distinction of parts as is essential to any degree of organism, may still display some of the phenomena characteristic of living beings; and in fact such, it is said, are displayed in the union of these globules—as in the process of constituting the mould and animalcules in infusions of organic matters—to form those very parts, the pre-existence of which is, on the other hand, considered necessary to give rise to irritability or vitality. This objection however to the doctrine which deduces vitality from organism has been incidentally replied to already, by the refusal to admit that these globules are organic molecules, or that it is from a union of them that the mould and animalcules which are developed during the decomposition of organic matters result. Their origin is in all probability, like that of all other plants and animals, from perfectly organized germs; (*a*) nor does their extreme minuteness—and it has been computed that not fewer than five hundred millions of such beings may be contained in a single drop of water—furnish any fair objection to this presumption: nay, for any thing that we know to the contrary, myriads of similar germs may harbour in one such globule of extractive or sodo-albumen as certain authors have been pleased to look upon as a monad. What must have been the size of the germ which is to become an individual of the last generation of Man which is to inherit the earth, if, as supposed by some physiologists of the highest eminence, (*b*) it existed ready-made in the ovary of the first mother; nay what must have been that of the germ which is to become a parasite destined to infest this individual, if this also, as has been likewise conjectured, existed within the former from the creation? But, reconcileable as all this is with the first principles of physical science, by which we are taught to regard matter as infinitely divisible, imagination turns dizzy at speculations like these. The common-sense view of the matter appears to be that every organized being is secreted in a rudimental state by a pre-existing organized being, whether of the same, or, as in the case of parasites, of a different species; that it possesses from the first, not indeed the rudiments of each individual organ as it is in future to appear—a doctrine which is quite incompatible with the frequent metamorphoses which most of these organs are now known to undergo during their progressive development—but a rudely organized structure, in virtue of which it is indued

(*a*) Ehrenberg.
(*b*) Haller, Bonnet, Spallanzani &c.

with a certain property which enables it, when acted on by appropriate powers, to form in the apparently simple germinal membrane all its distinct tissues and organs; (*a*) and that these afterwards, in virtue of the same property acted upon by the same powers, display all the other phenomena of Life, including that of in their turn secreting other organized germs, which, when again acted on in a similar way, again go through a similar process.

It is however chiefly the singular and apparently anomalous nature of the characteristic actions of organized beings when fully formed, which, as it first introduced, so it still serves to perpetuate the vague notion of some distinct substantial Principle as their cause. A corpse which has just ceased to live, that is to say to display any of those peculiar actions in which Life consists—respiration, circulation, deposition, absorption and so forth—cannot, without an effort, be conceived to have undergone so great a change, without having lost something substantial which it previously possessed, and which was the cause of its living. But if we reflect on these actions, anomalous as they appear, what do we find them in fact amount to, but certain movements of either particles or masses of matter, not certainly identical with, but still very analogous to those which, in inorganized matters, we call chemical and mechanical; and which we are contented to ascribe, not to any substantial Principle of action, but to certain properties and powers resident in these matters, the reciprocal action of which gives rise to what are called attraction and repulsion? And why need we hesitate to admit that similar, though not the same properties and powers may, in organized beings, be competent, while they are in mutual co-operation, to effect those actions in which Life consists, and which of course terminate on the cessation of this co-operation, as the ingredients of a chemical compound cease to be agitated when their affinities are satisfied, and a watch stops when either the susceptibility of motion in its wheels is destroyed, or the requisite power ceases to operate upon them? It is true a living being *appears* to require

(*a*) "The Vital power, (property)" says Dr. Clark, "is connected with the matter of the germ in the act of its formation," and elsewhere "The disc is capable of being affected by the matter in its neighbourhood. It is *excited* and it *reacts*." (*Report on Animal Physiology*, 1834) no such repeated additions of new ingredients as a chemical compound, and no such frequent winding up as a watch, to avoid falling into the soon-established repose of the particles or masses of inorganized matter. But we must keep in mind that, in the latter case, while the properties and powers of the substances in co-operation are soon satisfied and exhausted, there is no inherent renewal of these substances, and with them of these properties and powers, to renew their proper actions; whereas, in the former, it is the specific end of some of these actions to give rise continually to new aggregations of matter, distinguished by the same properties, and acted on by the same powers as the old which have disappeared, so that the conditions of continual action are never for an instant suspended. It is not then that there is in living beings no addition of new ingredients, and no winding-up, but that this addition and this winding-up are incessant; and all that death implies therefore is a cessation of these as the necessary conditions of Life or living action, not any abstraction of Life, in its character of a substantial Vital Principle on which such action depended.

But is not, it may be asked, design, such as can be attributed only to some such Vital Principle within them, manifested in the heaving and falling of the chest, the contractions of the heart, and the other sensible motions of various parts, as subservient to the several functions of organized beings; and still more in the various molecular actions, whereby with undeviating accuracy every particle of the machine is removed and deposited precisely at the time, and in the quantity that is required, not only originally to form these several parts—the eye or ear, for example, those finished examples of exquisitely adapted workmanship—but subsequently to maintain each in a state of integrity, ever varying yet ever the same? Undoubtedly; design deep and wonderful, if not indeed in the specific adaptation, *in all cases*, of individual organs to particular functions—for we know that many such functions may be performed in different animals by very different organs—at least in such an association of the collective organs in each individual, that every necessary function is properly provided for. But this design is that of the Great First Cause of all things, who has adapted in every case the physical causes—the immediate means—to the end to be fulfilled; not that of this miserable means, which acts, and can act only in blind obedience to the laws imposed upon it. (*a*) Nor perhaps are the evidences of design really greater in the motions, sensible or insensible, of the organic, than of the inorganic kingdom of nature, nor is the employment of the terms means and end—not merely cause and effect—more appropriate in the former case than in the latter. (*b*) The final causes are often no less obvious in the actions of inorganized than of organized matter. Can we behold the revolutions of the planets—the alternations of the seasons, and of day and night—

> Hunc solem et stellas, et decedentia certis
> Tempora momentis—

at one time the ascent of the waters into the atmosphere, at another its descent in rain or snow—the motions of the sea, the rivers and the springs—the occasional changes on the surface of the earth itself—without recognizing an all-wise and omnipotent design? Nor are the molecular actions here also—the aggregation of a crystal or a stalactite for example, or the feathery condensation of a vapour—less indicative of an end in view in their operation, or of consummate skill in regulating and adapting the means to this end. In the latter class of cases however we unhesitatingly admit that the design is, not that of the means—of the mere so-called forces of attraction and repulsion—but that of the Great Author of these forces; and why should we doubt that the same is the case in the former also? Nor are even the means employed perhaps less intricate and complicated in the instance of inorganized than of organized matter. When we speak of attraction and repulsion indeed we seem to be speaking of simple forces, producing certain actions; but we are in fact speaking of the actions themselves—those of attracting and of repelling—the forces being in both cases quite distinct from these actions, and

(*a*) "To ascribe," says Dr. Prichard, "to the Vital Principle such properties is to invest it, not only with reason and intelligence, but with the wisdom and power of an omniscient Creator, who, if He works by second causes, cannot be conceived to endow them with his proper attributes. Such language is an abuse of words, and contrary to every maxim of philosophy." (*On the Vital Principle*, 1829, p. 123)

(*b*) "Cause and effect," says Dr. Roget, "are concerned only with the natural powers of Matter—means and end involve the operations of Mind in conjunction with those of Matter." (*Bridgewater Treatise*, 1834, p. 22) But such cause and effect frequently imply no less than the operations of an Almighty Mind; and it is impossible that means and end can imply more.

consisting of a property of being attracted or repelled on the one hand, and a power of attracting or repelling on the other. And what more do we contend for with respect to Life than that it is, not a substantial Principle operating as a simple force, but a series of actions, resulting from the property of irritability or vitality operated upon by appropriate powers ? (*a*) There is nothing then in reality more singular in the actions of organized beings than in those of inorganized matters—nothing more indicative of design—nothing more obscure—nothing which stands more in need of a substantial Principle, or resident Entity, to account for it. We may indeed, if we please, in conformity with the views of many philosophers, not only ancient but modern, call these actions of Inorganized matters, chemical and mechanical, their Life ; but then, to be consistent, we must either allow, as the ancients did, a Vital Principle to inorganized matters in common with organized beings, or we must refuse to the latter a Principle of which the former are almost universally regarded in the present day as destitute. It is not contended that we understand the nature of any of these actions—it is not contended that we advance one step towards explaining them by ascribing them to the agents in question. But it is contended that we understand the nature of vital, as well as of either chemical or mechanical action : and that if we are satisfied to attribute the two latter to the agents above specified, as is almost universally done, we cannot without great inconsistency refuse to ascribe the former, which

(*a*) Magendie says it is "une étrange erreur" to compare vital action to attraction, because, while the laws of attraction are well known, those of vital action lie totally concealed. But the latter part of the proposition is not quite true ; nor would it furnish a fair objection to the comparison even if it were. The conditions of attraction do not more certainly exist at present than they did before Newton discovered the laws which these conditions obey, nor do those of vital action less certainly exist at present than they will do when the laws which they obey shall have been fully ascertained. The assumed analogy is between the general conditions of the two, as constituting respectively the proper actions of different forms of matter ; not between the specific laws which they severally obey. With how much greater truth is it observed by Dr. Wilson Philip, " The phenomena of Life are as open to observation and experiment as the phenomena of any of these powers, (i. e. those of attraction &c.) and we possess no information respecting any of them, but such as is derived from the senses. The greater appearance of mystery arises, not from the greater obscurity of the nature of Life, but from its phenomena bearing less analogy to those of the other powers of nature, than these bear to each other, in consequence of which the former are less frequent objects of contemplation." (*Phil. Trans. republished in Essay on Sleep and Death*, 1835) are in every respect so analogous to them, to similar agents, instead of to an imaginary substantial Principle, of the operation of which there is no more proof nor probability in the one case than in the other. Of the immediate nature of physical causes in general we know absolutely nothing, since we are capable of recognizing their existence only by their effects. We know not how or why a certain aggregation of matter called phosphorus should be capable, when exposed to certain agents under favourable circumstances, of exhibiting the phenomena of combustion; or a certain other aggregation of matter called ivory should be capable, when struck by a hard substance, of displaying those of sensible motion. But we know that they do so; and we satisfy ourselves in these instances with stating that the phosphorus is, *qua* phosphorus, combustible, and the ivory, *qua* ivory, elastic, without ascribing to them any substantial Principle of combustion or sensible motion. In like manner we know not how or why a certain aggregation of matter called organized should be capable, when acted on by certain appropriate powers, of manifesting the phenomena of Life. But we know that it does so—that the more perfect is the organism, the more remarkable are these phenomena, and that any change in the former produces a corresponding change in the latter; and what other proof can we require or possess that organized matter is, *qua* organized, irritable or endowed with vitality, and that it is not upon any substantial Principle of Life that these phenomena depend?

But admitting, it may be said, that quite the lower tribes of Organized beings do not display any actions which may not be explained away without conceding to them a substantial Vital Principle, it is impossible so to dispose of some of the more exalted actions of the higher—actions which are surely in no respect analogous to such as are merely chemical or mechanical? If however this sovereign principle can be dispensed with even in those chaotic tribes from which each kingdom of organized nature takes its rise—and to which, since they are often with difficulty distinguished either by their structure or their actions from mineral substances, it can hardly be considered necessary, even by the most determined substantialist—it will be difficult, if not impossible, to say at what point afterwards, in either of the ascending scales, it can be abruptly introduced. For so insidious are the steps by which we ascend from these to the very highest tribes of organized beings, and so slightly superior the actions of each tribe, as we proceed, to those of the one immediately below it, that we are almost compelled to grant that what was unnecessary to the one can hardly be necessary to the other, and that consequently what we denied to the Fungus and Polype must be denied equally to Man. And with respect to the more exalted actions of the higher tribes of organized beings, such as sensation and thought, these have manifestly no immediate connexion with the existence of a Vital Principle; since, while on the other hand they are certainly not a necessary consequence of its presumed presence, so on the other they may be easily supposed capable, where they are manifested, of doing without it. Many races of organized beings exhibit no traces whatever of these actions, and are still alive; and even in those tribes which habitually exercise them, they are always periodically to a greater or less degree suspended, as during sleep, and sometimes totally cease for an almost unlimited time, as in comatose diseases, without prejudice to the Life of the being. Whatever substantial Principle or Principles then we may find it convenient to introduce in order to explain these more exalted actions, it is obvious that they cannot be identical with the one called Life, and that it is not they which

"—— agitant molem, et magno se corpore miscent."

The admission then of one, or even of two such additional Principles, under the names of Sensitive and Rational, would not in any degree imply the existence of that called Vital, as the main agent of those baser actions in which alone Life, properly called, consists. On the other hand many of the arguments tending to disprove the existence of a Vital Principle serve to render it probable, *a priori*, that that of either of the others is also imaginary; and that, as one specific property, namely irritability or vitality, which is common to organized matter in general, qualifies it when subjected to appropriate stimuli to manifest those ruder and less elevated actions which constitute Life, so other specific properties, peculiar perhaps to certain forms only of such matter, may qualify them when properly acted upon to display those more delicate and dignified actions in which sensation and thought respectively consist. But into this department of the discussion it is unnecessary and inexpedient to enter at present.

The third head of evidence commonly adduced in favour of the existence of a substantial Vital Principle is founded on the presumed incompatibility of the opposite doctrine with a belief in the immortality of the Soul. There is in the minds of many persons, not only among the uninformed, but also among the educated, a vague, indefinite kind of impression, that the Vital Principle, the Sensitive Principle, the Rational Principle and the Immortal Principle, are all identical; and that he who denies the substantiality of the first does the same with respect to all the rest. This impression appears to have originated in the ancient complicated absurdity of applying to the three supposed principles of Life, of Sensation and of Thought, and to the one real Principle of Immortality, the same name, as Soul, Spirit and so forth; (*a*) an absurdity which, regulating as it has

(*a*) An attempt was indeed made at a semi-distinction by Aristotle, who, while he confounded together the Vital, Sensitive and Immortal Principles, under the general name of Ψυχὴ or Εντελέχεια, still subdivided this into the Θρεπτικὴ, or simply Vital, and the Αισθητικὴ, or Sensitive and Immortal, and at the same time admitted a distinct Rational Principle under the name of Νοῦς or Φρὴν; and a similar distinction was affected by the Romans, who, while they called the Vital and Sensitive Principles collectively Anima, distinguished the Rational by the name of Animus or Mens. Thus Juvenal—

> "Indulsit communis Conditor illis
> Tantum Animas, nobis Animum quoque," &c.

Galen again tried an arrangement somewhat different, splitting, as before remarked, the Vital Πνευματα into two classes, under the names of proper Vital and Natural, while he packed on the contrary the Sensitive and Rational together, under the name of Animal. None of these proposed distinctions however were ever steadily maintained; and indeed it was impossible that they should be so, thus discordant and irreconcileable as they were. Dr. Barclay indeed coolly argues that they were all unfounded; and that the four substances in question, real and supposed, are in fact all the same. The Immortal Principle he every where identifies with the Rational, as being responsible for the backslidings of the latter; and the Rational again must be identical, he infers, on the one hand with the Sensitive, and on the other with the Vital, for "What," says he, "can it will or think without feeling, and how can sensation subsist without life?" (*On Life and Organization*, 1822, p. 495) Upon such principles as these we might undertake to prove, on the one hand, that a surety is identical with the man for whom he is bound, and, on the other, that the second story of a tenement is identical with the first, and the third with the second, because they cannot respectively subsist independently of each other. Mr. Abernethy had some time before contended against confounding preception and intelligence with mere vitality; (*On Mr. Hunter's Theory of Life*, 1814) and Dr. Prichard rationally concludes that at least the Vital principle and the Sentient, Cogitative and Immortal principle—all which he unfortunately regards as one and the same—"supposing done, as well our most philosophical, as our most familiar expressions on these subjects, has not only always influenced to an incredible extent the ideas of the vulgar, high as well as low, upon these matters, but introduced into the best parts of the writings of even the greatest philosophers upon the subject of Life, so much error and confusion, that we are frequently compelled, while perusing them, to dissent from one half of those propositions in the remainder of which we most cordially coincide, and close their works in general chagrined and disappointed that what, but for this fatal amalgamation, might have been rendered so clear and perspicuous, should have been presented to us only "through a glass darkly." Upon this subject in general however it is sufficient to observe at present that no arguments adduced against the presumption of the existence of a Vital Principle—although, in as far as any arguments can establish a negative proposition, apparently conclusive—bear at all, otherwise than analogically, against that of the existence of either a Sensitive or a Rational Principle; nor do any arguments adduced against the doctrine which teaches that these exist—strong though they be—tend to shake in the slightest degree, either analogically or otherwise, our faith in—our conviction of that of the Principle of Immortality. That the Soul is something entirely independent of either a Sensitive or a Rational Principle, will be as far as possible demonstrated in future; and that it is independent also of a Vital Principle must in the mean time be obvious to any one who considers for a moment that this latter Principle is ascribed indiscriminately to every organized being—a quadruped, a bird, a reptile, a fish, an insect, a worm, a zoophyte, the lowest fungus—while a Soul is imputed to Man alone. The differences in the vital phenomena displayed by the most abject tribes of organized beings and by Man are only in degree; in this respect *Faba est cognata Pythagoræ;* the Principle which we concede to the latter as the cause of these phenomena must be conceded equally to the former; and if in the one case this Principle

"Redit in nihilum quod fuit ante nihil"—

for a moment that both really exist, are entirely distinct in their nature and attributes." (*On the Vital Principle*, 1829) To a similar effect says Dr. Alison, "Whatever notion we may entertain respecting the existence of a Vital Principle, it has no connection with our notion respecting the existence of Mind &c." (*Outlines of Physiology*, 1831, p. 3) if it be in the one case "the be-all and the end-all," it must be so in the other also: so that to connect Man's hopes of immortality with the admission of a Vital Principle within him, is so far from favourable, that it is directly opposed to all the best persuasions of religion, natural as well as revealed. But the hopes and expectations of Man are founded, or should be founded, on a basis infinitely more sure than the supposed existence within him of any such Principle—on a basis proper to him, not common to him and the vilest worm or weed—on the suggestions of his reason, and on the strength of his faith; and as, so long as these actuate him, every other evidence of the existence of a Soul must be superfluous, so, were these once withdrawn, every ether evidence must be nugatory.

So much then for the alleged testimony in favour of the *Existence* of a substantial Vital Principle. The next subject of inquiry, had this been established, would have been how far it might be regarded as adequate to effect all that has been ascribed to it: but into this question, after the express and unqualified denial of its existence above conveyed, it seems quite unnecessary to enter. A successful hypothesis has been compared to a key which fits and opens a lock; but when no part of the structure or motions of a lock are such as to warrant a presumption that there ever was a key, such as has been supposed, made to open it, or that it wants any such key, it seems idle to inquire whether such a key might not be competent, if found, to answer the purpose: we should rather proceed at once to open the lock by such means as its construction and mechanism seem to require, and such as we have immediately at our command. It may be shortly observed however, with reference to this question, that it is utterly impossible to conceive any single Principle or agent capable of effecting *per se* all, or a thousandth part of what has been imputed to this mysterious offspring at once of imbecility and boldness, of helplessness and daring. To resist chemical agency—to keep in constant motion the respiratory muscles and heart of animals, as well as to excite all the other muscles of the body, as occasion may require—to generate heat and cold—to effect every where the continual deposition and absorption of all kinds of different matters—to select or assimilate the aliment—to form and organize germs—to repair wounds and repel and counteract diseases—and to effect innumerable other processes, must require collectively, not only numerous modifications of any common property, such as we may presume to belong to organized beings, but numerous distinct powers to act on this property thus modified; and such actions must be attributed therefore, not to any one self-sufficient substance, however active and however intelligent, but to countless irrational and unconscious forces incessantly at work in every point of the system, in blind but implicit obedience to laws imposed upon them by the Supreme Being, and adapted every where to the end to be fulfilled. (*a*)

Since then the attempts to establish the existence of a Vital Principle as an Entity may be regarded as having failed—not to mention its incompetency to effect the phenomena which have been attributed to it, even though its existence had been established—we seem compelled to acquiesce in the proposed alternative, and to admit that Life is merely an abstract term, used to denote the sum of these phenomena, the forces immediately effecting which are to be sought for, at least partially, in the results of organism. (*b*) It seems indeed easy to con-

(*a*) It is excellently remarked by Dr. Prichard, "The hypothesis of a Vital Principle is a weapon ready to cut any knot, but capable of untying none;" (*On the Vital Principle*, 1829, p. 128) and Dr. Thomson observes that "to employ the term Life or Vital Principle to designate a single cause, power or property of the organized body, upon which the whole of the phenomena of living beings depend, seems as unphilosophical as it would be if, after inventing a term to denote all the various operations on which the motion of a complicated piece of machinery depends, we should fancy to ourselves that a general term so employed denoted a common power from which all these various operations proceeded." (*Life of Cullen*, 1832, vol. i, p. 450)

(*b*) Some faint glimmerings of the true nature of Life had, from time to time, broken in upon physiologists, even during the long period that the Vital Principle doctrines remained formally unquestioned; and it was as illumined by one of these that Mead compared the living body to a machine, endowed with the property of perpetual motion, "owing to its parts being so disposed that, while they performed their respective functions, they constantly and mutually repaired each other." That Life consisted in this motion however had never hitherto been explicitly taught; nor was it till long after the essential condition of this motion, namely Irritability, had been discovered, and the laws which it obeys had been established with considerable precision, that it began to be inculcated that it was in the phenomena resulting from the constant co-operation of this property and the stimuli which act upon it, that Life consisted. Perhaps it was at the hands of John Brown—low as was his condition, vagabond as were his habits, erroneous as were in many respects his views, pernicious as was his practice, and scorned and reviled as is for the most part his memory—that the "Vital Spark of heavenly flame," of which we have been speaking, received its first blow, and a degree of closeness and precision was introduced into physiological and pathological reasonings, of which, so long as men had the free use of this *Deus in fabula*, such reasonings would of course be destitute. It was he ceive that certain forms of matter may be possessed of properties distinct from such as are either strictly chemical or strictly

who distinctly showed for the first time, about the year 1780, that Life as a Ψυχὴ, or Anima, did not exist, being neither matter itself, as the Stoics and Epicureans among the ancients, and Dr. Priestley among the moderns, had supposed, nor an immaterial substance added to matter, as almost all the rest of the ancients, and so many of the moderns, had imagined; but that, as a Ζωὴ, or Vita, it consisted merely in a series of motions performed by organized beings, and resulting from the action of certain exciting powers attached to matter, on a certain susceptibility in other matter of being excited. "In all states of life," says Brown, "Man and other animals differ from themselves in their dead state, or from any other inanimate matter, in this faculty alone, that they can be affected by external agents, as well as by certain functions peculiar to themselves, in such a manner that the phenomena peculiar to the living state can be produced." (*Elements of Medicine*, 1788, vol. i, ch. 2) The whole merit of Brown however consisted in his including the necessity of a second condition—that of the constant co-operation of stimuli—to the phenomena of Life; since he was, in one view of the matter, a confirmed substantialist, denying indeed the existence of *Life* as an entity, but every where speaking of Excitability or *Vitality* in that character. It is unnecessary to say how eagerly this view of Brown's was taken up, and how extensive an influence it had upon the pathological doctrines of his day; nor was it long in making its way among physiologists also. Among the first to adopt it was the venerable Blumenbach of Goëttingen, who, although he has always continued, like many others of the same way of thinking, to use the word Vital Principle, still constantly speaks of it, not as a substance, but as a property—so that the term becomes synonymous in his hands, as the term Life unfortunately is in those of his translator Dr. Elliotson, with Irritability or Vitality—and explicitly asserts that no such actions as constitute Life can take place except when this property is acted upon by the requisite stimuli. (*Institut. Physiol.* 1786, sect. 4) Similar doctrines were promulgated soon afterwards by Soemmering and Reil, the latter of whom describes Vitality as the effect of the form and constitution of matter, and Life as this property in action; (*Archiv. für die Physiologie*, 1796) and they began, about the same time, to be taught in France by Baron Cuvier and Bichât. According to Cuvier—a name still deservedly in the highest repute, not less in physiology than in anatomy, notwithstanding the vituperation of his logic by Dr. Barclay, and the charge of hebetude latterly preferred against him by Geoffroy St. Hilaire—Life consists in "l'ensemble des phénomènes qui ont donné lieu à sa formation;" and he well remarks, that to define it with precision is to run over in detail all the characteristic actions of living beings. (*Leçons d'Anat. Comp.*, 1799) Bichât again describes it, in exactly the same acceptation, as "l'ensemble des fonctions"—unfortunately adding however "qui résistent à la Mort"—unfortunately, because these words, if they were intended to imply that death is anything substantial, are absurd, if only that it is the cessation of Life, superfluous. (*Anat. Gén.* 1801, and *Sur la Vie et la Mort*, 1802) According to Richerand "on appelle du nom de Vie une collection de phénomènes qui se succèdent, pendant un temps limité, dans les corps organisés;" and he further remarks that all the misconceptions concerning the nature of Life "tiennent à ce que, ne voulant pas la considerer comme un simple résultat, les physiologistes l'ont perpetuellement confondue avec les proprietés vitales." (*El. de Physiol.*, 1804, p. 1) The same view of the matter was taken by Cabanis; according to whom, "Vivre n'est antre chose que recevoir des impressions, et exécuter les mouvements que ces impressions sollicitent;" (*Rapports du Physique et du Moral de l'Homme*, 1805, tom. ii, p. 137) and although he also speaks of a Vivifying Principle or faculty, namely Irritability or Vitality, as "la condition sans laquelle les phénomènes propres aux différens corps organisés ne sauroient avoir lieu," distinctly adds "Je suis sourtout bien loin de vouloir conclure affirmativement de ces phénomènes l'existence d'un Etre particulier, remplissant la mechanical—at least, as these properties manifest themselves in inorganized matters—and that, as combustibility and elasti-

fonction de Principe, et communiquant aux corps les proprietés dont leur fonctions résultent." (Tom i, p. 245) In the mean time the same tenets were taken up in Italy, among others, by Rolando, (*Sur la cause d'ou dépend la Vie*, 1807) who beautifully describes Life as "le complement des fonctions," and consequently "un état forcé," they were further maintained in Germany, among many others, by Prochaska and Hildebrandt; and shortly afterwards were adopted by Mr. Lawrence, who was the first to present them in their properly physiological aspect—for by Brown the application of these doctrines had been principally pathological and therapeutical—to the physiologists of this country. Lawrence speaks of the substantial Vital Principle as hastening fast, at the time at which he wrote, to "the vault of all the Capulets;" and, following very closely Blumenbach, Cuvier and Bichât, represents Life as "consisting in the assemblage of all the functions or purposes of organized bodies, and the general result of their exercise," (*Int. to Comp. Anaty.*, 1816, p. 120) a definition which gave rise to the facetious comparison, already spoken of, by Mason Good of the human frame to a barrel organ. These doctrines of Mr. Lawrence, owing to some extraneous leaven with which they were unhappily and very unnecessarily mixed, but which needs not be particularly noticed in this place, were for some time any thing but popular in Great Britain; but they were nevertheless adopted, with some mitigations, by Burns, Gordon, Allen and others, and, not only unmitigated, but in rather an aggravated form, by Sir Charles Morgan. Like his predecessors in the same field, he defines Life to consist in "the sum total of functions which any individual can perform;" but, unlike them, he denies the existence in organized beings, not only of any substantial Principle of action, but even of Irritability or Vitality, as a property essentially distinct from those of which inorganized matters are possessed; "the difference between the two," he says, "being purely formal." (*Philosophy of Life*, 1818, p. 29) To this *ultra* proposition however as applied to the actions, any more than as applied to the structure of the two, in which respect also, as we have already seen, some attempts have been made to identify them, it is impossible to assent. Similar general doctrines were in the meantime advocated in France by Magendie, Broussais, Adelon, Dutrochet, Brâchet and others —in particular by Adelon, who, after enumerating the chief actions of organized beings, says expressly, "ces actions—constituent une Vie;" (*Physiologie de l'Homme*, 1823) and whose three admirable chapters on the Philosophy of Physiology might serve to settle, in all but the most blindly prejudiced minds, once and for ever the question respecting the existence of Life, "comme un Etre réel." (Tom. iv, p. 645) Dr. Milligan, the translator of Magendie, observes, in allusion to the doctrine of a Vital Principle, "the student will do well, in all such dubious expressions by authors, to substitute for Vital Principle the words Vital State or Vital Action." "The primary idea of Life," he remarks, "in our language, signifies motion—and if we analyze the idea, as it arises in our minds, we shall find that an inherent or independent power of motion, accompanied by frequent, actual, appreciable motion, constitutes the whole of our notion of Life, before it is adulterated by the study of the natural sciences, and the writings of philosophers." (*Translation of Magendie's Comp. of Physiol.*, 1823, note to p. 9, l. 16) Mr. Mayo again says, almost in the words of Lawrence, "the term Life is a collective expression for an assemblage of phenomena." (*Outlines of Physiology*, 1827, p. 8, and 1833, p. 2) But the author who in modern times has most systematically and successfully taken up the cudgels against the substantialists is Dr. Prichard, who, after enumerating, in a masterly manner, the chief phenomena to explain which a substantial Vital Principle has been so unnecessarily put in requisition, and showing the polypragmatical and often inconsistent nature of the part assigned to it, concludes "that the hypothesis of a Vital Principle has been proved, by a careful examination, to be wanting in every characteristic of a legiticity, as before observed, are properties of certain forms of such matters, so a peculiar susceptibility of another description may be in like manner a property of organized tissues. And it seems equally easy to conceive that, as the combustibility of a combustible substance, or the elasticity of one that is elastic, displays itself only when the former is subjected under favourable circumstances to the action of oxygen or some similar matter, when it gives rise to the phenomena of combustion, or the latter is struck by a hard body, when it gives rise to those of sensible motion, so this peculiar susceptibility of organized tissues manifests itself only when such are exposed to the agency of some peculiar powers, when it gives rise to the phenomena of Life. It is not Life then, but only a necessary condition of Life, namely irritability or vitality, which is the result of organism; and when we speak of organized matter we mean, not that it is endowed with Life—any more than any inorganized matter is endowed with combustion or sensible motion—but only that it possesses a property which, when acted on by

mate theory." (*On the Vital Principle*, 1829, p. 132) Dr. Prichard is somewhat too fond of chemical and mechanical explanations of vital processes, but, in as far as he admits of Vitality at all, seems to be persuaded that it results from organism; and it is only from having fallen into the common inaccuracy of confounding Vitality with Life, that he objects to the definition of Life given by Cuvier, Bichât and the rest, and says "that Life (meaning Vitality) may subsist without the performance of any function." (p. 1) They agree in fact, but differ in words. Since this time various other authors have adopted this view of the nature of Life—among the rest the laborious and talented Tiedemann, by whom the term Life is distinctly restricted to signify the sum of the actions, or, as he calls them, manifestations of activity of organized beings; and who, speaking elsewhere of Irritability or Vitality, aptly remarks, "how wrong the physicians and philosophers have been who created it as a fundamental force of Life, or the Principle of Life. (Ψυχὴ) They have mistaken for the cause of Life a simple property of organized bodies, which is the consequence of the plastic force." (*i. e.* of their organism) (*Translation of Tiedemann's Physiology, by Gully and Lane*, 1834, § 82 and 557) Lastly Dr. Roget, in his highly classical work published last year, describes Life as "consisting of a continued series of actions directed to particular purposes;" (*Bridgewater Treatise*, 1834, p. 58) Dr. Wilson Philip, one of the most deservedly celebrated of British physiologists, albeit in some points perhaps mistaken, in a work published only a few months ago, aptly remarks, "Life, without much violence done to language, has been called a forced state—it consists of excitement called into action by suitable stimulants;" (*Phil. Trans. republished in Essay on Sleep and Death*, 1835) and Dr. Clark, in his report still more recently published, describes living bodies as possessed of "as many species of excitability, and as many modes of reaction as there are tissues, and represents Life as consisting in this reaction, excited in each by its own appropriate stimuli." (*Report on An. Physiol. read in* 1834—*published in* 1835) The tendency in the human mind to personify its abstractions must really be insuperable, if it can resist all the weight of reason and authority which may be brought forward against the indulgence of it in this instance.

appropriate powers, is competent to give rise to that series of actions in which Life consists. Nor is the existence of this property of organized matter at all more doubtful, or its nature at all more obscure, as elsewhere remarked, than those of such as are chemical or mechanical. The latter indeed more frequently engage our attention, and what is familiar we easily persuade ourselves is real and intelligible; the former is seldom the subject of our contemplation, and what is rare generally appears, at first sight, fanciful and abstruse. But, upon reflection, we shall find that we have no more evidence of the existence, and know no more of the nature of combustibility, or of elasticity, than of irritability or vitality. It is from the effects alone of any one of these properties that we infer their existence, and determine their nature; and when we say of one substance that it possesses combustibility, all that we mean is that, when exposed to the action of certain other substances, it takes fire; of another, that it possesses elasticity, we mean only that when struck it rebounds; and of a third, that it possesses irritability, we mean only that when acted on by certain powers it manifests Life. We know fully as much therefore of any one of these properties as of the rest—that is to say, as we know matter only by its properties, so we know properties only by their effects. We know nothing of any one of these properties in the abstract, nor is it therefore by way of an explanation of any of the phenomena in question, that the terms denoting these properties are used. (*a*) They are employed merely as expressive of our belief in the existence of certain forces, which, as recognised by their effects alone, we determine to be distinct only because these effects are in different cases altogether dissimilar.

(*a*) Under whatever terms we may clothe the distinctive property of organized matter, it can signify only, as Magendie remarks, "la cause inconnue des phénomènes de la Vie." It is not then to any thing that we understand better than these phenomena, but to something which we do not understand at all, that we refer when we attribute them to irritability or vitality; and it cannot therefore be by way of *explanation* that we employ these terms.

CHAPTER III.

ON IRRITABILITY OR VITALITY, REGARDED AS A PROPERTY OF THE ORGANIZED SOLIDS.

The notion of Life to be deduced from what has preceded is that it consists in the sum of the characteristic actions of organized beings, performed in virtue of a specific susceptibility, acted on by specific stimuli; and as this susceptibility and these stimuli, when natural, may be regarded respectively as the *Predisposing* and *Exciting Causes*, as it were, and the actions resulting from them as the *Proximate Cause* of Health, so it is of some change in the first that every Predisposing cause, of some change in the second that every Exciting cause, and of some change in the last that every Proximate cause of Disease severally consist. But on this clear and simple doctrine of the connexion between Physiology and Pathology—in this view of the nature of Life—it will be necessary to insist in future: at present we have to inquire a little more particularly into the character and sources of this susceptibility on the one hand, and into the nature of those stimuli by which it is called into action on the other.

The characteristic actions of organized beings have been above shown to be all referable to certain movements effected in either particles or masses of matter. Of the former we have examples in those by which the vessels conveying the crude fluids to the respiratory organ secrete certain gaseous matters to be diffused through the atmosphere, and by which those carrying the mature fluid from this organ absorb certain other gaseous substances from it, as in *Respiration;* as well as in those by which the vessels proceeding from the heart, with the mature fluid, deposit new solids and fluids in every part of the body, and in those by which the vessels returning to this organ, with the crude fluids, break down and carry away old ones, as in *Deposition* and *Absorption* in general. Of the latter we have examples in those by which the chest and lungs, or corresponding organs, heave and fall upon these gaseous matters, as again in *Respiration;* those by which the heart is contracted and dilated upon its blood, as ministering to *Circulation;* those by which the stomach and intestines are elongated and shortened upon the alimentary matters, as in *Assimilation;* those by which the gravid uterus expels its contents, as in *Generation;* and those lastly by which all the muscles called voluntary act upon the parts to which they are affixed, as in *Voluntary Motion.* Now the first question that arises is whether does the susceptibility of those movements in which Life consists reside in the solids, in the fluids or in both? Whether is it the crude fluids which *per se* secrete certain gases, and absorb various solids and fluids, and the mature fluid which *per se* absorbs certain gases and secretes various solids and fluids; or is it owing to the action of the several vessels which contain these fluids that such movements take place? And again whether is it spontaneously that the gases enter and depart from the respiratory organ, that the blood issues from and returns to the heart, that the alimentary matters travel along the stomach and intestines, and that the contents of the gravid uterus escape; or is it in virtue of the actions of these several organs that such movements are effected? (*a*) There is one movement among those above specified—

(*a*) After what has been already said of the nature of Life, it would be absurd to enquire whether it be capable of residing as well in fluids as in solids, since it is obvious that it cannot, as a non-entity, reside in either; and the only question that can by any possibility be mooted—namely whether fluids and solids may be equally possessed of the property of Irritability or Vitality—has been already in a great measure answered by the two propositions, that this property is the result of organism, and that an organized being is necessarily composed of both solid and fluid parts, and not of either exclusively. It is true that some kinds of microscopic animalcules, as the Wheel-animal—*Rotifera* 1—may be so far dried as to fly in pieces, when touched with the point of a needle, like a piece of salt, without losing their Irritability, while other animals, on the contrary, as the Sea-blubber—*Medusa* 3—are naturally of the consistence of a thin jelly, containing sometimes only a few grains of solid matter to twenty or thirty pounds of water, and still abundantly irritable. But neither are the former destitute of their nourishing juices, nor the latter of their solid membranes and vessels. It is probable then that Irritability cannot be possessed by exclusively solid or exclusively fluid substances, whether as entire organized beings—could such exist—or as constituent parts of such beings. But, while the several fluid parts of an organized being are strictly what they are represented to be, whatever solid matters they may occasionally hold in solution, the reputedly solid parts of such a being are never without a large admixture of still fluid matters, which continually traverse them: consequently these reputedly solid parts—in other words the several organized tissues—may be *à priori* inferred, in conformity with the prevailing impression, to be alone capable of possessing Irritability or Vitality. It is contended by Blumenbach, (*Comment. de Vit. Sang.* 1788) as well as by his commentator Dr. Elliotson, that there is nothing irrational in assigning Life (i. e. Vitality or Irritability) to the fluids as well as to the solids; the latter observing, in namely that of the voluntary muscles—in which the fluids seem to have nothing to do, the action in this case beginning and ending, to all appearance at least, with the solids; (*a*) and in the cases of the ingress and egress of the gases to and from the respiratory organ, the course of the alimentary matters along the assimilating canal, and the passage of the contents of the gravid uterus out of this cavity, there cannot be a reasonable doubt that the sole active instruments are the respective solid organs in question. The only movements then, among those above enumerated, in which any active instrumentality can be with the least show of reason attributed to the fluids, are those by which the blood is circulated, and those by which deposition on the one hand, and absorption on the other are effected; in other words the only fluids of the animal body—and of those of plants it seems superfluous to speak at present—which can be with any degree of verisimilitude presumed to be possessed of the specific susceptibility of action which characterizes living matter, are arterial blood, venous blood, lymph and chyle. (*b*)

support of this position, " it is impossible to deny that the male and female genital fluids are alive, because, from their union, a living being is produced." (*Translation of Instit. Physiol.*, 1820, p. 45, and *Human Physiology*, 1835) But, to say nothing of the male genital fluids, the office of which in generation, since the explosion of the animalcular hypothesis, has not been very well established—although it certainly cannot be conceived to impart much substance to the embryo, if, as Spallanzani calculates, a quantity not exceeding the 2,994,687,500th part of a grain be sufficient for impregnation, and if one act of copulation can fecundate the females of nine or ten generations, as occurs in many mollusca and insects—the alleged female genital fluid is not merely a fluid, but, like organized lymph in the case of new growths, a substance possessing from the first such solid as well as fluid parts, as are necessary to the manifestation of the plastic power by which all the parts of the embryo are to become developed. If this then be all that can be said *à priori* in favour of the presumption of the Vitality of the fluids—a presumption which, as remarked by Dr. Milligan, " seems revolting to our common sense"—(*Translation of Magendie's Physiology*, 1823, Note to p. 11)—it must be allowed that we have no sufficient grounds *in limine* for questioning the justice of the prevalent opinion upon the subject.

(*a*) It is proper to observe that by some physiologists the contractions of muscles in general have been ascribed to the ingress into them of jets of blood or other fluids; but if this doctrine be admitted at all, it must be applied not only to the voluntary muscles, but perhaps to the muscular coat of the parenchymatous tissue, and certainly to the respiratory muscles, the heart, the muscular coat of the stomach and intestines, the uterus, and in short, all the solid organs, the movements of which are now under consideration, and the whole question of any primary action in the solids becomes at once disposed of. It will in future however be shown that the above hypothesis of the immediate cause of the contractions of muscles is altogether untenable.

(*b*) That the blood of an animal—to take this as *instar omnium*—contained within itself the substantial Life thereof, is distinctly stated in many passages of the writ-

The principal arguments adduced in favour—not of the inherent Life, for that implies an absurdity—but of the inherent Vi-

ings of Moses (*Genesis* ix. 4. *Leviticus* xvii. 11 and 14, &c.) however sceptical Spencer and others may have expressed themselves on the real meaning of these passages; and not only this doctrine, but an intimation of a knowledge of the circulation of the blood also, is supposed by some to have been implied by Solomon, where he says "Out of the heart are the issues of Life." (*Prov.* chap. iv. ver. 23) The ancient Greek philosophers continually spoke of the fluids of the body, to the exclusion of the solids, as the immediate domicile of Life: and frequently called the blood, *τὸ ζωτικὸν τοῦ ἀνθρωπου*, as something essential directly to accommodate the Πῦρ *καθάρσιον*, or substantial Life, under whichever of the thousand and one names this was at different times signified. The same doctrine was reiterated by the poets, both Greek and Roman, who frequently identified the blood with the Life or Spirit, as in the passage of Virgil,

"Purpuream vomit ille Animam;" (*Æneid.* lib. ix, l. 349)

and numerous similar passages might be quoted. In modern times this notion was inculcated principally by Harvey, the reputed discoverer of the circulation of the blood; who represented this blood, not only as "sufficiens et idoneus qui sit immediatum Animæ instrumentum," but also as containing within itself this Anima, "non Vegetativa modo, sed etiam Sensitiva et Activa." (*De Generatione Animalium*, 1651) It is true the ancient Medean operation of the transfusion of blood, which was introduced soon afterwards by Lower in this country, by Denys and Emerez in France, and by G. Riva and P. Manfredi in Italy, was very far from effecting the metempsychoses which, upon the presumption that the blood of an animal was the Life thereof, were fondly anticipated from it; but the doctrine was nevertheless espoused by many authors, down to the time of Haller and Zimmerman, in whose researches on Irritability, the blood was taken so little account of, that it sunk into comparative neglect, and this was still further promoted by the theories of Brown, by whom the blood was regarded in the light of a mere stimulus to the solids. The old notion was however revived in all its pristine glory by John Hunter; who, unaccustomed as he was to pay any regard to the literature of the science which he cultivated, blindly imagined that it originated with himself. By him the blood was represented as containing within it the proper materia vitæ, or the immediate domicile of Life—which by him it will be remembered was identified with Electricity or Galvanism—not indeed collected into masses or cords, as in the nervous system commonly so called, but broken down and diffused—the "materia Vitæ diffusa," as opposed to "coacervata." A similar view has been since adopted, under various modifications, by Fontana, Wolff, Rudolphi, G. R. Treviranus, Heidmann, Thackrah, Grainger, Cooper, Burrows and many others; so that, according to Dr. Clark, "there is no longer any question among physiologists as to the Life of the blood." (*Report on An. Physiol.* 1834) It is true the majority of modern physiologists do not assert that the blood is alive, or even that it is *per se* endowed with Vitality, but merely that it receives "a Vital Influence," "a Vital Impression," or "a Vital Power" from its nerves or blood-vessels; which appears to be only an evasive way of saying that the blood is neither possessed of Vitality, nor destitute of it. Reduced to plain terms the proposition must mean either the one or the other. If it mean that the blood acquires from the nerves or blood-vessels any degree of Vitality, it means an absurdity, since Vitality, as a mere property, cannot be transferable: if it mean that it acquires only a power of acting on vital parts, it means nothing to the purpose, since numerous agents do this which make no pretensions to Vitality. It is quite true that the blood, while in its proper vessels, whether in the course of circulation or not, resists coagulation for a somewhat longer period, as proved by Thackrah and Cooper, than under other circumstances; but it is not true tality of these fluids, or their competency, upon the application of the requisite stimuli, to manifest vital phenomena are, 1. That these fluids are as essentially a constituent part of organized beings as the solids, and therefore may be *à priori* regarded as equally possessed of Vitality. (*a*) 2. That it is of one or other of these fluids that all the organised tissues are directly composed, and that what imparts Vitality to other things cannot be supposed to be itself destitute of it. (*b*) 3. That

that this more tardy coagulation implies that any "Vital Influence"—if by this is meant the slightest possible degree of Vitality—has been imparted to it. There has been in the minds of many persons, since the time of Hunter, a kind of morbid association between the continued fluidity of the blood and its supposed Vitality; and indeed Mr. Thackrah expressly says "the vital or nervous influence is the source of the blood's fluidity, and its loss the cause of coagulation," (*On the Blood*, 1834) and Dr. Clark that "no theory can satisfactorily explain the phenomena of coagulation which has not a regard to the vital properties of the blood." (*Report, &c.*, 1834) Strange that, if this be the case, the blood should remain permanently fluid in most cases of sudden death; but the difficulty at once disappears if we look upon both its continued fluidity and its coagulation under all circumstances as purely chemical phenomena, and regulated by the merely physical condition of this liquid. "I regard," says Dr. Elliotson with great reason, "the coagulation of the blood as quite unconnected with its vitality or lifelessness, and as entirely a chemical result." (*Human Physiol.* 1835, p. 152) How this coagulation, regarded in this light, should be somewhat retarded when the blood is surrounded by still irritable parts, it will be time enough to explain when we can tell why fibrin coagulates at any time, and why so many other causes at one time, like cold and neutral salts, hydrogen, nitrogen &c., retard, and at another, like heat and acids, oxygen &c., accelerate this process. Every fair view of the matter seems to show that the blood—essential as it is to all the vital actions—is so principally in one of two capacities, either as a material to work upon, when it is no more entitled to be considered as possessed of Vitality than the food in the stomach, or as a stimulus to excite the working organs—that is to say the heart and capillary system—when it is no more entitled to be regarded Vital than caloric or any of the other numerous stimuli to Irritability. It is indispensable to Life, but it is not possessed either of Life or of Vitality. "No fact," says Blumenbach—willing as he is to admit the *possibility* of fluids being possessed of Irritability—"No fact has been adduced in favour of the Vitality of the blood, which may not be more easily, simply and naturally explained upon the contrary supposition."

(*a*) Albinus accordingly and some few others have attributed Life to all the fluids of the body, the excrement inclusive.

(*b*) It was the opinion of John Hunter, as elsewhere stated, that nutrition consisted in little more than a deposition, and subsequent coagulation of the blood; (*On the Blood, &c.*, 1794) and that at least all new growths originate in this way has been a very prevalent opinion. Mr. Mayo observes accordingly, more prettily than truly perhaps, "the frame that was, the body that is to be, may be said without too bold a figure to exist in solution in the blood;" (*Outlines of Physiology*, 1833, p. 17) and Dr. Burrows has lately gone over a great deal of ground to prove that effused blood frequently becomes organized, and is convertible, by inherent processes, into various perfectly formed tissues sound and morbid, such as bone, cartilage, encephaloid tumours, melanoses &c., as well as susceptible of suppuration. Innumerable cases also are adduced from Bouillaud, Andral, Gendrin, Velpeau, Reynaud, Rostan, Burns, Lee, Watson and others in support of this opinion. (*Gulstonian Lectures*, 1835) these fluids have the same ultimate globular structure as the organized tissues, such globules being every where presumed to to be organic molecules, and as such possessed of *l'aptitude à vivre*, or Vitality. (*a*) 4. That the chemical composition of these fluids is similar to that of the organized tissues, and that they resist, like the latter, during the continuance of their Vitality, the influence of common chemical agents, as manifested by their remaining fluid in spite of their fibrin, and by their not undergoing putrefaction. (*b*) 5. That they evince sensible motion, as actuated by their own inherent stimuli, without deriving any part of this motion from the action of the solid parts, as is obvious from the facts, that in some of the lower animals there are no containing vessels, and *perhaps* in Man a great part of the blood reaches the veins from the arteries through "membraneless canals;" (*c*) that in all embryos and new growths the vessels are formed subsequently to their contents; (*d*) that these fluids continue to be circulated in cases in which, from monstrosity or disease, the action of their containing parts is impossible; (*e*) and lastly that such inherent motions may, under favourable circumstances, be observed in them, not only while still in contact with living tissues, (*f*) but even after their removal from the body. (*g*) 6. That these fluids display phenomena from the action of certain stimuli, such as the venom of the viper, narcotic poisons, various salts &c., analogous to those displayed by the solid parts, and dependent in the latter certainly upon their Vitality. (*h*) 7. That, under the ordinary circumstances of death, they coagulate upon the same principle as the muscles become stiff, by their vital contractions excited by "the stimulus of death," whereas, when an animal has been killed by violent exercise, or any of

(*a*) The advocates of the doctrine which presumes upon the identity of the globules of extractive, sodo-albumen and other reputed proximate principles of organized beings and organic molecules, must necessarily concede to almost all the fluids of the body, if not Life, certainly Vitality.

(*b*) Stahl, Junker, J. Hunter &c.

(*c*) Doellinger, Müller, Wedemeyer, Hall, Earle &c.

(*d*) Harvey, Wolff, Pander, Doellinger, Kaltenbrunner, Baumgartner &c.

(*e*) See cases by Lawrence, Brodie &c., of acardiac monsters, and others by Meilleur, Levraud &c., in which the heart has been perfectly ossified.

(*f*) Prater, Alison &c.

(*g*) Kalk, Keilmeyer, Tiedemann, Schultz, Heidmann; (*Reil's Archiv.*, b. vi, sect. 417) Treviranus. (*Biologie*, b. iv, sect. 657)

(*h*) Fontana (*Sur le Vénin de la Vipère*, tom. i, p. 318) &c.

the other causes of sudden death elsewhere enumerated, they fail to coagulate, for the same reason as the muscles, under these circumstances, fail to stiffen—namely a preternaturally long retention of their Vitality. (*a*) 8. That even after coagulation, they actually betray, like the organized tissues, when acted upon by certain stimuli, sensible vital contractions. (*b*) 9. That if they have been once frozen—that is to say deprived of their Vitality—like an egg or any other organized substance which has been treated in the same way—they more rapidly undergo this process, upon being again exposed to the requisite degree of cold, than they did the first time. (*c*)

Now to the first of these arguments it may be replied that it is no more applicable to the fluids under consideration than to the various secreted fluids, few or none of which, except the genital fluids—the fallacy respecting which has been already alluded to—(*Note* (*a*) p. 41) have been commonly presumed to be possessed of Vitality. To the second it may be objected that it is not of any one of these fluids, nor of any pre-existing ingredient in them, that the organized tissues are directly composed, but of a proper secreted matter, or organized germ, in forming which, in all probability, these fluids did not act as instruments, but were merely acted on as materials; and that it is in virtue of its organism alone, and not in virtue of any thing derived from them, that this new matter possesses Vitality. It is sufficiently well known, not only that no deposition of blood is required to produce adhesions, new growths and so forth, but that such blood, deposited between the lips of a wound, is so far from favourable to its adhesion, that this process cannot proceed till the blood has become absorbed, and its place has been supplied by organized or plastic lymph, the product of a new secretion excited by inflammation; and it is reasonable to believe that in the few instances in which effused blood has *appeared* to have become organized—few certainly in comparison with the daily and hourly instances of such effusion where no such consequence

(*a*) J. Hunter.

(*b*) John Hunter, in attributing the nutrition of the body to the effusion and coagulation of the blood, states that "it changes into this or that particular kind of substance, according to the stimulus of the surrounding parts, *which excites this coagulum into action*, and makes it form within itself, blood-vessels, nerves &c.;" and Tourdes and Circaud have further seen the clot contract when stimulated!

(*c*) Corrie. (*On the Vitality of the Blood*, 1791) results—a similar process has been going on. The blood out of its vessels, or even out of the course of circulation is a kind of foreign body; and we know how readily all such bodies excite inflammation in the contiguous tissues, and how readily such inflammation gives rise to all kinds of preternatural depositions. (*a*) To the third argument in favour of the Vitality of these fluids it may be urged, that the globules alluded to, while they are found in many secreted fluids, of the Vitality of which no suspicion has been usually entertained, have seldom or never appeared to display themselves in the organized tissues—admitting that they exist in them at all—till they have lost their Vitality, so that their presence in the fluids in question is rather unfavourable than the reverse to the presumption of their possessing this property, such globules certainly not constituting organic molecules as has been supposed. With respect to the fourth argument it may be said, that if these fluids have the same chemical composition as the organized tissues, they in all probability contain no ready-made fibrin, so that their not coagulating, while in the course of circulation, is no proof of their resistance of ordinary chemical agents, since they can have no more tendency to do so than the still organized muscular tissue. Nor is the presumption of any such resistance on the part of these fluids, founded upon their either not congulating, or not putrefying, while in the

(*a*) This is the view of the matter taken by Dr. Thomson, (*Lect. on Inflammation*, 1813) and supported by all the recent investigations upon the subject. It is admitted indeed by Mr. Mayo that for the purpose of effecting the adhesion of divided surfaces " the intervening layer of blood must be the thinnest film: a sensible quantity of clot may indeed for a time unite the wound, but after a few days, instead of becoming organized, it loses its hold and is thrown off." (*Outlines of Physiology*, 1838, p. 27) What does this amount to but an admission that the less blood there is, the less mischief it will do, and the more easily it will yield before the real medium by which the adhesion is to be effected? Nor is this medium only not blood, but it is not any pre-existing ingredient of blood, any more than urine or milk are pre-existing ingredients of this fluid, nor is it merely effused, any more than they are merely effused. The practice indeed hitherto so common with physiologists, of speaking of the serum of dropsies, the lymph of adhesions, the callus of bone, and so forth, as merely *ready-made ingredients* of the blood, which, under certain circumstances, are *effused*, and the two latter of which are afterwards *inspissated by coagulation*, instead of regarding them as perfectly *new matters*, which, under certain circumstances, are *secreted*, and the two latter of which are afterwards *solidified by their plastic force*, is happily losing ground. It is impossible that any precision can be maintained in the science of physiology, so long as processes and substances so totally unlike each other, as the effusion of coagulable lymph, and the secretion of an organized germ, continue to be called by the same names.

course of circulation, at all necessary, even admitting them to contain fibrin, sodo-albumen and so forth—as we must do if we deny them Vitality; since the fibrin, as before remarked, is never, under these circumstances, for a sufficiently long time identical, to allow its property of spontaneously coagulating to manifest itself, nor, *à fortiori*, is either this or any other proximate principle of these fluids ever sufficiently long the same to admit in them of the putrefactive process. Again it may be alleged, in answer to the fifth argument, that these fluids, although in quite the lowest animals, and in the extreme spaces between the terminating arteries and incipient views of Man—if there be any such spaces—as well as in the early embryo, and in new growths they be not contained in proper vessels, may still owe what little motion they display to the surrounding solid parts, and that there is certainly no proper circulation till a distinct vascular system has been established, which moreover may in many cases exist, although not yet discovered. (*a*) Further in all recorded cases of monstrosity or disease the continuance of the circulation may be explained upon the presumption of certain parts of the vascular system having become vicarious of others; and all the appearances of spontaneous motion in these fluids, while still in contact with living surfaces, may be attributed to some agitation of these surfaces, analogous to that which produces the motions of the fluid in the internodia of the *Chara Hispida*, (*b*) or the currents of the water in contact with the surface of the mollusca, the larvæ of reptiles &c. (*c*) while similar appearances in these fluids, when withdrawn from the body, may be referred to processes preliminary to their coagulation or other physical changes, particularly as very similar motions have been noticed in numerous other fluids besides those under consideration. The sixth argument may be met by the remark, that the phenomena manifested by these fluids, on the application to them of certain agents, consist principally in an acceleration or retardation of their coagulation, which is not a vital, but a strictly

(*a*) How recently, for example, has the beautiful vascular sytem of insects been satisfactorily demonstrated; and how probable is it that a Carus, a Grant, a Newport or an Ehrenberg will in future detect distinct vessels in forms of being which appear hitherto to be utterly destitute of them.

(*b*) Corti, Raspail &c.

(*c*) Sharpey, Purkinje, Valentine &c.

chemical process; and although it is not denied that the blood or lymph, by being impregnated with many substances, may become the *vehicle* of disease, we have no reason to believe that it ever is, or can be the *seat* of it. (*a*) With respect to the seventh argument it may be observed that as the stiffening of the muscles, in cases of death under ordinary circumstances, pretty certainly depends, as has been elsewhere shown, on a strictly chemical process supervening upon the cessation of their Vitality, the analogous action of the blood is rather hostile than favourable to the notion of its being possessed of this property; and that the continued fluidity of the blood and flaccidity of the muscles, in cases of sudden death, are explicable also on purely chemical principles can hardly be questioned—it is at least certain that the former is not attributable to a longer retention of Vitality than usual, seeing that the latter is always attended with a total cessation of this property. As to the eighth argument, the assertion that these fluids are capable of effecting vital processes after coagulation is not only false, but absurd, since it would go to prove, not only that they were alive, but that they were alive after they were dead, their coagulation, be it remembered, having been already attributed to the stimulus of death. The assertion moreover that the clot can be made to contract on the application of stimuli has been expressly contradicted, even by some advocates for the Vitality of these fluids. (*b*) Lastly, to the ninth argument it may be answered that freezing is not necessarily destructive of Vitality—a fact which will be insisted on in future—so that, if these fluids possessed it before, they would not in all probability be thus deprived of it; and that the more rapid freezing of these fluids the second time than the first may be easily explained upon the presumption of numerous physical changes which they may in the meantime have undergone, without having recourse to any changes resulting from a loss of this property.

It seems then that all the commonly alleged arguments in favour of the inherent Vitality of all or any one of these fluids are more or less fallacious, and consequently that they may be

(*a*) "So long as morbid causes," says Broussais, "are confined to the fluids you have no sign of disease, and their presence in the fluids does not constitute disease." (*Select Lectures by Dr. Gully*)

(*b*) Heidmann. (*Reil's Archiv.* vi, sect. 417 &c.)

safely regarded as destitute of this property—the more especially as the presumption of their Vitality appears to be as totally uncalled-for as that of any of the other fluids of the body. It is with the heart alone, or corresponding organ, and its immediate appendages, the arteries, veins and lymphiferous and chyliferous vessels, with the parenchymatous and erectile tissues, that these fluids, all or any of them, come into contact. Now the heart or corresponding organ, as the centre of the circulating system, and the parenchymatous tissue, as the seat of deposition and absorption, are as certainly muscular, and therefore as capable of acting on their contents, as the parietes of the chest, the stomach and intestines or the uterus; and it is manifestly inconsistent to believe that in the former cases the organs require the co-operation of their contents in order to perform their functions, while in the latter they do not.

We appear to be justified then in concluding, from all that has preceded, that Irritability or Vitality, the primary condition of Life, and the predisposing cause, as it were, of all the functions in the sum of which Life consists, resides exclusively in the organized solids; and that it is by the action of these alone that all the vital movements, whether molecular or sensible, are effected. (*a*) Further it is manifest from the endless modifica-

(*a*) Among those who, like almost all the ancient physiologists, as well as so many of the modern, looked upon Life as something elementary, and, as it were, ready-made, it was not possible that Irritability or Vitality, an ingredient only, if it may be so called, of Life, and requiring to be compounded with others before it can give rise to vital phenomena, could attract any attention; nor can it be said that their Πῦρ καθάρσιον κ. τ. λ. was synonymous with what has been since called Irritability, when it is remembered that the former was regarded as a substance, the self-sufficient cause of living action, while the latter is considered as merely a property, and one condition only of such action. The term Irritability was used for the first time by Glisson, about the middle of the seventeenth century; and is by him defined to signify the Faculty of perceiving a stimulus, in contradistinction to Sensibility, which is defined to signify the Faculty of perceiving a perception. "Irritatio," says Glisson, "est Perceptio, sed Sensatio est Perceptio perceptionis"—(*De Ventriculo et Intestinis*, 1678, p. 239) a definition which, for either terseness or accuracy, cannot perhaps be improved. In the same track, and equally with reference principally to the Irritability of Man and the higher classes in general of organized beings—in which alone there is any occasion for contrasting it with sensibility—followed Baglivi, (*De Fibra Motrice, &c.*, 1703) De Gorter, (*Medicinæ Compendium*, 1731) Winter, (*De Certitudine in Med. Pract.*, 1746) Lups, (*De Irritabilitate*, 1748) F. Hoffman, (*Med. Rat. Syst.*, 1750) and many others; but the laws of Irritability were investigated with so much more care and precision by Haller (*El. Physiol.* lib. iv, sect. 5. and lib. xi, sect. 3) and his pupil Zimmermann, (*De Irritabilitate*, 1751) that the labours of all preceding physiologists became obscured, and the whole doctrine of Irtions of the vital movements, as well of different organized beings, as of the different organized solids of each, as excited by

ritability has been since inseparably connected with the name of Haller. It must be remembered however that the Irritability of Haller—or, as he sometimes called it, Vis Insita—was not precisely that of most of his predecessors; the latter having commonly used the term in the general sense above adopted, while by the former it was confined to the susceptibility of movement in the more obvious muscles—the Sensible Contractility afterwards of Bichât—the laws of which alone could easily be made the subject of investigation. By Brown (*El. Medicinæ*, 1780) the faculty of Irritability, in the most extended sense of the word, was in general amalgamated with every other analogous faculty, including sensibility, under the general term Excitability; but it was again distinguished by Girtanner, (*Sur l'Irritabilité*, 1790) who once more employed the term, not in the restricted sense of Haller, but in the comprehensive sense in which it had been employed by Glisson. Girtanner again, while he conceded more or less of this faculty to all the organized solids as well as to the more obvious muscles, regarded, like some others, the Vis Insita of Haller, or that faculty by which these organs contract upon the application of stimulus to themselves, as only one of several kinds of susceptibility of which they were possessed, such as a Vis Tonica, a Vis Nervosa and a Vis Animalis, or distinct faculties of contracting either upon being mechanically distended, upon the application of a stimulus to their principal nerves, or as acted upon by volition. Concerning the whole of this doctrine however, it is sufficient to observe once for all, first, that these so-called Vires, applying the term to the muscles, are not vires or powers at all, in the physiological sense of the word, but properties or faculties; and secondly, that, as resident in the same organ, they are no more distinct from each other than the property by which the stomach acknowledges the stimulus of various kinds of ingesta, and that we might with equal propriety attribute to the latter a vis panaria, a vis casea and a vis carnea, because it acts equally well on bread and cheese, and on beef-steaks. By Blumenbach, (*Instit. Physiol.*, 1786) as by Haller, the term Irritability is restricted to the susceptibility of movement in the more obvious muscles, which is otherwise called by him Vis Muscularis; while that in the insensible muscles or parenchyma—the Tonicity of Stahl, Whytt and Cullen, and the Insensible Contractility of Bichât—he calls simply Contractility or Vis Cellulosa. With Chaussier again (*Exposition, &c.*, 1807) the term Irritability includes the susceptibility of movement, not only in the obvious muscles, but in the insensible muscles or parenchyma likewise, the former of which however he characterizes by the specific appellation of Myotility, and the latter like Blumenbach, by that of Contractility properly so called. But there is no end to the different meanings attached to the word Irritability by different physiologists, to say nothing of pathologists, who, from the time of Gaubius, have added to the confusion by continually using the word in a morbid sense, or of moralists, who apply the same term to a certain state of the temper and disposition. There seems to be no advantage however, but, on the contrary, very great inconvenience, in the endless invention of new terms, to which modern philosophers have been in general so addicted, and by which many, who are incapable of distinguishing themselves in any other way, have sought distinction. Many better and less equivocal terms than Irritability might unquestionably have been originally invented to express the faculty under consideration; but no man has a right, in the present day, to expect that *his* new nomenclature, however abstractedly excellent, will entirely supercede the employment of a term already in general use, and, if this be not the case, the onomatomaniac, without obviating the necessity of our understanding old terms, only imposes upon us that of learning new ones likewise. Names in general are

"Not bad *simpliciter*, nor good,
But only as they're understood;"

the same stimuli applied either to different plants and animals, or to different parts of the same, that every organized solid is not only the seat of Irritability in general, but has a kind of Irritability peculiar to itself; a fact the knowledge of which is of the most essential importance in physiology, since it is upon this principle alone that we are enabled to explain the specific effects, both of their natural stimuli on different organized beings, and on the different organs of each, and of numerous preternatural agents, whether deleterious or salutary. (*a*) It is

and it seems quite sufficient to establish any given name as the best, that it is generally employed, and by all who employ it once clearly defined. The following then is a summary of the more or less comprehensive physiological acceptation in which the term Irritability is used by the authors above cited.

Perceptivity, without movement at all (?)			
Perceptivity, with insensible movement.	Glisson Girtanner		
Perceptivity, with sensible movement.		Chaussier	Haller. Blumenbach.

In the present work the term Irritability is always employed in its most extended physiological application, as synonymous with Vitality, and signifying the susceptibility of undergoing, on the application of a stimulus, any change, which, as not strictly either chemical or mechanical, is characteristic of organized beings.

(*a*) The doctrine of specific kinds of Irritability, as manifested by Man, was perhaps better understood in ancient times than that of Irritability in general; the necessity for admitting the latter, as a condition of vital action in general, having been superseded by the invention of the Vital Principle, whereas the peculiarities in the actions of different organs, under precisely the same circumstances, could not be got over without the admission of some modifying agent of this description. These specific kinds of Irritability accordingly very soon occupied a prominent place in systems of physiology. They were alluded to first under the name of Genii, or Demons or Decans of the air, which the ancient Egyptian Pastophori, and their immediate pupils the first Greek philosophers, supposed immediately to preside, under the control of the great Master Spirit, or Vital Principle, over the functions of each particular organ of the body; and a remnant of this absurdity is still perpetuated in some almanacs, in which the several members of the body are represented as under the especial care of certain planets. By Hippocrates and Galen, these specific kinds of Irritability were called Δυνάμεις, and were considered to reside one or more in each organ, in subserviency to the grand Ενόρμων, or Πνεῦμα, and to be the immediate cause of the peculiar function which it performed. Thus the heart had, according to Galen, at once a Δύναμις διαστελλομενη, by which it attracted the blood from the lungs, a Δύναμις περιστελλομενη, by which it retained this blood for an instant, and a Δύναμις συστελλομενη, by which at length it drove it into the rest of the body; and it was in this fancy that the still employed terms diastole and systole of the heart originated. The arteries in like manner, had a Δύναμις ἑλκτικη, καθεκτικη and ἀποκριτικη, by which they were adapted to their several supposed functions, and so of the stomach and other organs: all which, it must be confessed—for these Δυνάμεις, be it remembered, were all *per se*—furnishes a very good example of the "vox et præterea nihil," by which pretended explanations of physiological facts are so often distinguished. It was in ridicule of this that Dean Swift represents the action of a smoke-jack as depending on a meat-roasting power, and that of a fiddle on a tunetrue some kinds of stimuli, such as caloric, appear to act almost indiscriminately upon all plants and animals, as well as upon all the organs of each; but such is not the case with by far the greater number of such agents—the blood, for instance, being adapted only to the specific irritability of the heart and parenchyma, the alimentary matters to that of the stomach and intestines, and the indirect stimuli of sympathy and passion having both, in every variety of each of them, their own proper organs on which alone they display any effects. And if this be the case with respect to natural stimuli, it is still more remarkably so with respect to such as are preternatural, every exciting cause of disease, on the one hand, and every agent employed in relieving such disease, on the other, by whatever avenue they may be respectively introduced into the body, operating each on those organs to the specific irritability of which they are severally adapted, while with respect to all the rest they are either wholly or comparatively inert. (*a*) To this

playing power; and that Molière makes his candidate for a physician's diploma reply to the question Quapropter opium facit dormire? Quia habet vim dormitivam. But if strings of words like these furnish no explanation of the peculiar facts in question, they are at least an acknowledgement of this peculiarity. In after times these specific kinds of Irritability were understood by Van Helmont under the term Archæi Insiti, the number of which was almost infinite, but all were represented as held in subordination by the one sovereign Archæus, or the Vital Principle, whose court was in the stomach; and by Harvey again, under that of Sensus Proprii, resident one or more in each organ, and distinct from the Anima which governed them all. Glisson also, with whom originated the doctrine of Irritability in general, recognized in each organ a specific modification of this property under the title of Spiritus Regens, which, as he observes, "aliud in jecore, aliud in liene, aliud in pancreate, aliud in ventriculo et intestinis operatur." (*De Vent. et Intest.*, 1678) The subject of these imperia in imperio was still further prosecuted by Bordeu, the father of modern French physiology, who distinctly propagated the doctrine that it was in virtue of its specific kind of Irritability, "que chaque organe sent et se meut à sa manière;" (*Rech. Anat. sur les Glandes*, 1751) and who certainly suggested to Bichât all that the latter subsequently did in describing each organ as the seat of a Vita Propria, or specific modification of one or other of the two grand Lives—the organic and the animal—under which he thought proper to arrange the functions in general. The term Specific Irritability appears to have been employed for the first time by Dr. Farr, (*on Animal Motion*, 1771) and it has been adopted by Sir Gilbert Blane (*On Muscular Motion*, 1788) and others; and the subject has been collectively treated of in a very ample manner by Rolando. (*Sur les Différentes Espèces de l'Excitabilité, &c.*, 1822)

(*a*) The different character of the Irritability of plants and animals is well displayed, among numerous other phenomena, by the very different effects upon the two of galvanism; that of the Irritability of different plants by the often diametrically opposite effects upon any two of the same mode of culture; and that of the Irritability of different animals by the quite contrary effects on many of the inferior animals of some agents reputed by Man wholesome or injurious. Thus parrots are poisoned important principle it will be necessary to allude continually in future; but in the mean time this short notice of it must be sufficient, partly because any discussion of the question at all would involve the consideration of the action of the various stimuli by which irritability in general may be excited, and of which hitherto nothing has been said, and partly because a full elucidation of it would comprehend a multitude of facts each of which will fall to be considered much more conveniently elsewhere.

by parsely, hogs by pepper, and fowls, dogs and foxes by sweet almonds; whereas fowls are uninjured by darnel, and pheasants by stramonium, hogs thrive on henbane, and storks, sheep and goats on waterhemlock, the last again are uninjured by tobacco, and the wolf is said to take white arsenic, as the horse does corrosive sublimate with comparative impunity. In illustration again of the different character of the Irritability of different organs in the same animal, besides the examples alluded to in the text, may be mentioned, among the exciting causes of disease, the action of the syphilitic and hydrophobic virus, to whatever part they may have been respectively applied, the former on the tonsils, skin and bones, the latter on the muscles of the pharynx, while all the other organs are comparatively unaffected; and, among remedies, that of the white and black hellebore, by whatever avenue they may have been severally introduced, the one on the stomach almost exclusively, and the other equally exclusively on the rectum. But even the same organ in different individuals of the same species often exhibits very striking differences in the character of its irritability, as connected with age, sex, temperament, idiosyncracy and habit of body —witness that of the stomach, which, while in some persons it is turned by substances to most people highly acceptable, in others acts with energy on substances in general regarded as repulsive and disgusting. But the full consideration of this subject belongs to another place.

CHAPTER IV.

ON THE IMMEDIATE SEAT OF IRRITABILITY.

SECTION I.

On the Muscular and Nervous Systems generally, regarded as the immediate seat of Irritability.

Admitting that irritability or vitality, general and specific, is a property of the organized solids alone, it becomes a question of the highest interest, whether it be directly inherent in each of the organized tissues, either of plants or animals, or whether it merely appear to be possessed by them all in virtue of some one which is universally distributed over the organized being, and inextricably interwoven with every other. The characteristic actions of organized beings in general have been shown all to consist in certain movements, molecular or sensible, and the only or chief immediate instrument of motion in the higher tribes of animals is sufficiently well known to be Muscular fibre; but while, on the one hand, it is by no means certain—on the contrary it is very improbable—that it is directly upon this tissue, and not rather upon the Nervous, that the vital impression by which the Muscular fibre is excited to action is in these cases made, it is obvious, on the other, that in plants and quite the lowest tribes of animals we cannot regard irritability as seated in either a distinct Muscular, or a distinct Nervous system, since they appear to be, with very few and these somewhat questionable exceptions, equally destitute of both. The possession by them of this property is nevertheless distinctly indicated, not only by all the vital actions which they more or less constantly perform, in common with the higher tribes of organized beings, but also by certain sensible motions which many of them display on the application to them of a stimulus, apparently quite analogous to those which, in the latter, are effected by muscular contraction. Of these some of the best examples are afforded by the leaves of the Venus' fly-trap, (*Dionæa*) the Wood-sorrel, (*Oxalis*) the Humble-plant, (*Mimosa*) and the Sun-dew, (*Drosera*) as well as by the pistils of the Martynia, (*Martynia*) and the stamens of the Barberry, (*Berberis*) the Prickly-pear, (*Cactus*) the Roman nettle, (*Urtica*) the Pellitory (*Parietaria*) and the Swallow-wort, (*Asclepias*) all which appear to contract when a stimulus is applied to them; and how easily sensible motions may be excited by similar means in the Branched-polype, (*Hydra*, 2) the Sea-feather, (*Sertularia*, 3) the Sea-blubber, (*Medusa*, 3) the Sea-hedgehog, (*Echinus*, 5) and numerous other species among the lowest tribes of animals is sufficiently well known. It is probable indeed that many of these sensible motions are effected—as is known to be the case with those of the Humble-plant—by the momentary loss of balance in the distribution of the fluids through the parts manifesting such motions; so that it is by a kind of turgescence in one or other direction, like that which occasions the erection of the penis and other similar organs in the higher tribes of animals, that they are produced. But the action of the vessels, whence alone this loss of balance in the distribution of the fluids can result, does not less imply the possession of irritability than the contraction of the most obvious muscles. Irritability then is not the attribute only of a distinct Muscular or a distinct Nervous system, since it may exist independently of either: but, though neither of these systems may be so far developed in plants and the lower tribes of animals as to deserve to be considered as distinct tissues, we are not, on that account, justified in denying that both may exist in them in a diffused and rudimental state; and that in this state they may be still competent to impart to the rest of the economy that property which the higher tribes of organized beings derive from these tissues only when concentrated and perfect. If then the arguments in favour of the doctrine that either of these systems is, in the latter, the immediate seat of irritability appear to be well founded, we need have no hesitation in believing that it has a corresponding seat in the former; and should not certainly be deterred, as some have been, from regarding these arguments as tenable in their application to the higher tribes of organized beings, merely because the Muscular and Nervous systems are so little obvious in the lower that they seem to be quite wanting, any more than we are deterred from admitting that the lungs and heart, because so little concentrated in some tribes of beings—which nevertheless respire and propel their fluids—as to appear to be absent, are, in the higher races of animals, the chief instruments respectively of respiration and circulation.

The question then recurs—Do the various movements, molecular or sensible, in the sum of which life consists, and the only generally acknowledged instrument of which, at least in the higher tribes of organized beings, is Muscular fibre, whether insensible, as where it invests the capillary and erectile tissues, or sensible, as where it constitutes the obviously muscular organs, indicate that Muscular fibre is the immediate seat of irritability; or may the impression of the stimulus, by which the fibre is excited to contraction, be presumed to be made first upon some part of the Nervous system—which in this case must be regarded as the immediate seat of this property—and to be communicated to the Muscular tissue only secondarily? (*a*) That the Nervous system—in the vague sense in which the term was formerly, and still unfortunately is too frequently employed—was the immediate seat of sensibility—a property in so many respects analogous to irritability—had become firmly established among physiologists, long before the existence of irritability as a distinct attribute of organized beings was suspected; and it was therefore natural that, upon the introduction of this new property, a local habitation should be assigned to it similar to that which the property so nearly allied to it had so long occupied. It was indeed at this time almost universally admitted that the Nervous system—by which term was then almost exclusively understood the cerebro-spinal department—was alone susceptible of vital impressions of any kind, that is to say of undergoing, upon the application of a stimulus, any change not strictly either chemical or mechanical, and that it was by means of this system alone that the effects of such changes were extended to the other parts of the body; but the opinion, however well founded with respect to sensibility, had hitherto no support, except that of analogy, in its extension to irritabi-

(*a*) It is assumed above that motion, insensible or sensible, is always a concomitant of irritation; and regarding irritation and life as synonymous terms, and life as consisting in a series of motions, such an assumption is unavoidable. It is by no means certain however, as will be more fully explained in future, that irritation, or the "perceptio" of Glisson, is always followed by motion of any kind, although it is by such motion alone that we are capable of recognising its existence.

lity. (*a*) Some circumstances accordingly connected with the property of irritability soon began to attract attention, which were not easily reconcileable with the generally prevalent hypothesis. Independently of the circumstance that the proper cerebro-spinal nerves—which alone were then generally recognised—were too circumscribed in their immediate distribution to explain the communication, by this means, of a universally disseminated property, and of the obvious fact that all the functions of the body which consisted merely in irritation, or required for their exercise the property of irritability alone—in other words all the organic functions—continued uninterrupted during sleep, in comatose diseases, and even for some time after apparent death, in all which cases these nerves are to a greater or less degree in a state of inaction, it appeared to be disproved by direct experiment. It was found not only that a stimulus applied to all appearance directly to Muscular fibre, had the effect of exciting its contractions, (*b*) but also that this susceptibility of

(*a*) Such was however the vague surmise of almost all the earlier authors upon this property, who, in their ignorance or carelessness of the plurality of the Nervous system, while they *expressed* what is in all probability the truth, when they referred irritability to this system, *signified*, at the same time, what is in all likelihood the most remote to it; since they meant in general, when they meant any thing definite, a department of this system which is perhaps as little allied to that which is really the immediate seat of irritability, as this latter is to the Muscular, or any other system of the body. Of this stamp besides many of the authors already enumerated as having treated of the subject of irritability in general—in particular De Gorter and Hoffman—were Senac (*De la Struct. du Cœur.*, 1749) and Whytt; (*Physiol. Ess.*, 1755) and the same doctrine has been maintained since the time of Haller principally by De Haen, (*De Sensib. et Irritab. Hum. Corp.*, 1761) Unzer, (*Erste Gründe einer Physiol.*, *&c.*, 1771) Cullen, (*Instit. of Physiol.*, 1777) Scarpa, (*De Nerv. Gangl.*, 1779) Monro, (*On the Struct. and Funct. of the Nerv. Syst.*, 1783) Schaffer, (*Ueber Sensibilitat.*, *&c.*, 1793) Prochaska, (*De Carne Musculari*, 1798) Le Gallois, (*Sur le Principe de la Vie*, 1812) and some others, exclusive of Mr. J. W. Earle, (*Medical Gazette*, *&c.*, 1833) who although he denies in words the existence of the faculty of irritability, still in asserting that the muscles are kept "in a state fit to act" by means of one set of nerves—those commonly called Sensiferous—while they are excited to action by others—those commonly called Ganglionic and Motiferous—admits very nearly the same thing as the authors previously mentioned. In this enumeration are included only those authors who have either expressed or signified that irritability is seated primarily in the Cerebro-spinal system of nerves—or that which alone had, before the recognition of irritability as a distinct property, attracted any considerable attention—or if they have referred it to the Ganglionic system, it is only in the idea that this constitutes merely an appendage to the former. If it is possible to agree with persons in fact, while we differ from them most materially in the words used to express that fact, it is equally so to agree with them in words—as when they refer irritability to the Nervous system—and still differ from them toto cœlo in the fact implied.

(*b*) It was the observation of this fact, as already observed, which first led some contraction, or irritability, was not materially impaired by dividing the principal nerves with which a muscle was furnished, by removing the brain, nor even, for some time, by totally separating such muscle from the rest of the body ; and further that if the irritability of a muscle, the nerves of which had been divided, were by any powerful stimulus suddenly so far destroyed, as that it ceased to obey any stimulus whatever, it was, after a time, more or less perfectly restored. All this appeared to be quite inexplicable upon the hypothesis that irritability had its immediate seat in the Nervous system, in the circumscribed sense at that time attached to this term, and led many physiologists to regard this property, unlike sensibility, as the immediate attribute of the Muscular fibre. (*a*) But objections soon presented themselves to this inference ; and, among the rest, it became a problem, upon this presumption, why the heart and other organs which minister exclusively to the organic functions, and which are neither possessed of sensibility nor under the dominion of the will—the only two purposes, it was said, to which, if they are to be excluded from that of imparting irritability, nerves can be supposed to be subservient—should be supplied with nerves at all. This

certain physiologists, who were predetermined that no other but the Nervous tissue, in their sense of the word, *should* acknowledge a vital impression, to represent the muscles as merely an expansion of the cerebro-spinal nerves, and to class the two together under the name of *solidum vivum* in contradistinction to the *solidum mortuum*, which included every other tissue of the body. Dr. Gregory (*Conspect. Med. Theoret.*, 1790) is very full and edifying on this subject.

(*a*) This doctrine appears to have originated with Haller, the father of the Vis Insita department of irritability, (*El. Physiol.* lib. iv, s. 5, and lib. xi, s. 3) and has been since advocated principally by Zimmermann, (*De Irritabilitate*, 1751) Oeder, (*De Irritabilitate*, 1752) Dr. Battie, (*De Princip. Anim.* 1757) Fontana, (*Atti dell' Acad. delle Sc. de Siena*, 1775) Blumenbach, (*Inst. Physiol.* 1786) and Soemmering and his pupil Behrends ; (*Dissertatio qua demonstratur cor nervis carere, &c.*, 1792) and recently in this country by Dr. Wilson Philip, (*Phil. Trans.* 1815, *On the Vital Functions*, 1817, and again in his *Gulstonian Lectures*, 1835) Dr Alison, (*Outlines of Physiology*, 1831, and *Cyclop. of Pract. Med.*, 1835) Dr. Thomson, (*Life of Cullen*, 1833) and many more. Two only of the above-mentioned data on which this doctrine is founded appear to have been questioned, viz. the perfect retention of its contractility by a limb, the large nerves of which have been divided, which is disputed by Müller ; (*Arch. fur Anat.*, 1834) and the recovery, after a time, of its contractility by a limb, the principal nerves of which have been divided, and the contractility afterwards destroyed, which, according to Mr. I. W. Earle, if the destruction have been perfect, does not take place. The former objection however requires corroboration ; and, with respect to the latter, Dr. Alison, assisted by Dr. I. Reid, appears to have established the fact, that, if the means taken to destroy the irritability be not such as to disorganize the muscles, this irritability is after a time restored. (*Mem. read to the Brit. Sc. Association*, 1834, 1835) problem was found so difficult of solution, that, while it betrayed the founder of the doctrine into innumerable inconsistencies, it has driven some of its later advocates boldly to deny that the nerves furnished to the heart and other organs above alluded to are of any use at all, (*a*) while others have, with still greater boldness, denied the existence of any such nerves in the actual substance of the organs in question. (*b*) Others again have regarded these nerves, not as the seat of any susceptibility which these organs manifest, nor the vehicle of any stimulus which they ordinarily obey, but as the channel by which extraordinary stimuli, such as that of sympathy and passion, are conveyed to them: (*c*) and this is probably the truth, but it does not appear to be the whole truth. For it must be remembered that all the organs under consideration derive their nerves from at least two distinct sources—the Ganglionic system, or that of the great sympathetic nerve, and that department of the cerebro-spinal system which is called Respiratory, and to which the pneumo-gastric nerve belongs—and it appears to be the latter alone, as will be in future as far as possible demonstrated, which is useful in the manner above supposed, so that the object with which they are furnished with the former is still unexplained.

Upon a fair review of all that has been said, on the one hand in favour of, and on the other in opposition to the two hypotheses which would refer irritability respectively to the Nervous and Muscular systems, we shall probably find that, while the former has the strong argument of the most direct analogy in its favour, and every objection which has been urged to it applies only to one department of the Nervous system, although unfortunately that of which alone the early patrons of the hypothesis in question took any account, the latter, opposed as it is to all analogy, and adopted, as it has been, only as a kind of al-

(*a*) Fontana.

(*b*) Soemmering and Behends.

(*c*) This indeed was among the uses assigned to them by Haller. "Afferunt," says he, "ex cerebro efficacia imperia, non voluntatis, sed legum, corpori animato scriptarum, quæ volunt ex *certis stimulis* certos nasci motus." (*El. Physiol.* t. iv. p. 516) The same opinion has been adopted by Dr. Wilson Philip in opposition to Dr. Alison and others, who appear to attribute little or no influence to the nerves, or at any rate the cerebro-spinal nerves—which are all that Dr. Philip admits of—belonging to these parts. Dr. Philip, on the contrary, considers these nerves as furnishing to some of the organs which they supply, as the stomach, a constant and essential, and to all of them an occasional and powerful stimulus.

ternative of a doctrine which, in its proper acceptation, has never been refuted, is liable to objections which are apparently unanswerable. It has been recently shown moreover that the effects of narcotic substances and other agents, when applied to irritable parts, are the same, with respect to irritability, as when applied to that portion of the Nervous system which is known to be appropriated to sensibility, with respect to this property—(*a*) a circumstance which is decidedly in favour of the theory which would refer the former property, as well as the latter, to the Nervous system, in some one or other of its departments. (*b*)

SECTION II.

On the Ganglionic Nervous System in particular, regarded as the immediate seat of Irritability.

Before the theory which refers Irritability to the Nervous system can be adopted, we must be prepared to show, 1. That there is a system of nerves, which, unlike the Cerebro-spinal, is universally distributed over the body, and furnishes every muscle, whether ministering to the organic or animal functions, since the source of the irritability of all is unquestionably the same. 2. That this system of nerves, again unlike the Cerebro-spinal, continues to impart the quality which it is its office to furnish, during sleep and comatose diseases, and even for some time after apparent death. 3. That the filaments of this system of nerves, as distributed upon the muscular fibre, are often so minute as to be quite invisible. 4. That the quality derived from this system of nerves is not intercepted, like that derived from the Cerebro-spinal system, by the division of the principal trunks proceeding to a muscle, by the removal of the brain, nor even, for some time, by the total separation of such muscle from the rest of the body. And 5. That this system of nerves is competent, when the principal

(*a*) Dr. W. C. Henry, (*Ed. Med. and Surg. Journ.* 1832)

(*b*) " The nerves," says Tiedemann, " are an essential condition in the vital manifestations of the muscles. This condition doubtlessly consists in the communication, by the nerves which ramify on the muscles, of *an aptitude to be affected by excitants;* the action of stimuli inducing the contractions of the muscular fibres only by means of an action upon the nerves." (*Tiedemann's Physiology, translated by Gully and Lane,* 1834, § 443) nervous trunks of a muscle have been divided, to renew that quality which it is its office to impart to it, if this have by any means been artificially exhausted. Now all this can be, if not demonstrated, at least rendered highly probable with respect to the Ganglionic system of nerves, or that of the Great Sympathetic, so that no fair opposition to the theory in question, upon any one of the objections which were formerly regarded as fatal to it, can be sustained: and indeed, if irritability is to be referred to any department of the nervous system, this seems to be the only one which remains for it, the offices severally of the three departments of the Spinal cord and their nerves, and of the Brain—cerebrum and cerebellum—having been tolerably well established as quite distinct from that of imparting irritability. (*a*) But, besides these *negative* arguments in favour of

(*a*) It was formerly presumed with great vagueness by Willis, (*Anatome Cerebri*, 1664) followed by Vieussens, Boerhaave, Du Hamel and others, that, while the voluntary motions depended upon the Cerebrum, the involuntary, such as that of the heart and other organs which minister exclusively to the organic functions, depended upon the Cerebellum, and its presumed offset, the pneumo-gastric nerve. This has been taken as equivalent to ascribing to the Cerebellum the origin of irritability; and in as far as two conditions are essential to every display of motion, viz. a susceptibility of being excited, and a stimulus to excite, this office may be presumed to have been included in the proposition. It is important to remember however that it was never so much the source of the susceptibility of action which the physiologists of those days were in quest of—this being always at hand in the supposed vital principle—as that of the stimulus to action, in addition to that which the said vital principle supplied. Nevertheless if we concede to the Cerebellum that kind of reflex function, lately attributed to so many departments of the nervous system, of both perceiving a stimulus on the one hand, and communicating a stimulus, in conseqnence of this perception, on the other, the exercise of the latter office would of course imply that of the former also. More recently again M. Le Gallois, supported rather too hastily by Humboldt, Percy and Halle, in their report upon his experiments, (*Sur le Principe de la Vie*, 1812) has attributed a similar office, at least as far as the heart is concerned, to the Spinal cord. But that the muscles, if not of voluntary, certainly of involuntary motion, are as independent, for either their susceptibility of action, or their stimulus, of both the Cerebellum and Spinal cord as of the Cerebrum, was known, not only to Glisson, but even to Galen, who, in placing his vital and natural spirits respectively in the heart and liver, while his animal spirits were placed in the brain, indicated sufficiently distinctly his knowledge of the independence enjoyed by all the organic functions of every department of that system which is subservient to the animal. It has been satisfactorily shown also by Haller and Wilson Philip, in their attempts to establish the Muscular tissue as the immediate seat of irritability, as well as by Cruikshank, (*Phil. Trans.*, 1795) Bichât, (*Anat. Gén.*, 1801) Brodie, (*Phil. Trans.*, 1810) Clift, (*Phil. Trans.*, 1815) Wiltbank (*Philadelphia Journ.*, 1825) and many other experimenters, that all these organs—Cerebrum, Cerebellum and Spinal cord—may be either deadened by narcotic substances, or even destroyed or removed—provided this be not done so suddenly and so violently as to produce, as was done by Le Gallois, an irrecoverable shock on the whole system—without stopping, or the doctrine that irritability has its immediate seat in the Ganglionic system of nerves, not a few *positive* arguments may be adduced on the same side. Among these may be mentioned 6. The alleged earlier appearance, as we rise in the scale of animals, of this system of nerves than of any of the rest, corresponding with the exclusive display, by quite the lower tribes, of the property of irritability. 7. Its taking precedence also, as is stated, of all the rest in the order of its development in the human embryo, in correspondence with the earlier manifestation, by the fetus, of irritability, than of any other property of the nervous system. 8. Its being rarely or never found wanting in mature human monsters, appearing to indicate the greater indispensability of this system—as the source of irritability—to life, than of those departments of the nervous system which minister to sensation and thought, and which are so frequently defective. 9. Its being relatively more developed in infants and females, than in adults and males, corresponding with the higher degree of irritability in the former than in the latter. 10. Its general similarity in structure to the Sensiferous system of nerves—particularly the central portions of the latter—which are pretty certainly the seat of the directly analogous property of sensibility. 11. The precisely similar effects, already alluded to, of certain agents applied respectively to parts possessed of irritability, as imparted to them probably by the Ganglionic system of nerves, and to these central parts of the Sensiferous system. And 12. The differences in the aspect and physical properties of the Ganglionic nerves, corresponding to the different character of the irritability of the organs on which they are severally distributed.

On each of these alleged testimonies then in favour of the presumption that the Ganglionic system of nerves is the immediate seat of irritability in all the tribes of organized beings which are possessed of such a system, it seems proper—as the subject is of primary importance—to make a few remarks; and afterwards to state, and endeavour to reply to some of the

even materially impairing the greater number of the involuntary actions. The latter may indeed, as proved by the experiments, not only of the authors already mentioned, but of Treviranus, Wedemeyer, Marshall Hall and others, be affected *through* these organs, so long as they continue in action—as in the case of the passions, by which an inordinate stimulus is communicated—but they are not at all dependent upon them for either the susceptibility or the stimulus by which their regular and uniform performance is maintained.

principal objections which have been urged against it, and which may not have been already met incidentally in the previous observations. (*a*)

(*a*) Before the time of Galen the Ganglionic system of nerves was entirely unknown, and although by him and his followers the Arabians the existence of this system, as well as its supposed origin from the upper maxillary branch of the trigeminus nerve was pointed out, (*De Nerv. Orig.*) as its other supposed origin from the abductor nerve was subsequently by Eustachi, (*Tab.* xviii, fig. 2) it was not till the time of Willis that the Ganglionic nerves were generally considered as a part of the nervous system at all. Willis however still looked upon them as merely an appendage to the Cerebro-spinal system, and represented them, both in his verbal descriptions of them, and in his curious diagrams of their distribution, as growing upon the latter " ut frutex super alio frutice ;" (*Anat. Cerebri.*, 1664) and this notion having been adopted by Vieussens, (*Neurograph.*, 1684) Lancisi, (*Morgagni Advers. Anat.*, 1723) Meckel Sen., (*Mém. de Berlin*, 1745) Zinn, (*Mém. de Berlin*, 1753) Haase, (*De Gangl. Nervorum*, 1772) Scarpa, (*De Nerv. Gangl.*, 1779) Monro, (*On the Struct. and Funct. of the Nerv. Syst.*, 1783) Blumenbach, (*Inst. Physiol.*, 1786) Chaussier, (*Exposition, &c.*, 1807) Le Gallois, (*Sur le Principe de la Vie*, 1812) Béclard, (*El d'Anat. Gén.*, 1823) Mason Good, (*On the Study of Medicine*, 1825) Wilson Philip (*Phil. Trans.*, 1833—*Gulstonian Lectures, &c.*, 1835) and numerous other writers, both before and since the time that their independence was insisted on by Winslow, it has become a prevalent custom to regard these nerves as of very secondary importance, and the names imposed upon the system in general, as well as the uses assigned to it, have generally corresponded with this idea. Thus by Scarpa as the Cerebro-spinal Ganglions, or those appertaining to the sensiferous nerves, are called simple, so those of the Ganglionic system, properly so called, are designated compound, while by other authors, as the former are dignified by the appellations of primary Ganglions, or Ganglions d'origine, so the latter are sunk into secondary Ganglions, or Ganglions de renforcement ; and the whole system is pedantically described by Good as " an epicycle within the two cycles of cerebral and vertebral influence," and as " equally enriched with the nervous stores of the brain and spinal marrow." (*Study of Med.*, 1825, vol. iv) With respect to the uses also attributed to this system of nerves under the same impression, the Ganglions of the Sympathetic nerve were regarded by Galen, their discoverer, as serving in the manner of buttresses, as it were, interposed at convenient distances, in order to strengthen the nerves as they receded from their reputed origin in the spinal cord or brain ; and by Willis, on the one hand as a kind of diverticula of the animal spirits received from the brain, and on the other—as the name so unfortunately given by him to this system of nerves implies—as a means of keeping up a sympathy between distant organs. A similar opinion was adopted by Vieussens and Meckel, and has been embraced by Mason Good, and numerous other routine physiologists of later times. The opinion also of Virey, (*Nouv. Dict. d'Hist. Nat.*, 2d edit.) that this system of nerves is the vehicle of instinct is not very dissimilar to this, if instinct be merely a variety of passion, and passion merely a variety of sympathy, as will be stated more fully in future. Lancisi again looked upon the Ganglions of this system in the light of little forcing-pumps, adapted to propel the animal spirits along the nerves after the influence upon them of the dura mater—which, at that time, was regarded as a large muscle, serving to eject them primarily from the brain—was expended ; and he accordingly describes them as furnished, for this purpose, with a proper muscular apparatus. (*Morgagni Advers. Anat.*, part 5, p. 113) The rest of the authors who have adopted the notion of the subserviency of the Ganglionic to the Cerebro-spinal system, in particular Zinn, Scarpa, Monro and Wilson Philip, have in general represented them as serving, partly, by the concentration within them of numerous

I. The universal distribution of the Ganglionic system of nerves, although, at first sight, not very palpable, may very

nervous cords coming from the Cerebro-spinal system, to collect the so-called nervous energy—the old animal spirits—from various sources, and to transmit it afterwards in a more equable stream to the more important organs, and partly, by the subdivision within them of these nervous cords, and the subsequent re-union of the filaments into other cords, to obviate the dangers which would have arisen had these organs received their nerves directly from only a few sources, instead of indirectly from several. Supposing, it has been said, that the heart or intestinal canal, for example, had received twenty nerves each directly from a distinct point of the cerebro-spinal system, and that one of these points of origin had been cut off, it would have followed that a twentieth part of the organ would have lost the whole of its power, and disorganization and death must have ensued; but, from all these nerves previously passing through a Ganglion, where they are so subdivided, and their filaments so re-united, that every nerve afterwards proceeding from the Ganglion contains more or fewer of the filaments of every nerve which enters it, if one of the points of origin be cut off, it follows, not that a twentieth part of the organ loses the whole of its power, but that the whole organ loses a twentieth part of its power, which is an accident of much less consequence. This hypothesis, unlike all those previously mentioned—which, with the exception of that which ascribes the conveyance of sympathy to this system of nerves, and which will be considered in future, are unworthy of any serious attention—is so neat and plausible a one, that it is almost a pity that it is not well-founded. But it must be remembered, in the first place, that this appearance of certain nerves entering and others proceeding from a Ganglion, and this in such a manner as that the latter are formed by the re-union of the separated filaments of the former, would equally result from *all* the nerves which are connected with a Ganglion arising directly—as is in all probability the case—by minute filaments from the central parts of this organ, and proceeding to the circumference in opposite directions; and, secondly, that the character of the influence communicated by the Cerebro-spinal nerves, or those which are supposed to enter the Ganglions, is known to be quite different from that which the proper Ganglionic nerves, thus represented as directly derived from them, are known to impart. It could not indeed long escape observation that those organs which derived their nerves principally from the Ganglionic system, unlike those which were furnished by the cerebro-spinal, were destitute of sensibility, and out of the dominion of the will, and it became therefore a necessary principle in all the hypotheses invented to explain the uses of the Ganglions, that they served to intercept sensibility and volition, and to perform their part, as Willis says, "cerebro inconsulto;" but if their whole agency be as appendages to the Cerebro-spinal system, in intercepting the only generally acknowledged properties and powers which are derived from the latter, what, it may be asked, have they left to communicate? The remarkable differences also in the structure of a Ganglion and that of a mere plexus—the office of which really is probably to effect such an intermingling of the filaments of the Cerebro-spinal nerves as has been above described—the abundance of grey matter which they contain—and which there is good reason to believe is always a primary source of some distinct faculty or power—their frequently almost isolated situation, and the general want of correspondence in size or number between the nerves which are represented as entering, and those which are said to proceed from them, all seem to show that this, as well as all the other hypotheses, invented by authors who have presumed upon the secondary character of the Ganglionic system, is untenable, and, as remarked by Magendie, "n'est qu'un jeu d'esprit." "They teach us only," as Sir Charles Bell observes, "what the Sympathetic nerve is *not*, and by this means we are left to conjecture what really are its functions." (*Human Anat.*, vol. ii, p. 608) Mr. Mayo accordingly, in allusion to these speculations, follows Dr. Bostock and most other physiologists in saying that easily be inferred. It has indeed been the general practice to describe the nervous cords which pass between the cerebro-

the function of this system "is unknown;" (*Outlines of Physiol.*, 1833, p. 264) and Dr. W. C. Henry observes that it "is matter, at present, of conjecture." (*Report to Brit. Sc. Association*, 1833)

It was thus then from the circumstance of the Ganglionic system of nerves not having been generally introduced to the notice of physiologists, till their minds were fully made up respecting the cerebro-spinal system as the only primary source of nervous energy, as it is called, that the real independence of the former—nay in all probability its rather serving as a foundation for the latter, since it is actually the first formed, than being engrafted upon it as an insignificant appendage—was overlooked, and facts were warped in support of prejudice aud habit. Perhaps Winslow was the first to describe the Ganglions of the Sympathetic system as a kind of nuclei, or little brains, generating a peculiar property or power of their own—(*Exposition Anat.*, 1732, sect. 357—364) a description which was adopted by Le Cat; (*Traité du Fluide Nerv.*. 1765) but it is perhaps from the celebrated Essay of Johnstone, (*On the Use of the Ganglions*, 1771) that the origin of the opinion that they are the primary source of irritability may be dated. It is true the promulgation of this opinion, like that of Willis with respect to the cerebellum, and that of Le Gallois with respect to the spinal cord, in this character, was indirect; since, as before remarked, it was not so much of the source of susceptibilities as of stimuli, that physiologists have till very lately been in quest. Nevertheless, assuming this system to be *per se* the source of all the involuntary movements, since a susceptibility is equally essential to such movements as a stimulus, it must have furnished, in virtue of some such reflex function as has been already alluded to, the one as well as the other. The notion of the independence of the Ganglionic system was espoused by Cuvier, (*Leçons d'Anat. Comp.*, 1799) and particularly insisted on, with his accustomed eloquence, by Bichât, (*Anat. Gén.*, 1801, tom. i, p. 212) who represented all the Ganglions of this system as "des centres particuliers de la vie organique, analogues au grand et unique centre de la vie animale, qui est le cerveau;" and who further demonstrated, not only that all these Ganglions were collectively independent of the cerebro-spinal system, but that each Ganglion was independent of every other—nay, that each nerve proceeding from such a Ganglion was in a great measure independent of that Ganglion, and even that each point of such a nerve was independent of all the rest, and constituted alone a distinct focus of nervous influence. The previous speculations of Bordeu on the supposed three great centres of action in the animal economy the cerebral, the cardiac and the epigastric—which very nearly corresponded to the three habitats assigned by Galen to the supposed three varieties of the spirits, the brain, the heart and the liver—seem to have been the foundation of Bichât's peculiar views on this subject, Bordeu having been to him in physiology almost what Bonn was in anatomy. The doctrine which ascribes irritability to the Ganglionics ystem was however still more explicitly promulgated by Peffinger and Reil; according to the latter of whom, as cited by Lobstein, "Perceptionem quidem habet istud systema, impressiones nempe recipit, et contra eas reagit, sed ista perceptio in proprio manet territorio, et cerebro haud communicatur"—a definition of irritation, thus placed primarily in the Ganglionic system of nerves, which differs from the original one of Glisson only in being much longer, and much less elegant. Similar tenets were subsequently adopted by Richerand (*Physiologie*, 1804) and Gall, (*Anat. et Physiol. du Syst. Nerv.*, 1810) and they were further inculcated by Wutzer (*De Corp. Hum. Gangl.*, 1817) and Broussais; (*Journ. Univ. des Sc.*, 1818) the last in particular describing the Ganglionic system of nerves as possessing a peculiar kind of sensibility, (i. e. irritability) with which it immediately endows all the organs destined for deposition, absorption and the other organic functions, and, by means of its repeated connexions with the cerebro-spinal system, all the organs of spinal system of nerves and the Ganglions of the great Sympathetic as the roots or origins of the latter, and those only which

the body. By Bellingeri, (*Dissert. Inaug.*, 1818) a certain primary instrumentality in effecting all the involuntary motions is allowed to this system, although it must be confessed that this instrumentality signifies with him, not always irritability alone—or, as he calls it, organic sensibility—but sometimes, as it did with Johnstone, a stimulus also, such as passion or instinct; and the same reproach of want of consistency attaches still more forcibly to Lobstein, one of the reputedly strongest patrons of the doctrine under consideration. (*De Nerv. Sympath.*, 1823) He has evidently a glimmering of the truth of this doctrine, since he describes the Ganglionic system of nerves as presiding in general over the action of the heart, deposition, absorption and so forth; and remarks that whereas, with respect to the voluntary muscles, the nerves, of one kind or another, convey to them uninterruptedly their general properties—their "animalis naturæ characteres atque proprietates"—which, if it signify anything, signifies only irritability, and at intervals the stimuli by which they are excited to voluntary motion—in other words volition—with respect to the involuntary muscles, the nerves convey to them in general the former alone, their stimulus being commonly derived from other sources. Still as he appears to have no idea that different nerves are employed, in the former case, in the two processes alluded to—the irritability of the parts being derived, in all probability, from the Ganglionic nerves with which they are supplied, while the stimulus is certainly conveyed by the motiferous—but attributes both to the cerebro-spinal nerves in general, so he seems to think that, in the latter, while the irritability is always derived from the Ganglionic nerves, the stimulus may, in some cases, be so too. He appears in short to have no distinct idea of the plurality of the nervous energy, as dependent upon the several departments of the nervous system, every nerve being with him, as with Mason Good and other physiologists of the same stamp, a nerve of all work according to circumstances, and engaged apparently upon the condition of making itself generally useful; and, from this defect of an essential leading principle, his work, in the physiological part of it, is such a mixture of truth and error, that it is almost impossible to make any thing of it, and it has accordingly contributed perhaps very little towards establishing the doctrine which it is considered to advocate. On the other hand Brâchet (*Sur les Fonctions du Syst. Nerv. Gangl.*, 1823) distinctly represents the Ganglionic system of nerves as the seat of irritation, or, as he chooses to call it, "imperceptible sensation," and as presiding in an especial manner over the several viscera of the body. This is rather a loose and untangible way of expressing what is intended; but it amounts to this—that this system of nerves is adequate to effect all the functions to which irritability alone is essential, while others are requisite as often as either sensibility, the faculty of thinking or the power of exciting voluntary motion, is called for. Similar views are adopted and forcibly advocated by Dr. Copland, (*Tr. of Richerand's Physiol.*) and they have been since embraced by Mr. Parker of Birmingham, (*Medical Gazette*, 1831) Dr. Lovell Phillips of Bath (*On Inflammation*, 1833) and other British authors. Mr. J. W. Earle has lately represented the Ganglionic system of nerves as the source of one necessary condition of involuntary motion, but it is not in communicating a susceptibility of this motion—an office which he assigns to the reputedly sensiferous system—but in conveying a stimulus that he considers it useful. (*Medical Gazette, &c.*, 1833) In as far as words go then his opinion agrees with that of Johnstone; but, as before observed, Johnstone, though he spoke of these nerves as the source of a stimulus, may be very well understood to have regarded them, at least equally, as the vehicle of a susceptibility, which cannot be the case with Mr. Earle, who refers this property to a distinct department of the nervous system. Still more recently Mr. Walker has inculcated an opinion similar to that of Johnstone and Bellingeri, that this system of nerves is the source as well of irritapass between the Ganglions and other organs as their branches; and hence it is a very prevalent impression that the distribution of the Ganglionic nerves is extremely circumscribed, and almost confined to the viscera of the chest, belly and pelvis. We must remember however that the larger blood-vessels are everywhere directly supplied by these nerves, and that branches of the blood-vessels, carrying with them continuations of the same system, proceed to every organized point of the body—that is to say, to every point possessed of irritability; (*a*) so that, even admitting that the notion of the dependence of the Ganglions upon the cerebro-spinal system were a true one, no objection to the doctrine which ascribes to the nerves of this system the source of irritability, founded upon their supposed circumscribed distribution, could be maintained. But what right have we, except the gratuitous assumption that the cerebro-spinal system is the only source of nervous influence, to presume that the nervous cords which extend between this system and the Ganglions are always branches from the former to the latter; nay, have we not a greater right—considering the alleged priority of development of the latter system—to presume directly the reverse, and to consider them rather as branches from the Ganglionic system to the cerebro-spinal? Thus are we not equally, if not more justified *à priori* in regarding the twigs which extend between the motor oculi and the ophthalmic branch of the trigeminus, on the one hand, and the Ophthalmic Ganglion, on the other, as proceeding from

bility, or, in his language, of vital or unconscious sensibility, as of the stimulus to involuntary motion, and as communicating accordingly "sensation (i. e. irritation) and motion to the organs of Life." (*Nervous System*, 1834) However untenable then may be, as we shall find in future, the notion which attributes this double office to the Ganglionic system, the doctrine that it has at least that of communicating irritability has many powerful supporters; and upon the whole may be regarded as certainly increasing in popularity even among a people who are almost as notorious for the pertinacity with which they cling to the effete tenets of their Whytts, their Monros and their Cullens, as the ancient Egyptians for their blind adherence to the precepts of the renowned Tot, the Chinese to those of Confucius, or the Persians to those of Zoroaster.

