



# CAP2024

CURRENT AFFAIRS FOR PRELIMS

Crisp and Comprehensive Coverage of One Year Current Affairs for Prelims 2024

## Science & Technology



volume **01**

### KEY FEATURES OF CAP 2024

- Interactive classes with live doubt resolution by faculties.
- Comprehensive yet concise study material.
- Lectures that promote both conceptual clarity and interlinkage with Current Affairs.

## TABLE OF CONTENTS

<b>SPACE SCIENCE .....</b>	<b>HEALTH ISSUES .....</b>
Gravitational Waves (GWs)..... 1	Stem Cells..... 38
Space Governance..... 2	CAR T Cell..... 40
Voyager 2 Mission..... 4	Neglected Tropical Diseases (NTDs)..... 41
Black Hole..... 5	Vaccines..... 41
Pulsar Glitches..... 6	Bacteriophage..... 43
Rare Higgs Boson Decay..... 6	Sickle Cell Anemia..... 44
Euclid Space Telescope..... 8	WHO's GONE Initiative..... 44
Chandrayaan 3..... 9	Biosimilars..... 45
Einstein Cross..... 11	Bombay Blood Group..... 45
AGNIBAAN Suborbital Technological Demonstrated (SORTED)..... 12	Complete Sequence of Y Chromosome..... 45
Aditya L1 Mission..... 12	<b>MISCELLANEOUS.....</b>
High-Altitude Pseudo Satellite (HAPS) vehicle..... 15	Titan Submersibles..... 46
NASA's Perseverance Rover..... 16	SIGHT Programme..... 46
K2-18 b..... 17	Samudrayaan Mission..... 47
TOI-715 b..... 18	Li-Ion Battery (LIB)..... 48
Deep Space Optical Communications (DSOC)..... 18	Direct Methanol Fuel Cells (DMFCs)..... 49
Lucy Mission..... 19	Green Hydrogen Fuel Cells..... 50
International Space Station (ISS)..... 19	Project Taara..... 50
NASA's Atmospheric Waves Experiment (AWE)..... 20	XRISM Project..... 51
PACE Mission..... 20	Dark-Sky Reserve..... 51
Indian SPACE Policy 2023..... 21	India's First Indigenously Developed Nuclear Power Reactor..... 51
JUICE (JUperiter ICy moons Explorer) Mission..... 21	JT-60SA: Largest Nuclear Fusion Reactor..... 52
<b>EMERGING TECHNOLOGIES.....</b>	Nobel Prize in Physics 2023..... 53
DeepFakes..... 22	Nobel Prize in Medicine..... 53
Artificial Intelligence (AI)..... 23	Krutrim..... 54
Global Partnership on Artificial Intelligence (GPAI)..... 26	Codex Alimentarius Commission (CAC)..... 54
Wi-Fi 7 Technology..... 27	LK-99..... 55
Non Fungible Tokens (NFTs)..... 29	Dark Patterns..... 55
Nobel Prize in Chemistry..... 30	GM Mustard..... 56
5G and 6G Technology..... 32	Precision Fermentation..... 56
Radio Access Network (RAN)..... 34	Indian Science Congress..... 57
3D Printing..... 34	Radiocarbon Dating..... 57
e-SIM Card..... 35	Solar Geoengineering..... 58
Digital India RISC-V Microprocessor (DIR-V) Program..... 35	Operation AMRITH..... 58
Flex-Fuel Vehicles (FFVs) and FFV-SHEVs..... 35	Food Fortification..... 59
Brain-Computer Interface..... 36	Intellectual Property Rights (IPR)..... 60
NavIC System..... 37	

SPACE SCIENCE

GRAVITATIONAL WAVES (GWS)

About:

- These are the disturbances in the fabric of **space-time** caused by incredibly powerful and violent cosmic events.
- Albert Einstein, in his **general theory of relativity in 1916**, predicted the existence of gravitational waves, which are a consequence of massive accelerating objects, such as orbiting neutron stars or black holes.
  - ♦ According to Einstein's mathematical predictions, these objects disrupt space-time, creating undulating waves that propagate in all directions away from the source.
- These cosmic ripples move at the speed of light and carry valuable information about their origins, offering insights into the nature of gravity itself.
- In 2015, scientists detected gravitational waves for the very first time. They used a very sensitive instrument called **LIGO** (Laser Interferometer Gravitational-Wave Observatory).

- ♦ These first gravitational waves happened when two black holes crashed into one another.

NOTE

- **High Frequency Gravitational waves:** It originates from compact pairs of black holes swiftly orbiting each other just before their collision.
- **Lower-frequency Gravitational waves:** are believed to stem from massive black holes situated at the centers of galaxies, with sizes up to billions of times that of our sun.
- These colossal black holes move gradually and require millions of years before eventually merging.

What Causes GWs?

- The most powerful gravitational waves are created when objects move at very high speeds. Some examples of events that could cause a gravitational wave are:
  - ♦ when a star explodes asymmetrically (called a supernova)
  - ♦ when two big stars orbit each other
  - ♦ when two black holes orbit each other and merge

Scientists 'hear' universe's background hum

Researchers across the world have discovered the first evidence of a long-theorised form of gravitational waves that create a 'background hum' rumbling throughout the universe – giving first direct evidence of black holes distorting space-time.

What is the breakthrough?

Scientists said they had finally found evidence that gravitational waves, the ripples in the fabric of space-time which were predicted by Albert Einstein more than a century ago, are permeating the universe at low frequencies. They said they have been able to record shock waves from supermassive black holes at the centre of young galaxies.