(*a*) If this were not the case, what is called a palsy of any part of the body, that is to say a failure of the faculty of sensibility and of the stimulus of volition, would always entail a corresponding failure in the same parts of deposition and absorption. The latter class of functions however require for their exercise only the faculty of irritability, which is not impaired in this disease, whereas sensation and voluntary motion require in addition other properties and powers, in the failure of which this disease consists. As stated by Dr. W. Philip, "every organ of the body, with few exceptions, is supplied by Ganglionic nerves"—(*Gulstonian Lecture, delivered* 1835) not perhaps however for the purpose which he supposes.

the latter to the two former, than in the opposite direction; those extending between the upper maxillary branch of the trigeminus and the abductor nerve, on the one hand, and the Cavernous Ganglion, on the other, as branches from this Ganglion to the cerebro-spinal nerves in question, than the reverse; and those lastly which extend between the several cervical, dorsal, lumbar, and sacral nerves, and the corresponding Ganglions, as offsets backwards from the Ganglions, than forwards from the spinal nerves? Nor are there wanting many and strong arguments *a posteriori* in favour of this opinion. The connexion, for example, between the motor oculi and Ophthalmic Ganglion is not such as to warrant us in believing that the latter is at all derived from the former. (*a*) The twig again extending between the abductor nerve and the Cavernous Ganglion—to say nothing of the retrograde angle, at which, if we presume that it proceeds from the former to the latter, it is sent off (*b*)—partakes much more of the physical characters of a Ganglionic than of a Motiferous nerve, being much softer and less uniformly white and opake than the abductor, (*c*) and quite destitute of the fibrous structure, and proper tubular neurilema which characterize all the Motiferous nerves. (*d*) Further the abductor nerve is not smaller and weaker beyond the point where this union takes place, but larger and stronger, (*e*) appearing clearly to indicate that it has gained a filament, instead of losing one—nay this filament may, it is said, be easily separated from it. (*f*) Comparative anatomy moreover is decidedly hostile to the common opinion respecting the origin of the Great Sympathetic nerve from the abductor; since, in the majority of the lower animals, the filaments extending from the Upper Cervical Ganglion into the carotid canal have no connexion with this nerve whatever. (*g*) And similar remarks may be made

(*a*) "The lenticular Ganglion," says Mr. Swan, "has the appearance of being united with the branch of the motor oculi given to the inferior oblique muscle, rather than of receiving a filament from this." (*On the Nerves*, 1834)

(*b*) Winslow, Lobstein &c.

(*c*) Soemmering.

(*d*) Soemmering.

(*e*) Petit, Soemmering &c.

(*f*) Panizza.

(*g*) Swan. (*On the Nerves*, 1835) "No doubt," says Mr. Swan, "can be maintained that the branches proceed *from* the sympathetic *to* the sixth;" and Mr. Mayo admits that "the sympathetic certainly *gives* branches to different nerves, as well as receives them from the same."

with respect to the twigs which extend between the several spinal nerves and the corresponding Ganglions of the Great Sympathetic—that they approach much more nearly in their physical characters to Ganglionic than to cerebro-spinal nerves, and that there is frequently no manner of correspondence between the size of the respective Ganglions and the size or number of these twigs from which they are so confidently described as arising. Nor can it be said that this may depend upon the reinforcements which the Ganglions receive from above and from below, from the trunk of the Great Sympethetic, itself derived from the cerebro-spinal system, when it is considered, first, that this origin of the Great Sympathetic is one of the chief points at issue, and secondly, that the want of proportion in the size of the Ganglions is as remarkable when compared with their perpendicular, as with their lateral filaments—nay, that the Great Sympathetic nerve is sometimes, it is said, entirely discontinuous without making any considerable difference in this respect. (*a*) Now, if it be conceded that these and other filaments extending between the cerebro-spinal and Ganglionic systems of nerves are branches from the latter to the former, or even that, wherever such a union takes place, there is a mutual interchange of filaments—which is perhaps the most rational opinion (*b*)—it will follow that to whatever organ of the body any cerebro-spinal nerve proceeds, there a Ganglionic filament may be presumed to accompany it; since there is no such nerve, to whatever part of the cerebro-spinal system it may belong, with which the Ganglionic system is not more or less connected. (*c*) Thus, of the Respiratory

(*a*) Haller, Bichât &c.

(*b*) In these instances "we have reason to believe," says Dr. Wilson Philip, "a double communication takes place, the spinal nerves conveying to the sympathetic the influence of the spinal marrow, and the sympathetic sending with them, to the parts to which they are distributed, filaments conveying *lhe influence of the ganglionic system.*" (*On the Vital Functions*, 1817) How inconsistent is this—in all probability the true statement of the case—with the principle, only two pages before inculcated, that "we cannot hesitate to regard the sympathetic nerve as *arising from* the spinal marrow!" and elsewhere that "the only active part of the nervous system is the brain and spinal marrow." If all the properties or powers which this nerve possesses be derived from the source in question, what "influence" can it possibly communicate to the spinal cord, which that organ had not before?" Mr. Walker also observes that "these connexions (between the Ganglionic nerves and the roots of the cerebro-spinal nerves) are always by fibres which evidently both ascend and descend upon them, and consequently which are both given to, and received from them." (*Nervous System*, 1834, p. 614)

(*c*) The nerves of the human body may be conveniently classed under the two nerves, the pathetic is connected with the Ophthalmic Ganglion; the facial with the Otic, the Spheno-palatine and Sub-maxillary;

great heads of Ganglionic and Cerebro-spinal, the latter being subsequently distributed into the four sub-divisions of Respiratory, Motiferous, Sensiferous and Regular, the last including those which communicate both the faculty of sensibility and the stimulus of volition. Adopting this general arrangement, the following appear to be the individual nerves "after their kinds."

GANGLIONIC.	CEREBRO-SPINAL.			
	Respiratory.	*Motiferous.*	*Sensiferous.*	*Regular.*
Those immediately connected respectively with the *Ophthalmic*, the *Cavernous*, the *Otic*, the *Spheno-palatine*, the *Sub-maxillary*, the three *Cervical*, the *Cardiac*, the twelve *Dorsal*, the *Cœliac*, the five *Lumbar*, the five *Sacral*, and the *Coccygeal* Ganglions.	The Pathetic, The Facial, The Glosso-pharyngeal, The Pneumogastric, The Accessory, The Phrenic, The External Respiratory.	The Motor Oculi, A part of the Lower Maxillary branch of the Trigeminus, The Abductor, The Hypo-glossal.	The Olfactory, The Optic, The Ophthalmic branch of the Trigeminus, The Upper Maxillary branch of the Trigeminus, A part of the Lower Maxillary branch of the Trigeminus, The Auditory.	The Sub-occipital, The seven Cervical, The twelve Dorsal, The five Lumbar, The five Sacral.

Of the Ganglions above specified the Cervical, Dorsal, Lumbar and Sacral were known to Galen. The Cœliac was discovered by Willis in 1664, the Spheno-palatine and Sub-maxillary by Meckel in 1719, the Ophthalmic by Zinn in 1755, and the Cardiac by Wrisberg in 1780; and comparatively recently the Cavernous by Bock or Lermonier, and the Otic by Arnold. The Naso-palatine Ganglion, the reputed discovery of Cloquet, has been omitted, as its existence is somewhat questionable; and the Gasserian Ganglion is rather a plexus than a Ganglion, and belongs to the cerebro-spinal, and not to the proper Ganglionic system. With respect to the cerebro-spinal nerves and their arrangement, it is proper to observe that there are very few of those above enumerated the origin and functions of which have not been more or less questioned; and perhaps few or none of them, owing to the frequent union of most, if not all of them, with nerves of other systems, are exclusively what they are represented to be in the foregoing schedule. The present is not the place for discussing their pretensions to the positions which they severally occupy; but it is proper to observe in passing that by some recent authors, and in particular by Bellingeri and Mr. Walker, many other organs besides the Ganglions above enumerated—such as the restiform and olivary bodies, the gasserian ganglion and all the ganglions on the posterior roots of the spinal nerves—are incorporated into a common system with that above specified as the proper Ganglionic, and of course all the nerves connected with these organs —for example the Facial, the Glosso-pharyngeal, the Pneumogastric and other respiratory nerves on the one hand, and all the sensiferous nerves on the other—are regarded as belonging to this system. In this view of the matter the collective system is represented as in general at once the source of organic, vital or unconscious sensibility—in other words irritability—and the vehicle of the stimulus to involuntary motion—in other words sympathy and passion or instinct. It appears however *prima facie* inconsistent to represent any nerve as at the same time the source of a susceptibility and the vehicle of a power, and this inconsistency may very well be avoided by continuing to regard the last named organs as quite distinct from the proper Ganglions of the Sympathetic: at any rate no sufficient reasons seem hitherto to have been adduced for amalgamating them all together. If they be separated, and, while the faculty of irritability is attributed to the one, the power of exciting involuntary motion be ascribed to the other, the whole subject becomes materially simplified; and these two powerful names may be added to those who support in general the doctrines advocated above, excepting in as far as regards the sensiferous nerves, the office of which appears to be quite distinct from that which they have assigned to them.

the glosso-pharyngeal with the Upper Cervical; the pneumogastric with all the Ganglions of the spine, as well as with the Cardiac and Cœliac; and the accessory, phrenic and external respiratory again with the Cervical. Of the Motiferous nerves, the motor oculi is connected with the Ophthalmic Ganglion; the motiferous filament of the lower maxillary branch of the trigeminus with the Otic and Sub-maxillary; the abductor with the Cavernous, and the hypo-glossal with the Otic and Upper Cervical. Of the Sensiferous nerves the olfactory is connected with the Spheno-palatine Ganglion, the optic with the Ophthalmic, the ophthalmic branch of the trigeminus again with the Ophthalmic; the upper maxillary branch of the trigeminus with the Spheno-palatine and Cavernous, the sensiferous filament of the lower maxillary branch of the trigeminus again with the Sub-maxillary—to say nothing of the connection which each of these branches may be presumed to have with the Upper Cervical Ganglion, filaments of which are copiously distributed upon the gasserian ganglion through which they pass—and the auditory lastly with the Otic. Finally, of the Regular nerves, the sub-occipital is connected with the Upper Cervical Ganglion; and all the cervical, dorsal, lumbar and sacral nerves, not only directly with all the corresponding Ganglions throughout the whole course of the spine, but also indirectly with the Cardiac and Cœliac Ganglions. We seem to be fully warranted therefore in concluding, not only that wherever is a blood-vessel, there also are Ganglionic nerves as a part of that blood-vessel, but likewise that wherever is a nerve, to whatever department of the cerebro-spinal system it may belong, there some filaments from the Ganglionic accompany it; and consequently that, so far from this system being confined to the several viscera, it is so universally distributed over the body, as to be abundantly competent, as far as this condition is concerned, to impart irritability to every muscle, whether ministering to the organic or animal functions.

II.—With respect to the continuance in action of the Ganglionic system of nerves, under circumstances in which that of the cerebro-spinal system is suspended or has finally ceased, the fact that it does so has been acknowledged even by those who are the strongest advocates for its dependence upon the cerebro-spinal system; and it was to reconcile this fact with their general hypothesis, that they invented the doctrine that the Ganglions served as receptacles of animal spirits, which were derived primarily from the brain, but which might be so doled out by the Ganglions, as to carry on the organic functions for some time without the agency of the former. But why, it may be asked, should the animal spirits, as doled out by the Ganglions to the several viscera, differ so materially in their character from the same spirits as proceeding directly from the brain; and why should they, as conveyed to a limb by the Ganglionic nerves, minister only to deposition and absorption, whereas, as conveyed to the same limb by the cerebro-spinal nerves, they minister to sensation and voluntary motion? It is an obvious inference from the fact that all those functions, whether of the viscera or of the rest of the body, which require only irritability for their exercise continue unimpaired during sleep, in comatose diseases, and even for some time after apparent death, and from the acknowledgment that the Ganglionic system continues in action under these circumstances, that this system is, not a mere reservoir of properties and powers which it never imparts, but a primary source of a property which, during the suspended action of the brain, is alone in requisition. And it is a strong corroboration, as already remarked, of the principle which would trace Ganglionic nerves to every point of the body, that, so long as the functions of organs which minister exclusively to what is called organic life, and which are supplied almost exclusively from this system, continue to be performed, many of the functions even of organs which minister more particularly to what is called animal life, and which are supplied more remarkably from the cerebro-spinal system, remain unimpaired.

III.—It is a distinguishing feature in the character of the Ganglionic system of nerves, that its filaments are every where small, and in many parts so minute as to be altogether invisible; and hence not only was the system in general comparatively very late in being discovered, and much later in being generally admitted by physiologists, but the existence of some parts of it has been, in recent times, denied, as already stated, even in organs in which the filaments are much less obscure than in many others. (*a*) It is easy to conceive then that cer-

(*a*) Soemmering and Behrends.

tain stimuli, by which muscles have been excited to contraction, may have been really applied to such filaments, when, to all appearance, they were applied directly to the muscular fibres; and thus that the latter may have appeared to possess inherently a quality which in fact they derived from the former.

IV.—If filaments from the Ganglionic system of nerves everywhere accompany the blood-vessels, as well as, in all probability, are associated with all the cerebro-spinal nerves, it is evident that cutting the latter in their course to any organ, or even removing the brain, needs not materially interfere with the irritability of this organ, since a sufficient supply may still be furnished from the former source. But it is probable that no impediment whatever is offered to the function of a Ganglionic nerve by such a division as would entirely paralyze one from the cerebro-spinal system. Such is the case with the latter only because the white matter of the nerve, being dependent for its energy in all probability upon the grey matter of the central parts of this system, becomes of course inert when separated from it. But no such line of demarcation exists in the Ganglionic system, every point of every nerve of which contains white and grey matter intimately interwoven together, and may be considered therefore as a centre of nervous energy to itself; (*a*) and it is in this way only that it can be explained how the total removal of a muscle from the rest of the body, which implies a division, as well of its blood-vessels as of its nerves, is not, for some time, effectual in destroying its irritability. It has indeed long been known that dividing the large blood-vessels going to a muscular part has, after an interval, a much greater effect in impairing its contractility, than dividing its principal nerves, (*b*) a fact which has been supposed to show—as will be in future insisted upon at greater length—that, while the capability of obeying a stimulus is inherent in the muscular fibre, it is by a certain influx of blood into it that its contraction is immediately effected. But it is not perhaps either by preventing this supposed influx of blood, or by intercepting the influence of the Ganglionic nerves which accompany these blood-vessels, that a division of the large blood-vessels of a limb produces this effect,

(*a*) Bichât.
(*b*) Stenon, Cowper Boerhaave, Brunn, Brodie &c.

but by sooner or later impeding the functions of the parenchyma of the part, the office of which is to renew Ganglionic nervous matter, as well as every other tissue, in proportion as it is consumed. At all events no conclusion prejudicial to the doctrine that the Ganglionic nervous system is the immediate seat of irritability can be fairly drawn from the results of any experiments of this nature.

V.—Again, that this system of nerves would be competent to renew the property of irritability in a part the principal nerves of which had been divided, and so much of its immediate stock of irritability afterwards suddenly exhausted as to disqualify the larger muscles for any further contraction, might almost be inferred from the contents of the preceding paragraph. If irritability be the attribute of the tissue in question, it can be destroyed only in proportion to the destruction of this tissue; and were this destruction entire, it is obvious that any renewal of it must be impossible, since the failure would extend, not only to the larger muscular fibres, but to the parenchyma also, on the actions of which is our only reliance for the renewal of the Ganglionic nervous matter, and with it—independent, as it is, of any common centre—of its characteristic property. But we must remember that in all cases of a general failure of irritability from natural causes, that of the capillary vessels long survives that of the larger muscles; and if the same thing happen when it is withdrawn artificially, it is easy to understand how a degree of exhaustion of it which may entirely incapacitate, for a time, the larger muscles for any further contraction, should be quite compatible with a subsequent restoration of these organs to their natural susceptibility.

VI.—As far as regards the earlier appearance, as we rise in the scale of animals, of the Ganglionic than of the cerebro-spinal system of nerves, this argument, in favour of regarding the former as the immediate seat of irritability, is probably well founded, if it signify merely that we are to look upon the minute nervous nodules which first display themselves in animals, forming, as it were, a connecting link between those which present no traces whatever of nervous matter, and those which have a regular nervous apparatus, as appertaining rather to the Ganglionic than to the cerebro-spinal system of the superior tribes; but not if it compel us to regard—as some physiologists have done—the more or less concentrated nervous systems of all the avertebrated animals as corresponding merely to the Ganglionic system of the vertebrated. (*a*) Wherever a distinct nervous apparatus exists at all, whether in an avertebrated or

(*a*) So long as the cerebro-spinal system of nerves was alone generally recognised in the higher tribes of animals, it would of course follow that such nerves as could be detected in the lower tribes were considered to appertain to this; and such was at first the almost universal impression with respect to the nature of the nervous apparatus of the avertebrated animals in general. Nor did the general recognition of the Ganglionic system of nerves for some time make any difference in this respect, since they were for a long time regarded as merely an appendage to the cerebro-spinal. The subsequent establishment however of the independence of the former, coupled with the observation that the functions to which it seemed to be subservient in the higher tribes of animals were of more essential importance to their life and well-being than those to which the cerebro-spinal system was appropriated, soon led to the conclusion that in the avertebrated animals, which appeared to have only one of these systems, it was analogous, not to the cerebro-spinal, as had been supposed, but to the Ganglionic system of the vertebrated. This was the opinion of Bichât and Reil, and it soon became, like most of the doctrines which the former advocated, to a certain degree popular: it has been explicitly supported also by Ackermann, Virey, Parker of Birmingham and many others. Virey indeed has ventured to arrange animals, with reference to their nervous apparatus, into three classes; the first consisting of those which manifest nothing but nervous granules, more or less isolated, including only some of the lowest tribes of avertebrated animals; the second those which possess a distinct Ganglionic, but no cerebro-spinal system, including all the rest of the avertebrated tribes; and the last those which possess both, including all the vertebrated animals. Hence has probably originated the vague notion that the Ganglionic nerves are the vehicle of instinct, because such animals as are vulgarly supposed to be actuated by instinct alone, are presumed to be provided with only a Ganglionic system of nerves. It is probable however that—whatever we may think of the nervous granules here spoken of as corresponding exclusively to the Ganglionic system—there is no instance of a *distinct* nervous apparatus at all which does not include both the Ganglionic and cerebro-spinal systems; and consequently that Virey's supposed second class of animals has no existence. It is strange that the advocates of the doctrine which ascribes only a Ganglionic system of nerves to any of the avertebrated animals should have neglected to notice that many of them manifest the most unequivocal marks, not only of sympathetic and instinctive motion —which in all probability requires, as will be shown in future, a distinct department of the cerebro-spinal nervous system for its manifestation—but also of voluntary motion and of sensation; so that it would have been equally reasonable to conclude *à priori* that their supposed simple system was cerebro-spinal, as that it was Ganglionic. Nay, it would have even been more reasonable to come to this conclusion, since most of the other functions which these animals perform, they exercise only in common with plants and quite the lowest tribes of animals, which have no obvious nervous system at all; whereas in voluntary motion and sensation—to say nothing of sympathy and instinct—they approach the highest tribes of the latter, which are never destitute of such a system. It was from taking this view of the matter that the old opinion has been, in recent times, maintained by Blumenbach, Cuvier, Gall, Rudolphi, Bell and others, who look upon the apparently simple nervous apparatus of the avertebrated animals as corresponding, not so much to the Ganglionic, as to the cerebro-spinal system of the superior tribes—true to the maxim that "in vitium ducit culpæ fuga," as having failed to perceive that it corresponds equally to both. "The three systems," says Professor Grant—i. e. the Ganglionic, the motiferous, including the respiratory, and the sensiferous—"are developed together, almost from the lowest animals." (*Comp. Anat.* 1835, p. 180) vertebrated animal, that apparatus seems to correspond to both a Ganglionic and cerebro-spinal system, and not exclusively to either; and the only difference between such an apparatus as found in the avertebrated, and as found in the vertebrated animals, appears to be that the main portions of the two systems of which it consists are not, in the former, separated from each other by a distinct spinal column and skull, but directly incorporated together, whereas, in the latter, they are so separated, and connected with each other only by reciprocal filaments interposed at certain intervals. The only means—short of any positive evidence of its correspondence with one or other of these systems—of determining the character of the apparently simple nervous apparatus of the avertebrated animals appears to be by observing, 1st. the general aspect and relative size of this apparatus; 2ndly. the situation of its principal departments; 3dly. the functions of the organs on which it is distributed; and lastly the effects of direct experiment upon it.

With respect then to its general aspect and size, the usually knotted and disjointed appearance of the nervous system of the avertebrated animals seems, at first sight, to favour the opinion that it corresponds exclusively to the Ganglionic system of the vertebrated. But it must be remembered that, although, in the higher tribes of the latter, the Ganglionic system has this appearance, while the cerebro-spinal is more or less cylindrical and continuous, the reverse is the case in the lower, such as fishes, in which, with very few exceptions, the Sympathetic system is without knots and filamentous, while the spinal cord and brain have often a somewhat knotted and unconnected appearance; and it is only as we rise through reptiles and the other intervening tribes, that the two systems of nerves acquire gradually the appearance by which they are at length characterized. Now it is with fishes, as the next in rank to themselves, that the avertebrated animals should be compared in this respect; and the comparison necessarily leads to the conclusion that the bulk of their nervous apparatus is analogous to the cerebro-spinal system of the former, some minute filaments only corresponding to the Sympathetic—the more especially, as the transition from the large nervous apparatus of many avertebrated tribes to the ample spinal cord and brain of fishes is progressive and easy, while to their slender Sympathetic system it is retrograde and violent. We know moreover that in the metamorphoses of many insects, as the Moth (*a*)—*Sphinx* 25—and Hornet-Fly (*b*)—*Asilus* 26—from the state of larva to that of pupa, and from the state of pupa again to that of imago, several of these large nervous knots coalesce into a kind of knotted cords, making a very near approach, both in appearance and in relative size, to the spinal cord and brain of the lower vertebrated tribes, but altogether dissimilar, in both these respects, to their Sympathetic system.

The situation again of the principal departments of the nervous apparatus of the avertebrated animals—as far as this is of any importance—is favourable to the opinion that it corresponds at least as much to a cerebro-spinal as to a Ganglionic system. The first rudiments of a nervous system visible in these animals, and the part of it which is most constantly met with, is a knot on the dorsal aspect of the part corresponding to a neck, sending a kind of collar round the gullet; and it is from some part of this that a chain of knots in general proceeds along the body. Now this rudimental part of the nervous system is in some avertebrated animals, as the Cuttle—*Sepia* 11—contained in a kind of rudimental skull, and may be therefore fairly presumed to correspond to a brain; while the chain of knots along the body, contained as it is in some, as the Cray-fish (*c*)—*Cancer* 19—in a partial horny canal formed by the shell, and in others, as certain species of Grass-hopper—*Gryllus* 29—in a similar canal formed by the segments of their sheath, may be with equal reason presumed to be analogous to a spinal cord: nay the latter have, distinct from the main chain of knots in question, two smaller cords which seem to correspond with a Sympathetic system. It is true this main chain of knots, in many avertebrated animals, as the Leech (*d*)—*Hirudo* 12—the Earth-worm (*e*)—*Lumbricus* 12—the Sea-Mouse (*f*)—*Aphrodita* 13—the Cray-fish (*g*)—*Cancer* 19—and insects in general, runs along their abdominal, rather than along their dorsal aspect; but in others on the contrary,

(*a*) Newport; Roget. (vol. ii, p. 546)
(*b*) Swammerdam. (pl. xxxix and xl)
(*c*) Home; Carus. (pl. vi, fig. 1)
(*d*) Home. (vol. iv, p. 39)
(*e*) Home. (vol. iv, pl. 147)
(*f*) Pallas. (pl. vii)
(*g*) Home; Carus. (pl. vi, fig. 1 and 4)

as the Ascidia (*a*)—*Ascidia* 8—the Sea-hare (*b*)—*Aplysia* 9—and the Garden-snail (*c*)—*Helix* 9—it holds its course along their back, so that no weight can be assigned to the former circumstance, in regarding it as corresponding rather to the Ganglionic, than to the cerebro-spinal system. In some insects indeed, as the Grass-hopper just mentioned, while the portion of the nervous system which corresponds to a spinal cord, runs along their abdominal, that corresponding to a Sympathetic system runs along their dorsal aspect; but we know that the locality of parts is in general a consideration of very little importance in tracing structural analogies.

If we attend also to the functions of the organs on which the chief nerves of the avertebrated tribes are distributed we shall not hesitate to believe that they are analogous, at least equally, to the cerebro-spinal system as to the Ganglionic. The nervous collar just alluded to, as the first visible trace in animals of a distinct nervous system, ministers directly to the action of swallowing; and thus corresponds perhaps, not so much to the lower maxillary branch of the trigeminus nerve—in its motiferous and sensiferous filaments—(*d*) as to the glosso-pharyngeal nerve of the higher classes of animals; round the pharynx and gullet of which in fact a similar collar is formed by the nerve in question, although, from the comparative complexity of the parts, it is less immediately obvious. The first visible nerve then is a branch of the cerebro-spinal system. It is certain likewise that most avertebrated animals send nerves directly to other organs as well of sympathetic and instinctive motion, as of voluntary motion and sensation—the Star-fish (*e*)—*Asterias* 5—for example, to the tentacula, the Mussel—*Mya* 8—to the muscular cloak-bag, the Cuttle (*f*)—*Sepia* 11—as well to the cloak-bag, as to the tentacula, eyes and ears, the Garden-snail—*Helix* 9—to the muscles of the neck and of locomotion, as well as to the eyes and feelers, the Sea-mouse—*Aphrodita* 13—to the tentacula, the Cray-fish,—*Cancer* 10—as well to the muscles which move the plates of

(*a*) Carus. (pl. ii, fig. 3)
(*b*) Cuvier; Carus; Roget. (vol. ii, p. 548)
(*c*) Swammerdam. (pl. iv and vi)
(*d*) Bell.
(*e*) Tiedemann; Carus. (pl. i, fig. 2)
(*f*) Swammerdam. (pl. i. and iii) Carus. (pl. iii, fig. 2)

horn which surround the gills, as to the antennæ, legs and tail, the nostrils, eyes and ears, the Silk-worm (*a*)—*Phalæna* 25—to the moveable stigmata, and the muscles of the head, the feet, wings and eyes, the Bee (*b*)—*Apis* 26—to the feet, wings and eyes, and so forth; and such nerves must accordingly be presumed to correspond, not to the Ganglionic, but to the cerebro-spinal system of the superior tribes. On the other hand it must not be forgotten that it is not only to the organs of sympathetic and instinctive motion, and to those of voluntary motion and sensation, that nerves proceed from the apparently simple nervous apparatus of the avertebrated animals, but also to those of circulation, assimilation and generation, as is sufficiently manifest, among those just mentioned, in the Garden-snail, the Cuttle, the Cray-fish, the Silk-worm, the Bee and numerous others; and such nerves we are compelled to believe correspond, not to the cerebro-spinal system, but to the Ganglionic.

Lastly it has been found that the removal of the central parts of the nervous apparatus of the avertebrated animals is attended with fatal consequences; (*c*) which in all probability would not have happened, had it corresponded exclusively to the Ganglionic system, and not also to the cerebro-spinal. This assertion appears, at first sight, somewhat opposed to the presumption, hitherto constantly entertained, that the former furnishes a property more immediately essential to life than the latter. But it must be kept in mind that, every point of the Ganglionic system being a centre of nervous influence to itself, the system collectively is quite independent of any common centres; and accordingly, not only may all communication with such common centres be cut off—as has been already stated—but the latter may be altogether withdrawn—as will be stated more fully in future—without destroying, or even sensibly impairing the function of the nerves connected with them. Such is not the case however with the cerebro-spinal system; which, although it ministers to functions which, with the exception perhaps of respiration, are less immediately essential to life than those to which the Ganglionic system is subservient, cannot be supposed to be thus violently destroyed,

(*a*) Malphighi.
(*b*) Swammerdam. (pl. xli)
(*c*) Rolando.

without sooner or later involving the system in general in its destruction.

Every presumptive evidence then is in favour of the opinion already advanced, that the apparently simple nervous apparatus of such of the avertebrated animals as have a distinct nervous system at all is no less compound, than that of the vertebrated; and positive evidence to the same effect seems to have been afforded by numerous investigators. It has been found that, in some insects, the chain of knots above spoken of as a main part of this apparatus, besides supplying nerves to the parts which minister to the organic functions in the manner of a regular Ganglionic system, gives off distinct lateral nerves arising by single roots from the central parts, and distributed principally upon the respiratory organs, as well as others arising each by an anterior and posterior root, and going chiefly to the organs of voluntary motion and sensation; the whole constituting thus a perfect spinal cord as found in the highest tribes, except that it is in sections, instead of being continuous. (*a*) The argument therefore of the earlier manifestation, as we ascend in the scale of animals, of the Ganglionic than of the Cerebro-spinal system of nerves, in favour of regarding the former as the immediate seat of irritability, must not be extended to all the avertebrated tribes, however applicable it may be to those which, without any concentrated and distinct nervous apparatus, still display traces of nervous matter; although it must be confessed that it is not easy to say to which department the isolated nodules in question correspond. The analogy however, so constantly observed in other respects between the lowest animals and the human embryo in its earliest stages, is certainly favourable, as we shall find from the next paragraph, to the idea that such nodules belong rather to the Ganglionic than to the Cerebro-spinal system.

VII.—That the development of the Ganglionic system of nerves, in the human embryo, precedes that of the Cerebro-spinal has been confidently asserted; (*b*) although it must be presumed that by this is meant the *full development* of it, since

(*a*) Lyonet described the Respiratory and Motiferous columns of some insects upwards of seventy years ago; and the separate existence as well of these, as of the Sensiferous columns, has been since inculcated by Treviranus, Müller, Dufour Straus Durckheim, Grant, Newport and others.

(*b*) Ackermann. (*De Systematis Nervosi Primordiis*, 1813) the *rudiments* of the Spinal cord and Brain are among the first parts visible in the primitive trace. It is further said that the first portion of the Ganglionic system which becomes obvious is the Cardiac Ganglion; and these circumstances, taken in conjunction with the facts, that irritation precedes sensation, thought and voluntary motion, and that the heart—the *punctum saliens* of Harvey—is the organ of the body which first manifests such irritation, seem to be a strong corroboration of the doctrine which refers irritability to the Ganglionic system of nerves, as its primary seat. It is further asserted, not only that the Sympathetic nerve is remarkably distinct in the human embryo, and its Ganglions perfect and of their usual colour, while the Cerebro-spinal system is still very obscure, but also that all these Ganglions are relatively larger and more perfect in the fetus than after birth, except the Cœliac; (*a*) all which very well corresponds with the hypothesis under consideration, since, while the irritability of every organ of the body which ministers to the circulation of the blood, deposition and absorption, is unquestionably more in requisition during fetal, than during extra-uterine life, that of those which minister to assimilation and generation is as certainly much less so.

VIII.—Again it is abundantly well known how frequently mature human fetusses are born with a defective Cerebro-spinal system of nerves, or even altogether without a Spinal cord or a Brain; (*b*) whereas such defects are said seldom or never to occur with respect to the Ganglionic system of nerves, sufficiently indicating its paramount importance in maintaining that circle of vital actions which requires only irritability for its exercise. It is true not a few accounts are on record of monsters, born at the full time, without any appearance whatever of a nervous system of any kind; but, if we attend carefully to such accounts, we shall perceive that their authors have been in general employed in looking for a Spinal cord and Brain, and the larger nerves connected with them, and might easily have overlooked those smaller filaments which belong to the ganglionic system:

(*a*) Lobstein. (*De Nerv. Sympath.* 1823, 47 et seq.)

(*b*) Morgagni, Sandifort, Soemmering, Meckel, Pullin, Pole, Simmons, Cam, Osiander, Béclard, Burrows, Kelch, Lawrence, &c. The most complete treatise on the subject of acephalous monsters is by Tiedemann.

and this suspicion seems the more probable, when we call to mind how long it was before this system of nerves, even in the most perfect examples of the highest class of animals, was detected, and how recently the presence of nerves in the heart, upon which some of the most conspicuous filaments of this system of nerves are distributed, was resolutely denied. It is not indeed improbable that when the monstrosity is excessive, the unformed mass may have its nervous system, as well as all its other organs—as is the case in quite the lowest tribes of animals—so generally diffused as to be invisible; (*a*) but it is stated on good authority, and as the result of numerous and patient inquiries on the subject, that, so long as a human monster does not very considerably depart from the human form, the Ganglionic system of nerves is in general, if not always, quite perfect. (*b*) It is a good illustration also, as well of the independence of this system upon the Cerebro-spinal, as of its indispensability—whatever may become of the latter—to the proper vital functions, that in idiots, whose Cerebro-spinal system has become diseased and atrophic, the Ganglions of the Sympathetic nerve have been found in general perfectly healthy. (*c*)

IX.—It might have been almost inferred, from the contents of the seventh paragraph, that the Ganglionic system of nerves would be relatively more developed in the young than in the aged; and it has accordingly been found that this development is, in all animals, generally inversely as the age of the individual in which it is examined; (*d*) the Ganglions in old age being paler, drier and more attenuated, and sending out fewer filaments, than at any other period. (*e*) It appears also that the Ganglionic system of females bears in general a greater proportion to their Cerebro-spinal system than that of males. These facts, coupled with the acknowledged greater irritability of children and females, in comparison with their sensibility,

(*a*) Dr Clarke. (*Phil. Trans.* &c.)

(*b*) Lobstein alone (*De Nerv. Sympath.* 1823, p. 52 et seq.) relates no fewer than six remarkable instances, in which the Brain and numerous other organs were deficient, but in all which the Ganglionic system was quite entire, and in some more than usually developed.

(*c*) Dr Cayre's account of the dissection of nine idiots. (*Nouv. Journ. de Méd.* t. iv.)

(*d*) Weber. (*Anat. Comp. Nervi Sympathetici*, 1817)

(*e*) Lucæ; (*De Nervis Arterias Venasque Comitantibus*, 1786) Lobstein. (*De Nerv. Sympath.* 1823, p. 55) their faculty of thinking and their power of voluntary motion, than of adults and males, are very corroborative of the hypothesis in question. Perhaps also it may be added, under this head, that the length of time during which the irritability of each organ survives apparent death, seems to be, *cæteris paribus*, proportioned to the number and size of the Ganglionic nerves with which it is supplied; as is well exemplified in the auricles of the heart, as contrasted with the ventricles, and in the right side of the heart, as contrasted with the left. (*a*)

X.—It is further in favour of the doctrine that the Ganglionic system is the immediate seat of irritability that it is similar in structure to the generally reputed Sensiferous department of the Cerebro-spinal; since it renders it probable that the Ganglionic nerves, as they certainly do not communicate sensibility, communicate at least that property which is most nearly allied to it. This similarity is observable, first, in the manner in which the grey and white matters are intermingled in the former system, not only in all the proper Ganglions, but in all the nerves connected with them, and in the latter, in all the Ganglions placed on the roots of the several Sensiferous nerves; and secondly, in the general character of the white matter, so far as it can be ascertained, in both. It has been already noticed, under the head of the Nervous Tissue in general, that in the Ganglionic nervous tissue the grey and white substances are everywhere inextricably interwoven together; whereas in the Cerebro-spinal—including of course the Sensiferous department of it—this intermingling is in general confined to the central parts, so that the nerves consist of white substance alone. In this statement it was of course intended to include the Ganglions of the Sensiferous system of nerves among the central parts; and, in these, the mutual relations of the grey and white substances are almost entirely the same as in every part of the proper Ganglionic system. Nor is there any visible difference in the manner in which the nervous cords *appear* to enter each Ganglion of both systems, to be subdivided within its substance into more minute filaments, and to be re-united as they prepare to emerge from the opposite surface; although, if we are to regard the ganglions—not only the insensible, as already stated, but also

(*a*) Scarpa, Walter, H. Cloquet, &c.

the sensiferous, as will be stated in future—as independent sources of nervous influence, it would be more correct to represent all the nerves connected with them as proceeding from them, and to speak of such nerves as beginning each by minute roots from the central parts of the organ, and proceeding thence in opposite directions. However this may be, the relative distribution of the grey and white substances is, in both sets of Ganglions, almost entirely the same; (*a*) and when it is remem-

(*a*) The internal structure of the Ganglions, insensible and sensiferous, has been investigated principally by Meckel Sen., Haase, Scarpa, Monro, Bichât, Wutzer, and Lobstein, the four first of whom, as already observed, regard the former as merely appendages to the Cerebro-spinal system, and the three last as independent organs; and the general result of their inquiries appears to be that there is little or no perceptible difference in structure between the two. The investigations of Meckel (*Mem. de Berlin*, 1745) were confined almost to the Spheno-palatine Ganglion; but those of Haase (*De Gangl. Nerv.* 1772) were more extensive. By means of maceration and boiling he found that, in the centre of the Ganglions in general, the minute white filaments, of which they chiefly consisted, were apparently teased out into a kind of net-work, but that, towards the surface, more or fewer of them were united together at acute angles, and thus constituted the nerves supposed either to terminate in, or to arise from the Ganglions. These observations were confirmed by Scarpa (*De Nerv. Gangl.* 1779) and Monro, (*On the Struct. and Funct. of the Nerv. Syst.*) who further thought that they observed that the filaments of all the nerves supposed to enter a Ganglion, after having been unravelled within its substance, were so distributed, on preparing again to emerge from it, that every nerve proceeding from such a Ganglion received at least one filament from every nerve which had apparently entered it; and it was in this observation that the celebrated hypothesis of these authors, which has been already alluded to, respecting the use of the insensible Ganglions, originated. But it was not merely of these subdivided and re-united cords, as in a mere plexus, that the Ganglions, whether insensible or sensiferous, were found to consist; since in the interstices of these, a soft semi-liquid substance, of a colour between yellow and grey, and which by Winslow, Johnstone and others had been previously presumed to be analogous to the cortical part of the Brain, was uniformly met with. This substance, according to Bichât, (*Anat. Gen.* 1801) supported by Wutzer, (*De Corp. Hum. Gangl.* 1817) differs in several essential particulars from that to which it has been considered analogous, in as far as its merely physical and chemical properties are concerned; but it may still bear the same physiological relations to the nervous filaments of the Ganglions, whether insensible or sensiferous, as the grey substance of the Brain bears to the white substance of that organ. Wutzer moreover amply confirmed the observations of Scarpa and Monro respecting the manner in which the nervous cords appear to be unravelled, and their filaments again collected, in the Ganglions of both systems; and has given plates of the internal structure of some of the chief Ganglions of each, the appearance of which is almost precisely the same: it is unnecessary to repeat however that a very different view may be taken of the nature of these ramifications. By Lobstein lastly (*De Nerv. Sympath.* 1823) the presence of the soft greyish substance equally in the insensible and sensiferous Ganglions was further established, with the additional fact that, the smaller the Ganglion, in general the greater was the relative quantity of this substance which it contained; and he confirmed also the remarks of preceding authors respecting the intermingling of the nervous filaments in the substance of the Ganglions of both sorts. The fact therefore of the similarity in structure of the two appears to have been abundantly made out by the concurrent testimony, as well of the bered that the structure, not only of the grey matter, but, in these two systems of nerves, of the white matter also, unlike what it is in the Respiratory and Motiferous systems, is plexiform and soft, the general structural similarity of the proper Ganglionic and Sensiferous systems of nerves will be sufficiently apparent, and it will seem not unfair to infer that, as the Respiratory and Motiferous systems of nerves, the structure of which is similar, are, in all probability, the vehicles of different kinds of stimuli, so the Ganglionic and Sensiferous, which are equally similar in structure, are in like manner the seats of different kinds of susceptibilities.

XI.—It has been already stated that certain agents, such as narcotic substances, which, when applied to the central parts of the Sensiferous system of nerves, diminish or altogether destroy sensibility, when applied to all appearance directly to parts possessed of irritability, have similar effects with regard to this faculty; and as this is a fair *general* argument that it is not immediately on these parts, but intermediately through some department or other of the nervous system, that such agents operate so, taken in conjunction, not only with the direct analogy of sensibility and irritability, but also with the striking similarity in structure of the Sensiferous and Ganglionic systems, it is a fair *special* argument that it is through the latter system that they take effect, and consequently that this system is the immediate seat of irritability. The singular circumstance also that the stimulus of galvanism has no such action on either the Sensiferous or Ganglionic system of nerves, as to excite muscular contractions, while, applied to the Respiratory or Motiferous, its effect in this way is most remarkable, is a further proof of the functional analogy, as well between the two former as between the two latter, and has therefore an obviously favourable bearing on the hypothesis under consideration.

XII.—The last circumstance to be mentioned, as tending to the conclusion that the Ganglionic system of nerves is the immediate seat of irritability, is that of the nerves of this system, while they are of a similar form, colour and consistence, when distributed on parts the irritability of which is of the same cha-

opponents, as of the advocates of the doctrine, which ascribes to the Ganglionic system of nerves a property analogous to that which the sensiferous system is pretty generally acknowledged to impart.

racter—that is to say which are liable to be excited in the same manner by the same stimuli—being quite dissimilar in all these respects, when they supply parts the irritability of which is different. Thus, while the filaments going from the Ganglions to the several voluntary muscles, all which have one general character of irritability, are said all to display the same general aspect and physical properties, those which proceed from the Cœliac Ganglion, for example, respectively to the stomach, liver and other organs, each of which has a character of irritability peculiar to itself, have these properties very distinct; those sent to the stomach being conical, white and firm, those to the liver cylindrical, red and soft, and similar differences manifesting themselves between the filaments respectively of the splenic, mesenteric, hypogastric and other plexuses. (*a*) This remarkable coincidence then, if generally admitted, of certain modifications of a common faculty, as displayed by different organs, and corresponding modifications of a common system of nerves, as distributed to these different organs, seems to be a strong testimony in favour of the doctrine that this general system of nerves ministers directly to the general faculty in question.

Such then are some of the principal evidences brought forward in support of the hypothesis which places irritability in the Ganglionic system of nerves as its immediate seat. The principal objections, on the other hand, to this hypothesis, in addition to the supposed circumscribed distribution of this system of nerves, and some others which have been already incidentally answered, are the alleged facts—at first sight conclusive against it—first, that the application of stimuli to a Ganglion has little or no effect in producing any display of irritation, either in the Ganglion itself, or in the organs which it supplies with nerves; and, secondly, that the destruction or removal of a Ganglion has little or no immediate effect in diminishing the irritability of those organs, the nerves of which are derived from it.

It has been expressly asserted by many experimenters, (*b*) that the Ganglions of the Sympathetic system in general may be acted on, not only galvanically, but mechanically or che-

(*a*) Lobstein. (*De Nerv. Sympath.* 1823, p. 45)

(*b*) Haller, Soemmering, Behrends, Bichât, Wutzer, Bell, Lobstein, &c.

mically, without either betraying themselves any irritation, or giving rise to any irritation in the contiguous parts; and although some have stated that stimuli applied to the Cardiac Ganglion, for example, do excite the motions of the heart, as much as when applied directly to the heart itself, (*a*) perhaps it may be safely conceded that no manifestation any where of irritation follows the application of stimuli to the Ganglion, without any compromise of the doctrine that it is in the Ganglionic system that irritability is primarily seated. It is true, when the central parts of the Sensiferous system of nerves—between which and the Ganglionic system there is so close an analogy—are so acted on, the result is sensation, acute in proportion to the intensity of the stimulus applied; and it is highly probable, that when such stimuli as those just alluded to are applied to a Ganglion, the result is irritation in the part immediately acted on, but such irritation may exist without any *manifestation* of it. It cannot be evinced by any expression of pain on the part of the animal on which the experiment is performed, for irritation is without consciousness—it is "perceptio," but not "perceptio perceptionis;" nor can it be evinced by any obvious motion on the part irritated, for a Ganglion is without muscular fibres, and has not therefore the physical structure requisite to such motion. Nay it is by no means certain, as already stated, that irritation may not exist without even imperceptible motion, although in as far as it does so, it cannot be regarded as quite synonymous with life; but whether or not any insensible motion take place when a stimulus is applied to a Ganglion, it is evident that we cannot recognise irritation by this means. Whatever irritation may exist therefore it is impossible that there can be any manifestation of it in the Ganglion itself, and it is highly improbable that any such irritation will be extended elsewhere. The nerves supplied by the Ganglions to the contiguous organs, if they communicate any thing at all to them, as acted upon through the Ganglions, which is very doubtful, can be conceived, in conformity with the doctrine now under consideration, to communicate only an increased *susceptibility* of action on the application to the organs themselves of the requisite stimulus, not a *stimulus* capable of exciting the susceptibility already resident in them; and

(*a*) Whytt, Fowler, Humboldt, W. Philip, &c.

without this stimulus no irritation can, in any instance, take place. (*a*) It is a very different thing when any extraordinary stimulus is applied to the root of a Respiratory or Motiferous nerve, the office of which is to convey stimuli in general to the organs on which they are distributed, and which, furnished as these organs are already from another source with the second necessary condition of action—namely irritability—immediately obey such stimuli, and manifest irritation. But doubling or trebling one condition of action, if it were possible to do so, by stimulating the Ganglions, would not supersede the necessity of the other, which, in this case, is wanting; so that whatever irritation were thus excited, it might *à priori* have been conceived likely to begin and end in a part in which any display of it was impossible. It is hence probable that, when the heart has appeared to be called into action by a stimulus applied to the Cardiac Ganglion, it was by means of some filaments of the Pneumogastric nerve, with which the proper Ganglionic nerves were associated, that the stimulus was conveyed.

Nor does the fact, that the destruction or removal of a Ganglion does not immediately entail any diminution of irritability on the organs to which the nerves from this Ganglion extend, at all militate against the doctrine that it is in the Ganglionic system that this faculty is primarily seated. It is unquestionable that the destruction or removal of any portion of the central parts of the Sensiferous system of nerves—so analogous to the Ganglionic—entails a corresponding failure of sensibility on the organs which are supplied with nerves from this portion; but if a similar effect be anticipated with respect to the irritability of the heart, for example, from the demolition or abstraction of the Cervical Ganglions, (*b*) or even of the Cardiac Ganglion, (*c*) it must be by one unacquainted with the facts already more than once insisted on. It was stated when speaking of the non-interruption of the irritability of a muscle by the divi-

(*a*) The want of any sensible effect from these experiments seems to be very decidedly opposed to the opinion of those who ascribe to the Ganglionic system of nerves a *reflex* action—first, that of perceiving an irritation, and afterwards that of communicating, in virtue of this irritation, a stimulus. If they do not, when directly irritated, communicate a stimulus, it is most improbable that they will do so when this irritation is indirect.

(*b*) Brâchet. (*Sur les Fonctions du Syst. Nerv. Gangl.* 1823)

(*c*) Magendie, Dupuy, Dupuytren, Breschet, &c.

sion of the principal nervous trunks with which it is supplied, by the removal of the brain, or even, for some time, by the total separation of such muscle from the rest of the body; and again, when speaking of the fatal effects of withdrawing the central parts of the nervous apparatus of the avertebrated animals, as a proof of their corresponding rather to the Cerebro-spinal, than to the Ganglionic system of the vertebrated; that, from the intimate interweaving, in every point of every Ganglionic nerve, of grey and white matter, every such point is a focus of nervous influence to itself, and quite independent therefore, at least for a time, of any common centre, for the continued display of the peculiar faculty to which it ministers. On the other hand, the Sensiferous nerves, consisting as they do in general of white matter alone, must be regarded, not as sources of the characteristic faculty to which they are subservient, but merely as chains of communication between the organs on which they are distributed and the sensorium; so that instantly, upon the latter being injured or withdrawn, the former are paralyzed throughout their whole extent. We may liken, if we please, the individual Ganglionic nerves to wires composed of zinc and silver, and the Ganglions connected with them to a voltaic pile; the former perhaps under ordinary circumstances acting principally as conductors of a power generated in the latter, but, upon being separated from it, being still competent to afford a certain quantity of the same power generated in themselves. (*a*) Hence the division of the large vessels going to a limb, with which principally perhaps its Ganglionic nerves reach it, has no immediate effect in impairing its irritability; and what effect it has, after a time, in this way, is pretty certainly to be ascribed, as already remarked, rather to the defective supply of blood to the parenchyma of the limb, by which the ganglionic nervous matter therein contained should have been renewed in proportion to its exhaustion, than to any obstruction of the Ganglionic nerves in their course. A knowledge of these facts might have led us to expect an almost entirely negative result from the experiments just alluded to; (*b*) and we cannot therefore, from such a result, infer anything prejudicial to the hypothesis under consideration.

(*a*) Dr Lovell Phillips. (*On Inflammation*, 1833)

(*b*) This result is further unfavourable to the notion of any *reflex* action exercised

Upon the whole the doctrine which regards irritability, not as inherent in all or any of the organized tissues of animals, independently of the nervous, but as immediately seated in the latter, and that, not in all its departments, but in the Ganglionic department alone, seems to be as well entitled to credit as any doctrine, resting upon presumptive evidence alone, can be. The fact is not indeed demonstrated, nor is it perhaps susceptible of demonstration ; but he who determines to wait for demonstrative evidence on all, or almost any point of physiology, must make up his mind to halt on the threshold perplexed, and stationary in this perplexity. Upon every subject of physiology, and in every stage of our progress in the science, one opinion must be better supported than another ; and any opinion—even though in some measure conjectural—founded on the best information which the present state of our knowledge affords, and taken up, not more as a resting-place for the present, than as a stepping-stone to the future, must at least be better than no opinion at all, since it rather invites than opposes itself to further investigation, and, while it spares us much heart-sickening and hopeless confusion at first, often enables us, by working with our previous conclusions in future speculations, to arrive rapidly at truths for which we might otherwise have waited in vain for ever. (*a*) Let us not mistake, as is too often done, the vacillation of the timid, the indolent or the incompetent for the caution of the philosopher, nor the decision of those who have boldness, industry and talent enough to come to a legitimate decision for the rashness of the visionary. It has been admirably remarked that he who dares not form an opinion must be a coward—he who will not, must be an idler—he who cannot, must be a fool. Let us have an opinion upon every thing ; but let us take up such opinion only after mature and dispassionate consideration of all the established facts which bear upon the subject, and be ready at once to qualify

by the Ganglions, although it furnishes no objection to the presumption that each point of a Ganglionic nerve may exercise such an action. The whole doctrine however appears to be in the highest degree visionary and uncalled-for.

(*a*) " Hypothesis indeed," says Mr Walker, " is supposition ; it may be right or wrong. But there can be no true reasoning—no theory without it, for every theory must first be in some degree hypothesis—every true explanation must first be conjectural." (*Nervous System*, 1834, p. 6) or to resign it, should any new facts occur to stagger or to overthrow us. It is no reproach to any one to be wiser to-day than he was yesterday; but it is a severe reproach to be from first to last an irresolute waverer, from a silly affectation of seeking for positive evidence in a science where such evidence is often unattainable, and a captious and fidgety habit of starting difficulties, which a more powerful mind would either have disregarded as frivolous, or at once have dismissed as imaginary.

With respect to the manner in which irritability or vitality—presuming that its immediate seat is, at least in all the higher tribes of organized beings, the Ganglionic nervous tissue—may be supposed to be extended to the other organized tissues, so that each appears to be *per se* possessed of it, very little needs be said. In the case of sensibility, the immediate seat of which is the sensiferous nervous tissue, there is no difficulty in at once admitting that this is the exclusive seat of the property in question, and that the comparatively few other tissues which appear to be *per se* possessed of it are, except in as far as they contain this, entirely insensible. But with respect to irritability, we may have more hesitation in confining this property to the Ganglionic nervous tissue, since irritability is, unlike sensibility, not merely an adventitious, but an essential property of organized beings, and seems therefore to be necessary, not only to every organ and every organized tissue, but also to every point of such tissue, in order to effect its molecular actions. But we must remember that there is no point of any organized tissue which does not contain Ganglionic nervous matter, such matter being essential to its organism; and consequently there is no point which is not possessed of the property in question, which is accordingly—as has been from the first insisted on—the result of such organism. It is true, unless every organized tissue be one uniform mass of Ganglionic nervous matter, there must be interstices of some other matter. Thus there must be spaces in the Ganglionic nervous tissue, occupied by one or other of those peculiar aggregations of matter which go to form respectively the cellular, dermoid, mucous, serous, fibrous, vascular, osseous, cartilaginous or muscular tissues, wherever an organized part presents itself. But the spaces thus occupied are almost infinitely minute, and such as to be perceived only by the mind's eye; and we may therefore, without doing much violence to preconceived opinions, deny that the tissues occupying them have any direct participation in irritability or vitality. As merely a property, it can never be directly transferred; and if it be immediately, it must be exclusively that of the Ganglionic nervous system. (*a*) But such interposed substances, thus destitute *per se* of irritability or vitality, are not nevertheless in the condition of merely inorganized matter—of a mere "solidum mortuum," with respect to either their structure, their composition or their actions. It is never otherwise than as combined into a whole with Ganglionic nervous matter that they actually exist; and although the former alone perhaps has a structure and composition which can be strictly called vital, and is alone susceptible of vital changes, still the latter are not less *sui generis* in these respects, possessing, as they must do, such physical and chemical characters as qualify them to co-operate in these changes, and thus to temper and modify, in every part, the resulting phenomena. It is easy to conceive that, if a flame be applied to a mixture of combustible and incombustible matters, the former alone will burn, but the latter may still be competent to undergo, each according to its peculiar character,

(*a*) It was the opinion of Galen, although he knew nothing about irritability, that the nerves, as the immediate receptacles of his Πνευματα, vivified, as it were, all the parts in their vicinity, *καθάπερ ὅταν ἐπι τοῦ περιέχοντος ἀέρος ἐκ τῆς ἡλιακης αὐγης ὁρμηθεισα τις ποιότης*, (*De Placitis Hipp. et Plat.*) and a somewhat similar notion has been propagated in recent times by Reil, Humboldt, Aldini, Heinecker, Lobstein and others, who speak of a nervous halitus, gas or atmosphere, an organic ether, &c., as the immediate source of the vitality of all the tissues of the body. "Statuo," says Lobstein, "materiem subtilem, imponderabilem, incoercendam, magnetico vel electrico-galvanico fluido analogam, a pulpa nervea secretam, evolutam atque transmissam, solam actuosum, quod nervis inest principium constituentem. Admitto istam materiem mobilissimam, et summum nobilitatis gradum assecutam, circa nervorum funiculos atque ramos, tum et circa carnem muscularem, efformare atmosphæram—eam sensibilitate esse præditam, id est facultatem habere stimulum percipiendi, atque, ope organorum e quibus emanat, contra eum reagendi." (*De Nerv. Sympath.* 1823, p. 123) Dr. Lovell Phillips has lately endeavoured to illustrate the subject by comparing the changes effected by the property derived from the nerves in the organized tissues in general, to which this property gives, as it were, a new mode of being, to those effected by the matter of heat in water, which is thus converted into vapour, and distinguished afterwards by characters quite distinct from any which it previously possessed. (*On Inflammation*, 1833) All these attempted explanations however seem to proceed upon the presumption that irritability is a substance, and as such actually communicated by the nerves to the tissues with which they are associated, instead of merely a property, and therefore quite incapable of being so transferred.

such modifications of expansion, liquefaction, vaporization, incandescence, and so forth, as will materially qualify the nature of the combustion, and may even be essential to it. It is in a similar relation that the substances occupying the interstices of the Ganglionic nervous matter, in the several organized tissues, appear to stand to the nervous matter itself—they have *per se* no irritability or vitality, nor are the phenomena which they display primarily vital; but they are nevertheless such as no merely inorganized matters could have presented, and such as not only temper and modify vital action, but are perhaps necessary to render such action available.

Such then is Irritability or Vitality, and its probable immediate seat. *We have thus done with the lowest of the vertical wheels of the organised machine, as delineated in the Diagrams in the Title,* CONSIDERED AT REST; *and have now to pass on to the horizontal wheel below it, by the hitching of the cogs of which in those of the former, it is set in motion—in other words, to those Stimuli from the action of which on Irritability or Vitality, Irritation or Life results.*

CHAPTER V.

ON THE DIRECT STIMULI TO IRRITABILITY.

Irritability is only one of the conditions necessary to Life —it is only, as it were, the susceptibility of living, or, as the French call it, *l'aptitude à vivre*—and other conditions are still requisite in order to give rise to those phenomena in which Life, consisting as it does in the sum of the essential functions performed by organized beings, consists.

These Stimuli may be spoken of as either Direct and Primary, or Indirect and Secondary; the former acting *ab initio* on the irritability of the organs to which they are applied; the latter implying always a previous irritation of some one organ —no matter by what means excited—and consisting in a translation of this irritation, so as to act on the irritability of organs at a distance. Thus a pinch of snuff, applied to the schneiderian membrane, excites *ab initio* an irritation in that organ, indicated by the changes effected in its secretions; and this irritation may either go no further, or may be translated by sympathy to the abdominal muscles, and excite there a secondary irritation, indicated by the sneezing which so often follows. Snuff therefore is an example of a direct and primary stimulus to irritability, and sympathy an example of an indirect and secondary one. It is of importance to remark however that these stimuli are not, any more than the irritability on which they act, substantial, although, like irritability, they are necessarily attached to something that is so; and such substances accordingly, in the case of the direct and primary stimuli, are, for the purpose of avoiding circumlocution, always put for the stimulus of which they are at once the source and the vehicle. It is obvious that, if Life be a non-entity, neither of its conditions—neither irritability nor any stimulus by which irritability is excited—can be entities. When we say therefore that snuff or any other substance is a stimulus to irritability, we mean only that the substance in question possesses some power which acts in this capacity; and we specify the substance only as a summary way of indicating the power which it exercises.

We recognise these powers, as we recognise the property on which they act, only by their effects—we know nothing of them abstractedly. They are, in every case, the result of the peculiar aggregation of matter in which they reside, in the same way as irritability is the result of organism; but they are certainly no more identical with the substance of which they are characteristic, than irritability is identical with the organized tissues of which it is the attribute.

Of the Direct or Primary Stimuli to irritability, the chief are certain universally diffused agents, to which organized beings, in common with inorganic matter, are more or less constantly exposed, such as CALORIC, LIGHT and ELECTRICITY; others, of which they continually appropriate a portion to themselves, such as the medium by which they are directly surrounded, whether AIR or WATER, and the solid and liquid substances which they use as ALIMENT; and others lastly which constitute at all times a substantial part of themselves, such as their various FLUIDS, whether crude, mature or secreted. Of the Indirect or Secondary Stimuli, the principal are SYMPATHY and PASSION or INSTINCT—the two latter of which appear to be merely varieties of the former—and VOLITION. In addition to these, which may be regarded as more or less constant and salutary Stimuli to irritability, and which, when neither excessive nor defective, constitute what may be called the *Exciting causes of* HEALTH, (*a*) certain others occasionally come into

(*a*) At the time when it was customary to regard Life as something inherent in the living body, and *per se* competent to bring about all vital phenomena, it was the practice to speak of every thing relating to the structure and actions of the body, under the name of *Naturals*, of which seven were generally admitted—namely, its Organs, its Tissues or Associations, its Fluids, its Principles, its Properties, its Powers and its Functions—the first five of which have been already spoken of in the order in which they are above enumerated. The error of this schedule consisted in including the powers and functions of the body, which were represented as inherent in it, like all the rest, instead of the powers being regarded as more or less adventitious agents, from the co-operation of which with the characteristic property of the body—i. e. irritability—the functions resulted. This however would have been to deprive the everlasting Vital Principle of its self-sufficiency; and consequently all those agents which the patrons of the Vital Principle doctrine could not avoid observing very materially influenced vital phenomena, and should have been included under the head of the adventitious powers aforesaid, were regarded as quite accidental, and marshalled accordingly into a distinct phalanx, under the name of *Non-naturals*, of which it was customary to admit six—to wit, Air, Aliment, Exercise, the Secretions, the Passions and Sleep. Upon what principle the most natural things in the world, as remarked by Sterne, should ever have been called non-natural remains unexplained; but a remnant of this ancient absurdity is still perceptible in the advice sometimes operation, the action of which, as well as that of any of the preceding, when either in excess or deficiency, is prejudicial, and it is of these that the Exciting causes of DISEASE consist; but with these we have nothing to do at present.

SECTION I.

On Caloric, Light and Electricity, regarded as Stimuli to Irritability.

ONE of the most universal of the natural stimuli to irritability is CALORIC; which, in a sensible or latent state, is present in every form of matter, and is continually exercising a powerful influence on the actions of all organized beings. It is hardly necessary to observe that heat and cold are merely relative terms. We call it heat—sensible Caloric—when the quantity of this Principle is such, in relation to the capacity of the substance containing it, as to raise its temperature above that of the surrounding medium, and consequently to give off Caloric to this medium; and, on the contrary, we call it cold, when the quantity of Caloric is such, in relation to the capacity of this substance, as to allow its temperature to fall below that of this medium, and consequently to abstract Caloric therefrom. But in all forms of organized beings, as well as in every form of inorganized matter, more or less Caloric is always present, and in all it is constantly operating as a stimulus to their irritability, and producing irritation; nor is this more certainly the case with respect to those organized beings the temperature of which is generally above, than with respect to those in which it is upon a par with, or even below that of the air or water in which they live. It appears however that every organized being requires

even yet given to valetudinarians, to take care of their non-naturals. It was reserved for John Brown to abolish this non-natural and unfounded distinction, by demonstrating that Life, and of course all the functions of the body in the sum of which Life consists, depended solely on the operation of some of these non-naturals, in conjunction with many other agents more or less allied to them, but which the founders of this distinction, in the plenitude of the perplexity in which their untenable hypothesis respecting Life involved them, had inadvertently omitted. But it is idle entering into any investigation of the merits of a system, which is not less loose and arbitrary in its detail, than it is, in its general principle, opposed to every thing like reason and common sense.

a certain definite quantity of Caloric, in relation to its capacity, under the operation of which alone its functions proceed with energy. This in some cases is so considerable as to raise its temperature above that of the medium which it inhabits; and in such cases the office of such being is, as the result of some of its most indispensable functions, to extricate within itself sensible Caloric, or, as it is commonly expressed, to generate heat. In other cases, this definite quantity is such as to maintain its temperature upon a par with that of this medium; when the calorific and frigorific processes going on within it are precisely balanced. Lastly in other cases this quantity is so small as to reduce its temperature below that of this medium; when its business is to occasion an absorption from itself of sensible Caloric, or, in other words, to generate cold.

Thus, to confine the question at present to animals, most of the avertebrated tribes, which are what are called cold-blooded, seem to require a temperature nearly the same as that of the media which they inhabit: but an exception must be made of the entozoa which inhabit the bodies of hot-blooded animals, the temperature of which is nearly the same as that of the latter, (*a*) as well as of insects, the average temperature of which appears to be from 70° to 102°. The crustacea in general likewise are commonly 2° or 3° warmer than the medium which they inhabit. (*b*) The temperature required by most fishes and reptiles also, which are likewise called cold-blooded, is in general not very different from that of the surrounding medium. That of fishes is said to be sometimes a little lower, (*c*) sometimes the same, (*d*) and sometimes a little higher (*e*) than that of this medium, except in very hot water, when it is always considerably lower; (*f*) while that of the batrachian and ophidian reptiles is generally 3° or 4° higher, (*g*) and that of the saurian and chelonian reptiles 10° or 12°. (*h*) The temperature of birds and mammals, or hot-blooded animals, is in general very little affected by that of the media which they inhabit. That of birds varies from about 101° to 111°, the smaller being gene-

(*a*) Juch, Schultze, Braun &c.
(*b*) Rudolphi.
(*c*) Moseley &c.
(*d*) Braun.
(*e*) Perring, Davy, Buniva, Krafft, Broussonnet &c.
(*f*) Audirac.
(*g*) De la Roche, Hunter &c.
(*h*) Rudolphi, J. Davy &c.

rally hotter than the larger; (*a*) and that of mammals from about 96° to 106°. (*b*) The cetacea and amphibia, whatever be the temperature of the water which surrounds them, have commonly a temperature of about 100°. (*c*) It would hence appear that, while cold-blooded animals in general must have each its own appointed habitat, or at any rate a distribution more or less circumscribed, such would not be the case with hot-blooded animals, which can thus create, as it were, their own temperature; but as the latter are adapted to do this each with reference only to a certain degree of external temperature, it can hardly be said that they are more independent of this than the former. The fact is that no form of organized beings, except Man, has the power of counteracting external temperature to any considerable degree, or at any rate exercises such power with impunity. It is on this account that, while Man, the natural temperature of whose body is about 98°, is found the inhabitant of every clime, from the temperature of—55° to 125°, or can accommodate himself to any point within a range of 180 degrees, and even endure for a limited time a temperature of from 260° (*d*) to 320°, (*e*) almost every other form of organized being has its fixed habitat, or a comparatively limited scope within which alone it is competent to exercise its functions. Thus some plants, as Mosses and Lichens, thrive best in regions where no other tribes of vegetables could exist; and the Pine and Fir flourish where the Oak, the Elm, the Beech and the Chestnut would fail. A slight increase of external temperature however answers for these, but a more considerable increase is required for the Apple and the Pear, the Plum and the Cherry, and a temperature still more elevated for the Cedar and the Cypress, the Fig, the Olive, the Orange and the Lemon; while the Palm, the Date, the Cocoa, the Coffee-tree, the Bread-tree, the Banana and numerous others come to perfection only in the torrid zone. It is even alleged that some kinds of water-plants thrive abundantly well in water at a temperature which would have been sufficient to boil them, had they been destitute of vitality. (*f*) In these cases then we must conceive

(*a*) Braun, Pallas &c.
(*b*) Braun, De la Roche, Hunter, Pallas &c.
(*c*) Braun, Scoresby &c.
(*d*) Berger, Blagden &c.
(*e*) Chantry.
(*f*) Sonnerat, Forster, Abel &c.

that, if the external temperature be not precisely what they require, the power of extricating within themselves sensible Caloric, or compensating for the deficiency of it from without, has gone on progressively diminishing, while that of occasioning an absorption from themselves of sensible Caloric, or carrying off the excess from without, has gone on progressively increasing: but no one of these plants seems competent to do indifferently either the one or the other according to circumstances. (*a*) The various degrees of external temperature required by plants are beautifully exemplified in mountainous districts, the low valleys of which are frequently adorned with the vegetable products of the torrid zone, and the more elevated districts with those of temperate climates, while towards the summit nothing is met with but the meagre natives of the polar regions; and the lines of demarcation are sometimes so remarkable, that on the volcano of Teneriffe no fewer than five distinct zones, marked by the vegetable products which characterize different climates, are distinguished. In like manner with respect to animals, among fishes, the Cod—*Gadus* 35—among birds, the Eider-duck—*Anas* 41—the Albatross—*Diomedia* 41—and the Lapland-owl—*Strix* 46—and among mammals, the Whale—*Balæna* 47—the Rein-deer—*Cervus* 48—the Seal—*Phoca* 53—the Walruss—*Trichecus* 53—the Esquimaux-dog—*Canis* 54—and the Polar-bear—*Ursus* 55—are met with exclusively in frigid regions; others, as most of those animals with which we are familiar, and, among beasts of prey from which we are happily exempt, the Wild-boar—*Sus* 49—the Wolf—*Canis* 54—the Lynx—*Felis* 54—and the Brown-bear—*Ursus* 55—thrive best in temperate situations; while others lastly, as, among molluscous animals, the Pearl-oyster—*Ostrea* 8—among insects, the Mosquito—*Culex* 23—the White-ant—*Termes* 27—and numerous kinds of butterflies; among fishes, the Electrical-eel—*Gymnotus* 35—among reptiles, all kinds of serpents and lizards, the Crocodile, Alligator and Gavial—*Crocodilus* 39—among birds, the Parrot—*Psittacus* 44—the Toucan—*Rhamphostos* 44—the Humming-bird—*Trochilus* 45—and the Bird-of-paradise—*Paradisæa* 45—and, among

(*a*) It is denied by Nau, Treviranus, and others, in opposition to Hunter, Lamarck, Hubert, and most physiologists, that plants have any power of generating either heat or cold.

mammals, the Camel and Dromedary—*Camelus* 48—the Giraffe—*Camelopardalis* 48—the Elephant—*Elephantus* 49—the Hippopotamus—*Hippopotamus* 49—the Hyæna—*Canis* 54—the Lion, Tiger, Leopard and Panther—*Felis* 54—and the various kinds of Monkey—*Simia* 58—are confined to torrid districts. Nay some fishes are said to live and move and have their being in water, the temperature of which is only a degree or two below the boiling point. (*a*) And the same inference is to be drawn here as with respect to plants, that, if the external temperature be not exactly what they require, as the inhabitants of frigid regions excel principally in the power of extricating within themselves sensible Caloric, so those of the torrid zone, or those habitually exposed to intense heat in any form, are calculated rather for occasioning an absorption from themselves of a portion of that to which they are exposed. Temperate districts are accordingly too hot for the former, for the function of the lungs, a principal indirect office of which is to extricate sensible Caloric, being no longer in the usual requisition, is in a great measure superseded—and that to the great prejudice of the animal—by that of the liver; while they are too cold for the latter, the lungs being now more than usually, and equally prejudiciously, exercised: and it is a remarkable fact that, as the Rein-deer, the Esquimaux-dog and the Polar-bear, when brought to this country, commonly die of diseases of the liver, or other affections of hot regions, so the Camel and Dromedary, the Lion, the Tiger and the Monkey, under the same circumstances, generally perish of consumption, or other diseases peculiar to cold climates. Man almost alone, of all forms of organized beings, is competent to strike, with comparative impunity, such a balance in the functions of his several organs, under all ordinary degrees of external heat and cold, as to maintain the temperature requisite to the healthy excitement of his irritability. He is therefore every where indigenous; and the only effect which a higher or lower external temperature seems to have upon him, is in the establishment, according to the greater or less exercise of this or that organ in effecting this balance, of what are called national temperaments. Into a consideration of the means by which he is enabled to effect this balance, or the process of acclimation, as it is called

(*a*) Clarke, Saussure, Sonnerat, Bruce, Shaw, Humboldt and Bonpland &c.

—important and interesting as the question is—it would be out of place to enter at present. Suffice it to say, in conclusion of this subject, that to every action, molecular or sensible, of every organized being, in which its life consists—in other words, to every instance of excitement of irritability—a certain quantity of Caloric, in relation to the capacity of this being—that is to say, a certain temperature—is indispensable; and that if it meet with either less or more than this definite quantity from without, it must either increase or diminish it, as a result of certain processes going on within itself, although it is only within certain limits that such processes are in general exercised with impunity. It appears indeed that some even hot-blooded animals have very little of this power; such as among birds, the Cuckoo—*Cuculus* 44—and perhaps the Swallow—*Hirundo* 45—and among quadrupeds, the Hedge-hog—*Erinaceus* 51—the Dormouse—*Glis* 51—the Marmot—*Arctomys* 51—and the Bat—*Vespertilio* 57—the hibernation of all which seems to arise chiefly from their incapacity to counteract the external cold by any internal processes, and thus to keep up the requisite stimulus of Caloric. (*a*) That many worms, the pupæ of insects, some fishes, as the River-salmon—*Salmo* 35—and most reptiles, as Frogs, Salamanders, Serpents, Lizards and Tortoises, should undergo this change from cold is less remarkable. The young of all animals likewise possess this power to a much more limited degree than the same animals when mature; and hence newly-born animals are very soon destroyed by external cold, as withdrawing from them an indispensable stimulus, with which they are incapable of providing themselves.

This then is the relation, and the only relation, in which Caloric or heat stands to Life—it is essential to Life, but it neither is, nor can be identical with it, as was in former times so vaguely imagined. (*b*)

(*a*) De Saissy found the temperature of a Hedge-hog, which had been 99° in August, reduced to 57° in November, and Pallas has found it, when the animal was quite torpid, reduced to 39°: similar differences occur in the Dormouse and Marmot. Dr Marshall Hall ascribes this diminution of temperature, as well as of activity, to the diminished energy of respiration, which he represents as inversely as the degree of irritability. (*Phil. Trans.* 1833) But of this hereafter.

(*b*) It is quite unnecessary to recapitulate all that has been said concerning the supposed Πῦρ καθάρσιον, the Elementary fire, the Promethean heat, the Calidum innatum &c. as synonymous with Life. The error consisted only in mistaking a neces-

A second, and perhaps equally universal stimulus to irritability is Light, which, like Caloric, pervades every form of matter in either a sensible or latent form, and continually exerts perhaps a more powerful influence on the actions of organized beings than is commonly believed. It is perhaps difficult to conceive that such beings when in what we call darkness are still under the stimulus of Light; but we should keep in mind that Light is not in itself luminous, any more than Caloric is in itself heating, and that it appears so only when its equilibrium is destroyed—that is to say, when a portion of what is contained is sent off from one body to others. Light and darkness are, in fact, like heat and cold, merely relative terms, and an organized being in darkness is probably no more withdrawn altogether from the stimulus of Light, than a being the body of which is as cold or colder than the surrounding medium is entirely deprived of the stimulus of heat. Nevertheless it is sensible Light alone the stimulus of which is generally acknowledged; and even this is commonly regarded as very circumscribed in its operation, if not on the irritability of plants—which certainly appear to be very much under its influence—(*a*) at any rate on that of animals, the only parts of which generally regarded as acted upon by this agent being those of the eye. This however is in all probability a mistake; the parts of the eye alone appearing to be stimulated by sensible Light only because they alone are furnished with sensiferous nerves, capable of taking cognizance of the irritation so produced, and of converting it into sensation, but all parts so exposed being in fact equally the seat of such irritation. It is remarkable that certain animals which naturally undergo metamorphoses, such as the larvæ of the Frog, pass through these either very imperfectly, or not at all, if kept in darkness, (*b*) and it is said that pregnant women, who have been confined in dungeons, frequently produce monsters. Most animals likewise which inhabit dark places, are, like the Pro-

sary condition of Life for Life itself. Dr. Pring is among the few in modern times who have chosen to represent Heat as at least " a part of the Principle of Life !"

(*a*) " Exclude the agency of Light," says Dr Kidd, " and in a short time the most experienced botanist might possibly be at a loss to know the plant with which he is otherwise most familiar, so completely obliterated are all its natural characters, whether of colour, form, taste or odour." (*Bridgewater Treatise*, 1833, p. 92)

(*b*) W. F. Edwards. (*De l'Influence des Agens Physiq.* &c. 1834) teus, of a more or less hybrid character, and, to our view at least, of a lurid and forbidding aspect. It is not improbable that the diminished energy of the functions during the night, and the stinted growth and imperfect formation of most of the inhabitants, vegetable and animal, of polar districts, may be owing, at least partially, to the deficiency of sensible Light; and a similar cause may perhaps be assigned for the deformity and disease so prevalent among those who work in mines, or even who inhabit narrow and dark streets. It is at least certain that the naked inhabitants of countries in which the Light is intense are almost exempt from these calamities. (*a*)

It is probable that every plant and animal thrives best when acted on by a certain definite quantity of Light, as well as of Caloric, in relation to its own capacity; but it does not appear that organized beings in general exercise any power, like that manifested with respect to Caloric, of so destroying the balance of the Light within them and that of the surrounding medium, as to produce either a sensible extraction of it within themselves, or a sensible absorption of it from them. Many plants, it is true, both cryptogamic and phanerogamic, have been represented as extricating Light under some circumstances; and, among animals, some polypi, as the Sea-feather—*Pennatula* 2—some acalephæ, as the Sea-blubber—*Medusa* 3—and many insects, as the Lantern-fly—*Fulgora* 28—the Fire-fly—*Elàter* 28—and the Glow-worm—*Lampyris* 30—certainly possess this power to a very considerable degree, while innumerable others display more or less of it. It is in general confined however to a particular part of the plant or animal which possesses it, and is certainly exercised for a purpose very different from that of exciting their irritability, as a stimulus to which alone Light falls now to be considered.

With the instrumentality of Light to vision we have at present nothing to do; although it is in this way likewise indirectly a strong stimulus to irritability.

Light, sensible or latent, is perhaps as essential to Life as Caloric; but it is unnecessary to say that it neither is, nor can be identical with Life, although this opinion has not wanted advocates. (*b*)

(*a*) Humboldt.

(*b*) Light, the first of created things, and the creation of which is described in

A third stimulus to irritability, and one very analogous to the two just mentioned, is Electricity, and particularly that form of it which is called Galvanism. Like Caloric and Light it pervades every form of matter; and although its existence is not perceptible, any more than theirs, till the equilibrium of its distribution is destroyed, it has probably, even in its latent state, a very considerable influence on the actions of organized beings. Positive and Negative Electricity probably stand in the same relations to each other as Heat and Cold—or Light and Darkness—that is to say it is the former alone which has any real existence; and in no degree of negative Electricity perhaps are plants and animals quite withdrawn from the agency of this Principle. It is however only in its sensible state that this agent can be recognised; and in this state there are few or none, except Caloric, which can compare with it in universality of action, since every irritable organ appears to be subject to its agency, and none whatever is a match for it in power, since the results are more striking from this than from any other stimulus to irritability, and it takes effect long after every other has failed to do so. Whether Electricity or Galvanism accelerate vegetation, as has been asserted, (*a*) is somewhat questionable; (*b*) and it is at least certain that it exerts no sensible action on the irritability of plants, except when applied in the manner of a spark or shock; (*c*) whereas on that of animals, from the Leech up to Man, whether suddenly or continuously transmitted its action is most powerful and remarkable. As either applied directly to the several organs, or conducted to them by the respiratory or motiferous nerves, it excites the irritability of the respiratory muscles, and therefore may be made to effect ***Respiration;*** that of the heart, and therefore ***Circulation;*** that of the secreting and absorbing vessels, and therefore ***Deposition*** and ***Absorption;*** that of the stomach, and

the most sublime passage of written language, is spoken of, in almost every page of the oldest book in the world, as emblematical of all that is excellent, and of Life among the rest; and we have recently seen that Galen represented the influence communicated by the nerves to the contiguous parts, as something, if not identical with, certainly very analogous to this Principle. Among the few modern authors who have entertained themselves with promulgating the notion of the identity of Light and Life is Lamarck, who represents the latter as a substance composed of a kind of mixture of Light and Electricity!

(*a*) Mainbry, Nollet, Bartholon &c.

(*b*) Cavallo, Ingenhouz &c.

(*c*) Van Marum, Humboldt &c.

therefore *Assimilation*; that of the membranes of the nostrils, eyes and ears, of the tongue and of the skin, and therefore indirectly—the irritations so excited being taken cognizance of, so long as the animal functions are unimpaired, by the respective sensiferous nerves—the *Sensations* of smell, sight, hearing, taste and touch; that of the voluntary muscles, and therefore various *Writhings* of the features and *Contortions* of the limbs: and it does all this more forcibly, and for a longer time after apparent death, than any other known stimulus, (*a*) and may often therefore be substituted with effect for any of the ordinary stimuli, such as Caloric, Sympathy, Volition and so forth, by which these functions are naturally excited. (*b*) The general influence indeed of this agent as a stimulus to irritability is in some persons very remarkably displayed in the total relaxation which they undergo—quite independently of any apprehension—previously to, or during a thunder storm; and we all experience more or less of this in that kind of weather which is unfavourable to electrical experiments, and more or less of the reverse, in that kind of weather when such experiments are most successful. Exposing the body artificially also respectively to negative and positive Electricity produces, it is said, very similar results. (*c*)

It is probable that to every form of organized beings a certain definite quantity of Electricity or Galvanism, in relation to the capacity of each, as well as of Caloric and Light, is essential to the healthy performance of all its functions; but it is very doubtful whether such beings are in general provided with the means of either extricating it within themselves, or occasioning an absorption of it from their bodies, as in the case of Caloric, so as to render themselves, in this respect, in some measure independent of the medium which surrounds them. It has been supposed indeed that plants develop positive Electricity—that is to say extricate this Principle—by night, owing to the exhalation from them of carbonic acid, formed, as is imagined, by the direct union of carbon and oxygen; and that they develop negative Electricity—in other

(*a*) The most extensive series of experiments of this kind was performed on the victims of the guillotine, at Turin, by Nysten, who employed Galvanism as the test of the duration, in each part of the body, of its irritability.

(*b*) Hence its advantage, as a remedial agent, in asthma, dyspepsia, palsy &c.

(*c*) Dr. Hodgkin. (*App. to Transl. of W. F. Edwards*, 1832) words occasion an absorption of this Principle—by day, owing to the exhalation from them of pure oxygen; and that it is by this means principally that the varieties of the atmosphere, with respect to its state of Electricity, are produced.(*a*) That numerous animals also have the power of at least extricating Electricity is sufficiently well known. This is very remarkably the case with the Torpedo—*Raia* 32—the Electrical-eel—*Gymnotus* 35—and the Electrical-silure—*Silurus* 35—and many other aquatic animals possess the same power in a greater or less degree; but in all the Electricity so developed appears to be confined to a particular organ of the animal, and to be extricated for purposes very distinct from that of acting as a stimulus to its irritability.

The relation then in which Electricity or Galvanism stands to living action, or to Life, has been above pointed out; but, not content with regarding this Principle as the most efficient known stimulus to irritability, some physiologists have amused themselves, in the same manner as others have done with respect at one time to Caloric, and at another to Light, with representing it as identical, sometimes with Life, and at others with the so-called Nervous energy. The hypothesis is altogether so loose and untangible, that it is almost impossible to contend with it systematically. " Your true no-meaning puzzles more than wit;" but as it has attained, perhaps from its very vagueness, an undue degree of popularity with a certain class of physiologists, it will be necessary to say a few words on the subject. And first with respect to the alleged identity of Electricity or Galvanism and Life. (*b*) Of course if the doctrine concerning Life, already so fully inculcated—that it is not a substance at all, but a mere mode of being—be well

(*a*) Pouillet; (*Ann. de Chim. et de Phys.* t. xxxv.) Dr. Graves. (*Renshaw's Journ.* 1835)

(*b*) That Heat was Life, that Light was Life, that Air was Life, that Water was Life, that every thing in short with which mankind was acquainted was Life, had been successively maintained, and each occupant of the vital chair had been pretty satisfactorily in turn dislodged, when, fortunately for the lovers of an absolute monarchy in physiology, Electricity was discovered, and Electricity was at once promoted to the vacant throne. The notion of the identity of this Principle and Life seems to have been promulgated for the first time, as already remarked, by John Hunter, and it was of course adopted by his popular pupil, John Abernethy: fortunately however the reputation of both of them is founded on a more solid basis than the propagation of this flimsy and shallow hypothesis. Lamarck, as we have just seen, represented Life as a compound of this Principle and Light!

founded, it is quite out of the question entering at all into the inquiry whether it be identical with this Principle or any other; but admitting, for a moment, that Life is a substance, what evidence have we that it consists merely in Electricity or Galvanism? We have seen already that the principal arguments adduced in favour of the existence of Life as an Entity are, 1st, that such an entity is essential to the organization of a living being; 2ndly, that such an entity alone is competent to effect the characteristic actions of a being so organized; and 3dly, that our belief in a future state of existence hinges on the presumption of the existence of such an entity: and it is of course incumbent on those who contend for the identity of Life and Electricity or Galvanism—not indeed to apply these arguments to prove the existence of Electricity or Galvanism as an entity, for that is unquestioned—but to show that this Principle is competent to effect, and does in reality effect, all those phenomena from which the existence of Life, as an entity, has been inferred. Now, in the first place, does Electricity or Galvanism organize substances into which it is thrown? Does the prime conductor of an electrical machine, or the positive wire of a galvanic trough, become organized in virtue of the Electricity or Galvanism which it receives; or do any other matters in which these Principles are accumulated undergo organization as a consequence of such accumulation? The idea is absurd. Nevertheless, if organized beings became so solely in virtue of their substantial Life, and this were identical with Electricity or Galvanism, any matters transmitting or receiving this Principle must of necessity become organized beings. (*a*) Again do the matters by which this Principle is conducted, or in which it becomes collected, manifest the characteristic actions of organized beings; or, on the other hand, are such actions excited by this agent only in those which are already possessed of the property of irritability or vitality, quite independently of its operation? The answer is obvious. Nevertheless, if Life were nothing but Electricity or Galvanism, any matters into which this Principle was thrown must necessarily display living action; and it must be equally correct to say that an electric or galvanic apparatus produces its phenomena by means of the Life which

(*a*) Dutrochet has lately formed, we are told, muscular fibre by galvanizing a drop of serum, but we do not find that he was capable of organizing it by this means.

it develops, as that a plant or animal lives and moves by means of its Electricity or Galvanism. Further, if such were the case, we ought to be able, at any time, to stop the living actions of one body and to excite these actions in another—that is to say to withdraw and communicate Life, precisely as we withdraw or communicate the Principle in question. (*a*) And how can it be explained, upon the presumption of the identity of Life and Electricity or Galvanism, that this Principle cannot excite living action, even in organized bodies, beyond a limited time—Life should surely always make live? Nay, that excess of this Principle should be immediately fatal to both plants and animals—death should surely not result from excess of Life? (*b*) Is it not, on the other hand, evident that, in the former case, the Electricity or Galvanism, being a mere stimulus, becomes inert as soon as all irritability has departed; and, in the latter, that, in the same character of a stimulus, it destroys all irritability by the excess of irritation which it produces? Finally who will be so wild as to contend that the immortal part of our frame—that which leaves our bodies at the instant of death, and is destined to survive us to all eternity—is Electricity or Galvanism? Yet such must be the case if Life, or the presumed "Vital Spark of heavenly flame," and this Principle be identical. But it is mere waste of time dwelling any longer on this rambling dream. Not only is Life nothing, and incapable therefore of being identical with any thing, but, were it any thing, every view of the subject would demonstrate that it must

(*a*) Lawrence. Dr. Philip also, a chief advocate of the hypothesis next to be mentioned, admits that "Life exists only in living bodies, and no task can be more hopeless than to look for it elsewhere." (*On the Vital Functions*, 1827)

(*b*) "A calf's head," says Sir Charles Bell, "is made to yawn, or a man cut down from the gallows to move like a figure of cards pulled with strings. The jaws move, and the eyes roll, and this is done by conveying the galvanic shock to the nerves: hence it is supposed that nothing less than the Principle of Life itself can work such wonders, and that Galvanism is that principle. But in no circumstance is there a resemblance; and the whole phenomena resulting from Galvanism transmitted through an animal apparently dead are fairly to be attributed to its being a high stimulus, conveyed through the moist animal body, and exciting the powers (properties) which remain isolated in the several parts; and in exciting these powers, (properties) far from renewing them, it exhausts them altogether. (*Useful Knowledge*) It is quite true,

"Nutritur ventis, ventis extinguitur ignis,
Lenis alit flammas, grandior aura necat;"

but had the winds been identical with the fire, the gale with the flames, it is impossible that this could have happened.

be at least sui generis, and as distinct from Electricity or Galvanism as one thing can be from another.

But is this Principle identical, not indeed with Life—under which term are jumbled together all kinds of susceptibilities and all kinds of stimuli in most admired disorder—but with Nervous energy, as it is called; (*a*) by which term seems to be, in this case, understood—for it has been used in twenty different acceptations—not a susceptibility of any kind, but all kinds of stimuli, which, originating in the body of an animal, are capable of being conveyed by the nerves? According to this hypothesis, not only may Electricity or Galvanism, as artificially extricated and applied, be made to excite all the vital actions, and become thus a good substitute for the natural stimuli when these are defective, as has been already stated, but it is Electricity or Galvanism, as constantly extricated either in various parts of the body, owing to the mutual action of its various solids in general, and of nerve and muscle in particular, (*b*) or in the brain alone, owing to the mutual action of the alternate layers of grey and white matter of which it is composed, (*c*) and conducted by the several nerves, which naturally excites these actions. Nay even when they are excited by mechanically or otherwise stimulating a nerve, it is still presumed to be in virtue of the Electricity or Galvanism which is thus developed that they take place. (*d*) It is upon this agent accordingly that immediately depend, it is said, not only respiration, circulation, assimilation and the other functions consisting in sensible motion, but, in a more especial manner, secretion, and the rest of those which consist in molecular motion; the nature of which, if this hypothesis be adopted, is no longer involved in any obscurity. It was noticed in evil hour that the blood, when withdrawn from the body and subjected to Galvanism, had its sodo-albumen coagulated, and its salts separated; (*e*) and again, that the ingredients of a solution of muriate of soda could be made to pass se-

(*a*) This hypothesis originated perhaps with Valli, (*Journ. de Phys.* t. xli.) and was adopted by Dr. Young, (*Lect. IV*) as it has since been by Dumas and Prevost, W. F. Edwards, and so many others. The principal patron of it in this country is Dr. Wilson Philip.

(*b*) Sprengel.

(*c*) Reil, Rolando &c.

(*d*) W. F. Edwards. (*Mém. de l'Acad. Roy. des Sc.* 1825)

(*e*) Brande; (*Phil. Trans.* 1809) Sir E. Home &c.

parately through an organized membrane by the same means.(*a*) It hence became established that it was Electricity or Galvanism alone which performed all the incessant chemical actions of the living body; and, acting directly on the blood—(*b*) not merely stimulating the vessels to do so—converted this blood into every variety of solid and fluid, organized or otherwise, and transmitted each through the coats of the blood-vessels; and animal heat being soon afterwards *discovered* to be a secretion, it was to be expected that galvanized blood would be converted, among other things, into Caloric, which was accordingly found to be the case. But, in the first place, if Electricity or Galvanism be constantly extricated in the living body in the manner which has been supposed, why should those fishes which certainly extricate it, be furnished with a proper apparatus for the purpose; (*c*) and how is it that it cannot, as confessed by the strongest advocates of this doctrine, be estimated by the galvanometer? (*d*) But assuming, for a moment, that Electricity or Galvanism were constantly so extricated within the body—an assumption altogether gratuitous—and that it were the main stimulus to all the vital actions, sensible and molecular, it would be rather hostile, than favourable to the opinion that it is identical with the so-called Nervous energy. We know of only two modifications of this energy, regarded in the light of a stimulus—that of Sympathy and Passion or Instinct, and that of Volition—and both appear to act rather as accidental and occasional stimuli on the irritability of certain parts, than essentially and constantly on that of all; so that any stimulus supposed to be in perpetual and universal operation can hardly be identical with such Nervous energy. Moreover each of these modifications of the Nervous energy is quite distinct from the other, and is conducted by its

(*a*) Wollaston. (*Phil. Trans.* 1811)

(*b*) It is expressly said by Dr. Wilson Philip, "The vessels only convey the fluids to be operated upon by the Nervous power," i. e. Galvanism; (*On the Vital Functions*, 1817) and a similar opinion is maintained by Mr. J. W. Earle, who speaks of the "secernent power of the nerves" as acting directly on the blood. (*Med. Gazette*, 1835)

(*c*) Dr. Prout. (*Bridgewater Treatise*, 1834, p. 517)

(*d*) This has been tried in vain by Dr. Wilson Philip, assisted by Mr. Faraday; (*Gulstonian Lectures*, 1835) although perhaps but little importance should be attached to this objection, since it is doubtful how far Animal Electricity is ever appreciable by this means.

own proper department of the nervous system—the former probably by the so-called respiratory, the latter by the motiferous nerves—while Electricity or Galvanism, when artificially applied to the body, is conducted equally well by both. To say nothing therefore of the impossibility of its being identical with both, it cannot be identical with either. Again, Nervous energy is found to be at once intercepted by tying the nerve by which it is naturally conducted, whereas the conveyance of Electricity or Galvanism is not at all obstructed by this operation ; and if a respiratory nerve, in direct contact with a motiferous nerve, be so tied, or vice versâ, the stimulus of Sympathy and Passion is intercepted, while that of Volition is unobstructed, or the reverse, whereas Electricity or Galvanism is quite unsusceptible of any such isolation. Lastly, Electricity or Galvanism, waving all other objections, must be quite incompetent to effect, not only all, but almost any of the vital processes ascribed to it. For, to select even the stronghold of the advocates of this doctrine—the process of secretion—how can it be explained that Electricity or Galvanism, which is always the same, acting—not upon the capillary blood-vessels, each set of which may be presumed to have its own specific character of irritability—but upon the arterial blood, which is likewise always the same, should give rise, in different parts of the body, to depositions so entirely different from each other, as are the several secreted solids and fluids?(*a*) It has been suggested indeed that these differences may depend upon the quantities of this agent supplied to the different secreting organs;(*b*) but this is very improbable, inasmuch as, however such differences might modify the quantity of the secreted matters, it is impossible to conceive that they could so materially influence their quality. But the looseness of the arguments which would establish the identity of these Principles with either Life or Nervous energy must be too palpable to require any further exposure ; and it is only surprising that physiologists should have been so long in universally recognising the true relation in which this powerful agent stands to both. It is a stimulus to irritability, and

(*a*) Dr. Alison. (*Quarterly Journ. of Science*, 1819) A similar line of argument against the identity of Galvanism and Nervous energy is pursued by Dr. Prout. (*Bridgewater Treatise*, 1834, p. 517)

(*b*) Dr. Hunter Lane. (*Liverpool Med. Gazette*, vol. i, p. 305) in so far analogous to the Nervous energy in its capacity of a stimulus, and it is the most powerful means of promoting Life, or living action, with which we are acquainted; but it neither *is* identical with the one, nor *can be* identical with the other.(*a*)

SECTION II.

On the Circumambient Air or Water, regarded as a Stimulus to Irritability.

THE next stimulus to irritability to be spoken of is the medium, whether AIR or WATER, which immediately surrounds organized beings, and of which, in the process of respiration, they appropriate a portion to themselves. This stimulus acts principally on the irritability of the proper respiratory organ and of the surface. In the former of these it excites the capillary pulmonary vessels to those actions by which they give off and take up the requisite gaseous substances; while in the latter it excites, not only the capillary vessels of the whole dermoid tissue to those actions by which its peculiar secretions and absorptions—including in a minor degree a second respiratory process—are effected, but also, as is believed, through the skin generally, in some measure the subjacent parts, promoting thus the healthy excitement of every organ of the body. That the Atmosphere or Water generally is a stimulus to the proper respiratory organ, whether vesicles, lungs or gills, as the alimentary matters are to the stomach, is unquestionable; and that, while its secretions are excited by these media in general, its absorption of a portion of the oxygen, contained in these media, is excited chiefly by this principle, is manifest from the compa-

(*a*) It is sometimes urged, as an additional argument against regarding Galvanism as identical with the Nervous energy, and either the one or the other as essential to the organic functions, that respiration, circulation, deposition and absorption are performed by plants and by the lowest animals, as well as sometimes for nine months by human monsters, which do not manifest the least rudiment of a Nervous system at all. For the same reason however as a similar argument was not allowed to weigh any thing against the doctrine, that the Ganglionic nervous system is the seat of irritability in those organized beings which possess such a system—whatever may be the case with those which are destitute of it—this argument must be regarded as inadmissible; but fortunately it is quite unnecessary to the ample overthrow of an hypothesis, which has been aptly designated lately by an able medical reviewer "a gross and improbable fiction." (*Ed. Med. and Surg. Journ.* 1835) rative rapidity with which it is found to be absorbed from other internal surfaces which are sometimes accidentally exposed to its action. (*a*) Similar to this is the action of the Atmosphere or Water in general, and of the oxygen in particular, on the external surface of an organized being, regarded, in some degree, as a second respiratory organ, and how essential they are in this capacity—the effects of their abstraction from the surface being sometimes even worse than those of their abstraction from the proper respiratory organ—has been abundently proved by recent experiments. (*b*) But these agents are supposed to have another important relation to this external surface, in its capacity of a general envelope of the whole being, inasmuch as, by stimulating this surface by the pressure which they exercise upon it, they act indirectly upon all the organs of the body, and maintain them in a state of healthy irritation; and it has been accordingly presumed that it is to the increased pressure of the Air that we owe the alacrity and vigour which we usually experience on a dense cold day, and from its diminished pressure that result the langour and lassitude so generally experienced under opposite circumstances. It is very generally known that the pressure of the Atmosphere, under ordinary circumstances, is equal to 15lbs for every square inch of surface, and that that of Water, while immediately below the surface it is only the same as this, goes on increasing as it becomes deeper, till at the depth of thirty-four feet it is doubled, and so on in proportion. Upon these data the external surface of a man of ordinary dimensions is commonly represented as sustaining, under the usual barometric pressure, a weight equal to about 40,000lbs; but, as the range of the barometer in this country is through about 3°, or one-tenth of its whole average height, it follows that he must be subjected at one time to a pressure of 4000lbs more than at another. Nothing can be more fallacious

(*a*) Thus in pneumothorax, abdominal tympanites, pneumatosis and other diseases in which there are aëriform depositions in various parts of the body, the gas, which is at first in general merely atmospheric air, soon loses its oxygen, and becomes pure nitrogen. This can arise only from the stimulus imparted by the former having promoted its absorption; but there is, nevertheless, no good ground for the vague apprehension sometimes entertained from the accumulation of air in "the innermost recesses of the body," with which the second Dr. Monro has the credit of having filled [illegible] the vulgar, both in and out of the profession. It perhaps merely turns them for a time into a kind of respiratory surface.

(*b*) W. F. Edwards. (*De l'Influence des Ag. Phys. &c.* 1824) however than the conclusions to which these premises have sometimes led, respecting the average stimulus, and the greater or less degree of this at different times, exercised by the Atmosphere—and of course by Water—on the irritability of organized beings. For we must continually remember that these beings press upon the medium which they inhabit, from every point of their surface, with precisely the same weight as they are pressed upon by this medium, so that any general effect of this external pressure, regarded as a stimulus, must be in a great measure neutralized; and consequently, while the actual amount of such pressure is a point of little or no moment, any change in this, gradually as such changes are under ordinary circumstances made, and taking effect, as they do, only till the equilibrium between the external and internal pressure is established, could have little or no effect in modifying such stimulus, had it any existence. Perhaps therefore the greater or less energy of the functions commonly attendant respectively on a dense or rare Atmosphere is the effect, not of such density or rarity, but of the different degrees of temperature, and the different states of electricity of which they are in general the concomitants. It is a very different affair however if such changes are very abruptly effected, as occurs from suddenly descending to great depths below the Water in a diving bell, or from suddenly rising into the Atmosphere in a balloon, or even rapidly ascending a high mountain; from all which very remarkable consequences are sometimes experienced, (*a*) although any extraordinary hilarity in the former case, or any great depression in the latter, is not in general among the number. Such changes as these however appertain, not to the natural stimuli to the healthy functions, but to the exciting causes of disease; and, upon the whole, it seems fair to conclude that the medium which surrounds organized beings, exercises in general, when at rest, by its mere pressure, no stimulus upon their irritability. Such a being, whether almost in vacuo, or in a medium condensed to

(*a*) Among the chief of these are excessive difficulty of respiration, inflammations, hemorrhages from the various outlets of the body, copious perspiration, thirst, vomiting, acute pain in the ears &c., all which are very easily explained. The usually asthmatic habit and blear eyes of pearl-divers, and the abundant hemorrhages which Whales are accustomed to suffer, upon rising again to the surface of the water, after having dived to great depths upon being harpooned, furnish good illustrations of the deleterious effects of any sudden changes in the pressure of the surrounding medium.

hundreds of Atmospheres, would still perhaps after a time maintain a balance of pressure from without and from within; so that the stimulus from this cause would perhaps be in both cases the same. The stupendous Condor of the Andes is known to endure an atmosphere the pressure of which is less than one-third of that which we inhabit, while fishes, on the contrary, are presumed to exist at a depth of upwards of seven hundred fathoms of water! But though the permanent pressure exercised by this medium, when at rest, may perhaps be disregarded as a stimulus to irritability, such is not the case with the occasional impulse communicated by its agitation; and perhaps indeed the breezes and the tides are among the most salutary and essential stimuli respectively to terrestrial and aquatic animals, as well as to plants, to which they furnish almost the only exercise which they enjoy. Every body knows the ruddy healthy aspect of persons habitually exposed to a frequent renewal of the Air which surrounds them; and there is reason to believe that cretinism and other endemic diseases of the vallies of alpine districts result, in a great measure, from the stagnant state of the Atmosphere in these places. (*a*) Next to temperature, the character of the prevailing winds is perhaps the most important consideration in the choice of a locality—but this is not the place for entering fully into the subject.

The stimulus of the Air, as instrumental to respiration, is much less essential to the life of the sluggish water-plants than of others, and to that of cold-blooded than of hot-blooded animals in general, being the more so, in all tribes of organized beings, the greater their activity—hence it is the most so in mammals and birds. Perhaps there are no very well authenticated instances in which an adult human being has been entirely deprived of Air for more than five or ten minutes, without being asphyxized, (*b*) although some very wonderful stories of divers and others are related to the contrary; whereas the Frog

(*a*) Dr. James Johnson. (*On the Influence of the Atmosphere, &c.* 1818)

(*b*) Fothergill, Davy, Brodie, Edwards, Roesler &c. Few of the pearl-divers of Ceylon can remain immersed more than a minute and a half; and Dr. Lefevre found that none of the Greek divers—who are very celebrated—engaged lately to bring up the relics of the Turkish fleet, sunk in Navarino harbour, could remain under water for two whole minutes. It is a very different question after how long a period, from the supervention of asphyxia, life is restorable—that is to say, how long irritability or vitality may survive the abstraction of one of the principal stimuli by which it is excited.

is capable of sustaining life under water—particularly if the water be cold, so that its circulation is retarded—for two or three days. The period is of course longer if the water be aërated and running, than if it be deprived of Air and stagnant, owing to its respiratory influence through the skin. (*a*) The Leech and Earth-worm also will survive for days or weeks although surrounded by oil, or kept in vacuo. Newly-born animals again of all kinds are less rapidly affected by want of Air than adults, for reasons which need not be here explained, and they all seem to bear its privation the better the less heat they naturally produce. (*b*) In like manner, among aquatic animals, some fishes, as the Salmon-trout—*Salmo* 35—the Herring and Shad—*Clupæa* 35—and the Mackrel—*Scomber* 36—are very rapidly asphyxized by being removed from the Water, while others, as the Eel—*Muræna* 35—the Carp and Tench—*Cyprinus* 35—and the Perch—*Perca* 36—can live for hours or days without this stimulus. It is probable however that the fatal effects of exposing fishes to the air depend in a great measure on their rapid desiccation by transpiration; and the same thing occurs in toads and other reptiles if kept too long from the water. The latter will accordingly live longer when surrounded by paris-plaister, which partially obviates this desiccation, than when continually exposed to the atmosphere. (*c*) The cases in which living animals, both terrestrial and aquatic —Oysters, Worms, Cray-fish, Beetles, Frogs, Toads, Serpents, Lizards, even Bats—have been found imbedded in solid rocks, or in the heart of trees, are familiar to everybody; and are explicable probably on the presumption that such substances are sufficiently porous to admit the small supply of Air or Water requisite under circumstances in which all the functions must be presumed to have been so far from active. (*d*) We know, on

(*a*) W. F. Edwards. (*De l'Influence des Ag. Phys. &c.* 1824)

(*b*) It was found by Edwards that a Rabbit, immediately after birth, could sustain a want of Air for twenty-eight minutes, when five days old, for sixteen minutes, when ten days old, for five and a half minutes, and when fifteen days old, for only two and a half minutes—for which period it can commonly be sustained by the adult animal.

(*c*) Edwards.

(*d*) It has been proved by Hérissant and Edwards that many animals can live although entirely surrounded by paris-plaster, which almost instantly perish if the pores of this are obstructed by oil, mercury or any other means. The fetal chick also is well known to receive Air through the pores of the shell, and to be soon suffocated if these be stopped up.

the one hand, that Moles and other animals naturally receive Air through the pores of the earth, and that human beings have been sometimes engulphed in snow for many days without being asphyxized; and, on the other, that all animals during their hibernation—and the animals just alluded to were probably in a state very analogous to this—require comparatively a very small supply of these stimuli to support their existence.

With respect to the instrumentality of the Air or Water which surrounds organized beings to various other functions besides respiration, such as to the circulation of the blood—which the former at least is presumed to promote by the pressure which it exercises on the veins, upon a vacuum being formed about the heart, either by the natural resiliency of the lungs, or during expiration; to smell, taste, hearing and the voice—to which they are essential, as either conveying the immediate stimuli of the odoriferous or sapid particles of other bodies, or of vibrations excited in themselves; and lastly to locomotion—as exemplified in flight and swimming, or even in progression on land against gravity, in the manner of many molluscous animals and insects, some lizards and a few amphibious animals, to which they minister by admitting of what is called only suction; with this we have no concern at present, since it is as stimuli to irritability that they are now a subject of consideration. But the influence of these agents in all these cases is, not in exciting irritation, but in either superseding, as is supposed, such irritation by a merely physical process, in conducting the immediate stimulus which is to effect such irritation, in being themselves effected by such irritation, or in rendering such irritation available.

Such then appears to be the relation in which Air or Water stands to Life: that neither of them, nor any one of the principles of either of them is, or can be identical with Life, as has been idly supposed, (*a*) needs not be here insisted on.

(*a*) In Hebrew the words Nephesh and Ruach, in Sanskrit the words Atma and Pranah, in Greek the words Ψυχὴ and Πνεῦμα, and in Latin the words Anima and Spiritus, all directly inculcate the same vague idea of the identity of Life, Soul, Spirit, Ether, Wind, Air and Breath, and sufficiently indicate the prevalence of this idea from time immemorial. And as Life was a *Divinæ* particula *auræ*, so this aura was held sometimes as the Divinity himself. Αἰθέρα ναίων was a title of Jupiter, and sub Jove or sub Dio was used to signify in the open air. The remnants of this identification of Life with Air or Breath are still perceptible in the common phrase of "dying for want of Breath," which is intended as equivalent to saying, "dying for want

SECTION III.

On the Aliment, regarded as a Stimulus to Irritability.

ANALOGOUS to the last mentioned stimulus is that of ALIMENT, taken at intervals by most animals—for plants have no corresponding organ—into the stomach. Its action appears to be partly chemical and partly mechanical, and to be exerted, at once on the irritability of the capillary vessels of the stomach, so as to promote its proper secretions and absorptions, and on its muscular fibres, so as to excite its contractions; the irritation thus produced in the stomach being extended, by sympathy, to almost every organ of the body, and in particular to the muscles of voluntary motion, and the greater degree of healthy contractions thus produced in them giving rise to the renewed energy and alacrity so generally experienced from taking Aliment into the stomach, and quite independent of the nourishment which it is afterwards to afford. Hence the necessity of food and drink being, not only nourishing, but stimulating, and the impropriety of inculcating a long continued use of the same substance, or very great simplicity in Diet in general; and as, generally speaking, the most concentrated Aliment is the least stimulating, and therefore the least digestible, it is perfectly possible, however paradoxical it may appear, to starve an animal by giving it continually too simple and too nutritious food. (*a*)

of Life." We have seen however that by some certain of the ancients Life was represented, not as Air, but as Water. In after times Air was sunk into one of the six non-naturals, as already mentioned; but it was again—or at least its oxygen—exalted to honour in the hands of Girtanner, who, at a time when chemical explanations of all physiological facts were in vogue, once more deified it, not indeed as Life itself, but as the immediate and most essential stimulus to vitality.

(*a*) The fatal effect, already alluded to, of the attempts made by Dr. Stark to live on one kind of Diet alone, however nutritious, and those of similar experiments made by Magendie on dogs and other animals, sufficiently illustrate this important fact, and abundantly prove that it is not from their food being azotized or non-azotized, salt or fresh, that sailors on long voyages, or persons in besieged towns and other similar situations, take the scurvy, but from their getting little or no food at all, or —what amounts nearly to the same thing—food uniformly of the same character, and therefore ceasing after a time to communicate any stimulus. They likewise display the impropriety of giving to convalescents, and others whose digestive powers are impaired, arrow-root, sago, tapioca, jellies, eggs and so forth, consisting, as they do, of comparatively simple and highly concentrated matters, and they become still

All animals have accordingly a range, in this respect, more or less extensive; and even the young of mammals, which feed so long upon the milk of the mother, furnish no exception to this remark, for not only is the quality of this milk very different at different periods after parturition, but it is, at all times, a very compound fluid. The Brahmin thrives on rice, the African gum-gatherer on gum, and the West Indian negro on sugar, but it is only for a time, or with a due admixture of other substances; and it was the experience of this necessity of such additional stimulus which taught the Esquimaux, the Kamskatdales, the Ottomacs and others, who could get nothing better, to mix saw-dust, or even clay, with their train-oil or other food, and which has led mankind in general to the almost universal use of salt and other condiments. It is almost superfluous to remark that, however competent inorganic matters may be as an Aliment to plants, and even, under some circumstances, to animals also, the latter commonly use organic matters in this capacity; some feeding on exclusively vegetable, and others on exclusively animal substances, while a third set uses indiscriminately either or both. To this last class naturally belongs Man, as is obvious as well from the character of his intestinal canal, of his jaws and teeth and of numerous other parts, as from various other considerations directly at variance with the puerile speculations of certain pseudo-philosophers, who would confine him to vegetable food as alone natural to his constitution. A less proportion of animal food is perhaps requisite to the inhabitants of the fertile torrid regions, while a greater is endurable in the barren districts near the poles; but in temperate climates the proportion of each commonly employed by Man is perhaps very nearly that which is most conducive to his well being. Nor are the denunciations sometimes issued against all fermented liquors, upon the plea that they are as unnatural to Man as to the inferior animals, less canting and in-

more improper from being taken generally in a liquid or semiliquid state. Many would recover on hung-beef grated on bread and butter, or on the flesh of "a tough old cock boiled to rags"—a favourite prescription of the late Dr. Willan—who perish on veal and chicken-broth, and other slip-slop appurtenances of a sick-room, and for an obvious reason. The remarks of Dr. Latham (*On the Disease of the General Penitentiary*, 1825) and those of Dr. Paris, (*On Diet*, 1826) and Dr. Prout, (*Bridgewater Treatise*, 1834) together with the recent experiments of Raspail, Edwards, Balzac and others upon the properties of highly concentrated aliments tend very forcibly to the same conclusions.

judicious. It is not natural to Man to abuse any of the gifts of Providence; but it is quite natural to him to use with temperance all the luxuries which his superior faculties at once enable him to procure, and qualify him to enjoy, and this among the rest. (*a*) There is good reason to believe also that the censures passed, at different times, on various particular kinds of Aliment have in general been quite uncalled-for; and that Man, *in a state of health*, may eat with impunity all the ordinary articles of Diet, any great nicety in their selection—further at least than it is founded on each individual's personal experience—being for the most part very superfluous. (*b*)

(*a*) The principal patrons of this twaddle in modern times—to say nothing of Pythagoras and the ancients—have been Gassendi, Rousseau, Wallis, Lamb and Newton; the last of whom, in the plenitude of his infatuation, asserts that *real* men have never yet been seen, nor ever will be, till they shall be content to subsist entirely on herbs and fruits and distilled water! The late Professor Gregory also was accustomed to represent fermented liquors in general as slow poisons; and to affirm that a man had no more occasion for them than a horse! It is unnecessary, in refutation of this mummery, to appeal to the practices of the "prisca gens mortalium," or to remind its advocates that "the keeping of sheep" and "hunting before the Lord" are equally ancient, and therefore, we may suppose, equally natural avocations as "the tilling of the ground;" that Noah "planted a vineyard, and drunk of the wine thereof," and even, although a just man and perfect in his generations, was on one occasion "drunken;" and that the same predilection for flesh-pots and the slow poisons in question has unfortunately distinguished all his posterity. Nay do we not read that Nebuchadnezzar was condemned to "eat grass as oxen" as a punishment for his sins, and that he was so far from becoming a *real* man under this regimen, that he soon shuffled off almost every feature of humanity? Nor do the herbivorous men of modern times appear to have been more successful in realizing the *beau-ideal* of their species. (See the account of Antoine Julian by Dr. Layet in the *Lancette Franc.* 1835) With respect also to fermented liquors, slow indeed must those poisons be, which, used in moderation, frequently take half a century or more to produce their effects; and if a man were to use nothing but what a horse requires, what would have become of many of the learned Professor's appendages which he could have very ill spared? We commonly say that a man makes a beast of himself when he gets tipsy; but it appears that it is from *not* making a beast of himself that this accident is apt to overtake him. But the world is too old for this kind of trash at present. Even the good folks of the Temperance Societies do not restrict their proselytes to acorns and water. They know better than to cut off the arm because it may sometimes be employed in mischief; and their injunctions are in general as judicious, as their object is philanthropic and praiseworthy.

(*b*) We do not, it is true, hear quite so much in the present day as formerly of the πολυτροφα and ὀλιγοτροφα, of the εὔπεπτα and δυσπεπτα, of the εὔχυλα and κακοχυλα, as applied to individual articles of diet; but we have always heard, and still hear probably much more about these matters than they deserve. Thus, in England, how have beef and strong beer been at one time upbraided for all our misfortunes and melancholy, and at another lamb and veal and "thin potations," for all our degeneracy from the hardihood of our ancestors. There was a period at which tea was to be a cure for every ill, and another at which it was the reputed cause of numerous disasters, being particularly inimical, it was said, to the beauty and virtue of women.

The CHYME into which the Aliment is gradually converted in the stomach acts as a stimulus on the irritability of the capillary vessels and muscular fibres of the long intestinal canal, during its slow progress downwards; and thus the stimulus indirectly imparted to an animal by the Aliment, although taken often at long intervals, is hardly less continuous than that communicated by the Air or Water which constantly surrounds it, and with which its reciprocal action is uninterrupted. It is a common error to regard the stimulus of the Aliment as only an occasional one. It is undoubtedly in more active operation immediately after taking a meal than at other times; but it is perhaps never entirely withdrawn even from the stomach, during the longest natural intervals of abstinence, and it is certainly in constant operation indirectly on the intestines. (*a*)

Generally speaking the necessity for a frequent supply of Aliment is greater the higher is the rank of the animal, but the quantity taken at each meal is proportionally less; and this power of sustaining long abstinence, together with extreme voracity at intervals, is in general more remarkable in cold-blooded than in hot-blooded animals, and in the carnivorous than in the herbivorous tribes. That Man is capable sometimes of enduring very long abstinence has been sufficiently established by several very remarkable cases, both of individuals, (*b*) and

If the Welsh are hot and choleric, it is because they covet cheese and leeks; and if the French are fickle and inconstant, they own these qualities to their soups, frogs and mushrooms. Every article of Diet in turn is with some people the undoubted cause of every peculiarity which they display; and, reasoning upon their data, we should probably come to the same conclusion, with respect to each, that a certain traveller arrived at, on overhearing a conversation on the effects of cold-bathing—to wit, that it thickened and it thinned the blood—it strengthened, it weakened—it made people fat, it made them thin—it braced, it relaxed—it was good for every thing, and good for nothing! The maxim *sanis omnia sana* is perhaps the best that we can in general follow; and the story of Sancho Panza and his physician is conceived in the happiest spirit of deserved ridicule of any very scrupulous attention, by people in health, to what they eat and drink. It is said that the only advice ever given by Sir Richard Jebb, on the subject of their Diet, to healthy persons, was not to eat the fender or the fire-irons, for they were decidedly unwholesome; but, with respect to all ordinary dishes, to do as they pleased.

(*a*) It is very generally taught that chymification is completed in two or three hours; but this is true only of the outermost layer of the mass of Aliment, which is then ready to pass through the pylorus, a much longer time being required before this change has extended to the centre. Dr. W. Philip found that, in the Rabbit, sixteen or eighteen hours were requisite for this purpose; and, according to Sir E. Home, the stomach of this animal is never entirely empty, however long may have been its abstinence.

(*b*) Pouteau, (*Mém. de Paris*, 1769) Mackenzie, (*Phil. Trans.* 1775) Willan, of many persons together who have suffered shipwreck, or been exposed to any common calamity; (*a*) but that he does not, at least in a civilized state, habitually subject himself to this is certain. Again that he can occasionally devour an immense quantity of food at once is sufficiently well known; but it is equally certain that such is not, at least in a state of civilization, his usual practice. (*b*) On the other hand many insects, and in particular the lepidoptera, habitually subsist for weeks or months without food, and the Scorpion—*Scorpio* 29—has been known to endure an abstinence of three months, the Spider —*Aranea* 22—of a twelvemonth, and the Beetle—*Scarabæus* 30—of three years, without inconvenience. Among the vertebrated tribes also some fishes, as the Perch—*Perca* 36—are said naturally to take food only about once a fortnight. So among reptiles, the Crocodile—*Crocodilus* 39—has been known to sustain a want of food for two months, the Chameleon—*Lacerta* 39—for eight months, the Toad—*Rana* 37—for fourteen months, the Land-tortoise—*Testudo* 40—for eighteen months, and the Serpent—*Coluber* 38—for no less than five years. And even the hot-blooded vertebrated animals bear abstinence longer than is commonly supposed; the Eagle—*Falco* 46—for example, having been proved capable of doing without food for twenty-eight days, and, among mammals, the Civet—*Viverra* 54—for ten days, the Antelope—*Cervus* 48—

(*Phil. Trans.* 1793) Currie, (*Med. Rep.* 1804) Royston (*Med. and Phys. Journ.* 1809) *&c.* A very interesting fatal case of voluntary abstinence for eighteen days is copied from Hufeland's Journal by Marc; (*Bib. Med.* 1820) and one still more so, of abstinence incurred by confinement for twenty-three days in the gallery of a coal-mine is related by Dr. Sloan. (*Med. Gaz., Nov.* 1835) The case of Viterbi the Corsican, so often cited, is somewhat apocryphal. Of impostures and exaggerations in this way the two most celebrated examples are those of Eue Heigen of Meins and Ann Moore of Tutbury.

(*a*) See *Account of Siege of Jerusalem; Account of Wreck of French Frigate Medusa;* Franklin's *Narrative of Journey to the Polar Sea, &c.*

(*b*) Some savage and semi-savage tribes, as the Norwegians and other inhabitants of the north, are characterized by their ravenous and indiscriminate appetites. A Yakouti or Tongousi will eat forty pounds of meat a-day, and three of them easily make an example of a rein-deer at a meal. One Yakouti, attached to the suite of Admiral Saritcheff, is said to have been accustomed to consume daily the hind quarter of an ox, twenty pounds of fat, and a proportionate quantity of melted butter for drink! Our civic aldermen, with their six quarts of turtle soup per man, are after all mere triflers as to quantity; and, with respect to quality, even the notorious French soldier Tarrare, who used to eat every kind of offal, and even putrid limbs taken from charnel-houses and dissecting-rooms, or poultices and plasters, collected in hospitals, and reeking with blood and matter, hardly surpassed some of these tribes in the indiscriminate nature of the materials of their repasts.

and the Wild-cat—*Felis* 54—for twenty days, the Dog—*Canis* 54—for thirty-six days, and, it is said, the Bear—*Ursus* 55—for six months. The quantity however which the lower tribes of animals sometimes take, when they can get it, is enormous; the voracity of some fishes, for example the Dog-fish and Shark—*Squalus* 32—the Conger-eel—*Muræna* 35—the Pike—*Esox* 35—the Mackrel—*Scomber* 36—and the Perch—*Perca* 36—being proverbial, and that of many reptiles, as the Boa and Crocodile, of many birds, as the Vulture, and of many quadrupeds, as the Wolf and Hyæna, being almost equal to it. The young of all animals again, unlike what occurs with respect to want of Air, bear want of Aliment less easily than adults, and take it both more frequently and more copiously. The larvæ of insects are known sometimes to take many times their own weight of food in the course of a day; and the rapidity therefore—already alluded to—with which they are enabled to dispatch the carcase of a large animal is not wonderful. The quantity of food also consumed by a growing child is in general almost inversely as its age; and accordingly its weight is commonly tripled by the expiration of the first year after birth, while it takes six years more to double its weight at the first year, and seven years more again to double its weight at the seventh: perhaps also males in general bear abstinence less easily than females. It is unnecessary again particularly to allude to the cases in which living animals have been found imbedded in situations in which, if respiration were difficult, the reception of Aliment must be supposed to have been almost impossible. It has been imagined that, in these cases, they subsist upon their own exuviæ of one kind or other; (*a*) and perhaps these may be quite sufficient for the purpose, under circumstances of such diminished energy of all their functions. They must be conceived to be in a state analogous to what is called hibernation; and we know that Marmots, Bats and other quadrupeds, during this state, as well as insects during their metamorphoses, neither take nor require any Aliment whatever, their excretions becoming of course sparing in proportion as their Diet becomes scanty. They seem to subsist chiefly on their own fat.

The Aliment has never been explicitly identified with Life,

(*a*) Grignon &c.

although the hypotheses of some of the advocates of the vital principle doctrine tend directly to the inference that it contains this principle (*a*)—it is superfluous to say how unreasonably and absurdly.

SECTION IV.

On the Proper Fluids of the Body, regarded as Stimuli to Irritability.

The only remaining head of direct stimuli to the irritability of organized beings includes the various Fluids, whether crude, mature or secreted, which constitute a part of themselves. Of the Sap, Cambium and other Fluids of plants, in this capacity, it is unnecessary to speak particularly, since what is said of the corresponding Fluids of animals may be easily applied to them; and of the Arterial Blood, Venous Blood, Lymph and Chyle, in their character of stimuli to irritability, some notice was taken during the discussion of the question whether they were entitled to be considered as possessed of this property. And how constant and important a stimulus, partly chemical perhaps and partly mechanical, these must constitute to the heart and capillary system—the latter of which is universally diffused throughout all the organized tissues—will be sufficiently apparent when we reflect that not less perhaps than fifteen thousand pounds of Arterial Blood, or a quantity equal to more than a hundred times the average weight of a human being, is sent out from the left heart, and traverses the parenchyma of the body to reach the right heart by the veins and lymphiferous and chyliferous vessels, while of course the same quantity of Venous Blood, Lymph and Chyle is expelled from the right heart, and traverses the parenchyma of the lungs to reach the left heart by the pulmonary veins, in the course of twenty-four

(*a*) Such is the case with that of Dr. Pring, who represents Life as continually formed "by the assimilation of its identity from the Blood," the said Blood being capable of being formed of course only by the assimilation of its identity from the food; so that, if Life be a simple substance, the food must to all intents and purposes contain it. In general however the Vital Principle school of physiologists, as, under the ancient regime, they represented Aliment, not as Life, but as the staff of Life, so, under the more modern, they were satisfied with enumerating it as one of their six non-naturals.

hours. Upon this estimate each side of the heart, supposing the whole organ to weigh ten ounces, receives a daily supply of about forty-eight thousand times its own weight of these Fluids into its cavity, while every organ of the body—the heart included—receives a daily supply, upon an average, of not less than a hundred times its own weight into its parenchyma! The stimulus communicated then by these Fluids to the body collectively, supposing it to bear any proportion to the frequency of their renewal in each part, must be enormous; but we must take care to keep constantly in mind that these Fluids have two almost directly opposite relations to the heart and capillary system, and that as they are, on the one hand, a chief stimulus by which the motions of these organs are excited, so they are, on the other, the load to dispose of which alone these motions are in requisition. In the normal state of the body their co-operation as a stimulus is precisely such as to excite the motions required, either to urge them forward, or to dispose of a portion of them, in the processes of nutrition and secretion, as a load; but under various circumstances of disease, at one time their action as a stimulus is so great as to excite more violent motions than their resistance as a load requires, while at another their resistance as a load is too great to be overcome by the motions which their action as a stimulus is competent to excite. Of the former of these anormal conditions we have an example, with respect to the heart, in the second stage of fever, when the pulse is found to *fall* upon bleeding, and, with respect to the capillary vessels, in the stage of inflammation preparatory to that in which the blood becomes accumulated, when the parts are constricted and blanched; of the latter we have an example, with respect to the heart, in the first stage of fever, when the pulse is found to *rise* upon bleeding; and, with respect to the capillary vessels, in the stage of inflammation consisting in the accumulation of blood, when the parts are turgid and red. (*a*)

(*a*) There is no principle in semiology or therapeutics more important, or of more frequent application, than that which impresses this two-fold, and, as it were, adverse relation of the Blood to the reservoirs and vessels in which it is contained; and it was from the fatal oversight of regarding this Fluid always in the light of a stimulus, and neglecting to observe that it sometimes oppressed more by its bulk, than it stimulated by its surface, that all poor Brown's practical errors resulted—errors which are still held in remembrance only to be execrated, while his merits are unknown or unregarded. So true is it that "the evil that men do lives after them; the good is oft interred with their bones."

This is not however the place for insisting particularly on these antagonizing relations in which the Fluids in question stand to the heart and parenchyma, since it is in their character of stimuli only that they fall at present to be considered. And a similar excuse may be offered for declining here any agitation of the question whether these Fluids are, under all circumstances, equally efficient as stimuli, or whether their quality is liable to such changes as to render them more or less powerful, in this capacity, at one time than at another. That they undergo in many diseases very remarkable alterations, and such as may most materially modify their action in this way is certain; but our business at present is strictly physiological, and it would be quite out of place therefore to enter here at any length into a question, at once one of the most obscure, and one of the most extensive in all pathology. It may be repeated however that the presumption of any primary loss of balance in the principles of these Fluids, such as a superabundance or deficiency of sugar, of sodo-albumen, of fibrin, of acid or of alkali, of oxygen, hydrogen, carbon or nitrogen, ever occurring as a cause of diseases appears to be in a great measure unfounded; and that whatever alterations they may undergo in the course of such diseases are, in all probability, the result generally of a vitiation of the secreted fluids and solids, which are subsequently received into the circulating Fluids by absorption.

In the same manner as the Arterial Blood, Venous Blood, Lymph and Chyle act as stimuli on their respective systems of vessels, so, among the perspired secretions, act the Carbonic Acid and Halitus from the lungs upon the bronchial tubes, producing, by their momentary accumulation, an irritation which at once excites these vessels to contract, and, as extended by sympathy to distant organs, constitutes the chief primary stimulus to expiration. In like manner act the other perspired secretions, the Gastric Fluid, the Menstrual Fluid and the rest—among the follicular secretions, the Cystic Bile, the thick portion of the Semen, the Stools, &c.—and, among the glandular secretions, the Hepatic Bile, the Pancreatic Fluid, the Urine, the thin portion of the Semen, the Tears and the Saliva—first each upon its own proper secreting surfaces, follicles or ducts, and next upon the other organs to which many of them are subsequently conducted; the irritation so excited being often, like that of the rectum by the Stools, and urinary bladder by the Urine, extended by sympathy to those voluntary muscles which cooperate in evacuating them, and constituting thus the chief primary stimulus to their action in this way.

The greater number of these secreted Fluids are more or less proper to certain parts of certain animals; and they cannot therefore be essential otherwise than as local stimuli in any case, while their action even in this way is often unnecessary. Nor indeed are the Arterial Blood, Venous Blood, Lymph and Chyle, the distribution of which is so general, and some modifications of which are almost universally met with, any more than a great quantity of Caloric, or a frequent supply of Air or Aliment, equally indispensable as stimuli to the irritability of all tribes of animals. In general those animals which are the least dependent on the stimuli of Caloric and Air are the least so likewise on the Fluids in question; and accordingly cold-blooded animals commonly manifest this independence more remarkably than those with hot blood. In Man, as is sufficiently well known, the abstraction of even eight or ten ounces of Blood —probably not more than one-eightieth part of the whole amount of his circulating fluids—frequently produces a very striking diminution of general irritation or vital action; whereas the Frog or Newt continues sometimes to live for days, and to exercise most of its accustomed functions without apparent impediment, although the greater part of its whole mass of Blood has been withdrawn. The young likewise of all tribes of animals appear less easily to sustain a diminution of this stimulus than adults; and there are not wanting instances in which the quantity abstracted by the bite of a single leech has proved fatal to infants. Nor is it inconsistent with this remark that the heart appears to be more immediately essential to the life of an adult, than of a newly-born animal; (*a*) since it is probably in its character of a stimulus to the parenchyma chiefly

(*a*) It was found by Le Gallois that while the abstraction of the heart from a newly-born Rabbit did not prove fatal in less than fourteen minutes, it killed one which was fifteen days old in two and a half minutes, and another double that age in one minute. (*Expériences, &c.* 1812) that the Blood is so essential to young animals, the heart not having yet acquired that extensive sympathetic influence which it afterwards possesses.

With respect to the uses to which the Blood, Lymph and Chyle are subservient, otherwise than as immediate stimuli to the irritability of the heart and capillary system, such as that of producing, by their momentary accumulation, an irritation of contiguous organs — as in the lungs by the momentary retention of Venous Blood in the pulmonary arteries, which, extended by sympathy to distant organs, becomes the principal primary stimulus to inspiration; or that of serving by their retention for a time in the erectile organs—as in the papillæ of the dermoid and mucous membranes, the corpus spongiosum urethræ, the corpora cavernosa clitoridis, the fimbriated extremities of the fallopian tubes, the nipples of the mammæ, the corpora cavernosa penis &c. to distend these organs, and thus adapt them to their respective functions; or lastly—the most important office of all—that of furnishing the materials out of which the various solids and fluids of the body are secreted by the action of the capillary vessels; with these we have nothing to do here, since it is of these Fluids in the first of these capacities alone that we are now speaking. And the same thing may be said of the several secreted Fluids above-mentioned, many of which, besides acting as mere stimuli to the irritability of the organs with which they come immediately into contact, perform numerous other offices. It is, in fact, a trite leading distinction between the secretions, properly so called, and the excretions, that, while the latter are formed only to be voided, the former always minister to some function of greater or less importance—but we have to do with them at present only in their character of stimuli to irritability.

Such appears to be the true relation in which all these Fluids stand to Life; the notion of the Blood or any other of them being the immediate domicile of this, as a substance, being too obviously incorrect to require any animadversion, and that of any such Fluid being possessed, though not of Life, still of Vitality, having been already, it is hoped, sufficiently refuted. (*a*)

These then are the several Direct or Primary Stimuli to Irritability, represented in the Diagrams in the Title by the horizontal wheel, by the hitching of the cogs of which with those of the main or lowest vertical wheel, indicating the faculty of Irritability, the latter is set in motion, and Life, as manifested in Irritation, or Life in its simplest form, results.

(*a*) The patrons of the doctrine of the inherent vitality of the Blood have merely mistaken one condition of Life for the other. It is in general the most essential stimulus to vitality, and therefore as necessary to Life as vitality itself; but it cannot be both endowed with a power to act on this property, and possessed of the property of being acted on by this power. It is obviously the former, ergo—but the hypothesis has been already weighed in the balance and found wanting. *Requiescat in pace.*

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RUDIMENTS

OF

PHYSIOLOGY.

PART II.—*(Continued.)*

ON LIFE, AS MANIFESTED IN IRRITATION.

CHAPTER VI.

ON THE INDIRECT STIMULI TO IRRITABILITY.

SECTION I.

On Sympathy and Passion or Instinct, regarded as Stimuli to Irritability.

We come next to the indirect or secondary stimuli to irritability, beginning with Sympathy and Passion or Instinct, the latter of which is merely one department, as it were, of the former, while both again, regarded as stimuli to irritability, are merely varieties, as before observed, of Sympathy; inasmuch as by Sympathy, in the strictly physiological sense of the word—in which alone it is here employed—is to be understood the translation of a direct or primary irritation of any organ, except the brain, to any other organ, and by the term Passion or Instinct, in the same sense, the translation to any other organ of such a direct or primary action of the brain. It will be in future shown indeed that an action of the brain is, strictly speaking, never absolutely direct or primary, since it must be always preceded by sensation, as the only stimulus to every modification of thought, as this again must by irritation, as the only stimulus to sensation. Nevertheless in as far as regards Passion or Instinct considered as a stimulus to irritability, it originates in an action of the brain, which therefore, in relation to this stimulus, is direct or primary, by whatever conditions it may itself have been preceded. Hence Sympathy, on the one hand, and Passion or Instinct, on the other, are all resolvable into one species, as it were, of indirect or secondary stimuli to irritability, the former variety being sometimes called, by way of distinction, *Organic*, and the latter *Animal Sympathy.* And that such a stimulus to irritability as Sympathy and Passion or Instinct—vaguely and indefinitely as these terms are frequently employed in physiology—actually exists, and that the employment of such terms is not merely the substitution of words for ideas, as is sometimes supposed, is obvious from the familiar facts of sneezing—already instanced—which is effected principally by the action of the abdominal muscles being excited by snuff or any similar substance applied to the schneiderian membrane, and of starting, which is effected chiefly by the muscles of the spine, being excited by surprise or sudden apprehension of danger. The snuff cannot have produced a direct irritation of any part, except of the surface to which it was applied, nor the surprise or dread of danger a direct action of any organ, except of that which is the immediate seat of mental emotion; but the abdominal muscles, on the one hand, and those of the spine, on the other, must have been acted upon by a stimulus, or they could not have contracted. It is this translation then, by whatever means it may be effected, of a direct or primary irritation or action of one organ to organs at a distance, which is called respectively Sympathy and Passion or Instinct, when we speak of these as powers acting on irritability.

The examples of the operation in this way of Sympathy, properly so called, or ORGANIC SYMPATHY, as well in health as in disease, are innumerable. (*a*) It is by Sympathy that

(*a*) It was formerly the custom to call by the name of Sympathy proper, the more particular instances of the consent of organs, and by that of Synergia, those the primary irritation of the bronchial tubes, for example, by the momentary accumulation in them of carbonic acid and halitus, and that of the lungs generally, by the momentary accumulation of venous blood in the pulmonary arteries, become a stimulus respectively to the irritability of the *Expiratory and Inspiratory Muscles*, so that the immediate stimulus to respiration, or what may be called the fundamental function of the organized body, is in fact Sympathy; (*a*) and if we can prove by what means the direct or primary irritation is, in this case, conveyed to distant organs, it will furnish a strong collateral argument in favour of regarding this means as, in all cases, the vehicle of Sympathy and Passion or Instinct: but to this part of the subject we shall recur presently. Cold water again or cold air applied to the face has, by Sympathy, a similar effect in exciting the diaphragm and other inspiratory muscles; and it is, in all probability, upon this new stimulus that the first inspiration of the new-born infant principally depends. As connected also with the action of the proper respiratory muscles may be mentioned the effect of such an irritation of the diaphragm as produces its convulsive descent upon the muscles which depress the lower jaw, the jaw descending jot for jot with the diaphragm, so as to occasion yawning; that

in which the consent was more general: such a distinction however seems to be quite uncalled for. Some late physiologists again—M. Adelon for example—have affected to arrange the principal examples of sympathetic action under distinct heads, according as they manifest themselves between different parts of the same organ, between continuous organs, between contiguous organs, between organs functionally associated together, and so forth. To say nothing however of many of these alleged cases of Sympathy being not really such, it seems impossible to adopt a plan like this without perpetually raising questions as to the precise head under which each should stand, and thus hampering a subject, already quite sufficiently difficult, with artificial difficulties, the overcoming of which, though effected, would be attended with little or no advantage. It seems infinitely the simplest and best plan to enumerate them as displayed between organs subservient in turn to each of the several functions, in the order in which the latter have been already continually referred to.

(*a*) Dr Wilson Philip says that respiration is always a voluntary process, and that if the apoplectic man breathes, it is only from the intensity of the stimulus, attendant on an impediment of this function, acting on his sensation and volition. (*Phil. Trans.* 1821 &c.) We may within certain limits temper the respiratory process by volition, but it is only within certain limits that we can do this; and that respiration is, under ordinary circumstances, as totally involuntary as the action of the heart or stomach is unquestionable.

of certain irritations again of the stomach upon the diaphragm, so as to occasion hiccough; and that of the irritation of the nostrils by tobacco upon the abdominal muscles, so as to occasion sneezing, as has been already stated. (*a*) The irritation of the eye by a strong light has sometimes the same effect; and it is in a similar way that any irritation of the membrane of the larynx, or even sometimes of that lining the external auditory canal, excites the muscles of the glottis and abdomen, so as to produce coughing. So also with respect to the *Circulating Organs*, there is no part of the body with which the heart does not more or less intimately sympathize, the slightest affection, whatever be its nature, of any organ producing a corresponding, and to a greater or less degree specific action on the irritability of this organ, and consequently on the pulse; and indeed it is upon this fact, little as it is by most people adverted to, that is founded all our reliance on the state of the pulse, as indicative of the state of the system in general. Nor is the influence of Sympathy upon the irritability of the capillary arteries, as *Organs of Secretion*, less remarkable; an irritation of the female genital organs, for example, by copulation, utero-gestation or parturition, of the nostrils by mustard or onions, or of the mouth by tobacco, operating as powerfully in producing respectively a flow of milk, of tears or of saliva, as if the stimulus had been applied to the secreting organs themselves. An equally good illustration of the action of Sympathy is afforded by the *Assimilating Organs;* any considerable mechanical irritation of the fauces, as is well known, acting in such a manner, as well on the irritability of the muscular coat of the stomach, as upon that of the diaphragm and other muscles which cooperate with this organ in vomiting, as to produce this effect. A similar effect is produced upon the stomach by a primary irritation of the uterus as in pregnancy; and indeed the stomach, like the heart, has a more or less intimate Sympathy with every organ of the body, and participates more or less in the affections of each. It is by Sympathy also that from

(*a*) Physiologists have continually echoed one another in ascribing sneezing to a convulsion or spasm of the diaphragm. Such an affection may produce a sigh, a whoop, a yawn, a hiccough, a stitch, a paroxysm of angina pectoris; but by no possibility can it produce a sneeze.

the irritation of the rectum by the stools, and of the urinary bladder by the urine, the requisite muscles co-operate with these organs in expelling their contents. With respect likewise to the effects of Sympathy on the irritability of the *Organs of Sensation*, the irritation excited by light in one part of the eye constantly becomes, by this means, so strong a stimulus to another, as to occasion its expansion, and thus to give rise to a contracted pupil ; and the irritation of certain parts of the ear, produced by harsh and discordant sounds, not unfrequently acts by Sympathy so forcibly on the capillary arteries of the gums, as, by indirectly dilating them, to give rise to the sensation called setting the teeth on edge, and sometimes even to hemorrhage. Lastly, as examples of the action of Sympathy on the irritability of the *Muscles* more particularly included under the head of *Voluntary*, may be mentioned the effect of the salutary irritation of the Stomach by the aliment upon all the voluntary muscles of the body, so as to occasion that greater degree of healthy contraction of these organs on which the sensation of increased energy and alacrity, so generally found to succeed a temperate meal, mainly depends. A still more striking example of Sympathy as exercised on these organs is that of the irritation of the arm-pits or soles of the feet, as in tickling, which becomes frequently so strong a stimulus to various voluntary muscles at a distance, as to give rise, not only to uncontrollable laughter, but sometimes to almost universal convulsions. These then are a few of the most striking isolated instances of the operation of Sympathy, as a stimulus to irritability, in the state of health, and it is with this state alone that we have any thing to do at present, or still more remarkable examples might be adduced. Such are every where manifested in the action of the ordinary exciting causes of disease, which, when applied to any other organ than that which is to become the seat of the disease, perhaps generally, if not always, take effect by Sympathy; as well as in the translation of diseases from their primary seat to distant organs, (*a*) and in the operation of remedial agents, which, when administered by any other avenue than that on which they are intended to operate, in all probabi-

(*a*) The " Consensus *passionum*" of Rega, Bausner and others, as distinguished from the " Consensus *actionum*."

lity act only or chiefly by means of Sympathy: upon this wide field however it would be improper to enter in this place. But Sympathy is perhaps a much more general and important agent in promoting the ordinary vital actions, at least of the higher tribes of organized beings, than these isolated instances of it, from irritations more or less inordinate, would induce us to imagine—not less so perhaps than Caloric, or any other to which such beings are constantly to a greater or less degree exposed—and this quite independently of the mutual subserviency of the results of the several functions to the continuance of the rest, to which allusion has been made elsewhere. If it be true that the vital action of every organ of the body consists in its irritation —in other words, that life and irritation are nearly, if not quite synonymous terms—and if the inordinate irritations of individual parts have so obvious a tendency to be extended to others, is it not reasonable to believe that their ordinary irritations, or natural functions, exert likewise a considerable influence over those of more or fewer distant parts, according to the specific irritabilities of the latter, and that accordingly the natural irritation of every organ is in some degree essential to that of all the rest? (*a*) A beautiful illustration of the influence of one function over others is afforded by the higher classes of animals at puberty, when one new irritation being set up in the body, female or male—that of the ovaries in the former, and that of the testicles in the latter — the actions of distant organs are so modified by this new irritation, which is of a very different character in the two, that there is scarcely a square inch of the body which does not undergo some change, and almost every organ becomes, after a time, as characteristic of the different sexes as the proper genital organs, which had previously constituted almost the only distinction. (*b*) Nor is it only in establishing these differences that the new irritation operates, but it is essential also to perpetuate them; the subsequent abstraction of either the ovaries or the testicles, or even the cessation of

(*a*) " Confluxio una, conspiratio una, *consentientia omnia*." HIPPOCRATES.

(*b*) " Propter uterum," said the ancients, " Mulier est quod est." They should have said rather " propter ovaria;" but the saying, as it stands, sufficiently indicates their observation of the influence of the actions of one organ over those of all the rest.

the proper function of each, as in old age, going a great way, as is well known, towards obliterating the characteristic peculiarities which the setting up of this function had established: (*a*) and if the natural irritation of this one organ has so extensive an influence on that of others, can we doubt that those of all the rest have a similar influence, although it is less observable from the latter not being more marked at one period of life than another? A similarly extensive influence is exerted over the rest of the body by the new irritation which is set up by pregnancy: but it is superfluous accumulating examples of this kind. We indeed tacitly acknowledge that the healthy irritation of each part is more or less essential to that of others, when we ascribe, on the one hand, the failure of appetite and digestion to the generally diminished action of the system produced by sedentary habits and other similar causes, and, on the other, the general languor and listlessness which so commonly succeed a debauch to the stomach being out of order; and what we so unhesitatingly admit with respect to the function of the stomach, both as acted upon by those of distant parts, and as acting upon these,

(*a*) This effect of advanced age is often very remarkable in birds, the hen frequently, on ceasing to propagate, assuming somewhat of the voice and plumage of the cock, and even according to Aristotle getting spurs—πλῆκτρά τινα μικρὰ—on her legs. According to him this change takes place only after she has fought with, and vanquished the cock; but this is mistaking the effect for the cause. Corresponding effects manifest themselves in some quadrupeds; and we may notice something similar to them in our own species, on the approach of senescence, the silver tones of a woman becoming in general more gruff, as the rough voice of a man becomes more "piping and whistling in the sound," and her soft chin becoming grisly, as his stiff beard becomes soft and relaxed. The naturally capricious and timid mind of woman also acquires generally, about the same period, more firmness and courage, while the naturally steady and enterprising spirit of man degenerates in both these respects; and, while her feeble constitution becomes commonly more robust, his strong frame becomes in the same degree more infirm. Whether or not Peter Pindar was right, when he asserted, in allusion to the investigation of this subject—at that time a new one, or, like most reputedly new ones, an old one newly revived—by Sir Joseph Banks, that it was

> " ——— denied by no man
> That age had made Sir Joseph an old woman,"

it is at least certain that senescence has effects somewhat similar to those resulting from castration, and that, as it turns a male almost into a eunuch, so it converts a female almost into a virago.

may be perhaps admitted with as little hesitation, *mutatis mutandis*, with respect to that of every other organ of the body. And how extensive must be the application of this principle is sufficiently obvious. For if it be only during the natural irritation of each organ that all the rest receive their proper stimulus, all being less or more excited than natural when the irritation of any one is below or above par, it will follow that during inflammation or increased secretion in any one part, both which states imply, as will be explained in future, diminished irritation—the consequence, it is true, of a previously increased irritation—of the capillary vessels of this part, a less stimulus than ordinary must be communicated to all the other parts of the body, including the other secreting vessels, which, not undergoing therefore the necessary primary irritation, of course secrete less than usual, and hence the generally *diminished secretion* attendant on these states. On the other hand on the sudden cessation of an inflammation, or on the suppression of an ordinary secretion, both which circumstances imply renewed or increased irritation of the capillary vessels of the part in question, a greater than the usual stimulus must now be extended to all the other parts, and of course to the other secreting vessels, which, undergoing now more than the ordinary irritation, will have their secretions, on their subsequent collapse or diminished irritation, increased—each set of them according to its specific susceptibility of the new stimulus—and hence arise what are called *critical and vicarious discharges*, or, when the collapse succeeding the sympathetic irritation does not so rapidly terminate by secretion, *metastases*. It is sufficient at present to hint at this, as one of the numerous applications of the principle now under consideration, the full investigation of the subject belonging of course to another place. It is however only in the higher tribes of organized beings that this extensive influence of Sympathy displays itself, since it is only in proportion to the concentration of the several organs, and the adaptation of each to a distinct function, that it is called for: and it is remarkable that it is exactly in the same proportion that the system of nerves, which seems to be instrumental to the conveyance of this stimulus, becomes developed—but to this subject more particular allusion will be made after a few examples of the operation of Passion or Instinct, or Animal Sympathy, as a stimulus to irritability shall have been adduced.

Assuming then for the present what will be demonstrated, as far as possible, in future, that Passion or Instinct consists in an action of the brain, as the seat of every mode of thought, the examples of the translation of this action to distant organs, so as to act on their irritability, are perhaps even more remarkable than those of Sympathy properly so called. We shall begin with the effects of Passion in general, and subsequently enumerate a few of those resulting from that department of Passion called Instinct. Thus the shortness of breath produced by almost every emotion is a sufficiently familiar illustration of the operation of Passion, in the capacity of a stimulus, on the irritability of the *Respiratory muscles;* and the violent panting which succeeds one of the most intense of these emotions, namely venereal gratification, and which is so very disproportionate to the mere exercise which has been undergone, tends very much to strengthen the belief that it is by the same nerves which are naturally subservient to respiration, as effected by Sympathy, that the influence of Passion extends to distant organs. (*a*) The remarkable effect of Passion also on the respiratory muscles in general is well exemplified in the action of the various muscles by which sighing, yawning, groaning, screaming, sobbing and laughing are effected, respectively from sadness, annoyance of any kind or a tendency to imitation, deep affliction, sudden or intense joy or grief, childish sorrow and mirth. Again the frequent excitement of the *Heart,* producing an irregular pulse, palpitations, syncope and so forth, from various mental perturbations, are equally familiar to every body; as is also their influence on the irritability of the immediate *Organs of Secretion,* in producing at one time a constriction, and at another a dilatation—the result of a previous constriction—of the capillary vessels, whence arise paleness or blushing, flaccidity or turgescence, suppressed or increased and vitiated secretions. Every body knows the almost instantaneous effect, on the one hand, of fear in blanching the cheeks, and rendering

(*a*) " But *breathless* as we grow, when *feeling* most."

BYRON.

the eye dull—which is effected by a very similar process—as well as in producing temporary impotence, and that of almost any intense emotion in occasioning an immediate suppression of the menstrual fluid, the milk, the tears or the saliva; (*a*) nor is any one ignorant of the equally speedy operation, on the other hand, of diffidence in producing blushing of the cheeks, of anger and numerous other emotions in eliciting, as it were, a flash of fire from the eye, (*b*) of venereal desire and other passions in producing the erection of the clitoris or penis, the prehensile motions of the fimbriæ of the fallopian tubes, the erection of the nipples of the mammæ, and the turgescence of many other organs consisting of erectile tissue. And equally remarkable is the influence of various other mental affections in increasing and vitiating the several secretions. Thus, with respect to the perspired secretions, the halitus from the lungs is sometimes almost in an instant vitiated by bad news, so as to produce fetid breath; the quantity of the gastric fluid is increased by exhilaration, at least if we may judge by the increase of the digestive powers under these circumstances; (*c*) and the effect of fright in increasing the discharge of the intestinal gases, and in rendering them more than usually offensive, is frequently not less remarkable. The flow of the menstrual fluid likewise, if it is sometimes suppressed, is equally frequently increased by various emotions; and the effect of continued hilarity on the one hand, and of absolute despair on the other,

(*a*) Hence in intense grief the tears do not flow, and it is always a proof of a moderated sorrow when this takes place: tears do not bring relief, as is commonly believed, but they indicate that it has been brought. The cleaving of the tongue to the mouth from violent emotion—the *vox hæret faucibus*—is easily explicable upon the same principles. Every body knows the story of the detection of a thief, in an establishment of servants, by the dryness of the rice, which he, in common with the rest, had been compelled to hold in his mouth, while each was taxed with the theft.

(*b*) The fascinating power of "the magic circle of the eye," independently of any action of its own muscles, or of those of the eye-lids, which most materially adds to its expression, is by no means a mere illusion. The eye is as capable of turning pale—if we may so speak—and of blushing as the cheeks, but it is with white blood instead of red, so that fewer or more of the rays of light which impinge upon its surface are reflected.

(*c*) The mass of aliment, solid and liquid, which a man will devour without inconvenience at a dinner taken in company, in the midst of inflated speeches, roaring songs and so forth, is sometimes such as, had he taken it, without such condiments in his own solitary apartment, would have almost annihilated him.

in producing gradually an accumulation of the fat is not less striking. (*a*) How instantly also the whole surface is sometimes bathed in sweat from dismay, most persons have experienced. Among the follicular secretions the flow of the mucilage of the vagina is much promoted by venereal desire, as that of the stools is, as every body is aware, by almost every depressing passion; (*b*) nor is it less certain that the quantity of the sebacious discharge from the surface is increased by bashfulness (*c*) and other emotions, particularly venereal desire. (*d*) Lastly, with respect to the glandular and folliculo-glandular secretions, it is a prevalent and perhaps a well-founded opinion, that jealousy both increases the quantity and vitiates the quality of the bile; (*e*) and it is certain that, as numerous mental perturbations produce a suppression of the flow of the milk, so love of offspring and other affections in an equal degree promote it, while sadness again

(*a*) " Laugh and grow fat" is a common saying, but " Despair and grow fat" would be an equally true one. Persons left long to pine in condemned cells, without a shadow of hope, become frequently, in spite of their usually slender fare, remarkably fat. Absolute despair is as incompatible with solicitude, as total thoughtlessness; and it is solicitude which emaciates. Cassius was " lean" because he was anxious to redress his country's wrongs: had he either been indifferent to them, or despaired of redressing them, he would probably have been as " fat and sleek-headed" as any of those whom Cæsar wished to have about him.

(*b*) It is not, as is so generally believed, so much from a relaxation of the sphincter ani, that, as observed by Butler,

——" No man is master
Of his posteriors in disaster,"

as from the sudden increase and vitiation of the intestinal gases and stools, which alone are competent to explain the change in the quantity, consistence and odour of the discharge; and nature has even rendered this or some analogous excretion under emotion a means of security to some animals, at will be noticed in future.

(*c*) A raw girl, when first called upon to exhibit, before company, a taste of her quality, at the piano-forte or in any other way, affords frequently a good example of this effect of the passions. The unpleasant odour perceived by those standing behind her is often attributed to want of cleanliness—but most unjustly.

(*d*) See the ancient poets, whose mere descriptions of the stench sometimes set up by their Thaïdes on certain occasions are absolutely suffocating.

(*e*) Horace speaks of his liver swelling with bile, when he saw his mistress toying with another man; and the phrase of " green-eyed monster," as applied to jealousy, is well known. " I will possess him with yellowness," says lean Jack; i. e. " I will make him jealous, or give him the jaundice."

vitiates it, and renders it unpalatable. (*a*) The effect finally of venereal desire in increasing the secretion of the semen, and those of moderate joy or sorrow, and of moderate desire or disgust, in producing an inordinate flow respectively of the tears and the saliva, however prone intense emotions may be to suppress these secretions, are abundantly familiar to us all—so familiar indeed, that they cease to attract any attention, and are generally overlooked from the very circumstance which should claim for them the deepest attention. (*b*) Nor is the effect of Passion on the irritability of the *Absorbing Vessels* less remarkable than on that of the secreting; since it is to this that we must refer the blanching, in the course of a few hours, from strong emotions, sometimes of the skin, (*c*) but more frequently of the hair, (*d*) so many instances of which are on record. The remarkable effect of Passion also on the irritability of the stomach and cooperating muscles, among the *Digestive Organs*, is sufficiently manifest from the frequent occurrence of vomiting from disgust, as well as on that of the uterus, among the *Organs of Generation*, from the

(*a*) The effect, in producing a secretion of milk, of an intense desire to secrete it, has been often manifested, not only in mothers, but in young girls who have never been impregnated, and in old women who have long ceased to propagate—nay, even in males, both of the human species and of quadrupeds. Such cases of the formation of milk in young unimpregnated girls are related by Fodéré, Belloc and others; in old women, by Stark, Montégre and Kennedy; and in males, by Aristotle, Benedict, Donati, Borelli, Laurenberg, Paullini, the Bishop of Cork, Humboldt and Blumenbach.

(*b*) When we reflect on this tendency of the passions to change the character of the several secretions, and remember that it is by the secretions of the mother that the fetus, during its whole organization, is nourished, we may perhaps be excused from at once chiming in with the accustomed cant, that the emotions of the mother "cannot possibly" have any effect on its organism. We "cannot possibly" explain perhaps what is the immediate process by which such vitiated secretions have this effect, nor shall we be able to do so, till we know a little more of the vis plastica than its numerous appellations; but neither shall we be able, till then, to explain why this effect should be impossible. It is much easier, in these matters, to look shrewd and *incredulus odi-ish*, than to give any good reason for our unbelief; and if the result of no process—however well accredited—is to be believed in, till the nature of that process has been satisfactorily explained, we must be content to suspend, for the present, our belief in our own existence.

(*c*) See *Journal of Science and the Arts*, 1819. *Froriep's Notizen*, 1826 &c.

(*d*) Innumerable instances of this occurred, it is said, during the infatuated scenes of the French revolution; and there are few whose experience does not furnish one or more examples of it.

facility with which its contractions may be either brought on or stopped by various emotions. Again the effect of the same agent on the irritability of the more commonly reputed *Voluntary Muscles* is sufficiently displayed in the action of the various muscles by which distending the nostrils, turning downwards and outwards the eyes, winking, frowning and so forth, are effected, respectively from exultation, rage, momentary apprehension and displeasure; and the numerous alterations in the sound of the voice, as well as in the general expression of the features, owing to the action of numerous muscles, the ordinary stimulus to which is volition, from almost every kind of mental perturbation, are well known. Similar alterations also are constantly perceived, from similar causes, in the attitudes and gestures of the whole body, from the tremblings of doubt and fear to the utter relaxation of wretchedness on the one hand, and from the start of surprise to the full perpendicular of astonishment, the rigidity of terror, and the leaping and dancing of extatic delight on the other. How expressive lastly of the various mental affections are the motions of the hand has been a theme of admiration from the earliest period. (*a*) The whole art of the player consists in a delicate perception of these effects of Passion on the muscles of the eye, face, larynx, trunk and limbs, and in an accurate imitation of them by throwing into the same muscles the stimulus of volition, while he at the same time counteracts, by similar means, the expression of any emotion by which he may actually be excited. The tendency to beat time to music is a familiar illustration of the effects of Passion on the movements of the voluntary muscles.

Such then are a few of the principal isolated effects of Passion, collectively considered, as a stimulus to the irritability of the several organs; and some of those of Instinct—a term which, as will be in future shown, is applied only to that form of Passion which is attended with desire, and the actions excited by which conduce always to some definite end—are of course identical with many of them. But while, on the one hand, they cannot with propriety be made to embrace all the

(*a*) " Cæteræ partes," says Quintilian, " loquentem adjuvant, hæ (manus) prope est ut dicam ipsæ loquuntur."

actions excited by Passion in general, they include, on the other hand, not a few which are more properly regarded as instinctive, and which accordingly are seldom referred to Passion in general as their stimulus. (*a*) Among the irritations which may be said with equal propriety to result from either Passion or Instinct, in the sense of the latter term above specified, are those by which the mucilage of the vagina becomes accumulated preparatory to copulation; by which the intestinal gases and stools are, in some animals, increased in quantity and vitiated in quality as a means of self-defence; by which an increased secretion of milk is effected for the purpose of affording nourishment; by which the quantity of semen is augmented as instrumental to propagation; and by which the saliva becomes accumulated preparatory to manducation. The irritation likewise on which indirectly depends the erection of the clitoris, of the fimbriæ of the fallopian tubes, of the mammæ or of the penis, conducive as all these actions are to a definite end, is referable indiscriminately to Passion generally, or to Instinct in particular, as its stimulus. And the same thing may be said of the various irritations whence result sighing or yawning, both which tend to relieve the sensation of general oppression arising from sadness or annoyance; vomiting, the effect of which is to expel any matters which excite disgust; winking, the end of which is to defend the eye-ball from a threatened injury; starting, for the purpose of withdrawing the body from any object of alarm; and general tension of the muscles, as a means of bearing up against danger of any kind. The other actions above enumerated as resulting from Passion in general as their stimulus cannot with equal propriety be referred to Instinct, while, on the contrary, there remain to be mentioned some which, although, strictly speaking, they should be comprehended under the effects of Passion—since a whole must of course embrace all its parts, and Instinct is merely a department of

(*a*) No allusion is made, in the ensuing remarks, to the alleged instinctive actions of plants; since, taking Instinct as a department of Passion, and Passion as a modification of Thought, it seems to be conceding to them more than they are entitled to, to admit in them of the existence of this stimulus to irritability. Plants have not in all probability sensation—as will be shown in future—a necessary condition to every form of thought, all their actions arising from irritability, and consisting in irritation alone.

Passion—still, in common language, are referred to Instinct exclusively. Of this nature is the action of respiration as excited, not by sympathy in the ordinary way, but by a desire to breathe, produced by an uneasy sensation arising from some impediment in this function, quite independently of any affection of the proper respiratory nerves, and without any distinct act of volition as prompted by a deliberate persuasion of the competency of such action to alleviate such sensation. Of the same nature is the action of taking aliment and transmitting it to the pharynx by animals in general, and of sucking by the young of mammals, as excited by a similar desire, produced by the uneasy sensation of hunger or thirst; and those of voiding the stools or urine, and of copulating, as excited each in like manner by a desire produced by an uneasy sensation. And it is remarkable that all these actions, as prompted thus by an impulse far less fallible in its proposed end than that of reason, and as immediately excited by a stimulus far less uncertain in its operation than that of volition, are always precisely such as are best adapted to the end in view, and are as perfectly performed the first time they are attempted, as at any subsequent period. It appears indeed that these circumstances may be taken as a kind of test of an instinctive, as opposed to a rational action—that it *springs from a blind impulse independent of volition, and produced by an uneasy sensation*, without any rational persuasion of the adequacy of the means adopted to attain the end in view, that it *is nevertheless always precisely that which most directly conduces to this end*, and that it *is consequently quite unsusceptible of subsequent improvement.* (*a*) It is to Instinct then that are referable, not only all the ac-

(*a*) It needs hardly be observed that the present is not the place for discussing the abstract nature and differences of Reason and Instinct—a subject manifestly appertaining to the head of Thought. Instinct is spoken of here merely in its character of a simulus to irritability, exciting motion sensible or insensible; and it is no more necessary, for the purpose of following it out in this relation, to begin with a full description of its abstract nature, than it was to begin with a description of that of Caloric, Light or Electricity, in treating of these agents in a similar capacity. It is nevertheless proper to state here that it is quite impossible to assent to the proposition of Mayo and others, that Instinct " consists in a natural tendency to execute certain *voluntary* motions"—every thing concurring to prove that it is a stimulus altogether distinct from volition.

tions last enumerated, but also numerous others more or less connected, as well with other functions, as with that of voluntary motion—that is to say, the motion of muscles the usual stimulus to the action of which is volition. Thus the return by every animal, terrestrial and aquatic, to that element, whether air or water, in which alone its respiratory process can be exercised, and from which it has been for a time excluded, is excited, not by volition founded upon a deliberate persuasion of the subserviency of either medium to the end in view, but by the blind impulse in question. And the same is the case with the selection by all animals, herbivorous and carnivorous, of their own character of food the very first time they see it, as well as by each individual of its own particular variety of this, (*a*) in the same way as in certain states of the human stomach we swallow acid, and in others alkaline substances, without any thing like a reasonable conviction of their efficacy in removing the uneasy sensation which produced the desire to do so. All this is true equally of Man and the lower animals; but some of the instinctive actions of the latter so nearly correspond to others which in Man are excited by reason, that we may have more hesitation in referring them to a different source. Of this nature are the actions of hoarding up grain by the Ant, and honey by the Bee, as well as that of burying its superfluous food by the Dog, and numerous others, all manifesting apparently the most admirable foresight, but which are all probably to be traced to a similar desire, produced by an uneasy sensation, which a neglect of these actions, like a suspension of any one of the natural functions, occasions; and it is as actuated by some such impulse that the Cat is accustomed to cover her excrement with earth, and, like an automaton, makes the movement of doing so, even when she has been compelled to void it on a floor, and when of course such movement cannot conduce to any useful end. In like manner the deposition, by insects, of their ova in putrescent matters, calculated to afford nourishment to the larvæ upon their

(*a*) The experiment of Galen with the young kid, which selected milk the first time it saw it, in preference to any other food with which it was presented, is sufficiently hackneyed; and it is equally well known that a chick will peck at barley, or catch at a fly, while the shell is still sticking to its tail.

being hatched, is probably ascribable to a similar blind impulse. They think nothing of the furtherance of any ultimate end by their operations—for they do not in general live to see their offspring—but they are excited to the action by a desire, produced by an uneasy sensation, which arises probably from the peculiar odour of these substances, in the same manner as a Dog is excited to void its urine by the odour of certain plants, or of the stale urine of other dogs; and accordingly such insects, misled by the putrescent odour of some plants, not unfrequently deposit their ova in the heart of them. Again it is to a similar impulse or desire, produced by an uneasy sensation which that kind of locomotion adapted to the peculiar organism of each can alone allay—although without any such purpose on the part of the animal—that we must attribute the selection, by every animal, of that medium in which alone this locomotion is possible. It is this which leads the Tadpole, immediately upon becoming a Frog, from the water to the land, the Duckling, the first time it has an opportunity, from the land to the water, and the Fowl of the air—the native inmate of a cage—immediately on finding itself at liberty, into the atmosphere; (*a*) and it is thus that, without exciting any individual exercise of such locomotion, the ordinary stimulus to which is volition, the impulse in question carries each animal into that medium in which alone it can be exercised. Such likewise appears to be the indefinite desire, dependent in like manner indirectly upon their organism, which prompts the Bull and Ram, whether in sport or earnest, to butt with their heads, the Horse to kick with its feet, the Cat to seize with its toes, the Dog to snap with its mouth, and the Cock or Pheasant to strike with its legs. It is not the possession of weapons attached to these parts as instruments of offence, such as their horns, hoofs, claws, teeth and spurs, which gives them this desire—for they do so before they possess these weapons, and continue to do so although deprived of them—but a vague desire quite unconnected with any end

(*a*) "Take," says Galen, "three eggs, one of an eagle, another of a goose and a third of a viper, and place them favourably for hatching. When the shells are broken, the eagle and gosling will attempt to fly, while the young of the viper will coil and twist along the ground. If the experiment be protracted to a later period, the eagle will soar to the highest regions of the air, the goose will betake itself to the marshy pool, and the viper will bury itself in the ground."

to be effected. In like manner it is from a similar indefinite desire, and quite independent of any deliberate object of either resisting danger or procuring aliment, which excites some animals, as most of the herbivorous tribes, to become gregarious, and others, as most of the carnivorous, to avoid the society of their fellows; and it is as actuated by the same blind impulse that so many tribes, at certain seasons, engage in their several migrations, and accomplish in the course of them undertakings which reason would not have dared to prompt, and which volition would have been inadequate to accomplish. The degree of desire, in these cases, like that of venery, or that which actuates them in the defence of their young, appears to amount to a kind of enthusiasm; and all enthusiastic actions are instinctive, and therefore, in our own species, frequently such as to surprise even the enthusiast himself, on again subjecting himself to the sober dictates of reason and volition. They are like those of a person partially imbecile or insane; and if a special providence seems sometimes to preside over the actions of an idiot or a maniac, it is only because he is actuated, under circumstances of difficulty, by a power less fallible both in its end, and in the means employed to attain that end, than reason and volition. It is hence easy to understand how, in the lower animals, the blind impulse of Instinct should often supersede reason, and be competent to excite numerous actions, corresponding to those which, in Man, can be excited only or chiefly by volition. Thus when the latter would construct a fabric of any kind, he proceeds upon a plan more or less deliberate, and adopts means which are at first in a greater or less degree inadequate to the end in view; and it is only after efforts more or less frequently repeated—and that not by himself alone, but by his fellows for many succeeding ages—that he attains any thing like perfection in his manufacture. But the Snail in constructing its shell, the Spider its web, or the Silk-worm its cocoon, the Bee in building its comb, the Bird its nest, or the Beaver its hut, without any deliberation adopts at once the most effectual means of attaining a certain end; and the resulting fabric is as perfect the first time it is attempted, as it can ever by any possibility become. These are the criteria of instinctive, as distinguished from rational actions; and the more nearly Man, in attaining perfection in his works, approaches to these conditions—in other words, the more he is actuated in their production by Instinct—the greater is his genius, the more by reason and volition, the greater is his talent. It is most erroneous to imagine that we detract from the proper rank of the lower animals by representing them thus, with respect to many of their actions, as a kind of automatons; (*a*) since we are in fact raising them to that of artists, acting under an impulse which it is the highest glory of Man to obey. (*b*) It is this consciousness of the existence within us of a power superior to any over which we have control, which has led poets in all ages to invoke Apollo and the Muses to inspire their verse—in other words, to call upon Passion or Instinct to supersede reason; and that some such instinctive power at once absorbed the mind, and actuated the mighty hand of a Michael Angelo and a Raphael, and excited, not only the conceptions, but the merely physical movements destined to develop works on which ages were to ponder with admiration and delight, is unquestionable. (*c*) It is true the Instinct thus running riot over the reason, is, in Man, very liable to become morbid, and even to terminate in confirmed idiotism or insanity; (*d*) and it is this constant subserviency of many of the actions of a great genius and of a fatuous or furious person to the same blind impulse, which pro-

(*a*) Pereira, Descartes, Pascal, Malebranche &c. Wagner, quoted by the Wenzels, (*De Penit. Struct. Cereb.* 1812) says that the fabrics of the lower animals effected by Instinct, are "nihil aliud quam crystallizationes per sensibilitatem productæ!"

(*b*) The Instinct of animals, which appear frequently to be so much wiser, in their generation, than the sons of men, is accordingly called by Sir Isaac Newton "the wisdom and skill of a powerful ever-living Agent;" by Addison, "an immediate impression from the First Mover;" by Hartley, "a kind of Inspiration;" by Hancock, "the Divine energy;" by Mason Good, "the Divinity that stirs within them;" and by Kirby, "the interagent of the Deity."

(*c*) That a man of genius "nascitur, non fit" is proverbial. It is said that Paesiello, in his fits of composition, used to bury himself under the bedclothes, trying to banish from his memory all the rules and precepts of his art, and giving vent to his feelings in the exclamation "Holy Mother grant me the grace to make me forget that I am a musician."

(*d*) Among the numerous melancholy instances of partial or total imbecility or madness, a concomitant of the "fine phrensy" of poesy, may be mentioned in our own country, and almost in our own age, Ben Jonson, Pope, Denham, Collins, Swift, Smollet, Samuel Johnson, Cowper and Byron.

duces that close alliance of the sublime and the ridiculous, the lofty and the bombastic—as well in works, as in thoughts and words—which has furnished, in every age, so fertile a theme of animadversion. Both equally recede from the reasonable —and the only difference between them appears to consist in this, that, while the former so far carries with it the mind of the judge, as to warp his judgment, by inspiring him with some degree of that enthusiasm in which the conception originated, the latter fails in this object, and by leaving him in full possession of his reason, stands exposed at once in all its native deformity. An unhappy point in the most majestic statue or picture, like an ill-timed word in the most elevated sentence, frequently has the effect of suddenly awakening us from a day-dream of admiration; and what we were perhaps about to pronounce a model of the grand, becomes at once a beacon of the ludicrous: the insignia of royalty differ only in the spirit in which we contemplate them from the tinsel of punchinello. It is a similar morbid preponderance of Instinct over reason which leads Man into every description of intemperance; although this results much more frequently from the reason being too weak, as in the case of ordinary debauchees, than from the Instinct being too strong, as in that of men of genius, who are unhappily so often characterized by this infirmity. (*a*)

(*a*) Among the " five fathoms deep" men—still to confine ourselves to poets, and those of our own country, and almost our own age—it is sufficient to mention Rochester, Parnell, Otway, Sheffield, Savage, Churchill, Prior, Dryden, Cowley and Burns. " Let those," says Dr Currie, " who are without follies cast the first stone at their infirmities, and thank their God that they are not like the poor children of genius, frail in health, feeble in resolution, in small matters improvident, and unfortunate in most things." (*Life of Burns*) But if Instinct, thus opposed to reason, sometimes betrays Man into errors, is reason, when opposed to Instinct, quite exempt from a similar imputation? Whence have originated all the absurd attempts, made by reputed philosophers from the earliest periods, to counteract the natural tendencies as well of brutes as of Man, and to make them what nature never designed that they should be? What was it which has led some of them to forbid us to sit near the fire when we are cold, lest peradventure we should dry up our radical moisture; or to court the refreshing gales of heaven when we are in a fever, lest perchance we should interfere with the salutary fermentation of our fluids? What was it which has prompted some to the idle attempt to make aquatic animals terrestrial, and terrestrial aquatic; to render herbivorous creatures carnivorous, and carnivorous chewers of the cud; or to turn quadrupeds into bipeds, and bipeds into quadrupeds? Whence have arisen

One more remark remains to be made respecting Instinct, as a stimulus to the irritability of the various organs, particularly of those which, under ordinary circumstances, obey rather that of volition, and that is, that it is probably the source of that ease and accuracy in the several movements which are gradually acquired by habit. It has been already remarked that an instinctive action is unsusceptible of improvement; but this furnishes no objection to the above proposition, since it is not as instinctive that such actions are improvable. In every step which is made towards progressive perfection, the agent in effecting this is volition; but at any given stage of this progress these actions may be further excited by Instinct, which thus perpetuates the improvement which volition has made, and at length renders such habitual actions as prompt and correct as if they had been originally instinctive. The action of sucking, for example, is instinctive; it is perfect from the first, and not only is the exercise of this action in any given instance determined, but all the motions requisite to it are excited, and excited readily and accurately by Instinct alone. On the other hand that of speaking is voluntary; many and many failures are made before a single word can be articulated, but when the difficulty has been once thoroughly overcome, the action becomes habitual, and so on with respect to every other word, till the language

the injunctions, which we are condemned still sometimes to hear, not to eat when we are hungry, nor to drink when we are thirsty, and to feed exclusively on herbs and fruits and water from the spring, or at any rate to be satisfied with the least possible quantity of the simplest possible fare? What is it which has led, and still leads some misguided wretches to refrain from sexual intercourse, as insalutary and even criminal, and has thus not unfrequently betrayed them into the most revolting abominations? What formerly induced our boarding-school mistresses to endeavour to improve the shape and carriage of the poor things committed to their care by debarring them from all natural exercises; and what is now leading them, with almost equal absurdity, to attempt the same by all sorts of unnatural gymnastics and calisthenics? There are few who have not, at one time or other of their lives, tried to supersede their instinctive and wholesome impulses by some *rational* system of diet and regimen, and there are few who have not found themselves the worse for their pains; and if Man is more prone to deformity and disease than any other animal, he perhaps owes a great part of the melancholy distinction to so frequently allowing the artificial precepts of reason to interfere with the natural dictates of instinct. We may distort the propensities, as we may deform the skull like the Charib, or the nose like the African, or the foot like the Chinese; but we cannot improve them.

formed of these words has been mastered—and now volition only determines the exercise of speech on any given occasion, and excites the necessary motions, but it is Instinct or desire, produced by the uneasy sensation which a suspension of a function, not indeed in this instance natural, but acquired, always occasions, which calls them into action with facility and precision.

These then are a few of the most remarkable examples of the operation of Passion or Instinct as a stimulus to irritability during health; and were it consistent with our present object to regard them either as agents in the production of diseases, as constituting a feature in their symptoms, or as instrumental to their cure, still more striking instances of this operation might be adduced. Suffice it to say at present, that there is scarcely any disease, organic or functional, which may not be excited by one kind of Passion or another; that there are few or none, in the course of which the passions do not play a more or less active part; and that upon almost all, the several passions have been brought to bear with greater or less effect as a remedy, from the times of the priests and prophets, through those of the magicians, sorcerers, wizards, necromancers, astrologers, conjurers, exorcists and rosicrucians, to the days of the followers of Greatorex, Messmer and Perkins, the worshippers of Hohenloe and the proselytes of St John Long. "A merry heart," saith the preacher, "doeth good like a medicine;" and he might have added often much more abundantly—a fact known to charlatans from time immemorial, but which regular practitioners, in the pride of their superiority, for the most part have yet to learn, or, if they know it, have at any rate yet to avail themselves of that knowledge. And to a still greater degree do they require even yet to be impressed with a knowledge of the generally salutary operations of an unerring Instinct in prompting us to avoid what is injurious and to seek what is salutary, not only in health, but in disease. It may be judicious to try to temper and regulate these propensities, but it is madness to endeavour to eradicate them.

Nor is Passion or Instinct in all probability a less general and important agent in promoting all the vital actions, at least of the higher tribes of animals—in addition to these more or less isolated examples of its operation—than Sympathy. If the healthy irritation of each organ of the body be in some degree essential to that of all the rest, it seems to follow *a fortiori* that the healthy action of the brain—the seat of Passion or Instinct—will be at least equally necessary; and it is accordingly this stimulus which we allude to when we speak of a more or less permanent influence from the brain, as conducive to all the natural functions of the body. The irritability of the respiratory muscles is indeed immediately excited principally by an especial Sympathy, that of the heart and capillary system principally by the blood, that of the stomach principally by the aliment, and so forth; but to the perfectly healthy action of each of these organs, such as takes place during the waking hours, many other stimuli, including the one now in question, are requisite, as is obvious from the tardy respiration, the slow pulse, the diminished secretions, the torpid digestion &c. which characterize those states of the system in which the action of the brain is suppressed or impaired, as in sleep or coma. In certain morbid states of the brain also, although the influence of such diseases is perceived principally in the animal functions, the organic functions are sometimes involved in a very remarkable manner; and when only one side of the brain is affected, the opposite side of the body sometimes participates, not only with respect to the former, but also with respect to the latter, of which some very singular instances are recorded. (*a*) Such however is of course the case with Animal Sympathy, as well as with Organic, only in those tribes of animals in which the brain, in common with the other organs, is so concentrated, as to call for this indirect association of its functions with those of the rest of the system; and in precisely the same ratio that system of nerves, which we shall presently find is, in all probability, the means by which this association is maintained, is found to be developed. (*b*)

(*a*) Elliotson. (*Human Physiology*, 1835, p. 21)

(*b*) Passion has never been quite identified, like Caloric and so many other stimuli to irritability, with life; but it was regarded by the ancients as the next thing to it. This is sufficiently indicated by the fable of Prometheus, who, after he had vivified his clay statues with fire, as before stated, is represented to have found, as

SECTION II.

On the Conveyance of Sympathy and Passion or Instinct, regarded as Stimuli to Irritability.

The question now arises, By what channel is the direct and primary irritation or action of one organ so translated to a distant one, as to become there a new stimulus to irritability? And in the first place it may be observed that the irritation or action, either sensible or molecular, of solid tissues, may be as easily supposed capable of exciting the irritability of parts directly contiguous to those which are undergoing it, as the direct application to these parts of any new chemical or mechanical agent; the immediate stimulus to irritability not being, any more than irritability itself, in any case substantial, but merely a power attached to something that is so, and capable therefore of arising, as well from a new mode of being of substances already present, as from new substances being brought into operation. Irritation then or action is not only the result of a stimulus acting on irritability, but it may be itself a stimulus to irritability, and thus excite further irritation, at least of contiguous parts, as well as, under certain circumstances, a stimulus to sensibility, and thus excite sensation, as sensation again is a stimulus to the faculty of thinking, and thus excites thought. All this will be more particularly explained in future; but in the mean time it becomes a question, by what means is it that, passing over contiguous parts, a direct and primary irritation or action, whether of other organs or of the brain, becomes so frequently an indirect and secondary stimulus to the irritability of parts at a distance, and that apparently on grounds altogether indefinite and arbitrary? Previously to entering on this inquiry however it is to be observed that, by some authors, the immediate seat of Passion

Dean Swift says, that "they looked so like the latter end of a Lord Mayor's feast, that he could not bear the sight of them." He was obliged accordingly to actuate them by various passions, which he culled, for the purpose, from the different tribes of animals, "and so tempered together before infusion, that they became the most amiable creatures that heart can conceive." The passions, as before observed, were one of the six non-naturals of after times.

or Instinct has been presumed to be, not the brain, but the several viscera of the chest and belly; (*a*) so that it would appear that the translation of the irritation is, in this case, rather from the organs in question to the brain—if the brain have any thing to do with the matter—than in the opposite direction. But there is a fallacy in this view of the subject which must be met *in limine*. That Passion or Instinct, as a mode of thought, must be preceded by sensation, as sensation must by irritation, has been already admitted; but it is absurd to call the seat of this primary irritation that of Passion or Instinct, or to confine it to the viscera of the chest and belly, if we do so. Passion or Instinct, as a mode of thought, can no more be seated in any organ except the brain, than palpitation of the heart can be seated in any organ except the heart; and though such Passion or Instinct may be produced by the sensation of touch or tact, in one or other of its innumerable modifications, arising from irritations of some of the viscera just mentioned, as is the case of a desire to eat, to void the stools or urine, or to copulate, indirectly from irritations respectively of the stomach, rectum, urinary blad-

(*a*) This was the opinion of all the ancient philosophers and physicians almost without exception, who, while they placed reason in the brain, uniformly consigned the passions to the viscera of the chest and belly, or to these organs and their contents collectively; and hence we find the words breast, heart, belly, stomach, bowels, liver, reins or kidneys, στῆθος, καρδία, φρένες, σπλάγχνα κ. τ. λ. constantly used by them as synonymous with Passion in its various modifications—a practice which still extends, as will be more particularly insisted on in future, a very remarkable influence over our most familiar expressions. Nor have modern authors been wanting to follow this conceit, Bordeu, Buffon, Bichât, Cabanis, Reil, Broussais and many others having represented the passions as rather springing from, than giving rise to certain states of the viscera and the ganglionic nerves supplying them. Broussais indeed defines Passion to consist in "the triumph of the viscera over intelligence;" (*Principles of Med.* § 47) but, as has been aptly asked by Dr Wilson Philip, "Can the passions belong alone to that life (the organic) in which they never can be excited—on which they never could operate;" (*On the Vital Functions*, 1817) and by Dr Elliotson, "are not the passions a part of the mind?" "We might as well," he continues, "consider the cheeks as the seat of the feeling of shame, because in shame we blush," (*Human Physiology*, 1834, p. 22) as refer any Passion to any other organ than the brain. No irritation of the stomach or genital organs can by any possibility *constitute* the desire for food or venery; and if the actions in which these desires consist be not there, they must be elsewhere, and translated thence, so as to act as a stimulus on distant organs, by some means or other, which still remains to be explained.

der or genital organs, it is much more frequently produced by the sensations of smell, sight, hearing or taste, arising from irritations severally of the nostrils, eyes, ears or tongue. But speaking, as we are now doing, of Passion or Instinct merely as a stimulus to irritability, we have nothing whatever to do with its origin: we regard it as a ready-made direct action of the brain; and in this view of the matter, have now to attempt an explanation of the manner in which this action, in common with that in which Sympathy in general originates, is translated to other parts.

The first opinion entertained upon this subject was founded upon the tenets of the ancient Humoral Pathology, which inculcated that whenever irritation—which term was always employed by them in a morbid sense—was excited in any part by the application to it of some peccant matter, one or other of the four principal fluids of the body, already alluded to, set off, urged by the everlasting vital principle, on an expedition against it; and hence arose the vague and absurd axiom, *ubi irritatio, ibi fluxus*, still unhappily often in the mouths of pathologists. But in the course of the disease, thus excited, the vital principle seems sometimes to have changed its mind; and the fluid in question being drawn off, in some arbitrary way or other, from the post which it first occupied, proceeded elsewhere, and excited critical discharges and so forth—a consummation to be as much as possible promoted by the use of reputedly revulsive remedies, the operation of which is still so frequently and so idly referred to counter-irritation. The seat then of the primary, and that of the secondary irritation were accordingly said to sympathize with each other; and the presumption of these spontaneous influxes of imaginary fluids was received as an explanation of the manner in which they did so. (*a*) On this hypothesis of course any comment will be quite superfluous.

(*a*) This was the doctrine of all the ancient dogmatic or rational physicians, (heaven save the mark!) in opposition to the empirics, who honestly confessed that they knew nothing at all about the matter; and it prevailed of course during the twenty centuries that the Humoral Pathology held an almost undisputed sway over the schools of medicine, and every physician employed the word humour, like Corporal Nym, as a convenient substitute for almost every other. Few are aware how much of the leaven of this pathology still clings to us, in this the nineteenth century of human redemption.

Analogous to this vague doctrine of alternating influxes—nobody knows by what channel—of various imaginary fluids, as a cause of sympathetic irritations, is that of either alternating or simultaneous Determinations of Blood, which superseded it soon after the discovery of the circulation of this fluid, and which is still not unfrequently alluded to as a means of explaining such irritations. It is in this way, for example, that the participation by the mammæ in the affections of the female genital organs is sometimes explained, the communication between the two, by means of the inosculation of the internal mammary and epigastric arteries, being quite competent, it is presumed, to account for such a relation between them. (*a*) It appears however quite unnecessary to descant on the merits of an explanation which is not only quite inapplicable to ninety-nine out of a hundred cases of the most obvious sympathetic action, but altogether inconsistent with every thing that is known respecting the laws which regulate the course of the blood; every acknowledged fact tending to the conclusion that, if ever there was one doctrine in physiology more totally unfounded than the rest, that doctrine is the presumption of a determination of blood in any case, and *a fortiori* of any such alternating or simultaneous determinations as are here supposed. Nor is the doctrine, that it is by means of the blood-vessels or lymphiferous vessels *per se* that the stimulus of Sympathy is conveyed, (*b*) in any degree more tenable; since it must be obvious that, as these vessels, without their nerves, are quite incompetent to communicate any vital impression, so what nerves they have are for a very different purpose.

The next hypothesis advanced, respecting the medium of sympathetic irritations, was that they took place through the Ganglionic nerves, or system of the Great Sympathetic, as the name so unfortunately given to this system, by the first physio-

(*a*) Such was the hypothesis of Riolan, the contemporary of Harvey, who was the first to describe the inosculation above alluded to, which it is remarkable he always met with *in women!* "In mulieribus," says he, "semper animadverti!"

(*b*) Blumenbach; (*Inst. Physiol.* 1786) Soemmering. (*De Morb. Vas. Absorb.* 1795) &c.

logist who well described it, sufficiently indicates (*a*)—and indeed the hypothesis last mentioned is little more than a modification of this, since the only or principal nerves of the blood-vessels and lymphiferous vessels, by which alone, as just observed, they can communicate any vital impression, are derived from the ganglionic system. Nor is it at all surprising that this opinion should have been promulgated. Sympathy and Passion are strong stimuli to irritability, analogous to volition; and as it had become established that, while sensibility was the attribute of one of the only two departments of the cerebro-spinal system then known, volition

(*a*) In speaking of the various alleged uses of the Ganglionic system of nerves, it was observed that the above use, among others, had been assigned to them by Willis, followed by Vieussens and Meckel, and that their opinion had been currently adopted by the common-place physiologists of the present day. Mason Good, for example, describes the ganglionic system of nerves as " the emporium of nervous communication, and the instrument of general sympathy," (*Study of Med.* 1825)—a strong presumptive evidence, if other arguments were wanting, that it is neither the one nor the other. By Virey likewise, as we have seen, they are regarded as vehicles of Instinct which amounts to nearly the same thing; and a similar opinion has been embraced by Mr J. W. Earle. By Bellingeri and Walker, after Johnstone, the opinion that the ganglionic nerves, besides being the source of irritability, or vital or unconscious sensibility, are the vehicle also of Sympathy and Passion or Instinct—or the stimulus to involuntary motion—is also maintained. But this, as already observed, is probably incorrect as applied to the proper ganglionic System, however correct it may be as applied to some of the numerous other nerves which they have chosen to incorporate with this system—for example, all those connected with the restiform bodies according to the one, and the olivary bodies according to the other, and therefore all those arising from the lateral columns of the spinal cord. Their ganglionic system also includes, as has been elsewhere stated, all those nerves connected with the gasserian ganglion and the series of ganglions within the spinal canal, in other words all the commonly reputed sensiferous nerves of the body. To say nothing however at present of the latter set of nerves, there is little question but that the former—including the Facial, the Glosso-pharyngeal and the Pneumogastric, which has been sometimes called the Little Sympathetic—are really vehicles of the stimuli in question; and the only difference therefore between the opinion of these authors, and that to be presently maintained, is that it is not as a part of the proper ganglionic system of nerves that they are so, but as constituting with some others a system *per se* under the name of Respiratory. Their statements therefore, however nominally in favour of the ganglionic nerves in this capacity, are perhaps really in favour of the Respiratory; nor are Dr W. Philip's proofs that the nerves of the heart convey to this organ extraordinary stimuli, such as those of Sympathy and Passion, at all less in favour of the former than of the latter; since it is not, in all probability, as elsewhere remarked, in that department of them which is derived from the proper ganglionic, but in that which belongs to the Respiratory system, that they perform this office.

was conveyed by the other, it was very natural to refer the conveyance of Sympathy and Passion to the ganglionic nerves, as a part of the nervous system hitherto unoccupied, its subserviency to irritability not having yet been thought of. But that this cannot be the office of the ganglionic system of nerves necessarily follows, if the arguments which have been already adduced, at so great a length, to prove what is its office, be admitted. Most of these arguments are indirectly opposed to the proposition in question, and some of them are directly so—in particular the facts that these nerves are developed in all tribes of animals, not in the ratio of their manifestation of Sympathy and Passion or Instinct, but in that of their manifestation of irritability; that they are, in structure, much more nearly allied to the sensiferous, than to the motiferous nerves; that, like the former, and unlike the latter, they do not so conduct galvanism as to excite muscular action; and that, when stimulated in any way, they occasion no irritation in the parts which they supply—facts which, although they are easily reconcileable with the presumption of their communicating only a susceptibility of action to these parts, are quite incompatible with the doctrine that they conduct to them a stimulus. Further the greater number of the arguments which will be presently brought forward in favour of the opinion that a very different system of nerves—and one which was quite unknown, as a distinct system, at the time that the doctrine in question was first broached—is really the vehicle of Sympathy and Passion, bear of course indirectly against this doctrine; while there is one which militates directly against it, and that is the fact that cutting the nerves of the system last alluded to seems at once to put a stop to the conveyance of the stimuli under consideration. It would give rise to endless, and very unnecessary repetitions, on the one hand to recapitulate here all that has been said in favour of attributing a very different office to the ganglionic nerves, and on the other to anticipate all that will in future be said in favour of ascribing this office to a very different system: suffice it to say that every unprejudiced view of the matter must tend to dislodge the ganglionic system from the post which it has, with a certain class of physiologists, so long and so undeservedly occupied.

Another doctrine, and still a somewhat prevalent one, with regard to the nature of sympathetic irritations, is that they take place through the Brain, the direct and primary irritation exciting first, by some unknown means, sensation, which sensation further excites, by means equally unknown, indirect and secondary irritations in distant parts. (*a*) And the proof of this, say the advocates of this doctrine, is that the *same* sensation—for example, that which gives rise to a desire for venery—excited by primary irritations of two different organs, gives rise to secondary irritations of the *same* distant part; whereas *different* sensations—for example, those producing gratification and annoyance—excited by primary irritations of the same organ, give rise to secondary irritations of *different* distant parts. Such sympathetic irritation therefore, they contend, cannot depend on the character of the irritation primarily excited, but must arise from that of the sensation thence resulting. But all this applies only to Passion or Instinct—not to Sympathy properly so called—and in as far as it does even this, it only tells us what we do not require to be informed of, namely that every form of Passion must be preceded by sensation, as the latter must by irritation, while it gives us no sort of clue to what alone we want to know, to wit by what means Passion—no matter how excited—acts as a stimulus on the irritability of distant organs. And that it cannot apply to Sympathy, properly so called, is manifest from the following facts—that sympathetic irritations are not less observable when the primary irritation is seated in an organ apparently destitute of sensiferous nerves—the lungs or stomach for instance—than in one furnished with them; that even the division of these nerves, when they exist, makes

(*a*) The principal authors who have maintained this opinion are Astruc, Van Swieten, Whytt, (*Physiol. Ess.* 1755) Haller, (*El. Physiol.* 1757) Monro, (*On the Struct. and Funct. of the Nerv. Syst.* 1783) and, with respect at least to some cases of Sympathy, Blumenbach. (*Inst. Physiol.* 1786) It has been recently advocated also by Professor Alison; who has, apparently rather too hastily, concluded that, because Whytt, Haller and Monro could not half a century ago explain the communication of sympathetic irritations upon the principle of any association of nerves, such an explanation must be still impossible. (*Ed. Med. and Surg. Journ.* 1826) There are probably however many more things in heaven and earth than were dreamt of in their philosophy. Similar doctrines are maintained likewise by Broussais, Georget, Roux and others.

no material difference in the certainty with which such secondary irritations are excited in distant parts, as in the case of sneezing from volatiles to the nostrils, after the destruction of both the olfactory and trigeminus nerves; (*a*) that some of the most striking examples of sympathetic irritation — for example the act of respiration—are not interrupted during sleep, or in comatose diseases, and are compatible with the congenital defect of the greater part of the brain; and that even the artificial removal of the greater part of this organ does not obviate the occurrence of convulsions, in almost all the voluntary muscles of the body, from a primary irritation of one part of the surface. How is all this reconcileable with the doctrine that it is only through sensation that Sympathy operates on distant organs, and that it always takes the brain as a kind of half-way house on its journey? It is true the advocates for the hypothesis in question take no account of the nerves—sensiferous or any other—assuming it is a fundamental axiom that no anatomical principles are at all adequate to explain the route which sympathetic irritations are frequently observed to follow. If, say they, the nerves were the vehicles of the primary irritation—becoming always, as they imagine, sensation—which excites sympathetic action, since different primary irritations of any one part, in journeying to different parts, must each travel by a different road, it follows that every one which is adapted to excite a distinct sympathetic action, must have a distinct nerve to convey it to and from the brain. Among the examples of the action of sympathy already enumerated, have been mentioned that of sneezing from acrid substances applied to the nostrils, and among those of the operation of Passion, as a stimulus to irritability, that of syncope from depression, such as is excited by mawkish odours, that of a flow of saliva from desire, such as is excited by savoury odours, and that of vomiting from disgust, such as is excited by nauseous odours. Now, admitting

(*a*) Magendie has shown this with respect to the olfactory nerve—and it is his principal argument, although a very fallacious one, to prove that this is not the nerve of smell—and Sir Charles Bell with respect to the trigeminus, a palsy of this nerve on the right side having been found quite compatible with the usual effect of volatiles, applied to the right nostril, in exciting sneezing. It is fair to acknowledge however that the latter fact is denied by Bellingeri.

for a moment that all had to pass through the brain, if we presume, say those who attempt to explain sympathetic action by affirming that it is inexplicable, that such primary irritation is translated by nerves, we must conceive that there are bound up in the sensiferous nerves leading from the nose to the brain, one filament for acrid, a second for mawkish, a third for savoury, and a fourth for nauseous odours, since the irritation excited by each has to be conveyed afterwards to a different distant part. (*a*) But, even continuing to admit that it is through the medium of sensation that all such irritations operate—and such is certainly the case with those which give rise to Passion—it seems perfectly easy to understand that the character of the sensation will vary in every case, although conducted by the same nerve, according to that of the exciting cause of the irritation whence it arises. It is true the olfactory nerve takes cognizance only of that produced by odoriferous particles, the optic of that produced by light, and the auditory of that produced by the vibrations whence sound arises; but each is susceptible of very different impressions from different modifications of these respective irritations. And when such impressions, or their consequences, are to be again conducted from the sensorium or brain, so as to act as stimuli on the irritability of distant organs, it is equally easy to conceive, either that they may travel by this or that nerve, according to circumstances, or that, travelling equally by all the nerves belonging to a certain system, they may still display their effects only or chiefly on those parts to the specific irritability of which they are respectively adapted—in the same manner as the primary irritation on which expiration depends is conveyed probably by the same nerves as that on which inspiration depends, but, being of a different character, it acts on a totally different set of muscles. But with cases of Sympathy properly so called it is probable, for reasons already assigned, that sensation has nothing whatever to do; nor is its instrumentality in exciting the action of the brain, in which Passion or Instinct consists, at all connected with the present inquiry, since, in regarding this agent as a stimulus to irritability, we start di-

(*a*) Alison.

rectly from the action of the brain, however produced, and it is the translation of this to other parts which alone requires to be explained. We may conclude then that the doctrine of intermediate sensation, as applied to sympathetic irritation generally, is erroneous, and, as applied to that excited by Passion or Instinct, superfluous; while that which assumes that any association of nerves must be incompetent to explain the translation of the primary irritation or action in which both originate, has not been established by any argument *ad absurdum*.

There still remain two other opinions respecting the communication of sympathetic irritations—one, that it depends on either the contiguity or continuity of the sympathising organs, the other, that it hinges on their similarity in either structure or function. (*a*) But with respect to contiguity or continuity, as a means of explaining the simultaneous irritation of any two organs, upon a stimulus being applied to one of them, it is sufficient to refer to the above enumerated instances of proper sympathetic irritations—and to those excited by Passion or Instinct the doctrine is obviously quite inapplicable—in order to show that, while frequently little or no Sympathy exists between organs the most favourably situated in these respects, some of the most remarkable of these sympathetic irritations take place between organs neither contiguous to, nor continuous with each other, and consequently that such conditions, when they present themselves, are quite accidental. What contiguity or continuity, for example, is there in the case of the lungs and respiratory muscles, in that of the female genitals and mammæ, in that of the diaphragm and muscles which depress the jaw, or in that of the nostrils or larynx and abdominal muscles? And even where one or other of these conditions exist, as between the fauces and stomach, it has been found that this connexion may be severed without impairing the Sympathy between them. (*b*)

(*a*) These complete the number of the six modes, enumerated by Haller, in which sympathetic actions have been presumed to be effected, 1. by Blood-vessels; 2. by Nerves; 3. through the Sensorium; 4. by Contiguity of cellular tissue; 5. by Continuity of membranes; and 6. by Similarity of structure or function. The contiguous doctrine found an advocate in Bordeu; the continuous, in John Hunter; the analogous, at least in some cases, in Blumenbach.

(*b*) It was found by Bichât that vomiting was produced by irritating the fauces, as certainly after dividing the gullet, as when this organ was entire.

Moreover such contiguous or continuous organs cannot, any more than blood-vessels or lymphiferous vessels, convey vital impressions otherwise than by their nerves; so that, although this explanation of sympathetic irritations were true, it would be so only at one remove. And similar objections apply to the hypothesis of a similarity in structure or function, as a means of explaining such irritations, no very obvious consent being met with between many parts the most nearly allied in these respects, while such consent is very striking in others without either of these conditions. Besides a correspondence of tissue can do no more than produce a correspondence of susceptibility—and it is by no means a necessary consequence that it should do even this—so that, from the same stimulus directly applied to two several organs, similar effects should arise: it cannot certainly afford any explanation of the fact that a stimulus applied to the one should be extended to the other, which is what is understood by Sympathy. And to bring in analogy in function, when such is observable, as a means of explaining sympathetic irritations, is obviously to confound an effect with a cause; since it is not because the functions are connected, that the parts sympathize, but because the parts sympathize, that the functions are connected.

Upon the whole it appears that we must return to the Nervous system as the vehicle of Sympathy and Passion or Instinct, considered as stimuli to irritability; but not to that department of it which was lately mentioned. That the direct and primary action, of whatever nature it be, by which the voluntary movements of the body are excited, is conveyed to the requisite muscles by proper nerves adapted to the purpose, is unquestionable; and for the same reason that the established residence of sensibility in one department of the nervous system was allowed to furnish an argument *a priori* for referring the analogous property of irritability to another, the established conveyance of the stimulus to voluntary motion by one department of this system may be taken as presumptive evidence that it is by another that the analogous stimulus of sympathy and passion or instinct is translated. We shall probably find also that the objections which have been stated against regarding the Ganglionic system as instrumental in this way, do not apply equally to every other.

SECTION III.

On the Respiratory System of Nerves, regarded as the vehicle of Sympathy and Passion or Instinct.

If the doctrine that any department of the Nervous system is the vehicle of Sympathy and Passion or Instinct be maintained, we must be prepared to show, 1. That there is a system of nerves which, unlike that by which the stimulus to the voluntary movements is conveyed, is very extensively distributed, since the influence of sympathy and passion or instinct manifestly extends to almost every organ of the body. 2. That this system of nerves is quite independent of the sensiferous department. And 3. That its action is not interrupted by sleep or coma, nor even by the want of the greater part of the brain. Now all this is true of the system of nerves called Respiratory. It is admitted that it is equally so of the Ganglionic system; but besides these *negative* arguments, there are not a few *positive* arguments in favour of the Respiratory nerves in this capacity. Among these may be stated, 4. That they are developed in all animals in the direct ratio, not of their irritability, like the Ganglionic, but of the manifestation by them of the stimulus of sympathy and passion or instinct. 5. That they are, unlike the Ganglionic, similar in structure to the proper motiferous nerves, which convey the analogous stimulus of volition. 6. That, again unlike the Ganglionic, they efficiently conduct, in common with the proper motiferous nerves, the stimulus of galvanism. 7. That any stimulus applied to them, unlike what happens with respect to the Ganglionic nerves, occasions a display of irritation similar to the ordinary effects of sympathy or passion in the parts on which they are distributed. And 8. That a lesion of these nerves produces a corresponding failure in the conveyance of the stimulus of sympathy and passion or instinct, while a lesion of the Ganglionic nerves has no such effect. If all this can be made out, we shall perhaps have little hesitation in admitting the Respiratory system of nerves as the exclusive vehicle of the stimulus in question, particularly when we remember that not only the Ganglionic system, but every department of the Cerebro-spinal system except this, as well as the Brain—cerebrum and cerebellum—is pretty well known to be otherwise appropriated, so that this alone of the whole nervous system is left for the purpose.

But it will be necessary to examine a little more in detail each of the foregoing arguments in favour of the doctrine that it is by means of the Respiratory nerves that the direct and primary irritation or action in question is so translated to distant parts as to become there a new stimulus to irritability; and afterwards to mention, and endeavour to obviate some of the chief objections to which this doctrine is amenable. (*a*)

(*a*) In the tabular view formerly presented of the nerves of the human body, arranged " after their kinds," the Respiratory system comprehended the Pathetic, the Facial, the Glosso-pharyngeal, the Pneumogastric, the Accessory, the Phrenic, and the External respiratory; but the uses formerly, and still by many ascribed to most of the individual nerves of this system—for of the whole collectively nothing was till very lately known—have been extremely various. Thus the Pathetic has been commonly regarded as a simply motiferous nerve, as it is still by Mayo, Earle, Arnold and most others. The Facial was formerly looked upon in general as a regular nerve, or both a vehicle of volition, and a source of sensibility, and it is at present regarded by Mayo, Earle, Arnold, Panizza &c. as a simply motiferous nerve; while by Bellingeri and Walker it is considered as at once a vehicle of sympathy and passion or instinct—in other words as ministering to involuntary motion—and a regular nerve. The Glosso-pharyngeal nerve is regarded by Earle and Panizza as sensiferous—the latter representing it as the nerve of taste—and by Mayo as in some of its filaments regular, in others sensiferous only; while, according to Bellingeri and Walker, it partakes of the compound character of the Facial. The same is supposed to be the case also by the last-named authors with the Pneumogastric nerve; while by Mayo it is looked upon, generally speaking, as a regular nerve, and by Rolando, Brâchet, Earle and Arnold as simply sensiferous, inasmuch as it is supposed to convey certain irritations from the viscera to the sensorium, so as to occasion the sensations giving rise to the desire to breathe, to eat, and so forth. Lastly the Accessory, Phrenic and External respiratory have been commonly regarded either as simply motiferous, or as regular nerves. The idea of associating all these nerves into a common system seems to have originated in the observation that the function of respiration was more particularly under the influence of the lateral portions of the spinal cord—which had been described as distinct from the anterior and posterior portions of it by Chaussier—(*Exp. Sommaire &c.* 1807) and especially, as suggested by Le Gallois, of that portion of it which is within the skull, (*Sur le Principe de la Vie,* 1812)) whence many of the principal nerves above enumerated arise. The existence and importance of these lateral columns, and the origin from them of several of the nerves under consideration, were further insisted upon by Bellingeri; (*Dissert. Inaug.* 1818) but it was reserved for Sir Charles Bell (*Phil. Trans.* 1821 and 1822) and his coadjutor Mr I. Shaw, (*Lond. Med. and Phys. Journ.* 1822) to attempt to establish this as at least a partially distinct System of nerves,

I. The distribution of the Respiratory system of nerves appears, at first sight, very circumscribed, and quite inadequate to explain the almost universal extension of sympathy and passion or instinct over the body. The proper Respiratory tract, beginning at the medulla oblongata, and descending on each side of the spinal cord between the anterior or reputedly motiferous, and posterior or reputedly sensiferous columns, is presumed to terminate about the middle of the back, having given off in its course only seven pairs of nerves, the distribution of most of which is apparently by no means general; to which must be added perhaps some filaments from the Intercostal and Abdominal nerves, the course of which however is still to all appearance confined to the parietes of the chest and belly. But we must remember that—to say nothing of the numerous other probable ramifications of these nerves—the Pneumogastric nerve, throughout the whole neck, chest, belly and pelvis, is inextricably interwoven with the roots of the ganglionic system; and as this system may be presumed, as already explained, to be universal in its distribution—partly from its everywhere accompanying the blood-vessels, and

and to give to it collectively the name of Respiratory. It must not be concealed indeed that, while some physiologists, admitting the existence of this System of nerves, deny to Sir Charles Bell the credit of having been the first to draw attention to it, a still greater number deny that it has any existence. The bulk of evidence however is decidedly in favour of admitting a System of nerves at least partially distinct at once from the proper ganglionic, the proper motiferous, the proper sensiferous and the proper regular Nerves—which is all that is here contended for. The name Respiratory, as applied to this System of nerves, is unfortunate, since it alludes only to an indirect, instead of a direct effect of their agency, and what is worse, to one effect only out of thousands; but to have called it Sympathetic, would have been still more ambiguous, this name having been appropriated, by general consent, to a system of nerves which has pretty certainly nothing whatever to do with sympathy. And perhaps it is of very little importance what it is called, provided we do not allow the name to circumscribe in any degree our ideas of its nature and office.

> " What's in a name? That which we call a rose,
> By any other name would smell as sweet."

It is to be observed further that the admission of these nerves as Respiratory is equivalent to the admission of them as vehicles of sympathy, at least in one instance, since it is by sympathy alone between distant parts that respiration is effected: and as nature never uses two hands where one will do, we might hence have inferred that they were, in every instance, the vehicle both of sympathy in general, and of that particular sympathy in which passion or instinct, regarded as a stimulus to irritability, consists.

partly from every cerebro-spinal nerve, the respiratory inclusive, being reinforced by one or other of its several departments—so, whithersoever a ganglionic nerve goes, thither a Respiratory filament may be presumed to accompany it. Not to mention then any of the other nerves of the Respiratory system, the probable distribution of the Pneumogastric nerve alone seems sufficient to establish the claim of this system to be regarded as almost universally disseminated. We know that such is the case with the Pneumogastric nerve of fishes: and when to this we add, in the superior tribes of animals, the various other nerves belonging to this system, and consider them as all associated together at their common origin, (*a*) through which an impression made upon any one is

(*a*) It would be improper to assume the existence of this Respiratory tract, and the origin from it of all or most of the nerves above enumerated, without observing that neither of these presumed facts has been by any means clearly established. There can be no question indeed that there is on each side of the spinal cord a large cylindrical mass of white matter partially encircled by the horns of grey matter, which, with their transverse connecting band, occupy the centre of the cord, and quite distinct from the two anterior and two posterior columns, the former of which lie before, and the latter behind this transverse band; but whether these, which are the lateral columns of Bellingeri and Walker, correspond to the Respiratory columns of Sir Charles Bell, which he describes as very small, and coming to an end about the middle of the back—neither of which assertions can be true of the columns just spoken of—is doubtful. At any rate there do exist lateral columns, which, if we please, we may call Respiratory, whether they precisely correspond to the Respiratory columns of Bell or not; and from these there do arise nerves, very nearly, if not quite corresponding to those which he has classed together as Respiratory. It has been already stated that the lateral columns of Bellingeri are represented by him and Mr Walker as continuations respectively of the restiform and olivary bodies; and it is on this account that they and the nerves arising from them are regarded as belonging, in part at least, to the ganglionic system. By Bell, on the contrary, the Respiratory tract is said to descend from the medulla oblongata *between* these bodies; and it is remarkable that most of the reputedly Respiratory nerves are admitted by all to have their origin about this part. Thus the Pathetic nerve, which has been commonly described, since the time of Vieussens, as arising from the corpora quadrigemina, is said by Swan to arise from "that portion of the process extending from the cerebellum to the testes to which the valve of Vieussens is attached," by Bellingeri from the fore part of the restiform bodies, and by Walker from "behind the posterior tubercles" or testes, which would bring its origin to very nearly the precise point described by Bell. The Facial Nerve, in like manner, is represented by Swan as arising "deep in the fissure between the posterior part of the annular tubercle and the olivary body," and by Mayo "apparently between the corpus restiforme and corpus olivare;" while by Bellingeri, Walker and Arnold it is described as composed of a larger and a smaller portion, of communicated, according to its intensity, to more or fewer of the rest, we shall be at no loss, on the score of limitation,

which the former is said to come from the restiform, and the latter from the olivary bodies, or "the margin of the annular protuberance"—so that in all likelihood the bulk of the nerve arises from between the two, while one part of it has, as we shall in future find, a distinct origin in the olivary bodies, *really* connected, as they probably are, with the anterior or motiferous columns of the spinal cord. It is of importance to remark however that this view of the matter is directly opposed to that of Bellingeri and Walker, who look upon the function of the olivary portion of the nerve, *qua* ganglionic, as that of conveying the stimulus to involuntary motion, while the function of the presumed restiform portion, as connected with the cerebellum, is that of conveying volition and communicating sensibility. But with the arguments against this view of the matter we have nothing to do at present. Again the Glosso-pharyngeal and Pneumogastric nerves are represented by Swan as beginning "from the restiform body, by the side of the groove between this and the olivary body," by Mayo "from the fore part of the restiform bodies," by Bellingeri and Arnold from the restiform bodies, and by Walker, after Vieussens, Santorini and others, from between the olivary and restiform bodies, so that in all probability these nerves, like the Facial, are in part Respiratory and in part motiferous. The Accessory nerve is described by Swan as arising, at least partially, "from the spinal cord between the origin of the posterior fibrils and the denticulated ligament," and by Mayo "from the side, or rather the back part of the spinal marrow, not far from the posterior roots of the spinal nerves," but still quite distinct from them, as is expressly stated also by Bellingeri and Walker; so that Mr Earle's assertion that it arises from the posterior columns, as he states that the Facial does from the anterior—thereby trying to invalidate the whole doctrine with respect to the presumed Respiratory tract—appears to be unfounded. He is perhaps more correct in representing the Phrenic and External respiratory nerves—inasmuch as they seem to be branches of the proper cervical—as having each a distinct origin in both the anterior and posterior columns; but that these nerves have some filaments from the lateral columns, so that they are in all probability at least partially Respiratory nerves, is not improbable. Sir Charles Bell however himself admits that this part of his general doctrine is somewhat apocryphal. Upon the whole it appears that all the nerves above enumerated are, to a greater or less degree, entitled to the place which they occupy, as having in fact, some of them exclusively, and all in part, the origin which has been ascribed to them; and, however much we may be disposed to deny the existence of any such visible tract as has been described by Bell, we must believe that they all arise wholly or partially almost in a perpendicular line with each other, and that this line is quite distinct from both the anterior and posterior columns of the spinal cord. It may be observed moreover, in conclusion, that it is only upon the presumption that the functions of the several cerebro-spinal nerves must be different, as arising from different parts, that any necessity exists for showing that all the nerves above enumerated have a common origin, in order to be justified in regarding them all as vehicles of sympathy and passion or instinct. It has never been proved, although it is no doubt highly probable, that not more than one central portion of the cerebro-spinal system and the nerves immediately connected with it can perform this office: so that if any strong reason exist for regarding any one of these either in tracing a Respiratory nerve to every organ of the body, or in explaining, by means of such nerve, its sympathy with others. Thus between the lungs and expiratory muscles the sympathy appears to be maintained by the Pneumogastric nerve, with which the former are furnished, being associated at its origin, with the roots of the Abdominal nerves, so that the primary irritation calling for the expiratory process excites the abdominal and lumbar muscles to action, more or less violent in proportion to its intensity. And with respect to the sympathy between the Lungs and Inspiratory muscles, the Pneumogastric nerve is associated at its origin with the roots of the Intercostal and Phrenic nerves, so that, when the primary irritation calling for the inspiratory process is moderate, the intercostal muscles and diaphragm alone are excited; with those of the Accessory and External respiratory nerves, so that, when this primary irritation is more severe, the muscles on the front of the neck also and sides of the chest are called into action; and with those of the Pathetic, Facial and Glosso-pharyngeal nerves, so that, on this primary irritation becoming intense, many of the muscles of the eye-lids and eye-brows, nostrils, face and throat are involved in the general perturbation. (*a*) The sympathy again which subsists between the diaphragm and the muscles which depress the lower jaw seems to depend upon the association at their origins of the Phrenic and Facial nerves; between the stomach and diaphragm, of the Pneumogastric and Phrenic; and between the nostrils, larynx, eye &c. and the abdominal muscles, respectively of the Facial, Pneumogastric and Pathetic, and the Abdominal nerves. Upon the same principle the sym-

nerves as ministering to this end—such as the circumstance of its being, in certain animals, vicarious of some other nerve, which, in other animals, is known to do so, or the effects of direct experiment upon it—it needs not be at once excluded from this office because it cannot be distinctly traced to the common centre in question. There may be association without unity.

(*a*) In these cases the translation of the sympathy is *from* the lungs, through the common centre of the Respiratory system of nerves, *to* the muscles in question; and it is obvious that, in every case of sympathy, there must be, in like manner, a starting post and a goal. The organ furnishing the former, is sometimes described as displaying an *active*, and that furnishing the latter, a *passive* sympathy, with respect to the other; but there appears to be very little advantage in retaining these terms, particularly as such sympathies seem to be in general, as we shall in future find, mutually convertible. We have in this case pathy between almost every other organ of the body and the heart seems to be maintained by the several Respiratory nerves which are supplied to these organs, being associated at their origins with the Pneumogastric; that between the nostrils and lacrymal gland by a similar association of the Facial and Pathetic; (*a*) that between the mouth and salivary glands of the Facial, Glosso-pharyngeal and Pneumogastric; that between the female genitals and mammæ, of the Pneumogastric and Intercostal, and perhaps also the Phrenic and External respiratory; that between the fauces and stomach, of the Glosso-pharyngeal and Pneumogastric; and that between almost every other part of the body and this latter organ, of numerous other Respiratory nerves and the Pneumogastric. So also between the rectum and urinary bladder and the abdominal muscles the sympathy may be presumed to be effected by the association at their origins of the Pneumogastric and Abdominal nerves; that between the choroid coat and iris upon a similar association of different parts of the Pathetic nerve; (*b*) and that between the ear and gums of the different portions of the Facial. Lastly the integuments of the arm-pit or sole of the foot appear to extend a sympathy to the expiratory muscles, and indeed to almost all the muscles of the trunk and limbs, by the association of the Pneumogastric—connected as it may be presumed every where to be with the several ganglionic nerves going to the surface of the body—and the Abdominal and numerous other nerves of the same system. With respect again to passion or instinct, the primary action constituting which is always in the brain, and immediately communicated, we must suppose, to the Respiratory tract, we have only to find a nerve tending from this tract to the organ which

then a real " return of action," or " reflex action," such as has been supposed to be the case with respect to the ganglionic system of nerves, but such as may be presumed, for reasons already stated, to be, in their case, only imaginary.

(*a*) The lacrymal portion of the ophthalmic branch of the trigeminus, by which principally the lacrymal gland appears to be supplied, is described by Amussat and Swan as receiving a filament from the Pathetic. It has likewise, according to Bellingeri, a connection with the Facial nerve.

(*b*) The ciliary nerves, like the lacrymal portion of the ophthalmic nerve, are furnished with a filament from the Pathetic through the nasal portion. Their chief branches however are perhaps for the ganglionic system, as already stated.

is to display the secondary irritation, in order to explain its translation by this system of nerves; and that such a nerve may be always either directly or indirectly traced to every organ liable to be so acted on may be easily inferred from what has preceded. We seem quite justified in concluding then that the Respiratory system of nerves, so far from being circumscribed in its distribution, is almost universally disseminated over the body; and that it is quite adequate, as far as regards this condition, to be the vehicle of the stimuli in question.

II. It has been said above that sympathy, properly so called, may display its effects without exciting intermediately any sensation; that it takes place where the primary irritation is seated in parts destitute, to all appearance, of sensiferous nerves; and that, when such nerves exist, it is not obstructed by their division: and with respect to passion or instinct, that, although sensation is a necessary prelude to this, regarded as a mode of thought, it constitutes no link in the chain of its translation, regarded as a stimulus to irritability. The nerves therefore by which sympathy and passion or instinct are conducted must be such as are quite independent of the sensiferous system; and that this is true of the Respiratory nerves, connected as they are with a tract which occupies the lateral parts of the spinal cord, while the sensiferous column is in all probability on its posterior aspect, is sufficiently obvious. In the case of sympathy, properly so called, the primary irritation may, or may not excite sensation, according as the part to which the stimulus is applied have or have not sensiferous nerves; but the sensation of the odour of snuff, for example, contributes nothing to the sympathetic action, on either the lacrymal gland or the abdominal muscles, resulting from its application to the schneiderian membrane, and constitutes no part of the specific gratification which, whether it occasion sneezing or not, it habitually produces, and which appears to consist in a general excitement of the Respiratory system of nerves throughout all its ramifications. No direct sensation is excited by nitrous oxyd taken into the lungs, nor by alcohol received into the stomach, and yet how strong is, in both these cases, the sympathetic action on the rest of the system! It is hardly necessary to add that the system of nerves by which sympathy and passion or instinct are conveyed is equally independent of the proper motiferous, as of the sensiferous system.

III. That the influence of the Respiratory system of nerves would not be interrupted by sleep or coma might almost have been anticipated from a knowledge of the origin of the Respiratory tract in the medulla oblongata. Hence the persistence of respiration and the other sympathetic actions, properly so called, not only in natural sleep, but in apoplexy, or even after an artificial removal of the brain, (*a*) till the injury has reached this justly reputed citadel of life, when, the extension of the primary irritation of the lungs, along the Pneumogastric nerves to the common centre of the Respiratory system, and thence to the nerves distributed on the respiratory muscles, being thus intercepted at the summit of this common centre, the fundamental vital action is stopped, and death is the result. Upon the same principle of the comparative independence of the Respiratory system of nerves upon the brain, is to be explained the occasional respiration, for some time after birth, of acephalous infants, provided the origin of the Pneumogastric nerve is entire, but not otherwise; (*b*) and even the continuance, as lately observed, of some other sympathetic actions after the artificial removal of the greater part of the brain. It is almost superfluous to observe that, although sympathy, properly so called, is thus independent of the brain, passion or instinct, originating as it does in a primary action of that organ, cannot be so: the Respiratory nerves are ready to convey this action, but they cannot convey what is not imparted to them.

IV. With respect to the correspondence, in all classes of animals, of the development of the Respiratory system of nerves, and the manifestation of the stimulus of sympathy and passion or instinct, this argument in favour of the theory under consideration seems to be in general well founded. It has been already remarked, that in some of the avertebrated tribes rudiments of a distinct Respiratory tract have been detected, giving rise to nerves which seem to be distributed

(*a*) Le Gallois &c.

(*b*) Brâchet. (*Sur les Fonctions du Syst. Nerv. Gangl.* 1823) principally upon the respiratory apparatus, so that in them, as well as in the higher tribes of animals, respiration appears to be effected by sympathy. These nerves are well seen in the Scorpion—*Scorpio* 22 (*a*)—and in the larvæ of some insects, (*b*) but they are for the most part so obscure that it is impossible to say to what particular Respiratory nerves of the vertebrated animals they correspond. It is probable however that they answer only or chiefly on the one hand to the Glosso-pharyngeal, for the purpose of swallowing, and on the other to the Pneumogastric, by the association of the different portions of which, at its common origin, the sympathy between the organ corresponding to lungs and the active instruments of respiration is maintained. Such appears to be the vehicle of the stimulus to the action of the muscular cloak-bags of the fresh-water Mussel—*Mya* 8 (*c*)—and Cuttle—*Sepia* 11 (*d*)—and of the muscles moving the shell of the bivalve mollusca in general; as well as to that of the muscles which move the plates of horn which surround the gills of the Cray-fish—*Cancer* 19 (*e*)—of the moveable stigmata of some insects, as the Silk-worm—*Phalæna* 25 (*f*)—and perhaps even of the ciliæ on the surface of some molluscous animals, by which eddies subservient to respiration are effected. (*g*) In as far then as the respiratory process of the avertebrated tribes of animals is active—for this is by no means always the case—it seems to be effected on the same principles as that of the vertebrated; and the development in them of the Respiratory system of nerves appears, in a great measure, to correspond to this process and that of swallowing, the two chief manifestations in them of sympathetic and instinctive action. The display of passion and instinct indeed by some avertebrated tribes, in the acceleration of the action of their heart or corresponding organ, the increase or vitiation of their secretions, (*h*) and the perturbations of their movements in general from violent emotion,

(*a*) Treviranus; Grant. (p. 179)
(*b*) Lyonet; Grant. (p. 197)
(*c*) Carus. (pl. ii. fig. 11)
(*d*) Carus. (pl. iii. fig. 2)
(*e*) Carus. (pl. vi. fig. 4)
(*f*) Malpighi.
(*g*) Sharpey, Purkinje, Valentine, Grant, Carus, Raspail &c.

(*h*) It is thus that the Cuttle conceals itself, when in danger, by colouring the water black with the matter discharged from its ink-bag; and numerous similar illustrations of this operation of passion among the avertebrated animals might be instanced.

as well as in the ordinary actions of discharging their excrement and of copulating, and the more extraordinary actions of selecting each its proper kind of food, of hoarding up grain, of depositing its eggs only in certain places, of choosing the proper element for its locomotion, of migrating, and of constructing the curious fabrics elsewhere alluded to, is much more remarkable than that of sympathy, properly so called; but not more so than the presumed general distribution of the Pneumogastric nerve—supposing their Respiratory system to be confined to this and the Glosso-pharyngeal—seems to be quite competent to account for. Perhaps indeed the bulk of the cerebro-spinal system of many of the avertebrated animals consists of these nerves, their voluntary motions and sensations being apparently much less energetic in general than their sympathetic and instinctive actions. But it is in the vertebrated tribes principally that this correspondence between the development of the system of nerves in question, and the manifestation of sympathy and passion or instinct is observable. The first Respiratory nerves, as we ascend in the scale of animals, capable of being recognised as decidedly corresponding to any one found in Man, are the Glosso-pharyngeal and the Pneumogastric, both which are met with in fishes, and the latter of which, as standing in them in the place of so many others, is of very great size. It is by this nerve principally that, not only their gills, but the muscles of their gill-flaps, which are instrumental to expiration, as well as those of their jaws and thoracic ribs, which it was necessary should sympathize with the gills, in the process of inspiration, are supplied; and a further reason for the great size of this nerve in fishes is perhaps to be found in the very laborious nature of their respiratory and other sympathetic and instinctive actions, as effected in so dense a medium as water. Fishes evince few other striking examples of proper sympathetic action, with the exception of that of the heart and stomach—both which receive their nerves likewise from the Pneumogastric—with every organ of the body; but their motions under the stimulus of passion or instinct are numerous and remarkable. Of this we have examples in the change of colour—analogous perhaps to blushing—which many fishes, as the Perch—*Perca*, 36—and Stickleback—*Gasterosteus*, 36

—undergo from emotion; as well as in the increase and vitiation of their several secretions, by means of which it is probable that the Diodons and Tetrodons inflate themselves when irritated, so as to render all their spines erect, and in the violent instinctive movements by which many species of fishes, of the genera *Scorpæna*, *Perca*, *Trachinus*, *Trigla*, *Raia* &c. inflict sometimes severe wounds on their aggressors—to say nothing of the more ordinary instinctive actions which they perform in common with animals in general, or of those more extraordinary, by which their migrations and other habitual processes are effected. To all these the very extensive distribution of the Pneumogastric nerve, as well on the external, as on the internal organs of fishes seems quite adequate; and it is strongly in favour of the presumption that it is by means of this nerve that the stimulus of passion or instinct in general is in them conveyed, that the electrical apparatus of such fishes as possess one, like the Torpedo—*Raia* 32—the Electrical-eel—*Gymnotus* 35—and the Electrical-silure—*Silurus* 35—which is well known to be so much under the influence of this stimulus, is supplied in general, partially or entirely, by an immense branch of the nerve in question. The only other proper Respiratory nerve possessed by fishes is the Pathetic, which seems, in all, to be subservient to the sympathetic motions of the iris, as well as in those fishes in which the eyeball is moveable, to regulating the motions of this organ under emotion. It is not till we come to reptiles that we meet with, in addition to a Glosso-pharyngeal, a Pneumogastric and a Pathetic, a proper Facial nerve; and this appears to be to them in place of that portion of the Pneumogastric nerve of fishes which supplies the muscles of the jaws, by which organs exclusively the batrachian and chelonian reptiles, and in a great measure the ophidian also inspire, the saurian reptiles alone using their intercostal muscles to any great extent in this operation. The last of course possess in addition Intercostal nerves, as nerves of inspiration, and all are furnished with Abdominal nerves, as nerves of expiration, the place of both of which is, in fishes, supplied by those portions of the Pneumogastric nerve which go to the muscles respectively of the thoracic ribs and of the gill-flaps. Now if the last-mentioned nerve be, in fishes, a vehicle of sympathy and passion or instinct, it seems fair to conclude that all those which are successively substituted for it—in these instances the Facial, the Intercostal and the Abdominal—have a common origin, and are so likewise; and that such nerves become more numerous, only in proportion as the actions resulting from these stimuli are to become more remarkable. The other proper sympathetic actions of reptiles are not very striking, but some of those resulting from passion are exceedingly so. Of this nature is the change of colour which the Chameleon—*Lacerta* 39—is so well known to undergo from emotion, as well as perhaps the increased brilliancy in the eye of the Rattle-snake—*Crotalus* 38—in which appears to consist its reputed fascinating power—from desire; (*a*) and it is perhaps to the same head that we must refer the copious flow of tears, which, as said to be shed by the Crocodile—*Crocodilus* 39—on some occasions, has been so long regarded as emblematical of hypocrisy, the increase and vitiation of the cutaneous exhalation of the Alliacious and Mephitic Toad—*Rana* 37—when the animal is irritated, and the bath of sweat which, under similar circumstances, is said to envelop the Salamander—*Salamandra* 37—and which seems to have given rise to the notion that the animal can inhabit fire. The pouching of the neck also by some species of serpents, as the Cobra-da-capello—*Coluber* 38—from agitation, is an instance of the influence of passion, in reptiles, on the action of muscles generally voluntary. The proper instinctive actions of reptiles, ordinary and extraordinary, are not, generally speaking, very remarkable; and upon the whole, the manifestation by this tribe of animals of sympathy and passion or instinct seems to be in no degree disproportionate to the development in them of the system of nerves in question. With respect to birds, they have only the same respiratory nerves as the higher tribes of reptiles, but their distribution is somewhat different—that of the Facial nerve in particular, which being now no longer wanted as a nerve of inspiration—a process which is effected, in birds, exclusively by the inter-

(*a*) The reputation of the Rattle-snake in this way, with respect to small birds, squirrels &c. seems to have suggested to Milton the idea of endowing the serpent in the garden of Eden with a similar power.

> " — its gentle, dumb expression turned at length
> The eye of Eve."

costal muscles—and not yet required to effect a change in the general expression of the countenance from emotion—their horny bill being of course unsusceptible of any such change —is turned backwards over their neck and shoulders, where it is productive of the most striking changes from this cause, as in the bristling of the feathers of the neck on preparing for the fight. It is accordingly very large in the Game-cock—*Phasianus* 43—but very small in the Duck—*Anas* 41—which has very little power of displaying emotion in this way. Besides the process of respiration, birds, like reptiles, manifest but few instances of proper sympathetic action; but of those, so much more numerous, which are excited by passion, we may take as examples the blushing of the wattles of the Turkey-cock—*Meleagris* 43—the vomiting of the Vulture—*Vultur* 46 (*a*)—the erection of the neck feathers by the Game-cock —analogous perhaps to the pouching of the neck by the Cobra-da-capello—and many others displayed by birds under strong excitement of various kinds. Their proper instinctive actions also are often very remarkable, and some of these, as their selecting proper places for depositing their eggs, the running by the aquatic tribes into the water the first time they see it, the construction of their nests, and their migrations, have been already alluded to: they appear to be all however, as well as the actions before spoken of, easily explicable upon the presumption that it is by the Respiratory system of nerves that the stimulus, on which they severally depend, is conveyed. Finally in mammals the complement of this system of nerves is at length filled up by the addition of the Accessory, the Phrenic and the External respiratory. The two latter become necessary from the addition, in mammals, of those proper inspiratory muscles, to the motions of which these nerves are subservient; and it is in mammals accordingly that we meet with for the first time, not only a perfect inspiratory process, but that extensive train of sympathies in which the diaphragm is implicated, such as yawning, hiccoughing and so forth. The Accessory nerve is, in mammals in general, in place of the Facial nerve of some reptiles and birds—an excellent pre-

(*a*) The Vulture is said sometimes to effect its liberation from its captors by vomiting, under its agitation, matters so excessively offensive that they are fain to let it go.

sumptive proof of a common origin—serving, in quadrupeds, to raise the mane, as well as to inflate the neck and arch the shoulders, when they are irritated; while their Facial nerve, distributed as it is, as well on the skin of the cheeks and tunicæ conjunctivæ, as on the muscles of the cheeks, nostrils, eye-lids and eye-brows, not only involves most of these parts, as other Respiratory nerves do other organs, in one common sympathetic action during any impediment to respiration, but gives an intensity and variety to the countenance from emotion, of which no other tribe of animals offers any example. This nerve is relatively small in the Sheep—*Ovis* 48—but becomes progressively larger in the Deer—*Cervus* 48—the Ox—*Bos* 48—the Ass and Horse—*Equus* 49—the Camel—*Camelus* 48—the Dog—*Canis* 54—the Lion—*Felis* 54—and the Monkey—*Simia* 58—its size corresponding almost precisely with the degree of expression evinced by each; but in no one does it make any approach to its relative size in Man, who so infinitely surpasses all other animals in this respect. The instinctive motions of the external ear again in the timid quadrupeds are effected probably by means of this nerve. In the greater number however of the actions which mammals in general display, from either sympathy or passion, they seem to differ from Man only in degree. In the remarkable sympathy between the female genital organs and mammæ, which is peculiar of course to mammals, some quadrupeds are hardly inferior to the human species; (*a*) the effects of passion on the expression of their eye-ball, (*b*) and in producing an increase and vitiation of their secretions in general, are equally remarkable; (*c*) and if Man appear to stand almost alone, in his susceptibility of a flow of tears from affliction, and of laughter from mirth, it is perhaps, not because there is no tendency in other mammals to the same actions from the same primary

(*a*) We learn from Herodotus that the ancient Scythians were accustomed to increase the flow of milk from their mares by irritating the vagina.

(*b*) This is said to be particularly the case with the Wolf and the Hyæna, the fascinating power of which is represented as similar to that of the Rattlesnake.

(*c*) A good example of this is afforded by the American Skunk, which is said to use its intestinal secretions as the Cuttle does that of its ink-bag, and the Vulture that of its stomach, as a means of defence, voiding when pursued, and of course put into bodily fear, in the face of its pursuers a mass of filth so copious, and so intolerably fetid, that they are compelled to desist from the pursuit. The offensive odour of the sebaceous matter of stags and other animals during their rutting season is equally illustrative of the same fact.

stimuli, but because they are in general incapable of the peculiar emotions in which these primary stimuli consist. (*a*) The proper instinctive actions also of other mammals are equally similar in general to those of Man—an analogy very well corresponding with the general similarity in their Respiratory system of nerves—and upon the whole it can hardly be denied that there is, in all tribes of animals, a more or less intimate relation between the development of this system of nerves and the manifestation of sympathy and passion or instinct, and that consequently this argument in favour of regarding the former as the vehicle of the latter, considered as stimuli to irritability, is admissible. It may be repeated also that the frequently vicarious nature of the several Respiratory nerves, which this summary review discloses, in the various tribes of animals—the Pneumogastric nerve of fishes, for example, standing in place of the Facial nerve of most reptiles, the Facial nerve of most reptiles in place of the Intercostal nerves of birds, and that of birds in place of the Accessory nerve of mammals, while the Intercostal nerves of birds do, not only their own duty, but that of the Phrenic and External respiratory nerves of mammals—is strongly corroborative of the opinion that they constitute one collective system; and when we know that at least some of these nerves convey sympathy, while others equally certainly convey passion or instinct, we can hardly refuse to allow to them all a general unity, not only of origin, but of office, or to admit that this office is the one above ascribed to them.

(*a*) The only brutes said on good authority to weep from sorrow are some species of Monkey, the Seal and the Camel, the first by Humboldt, the second by Steller, and the last by Pallas: the Dog however should certainly be added to the list. The alleged " big, round tears," which " course one another down the innocent nose" of the Deer, the Hare and other animals when hotly pursued, are in fact only sebaceous matter, which under these circumstances flows in profusion from a collection of follicles in the hollow of the cheek; and the far-famed " Crocodiles' tears," although *boná fide* tears, do not flow from affliction. But if crying is not confined to Man, he is perhaps exclusively " a laughing animal," as he has been sometimes defined. We have the authority of Milton for the fact, that

——— Smiles from reason flow,
To brutes denied,

no brute apparently being capable of that sense of the ridiculous, arising from incongruous associations, in which laughter originates. The reputed laughing of the Hyæna and some other animals, it needs hardly be observed, furnishes no exception to this remark.

V. When on the subject of the similarity in structure of the Ganglionic and reputedly Sensiferous systems of nerves, as a presumptive argument in favour of the analogy of their office, it was incidentally remarked that the nerves of the Respiratory system and the proper Motiferous nerves have a structure equally similar; and if the former fact furnished a fair presumption that, as the Sensiferous system was known to be the seat of one kind of susceptibility, the Ganglionic was that of another, it is equally fair to presume from the latter that, as the Motiferous system is known to convey one kind of stimulus—that of volition—the Respiratory system conveys another—that of sympathy and passion or instinct. As the nerves of the two former systems are plexiform and soft, with ganglions also of a very similar structure, so those of the two latter are fibrous and hard, and without perhaps any ganglions at all. It is true the Pneumogastric nerve, and perhaps some others of this system, frequently present ganglions in their course; but it is probable that such ganglions belong rather to some of the numerous nerves with which they are in their course associated, than to the nerves in question, considered as exclusively Respiratory (*a*)—but to this source of ambiguity further allusion will be made in future. In the mean time the general similarity in the structure of the Respiratory and Motiferous nerves will be very obvious if we compare the Facial, the Pneumogastric or the Phrenic nerve with the Motor oculi, the Abductor or the Hypoglossal; and the general dissimilarity in that of the Respiratory and Sensiferous nerves, if we contrast the Facial and Trigeminus nerves, as distributed upon the face. In as far then as similarity in structure implies analogy of office, this argument in favour of the theory in question appears to be tenable.

VI. The fact that, while the Ganglionic and Sensiferous nerves are not liable to be so affected by the galvanic aura, as to excite the action of the muscles, the Respiratory and Motiferous nerves produce remarkable effects in this way, has been already more than once alluded to; and as, in this one

(*a*) " C'est à tort," says Adelon, speaking of the Pneumogastric nerve, " que Reil le disait formé d'une série lineaire de ganglions : il a évidemment la même structure, les mêmes proprietés, que les autres nerfs spinaux et encephaliques." (*Physiol. de l'Homme*, 1824, t. iv. p. 218) respect at least, the similarity in structure is attended with an identity of office, we have an additional reason for believing that the natural function of both, which we know is not identical, is at least analogous.

VII. But a still more direct argument in favour of the doctrine that it is by means of the Respiratory system of nerves that the stimulus of sympathy and passion or instinct is conveyed, is derived from the fact that a slight compression, or direct stimulus, mechanical or galvanic, artificially applied to the trunks of the nerves of this system, while it gives rise to no manifestation of pain or sensation of any kind, occasions in general motion, not only in the parts to which these nerves immediately proceed, but also in such others as are known to be sympathetically connected with them. Thus, any such stimulus applied respectively to the trunks of the Facial, (*a*) the Glosso-pharyngeal, the Pneumogastric, (*b*) the Accessory and the Phrenic nerves, as well as to some others of this system, has been found, after a longer or shorter period, to effect various actions of parts connected with those on which the nerve in question is immediately supplied only by sympathy. This circumstance can be attributed only to the association, at their origins, of these nerves with the other nerves of the same system; and as, in these instances, the nerves operated upon were obviously vehicles of sympathy, of which passion or instinct is merely a modification, it seems fair to infer that such is the office of all the nerves of this system, which are so frequently vicarious of each other, in all cases of the operation of these agents as stimuli to irritability. The same thing occurs from inflammation of these nerves, or slight pressure made upon them by tumours or other diseases

(*a*) The fact in question has been sufficiently established with respect to most of these nerves by the recent experiments of Mr Broughton, the general result of which was read to the British Scientific Association assembled at Edinburgh in 1834.

(*b*) This experiment has been performed by Cruveilhier, (*Nouv. Biblioth. Méd.* 1828) and excited violent coughing; and the same thing not unfrequently takes place from the irritation which this nerve undergoes in the operation of taking up the carotid artery, as occurred in a case of Sir A. Cooper's, and another of Mr Vincent's, related by Dr Ley. (*Med. Gazette* 1835) Tiedemann and Gmelin also excited extensive peristaltic movements of the stomach and intestines by irritating the esophageal portions of this nerve.

of the contiguous parts, as numerous cases on record abundantly demonstrate. (*a*)

VIII. It has hitherto been presumed that the Respiratory system of nerves is the vehicle of sympathy and passion or instinct, principally from the facts, that all the organs liable to be acted on by these stimuli, as well as those which are the seat of the primary irritation, may be presumed to be furnished with such nerves; that the conveyance of these stimuli is certainly independent of both the Sensiferous and Motiferous departments of the nervous system, as well as of the greater part of the Brain; that the more striking are the evidences, in all tribes of animals, of the action of these stimuli, the more is the Respiratory system of nerves developed; that the nerves of this system are in structure similar to the Motiferous nerves, which are known naturally to convey a stimulus analogous to these; that the two systems may be made to convey certain stimuli in common; and that certain other stimuli applied to the trunks of the several Respiratory nerves frequently excite sympathetic actions. But the most conclusive evidence in favour of this theory remains still to be mentioned; and that is the circumstance that the conveyance of sympathy and passion or instinct is at once intercepted by the obstruction of the nerves in question. It has been proved that after the division of the Pathetic nerve, by cutting across the tendon of the superior oblique muscle, (*b*) the eye-ball no longer turns downwards and outwards, either in any impediment to respiration, or in rage and other exciting passions, but, on the contrary, remains permanently twisted upwards and inwards; the action of the superior oblique muscle now not only not overcoming, but no longer counteracting that of the inferior oblique—which is moved by the motor oculi—as is naturally the case in dismay and other depressing emotions, when the eye-ball is always turned in this latter direction. It is obvious therefore that these movements of the eye-ball from sympathy or emotions, exciting or depressing, depend on the Pathetic nerve, which naturally communicates in the former kinds of emotion more,

(*a*) Autenreith, Breschet, Gendrin &c.

(*b*) This experiment was performed by Sir Charles Bell on a Monkey.

and in the latter less, than its usual stimulus; (*a*) since there still remained, after the experiment above alluded to, other muscles by which the outward and downward motion of the eye-ball might have been effected, had the nerves with which these muscles are supplied been competent to convey the stimuli in question. The section of the nerve in this place was not of course calculated to impede either the contractions of the iris from sympathy, or the flow of tears from either sympathy or passion. But still more remarkable effects follow the division of the Facial nerve. (*b*) There is now no longer, on the side affected, any participation by the muscles of the eye-lids or eye-brows, nostrils or face, in the general perturbation arising from impeded respiration, (*c*) any tingling of the gums from irritations of the internal ear, nor any other indications of what has been called *passive* sympathy, or of a primary irritation having extended from a distant organ to the parts furnished by this nerve; nor, on the other hand, is there any acceleration of respiration from sprinkling cold water on the face, any flow of tears from onions, nor any sneezing from snuff, or other acrid substances applied to the nostril, (*d*) any coughing from irritating the external auditory canal, nor any other indications of *active* sympathy, or of a primary irritation of the parts furnished by this nerve having been

(*a*) This influence, at one time active, and at another passive, of the Pathetic nerve, renders it easy to understand how the supply of a Respiratory nerve to one only of the two oblique muscles of the eye should be quite compatible with the doctrine which ascribes to the oblique muscles in general all the involuntary motions of the eye-ball.

(*b*) This experiment has been often artificially performed on the Ass, the Deer, the Monkey and many other animals.

(*c*) It is a common notion that the nostrils are expanded in difficult respiration in order to admit more air to the lungs—an end which would be so much more effectually attained by opening the mouth. They are distended under these circumstances for the same reason as under exciting passions, as when a person flatters himself he has accidentally said a good thing &c.

(*d*) "When carbonate of ammonia," says Sir Charles Bell, "was put to the nostrils of an Ass, the Facial nerve of which had been cut, the side of the nose and face on which the nerve was entire was curled up with the peculiar expression of sneezing: but on the other side, where the nerve was divided, the face remained quite relaxed; and the same effect has resulted in Dogs and other animals, on which the experiment has been repeated." (*Exposition of the Natural System of the Nerves* &c. 1824) It has been elsewhere remarked that the division of the olfactory or trigeminus nerve has, according to this author, no such effect.

transmitted to distant organs. Further the colour of the cheek and the refulgence of the eye remain now quite unchanged under those emotions which usually excite blushing and increased brilliancy of the eyes. (*a*) There is no longer any winking from apprehension of danger—the orbicularis palpebrarum being now unable to overcome the resistance of the levator palpebræ superioris, which is moved by the motor oculi—nor is there any frowning from anger. The nostril remains pinched, however exciting may be the emotion—the elasticity of its cartilages being now, as is naturally the case under depressing passions at all times, no longer antagonized, and more than antagonized by the requisite muscles — and the general expression of the features from sorrow, mirth or any other mental perturbation, continues unaltered. (*b*) In birds again, after the division of the Facial nerve, the power of expressing emotion by the movements of the neck and shoulders is entirely lost. It may be said indeed that, the Facial nerve being not only a Respiratory nerve, but the only Motiferous nerve of the parts on which it is supplied, these facts prove nothing in favour of the presumption that it is by the Respiratory system that the stimuli of sympathy and passion or instinct are conveyed: but as the simply Motiferous nerves certainly never do convey these stimuli, while the simply Respiratory as certainly do so, it must be presumed that it is in the latter capacity that it operates in this way. The effects of a division of the Glosso-pharyngeal nerve have been very diffe-

(*a*) In the case of a Terrier, in which the Facial nerve had been divided on one side, Sir Charles Bell expressly remarks, " There is a brilliancy in the eye of the sound side, while that of the injured side is perfectly inanimate"—a fact which has been frequently noticed since, (*Appendix to Exposition* &c. 1827) and is of particular value, as demonstrating the influence of this nerve, and therefore probably of all the other nerves of this system, on the capillary vessels, the seat of all the molecular actions of the body.

(*b*) A Monkey, on which this operation had been performed by Sir Charles Bell, no longer displayed, on the injured side, the characteristic motions of the eye-lids and eye-brows from fear or anger; and, when enraged, could grin only on the opposite side, like a paralytic drunkard: and a Terrier which had been subjected to it, lost all power of expression on the affected side; and when he wished to shew his teeth, the face, which had been balanced before, became twisted to the healthy side, and the eye-lids of the two sides being, in this state of excitement, very differently affected, presented a sinister and ludicrous expression.

rently represented by different authors; but those of an injury or division of the Pneumogastric nerve are sufficiently well established. If both are divided, besides many minor consequences, such as that of intercepting—by the impression thus made perhaps upon the chief nerve of the whole Respiratory system—all sympathy between the nostrils and fauces respectively, and the muscles of the abdomen, so that neither sneezing nor vomiting is excited by irritating the two former, (*a*) the natural respiratory process, the regular action of the heart, and the healthy function of the stomach are all simultaneously impeded, and death is sooner or later the result. (*b*) Now all these effects appear to result from

(*a*) Brâchet. (*Sur les Fonctions du Syst. Nerv. Gangl.* 1823) From the circumstance that no respiratory efforts are made, whatever may be the impediment to respiration, and no food taken, however empty may be the stomach, after a section of this nerve, it has been presumed by Rolando, Brâchet and others, as before observed, that the Pneumogastric nerve is the vehicle of the irritations on which the sensation producing a desire to breathe under any impediment to respiration, and that of hunger respectively depend; in other words, that it is not a Respiratory, but a Sensiferous nerve. These effects however may certainly, with an equal show of reason, be referred to a defective conveyance of the natural stimulus whence all instinctive actions arise, as to a want of certain sensations, which, however necessary they may be as precursory to passion or instinct, certainly constitute no part of the chain by which it is conveyed as a stimulus to irritability.

(*b*) Dividing the Pneumogastric nerves has been a favourite experiment of physiologists ever since the time of Galen, and its fatal effects have been ascribed to the impediment, at one time, as by Cruickshank, Bichât, Le Gallois, Magendie, Broughton, Holland, Dupuy, Mayer and Brâchet, of the function of the lungs; at another, as by Willis, of that of the heart; and at a third, as by Valsalva, Haller, Blainville and Haighton, of that of the stomach. That the first opinion is the true one there can be no reasonable doubt; but presuming that such is the case, the fatal effect may be brought about it is said, in any one of six different ways.—1st, By obstructing the conveyance of the natural stimulus of sympathy from the lungs to the respiratory muscles, as has been above presumed.—2dly, By occasioning a deposition of mucilage in the bronchi, as supposed by Brâchet. 3dly, By occasioning such a collection of air in the air-cells as to produce vesicular, or, owing to a rupture of some of these cells, interlobular emphysema, as supposed by Mayer sometimes to occur. 4thly, By causing the coagulation of the blood in the pulmonary vessels, which, according to Mayer, is the most common result. 5thly, By paralyzing the muscles which keep open the rima glottidis—the cricoarytenoid—so that it becomes permanently closed, as supposed by Holland and Dupuy. And lastly, by paralyzing, on the contrary, the muscles which close the rima glottidis—the proper arytenoid—so that it remains permanently open, and matters thus pass, as the cardia is likewise palsied, from the alimentary into the respiratory passages, which is another occasional occurrence according to Mayer. It may be observed however that the second, third and fourth of these modes of operating all resolve themselves into the first, since they are the natural results of the obstruction of sympathy and passion or instinct; the former of which at least, if not the latter also, is certainly

the obstruction of respiration. Every attack of asthma is commonly terminated by a deposition of mucilage in the bronchi, which may be further accumulated in this case, as happens in most cases before death—constituting the well known death-rattle—by the palsy of the transverse fibres of the muscular coat of the trachea, by the action of which, according to Sir Charles Bell, it should be expelled. Again in the chronic disease there is usually a greater or less collection of air in either the air-cells or cellular tissue of the lungs—so that, mistaking effects for causes, Bree has traced asthma to bronchitis, and Watson, Baillie and Laennec to emphysema. Lastly the total want of the accustomed molecular changes of the blood, resulting from a total cessation of the respiration, might have been expected to occasion its coagulation, upon principles already stated. And with respect to the fifth and sixth modes of operating, it appears that palsy of the crico-arytenoid muscles takes place only when the recurrent or dilator nerves, *per se*, are divided, and that of the proper arytenoid, when the upper laryngeal or constrictor nerves *per se;* while the division of the trunks of the Pneumogastric nerves, by paralyzing both, keeps the rima glottidis something intermediate between extreme constriction and extreme dilatation, but of course totally immoveable. When however death results from the entrance of alimentary matters into the air-passages, it must be regarded as entirely accidental; although it will be very likely to take place, not only from the constrictor muscles being incompetent to exclude them, but also from the lining membrane both of the trachea which is supplied by the recurrent, and of the larynx which is supplied by the upper laryngeal nerves, being now quite destitute of that power of conveying sympathetic irritation—attended in this case with acute sensation —which should either prompt the muscles of these parts to exclude foreign matters, or call upon other muscles to expel them by coughing. The alleged possibility of obviating all difficulty of breathing, after this operation, by inserting a tube into an aperture made in the trachea, as done by Holland and Dupuy, occurs only, for an obvious reason, after the division of the recurrent nerves: if the Pneumogastric nerves are divided near their origin, as done by Brâchet, the insertion of a tube in the way proposed has been found to be quite inadequate to prevent asphyxia. The modus operandi of the division of the Pneumogastric nerves with respect to the heart has been less investigated than with respect to the stomach; and in fact, supplied as it is so much less copiously than the lungs and stomach from this source, we should not anticipate that it would be in this organ that any very remarkable effects would display themselves from its section. With respect to the stomach however it has been abundantly established by Wilson Philip, Clarke Abel, Hastings, Vavasseur, Milne Edwards, Breschet and others, that, if these nerves be divided in animals which have recently taken food, digestion is materially impeded, and that it is restored by passing the galvanic aura along the cut nerves—and hence has been derived one of the principal arguments in favour of the untenable and almost unintelligible hypothesis that galvanism and the nervous energy are identical—but it is still questioned in what manner the division of the Pneumogastric nerve operates in this instance. It has been above assumed that it is by obstructing the conveyance of the natural stimuli of sympathy and passion from other organs to the stomach necessary to call the respiratory muscles into action, nor is it less essential perhaps to that of the heart and stomach, no two organs having so intimate a sympathy with every other as these, and such a stimulus as this extensive sympathy affords being, in all probability, quite necessary to maintain their healthy functions. There is indeed good reason to believe that asthma, habitual syncope and dyspepsia, when merely functional, are all analogous diseases, and all dependent on an inadequate conveyance, by the Pneumogastric nerve, of the stimuli of sympathy and passion or instinct

—the main centre, as it were, of the sympathetic influence of every organ of the body. It cannot be by imparting to the stomach its irritability that these nerves are essential to digestion, since we must, consistently with what has been already at so great length insisted on, conceive that this is derived from the ganglionic system; nor by furnishing it with its ordinary stimulus, since this is provided by its contents; further, the stomach is not indued with sensibility, and is exempt from the control of the will. What then can the Pneumogastric nerves communicate to it but the additional stimuli in question; which may be regarded as hardly less essential to its healthy secretions and motions, than that of sympathy to the action of the respiratory muscles, particularly when it is remembered that both are equally disturbed by a section of these nerves, and equally restored by galvanism? Magendie believes that the division of these nerves affects digestion only in as far as it affects respiration; but this seems as improbable as that it affects respiration only in as far as it affects digestion. It most probably affects both directly and *per se;* although its fatal effects seem to be owing to its influence chiefly on respiration, as the function most immediately essential to life. According to Holland and Dupuy, who follow the same idea, it ceases to impede digestion as well as respiration, if a tube be afterwards inserted into an aperture of the trachea: but this remark has been replied to already. Lastly it is the opinion of Leuret and Lassaigne (*Rech. Physiol. et Chim. sur la Digestion*, 1825) that the only effect of cutting the Pneumogastric nerves, as far as regards digestion, is that of paralyzing the cardia, the consequence of which is that, by the contractions of the cardiac end of the stomach, the portion of chyme which is first formed is propelled backwards into the gullet, instead of forwards into the pyloric cavity, and during the subsequent relaxation of this cardiac end, returns into the left cul-de-sac, so that no new portion of the alimentary mass ever becomes exposed to the action of the gastric fluid; but this opinion is a very improbable one. The palsy of the cardia may be a collateral effect of the division of these nerves—like many of those which take place in the lungs from the same cause, but it appears to be—like most of those—resolvable into the generally impeded function of the organ in question. It should not be forgotten that a very common effect, with respect to the stomach, of dividing the Pneumogastric nerves, according to Brodie, (*Phil. Trans.* 1814) is inflammation; a fact which further illustrates the strict analogy in the office of these nerves here and in the lungs, the bronchitis, to which the fatal effects have been in the latter case attributed, being an equally common occurrence from the same cause.

respectively to the respiratory muscles, the heart and the stomach; and it is a strong corroboration of this opinion that the substitution of the strong stimulus of galvanism is equally beneficial in them all—but into a full consideration of this subject it would be improper to enter at present. Among the minor effects of a section of the Pneumogastric nerves will be of course a loss, more or less entire, of the voice, and a corresponding want of change in this function from emotion. The Pneumogastric nerve, regarded as Respiratory, seems to stand in the same relation to the larynx as the Pathetic nerve does to the eye-ball, and the Facial nerve to the features of the face ; but with respect to the Pneumogastric nerve in this part of its distribution, the same remark may be made as has been already made with respect to the Facial nerve in its distribution on the face, that as the Pneumogastric is not only a Respiratory nerve, but the only or chief Motiferous nerve with which the muscles of the larynx are supplied, the want of change in the voice from emotion, after a section of this nerve, proves nothing in favour of the presumption that it is by the Respiratory nerves that the stimuli of sympathy and passion or instinct are conveyed. With respect to the division of the Accessory nerve, this has been found to cut off all sympathy between the lungs and muscles of the neck and shoulders, as well as all effect of emotion on these muscles, so that they no longer act under either the most violent impediment to inspiration, or the most intense mental perturbation, although the animal can still call them into play by volition. And it is thus that in asthma—which appears to consist in a defective conveyance along the Pneumogastric nerve of the natural stimulus of sympathy—these muscles are excited, not involuntarily by this natural stimulus subsequently conveyed to them by the Accessory nerve, but with great efforts by the stimulus of volition conveyed to them by numerous Motiferous nerves with which also they are supplied. This fact furnishes a beautiful illustration of the different functions of the Respiratory and Motiferous nerves, particularly if taken in conjunction with the converse fact, that in palsy—which affects the latter only—while the animal is now incapable of calling these muscles into action by volition, they continue to be excited as usual by every impediment to inspiration, and by every violent mental emotion. Again the division of the Phrenic nerve of course prevents the diaphragm from taking any part in inspiration as exited by sympathy, as well as puts a stop to all the other numerous sympathies in which this organ is naturally engaged. Thus with respect to its *active* sympathies, there is no longer any gasping from cold applied to the face, any vomiting from a mechanical irritation of the fauces, nor any hiccough from an affection of the stomach; and with respect to such as are *passive*, an irritation of the diaphragm no longer excites the convulsive descent of the lower jaw, as in yawning. It is indeed in all probability by at once paralyzing the whole Respiratory system of nerves, from the violent shock communicated to the Phrenic, and thus shutting up, as it were, the fountain of all the sympathetic actions of the body, and not, as is commonly supposed, by any impression made on the cœliac ganglion, (*a*) that a violent blow on the pit of the stomach is sometimes so suddenly fatal. (*b*) Lastly a division of the External respiratory nerve prevents, of course, the co-operation of the muscles on the sides of the chest with those of the neck and shoulders during either impeded respiration or violent mental emotion. Upon the whole then it appears that the result of direct experiments by which the several Respiratory nerves have been obstructed is decidedly favourable to the doctrine that they are the vehicle of sympathy and passion or instinct, since the conveyance of these stimuli is for the most part at once intercepted by such obstruction. The same phenomena will of course occur when the influence of any one of these nerves is obstructed by considerable pressure made upon them by tumours or other diseases of the neighbouring parts, or by their destruction by suppuration, of which innumerable cases

(*a*) Van Helmont, Buffon, Bordeu, Barthez &c.

(*b*) " A blow on the pit of the stomach," as remarked by Sir Charles Bell, " doubles up the bruiser, and occasions the gasping and crowing which sufficiently indicate the course of the injury—a little more severe, and the blow is instantly fatal. A man broken on the wheel suffers dreadful blows, and his bones are broken, but life endures—the coup-de-grace is a blow on the stomach."

are on record, in particular as affecting the Facial (*a*) and Pneumogastric nerves. (*c*)

The foregoing then are the chief arguments which can be adduced in favour of the hypothesis in question. The principal objections to it, on the other hand, besides the commonly believed circumscribed distribution of the Respiratory system of nerves, and the alleged impossibility of tracing them all to any common origin—both which objections have been already replied to in passing—are first, that many of the most remarkable instances of sympathetic action take place when, upon the presumption that the immediate stimulus by which these actions are excited is conducted by the Respiratory nerves, we should not have expected them, while, on the contrary, such actions are sometimes quite wanting when, upon the same presumption, they would appear to be unavoidable; and secondly, that not a few of the nerves above assumed as nerves of involuntary motion are pretty certainly nerves of voluntary motion and even of sensation.

There is, it may be observed, no immediately obvious connection by large or numerous Respiratory nerves between the female genital organs and mammæ, between the diaphragm and lower jaw, or between the schneiderian membrane or that lining the glottis and abdominal muscles, and yet no parts more intimately sympathize with each other than these; while, on the contrary, the connexion by such nerves is most direct and conspicuous between the glottis and gullet on the one hand, and between the lungs and stomach on the other, and yet these organs offer comparatively very obscure indications of mutual sympathy. It implies however a very inadequate

(*a*) Some remarkable cases of such injury of the Facial nerve were related by Percival and others, (*Med. Chir. Trans.*) before the appearance of Sir Charles Bell's remarks on the subject; and numerous others are added by him, both from his own experience, and from that of Mr John Shaw and other authors. Since this time the affection has been very frequently noticed. Some of the most recent cases on record are by the late Dr William Gregory and Dr Christison. (*Ed. Med. and Surg. Journ.* 1834)

(*b*) F. Plater, Bonet, Morgagni, Rush, Cruickshank, Bourdon, Montault, Andral, (*Bull. de l'Athenée,* 1826) Drs Graham and Alison, (*Ed. Med. and Surg. Journ.* 1835) Albers, (*Rust's Mag.* 1835) &c. Many of the most urgent symptoms of aneurism often result from the pressure made by the tumour on the Pneumogastric nerve.

conception of the principles of the doctrine in question to look for any *direct* connexion by Respiratory nerves of organs sympathizing with each other, as if the stimulus were to be conveyed *immediately* from the one to the other. It is a fundamental principle of this doctrine that every sympathetic connexion between the various organs is through the medium of the respiratory tract, or common root of all the nerves of this system—the stimulus, of whatever nature it may be, first arriving at this tract from the seat of the *active* sympathy, and afterwards, by a reflex action, departing from it to that of the *passive* sympathy—and in this view of the matter perhaps all the organs of the body are almost equally connected together by the Respiratory system of nerves. But why then, it may be asked, should not all the organs of the body sympathize equally with any one in a state of primary irritation, instead of some certain organs only being thus involved? In order to understand this, we must keep in mind that every organ of the body has its own specific character of irritability, and undergoes therefore, on the application of any stimulus, a specific kind of irritation; which irritation having now become a secondary stimulus, although conveyed perhaps indiscriminately to all the other organs of the body, will nevertheless act only or chiefly on those to the specific irritability of which it is adapted. The size or number of the Respiratory nerves sent from the common root of all to each part may perhaps be a measure of the *quantity* of stimulus sent to this part in every case of primary irritation at a distance; but of its *quality* we have no measure, any more than of the quality of the irritability of the part to which such nerves tend; and we must never forget that two conditions are essential to every vital action—namely, a specific stimulus to act, and a specific susceptibility to be acted on. We must not calculate then upon the quantity of stimulus alone, when the quality, not only of this, but of the irritability of the part to which it is conveyed, may be such as at one time to give rise to very violent effects from the slightest degree of stimulus, and at another to counteract any effect from the most considerable. A small spark falling among combustible matter excites a violent commotion, and a few grains of mercury introduced into the system act forcibly upon the salivary glands; but an intense flame plays without effect on incombustible materials, and a bushel of mercury thrown into the body does not affect organs to the specific irritability of which it is not adapted. Upon these principles it is easy to understand the fact which has been before alluded to, that one kind of primary irritation of the lungs acts on the expiratory, and another on the inspiratory muscles. The nerve conveying these primary irritations to the common tract is in both cases the Pneumogastric, and each traverses afterwards the sum of all the nerves connected with this common centre, and that more or less copiously perhaps, according to their size and number; but it displays its effects, not indiscriminately on every organ in proportion to the supply of this stimulus, but on that set of muscles alone, whatever be the supply, the specific irritability of which is alone competent to acknowledge it. It is hence obvious that while no fair objection to the hypothesis in question can be founded on the want of correspondence between the more or less conspicuous connections of parts by means of Respiratory nerves, and the greater or less manifestation between these parts of a mutual sympathy, the incorporation of them all, through the medium of a common root, into one universally diffused system, by no means involves as a consequence the indiscriminate participation by every organ in the primary irritation of every other.

Again it is true that some of the nerves above enumerated as Respiratory, or subservient to involuntary motion, are likewise the instruments of voluntary motion, and even of sensation—like those branches of the Pneumogastric nerve which proceed to the larynx—to the parts on which they are distributed. There are no organs, for example, over which we have a more decided control, under ordinary circumstances, than the muscles of the face, those of the root of the tongue, and those of the larynx; yet the first are supplied, as an instrument of voluntary motion, only with the Facial nerve, the second chiefly with the Glosso-pharyngeal, and the last only with branches from the Pneumogastric. But this circumstance, so far from militating against the hypothesis in question, serves rather to confirm the justice of its principles; for each of these nerves, although derived mainly perhaps from the Respiratory tract, receives at its origin, as has been already remarked, some filaments from the corpora olivaria, which, as immediately connected with the anterior columns of the spinal cord, may be presumed to impart to it the power of conveying the stimulus of volition, while all the rest of the nerve conveys only the stimuli of sympathy and passion or instinct. Now this motiferous portion of the cylinder may sometimes act independently of, or even as an antagonist to the other; as happens, on the one hand, when we counterfeit the effects on the features and voice of a passion which we do not feel, and, on the other, when we conceal such effects of an emotion by which we are actuated, or even sometimes—combining simulation with dissimulation—not only constrain the expression of one passion, but substitute for it that of another of a diametrically opposite character. Nor is it only by additions made to them at their origins, that the so called Respiratory nerves may become qualified in their character, since most of them are united in their course with nerves coming from other systems; so that what was at first a simple Respiratory, or a combined Respiratory and Motiferous nerve, may become at length of a very complicated character. Thus the Facial nerve, after emerging from the parotid gland, is united with filaments from the Sensiferous portions of the Trigeminus, so that, in its subsequent course, it is so far from a simple Respiratory nerve, that it possesses a triple character (*a*)—nay, combined as it may be presumed to be, like all the other cerebro-spinal nerves, with filaments from the Ganglionic system, it perhaps plays at last a quadruple part! (*b*) And it is thus perhaps, as already stated,

(*a*) It was accordingly found by Mr Broughton (*Mem. read to the British Scientific Association at Edinburgh*, 1834) that a stimulus applied to the Facial nerve, anterior to the parotid gland, excited, in addition to twitches of the muscles &c. symptoms of acute pain, although no such symptoms manifested themselves when it was irritated within the substance of the gland. The same fact is noticed by Panizza. We have seen accordingly that the Facial nerve is represented by Bellingeri and Walker as, among other things, a regular nerve; and that a similarly complex office is assigned by numerous authors to the Glosso-pharyngeal, the Pneumogastric and other reputedly Respiratory nerves, all which are described as at least in some degree sensiferous.

(*b*) The probability of this complication in the office of the several nerves, owing to the union in each of the filaments coming from distinct systems, is very explicitly admitted by Sir Charles Bell himself. Speaking of the different actions performed at different times by the Facial nerve, and as he then supposed by the Trigeminus also, he remarks, " It remains a question whether these different actions do not depend upon the influence of distinct filaments of which each nerve is composed. I believe," he adds, " that these nerves consist in a great measure that we must explain the occurrence of the ganglions, before alluded to, on some of the chief branches of the Respiratory system of nerves, and, in particular, the Pneumogastric; such ganglions—which have served to throw still further ambiguity on the nature and office of these nerves—belonging probably not to them, regarded as simply Respiratory, but to some of the other nerves with which they have become associated. The probability of a mutual interchange of filaments wherever nerves of different systems unite together, is too great to allow us, when speaking of any individual nerve, whether of the Respiratory or any other system, to assume that it is to that system that it exclusively belongs, every reputedly Ganglionic nerve, for example, comprehending perhaps some Respiratory, some Motiferous, and some Sensiferous filaments, every reputedly Respiratory nerve, some Ganglionic, some Motiferous, and some Sensiferous, and so forth—although each nerve is, with propriety, regarded as belonging more peculiarly to that system from which the greater number of its filaments seems to be derived, and to the proper function of which it appears to be in a more particular manner subservient. The objection then to the hypothesis which regards the Respiratory nerves, *qua* Respiratory, as the vehicle of sympathy and passion or instinct, founded on the complex functions to which some of these nerves, taken collectively, appear to minister, cannot, any more than the one already disposed of, be fairly sustained.

In conclusion, we seem warranted in believing that the office above assigned to the Respiratory nerves is the one which they really perform in the animal economy, particularly when we find it impossible otherwise to explain why almost every organ of the body should derive its nerves from sources so very different. Thus all the motions of the eye-ball, involuntary and voluntary, might have been performed without the Pathetic nerve, all those of the face without the Respiratory portion of the Facial, and all those of the tongue without the Glosso-pharyngeal, provided only nature had supplied each of these organs with a few additional nerves from

of distinct filaments bound up together, and analogy would lead me to suppose them capable therefore of distinct functions."

the Motiferous system; and this she would unquestionably have done, had not all these parts been destined to be acted upon, either constantly or occasionally, by stimuli distinct from that of volition, and to the conveyance of which the Motiferous nerves were inadequate. At the same time it must be conceded that there are many points in this hypothesis which require further investigation, and that it is probable that such investigation will detect in it many mistakes and oversights: but was it to be expected that so bold and comprehensive a speculation should be, from the first, without spot or blemish—without errors to correct, or gaps to fill up? If it appear, upon a cool and patient review of the whole question, to be substantially correct, let us not immediately reject it because certain points in the detail require corroboration, but assume it to be at least generally true, till it is proved to be otherwise, upon the principle already insisted upon, that any opinion in physiology, which has been deliberately taken up upon the best evidence which we can at any given time command, is always preferable to no opinion at all. Such an opinion not only gives the mind the temporary relief which is essential to renewed efforts, but by furnishing it, not so much with a haven in which to cease for ever from labour, as with a starting point, whence it may take another sweep, often conducts it by a comparatively short route to conclusions at which, by floundering on for ages in a sea of conflicting and unarranged facts, it could never by any possibility have arrived. Let us have upon every point an axiom, if we can get it; if not, a theory; if not, at least an hypothesis—for "every true explanation must first be conjectural"—but let us always have something upon which we may proceed; taking care, in the mean time, to attach to our doctrines no more credit than they severally deserve, and being always ready to modify or to discard them, when we meet with facts which are not reconcileable to them as they stand. It may be somewhat irksome to be thus continually untying our faggots and binding them up anew, perhaps from a single stick having become loose; but it is infinitely more so to be lost from the first and for ever in a chaos of such sticks, without any arrangement at all. If the tendency to systematize on few and ill-established facts is vicious, the propensity to accumulate facts, without referring them to any system at all, is at least equally so. True philosophy consists not in separating, but in combining the two—in regarding speculations as valuable only in as far as they are founded on facts, and facts as no further useful than in as far as they are susceptible of some generalization. (*a*)

In regard to the *manner* in which the stimuli of sympathy and passion or instinct are conveyed—whatever be the *channels* through which they pass—we are almost entirely in the dark. In speaking of the ganglionic nervous tissue as the seat of irritability, the latter was described as a property with which this tissue becomes endowed in virtue of its peculiar aggregation; and, in conformity with this view, we must regard the nerves by which the stimuli in question are conveyed as the seat of these stimuli, considered not as entities, but merely as powers with which they become endowed likewise in virtue of their peculiar aggregation. But such powers are not—at least very obviously—constantly in operation, nor therefore constantly in existence; for the other condition of vital action—namely irritability—being always, we may suppose, at hand, wherever no action takes place, we have a right to infer that the power which should excite it is wanting. Hence it results that, in order to develop this power, the nerves in which it is resident must undergo some molecular change, as a consequence of the primary irritation which they are to extend to distant parts, similar to that which they undergo from a direct chemical or mechanical stimulus; and that it is in virtue of this change in the nervous matter throughout all its ramifications that such distant parts become involved, the nervous matter now acting on these parts in the same manner as any direct stimulus acts on such as are the seat of a primary irritation. Of the nature of this molecular change however we are utterly ignorant: it is in all probability entirely *sui generis*, and such as cannot be illustrated by a reference to any thing out of the

(*a*) " In the cultivation of Science," says Mr Walker, " without facts we are idle dreamers; without reasoning we are trifling fools, and to the folly we add knavery, when we pretend that it is not yet time to reason, and throw on nature or on science the fault of our own capacity." (*Nervous System*, 1834, p. 10) body—we recognise this change only by the powers which it develops, and we recognise those powers only by their effects. (*a*)

(*a*) At the time when it was customary to regard every kind of nervous energy as it is called, or stimulus conveyed by the nerves, as substantial—as much so as the air which we breathe, or the aliment which we swallow, in conjunction with which indeed the passions, one variety of this nervous energy, were enumerated among the non-naturals—it was usual to represent it as a kind of fluid, and to explain the transmission of such nervous energy to distant parts upon the presumption of the flow of such fluid along the nerves. Dr Mason Good accordingly states that it is for the purpose of "elaborating this exquisitely fine and active fluid"—this quintescence of an atom, as La Fontaine would call it—that the brain is glandular in its construction; and that it is because we require a fluid of very different qualities on different occasions, that the nervous system is of so "composite" a "fabrication!" (*Study of Medicine*, 1825) The advocates of this doctrine however have unfortunately omitted to adduce any kind of evidence, either of the existence of this fluid, or of its competency to explain any of the phenomena ascribed to it, while, on the other hand, its admission brings with it many more difficulties than it removes. Without this admission we have merely the difficulty of explaining the nature of the molecular change which the nervous matter itself may be presumed to undergo when it is to develop the power in question; whereas, with it, we have to explain, first, by what process this fluid is formed; next, by what powers it is moved forwards; and lastly, by what means nerves which, though fibrous, are in all probability not tubular, can transmit it, as well as why, when tied, they do not, like an obstructed blood-vessel, become turgid on either side of the ligature. The last difficulty may indeed be got over by presuming that the fluid in question is of the nature of caloric or galvanism, and therefore neither requires that the nerves should be pervious in order to conduct it, nor is capable of rendering them turgid if obstructed in its course—and we know, in fact, that such nerves do act as conductors of galvanism. Against the doctrine however that the nervous energy is *identical* with galvanism abundant evidence has been already adduced, and the notion that it is a fluid at all *allied* to it is destitute alike of proof and probability. "Nervous power," says Dr Symonds, "is nothing but *function* of nervous substance," and therefore cannot be substantially conveyed. Opposed to this doctrine of the substantial nature of the nervous energy in the form of a fluid, was that of Hartley (*On Man*, 1749) and Darwin, (*Zoonomia*, 1794) who imagined that it consisted in vibrations excited in the nerves, and that it was thus communicated from one part to another. A similar doctrine had been before promulgated by Glisson and Malpighi, to explain the nature of the influence communicated by the nerves in giving rise to sensation, such nerves being represented as having been previously rendered sufficiently tense to admit of vibrations by the influx into them of a certain "succus nervosus" supposed to be secreted by the brain; so that, although this supposed fluid was no longer regarded as *per se* constituting the nervous energy, it was still considered necessary to its development. The hypothesis of Hartley and Darwin differed from that of Glisson and Malpighi principally in as far as they applied it to explain motion rather than sensation, and represented the course of these vibrations

SECTION IV.

On Volition, regarded as Stimulus to Irritability.

THE last of the stimuli, by which irritability may be excited, and which, like sympathy and passion or instinct, is likewise an indirect one, is VOLITION. Like passion or instinct also Volition, regarded as a stimulus to irritability, consists in a translation of a direct or primary action of the brain to any other organ; and in this view of the matter, Volition, as well as passion or instinct, may be represented as merely a variety of sympathy, and as constituting a second

as rather from the origins of the nerves towards their extremities, than in the opposite direction: in effecting the proper sympathetic motions however, such vibrations, if they took place at all, would have to proceed first in the latter direction, and afterwards in the former. But against this doctrine of vibrations *in toto*—not to recur to the imaginary nervous fluid as instrumental to them—it may be objected that none of the nerves have either the hardness, the tension, or the freedom from contact necessary to this condition; and though this doctrine is less exceptionable perhaps than that which represents the nervous energy as an entity, it is still very wide of the mark, and worthy of remembrance only as furnishing a good example of the common reproach of physiologists, of endeavouring to identify processes which every view of the matter might induce us to regard as molecular and peculiar to living matter, with others with which, as obvious to the senses, and as displayed by lifeless matter, we are more familiar. We should never forget that there may be many things to the knowledge of which we can never arrive, because they have no analogy with any thing that we at present know, and there is no means of arriving at a knowledge of any thing of which we are ignorant, except through the medium of something with which we are already acquainted. "Omnes nostræ perceptiones," says Bacon, "sunt ex analogia hominis, non ex analogia universi." There *may be* many things therefore essentially beyond our reach; and though we are perhaps quite unjustified in pronouncing that any individual thing *is* so—since this implies an absurdity, inasmuch as we cannot know that it *is* beyond our reach without knowing what it is—still when any thing may be reasonably supposed to be, as in this case, *sui generis*, and we cannot exalt our capacities to the comprehension of it, it is much better to say so, than to endeavour to bring it down to the level of our capacities. It has been well remarked lately by an intelligent Medical Reviewer, that "by applying to vital phenomena and properties regulated by physiological laws, ideas derived from the physical world, and founded on mechanical principles, Physiologists have only rendered these vital phenomena more familiar to the grossness of their conceptions, but have not made any step nearer to the true elucidation of the actual functions of the Nervous System. They have coined many *words*, but they have not fabricated a single new *idea*." (*Ed. Med. and Surg. Jour.* 1834) department of what is called ANIMAL SYMPATHY in contradistinction to ORGANIC. As however passion or instinct, and reason, including Volition, are, with propriety, regarded as two very distinct modes of thought, and as the Volition, acting as a stimulus to irritability, appears to be translated by a system of nerves quite distinct from that by which passion or instinct is conveyed, it was proper to treat of them under distinct heads, and while the consideration of the latter was incorporated with that of sympathy in general, to speak of the former *per se.* It is hardly necessary to repeat here that the action of the brain, in which Volition originates, is not, any more than that which gives rise to passion or instinct, absolutely direct or primary, such action being necessarily preceded perhaps—as will be explained in future—by sensation, as such sensation is by irritation of some other part: contemplating Volition however merely as a stimulus to irritability, we begin with this action of the brain, without reference to any conditions on which it may be dependent. (*a*) And that such a stimulus to irritability exists is sufficiently manifest. We all know that when we wish to bend the finger the flexor muscles of this part are immediately called into action. This wish cannot have produced a direct action of any part, except of that which is the immediate seat of Volition, but the muscles so called into action must nevertheless have been subjected to some stimulus, or they would not have acted; and it is this translation of a primary action of the brain, distinct from that in which passion or instinct consists, to distant organs, which is understood by Volition in its character of a stimulus to irritability.

The examples of the operation of Volition in this character (*b*) are much less numerous than those of the action of sympathy and passion or instinct; the former being confined

(*a*) It would be as improper as it is unnecessary to enter at present into any discussion on the abstract nature of Volition, as a department of reason—a subject obviously belonging to the head of Thought. It may be spoken of as a stimulus to irritability, like all the rest, without any regard to its essential character.

(*b*) It is almost superfluous to say that plants, in all probability, perform no actions corresponding to the voluntary motions of animals. If plants are destitute of sensation, they must *a fortiori* be destitute of every modification of thought—but this subject will be resumed in future.

principally to the external muscular tissue, or that constituting the muscles which enter into the composition of the containing parts, and which are for the most part attached, directly or indirectly, to the skeleton, whether connected or not with the mucous membranes, while the latter is not only exercised on this, but is extended likewise to the internal muscular tissue, or that constituting the muscles which enter into the composition of the contained parts, which are unconnected with the skeleton, and generally in contact with mucous membranes, with the exception of the heart, the parenchymatous tissue and the irides. The action of the voluntary muscles moreover is always sensible—that of the involuntary may be either sensible or molecular. Accordingly Volition is perfectly powerless as a stimulus to the heart—the action of which is so much under the influence of sympathy and passion—(*a*) as well as to the capillary vessels, so that it never gives rise, as they do, to either blushing or paleness of the cheeks, refulgence or dullness of the eyes, turgescence or flaccidity of the clitoris or penis, the fimbriæ of the fallopian tubes, the nipples of the mammæ or other erectile organs, and it has no influence, like them, on the secretion of the halitus from the lungs, the gastric fluid, the intestinal gases, the menstrual fluid, the fat or the sweat, the mucilage, stools or sebaceous matter, the bile, milk, semen, tears or saliva. Further Volition is quite inert with respect to the stomach, and the muscles by which vomiting is effected—over the actions of which both sympathy and passion exercise so much control—as well as with respect to the uterus—the action of which is so easily influenced by passion—and among the organs of sensation, with respect to the iris, the motions of which are, at least in general, effected exclusively by sympathy. (*b*) On the other hand Vo-

(*a*) And how well is it for us, as remarked by Sir C. Bell, that the actions of this and other organs directly instrumental to the organic functions are placed out of our control! " A doubt—a moment's pause of irresolution—a forgetfulness of a single action at its appointed time would otherwise have terminated our existence." (*Bridgewater Essay*, 1834, p. 12)

(*b*) Some extraordinary cases have occurred in which the heart and stomach have appeared to be voluntary muscles—the former, in the remarkable case of Colonel Townsend, related by Dr Cheyne, (*English Malady*, 1734) and in another recorded a short time ago by Ribes, the latter in the numerous cases on record in which persons have been capable of ruminating or vomiting at will.

lition is quite competent to effect or control many of the motions which, under ordinary circumstances, are excited and regulated by sympathy and passion or instinct alone. It is thus that in some cases of impeded respiration, for example asthma, originating as it appears to do in an affection of the respiratory nerves, Volition appears to stand in the place of sympathy, or even instinct; although its influence, extending only to a few of the respiratory muscles, and these not very effective ones, it performs its part, not only with great effort, but very inadequately. It is at all times however in our power to control, to a certain degree, the natural respiratory process by Volition; and this we constantly do under the various circumstances of speaking, singing, playing on wind instruments, violent efforts of every kind, and on innumerable other occasions: it is only however within certain limits that we can do this, the natural stimulus to respiration becoming after

It is probable however, that it was not Volition which in these cases immediately operated on the organs in question, but passion, their possessors having been capable, by the force of imagination, of exciting the requisite emotion at pleasure. Many persons can blush and make their eyes sparkle, all can produce a turgescence of certain organs, and not a few can shed tears when they choose to do so; but it is not Volition which immediately excites these actions, but the emotions which Volition has called into existence. The only thing wanting to render the act of the player perfect is a command, as well over the capillary vessels of his cheeks, eyes and lacrymal glands, as over the voluntary muscles; and even this is sometimes furnished by the force of imagination, which inspires an enthusiastic actor with some degree of those emotions, the effects of which it is his business to embody. The player in Hamlet is described as "turning his colour, and having tears in his eyes;" and Miss Fanny Kelly has been known actually to faint precisely at that instant when the business of the stage required that she should appear to do so. Nay how often death itself has resulted from the force of imagination is familiar to every body. The phenomena of animal magnetism furnish many illustrations of this principle; but to these it is unnecessary to refer at present. At the same time there is nothing improbable in the idea that, in some cases, in the interchange of filaments between the ganglionic and cerebro-spinal nerves, more motiferous filaments than ordinary have reached organs commonly involuntary, and thus subjected them to the stimulus of Volition. That the ganglionic system communicates, not exclusively with either the sensiferous or motiferous system, but equally with both, has been shown by Scarpa, Soemmering, Panizza and others; and that the organs supplied by the ganglionic system at all times receive some motiferous filaments is probable from what we know is the case with respect to the sensiferous nerves; almost every organ of the body, however insensible to common impressions, being sensible under extraordinary excitement, such as that produced by inflammation or spasm.

a time too powerful to yield to any exercise of Volition, so that no man can voluntarily asphyxize himself. So also the actions of the various muscles by which sighing, yawning, hiccoughing, sneezing, groaning, screaming, sobbing, laughing and coughing are severally effected, although commonly excited by sympathy and passion or instinct, may be excited also by Volition, and such affections therefore are all more or less easily and perfectly counterfeited; or these actions may be to a certain extent controlled, and the tendency to such affections may therefore be in general counterated when circumstances forbid their indulgence. (*a*) In like manner the action of the numerous muscles by which the alimentary matters are taken, chewed and transmitted to the pharynx, by which the stools and urine are excreted, and by which copulation is performed, although commonly either sympathetic or instinctive, may be excited, or, to a certain degree, coerced by Volition; and it is thus that we are enabled to modify these actions according to circumstances, as well as to choose a proper time and place for their performance. (*b*) Again

(*a*) Some of these processes are with great difficulty, and in general very imperfectly feigned—for example, sneezing; and there are not many good artificial sobbers or laughers. The late Mrs Jordan owed her celebrity in a great measure to her excellence at a guffaw, as Mrs Keely at present does her's to her inimitable blubber. On the other hand some require a very strong effort to restrain them—for example, hiccoughing; and every schoolboy has felt the inconvenience, in the form of a good caning, of the difficulty with which a strong tendency to laughter is kept in wholesome subjection.

(*b*) We make however in general a very indifferent affair of these processes when the " hey-day of the blood is tame, and waits upon the judgment"—in other words when we are prompted to them, not by instinct, but by reason and Volition. What an insipid business is eating without appetite, or venery without enthusiasm; and how unsatisfactory are in general the results of both. The lower animals, which obey instinct alone in these instances, know not indigestion, and seldom copulate without effect; and the more nearly Man approaches them in this respect the better for himself and his progeny. Savages and rustics are seldom barren; and it is a remarkable fact that many of the greatest men in every age have been bastards—got " in the lusty stealth of nature"—whereas the produce of " a dull, stale, tired bed," and particularly the children of men whose intellect almost supersedes their instinct, are frequently very poor creatures. It was an ancient proverb ἀνδρῶν ἡρώων τέκνα πημάτα· and the sons of Socrates, Hippocrates, Thucydides, Chrysippus, Cicero, Racine, La Fontaine, Crébillon, Chesterfield, John Hunter and thousands of others abundantly verify it. Common prostitutes seldom conceive; for with them copulation is in the way of business, and therefore a *rational* act.

the dilatation of the nostrils, the downward and outward motion of the eye-ball, winking, frowning, and the innumerable changes in the expression of the features, the voice, the attitudes and the gestures, commonly resulting from various kinds of emotion, are all more or less easily and accurately effected or regulated by Volition also; and it is, as before observed, in the delicacy of his perception of these effects of passion, and the skill with which he imitates them, taking care, at the same time, to control the expression of any real emotion by which he may be actuated, that the whole art of the player consists. (*a*) Such are some of the principal actions to which sympathy and passion or instinct are the ordinary stimuli, but which Volition can, to a greater or less degree, effect or modify; but there are others, on the contrary, which are commonly excited, at least in Man, by Volition, and only occasionally by sympathy and passion or instinct. Of this nature are those, more or less connected with respiration, by which we whistle, whisper, speak, sing and blow wind instruments; those connected with sensation, by which we regulate the motions of the nostrils, the eye-balls and their appendages, and the external ears, so as to adapt them to their respective functions; and those comprehended more particularly under the head of voluntary motion, by which we bend in any direction, and rotate the head and spine, and by which we effect the several processes, on the one hand, of pushing, pulling, grasping, dividing, striking a blow, constructing works of art, and so forth; and on the other, of standing, sitting, kneeling, lying, walking, leaping, running, swimming and numerous others. All those actions in short which commonly originate in deliberate design, which are at first generally more or less incompetent to effect the desired end, and which become only progressively perfect, are with propriety referred to this head, since these, as already stated, are the characteristics of a rational, as distinguished from an in-

(*a*) It will hence be easily understood why a man of genius is generally a bad dissembler, and a man of talent a good one; in the former, the instinctive impulses preponderating, in the latter, the rational. The same preponderance of the feelings over the judgment distinguishes a partially imbecile or insane person; and hence the privilege generally conceded to such persons of speaking and acting as they list.

stinctive action. (*a*) Many of these actions however become, even in Man, occasionally instinctive, as in the case of enthusiasts, or persons under extremely strong excitement, or those in whom the influence of reason has been diminished by a certain degree of fatuity or furiosity, provided always such persons have previously possessed reason sufficient to bring these actions to perfection. And indeed all these actions become by habit in a certain sense instinctive, the instinct perpetuating the successive improvements which Volition has made, till at length Volition only determines the performance of these actions on any given occasion, and sets the requisite muscles in motion, while it is instinct which enables them to act with ease and accuracy. But, in the lower animals, a great number of these actions appear to be always and from the first instinctive. Thus the process of hoarding up grain by the Ant, and honey by the Bee, that of depositing their ova by many of these animals in appropriate places, that of migrating by several gregarious tribes, and that of constructing its shell by the Snail, its web by the Spider, its cocoon by the Silkworm, its comb by the Bee, its nest by the Bird, and its hut by the Beaver—all involve many of the actions above enumerated, but the stimulus by which they are excited is apparently, not Volition, but instinct; and such actions are accordingly undertaken by them without any deliberation, conduce in the most effectual manner to the end in view, and are as perfectly performed the first time they are undertaken, as at any subsequent period. It would be nevertheless as great a mistake to believe that *all* the actions of the lower animals are instinctive, as to imagine that all those of Man are rational. The Ant hoards its grain as actuated by instinct; but it is as actuated by reason that it bites off the germinating part of it, if such grain have ever sprouted on its hands. It is from

(*a*) Accordingly no brute, however perfectly formed its vocal organs, can ever acquire perfect speech, and in an idiot, who has never possessed sufficient talent to attain this perfection, the speech is commonly harsh and inarticulate; the eyeballs moreover frequently have not in the latter, when he is a perfect driveller, the degree of convergence requisite to single vision, or there is a decided squint; and the motions of the head, trunk and limbs are awkward and ungainly in the extreme. This furnishes sufficient evidence that all these actions are in Man naturally rational and not instinctive, for all instinctive actions are in general as accurately performed by a confirmed idiot as by other persons.

instinct that the Spider constructs its web; but it is from reason that it chooses its time for pouncing on the prey which this web has entangled, and refrains from doing so whenever it perceives at hand an enemy to be dreaded. It is instinct which prompts the Bird to build her nest; but it is reason which instructs her to choose a more secure place for doing so, if she ever have had her eggs stolen. All the former actions are impetuous, immutable and perfect from the first—all the latter are deliberate, adapted to the occasion, and improvable by practice. It requires no experience to excel in instinctive actions; but it is experience alone which renders a Cat wary and successful in secreting her kittens, or a Hare or Deer in eluding the arts of the huntsman; and the tricks of an old Fox, both in attaining his prey, and in avoiding the snares spread for him, are so remarkable, that the term has become emblematical of a cunning fellow. Any animal which is educatable—if the expression may be allowed—is in the same degree rational; and that many of the actions of the lower animals are improvable by education, natural or artificial, is as certain as that many of those of Man are not so. The actions of both have obviously a double origin; and the only difference between the two appears to be that, while the greater number of the actions of Man spring in general from reason, and comparatively few from instinct, in the inferior tribes of animals the majority are instinctive, and few only in comparison are rational. Hence, while some of the analogous actions of both are excited in both by instinct, and others in both by reason, there are not a few of these analogous actions, which have in Man, as elsewhere observed, a very different origin from what they have in brutes. The fabric which Man brings to comparative perfection only after long reflection and repeated failures, and profiting, not only by his own experience, but by that of the myriads who have gone before him, the worm, the insect, the bird, or the quadruped undertakes without deliberation, and brings to perfection, not only in its own generation, but the first time it is attempted. The sounds which Man acquires the power of uttering only after months and years of observation, and fruitless efforts at imitation, the bird or the quadruped emits from the instant that its organs are sufficiently developed for the purpose, and would have done so equally well had it never heard a similar sound before. Man does these things by reason—the brute by instinct. Man is, in these respects, a free agent, and revels in his freedom, attempting much, and this infinitely diversified, but as often failing as succeeding in his attempts, and never arriving at absolute perfection in their results. The brute is in these respects a blind machine, engaging in little, and this always the same, but in its operations unerring, and in their results absolutely perfect. With respect indeed to the actions exercised by every form of matter, Man or brute, organized or inorganized, it appears that such actions are, for the most part, the more precisely adapted to the end in view, and their results the more admirable, the further removed is the power by which they are severally excited from reason and Volition—at least as exercised by the immediate instruments of these actions—and consequently the more these instruments act in blind obedience to immutable laws imposed upon them by the Creator. What action, sensible or molecular, of organized beings, can compare in accuracy of movement, or harmony and beauty of results, with the revolutions of the planets on the one hand, or the crystallization of a mineral on the other, the only power engaged in which is that of *attracting* and *repelling?* What action of organized beings, excited by sympathy and passion or instinct, can compare, in these respects, with the contractions of the heart, or the process by which the flower of the humblest plant, or the eye or ear of the lowest animal is constructed, the only or chief power engaged in which are certain *direct stimuli* applied to the acting organs? And what action lastly excited by Volition, can compare in these respects with the motions of the chest in respiration, or the formation by the lower animals of any of their natural fabrics, the only power engaged in which is *sympathy* and *passion or instinct?* The most precise actions excited by Volition—at any rate before such actions have become partially instinctive by habit—are but bungling imitations of the least accurate of these, and give rise — at least before they have been improved by long and patient cultivation—in comparison with the least admirable results of the latter, to rude and coarse performances. The being thus exercising Volition is perhaps morally exalted in proportion as he becomes a free agent; but such Volition, in its physical operations, is but a poor substitute for the powers which it affects to supersede.

Volition, as a stimulus to irritability, is not only much less extensive in its operation than sympathy and passion or instinct, but this operation is much less constant. If life and irritation be almost synonymous terms, and if the irritation of each part of the body, at least in the higher tribes of animals, exert by sympathy a more or less powerful influence over all the rest, it is obvious that during life this power can never be quiescent; and if the irritation of other organs be thus continually extended to the rest by sympathy, there is good reason to believe that the action of the brain is equally constantly—at least during the waking hours—extended to the rest by passion or instinct—not indeed in any very sensible form, but uniformly and equally. But such does not appear to be the case with volition, its exercise as a stimulus to irritability taking place apparently at irregular intervals only. And it is in this way that we may perhaps explain the origin of the common error, that the so called voluntary muscles are alone liable to fatigue. All the muscles of the body, whether involuntary or voluntary, are perhaps equally liable to fatigue, provided their irritability be stimulated to a greater degree, or for a longer time, than natural; but, while this is never the case, at least under ordinary circumstances, with the former, the stimulus of volition acting upon the latter is always in some degree a preternatural one, and the action so induced is consequently sooner or later succeeded by exhaustion. Nor is it true, as is sometimes added in order to increase the marvel of the thing, that the involuntary muscles are capable of sustaining, generally speaking, a much more permanent action than the voluntary. It is common to contrast the heart, as continuing in constant action during a long life, with the muscles of the trunk and extremities, as enjoying a great deal of repose; but it is probable that the sum of repose enjoyed by the heart is, in fact, as great, or greater, than that enjoyed by many of the muscles last alluded to. For we must keep in view that the heart is two muscles, and not one only, the auricles acting at one time, and the ventricles at another; and this circumstance, in addition to the short repose of the whole heart during each series of actions constituting its rhythm, reduces the proportion of each twenty-four hours occupied by the actual contractions of the auricles to about six, and that by the contractions of the ventricles to about twelve, whereas that occupied by the contractions of many of the muscles of the trunk—of those which keep the head erect for example—is not, in general, less than sixteen, that is to say, the whole time the person is otherwise than in the recumbent posture. Nevertheless it is not as determined by the relative duration of the contractions of the voluntary muscles, that they become so frequently affected with fatigue, while the involuntary muscles do not, but from the contractions of the former, as just observed, being always more or less a forced state, the stimulus of volition being, as it were, accidental and adventitious in its operation; but to this subject further allusion will be made in future.

SECTION V.

On the Conveyance of Volition, regarded as a Stimulus to Irritability.

With respect to the channel by which the direct and primary action of the brain, in which volition consists, is translated to distant parts, so as to act on them as a stimulus to their irritability, there is not the same controversy as with respect to sympathy and passion or instinct, regarded in this capacity. It is pretty certainly the system of nerves called the proper Motiferous, and the Motiferous portions of those called regular, in conjunction with such of the respiratory nerves as are furnished also with Motiferous filaments. It may be a question from what particular parts of the Cerebro-spinal axis these nerves arise, and consequently whether volition be conveyed immediately from the Brain—Cerebrum or Cerebellum—or only intermediately from the Brain, and immediately from the Spinal Cord—the anterior and posterior columns conjointly, or the anterior columns exclusively—but that the nerves in question are the direct vehicle of the stimulus of volition to the muscles which obey this stimulus is unquestionable. Previously however to adducing the principal proofs of this fact, and the chief arguments in favour of the doctrine, that these nerves arise exclusively from the anterior columns of the Spinal Cord, it will be proper to say a few words respecting a peculiarity in the operation of volition in this way, as distinguishing it from that of the other indirect stimuli just mentioned. The peculiarity alluded to consists in this, that, whereas in the case of sympathy and passion or instinct, the direct irritation of any other organ or the direct action of the brain is the immediate means, through the nerves, of exciting that indirect irritation constituting the obvious phenomena, in that of volition the indirect action of the brain appears to involve first an intermediate action of another part of the nervous system, and it is this intermediate action which is the immediate means, as translated by the nerves, of exciting that in which voluntary motion consists. It may appear at first sight that this is a very unnecessary addition to the complexity of a process already by no means simple; but numerous considerations seem abundantly to justify, and even to require it. Thus, in the first place, it will be evident upon reflection that volition, which implies a distinct consciousness, on the part of the being exercising it, of the end in view, is never exercised with respect immediately to any of the muscles, such muscles being excited to action, not by their possessor willing that they should act, but by his willing to effect certain movements, which movements require the action of such muscles. A man never wills, for example, that the flexor muscles of his finger should contract—he wills merely to bend his finger, and these muscles—of the very existence of which he is most probably quite ignorant—act in consequence. It is not the *muscles* then, but the *movements*, which are in any case voluntary, since it is absurd to represent any power as exerting a deliberate influence over organs altogether unthought of or unknown. It is a very different thing with respect to passion or instinct, which, whether it conduce or not to a definite end, does not imply any consciousness of that end on the part of the being exercising it, and which therefore may be presumed to extend its influence immediately to the muscles—however ignorant this being may be of their existence—the resulting movements being altogether unanticipated and uncared for. Both volition and passion or instinct consist in certain actions of the Brain extended to other organs; but while the latter, which is without deliberate design, is transmitted immediately to the muscles to be acted on, the former, which implies such design, cannot be presumed to be so; and if it be not the action of the Brain which, in this case, is so translated to the muscles, it must be that of some other part directly connected with the Brain, and involved in this particular action of that organ, but the action of which is, like that of the Brain itself in the case of passion or instinct, without any consciousness of an end in view. Again volition, implying, as it does, a distinct consciousness of one definite end, cannot easily be conceived capable of exerting a simultaneous operation upon so many different muscles, as are often called into action in effecting even the simplest movement; and perhaps the totally different movements of the right hand and the left, as manifested in playing on a musical instrument, imply at least two general seats of action more decidedly distinct from each other, than that of mere volition can be presumed to be. And what shall we say of the manifold seats of the power which actuates the three hundred muscles, estimated as simultaneously in action, when a person is dancing, singing and playing on a musical instrument all at the same time? Further there is reason to believe, that volition is not only incapable of a simultaneous operation on several muscles, but that it is not in constant operation during any continued exercise of voluntary motion, such as takes place in playing a piece of music with which one is familiar, or even in continued walking, or in maintaining any forced position; in effecting which, volition, or the primary action of the Brain, appears to be instrumental only in setting off these motions, as it were, while it is by that of some other organ that they are perpetuated, the requisite precision in the actions of the muscles having been already acquired by habit, and having become therefore instinctive. We know at least that the rational thoughts are often constantly and intently engaged in other things, while such actions are going on without the least interruption; but this will do only provided instinct, as excited by the uneasy sensation which a suspension of any natural function always occasions, continue in operation. (*a*) Another argument in favour of the presumption that, when volition acts in effecting the voluntary movements, it is only through some intermediate action, is the fact, that the most powerful act of volition is quite inert in exciting these movements when this intermediate action does not take place, whereas, without any act of volition, they are so excited by the spontaneous occurrence of such action. Of the former of these phenomena we have examples in a palsy of voluntary motion alone, in incubus or common night-mare, and in trance, in which, however energetic may be the will to effect certain movements, the power of doing so is quite lost; of the latter, in a palsy of sensation combined with cerebral apoplexy, in somnambulism and in walking catalepsy, in which, without any volition, the movements of the so-called voluntary muscles are as perfect as when consciousness is entire. Nay it has been established by observation and experiment, as will be stated more fully presently, that the communication between the Brain—the seat of volition—and the immediate source of the nerves going to the voluntary muscles may be entirely intercepted, and still these muscles be excited to action. Nor is it only without the will, but even against the will, that the contrac-

(*a*) A striking illustration of this fact is given by Dr Yelloly, in the case of a person affected with anæsthesia, who was liable, " on turning her eyes aside, to drop glasses, plates &c. which she held in safety so long as she looked at them ;" (*Med. Chir. Trans.* vol. iii. p. 99) and another by Sir Charles Bell, in that of a woman with the same affection on one side, who could hold her child in the diseased arm, " so long as she looked at it," but whenever her immediate attention exciting continued volition was withdrawn from it, the arm became powerless. (*Bridgewater Treatise*, 1834, p. 226) By Sir Charles Bell this want of continued action is explained upon the principle of the defective reflex action of the spinal cord, of which mention will be made presently, and by means of which it is presumed that the sensation excited by the action of any muscle, or what he calls " the muscular sense," being conveyed to the cord by the sensiferous nerve, a corresponding stimulus is returned by the motiferous nerve to the same muscle, and its action is thus perpetuated. That such may be the means by which convulsive actions are excited in a limb, after the separation of the cord from the brain, by irritating that limb, is not unlikely ; but that in the natural state of the parts sensation produces a mode of thought, and that it is by this mode of thought or instinct that such action is, not indeed perpetuated, but effected with the degree of precision requisite to its perpetuation, seems, from many considerations, far more probable.

tions of the muscles, which are usually called into action by volition alone, are frequently excited ; as occurs in tetanus, epilepsy, hysteria, chorea, and all the spasmodic and convulsive diseases which are confined to muscles appertaining to the proper animal functions. It may appear indeed that, if this be admitted as an argument in favour of the doctrine under consideration, the occurrence of angina pectoris and pertussis, of palpitation of the heart, of gastrodynia, colic, hydrophobia and so forth, which consist of spasmodic or convulsive affections of muscles commonly excited, among many other causes, by sympathy, might with equal propriety be cited to prove that sympathy acted on such muscles, not immediately, but through the medium of a new irritation, which might take place sometimes independently of sympathy. This however is not the case ; for, while it is always from excess of either sympathy, or some other stimulus to which these involuntary muscles are naturally subservient, that these latter diseases arise, it is never by excess of volition, which is the only stimulus that the voluntary muscles in an indirect manner exclusively obey, that the former diseases—distinctly confined as they are to these voluntary muscles—are excited. It is clear then that volition is, under ordinary circumstances, only the first link in a chain consisting of three such links, since, under extraordinary circumstances, there still remain the two necessary to every instance of indirect and secondary irritation, which two are capable of acting, not only without the aid of the first, but even in opposition to its influence. Lastly if the action of the Brain in which volition consists operated, like that constituting passion or instinct, on the irritability of the muscles without any intermediate action, we should expect that the Brain would be found to be large in all animals in proportion to the force and energy, as well of their voluntary movements and sensations, as of their instinctive movements and mental operations. Now it is sufficiently well known that, while this correspondence is pretty well observed with respect to the two latter, it is so far from being the case with respect to the two former, that the size of the Brain is within certain limits rather inversely, than directly as the force and energy of the voluntary motions and sensations; as will sufficiently appear by contrasting, in these respects, almost any one of the lower animals with Man. It seems quite fair to conclude then that the Brain is not the seat of the *direct* stimulus to voluntary motion; (*a*) and

(*a*) Some very vague notions have been from the earliest ages afloat respecting the instrumentality of certain portions of the Brain in directly effecting voluntary motion. By Galen, as the sensiferous nerves were represented as arising from the Cerebrum, so the motiferous were described as arising from the Cerebellum; and the doctrine that the Cerebellum therefore was immediately subservient to this process continued in vogue till the time of Willis, who, followed by Vieussens, Boerhaave, Du Hamel and others, chose to regard the Cerebrum as the direct source of the voluntary, and the Cerebellum that of the involuntary motions. Respecting the involuntary motions however the question has been despatched elsewhere. In more modern times Foville, Pinel-Grandchamps, Dugès, Loustan and others have followed Willis, in as far as they regard the Cerebrum as the direct source of voluntary motion, considering the Cerebellum, on the other hand, as the source of sensation: whereas Walker, Rolando and Flourens have returned in some measure to the hypothesis of Galen, placing sensation in the Cerebrum, and representing the Cerebellum as either the originator or regulator of voluntary motion. Bellingeri again and his followers regard both Cerebrum and Cerebellum as directly intrumental to voluntary motion, representing the former as effecting the flexion and abduction of the limbs, and the closing of the sphincters, and the latter as effecting the extension and adduction of the limbs, and the opening of the sphincters. Among the arguments adduced in favour of regarding the Cerebrum as the direct source of voluntary motion — to say nothing of the circumstance of its continuity with the anterior columns of the Spinal Cord, whence all the nerves which minister to voluntary motion appear for the most part immediately to arise—may be mentioned the facts, that, while slight pressure or irritation of this organ usually produces convulsions, severe pressure produces palsy of the voluntary muscles in general; and that a general disease of one side of the Cerebrum usually paralyzes all the voluntary muscles on the opposite side of the body—the fact of the palsy being on the opposite side being explicable from the decussation of the fibres which takes place between the Cerebrum and anterior columns of the Spinal Cord on a line with the corpora pyramidalia. Again a local disease of certain parts of the Cerebrum, for example the thalami optici or corpora striata, paralyzes particular voluntary muscles, such as, in the former case, those chiefly of the upper, and in the latter, those chiefly of the lower limbs; and it is further remarkable that a section of one thalamus opticus or one corpus striatum appears so to act on the voluntary muscles as to cause an animal to revolve incessantly towards the injured side, while a section of both seems to have the effect of causing it to move constantly forwards. On the other hand it has been alleged in favour of regarding the Cerebellum as the direct source of voluntary motion, that although it is not continuous with the anterior columns of the Spinal Cord, like the Cerebrum, yet it has been by no means established that the motiferous nerves arise more from these than from the posterior columns, with which the Cerebellum is continuous; and it is certain that a general disease of one side of the Cerebellum as commonly paralyzes all the voluntary muscles, sometimes on the opposite side of the body, at others on the same side, as such a disease of the Cerebrum does—the fact that the

the fact that none of the motiferous nerves have their actual affection is sometimes on the same side of the body being perhaps explicable from the circumstance that there is between the Cerebellum and Spinal Cord no such decussation of fibres as takes place between the Cerebrum and the latter organ. Further a local disease of the Cerebellum produces on particular voluntary muscles effects similar to those resulting from such diseases of certain parts of the Cerebrum ; and as a section of certain parts of the latter seems to cause an animal either to revolve towards the injured side, or to move forwards, so a section of one of the crura of the Cerebellum, or the removal vertically of a large portion of one of its hemispheres, appears to give rise to the same kind of rotatory motion—this motion being instantly stopped by injuring the other side of the organ in a similar way—while the removal horizontally of a large portion of both hemispheres of the Cerebellum seems to cause an animal to move constantly, not forwards, but backwards. All this has been established by the experiments of Saucerotte, Rolando, Flourens, Serres, Schoepf and others. It appears accordingly that the arguments are almost equally valid, or rather equally destitute of validity, for regarding either the Cerebrum or the Cerebellum as the direct source or regulator of the voluntary motions, some of them even going to prove, as observed by Magendie, that these organs are useful, not so much in moving the body, as in keeping it still. With respect to the general or local diseases of the Brain, followed by palsy of the voluntary muscles, unless such diseases involve also the Spinal Cord—as is very frequently the case—they take effect probably only as far as they intercept volition ; and with respect to the various local lesions of the Brain followed by such singular effects, they prove only that the voluntary motions may be affected through the Brain, not that they immediately depend upon this organ. Indeed, if this argument in favour of the doctrine in question be allowed, we must conclude that the Brain is the direct source or regulator, not only of the voluntary, but of the involuntary motions also—of that of the heart for example, which is so easily influenced by the state of this organ. The perturbations of the Brain may disturb the actions of either the voluntary or involuntary muscles. It has been already stated that they involve sometimes the organic functions, as well as the animal, in a very remarkable manner, and it was indeed found by Dr Wilson Philip that such perturbations produced very similar effects on both; (*Phil. Trans.* 1815) but that organ is surely not to be regarded as the direct source or regulator of the motions of another, which only requires of it not to interfere, otherwise than in its own proper character as the organ of volition. And even admitting that the effects of actual physical lesions of the Brain are more remarkable on the voluntary than on the involuntary muscles, is not this fact easily explicable, when we reflect on the intimate structural union between this organ and that which really is, in all probability, the direct source of voluntary motion ; so that while the involuntary motions are involved only sympathetically in such lesions, the voluntary are so, not only sympathetically, but immediately also ? Hence we find that while superficial injuries of the Brain, or the compression of this organ in a transverse direction are comparatively inert with respect to the voluntary motions, the more these lesions bear vertically upon the Spinal Cord, and the nearer they approach the point of union—in other words, the nearer they are to the base of the Brain—the more striking these effects become. They take effect likewise in general much more sensibly on the upper than on the lower limbs, seeming to show that their operation is merely mechanical. But, besides this, it origin in that organ is a further corroboration of the doctrine in question. (*a*)

is not improbable that some of these effects may depend, not upon any immediate influence exercised by the Brain as the direct source of voluntary motion, but upon mere volition, exerted in consequence of the lesions above alluded to. Thus a section of one thalamus opticus, of one corpus striatum, or of one of the crura of the Cerebellum, or a removal in the vertical direction of a large portion of one of the hemispheres of the latter, in all likelihood produces a kind of vertigo, in which the animal fancies itself forcibly urged in a direction contrary to that in which it is found to revolve ; and this revolving motion is perhaps excited by the will, for the purpose of counteracting this supposed impulse. In the same manner probably a section of both thalami optici, or of both corpora striata on the one hand, or a removal in the horizontal direction of a large portion of both hemispheres of the Cerebellum on the other, gives rise to an impression of being violently propelled respectively backwards or forwards ; and the animal perhaps voluntarily moves forwards or backwards, in order to resist this imaginary power. We know indeed that similar irregular motions are excited by lesions of the semicircular canals of the ear, probably owing to a kind of vertigo of this description, arising from the perturbation of the function of hearing ; but nobody has on this account represented the semicircular canals as the seat of the direct stimulus to voluntary motion. A wonderful case related by Dr Watt, (*Medico-Chir. Trans.* 1814) and another by Mr Mayo, (*Outlines of Physiology,* 1829) in which, among other singular notions, this revolving motion was more or less constantly maintained, and the Forfarshire louping ague, as it is called, (*Edin. Med. and Surg. Journ.* 1807) manifesting itself principally in an uncontrollable propensity to run straight forwards, or to dash head-foremost in the same direction, as in a remarkable case lately related by Mr Marshall of Forfar—(*Edin. Med. and Surg. Journ.* 1833) to say nothing of the epidemic dancing mania so common in the middle ages, or the tarantism of modern times—afford beautiful illustrations of the influence of certain morbid affections of the Brain upon the voluntary motions ; but no more justify us in believing that it is the direct source of such voluntary motion, than the alterations which the hand sometimes makes in the movements of a watch would justify us in the belief that it is by this hand, and not by its own spring, that such movements are under ordinary circumstances effected.

(*a*) It is only very lately that it has been pretty generally inculcated that the nerves already enumerated as motiferous arise, not any of them from the Brain properly so called, but all from the Spinal Cord ; and that there are not, in fact, any cerebral nerves in the body, all those belonging to the cerebro-spinal system, whether respiratory, motiferous, sensiferous or regular, although they may pass through certain parts of the Brain in their course, actually originating below this organ. This doctrine was distinctly propagated for the first time by Gall ; and, whatever may be the case with respect to the other cerebro-spinal nerves, it is certain, as we shall presently find, that all those which minister to the voluntary motions are spinal and not cerebral. And indeed, independently of autopsia and analogy, the simple fact that in a general palsy affecting the regular nerves of one side of the body—all which obviously arise from the Spinal Cord—the proper motiferous nerves *of the same side,* and not of the other side, are usually involved, ren-

If then there be some intermediate action in every case of voluntary motion, the next question that arises is, what is the seat of it? And the answer may be tolerably decided—that it is the Spinal Cord, whence all the nerves ministering to the motions of the reputedly voluntary muscles directly arise. This presumption, while it is quite compatible with all the facts which have just been enumerated as militating against the doctrine that it is by the immediate translation of the stimulus of volition to the muscles to be acted on that voluntary motion is effected, seems to be borne out by direct observation and experiment. In the avertebrated animals the Spinal Cord is not directly continuous either with the Brain, or with itself, occurring as it does in a kind of distinct segments; and it has been shown, as lately stated, not only by numerous cases in which a separation has occurred in Man, from either monstrosity or disease, between the Brain —the seat of volition—and the Spinal Cord, or between the upper and lower portions of the latter, but also by experiments on the lower vertebrated animals, in which this connexion between the Brain and either the whole or a part of the Spinal Cord has been artificially cut off, that the motions of the muscles supplied by nerves coming from the part of the Cord below the division, which motions are naturally excited by volition, were not materially impaired.

ders it pretty clear that they all arise from the same organ; since, had the former arisen from the Spinal Cord—that is to say below the point of decussation between this organ and the Brain—and the latter from the Brain—in other words above this point—it is obvious that if the former had been palsied on the right side, the latter would have been palsied on the left, and vice versa. But to this subject further allusion will be made in future. It is singular how men will sometimes cling to old notions in spite of every evidence of their fallacy. M. Andral, in his recent *Clinique Médicale* objects to attributing the palsy of the extremities of the opposite side, after an injury of one side of the head, to the decussation of the fibres at the summit of the Spinal Cord, because, he says, this explanation cannot apply to the corresponding palsy of the face, "the nerves distributed to the muscles of the face arising *above* the crossing of the cords." Would it not have been more rational to have taken this fact as a proof that this, though their apparent, was not their real origin? When the parts of the head, such as the nostrils or eyes, are palsied on the side opposite to that on which the extremities are palsied, as sometimes happens, it must be ascribed to some direct affection of the nerves going to the former parts, in their subsequent course along or through certain parts of the brain, while those going to the latter are affected at their extreme origins.

The mere action of the Cord then excited by other means, as happens in palsy of sensation combined with cerebral apoplexy, in somnambulism and in walking catalepsy, appears to be, under these circumstances, still competent to produce them. (*a*) And it seems hence fair to infer that, as in palsy of voluntary motion alone, and in incubus, the Brain and posterior columns of the Spinal Cord are still in action, while the anterior columns are not so — presuming for the present that the former are the seat of sensibility, as the latter are that of the power by which voluntary motion is intermediately excited—and in trance the Brain without either the posterior or anterior columns, so in the three diseases just mentioned the action of the Brain is suspended, while that of the anterior columns is still maintained, in the first without the continued action of the posterior columns, and in the two last with it. Further it is not very easy to explain why in the two anterior pillars of the Spinal Cord the nerves should appear to arise principally from grey matter, which is not the case with the two lateral pillars—still presuming that it is by

(*a*) One case of this kind is related in the *Journal de Physiologie* for 1823, in which the power of moving the voluntary muscles, as well as the faculty of sensibility, was unimpaired in a man between the upper and lower portions of whose Spinal Cord there was an almost total want of continuity for six or seven inches; and some analogous cases have been since recorded. The same negative result of artificial division of the Spinal Cord in the lower animals was noticed long ago by Redi and Swammerdam; and it is expressly stated by Dr Wilson Philip, as the conclusion to be drawn from his experiments, that "the division of the spinal marrow does not destroy any of the functions of either half of it, the palsy of the lower part of the body, occasioned by its division, arising from that part having its communication with the principal source of sensorial power (*i. e.* the seat of volition) destroyed." (*On the Vital Functions*, 1817) In his Gulstonean Lectures also, delivered in 1835, he confutes at great length the doctrine of Dr Henry and Dr Alison, that the Spinal Cord acts merely as the vehicle of impressions from and to the Brain. It is observed likewise by Mr Mayo, that if the Spinal Cord be divided in a rabbit in the centre of the back, the hind leg still retains both the power of motion and the faculty of sensibility; (*Outlines of Physiology*, 1829) so that we must believe that the "palsy" which a few pages onwards he describes as "the uniform result" of such a division, relates only, in as far as voluntary motion is concerned, to the interception of volition. Volition may be entire, and the intermediate action which should directly excite the voluntary movements may likewise be entire, but the former does not now give rise to the latter. Similar remarks have been made by Marshall Hall, Walker and many other physiologists; but the subject will be resumed when the connection between sensation and the stimulus to voluntary motion falls to be considered.

the two anterior, as well as by the two lateral pillars that some stimulus is imparted to distant parts—unless it be conceded that the two former are not only the channels of a power, but the seat of the action in which this power immediately consists, whereas the two latter serve only to communicate a power generated elsewhere. It has been already presumed, in speaking of the office of the ganglionic system of nerves, that the grey matter of the nervous tissue is always the source of that particular property or power which distinguishes each department of the nervous apparatus, while the white matter may be regarded as only a kind of conduits, by which this property or power is, as it were, disseminated, not indeed *per se*, but by virtue of some molecular change effected in the matter in question; (*a*) and if this be the case, as every view of the matter seems to testify, it will follow that the possession by the anterior columns of the Spinal Cord of grey matter is a strong collateral argument in favour of the doctrine that voli-

(*a*) An indefinite sort of surmise that the grey matter of the nervous tissue is analogous to the secreting part of a gland, as the white matter is to the ducts of such gland, appears to have been from the earliest times entertained. Thus by Hippocrates the Brain has been described ὥσπερ καὶ ἀδένες, while by Praxagoras the nerves were represented as performing the office of ducts, and similar notions were inculcated by Harvey, Spiegel, Bartholin and others; but it was Malpighi who attempted for the first time to demonstrate, by means of long boiling, and with the help of the microscope, the glandular structure of the grey matter of the nervous tissue, and the fibrous structure of the white, and to prove that the latter was to every point of the former " veluti proprium vas," for the conveyance of whatever it was pleased to furnish. In these speculations Malpighi was supported by Willis, Malacarne, Vieussens, Wepfer, Bohn, Leeuwenhoek, and many others, almost down to our own times; and although the grey matter of the nervous tissue certainly does not, like truly glandular structure, secrete any thing substantial, whether " an exquisitely fine and active fluid," in the character of " nervous energy," or a proper " succus nervosus" indirectly ministering to such nervous energy, the comparison is nevertheless an impressive and instructive one. By Gall and Spurzheim the grey matter of the nervous tissue is represented rather unhappily as the matrix of the white—a position which has been since combated by Tiedemann, Magendie, Desmoulins and others, who have shown that in the embryo the formation of the white matter long precedes that of the grey. It is remarkable however that this observation is so far from controverting, that it very strongly corroborates the notion of a kind of analogy between the grey and white portions of the nervous tissue and the parenchymatous and tubular parts of a gland, the tubular part of the latter being now well known long to precede the parenchymatous part in the date of its development.

tion operates in exciting the action of the voluntary muscles, not directly, but only through the medium of a new power consisting in a proper simultaneous action of this part. It must not be concealed however that by some physiologists (*a*) the grey matter of the Spinal Cord in general is regarded as the seal of sensibility, but this is by those who ascribe the power of exciting voluntary motion to the white matter indiscriminately of both anterior and posterior columns; while by others (*b*) it is looked upon as useful principally in preventing the proper function of one part of the Cord from interfering with those of the others. Lastly the size of the Spinal Cord, taken collectively, as compared with that of the Brain, is, in almost all classes of animals, great in proportion to the force and energy of their voluntary motions and sensations, as compared with that of their instinctive motions and mental operations; the relative size of the Spinal Cord of fishes and reptiles in general being as about 1 to 2, that of birds as 1 to 3, that of quadrupeds as 1 to 4, that of the male of the human species as 1 to 24, and that of the female as 1 to 25 or 26. It is worthy of remark likewise that if this doctrine be admitted—that the anterior columns of the Spinal Cord are the seat of the intermediate stimulus to voluntary motion, which stimulus, as it is excited by that primary action of the Brain in which volition as a mode of thought consists, so it gives rise to an irritation of a part at a distance—a very beautiful inverse analogy is maintained between this stimulus to voluntary motion and sensation, which in like manner has its seat in all probability in the posterior columns of the Spinal Cord, and which, as it is excited by some irritation at a distance, so it gives rise to some mode of thought. Two journeys, as it were, in opposite directions, seem to be taken in the two processes; but in both the Spinal Cord appears to be, not merely a channel of conveyance between the Brain and the distant organ, but a very important means of modifying the thing conveyed.

(*a*) Bellingeri &c. (*b*) Walker &c.

SECTION VI.

On the Motiferous System of Nerves, regarded as the Vehicle of Volition.

We have now to return to the proper Motiferous nerves, and the Motiferous portions of the Regular nerves, in conjunction with a department of some of the respiratory nerves, which, like the facial and pneumogastric, are furnished with Motiferous filaments, as the channel by which this intermediate irritation of the anterior columns of the spinal cord is translated to the voluntary muscles, so as to act as a stimulus on their irritability. The chief circumstances tending to prove that this is their office, may be shortly spoken of in an order similar to that in which those were described, which render it probable that the office of the respiratory nerves is to convey the stimulus of sympathy and passion or instinct. These circumstances were connected 1. With their distribution. 2. With their association with other nerves. 3. With their relation to the action of the brain. 4. With their development in the various tribes of animals. 5. With their structure. 6. With their competency to conduct certain artificial stimuli. 7. With the phenomena resulting from their irritation. And 8. With the phenomena resulting from their obstruction. (*a*)

(*a*) The proper Motiferous nerves, enumerated in the tabular view of the nerves of the human body already presented, consist of the Motor oculi, a part of the lower maxillary branch of the Trigeminus, the Abductor and the Hypo-glossal; and the Regular nerves—one portion of each of which is also Motiferous—of the Sub-occipital, the seven Cervical, the twelve Dorsal, the five Lumbar and the five Sacral. To these must be added, as elsewhere explained, a portion of the facial nerve, as well as of the glosso-pharyngeal and pneumogastric; the other respiratory nerves, although most of them have been looked upon at one time or other as Motiferous, being, if at all, certainly very obscurely connected with the system in question. The greater number of these nerves have been pretty generally admitted, from a very early period, as performing the office above ascribed to them. It is a very common, but a very erroneous impression, that the ancient physiologists were quite ignorant of the plurality of the nervous system, and that, ascribing as they did merely the power of exciting voluntary motion and of communicating sensation to these agents, they attributed these offices conjointly and indiscriminately to all the nerves with which they were acquainted. So far

I. With respect to the distribution of the proper Motiferous and Regular nerves, this is found to correspond very accurately with the presumption that it is these systems which

however is this from being the case, that even Herophilus and Erasistratus—the first to dissect a human body—were accustomed to distinguish the Νεῦροι κινητικοὶ from the Νεῦροι αἰσθητικοὶ; and Galen expressly says that all the hard nerves belong to the former set, and all the soft ones to the latter; (*De Administrat. Anatom.* lib. iii. c. 17; *De Usu Partium*, lib. viii. c. 16 &c.) a statement which, with a very little alteration, would strictly correspond with the fact. At the same time it must be confessed that the ancients do not any of them appear to have been aware that this functional difference depended at all upon the different origin of the several nerves, conceiving that any branch of a nerve which was firm would convey Volition, and any which was soft would convey Sensation in virtue of its texture alone. Similar doctrines were inculcated by Aretæus, (*De Paralysi*) Ruffus (*De Appel. Part.*) and other ancient authors, and more recently by Fallòpia, (*Obs. Anat.*) Willis, (*Anat. Cereb.*) Van Swieten, Tissot, Cabanis and numerous other writers; but the subject of the plurality of the nervous system had nevertheless been almost lost sight of in books, as well as in schools of anatomy and physiology, till it was revived and presented to the world in a more or less collective form, and with many additions, by Gall, Walker, Bellingeri, Bell, Magendie, Mayo, Earle, Arnold and other cotemporary authors, to whom we are indebted for almost all that has been established—if indeed any thing can be said to have been fully established—on the subject. The discrepancies of opinion still prevalent respecting the offices of many of the individual nerves above assumed as constituting a system under the name of respiratory have been already alluded to; and similar or still greater discrepancies still exist respecting those of many of the nerves now assumed as Motiferous. Thus by Bellingeri and Walker the Motor Oculi is regarded as a nerve both of involuntary and voluntary motion, while by most other authors it is represented as ministering to voluntary motion alone. The Motor portion of the third branch of the Trigeminus, commonly called the Masticatory nerve, has been pretty generally admitted, since the researches of Palletta, Bellingeri and Mayo, as a vehicle of volition alone, and the same is the case with respect to the Abductor and Hypoglossal nerves; but it is a very different affair with the anterior or reputedly Motiferous branches of the proper spinal or Regular nerves, all which are supposed by Bellingeri merely to cooperate with the posterior or reputedly Sensiferous branches, as vehicles of both instinct and volition, and to differ from the posterior only in not ministering at the same time to sensation. It is further an inference from what has already been stated, that the former, as connected with the cerebrum, should be believed to be subservient to the action of the muscles employed in flexion and abduction, while the latter as connected with the cerebellum, should minister to the action of those employed in extension and adduction. Mr Walker again regards the anterior roots of the spinal nerves as *Sensiferous*, and the posterior as *Motiferous*, ministering at once to involuntary motion, by means of the filaments derived from the lateral or olivary columns, and to voluntary motion, by means of those derived from the proper posterior or cerebellic columns. On the other hand Sir Charles Bell, Mayo, Earle, Arnold &c. inverting, as Mr Walker says, *his* doctrine, represent the former as Motiferous, and the latter as Sensiferous. The present however is not the place for entering into the arguments of the several controversialists.

communicate the stimulus to voluntary motion—such organs as are not amenable to this stimulus having no obvious supply of nerves from these systems, while those which either occasionally or habitually obey it derive their nerves either partially or principally from these sources. All the nerves conveying this stimulus appear to arise from the two anterior columns of the spinal cord, the proper Motiferous having no other origin, but the Regular having a second root from the posterior columns, in virtue of which they conduce, not only to voluntary motion, but to sensation also; (*a*) and these

(*a*) Upon the presumption of the anterior columns of the spinal cord being the seat of the intermediate stimulus by which the voluntary motions are excited, it seems to be necessary to show that it is from this part that all the proper Motiferous nerves, as well as all the Motiferous portions of the Regular and respiratory nerves originate; and such appears to be really the case, regarding the crura cerebri and the anterior portion of the medulla oblongata, with its appendages the olivary and pyramidal bodies, merely as continuations of these. With respect to the Motiferous filaments of the facial, of the glosso-pharyngeal and of the pneumogastric nerves, it has been already stated that these take their rise in all probability from the olivary bodies. The Motor oculi has been almost universally represented, since the times of Vieussens, Morgagni, Winslow, Lieutaud and Soemmering, to arise from the inner portion of the crura cerebri, near the tuber annulare; and such is the description of its origin given by Swan, Mayo and others, Bellingeri, Walker and Arnold again ascribing to it, after Malacarne and Palletta, a second origin from the crura cerebelli, which is not at all incompatible with the main origin above assigned to it. A somewhat greater difficulty exists with respect to the Motiferous portion of the third branch of the Trigeminus, which, contrary to the description of its origin, in common with the larger or sensiferous portion, by Haller, Wrisberg and Vicq d'Azyr, from the tuber annulare, appears to have been traced by Santorini, Winslow, Soemmering, Girardi and in particular Palletta, to the crura cerebelli, so that, consistently with the above adopted principles, it ought to be rather a Sensiferous than a Motiferous nerve. This description of it is followed by Bellingeri and Walker, and according to Mr Swan it arises "from the *anterior* edge of the crus of the cerebellum joining the annular tubercle," while Mr Mayo describes it as arising from "the upper part of the medulla oblongata." From these descriptions it is clear that its alleged origin is as near as possible to the crura cerebri, from the posterior edge of which it does really, in all likelihood, arise. Nay it is stated by Mr Mayo that in the fetus, owing to the earlier development of the posterior portion of the tuber annulare than of the anterior portion, this nerve actually has its origin *before*, instead of *behind* it—in other words from the rudimental crura cerebri. The Abductor nerve again arises, according to Bellingeri and Walker, externally close to the pyramidal bodies, but internally from the crura cerebelli; according to Mayo, "from the outside of the anterior pyramid at the edge of the pons Varolii;" and according to Swan, "partly from the anterior extremity of the pyramidal body, and partly from the posterior edge of the annular tubercle." Lastly the Hypoglossal nerve is pretty generally referred to the fore part of the olivary nerves, extensive as is the collective area over which they are distributed, are nevertheless less generally disseminated than the respiratory nerves, in proportion to the less extensive sphere of their operation. Thus no such nerves appear to be distributed to the heart, the various secretory organs, the stomach, the iris, (*a*) or any other parts over the motions of which we exercise no control. They are found however to supply, in common with obvious branches from the respiratory system, the respiratory muscles, and all those by which the numerous motions connected with the process of respiration are effected, those by which the aliment is received and transmitted to the pharynx, those which minister to the excretion of the stools and urine, those by which copulation is performed, and those which conduce to certain movements of the nostrils, eyes, face and other organs commonly excited by sympathy and passion or instinct, but capable of being effected, as well as liable to be continually modified by volition. Lastly it is from these systems principally that those muscles by which we whistle, whisper, speak, direct the organs of the nerves in the proper discharge of their functions, and effect the various movements of the head, trunk and extremities, are found to be supplied. Accordingly, in effecting the former series of processes, the respiratory nerves are more frequently in requisition, and in effecting the latter, the proper Motiferous and Regular. Thus when we respire as actuated by the ordinary stimulus of sympathy and passion or instinct, it is by means of a smaller or greater number of the proper respiratory nerves, in proportion as this process is less or more energetic, that we do so; but when, as in asthma, we respire by volition, or when we temper this process according to circumstances, we use the Sub-occipital, Cervical, Dorsal

body, or the groove between this and the pyramidal body, as its point of origin. No radical objection therefore, on the score of want of consistency in their respective origins, can be urged against regarding all these nerves as ministering to a common office with those which directly and obviously arise from the anterior columns of the spinal cord.

(*a*) It has elsewhere been explained that the ophthalmic ganglion, whence the bulk of the ciliary nerves arise, may be presumed rather to send filaments to the Motor oculi and ophthalmic branch of Trigeminus, than to receive filaments from them. It is a remarkable fact however that in those animals in which the iris is a voluntary muscle—the Ray, the Owl, the Parrot &c.—there is no ophthalmic ganglion, and the iris is supplied directly by the Motor oculi.

and Lumbar nerves for this purpose. When we sigh, or yawn, or hiccough from either sympathy or passion, as is generally the case, the action is effected by means of the intercostal and phrenic nerves, acting simultaneously, in the second case, with the respiratory portion of the facial, and when we sneeze, groan, scream, sob, laugh or cough from these ordinary stimuli, we do so by means of the abdominal nerves, together with the respiratory portions of the pneumogastric as distributed upon the larynx and other parts; but when, on the contrary, we effect these processes voluntarily, we employ on the one hand the Sub-occipital, the Cervical and Dorsal, and on the other the Lumbar nerves, together with the Motiferous portions of the facial and pneumogastric nerves for that purpose. Again the processes of receiving aliment and transmitting it to the pharynx, of excreting the stools and urine, and of copulating, as excited by the usual stimuli of sympathy and passion or instinct, are effected by the agency of the respiratory portion of the facial, the glosso-pharyngeal, pneumogastric, abdominal and other respiratory nerves; but as excited by volition, by the Motiferous filament of the lower maxillary branch of the trigeminus, the Motiferous portion of the facial, the Hypoglossal, Sub-occipital, Cervical, Dorsal, Lumbar and Sacral nerves. As the involuntary motions of the nostrils also, as well as of the eye-brows and features of the face generally—and their motions are usually involuntary—depend upon the respiratory portion of the facial nerve, so their voluntary motions depend upon the Motiferous portion of the same; and as the usual involuntary motions of the eye-lids—as far at least as closing them is concerned—depend upon the respiratory portion of the facial nerve, and those of the eye-balls upon the pathetic nerve, so the voluntary motions of both depend upon the Motiferous portion of the facial, the Motor oculi and the Abductor. On the contrary to the motions of the lips and tongue, as instrumental to whistling, whispering and speaking, the ordinary stimulus is volition, and their processes are consequently effected respectively by the Motiferous portion of the facial nerve and Hypoglossal nerve. The same is the case with those of the nostrils, eye-balls and external ears, which are subservient to the proper functions of these several organs, and they are effected accordingly by the Motiferous portion of the facial, the Motor and Abductor oculi, and some of the Cervical nerves; as well as with those lastly which minister to the various movements of the head, trunk and limbs, which are excited therefore by the Sub-occipital, Cervical, Dorsal, Lumbar and Sacral nerves.

II. The proper Motiferous system of nerves, and that of the Motiferous portions of the Regular nerves, are in immediate union by their central parts with the proper Sensiferous system, unlike the respiratory system, which is quite distinct from both; and it is hence easy to understand why, while the operations of the respiratory system are independent of those of either of the other two, these two should in general act, as during watching, and cease from acting, as during sleep, almost simultaneously, as well as why each should be in general more or less involved in cerebral apoplexy, and all diseases affecting the other. In this way also it is not difficult to explain why affections of the posterior columns should sometimes produce tetanus, without presuming that these columns have directly any influence on the action of the voluntary muscles. This union however is not so intimate but that either may, under certain circumstances, continue in action or have its action suspended independently of the other; and indeed we are all conscious that, in the gradual processes of falling asleep and awakening, the function of sensation in the one case is longer maintained, and in the other is sooner restored than that of voluntary motion. The phenomena of palsy and incubus also abundantly prove that the failure of these two functions is by no means always in the same degree, or even necessarily coincident. (*a*)

(*a*) Allusion was made some time ago to a kind of "reflex action" supposed to be exercised by the ganglionic system of nerves, and more lately to a similar kind of action perhaps really exercised by the respiratory, so that receiving impressions on the one hand, it communicated impressions on the other; and a similar doctrine has been recently maintained with respect to the Sensiferous and Motiferous departments of the spinal cord. It was lately mentioned that there appears to be a kind of inverse analogy between sensation, as seated in the posterior columns of this organ, and the stimulus to voluntary motion, as seated in the anterior columns, in as much as the former, excited by irritation, gives rise to thought, while the latter, excited by thought, gives rise to irritation. In this view of the matter, the action of the brain is of course in both instances involved;

III. The proper Motiferous nerves also, and the Motiferous portions of the Regular nerves arise from a part which is directly continuous with the bulk of the Brain, again unlike

but in the view recently taken, each segment of the spinal cord is regarded as the direct seat, not merely of sensation, and of the immediate stimulus to voluntary motion, but of this reflex action, receiving impressions directly by the Sensiferous nerves, and, in consequence of these, communicating impressions equally directly by the Motiferous. It has been long understood by physiologists that the nervous influence producing sensation proceeds along the nerves from their extremities towards the brain, and that that producing motion proceeds from the brain towards the extremities of the nerves. This fact may be collected from the works of Haller and Tissot, and is distinctly inculcated by Soemmering, Bichat and others: but the idea that the course of this influence in the former direction was the immediate cause of its course in the latter—so that there was a kind of circulation of this influence upwards and downwards—and that it did not *necessarily* traverse the brain, but might pass directly from the termination of the Sensiferous nerves to the beginning of the Motiferous in the spinal cord, seems to have originated with Prevost and Dumas. (*Journ. de Physiol.* 1823) With them however it was a mere suggestion; but the doctrine assumed a more tangible shape in the hands of Sir Charles Bell, who, during his investigations of the functions of the Trigeminus nerve, was led to believe that by the Sensiferous portions of this nerve, as distributed on certain organs, such an influence was conveyed, as, being immediately returned by the Motiferous portions, called these particular organs into action, and again, that by the muscular motion so excited, such a sensation was produced, as served to regulate and perpetuate it. (*Phil. Trans.* 1828) On the latter part of this doctrine the same author has particularly insisted lately, as already observed, when discussing the subject of what he calls " the Muscular Sense." (*Bridgewater Treatise*, 1834) In the mean time it was noticed by Mayo, that, generally speaking, " the nerves of motion take their rise from the same region or segment of the spinal marrow with those sentient nerves which transmit the impressions by which their action is usually regulated;" (*Human Physiology*, 1833, p. 267) and it has been observed by numerous authors—among the rest by Mr Walker—that after all communication with the brain has been cut off, exciting sensation in any organ has the effect of calling the muscles of that organ into action. (*Nervous System*, 1834) The same fact is alluded to, and a similar explanation of it is given by Arnold; (*Icon. Nerv. Capitis*, 1834) but the author who has entered most fully into the subject is Dr Marshall Hall, who has adduced abundant evidence of the influence of an impression made upon the Sensiferous nerves in exciting through the spinal cord the action of the Motiferous, and who observes that " in every instance in which the reflex power is excited, an impression made upon the extremities of certain nerves is conveyed to the medulla oblongata, or medulla spinalis, and is reflected along other nerves to parts adjacent to, or remote from that which has received the impression." (*On the Reflex Action of the Spinal Marrow*, 1834) It is hardly necessary to say that this doctrine and the facts upon which it is founded furnish additional corroboration of the principle already inculcated, that the seat of the immediate stimulus to the motion of muscles usually voluntary is not the brain, but the spinal cord, and that when the brain acts in effecting this the respiratory nerves, which arise from a part not continued further than the medulla oblongata; and it is thus easily explained why the action of the former systems, unlike that of the latter, should continue in general only during the action of the Brain, and be suspended during sleep and coma, in which volition is intercepted, and why, as already observed, it should be commonly in a greater or less degree involved in the morbid conditions of that organ. Like the Sensiferous system however, the Brain may be in action without the Mo-

motion, it is only indirectly as the seat of volition. So long as the parts are entire, the following, according to Mr Walker, is the connection between sensation and voluntary motion, consistently of course with his doctrine that the anterior pillars of the spinal cord minister to the former, and the posterior pillars to the latter. "Medullary action," says he, "commences in the organs of sense, passes in a general manner to the spinal marrow, by the anterior fasciculi of the spinal nerves, which are therefore nerves of sensation, and the connections of which with the spinal marrow or brain must be termed their spinal or cerebral *terminations;* ascends through the anterior columns of the spinal marrow, which are therefore its ascending columns, passes forwards through the anterior fasciculi of the medulla oblongata, and then through the crura cerebri; extends forward, outward and upward through the corpora striata, and reaches the hemispheres of the cerebrum itself. This is the course of its *ascent* to the sensorium commune. From the posterior part of the medulla of the hemispheres it returns by the thalami, passing backward, inward and downward, flows backward on the fasciculi under the nates and testes, backward and upward through the processus cerebelli ad testes, or anterior peduncles of the cerebellum, and then reaches the medulla of the cerebellum itself. From the cerebellum it *descends* through the posterior columns of the spinal marrow, which are therefore its descending columns, and expands through the posterior fasciculi of all the nerves, which are therefore the nerves of volition, and the connections of which with the spinal marrow or brain must be termed their spinal or cerebellic *origins.*" (*Nervous System,* 1834, p. 54) A very similar hypothesis has been lately maintained by Mr J. W. Earle, except that, regarding the posterior pillars of the cord as Sensiferous, and the anterior as Motiferous, he speaks of the supposed current as upwards by the former, and downwards by the latter, and "ventures to call it the CIRCULATION of the NERVOUS SYSTEM." (*New Exposition of the Functions of the Nerves,* 1833) So long as the parts are entire then, the reflex action of the spinal cord is represented as taking place *through* the brain; but even under these circumstances, the origin of certain Motiferous nerves, on the same plane with certain Sensiferous, may be presumed to determine the particular motions which result from particular sensations. By Bellingeri, on the other hand, this origin of the posterior and anterior roots of the Regular nerves of each part from the same plane, is referred to the principle of antagonism of the muscles—a subject so much insisted upon by Boerhaave, Haller, Soemmering, Sprengel, Barclay and others—the posterior roots having, in his idea of the matter, to effect the extension and adduction, and the anterior, the flexion and abduction of the parts to which they proceed.

tiferous system, as in palsy of voluntary motion alone, in incubus, and in trance, or the last-mentioned system may be in action without the Brain, as in somnambulism and walking catalepsy, as well as in palsy of sensation combined with cerebral apoplexy; and numerous are the diseases which show that lesions of either the Motiferous system of nerves or of the Brain may exist the one quite independently of the other. (*a*)

IV. The inferior animals are found in general to possess Motiferous nerves precisely corresponding to the voluntary motions which they severally perform; and these nerves, as well as their common source, are observed to be in general large, in proportion to the force and energy of these motions. In the greater number of the avertebrated tribes, the motions of which appear to be more frequently sympathetic or instinctive than properly voluntary, and the sensations of which are not perhaps very acute, the bulk of that portion of the nervous apparatus which corresponds to the distinct cerebro-spinal system of vertebrated animals is, perhaps, rather respiratory than either Motiferous or Sensiferous, and consists principally of nerves corresponding to the glosso-pharyngeal and pneumogastric—but it is not easy in them to draw any very precise line of demarcation between these three departments. We know only that nerves for motion proceed in them to the tentacula, the legs, the tail and other organs; but whether these nerves be respiratory or proper Motiferous—in other words, whether the motions which they effect be sympathetic and instinctive, or properly voluntary—we are often incapable

(*a*) The following tabular view of the state of the Posterior columns of the spinal cord, of the Brain, and of the Anterior columns, in the various affections in which they are severally or collectively involved, is perhaps an approximation to the truth, regarding the *posterior* columns as the seat of sensation, and the *anterior* as that of the intermediate stimulus to voluntary motion.

	Posterior Col. of Sp. Cord.	*Brain.*	*Anterior Col. of Sp. Cord.*
In NATURAL WATCHING	Active.	Active.	Active.
In somnambulism and walking catalepsy	Active.	Inert.	Active.
In palsy of sensation alone	Inert.	Active.	Active.
In palsy of sensation with cerebral apoplexy	Inert.	Inert.	Active.
In palsy of voluntary motion alone, and in incubus	Active.	Active.	Inert.
In palsy of voluntary motion with cerebral apoplexy	Active.	Inert.	Inert.
In palsy of both sensation and voluntary motion without cerebral apoplexy, and in trance	Inert.	Active.	Inert.
In palsy of both sensation and voluntary motion, with cerebral apoplexy, and in NATURAL SLEEP	Inert.	Inert.	Inert.

of determining. In the vertebrated tribes, on the contrary, the voluntary motions are more easily distinguished from the involuntary, and in them accordingly we meet with Motiferous nerves in the same degree distinctly developed. Thus in such fishes as have the eye-balls moveable, as there is a pathetic nerve for its involuntary movements, as well as for those of the iris, so there are a Motor oculi and Abductor for such as are voluntary; and it is remarkable, that in those in which the iris is a voluntary muscle, it derives its chief nerves, as already mentioned, directly from the former of these. As again they have a glosso-pharyngeal nerve for the instinctive process of taking aliment, so they have a Motiferous portion of the lower maxillary branch of the Trigeminus for the voluntary movements of their jaws; while, having no voice, and consequently never using their tongue in any attempt at articulation, they are quite destitute of a Hypoglossal nerve. The same correspondence is observable, on the one hand, between the other involuntary motions of fishes and their pneumogastric nerve, and on the other, between their other voluntary motions and the Motiferous portions of their Regular nerves; and if we follow these relations through the tribes of reptiles, birds and mammals we shall find this correspondence between the voluntary movements of each, and the development in them of the Motiferous nerves, equally well maintained. How much greater also is the relative size of the spinal cord —anterior and posterior columns collectively—of brutes than of Man has been already noticed—a circumstance which strictly corresponds with the greater force and energy of the voluntary motions as well as of the sensations, as contrasted with the intellectual operations, in the former than in the latter.

V. It would be reasoning in a circle to adduce the similarity in structure of the respiratory and Motiferous nerves, first, as as proof by analogy of the former being the channel of sympathy and passion or instinct, upon the presumption that the latter are that of volition, and afterwards as a proof by analogy of the latter being the channel of volition, upon the presumption that the former are that of sympathy and passion or instinct. Taking it as abundantly established however by other circumstances, that the office of the Motiferous nerves is what is here ascribed to them, it was quite allowable to bring forward this similarity as an argument for attributing an analogous office to the respiratory nerves; and it is not less so, assuming it as, if not proved, at least rendered highly probable by other circumstances, that the respiratory nerves do perform the office which has been assigned to them, to adduce this similarity as a further confirmation of the fact already established with respect to the Motiferous.

VI. The same remark may be extended to the further analogy between these two systems of nerves, in their liability to be so acted upon by the galvanic aura as to excite the contractions of the muscles—that, if other reasons exist for regarding the one as the channel of volition, while the other certainly is not so, this analogy may strengthen our opinion, that this other is the channel of some similar power; and again, if we have good reason, from other circumstances, to believe that the respiratory nerves convey sympathy and passion or instinct, while the Motiferous certainly do not, we may fairly employ this analogy to strengthen our belief that they convey some power of a similar description.

VII. The circumstances hitherto adduced afford presumptive evidence that the proper Motiferous nerves and the Motiferous portions of the respiratory and Regular nerves are the means by which volition is translated so as to act as a stimulus on the irritability of distant parts, but those still to be mentioned furnish conclusive evidence to this effect. It has been stated elsewhere that direct stimuli, mechanical or galvanic, applied to the trunks of the respiratory nerves, are found to excite certain actions which are usually sympathetic; but it is still more remarkably the case that such stimuli applied to the trunks of the nerves in question excite motions in parts, which under ordinary circumstances act only or chiefly in obedience to the will. Thus it has been abundantly established, that any such stimulus applied to the Motor oculi, (*a*) the Motiferous portion of the lower maxillary branch of the Trigeminus, (*b*) the Abductor, (*c*) or the Hypoglossal nerve, (*d*) while it produces no indications whatever of pain or sensa-

(*a*) Bell, Magendie, Mayo.
(*b*) Palletta, Bellingeri, Bell, Mayo.
(*c*) Bell.
(*d*) Müller, Panizza.

tion of any kind, calls into spasmodic or convulsive motion the muscles which these nerves severally supply; and that a similar stimulus, applied successively to the anterior or Motiferous roots of the Regular nerves, as they arise from the spinal cord, excites similar spasmodic or convulsive motions in the muscles to which these nerves respectively proceed, which succeed each other almost like the notes of a piano-forte, on running the fingers in succession over the keys. (*a*)

(*a*) These facts were established principally by Sir Charles Bell, (*Phil. Trans.* 1821 and 1822) Magendie, (*Journ. de Physiol.* 1822) Mayo, (*Anat. Comm.* 1822) and Fodera. (*Journ. de Physiol.* 1823) " I struck," says Sir Charles Bell, " a rabbit behind the ear, so as to deprive it of sensibility by the concussion, and then exposed the spinal marrow. On irritating the posterior roots of the nerves I could perceive no motion consequent on any part of the muscular frame, but on irritating the anterior roots of the nerves, at each touch of the forceps there was a corresponding motion of the muscles to which the nerve was distributed." This was one of the first experiments tending to establish the fact in question, and such experiments have been frequently repeated since with similar results; although it is fair to acknowledge that they have not been equally successful in the hands of every body who has tried them, and some persons have accordingly denied the conclusions drawn from them, and even attributed to Bell and the rest a deliberate intention to deceive. Magendie for one has always believed that the anterior roots of the spinal nerves are not exclusively Motiferous, (*Journ. de Physiol.* 1822) but only that " les contractions par les racines antérieurs sont en général plus fortes et plus complétes que par les racines postérieurs." (*Anat. des Syst. Nerv.* 1825) Similar to this is the opinion of Schoepf; (*Ann. Univ. di Med.* 1828) and we have already seen that by Bellingeri both roots are regarded as Motiferous, a conclusion which he adopted after numerous experiments, and a laborious train of reasoning. By Meckel, Rudolphi, Weber and others likewise, the doctrines of Bell and Mayo, although they have been in general admitted, are regarded as conjectural only. On the other hand Müller of Bonn, after a series of experiments made on Frogs, has recently adopted these conclusions with little or no qualification, (*Ann. des Sciences Nat.* 1833) the deservedly celebrated Arnold still maintains them, (*Icon. Nerv. Cap.* 1834) and Sir C. Bell himself, during a period of thirteen years after his first statement, had found no reason to desert or alter what Mr Walker calls " his borrowed and blundering hypothesis." (*Lecture read to the British Scientific Association assembled at Edinburgh in* 1834) Mr Walker's conclusions against this doctrine are founded on reasoning, not on experiment, having made only *one experiment* during twenty-five years' investigation of the subject, the result of which was similar to that obtained by Bell! He explains however the motions excited by irritating the anterior roots by the sensation thus produced acting as an indirect stimulus, in the manner lately mentioned, to motion; while the pain excited by irritating the posterior roots is considered, not as any indication of natural sensation, but as the result of the perturbation of a function of the highest class. There is perhaps no point in modern physiology on which greater virulence and illiberality have been displayed by the contending parties and their proselytes than on the subject of the particular offices of the several departments

A kind of gamut of this description—a melancholy one it is true — is sometimes run down by nature in tetanus, in which the successive occurrence of the gaping and fixed eye, the locked jaw, the elevated eye-brow, dilated nostril and sardonic grin, the hurried and inarticulate speech, the rigid head, arched spine and stiffened limbs, corresponds almost precisely with the gradual extension of the disease along the roots of the Motor oculi and Abductor, the Motiferous portion of the lower maxillary branch of the Trigeminus, the Motiferous department of the Facial, the Hypoglossal, and the Sub-occipital, Cervical, Dorsal, Lumbar and Sacral nerves. Nothing can be more beautiful or satisfactory than this lesson, taught us by nature, of the incorporation of these nerves into one system, the office of which is to excite muscles the ordinary stimulus to the action of which is volition, and of the total isolation of this system from the respiratory; since, while none of the reputedly voluntary muscles escape in this disease, none of those the natural stimulus to the action of which is sympathy and passion or instinct are affected, any further at least than these muscles obey likewise the stimulus of volition, and, being thus supplied at the same time with respiratory and Motiferous nerves, become in some degree involved in the affections of the latter.

VIII. The last circumstance, and one equally conclusive as the preceding, in favour of this doctrine is the fact, that, as any action ordinarily excited by sympathy and passion or instinct is intercepted by the division of the individual respiratory nerves, so any action commonly excited to volition is at once obviated by the division of the individual Motiferous;

of the nervous system, and the particular claims of individuals to the merit of priority in having pointed out these offices. With respect to the former part of the question the bulk of all substantial evidence is decidedly in favour of the views advocated above; and into the latter it appears worse than superfluous to enter, further than to remark that the controversy, in all its branches, seems to furnish an example quite unique in its way, of a series of accusations of plagiarism, and these couched frequently in the coarsest and most irritating terms, committed by authors, between whose opinions and those of the persons from whom they are charged with having borrowed, there is hardly a point of correspondence. When the term plagiarism comes to signify in many respects the flattest possible contradiction, then, and not till then, can Bell, Magendie, Bellingeri and Walker be fairly accused of having been guilty of it with respect to each other.

and consequently, if the common root of this system be destroyed—as has occurred in some memorable cases of a decay of the anterior columns of the spinal cord—all such actions are of course for ever lost. To omit the effects resulting from injuries of the individual Motiferous nerves, those of the impeded function of this system in general are beautifully illustrated by that form of palsy in which one side of the body no longer receives any stimulus from the Motiferous nerves, and the contrast therefore which the so-called voluntary muscles on this side offer to those on the other is particularly striking. In this disease, when perfect, contrary to what occurs in tetanus, the upper eye-lid of the affected side is pendulous under every effort to raise it; (Motor oculi) the eye-ball is stationary, as far at least as volition is concerned, not however from excess, but from defect of stimulus; (Motor oculi and Abductor) the jaw partially falls; (Motiferous portion of lower maxillary branch of Trigeminus) the eye-brow sinks, the nostril is pinched, and the mouth, yielding on the diseased side, is drawn over to the other; (Motiferous department of Facial) the speech is imperfect—again from defect, and not from excess of stimulus—and the tongue, while it is collectively pulled towards the sound side, has its tip, when protruded from the mouth, drawn towards the diseased side, the genio-glossus of this side yielding to the action of that on the other, so that the point of the tongue is moved, as it were, upon a pivot; (Hypoglossal) the head also, while it is pulled down towards the sound shoulder, is at the same time a little rotated towards the diseased side, from the yielding of the sterno-clido-mastoid muscle on this side to the action of its fellow; the spine, again, is curved towards the sound side, owing to the yielding of the muscles on the other; and the limbs of the affected side are flaccid and powerless. (Sub-occipital, Cervical, Dorsal, Lumbar and Sacral) In the meantime however the action of all the muscles, the natural stimulus to which is sympathy and passion or instinct, is quite unimpaired, except in as far as such muscles are liable to be acted upon likewise by volition, and consequently from the change which they undergo from the lesion of their Motiferous nerves, become less competent to act under the influence of their respiratory. No such change however occurs in those muscles which are furnished exclusively with respiratory nerves; nor does such a change always result from palsy, even in those which are furnished with both respiratory and Motiferous nerves, as prevents altogether the display of sympathy and passion or instinct—the shoulders, for example, as has been already mentioned, continuing to be raised by sympathy, when the respiration is obstructed, long after they have ceased to acknowledge the stimulus of volition.

It appears to be then, if not established, certainly rendered in the highest degree probable, that the proper Motiferous nerves, and the Motiferous portions of the Regular nerves, in conjunction with such of the respiratory nerves as are furnished with Motiferous filaments, all arising as above stated from the anterior columns of the spinal cord, are the channel by which the stimulus of volition is, by means of an intermediate action, conveyed to the organs on the irritability of which it acts as a stimulus; and with respect to the manner in which they so act as conduits of a direct or primary action in one part, so as to excite an indirect or secondary irritation elsewhere, nothing remains to be added to what was said respecting the operation of the respiratory nerves in a similar capacity. That it is by means of some molecular change effected in the nerve which operates as a conduit is quite consistent with the fact, that the distal extremities of the limbs are always affected before the proximal, in any general failure of the power of voluntary motion, and that cold applied to this distal extremity is often a very effectual means of producing the failure in question.

These then are the two indirect or secondary stimuli to irritability — Sympathy and Passion or Instinct on the one hand, and Volition on the other. *Of these the former, as originating in any organ of the body, and acting on any organ, could not have been represented in the Diagrams in the Title without confusion; but the latter, as originating always in the brain, and acting only on the Irritability of the voluntary muscles, is represented in these Diagrams by the cord extending from the uppermost wheel to the small wheel—supposed to revolve on a pivot of its own—in the centre of the main or lowest vertical* *wheel, and indicating, with this, the general faculty of Irritability.* The motion of this central small wheel indicates, it is true, one of the animal functions, and implies the previous motion, first of the main or lowest vertical wheel, as moved by the horizontal wheel; then of that interposed between this and the uppermost wheel; and lastly of this uppermost wheel—the first step to voluntary motion being, as we shall find in future, that irritation in which the organic functions consist, dependent principally on certain direct or primary stimuli; the second, sensation, dependent on irritation; and the third, thought, in that mode of it which constitutes volition, dependent in like manner on sensation. It was nevertheless proper to speak of voluntary motion in this place, since one of its immediate conditions is irritability, and it consists only in irritation—the laws of which we are now investigating; and it was in no degree necessary, as already observed, to enter at all into the conditions on which volition itself depends, in speaking of it merely as a stimulus to irritability.

CHAPTER VII.

ON THE EFFICIENT CAUSE OF MUSCULAR MOTION.

Irritation, Life or Living Action is the result of the mutual co-operation of more or fewer of the Stimuli just enumerated and of Irritability or Vitality; and it is in such irritation, modified according to the apparatus, or series of organs which displays it, that every primary and essential function of an organized being—respiration, circulation, deposition, absorption, assimilation and generation — consists. To these may be added, as consisting also in mere irritation, the function of voluntary motion, although this last is not, any more than sensation and thought, a primary and essential, but, as it were, an adventitious function, since it requires indirectly, as the two latter do directly, other vital properties besides irritability for its manifestation. Irritation then consists in primary vital action, sensible or molecular, modified according to the part which displays it. We can indeed conceive irritation, or mere vital perception, to exist, as elsewhere stated, without any action whatever; but we can never recognise it otherwise than by such action, so that, for all tangible purposes, the two may be identified. But the only universally acknowledged instrument of vital action is the Muscular fibre: it remains therefore a question of some interest to determine in what manner this Muscular fibre, under the application of a stimulus, is affected—in other words, what is the efficient cause of Muscular motion?

The investigation of this question must be premised by the remark that all that we can pronounce *a priori* upon the subject is, that the Muscular fibre undergoes in this case some physical change, since it is by such change alone that the mutual relations of the parts, solid or fluid, in contact with such fibre, can become altered; but whether this change consist in a shortening or elongation of itself, we are quite incapable of determining abstractedly, since either process is equally competent to explain the resulting phenomena. If a joint, for example, be held at rest, or a portion of fluid in a duct be kept stationary, by a certain balance being maintained between the length of those fibres which are inserted into the opposite surfaces of the one, or are situated on this and that side of the other, the former will be equally bent, whether those fibres which are attached to one surface be shortened, so as to *pull* it, or those which are attached to the other be elongated so as to *push* it in this direction, and the latter will be equally urged forwards, whether the fibres behind it are constricted, so as to act like a forcing pump, or those before it are dilated, so as to act like a sucking pump upon it. It was accordingly, in former times, a prevalent notion that the physical change which the Muscular fibre undergoes under stimulation was that of *active elongation ;* and this notion has been adopted in modern times by some physiologists, with respect in particular to the sphincter muscles; that state of diminished length, in which they are while closing the passages which they defend, being regarded as their state of quiescence, while that state of elongation, in which they are when these passages are open, is looked upon as their action. (*a*) Against this doctrine however, as applied as well to the sphincters as to any other Muscles, it seems sufficient to say that all are actually observed to become shortened, not elongated, under the operation of a stimulus stronger than those to which they are constantly and naturally exposed; and that the sphincters obey the same laws in this

(*a*) The idea of an active elongation of the Muscular fibre, as constituting the proximate cause of Muscular motion, seems to have been prevalent, at any rate with respect to the sphincters, before the time of Galen, since we find him formally contending against it. He nevertheless admitted the possibility of such an active elongation, which he called ἔκτασις, in opposition to an active contraction, which he called συστολὴ· (*De Motu Musc.* lib. i. c. 9) and the same supposed active elongation has been put in requisition in modern times, as the proximate cause of Muscular motion in general, by D'Hamberger, (*El. Physiol.* 1751) Barthez, (*Nouv. Méchanique* &c. 1798) Sprengel, (*Instit. Physiol.* 1819) and many others. This doctrine however is, in the case of the sphincters, pretty obviously unfounded ; and perhaps whenever such an elongation of the Muscular fibre appears to take place—as in the instance of the diastole of the heart, which sometimes, as recently removed from a large animal, recoils after contraction with a force sufficient to overcome every resistance which the hands can oppose to it—every thing may be ascribed to the elasticity, partly of the Muscular fibres themselves, but chiefly of the cellular tissue which is interwoven with them, and which, by the contractions of the Muscular fibres, had been thrown into a constrained position.

respect as other Muscles, may be inferred, among many other things, from what commonly occurs in tetanus on the one hand, and in palsy on the other. The sphincter ani, for example, is frequently so tightly constricted in the former disease, as not to admit the smallest clyster-pipe, and so dilated in the latter as to be incompetent to restrain the natural discharges; whereas, had the active state of the Muscle consisted in its elongation, it should, under the general excitement of the voluntary Muscles which occurs in tetanus, have yawned in a most unseemly manner, and under the defective stimulation of these Muscles, which takes place in palsy, it should have shrivelled up into nothing. (*a*)

We seem justified in presuming then that the action of Muscular fibre in general, visible or invisible, under excitement, is to shorten itself; but it does not on this account follow that all motion, produced by a physical change in the condition of such fibre, is the effect of its shortening or contracting itself—on the contrary it appears that, in not a few instances, very remarkable motions result, not indeed from an *active*, but from a *passive elongation* or relaxation of the Muscles. All the Muscles of the living body must be regarded as constantly in a state of some degree of contraction, as might indeed have been *a priori* presumed likely to result from the permanent application of many of the stimuli to which they are exposed—that of caloric for example, of the blood circulating in its vessels, and of other direct stimuli, as well as that of sympathy, and in many parts perhaps that of the reflex stimulus from the spinal cord excited primarily by

(*a*) It is quite true that cases occasionally occur of tetanus in which the sphincter muscles are not closed, and of palsy in which they are not opened. In such cases the affection is supposed by Bellingeri to originate in the posterior columns of the spinal cord and cerebellum, the office of which is, according to him, to effect the opening of the sphincters, so that when its influence is too great they will be forced open, when too little, they will not sufficiently resist the action of those Muscles which should close them. In the former case the affection should of course be combined with opisthotonos and a violent adduction of the limbs, since it is over the extension and adduction of the joints, as well as over the opening of the sphincters, that the cerebellum is presumed to preside. Admitting all this however, the action of the Muscular fibres of the sphincters may still perhaps be regarded as exclusively that of shortening themselves, the only peculiarity consisting in this, that when they are closed, the annular fibres, and when opened, certain radiated fibres may be presumed to be in operation.

sensation—(*a*) so that what is commonly understood by the term Muscular contraction, signifies only an increased degree of that state in which living Muscles constantly exist. But assuming this as the case, it follows that motion may sometimes result as well from a diminution of this contraction, as from an increase of it; and that if the finger, for instance, be held in a state of rest by the equal contractions of its flexor and extensor Muscles, it will be bent as certainly by the extensors contracting less than usual, so as to *allow* of this flexion, as by the flexors contracting more, so as to *effect* it. This doctrine, it will be observed, although, like the preceding, it refers the motion produced to an elongation of Muscular fibre, still differs essentially from it; since, while in the former the rest was represented as passive, and the motion active, in this the rest is regarded as active, and the motion passive. And that such diminished contraction of the Muscles is really the cause of some motions is sufficiently certain—

(*a*) This permanent action of the visible Muscles, as well as every kind of action of such as are invisible, was referred by Stahl and his immediate followers, as it still is by some authors, to their tonicity; a property which all Muscles were supposed to have in common, while the invisible Muscles, like those of the parenchymatous tissue, were considered, as before observed, to have this property alone, and therefore not to be Muscles in the strict acceptation of the term. The proposed distinction however between tonicity and the proper contractile property of Muscles—which is the same as that betweeen the contractility of Blumenbach and Chaussier, and the irritability of the one, and the myotility of the other—seems to be founded principally, as stated by Fordyce, (*Phil. Trans*. 1788) upon the fact that the operation of the former is perpetual, and upon the presumption that it does not require any particular stimulus for its exercise, while that of the latter takes place, it is said, only at intervals, and requires always some particular stimulus to excite it. The distinction however appears to be quite imaginary. At no period during life are the Muscles exempt for an instant from the action of stimuli; and the operation of tonicity, permanent as it is, " can signify only," as observed by Dr Hastings, " a mean state of contraction, and, as such, must necessarily be dependent on irritability"—that is to say, as displayed by muscles, the contractile property characteristic of these organs. It seems indeed quite superfluous, as already remarked, to admit of any hybrid property, as it were, between contractility and elasticity, with which indeed the so-called tonicity is very often confounded, as, among many others, by Bostock. " I conceive," he remarks, " that there is nothing in the phenomena that have been ascribed to tonicity, which may not be referred to the operation of elasticity." (*Syst. of Physiol.* 1824, p. 177) That it is not a distinct property is more than probable; but every view of the matter seems to justify us in identifying it, not with elasticity, but with the proper contractile property of the Muscular fibre.

for example, of the turning upwards and inwards of the eye-ball, of the pinching of the nostrils and of the falling of the jaw under depressing emotions, when the superior oblique Muscle of the eye is inadequate to resist the inferior, the levator labio-nasalis to oppose the elasticity of the nasal cartilages, and the masseter and temporal Muscles to counteract the weight of the jaw. The closing of the eye-lids and the falling forwards of the head from weariness are equally good examples of motion from diminished contraction of the Muscles, the levator palpebræ superioris in the former case, and the Muscles on the back of the neck in the latter, being no longer competent to antagonize respectively the orbicularis palpebrarum and the weight of the face. It is from the same cause also, that the angle of the mouth is drawn towards the sound side, the side of the head pulled down towards the sound shoulder, and the trunk curved in this direction, while the head is rotated towards the affected side in hemiplegia, the paralyzed Muscles having lost the power of preventing these several motions; and a similar explanation may be given of the chattering of the teeth from cold—the Muscles which naturally keep the jaw steady, deprived thus of a portion of one of their chief stimuli, acting now only at intervals—and of the shaking of the whole body, either in mental perturbation, or in the cold stage of fever—the several Muscles, under these circumstances, acting, not more, but less than they should do. And it appears to be in this respect that tremors of all kinds differ from convulsions. The motions of the limbs are often in both cases equally powerful; but they take place in the former from an alternating failure of the contractions of certain Muscles allied to palsy, in the latter from an alternating excess of such contractions, allied to spasm, the uniform and mutually neutralizing action of antagonizing Muscles, which is essential at all times to keep the parts at rest, being equally perturbed in both. Nor is it only the obvious motions which may thus result from a diminished action of Muscles, since many molecular motions also, such as those which give rise to blushing, the increased brilliancy of the eye, the turgescence of erectile organs, and every kind of increased secretion, are dependent on the same cause. Hence it has been presumed by some physiologists, that, while the action of Muscles really does consist in contraction, Muscular motion in general depends upon a diminution of this contraction—in other words, upon a loss of balance produced by the relaxation of certain Muscles the continued contraction of which was requisite to continued rest. But that this is not the case is obvious from the fact that a stimulus applied directly to a flexor Muscle produces flexion; and in doing this it must be supposed to have produced excitement in this Muscle, not to have withdrawn it from its antagonist—to have acted positively on the organ to which it was applied, not negatively on an organ with which it did not come into contact. Not only then is the only action of Muscles that by which they shorten themselves, but by far the greater number of the motions to which they give rise results from an increase in the action of those which move, and not from a diminution in the action of those which prevent motion.

The only obvious change which a Muscle undergoes under stimulation is a diminution of its length, with an increase of its thickness; and the two appear to be so precisely proportioned to each other, that its whole bulk remains quite unaltered. This is easily ascertained by placing a Muscle, while still possessed of its contractile property, under water, contained in a vessel the neck of which is drawn out into a capillary tube, when the height of the water in the tube will be found to be exactly the same, whether the Muscle be undergoing the most violent contractions, or be completely at rest. (*a*) The only question therefore is, how is this change

(*a*) Experiments of this kind have been conducted principally by Glisson, Swammerdam and Goddart, who represent the water as sinking during the contraction of the Muscles, appearing to indicate that Muscles lose in bulk, or, what amounts to the same thing, gain in density by this process; by Borelli, D'Hamberger, Prochaska and Carlisle, who describe it as rising, seeming to show that their bulk becomes increased, or their density diminished under contraction; and lastly by Soemmering, Barzelotti, Blane, Sprengel, Meckel, Dumas and Prevost, Mayo and others, who assert that it remains quite stationary, appearing to demonstrate that their bulk and density remain, as above assumed, unchanged. A great deal of the discrepancy in the results of these experiments may have arisen from the very unsatisfactory manner in which they have been often conducted; sometimes, for example, by thrusting the arm, as was done by Glisson and Carlisle, into a bucket of water—in which case of course no allowance could be made for the different quantities of blood which the limb might, under the different condiof figure in the Muscle—for this is the only change which it appears to undergo during contraction—immediately effected? The principal hypotheses which have been at different times invented to explain this appear to be resolvable into six; two of which hinge upon the presumption of some influx into the Muscle, two, upon that of some chemical change, and two, upon that of some mechanical change which it undergoes. The alleged influxes are those either of the supposed Nervous energy or of the Blood; the alleged chemical changes relate either to certain Gases which the Muscle is presumed to contain, or to its Fibrin; the alleged mechanical changes appertain either to the Globules of which its ultimate fibres are said to consist, or to its Fibres, large and small, themselves. A few words may be subjoined with respect to each of these hypotheses.

I. The first opinion, that the change in the figure of a Muscle, during its contraction, is effected by an influx into the vesicles of which its ultimate fibres were supposed to consist, of Nervous energy—which was believed to be capable of swelling them in one direction, while it shortened them in another—is the most ancient one upon the subject, and it has been adopted by some physiologists of our own times. (*a*) The latter have attempted to support it, not only by trying to demonstrate the really vesicular structure of the ultimate

tions of the rest and action of its Muscles contain, or the different states of the subcutaneous cellular tissue and skin; at other times, by placing under water a Muscular portion of a Frog or Eel, as was Barzelotti and Blane's plan—in which case of course no allowance could be made for any opposite change which one set of Muscles might be presumed to undergo during the contraction of their antagonists: nor was this source of fallacy obviated by employing, as Mayo did, the heart of an animal for this purpose, the heart consisting of two quite distinct Muscles, the action of which is alternate. Allowing for all this, it is only surprising that experimenters should have come so near one another in their results as they have done; and it may be fairly presumed that, had every source of ambiguity been avoided, the uniform result would have been the mean of the opposite conclusions, at which indeed, as it is, so many have contrived to arrive. Magendie remarks, " La question ne nous parait pas résolue, mais heureusement elle est peu importante."

(*a*) This was the surmise of Galen; and it has been supported by Descartes, F. Sylvius, Borelli, Hoffmann, Stuart and others, in modern times, as well as by many of those physiologists in our own day, who choose to identify this imaginary substantial Nervous energy with Galvanism.

fibres of the Muscles, and by laborious calculations of the necessary effects of their inflation, but by the observation, that the contractions of a Muscle always take place in a vibratory manner; (*a*) and this, they say, may be presumed to correspond with the intermitting jets into them of the Nervous energy, which is by many of the modern advocates of this doctrine identified with Galvanism. To omit however all the anatomical and mathematical parts of the question—the former of which are pretty certainly erroneous, and the latter equally certainly inapplicable—the circumstance of the vibratory character of muscular contraction may surely be, with as much likelihood, ascribed to numerous other necessary conditions of this contraction, as to successive jets into the Muscles of a supposed substance, of the existence of which there is neither proof nor probability. The only stimuli to Muscular contractions, which are conducted by nerves, appear to be sympathy and passion or instinct on the one hand, and volition on the other; and that these are not, any more than any other such stimuli, material, has been already abundantly insisted upon. They may excite the Muscles to undergo the change in question, but they do not immediately effect that change by pouring any thing into them. Besides how are we to conceive that Caloric and the numerous other direct stimuli to irritability operate in exciting Muscular contraction, if it be by the influx into the Muscles of nervous energy that it is effected; and how is it to be explained, upon this principle, that Muscles continue to contract, upon the application to them of these direct stimuli, during sleep or coma, and even after apparent death, as well as after all their principal nerves have been tied, after the brain has been removed, or after the Muscle itself has been separated from the body, when of course every avenue, by which a supply of the supposed nervous energy can be presumed to be furnished, must have been cut off?

II. The second influx which has been brought forward in explanation of the proximate cause of the contraction of Muscles is that of Blood, which is presumed to pucker up the

(*a*) Roget; (*De perpetua Fib. Musc. Palpitatione,* 1760) Wollaston; (*Phil. Trans.* 1810) Laennec. (*De l'Auscultation Médiate,* 1819) &c.

Muscular filaments by the turgescence which it occasions in the contiguous blood-vessels. (*a*) The principal arguments in favour of this hypothesis—in addition to the established fact that the force and celerity of the contractions of Muscles in all animals, at all ages, and under every variety of circumstances, are in the direct ratio of their vascularity—are, in the first place, that such contractions, on the application of any stimulus, are found to become stronger and quicker upon increasing the quantity of the blood sent in a given time to the Muscles; (*b*) secondly, that the force and celerity of these contractions are diminished by diminishing the rapidity of the circulation through the Muscles, as is supposed to be proved by the peculiar arrangement of the arteries going to the extremities of the tardigrade animals, as the Sloths and Lories, which is such, it is believed, as must retard the flow of the blood, and may thus explain the feebleness and sluggishness of their motions; (*c*) and thirdly, that these contractions are altogether prevented, after a time, by tying the arteries going to a limb, while obstructing the larger nerves is, as has been already explained, comparatively nugatory in this way— (*d*) a circumstance which can be accounted for, it is imagined, only on the presumption that the former operation obviates, while the latter does not, the jets of blood into the Muscles in which the proximate cause of Muscular motion is conceived to consist. Against all these arguments however, supposing the facts to be as is stated, it might perhaps be sufficient to say that, the blood being one of the most powerful stimuli to the contractility of Muscles, it might easily be supposed that an increase, a diminution or an exclusion of this fluid, would produce a corresponding effect on their contractions, without the inference that it was upon any direct influx of blood into the Muscles that these contractions immediately depended. But against the second and third of these arguments it may be alleged further, that the one rests

(*a*) This hypothesis has been maintained principally by Swammerdam, Baglivi, Cowper, Fowler, Ward and Prochaska.

(*b*) This fact was observed by Fowler, while engaged in exciting the contractions of the Muscles of a Frog by electricity. (*On Animal Electricity*, 1798)

(*c*) Sir Anthony Carlisle. (*Croonian Lectures*, 1800-1805)

(*d*) Stenon, Cooper, Boerhaave, Brunn, Brodie &c.

on the presumption of facts which have never been made out, and that the other admits of an explanation even more satisfactory than that founded upon an exclusion of a natural stimulus. For, with respect to the alleged diminution in the action of muscles, produced by retarding the flow of blood, it remains to be proved, first, that the peculiar distribution of the large arteries of the limbs of tardigrade animals is such as to retard the circulation of the blood through them; secondly, that the motions of these animals are really, under equally favourable circumstances, weaker and slower than those of others; and thirdly, that, if both these facts are as stated, the one is the cause of the other. The peculiarity alluded to consists in this, that the humeral and iliac arteries of some of the bradypoda are found, like the internal carotid arteries of some browsing animals, to be very much subdivided in their course; and these subdivisions will unquestionably, by increasing the collective calibre of the passage for the blood, retard its course *in this particular part*—but if these arteries are afterwards re-united as before, previously to being distributed into the branches which supply the muscles, it is manifest that the original celerity will be restored. Again, although the Sloth and other reputedly tardigrade animals when crawling along a flat surface—in which case their long claws are an encumbrance to them, and every feature of their structure is ill adapted to a rapid progress—move sluggishly and with difficulty, is such their motion when hanging by their claws from the lower part of the branches of trees, agitated by winds and storms, and under circumstances in which many animals, the fleetness of which on even ground is so superior, could not move at all? Further it seems to be absurd to connect the idea of essential force and celerity of Muscular contractions with any distribution of the arteries, as if the motions of the same animal were not strong or weak, quick or slow, according to many circumstances, while the distribution of its arteries remains unchanged; and as if the course of these arteries were not often materially altered, without entailing upon an animal any general peculiarity in these respects—without converting, as it has been idly attempted to do by these means, the Sloth into the Spaniel, or the Spaniel into the Sloth. (*a*) Every thing relating to this argument therefore appears to be objectionable; and with respect to the last argument on the same side, that tying the arteries of a limb after some time quite destroys the contractility of its muscles, this may be easily explained, as elsewhere stated, without the presumption that it is in any direct influx of blood that the proximate cause of Muscular contraction consists. For, not to recur to the want of the proper supply to the Muscles, in this case, of one of their most essential stimuli, we must remember that it is by the blood that the nutrition of the limb is maintained, that its ganglionic nervous tissue ceases in this case to be renewed, in proportion as it is exhausted, and that there is consequently, after a time, a cessation of irritability—a necessary condition of Muscular contraction. (*b*) Nothing of this kind takes place when only the

(*a*) It is astonishing how persons who are aware that one artery after another, as well in the human body as in that of brutes, has been tied, and every possible variation in the character of these vessels, as ministering to the several organs, has been thus produced, without any, or with very inconsiderable effects on the functions of these organs, can still continue to vapour about the subdivisions, angles, degrees of tortuosity and so forth, of particular arteries, as influencing in any remarkable degree the functions of the parts which they respectively supply. The doctrine is not quite obsolete that, as the apparent inactivity of the Sloth depends upon the subdivisions of the main arteries of its limbs, so the usually greater energy of the motions of the right arm of Man, than of the left, arises from the greater concentration of the artery by which it is primarily supplied, without regard to the fact that the motions of the right leg and whole right side of the body are in general as much more energetic than those of the left, as the motions of the right arm. There are many too who still cling to the belief that an artery which, like the renal, arises from the aorta at a right angle, or one which, like the internal carotid, proceeds in a tortuous manner to the place of its destination, receives less blood, or conveys it with less impulse, than it would have done under different circumstances. It is quite time that all this trash, irreconcileable as it is with reason, and inconsistent as it is with numerous recently established facts, should be abandoned.

(*b*) Dr Elliotson attributes the " palsy," which results from this operation, principally to the want of nourishment of the motiferous nerves, so that they can no longer act as vehicles of the accustomed stimulus. (*Trans. of Blumenbach's Instit. Physiol.* 1820) But it is not merely " palsy"—which consists only in a defective conveyance of such indirect stimulus—but a total want of capability on the part of the Muscle to obey any stimulus whatever, indirect or direct, which is the consequence of the operation in question—a loss, not of the power to excite, but of the faculty of being excited. If its effects were on the motiferous, and not on the ganglionic nerves, how could it happen that dividing the larger nerves of a limb are divided, which sufficiently explains why the retention of Muscular contractility in the part is quite compatible with this operation. And that it is by impeding nutrition, and not by obviating any presumed jets of blood, as immediately instrumental to the contraction of Muscles, that this tying of the arteries operates, is rendered further probable by the fact that if the veins, as well as the arteries, are included in the ligature, the contractility of the part is preserved for a longer period than if the arteries alone are tied. (*a*) It is very easily understood that, from the blood being retained in the capillary tissue—the immediate instrument of nutrition — longer in the former case than in the latter, this process will continue for a longer time uninterrupted ; but it is much less intelligible how any retention of blood in this tissue should be favourable to Muscular contraction in the manner above supposed. It may be remarked further that the retention of their irritability by the several organs after apparent death, is found to be, *cæteris paribus*, proportioned to the quantity of blood which they contain—a fact which is much more easily reconcileable with the presumption that this blood still ministers in some degree to nutrition, than that it effects—now that the larger arteries are all for the most part empty—any such jets as have been imagined. But, besides these objections tending to neutralize the several arguments in favour of the hypothesis in question, it may be alleged as positive evidence against it, that, supposing the blood to reach the Muscle in action from the contiguous parts, it is quite inapplicable, like the doctrine of an influx of nervous energy, to explain the contractions of a Muscle—on the application to it of the requisite stimulus—after its removal from the body, when every such supply of blood has been intercepted, and that it is quite inconsistent with the fact that the bulk of Muscles, during their contractions, appears to be unenlarged; and whether this be the presumption, or whether it be supposed that the blood merely shifts from one part of the Muscle to

former does not produce it? It does produce palsy, but that is a very different affair.

(*a*) W. F. Edwards ; (*De l'Influence des Agens Physiques*, &c. 1824) Dr J. P. Kay. (*Edinb. Med. and Surg. Journ.* 1828, *and on Asphyxia*, 1834) another, it is quite irreconcileable with any of the generally acknowledged powers of the circulation. It may be urged indeed that, conceding the independent action of the arteries, large and small, we have a power quite competent to produce the jets in question, whencesoever the blood may come; but allowing the greatest possible degree of latitude to this presumed independent action of the arteries—an action which, in the case of the larger arteries, is pretty certainly altogether imaginary—we must still, if this hypothesis be admitted, come to a point where all plausibility seems to desert us. For it must not be forgotten that the independent action of the larger arteries, if they have any such action, as well as that of the parenchymatous tissue, itself consists in Muscular contraction; and whence can their coats be presumed to get the necessary jets of blood? If we say, in the former case, by their vasa vasorum, we still imply the Muscular contraction of the latter; so that we are driven at last to the presumption that the blood, in the process of effecting Muscular contraction, moves spontaneously, and that through filaments confessedly much too small to admit it! The muscular parietes of a capillary artery must themselves be destitute of blood-vessels.

III. But if the Muscular fibre acquire nothing new during its contraction, in the way either of Nervous energy or of Blood, by what changes, chemical or mechanical, in its substance is this contraction effected? It is hardly necessary to show that it is not, as was at one time supposed, (*a*) by the expansion of the Air which the Muscle contains—like that which occurs in a shrunk bladder upon the exhaustion of the circumambient atmosphere—that this takes place; and the doctrine that it depends upon a kind of effervescence or explosion, arising, as some have imagined, (*b*) from the combination of certain inflammable Gases or other matters contained in the Muscles, with the Oxygen or other matters constantly brought to them with the blood—a combination which is effected by the nervous energy conveyed to them at the requisite periods—cannot surely require any serious refutation. It may be allowed, like the two former, to sink quietly into

(*a*) Boyle, Keill.

(*b*) Willis, Mayow, Girtanner, Richerand &c.

the vault of all the Capulets, in company with all the rest of that chemical mummery which was at one time unfortunately so fashionable in physiology.

IV. Nor is the hypothesis that Muscular contraction depends upon the coagulation of the supposed Fibrin of the Muscle, dependent upon some change in the proportion of its elements, (*a*) at all more happy, or more worthy of a lengthened examination. It has been already weighed in the balance incidentally, and found wanting. Such coagulation of their fibrin is pretty certainly the cause of the rigidity of the Muscles after death: but how different a process this is from their contraction during life, is clear from the fact that the former does not take place while irritability is still energetic—in other words immediately after apparent death, but only when this is already exhausted—from two to eighteen hours afterwards; and from its occurring as remarkably—perhaps even more remarkably, like all dead processes—in weak subjects than in strong ones. If this hypothesis respecting the proximate cause of the contraction of Muscles were true, it would cease to be a question whether the stiffness of the joints after death depended, in any given case, on the ordinary *post mortem* rigidity, or on spasmodic contraction—a question sometimes of very great interest—since it is obvious that no distinction would exist between them. But the circumstances of the two are in every respect different, and their efficient causes must therefore be presumed to be so too. Living Muscles contain, in all probability, no fibrin; and it is fortunate for us that they do not, since if they did, it must—for it would not otherwise be fibrin—coagulate, and such coagulation, so far from effecting, would be incompatible with Muscular contraction.

V. There remain only the doctrines of some mechanical changes in the Muscles to explain their contraction; and according to some physiologists, it consists merely in an increased degree of that attraction by which the particles of matter of every kind are kept in contact. (*b*) This explanation however, unless it be so far modified as to allow that the

(*a*) Humboldt, Cuvier, Rudolphi &c.
(*b*) Haller, Cullen, Fordyce &c.

increased attraction takes place in one direction only, and that, in proportion as it is diminished in another, is quite inconsistent with the fact that the volume of a Muscle is not altered during its contraction. But such a modification has been attempted ; and the whole thing has been referred to the Globules, of which the ultimate fibres of Muscles are supposed to consist, which are presumed to become changed, by some peculiarity in this attraction of cohesion, either in their figure, or in their relations to each other in this process. It has been imagined, that, whereas when the Muscles are in a state of rest, or contracted only to a degree which we consider as their rest, these globules are rather elongated in the direction of the fibres of the Muscle than spherical, and the amorphous matter between them is copious, so when they are in action, the globules are brought each to the figure, not only of a sphere, but even of a compressed spheroid, and the previously interposed amorphous matter is squeezed out from between them. (*a*) The principal objection to this doctrine—to say nothing of its offering no explanation of this peculiarity in the operation of the ordinary cohesive attraction—is that it is a mere hypothesis, without any substantial evidence in its favour. It is perhaps adequate to explain the phenomena in question, but it is time enough to inquire, according to the admirable rule of Newton, already spoken of, whether any doctrine " phænomenis explicandis sufficiat," when we have adduced some reasons for believing that " vera est;" and that this doctrine cannot possibly be so, if the objections to the globular structure of the Muscles already alluded to be substantiated, is obvious.

VI. The last, and perhaps the least objectionable explanation of the proximate cause of Muscular contraction is founded on the presumption that it depends upon the bending at more acute angles—not as dependent on any influx of blood, but spontaneously—of the larger Fibres of the muscles, in conjunction with a similar bending, first of the smaller fibres of which these larger fibres are composed, then of those of which this second set consists, and so on till we come to the primitive fibres, which likewise — as perhaps

(*a*) Sir Everard Home.

always in some degree tortuous—are all bent in the same manner. (*a*) In this way it is attempted to explain how it happens that, while a Muscle in general becomes shorter during its action, in proportion to the intensity of this action, it may act more or less forcibly with precisely the same degree of shortening—as in the instance of closing the jaws more or less firmly—as well as that it may sometimes act violently without any diminution of length at all—as is frequently the case in cramp. For it must be obvious upon reflection, that, although the more zig-zag direction of those fibres which run parallel with the general course of the Muscles—as we may, for the sake of simplicity, suppose them all to do to begin with—must tend to shorten this organ, a similar zig-zag direction of those fibres which run diagonally with respect to the general course of the Muscle—as must be the case with all those of which the first set of fibres consists, upon the direction of this set becoming zig-zag—will have no effect in either shortening or lengthening it, while the same zig-zag direction of those fibres which run transversely with respect to the general course of the Muscle—as many must do in the course of these repeated bendings within bendings—must tend to render the Muscle longer instead of shorter than before. Hence it is easy to understand that, so long as the chief seat of this bending is in those fibres which run parallel with the course of the Muscle, the action of the Muscle will shorten it; but that, while other fibres may be called into action without any further diminution of its length, so when the latter fibres are the chief seat of the bending, or when the bending of those fibres which tend to lengthen the Muscle is such as to neutralize that of those which tend to shorten it, no change whatever in its length needs take place. This zig-zag direction, as well of the minute filaments, as of the larger fibres of the Muscles during their contraction, appears to have been verified by microscopic observations; and the theory which ascribes the contraction of Muscles to this cause does not seem to be liable to any of the principal objections which have been urged against those which have preceded it. It implies no direct connexion with the cerebro-spinal system of nerves,

(*a*) Dumas and Prevost, Dutrochet &c.

no immediate influx of blood, no increase in the bulk of the Muscle, no presence of principles or ingredients which it pretty certainly does not contain; and it further explains more satisfactorily than any other doctrine, the increase of mechanical cohesion with which Muscles, during their contraction, are well known to be endowed. (*a*) There is, it is true, sometimes slung to this theory an appendage which, however favourable we may be to it in other respects, it is quite unnecessary to adopt—namely, that this zig-zag course of the fibres and filaments of a Muscle is owing to the approximation of the transverse nervous branches with which they are supplied, and which encircle them, it is said, in the manner of a loop, precisely at those points where they are to be bent during the contraction of the Muscle; such approximation of the said nervous branches being by virtue of galvanic attraction, on the transmission to them of the galvanic aura by the main trunks. All this appears to be gra-

(*a*) It has been abundantly established by Bernouilli, Reaumur, Spallanzani and others, that a Muscle during its contraction easily sustains a weight which would have instantly ruptured it, and easily resists the entrance of sharp instruments which would at once have penetrated it, in a state of relaxation. It is obvious therefore that the weight which a Muscle will support, or the impulse which it will repel after death, can be no measure whatever of the force which it is capable of exerting during life, regulated as this force is by a vital change, of the degree of which, in any given instance—as determined by the irritability of the Muscle on the one hand, and the stimulus acting upon it on the other—we can form no sort of estimate. The mere physical cohesion of a Muscle is perhaps as great after a long walk as before it, and when we are under the influence of a depressing, as when under that of an exciting emotion; and yet how totally powerless is it in the former cases, and how powerful in the latter! If vitality renders us almost independent of chemical science, in determining the composition of the organized body, it renders us almost equally independent of mechanical science in calculating the power of its actions; and we may form some idea how difficult is the problem respecting the force of Muscular contraction, from the discordancy of the solutions given of it by the ablest mathematicians, Borelli for example representing the force of the ordinary contractions of the heart as equal to 180,000 lbs. and that of those of the stomach as equal to 261,186, while by Keill the force of the former is reduced to 5 oz. and by Astruc that of the latter to 3! It is unnecessary to say that the principles upon which these calculations were founded were in the different cases very different; but their result is sufficient to show that little or no greater reliance can be placed upon any other data, than upon their degree of mere physical cohesion, in determining the force of the contractions of Muscles. The fallacy however of these pursuits is at present pretty generally admitted by physiologists—pity that that of chemical doctrines, in their application to physiology, is not equally obvious.

tuitous, and a great part of it untenable, even admitting the simultaneous extrication of electricity or galvanism in every instance of Muscular contraction. Without this codicil however it is probable that the doctrine last stated gives the best explanation hitherto offered of the mere mechanism of Muscular contraction; but at the same time it must be continually kept in mind that there is still a wide unoccupied gap between simple irritation, or the perception by a Muscle of a stimulus, and the assumption, by its fibres and filaments, of this zig-zag direction, as a consequence of it. In what way the former gives rise to the latter, if indeed it do so, is still totally unexplained, and in all probability, as a process entirely *sui generis*, is totally unsusceptible of explanation—at any rate, a knowledge of the mere mechanism of Muscular contraction, were it attained, would throw no more light on this process, than a description of the wheels and motions of a carriage tends to illustrate the nature of the power by which it is propelled forwards.

CHAPTER VIII.

ON THE VARIOUS MODIFICATIONS OF IRRITATION.

SECTION I.

On the different Degrees of Irritation.

FROM what has been above said of the nature of Irritability and Irritation—or Irritability called into action by the requisite stimuli—it will readily appear that the practice of speaking of Irritability or Vitality as of something substantial, something which may be *per se* accumulated, diminished, exhausted, is erroneous; but the error amounts merely to this, that, for shortness' sake, we speak of the *property* as directly so affected, whereas it is in fact the *substance* of which this property is the attribute that is so, the property however manifesting of course corresponding changes, since the degree of Irritability in any part will necessarily be in the direct ratio of the quantity and quality of the irritable matter which it contains. (*a*) But the ganglionic nervous tissue—assuming this as the immediate seat of the property in question—is of course continually renewed and consumed, like all the other tissues of the body, by molecular processes, the seat of which is the parenchyma; which thus effects incessant changes in this tissue, not only as interwoven with the substance of every other organ, but also as entering into the composition of the minute vessels of which itself consists. While the capillary arteries therefore are continually depositing new portions of this tissue from the mature fluid which they contain, the radicles of the veins and lymphiferous and chyliferous vessels are equally continually breaking down and conveying away

(*a*) "We are not to imagine it (Irritability or Excitability) as an *isolated force*, merely attached to organisms, and objectively different from their organic constituent matter, capable of change, of exaltation or diminution, without a simultaneous change in that matter. On the contrary, we are to regard it as a *quality*, founded on the specific state of the organic matter and the organization, (organism) and altogether dependent on these." (*Tiedemann's Physiology, by Gully and Lane*, 1834, sect. 557) into the crude fluids other portions of it; and so long as the various stimuli to which these two sets of vessels are exposed are natural—in other words, so long as the excitement of any given part is neither greater nor less than it should be —the one process precisely balances the other, and neither a deficiency, nor an accumulation of this tissue, nor consequently either a diminished or increased display of Irritability or Vitality is the result. Deposition however is a process to which inordinate excitement—however favourable it may be to it indirectly, by the subsequent collapse which it occasions—is directly prejudicial, the amount of the matters deposited being, generally speaking, in the *direct* ratio of the quantity of blood contained in the capillary arteries; and this will of course be greater as their excitement is less. On the other hand absorption is, like all the other processes of the living body, directly favoured by inordinate excitement, the amount of absorbed matters being, generally speaking, in the *inverse* ratio of the quantity of fluid which the radicles of the veins and of the lymphiferous and chyliferous vessels contain; and this will necessarily be less as their excitement is greater. This is not the place for attempting to establish these facts at any length: it is sufficient to mention at present, in support of the above propositions, the mere circumstances of deposition being promoted by plethora, and of an excess of it being a constant consequence of that diminished Irritation of the capillary arteries which constitutes inflammation; while absorption, on the other hand, is promoted by depletion, and by the increased Irritation produced by pressure, friction and stimulating applications of all kinds. Now, upon these principles, what must be the consequence of a greater or less excitement than natural of any part, with respect to the condition of its ganglionic nervous tissue, and consequently with respect to its subsequent manifestation of Irritability or Vitality? The ordinary deposition, or process of renewal, is incompatible, as has just been said, with more than the ordinary Irritation of the depositing vessels; while the ordinary absorption, or process of consumption, is, not only compatible with, but favoured by a preternatural Irritation of the vessels employed in this process. Hence it must result that every greater degree of excitement than natural will be followed by a proportionate deficiency of irritable matter—at once from defective deposition and excessive absorption—and a correspondent failure of Irritability, (*a*) and that every less degree of excitement than natural will be followed by directly opposite effects. (*b*) It is quite unnecessary then to receive as an ultimate fact, as is usually done, the axiom that *Irritability is diminished by every excess, and increased by every deficiency of Irritation,* when it is susceptible of so simple and satisfactory an explanation. The fatigue experienced from over-exertion, which consists merely in an incapacity, owing to defective Irritability, to obey the usual stimuli, and the increased energy acquired by rest, which implies nothing more than a preternatural susceptibility, owing to excessive Irritability, of the action of such stimuli, are familiar illustrations of this law of the animal economy—a law which extends equally to all instances of Irritation, whether the action which has been excited be sensible or molecular, and whether the function involved belong to those called organic, or to those called animal, in the former of which Irritation is all in all, and of the latter of which it constitutes a fundamental and essential part.

It is thus that we explain the comparative immunity from the effects of intense heat, of air vitiated by various deleterious gases, or by certain contagious or infectious miasms, of some unwholesome kinds of diet, and of certain poisons, of violent mental emotions, and of numerous other agents at first highly prejudicial, acquired by long or frequent exposure to them; and it is from the same cause that we cease to experience any good effects from the most wholesome aliment, from the most salutary medicines, or from any other agent however beneficial at first, in proportion as the system becomes accustomed to them. Among the most striking examples of this diminution

(*a*) "It seems probable," says Mr Walker, "that the nervous matter is actually wasted during muscular and other excitement." (*Nervous System*, 1834, p. 527)

(*b*) Valuable as were many of the doctrines of Brown, he was manifestly wrong in his principle that Irritability, or as he called it, Excitability, was an entity imparted to every living being in a certain proportion at birth, and that when his stock was exhausted, there was an end of him. No arguments can be requisite to disprove this untenable hypothesis.

of Irritability from inordinate Irritation, is that diminished liability to certain diseases, which results from their having once occurred; some, like rubeola, scarlatina, varicella, variola and pertussis, affording an immunity in general for the remainder of life, others, like the plague and yellow fever, for years, others, like ordinary typhus fever, at least for weeks, and perhaps almost every disease for some time, longer or shorter, in proportion to the character and intensity of the Irritation which it occasions. In general it is only with respect to that particular stimulus by which the inordinate Irritation was in any given case occasioned, that the Irritability is diminished; a fact which may be easily explained, when we reflect on the almost infinitely numerous modifications of this property, any one of which alone may be readily supposed to be diminished or exhausted by one particular character of Irritation. Thus the nostrils which have become almost callous to the stimulus of snuff, are still affected as violently as ever by ammonia; and the sore which is no longer benefited by a lotion which has been for some time employed, improves rapidly under a new, although perhaps, abstractedly, a less powerful application. In some cases however one kind of Irritation may diminish or exhaust the Irritability, not only with respect to that particular stimulus by which itself was excited, but with respect to more or fewer others; and it is thus that we must account for the immunity resulting, it is said, from the Irritation produced by belladonna, with respect to the exciting cause of scarlatina, and from that produced by vaccinia, with respect to the contagion of variola: nor is it improbable that many other comparatively mild kinds of Irritation may in future be found capable of destroying, in a similar manner, the susceptibility of numerous other equally destructive diseases. On the other hand the increased susceptibility of the action of various agents, resulting from diminished Irritation, is very well illustrated by the baneful effects of even the most ordinary stimuli upon persons from whom such stimuli have been for some time withdrawn. Every body knows how violent are sometimes the effects of the slightest heat on those who have been long exposed to cold, and of the smallest quantity of the most simple aliment, on those who have suffered from long abstinence; and if frequent exposure to the exciting causes of diseases, and still more the actual occurrence of such diseases, renders the body comparatively exempt from their influence, a long continued freedom from such exposure is not less effectual in increasing the liability to be affected by them the first time we are thrown in their way. Upon the same principle however, if we are more likely to be injured by deleterious agents, we are at the same time more likely to be benefited by such as are salutary, from a long disuse of them.

It will hence appear how very materially the law of Irritation now under consideration must operate in keeping us, generally speaking, under almost every variety of circumstances, in a comparatively steady course; and how effectually it must tend to counteract, on the one hand, the influence of many agents calculated to do us harm, and, on the other, every attempt on our part to work miracles on our constitution, and to render ourselves invulnerable and immortal. If, in proportion as we are subjected to the operation of deleterious agents, they lose a part of their ascendancy over us, and the more carefully we recede from them, the greater is the effect which we experience from them upon every accidental exposure, and if again any beneficial agent becomes inert in proportion to the frequency of its application, while it acts the more powerfully the more rarely we have recourse to it, how comparatively independent must this make us, in the long run, of almost every change of condition; how satisfactorily does it explain the fact, otherwise so inexplicable, that Man has in all ages existed, and does still in all places exist, nearly or quite the same, in all his physical characters, as at the first; and how clearly does it demonstrate the futility of a great part of the precepts of physicians, in regard to many practices which they are pleased to pronounce absolutely and constantly prejudicial or the reverse! Such is the levelling influence of this law, that the greater number of those deleterious powers which, had they the same effect upon us on frequent repetition as they have the first time we are exposed to them, would soon overwhelm us with destruction, and most of those salutary agents which, did they continue after a time to affect us as they do before we are accustomed to them, would soon exalt us beyond our sphere, become in a short time comparatively inert in bringing upon us either evil or good; and if it do not prevent us from being depressed or raised for a time by numerous contingencies, it effectually preserves us from undergoing from them any very remarkable permanent alteration. Man is found in every climate, in every condition, from that of the most abject penury, to that of the most luxurious ease, and feeding by turns on every thing which comes in his way; and what must have been the consequence, had nature not implanted in him a faculty which prevents any thing from being either very bad or very good for him, except for a time, while it renders every thing, sooner or later, subservient to maintaining him in equilibrio, and to keeping the Esquimaux and the Negro, the rustic and the citizen, the beggar and the king, the same "poor, bare forked animal" that he was originally created? It is this faculty in virtue of which use becomes, as it is so generally called, second nature; and this faculty, proportioned as it appears to be in all animals to their opportunities of tampering with themselves, is greater in "poor unaccommodated Man" than in any other. Not only is he much more exposed in his various pursuits to innumerable evils than any other animal, but he alone of all animals is continually allowing the artificial dictates of reason to interfere with the natural impulses of instinct in the management of himself, and he is consequently much more frequently the victim of disease than brutes. But a great part of what would otherwise be the effect of his malpractices is still constantly counteracted by this safety-valve within him, which, neutralizing, as it does, nine-tenths of all the bad consequences which we should anticipate from *a priori* reasonings, laughs to scorn many of the solemn denunciations and injunctions of those who indulge in them, and, by opposing every day's experience to their conclusions, has always rendered, and must continue to render them suspected and ridiculous. (*a*)

(*a*) It would be amusing, if it were not melancholy, to notice the infinite attention with which some persons are accustomed to regard the veriest trifles in the care of themselves, and the ardent hopes which they entertain of incalculable advantages from some established system of self-management; and it would be laughable, if it were not disgusting, to find such persons continually encouraged

What has preceded appertains chiefly to certain more or less permanent changes in the degree of Irritability, arising

in their delusions by those who ought to know better. A man observes that by going for once into cold water he derives from it additional vigour both of body and mind, and he imagines that he can make himself impregnable and almost immortal by persevering in its use ; but alas ! if he shall accustom himself to it for only a week, he will find himself less invigorated by its employment than debilitated by its disuse. In like manner a few glasses of wine to one unused to them are no doubt vastly refreshing ; but he who would perpetuate their grateful influence from day to day *may* descend into habits of drunkenness, but cannot rise into preternatural health, since it is only by exceeding custom that the body can be for a time excited, and it soon again finds its level, if it do not sink below it. We may accumulate artificial wants, but we cannot make ourselves what nature has not made us ; and it is written, Man is not made to be exempt from maladies, or to last for ever. The very care to preserve health is, by increasing susceptibility, the indirect cause of disease ; the more rigid has been the observance of regimen, the more pernicious will be the slightest aberration from it ; and one act of intemperance, or one deviation from a settled plan, shall do more mischief to the man of rule, than repeated irregularities to the habitual rake, since, in the latter case, what they gain in frequency they lose in force. Of a similar nature is perhaps in all things man's imaginary power over his own constitution. As he resolutely recedes from one hastener of destruction, he inevitably approaches another ;

> " Gross riot treasures up a wealthy fund
> Of plagues, but more immedicable ills
> Attend the lean extreme ;"

or if he shall be content to " use all gently"—as nature is a glutton in nothing—he will probably, like other moderate livers, have his share of sickness and sorrow in this world, and, when his time cometh, be called upon to leave it for another. Nevertheless, if one should listen to the whining of philosophers, poets and physicians from time immemorial, one would be led to believe, that, under certain circumstances there could be no disease, and under others, no health ; that he who lived in the country, on the produce of the ground which his own hands had tilled, without ambition, and almost without passions, would live on so for ever ; while the miserable inhabitant of cities, in the midst of vitiated air, unnatural hours, " fresh cups, soft beds, sweet words," would enjoy a mere ephemeral existence, and sink into an early grave, overwhelmed with all manner of disasters. But what is the fact ? The latter is perhaps less robust and ruddy than the countryman, but not less healthy ; and if he have not so much strength, has still quite as much as he has occasion for, can bear many fatigues under which the rustic would sink, and, in all likelihood, lives equally long and equally happily. " Toil and be strong," says the poet ; but we must distinguish health from bodily power, as we distinguish the accurate balancing of a pair of scales from the weights which they sustain. Our women " toil not"—at least those of the middle and higher classes—and yet they generally contrive to outlive us. The fact is that the greater part of what is commonly advanced on these subjects, however well intended, is little better than cant ; and the permanent effects commonly attributed to country air, from causes which, owing to their operation being slow and progressive, give rise to no secondary effects. But an important consequence of the fact lately laid down as an axiom remains to be mentioned, with reference to such changes in the degree of Irritability as are brought about suddenly. In this case, upon the Irritability being diminished by excessive Irritation, the part subsequently—owing to one of the conditions of its action having been lessened—undergoes of course diminished Irritation from the usual stimuli; but as diminished Irritation is, according to the same axiom, a cause of increased Irritability, the part afterwards—owing to this condition of its action having been now increased—undergoes of course increased Irritation from the same stimuli; and its action thus vibrates, as it were, on either side of the line of health, till the healthy action is at length restored. And if this line of action be thus set up by a primary diminution of Irritability as the result of excessive Irritation, it must be equally established by a primary increase of Irritability as the result of defective Irritation, the only difference consisting in this, that the second link in the first chain of actions corresponds to the first or third link in the second,

a rule-of-three kind of diet, regular exercise and so forth, upon *a priori* reasoning—however powerful these agents may be as remedies of disease, when our object is to effect only the temporary change in which a return to health consists—are perhaps always considerably over-rated. Vice and disease are confined to cities, and virtue and health to the country, only in the works of vapid moralists and muling poetasters; and if it is consistent with every body's observation that man can subsist and undergo great exertion for years together, on only a few ounces of oatmeal or potatoes and a little water daily, it is not less so that he can bear for years together many pounds of high-seasoned meats and a large quantity of fermented liquors daily, with little or no exercise at all. We commonly, like young logicians, prove too much, when speaking of the effects of practices unquestionably in some degree pernicious, and render our advice mistrusted by exaggerating these effects, and by founding our representations rather on what *ought to happen*, consistently with our limited views of the resources of nature, than on what really *does happen*, and may be observed to happen by all men. It is very shocking that persons will not always die nor continue to live under circumstances when, according to established rules, it seems incumbent upon them to do so. But such is the contumacy of nature, that, while she leaves to philosophers the privilege of determining the prognostics of every case, she always reserves to herself the right of settling the facts; and both before and since the days of the doctors of the Sorbonne, has seemed to take delight in exercising this right to their constant mortification and discomfiture.

and so on for the rest. Hence it follows, as a corollary from this axiom, but more especially with reference to what may be called acute cases, that *a precisely similar state of either excessive or defective Irritation may result equally from the operation of two agents the primary action of which is diametrically opposite*, and that either a stimulant or a sedative application (*a*) may appear to give rise to either the one or the other exclusively, according as this or that stage of its action is the more prolonged. It is thus only that we are enabled to solve the apparently difficult problem, how not only extreme de-

(*a*) Whether there be any agents upon the body, except such as are negative, like cold, want of food and so forth, which operate directly in diminishing Irritation, is more than doubtful. It is indeed a leading tenet of the modern Italian school—of Rasori, Tommasini, Borda and the rest—that there do exist agents, which they distinguish by the names of contra-stimulants or negative-stimulants, the operation of which is *immediately* to lower Irritation ; and of this nature is presumed to be the celebrated tartar-emetic in its effect upon the action of the heart. It seems however reasonable to believe that the effect of the operation of every positive agent on Irritability must be Irritation—since all that we understand by Irritability is the property of being called into action by all kinds of agents applied to it. Irritation is indeed susceptible of diminution in either of two ways—by the abstraction of stimuli, by which one of its conditions, or by that of Irritability, by which the other is to a greater or less degree withdrawn ; but, while the former is easily effected by the employment of negative agents, we know of no means of effecting the latter, except by exciting preternatural Irritation, and it is in all probability in this way that all the reputed contra-stimulants produce their effect. It is true the sedative effects of these agents on certain organs are frequently much greater than appear to be explicable upon the presumption that they are merely the consequences of the previous excitement of these organs ; but there is a source of fallacy here of which it is of importance to be aware. If tartar-emetic, for example, first violently excited the action of the heart, we should imagine that we had no difficulty in understanding how this action should be afterwards in an equal degree diminished ; but, on entering a little into the subject, we should find that we could explain it only on the presumption of some deleterious change having been effected in its nervous matter by the preponderance of absorption, as the *indirect* result of this Irritation of its muscular tissue. And why may there not exist substances capable of increasing *directly* this action of the absorbing vessels, and thus of diminishing the proper action of the heart, without having previously increased it ? It needs not perhaps be always *through* an Irritation of tissues capable of displaying any sensible action, that a stimulus takes effect upon their absorbents ; and if it operate on the latter directly, we can have no measure of its primary stimulating action —involving as it does only the molecular process—and can recognise it only by its secondary and sedative effects upon processes obvious to the senses. Perhaps had we any criterion of the former, we should find that the latter always in fact accurately corresponded with it.

grees of heat and cold, but excess and deficiency of food, a superabundance of blood and too great depletion, and numerous other opposite causes should give rise often to precisely the same effects. It will be obvious that all the positive agents increase *directly* one condition of excessive Irritation—namely the stimulus in action, while all the negative increase *indirectly* the other—namely the susceptibility acted on; but both equally occasion increased Irritation, and its consequence diminished Irritation, in which inflammation—the head and front of the great majority of diseases to which the body is liable—consists. The same principles are adapted further to explain the nature of what is commonly called the latent stage of inflammation; which stage is in fact the most active stage of any, consisting as it does in that state of increased Irritation of the capillary vessels, which is preparatory to the state of diminished Irritation in which the disease essentially consists. It gives rise, it is true, of itself to no particular symptoms, and it is by those alone which take place during the subsequent stage—which is perhaps always the longer and more violent, the longer and more intense has been this alleged latent stage—that we at length recognise the disease; but it is not on that account the less active. Nor is there any difficulty in understanding, upon these principles, how the same agents, positive or negative—for example, heat or cold—which are often instrumental in producing inflammation, should be so frequently among the most effectual means of removing it. Indeed, if the above doctrines are well founded, it could not have been otherwise; for since these agents produce the disease only by the collapse which follows the inordinate Irritation which they occasion, the one directly and the other indirectly, it would necessarily follow that a renewal of this Irritation, not beyond, but only up to the natural point, must alleviate or remove it. Hence the benefit derived in inflammatory diseases in general—after the abstraction, if necessary, of a part of the load to be moved forwards by the capillary vessels—from every agent which operates in exciting the moving powers; and such agents we accordingly apply either directly to the part affected, if it be one which admits of this, or sympathetically, if it be one which does not: and it is in the latter way that all the reputedly revulsive remedies are of advantage in such diseases—not by counter-irritating, as is sometimes so vaguely supposed, or withdrawing Irritation from a part already undergoing too little—but by communicating to it a stimulus by which that Irritation is to the requisite degree increased. (*a*) It might further have been expected that that particular stimulus would be found most competent to effect this end, which had already, by its deleterious action upon the part when in a state of health, proved its adaptation to the specific Irritability of this part; and it is upon this principle that the whole doctrine of the homœopathia—ignorant as the patrons of this doctrine for the most part are of the fundamental truth on which they are proceeding—essentially hinges. But the subject of the mode of action of the causes and remedies of diseases, however connected it may be with that of increased and diminished Irritation, is almost an inexhaustible one; and its full consideration belongs rather to pathology and therapeutics than to elementary physiology. It may be repeated here however, in conclusion of the subject for the present, that, as it is of some change in that Irritability or susceptibility which when natural is the *Predisposing cause*, as it were, of HEALTH, whether of the whole body or of certain organs, and whether acquired in the manner recently described, or natural to a certain age, sex, temperament, idiosyncracy or habit of body, that every Predisposing cause of Disease consists, so it is to some change in those salutary powers by which Irritability is excited, and which when natural are the *Exciting causes* of HEALTH, or to some other powers which are altogether accidental and deleterious, that every Exciting cause of Disease is referable; the Proximate cause of Disease, in the mean time, bearing the same relation to the two, that a healthy function bears at once to Irritability in its natural degree, and to those powers by which it is naturally called into action.

(*a*) If any two subjects had to be selected, among those which are most frequently in the mouths of medical men, upon which they are, generally speaking, the most totally destitute of the faintest outline of the shadow of an intelligible idea, we could not perhaps do better than pitch upon the two last alluded to—the nature of the latent stage of a disease, and the operation of a so-called revulsive remedy. It would be flattery to call the opinions commonly entertained on these subjects erroneous—they have no pretensions, for the most part, to the name of opinions at all. The subject will be resumed in its proper place.

SECTION II.

On the Total Failure of Irritation, Permanent or Temporary.

As Life and Irritation are virtually synonymous terms, it follows that the total cessation of Irritation must constitute Death; but as this cessation may arise from a failure either of Irritability, which is irrecoverable, or of the requisite stimuli, which may be restored, it results that Death may be either permanent or temporary, the latter constituting what is commonly called suspended animation, or more vaguely, when general, asphyxia, syncope or prolonged apoplexy, in which, although there is no Life or Irritation, there still remains a susceptibility of it. (*a*) Permanent Death may be either of a certain part alone, or of the whole body. When it is only of a certain part, it constitutes what is called mortification or gangrene, which is of two kinds, dry and humid—the former arising from a mechanical obstruction of the larger blood-vessels of the affected part, (*b*) so that the renewal by the capillaries of the proper ganglionic nervous tissue—still presuming this to be the immediate seat of Irritability or Vitality —in proportion to its consumption, is impossible; the latter, from such a degree of that diminution of the Irritation of these capillaries, in which inflammation consists, (*c*) as, instead of favouring, is incompatible with deposition, so that the same effects result. When the Death is of the whole body, it may be presumed to result from a similar deterioration taking place in the ganglionic nervous tissue in every part; in other

(*a*) It will be observed that Death is here spoken of merely in relation to the failure of the two conditions of life—Irritability and the Stimuli by which it is excited—quite abstractedly, and without any reference to the efficient cause of the cessation of the individual functions, which could not of course be entered into before these functions had been severally and collectively discussed.

(*b*) Dodart, Noel, Lange, Bouchet, Hodgson &c.

(*c*) " Mortification," says John Hunter, " is the most simple effect of debility;" and according to Dr Thomson, " the two morbid states (that is mortification and inflammation) may in some measure be regarded as stages or periods of *the same disease*"—facts, which are of themselves a sufficient refutation of the opinion of those who, while they allow that mortification consists in a total cessation, or the greatest possible diminution of Irritation, still assert that inflammation, which is *the same morbid state*, consists in an increase of it.

words, from each part becoming disorganized—for if Irritability or Vitality is the result of organism, as has been from the first assumed, this is a necessary inference—by the process of deposition falling short in every part of that of absorption, in consequence of the excessive Irritation either of every part directly, or of some one part which by sympathy involves all the rest. Such a total exhaustion of Irritability or Vitality is sometimes very suddenly effected, as when Death is occasioned by electricity, by violent exercise, by an intense emotion of the mind, by certain poisons, or by a blow on the head; all which circumstances have been already stated as preventing, as well the natural coagulation of the blood, as the usual rigidity of the muscles, owing probably, the former to a defective recomposition of the blood, and the latter to a deterioration of the muscular tissue. But besides these phenomena, which seem to be susceptible of a purely chemical explanation, the muscles after death, under these circumstances, do not in general contract under the strongest known stimuli; which can arise only from a sudden failure of that property which, under the ordinary circumstances of Death, is only very gradually abstracted from them. In the latter case the Irritability or Vitality appears to fail first, as already observed, in those organs which have the smallest and fewest ganglionic nerves, and the parenchyma of which is soonest deprived of its blood, and to be retained for the longest time in those the nerves of which are the largest and most numerous, and the parenchyma of which retains its blood the most tenaciously. It seems to be exhausted accordingly, among the larger muscles of Man, first in the left ventricle of the heart, the nerves of which are few and small, while its contractions are so forcible as very rapidly to expel most of the blood from its parenchyma. This organ generally ceases to obey the strongest stimulus in about half an hour; and the Irritability ceases afterwards successively in the muscular coat of the large intestines, in that of the small intestines, in that of the urinary bladder, in the right ventricle of the heart, in the voluntary muscles in general, in the muscular coat of the gullet, in the left auricle of the heart, and lastly in the right auricle, the nerves of which are numerous and large, while its contractions are so feeble as to allow of a great accumulation of blood in its parenchyma, so that this organ sometimes retains its Irritability for eight or nine hours. (*a*) Now even the shortest of these periods, it may be observed, is much longer than the blood, when drawn from the body, takes to coagulate—consequently it might at first sight appear that to attribute the longer or shorter retention of the Irritability or Vitality of the several parts, under these circumstances, to the continuance in them of any function to which this fluid is instrumental, must be erroneous; but we are not to imagine that the process of the coagulation of the blood in its vessels begins at the period from which we are accustomed to date Death. There can be no question but that the Irritability or Vitality of the parenchymatous tissue, with its oscillating and often retrograde currents of blood, very long survives, as has been elsewhere stated, that of any of the larger muscles—probably from its preserving the integrity of its own ganglionic matter much longer than that of the same matter as interwoven with the other tissues—and that long after the sensible motions in which respiration, circulation and so forth consist have ceased, the molecular actions, in which deposition and absorption consist, and those by which the coagulation of the blood is prevented, continue to be performed. (*b*) It has been pretty well established that the hair and nails continue to grow, that the perspiration sometimes appears, and that the tears not unfrequently flow for some time after apparent

(*a*) This very nearly corresponds with the results of the experiments of Nysten, which have been already alluded to. It appears from the observations of Bikker, Sir Anthony Carlisle and others, that some chemical agents, applied to muscles after apparent Death, have the power of retarding, while others have that of accelerating this exhaustion of their Irritability. The action of these substances however is, in all probability, not chemical—since such an action upon muscles is perhaps incompatible with any retention of Irritability—but strictly vital, the former class of substances perhaps tending to diminish, the latter to increase that preponderance of absorption over deposition—processes still going on in the parenchyma of the muscles—on which the ultimate failure of this property appears to depend.

(*b*) That the motion of the fluids in the parenchyma is in a great measure independent of the action of the heart was shown long ago by Spallanzani, who has been abundantly supported lately by Marshall Hall and Wedemeyer. We know likewise that at first the two had no connexion with each other.

Death, (*a*) and that a person who at the time when respiration and circulation ceased had an anasarcal tumour, is often buried without it; and if the vital processes of deposition and absorption (*b*) thus continue in the parenchyma so near the surface of the body, from which the blood is comparatively so soon withdrawn, how much more will this be the case in the internal parts, in which it is in the same degree accumulated. (*c*) It appears therefore perfectly reasonable to presume that, as in cases of sudden Death, produced by any one of the agents lately enumerated, the process of deposition instantly so far falls short of that of absorption as at once to deteriorate the ganglionic nervous matter—and it has been already presumed that it is by a similar deterioration of the proper muscular tissue, under these circumstances, that the ordinary rigidity of the muscles is prevented from taking place—so in ordinary cases the former process only gradually succumbs to the latter, and that it continues the longer in every part, according as the conditions, at all times favourable to deposition, are the better maintained. But absorption is a vital process; and as it is by absorption that that degree of disorganization on which the failure of Irritability or Vitality depends, is directly effected, it is obvious that, not only is to die as characteristic of organized beings as to live, but, as elsewhere remarked, it is from a distinct vital process that Death in all cases immediately results. It may be alleged indeed—to omit the mere truism that if a being had not lived, it could not die—that it is not because absorption continues,

(*a*) Rudolphi contends rather that these parts *cannot* grow after Death, than that they *do* not. (*Grund. der Physiol.* 1821, 1. § 243) Perhaps we might reply with Alice in the play, " we never said it was *possible* —we only said it was *true.*

(*b*) In adopting this opinion we must take care not to confound exudation and imbibition with deposition and absorption. The two former are merely physical processes, and perhaps never take place—notwithstanding some recent experiments by Fodera, Magendie, Wollaston, Marcet, Home, Ségalas and others, which *seem* to prove the contrary—through living tissues; the two latter are strictly vital processes, and certainly never happen after Irritability is exhausted.

(*c*) That this is the case is obvious from the remarkable fact, that, while the marks of an inflammation of the surface, such as erysipelas or ophthalmia, frequently entirely disappear soon after Death, those of an inflammation of an internal organ are in general manifest till decomposition ensues—nay, not unfrequently even healthy internal parts acquire, after Death, a pseudo-inflammatory appearance, as noticed long ago in particular by Dr Yelloly.

but because deposition does not, that Vitality fails; therefore that the process is not a positive, but a negative one. This however is not the case; for when both simultaneously cease, as occurs in suspended animation, Vitality is not destroyed; consequently, when it is so, it must be attributed to that process which is continued to the exclusion of the other, and must be regarded therefore as an active and positive, and not as a passive and negative one. We owe our organization originally to a vital process—that of deposition, when there was no corresponding absorption; we owe the perfection of our organism likewise to vital processes, those of deposition and absorption, the former somewhat preponderating over the latter; we owe the maintenance of our organism to the same vital processes, the two being now precisely balanced; we owe the decay of our organism still to these vital processes, but now absorption somewhat preponderates over deposition; and we owe the destruction of our organism also to a vital process, that of absorption, when there is no corresponding deposition. (*a*) When we die temporarily we merely cease to live; but we cannot die permanently otherwise than from the destruction of our Vitality, which can be destroyed only simultaneously with our organism. The last vital process implies, it is true, the possession still of Vitality; but it is one which actively destroys the structure whence results the property on which itself depended, and all is afterwards the repose of inorganized matter. And that such is the case is rendered probable, among many other things, by the long retention of their Vitality by the sluggish water-plants, and by cold-blooded and torpid animals in general. The difficulty with which reptiles are deprived of Vitality is well

(*a*) A beautiful illustration of the proximate cause, if we may so express it, of Death, might be drawn—were this the place for doing so—from the phenomena of Death from sheer old age; in which every dry, shrunk and opake tissue, and every failing fluid betrays this preponderanec of absorption over deposition, while every faculty, irritable, sensitive and rational, manifests the effects of it. Not all the soaking in the world in the cauldron of Medea, nor sleeping with fair Shunamites, nor drinking potable gold, nor replenishing the veins with young blood can ever enable Man to resist his own inherent causes of decay, till he shall find out the secret of controlling the process of absorption. Till this be done, " vain are the hopes of men," as observed by Dr Symonds after Boerhaave, " who look for an agerasia."

known, and fishes in general retain the same property very tenaciously. The heart of the Eel—*Muræna* 35—for example, will palpitate for thirty or forty hours after having been removed from the body; and it is upon the long and forcible contractions which the muscles of the Carp—*Cyprinus* 35—undergo after apparent Death, that the practice of crimping them depends. It is very remarkable also, that the retention of their Irritability is very much increased, in those mammals which hibernate, during their hibernation; the heart of a Hedgehog—*Erinaceus* 51 — which has been destroyed during this state sometimes continuing to beat for ten hours after apparent Death. (*a*) But had the cessation of Vitality been effected by a negative, and not by a positive process, those beings should surely have been the first, and not the last to display it, in which the vital processes are most languid. Such as were slow to live, should have been quick to die; but, as it is, the less energetic the other manifestations of Life, the less rapid the destruction of Vitality. The "function of Death" partakes only of the inactivity of the functions in general.

But Irritation, and therefore strictly speaking, Life, may cease from the failure, not of Irritability, but of some of the stimuli by which it is naturally excited, and thus give rise to temporary Death, otherwise called suspended animation; or, when general, asphyxia, syncope or prolonged apoplexy. (*b*)

(*a*) Dr Marshall Hall. (*Phil. Trans.* 1833) We have already seen that by Dr Hall the respiratory process, on which the activity and temperature of animals depends, is described as inversely as their Irritability. It is probable however that it is not the degree but the duration of Irritability which is increased simultaneously with the failure of the fundamental functions, and that the former is not the cause, but the effect of the latter.

(*b*) These three morbid conditions of the body are very frequently confounded together; and indeed the names Ασφυξια, ἀσφυγμια, λειποθυμια, ἀποψυχια, λειποψυχια, κ. τ. λ. which have been applied almost indiscriminately to them all, seem to imply that the symptoms are almost undistinguishable. The difference however consists in this, that in asphyxia the exciting cause, whatever it be, takes effect first on the lungs, the suspended function of which involves very rapidly those of the heart and brain; in syncope the exciting cause takes effect first on the heart, the suspended function of which extends instantly to those of the lungs and brain; while in apoplexy the exciting cause takes effect first on the brain, and it is not till after an interval more or less prolonged—since, immediately necessary as are the organic functions to the animal, the animal are not equally so to the organic—that its suspended function involves those of the lungs and heart. Thus hanging, Temporary Death also, like permanent Death, may be either of certain parts alone, or of the whole body. Of the former we have examples in the effects of cold, or the abstraction of heat, on certain parts of living animals, as the ear of a Rabbit, which, after having been frozen, frequently resumes its vital actions on the re-application of heat; and of the latter in those of the same negative agent on Leeches, Perch and many other animals, which are often conveyed in a congealed state for many miles, and still return to Life on being thawed. A similar state, although in a minor degree, occurs in all those which hibernate, owing to their incapacity to counteract the effects of external cold by their own internal processes; as is the case with the pupæ of insects, most reptiles, among birds the Cuckoo and perhaps the Swallow, and among quadrupeds the Hedgehog, the Dormouse, the Marmot, the Bat and many others, the animation of all which is in the winter to a greater or less degree suspended. The same thing occurs to terrestrial animals in general from an abstraction of air, as by hanging or drowning; to aquatic animals, and to some not aquatic, as the Garden-snail, from an abstraction of water, and to all, in a greater or less degree, from an abstraction of their blood. Plants again, and the seeds of plants, experience the same from an abstraction of soil and moisture; and in short every form of organized being is liable to it from an abstraction of any stimulus requisite to its natural Irritation. Some of these negative agents produce merely, when their operation is temporary, a primarily diminished and a secondarily increased degree of Irritation, as already explained; but when it is permanent, they do not merely diminish Irritation, and thus, by destroying the balance between certain vital processes, effect certain changes of structure and consequent changes of property and resulting action, but they obstruct Irritation altogether, and thus, by sus-

drowning, negatively deleterious gases &c. produce asphyxia; abstractions of blood, the long-continued erect posture and so forth, produce syncope; and all causes so acting on the cerebro-spinal system as to occasion a deficient conveyance of the stimulus on which respiration immediately depends, produce that extreme degree of apoplexy which involves at length the organic functions: but in all these diseases, when fully established, the symptoms are the same, with whatever organ they may have respectively begun.

pending in an equal degree every vital process, put a stop to Life, without impairing Vitality. The only wonder is the length of time that this state of ambiguous existence, this retention of organism and of *l'aptitude à vivre*, without *la vie*, sometimes lasts; (*a*) but the wonder ceases when we

(*a*) The instances of an obstinate retention of Irritability by Man are much less remarkable than those by some other tribes of organized beings; but still not a few well-known melancholy cases of premature interment sufficiently testify its occasional occurrence after apparent Death from natural disease, and it is still more common in suspended animation from the ordinary causes. It is said by Winslow that the Emperor Zeno, upon his tomb being opened some time after his burial, was found to have devoured a part of his arm; and the same thing is reported to have happened in the case of the celebrated Duns Scotus. The great anatomist Vesalius is well known to have been persecuted by the Inquisition for having opened the body of a Spanish nobleman, who upon the first incision betrayed signs of life; and it is said by Grainger, in his Biographical Dictionary, that the Earl of Pembroke, who died in 1630, upon being opened for the purpose of being embalmed, raised his hand. A lady also, who died in Herefordshire, is represented in the Reports of the Humane Society for 1787, to have been restored to life after interment, by the attempt of a thief to steal a valuable ring from her finger; and numerous similar cases are on record by Diemerbroeck, De Hilden, and many others, sufficient to teach us great caution in pronouncing any person irrecoverably dead, before indications of actual decomposition have occurred. With respect to suspended animation from cold, it is said by J. Chr. Fabricius that men have been sometimes blocked up in the mountains of Liffland, and have hibernated for months without injury; and by Guagin, that in some countries Man is a regularly hibernating animal, and that there is a people of Muscovy who die every year on the 27th of November, and are not restored to life till the 24th of April following! But whatever we may think of this, the instances of a pertinacious retention of Irritability by Man after hanging and drowning—exclusive of those cases of preservation from the effects of the former, owing to nature having furnished the culprit, apparently in anticipation of such an accident, with an osseous trachea—are innumerable. Among the best accredited instances of recovery from suspended animation produced by hanging, are those of Ann Greene, who was executed at Oxford in 1650, and of Margaret Dickenson, who suffered in Edinburgh in 1727, both of whom were restored after a considerable interval; and resuscitation from the effects of drowning is possible, according to Currie, after half an hour from the supervention of asphyxia, according to D'Egly after nine hours, according to Pechlin, after eighteen hours, according to Willis, after twenty hours, according to Tilesius, after three days, according to Kunckel, after eight days, and according to Burmann, after seven weeks! The greater part of all this, it is hardly necessary to say, is fabulous. But examples of a long retention of Irritability become more and more remarkable as we descend in the scale of creation; and some recorded cases of it in quite the lowest tribes of organized beings are almost incredible. Various species of Tremella for example, a kind of fungus, display this faculty to a very great degree; the Tremella nostoc having been looked upon in former times as a prodigy, from its appearing frequently, immediately after heavy rains, in places where, during the recur to the fact, that organized tissues are in their chemical nature entirely *sui generis*, and held together by vital affinities—not composed of sodo-albumen, gelatin and so forth, and held together by common chemical attraction; and that till this takes place—which is not till they have become disorganized, and their Irritability or Vitality has deserted them—they are unsusceptible of the usual chemical decomposition. But their Vitality cannot desert them otherwise than by a vital process; so that there seems to be no cause why the duration of these tissues should not be as perpetual as that of inorganized matters—and in fact the supervention of permanent Death, and consequent chemical decomposition, in these cases appears to imply at least a momentary and partial return of Irritation, for which perhaps it is more difficult to account than for the persistence of their repose. That such however really takes place when temporary terminates in permanent Death, is more than probable. Innumerable causes may give rise to this return of Irritation, in as far as regards the molecular processes, which alone are concerned in effecting that disorganization on which the destruction of Irritability depends, but which of course gives rise to no perceptible phenomena; and there is every reason to believe that, as these molecular actions long survive the

longest drought, no traces of it had been perceptible, and other species often suddenly covering ditches, after a shower, with beautiful verdure, which had for weeks or months before presented the appearance only of dry colourless hairs. But it is manifested even still more strikingly by some of the lowest animals, and in particular by the microscopic Wheel-animal, (*Rotifera*, 1) which, as noticed by Leeuwenhoek, Barker, Spallanzani and others, after remaining for three or four years in the form of a shrivelled point, which may be broken in pieces with a needle like a crystal of salt, is still recoverable by a drop of water; and by the Eel of blighted corn, (*Vibrio*, 1) which retains the faculty of being resuscitated, as asserted by Ginnani and Needham, for twenty or thirty years. It is worthy of remark that in all these animals this property is destroyed by electricity, seeming quite sufficiently to show in what it consists. Many Lichens and Mosses also, preserved in old herbaria, have been known to be restored to life by moisture after a hundred or two hundred years. But the most wonderful instances of obstinate retention of Irritability are met with in the seeds and bulbs of plants, which sometimes remain for many centuries buried in the bowels of the earth, and still, on being thrown up into a congenial soil, spring into life; and it is said that some bulbs which were taken not long ago from the hand of a mummy found in one of the pyramids, and which must have been immured between two and three thousand years, produced unknown plants when sowed in one of our botanic gardens!

sensible actions when both are failing from the cessation of Irritability or Vitality, so they will be the first to be restored upon any stimulus again taking effect upon the system in cases of suspended animation. The slightest returning Irritation, confined thus to the parenchyma, is now excessive, and of course establishes and maintains a balance of action in favour of absorption over deposition, tending to disorganization and the destruction of Vitality; and it is only upon such stimuli taking effect more generally upon the system, and restoring the action of the lungs and heart, so that a portion of fresh blood is sent into the parenchyma—while the very diminution of Vitality, which has already supervened there, is now a cause of diminished Irritation, and consequently of a regeneration of irritable matter and a re-accumulation of Irritability—that recovery can take place. It is well known how precarious is, in every instance, the health for a long time after restoration from suspended animation, if it have been of any considerable duration, and how great the liability to inflammation, hemorrhages and so forth, as is commonly said from the violence of the re-action. This is a sufficient proof how severe a shock, even in these fortunate cases, the Irritability has sustained, and how narrow has been the line by which a return to health was separated from permanent and irrecoverable Death. The process from which either might have resulted was the same, differing only in degree; and had only one link of the chain of functions in which Life consists been re-established, it would have been that which constitutes "the function of Death"—the last to be maintained in the former case, the first to be restored in this.

Upon this at length occurring—at the instant of a total cessation of its Irritability or Vitality—all that an organized being had possessed as characteristic of its composition ceases also; and, that power by which its elements had been previously united into a living whole giving way to common chemical affinity, there result now, as its really proximate principles, sodo-albumen, gelatin, fibrin and all the others commonly so reputed, such having been previously the association of these elements in each organ, as to give rise, after Death, to the development in each of these principles in definite proportions. But such principles are not long stationary.

In obedience to laws which have been elsewhere explained, they become more or less rapidly decomposed; and what was Man, in common with the lowest worm—that "noble piece of work—the beauty of the world—the paragon of animals" —becomes at length a loathsome mass, useful only in ministering to the nourishment of still organized beings, in return for having, in the pride of his organism, appropriated the disorganized remains of so many similar beings to his own.

PREFACE

TO THE

THIRD PART OF DR FLETCHER'S RUDIMENTS OF PHYSIOLOGY.

By ROBERT LEWINS, M. D.

I AFFECT not to conceal my anxiety for the fate of the posthumous part of Dr FLETCHER'S Work on Physiology, but it arises solely from the dread of not being able to do justice to the merits of my departed friend. Occupied with the harassing duties of medical practice, it will easily be believed, that I reluctantly placed myself in the responsible situation of Editor; but when it is known, that unless I had done so, his valuable observations on Life, as manifested in Sensation and Thought, would have been lost to the world, the undertaking will be considered at least excusable, especially by those who know the opinion entertained of their merits by the Author, and by his most intelligent pupils.

It is a fact which, under existing circumstances, need not be concealed, that Dr FLETCHER anticipated a still more favourable verdict for the Third Part than had been awarded, by competent judges, to the First and Second Parts of his Work; and doubtless, had he lived to complete it himself, his expectations would have been realised; but it may be otherwise under the management of another. Indeed, this Production cannot but be very different in many respects from what it would have been, had it issued from the press under the Author's own superintendence.

After Dr FLETCHER's decease, when his immediate connexions resolved to publish his work on Life, as manifested in Sensation and Thought, (a resolution which was influenced by his own known opinion on the subject,) it was hoped that one of his Colleagues in the Argyle Square Medical School, or some other individual whose habits peculiarly fitted him for such duty, would be found to edite the work; but this expectation was disappointed. On examining Dr FLETCHER's papers, it was ascertained, contrary to previous understanding, that he had not arranged the manuscript for the press, although a memorandum proved that he had just commenced doing so, at the moment he was seized by the fatal illness which so speedily numbered him with the dead. There was no alternative, but to abandon the idea of publication, or to have recourse to the notes from which he lectured. These, however, were in some parts deficient, or at least not intended to be intelligible to any person except himself; and a learned individual, who, from his knowledge and experience of such matters, was considered best qualified to give an opinion on the subject, declared, "that to bring out the work was impossible." I, perhaps presumptuously, ventured to entertain a contrary opinion, and undertook the editorial responsibility. The wisdom of this act remains to be proved. Prudence admonishes me to be silent as to the pains which have been taken to execute this task, at least until it be known whether or not my exertions have served any useful purpose. But this may be said, that I laboured most willingly in the cause, since it was that of departed worth and talent, as well as of friendship,—friendship formed in the days of youth, and confirmed in riper years, on which death had set his seal.

I cannot omit mentioning the assistance received from Mrs

Fletcher, and Mr William Forrester, a medical student of much promise, whose studies I have had the pleasure of directing. Their joint assiduity in deciphering and copying writing, which at first appeared illegible, tended much to facilitate my task. I therefore take this opportunity of publicly acknowledging my obligations to them; and I ought to add, that the use of notes taken by Mr Forrester from the last winter course of lectures Dr Fletcher delivered, materially contributed to make some parts of this work, imperfect as it may be found, more complete than it possibly could have been without such assistance.

Late events make this, I conceive, a proper time to speak of the truth or fallacy of Phrenology, as propagated by Gall and Spurzheim, and taught by their followers. To me it appears that they have been proclaiming the triumph of their principles with a degree of confidence not warranted by legitimate induction. Total silence in regard even to what may be considered fallacious is sometimes prejudicial to the cause of Truth. In an Appendix to Dr Fletcher's Work, therefore, I have thought it expedient, in stating his opinion, cursorily to advert to this keenly agitated subject.

It is rather extraordinary that the third and last part of the Rudiments of Physiology will, accidentally, be published on the first anniversary of the Author's death. I feel it due to myself to state, that it ought to have appeared before the close of last year. The manuscript was sent to a printer, (not the respectable one whose name is attached to the Work,) at the commencement of last Winter's Session; but, unfortunately, circumstances over which I had no control have thus long delayed its publication.

Leith, *May* 5. 1837.

RUDIMENTS

OF

PHYSIOLOGY.

PART III.

ON LIFE, AS MANIFESTED IN SENSATION AND IN THOUGHT.

It has been already stated, that in addition to those actions of Organized Beings by which all are characterised, there are some others commonly presumed to be proper to Animals, and certainly requiring other conditions besides those which alone are necessary to the characteristic actions in question. These actions were further said to consist of those by which Organized Beings become conscious of impressions made upon them; those by which, in virtue of this consciousness, they reason and will; and those, lastly, by which, in virtue of this will, they effect various movements. They comprise, therefore, the Functions of Sensation, Thought, and Voluntary Motion, or those called Sensitive, Animal, or Relative, in contradistinction to what are called the Vegetative or Organic Functions, consisting of Respiration, Circulation, Deposition, Absorption, Assimilation, and Generation, which are all modifications of Irritation, in the sum of which, Life, in its simplest form, or, as the French call it, "la veritable vie," consists; and the failure of which, as involving that of all the rest, in cases where they were previously manifested, is Death, temporary or permanent. These Sensitive, Animal, or Relative Functions, therefore, may be called Adventitious; they may or may not be performed at all by any given Organized Being, and in those Beings naturally performing them they are liable to be, either periodically or by various accidents, suspended, without prejudice to their Life properly so called. They are, as it were, an improvement upon life, but not another life. They do not, and cannot constitute this state, for no form of Being ever displays these functions otherwise than as an appendage to those already spoken of, but they render this state more perfect. They are a new, but not an independent mode of Life—a class of functions superadded to those in which Life fundamentally consists, but not capable of subsisting *per se.* (*a*)

But while irritation, in the various modifications of which all the numerous Organic Functions consist, is dependent upon one common property, or that of Irritability, acted upon by certain powers, likewise more or less common, and required, therefore, to be treated of collectively, such is not the case with Sensation and Thought, which appear to be dependent severally upon an essentially different property, acted upon by essentially different

(*a*) This class of Functions, as already observed, was denominated Animal by Aristotle, the first to attempt a systematic arrangement of the characteristic actions of Organized Beings, upon the presumption that Plants, although they perform the vital and natural functions, did not exercise them; and that they were therefore distinctive of Animals, is a question which will fall to be considered in future. By Paracelsus they were said to constitute a second Life, or one which acted without the body, as the other Functions composed a Life which acted within it. By Harvey these Functions were called Sensitive, as either consisting of, or essentially founded on, Sensation, and they were supposed to be presided over by the ψυχη αισθητικη, or *Anima Sensitiva;* while all the rest, or Vegetative Functions, were under the control of the ψυχη θρεπτικη, or *Anima Vegetativa.* Bichat, again, returned to the appellation Animal, as applied to these Functions, but was guilty of an inaccuracy in representing them, after Paracelsus, as constituting a proper Life—the Animal Life, as opposed to Organic Life. If Life consists in the sum of the Functions performed by an Organized Being, it is obvious that it must be one, and one only, of whatever number of Functions the complement be made up.—We speak, therefore, with propriety of them as a new class of Functions, but not as a new Life. The best appellation that can be applied to them is, probably, the more recent one of the Relative Functions, or the Functions of Relation; since, while all the others conduce to the preservation of the individual which exercises them, or to the perpetuation of its species, it is by means of them principally that Organized Beings maintain an intercourse or relation with the external world. The former may be said to be "ad vitam," the latter, "ad beatam vitam;" the former essentially constitute Life, the latter render Life a blessing.

powers, and they must accordingly be treated separately; while Voluntary Motion, again, one condition of which is Irritability, already described, and the other that modification of Thought called Volition, likewise already spoken of among the indirect stimuli to this faculty, although it is with propriety regarded as an adventitious function, like the two just mentioned—the exercise of one of which it implies—need not be again particularly referred to.

This third part of our subject, then, not only admits of, but seems to call for a division into two distinct heads, the one devoted to Sensation alone, the other to Thought alone; and it is accordingly under a distinct head that each will be spoken of.

ON LIFE, AS MANIFESTED IN SENSATION.

CHAPTER I.

ON THE PHENOMENA OF SENSATION.

Inorganic matters, we have the best reasons for believing, take no cognizance whatever, worthy of the name of consciousness, of any impression made upon them; or they may be acted on in various ways, chemically or mechanically, but they may be said to be quite unconscious of such actions. Nor do all forms of organized beings betray any consciousness, properly so called, of the numerous impressions made upon them, whether in furtherance of the vital processes which they continually perform by the ordinary stimuli to irritability, or by any other agent, positive or negative. All the functions of plants, for example, seem to imply only Irritation, displaying itself in those actions, molicular or sensible, in which Respiration, Circulation, Deposition, Absorption, Assimilation, and Generation, severally consist. They manifest no proper consciousness of this irritation—no sensation. Whether they do or do not possess that consciousness, can be determined of course only by the circumstance of their displaying or not such phenomena as we find in animals to result only from sensation. We know that irritation commonly, although perhaps not always, calls forth certain actions, molicular or sensible, which actions, as usually coincident with irritation, may be for all practical purposes identified with it, and said to constitute life in its simplest state, but such actions do not imply sensation. If a muscle be irritated by any of the ordinary stimuli to irritability, it contracts; but we do not regard this as any manifestation of such a consciousness on the part of the muscle as constitutes sensation, because we know that it takes place in sleep, or during comatose diseases, when all sensation is to a greater or less degree suspended. In like manner, the sensible motions manifested by the leaves of the Venus Flytrap, (*Dionæa*) the Wood-sorrel, (*Oxalis*) the Humble plant, (*Mimosa*) and the Sun-dew, (*Drosera*) by the pistils of the Martynia, (*Martynia*) or by the stamens of the Barberry, (*Berberis*) the Prickly Pear, (*Cactus*) the

Roman Nettle, (*Urtica*) the Pellitory, (*Parietaria*) or the Swallow-wort, (*Asclepias*) all which have been already adduced as evidences of the irritability of plants, are no indication of their possessing sensibility, since they seem to be analogous only to the actions of the muscles of animals, under the immediate application of a stimulus. But it is only as actuated by sensation, and the desire which such sensation engenders, that a muscle ever contracts, as it were, spontaneously, and effects motions by which either some good is obtained, or some evil is avoided: and if, accordingly, any analogous motions take place in plants, we seem to have a right to infer that they are capable of being actuated by similar powers, and that plants consequently possess sensation. Now, such motions are said to take place in plants. The Hop Plant and Sun Flower move in pursuit of the *Heat* of the Sun; a Plant in partial darkness proceeds towards the *Light;* the Water Lily and Vallisneria rise from the water in search of the *Air*, while the Plumula of Seeds moves into the air, and the Radicle into the *Soil.*

In these cases, the motions in question appear to be excited not by the heat, the light, the air, or the soil respectively, in the manner that the immediate application of these agents calls forth such actions, but by a consciousness of the want of these stimuli; in other words, sensation producing a desire, which prompts to the motions requisite to bring the plant under their influence. They appear to be excited, not by the stimuli, but by the consciousness of the want of them. But, to omit an objection to this doctrine, founded on its proving too much, since it tends to prove that plants exercise not only sensation, but thought also—since desire is also a modification of this function in the form of passion or instinct—it is by no means certain, or even probable, that these motions imply sensation. It has been abundantly insisted on already, that the same actions of animals may be excited by a negative as by a positive stimulus—that deficiency as well as an excess of heat, too rare as well as too dense an atmosphere, too little as well as too much food, inordinate depletion as well as too great a quantity of blood, are competent to produce inordinate actions—the former by increasing the susceptibility of such action, the latter by increasing the other conditions on which it depends; and keeping this in mind, it appears not difficult to refer all these actions of plants, as well as those previously spoken of, to the influence of such stimuli, independent of sensation; and if we can explain the source of the mere actions in question, it is quite enough, without attempting any explanation of their adaptation to any apparent end in view. All the motions consisting in irritation, sensible or molicular, conduce to some useful end in the economy of the being performing them; but this is never held to imply any consciousness of this end in the organs undergoing such motions. The design in such cases is, that of the Great First Cause—the organs, the motions of which are subservient to such design, are but the blind and unconscious instruments by which it is fulfilled. And if we deny sensation to plants, we must of necessity deny that they sleep, the state of sleep signifying nothing more than a periodical cessation or diminution of sensation, thought, and voluntary motion. The phenomena supposed to be indicative of the sleep of plants are principally the closing of the petals and the drooping of the flowers, so remarkable in the plant called the Poor Man's Weather Glass, as well as in many others, on the approach of evening, or previously to rain. But these circumstances imply a withdrawal of a portion of the heat, or light, or other stimuli, to which the plant is at other times exposed, and accordingly may be presumed to act in the same manner as negative stimuli in general in producing inordinate action; if, indeed, this closing of the petals and drooping of the flowers be not rather a cessation of actions, by which the former were expanded and the latter held erect, and which, of course, takes place on the abstraction of a portion of those stimuli by which such actions were excited. At all events, nothing hitherto noticed in the economy of plants appears to indicate that they exercise sensation, or that their functions are liable to undergo any suspension analogous to that in which the sleep of animals consists. The irritation in which exclusively their life appears to consist, may be by various causes increased or diminished, but no higher functions seem to be implied by any of the phenomena which they display. And it may be questioned whether the same remark may not be extended to quite the lowest tribes of animals, all the actions of which, probably, like those of plants, begin and end with irritation; so that the appellation of animal to those functions, the head and front of which is sensation, is perhaps not strictly appropriate, as founded on an implied distinction between plants and animals, which is by no means precise. (*a*) It is true that even the lowest of these

(*a*) Indeed, if the lower classes of animals rank only with the lower classes of plants in the scale of organized beings, and are inferior to the higher, as already insisted on, it appears inconsistent to presume that they exercise a function which is denied to plants in general, and the exercise of which would alone establish their pretensions to precedence.

tribes of animals are observed to shrink from the touch, as if actuated by a consciousness of the impression made upon them, and a consequent desire to avoid it; that they select their food as prompted apparently by taste; that they afford many indications of a susceptibility to all appearance of peculiar odours; that some of them, like the Branched Polype, (*Hydra*) court the light, while others, like the Sea-feather, (*Sertularia*) and Coral, (*Gorgonia*) try to hide themselves from it, excited in both cases, as is supposed, by a consciousness of its influence; and, lastly, that they withdraw themselves frequently from certain sounds, as if taking cognisance of the impulse which they communicate. But may not all these phenomena arise from mere direct irritation, without any consciousness on the part of the animal of the impression made upon it? The Polype does not shrink from the touch more obviously than the Humble Plant, nor do any of these tribes select their food with greater precision than plants in general, and yet we deny to plants the exercise of either touch or taste. The influence of odoriferous vapours on plants has been abundantly proved; that of light is not less remarkable, perhaps even more remarkable on plants in general, than on the animals above alluded to; and it may be presumed that plants are not less susceptible than some animals of the impressions communicated by those tremors of the air in which sound originates. Perhaps, then, it may be presumed, that sensation is exercised by animals only when their organism has attained a certain state of advancement, and that as the rudest degree of organism gives rise to the faculty of irritability or vitality, so a more refined degree of organic structure than is possessed by any plants, and many animals also, is necessary to develop that of sensibility.

But whatever may be the case with quite the lowest tribes of animals, it is certain that we ourselves are conscious of certain impressions made upon us by the contact of material substances, such as give rise to the sense of touch; by that of soluble and sapid particles of those bodies, such as give rise to taste; by that of the volatile odoriferous particles of such bodies, such as give rise to smell; and by that of rays of light or tremors of the air, such as give rise respectively to sight and hearing; and we rationally infer that the majority of other animals take cognisance of the same impressions, by observing that they betray, when exposed to the same agents, phenomena similar to those which we manifest under their operations. (*a*) It is important to observe, however, that sensation in general is not strictly a *mental*, or at any rate a rational consciousness. It is very difficult to divest the mind of the tendency to associate with sensation the phenomena of thought, or those actions of the mind which ordinarily result from sensation; and perhaps, indeed, the exercise of sensation is inseparable from that modification of thought constituting instinct, and through which alone, as elsewhere observed, we are capable of recognising the exercise of sensation in other forms of beings; but the effort to separate sensation from at least any rational consciousness must be made, if any attempt is to be made at precision on this subject. For this purpose, it is proper to contemplate the phenomena of sensation under circumstances in which such rational thought is suspended, as in the state called somnambulism, and the disease called walking catalepsy, or even in an ordinary reverie. (*b*) It has been elsewhere remarked, when speaking of the immediate seat of the stimulus by which the actions reputedly voluntary are excited, that "the rational thoughts are sometimes constantly and intensely engaged on other things, while such actions are going on, without the least interruption;" and again, that these actions are not interrupted in somnambulism and walk-

(*a*) It is only as made on certain parts of the body, however, that any such impressions give rise to sensation. Thus, the lungs, the heart, the stomach, and intestines, the uterus, the brain, and the internal organs in general, are quite insensible to any common impressions, and the same is the case with the tendons, ligaments, cartilages, &c.; and well for us is it that such is the case, since we should otherwise have been distracted by the continued attention which the performance of every function would have excited. On the other hand, the skin, in general, and particularly at the tips of the fingers, as well as some of the mucous membranes, as the conjunctiva, and that lining the larynx, the surface of the tongue, the lining membrane of the nostrils, and the internal parts of the eyes and ears, are acutely sensible each of its own particular impression; and all the voluntary muscles have a certain degree of sensibility. Nor is this faculty quite wanting perhaps in any one of the internal organs already enumerated, since it is apparently in peculiar sensations excited in the stomach, rectum, urinary bladder, internal genital organs, &c. that hunger and thirst consist, and that give rise respectively to the desire to void the stools and urine, and to copulate. Every organ of the body locally seems sensible to the pain excited by spasm or inflammation, so that it is only with respect to ordinary impressions that we can represent any part of the body insensible.

(*b*) In which, although not suspended, it is wrapt and absorbed in one idea.

ing catalepsy; and the same arguments may be extended to sensation. That a person, under all these circumstances, feels, tastes, smells, sees and hears, is abundantly obvious.

If he did not feel, he could not, as elsewhere explained, maintain continued action of any of the muscles reputedly voluntary. If he did not taste and smell, he could not, if at a meal, at once detect any peculiarities in the flavour or odour of what he is taking; and if he did not see and hear, he could not, if walking, avoid running against the lamp-posts, and allowing the carriages to run over him. But he is mentally quite unconscious of these impressions; and if afterwards his recollection be challenged on the subject, he will disclaim the slighest remembrance of having experienced them. Sensation, then, appears to be a state intermediate, as it were, between that total unconsciousness of impressions, in which irritation consists, and that vivid mental consciousness which constitutes thought. We cannot reflect on our sensations: when we appear to do so, we, in fact, reflect on the ideas which these sensations have excited. (*a*)

Sensation, like all the other animal functions, is liable to a periodical cessation, or at least diminution, constituting the state called sleep; and it is either suspended or destroyed in apoplexy, and other comatose diseases, without prejudice, however, to those organic functions in which life in its simplest form consists. That some degree of sensation, however, usually continues during sleep,

(*a*) All the proper instinctive actions accordingly are much more intimately connected with sensation than with thought, since they all spring from an uneasy feeling, which involves only a vague, however impetuous, desire, the lowest degree of the latter function. Of this nature is the action of respiration, excited indirectly by an uneasy sensation arising from some impediment to this process, as well as those of taking aliment and transmitting it to the pharynx, of sucking, of voiding the stools and urine, and of copulating, all dependent indirectly on similar uneasy sensations. The selection also by each animal of its proper element for respiration and locomotion, and of its proper food, and even the hoarding up of grain by the ant, and honey by the bee, as well as the herding together and migrations of so many tribes; the deposition of their ova in putrescent matters by insects; the construction by various animals of those singular fabrics which delight and astonish us, and other arts already enumerated, as immediately excited by instinct, are much more closely associated with sensation than with thought. The same is the case also with all the actions which in animals spring from genius and not from talent: they imply rather acute feeling than strong ratiocination — sensuality in its noblest form, indeed, but still sensuality rather than intellect.

is manifest, from the singular effect which certain impressions made during sleep are sometimes observed to have upon our dreams or sleeping thoughts, as well as on our motions. How frequently bad dreams result from the uneasiness produced by lying on the back, is familiar to every body; and that dreams of travelling over Mount Etna, of being on leaden legs, or of being scalped by Indians, have resulted severally from hot water having been applied to the feet, from the legs having become uncovered, or from the operation of a blister on the scalp, is equally well known. All this indicates the persistence of some degree of touch or feeling; and with respect to the other senses, the fact, that a sleeping man is sometimes awakened by the uneasiness arising from the vitiated secretions of his mouth, that he subsequently experiences headach if he have slept in bad odours, that he turns from the light if this be let in upon him, and that if he have gone to sleep during a continued sound, he is sure to awaken on this sound being discontinued, are all sufficient evidences that the senses of taste, smell, sight and hearing are diminished only, not entirely suspended, during sleep, unless when this is so deep as to amount almost to coma.

CHAPTER II.

ON THE NATURE OF SENSATION.

Irritation, or life in its simplest form, has been represented as consisting in the perception by organized beings of certain stimuli acting upon them otherwise than either strictly mechanically or strictly chemically; and sensation, or the first of those functions which render life complicated, consists equally in the perception by organized beings of certain stimuli acting upon them in a similar manner; but besides, that the character of the faculty through which these stimuli take effect, as well as that of the stimuli themselves, is very different in the two cases, an essential difference between irritation and sensation is, that the latter must be preceded by the former, on which it is directly dependent. Sensation is not, however, merely a higher and more refined degree of irritation; it is a mode of existence distinct, not in degree, but in kind, from irritation; as the latter is a mode of existence equally distinct from attraction or any other which characterises inorganic matters, in which they are mutually acting and acted on. (*a*) The thing acted on must, even in the last case, have perceived the influence of the thing acting, or it would not have obeyed this influence; the organized tissues in general must, in the second case, have *perceived* the influence of the stimuli which they obey, or they would never have manifested this obedience; and it is only in another kind of *perception* enjoyed by some only of the organized tissues that sensation appears to consist—a perception so far elevated above that in which mere irritation, which always precedes it, consists, that a certain degree of consciousness attends it. *The being manifesting it not only perceives, but perceives that it is perceiving.* The mode of existence in which perception in its most circumscribed and simplest form, as displayed by inorganic matters, consists, is exalted in irritation to another mode of existence, in which the character of the perceptions is altogether changed: one step further and the perception becomes such as to be, not indeed directly acknowledged by any outward manifesta-

(*a*) But there is, nevertheless, an analogy between them all.

tions, but to be for the first time more or less distinctly recognised by the percipient itself. (*a*) The creature exercising it is not yet mentally individualized; it is not yet rendered distinctly aware of its own existence as a result of this mode of existence; but it is approaching such a sense of individuality,—such an apprehension of its own being and attributes.

If, then, irritation consists essentially of one kind of perception resulting from irritability, or one kind of susceptibility acted upon by appropriate stimuli, sensation appears equally to consist of another kind of perception resulting from sensibility, or another kind of susceptibility acted upon in like manner by stimuli adapted to the purpose. Sensation, or the fundamental function of life, in its more complicated form, is no more dependent on a substantial sensitive principle than irritation, or life, properly so called, is upon a substantial vital principle.

Sensation may perhaps be well defined to consist in the perception of an irritation of any part of the body, agreeably almost to the words of Glisson, the first author upon irritability, who describes irritation as a *perceptio*, and sensation as a *perceptio perceptionis*, a description which in my mind cannot be easily improved. To the function of sensation, as well as to that of simple irritation, two

(*a*) If it be denied that any mode of being like perception can develop consciousness, it may be reasonably asked, How do we know that? Nay, how do we know, on the other hand, that every mode of being does not develop this condition in a degree more or less proportioned to its more or less exalted character? We are accustomed to think of consciousness only as connected with thought, and that highest degree of consciousness which constitutes thought in ourselves under ordinary circumstances, absorbs all minor degrees, and is, as it were, identified with our collective existence. "We think, therefore, we are." But what right have we to assert that no other degree of consciousness can exist, or be certain that that degree of consciousness which attends sensation, or even that extreme degree of it which constitutes thought, cannot result from any mode of being of either the whole or a part of our body, because no such consciousness results from any other mode of being? How do we know this? As individualized by the exercise of thought, *we* cannot appreciate any minor degree of consciousness either in ourselves or other beings; but some degree of this state appreciable by the beings, or part of the beings, in which it takes place, is perhaps so far from never resulting from any, that it always results from every mode of existence. There is no real violence done, then, by the apparently abrupt introduction, as a result of a certain mode of being, even of that degree of consciousness which constitutes thought, and still less of that minor degree which constitutes sensation.

conditions are necessary, viz. a peculiar susceptibility and a peculiar stimulus. In the case of irritation this susceptibility is what we distinguish by the name of irritability, and the power which calls it into action may be of very various kinds. In the case of sensation, on the contrary, the susceptibility consists in a new property called sensibility, and the power by which it is excited is always irritation, by which is understood, that when caloric, light, galvanism &c. or any other ordinary agent, is applied to a part of the body, it does not immediately act upon the sensibility of this part, and thus excite sensation, but upon its irritability, exciting in the first instance irritation, which irritation becomes now a new power, and operates upon sensibility, so as to produce sensation. This we know is the case, at least, with galvanism, which has no action on the sensiferous nerves. On account, however, of two conditions being necessary as well to sensation as to irritation, it has been usual to speak of sensibility as not only analogous to irritability, but as an independent attribute of what has been called animal life, as the latter is of organic life. It has been formerly shewn, however, that the notion of the existence of two lives is founded on misconception, and that life, under whatever form it may appear, consists essentially of a series of phenomena, the result of the action of certain powers upon irritability alone. The irritations so produced may either go no farther, or they may act as stimuli to a superadded property, possessed in any remarkable degree by the higher orders alone of organized beings. But this latter property, called sensibility, which is not only dependent for its existence upon irritability, since it is a property of matters deposited by secretion, (a function directly dependent upon irritability) but requires the previous excitement of irritability for every separate instance of its own action, cannot with propriety be put upon a par with it, nor be made the foundation of an additional *life*, however justly it may be made the foundation of an additional *class of functions*, performed most remarkably by the higher orders of living beings.

It is organic life alone which, as has been already observed after Rolando, constitutes "*la veritable vie*," or that function, or sum of functions, which distinguishes living from dead beings, while what is called animal life only renders living beings more perfect, and instead of by itself constituting any such distinction, ceases instantly on the cessation of the former—a circumstance which of itself is sufficient to prove, that sensibility is not acted upon directly by the ordinary stimuli applied to the body, but indirectly by irritation. The notion of this dependence of sensation upon irritation, or at least of the functions constituting what is called animal life, upon those constituting the true or organic life, is a very old one, and was sufficiently clearly indicated by Galen, who represented the animal spirits, or the *primum mobile* of the animal life, as generated (in an organ adapted for the purpose) from the vital spirits, or the *primum mobile* of organic life, which were said to be carried to this organ with the arterial blood. This supposed generation of the animal spirits was looked upon by the early physiologists, who all regarded life in all its forms as something substantial, very much in the light of a glandular secretion, and they were supposed to be radiated throughout the body by proper channels or nerves. The notion that sensation was a kind of secretion, was for a long time almost universal, and was rendered particularly attractive by the preparation of it, being compared by De la Boe and others to the separation of alcohol by distillation. Malpighi's notion of the nature of sensation was somewhat different from this, since he conceived it to depend upon the degree of tension in the channels or nerves just mentioned, produced by the flow into them of a proper secretion; but this secretion, according to him, was not itself sensation, but a material juice, or *succus nervosus*, which, filling the channels in question, put them into a state of tension, and thus rendered them capable of transmitting vibrations, in which he considered that sensation consisted; and he explained the differences in the different sensations, by the different lengths of the chords along which they were transmitted, as intercepted at different intervals by transverse chords in the brain, in the same manner as the different tones of a fiddle depend upon the different lengths of its strings, as pressed at different intervals by the fingers! It was the investigation of the analogous property and function of irritability and irritation which first gave rise to better ideas than had been previously entertained of the nature of sensibility and sensation, though the immediate dependence of the latter upon the former has never been lost sight of.

CHAPTER III.

ON THE IMMEDIATE SEAT OF SENSATION.

SECTION I.

In the Nervous System in general.

When speaking of irritability, it was mentioned that great doubts were entertained as to its immediate seat; whether it be in an equal degree really common to all the living tissues, or only appear to be so from being situated in one which is universally diffused through them all; but with respect to sensibility, it can hardly be doubted that it is seated exclusively in that part of the spinal system of nerves, the centre of which is formed by the posterior columns of the spinal marrow. The practice of referring sensibility to the spinal marrow, instead of the brain, is almost entirely a modern one. From the earliest times it had been generally understood, that the seat of sensibility was not the organs of the senses themselves, and that Νοῦς ὁρῇ, και νοῦς ἀκουει, the mind sees, and the mind hears, is one of the earliest axioms of Physiology. But the established seat of the said Νοῦς, or mind, was the brain: and it followed that the brain, therefore, was the seat of sensibility. And the opinion at present generally entertained differs from this perhaps rather in appearance than in reality, the line of demarcation between the spinal marrow and the brain being now fixed, not as formerly at the Foramen Magnum, but so far within the skull as to make the former embrace the origins of all the nerves, cerebral as well as spinal. Whether, however, they meant the same as we now mean by the brain or not, this organ is universally represented by all the earlier physiologists as the exclusive seat of sensibility; (*a*) and it was, accordingly, till

(*a*) It was in this sense that while the heart was said by them to be *ad vitam*, the brain was said to be *ad beatam vitam;* and as it had been estavery lately a question, whether it were resident not in the brain or spinal marrow, but (assuming it to be in the brain) whether it were in the cerebellum or cerebrum ; Foville, Pinel, Grandchamps and Duges, endeavouring to prove that it was in the former, while Rolando and Flourens tried to establish it in the cerebrum. To the arguments in favour of the former opinion, cerebellum, we need not allude very particularly, since it is at present by no means a prevalent one. The chief thing which can be said in its favour appears to be, that as certain affections of particular parts of the cerebrum, (the Thalami Optici and Corpora Striata, for instance) connected as these parts are with the anterior columns of the spinal marrow and motiferous nerves, have very remarkable effects on the voluntary motions, over which they may, therefore, be presumed to preside, so the cerebellum being equally intimately connected with the posterior columns and sensiferous nerves, may, by a parity of reasoning, be conceived to be the primary seat of sensibility. But it is forgotten, in the meantime, that equally remarkable effects on the voluntary motions result also from lesions of the cerebellum ; and that the cerebrum is not more connected with the anterior than with the posterior columns, nor the cerebellum more with the posterior than with the anterior, the only difference being, that, in the former case, the connexion is with decussation, and in the latter without it. The conclusion, therefore, founded upon these premises, that the cerebellum is the primary seat of sensibility, necessarily falls to the ground. The opi-

blished by Galen, that all the softer nerves of the body, which, according to him, were for sensation, arose from the cerebrum, it followed that this division of the brain, and not the cerebellum, was the immediate seat of sensibility. Still, however, it was a question whether sensibility resided in the grey matter of the brain, according to the most ancient opinion, supported by Lorey, Le Cat, Haller, and others, or in the white matter, according to Boerhaave and Meckel ; but it was unfortunately at length discovered that neither the grey matter nor the white matter of the brain appeared to be sensible ; and, although the experiments of Redi, Swammerdam, and others, demonstrating that the sensibility of the rest of the body often survived the total separation of the spinal marrow from the brain, could not but give rise to some doubts with respect to the accuracy of the old opinion on the subject, still the direct influence which affections of the brain were observed to have upon sensibility, (not more sure indeed than upon irritability, but certainly more remarkable, perhaps from the more extensive connexion between the brain and spinal marrow, than between the brain and the ganglionic system of nerves,) occasioned it to be generally referred to that organ.

nion of Rolando, (*a*) however, and more particularly of Flourens, that sensibility is primarily seated in the cerebrum, requires a little more investigation. It had been long before shewn by Zinn, Haller, and others, that certain lesions of the cerebrum produced either a profound stupor, or symptoms similar to drunkenness. Zinn, on one occasion, plunged a trocar into the anterior part of the cerebrum of a dog, and " soon afterwards," says he, " the animal fell into a state of stupor, from which I recovered him by a moderate stimulus ; but he soon again fell into the same state. His stupor became more and more profound, and he was roused with more and more difficulty, till at length he could not be roused at all." Haller, on the contrary, found, that by driving a silver sound into the cerebrum of a dog, he excited in the animal all the symptoms of drunkenness. The experiments of Rolando were more numerous and varied than those of preceding authors, but they did little more than establish that sometimes the one state and sometimes the other resulted from lesions of the cerebrum. On one occasion, after cutting through both hemispheres of a goat, (*Chevreau*) " the animal," he says, " remained firm and immoveable on his feet for the space of two hours. He made no movement, unless, by a violent shock, he was compelled to change his situation ; but other irritations, such as the *presence of aliments*, or a *pretty loud voice*, did not excite in him the slightest motion. At the expiration of this time he walked a few paces, in order to support himself against a wall, or to get into a corner, and he passed, in this way, two or three hours more in a state of profound stupor. Towards evening he lay down, and slept probably all the night, since, on the following morning, he was found in precisely the same posture." In this instance, it is pretty obvious that the lesion of the cerebrum had brought with it blindness and deafness, since the animal gave no indication of seeing its food or hearing a loud sound. On another occasion, however, Rolando having removed a portion of the hemispheres of the cerebrum from a fowl, which appeared to suffer pain during the operation, found that the animal continued to walk, and eat, and drink, but in the manner of a drunken person ; and, when desirous of picking up a crumb of bread, could only succeed after several efforts. Here it appears that the deprivation of the senses, by the lesion of the cerebrum, was only partial, this lesion having been comparatively superficial ; and, accordingly, when it was carried to a

(*a*) Saggio sopra la vera struttura del Cervello. 1809.

greater extreme in a vigorous cock, the animal displayed no indication of either sight, hearing, or feeling, but remained perfectly quiet when presented with food or water, or when exposed to noise or even to pricking. Very similar results were obtained by wounding *deeply* the cerebrum of a crow and several other birds; and the same experiments were afterwards repeated on the cerebrum of reptiles and fishes, with almost the same effects. They became stupid, but lost no part of the power of voluntary motion, though they seldom exercised it.

The experiments of Flourens (*a*) are, however, much more valuable than those of Rolando, since by taking care to ascertain precisely the parts which he injured, their results were more uniform, and they appeared therefore to establish more satisfactorily the several distinctive functions of each of the several parts of the Brain. It was for want of this precaution, says Flourens, that in one of Rolando's, the mutilation of the hemispheres of the cerebrum produced stupor and insensibility, in another drunkenness; in one, the animal was stupid and calm during the operation, in another, it seemed to suffer pain; in one, lastly, neither noise nor the aspect of food excited in it any motion, in another, it continued to eat and drink. The conclusions which M. Flourens draws from a more careful repetition of Rolando's experiments, are, 1. That the cerebrum is the exclusive seat of Sensation, Instinct, Volition, and all the Intellectual faculties; 2dly, That the Corpora Quadrigemina, Medulla Oblongata, and Spinal Marrow, are alone capable of *exciting* the voluntary motions; and, 3dly, That the cerebellum alone seems to *regulate* these voluntary motions, but not to excite them. We have at present, however, only to speak of the first part of his theory, or that which represents the cerebrum as the seat of Sensation. In corroboration of this, his experiments were most numerous, and were repeated and varied on almost all the species of all the orders of all the classes of the vertebrate animals. "When we remove," he says, "the hemisphere of one side of the cerebrum, the animal sees no longer with the eye *of the opposite side;* and if both hemispheres be removed, it becomes both blind and deaf." Vision and audition, therefore, unquestionably reside in these hemispheres, since they are constantly lost by their removal; but, for the other senses, it was not so easy to decide at first, whether they were equally constantly lost from the same cause, since they might appear to be so, only be-

(*a*) Ann. Gen. de Med. I. II., &c.

cause the animal was not immediately exposed to the stimuli by which they are excited. This could only be determined by keeping the animal alive as long as possible after the experiment, (and they will sometimes live under these circumstances for more than a twelvemonth) and observing, whether, during that period, it betrayed any symptom of such sensations. This was accordingly done by M. Flourens; and he observes, that however long such animals might survive, they remained constantly in a state of stupor, and did not appear to use any one of their senses. They neither tasted nor smelt any longer what they were compelled to eat, they ate no longer of themselves, and had no longer the sense of touch; in a word, all the senses were destroyed by the removal of the parts in question. It is a curious circumstance, too, that the abolition of *every one of the senses seemed in these instances to be always in precisely the same degree*, seeming to prove, that the immediate seat of them all was the same. According to Flourens, however modified be the removal of these hemispheres, and whatever be the point, the direction, or the limits of the operation, as soon as one sense is lost, all are lost; as soon as one faculty disappears, all disappear; but, as before mentioned, a very considerable lesion of these organs may be effected, without any one of the senses appearing to suffer; and it is not less important to keep in mind, that even though a loss of the senses have attended such a lesion, such loss is *not always irrecoverable*, but the senses are sometimes, after a longer or shorter interval, restored. The experiments of Flourens, also, were varied by the application of various deleterious substances to different parts of the cerebrum, and the result of these also were favourable to the conclusion previously drawn from its mechanical injury, that the exclusive seat of sensation was the cerebrum. As *instar omnium*, one of the first series of the experiments of M. Flourens in support of this position may be related. He removed from a pigeon the *right* hemisphere of the cerebrum: the animal immediately lost the sight of the *left* eye, but the contractility of the iris remained unaffected, and it continued to hold itself erect, to walk, to rise, to fly, to see with the other eye, to hear, to will, to perceive in every respect as before. He then removed the other hemisphere: the sight was suddenly lost, but not the contractility of the iris, and the animal remained perfectly well supported on its feet, walked when pushed, and flew when thrown into the air; but left to itself, remained perfectly still, and in a state of profound stupor. Memory, vision, audition, volition, and all the perceptions appeared now to be entirely extinct.

Now, how is all this reconcileable to the doctrine, that the immediate seat of sensation is not the cerebrum, but the posterior columns of the spinal marrow? It is perfectly so; and might, *a priori*, have been anticipated from an admission of the doctrine. It has been already remarked, that the removal of the upper part of the hemispheres of the cerebrum is not attended with loss of the senses, and that it is only when these are removed almost close to their base that such is the result. Now, it is impossible that the base of the cerebrum can be materially injured without injuring the summit of the spinal marrow, and consequently paralysing all the nerves which immediately arise from it, and this produces a loss of sensation; but we have not, on this account, any right to conclude that the cerebrum is the immediate seat of this function. On the contrary, if we can establish that all the sensiferous nerves do actually arise from the upper part of the posterior columns of the spinal marrow, and not from the cerebrum, we shall appear to be quite justified in referring to this part the immediate seat of sensation, however totally the sensation of the several organs may be obliterated, by the destruction of the nerves going to them at their respective origins. Nevertheless, why, under these circumstances, the loss of the power of voluntary motion should not take place in the same degree, (since the motiferous nerves arise from the same plane of the spinal marrow as the sensiferous) is not very obvious. Perhaps, however, the connexion between the cerebrum, in the greater part of it, and the posterior columns, may be more intimate than between the same organ and the anterior columns; although in some parts of it, it is well known, that the latter connexion is sufficiently so. It is, moreover, particularly unfortunate for the opinion of Flourens, that when one hemisphere of the cerebrum alone is removed, the sensations not upon the *same* side, but of the *opposite* side, are lost; since the only acknowledged decussation of the fibres of these hemispheres takes place not in any part of the brain, but opposite to the corpora pyramidalia at the summit of the spinal marrow; so that we must believe that, in these instances, the loss of sensation results not directly from the injury of the hemisphere of the cerebrum, (since, if so, it should have taken place on the same side) but indirectly from the injury of the spinal marrow, which, consequently, and not the hemispheres, must be presumed to be the seat of sensation. The circumstance, that all the senses are lost together, and in an equal degree, is likewise evidently unfavourable to the doctrine of Flourens, and the fact of their being subsequently recoverable after such an operation is equally so, as it indisputably proves that the location of the senses is not in the cerebrum. (*a*)

The experiments of Sir Charles Bell have fully determined that it is in the spinal cord that sensibility is resident. His experiments, so far as the sensiferous nerves are concerned, were confined principally to the Trigeminus, or fifth pair, and by establishing it, that this nerve was in its principal branches destined to impart sensibility to the organs on which it was distributed, (as the portio dura imparted the power of motion) and that these principal branches arose from the posterior columns of the spinal marrow, clearly proved that this was the seat of at least that modification of sensation constituting touch. On dividing the upper maxillary branches of this nerve in an ass, he found " that he could no longer pick up his corn, the power of elevating and projecting the lip *appearing* to be lost." This, however, depended, as he afterwards found, not upon any actual loss of power in the muscles, but upon the loss of sensation in the lips, so that they no longer acted upon what they no longer felt. This property of the Trigeminus he further established by a remarkable case, among many others, in which a person, after an unskilful extraction of one of his lower grinding teeth, by which a branch of this nerve had been injured, completely lost all sensation in the parts on

(*a*) Some of the facts, then, as well of Foville and Grandchamps, as of Rolando and Flourens, appear to be *against* the doctrine which they advocate, and all of them seem susceptible of a very easy solution, without admitting that either the cerebellum or the cerebrum is the immediate seat of sensation; and the experiments of Lorey and Le Gallois, to prove the continuance of sensibility after the separation of the spinal marrow from the brain, having corroborated the conclusions necessarily resulting from those of Redi and Swammerdam, that the immediate seat of sensibility was the spinal marrow, rendered this opinion a very prevalent one among physiologists. It could not escape notice, also, that had the brain, cerebellum or cerebrum, been the seat of sensibility, man should have excelled all other animals in acuteness of sensation. It remained only for Sir C. Bell in 1821 and 1822, for Magendie and Mayo likewise in 1822, for Fodera in 1823, and for Bellingeri in 1824, to establish it by a series of conclusive experiments, that it was in the spinal marrow alone that sensibility was resident; but that it was not equally in every part of the spinal marrow, but only in the two posterior columns; as it was in the two anterior columns that resided the power of exciting voluntary motion.

which this nerve had been distributed. On putting a tumbler of water to his lips, he asked his attendants why they had given him a broken glass? but he presently found that the glass was entire, but that he had lost the sensation of one-half of his lower lip. He thought that he had put half a glass to his lips, because he felt only one-half of it. He retained the power of moving the lip, but not of feeling with the lip; and at the time when the case was related, which was many years after the injury of the nerve, he did not know when a portion of food or a drop of liquid hung on the side of the lip, though there was not the slightest impediment in its motions. In another case, in which this nerve was paralysed from repeated attacks of apoplexy, the patient had a constant flow of saliva from the affected side of his mouth, and when drinking, a part of the liquid always escaped from that side. The loss of the sensibility of the orbicularis oris was further shewn by his inability to hold a pencil or a tobacco pipe in the right side of his mouth. Bell further proved, that the section of this nerve, or of any other, the origin of which is from the posterior columns of the spinal marrow, always occasioned acute pain, while the section of any nerve arising from either of the other columns was unattended with any pain whatever.

The experiments of Bell, tending to establish the seat of sensibility in the posterior columns of the spinal marrow, met with great corroboration from the researches of Magendie. In one case related by this author, a man had lost the motion of both arms for several years, but retained an acute sensibility in these parts; and, upon the examination of his body after death, the anterior roots of the nerves going to these parts had lost all their medullary substance, and were reduced to mere membranous sheaths, while the posterior roots were in a perfectly healthy state. In another, a patient of the hospital of Charenton had lost for seven years the power of motion over his whole body, but retained his sensibility unimpaired; and, on examination after death, it was found that there was an evident change of structure in the anterior columns of the spinal marrow, while no such change was observable in the posterior. From these and numerous similar instances of disease, as well as from the results of various experiments, it is concluded by Magendie, that all the parts of the body, without exception, derive their sensibility from the nerves, with which they are supplied from the posterior columns of the spinal marrow, which is therefore to be regarded as the citadel of this property. Still it must be remarked, that in all these instances allusion is made only to touch and taste, (which is merely a modification of it) and that we require other proofs before we can establish it, that the senses of smelling, seeing, and hearing are, in an equal degree, primarily dependent upon the spinal marrow. The trigeminus in the lower animals is often vicarious of the first, second, and seventh pairs, which would seem to shew a common origin; and if any general cause, such as an injury of the brain, while it paralyses the sense of touch, paralyses also that of smelling, seeing, and hearing, and that on the same side of the body, namely, the opposite side to that of the primary injury; and if this is attributable, in the case of touch, to the nerves which impart this sense arising below that part where the decussation of the nervous filaments at the summit of the spinal marrow takes place, we must conclude that the corresponding failure of smelling, seeing, and hearing of the same side, is occasioned by the nerves which minister to these senses arising also below the decussation, that is to say, from the spinal marrow and not from the brain, through some portions of which they severally pass on their way to their respective organs. Since the researches of Bell and Magendie, there has been little difficulty in explaining many of the phenomena of palsy, which previously appeared to be quite anomalous; and numerous other instances have been adduced by various authors in support of their opinions, respecting the independence, at least as far as the touch is concerned, of the spinal marrow upon the brain. Among the rest, one is related in the *Journal de Physiologie*, for 1823, of the perfect preservation of the faculties both of sensibility and of the power of exciting voluntary motion in a man, between the upper and lower parts of whose spinal marrow there was an almost total want of continuity for the space of six or seven inches; and many similar cases, though less striking than this, have been at various times recorded. (*a*)

(*a*) Mayo suspects some fallacy in the case, and says that palsy is "a uniform result," when the spinal cord is divided. Only a few pages before, however, he himself states, that if this cord be divided in a rabbit, in the centre of the back, the hind-leg retains both sensibility and the power of motion!—*Outlines of Physiology*, p. 233.

SECTION II.

In the Sensiferous System of Nerves in particular.

HAVING thus assumed one department of the spinal marrow as the immediate seat of sensibility, another having been presumed formerly to be the immediate seat of the power to excite voluntary motion, and a third to be a channel by which sympathy and the passions are communicated; it seems proper now to describe the origins and part of the course of the sensiferous nerves commonly reputed cerebral, in order to establish it that they are really spinal nerves, and that the posterior columns of the spinal marrow are the seat of sensibility. (*a*)

The Olfactory nerve (the first of the sensiferous nerves) is the only one of which any reasonable doubt, with respect to its origin from the spinal marrow, can be entertained. Its filaments are visible first in the grey matter at the anterior part of the base of the middle lobes of the cerebrum, and, approximating gradually,

(*a*) The sensiferous nerves, as already mentioned in the tabular view of the nerves of the human body presented in a former part of this work, appear to consist of the Olfactory pair, the Optic pair, the Ophthalmic branch of the Tregimini, the Upper Maxillary branch of the Trigemini, a part of the Lower Maxillary branch of the Trigemini, the Auditory, (which were until late years considered cerebral nerves,) and the sensiferous portions of the regular nerves, the Sub-occipital, the seven Cervical, the twelve Dorsal, the five Lumbar, and the five Sacral. The subject of the plurality of the nervous system was first presented to mankind, in a collected and definite form, by Gall, by whom four classes of nerves were admitted, viz. the proper ganglionic nerves of Bichat; those which belong to the specific senses of smelling, seeing, and hearing; the combined sensiferous and motiferous nerves, or what are called regular nerves; and those which minister to the mental faculties, the last being in fact not nerves in the common acceptation of the word, but the white fibres of which the bulk of the brain is said by him to consist. There seems to be great impropriety, however, in representing the nerves of the specific senses as distinct from the nerves of general sensation, since, as has been already hinted, and shall presently be shewn, they slide into each other, and are in truth parts of the same system; and a still greater one in not admitting a distinct head of motiferous nerves, which are not always found in combination with such as are sensiferous, but exist separately. It is also an obvious defect in this system, that no notice is taken of the respiratory nerves, a system of so much interest and importance.

form commonly three roots, which unite into a trunk, separating itself from the cerebral mass about the beginning of the anterior lobe, and running forwards afterwards in the most internal of the grooves formed by the base of this lobe. Above the cribriform plate of the ethmoid bone it forms a kind of bulb, from which numerous filaments descend into the nostrils. But although it is here that the filaments of these nerves first become sensible, still there are above this part bands of nervous matter coming from the corpora geniculata interna and testes, from which analogy with the established origin of the optic nerves would induce us to imagine they had their true origin; and as the testes pretty certainly receive corresponding filaments from the medulla oblongata, (*a*) we seem justified in presuming that it is from this part at length that the olfactory nerve primarily arises. (*b*)

Independently, however, of anatomical and physiological evidence, analogy, and the effects upon these nerves of some common causes of disease, seem perfectly to justify us in making this assumption. The latter remark alludes particularly to the effects of a blow inflicted on one side of the head, which is found frequently to paralyse all the nerves of the opposite side; and when this is the case, it is not the eye and ear of one side, and the nostril of the other, which are so affected, (as it should be if the

(*a*) These are very obvious in the Mole, (*Talpa Europæa*) according to Carus.

(*b*) This opinion moreover is supported by the much greater size of the corpora geniculata interna and testes in carnivorous than in herbivorous animals, as among Birds, in the rapacious, and especially the Grallæ, and among Quadrupeds, the Bear, (*Ursus*) and the Dog, (*Canis*) corresponding with their greater development of this nerve, and the greater accuracy of their sense of smell; but it must not be concealed that these bodies are found also in the Porpoise, (*Delphinus Phocæna*) the Whale, (*Balæna Mysticetus*) the Narwhale, (*Monodon Monoceros*) and other animals in which no olfactory nerve has been yet detected. Such nerves, however, may exist, although perhaps, from not following the usual course, they have not yet been recognised; or they may be perfect in the early part of their course, though discontinued to the nostrils, precisely as occurs with respect to the optic nerves in the Mole. Nay, it has even been asserted by Jacobson and Blainville, that they certainly exist, and have their usual course, though this has been subsequently denied by Rudolphi and Otto. The description therefore of the origin of the olfactory nerve, as given by Willis, Vieussens, Winslow, Cuvier, and others, who derive it from the corpora striata, and by Vicq D'Azyr, Prochaska, Scarpa, and Soemmering, who derive it from various other parts of the cerebrum, is probably inaccurate.

nerves of the two first arose *below* the tuber annulare, and that of the last *above* it) but all these organs of the same side equally suffer. It may be mentioned likewise in passing, that the circumstance of the eye and ear of the same side, as the trunk of the body being commonly affected in hemiplegia, and not the opposite eye and ear, is a strong argument in favour of this doctrine. In conclusion of the subject of the olfactory nerve, it may be noticed, that in the invertebral animals it is not improbable that its place is frequently supplied by the fifth pair, which is confessedly a spinal nerve, so that this also is in favour of the opinion respecting its low origin. (*a*)

The Optic nerves arise from the posterior columns of the medulla oblongata, and originating in the manner which the olfactory have been presumed to do, become reinforced only by the nates. (*b*) Meeting the corpora geniculata externa, the optic nerves pass forwards and proceed like a thin nervous expansion along the thalami optici, by which, however, they are NOT reinforced. (*c*)

(*a*) This nerve is indeed to be detected in some insects, as the Cancer Astacus, but for the most part it is wanting in the invertebral animals; and as many of these animals, such as the Snail, (Swammerdam) the Sepia, and most insects, certainly display indications of smelling, the Sepia, in particular, being very much offended by odoriferous plants, we must presume that its place is supplied by some other. Now, we know that in the highest class of animals, the place of a proper Gustatory nerve is supplied by a branch of the fifth pair, which is a nerve at once of touch and taste; that in some of the mammifera, as some species of Sorex, Mus, Talpa &c. as well as in some reptiles, for instance, certain species of Proteus, Syren, Cæcilia &c. a branch of the fifth pair is in like manner substituted for an optic nerve; and that in fishes in general, a similar branch of the fifth pair is in place of an auditory. Why should not then the same fifth pair in some animals which do not display a proper olfactory nerve be to them in place of it?

(*b*) The optic nerves were represented by Galen, Eustache, Varolius, and the earlier anatomists, to arise from the thalami optici, and by Ridley, Winslow, Zinn, Morgagni, Santorini and Scarpa, to arise from the nates. They are reinforced merely by the latter organs, which are accordingly bulky in Fishes, Reptiles and Birds, (in which they have till recently, according to Gall, Cuvier, and Tiedemann, been mistaken in the two former for hemispheres, and in the latter for thalami optici) and among the mammalia in the Squirrel, (*Sciurus*) the Rabbit, (*Lepus Cuniculus*) the Hare, (*Lepus Timidus*) which have large optic nerves, while, on the contrary, they are small in the Mouse, the Rat and the Bat, (*Vespertilio*) in which these nerves are diminutive.

(*c*) This membranous structure of the optic nerve is in some animals

From the thalami optici the optic nerves, taking a circle round the crura cerebri, meet, and, perhaps, decussate each other before the sella turcica. Concerning this connexion of the optic nerves much diversity of opinion has prevailed from the earliest times. (*a*)

continued to its termination, particularly in Fishes and Birds. Nay, in some birds with piercing sight, as Falcons, Cranes &c. the optic nerve is not only an expanded membrane, but has one of its surfaces folded into numerous plicæ, bearing the same relation to the others as the leaves to the back of a book ; and the extent of surface thus gained may be easily imagined.

(*a*) This was the case even before the time of Galen, since we find him engaged in a controversy on the subject. His idea was, that there was no decussation of nervous matter, and that the connexion was by the membranes alone ; and in this he is supported by Væsale, Cæsalpino, Santorini, Zinn, Vicq D'Azyr, Morgagni, Petit, Haller, Monro Secundus and many more. Others on the contrary, as Lancin, Cheselden, Soemmering, imagine that there is so entire a decussation, that all the filaments from one side of the spinal marrow pass to the other retina ; while a third set of writers, including Michaelis, the Wenzels, Ackermann, Treviranus, and Dr Wollaston, suppose, that while the more external of these filaments pass on directly to the retina of the same side, the more internal decussate each other, and pass to the opposite eye. It is unnecessary to detail all the arguments in support of these several opinions derived from αυτοψια, from analogy with the lower animals, or from pathology; those from the first, being very questionable ; those from the second, at best, but presumptive ; and from the last, by turns almost equally favourable and inimical to all. With respect to comparative anatomy, for instance, while in those invertebral animals which display an optic nerve, the Snail, the Scorpion, the Cray-fish, the Bee, the Silkworm, there is so far from a decussation, that there is not even an approximation of these nerves, in many of the lowest class of vertebral they evidently cross without being at all united. This is the case in fishes in general, with the exception of the Sole and the Cod ; and it is equally so in some reptiles, for instance in Frogs and Serpents. On the contrary, in other reptiles, as Tortoises and Lizards, as well as in birds in general, they seem to interlace with each other in such a manner, that the decussation is partial ; and in the Mole, among mammiferous animals, they unite together, so as to form a transverse band, from which, however, no nerves are continued to the retina. The semi-decussation of the optic nerves is said to have been satisfactorily shewn in the Ape, (Treviranus) the Horse, (Cuvier) the Ox, the Sheep, the Rabbit and the Guinea Pig, and to be very evident in the human fœtus. (Serres) It is less obvious in the Cetacea than in the other mammalia. With respect to the proofs to be derived from pathology, a failure of the sight of one eye produces a shrinking of the optic nerve within the skull, sometimes of the same side, (Galen) and sometimes of the other, (Soemmering, Cuvier, Gall &c.) ; and a compression of one optic nerve within the skull produces an amaurosis, sometimes of the eye of the same side, and sometimes of its fellow.

The most probable opinion appears to be, that there is a partial decussation, perhaps, of that nature which is presumed by Michaelis, viz. the more external of the filaments from one side of the spinal cord pass directly to the retina of the same side, the more internal decussate, and pass to the opposite eye. After this union of the optic nerves they pass through the optic holes, a little beyond which part they receive a twig from the ophthalmic artery into the centre of their substance, and perforate the exterior coats of the eye to form the retina. In such of the invertebral animals as have no optic nerve, it is probable that its place is supplied by the fifth pair, since they are certainly sensible to light.

The Auditory nerve takes its origin from the corpora restiformia, a production of the posterior columns of the spinal marrow ; (*a*) and passing almost horizontally through the meatus auditorius interior together with the facial nerve, (round part of which it forms a kind of membranous groove) is divided in the labyrinth of the ear into two principal branches, one of which goes to the membrane lining the vestibule and semicircular canals, and the other to that lining the cochlea. (*b*)

The Trigemini arise not from the proper crura cerebelli, nor from the tuber annulare, as represented by Michaelis, Haller, Wrisberg, Vicq D'Azyr and Scarpa, but below the tuber annulare ; (*c*) each by one large posterior root from the corpora restiformia, and by two small anterior roots from the corpora olivaria, whence, proceeding forwards to the side of the sella turcica, the filaments composing the large root are collected into a semilunar knot, injudiciously called a ganglion, which is named Gasserian, from its discoverer, and the first of a series of

(*a*) Demonstrated by Prochaska, in 1800, and confirmed by the Wenzels, in 1812.

(*b*) It was stated by Piccolomini, Redi, Haller, Vicq D'Azyr, that the auditory nerve arose from the walls of the fourth ventricle. Its office in most of the invertebral animals, (very few of them, like the Sepia and Cray-fish, being possessed of one) is in all probability performed by the fifth pair, a presumption the more likely, as in Fishes in general, as before said, this appears to be the case, though it is said by Desmoulins, Rudolphi, Weber, and others, that in most Fishes the auditory nerve is rather closely connected with the fifth pair than a branch of it. The former opinion is however most general, and decidedly in favour of the spinal origin of the auditory nerve.

(*c*) First shewn by Santorini and Winslow about 1730—corroborated by Soemmering in 1778.

these bodies which occur on the roots of all the sensiferous nerves. Emerging from this ganglion, the filaments, of which the large root consists, form with those constituting the small roots, and which had not passed through the ganglion, two flattened trunks, each of which is soon divided into three branches, in such a manner, however, that the first, or ophthalmic branch, and the second, or upper maxillary branch, are composed exclusively of those filaments which have arisen from the corpora restiformia, and passed through the Gasserian ganglion; while the third, or lower maxillary branch, is composed partly of these filaments, and partly of those which have arisen from the corpora olivaria, and passed on one side of the ganglion without going through it. Of course, the whole of the first and second branches, and a part of the third branch, are sensiferous nerves, and appertain to our present subject; the remaining part of the third branch being motiferous alone, has been disposed of already. The first, or ophthalmic branch, passes into the orbit, through the foramen lacerum anterius, and divides into its frontal, its nasal, and its lachrymal twigs. The second, or upper maxillary branch, passes through the foramen rotundum, and divides, in like manner, into its orbital, dental, and infra-orbital twigs, while the sensiferous part of the third, or lower maxillary branch, passes with the motiferous part through the foramen ovale, and divides into its inferior dental, lingual, and auricular twigs. (*a*)

The sensiferous portions of the fifth pair, the acknowledged instruments of touch and taste, are sometimes also, as already noticed, those of smelling, as, if not in the cetacea, perhaps in most invertebral animals; of sight, as in many invertebral, and among the vertebral, in the Shrew, (*Sorex*) the Mole, (*Talpa Europæa*) and many others; and of hearing, as likewise in most invertebral, and among the vertebral in fishes in general. By Bell, the trigemini, or fifth pair of nerves, are represented as the first of the regular nerves, and in as far as they communicate, collectively taken, both sensation and the power of motion, they may be so

(*a*) It seems to be this branch of the trigeminus which, encircling as it does the pharynx of man, corresponds to that ring of nervous matter round the gullet which is so universally found in the invertebral animals, from the lowest to the highest. Whether its origin be in the one from the uppermost ganglion or that corresponding to the brain, or from the lowermost to that corresponding to the summit of the spinal marrow, we are of course profoundly ignorant, although the latter opinion is preferable.

called. As, however, each individual filament of these nerves, as abundantly proved by Mr Mayo, is exclusively either sensiferous or motiferous, and not, like each filament of the really regular nerves, both the one and the other, it seems proper to separate them from the latter, and to divide them between the sensiferous and motiferous systems, as has been done.

CHAPTER IV.

STIMULI TO SENSIBILITY.

Having said so much of the seat of sensibility, we can easily explain why this faculty, unlike irritability, is not, at least under ordinary circumstances, displayed by every organ of the body, since it is only to certain organs that sensiferous nerves, at least in their more palpable form, are distributed. We, in general, form our notions of sensibility from that of the skin or touch; and it is, no doubt, necessary that we should do so. It is in constant communication with things around us, and affected by their qualities; it affords us information which corrects the notions received from the other organs of sense, and it excites our attention to preserve our bodies from injury. We are so familiar with the painful effects of injuries upon the surface, that there is nobody who does not imagine, that the deeper the injury, the more dreadful the pain. But, on the contrary, it is a well-established fact, as already mentioned, that to such irritants as would give the skin pain the internal parts are totally insensible.

At the same time it must be remembered, that both the ganglionic and respiratory system of nerves in all probability receive filaments from the sensiferous system, as well as communicate filaments to it; and it is in this way that the sensibility evinced under some circumstances even in health, by organs not commonly reputed sensible, as the stomach, rectum, and urinary bladder &c. as well as that evinced during disease, by almost every organ of the body, must be explained, the filaments sent from this system to others being probably so minute as to be incapable of conveying merely ordinary irritations.

Since, then, sensibility is not like irritability, resident in every isolated part of the system of nerves to which it is proper, that of any organ is, of course, immediately destroyed if the free communication of the sensiferous nerves with their common centre be obstructed. The nerves of this system, therefore, must be conceived of as merely conduits of the irritation by which sensibility is excited, not as the seat of sensibility itself, and the difference in the structure of the central parts of this system and in that of the nerves derived from them may well account for the peculiarity in the office of each. Not only in the ganglions, as before said, but in every point of a ganglionic nerve, there is an intimate union of grey and white matter, so that every point of such nerve is, as it were, a centre of energy to itself; but in the sensiferous system of nerves, on the contrary, there is a perfect line of demarcation between them, the grey matter being found in the central parts alone. As, therefore, the central parts of this system are analogous to the ganglionic system in general, so the nerves proceeding from these central parts, in as far as they are conduits alone, are analogous rather to the respiratory nerves, and in the same manner as the respiratory nerves extend a local irritation to a distant organ, so as to produce there a secondary irritation, (as in the case of sympathy) these nerves appear to extend a local irritation to the central parts of this system, so as to produce sensation. Another point of similarity, in sensibility and irritability is, that the former is not, any more than the latter, everywhere the same in quality, any more than in degree, but, on the contrary, in almost every two organs different, being adapted to the peculiar kinds of irritation to which each organ is subjected; and how different these irritations must be will be evident, if we reflect that they are the result, as well of very various kinds of irritability, as of very various stimuli. Whatever be the character of this stimulus, however, and however different the *irritation* may be, the *sensation* resulting from the irritation of any individual organ, as conveyed by any particular nerve, is, perhaps, always the same. Some of these stimuli, then, like caloric, excite irritability, so as to produce *evident* irritation, whether going on to sensation or not, while others, as odoriferous substances, light, tremors of the air &c. excite irritability, so that the irritation is *not perceptible*, and serves only as a prelude to sensation. The latter class of stimuli are commonly regarded as direct stimuli to sensibility, although (as it would seem) they are so only in as far as they excite irritation in parts furnished with nerves adapted to convey this irritation, so as to excite sensation elsewhere. The peculiarities in some of the sensations so excited are so remarkable as to have given rise to quite distinct terms to express them, and it is to such modifications of sensation in general that are referrible, as has been already said, not only the five proper senses, of smell, light, sound, taste and touch, but also hunger, thirst, the feelings which produce the desire to void the stools or urine, and the desire of venery, as well as many other feelings common in health, and innumerable others properly considered morbid. Like irritability, also, sensibility may be increased by want of use, or exhausted by excess of it; and the habitual excitement of certain sensations seems to render organs more susceptible with respect to certain irritations, in the same way as the habitual excitement of certain irritations renders them more susceptible with respect to certain stimuli. It is perhaps in this way that we must explain the beneficial effects in cases of Palsy, affecting the sensibility of certain organs, of Electricity, Galvanism, Acupuncture, Frictions, Epispastic medicines, and so forth; all which seem to operate on the sensiferous nerves, by means of irritation, as strong stimulants, and thus to excite in the seat of sensibility a strong sensation, which perhaps stimulates the capillary arteries of this part to renew that deposition of nervous matter, of which sensibility is the essential attribute. We come now to treat of the individual senses, in the order in which the nerves on which each immediately depends have been spoken of previously.

SECTION I.

On the Irritation of the Nostrils, regarded as a Stimulus to Sensibility.

The seat of the Irritation, the perception of which constitutes Smell, is in Man the Schneiderian membrane of the Nostrils, and the nerves which convey it, in all probability, principally the Olfactory. (*a*)

(*a*) This was questioned long ago by Mery, as it has been lately by Magendie, who destroyed the olfactory nerves *apparently* without rendering the animal incapable of smelling, while, on the contrary, the destruction of the Trigemini seemed at once to deprive them of this function; and a remarkable case was related about the same time by Serres, in which a morbid state of the Trigeminus nerve on one side was attended with a total loss not only of general sensation, but of the senses of smell, sight, and sound on *that* side. Hence it has been inferred by Magendie and others, that the nerves commonly reputed those of the Specific Sensation are not really so, but that the Trigemini are those of all the proper senses, as well as those of sensation in general. But this conclusion appears to be a very hasty one. It has been remarked more than once, that in several of the lower animals these nerves do certainly perform the offices respectively of the Olfactory, Optic, and Auditory nerves,—a fact which seems to justify us in believing, that they may even in Man materially conduce to the Specific Sensations; but we cannot suppose that the proper specific nerves are given to us in vain; and it does by no means follow, that

Each nostril is formed essentially of the membrane just mentioned, (*a*) extending from its exterior margin where it is continuous with the dermoid tissue to the pharynx, and partially divided by projecting bones into an upper, a middle and a lower passage, which are said to be remarkably large in the Negro, and from which in Man proceed various tortuous ducts, some terminating in sinuses and cells, while others open on the mouth and eyes. These cavities do not appear to contribute any thing to the smell, and the direction of the ducts of all of them, except those which lead to the Sphenoidal Sinuses, being forwards towards each, is much less calculated for the

because the Trigemini are essential to the exercise of the Specific Senses, they are of themselves sufficient to produce them in animals furnished with Specific Nerves for the purpose, any more than because some animals breathe exclusively by the Skin, and the function of the Skin is essential to the perfect respiration of Man also, that his lungs are therefore superfluous. It is easy to understand how smell should be destroyed by the division of the fifth pair; but the statement, that smell continues after the destruction of the olfactory nerves, certainly requires corroboration, particularly as we know that the destruction of the optic and auditory nerves entails certain blinding and deafness upon the animals upon which it is practised. It is true animals continue to sneeze after the division of their olfactory nerves upon the application of volatiles; but sneezing has nothing to do with smelling. It results from the primary irritation of the Schneiderian membrane conveyed by the Portio dura, so as to provoke a sympathetic action of the Respiratory Muscles, and is quite independent of the Olfactory nerves. The chief luxury of Snufftaking does not (as before observed) consist in the odour of the snuff, but in the stimulus imparted by the tobacco to the whole respiratory system of nerves. It is even questionable whether the integrity of the fifth pair be quite essential to sneezing; at any rate, in one case related by Bell, in which the right side of the face, in general, was insensible from an affection of this nerve, the power of ammonia to excite sneezing was as entire when applied to the right nostril as to the left. It is well known, moreover, that the division of the Portio dura at once takes away this power. It appears, therefore, that the evidence of the continuance of smell, after the destruction of the Olfactory Nerves, is defective; and that the destruction of this sense, after the division of the Trigemini, proves only that these nerves are one of the instruments, but not the only or even chief instrument of this function. The large size also and particular distribution of the olfactory nerves in those animals which are endowed with a remarkably acute smell, (Carnivorous) cannot be without some purpose; and the frequent destruction of smell in individuals who seem to enjoy all the other functions dependent upon the Trigemini in the greatest perfection, is decidedly against the doctrine, that it is by these nerves alone that smell is communicated.

(*a*) This membrane was described by Schneider, in 1655, to line the ducts which proceed from the passages of the nostrils, and its discovery formed an important era in Physiology, as it tended to abolish the absurd notion of the ancients, that the mucilage of the nostrils was derived from the ventricles of the brain, and conducted to these organs by means of the Olfactory nerves, which they regarded not as nerves, but as mere common sewers for its conveyance.

reception of inspired than expired air, and affords a strong proof that they are instrumental rather to the voice, which is effected during expiration. It is said also by Desault, Deschamps and Richerand, that the mucous membrane investing these cells is quite insensible to the strongest odours; but this is questioned by Blumenbach.

The organ which corresponds to the nasal fossæ of Man in the Invertebral animals is in general very obscure. In the Snail it has been commonly considered to be their short feelers, but without any good reason, and in most other animals of the last class either to be their surface or their pulmonary organs. In Insects it has been referred either to their stigmata, (*a*) to their palpi, (*b*) or to their antennæ. (*c*) In the Cancer Astacus, which has a sufficiently obvious Olfactory nerve, it is certainly situated in their smaller antennæ, at the root of which the nasal fossæ are sufficiently evident, as they are in all the tribes of Vertebral animals. In the osseous Fishes, however, they are little more than two blind fossæ, situated on the sides of the snout, and lined by a *plaited* mucous membrane; but in some cartilaginous Fishes, as the Lamprey, they open from immediately before the skull into the pharynx. In Reptiles also they have a posterior as well as an anterior opening, the latter being, in Frogs, Turtles, Serpents &c. in their palate; but in Lizards, in some of which, as the Crocodile, the fossæ are exceedingly long, near the pharynx. In Birds these fossæ are in general very large, their anterior opening being in the upper nostril, and their posterior in the pharynx. In the Mammalia the fossæ have always two apertures, and run in general horizontally; but in the Cetacea their inclination is perpendicular, the outer opening being on the top of their heads. The projecting bones by which these fossæ are, from Reptiles upwards, divided, are in Man extremely simple, but much less so in Quadrupeds, being in most herbivorous animals both variously convoluted and pierced sometimes like lattice-work, and in most carnivorous lamellated like the leaves of a book,—a structure calculated, together with the great length of their snout, immensely to extend the surface of the lining membrane. It is computed that in the Seal this membrane presents a surface in each nostril of 120 square inches.

In the formation of each nostril in Man nine bones are instrumental; but these it is unnecessary to describe; and besides these there are three cartilages, which are simple in Man, but constitute in some Quadrupeds, as the Tapir, (*Tapir*) Hog, (*Sus*) and Peccari,

(*a*) Cuvier, Reimar.
(*b*) Bondorff, Knoch.
(*c*) Reaumur and Rosil.

Dicotyles) a complete moveable tube, which in the Elephant (*Elephas*) is prolonged into the proboscis.

These cartilages are compressed, raised or depressed by proper muscles, and similar means of regulating the passage of the air through the nasal fossæ is found in many of the inferior animals. To say nothing of the contractile stigmata of Insects, (supposing these organs to be in most of them the instruments of smell) many Fishes, and among Reptiles, the Frog, (*Rana*) have certainly a kind of moveable lid at the aperture of their nasal fossæ, by which they close them at pleasure; and this is still more remarkably the case in the Seal, (*Phoca*) the slit-like aperture of its nostrils being entirely closed during diving. The Cetacea also have a kind of muscular pouch below the orifice of their perpendicular nostrils, separated from the lower part by a valve by which the entrance of the water is prohibited, but the exit of that received by the mouth is, during the contraction of their pharynx, and the subsequent contraction of their muscular pouch from below upwards, allowed of, so as to form a kind of fountain sometimes forty feet high.

The odoriferous particles of bodies, then, conveyed by the air, and received in the higher classes of animals during inspiration into the nostrils, constitute the ordinary stimulus to that irritation on which Smell depends; but it may be excited also by galvanism, (a good proof that it is through *irritation* that *sensation* is produced, since galvanism has no effect on the sensiferous nerves) or by mechanical irritation of the olfactory nerves, which, like the other nerves of specific sensation, whatever be the nature of the irritation applied to them, are capable of giving rise to only one kind of sensation. Nor needs this surprise us, since even the nerves of general sensibility often impart precisely similar sensations, when acted upon by very different stimuli, as is obvious from a twist giving rise to a pain exactly like that of cramp. The diffusibility and minuteness of the odoriferous particles instrumental to smell are almost inconceivable. The odour of the Cinnamon trees of Ceylon is said to be perceptible at twenty or twenty-five miles distance from the shore, and a grain of Musk or of Camphor is capable of throwing off such particles for twenty years, without losing any appreciable portion of its weight. Odours are more perceptible early in the morning and in the evening than at mid-day, owing to the greater density of the air. In Aquatic animals, the odoriferous particles of bodies are, of course, conveyed not by the air but by the water, although we may consider the sensation thus imparted as analogous rather to Taste than to Smell. It is wonderful, however, to how great a distance Fishes, for instance, will sometimes scent a putrescent carcase, particularly when we reflect that their nasal fossæ being blind sacs, the impulse of the water containing these particles is not augmented by the process of respiration. The sense of Smell is, in most Birds and Quadrupeds, very acute. The Vulture, (*Vultur*) for instance, has been reported capable of smelling carrion over the whole breadth of the Mediterranean; but it is questionable whether these animals be not sometimes directed to their prey almost as much by their Sight as by their Smell; and White Bears (*Ursus Maritimus*) come swimming to the Greenland ships, when a Whale is cutting up, from all quarters, and far out of sight. On the contrary, the Porpoise, the Whale, the Narwhale &c. are commonly reputed destitute of this function, from the apparent want of a proper olfactory nerve; and it is certain that the dry and hard lining of their nostrils, like that of the proboscis of the Elephant, is apparently ill adapted to this sensation. Smell is the only one of the senses in which infants excel adults, and for an obvious reason. The Negro also has generally a more acute smell than the European, and men than women. (*a*)

SECTION II.

On the Irritation of the Eyes, regarded as a Stimulus to Sensibility.

THE seat of the irritation, the perception of which constitutes Sight, is in Man and the higher classes of animals the membrane of the eyes, on which the Retina (*b*) is expanded, and the nerves which convey it, the Optic—the Trigemini being instrumental only secondarily.

(*a*) It is remarkably the case, that male birds very much excel the female in this particular. (Scarpa)

(*b*) The Retina is a net-work of nervous filaments, with their neuralima, derived from the Optic nerve, which enters the eye not immediately in its axis, but a line nearer the nose, expanded into a globe, and having a hole with a yellow border at its back part, immediately opposite the pupil, called the spot of Soemmering. In the Cancer and Insects in general, the retina is disposed into a number of pyramids, each of which corresponds to one of the facets into which the cornea is divided in these animals. In the Petromyza or Lamprey tribe, in which the optic nerve is ribband-like, the retina is plaited into numerous folds, arranged like the meridian lines on a globe. In Birds the blood-vessels penetrating the optic nerve before its entrance are expanded, between the retina and lens, into a kind of plaited membrane, called Marsupium or Pecten, by which the access of a great part of the rays entering the eye to the retina is prevented. It is said that in some of the Mammifera, as the Seal (*Phoca*) and Porcupine, (*Hystrix*) the entrance of the optic nerve is not on one side, but directly in the

The usual stimulus to this irritation is rays of light; but similar irritations may be excited by Galvanism, or by a mechanical stimulus, such as a blow on the eye, or a wound of the Optic nerve, or of the Retina, like that which is often inflicted in the operation of couching. Before speaking of the several parts of the eye, it is proper to call to mind that rays of light, in their passage from every point of a visible object, form pyramids or cones; and that such rays as impinge otherwise than perpendicularly upon the surface of a transparent body, if they pass from a rarer into a denser medium, are refracted (in proportion to the increase of density) towards a line drawn perpendicularly to that surface; whereas if they pass from a denser into a rarer medium, they are refracted (in proportion to the diminution of density) so as to recede from such a line. Such rays, then, emanating from every point of every visible object, form innumerable pyramids or cones, with each its base upon the Cornea; and had this been the seat of vision, without the rays having been again collected into focuses, all the points of all the images of every visible object would necessarily have been jumbled together, and all have been weak in proportion to the diffusion of the rays. The main object, then, of all the principal parts of the globe of the eye is to collect diffused rays again together, and thus to make a distinct and strong impression of every point of every visible object upon the Retina. The papillæ, therefore, of the Zoophytes, and the stemnata of the Leech and of Insects may perceive light, but cannot perceive *images* or *arranged* light, as this requires refraction. All the pyramids of rays accordingly impinging with their base upon the Cornea, and passing from the air into this membrane, are of course refracted, each in the direction of a line drawn perpendicularly to the surface of this membrane, and this refraction is, in all Terrestrial animals, greater at the Cornea than at any other part of the eye, the difference in density between the air and this membrane being much greater than between this membrane and any other part of the eye-ball. It is not an uncommon error to imagine, that as the Crystalline Lens is the densest, and has the greatest refracting power of all the humours of the eye, it is here that the rays of light undergo the greatest refraction; but there is a fallacy in this idea of the matter, the density of the Crystalline Lens exceeding that of the Cornea and Aqueous Humour only in

axis of the eye, and the spot of Soemmering has been hitherto noticed only in Man and in Apes. The retina and its neuralima probably terminate about a quarter of an inch from the margin of the lens, but there is much uncertainty in this respect. They seem, however, to terminate sooner in Birds, and in the Rodentia and Pecora among Quadrupeds.

the ratio of 1114 to 1000, and its refracting power is that of only 1384 to 1337; whereas both the density and refracting power of the Cornea and Aqueous Humour exceed those of the air in the ratio of about 800 to 1, or 1000 to $1\frac{1}{4}$; so that, though the rays of light, in passing from the Aqueous Humour into the Lens, are indeed slightly turned again towards the perpendicular, there is no sort of comparison between the refraction which they here undergo, and that which they undergo in passing from the air into the Cornea. Of all Terrestrial animals Birds are those by the Cornea of which the rays are not most refracted, (for that depends upon change of density alone) but made most to converge, owing to its great degree of convexity; whereas in the Cetacea and Fishes, the rays not only scarcely undergo any refraction at all in the Cornea, because this membrane is nearly of the same density as the medium in which they live, but are made to converge very little, because it is comparatively very flat. From what has been just said, it will be easily understood why Terrestrial animals see imperfectly under water, and Aquatic animals in the air; in the former case there being too little change in the direction of the rays when they impinge in the Cornea, and in the latter too much; so that in the former case the rays are not sufficiently soon brought to a focus; in the latter, on the contrary, too soon.

Amphibious animals seem to have a power of adapting the eye, so as to enable them to see equally well in the air and under water, perhaps by either pulling the eye-ball backwards, or neglecting to press it forwards: In the former case, so that the distance between the Cornea and Retina is diminished, and a considerable refracting power therefore required; and by neglecting to pull it backwards, or pressing it forwards in the latter case, and thus increasing the distance, so that a less refracting power is sufficient. The Cobitis Anableps is the only animal which is capable of seeing with the same eye partly in and partly out of the water. To accomplish this double object, it has, in fact, in the same eye an upper and lower Cornea, an upper and lower Pupil, and an upper and lower Lens; and we must presume, that as all the upper parts are adapted to refract, in an adequate manner, the rays transmitted by the air, so all the lower ones are equally well adapted to refract those transmitted by the water, and thus each class of rays is brought to a focus in the proper place. With respect to Man, it is easy also to understand why imperfect vision should result equally from too great or too little convexity of the Cornea, the rays being collected into a focus either too soon, and therefore again dissipated; or too late, and therefore not yet united; so that, in the former case, the person is short-sighted, or what is technically called a Myops, while in the latter case he is long-sighted, or what is technically called a Presbyops. (*a*)

It is proper to remark, that it is not only from too great or too little convexity of the Cornea that these defects proceed, but that the same effects may result from too great or too little density of the Humours, too great or too little convexity of the Lens, or too great or too little depth of the Eye-ball; and hence we are not immediately to

(*a*) It does not immediately appear from this why rays of light, coming from a near object, should be impressed sufficiently distinctly on the Retina of a Myops, and those coming from a distant object on the Retina of a Presbyops; but when we reflect on the different angles at which the rays from near and distant objects impinge upon the Cornea, it will be sufficiently evident that a great power of producing convergence will be requisite in the former case, in order to bring them sufficiently early to a focus, while a slight power will be favourable in the latter case, in order that the focus may not be formed too soon. Myopia is most common in early life, and is very frequently induced by long-continued study, or the frequent contemplation of near objects, the parts of the eye-ball appearing gradually to adapt themselves, so as to effect that degree of convergence which is most frequently required of them. Such persons also commonly see such objects as they see *at all* better than others, owing to the greater number of rays which the inordinate convexity of their Cornea allows to fall on that portion of it opposite to the Pupil. The great size of the whole Cornea, such as occurs in the Porcupine, probably makes no difference in this respect. It is sufficiently well known, that the inconveniences arising from Myopia are to be obviated by doubly concave glasses, the effect of which is to produce a divergence of the rays coming from distant objects before they impinge upon the Cornea, so that they strike this membrane with that greater degree of obliquity with which those coming from near objects do naturally, and all the preternatural refracting power of the eye-ball therefore is required to set them right again. The same object is partially fulfilled by looking through a minute aperture, as a pin-hole, which admits so small a pencil of rays, that their dissipation after convergence produces little confusion, as well as by at once diminishing the aperture, and compressing the globe of the eye with the eye-lids, (the usual practice of short-sighted persons) so as not only to operate in this way, but perhaps also to bring the Retina nearer to the Cornea. Presbyopia, on the contrary, is incidental chiefly to the aged, and the inconveniences to which it gives rise are corrected by doubly convex glasses, by which the rays coming from near objects are made to converge before they reach the Cornea, so that they impinge upon that membrane with that slight degree of obliquity with which those coming from distant objects always do, and the slight power to produce convergence in their eye-ball is therefore sufficient to bring them to a focus in the proper place. It is not out of place to mention, that it was not till about the year 1300 that spectacles were invented. Alhazen, who lived in 1100, says, that objects seen through segments of spheres of glass appear enlarged; but it was not till the time of Friar Bacon, who died in 1292, that such instruments were represented as "utilia senibus, et habentibus oculos debiles."

fancy that a person is affecting short-sightedness when we do not observe that his Cornea is preternaturally convex, although this will generally be found to be the case in those who labour under this calamity, and it is by diminishing this convexity that old age becomes frequently a cure of it. Animals with very small eyes see only near objects; and accordingly, it has been presumed, that the simple eyes of Insects are for seeing near objects, as their compound ones are for seeing more distant ones. (*a*) But it is doubtful whether the former can distinguish *objects* at all. This incompetency to see distant objects with small eyes, however, has nothing to do with too great refraction of the rays as coming from a distance, but depends entirely upon the too small space which there is in such an eye for the expansion of the visual angle, always so small as resulting from distant objects. The direction of the axis of the Eye, and consequently of the Cornea, as forwards, laterally, upwards, backwards &c. is of course such as to meet the peculiar necessities and habits of particular animals, (*b*) and the degree of mobility of the Eye-ball enjoyed by each is of course with reference to the same circumstances. The Cornea of the compound eyes of Insects, composed as it is of numerous hexagonal facets, would necessarily have had the effect of a multiplying glass, and produced inextricable confusion, had the other parts of the eye been formed as in animals in general, but fitted, as each of these facets is, upon a corresponding process of the Retina, the cones of rays which it receives, being by this membrane alone (for there are no humours) sufficiently refracted, at once form opposite cones on this process of the Retina, so that each facet and its appendage is an eye of itself, and not merely a part of an eye, and the number of them is obviously to compensate for the immobility of each. The rays of light, as they traverse the Aqueous Humour, by which their course is but very little changed, pass through the Pupil, more or fewer, according to the less or greater expansion of the Iris; and this is always in proportion, not to its own direct irritation, (for it is itself quite insensible to light) but to the irritation of those membranes of the eye on which sight immediately depends, the motions of the Iris being excited by sympathy with these membranes, or rather with that part of the sensorium which takes cognisance of the irritation produced by light, as is proved by the Iris becoming in general quite immoveable when

(*a*) Blumenbach.

(*b*) In Man as well as in the Monkey tribe, and among Birds in the Owl, its direction is forwards; so that those of the two globes are parallel, while in most Quadrupeds, Birds and Fishes the axis is directed outwards. In some Fishes, as the Star-gazer, (*Uranoscopus*) and in the genus Pleuronectes, the eyes are both placed on one side of the head, because these animals, wanting a swim bladder, always lie on one side at the bottom of the water.

this part is insensible, as is the case in the disease called Amaurosis. In this disease, however, there is sometimes a fallacy with respect to the motions of the Iris, this membrane appearing sometimes to expand upon being exposed to light when the sight of the eye is totally gone; but in these cases it will frequently be found that it is by Sympathy with the sensorium receiving impressions from the other eye that the Iris of the diseased eye was stimulated, and that if the sound eye be kept in darkness, (as it should always be during the examination of the diseased one) that no such effect will be produced. Still, however, the Iris does appear in some rare instances to expand on being exposed to light with every precaution, in an eye the sight of which is totally gone; and this fact appears to me to be a strong confirmation of the doctrine which has been inculcated, that it is not the light which the sensorium perceives, but the irritation which that light occasions, which irritation may be presumed sometimes to be sufficient to stimulate the Iris by Sympathy, even after the sensorium has ceased to be at all sensible of it. The expansion of the Iris is commonly attributed to a contraction of its circular or external fibres overcoming that of its radiated or internal fibres, supposing both to be muscular; but as this membrane does not appear to obey any of the usual Stimuli of muscles, to say nothing of the total want of evidence of muscularity in the Iris, in as far as Chemistry or Anatomy are concerned, it is frequently attributed (like the erection of the penis and other organs composed of erectile tissue) rather to a dilatation of its vessels excited by the Stimulus of Sympathy as above described. It is well known that the Iris may be pricked with a needle without displaying any sensible motion, which is not the case with any other organ confessedly muscular; and though its circular fibres are said to contract when exposed to Galvanism, it is not easy to conceive that Galvanism could be so applied to the Iris as not to affect the other membranes of the eye, the irritation of which may be presumed to be quite sufficient to stimulate this membrane by Sympathy. It is observed, however, by Carus, that the reason that the Iris does not contract when wounded is, because both the external or circular, and internal or radiated fibres are usually injured, and the contraction of both produces of course a negative effect. If care be taken to wound the outer layer alone, the contractions of the pupil, he says, are always apparent, and *vice versa*. The motions of the Iris are wanting in Fishes, and very languid in Reptiles, probably from their deficient sensibility; while on the contrary they are very active, and even apparently voluntary in some Birds. The Ring formed by the Iris being necessarily very narrow in darkness, whatever be the degree of sensibility in the Retina, (since now the usual indirect stimulus to its expansion is wanting) renders it probable that the chief use of the Pupillary membrane in the fœtus is to keep the Iris mechanically expanded so as to admit of its proportionate growth; since, had the Iris been made of a corresponding size without this mechanical distention, and been still gifted with the requisite degree of irritability to take upon itself immediately after birth the function which it was to perform, its further expansion would probably have altogether closed instead of merely diminishing the pupil. (*a*) The larger size of the pupil in infancy and in females pretty certainly arises from the less degree of sensibility with which these are endowed, and it will be easily understood how the same effect is produced by the use of Narcotic Medicines, as well as how it is symptomatic of so many diseases. It will be easily understood also, why a person coming out of comparative darkness is dazzled by even a moderate light, as well as why a person who has been just subjected to a glare of light seems to be in almost utter darkness if suddenly removed from it, though, when the Iris has had time to contract itself, what at first appeared to be total darkness is found to be a very sufficient degree of light. The colour of the eye, it is hardly necessary to say, depends upon that of the Uvea which lines the Iris, such rays of light as this membrane refuses to transmit by the Pupil being of course reflected from its surface. It is almost equally unnecessary to observe, that whatever be the size of the Pupil, the sphere of vision remains the same. (*b*) Many imagine, that when the Pupil is very much diminished, nothing but the central parts of objects can be seen, and that all the borders of them must be necessarily cut off; but this is palpably false, since the only effect which the constricted state of the Pupil produces is that narrower pyramids of rays are transmitted to the interior of the eye, (so that the intensity of vision is diminished) not that these rays come from fewer points than before, (so that its sphere should be contracted.) Whether the various form and direction of the Pupil in some of the lower animals make any material difference in the nature of their sight is not very well ascertained; but it is probable that it does not, since we know, that after the operation of making an artificial Pupil the vision is not much influenced by the form of the aperture, and our chief solicitude in making it is to produce one which shall be least liable to become obliterated.

From the Aqueous Humour the rays of light impinge upon the crystalline lens, from which they are again refracted towards the perpen-

(*a*) Bell.

(*b*) The diameter of the sphere of vision has been computed in Man to be about 110°.

dicular; although the additional convergence here is in a comparatively slight degree in the adult age, while in that of the fœtus and of infants (from the more globular form of the Lens) it is much more considerable. In Fishes, also, and in the Cetacea it is in this part of the eye that the rays of light are made most to converge, not only undergoing here their greatest refraction, from the increased density of the medium, but also being brought more to a focus by the very convex form of the Lens. Very little refraction, as has been said, is in them effected at the Cornea, and hence the necessity that the Lens of Fishes should be almost entirely globular, while in Birds (the Cornea of which is so remarkably convex, as to produce almost all the refraction they require) the Lens is comparatively flat without inconvenience. It has a greater refracting power in some parts than in others, and this structure is supposed to be further useful, *first,* in obviating spherical aberration; and, *secondly*, in giving to the eye its achromatic power. It is well known that rays directed from a plane surface upon a portion of a sphere, owing to the different distances at which the several radiating points are from the several parts of this spherical body, reach it at different angles, and are, of course, therefore refracted, (if its refracting power be throughout the same) some more than others, the focus for all being therefore not precisely the same. Now, those points of the plane surface will require the greatest refraction, as falling with the greatest obliquity, which are opposite to the central parts of the Lens, and therefore the nearest to it; and it is accordingly in this part that the greatest refractive power is situated. With respect to the achromatic power of the eye, this also is referred to the Lens. The seven prismatic rays of light are of different degrees of refrangibility; consequently in their passage through the Cornea and Aqueous Humour some are refracted more than others, (the violet, for example, most, the red least) and white light is therefore decomposed. Now, such is the situation of the parts of the lens which refract to a greater or less degree, that those rays which have been most refracted by the Cornea and Aqueous Humour impinge upon those parts of the Lens which have the least refracting power, and *vice versa*, so that white light again results. But that both the spherical aberration and decomposition of light are so slight as to be almost inappreciable, is quite obvious from what occurs after the removal of the Lens, when there are never observed these inconveniences which this structure of the Lens is said to be intended to obviate. The chief effect of this removal of the Lens is, that the image of the object on the Retina is, as in Presbyopia, less distinct than before; the effect of the Lens in bringing the pencil of rays to a perfect point upon the Retina being wanting, and this defect being only to be compensated for by the use of exceedingly convex glasses, which are a kind of Lens placed before the Cornea, instead of behind it.

As the rays in impinging upon the convex surface of the Lens, the density of which is greater than that of the Aqueous Humour, are, for the second time, refracted towards the perpendicular line, so, in impinging upon the concave surface of the Vitreous Humour, the density of which is less than that of the Lens, they are, of course, so refracted as to recede from the perpendicular of this concave surface, and thus to make the rays still further converge towards the focus to which they were previously tending, till at length each pyramid of rays, which had fallen with its base on the Cornea, forms an opposite pyramid with its apex on the Retina, the generally admitted seat of vision. When the mind sees any object by means of rays collected into cones, the Retina receives these rays at different degrees of obliquity, and yet the point is seen only in one direction, namely, in the direction of the central ray of the cone whose apex is on the Retina. This, however, does not arise from that ray being the resultant, as it were, or the mean of the directions of all the other rays; for if we close up all the Pupil excepting a small opening at its margin, the point will be represented only by the most oblique rays of the conical pencil, and yet it will still be seen in the same direction as before. Hence we conclude, that when a ray of light falls upon any point of the Retina, in any direction however oblique to its surface, the object will be seen in the direction of a line drawn between this point and the centre of the Pupil, which may be called the centre of visible direction, because every point of an external object will be seen in the direction of a line joining that centre and the given point. Hence a partial obliteration of the Pupil by adhesion, so that it ceases to be in the axis of the eye, or the formation of many Pupils by ulceration, makes no difference. These rays do not immediately *stimulate* the Retina, but seem to act upon it *indirectly*, by irritating the Choroid Coat. (*a*) The actual incidence of the rays of light on the Retina

(*a*) It was supposed by the ancients that the seat of the impression whence sight immediately proceeds was the Crystalline Lens, nor was it till 1604 that Kepler demonstrated, for the first time, that the most important part of the organ of vision was the Retina, and the real use of the Crystalline Lens was discovered by Platner about forty years afterwards. By Mariotte, Priestley and others, who had noticed that at least one part of the Retina was insensible, it was imagined that the seat of the impression from which sight proceeds was the Choroid Coat, an opinion assented to by Le Cat, who ascribes it to the Pia Mater, which, with him, was identical with it, as the Sclerotic Coat was with the Dura Mater. But though these Physiologists were probably incorrect in regarding the Choroid Coat as exclusively instrumental to vision, they were quite right in looking upon the *irritation* of this coat by the light as necessarily appears to be rather accidental than essential. In the eye of the Cuttle-fish, (*Sepia*) there is interposed between the Vitreous Humour and the Retina an excessively dark and opaque pigment of considerable consistency, assuming the form of a membrane; (*a*) hence the irritation by the light of this dark membrane must be conveyed to the retina *behind it*, and why should not a similar irritation by the sight of either this dark membrane, or the Choroid Coat, in the human eye, be conveyed to the Retina before it? This view of the matter reconciles the opposite sentiments which have been so long entertained with respect to the seat of vision, and not only explains in what way vision is effected, but also why there should be no such impression opposite to the entrance of the Retina when the Choroid Coat is wanting; and why it should be most distinct where there is a deficiency of the Retina, as at the hole of Soemmering.

The rays of light, in their passage to the Pupil, must be reversed from above to below, and from right to left; (*b*) and as the image of objects is therefore always represented inversed on the Retina, it has always been considered an exceedingly difficult problem to explain in what way the mind takes cognisance of the objects themselves in their natural situation. (*c*)

precursory to the subsequent conveyance of this irritation by the retina and optic nerve, so as to produce sensation or vision.

(*a*) Knox.

(*b*) That they are so is shewn by directing a stream of light through a hole in a shutter upon either the eye of an adult animal, divested of its opaque coats by dissection, as practised by Des Cartes; or the eye of a young animal, the coats of which have not yet become opaque, as practised by Malpighi; or an artificial eye made of glass, as employed by Le Cat; or, lastly, the eye of an Albino, as practised by Magendie, when the images of all objects will be found to be reversed in both respects.

(*c*) It was said at one time as by Le Cat and Buffon, that the false impressions derived from the sight are habitually corrected by true impressions derived from the other senses; at another time, that it is not the eye which sees but the sensorium, and that there is perhaps a second reversion, which compensates for the first, between the eye and the sensorium. The former of these explanations implies a great deal of bungling on the part of nature; the latter is altogether gratuitous. A better explanation may perhaps be found in the centre of visible direction lately alluded to. Nollet has remarked, that there is a habitual tending in the mind to refer the situation of every object to the beginning and not to the end of the ray which renders it visible; and as the lines of visible direction must necessarily cross each other at the centre of visible direction, those from the lower part of the image must go to the upper part of the object, and those from the upper part of the image go down to the lower part of the object; and hence an erect object is the necessary result of an inverted image. It appears, however, a much better plan, though still not the best, to deny that

The best explanation may perhaps be found in the presumption, that the ideas formed of the relative situation of objects have really no more to do with the physical relation of their images on the Retina, than those formed of the direction whence sounds proceed have to do with the impressions made on one or other part of the auditory nerve. (*a*) It is essential that rays should be *arranged*, in order that the otherwise *general irritation* produced by the collective rays of light from every radiating point within the sphere of vision should be converted into a series of *particular* irritations produced by individual rays of light from each ; but it is quite unimportant in what physical relation these particular irritations stand to each other, as influencing the impression on the sensorium. The connection between mind and matter is so entirely unintelligible, that it is useless to attempt to understand it ; and as sight is in the mind, while the object which is seen is exterior to the body, and the image of that object is on the Retina, it is altogether vain to endeavour to explain how the one is or can be influenced by the other. There is as impossible a gulf between the mind and an image of an object, as between the mind and an object itself. We have advanced not one jot in explaining the nature of sight, by finding that there is such an image ; and the idea that sight is in any degree influenced by the non-inversion or inversion of this image, seems to be a great deal too gross and mechanical to be true. Such an image is incidental to the structure of the Retina, and such an inversion of it a necessary consequence of optical laws ; but as the former was perhaps in no degree essential to vision, (and we know it is not always so) so the latter

there is any inversion at all. The term inversion signifies merely a relative and not an absolute difference. A table is inverted when its legs are opposed to the ceiling and its flat surface to the floor ; but had the ceiling and the floor undergone corresponding changes there would be no inversion at all. It is precisely thus with the inversion of the images of objects on the Retina. They are none of them inverted with respect to each other, but only with respect to the objects themselves ; and as the sensorium takes cognisance only of the images, and never of the objects, it is quite incapable of making any comparison between them ; and as there can be no inversion without comparison, there is consequently no inversion in this case, and the relative situation of objects being conveyed to the sensorium without change, the absolute situation of them all, with respect to the objects themselves, is of no more consequence to perfect vision than it is to a Hottentot what is his absolute situation with respect to us, so long as the relative situation of every thing around him remains unchanged, which is the explanation of Blumenbach. Could we see both the *Objects* and their *Images* we should be conscious of the inversion ; but we never see the objects.

(*a*) Gall.

has perhaps no effect whatever in modifying it. It is farther probable that the irritation made, not by the sum of the rays at any given time on the Retina, but by such only as come from individual points of the objects seen, is alone perceived at any one time by the sensorium, and this without regard to the situation which they occupy on the Retina; and that it is only as connected with others by memory that an idea of a general image is formed, in the same way as the irritation made by individual currents of tremors of air is perceived successively by the sensorium, without regard to the particular part of the Auditory nerve by which they are conveyed, and being connected with others by memory, communicate an idea of a general sound. What then can the ready-made image have to do with sight? Nothing at all.

The distance at which small objects are distinctly visible by a well-constituted eye has been said to be about fifteen inches. If, therefore, the eye refract in the precise degree requisite for this distance, it will refract certainly somewhat too little for nearer, and somewhat too much for more distant objects; and we have every reason to believe that it does so, and that no other objects but those at one certain distance are ever brought to a perfectly accurate focus on the retina. If they were, why should we not see equally well within certain limits at any distance? It is true, we seem to exert some power in adapting the eye to the different distances of objects, and there is no question but that an uneasy sensation is excited by frequently shifting the eye to objects at different distances; but there is no proof that this uneasy sensation depends upon any change in the parts of the eye-ball, which, if a natural formation of the organ, should no more produce it, than singing should produce an uneasy sensation in the larynx. (*a*) On the contrary, there is every reason

(*a*) By what mechanism this adaptation of the eye to different distances is effected has been long a question. It has been generally attributed to some change which the eye-ball undergoes. By Mr Crampton, it was referred to a specific action of the cornea, (which, according to him, is provided with a muscle capable of flattening it for the perception of distant objects) by Sir D. Brewster, of the iris, (enlarged for distant objects) by Kepler and Jacobson, of the ciliary ligament, (circle relaxed for distant objects) by Des Cartes and Dr Young, of the crystalline lens, (relaxed for distant objects) by Blumenbach and Sir E. Home, of the straight muscles of the eye, (relaxed for distant objects) and by Kiel, Briggs, Monro, and many others, of the oblique muscles of the eye, (which, they presume, are contracted for distant objects, so as to press the eye-lid and thereby diminish the distance between the cornea and the retina.) It appears absurd to attempt to explain a fact which has probably no real existence, since it has never been proved that the eye-ball has any capability of adapting itself to different distances, or that any such adaptation is required.

to believe that it is occasioned entirely by the frequent shifting of the attention from vivid to faint impressions, and *vice versa*, which frequent shifting the sensorium does not undergo with impunity. Moreover, whoever talks of adapting the ear to sounds coming from different distances, any further than as such sounds are more or less intense, for which purpose, as far as light is concerned, the acknowledged action of the Iris is abundantly sufficient ? It is almost certain that there is no such shifting of the eye-ball in contemplating near and distant objects, since, if it were so, how could it happen that the image of a perfect Landscape is found impressed upon the Retina of a dead animal, the near and the distant objects being distinguished indeed by their different size and more or less vivid colouring, but both in every other respect sufficiently; whereas, had the eye been taken at a time when it was adapted only to perceive objects at a particular distance, it follows that the Retina would have been studded over with clear images of all the objects within the sphere of vision at that precise distance, while those at every other distance must have been thrown into obscurity, since the power of adaptation had certainly by this time ceased ? This is a sufficient proof that no mechanism is employed in shifting the eye from near to distant objects, when only one eye is employed, but it is a very different affair when two are used, as shall presently be mentioned; but those phenomena of vision which regard the use of one eye only are to be treated of in the first instance. The chief use of the Pigmentum Nigrum is to render vision stronger and more distinct, by absorbing all superfluous rays, and thus tempering the irritation of the Choroid Coat; and hence, in Albinos, whether of the human race or among the lower animals, the sight is in general weak and indistinct. On the contrary, when the Pigmentum is bright and transparent, as in many animals of prey, instead of absorbing the rays of light, it transmits them undiminished, and thus increases this irritation; and hence, such animals are vulgarly said to be capable of seeing in the dark, which, though not strictly true, is an approximation to the truth, since they can see in what would be darkness to any other animal. The use of the spot of Soemmering is to admit the immediate passage of the rays to the Choroid Coat, and thus to give the intensity required.

It remains only to speak of the object of the entrance of the optic nerve in the human eye, not immediately opposite the pupil, but nearer to the nose, and this is in order to remove it out of the way of the sphere of distinct vision, which seems to be immediately opposite the pupil, or about the spot of Soemmering, for it has been very generally conceded since the celebrated experiment of Mariotte, that

that part of the Retina at which it enters is insensible. (*a*) How far the reputed entrance of the optic nerve, in the Seal and Porcupine, immediately in the axis of their eye, affects the vision of these animals, has not been ascertained; nor how far the interposition of their Pecten in Birds, between the Lens and Retina, does so, though one would imagine that the impediment to distinct vision would be in both cases very considerable.

In order that a firm and lasting impression be made upon the mind by the image of an object, it is requisite that this image be of a certain intensity, otherwise the impression will be flittering, and as it departs and returns will assume all sorts of wild and fanciful aspects. This is particularly observable when, in a dim light, we have caught sight for a moment of an obscure image, and has probably given rise to many hobgoblin stories. Such, however, is not perhaps the most common origin of these stories, the majority of which have probably arisen from spectral illusions, or a kind of hallucination, in which images previously impressed on the eye have been recalled by memory, and embodied by imagination. Their seat is therefore the brain or "mind's eye," and not the body's eye. If the image, however, be of the requisite intensity, though presented but for a moment, it leaves for some time an impression behind it; and something analogous takes place with respect to colours; for the impression of one colour made upon the Retina is, under certain circumstances, always followed by the impression of some other, these secondary impressions constituting what are called Ocular Spectra, or accidental colours. If we place a red wafer on a sheet of white paper, and closing one eye, keep the other directed for some time to the centre of the wafer, then, if we turn the same eye to another part of the paper, we shall see a *green* wafer, the colour of which will grow fainter and fainter as we con-

(*a*) Mariotte's experiment consisted in fixing on a blank wall, at a level with the eye, two wafers apart from each other, and observing them with one eye shut. When standing near, the spots are too distant from each other, and both are perceived. One disappears at about five times the distance between the wafers, the rays from the spot hitherto seen impinging now upon the entrance of the optic nerve. On receding farther it re-appears, for an obvious reason. It is a common impression that this disposition of the two optic nerves is useful in preventing the suffocation, in both eyes, of rays coming from the same point of an object, which would render this spot invisible, such rays as enter the pupil, so as to impinge upon the entrance of the right optic nerve, necessarily escaping the entrance of the left, and *vice versa*, so that one eye at least takes cognisance of them; but this explanation belongs only to those rays which fall on one side or other of the sphere of distinct vision, and of which, therefore, we have no distinct perception; so that little is gained, under ordinary circumstances, by either eye taking cognisance of them.

tinue to look at it. This *green* image of the wafer is called an Ocular Spectrum, or the *accidental*, or *opposite*, colour of *red*. By using differently coloured wafers the following results are obtained:

Colour of the Wafer.	Colour of the Spectra.
Black	White.
White	Black.
Red	Bluish Green.
Orange	Blue.
Yellow	Indigo.
Green	Violet with a little Red.
Blue	Orange Red.
Indigo	Orange Yellow.
Violet	Bluish Green.

If we arrange all the colours in a circle, in certain proportions, the red and the violet extremities of the Spectrum meeting at 0°, then the accidental colour of any other colour will be always found directly opposite that other colour, and for this reason these colours have been called *opposite* colours; and if we suppose the primitive colour to be reduced to the same degree of intensity as the accidental colour, then we shall find that the one is the *complement* of the other, or what the other wants to make it white light; *i. e.* the primitive and the accidental colour, when mixed together, will make white light. Hence the *accidental colours* have also been called *complementary colours*. Since a mixture of all the colours of the spectrum forms white light, it is obvious, that if one is left out, the mixture of the remainder will not be white, but some other tint. The explanation is very simple. When the eye is fixed for some time on the red wafer, the part of the Retina on which the red rays fall is strongly excited by their continued action. The sensibility to red light must therefore be diminished, in the same manner as the palate, when long accustomed to a particular taste, ceases to feel its impression. When the eye, therefore, is turned from the red wafer to the white paper, the excited portion of the Retina is insensible to the red rays in the white paper, and consequently sees that colour which arises from the union of all the other rays but the red, that is, a *greenish-blue*. The same explanation applies to all the other colours. If the wafer is *white*, and placed upon a dark ground, the accidental colour must be *black*; because the enfeebled portion of the Retina is insensible, as it were, to all the colours which compose white light. When the wafer is *black* upon a white ground, the portion of the eye upon which the image falls, in place of being enfeebled, is refreshed by the absence of light, while the rest of the Retina around it is enfeebled by the white light of the paper. Hence, when the eye is turned upon a white ground, it will see a portion whiter than the rest, so that the accidental colour of *black* is *white.* This theory of the production of accidental colours is applicable only to such primary colours as are not very intense, such as the light of the sun, or even of a candle, the accidental colours produced in these instances being very variously modified. In conclusion of the subject of colours, it may be observed, that various cases have been described, in which persons capable of performing the most delicate functions of vision are unable to distinguish particular colours; and what is certainly a curious fact, this imperfection runs in families. (*a*)

In all the cases there was an insensibility to red light and its combinations. Perhaps this was absorbed by the blue Vitreous humour, (*b*) or blue Retina. If not, it would seem to be owing to insensibility to

(*a*) Mr Huddart mentions, in the Phil. Trans. for 1777, the case of Harris, a shoemaker, who could only distinguish *black* and *white.* He was unable, when a child, to distinguish the cherries on a tree from the leaves by any other means than their shape and size, and was surprised to find that his companions could discern them at a much greater distance than he could, although he saw objects in general as well as they did. He had two brothers almost equally defective, one of whom constantly mistook orange for grass-green, and light green for yellow. Another case of a Mr Scott is described by himself in the same Journal for 1778. He did not know any green colour: a pink colour and a pale blue were perfectly alike to him; and a full red and a full green were so alike, that he often thought them a good match. He was very angry at the gentleman who married his daughter for coming to the ceremony in black, (as he supposed) whereas the said gentleman was in a fine rich claret-coloured dress. Mr Scott's father, his maternal uncle, and one of his sisters and her two sons had all the the same defect.

Mr Dugald Stewart experienced the same inability to distinguish certain colours. He first perceived this defect when one of his family was calling his attention to the beauty of the fruit of the Siberian crab, which he could not distinguish from the leaves but by its form and size. Mr Dalton also cannot distinguish blue from pink by day light; and in the solar spectrum the red is scarcely visible, the rest of it appearing to consist of two colours, yellow and blue. Mr Harvey has described, in the Edinr. Trans. the case of a tailor, still I believe alive, who can distinguish with certainty only white, grey and yellow. On one occasion he repaired a pair of breeches with crimson, in place of black silk; and at another time he patched the elbow of a blue coat with a piece of crimson cloth. Dr Nicol has recorded a case in the Med. Chir. Trans. where a person in the navy purchased a blue uniform, coat and waistcoat, with red breeches to match the blue; and he has mentioned a second case, in which the defect was derived from the father; and a third, where it descended through the mother.

(*b*) Dalton.

one end of the Spectrum, like that to one extremity of the Scale of musical notes. (*a*)

Single vision with two eyes in Man, Apes, Bats, as well as in those animals the axes of whose eyes incline upwards or backwards, is effected by their making the axes of the two eyes so to converge, according to the greater or less distance of the object to be viewed, as that the rays coming from the same points of this object may fall upon the central parts of both Retina, between which there appears to be an intimate sympathy, so that a line drawn from the radial point of this object, through each pupil, would fall directly on the central part of both Retina, the sphere of distinct vision. It follows therefore, that single vision in man is the result of voluntary efforts, such efforts being required in order to effect the requisite degree of convergence of the axes of the two eyes; a very great degree, for instance, being necessary when the object to be viewed is near, as when a man tries to see the tip of his nose with both eyes, and a very slight degree when it is at a distance; and that single vision really arises from such voluntary efforts is obvious from what happens when these voluntary efforts cannot be made. Thus, in infancy, before the muscles of the eyes have acquired, by practice, the power of properly adapting their axes, there can be little question but that the vision is double, and any person attentively examining the eyes of a very young infant will be quite persuaded, from their peculiar expression, that the child has no single and distinct impression of what it is looking at; and a precisely similar aspect is observable in the eyes of a person in a deep reverie, in which the voluntary efforts necessary to single vision are suspended; and if we suddenly address a person in this state, and at the same time examine his eyes, we shall observe in them a sort of twitch, indicating in them a return of that degree of convergence in the axes upon which single vision depends. In incipient drunkenness also, it is sufficiently well known that persons see double; the axes of the eyes have become paralleled from a relaxation of those muscles by which the convergence requisite to single vision was effected; and a similar double vision is permanent in extreme idiotism, the vacant and unmeaning aspect of the eyes, in this state, being occasioned by either the inadequate convergence or perfect parallelism of their axes. But a more extensive consequence follows

(*a*) According to Sir D. Brewster the prismatic spectrum consists of three equal and coincident spectra of red, yellow and blue light, so that when there is an insensibility to the red, much yellow and a little blue will be seen in its place. When black is seen the insensibility is more general.

from what has been just stated, of the means by which single vision is effected, and that is, that we cannot perfectly perceive, with both eyes, any one object at the same instant, every variation of situation requiring a corresponding variation in the convergence of the axes of the eyes. When, therefore, we imagine we see a whole landscape, or even a very inconsiderable part of such a landscape at once, we are deceived by the inconceivable rapidity with which this change of convergence is effected, and with which the memory connects successive impressions into one collective idea,—a rapidity which as perfectly eludes all consciousness as the passage of a common ball through the air, though no one on this account questions that such has been its course; and if the sensation is uneasy in suddenly shifting the sight from one object to another, at considerably different distances, when we employ only one eye, it is necessarily much more so when we use two, since we have now to contend with not only the alternately more vivid or fainter impressions derived from these objects, but the alternately greater or less degree of convergence in the axes of the two eyes; and the difficulty of regulating this under such circumstances is so great, that we almost instinctively close one eye when we are required frequently to shift the sight from a near to a distant object, and *vice versa*. But in proportion to the increase of difficulty in using two eyes under these circumstances, is the increased accuracy of our judgment with respect to distances, and hence it is difficult to thread a needle or even to snuff a candle with one eye blind. In those Fishes, Birds and Quadrupeds, the axes of the eyes of which are directed outwards, and in Insects, where they point in almost every direction, single vision appears to depend, not as in man, upon their axes converging so as to present only one impression to the sensorium, but as in squinting, upon the sensorium taking cognisance of the impression made upon only one eye at a time, though it is capable of shifting with such rapidity, that the animal appears to see on both sides, or on all sides at once.

SECTION III.

On the Irritation of the Ears regarded as a Stimulus to Sensibility.

THE seat of the irritation, the perception of which constitutes Hearing, is in Man the thin membrane lining the Labyrinth of the Ears, and the nerves which convey it are the Auditory, the Trigemini being instrumental only secondarily. (*a*) In some of the Lower tribes of animals which have no auditory apparatus, a sensation analogous to hearing may be effected by means of the whole surface of the body. In Insects, which certainly hear very acutely, it has been presumed, that the chief instrument of this function is the membrane which connects their antennæ with the head; but Spiders hear, which have no antennæ, and Grasshoppers, after these have been removed.

The stimulus to this irritation is, under ordinary circumstances, currents of tremors,—in terrestrial animals, generally of air,—in aquatic animals, of water,—and in some which burrow under ground, of solids. The same irritation, however, may be excited either by Galvanism or by Mechanical Stimuli; the Auditory Nerve, like the Olfactory and Optic, being apparently incapable of conveying any other impression but such as is calculated to produce the sensation of sound. The tremors in question are always excited by the collision of two or more elastic bodies, the agitation of the particles of which is communicated to those of the medium, by which they are surrounded, producing a shock which extends along the latter in straight lines, but, unlike the rays of light, without any actual displacement. Light is conducted through a vacuum, but this is not the case with sound; and every body has seen the clapper strike a bell, under an exhausted receiver, without effect. Other elastic fluids, as well as air, conduct sound; but, in general, the denser the body the better vehicle it is of sound; and hence solids conduct it better than liquids, and liquids better than air, the shock being great in proportion as the particles are unyielding. Air is, of course, a better conductor of sound within certain limits in the direct ratio of its density. Hence sounds are more audible in valleys than in mountains, by night than by day, and in the winter than in summer. But air may be too dense to admit of the necessary tremors, as in a diving-bell, at great depths. Dr Colladon, in a diving-bell at Howth, in 1820, could not hear himself speak.

The currents of tremors of air are conjectured to travel at the rate of only 1130 feet in a second, while the rays of light move through 195,000 miles in the same period; and in general the denser the body, not only the more forcibly, but the more rapidly it conducts sounds. (*b*) These tremors emanate in straight lines from every point of sub-

(*a*) In the genus Cancer, the nerve going to the ear is merely a branch of that going to the antennæ; and in Fishes in general, as formerly mentioned, the Auditory nerve, if not a branch of the Trigeminus, is at least very intimately connected with it.

(*b*) Biot.

stances in collision; and as the intensity of sound, like that of light, depends always on the number of the currents or rays in any given space, it follows that this intensity must diminish in proportion to the distance. In another respect also these currents of tremors are analogous to rays of light, that of being susceptible of reflection. The tone is a very different thing from the intensity of sound, and corresponds rather to colour, among other things, in the remarkable circumstance, that the number of simple tones precisely agrees with that of simple rays constituting colour. The differences of tone depend not like those of intensity upon the number of currents thrown into agitation, but upon the rapidity with which the tremors succeed each other; the tone being grave or acute, according as these tremors succeed each other more slowly or more rapidly. It has been made a question, how two distinct simultaneous tones, whether harmonising with each other or not, can be conveyed by the same air without comparison. According to M. Mairan, it depends upon each distinct tone calling into tremors particles only of a certain size; almost in the same way as, according to Newton, each distinct prismatic colour resulted from a certain size of the particles of light. On these subjects, however, there is still much to learn.

The currents of tremors in the air are in Man and most Quadrupeds collected and conveyed to the Tympanum by the several external parts of the ear, which in some Quadrupeds are always directed for this purpose towards the place whence the sound comes, and it is for this purpose that numerous muscles are given to them. A frequent and rapid motion of the ears is commonly considered indicative of a timid disposition; and it is remarkable, that there seems to be a more intimate connection between the consciousness of weakness, in other words fear, and the sense of hearing, than between this consciousness and any other sense. Savages also, and others who rely much upon the acuteness of their hearing in their several pursuits, generally acquire by habit the power of moving the external parts of their ears to a remarkable degree. The use of some such mechanism in collecting and directing the currents of the tremors of the air instrumental to sound, is sufficiently obvious, from the great assistance which deaf persons frequently derive from the use of an ear trumpet, or from even applying their hands in such a manner to the external orifice as to represent the ear of a Quadruped; and it is equally so, from the dulness of hearing, which is said always to arise when the Pinna has been removed, as is frequently done by way of punishment among barbarous tribes. The Seal and Walruss also, (at least when on land) and such of the other Mammalia as want this appendage, are distinguished by great dulness of hearing, in so much that Seals may be easily slain as they lie basking on the shore, if one has only the precaution to come behind them. The Mole is a remarkable exception to this; but the immense size of its Membrana Tympani may more than compensate for the want of a Pinna. It must be remembered too, that the Mole displays its acuteness of hearing principally when under ground, and we know how intense are the sounds produced by the vibrations of solid bodies. The use of the tuft of feathers with which most Birds are furnished by way of external ear will be from this sufficiently evident. The tremors of water are so much more powerful than those of air, that such an appendage to Aquatic animals would have been altogether superfluous; and hence in them a Pinna is in general wanting, and it is probable that the eyelid, like rudiment of a Pinna in the Crocodile, is, like the double valve with which the Shrew is furnished, rather for the purpose of partially excluding sound when under water, than of collecting it. The use of the Cerumen and Hairs, which in Man line the external auditory canal, is principally to deter insects from attempting an entrance, or to entangle them should they proceed too far.

From what has been said, it will easily be understood why, to the ear of Terrestrial animals placed under water, the intensity of sounds excited by the percussion of bodies likewise under water is greatly increased, although sounds excited in the air are not easily perceived by animals under water, since the tremors of the air are not readily communicated to the water; and it will be equally easily understood why, to the ear of Aquatic animals brought into the air, the intensity of sounds is in the same degree diminished, as has been just observed in the case of Seals. The same inconveniences then with respect to hearing, as with respect to sight, attend the removal of Terrestrial and Aquatic animals respectively from their natural element, which inconveniences in the Amphibious animals seem to be obviated, with respect to hearing, by a power of adapting their ear to the circumstances under which they are placed. It has been already mentioned that the Crocodile and Shrew, which have the passages open when on land, in all probability exclude too intense sounds when under water by closing their external ear; but the greater number of Amphibious and diving animals adapt their ears, at least partially to their varying circumstances, by putting all the parts upon the stretch by means of the muscles adapted to the purpose when in the air, so as to qualify them to receive slighter impressions, and by throwing them all into a state of relaxation when under water, so as to prevent them from being stunned by more powerful ones.

These currents of tremors, then, being collected by the Pinna, are conducted along the external auditory Canal to the membrane of the Tympanum, which is stretched or relaxed by the two muscles attached to the Malleus, according to the intensity of the sound, in precisely the same way as the Pupil is diminished or enlarged by the expansion or relaxation of the Iris, according to the intensity of the light; (*a*) and as the stimulus to the expansion of the Iris = contraction of the Pupil appears to be Sympathy with the Retina, or rather with that part of the sensorium which takes cognisance of the irritation produced by light; so the stimulus to the contraction of these muscles appears to be Sympathy with the Auditory nerve, or rather with that part of the sensorium which takes cognisance of the irritation which it conveys. Hence, the acuteness of hearing after listening to dull sound, the Tensor Tympani and Stapedius being still upon the stretch, and the deafness for some time experienced after very loud ones, these muscles not having all at once contracted, and the Laxator Tympani being still in action, precisely analogous to the great susceptibility to light after comparative darkness, and the temporary blindness after exposure to a strong light. It is proper to keep in mind, however, that the membrane of the Tympanum, although affording considerable assistance in hearing, is not essential to the function, since in some persons it is naturally perforated, or altogether wanting, and is liable to be destroyed by ulceration without the hearing being entirely lost, although it certainly becomes considerably more dull than in the natural state of the membrane. (*b*) From the membrane of the Tympanum the currents of tremors are continued along the four bones situated within this cavity to the Fenestra Ovalis; but it is not only by the membrane of the Tympanum that these bones are thrown into vibrations, but by currents of tremors received also by the Eustachian Tube. (*c*) The

(*a*)

Eye.	*Eye.*
Radiated Muscles.	Circular Muscles.
(Weak Light.)	(Strong Light.)
Ear.	*Ear.*
Tensor Tympani.	Laxator Tympani.
Stapedius.	(Strong Sound.)
(Weak Sound.)	

(*b*) It was from an observation of these facts, made for the first time by Willis, that Cheselden first proposed perforation of the membrane of the Tympanum, as a means of removing one kind of deafness; and this operation, though of late in a little disrepute, was for a long time a very fashionable one.

(*c*) It is a common opinion, that the only use of this canal is to keep the Tympanum filled with air; but it is more than probable, that by this passage also, as well as by the membrane of the Tympanum, some tremors are conveyed to this cavity, since persons who hear dully are observed generally to listen with their mouth open. Nay, there is some reason for believing, that in such of the bones just mentioned, though subservient to *acute* hearing, are by no means essential to some degree of that function. Many of the Mammalia (to say nothing of Serpents and Birds, which have in general only their columella) have naturally only two bones, and the possession of the Stapes is alone necessary, it is said, to Man, since all the other bones may be voided by the process of ulceration, and the hearing nevertheless not entirely lost. (*a*) The tremors thus communicated to the Fenestra Ovalis are by this membrane conducted to the fluid of Cotugno contained in the Vestibule, which is in like manner thrown into vibrations. It is this part which alone is found in the simplest ears, and which is alone quite essential to hearing, since every other may be destroyed without abolishing it. It appears to be for the purpose of assisting these vibrations, that, in the Sepia, the Cancer, Fishes in general, and some Reptiles, in which all the parts exterior to the Fenestra Ovalis are wanting, this fluid contains portions of solid matter. From the Vestibule the vibrations are extended in all animals above the rank of Fishes by the five Ampullæ, along the three semicircular Canals; and at the same instant in the superior classes, by the aperture leading to the Cochlea, up the Scala Vestibuli to the Cupola, and then down again by the Scala Tympani to the Fenestra Rotunda. It appears to be for the purpose of allowing of the more perfect agitation of this fluid throughout the whole Labyrinth, that such animals are furnished with a Fenestra Rotunda. Had the fluid of Cotugno been surrounded on all sides except at the Fenestra Ovalis by a bony case, it is probable that the vibrations excited in it by the percussion of the Fenestra Ovalis would have been comparatively very circumscribed, whereas the Fenestra Rotunda readily yielding to the pressure of the water on the Labyrinthal side, as the Fenestra Ovalis is struck on the side of the Tympanum, permits a free

Lower tribes of animals as possess a Eustachian tube, as well as in the Cetacea, it is by this passage more than by their surface that sounds reach their Tympanum, since the development of the Eustachian tube is generally in the former in the inverse ratio of that of the Cutaneous Passages; and since in the Cetacea the bones of the Tympanum are not immediately connected with the membrane, which they would probably have been had sound entered principally by their external auditory Canal. The connection likewise, lately detected by Weber, between the Air-bladder of many fishes and their Labyrinth, seems to be in favour of the opinion, that it is by the pharynx, perhaps more than the surface, that sounds reach the ear of many of the Lower tribes of animals; and that it is only in proportion to the development of the external auditory Canal that this access is diminished,—but diminished only,—never altogether superseded, as indeed is evident from an obstruction of this Canal entailing even a more equally certain deafness than an obstruction of the external passage.

(*a*) Flourens.

agitation of the whole of the fluid of Cotugno, consequently, a strong impression to be made upon the membrane, which is the immediate seat of the irritation on which hearing depends. In this view of the matter the Fenestra Rotunda bears the same relation to the Fenestra Ovalis which the opposite parchment of a drum does to the parchment which is struck; and a free transmission of tremors is thus insured throughout the Cochlea, since it is necessary that they should pass up the Scala Vestibuli to the Cupola, and thence down the Scala Tympani before they can arrive at the Fenestra Rotunda. (*a*)

Musical ear depends on the emotions of sadness, joy &c. excited in the mind, not on mere perception; as a taste for painting consists in the different thoughts which various combinations of light and shade produce, and not in any difference in the mere faculty of perceiving them. A man totally destitute of taste, in either the one way or the other, may see and hear with as much or more accuracy than one who is susceptible of the highest delight from these sources; but they excite in his mind no corresponding emotions; whereas persons half blind have been known to amuse themselves with painting; and the celebrated Beethoven, though, in the latter years of his life, almost entirely deaf, was still constantly at his pianoforte, and dwelt with rapture upon the imperfect perception which he still enjoyed of the sounds he elicited from it. It is unnecessary to recapitulate all the conjectures that have been hazarded with respect to the proximate cause of a musical ear. By Willis, it was attributed to a particular softness of the auditory nerve; by Buffon, to a want of sympathy between the two ears; by Sir E. Home, to a want of command over the supposed muscular fibres in the membrane of the tympanum, and so forth. But the softness of the auditory nerves has never been remarked in persons most susceptible of delight from music, and a want of sympathy between the two ears produces an affection very different from an aptitude to appreciate musical sounds, viz. a kind

(*a*) The common impression from the time of Duvernay to that of Scarpa has been, that the tremors communicated to the membrane of the Tympanum were conducted through this cavity, as well by the air contained in the Tympanum to the Fenestra Rotunda, as by the chain of bones to the Fenestra Ovalis; but this opinion is, for several obvious reasons, improbable, and among the rest, the confusion of sounds which would, in this way, almost necessarily be produced. (Biot) The use which has been above assigned to the Fenestra Rotunda was suggested, for the first time, by Bell; and that it is the true one seems probable, not only for the reasons just assigned, but also because the ossification of the membrane, as stated by Ribes, brings with it almost total deafness, which it should not do if it were a mere succedaneum, and most useful rather in permitting vibrations excited by another membrane, than in exciting additional vibrations itself.

of double hearing, very analogous to the affection of the sight called squinting. The inadequacy of Sir E. Home's explanation need not be insisted on. But though there are many persons quite unsusceptible of pleasure from music, there are very few who are not annoyed by harsh and discordant sounds, a very remarkable effect of which, on some people, is that of setting their teeth on edge as it is called. This, however, is quite unconnected with any mental emotion, and arises entirely from Sympathy between the membrane of the Labyrinth, in a state of high irritation, and the mucous membrane of the Mouth, the capillary arteries of which allow of such an accumulation of blood in them as, irritating the contiguous nerves, produces a sensation analogous to formication, and sometimes actual hæmorrhage. As some persons are, from some cause or other, insensible to one end of the spectrum, so others are equally insensible to one extremity of the scale of musical notes ; but of this fact no explanation can be given, further than that the stimulus in this case is not adequate to produce the requisite irritation. This is a mere truism, but it is nevertheless all that can be said upon the subject. (*a*) The circumstance of the hearing being single with two ears, depends upon the sympathy between the sentient parts of the two Auditory nerves, as single vision depends upon a corresponding sympathy between the two sentient parts of the two Optic nerves ;—the sensorium thus perceiving the impression made on both at once, though each of their axes is directed outwards. Nor was it necessary that they should be capable of converging like those of the eyes, since the currents of air, on which sounds depend, do not require to be *arranged*, like those of light, in order to form distinct impressions, but are universally diffused, like those of unarranged light, which may be taken cognisance of by both eyes, however differently they may be directed. Sounds diffuse themselves, though not equally strongly, in every direction. The human voice, for instance, is heard much more distinctly, and to a greater distance, in front of the speaker than at his side ; and much more distinctly, and to a greater distance, at his side than behind him ; and these differences evidently arise from the impulse communicated to the currents of tremors, in this case, more in one direction than in another. But they still do diffuse themselves more or less in every direction ; and hence both ears, whatever be their axis, are capable of perceiving them.

(*a*) We have spoken elsewhere of Spectral or Ocular illusions, and Acoustic illusions *per se* much more rare. They also are not in the body's ear, but in the mind's ear. " The memory of a previous sound, realised by imagination."

SECTION IV.

On the Irritation of the Mouth, regarded as a Stimulus to Sensibility.

The seat of the irritation, the perception of which constitutes Taste, is the Mucous Membrane principally of the Tongue, but in some degree also of the whole interior of the Mouth; and the nerves conveying it are principally the filaments of the Lingual branch of the sensiferous portion of the Lower Maxillary nerve. This nerve, however, being only one of the subdivisions of the Trigemini which are appropriated to the excitement of general sensibility alone, and not of specific sensibility, like the Olfactory, Optic and Auditory, it follows, that Taste must be considered only as a more delicate kind of Touch, and is consequently, unlike the three specific sensations just treated of, convertible into pain. A stimulus, for instance, which in a slight degree applied to the organ of Taste excites merely taste, in a violent degree excites pain; but any stimulus which, in a minor degree applied to the organ of smell, sight or sound, excites these sensations, in whatever degree it is applied never excites pain, since of this, as a modification of Touch, the nerves of specific sensibility are not susceptible. It is true that, with reference to the stimuli by which they are primarily excited, all the senses may be considered modifications of Touch; (*a*) but such is the immense subtilty of the particles which excite those of Smell, Light and Hearing, in comparison with those which excite Taste and Touch, that, independently of the distinct nerves by which these irritations are conveyed, the stimulus itself may be considered as of almost a different nature. Strictly speaking, however, the stimulus differs in degree only, not in nature, and in Aquatic animals accordingly, what is called Smell is in fact Taste; and as the fifth pair of nerves, or that of Touch and Taste, is frequently in place, perhaps, of the Olfactory, and certainly of the Optic and Auditory nerves, the actual identity of all the senses may be considered as established. This is, nevertheless, the most decided with respect to Touch and Taste; and it is accordingly extremely difficult to say, with respect to the Tentacula and Palpi, and even the Tongue of many of the lower animals, whether they should be regarded as organs either of the one or the other. The natural stimulus to the irritation, the perception of which constitutes Taste, is the acrid particles of bodies either already or to be dissolved, after their reception into

(*a*) Cuvier, Anat. Comp. i. 25.

the mouth, in the saliva; and it seems to be rather for the purpose of effecting the solution of such bodies, and of being thus instrumental to taste, than for any purpose connected with digestion, that most animals are furnished with this fluid. (*a*) In proof of this opinion it may be alleged, that, in several instances, where it has been necessary to introduce food into the stomach of man without any previous intermixture of saliva, as after a division of the gullet by cutting the throat, the healthy digestion of this food did not appear to have been at all diminished. An additional argument also may, perhaps, be drawn from the greater acuteness of Taste in the Herbivorous Birds and Quadrupeds than in the Carnivorous, corresponding with the greater development of the Salivary glands in the former than in the latter. Carnivorous, on the contrary, excel in Smell. But although the usual stimulus to this irritation is the acrid particles of bodies, either previously in solution, or thus dissolved in the saliva, other stimuli, particularly Galvanism, may produce a similar effect. The peculiar taste which is perceived when different metals are applied to different parts of the tongue, and made to touch each other,

(*a*) The Saliva of Man has been commonly considered to be perfectly similar in its nature to the Pancreatic fluid; but this opinion has been shewn by Tiedemann and Gmelin to be rather too hasty, since it contains a much less quantity of albumen, while it has as ingredients, mucus and sulpho-cyanate of soda, which the Pancreatic fluid wants, and, unlike this fluid, it is rather alkaline than acid. The common principles of both are said to be, besides Water, Osmazom, Casein, and sundry Salts of Potass, Lime and Magnesia. All this, however, helps us very little in understanding the particular purposes to which the saliva is instrumental, and how little we are to expect from such analyses, may be collected from this remarkable fact, that the deadly venom of the Viper affords on analysis almost precisely the same ingredients as the most innocent vegetable gum. The saline matters are pretty obviously useful in rendering some bodies sapid, (for instance metals) by acting upon them in a way which simple water would not have done. The quantity of saliva secreted daily by man has been very differently estimated. Nuck considered that it was about eight or ten ounces, Cruikshank that it was about a pound, and Dr Paris presumed that from five to eight ounces are secreted at every meal. The data upon which these estimates have been founded have been furnished generally by the quantity voided at each meal from a wound in the cheek, by which the Parotid duct has been divided, of which a memorable instance was related by Helvetius in 1720, where the quantity voided at each meal was estimated by the increased weight of cloths applied to the cheek during the mastication, and multiplying this in proportion as the whole mass of salivary glands seemed to exceed in bulk one of the Parotid glands. But it is needless to say that such data as this can furnish but a very coarse approximation, if any at all, to the truth; and the quantity secreted by different individuals, and under different circumstances, must necessarily be so various as hardly to admit of any general estimate.

is familiar to all. It is essential to the success of the experiment that the surface of the tongue should be moist; for when the tongue is previously wiped very dry, the effect is considerably diminished, and it is not at all perceptible if the surface is absolutely dry. The quality of the metal laid upon the tongue influences the kind of taste which is communicated; the more oxidable metal giving rise to an acid, and the less oxidable metal to an alkaline taste. Similar differences have been observed with regard to the sensations excited in the tongue by common electricity, directed in a stream upon that organ from a pointed conductor; the taste of positive electricity being acid, and that of negative electricity caustic and alkaline. (*a*) This circumstance would tend to prove that the taste perceived in the galvanic experiment is owing to the actual presence of acids and alkalies, derived from the chemical decomposition of the salts contained in the saliva.

The variety of flavours, like that of odours, seems to be almost infinite, and the diffusibility of these flavours through the medium of water hardly less wonderful. Some of the more striking differences of flavours, as Sour, Acid, Bitter, Salt, and their opposites, can be expressed intelligibly by these general terms; but neither are all sour, all acrid, all bitter, nor all salt flavours alike; and there are innumerable others, which are not referable to any one of these heads, and can only be expressed by a reference to the substance affording it.

The irritation then, however excited, the perception of which constitutes Taste, is conveyed in man directly to the papillæ upon the Tongue, and other parts of the mouth, particularly those about the apex of the Tongue, but it is not in every state that the nerves distributed upon these papillæ seem to be susceptible of the impression upon which Taste depends. When these papillæ are in a flaccid state, the nerves distributed upon them seem to convey only that kind of irritation, the perception of which constitutes Touch, or rather Tact, the distinction between which shall shortly be explained; but when they are erected, then, and not till then, their nerves seem to be capable of communicating the impression which constitutes Taste, the difference between which and Touch or Tact seems to be in no degree more remarkable, than the difference between the touch or tact of some organs, consisting, like the papillæ, of the mucous membranes of the mouth, of erectile tissue, such as the Penis when in a flaccid state, and the touch or tact of the same organ when erected. The nerves in both cases are precisely the same, and the irritation

(*a*) Berzelius.

which they are to convey may be the same likewise; but the sensation excited, (according as these nerves are relaxed or rendered tense, by either the flaccidity or erection of the organs upon which they are distributed) is so different as to appear to constitute almost a distinct sense. It is on this account that we must conceive, that in those animals in which, like the Snail, Sepia, and Fishes in general, as well as some individuals of the Superior classes, the tongue is hard and cartilaginous, the sense of taste is very obtuse, or at any rate, that (as in those Fishes and other animals which are destitute of a Tongue) it does not reside in that organ; and the same may perhaps be said also of the numerous animals in which the Tongue is covered more or less perfectly with prickles, or feathers, or scales, which are not only incompatible with many papillæ, but which must in a great measure obviate the contact with these of the sapid bodies. When it is considered, however, that the whole mucous membrane of the mouth abounds with papillæ very similar to those of the tongue, we need not deny the presence of Taste, because the tongue seems ill calculated to afford it. And this is true not only of the higher, but of the lower orders of Animals. That the Leech, the Gnat, the Hornet-fly, the Bee, all taste, and taste with great acuteness, can hardly be questioned; and yet how little calculated do their organs in general appear to be for that purpose. The diminution of the acuteness of the Taste in Man by closing the nostrils, as persons are accustomed to do when about to take any thing nauseous, and the increase of acuteness which immediately follows admitting a current of air again through the nostrils, is not very easily explained. (*a*) The operation of closing the nostrils appears to blunt the sense of Taste, if not wholly, at least in some measure, by rendering torpid some of the branches of the Trigemini nerves, the partial palsy thus produced being extended throughout the whole of these nerves, to a degree which is incompatible with the delicate function of Taste. It is known, that by producing a partial palsy of the Sensiferous nerves distributed upon the temples, as by the application of an opium plaster, we frequently succeed in diminishing the pain of Toothach;

(*a*) By Cloquet, the connection between the functions of the nostrils and those of the mouth has been attributed to the naso-palatine ganglion, of which he was the discoverer; but it is impossible to make any thing of this notion, the ganglion in question, like all the other ganglions of the same system, having probably nothing whatever to do with sensation of any kind, but being instrumental only to irritation; nor does it appear to be merely by blunting the smell that the diminution of Taste by compressing the nostrils is occasioned, since persons who have no smell are still capable of diminishing in some degree their Taste by this means.

and as this fact must be explained, by presuming that we produce a nebitude to a greater or less degree of all the branches of a sensiferous nerve, by paralysing a few of them, it is reasonable to suppose, that, by a mechanical compression of the nostrils, we may in some degree deaden the sensibility of the gustatory nerves; and it is in a similar way that the well-known fact, that is only the last gulp of a full draught of any liquid which excites the sensation of Taste, must be explained,—the bulk of the fluid having compressed the nerves to a degree which is incompatible with the sensation of Taste, till this bulk is very considerably diminished. The fact, that Taste becomes acute precisely at the instant when a man draws his breath after his respiration has been long suspended, has given rise to the common idea, that a perfect state of respiration is essential to Taste; but it is not easy to say why it should be so to Taste, any more than to Sight or Hearing; and its indispensability to smell arises entirely from the inspired air furnishing the vehicle by which the odoriferous particles are drawn into the nostrils, a rationale quite inapplicable to Taste.

SECTION V.

On the Irritation of the Skin regarded as a Stimulus to Sensibility.

The seat of the irritation, the perception of which constitutes Touch, properly so called, is in all the superior classes of animals the Dermoid Tissue, and the nerves which convey it are the Sensiferous portions of the Trigemini, and of all the Regular nerves which are distributed upon the surface of the body. The stimulus to this irritation is the contact of palpable material substances in general, and it is necessary, at least in man, for its full perception, that the papillæ on which the Sensiferous nerves are distributed should be erected. It will now be understood what is meant by the distinction between Touch and Tact,—the former term being used to signify that sensation which is communicated by the Sensiferous nerves thrown into a state of tension by the erection of the organs on which they are distributed,—and the latter, that sensation which is communicated by the same nerves in a state of relaxation. Touch, therefore, which is in some respects voluntary and active, is necessarily most acute in Man and Apes, and some of the Rodentia, at the tips of the fingers; in some Quadrupeds at the roots of the whiskers; in others about the snout, or proboscis; in others upon the tail; in the Bat about what are called the wings; in the Ornithorynchus and most Birds about the bill; and in Reptiles, (the last class which have such papillæ) at the soles of the feet; while Tact, which in these animals is quite involuntary and passive, is almost equally acute in every part of the surface of the body. Perhaps it is only in these animals that this distinction between Touch and Tact can be strictly maintained, the organs employed in either sense being in all others probably always in the same condition; and accordingly we must conceive that the tentacula and other analogous organs in the Lower Classes of Animals, and the whole surface of the body in Worms, and such other animals as have no tentacula, with the exception of Spiders, which use their feet in this way, are capable of communicating only the coarser modifications of this sense. Touch is the only sense in which Man excels every other class of animals, unless we add Taste also, which however, as a modification of Touch, may be considered as included in the first proposition. (*a*)

The Sebaceous Matter with which the surface of the body is bedewed, and which may be considered as bearing almost the same relation to the organ of Touch which the Meibomian fluid does to that of Sight, and the Cerumen to that of Hearing, answers the purpose in Man chiefly of diminishing the effects of Friction; but in Aquatic Birds, and in the Cetacea, it seems to answer the further purpose of preventing the water from adhering to the surface of their bodies, since it is always of an oleaginous nature. Its odour in some parts of the body, as in the Arm Pits, is extremely disagreeable; (*b*) but it is quite distinct in different persons, and it is by this means that Dogs are enabled to distinguish individuals when they have nothing else to guide them. It is also from the peculiar odour of the Sebaceous Matter of other animals that they are enabled to follow by

(*a*) This fact was noticed by Aristotle, Pliny, and all the ancient naturalists; and as the hand was observed to be the chief instrument of Touch, it was emphatically called by Aristotle, "organum organorum," the organ of organs; and many philosophers, both of ancient times, as Anaxagoras, and of modern times, as Condillac, Buffon and Helvetius, have attributed to the greater perfection of his hand all the pre-eminence which Man enjoys over other forms of animated nature. It was sagaciously observed by Galen, however, that it was not because Man has a hand that he was wiser than other animals, but because he was wiser than other animals that a hand was given to him, since he alone would know how to use it with advantage.

(*b*) It is generally compared by the ancient Poets to the Smell of a He-Goat; and it was with this Smell that they used to reproach their mistresses when they got tired of them.

> ——— sagacius unus odoror,
> Polypus, an gravis hirsutis cubet hircus in alis,
> Quam canis acer, ubi lateat sus. HORACE, Epod. xii.

Scent; and they are observed to hold their Noses closer to the ground when in pursuit of a Hare than of a Fox, the Scent of which is stronger. (*a*)

When the Secretion of the subcutaneous follicles is Mucilaginous, and not Sebaceous, as in the Pinna and Mytilus, in Fishes in general, but particularly the Cartilaginous, and in many Reptiles, it must be presumed to serve chiefly as a defence, except in the two first named animals, which draw it into threads similar to those spun by the Spider or the Silk-worm, by which they attach themselves to rocks. In some species of Medusa this secretion is luminous, in the Toad it is mucilage of a poisonous nature; in the Lacerta Geitza, so acrid as to blister the skin; and in the Salamander, it is so copious at times as to extinguish fire,—hence the fable. As this Sebaceous or Mucilaginous matter seems to be analagous to the Meibomian fluid and Cerumen, so the Halitus or perspiration from the surface of the body seems to be analogous to the Mucilage of the Nostrils, the Tears, and Saliva; and it is probable, that, like the Mucilage and Saliva, a certain quantity of it is essential to the accurate perception of those qualities of bodies which are taken cognisance of by the Touch, since we know that a preternaturally dry skin is as unfavourable to acuteness of Touch, as preternaturally dry Nostrils or Tongue to acuteness of Smell or Taste. The Halitus from the skin is in Man the most copious of all the Secretions, its average quantity being about forty ounces daily. It is considerably more than this in the summer, and less in the winter, while the reverse is the case with respect to the quantity given off by the Lungs. It has all the sensible properties of Vapours in general, and those of the Sweat are sufficiently well known. (*b*) Some Terrestrial animals, as the Dog, seldom or never

(*a*) Boyle.

(*b*) The Halitus contains, together with the Vapour of Water, and a portion of the odorous matter just mentioned, some Carbonic Acid; and it may be noticed here, that we owe to Sanctorius the discovery of this Insensible Perspiration, and of the amazing quantity of it given off every day from the body;—a discovery which has effected some very fundamental and important changes both in Physiology and Pathology, and more especially taught us to rely much in the cure of diseases upon a Class of Medicines which had been before comparatively neglected. This discovery he made by means of his Statical Chair, by which he was enabled to measure with accuracy the weight he had lost in any given time without having effected any sensible excretion; and having, after thirty years' experiments with respect to the variation of this quantity under every possible variety of circumstances, formed his conclusions, he published them in 1614, in the form of a collection of Aphorisms, which can be put almost in the waiscoat pocket, an example of conciseness which it is a great pity so few subsequent experimenters have thought proper to follow. The sweat consweat; but it is remarkable that the tip of a Dog's nose, which is his principal organ of Touch, is always, in a state of health, bedewed with moisture. In Aquatic animals this excretion would be superfluous.

Respecting the uses of each particular tissue of which the common integuments consist, it is not necessary to say much. Many advantages have been fancifully attributed to the Corpus Mucosum of the Ethiopian, but there is not one that is in any degree satisfactory; and it is not, perhaps, a question that can be philosophically asked, any more than what is the use of one horse being black and another white. If we must ask any thing about the subject, it would seem more german to the matter, to ask what is the use of the *White* Corpus Mucosum of the European, since this is, in all probability, the adventitious colour. From the fact of persons exposed to the sun becoming tanned, and of the inhabitants of the torrid zone being frequently black, while, as they recede from this, they often become progressively of a lighter colour, degenerating at length into the "pale, insipid beauties of the north," it is vulgarly supposed to depend upon the action of the sun and heat.

There is, it is true, in the colour of different varieties of mankind a certain relation to climate. We observe that the *black* races of men are principally situated within the torrid zone, and the *white* races in the regions approaching towards the pole, and that the countries bordering on the torrid zone are generally inhabited by nations of a *middle* complexion. It further appears that the natives of mountainous and elevated tracts are usually of lighter colour than the natives of the low and hot plains on the sea-coast.

Still the dark colour is evidently not the result of climate, since, in the same latitude, the human body presents almost every variety of hue. In Asia and America, the inhabitants of countries in the same latitude with Ethiopia are not black, but tawny, and even in Ethiopia all the inhabitants are not negroes. Nay, it is said that the inhabitants of the Northern and Southern shores of the Senegal River are of very different complexions. The inhabitants of northern districts, moreover, are not uniformly of a light colour; that of the Swedes, for instance, being darker than that of the Danes, and that of the Greenlanders and Esquimaux being exceedingly dingy. But there are other circumstances which militate against this opinion. There is positive testimony that the offspring of individuals darkened by the sun in hot countries is born with the *original complexion*, and not

tains, besides the above ingredients, according to Dr Anselmino, some Osmazom and Casein, and divers Salts of Ammonia, Potassa, Lime and Iron.

with the acquired hue of the parents; besides which, it is known that white races of men, who have been removed from a cold to a hot climate, and have not intermarried with the natives, have retained for ages their original colour; while, on the other hand, black families, when transplanted into more temperate countries, have remained for generations of exactly the same hue. It has been also remarked that the above supposition is contrary to a general law of the animal economy, according to which acquired varieties are not transmitted from parents to their offspring, but terminate in the generation in which they had their origin. (*a*) So much then for the origin of the blackness; and that its use is not to counteract the effects of the Sun and Heat, may be concluded, partly from this circumstance, and partly from the fact, that of all colours black is the least favourable under these circumstances. Every body knows that snow melts more rapidly under a piece of cloth of a dark than of a lighter tint, and that black clothes are the warmest dress one can wear during the summer months; and it is pretty generally believed that black horses are less capable of enduring fatigue in a hot country than those of any other colour. (*b*)

The indurated Corpus Mucosum of many of the lower animals, constituting their Shells, Sheaths, Scales, Shields, is obviously to them *in place of* an external Skeleton, and answers all the purposes to which this is subservient. Of the uses of Nails, Claws, Hoofs, Horns, of those of Hairs, Feathers, Bristles, or of those of the Epidermis, it seems quite unnecessary to say any thing, since they are abundantly obvious.

(*a*) Prichard.

(*b*) The experiments of Sir E. Home are contrary to all this. He found that black kerseymere protected his skin from a degree of heat which, under white kerseymere, soon blistered it; and that a Negro felt no effects from a degree of heat which to him was extremely irritating. With respect to the former part of this statement, so opposed to all that is known, we must suspect some fallacy; and with regard to the latter, attributable to habit, diminished irritability, and copious sweating. Black is certainly bad in intense heats; and it is in this view alone that blackness can be considered a curse, as it was long supposed to be, rendering the unfortunate negroes more susceptible of the scorching sun to which they are exposed; but, as far as beauty is concerned, it is well known that they are so well satisfied with their colour in this respect, that they paint the devil, as an object of horror, of a white colour. Still, it must be remembered, that it is only in *intense* heats, such as the human body is very rarely, even in the hottest climates, exposed to, that black is bad, the heat of the body being, in all climates, generally about that of the surrounding medium; and whenever this is the case black is favourable, for it promotes its passage from within to without.

The principal use of the Fat appears to be to fill up interstices, and thus to give a pleasing contour to the body. (*a*) In Fishes also and the Cetacea, one of its main uses probably is to diminish the specific gravity of the body, and we accordingly find that these animals very much abound with it. The mean quantity of Fat in the human body is computed to be a twentieth of its whole weight, or, in a person of ordinary size, about seven or eight pounds, and its quantity is for the most part relatively greater in females than in males (*b*).

(*a*) There is no end to the uses which have been assigned to the Fat. It has been said to lubricate the parts, forgetting that every particle of it is in a distinct vesicle, from which it can no more get out than Sterne's Starling; to keep them warm, forgetting that it is *under* and not *above* the sensible skin; to fill up the interstices, and thus to give a pleasing contour to the body; to serve as a reservoir of nourishment, in cases of animals being put upon short commons; to blunt any acrimony, by being absorbed as often as any acrimony enters the blood. But not one of these alleged uses is in any degree satisfactory, though perhaps it is not easy, nor very necessary, to find a better. It is very well known that fat persons keep themselves more easily on the surface of the water than thin ones, and that Sir John Falstaff was therefore exceedingly mistaken in representing himself as possessed of a kind of alacrity in sinking. The alacrity of the " fat-kidneyed rascal " would have been only of a piece with that which he displayed in every thing else, except wit and knavery, and far inferior to that of the " lean and slippered pantaloon." The fact is, that a very fat person cannot sink in water; and some time ago there was a very fat lighterman on the river Thames, who had fallen over board repeatedly, without any further inconvenience than that of a good ducking, since, though he knew nothing whatever of the art of swimming, he always continued to flounder about like a firkin of butter till he was picked up. It has been accordingly said, that one use of the Fat is to diminish the specific gravity of the body, and it certainly may be of considerable use to its possessor in this way; but it is not easy to imagine that nature had this particularly in view in giving fat to Man.

(*b*) It is a singular fact, that whereas in infants almost all the Fat of the body becomes accumulated under the skin, all the internal organs being nearly destitute of it, in old age the greater part of the Fat recedes from the surface, and becomes accumulated about the heart, kidneys, omentum and other internal parts. I am not aware that any use has been assigned by Physiologists for these peculiarities; but the cause of them is pretty evidently the external circulation of the blood, as Dr Holland would call it, which takes place in early life, and the internal circulation which takes place in old age. It may be noticed, that the word Fat, like milk, has been employed from time immemorial to signify plenty and richness; and the phrases, " fat of the land," " fat of wheat," " fatness of the olive," &c. must be familiar to every body. It is not, however, so generally known, that in token of fertility, a bride among the ancient Romans, on entering her house for the first time, was accustomed to touch the

SECTION VI.

On the Irritation of the Lungs, Stomach, and other Parts of the Body, regarded as Stimuli to Sensibility.

Connected with Touch, or at least with Tact, are the Sensations exciting a desire to breathe in any impediment of Respiration; those called Hunger and Thirst; those which produce a desire to void the Stools and Urine, a desire of Venery, and all the other feelings, whether healthy or morbid, to which the body is subject, the irritation being seated respectively in the Lungs, Stomach, Rectum, Urinary Bladder, Genital Organs, or other parts; and this irritation being conducted, we must suppose, by certain filaments of the sensiferous nerves, although such filaments may be so minute, as, under ordinary irritations, to refuse to transmit them, and thus to give rise to the notion that these Organs are insensible. The Stimulus to these various irritations appears to be in general either certain Mechanical or Chemical Stimuli, situated within or near the organ in question, certain spontaneous conditions of this Organ, Sympathy with other organs, or some general Stimulus derived from the Brain. What is properly called Touch is excited perhaps exclusively by the contact of palpable material substances; but anxiety or pain, which is nothing but excessive Touch, may certainly be excited by other means, as, for example, a Cramp; and it is probable that every description of Stimulus capable of exciting irritability may produce, in particular organs, such an irritation as, conveyed to the sensorium, may give rise to a particular sensation in like manner strictly analagous to Touch.

With respect to the desire to breathe, it is only when the Respiration is impeded that we are conscious of the Sensation which produces it, and this Sensation must thus be supposed to arise from a preternatural degree of the irritation on which natural Respiration depends, and which has been spoken of already. With respect to Hunger, (*a*) the most probable doctrine appears to be, that it arises

posts of the door with fat; and it is from this circumstance that the word uxor quasi unxor, or anointer, was applied to her.

(*a*) It has been attributed at one time to mere emptiness of the Stomach; at another, to the attrition of its parietes in consequence of this emptiness; at a third, to a supposed accumulation in it of the gastric fluid, acting upon it either as a Chemical irritant, or as a Specific irritant, like Light upon the Retina; at a fourth time, to an influx into it of bile from the Duodenum, and to numerous other causes; but insurmountable objections occur to every one of these from a kind of permanent though partial contraction of the muscular fibres of the Stomach; not that alternate general contraction and relaxation which produces a sensible motion of this organ, nor that permanent general contraction which would serve to diminish its cavity, but that kind of permanent contraction which takes place in certain fibres alone, and perhaps through a part of their length only, and by which these fibres are, as it were, drawn away from the others, or, in other, words a minor degree of Cramp.

In support of this opinion it may be stated, that every cause which has a tendency to increase the strength of the muscular contractions in other parts of the body, such as cold, has an almost precisely equal tendency to increase the appetite; while all those causes, on the contrary, which tend to diminish the muscular contractions elsewhere, such as heat, tend in the same proportion to diminish the appetite: That, in like manner, a violently increased appetite is one of the most constant symptoms of an incipient attack of Gastrodynia or perfect Cramp of the Stomach; and that a similar ravenous appetite is not an unfrequent attendant on some forms of Colic or Cramp of the Voluntary Muscles of the body; and that hunger is capable of being removed by almost precisely the same means as are adapted to relieve Cramp in other parts of the body, particularly by opiates or other narcotic medicines, and by violent pressure. It is probable that most of the substances celebrated by the ancients as preventives of Hunger were of this nature.

The Indians of Asia and America are well known, before undertaking their long journeys into the deserts, to provide themselves with Boluses containing Tobacco, so mixed with the ashes of cockle-shells and other substances, as to act gradually on the stomach in proportion as these substances are slowly dissolved; and these they use on all occasions as an antidote to Hunger, when they have not the means of satisfying it in the natural way. The practice of sailors

hypotheses. Against the first, it may be alleged that mere emptiness is nothing, and therefore cannot be a stimulus to any thing; and that the Stomach is often perfectly empty, as after long fasting, without there being the least appetite:—against the second, that it is not till food has been received into the Stomach that its motions are perceptible; and that if Hunger depended upon attrition, the first Mouthful of Aliment swallowed should remove it as effectually as a full meal:—against the third, that it is only or chiefly when aliment has been taken into the Stomach that the Gastric fluid becomes accumulated in it, as it is only or chiefly upon the reception of Matters into the Mouth that the quantity of Saliva is much increased;—and against the fourth, that no such influx of Bile, as has been presumed, in all probability ever takes place in the healthy Stomach.

and others, when short of provisions, of alleviating Hunger by tight bandages tied round the Belly, assisted sometimes by the addition of pieces of board, which they press over the Stomach, is sufficiently well known. For the same purpose, wild Beasts and Birds frequently swallow stones ; and the inhabitants of some countries, as the Egyptians, (*a*) the Javanese and Guinea negroes, (*b*) and the Ottomais, (*c*) are accustomed to eat vast quantities of a kind of earth, African Cachexy. Admitting this doctrine, too, it is quite easy to explain how the appetite for food is sometimes instantaneously lost upon the reception of bad news,—a fact which is quite inexplicable if we attribute it to any other cause.

It has been objected to this doctrine, that Hunger arises from a contraction of the muscular fibres of the Stomach ; that, after subjecting animals to very long fasting, the size of the Stomach is not sensibly diminished ; (*d*) but neither is it in a perfect Cramp of the Stomach, as is supposed to be proved by the very large draughts of liquid which persons affected with this disease are capable of swallowing ; and yet no one will question that this disease arises from muscular contractions ; and it has been formerly shewn, that inordinate muscular contractions are perfectly compatible with an undiminished size of the organ afflicted with them, in the same way as a violent cramp of the leg may take place without producing any approximation of the heel to the knee. Such then appears to be the nature of the *irritation* upon which the sensation of Hunger depends ; but what is the nature of the stimulus by which this irritation is excited at *certain seasons*, we can no more explain than we can what is the stimulus which excites periodically the secretion of semen in the inferior animals, or that of the menstrual fluid in women, all which seem to be resolvable by certain laws of the animal economy, of which we can give no manner of explanation. During Hunger, if it be considerable, the other sensations are in a great measure suspended, the intellectual faculties are weakened, the spirits are depressed, the muscular powers are diminished, and the whole system is felt to be below par. How different this state from that when the appetite is satisfied, when every man feels himself comparatively a wit and a hero, and not only, like Sir John Falstaff, a wit and a hero himself, but the cause of wit and heroism in others. If Hunger become excessive, it is sooner or later superseded by raging thirst, which terminates in delirium and madness.

The irritation which gives rise to the sensation of Thirst is com-

(*a*) Sonnini. (*c*) Humboldt.
(*b*) Dr Wm. Hunter. (*d*) Magendie.

monly represented as a preternatural dryness of the Fauces, and there is no question that when a man is thirsty his throat is commonly dry. But such dryness may be a concomitant of Thirst, as well as a cause of it; and it is highly probable that both arise from one common cause, perhaps some degree of acrimony in the Secretions of the Stomach, which is to be either diminished by dilution, or corrected by its proper antidotes.

That Thirst does not arise from mere dryness of the Fauces, is evident from the circumstance, that it is not alleviated by a few drops of liquid, which would be quite sufficient to remove such dryness, but requires a full draught for the purpose. Nay, an excessive quantity of fluids, if applied merely to the Mouth and Fauces, is inadequate to the purpose. If it arise from mere *dryness* also, whether of the mouth or any other organ, why should certain liquids, such as ascescent fruits, be more powerful in relieving it than mere water? All this is in favour of its seat being the Stomach, and its cause a change in the secretions of that organ; and that Thirst does imply some acrimony in the secretions of the Stomach, seems evident from the fact, that much Salted Meat, which may be supposed to operate by its acrimony, is an almost certain means of producing it; and that it is an almost constant attendant on febrile diseases, in which the secretions of all the Mucous Membranes, and particularly that of the Stomach and Bowels, seem to be preternaturally acrid. It is in favour of this opinion also, that Thirst may be alleviated, it is said, when drink cannot be procured, by the application of moist substances to the Skin. (*a*) In such instances the advantage depended rather perhaps on the Sympathy between the Skin and Stomach, so that the former being refreshed, the secretions of the latter were ameliorated, than upon any absorption of the liquid. Cold affusion has often the same effect in Fevers; but the contact of the liquid is here much too short to allow of any such absorption. It will be found also that the irritation producing Thirst bears the same relation to the Stomach, which the irritation producing a bad Taste does to the Mouth, or the irritation producing the Sensation called itching does to the Surface of the body; and that they all arise from some vitiation of the Secretion of the parts. By what law it is that these Secretions are in most people occasionally so vitiated cannot be explained. It deserves to be remarked, that some people in a state of health never experience Thirst; and many of the lower animals, such as Parrots, Rabbits and Mice, seem to have, under ordinary circumstances, no such Sensation.

(*a*) A memorable instance of this occurred during the voyage of Commodore Anson.

Excessive Thirst, like excessive Hunger, is a most absorbing Sensation, and even frequently still more intolerable.

The nature of the Stimulus exciting that feeling which calls upon us to void the Stools and Urine is sufficiently palpable. The accumulation of Stools in the Rectum, for any thing we know, irritates equally every part of this gut; but the accumulation of Urine in the Bladder seems to irritate more particularly that part which is called the sensible spot of the Bladder. It is situated in the Trigone, almost immediately behind the Urethra, and owes its sensibility to some very large nerves, which are distributed upon that part. (*a*)

There is a peculiarity in some of the Feræ, and particularly in the Dog kind, with respect to voiding their urine, which does not occur in other animals, and that is a tendency, as it were, to housewife his urine, and not part with too much at once. Upon being first set at liberty in the morning, a Dog may be observed to urinate, in general, six or eight times in rapid succession, and not, like most other animals, at once to expel the contents of his bladder. It is said that the odour of certain plants also, as that of the Great Water-dock, excites in the Dog a strong desire to void his urine. The stimulus in these cases seems to be some affection of the mind excited by the smell of urine, not the presence of a certain quantity of urine in the bladder, since a Dog, which, when at liberty, will probably urinate one hundred times in an hour, is capable perhaps of holding his urine for six or eight hours if not subjected to this stimulus. Other stimuli also, besides the presence of urine, sometimes excite the same desire in Man.

The irritation which produces in the natural state a desire for venery, seems to be in Man partly a certain natural turgescence of the genital organs by blood, as occurs in Eunuchs, and partly the

(*a*) This was first noticed by Sir Charles Bell, who was led to look for some peculiarity in this spot, from having noticed, that during the introduction of the Catheter, Patients generally complained of a violent desire to void their Urine, upon the point of the instrument coming in contact with the part in question, although perhaps there was not more than a few drops of Urine in the Bladder; and he attributes it to the pressure made by the Urine on this spot, when we lie on the back, that children, who frequently sleep in this posture, are accustomed during their Sleep to wet the bed. Every one must have experienced, in his own person, that when the Bladder is full, lying on the back is much less tolerable than lying on the side, and that standing erect is the most intolerable of all, since in this way a still greater pressure is made upon the sensible spot of the Bladder, than by even lying on the back; and hence the first impulse, upon rising from bed in the morning, is always to fly to the chamber-pot, although we could probably have continued in bed for some hours longer without experiencing any desire to void the urine.

presence of an abundance of semen in the semeniferous vessels; and in Women, as in Eunuchs, exclusively a certain natural turgescence of the genital organs by blood. But it is capable of being excited also by other stimuli, as certain poisonous medicines, which irritate the mucous membranes, particularly of the uriniferous and semeniferous passages, and mechanical irritation of these passages, such as is occasioned in Man by an Hypertrophy of the Prostate gland, and in Woman by Worms in the Vagina. The manner in which these irritations produce the feeling which prompts persons to sexual intercourse, seems to be quite analogous to that by which the several irritations just mentioned in the Stomach, the Rectum, the Bladder, excite the feelings which prompt persons to use the proper means of relieving them. As the feeling of a desire for Venery, so the gratification derived from it is obviously merely a modification of Touch, which is here more intense than elsewhere, only because the erectile tissue of the Penis and the Clitoris is more calculated than that of other parts to put the sensiferous nerves upon the stretch, and thus to adapt them for the more vivid communication of impressions. A minor degree of the same kind of gratification is experienced by Females when giving suck. The desire of Venery, if excessive, exerts a very extensive influence over both body and mind; the former of which it exalts frequently to preternatural energy, while the latter is thereby absorbed, disturbed, and even maddened. This is particularly evident in male animals during their rutting season, when the most timid of them will frequently brave the wildest danger in pursuit of their desires. The females of all animals, in spite of the common-place jokes of Libertines, are unquestionably, in general, much less the slaves of venereal desires than males. The ferocious actions and wild looks of the latter have no parallel in females in general.

The return of the gratification which attends the consummation of venereal desires, and the singularly enervating effects which follow it, need not be described. The latter, however, have been attributed to the simple evacuation of the semen; but this cannot be the case in females. It is unquestionably to be ascribed to the collapse which follows every excessive excitement. It would be improper to leave the subject, without remarking, that in all the last-mentioned instances of Feelings exciting desires, although the seat of the Feeling may be a certain part of the Spinal Marrow, the seat of the desire, as a modification of Thought, must be presumed to be in the Encephalon; but as it is Sensation only, and not Thought, that is now under consideration, this subject shall be deferred for the present.

CHAPTER V.

ON THE INCREASE AND DIMINUTION OF SENSATION.

The peculiarity of the Sensation of venereal gratification, as well as many other circumstances, such as that of a person being able to direct himself while walking in his sleep,—that of a Bat being able to direct its flight through very intricate places, without striking any thing, though deprived of the use of its eyes and ears,—that of ducklings running at once into the water, which they see for the first time, while chickens cautiously avoid it; and many others of this kind which are not at first sight easily explicable, as arising from impressions derived from any of the five commonly acknowledged senses, have given rise to the notion, that there exists a sixth sense, to the impressions derived from which all these and numerous similar circumstances may be traced. There appears, however, to be no sort of reason for believing that any such sixth sense exists. The cause of the peculiar pleasure derived from venery has been just mentioned. The means by which a bat is enabled to avoid the contact of objects, without either seeing or hearing, is evidently the delicacy of the touch resident about what are called its wings, which immediately informs it of the peculiarity in the motions of the air, produced when objects are contiguous; and a similar delicacy is sometimes acquired by man in certain diseases. (*a*)

Again, that a person, when walking in his sleep, employs all his ordinary senses, and not a sense of all work as their substitute, must be evident to any one who reflects, that such persons are as capable of distinguishing things by their odour,—of seeing to write long letters,—of amusing themselves with recitation or singing, and of enjoying a good supper, as when awake. (*b*)

(*a*) A case is related by Platner, of a woman, "who being taken ill of a sudden, continually complained that she would be suffocated, though no signs of it appeared. This complaint of hers was always the greatest when any of the byestanders approached her, though ever so gently; for she said that she at those times felt a breath of air come upon her, as if she were instantly going to be choked. She hardly remained in this condition for two days, and then died." The same thing is often observed in Hysteria, and still more remarkably in persons affected with Hydrophobia.

(*b*) It was another of the errors of Shakespeare, that he described the sense of the eyes as shut during sleep-walking; and it was one of the few inaccuracies

With respect to what is called instinct in animals, as in the case of the ducklings, it cannot be questioned but that it arises from some uneasy sensation, a modification of Touch or Tact, proceeding from certain irritations of particular organs, quite analogous to those on which it has been presumed the desire to Breathe, Hunger, Thirst, the desire for Venery, depend, and prompting them to use the proper means of removing them, as Hunger prompts us to take food, and to do nothing else; Thirst, to take drink, and to do nothing else; and the desire of Venery to have recourse to Sexual Intercourse, and to do nothing else. To investigate how particular sensations excite particular desires, the indulgence of which is calculated to remove this, belongs rather to the head of Thought than of Sensation, and is the business rather of Metaphysics than of the Physiologist. It is our present object only to show, that what is called Instinct, (like Hunger &c.) is a Desire or Passion excited by a Sensation arising from certain irritations. The perception of these irritations is the Monitor by which we are warned of the necessity of effecting some change in the system; and it is a Monitor, the voice of which it is not possible either to disregard or to misunderstand, since it unfortunately increases in proportion to the increased demand for such a change, and its injunctions are enforced by laws far less fallible than those of Reason.

The term Instinct has been very generally used in an extremely vague acceptation, but it may be probably defined to be, "an involuntary performance of an action calculated to procure some good, or to obviate some evil;" and this impulse springs, in all cases, from an uneasy sensation of some kind or other. This Instinct is well defined, to "consist in sensations which solicit a living being to execute involuntarily, and often unconsciously, certain acts necessary for its welfare." (*a*) To say nothing of the act of respiration, the taking of food and drink, the voiding of the stools and urine, and the performance of venery by animals in general, actions which are evidently instinctive, and excited by uneasy sensations, producing such impulses and desires, there can be but little doubt, that actions the most nearly allied, apparently, to those resulting from reason, are really referrible to the same involuntary impulse arising from uneasy sensations.

of the late admirable Mrs Siddons, in her delineation of Lady Macbeth in the sleep-walking scene, that although, in speaking of the smell of the blood on her hand, she naturally enough carried it to her nose, still, in exclaiming, "Yet here's a spot," she was accustomed, certainly with great inconsistency, to fix her fine eyes upon the galleries, where it is true they might detect many a spot, but certainly not the spot in question.

(*a*) Broussais.

Thus, the selection by each variety of animals of its natural food, evidently arises from the uneasy sensation which the want of this excites, and which is different in each, according to its different organization, in the same way as, in certain states of the human stomach, a desire for acid, and in others, a desire for alkaline substances, is perceived, without, however, any thing like a reasonable conviction of their efficacy. In like manner, the Ant hoards up its grain, and the Bee its honey, not from any reasonable persuasion that they shall in future stand in need of them, but because the organization of each is such, that omitting to do so would be felt by these animals as a natural appetite ungratified. It is on this account also that Moths and Butterflies are observed to lay their eggs always in situations where the young Caterpillar, on being hatched, can procure substances adapted to nourish it. They think nothing of this, but they lay their eggs in these situations because they are stimulated to do so by an uneasy sensation, excited probably by the odour of these substances, as a Dog is stimulated to void his urine by certain odours. The duckling also runs into water the first time it beholds it, evidently as a means of obviating the uneasy sensations arising from the suspension of one of its natural faculties, that of swimming, which could not be exercised while on dry land; and it is from a similar cause that every animal at once betakes itself to that element to which its organization is adapted, and an exclusion from which is, like confinement and restraint of every kind, felt as an evil.

So far, then, all the acts commonly referred to Instinct are distinctly to be ascribed to the kind of impulse just mentioned; but there are others frequently classed under this name, which do really result from reason. Of this nature are the selection by Hens of a new place for laying their eggs, if they have found the former place insecure; the various stratagems employed by Cats for the preservation of their young; and the innumerable contrivances employed by Hares, Foxes and Deer, in order to elude their pursuers. These actions appear to be the result of reason rather than of instinct; *first*, because many animals, for instance Dogs, display, in innumerable instances, evident marks of this faculty; and because, in these instances just mentioned, it is chiefly old and experienced animals which excel in this kind of craft; and one essential distinction between actions resulting from Instinct, and those resulting from Reason, is, that the former are as perfectly performed the first time as ever afterwards, and can never be adapted to particular circumstances; while the latter are susceptible of progressive improvement, as resulting from a controllable faculty, and may be made to vary with every change of circumstance.

The other instances of the Instinct of Animals commonly brought forward, and which appear to be perfectly legitimate ones, are the beautiful fabrics so frequently constructed by the lower animals, and the admirable adaptation of them to the ends which they are intended to serve. Of this nature are the webs of the Spider and Silk-worm, the comb of the Bee, the nests of Birds, the huts of Beavers, and innumerable others, which display at once the most delicate mechanism, and apparently the most admirable foresight. Concerning the foresight, enough has been said in speaking of the hoarding of grain by the Ant, and honey by the Bee; and concerning the mechanism, we shall find but little grounds, on this score, for attributing to the above animals any thing more than the blind impulse just alluded to. The art displayed is as perfect at first as at last, and it is unattainable by any animals which have it not naturally; but what is more conclusive still, it is displayed in still greater perfection by agents to which we allow neither reason nor instinct. What Spider's web, what Bee's comb, what Bird's nest, what Beaver's hut, can compare in delicacy of mechanism, or subserviency of the means to the end to be fulfilled, with the leaf of the simplest Plant, or the eye or ear of the meanest Reptile? And by what means were these originally formed, and how are they continually renewed, and their occasional lesions repaired? By secreting vessels, the only acknowledged impulse to the action of which is neither Reason nor Sensation, but merely Irritation excited by their contained fluids. They do not imply even Sensation, but only Irritation; and if, then, Irritation be sufficient for such subtile products, *a fortiori*, Sensation must be adequate to them. (*a*)

(*a*) It has been well remarked, that a New Hollander is not by half so good a builder as the White Ant in his woods, or the little Coral Worm in the sea that surrounds him; and the European must yield the palm to a Snail or an Oyster! The tree that adorns the forest, the flower that enamels the parterre, the very rankest weed that grows, the particles of earth that arrange themselves into an agate or a crystal; nay, the very moisture of the air of a room on a winter's night, which does not appear, till coming in contact with the cold glass of the window, it shoots into beautiful feathers of ice;—these, nay any thing else of Nature's forming, are all much greater adepts in the arts of form and construction than Man is. Of his Painting we need not speak; and as for his Chemistry, why, in the practice of it, he is outdone by a vine, a mountain berry, or even a sun-beam. If, therefore, we were to take the mere arrangement of Matter as the evidence of Mind, Man would be placed far down in the scale, and his immortality would stand upon no better foundation than that of an insect, a stone, or even a drop of dew. But that is not the philosophic view of the matter. The most ingenious performances of Animals, those which have been described as the results of an inferior sort of reason, have really nothing more to do with reason, viewed as an attribute of mind, than has

It remains only to say, with respect to the senses in general, that a kind of universal sense has been presumed to exist, to which were referrible all the sensations, whether pleasing or otherwise, which could not be distinctly traced to any one of the generally admitted senses. (*a*) Every one is conscious of feeling at one time a sensation of general alacrity and vigour, both of the mind and body, for which he can assign no adequate cause, and at another a sensation of general listlessness and weakness, the cause of which is equally obscure. This universal Sense has been called Cœnesthesis; (*b*) but apparently this Cœnesthesis is nothing more than Touch or Tact, which, as we have seen, is universally distributed over the body, subject however to varieties according to the structure of each individual organ, and the particular irritation to which each is liable; and it is not difficult to conceive, that when the irritation of each is precisely such as it is intended by Nature to undergo, we feel well and happy; but when either more or less than this, we feel, on the contrary, out of sorts and out of spirits, though we cannot tell very distinctly what is the matter with us. (*c*)

the motion of a planet, or the falling of a stone, or the congelation of water by cold, and the thawing of it again by heat. The rose-bud of this year takes no copy from the rose-bud of the last: the Bee is not schooled in wax-making or cell-building by its parents; for the one parent is a queen, and as such exempted from labour, and the other is an idler or drone. Taking this view of the matter, then, we cannot but subscribe to the opinion of Descartes, that Animals with respect to many of their actions, and Plants with respect to all, are mere machines, acting in blind obedience to certain laws of which they are unconscious, in order to obviate certain uneasy sensations, which a neglect of these actions would excite. We cannot nevertheless refuse to Animals the possession of thought displayed sometimes in a surprising degree by the lowest tribes of them on certain emergencies; but it cannot be believed that any of the habitual actions above alluded to indicate this function. We shall recur to this subject, and still further illustrate it under the head of Thought.

(*a*) The chief advocates of the existence of a universal Sense were Varini, Scaliger, Spallanzani and Darwin.

(*b*) Hubner, Comment. de Cœnesthesi, 1794.

(*c*) Every creature has pleasure in the mere exercise of his body, as well as in the repose that follows exertion; and what is apparent in the body is true of the mind also. It is this delight which we experience in the exercise of our functions, both Corporeal and Mental, which constitutes the love of Life and fear of Death, so universally pervading all descriptions of Animals. "And what thinkest thou," said Socrates to Aristodemus, "of this continual love of life,—this dread of dissolution, which takes possession of us from the moment that we are conscious of existence?" "I think of it," answered he, "as the means employed by the same great and wise Artist, deliberately determined to preserve what he has made." But this desire of Life influences us no longer than we derive

In a very great majority of cases, probably the sensation, whether of alacrity and happiness, or of lassitude and depression, is referrible to the Stomach, and, even in its natural state of moderate and healthy tension, seems, by the universal sympathy which subsists between this organ and almost every other organ of the body, but more especially all the voluntary muscles, to communicate to them a healthy Stimulus, and thus to excite in them that degree of contraction which is favourable to exertion, and which communicates to the sensorium a sensation of vigour and readiness for any undertaking; and persons in this state are commonly said accordingly to be looking well, and describe themselves as feeling so.

Such is the state common to infancy, and at all periods to persons of a sanguine temperament, who live temperately, and whose circumstances are easy. On the contrary, most people are aware of the depression, the uneasiness, the loathing of one's self and all around one, and the total inaptitude for exertion, either of body or mind, which succeeds a debauch, and which is obviously referrible to a relaxed and weakened state of the Stomach, which, ceasing to communicate the healthy Stimulus to the voluntary muscles, allows them to fall into a state of flaccidity, incompatible with almost any bodily exertion, and conveying the sensation to the sensorium of utter helplessness and imbecility,—a sensation disagreeable not so much positively as negatively, and consisting rather in a want of every thing that is pleasant, than in the presence of any thing absolutely the reverse. Such a general sensation of either pleasure or uneasiness is apparently as distinctly referrible to the sense of Touch or Tact as Hunger and want of appetite, from which it differs chiefly in the seat of the irritation whence it proceeds being only more generally diffused; and there is no reason to admit of this Cœnesthesis as a sixth Sense, although we may employ the term, if we please, to signify the universal sensation above alluded to, and which undoubtedly arises from a greater or less degree of contraction of the Voluntary Muscles, produced in general by the greater or less Stimulus which they receive from the Stomach.

All the Senses may be improved by exercise; and as examples of the greater Susceptibility, with respect to certain irritations, acquired by the habitual excitement of those sensations which they respectively produce, and by a habit of relying on the information which these sensations convey, may be mentioned the almost incredible

pleasure from the exercise of our Functions. It is consequently weakened by long disease or severe mental suffering, and sometimes unhappily entirely obliterated.

delicacy of Smell and Hearing in Savages, who are in the habit of finding out their prey by its odour, and the increased accuracy of the Touch in persons both blind and deaf, who have of course little else to rely upon on all occasions. (*a*)

It would be improper to quit this subject without alluding to the remarkable effects said to be produced on Sensation by Animal Magnetism. It has been noticed, that the fifth pair of nerves, (ordinarily instrumental to Touch and Taste alone) stands in some animals in the place of an Olfactory Nerve, in others of an Optic, and in others of an Auditory; and the fact, that all the senses are in every animal only modifications of Touch, has been already insisted on. It was left for the Animal Magnetisers, however, to discover that the Nerves of Touch, in general, could, even in Man, under

(*a*) A remarkable instance of the delicacy of Smell is related by Dr Wardrop, the case of James Mitchell, a native of Scotland, who was capable of distinguishing individuals by their odour, as a Dog. With regard to Sight, Borelli mentions the case of a man, who could understand all that was said by merely noticing the motions of the lips; another is told by Piso, of one who could distinguish Latin by the same means; and another case is related by Peter-a-Castro. The increased accuracy of Sight also, in relation to distant objects, acquired by Sailors and Astronomers, and in regard to near objects by Watch-makers, and those who engage much in microscopical investigations, is hardly less remarkable, such persons being capable of distinguishing objects which to another person are totally invisible. The same thing may be said of the sense of Hearing, the accuracy of which in some savages is hardly credible, as well as of the Taste, which, in those who rely much upon this sense, as Wine-tasters, purchasers of Drugs, and Epicures, acquires a degree of delicacy, which, with those who do not possess it, often passes for affectation. But there is no sense which is susceptible of greater improvement by cultivation than Touch, which, every one is aware, becomes inordinately accurate in blind persons, who, it is said, may be taught to read by merely passing their fingers over the letters of a printed book, if these letters be pricked or scratched, particularly if they are a little elevated, as they have lately been in some publications adapted for the blind. Boyle gives an account of a man at Maestricht, who was capable of distinguishing colours by the Touch alone. Black and White were roughest, but very nearly alike; then in order came Green, Grey, Yellow, and lastly Red and Blue, which were nearly similar. Still more wonderful is the story of Joannes Gumbassius Vodateranus, the sculptor of Rome, in 1636, who made effigies of many of the great men of the age, and worked equally well in a dark room as a light one. But while we assent to all this, there is no occasion to believe that the Touch of a blind person can ever become, at least under ordinary circumstances, so delicate as to be capable (as that of Miss M'Avoy was said to be) of altogether superseding the Sight, and thus of distinguishing the hour by merely passing her fingers over a watch-glass, or even of distinguishing persons on the opposite side of the way, by touching with her fingers the pane of glass which transmitted the image of them!

some circumstances, take on themselves the office of many of the other sensiferous nerves. Thus a case is related by Rostan, of a patient whom he magnetised in the presence of Dr Ferrus, and who told, without once mistaking it, the time of a watch placed three or four inches behind the occiput. This is quite incredible. It might be possible to perceive *Light*, but not Images or *Arranged light*. Professor Dumas also, of Montpelier, mentions the case of a young lady in whom all the senses appeared to be concentrated at the Epigastrium, and who referred to the Stomach, instead of to the Eye and Ear, all the impressions produced by Luminous or Sonorous bodies. In this case the *stimuli* to Sight and Hearing were as usual, and it was increased susceptibility of the Nerves of Touch alone which produced impressions, when, under ordinary circumstances, no impressions would have resulted. But in some cases the stimulus has been not rays of light, but actual contact of solid bodies, or that usually of Touch alone, and the nerves also those of Touch alone; and still the impression has been that of Sight, as in not a few cases on record, of persons under the influence of Animal Magnetism being capable of *seeing* (as they called it) their internal organs! or at least of perceiving impressions from them allied to Sight. Of these cases, if they are credible, and they come supported by evidence to which it is difficult to refuse our assent, (*a*) the only explanation which can be given is, that the Stimulus to every form of Sensation is in nature the same, differing only in degree, and that all the Sensiferous Nerves have probably a similar origin, and minister in fact to the same function, the difference being here also only in degree; so that it would perhaps have been fair to presume, *a priori*, that, under circumstances in which the obtuser of these nerves acquired a preternatural degree of acuteness, they might perform the office of the rest. We cannot tell why the Olfactory Nerve should alone, under ordinary circumstances, take cognisance of Volatile Particles, the Optic of rays of Light, or the Auditory Nerve of tremors of the Air; and till we can do this, we cannot tell why, under extraordinary circumstances, the other Sensiferous Nerves should not be capable of doing the same; nor can we tell in what particular the impression which we call Smell, Sight, or Hearing, differs from the impression which we call Touch; and till we can do this, we cannot tell why the latter impression should not, under certain circumstances, be convertible into any one of the former. But it is not in general by rendering Sensation preternaturally acute,

(*a*) Believed by Hufeland, Treviranus, Kieser, Carus, Georget, Chevenix &c.

but by altogether suspending it, that Animal Magnetism operates, inducing commonly a state absurdly called Somnambulism, but really analogous to Reverie, Trance, or Ecstacy. In this state, " External Life has ceased,—the Patient lives without himself;" that is to say, the operations of Thought are so energetic as entirely to suspend those of Sensation. The subjects of these experiments are usually Nervous Females or Hypochondriacs, in whom the influence of Imagination is the strongest; and there can be but little question, that the grimaces of the Magnetiser excite on their imagination a power which becomes real, only from their belief of its reality, particularly as sceptical people have been magnetised in vain. Now, how wonderful are the effects of Imagination in such persons needs not be told. All Functions are absorbed in those of the Brain: the Memory and other attributes of the Brain become exalted to an incredible degree: the person absorbed in his own speculations appears a being of another world,—to descant on the past, and to foretell the future with astonishing precision; and all this in a style of language far superior to his ordinary discourse, and even in tongues with which he is in his ordinary state very indifferently acquainted. Such has been the state of religious enthusiasts of all ages, and such is often that of Cataleptic persons, and others afflicted with diseases producing extraordinary excitement of the functions of the Brain, from whom the subjects of Magnetical Reverie appear to be in no respect different. But a certain influence derived from the Brain is essential to the action of every other organ; and it is easy therefore to conceive, that if the Brain be excited, so long as this is within certain limits, it may render more energetic the functions of the Spinal Marrow; and this produces the increased acuteness of some of the Senses already alluded to, as well as Convulsions, Hurried Breathing, Violent Perspirations; but if it become such as entirely to absorb the Brain in its own proper functions, then that of the Spinal Marrow, as well as of all the other organs, will fail. Accordingly, in a case in the Salpetriere, the strongest liquid Ammonia was applied to the nostrils in vain. (Smell) In many others the eye was not affected by the strongest Light. (Sight) In one case, in the Hotel Dieu, the report of a Pistol produced no effect: the patient continued a sentence she had begun. (Hearing) Taste has not been examined. With regard to Touch, Recamier applied the Moxa! and Cloquet amputated a Mamma without pain or consciousness!

ON LIFE, AS MANIFESTED IN THOUGHT.

CHAPTER I.

ON THE PHENOMENA OF THOUGHT.

"In order to have a just idea of Thought," says Cabanis, "it is proper to consider the Brain as an organ specifically adapted to produce it, in the same way as the Stomach and intestines are adapted to produce digestion. The impressions derived from the senses upon arriving at the Brain, make it enter into action precisely as the aliments do with respect to the Stomach, upon arriving at that organ." The faculty of Thinking is born and developed, decays and dies with the body; but it must be kept in mind, that it is with one part of the body alone, viz. the Brain, that it has any immediate connection. Its development is co-existent with that of the Brain, and it undergoes alterations in the progress of life, and during disease, precisely proportioned to those which the Brain suffers. Further, the extent, the diversity, the energy and complication of the intellectual operations, are, in general, both in Man and the Lower animals, in the direct ratio of the volume and multiplicity of the Brain. In the Zoophytes and Corallines, for instance, which present no appearance whatever of a Brain, nor even Spinal Marrow, we have no indications of Thought, nor even *very decidedly* of Sensation. Every thing with them may perhaps be referred to Irritation. Among the Testaceous and Molluscous animals, the appearance of a Brain is still somewhat problematical; but they have certainly a kind of Spinal Marrow: and whether they have Thought is, in like manner, doubtful; but it is certain, on the contrary, that they have Sensation; but this does not require the possession of a Brain. In Insects, the appearance of a regular Brain is much less equivocal than in any other order of Invertebral animals, and the development of intellect in them seems to bear an exact proportion to it. Those also with the largest Brains are, in a corresponding degree, equally distinguished from the rest by the superiority of their intellect. In short, the higher we rise in the scale of animal creation, the more voluminous and complicated becomes the Brain, and in an equal degree the more numerous and decided the manifestations of intellect. How infinitely superior are the habits of the Spider, the Ant and the Bee, to those of the Zoophyte, the Worm, or the Oyster, yet they are not more so than the greater development of the Brains of the former seems abundantly to account for! Even in Insects, however, the structure of the Brain differs very little from that of the rest of the nervous system but by its situation; whereas, in the Vertebrate animals, it is always composed of various parts, more or less distinct from each other. It is progressively more and more complicated as we ascend through Fishes, Reptiles, Birds and Mammals up to Man, and the degree of intellectual superiority in each may be said to correspond almost entirely with this greater complication. Hence in Birds, and more especially in the Mammals, we observe the same intellectual faculties, differing only in degree, and the same propensities which distinguish the human race. They learn to put in practice the means proper for their preservation,—to avoid dangers,—to procure the aliment destined for their nourishment; they regulate their conduct according to circumstances; they have judgment, comparison, discrimination, memory, recollection, and they are consequently (unlike those which are governed by a blind instinct) susceptible of a greater or less degree of education. In every respect, in short, they are distinguished from Man by the degree only, and not the nature of their intellectual operations. It has been before said, that many of the actions of the lower animals, as the selection of their proper food, and even the hoarding up of this food,—the choice of convenient places to lay their eggs in, and of that element to which they are adapted,—the construction by the Spider of its web, by the Silk-worm of its cocoon, by the Bee of its comb, by the Birds of their nests, and by Beavers of their huts, are probably examples, like the satisfying of Hunger in Man, of Instinct alone, or of blind obedience to certain laws, of which they are unconscious, in order to obviate certain uneasy sensations, which neglect of these actions would excite; but it was then admitted, that many animals frequently perform actions which cannot be referred to the same blind impulse, but which obviously result from reason. Of this nature are all those actions which are capable of being adapted to particular circumstances, and susceptible of progressive improvement. Thus, it is probably from instinct that the Ant hoards up grain, but it is from reason that it bites off the germinating part of it, if it have ever sprouted on its hands: it is probably from instinct that the Spider makes its web, but it is from reason that it refrains from seizing a fly upon it, if there be there, at the same time, an enemy to be dreaded: it is probably from instinct that Birds build their nests, but it is from reason that they build them in inaccessible places, if they have ever had their eggs stolen. All the former actions are immutable, and perfect from the first;—all the latter are adapted to the occasion, and improveable by practice; and it appears to me as certain, that the actions of many of the lower animals have a double origin, as that those of man have; and that the operation of sucking in the new-born infant, or taking food at any time, is regulated by different laws from those by which an experienced man regulates his conduct in any critical emergency, must be admitted by every one. *In as far as an animal is capable of profiting by experience, in other words, in as far as it is educable, if the expression may be used, it appears to be intellectual,* and it is so, almost uniformly, in proportion to the development of the Brain. Thus, of all animals, Man, who has the largest and most complicated Brain, is the most improveable. He is the most capable of advancing from what he does know, to what he does not,—from what he can do, to what he cannot; and being capable of leaving behind him records of his attainments, so that his successors may begin where he leaves off, he is capable likewise of progressive civilisation. It is only in the last particular that he is otherwise than in degree superior to the lower animals, which being incapable of leaving behind them any such records, the attainments of each individual necessarily die with it, and the race therefore remains *in statu quo.* But how much each individual, in all classes of animals furnished with Brains, is improveable, not only by artificial, but by natural education, in other words, experience, is well known to every body. A beautiful example of this is recorded by Darwin. A Wasp had caught a Fly almost as large as itself. It first cut off the head and tail, but could not rise for the wind catching the wings—alighted again, and deliberately sawed off first the one and then the other! An experienced Cat will know how to secrete her Kittens: an experienced Hare or Deer will know how to elude the huntsman. Any animal almost, furnished with a Brain, if it have once suffered by Man, will in future keep out of his way; and the tricks of an old Fox, both in attaining its prey, and avoiding the snares spread for him, are so remarkable, that the term is emblematical of a cunning fellow.

Who, moreover, has not seen artificially educated Horses, Dogs, Lions, Pigs, Elephants, Bears, Monkeys and Canary Birds, even Hens, but who has ever seen, or will ever see an educated Worm or Oyster? The educability of animals then, in other words, their intellect, is proportioned to the size and complication of their Brains. But is the same the case with the Passions? This question is answered by observing, that the Passions, as merely perturbations of the Thoughts, must necessarily have the same seat,—that is, the Brain. They can no more have a seat distinct from that of Thought, than a palpitation of the Heart can have a different seat from the healthy action of that organ. The Passions, then, like the Intellect, are consequently energetic in proportion to the development of the Brain. Thus, it is only in the superior classes of animals,—those in which the Brain is well developed, that we meet with evident indications of Love, Friendship, Courage, Ambition, Anger, Jealousy, Hatred, Fear, Joy and Grief. "Passion," says Bonnet, "has always an object: one does not desire what one does not know." Now, almost all Metaphysicians have placed intelligence in the Brain: the Passions therefore can have no other seat than this. Besides, the Passions take place only in consequence of the perception of their object. One has no fear, except at the approach of danger; no anger, except in consequence generally of wounds of our self-love; no grief, except in consequence of impressions made upon the Brain. It is the Brain, therefore, which is always affected the first, and from which the manifestations of the Passions extend by Sympathy to the rest of the Body. If, on the contrary, the Passions had their primary seat in the viscera of the chest or belly, they should be numerous and strong, (as it was formerly, but very erroneously, supposed they were) in proportion to the magnitude and multiplicity of these viscera. Now some of these viscera, the liver for example, are relatively most voluminous in some of the lowest order of animals, which betray few or no indications of passion. The Herbivorous Animals, also, among the higher order, have in general larger and more complicated viscera than the Carnivorous; but has the peaceful Cow, with its four stomachs, long intestines, and voluminous liver, more energetic passions than the savage Tiger, in which all these organs are comparatively short and simple? Among Mankind also, those individuals who live, as it were, under the dominion of the Belly, have in general enormous viscera, but are comparatively without Passions or Affections (Abdominal Temperament); whereas those who exercise rather the functions of the Brain are commonly distinguished by the acuteness and intensity of all their feelings, (Cephalic Temperament.)

Besides, although this or that viscus may frequently display very powerfully the effects of certain Passions, these effects are often extended over the whole system, in a manner which cannot be explained otherwise than by supposing that the first seat of the Passions is in an organ which has a more extensive Sympathy with every other, than any one of the Thoracic or Abdominal Viscera confessedly has; and as the only organ so circumstanced is the Brain, we must believe that it is here that the Passions as well as the Intellect, have their primary seat. This Sympathy is communicated to the different parts of the body by the Respiratory Column, as before explained. Hence Passion is only a *species* of general Sympathy—Sympathy with the Brain. But neither Reason nor Passion are essential to life; therefore many of the lower Animals have naturally no Brain; and it may sometimes be artificially abstracted from Animals naturally possessed of it without fatal effects.

CHAPTER II.

ON THE NATURE OF THOUGHT.

Thought bears the same relation to Sensation, as Sensation does to Irritation. It consists in Phenomena arising from a certain susceptibility acted on by a certain power. As Irritation, then, may be defined to be perception of any Stimulus, and Sensation, perception of an Irritation, so Thought may perhaps be defined to be perception of a Sensation, being built, as it were, upon Sensation, as Sensation is upon Irritation. Thought therefore is not, any more than Life, any thing substantial, but an abstract term, by which are signified certain phenomena peculiar to the higher orders of living beings, and necessarily resulting from one property of their organisation, viz. the faculty of Thinking in action. This view of the subject is particularly to be inculcated, as it is from not looking at it in this way that all the difficulties attending the investigation of the mental operations have arisen. It has always till lately been supposed and inculcated, that these operations are altogether isolated, and have no parallel in the animal economy; and the actions of the Body and those of the Mind, the business of Physics and that of Metaphysics, have been considered as direct antitheses to each other. (*a*)

(*a*) We know Matter, it is said, only by its properties, extension, impenetrability &c.; and we know Mind also only by its properties, Reason and Passion; and where the two sets of properties are so decidedly dissimilar, they must indicate, it is argued, different entities. Thought, therefore, may be *attached to* Matter, but cannot be a *Mode of being of* Matter, since Matter in no case betrays those indications by which we recognise Mind. In no *other* case certainly, for in no other case is the organism of Matter such as to be susceptible of this mode of being. Are the indications of Mind more distinct from those of Matter in general, than are the indications of Sensibility, Smell, Sight, Hearing &c., or even the indications of Irritability, Muscular Contraction, Secretion, Absorption, &c.? Certainly not. So that if a difference in properties evinces a difference in entities, we must regard Sensation and Irritation not as Modes of being of Matter proceeding from a Susceptibility which results from its peculiar organism, but each as a distinct entity, attached also to Matter in the same way as Thought. They all consist in perceptions of a certain character, corresponding to the susceptibility of the organ acted on and the Power acting. The Muscular fibre must have *perceived* the Stimulus which calls it into action, or it would not have contracted. The Sensorium must have *perceived* the Stimulus of the irritation of the Schneiderian Membrane, or it would not have Smelt. The Seat of the Faculty of Thinking does nothing more than *perceive* the Stimulus of certain Sensations, and Thought is the result; the conscious-

If, then, by the word Mind we understand the Faculty of Thinking, it is as decidedly an attribute of one part of the Corporeal System, as Irritability and Sensibility are of others; and as the two latter, when acted upon by certain Stimuli, give rise respectively to Irritation and Sensation, so the former, when acted upon by certain Stimuli, gives rise to Thought. But nobody has ever regarded Irritability, whether at rest or in action, as constituting a branch of Study quite distinct from the other properties of Matter in general. It is true it is proper to Organised or Living Matter; but it is as characteristic of this as Inflammability is of Phosphorus, or Elasticity of Ivory. But Irritability and Irritation are certainly equally remote from the other properties and actions of Matter, as Sensibility and Sensation are from these, or the Faculty of Thinking and Thought are from Sensibility and Sensation. There is the strictest analogy between them all, and it is an analogy which should never be lost sight of, since it is only in so far as this Analogy is admitted, that the operations of the Mind become a legitimate object of Physiological investigation. Nor is this view of the Matter, as is sometimes vaguely supposed, in any degree hostile to or inconsistent with the purest and loftiest Religion. The hackneyed arguments against this opinion, founded upon its supposed immoral tendency and impiety, appear to proceed upon the principle, certainly erroneous, that the Mind and the Soul are identical. Who, that has watched for five minutes the action of a Dog, can be so blinded as to deny that he possesses attention, imagination, abstraction, judgment, desire, grief, in short all the intellectual faculties and passions, in the display of which *Thought* consists; but who will attribute to him an immortal *Soul?* The existence of such a substance, attached during life to the body of responsible Man, and surviving him to all eternity, we are at once intuitively led and explicitly taught to believe; but it is a question of morality and faith, not of physics and demonstration, and to be determined not by its susceptibility of proof, but at once by its verisimilitude, and by our confidence in the authority on which it rests. Who that has contrasted, as every one does and must do, the chaotical condition of the Moral world in this State of our existence, with the harmonised operation of the Physical, if he believe that they are equally directed by the same Almighty hand, can avoid believing, (and the belief is therefore, and has always been almost universal) that this Almighty hand has set apart His own time for rectifying

ness of which, overwhelming as it is, is only proportioned to the extent of the thinking organ, naturally identified as it were with the individuality of the Animal to which it belongs, and the sublimity of the function which it exercises.

this inconsistency; and when, in addition to this intuitive persuasion, we have the assurances of Revelation to the same effect, what need have we to look to Physical Philosophy to corroborate it, or what power can we allow to Physical Philosophy to shake our confidence in its truth? The two subjects seem to be utterly unconnected. "I have no hope of a future existence," observes the late talented Regius Professor of Divinity in the University of Cambridge, "except that which is grounded on the Truth of Christianity;" and it was well remarked lately, "that if Man be not satisfied to place his hopes of immortality in a Divine gift, he must confess that the difference between his own claims and those of many other Animals is in degree only, and that degree in some instances a very small one." That the Soul is something absolutely distinct from Mind, which is *nothing*, or at least *nothing substantial*, cannot be doubted; but what the nature of the Soul is, it will be time enough to begin to investigate when we can conceive the nature, distinct from the properties, of the least of the particles entering into the composition of one of the filaments of the down upon a blade of grass; though even when we have succeeded in perfectly comprehending this, and much more than this, what right have we to presume that nothing *can* exist which is beyond the sphere of our comprehension? The nature of the Soul is probably such as Man in his present State has neither words to describe, nor faculties to understand. His efforts to do so, like the attempts of one born blind to conceive and describe the nature of light, are perhaps as unreasonable in their object, as they have hitherto been unsuccessful in their result; and for aught we know, a true sixth Sense, (for who shall say that every possible form of Sense has been in Man exhausted?) with all the new ideas which would thus be excited, and all the new symbols to which such ideas would give rise, may still be necessary before it can be comprehended and expressed. What would be the consequence of a further insight,—whether it would conduce to our peace or happiness,—whether it would assist us in our duties, or divert us from the performance of them, is very uncertain. The withering and impious inference, therefore, which has sometimes been drawn of the Mortality of the Soul from that of Mind, is as totally unwarrantable on the one hand, as the whining and canting exception which has been so commonly taken to the Mortality of the Mind, from the supposed necessity of that inference. We cannot conceive, it is said, the nature of the Soul distinct from Mind. God alone knows how little the most profound of us, big with the conceit of penetrating into the sublimest mysteries of his greatest works, really and truly knows of the most familiar features of the least of them; and God, it is to be hoped, will pardon as well as pity (for he made Man daring as well as imbecile) at once the rash flippancy with which the firmest and best persuasions of natural reason, and the most sacred doctrines of Revelation have been braved, because they have *appeared* to be incompatible with Philosophy, and the bigoted blindness with which the most evident deductions of Philosophy have been spurned, because they appeared to be opposed to natural reason and Revelation. As often then as it shall be said that Mind, or the Faculty of Thinking, is a property of Living Matter, as much as Irritability or Sensibility are properties of it,—that it is born with the body, is developed with the body, decays with the body, and dies with the body,—it is to be understood to mean the Mind only, and not the Soul. The Soul is certainly something not material indeed, but substantial,—a divine gift to the highest alone of God's creatures,—responsible for all the actions of the Mind, but as totally distinct from it as one thing can be from another, or rather as something is from nothing. (*a*)

(*a*) The Faculty of thinking, = *Mind*, constituted a second department of the animal spirits of the ancients; sensibility and the power of exciting voluntary motion making up the complement; and as all these were regarded in the light of Secretions from the Arterial blood, it was at first generally supposed, as we learn from Pliny, that the Thoughts were subtile in proportion to the blood's tenuity. Of course, by all the ancient Philosophers, Thought, like Life, was regarded as something substantial,—as a subtile substance,—a " Divinæ particula auræ," added to matter, although this idea was entertained generally with respect rather to the Faculty of Thinking than to Thought itself; and the same opinion has been supported in modern times, as well by all the authors who conceived that life is substantial, as by Bacon, Descartes, Malebranche, Cudworth, Locke, Condillac, Price, Reid, Stewart, Brown, and many other professed Metaphysicians. With all these it is not material indeed, but substantial,—a subtile something *added* to matter, and possessed of properties by which alone, like matter, it is to be known. The opposite opinion, however, that Thought, or rather the Faculty of Thinking, is merely the result of organization, has been supported not only by all those formerly mentioned as maintaining this opinion with respect to Life, or rather the aptitude à vivre ; but also by Gassendi, Hobbes, Berkeley, Priestley, Leibnitz, Maupertuis, Buffon, Darwin, Hume, Bonnet, Cabanis, Kant, Gall, Georget, and a host of other authors, of whom however some have regarded it as matter itself, others as a simple property of matter, and others as a Series of Phenomena, the result of the action of certain powers on a certain susceptibility. It is lamentable that the last, and certainly most philosophical view of the question, should have been allowed, by the intemperance of some of its partizans, (forgetful of the excellent maxim, " Tout ce qui est au dessus de la raison est contre la raison ") to involve inferences which have rendered the word Materialism hateful to all pious Men, and gained for its advocates the title of Philosophers, at the expense of one which should have been much dearer to them. Many of these Authors will be mentioned, when speaking of the doctrine of Innate Ideas, with which, however, that of the substantial or non-substantial nature of Thought has nothing to do ; and accordingly we find, among both patrons and opponents of the doctrine of Innate Ideas, substantialists and non-substantialists.

CHAPTER III.

ON THE IMMEDIATE SEAT OF THOUGHT.

SECTION I.

In the Nervous System in general.

The Faculty of Thinking is pretty certainly seated in the Brain. It is this organ which thinks and wills, and which is the seat also of the affections and passions.

The number and extent of the Intellectual operations bear an exact relation, in all animals, to the degree of organization of their Brain, and result from the conjoint influence of the innate properties of this organ, and stimuli derived from without. This opinion with respect to the Seat of the Faculty of Thinking,—at least, that modification of Thought called Reason or Intellect, has been prevalent from the earliest periods, as is sufficiently evident from the old fable of the birth of Minerva, who was represented as issuing ready armed from the head of Jupiter ; and the same doctrine was explicitly inculcated by Hippocrates, Plato, Aristotle, Erisistratus and Galen, the last of whom, with much prolixity, refutes the notion of Chrysippus, who had thought proper to place reason in the heart ; and it has been almost universally adopted since their times, as is sufficiently evident from our every-day expressions, long-headed, plenty of Brains, as applied to an intelligent person ; and numskull, thick-headed, addle-pated, and so forth, as applied to a fool. But although it has been commonly understood that the general Seat of Reason or Intellect is the Brain, it has not been by any means agreed upon in what particular part of the Brain it resided, or whether each particular faculty of the Mind had or had not its own particular domicil. Thus, by Erisistratus, the ideas in general were placed in the Convolutions of the Brain, while Galen looked upon them as situated rather in the Ventricles, which of course was the opinion of all Physiologists so long as the supremacy of Galen endured ; and as Galen had thought proper to place memory in the back part of the Brain, judgment in the centre, and imagination in front, so these also became the established seats of each of them among Philosophers for many ages. But while all this was the case with respect to reason, which retained its post in the Brain with little or no opposition, it was a very different affair with passion, which was not allowed to be seated in this organ, but was almost universally referred either to the Viscera of the Chest and Belly, or to the Chest and Belly themselves. (*a*)

By Hippocrates and Plato also, while the reason was placed in the Brain, the passions were explicitly stated to reside in the Heart and Diaphragm; and Galen, while he placed the animal spirits, including reason, in the Brain, placed the vital and natural spirits, including, the one the irascible, and the other the concupiscent passions, respectively in the Heart and Liver; and it is as influenced by these old notions that we still so universally use the words Hearty, Heartless, a Stomach for any thing, a yearning of the Bowels, hot Livered, white Livered, Choleric, cooling of the Reins &c. these several Viscera being taken as emblematical of the passions, which were formerly supposed to reside in them, and that players constantly place their hands upon their chests when they wish to indicate deep emotion. (*b*)

(*a*) Thus, as has been already observed, the words Breast and Heart are used in almost every page of the oldest book in the world to signify the affections, and the same significations are frequently attached to the words Belly, Bowels, Liver, and Reins or Kidneys. Job talks of Men's *Belly* preparing deceit, and to describe his affliction, says that his *Bowels* boiled and rested not; and Isaiah uses the phrase sounding of the *Bowels* to signify pity. Jeremiah also, to represent his affliction, says that his *Liver* is poured out; and King David frequently speaks of his *Reins* to signify his desires, which he represents as troubling him exceedingly in the night season. In the earlier profane writers, also, the same impression is manifest in their continual use of the words Στηθος, Καρδια, Φρενες, Σπλαγχνον &c. and the term μεγαλοσπλαγχνος, or big-gutted, was not unfrequently applied to persons of strong passions, as if there was a direct connection between the strength of the Passions and the size of the Viscera.

(*b*) Such were the common opinions with respect to the Seat of Reason and the Passions, (which, though consisting merely in perturbations of the Thoughts, have been ingeniously considered as distinct from them in their seat) at the time of the revival of literature, the Arabians having done little more in improving the opinions of Galen, than in as far as regards assigning to each individual modification of Thought, or rather of the Intellectual Faculties, a more distinct seat in the Brain than Galen had ventured to do. Since this time the subject of the particular residence of individual Thoughts has been prosecuted successively by Albert le Grand, Pierre de Montagna, Willis, Vieussens, Boerhaave, Van Swieten, Haller, Soemmering, Bonnet, Prochascka, Cuvier, and, lastly, by Drs Gall and Spurzheim. Of these authors the greater number have been satisfied with regarding the Brain as the seat not only of Reason, but of Passion; but some, as Bordeu, Buffon, Bichat, Cabanis, Reil, Broussais, have thought proper to represent the latter as situated either in the Ganglionic System of Nerves, that with which the Viscera of the Chest and Belly are principally supplied, or some other part distinct from the Brain; Bichat, in particular, using

It is remarkable that the argumentum ad percussionem,—the practice of pommelling and cudgelling certain parts of the body, has always been much relied on, in establishing the seat of the Faculties and Propensities. Willis in particular, who has the credit of having revived the doctrine, that it was in the Convolutions of the Brain, and not the Ventricles, that the Ideas resided, having established it, that Memory was seated in the fore part of the Brain, and not the back part; since, as he says, a man desirous of recalling an Idea never strikes his occiput, but always his forehead, as if conscious that it was there the idea was concealed, and desirous of shaking it out; and Gall having used the same argument, as one proof of the seat of sexual love being some where about the occiput. It was reserved for the last-named Philosopher, (if indeed the credit be not rather due to the celebrated Theologian Swedenborg) to presume, not only that each part of the Brain was appropriated to a particular property of the Mind, but that, when any one of these properties of the Mind was remarkable, it became so in consequence of such a development of a certain part of the surface of this organ as was indicated by external marks, and that consequently by such marks the particular tendencies of each individual might be discovered.

SECTION II.

In the Brain in particular.

THE Seat of the Susceptibility of Thought is then the Brain, Cerebellum and Cerebrum conjointly, although, as has been mentioned, some modern authors (*a*) have endeavoured to prove that the Cerebellum, and others (*b*) that the Cerebrum, is the seat of Sensibility. Against this opinion enough has been already said, and similar objections may be urged against regarding either the Cerebellum or Cerebrum as the seat of the power of exciting voluntary motion; the notion of Rolando, that this power is seated in the former, being founded chiefly on the wild presumption before alluded to, that the nervous energy which excites voluntary motion is identical with Galvanism, and that the cerebellum, composed of parallel layers, is identical with a galvanic

as chief arguments the remarkable effect which Passion has upon these Organs, and the practice which has been just mentioned, of persons thumping their chests when desirous of indicating emotion.

(*a*) Foville, Pinel, Grandchamps, Duges.

(*b*) Rolando and Flourens.

battery; and the notion of Foville and others, that it is seated in the cerebrum, being founded chiefly on the fact, that an injury of the Cerebrum, and particularly of the Thalami Optici and Corpora Striata, immediately paralyses the voluntary muscles,—of the Thalami, principally those of the upper extremities, and of the Corpora Striata, principally of the lower. In support also of the opinion, that the Thalami preside over the voluntary muscles of the upper extremities, and the Corpora Striata of the lower, it has been noticed that the latter are formed after the former in the human fœtus, in which the lower limbs are last developed, and that they are generally considered to be quite wanting in Fishes and Serpents, as well as the Cetacea, which have no lower limbs. Why these animals should have Thalami Optici, however, since they are as destitute, or almost as destitute, of upper limbs as of lower ones, remains unexplained; and it may easily be conceived, that parts so immediately connected with the Anterior columns of the spinal marrow, as the Thalami Optici and Corpora Striata, cannot be destroyed or injured, and the proper functions of these columns remain entire, without believing that the seat of the power of exciting voluntary motion resides in them. The deficiency also of these parts in Fishes, Serpents and the Cetacea, is no more remarkable than the deficiency of many other parts to which the power of exciting voluntary motion has never been ascribed. Upon the whole, it appears that the principal, if not the only function exercised by both cerebellum and cerebrum is Thought, and that modification of Thought called Passion. Thus, we know that the Land Tortoise can live six months though deprived of its Brain, (*a*) and that the Newt and Frog can do almost as well without a brain as with one. (*b*) In the Human Embryo also, as Thought is the last function of the Nervous System which comes into play, so the Brain is the last part of this system which is developed; and that Thought is less requisite to the well-being of the Embryo than any other function of the Nervous System, is evident from the fact, that while no mature fœtus has been born without a ganglionic system, and extremely few without a spinal marrow, so innumerable instances are on record of their being born without a Brain.

As Irritability and Sensibility are situated, in all probability, exclusively in the grey matter of those portions of the nervous system of which they are the properties, so, from analogy, we should presume that the susceptibility of Thought would have its immediate seat in the grey or exterior part of the Brain; and that such is the case appears to be evident, from this being the part of the organ which was

(*a*) Redi. (*b*) Spallanzani.

last formed, (which supports the analogy between the Brain and the several conglomerate glands, the parenchymatous or secreting parts of which are always formed after the medullary or conducting part) and from the convolutions being more numerous and deeper in the Brain of Man than in that of any other animal, and becoming less and less as we descend in the scale of the creation. How insensibly also the surface of these convolutions must be increased, if we admit Gall's notion of the grey matter being laid upon the white in plaits, must be sufficiently obvious, as well as how a great degree of attenuation of this substance, such as occurs in Hydrocephalus, is quite compatible with the full possession of all the intellectual faculties; these convolutions, and perhaps also these plaits, being in such cases merely unfolded like the plaits of a napkin, without any portion being absorbed, as was formerly supposed to be the case. If this view of the matter be adopted, the white matter of the Brain must be regarded like the white matter in the Spinal System of nerves, in the light of mere conduits, for the purpose of extending the stimulus calculated to excite Thought to that part of the organ in which the faculty of Thinking has been presumed to reside; and it is in this view of the matter that Gall speaks of this matter as composed of a series of excurrent and recurrent nerves, the former of which are useful in conveying the Stimulus by which Thought is to be excited to the surface of the Brain, and the latter in keeping up a Sympathy between the two hemispheres; so that the Thoughts of one side of the Brain may correspond with those of the other, in the same way as single vision and single hearing are effected by means of a Sympathy between corresponding parts of the Optic and Auditory nerves.

It would seem to be in vain to attempt to assign particular portions of the Brain as the exclusive residence of the really elementary forms of Thought, when it is so utterly impossible to establish any forms of Thought as essentially distinct from each other. The attempt has nevertheless been continually made. It has been mentioned, that Galen thought proper to place memory in the back part of the Brain, judgment in the centre, and imagination in the front; and the subject of the particular existence and residence of individual forms of Thought has been, since his time, successively prosecuted by many others, particularly by Albert le Grand, Bishop of Ratisbon, by Willis, Vieussens, Haller and Van Swieten. It is, however, Bonnet who first distinctly assumes the subserviency of the different parts of the Brain to different forms of Thought. "Without being initiated into the secrets of Anatomy," says he, "every body knows that the Brain is an organ extremely complicated, or rather an assemblage of many different organs, each of which is formed by the combination of a prodigious number of fibres, corresponding to the multiplicity and prodigious diversity of ideas which arise from the different operations of our mind."

Cuvier, also, the most celebrated of modern naturalists, with reference to this subject, expresses himself thus: "It appears that there are always certain relations between the faculties of animals and the proportions of the different parts of their Brain. Thus, their intelligence appears to be always great in proportion to the development of the hemispheres, and their several commissures. Man has these parts thicker, more voluminous, and more complicated than other animals, and as we recede from Man they become thinner and more simple. In like manner, Man excels all other animals in intelligence. It appears even," he continues, "that certain parts of the Brain attain in all classes of animals a development proportioned to the peculiar properties of these animals, and one may hope, that, in the following up these researches, we may at length acquire some notions respecting the particular uses of each part of the Brain."

These passages shew, that however doubtful may be the claim of the various forms of Thought to be regarded as elementary, the notion of the subserviency of particular parts of the Brain to particular forms of Thought did not originate, as is sometimes supposed, with Gall, and that, in setting our faces against this doctrine in general, we do not oppose him alone, but many of the most enlightened Physiologists both of past ages and of the present. The admission of this as a fact has, however, nothing whatever to do with the admission of those laid down by Gall as really elementary forms of Thought, and still less with the admission of Phrenology as a branch of Science. The former presumes only there *exists* a relation between the several portions of the Brain, but does not presume that we know what they are, and still less that the relation between these and the Brain is such as to be obvious through the Skull,—a circumstance which may or may not happen, but which no more follows from the admission just stated, than that it is possible, by looking at or handling the trunk of a man's body, to ascertain the particular state of his digestion, because we admit that in this the digestive organs are contained. The chief arguments brought forward by Gall in favour of the doctrine, that each peculiar form of Thought has its specific seat in the Brain, are, 1. That the phenomena of Thought are not less complicated, on the contrary, infinitely more complicated, than those of any other Function, for example, Digestion; and that, as Digestion requires several organs to perfect it in all its stages, those of chewing, chymification, chylification &c. so Thought may be concluded to require several organs to fill up all its various departments.

2. That to the perception of all the properties of matter no fewer than five organs of sense are necessary; and we cannot conceive, therefore, that for the display of the far more varied indications of Mind, *one* organ should be sufficient. The Nose does not take cognisance of colour, nor the Eye of sound; how then can we imagine that every part of the Brain engenders every variety of Thought? 3. That without this admission we cannot assign any use to the numerous fibres, convolutions, folds and eminences which are met with in the Brain, and the number of which always corresponds more or less to the number and complexity of the intellectual operations. 4. That the differences in the capacity of individuals for particular forms of Thought are explicable only upon the principle of each having a particular seat. We cannot by any process of education make a Man pre-eminent as a Poet, as a Musician, a Mathematician, a Philosopher, if he have not the necessary organs, or have them only moderately developed; whereas, if no such organs were necessary, we might, by a process of training, lead him to any thing,—to the rank of a Homer, a Mozart, a Newton, or a Socrates. Lastly, That it is only upon this principle that the occurrence of monomanias, or partial insanities, as well as particular mental defects, can be explained. If the whole Brain presided equally over all the forms of Thoughts, how is it to be explained that frequently only certain of these forms are perturbed or defective, while others, perhaps, are at the same time not only unimpaired, but even exalted? And yet every body knows that frequently persons are insane with respect to one subject alone; and that after apoplexy, or other lesions of the Brain, one or other faculty of the Mind is often quite destroyed,—as the power of Counting, for instance, the Taste for Music, or the Memory of Names, while all the rest remain completely entire, or are even improved. Upon the whole, it is undoubtedly the case, that every individual portion of the Brain *does* minister to one mode of Thought, the elements of which are still to be discovered; and that as air or water have been ascertained to be compounds, and instead of being quite distinct, to contain at least one element in common, so most of the Thoughts, *as we observe them*, are also compound, and partially also convertible into one another. Now, it is probably to the accommodation of more or fewer of the elements of these Thoughts, whatever they be, that the several parts of the Brain are subservient, each furnishing not merely the element of an Idea, but an Idea properly so called, the Brain collectively probably being engaged in forming the elements; so that we cannot draw any strict analogy between the different parts of the Brain and the different organs of the Senses, each of which informs

us of certain properties of bodies, but no one of which gives us a ready-made perception of them all. It is in this way, then, that we may conceive that any form of Thought, such as have been proposed, as specifically resident in one or other of the several organs of the Brain, the principal element of this or that form of Thought having such a local habitation; and we may thus be justified in taking the greater or less development of this organ as a criterion of the greater or less tendency to this form of Thought. Thus, although we cannot perhaps say that one part of the Brain is the Seat of Sexual Love, another of the Love of Offspring, and so forth, as *elementary* forms of Thought, we may do so if we regard them as compounds, and may be justified by experience in saying, that in proportion to the development of this or that portion of the Brain will these propensities display themselves. (*a*) And this accordingly is the Psycology of observation—the professed Psycology of Dr Gall.

It is a leading principle, that in every department of animated nature, size is, *ceteris paribus*, the measure of power; for instance, the dog possesses a large nose corresponding to the acuteness of his smell. If then a certain degree of development of an organ is always or generally found connected with a certain degree of acuteness in the function to which *it is known* to be subservient, we seem to have a right to infer universally, that a certain degree of intensity in any particular mental function is always, in general, found connected with a certain degree of development in a particular part of the Brain, and that this particular part of the Brain is subservient, in some way or other, to the particular mental functions in question. But although certain faculties and propensities in general be admitted to depend upon peculiar developments of certain parts of the Brain, it is a very different

(*a*) Thus, in general, in proportion to the development of,

I. Back.	II. Base.
(Good Passions.)	(Bad Passions.)
1. Sexual Love.	6. Destruction.
2. Love of Offspring.	7. Cunning.
3. Love of Country?	8. Acquisition.
&c.	&c.

III. Top.	IV. Front.
(Principles and Sentiments.)	(Genius and Talent.)
13. Benevolence.	22. Detail.
14. Veneration.	30. Eventuality.
15. Firmness,	34. Comparison.
&c.	&c.

question whether such development of the surface of the Brain be recognisable by any certain marks through the Skull; and it is this question which furnishes the chief bone of contention between the Phrenologists and their opponents. It is not the question, whether we know what are the several distinct elementary forms of Thought—it is not the question, whether *any* form of Thought, simple or compound, arises from a development of certain parts of the Brain—it is the question, whether such a particular development of the Brain produces a correspondent change in the character of the Skull, to be ascertained through its integuments? Now, it is evident that it does not *always* do so. In no class of Animals below the rank of Birds is the skull at all accurately adapted to its contents. In some even, as in Tortoises and Lizards, the former recedes from the other in a very remarkable manner; and even in Birds, the air contained in their Diploë produces generally a very great dissimilarity in the form of the Brain and that of the external surface of the Skull. This dissimilarity is less, probably, in the Mammalia than in any other class of Animals, and of the Mammalia, the least of all in Man; but it is still so great as to have thrown considerable doubts over the main principle of the Phrenologists. To say nothing of the disproportionate development of the two tables of the Skull as the child is advancing to maturity, the outer table corresponding to the incumbent muscles, while the inner only corresponds to the Brain, it is sufficiently well known, that even in adult age there is often little or no immediate correspondence between the projections upon the surface of the Brain and those upon the *outer* surface of the Skull, the inner table of which is often that alone which is impressed by these projections. But it is not to superficial eminences, such as might be obscured by disparities like these, that the Phrenologist looks, but to a general development of the Brain in certain parts, as calculated from the centre of the organ to the circumference, and in comparison to which these superficial eminences will be as nothing. And even though this correspondence were less than it actually is, it would not furnish a fair objection to the conclusions of Phrenology. The external Skull may not be mostly developed precisely where the Brain is most developed; but it does not follow that certain developments of the Skull do not always bear some fixed and definite relation to certain developments of the Brain; and if this be admitted, the eminences in the former may still be properly enough taken as indicative of certain faculties and propensities, though the particular eminences of the Brain may not exactly correspond to them. It was only on the presumption that the development of the Brain was always proportioned to the eminences of the Skull that certain parts of the Brain became established as the seats of the faculties and propensities in question. The origin of Phrenology was in the observation that there was a correspondence not between the Brain and the Skull, but between the form of the Skull and the particular character of Individuals; and the latter correspondence may still be uniform, although the presumption of the former be founded on error. The whole question of Phrenology is one which cannot be determined by reason, but by careful and long-continued observation. We cannot determine that it *must* be true or false, but we may thus determine that it *is* the one or the other. Every thing here rests on the credibility of Authors and our own individual observation.

The arguments of which the Anti-phrenologists make great use, are, that the extreme surface of the Brain is not its actual surface, which will vary with the number and depth of the convolutions; and again, that size is a measure of power only *ceteris paribus*. The quality of the Brain and its several parts must also be taken into consideration, and of this we have no measure. To the former of these objections, however, it has been replied, that it is with the external surface alone that we have any thing to do in Phrenology; and to the latter, that we *have* a measure of the quality of the brain in the temperament of the individual. A more valid objection, if it were tenable, would be found in the statement, that numerous lesions of the Brain in each of the presumed seats of the several Propensities, Sentiments and Faculties may and do frequently occur without any corresponding failure of these; but in this objection there appears to be a double oversight; first, in regarding certain superficial eminences alone of the Brain as the Seats of such endowments, instead of the whole Cone formed from this part to the centre, and of which this surface is only the base; and, secondly, in regarding each of the organs as single instead of double. Now, it seldom or ever happens that the whole substance of any one of these organs is injured from base to apex, consistently with the continuance of Life; and if this should happen on one side, it is next to impossible that it should do so on both sides, and Life continue. This argument, therefore, like all the others, the tendency of which is to shew that Phrenology *must be* false, is obviously untenable. It *may be* false,—a fact which can be established only by continued observation. (*a*)

(*a*) See Appendix.

CHAPTER IV.

ON SENSATION, REGARDED AS THE STIMULUS TO MIND.

It will now be distinctly understood what was meant by representing Sensation as built upon Irritation, and Thought upon Sensation. Any external stimulus for instance, as some odoriferous particles applied to the Schneiderian Membrane of the Nostrils excite there a peculiar irritation; and had there been no olfactory nerves distributed here, this irritation would have gone no farther; and such is the case in animals destitute of a spinal marrow, or in which the functions of this organ are suspended, as in apoplexy. In the higher classes, however, during health this irritation is conveyed by the olfactory nerves to the Seat of Sensibility, or the grey matter of the posterior columns of the Spinal marrow, so as to excite these Sensations. This likewise, had there been no excurrent nerves leading from this part, would have gone no farther; and such appears to be the case in Animals which have no brain, or in which more or fewer of the functions of the brain are suspended, as in Sleep-walking. So also in Absence of Mind. In the highest classes of animals, however, while in the full enjoyment of all their functions, this Sensation is conveyed by the excurrent nerves to the Seat of the Faculty of Thinking, or the grey matter on the surface of the Brain, so as to excite Thought at length. It is true the continuance during Life of Thought, when every avenue of Sensation is apparently closed, is at first sight certainly against this doctrine. But the avenues of Sensation from the internal organs are never closed; (*a*) and even though they were so, Thought might continue without prejudice to the theory in question. Neither Irritation nor Sensation instantaneously cease on the abstraction of the powers by which they are excited; and the longer continuance of Thought once excited by the Sensations, implies a difference in degree only, and not in kind; nor can we with greater reason deny that Thought was excited by the Sensations, because they are now quiescent, than that the motion of a tennis ball was occasioned by the racket which struck it, because that racket is now at rest. The senses are suspended in Reverie, Dreaming, Trance,

(*a*) Cabanis' internal Sensations. These are nothing but Touch, and therefore no modification of the opinion expressed above, that Sensation is essential as a Stimulus to Thought.

Animal Magnetism and Catalepsy, but the Thoughts still go on. The memory of Sensations are so vivid, that they appear to be experienced anew; and we persuade ourselves that they are not real, only by their want of consistency with our other impressions. The limits between sleeping Thoughts, which are suggested by Memory, and waking Thoughts, which are suggested by Sensation, are often not well defined, and it requires an effort to establish it when actual Sensation again begins. We thus believe in the existence of matter only by a process of Memory, whereas this very process furnishes intuitive evidence of the existence of Mind. " I think, therefore, I am." How then, it is asked by the Immaterialists, can we make mind, which we know, a property of matter, which we only infer? Perfectly well. Thought or Mind in Action, when pre-occupied by Memory, is not immediately susceptible of any other impression; but in a state of Laxity it soon acknowledges its ordinary stimulus; and in any condition Thought can never wander into a field which has not already been traversed by the senses. We may think of Sirens, and Mermaids, and golden mountains, which we have never seen; but we have seen the elements of them all, or we could never fancy them.

So far, then, Thought appears to be as dependent on Sensation, as Sensation is on Irritation; and as, while Irritability is the greatest in Infants and Females, Sensibility is least in these, so also appears to be, in general, the faculty of thinking. This is the case in all its branches in Infants, who are always in that state, with respect to this faculty, which in those of more advanced years would constitute Idiotism; but only in most of its branches in Females, since in some few they appear to be pre-eminent. The size of their Brain, as compared with their Spinal Marrow, is somewhat greater in Females than in males. Hence we might be led to conclude, that in reality it is not their faculty of Thinking, but their materials for Thought which are less than in males.

As Irritability and Sensibility are not every where the same, so the faculty of Thinking, in the several parts of the Brain, may be presumed likewise to be very different, being adapted in each to the different kinds of Sensation by which each is liable to be principally affected.

The Posterior columns of the Spinal Cord are the Seat of Sensation in general,—the Brain of Thought in general; but as different portions of the Spinal Marrow are unquestionably adapted to perceive the several irritations affecting the various organs of the senses, and thus to give rise to Smell, Sight, Hearing, Taste and Touch, so we may presume, that although every portion of the Brain is perhaps capable of perceiving all the several Sensations affecting the Spinal Marrow, yet each portion of it modifies these in its own way, and thus gives rise to the various forms of Thought by which intelligent beings are distinguished; and, if this be true, the Brain is to be regarded not as one organ, but as a collection of several. It is true that the various forms of Thought are not marked by those precise lines of demarcation which distinguish the several forms of Sensation, and there is accordingly considerable difficulty in settling what they are. This, however, must be attempted, before we venture to ascribe to any one its proper Seat in the Brain. Since the time of Locke, it has been customary to enumerate, as distinct forms of Thought, principally Attention, Comparison, Judgment, Reason, Memory, Recollection, and so forth. Of these, Attention is said to consist in a mere perception of Sensation; Comparison, in a perception of the points of resemblance or difference in any two; Judgment, in a perception of the various relations of several; and Reason, in the exercise of a series of Judgments; Memory, in the perception of a Sensation previously *experienced*, and Recollection, in the perception of a Sensation previously *remembered*. It has been presumed that these reputed *forms* of Thought bear the same relation to this Function in general, as Smell, Sight, Hearing &c. bear to Sensation in general; and as some persons excel in one or other of these senses, while they are comparatively deficient in the rest, so some persons excel in Comparison, others in Judgment, and so forth, while their Memory probably is comparatively defective. But it is the province of Smell to perceive exclusively certain properties of bodies; namely, the odoriferous and volatile particles; of Sight to perceive exclusively their colour, figure, extent, and so forth: is it, in like manner, the province of Comparison, Judgment, Memory &c. to be exerted only on certain subjects, or does the analogy here fail us? It certainly does. That these presumed *forms* of Thought are exercised on every occasion, not always equally indeed, but always in some degree, and that they do not correspond therefore to the several Sensations, but rather to the certain conditions necessary to the exercise of any one of them, as the proper direction and healthy state of the percipient organ &c. are conditions necessary to Smell, Sight, and all the other senses.

It is probable that the simplest exercise of Thought requires that every one of these reputed modes be called more or less into play, so that they cannot be regarded as distinct *forms* of Thought, so much as certain conditions necessary to its display in any form. Are there, then, *any* forms of Thought which correspond to the different forms of Sensation? It is reasonable to suppose that there are; but it is very questionable whether we can accurately ascertain and distinguish them. The attempt to do so has been made, in recent times, principally by Kant and Gall. By the former, twenty-five such primary forms of Thought are admitted as essentially distinct from each other. Of these, two appertain to the senses, and consist in the appreciation (as of Odoriferous particles by the Smell, of Colour &c. by the Sight) of Time and Place; twelve appertain to the Understanding, and consist in the appreciation of Unity, Plurality, Totality, Affirmation, Negation, Limitation, Inherence and Subsistence, Causality and Dependence, Society, Possibility and Impossibility, Being and not Being, Necessity and Contingence; eight are dependent on these, and consist in the Appreciation of Identity, Diversity, Agreement, Contradiction, Interior, Exterior, Matter and Form; and three, *lastly*, appertain to Reason, and consist in the appreciation of the Soul, God, and the Universe. From this enumeration it will at once be perceived upon how very vague and arbitrary grounds the establishment of distinct forms of Thought, corresponding to distinct forms of Sensation, have been attempted even by Philosophers of the highest rank; and that such must be the case will be evident upon the slightest reflection upon the nature of the subject. The Physical properties of bodies, such as are taken cognisance of by the Senses, are comparatively few, and easily determined; but what limits can be fixed to the various relations and combinations of the subjects of contemplation in the moral world, or how determine when one ends and another begins? In taking cognisance of the odour or colour of an object we employ only one sense, and could do so equally well though the other four had no existence; but in taking cognisance of Time or Place, of Unity, Plurality, and so forth, do we employ only one portion of the Brain; and would this be equally effectual though all the rest were wanting? It has been said, that, to the exercise of Thought on any subject, Attention, Comparison, Judgment, Memory &c. are probably indispensable, and these conditions must be therefore conceived to be necessary to the exercise of its proper functions by every portion of the Brain; but, more than this, can we reflect on any one of the subjects just mentioned without incessant reference to innumerable others? How is an idea of any particular Time or Place formed, but by attention to every thing by which one time or place is distinguished from another, and which may include subjects of every possible description? It is evident, therefore, that an idea of Time or Place is not an elementary or proper form of Thought; and the same thing may be said with respect to almost every one of the others. There is no one of them independent of all, or at least many of the rest; and therefore no one to the contemplation of which we can suppose any particular portion of the Brain is specifically adapted, in the manner that the nostrils are adapted to the perception of an odour, the eyes to that of colour, and so forth.

By Dr Gall, the attempt to establish distinct forms of Thought has been made upon principles very different from those of Kant, since he regarded, as foundations for his distinctions, not supposed differences in the nature of the Thoughts themselves, considered abstractedly, but *real* differences in the character of the Thoughts, displayed in individual instances. Kant was a Metaphysical Philosopher, and followed the synthetical method, which such have always followed. Gall was an experimental Physiologist, and followed the so much vaunted analytical method of modern times. Kant, reasoning *a priori*, said, that certain forms of Thought *must be* distinct from their nature; Gall, reasoning *a posteriori*, said, that certain forms of Thought *are* distinct, since different individuals are distinguished by them. We could not synthetically have made out the number of the Senses by reflecting on the properties of bodies to be appreciated by them, since (bating the probability of error in our enumeration of their properties) one Sense may take cognisance of more than one property, or one property be taken cognisance of by more than one Sense; (*a*) but we might have done so perhaps by noticing that certain persons excelled in detecting minute differences in odours, others in colours &c. and it is upon this principle of observation that Gall works.

By him and his coadjutor, Dr Spurzheim, and their successors, are admitted about thirty-five primary forms of Thought,—nine of which are referrible to the head of Propensity, twelve to that of Sentiment, and fourteen to that of Intellect. They are the following:

Propensities.	*Sentiments.*	*Intellectual Faculties.*
1. Sexual Love.	10. Self-esteem and Pride.	22. Talent for Detail.
2. Love of Offspring.	11. Love of Praise.	23. Form.
3. Love of Country?	12. Caution.	24. Size.
4. Propensity to Contention.	13. Benevolence.	25. Weight.
5. Attachment.	14. Veneration.	26. Colour.
6. Propensity to Destruction.	15. Firmness.	27. Place.
7. Cunning.	16. Conscientiousness.	28. Number.
8. Desire of Acquisition.	17. Hope.	29. Order.
9. Constructiveness.	18. Wonder.	30. Eventuality.
	19. Imagination.	31. Time.
	20. Wit.	32. Music.
	21. Imitation.	33. Language.
		34. Comparison.
		35. Metaphysics.

(*a*) Form, for example, by Sight or Touch.

It seems quite unnecessary to investigate particularly the claims of each or any of these Propensities, Sentiments or Faculties, to be considered as distinct and elementary forms of Thought, since it must be obvious, at first sight, that they are almost all of them open to the same objections as have been already urged against those enumerated by Locke and Kant; namely, that while some of them seem to be little more than the mere conditions necessary to every exercise of Thought, like Attention, Comparison, Judgment and Memory, the exercise of almost any one of them implies that of many more. Of this nature are Imagination and Wit, which require innumerable others before they can be developed, and almost precisely the same thing may be said of each of the other forms of Thought above enumerated as distinct from one another. Who does not perceive also that many of them are merely modifications of each other;—that the Love of Offspring, for instance, and Attachment in general, are only simple modifications, more or less perfected, of one and the same sentiment; and Contention, Theft, Cunning, and numerous others equally spring from Self-love, a principle inherent in every form of animated nature? Can we moreover seriously admit any fundamental difference between Self-esteem and a Love of Praise, or between the Memory of Things, Persons, Places and Words? They are modifications, but they are only modifications of each other.

The necessity of some stimulus to excite Thought has been continually insisted on, the Brain being the Seat of the Faculty of Thinking alone; but this necessity was not always admitted. Before the time of Aristotle Thought was spoken of with reference to the Brain, as Life was with reference to the Body in general—as something inherent in it, and not merely as a series of Phenomena resulting from the action of certain powers on certain Susceptibilities; and this ancient view of the nature of Thought, like that of the nature of Life, has been surprisingly enough retained by not a few modern Philosophers. We shall see, however, that though in *words* the latter differ from those who support the view which has been inculcated, they do not so in *fact;* that their "innate ideas" are really only innate susceptibilities, which every body admits; and that the only real question with respect to Thought is, whether these susceptibilities be any thing substantial added to the Brain, or merely a necessary result of its organization. The Partizans of Innate Ideas, however, *think* that they differ essentially from the view above taken; and, accordingly, it will be necessary to say a few words in this place of their doctrines.

According to Plato, the professed Father of the Innate Idea School, there are in the Mind, from the beginning, certain abstract beings, immaterial forms, essences, eternal designs and models, types, archi-types and prototypes, of which material beings themselves are only as it were the copies, and by which the Mind ascertains the nature of these Beings, rather than by the Beings themselves, which have nothing in them fixed or permanent. These abstract Beings may, in his opinion, remain latent till called forth by the perception of some-thing real; but when they are so called forth, it is in the manner of a reminiscence, and not as a new suggestion; and the senses are use-ful, therefore, as mere joggers of the memory, and not as informers. The same opinion is embraced by Descartes, with this modification, that he regards the immaterial forms &c. of Plato, not as distinct Beings, but as a part of the Mind itself, and was the first to apply to them the term of Ideas. According to Malebranche, however, nobody can doubt that Ideas are really distinct beings, since they have real properties; and, with respect to their being innate in the mind, he says, " It is absolutely necessary that God had from the first, *before the beings themselves existed*, ideas of all the beings which he has created, otherwise he could not have created them; and it is equally certain that God is intimately united to the Soul of Man. Now, as by means of the soul we can see God, who represents all created things, it follows that the Soul has innate ideas of every thing which is in existence."

Similar notions are propagated, with certain modifications, by Bos-suet, Fenelon, and Leibnitz. It was the last who added to the cele-brated axiom of Aristotle, " Nihil est in Intellectu quod non fuit prius in Sensu," the words " nisi ipse Intellectus," which he considers to comprise some fundamental ideas, not all at once developed from in-fancy, but only as occasion draws them forth. From the vagaries of these, and other similar authors, Idealism in all its purity took its rise. With them the senses are of little use; they perceive material sub-stances not such as they are, in virtue as well of their own nature, as of that of the mind which perceives them, but as they are, according to the innate notions, in the mind alone; and many of them have ac-cordingly considered every thing in Nature as a mere illusion, like the day-dream of a Maniac, and have doubted of every thing, even of their own existence.

A diametrically opposite doctrine originated, as has been said, with Aristotle, and has been supported in modern times principally by Bacon, Locke, Condillac and Buffon. With these Philosophers it is a fundamental principle that the Intellectual Organ resembles at birth a Tabula Rasa, and acquires its ideas and principles only by expe-rience, the senses being the only inlets to every description of know-ledge. Hence the axiom just alluded to, " Nihil est in Intellectu quod non fuit prius in Sensu," an axiom the truth of which it has been my chief effort to establish. But it is not necessary, that because this position be true, that *all* the doctrines of the Realists, any more than of the Idealists, should be so too; on the contrary, the *mutual* agency of the percipient being and the thing to be perceived has been neglected by both, and, as it is to be shewn, erroneously. Previously, however, it must be observed, that it was with the Realists that the doctrine lately mentioned, of the high influence of the structure of the organs of the Senses in Man, and particularly of the Human Hand, in making man what he is, originated; Helvetius having even gone so far as to say, that if a Horse had had the Hand of a Man, he would have been equally intelligent!

If the Idealists made too little of the Senses and their organs, the Realists in an equal degree made too much of them. If the former considered the Mind as every thing, and the Senses as nothing, or worse than nothing, since they frequently only deceived us, the latter regarded the Mind as nothing, or nothing more than a kind of looking-glass, capable of reflecting objects conveyed to it by the Senses, but incapable of contributing any thing towards them, in the way either of embellishment or deterioration. But to descend a little to particulars.

With respect to the abstract ideas of things supposed by Plato and Descartes to be inherent in the mind, whether as new beings or as integrant parts of the said mind, it is sufficient to say that the supposition is entirely gratuitous and unnecessary, and, what is worse, entirely unintelligible. It was well remarked by Diogenes, in conversation with the former on the subject, that though he could see the table and the goblet which were before them, he had no abstract notions of *tableity* and *gobletity*,—he saw and understood the things themselves, but he had no conception of their Types, Architypes, or Prototypes; and how he should would be difficult to tell. The alleged proof advanced by Malebranche, that Ideas must be substantial, since they have distinct properties, is quite untenable. Ideas have no properties. They are nothing but a mode of existence of the thinking organ, acted upon by its proper stimulus, and no more substantial than combustion or motion, which are, in like manner, modes of existence of the thing burning, or the thing in motion. The testimony also adduced by Malebranche, of the innateness of these substantial ideas, founded upon the intercourse of our souls with God, (whose mind necessarily embraces every thing) is that of a Theologian, not of a Physiologist, and presumes upon the notion of the identity of the Soul and the Mind, which has been shewn to be erroneous. It might be further objected also to this notion of our having inherent ideas of every thing through God, that our notions are as often false as true, unjust as just, which they should not have been had they come to us through this medium. This objection is particularly applicable to Fenelon's ultra-Malebranchism, who makes our abstract Ideas God himself,—" elles sont Dieu même ;"—but it is in vain discussing the vague flights of Divines on any subject of Physiology. In fine, the illusionary world of the Idealists has no existence, and can have no existence in Nature. No Function (and Thought is a function) can exist without *two* conditions,—a substance to be acted on, and a substance acting. The Idealists looked to but *one;* not either of them individually, but both combined into one. It is quite true that we have no ideas of external objects themselves, and that we cannot know any thing of them otherwise than as they affect our minds: that therefore our notions of them must be derived, as well from the quality of our minds as from the nature of the objects themselves. The qualities of colour, hardness &c. have as close a reference to the thing perceiving as to the thing perceived. What is of one colour or one degree of consistency to one animal, is not necessarily of the same to others; and there is *no* such thing as colour, *no* such thing as hardness at all, but where there is a being conscious of these properties. But it is not true that this being has or can have any ideas of colour or hardness, independently of such bodies as are calculated to inspire these ideas, nor, consequently, that the senses are otherwise than essential to our having ideas at all. The wildest *maniac* derived all his ideas originally from the senses: his hallucinations arise from perturbed combinations of them.

But the Senses are not, nevertheless, as supposed by the Peripatetic School, all in all sufficient, the mind being a mere mirror, in which the images continually thrown off by objects so entering are reflected. If this were the case, whence all the differences of attainment, character and disposition, under precisely similar external circumstances? (*a*) Two conditions, it has been repeatedly said, are always necessary to every function; and the Peripatetics under Aristotle, like the Academicians under Plato, make but one,—a different one indeed, but still only one. Our ideas of colour and hardness result not from the object *alone*, any more than from the mind *alone*, but

(*a*) It is well remarked by Dr Barclay, that we may as well say that Arts and Manufactures are derived from the doors and windows by which the raw materials enter, as that Thought is derived from the Senses *alone.* There must be something within to act on these raw materials, and to construct out of them new fabrics, which are the result of the *combined* agency of the thing acting and the thing acted upon.

from the combined agency of both, and a change in the condition of either effects a corresponding change in the Idea in question.

So far then as *words* go, both the Idealists and Realists are equally mistaken; but it is amusing to observe that the former at least, if not the latter also, are so in words alone; and it would not be very difficult to prove that they both agreed in *fact* with each other, and what is more, with the views advanced above. For what in fact were the abstract ideas of the former, and the looking-glass of the latter, but a susceptibility, resident in the body, of being affected in a certain way,—what was the information derived from the Senses but the stimulus to such an affection, and what was an individual idea but the result of the two mutually acting on each other? The chief difference is, that the Idealists have exaggerated the influence of the percipient, the Realists that of the thing perceived. Thus, among the former, Descartes distinctly defines an innate idea as a "*faculty*" of engendering ideas,—not an idea in the common and correct acceptation of the word; and Fenelon speaks of it as "une *règle* par laquelle on juge de tout,"—not a judgment, but a capacity for judging. On the other hand, Locke, among the Realists, speaks of his mirror &c. as "a *disposition*,—a *faculty* to receive impressions;" and distinctly states, that it is from the capacity to act upon the impressions received, as well as from the impressions themselves, that all our ideas arise. What is this but the view all along inculcated above? Both *virtually* admit the two conditions required, though both *explicitly* admit only one. (*a*)

It is to Bonnet, to Kant, and to Gall that we owe the fullest illustration of the real nature of Thought. "Our Brain," observes Bonnet, "is organised with direct reference to the wonderful operations of our Mind, and the organs of our Senses, in like manner, are adapted to the organisation of our Brain; but the latter are in every thing subservient to the former." And so it is with all the lower animals. The Brain of Man and the hand of Man, the Brain of the Horse and the hoof of the Horse, have a direct relation to each other; but the Horse would no more be raised to the intellectual rank of Man by giving him a Hand, than a man is sunk to the condition of a horse by depriving him of it. The Philosophy of Kant is, in like manner, the mean of that of Plato and Aristotle, of Descartes and Locke;—that

(*a*) To make use of a simile. The Idealists SAY that the green tint is composed of blue alone, but they *imply* that a little yellow is necessary;—the Realists SAY that the green tint is composed of yellow alone, but they equally *imply* that a little blue is necessary: they both agree in fact, that Thought is a compound of two conditions, but they still in words represent it as a simple. They both go hand in hand with Truth without perceiving her.

is to say, he has the same general ideas as they had, (for it has been just shewn that they did not essentially differ from each other with respect to the instrumentality of both the percipient, and the thing perceived, to Thought) but without falling into their exaggerations on one side or the other. " The faculties of the Mind," says he, " are *a priori;* but it is external occasions which determine their exercise.—Thought is that form of being derived from both." Dr Gall follows in the same tract, and his proofs of this are derived from the intellectual differences in different individuals, and in Man and the Lower animals, which have been spoken of before.

CHAPTER V.

ON THE INCREASE AND DIMINUTION OF THOUGHT.

The Faculty of Thinking may, like Irritability and Sensibility, be increased or diminished by causes which may be presumed to increase or diminish the quantity of nervous matter in which it resides, and it is thus that the energy of Thought is increased by intermission, and diminished by long exercise.

It is farther remarkable that this energy is always within certain limits, in proportion to the quantity of blood in the Capillary Arteries of the surface of the Brain, by which more copious secretion of this matter may be reasonably supposed to be effected; and it is thus that we must explain the effects of inflammation of the Arachnoid Coat and surface of the Brain, in rendering all the Thoughts preternaturally vivid. Most persons also must have noticed the fact, that the Thoughts are more energetic when they are in the horizontal posture than when erect; and the reason appears to be, that, in the former case, the return of the blood from the Brain is less easy, and the deposition, therefore, of that form of nervous matter, of which the Faculty of Thinking is the distinguishing property, more copious than in the latter. It is not an uncommon practice with studious persons, and it seems to be a very judicious one, when more than usually puzzled with the subject of their studies while at their reading-desk, to retire to a sofa, and reflect upon it in a horizontal posture; and every one must have experienced how clear and perspicuous these subjects frequently are upon first awakening in the morning, which appeared to him the night before utterly unintelligible. Hence, probably, has arisen the old-fashioned piece of advice to persons, in cases of considerable embarrassment, to go and consult their pillow; that is to say, to reflect upon the subject of their embarrassment for a time in the horizontal posture. This view of the matter is directly opposed to the one commonly entertained, that a great quantity of blood in the Brain is so far from favourable, that it is exceedingly inimical to acuteness of Thought; and it is not uncommon to imagine that the state of Sleep, in which Thought is in a great measure suspended, depends upon too much blood in this organ, as Apoplexy, in which the Thoughts are entirely suspended, pretty obviously does. The persons, however, who consider that too much blood in the Brain is inimical to acuteness of Thought, usually make no distinction between this superabundance of blood in the grey and white matter of the Brain, upon which, as it would appear, all the ambiguity hinges.

This subject shall be again talked of in speaking of Sleep; but, in the meantime, it may be stated a second time, that whatever may be the effect of an accumulation of blood in the white part of the cerebral mass, an accumulation of it in the grey part is favourable to acuteness of intellect, and that such an accumulation is, in general, promoted by the horizontal posture. It is proper to keep in mind, however, that though the horizontal posture promotes this accumulation of the blood in the Brain by retarding its return by the veins, every kind of rest impedes it, by diminishing its flow by the Arteries, and it is possible that what we gain in one way may be sometimes more than lost in another; and it thus often happens, that one of the most effectual means of clarifying muddled ideas is taking a good sharp walk, or undergoing any other violent exercise.

Ceteris paribus, the mental faculties are usually, for reasons already given, more energetic under those circumstances in which the expirations preponderate over the inspirations, and which are precisely the same as those in which the pulse is fullest, the course of the blood most towards the surface, and the chymification most perfect; and it is thus that they are more so commonly in the evening than in the morning, with the exception of the period immediately succeeding sleep, that is, before we have assumed the erect position; when exposed to heat rather than to cold; after food than after long fasting; under the influence of exciting passions, rather than the contrary; during exercise, as just observed, than during rest; as well as generally more so in females, and during infancy, in both of whom, though the susceptibility of intense thought be less, the energy of the thoughts, such as they are, is commonly considerably greater; persons of the sanguine or choleric temperament than in others; and in the summer than in the winter,—the rationale of all which has been already more than once given.

The Faculty of Thinking, also, as well as Irritability and Sensibility, with respect to any particular stimulus, is much increased by habitual excitement; thus a picture, or a piece of music, will excite in the Mind of a Painter or Musician, (although they do not see nor hear better, nor even half so well as other men) a train of ideas very superior to any which other men are capable of deriving from them. It appears also, that even the exercise of Thinking, within moderate bounds, is favourable to the generation of this faculty, perhaps by stimulating the capillary arteries of the seat of it to an increased secretion of nervous matter; and it is by such an exercise of the Faculty of Thinking, that persons of weak minds may be sometimes brought forward, in the same way as, by exciting in the seat of sensibility strong sensations, we are sometimes enabled to restore the sensation of Paralytic parts. With respect to the individual mental actions, and their mutual relation to each other, the consideration of them belongs much more to the Moral Philosopher than to the Physiologist.

ON SLEEP.

Connected with the functions of Sensation, Thought, and Voluntary Motion, is Sleep, consisting in a periodical diminution of all these functions; while Irritability, and all the functions immediately dependent upon it, continue as before. Sleep, therefore, is not any thing absolute, but negative; and consists not in any additional action of certain organs, but in a partial cessation of those which they before displayed. The state of sleep may depend, with respect to Sensation and Thought, on either the diminution of Sensibility and the Faculty of Thinking, on the one hand, or on a defective conveyance of the stimuli by which these faculties are excited, on the other; but with respect to Voluntary Motion, it can depend only upon a diminution of that power by which it is excited,—Volition; and though a defective conveyance of the natural stimuli to Sensibility, and the Faculty of Thinking, may perhaps be sometimes a cause of morbid sleep, it probably never takes place in such as is natural. Natural sleep consequently depends always upon a diminution of Sensibility and the Faculty of Thinking and of Volition, and not upon any change in the other necessary conditions to the display of the functions to which these give rise. Now, assuming that the full possession of the faculties and powers above mentioned depend upon a certain condition of the nervous matter in which they are severally resident, viz. of the grey matter of the posterior columns of the Spinal Marrow with respect to Sensibility, of that of the Brain with respect to the Faculty of Thinking, and of that of the anterior columns of the Spinal Marrow with respect to the power of exciting Voluntary Motion, it is easy to say that natural sleep consists in a less perfect condition of this matter; and looking upon this matter, like every other part of the body, as a Secretion, it is equally easy to say that this Secretion is periodically diminished, or rather that, like some other Secretions, it is only periodically renewed. But all the Secretions are, *ceteris paribus*, copious in proportion to the quantity of blood contained in the capillary arteries of the secreting organs; and hence we are led, *a priori*, to conceive, that during Sleep the capillary arteries of the organs in question contain less blood than during the waking hours. This view of the matter is strongly corroborated by the well-known fact, that when the capillary arteries of these parts are loaded with blood, as in Arachnitis, Sleep is utterly impossible; while on the contrary, when these arteries may be presumed to be in a great measure depleted, as after copious hemorrhages, bloodletting, or tying the carotid arteries, Sleep is much more continued and profound than under any other circumstances.

It is with many people a common impression, that sleep depends not upon too *little*, but upon too *much* blood in the Brain; and they adduce in favour of this view, the deep sleep which attends apoplexy, a disease arising from either a deposition of blood into this organ, or from a preternaturally distended state of its blood-vessels. But, as has been before observed, it is necessary to make a distinction, when speaking of an accumulation of Blood in the Brain, between the grey and white matter of this organ, an accumulation in the former being as certainly productive of Watchfulness, as an accumulation in the latter is of Sleep. Nor is it difficult to conceive how a distention of the white matter by blood, should, by compressing the grey matter, exclude from the vessels of the latter their requisite portion of Blood, and thus operate in producing Sleep, almost in the same way as a depression of the bones of the skull,—perhaps, however, the quantity of blood in the Brain is always the same. Thus, the very fact of Sleep being induced by such a distention of the white matter of the Brain, as occurs not only in Apoplexy, but in Encephalitis, is decidedly favourable to the doctrine, that Sleep immediately arises from too little blood in the capillary arteries of the grey matter; and when this is taken in conjunction with the perpetual watchfulness which we know arises when these arteries are distended with blood, and with the effects in inducing Sleep of blood-letting, and the other circumstances just mentioned, we can hardly refuse to believe that Sleep depends upon a periodical constriction of these vessels, or as we perhaps should rather express it, that watchfulness depends upon a periodical dilatation of them, since we must never forget that the state of Sleep is negative, and that it is rather the positive state, the cause of which we are called upon to explain, the negative state being of course explicable upon the presumption that this cause has ceased to operate. Why the recurrence of the state of Sleep should be periodical it is idle to attempt to explain, till we have ascertained why the secretion of semen in the lower animals, or the flow of the menstrual fluid in women, is intermitted at certain intervals, since they are all resolvable into certain laws of periodicity, of which we know little or nothing. (*a*)

(*a*) The notions of the ancients respecting the proximate cause of Sleep are not worth dwelling on. The idea, that it depended on defective secretion, was supposed probable by Haller, and that this defective secretion arose from too little arterial blood in some parts of the Brain, has been particularly insisted upon by Blumenbach, who, however, attributes this defect of Blood, not to

That the several faculties, of *perceiving certain irritations,* which constitutes Sensibility, of being *excited by certain sensations,* which constitutes the susceptibility of Thought, and of *calling into action certain muscles,* which constitutes the power of exciting Voluntary Motion, are never entirely suspended by sleep, is sufficiently obvious ; and the degree in which they are collectively or severally diminished by it is probably very various at different times, from the almost perfect enjoyment of them all, with the exception of consciousness, as in *sleep-walking,* to the enjoyment of some and the suspension of others, as in *nightmare,* and to the almost perfect suspension of them all, as in *apoplexy.*

The perception of odours, of light and of sounds during sleep, (Smell, Sight, Hearing) and that of uneasy feelings arising from an awkward posture, such as lying on the back, or from cold or other similar causes, (Touch) are sufficiently manifested by the remarkable influence which these often have upon our dreams or sleeping thoughts, as well as from the instantaneous awaking of one who has fallen asleep during a noise, for example, when that noise ceases. (*a*) How intimately, also, our dreams are connected frequently with our waking thoughts, from which they appear to spring sometimes in a continuous chain, must have been observed by every one. Nor is it less certain, that during the profoundest sleep we often move our limbs, and even speak ; from all which it is clear that natural sleep consists only in a *diminution* of Thought and Voluntary Motion, and by no means in a total suspension of these functions.

constriction of the capillary arteries, but to a minor influx by the larger branches, and his commentator, Dr Elliotson, has thought proper to regard this supposed minor influx as a consequence and not a cause of sleep. He says, the Brain, like all other organs, is liable to fatigue, and that when, in consequence, " it falls asleep," the diminution of its circulation ensues. All this is either too obviously erroneous to require, or too vague to admit of any correction.

(*a*) It was not without reason that Hippocrates, in his book concerning dreams, deduces from them many prognostics in disease ; and Galen, for the same purpose, cites many examples of the origin of certain dreams, from certain corporeal affections, such as dreaming that one has a leaden leg, for example, from its being perchance uncovered, and so forth. His notions, that dreaming of fire might arise from abundance of yellow bile, and dreaming of smoke from an abundance of black bile, though founded on a false hypothesis, all tend to the same conclusion; and numerous similar instances of the correspondence of the dreams with the Sensations might be collected from his time, down to that of Dugald Stewart, who mentions, among others, the occurrence of a dream of walking over Mount Etna, from hot water having been applied to the feet ; and of another, of being scalped by Indians, from a blister having been applied to the head. All this shews that Sensation is not entirely suspended.

The phenomena of sleep need not be particularly described. In this state, as far as the organic functions are concerned, the respiration is usually somewhat slower and deeper, the heat of the body less, the pulse slower and fuller, all the secretions, with the exception perhaps of fat, diminished and vitiated, and digestion less perfect than during the waking hours; all owing probably to a defective supply of that stimulus which, during the waking hours, is continually conveyed to all the organs from the Brain. (*a*) With respect to what remains of the Animal functions, it is supposed that the thoughts, imperfect as they are, being now left to themselves, traverse the mind with infinitely more celerity than during the waking hours, when we are capable of detaining them almost at pleasure. It has been calculated by Darwin, that the mind left to itself may fancy the incidents of two hundred years in half a minute; and it has been often observed, that a flash of light or a noise, which has the effect, and, as it appears to the byestanders, the instantaneous effect, of awakening one from sleep, frequently gives rise in this almost inappreciable interval to a long and eventful dream, in which the person shall probably appear to himself to have passed from boyhood to manhood,—to have travelled over half the globe, to have married, got a large family,—and perhaps seen some of his children settled in the world. It is a singular *apparent* inconsistency, that persons can awake at what time they please, as if we scanned the passage of time in this state very accurately; but in reality it is not so. We wind ourselves up, *while yet awake*, for a certain spell, as we wind ourselves up for a long walk; and at

(*a*) It is a common impression, that the organic functions in general, (and particularly digestion) are energetic in proportion to the failure of the animal; and that the reason of this is, as Broussais expresses it, an accumulation of "Nervous Energy" in the ganglionic system, proportioned to its abstraction from the Cerebro-spinal. But the nervous energy of the former is Irritability, that of the latter Sensibility, the Faculty of Thinking, and the power of exciting Voluntary Motion,—all mere properties of this system of nerves, and incapable equally of being *per se* abstracted, and of being a substitute for Irritability if they were. Into how many vague absurdities do the presumption of the substantial nature of the eternal Nervous Energy on the one hand, and the ignorance of or inattention to its plurality on the other, continually betray us! But the organic functions are not more energetic, but, on the contrary, considerably less so in sleep than during the waking hours. How is it in Apoplexy, which is only a major degree of the same state? People fall asleep after a full meal, not in order that they may digest it better, but because they have stimulated the capillary arteries of the brain, by sympathy with the over-loaded stomach. The same effect, and to a much greater degree, results after a debauch of spirituous liquors, where no digestion is requisite.

the expiration of the allotted time we awake, as at the close of our walk we are fatigued.

The approach of Sleep is favoured by moderate fatigue of both body and mind, by darkness and silence, or what is still better, dull, monotonous sounds, by the warm bath, friction, the absence of care; while, on the contrary, it is impeded by great fatigue, and particularly mental, by light, by noise, by cold, (if not intense) by strong passions, pain, the explanation of all which may be easily collected from what has preceded. Sleep is longer indulged in both extremes of life than in middle age. It is probable that the fœtuses of all animals are in this state; at least such was the opinion of Aristotle, and has been very generally prevalent since his time. (*a*) After birth, the length of time given to sleep is generally in the inverse ratio of approach to maturity, and it becomes again progressively greater as old age advances. In adult age about a third of every twenty-four hours is usually passed by civilised man in sleep; but considerably more by savages, and still more by brutes, which in fact, unless when in action, are almost always in this state. Instances are however on record, where sleep has been scarcely or not at all enjoyed for a month, for three months, and even for years. On the contrary, sleep has sometimes been prolonged more or less perfectly for forty days, for six or seven weeks, and even for five or six months. (*b*)

In speaking of the length of time during which Irritability may be retained, it was mentioned that the Dormouse, the Marmot, the Bat, other animals called hibernating, as well as some Birds, as the Cuckoo and Swallow when it does not migrate, and most amphibious animals, and the pupæ of many Insects, pass all the cold months of the year in what is called Sleep. The Perch also, and some other Fishes, may be frozen, and for some time retain their Irritability. The common garden Snail also becomes torpid if deprived of moisture, as do many animalcules under the same circumstances, some of which may be revived by water after the lapse of twenty or thirty years. (*c*) It is questionable, however, whether these latter instances, any more than the torpid state of vegetables during the winter, or even the drooping of their heads and the closing of their flowers when the night comes

(*a*) According to Harvey, however, the chick in the egg leads a much more gentlemanly sort of life. "Modo dormit," says he, "modo vigilat, movensque sese respirat et pipit." These piping propensities of fœtuses, however, though insisted on by Boyle, have not been generally admitted by later authors.

(*b*) Cases of this nature are related by Pliny, Spinck, Bartholin, Dr Gooch and Sir D. Brewster. See also the Memoires de Paris, and the Philosophical Transactions.

(*c*) Spallanzani.

on, be at all analogous to the Sleep of the higher classes of animals, and whether it be not rather Asphyxia, the more especially as a precisely similar state was produced in Flies (*a*) and Bees, (*b*) by long immersion in water; in both which cases the animals afterwards revived. In all, indeed, the usual phenomena characteristic of the full enjoyment of all their functions cease to be displayed; but while true sleep seems to arise from a diminished generation of those faculties on which the animal functions depend, while the stimuli to the faculties continue the same, this false sleep seems to arise not from any diminution of the faculties, (the only one which any of them possess being most probably Irritability) but from a diminution of the stimuli by which this faculty is commonly excited. It appears, indeed, *prima facie* absurd to ascribe any thing like Sleep, by which we understand alone a periodical diminution of Sensation, Thought and Voluntary Motion, to beings, many of which in all probability never exercise any one of these functions. During the torpid state of the truly hibernating animals, the diminution of the faculties on which the animal functions depend is infinitely greater than in common Sleep, since it is impossible to excite them by pricking or wounding them, or even by breaking their limbs; (*c*) and it is perhaps from the total absence in this state of the usual stimulus derived from the Brain, that Respiration, and all the other organic functions also, are so remarkably retarded. It is in fact Asphyxia or Nervous Apoplexy induced by cold.

(*a*) Redi. (*b*) Reaumur. (*c*) Reeve.

APPENDIX,

BY

ROBERT LEWINS,

M. D. &c.

The lofty position which the Edinburgh Phrenologists, in particular, have lately attempted to assume, and their high pretensions to metaphysical and medical distinction, make this a proper time and place to inquire into the validity of their claims. I am not sufficiently conversant with metaphysical reading to make me disposed to meet the subtile phrenologist on that very debateable ground ; but I agree with a learned Professor of Physiology, who, in a late controversy on the merits of the " New Philosophy," as Phrenology is styled by its advocates, has said that " this discovery (supposing it to be fully made out) would be merely an addition to our knowledge of the mind, rendering advisable probably a change in the arrangement by which a part of the science is taught," (and perhaps he should have added, some change in the nomenclature employed) ; " but that the science would still consist of facts ascertained by the methods laid down by Reid and Stewart."

I feel more at home in discussing the pretensions of the Phrenologists in regard to their medical claims, and am fully competent to give an opinion on that subject. They boldly assert that Phrenology is actually embraced as a science by the most eminent Physiologists in Europe ; that it is rapidly extending itself over the civilised world ; and in corroboration of this astounding announcement, they quote the names of many deservedly eminent men as having become converts to their doctrine, amongst whom are Broussais, Andral, Jules Cloquet, Vimont of Paris, Drs Johnstone and Elliotson of London, Dr Robert Hunter and the late Dr Macnish of Glasgow, Dr Mackintosh of Edinburgh, Professors Evanson and Drummond of Ireland,

and Professor Otto of Copenhagen, &c. Dr Fletcher, too, has been represented by the Edinburgh Phrenologists as favourable to them, and Blumenbach, they report, to be "rather Phrenological than otherwise." To what extent all the above-named individuals are Phrenologists I know not; but certain it is, that some of the Edinburgh School believe all to be converts who are not declared opponents of their doctrines. The assertion of the Phrenologists, in reference to Fletcher's opinion of their tenets, has been stated above; but I have evidence in his own handwriting to the contrary. (*a*) With the highest respect for the talents and attainments of those other distinguished men, (some of whom have undoubtedly done much for medical science,) I cannot allow that they, either individually or collectively, are entitled to be considered first-rate authority in Physiology; and since Magendie, Tiedemann, Sir Charles Bell, Professor Alison, and many others, are Anti-phrenologists, it may unquestionably be affirmed that the "New Philosophy" is not embraced as a science by the first Physiologists in Europe.

Magendie distinctly states that he is not a believer. His words are, "La Phrénologie, que je nommerais volontiers une *pseudo-science*, comme était naguère l'astrologie ou la nécromancie, a tenté de localisèr les diverses sortes de mémoires; mais ces tentatives, louables en elles-mêmes, ne soutiennent pas encore l'examen." The late Dr Gordon, who made Physiology the principal study of his life, was a decided opponent of the Phrenology of Spurzheim. So was Dr Milligan, who has discussed the question with much ability, at considerable length, in the notes to the last edition of his translation of Magendie's Work, and made it pretty evident, by simple calculation, that the chances of a Phrenologist finding some of the faculties manifested by external appearances could never be less than about the proportion of three to one; and in another work, Dr Milligan has explained that principle of human nature, by which occasional coincidences, such as that of a faculty chancing to correspond to cranial development, are by the mind of man, a creature of hope, admired and remembered; whilst instances of failure, as was the case in astrology, were almost instantly forgotten. Besides, many of the striking experiments of Phrenologists, which have been considered decisive of the truth of their doctrine, were made on classes of indi-

(*a*) His precise words are, "For my own part I am not a Phrenologist, but I am desirous that the thing should have fair play. I implicitly believe some of the leading facts, particularly with regard to National Peculiarities; but my own observation induces me to doubt many of the tenets with respect to individuals, the exceptions having been at least as numerous as the examples."

viduals whose character and habits in general were perfectly known, —convicted criminals, for instance, and inmates of penitentiaries or mad-houses; and even with such subjects, Phrenology, when exclusively trusted to, has often failed in divining real character.

Phrenologists affirm that they see with anatomical eyes proof of the truth of their system. It is unfortunate for this averment that the most celebrated Anatomists in Europe of the last thirty years have been opposed to Phrenology, as taught by Spurzheim and his disciples. In the list of able men who have taught Anatomy in Edinburgh, with so much credit to themselves, and advantage to our medical school, during that period, from the late illustrious veterans, Monro and Barclay, down to our deservedly eminent junior Anatomist Handyside, *all* have been Anti-phrenological.

I shall say nothing in this place of the observations and experiments of Sir William Hamilton and Dr Stone, which, in the opinion of some Physiologists, utterly refute the doctrine of Spurzheim, as taught by Combe; but, passing from remarks on Phrenology in general, will proceed to consider its merits, when tested by a *particular* case lately published by Mr George Combe, in a Journal exclusively devoted to the dissemination of phrenological principles. The case is certainly an important one, since sophistry cannot enable either party to escape from conclusions that may be fairly deduced from it in regard to the controversy.

" *Case of Disease in the Organ of Combativeness on the Left Side,* attended with Change of Temper; and of Disease in the left Corpus Striatum, attended with Loss of Knowledge of the Signification of Words.

" In the beginning of October," (1836,) Mr Combe says, " I received, with Mr Craig's compliments, a separate copy of " History of a Case of Spectral Illusions, with subsequent loss of memory of words and names; with appearances on dissection, by James Craig, Esq." &c. extracted from the Medical Journal before mentioned, and having subjoined to it " Pathological Observations on the foregoing Case, by David Craigie, M. D." &c. I was then on the eve of leaving home for Aberdeen for three weeks. On my return I addressed the following letter to Mr Craig:

" *Edinburgh, 3d November* 1836.

" My Dear Sir,—I received your printed report of the case of Mr N. when I was preparing to go to Aberdeen, and had not time then to acknowledge the receipt of it, and to thank you for your attention. In your note to me of the 25th of July you said, "As soon as I get my notes put into a legible form, I'll send them to you for perusal." This seems to have escaped your recollection, as the notes were not sent. I regret to observe that you omit all notice of the change of Mr N.'s temper from a state of placidity to one of irritability at the time when his embarrassment in expressing his ideas by language occurred. The paramount object in reporting a case of this kind, is to state the *whole* facts and circumstances; as it often happens that the omission of some, not only leaves the report incomplete, but gives a different character to the facts reported. It has been made a charge by the phrenologists against non-phrenological medical practitioners, that when diseases occurred in parts of the brain devoted to the manifestation of the propensities or sentiments, they did not take due pains to ascertain and report the state of the related feelings in the patients. In the present instance, this omission is important. According to your report, a large cavity appeared in the region of Combativeness on the left side, the corresponding part in the right hemisphere being entire; but not one word is said about the temper of the deceased. As my notes, which you perused before drawing up your report, particularly adverted to this point, I did not expect to see it overlooked. I shall now publish my report under the same name with yours.

"I regret to observe, that you have omitted the *e* in my name in your Report, and also my Christian name, in consequence of which no one who reads it will discover that I was the individual who was present at the dissection. I am, &c. GEO. COMBE."

"To this letter the following answer was received:

"MY DEAR SIR, *Ludgate Lodge, 5th November* 1836.

"In reply to yours of the 3d, which I received this morning, I have to state, that my promise did not escape my recollection; the printed copy of Mr N.'s case was what I meant for your perusal, ('tis verbatim from my notes,) and I sent you a copy the very day it came into my possession.

"As to the omission you complain of, I have distinctly to state, that the irritability of temper you allude to never once came under my own observation, nor do I believe it existed, except when Mr N.'s wishes or orders could not be understood,—in short, when his desires were virtually disobeyed,—or when he came into contact with those against whom he (from a very evident cause) looked with disapprobation, of whom I knew several; and in all these cases, 'twas more an expression of dissatisfaction or impatience than irritability. I believe few men, if any, who had been during a long life accustomed to such implicit obedience as he was, would have remained placid when their own servants, as well as others, (as Mr N. must have thought,) disregarded their commands. I have, moreover, repeatedly heard the remark made by those who were in the habit of seeing him frequently after his illness, 'that he was the same affable, polite person as ever.'

"My report was submitted to the perusal of Drs Abercrombie, Davidson and Thomson, before it was printed, all of whom had frequent occasions of testifying its accuracy. No one had such opportunities of observing the case in all its features as myself, to which, throughout, I paid a very strict attention. From what rumour or report you derived your information I am at a loss to comprehend; but I feel assured, if you had had the frequent personal opportunities of observation which I had, I cannot believe you would have formed the opinion you now maintain; and I deny, *in toto*, the suppression, omission, or misrepresentation *of a single fact* which occurred to my observation during the progress of the case. Indeed, had I not wished to be scrupulously accurate, I would not have made its history so unusually, nay unnecessarily long: whatever the 'general charge,' therefore, may be against 'non-phrenological medical practitioners,' in this instance I do believe it to be inapplicable.

"My report, as it is printed to page 17, where it commences the account of 1835, was drawn up and perused by several individuals at least twelve months before Mr N.'s death; it is therefore not the fact when you say, 'I perused your report before drawing up mine.' I wrote to you requesting your notes of the dissection, because you noted them down on the spot, to compare with and insure the accuracy of mine, which were written when I returned home; and I saw with surprise in your report, the statement, new to me, and made for the first time, charging Mr N. with irritability of temper. I marked, either in pencil or with ink, 'incorrect,' or some such expression, and afterwards rubbed or scratched it out, leaving you to judge of the *actual facts* of the case as reported by me.

"I regret extremely the unintentional mistake regarding your name and surname, which never occurred to me until I received your letter. I could have no possible motive for not wishing it made perfectly public, and have uniformly stated unreservedly, that you were present at the post-mortem inspection. I am, &c.

"JAMES CRAIG."

"I addressed the following letter to Mr Craig:

"My Dear Sir, *Edinburgh, 18th November* 1836.

"I received your letter of the 5th of November, and beg to mention, that I am now printing Mr N.'s case from my notes, adding my letter to you dated the 3d of November, and your letter to me dated the 5th of November, *ad longum*. I have given a statement of the grounds on which I made the remark, that there had been a change of Mr N.'s temper, contemporaneously with the disorder of the function of language. I sum up the whole by some remarks on the points in which your report and Dr Craigie's differ from mine. I shall send you a copy of the whole as soon as published. I am, &c.

"Geo. Combe."

"The evidence on which I made the statement that Mr N.'s temper changed contemporaneously with his loss of the use of language shall now be given.

"I addressed the following letter to Dr Mackintosh:

"My Dear Sir, *Edinburgh, 18th November* 1836.

"I beg leave to refer you to the report of the case of Mr N., in the 129th No. of the Edin. Med. and Surg. Journal, in which I see your name mentioned as having been in consultation, and to the inclosed proof of my own report of the same case; and to request that you will inform me whether you know any thing about a change of temper in Mr N., contemporaneously with his loss of the power of using language. I am, &c. Geo. Combe."

"To this letter Dr Mackintosh returned the following answer:

"My Dear Sir, *Edinburgh, 19th November* 1836.

"In reply to your note of yesterday's date, I have to state that there is a distinct impression on my mind of a remarkable change of temper in Mr N.'s case, contemporaneously with his loss of power of using language correctly.

"I had several interviews with his confidential servants, to enable me to make up my mind whether restraint should be employed, as such a step was touched upon in consultation. Indeed, my belief is, that one of my visits to ——————— was to assist with others in determining whether restraint should be employed. All his servants led me to believe that he was excessively irritable and obstinate in temper, difficult to please, and sometimes unmanageable, from the period of his attack; and some of them contrasted this conduct with his usual kind and easy manner towards them. At my visits there was always some management necessary before I was introduced, and he appeared impatient, and often so irritable, that I was guarded in my expressions, and always made my retreat as soon as possible. On entering the room, however, he always received me in the most polite manner. I am, my dear Sir, yours truly,

"JOHN MACKINTOSH."

"The following declaration was made to me by the individual who subscribes it, in presence of two of the personal friends of Mr N.

"*Statement made by John Smeal, son of Joseph Smeal, gardener to Mr N.*

"My father was gardener to Mr N. for thirty-four years before his death. I have been nine years in the garden under my father. Before Mr N. was taken ill in 1832, he was remarkable for mildness of temper, and in speaking to his servants he was kind and civil. At that time a striking change took place in his temper. In coming into the garden, if he saw a straw or a leaf on the walk he flew into a passion. He became extremely irritable towards my father, and at one time struck him; at another time he threw a lock at him, and on a third occasion spat in his face. I felt myself obliged to go out of the way occasionally, when I saw him coming, and hid myself among the bushes to avoid him. My father and myself did every thing possible to please him. At one time my father was so much distressed by Mr N.'s bad temper, that he spoke of giving up his situation, as he could not manage with him. Mr N.'s condition was variable. On some days he was pleasant, on other days the least thing would have put him quite out of temper altogether. He continued in this condition to the last. The same occurrences took place with his other servants, and I could give a great many similar examples. There was only one servant who was ever heard of as being inattentive to Mr N., and with whom he had just cause for offence. His other servants have been from ten to fifteen years in his service, and are respectable men, and his temper was equally trying to them. Mr Craig told my father at one time, that he did not think that he could continue to visit Mr N., on account of his bad temper towards him. Mr N. was aware that he was not intelligible. I often had occasion to tell him that I did not understand him, and he shewed me by signs what he wanted. He knew that my father did not understand him when he struck him and spat on him as before mentioned; and when my father told him that he could not any longer support his temper, and must give up his situation, Mr N. burst into tears, took him by the hand, and, pointing to his own bosom, made my father to understand that he wished that he would not leave him as long as he lived. My father would confirm all that I have said, for he and I were talking about the matter last night.

"19*th November* 1836. JOHN SMEAL."

"Dr Craigie, in his remarks on Mr Craig's report, observes that Mr N. was *not insane;* and all the evidence to which I have had access confirms this view of the case. I have been told by a Bank-Director that Mr N. continued to draw sums from his cash-account, on his own orders, almost to the time of his death. The orders were not regularly subscribed; but he presented them himself, and the money was paid to him. All these authorities concur in saying, that in his intercourse with persons of his own rank, in the way of business or friendship, Mr N. generally continued polite and affable to the last, although there were exceptions to this rule.

"Mr Craig, in his letter dated the 5th of November, seems to admit that when Mr N. was not understood, and when his orders were virtually disobeyed, he became irritated. The real questions are, 1*st*, Whether his temper changed at the time of his malady? I have endeavoured to shew that it did; and farther, a very intimate friend of Mr N., after reading Mr Craig's letter, says in a note to me: "I never supposed that any one who saw Mr N. in his latter days, and knew him previous to his illness, would have called in question the alteration in his temper." And, 2*dly*, Whether his bad temper was morbid, or the healthy action of his faculties in his peculiar situation? I infer it to have been morbid, *first*, Because he was not insane, and was aware that he had become unintelligible, and that, therefore, his servants were not to blame for not understanding him.

"He in general gave effect to this knowledge in his intercourse of friendship or of business with persons of his own station; and if there had not been morbid irritability in his temper, he would have restrained his passion also in regard to his servants. *Secondly*, Because his ebullitions of violence, such as are described by John Smeal, were numerous, and occurred without the existence of causes sufficient to have provoked them in his mind when in a state of health. *Thirdly*, Because he was a man not only of courteous but of courtly manners, and unless impelled by morbid irritation, was incapable of such acts as striking, or throwing a lock at, or spitting on a servant whom he esteemed, and whom he entreated with tears to continue in his service till his death, even after he had treated him with this violence and indignity."

" *Remarks on the Report of the Case of Mr N., given in the Edinburgh Medical and Surgical Journal, No.* 129.

" When Mr Craig called for me on the 15th of July, and invited me to attend the examination of Mr N.'s brain, I mentioned to him that Mr Hood of Kilmarnock had, in the Phren. Trans. and Phren. Journ., (*a*) reported a case very similar to that of Mr N., in so far as related to the diseased state of the faculty of Language ; and that, on dissection, that surgeon had found in the left hemisphere a lesion of the parts, which terminated " at half an inch from the surface of the brain, where it rests over the middle of the super-orbitar plate." Two small depressions or cysts were found in the substance of the brain, " and the cavity, considered as a whole, expanded from the anterior part of the brain, till it opened into the ventricle in the form of a trumpet. The right hemisphere did not present any remarkable appearance." I observed to him that the situation of this lesion corresponded to that of the organ of Language. After the dissection of Mr N.'s brain, and after Dr Abercrombie had left us, (for, as he was much pressed for time, he did not wait to see the opening of the thorax,) I called to Mr Craig's recollection the resemblance of the lesion in the left hemisphere in the present case to that which had presented itself in the case of Mr Hood's patient, when he acquiesced in the justice of the remark.

" After receiving back my " Notes " on the 25th July, no communication was made by Mr Craig to me until he sent me his own report, by that time published in the Medical and Surgical Journal. I read it with much interest, to see how the bearing of the facts on Phrenology should be treated ; and I was much edified by the result. It is well known that that Journal at first violently opposed, and that it has subsequently treated with contemptuous silence, the facts and doctrines of the phrenological school. In the present instance matters were managed as follows : Mr Craig furnished his long report of the mental manifestations of Mr N., dilating on his spectral illusions and impaired language, but omitting entirely all notice of his change of temper ; to which he added a simple description of the morbid appearances of the brain, without saying one word on any supposed connexion between the mental phenomena and them. This report was handed over to Dr Craigie, the editor of the Journal, who wrote an ample dissertation " On Spectral Illusions," and on " the State of the Brain causing them," but in which, from begin-

(*a*) Phren. Trans. p. 235 ; Phren. Journal, vol. iii. p. 28 ; see also Combe's System, 4th edit. vol. ii. p. 554.

ning to end, he does not permit even a hint to escape him of any thing observed or written by phrenologists in elucidation of this subject. He also, faithful to his text in Mr Craig's report, knows nothing, and says nothing of any change of temper in the patient; and of course the large cavity in the left organ of Combativeness is not connected with the phenomena to which, according to all appearance, it gave rise. So far from connecting it with the change of temper, Dr Craigie ascribes to this lesion the loss of the use of words, thereby applying the morbid appearances as directly as possible in contradiction to Phrenology. He says, "*The explanation of this occurrence*," (the loss of the use of words,) "and of the symptoms which took place on the 21st of August 1832, I think *is to be found in the state of the posterior lobe* of the right" (he probably means the *left*) "hemisphere, as disclosed by inspection. It is clear that, whether the orgasm which had terminated in this process of softening took place suddenly or slowly, it did not co-exist with the spectral illusions, nor could it have taken place within a few months or even days before the fatal termination. Every thing, on the contrary, in the case concurs to shew that at this time, perhaps some months previously, for instance, in May 1831, a degree of vascular orgasm and excitation had commenced *in this part of the brain;* that after going on for some time it had undergone a temporary abatement; *that it had given rise to the loss of memory*, then remarked; and that, after the first abatement, it had recurred in a more decided form, in August 1832."

"Dr Craigie does not see any connection between the lesion reported by Mr Craig to have existed "in the middle lobe, on the left side, a little behind the pituitary gland, and to the left of it," "not exceeding a quarter of an inch in extent," and the loss of the use of words. To have discovered this connection would have been to admit a fact in favour of Phrenology.

"With all deference to Dr Craigie, there are better grounds for viewing the lesion in the left posterior lobe to be connected with the change of temper, and that in the left middle lobe with the loss of the use of words, than for his supposition, because the functions of these different parts in a state of health are known to be connected with the manifestations of the combative propensity and the faculty of Language. Besides, in the case reported by Mr Hood, the phenomena attending the loss of the use of words were remarkably similar to those which presented themselves in the case of Mr N.; and in Mr Hood's case there was no lesion *in either of the posterior lobes*, while there was disease in the region of the brain, on the left side, corresponding with that in which the small cavity was found in Mr N.'s brain.

" Dr Craigie adds some observations on the loss of the faculty of language, in which he says, that " it is manifest that the privation was not universal, as it did not extend to the remembrance of places, persons, or objects." The phrenologists agree in this remark; but they humbly think that this affords a strong confirmation of their doctrine, that the faculty of language is manifested by a part of the brain different from those parts which manifest " the remembrance of places, persons, or objects."

" I must here limit myself to the following observations:

" I. Mr N. was known to have acquired from ten to fourteen languages; and the examination of his brain afforded an opportunity of observing the size of the convolution, which, according to the phrenologists, constitutes the organ of the faculty of Language. Mr Craig takes no notice of its size. I affirm that it was unusually large, and that there was a distinct transverse furrow in each super-orbitar plate, of more than ordinary depth, corresponding to its dimensions.

" II. Mr N. retained the knowledge of the signification of words when addressed to him, but could not use words intelligibly himself, so that his faculty of Language was impaired, but not destroyed. In concomitance with this fact, the organ of Language was entire in the right hemisphere, while in the left there was a cavity in the line of the fibres of it. Mr Craig and Dr Craigie avoid all allusion to the phrenological doctrine that there are separate organs for the faculty of Language independent of the other organs, and also all notice of the bearing of the facts of Mr N.'s case on these doctrines.

" III. Mr Craig denies all morbid change of temper in Mr N. at the period of his loss of the use of language. I have produced evidence of the change, and it forms an important feature in the case, taken in connection with the morbid appearances in the organ of Combativeness. To record the latter, and omit the former, is to mutilate and give a signification to the facts at variance with their real import.

" IV. In the phrenological works published by Dr Gall, Dr Spurzheim, and their followers, facts are stated, tending to shew that spectral illusions are connected in some way with large development or diseased action of the organs of Wonder, or of those of Wonder and Imitation. In the present case the skull was thickened over these organs in the left hemisphere, indicating a degree of morbid action in that region which did not present itself in other parts of the skull. No notice is taken of this concomitance in Mr Craig's report.

" V. Dr Craigie cites some cases of lesions of the brain accompanying loss of the use of words, but he makes no allusion to Mr Hood's case, which, in regard both to the mental manifestations and morbid appearances, was closely analogous to the present, but which contradicts Dr Craigie's supposition, that the lesion in the posterior lobe was the cause of the loss of the use of words.

"In short, if scientific truth be an object worth pursuing, I leave the reader to judge to what extent its cause has been promoted by the manner in which Mr Craig and Dr Craigie have brought this case before the public and the medical profession. It is the fashion with those who oppose Phrenology, and also with those who, like Dr Prichard and Academicus, simply affirm that there is no evidence of its truth, to treat with incredulity every fact observed and reported by phrenologists. In this instance we see, that when facts of the most palpable character are presented to non-phrenological or anti-phrenological observers, they do not perceive them, or do not report them. How, then, can Phrenology ever be proved to be true to the satisfaction of such men, while this system shall be pursued? If a phrenologist had not had access to the facts of this case, it would have continued to be cited as a striking evidence against the doctrines. How many similar examples may exist *? "G. C."

"*Edinburgh*, 21*st Nov.* 1836."

* Such is the language uttered by Mr George Combe, writer to the signet, the "great Apostle" of Phrenology, and directed to Academicus, a most industrious cultivator of Medical Science, and a distinguished Professor of Physiology, —to Dr David Craigie, Editor of the Edinburgh Medical and Surgical Journal, formerly Teacher of Anatomy, and to Mr Craig, a respectable Medical Practitioner, who had seen the patient daily for years, whose case is referred to, and who, in the performance of his professional duty, made the *post mortem* examination; and moreover, whose opinion is sanctioned, and his statements corroborated, by Drs Abercrombie, Davidson and Thomson.

Let it be borne in mind, that Mr Combe proceeds on the strength of *his* opinion of the morbid appearances observed in the brain of Mr N., and on the evidence of an *assistant* gardener, in opposition to that of Mr Craig, in regard to the dispute as to change of temper.

Fortunately for the opinion of the *Medical* Gentlemen here concerned, that of Magendie may be cited as evidence in their favour, on an important point of the controversy. "La mémoire," says he, "s'exerce d'une manière pour ainsi dire exclusive sur des sujets très-différents: il y a la mémoire des mots, celle des lieux, celle des noms, des formes, celle de la musique, etc. Un homme présente rarement toutes ces mémoires réunies; elles ne se montrent guère qu'isolément, et presque toujours elles forment le trait le plus marquant de l'intelligence dont elles font partie.

Les maladies nous offrent aussi des analyses psycologiques de la mémoire: tel malade perd la mémoire des noms propres; tel autre celle des substantifs; tel autre celle des nombres, et ne peut compter au-delà de trois ou quatres. Celui-ci oublie jusqu'à sa propre langue, et perd ainsi la faculté de s'exprimer

" *P. S.* Before the foregoing remarks were printed off, I received an answer to my letter to Mr Craig, dated the 18th of November, which I consider it due to him to present also to the reader.

" My Dear Sir, *Ludgate Lodge*, 19*th Nov.* 1836.

" My letter to you of the 5th was never intended for publication. If, however, you do so, you will see the propriety of omitting the real, and substituting the fictitious name of Mr N.

" Upon maturely re-considering the case,—upon examining those who had every opportunity of seeing the subject of it,—I see not the slightest grounds for altering my deliberately formed opinion, confirmed as it is by the eminent medical men who visited along with me, as well as others who were in the habit of seeing Mr N. frequently, and giving the decided preference to an opinion formed upon my own daily personal observation, to your report, second hand as it must be, which, however, I shall be glad to see when published. I am, &c. " James Craig."

" This letter led me to make additional inquiries to ascertain to what extent the statement of John Smeal might be relied on; and I have received the following letter from a gentleman of great respectability, well known to the public.

" My Dear Sir, 21*st November* 1836.

" Only once after the loss of the command of words did I happen to come in contact with Mr N., when he immediately recognised me, and I believe alluded to Dr J——; but he spoke what appeared to me to be Spanish, or chiefly Spanish, and of course I made my bow as speedily as possible. Only once, too, did I see Mr Smeal senior after that event, and I can assure you, that all that I gathered from him, confirms most amply the account given by you of the change of temper from remarkable mildness to marked irritability. Whoever knows the character of Mr Joseph Smeal, for quietness, mildness, attachment to his old master, well-tried probity, and general worth of every sort, cannot hesitate a moment in giving implicit credence to his report, and in being satisfied that it would not be exaggerated, but rather understated, and the examples of bad temper either con-

sur aucun sujet. *Dans tous ces cas, après la mort, on observe des lesions plus ou moins grandes du cerveau, ou de la moelle allongée; mais l'anatomie morbide n'a pas encore pu établir aucune relation entre le lieu lésé et l'espèce de mémoire abolie, de sorte que nous ignorons encore s'il existe quelque partie du cerveau qui soit plus particulièrement destinée a exercer lá mémoire.*"

cealed or apologised for. His son I believe to be equally trustworthy. I am, &c. "—— ——."

" I am authorised to communicate to Mr Craig the name of the writer of this letter.

" The public will now form their own judgment on the case.

" G. C."

" 23*d November* 1836."

We here find the Physician and the Phrenologist fairly at issue. In order that a correct opinion may be formed of the merits of the case, I have quoted fully from Mr Combe's report, and repeat that the proof adduced of violence of temper, supervening on the patient's illness, rests solely on the evidence of the gardener lad, Smeal; for it will be observed, by an examination of the letter of my estimable and respected friend, Dr Mackintosh, that it does not authorise Mr Combe's conclusion. I would also particularly direct attention to that gentleman's admission, in regard to the information he received from a Bank Director, and to the other authorities, as to Mr N.'s " generally polite and affable deportment to the last, although there were exceptions to the general rule." I was myself in the habit of seeing Mr N. occasionally, at the house of a mutual friend, whom he was wont to visit, until a very short time before his death, and certainly never noticed any thing like impetuosity of temper, but the contrary, sometimes under circumstances likely to have made it manifest itself, had such a disposition existed. Mr N. never spoke one word of English; but his deportment during these interviews was always mild and urbane in a high degree, but dignified,—precisely such as might have been expected in one who had long been the representative, at foreign courts, of the King of Great Britain. Further, it appears, by Mr Combe's own shewing, that he is inconsistent in his report of this case to a degree really extraordinary in one usually so cautious. The " morbid irritability " occasioning " ebullitions of violence " was, according to him, the effects of disease, (" lesion,") in the organ of Combativeness on the left side. Now, had this really been the case, it must, without doubt, have shewn itself in presence of Bank Directors, or other persons in his own rank of life, as well as to those in an inferior station, in the same way as the effects of lesions in other organs do. The violence of temper was, in fact, according to Mr Combe, a symptom of disease. No person ever imagined that the peculiar signs, by which organic disease of the brain is characterised, can be influenced by such a cause as the condition of the persons with whom the patient holds intercourse. The idea, I am convinced, will be considered preposterous by all physiologists and practical physicians.

Phrenology, according to its disciples, not only throws light on the phenomena of disease, but it also points out the best method of cure. There are, I believe, few diseases to which, in the opinion of the Phrenologists, their principles may not be applied; but Insanity is the malady to which they say their principles are especially applicable; and it is averred by them, that the cure of that most dreadful of human ills was never rationally attempted until Phrenology explained the phenomena. I have often discussed this interesting subject with a phrenological medical friend, in whose judgment I have great confidence,—and have treated cases of Mania with this gentleman, and also with the Magnus Apollo of Phrenologists, the author of "Observations on Mental Derangement, being an application of the Principles of Phrenology to the elucidation of the Causes, Symptoms, Nature and Treatment of Insanity," without ever being able to discover that their practice differed materially from that of other well-informed Physicians not guided by the "light of Phrenology." The Phrenological Doctors employ the usual remedial measures, according to circumstances. They speak much and sensibly of the imperative necessity of proper *moral* management, and on it they rest the peculiar claims of the excellence of their practice. How far they are entitled to pre-eminence for their method of managing Maniacs on that ground, may be decided by a reference to medical authors, who wrote before the votaries of Phrenology applied its principles to the cure of diseases. The following passage from an Inaugural Dissertation, written before I had finished my medical studies, in the year 1812, speaks directly to this point: "Obtinuit olim opinio, mania laborantes, non nisi vinculis, plagis, carceribus terreri posse; quam diram curationem mens meminisse refugit, horum infelicitum multos occidisse. Effectus boni disciplinæ penitus penitusque diversæ, in felicitate, solatioque quibus miserandi frui videntur, in asylo illo admirabili Eboraci finitimo, facile perspiciuntur. Asylum ab Amicorum Societate, (Anglice, Quakers,) fundatum est, iique nomen indiderunt: in hac valle reducta opinionibus illius convenienter sectæ dignissimæ, moderatio maxima semper habita est. Quæque, mania laborantes ingenium in propatulo habere cogunt, magnopere laudanda, nisus enim primus cogitationis ad mentem sanam sæpisse perduxit. Ferriarus nos certiores fecit, medelam ab iis cogitationibus effectam, quibus medici aditus officiosi ortum dederant." (*a*) I take no credit to myself for the publication

(*a*) Ferriar's Medical Histories and Reflections.

of the views here developed in regard to the subject under consideration, as I merely adverted to the opinions and advice of others; but I maintain, that we have proof in the passage referred to, that the vital importance of proper *moral* treatment in Mania was understood and acted on before Phrenological Physicians were in existence.

Without any previous communication with Mr Craig, to whom I am scarcely personally known, I sent him a copy of the proof sheet, containing the matter included from page 129 to 142 of this work, with a note, proposing to insert any thing he might be disposed to add, which, *scientifically viewed*, bore on the question; or at least offering to take into consideration the propriety of doing so. On the following day I received the annexed communication from that gentleman:

"*Ludgate Lodge, 5th May* 1837.

"Many thanks for your attention.

"I have read your proof sheet, and if the following short statement throw any additional light on the subject, you are quite at liberty to use it.

"Let it be distinctly remembered, that the power of articulating language was the undisputed deprivation under which Mr N. for years laboured. If, therefore, Phrenology be true, as taught by Gall, Spurzheim, and Combe, one would naturally have expected to have found the *principal* seat of disease where they suppose the organ of language to be situated. Now, on the left side of the brain, in the middle lobe, a little behind the Pituitary gland, there was a small diseased appearance, in a pathological point of view, supposed by us to be of no consequence, which I was, at the time of the *post mortem* examination, led to believe was in the organ of Language. Mr Combe attached much importance to that at the time of the dissection; but, in his printed statement, he merely tells us that "this lesion was directly *in the line of the fibres* of the organ of Language."

"The great mass of disease in Mr N.'s brain was found where it seems Phrenologists place Combativeness. Mr Combe immediately endeavours to prove Mr N. to be extremely irritable; nay, is quite surprised that I did not pay a greater deference to his notes, written after he had seen the dissection, than to my own daily personal observations. He brings no evidence from any one who was in *immediate attendance* upon Mr N. to prove his views. Why did he not precognosce the overseer, the butler, the valet, the coachman, or the housekeeper? The assistant gardener, whose prospects were somewhat cramped by his master's illness, set off to America; and, after this Transatlantic trip, he is employed to write a letter, in which he gives a most perverted statement of an occurrence bearing a very different explanation, does not disprove a word of my statement, and who, when straw or leaves, which it was his duty to remove, were found on the walks, took guilt to himself, and, like the primitive tiller of the ground, "hid himself among the bushes."

"In opposition to Mr George Combe, W. S., I maintain the simple fact, that Mr N. never did shew the slightest irritability of temper, "except when he could not be understood, or when he came into contact with those upon whom (I had reason to know) he looked with displeasure; and, in the former case, he at first seemed surprised, then impatient, then dissatisfied, and finally irritable. In the latter case, his manner was first that of distant reserve, and then, I should say, lofty contempt rather than irritability. Indeed, I have seen many an example where his patience was sorely tried, yet he retained the perfect command of his temper. We never heard of Mr N.'s irritability of temper until *after Mr Combe had seen the dissection*. I made up my mind, in regard to the disputed point, from patient and protracted observation; he from rumour and second or third hand report. Believe me to be, my dear Sir, truly yours,

"JAMES CRAIG."

"*Dr Lewins*."

I have only further to add, that the remark made, page 140, in reference to my worthy friend Dr Mackintosh's letter, was merely from a perusal of it as given by Mr Combe, without any knowledge of the circumstances under which the former made his visits to Mr N. I have since received a perfectly satisfactory explanation of any impatience he may have manifested in Dr Mackintosh's presence. Mr N. had almost an insuperable objection to have direct intercourse with any one who had come in contact with persons labouring under cholera; and it is well known that Dr Mackintosh's professional zeal and philanthropy led him to do so to a greater extent than perhaps any man in the kingdom. (*a*)

(*a*) Dr Mackintosh, in a Memorial to The Right Honourable the Lord Provost, Magistrates and Council of the City of Edinburgh, when a candidate for the Chair of Pathology in the University, has given the following plain, and to him most creditable statement of facts in reference to his services during the cholera visitation:

"When the Cholera approached this City, your Memorialist gave a large proportion of his time to arrange an Hospital Establishment, and during the period that the disease prevailed, he visited the Drummond Street Hospital six or seven times daily, very frequently during the night, and he passed thirty complete nights in the Hospital. With few exceptions, each body after death was carefully examined, to ascertain the true character of the disease, and for the most part these pathological examinations were conducted with his own hands. Twice he was seriously injured by punctures, and on one of those occasions his life was in imminent danger: 280 bodies were examined. By thus devoting himself, without recompense or reward, to the relief of the poor, and to the advancement of Pathological Science, your Memorialist incurred not only a heavy pecuniary loss, but his health was for a considerable period materially injured."

THE END.

James Walker, Printer,
6. James's Court, Lawnmarket,
Edinburgh.