The leading theory is that the waves are coming from pairs of **supermassive black holes** sitting at the centre of galaxies that are slowly merging.

Unlike those that caused the previously detected gravitational waves, these black holes are almost unimaginably huge – sometimes billions of times bigger than the Sun.

The breakthrough was hailed as a major milestone that opens a new window into the universe.

HOW THEY DID IT: USING DEAD STARS AS CLOCKS

The discovery was made by hundreds of scientists using radio telescopes in North America, Europe, China, India and Australia joining forces under the banner of the International Pulsar Timing Array consortium.

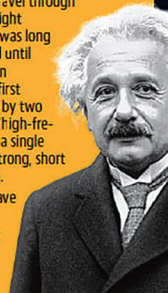
As gravitational waves travel through space, they very subtly squeeze and stretch everything they pass through. To find evidence of this squeezing and stretching at low frequencies, astronomers looked at pulsars, the dead cores of stars that exploded in a supernova.

Radio telescopes around the world were aimed at a total of 115 pulsars throughout the Milky Way. Scientists then measured the incredibly small differences in the timing of the pulses, searching for telltale signs of gravitational waves.

Pulsars are rapidly rotating stars that blast out pulses of radiation at extremely precise intervals, practically acting like cosmic lighthouses. This means they can be used as a very, very precise clock.

Why the findings are important

First predicted by Albert Einstein more than a century ago, gravitational waves are ripples in the fabric of the universe that travel through everything at the speed of light unimpeded. Their existence was long theorised but not confirmed until 2015, when the US and Italian observatories detected the first gravitational waves created by two black holes colliding. These "high-frequency" waves were due to a single violent event that sends a strong, short burst rippling towards Earth. But for decades scientists have been searching for low-frequency gravitational waves, thought to be constantly rolling through space like background noise.



"We now know that the universe is awash with gravitational waves," Michael Keith of the European Pulsar Timing Array told AFP. "The background hum of all these black holes is like sitting in a noisy restaurant and hearing all these people talking."

### LIGO:

- LIGO stands for "Laser Interferometer Gravitational-wave Observatory".
- It is the world's largest gravitational wave observatory and a marvel of precision engineering.
- **About Interferometer**
  - ♦ Interferometers are investigative tools used in many fields of science and engineering.
  - ♦ Pioneered in the mid- to late-1800s, they are called interferometers because they work by merging sources of light to create an interference pattern, which can be measured and analyzed: hence 'Interfere-meter', or interferometer.
- Comprising two enormous laser interferometers located 3000 kilometers apart, LIGO exploits the physical properties of light and of space itself to detect and understand the origins of Gravitational Waves (GW).
- LIGO is not the only gravitational wave observatory in the world.
  - ♦ While LIGO's two detectors constitute a mini internal collaboration between LIGO Livingston Observatory (LLO) and LIGO Hanford Observatory (LHO),
  - ♦ There is an even larger gravitational wave observatory collaboration exists between LIGO and other detectors and researchers around

the world, including **Virgo** in Italy and **KAGRA** in Japan.

- ♦ **LIGO-India:** A Planned Joint India-US Detector Describes the proposed LIGO-India project

### LIGO India:

- LIGO-India is a high-tech observatory for gravitational waves planned to be in Hingoli district of Maharashtra as part of a global network.
- It's a teamwork project involving Indian research institutions and the LIGO Laboratory in the USA, along with international partners.
- **Built by:** The Department of Atomic Energy and the Department of Science and Technology.

### Benefits of Detection of GWs:

- **Probing Cosmic Events:** Gravitational waves unveil violent celestial phenomena, offering unique insights into black holes, neutron stars, and mergers.
- **Fundamental Physics:** Detection confirms Einstein's predictions, advancing our understanding of gravity, space-time, and the universe's fundamental principles.
- **New Observations:** Gravitational wave observations provide a novel tool for studying the cosmos, expanding our observational capabilities beyond traditional electromagnetic methods.

### OBSERVATORIES FOR GRAVITATIONAL WAVES IN SPACE

LISA Pathfinder	LISA (Laser Interferometer Space Antenna)	Evolved LISA
Launched to test technology for future gravitational wave detection missions with a space-based observatory.	A space-based observatory building on the success of LISA Pathfinder and LIGO.	A mission aimed at exploring the Gravitational Universe from space for the first time.
European Space Agency (ESA)-led mission. It involves European space companies and research institutes from France, Germany, Italy, Switzerland, UK and the US space agency NASA etc.	Led by ESA, NASA, and an international consortium of scientists.	It involves scientists from eight European countries: Denmark, France, Germany, Italy, etc.

### SPACE GOVERNANCE

- A policy brief titled "**For All Humanity — The Future of Outer Space Governance**" has been recently issued by the **United Nations (UN)**.
  - ♦ The policy brief scrutinizes developments in outer space, such as space tourism and militarization, providing an evaluation of the sustainability,

safety, and security implications arising from these changes, attributed to gaps in the current regulatory framework.

### Existing Space Governance Framework

- In 1958, the **United Nations General Assembly formed the Committee on the Peaceful Uses of Outer Space (UN COPUOS)** to regulate space exploration for the benefit

of humanity. The **UN Office for Outer Space Affairs (UNOOSA)** supports its work. This collaboration resulted in five international space treaties:

- **Outer Space Treaty (1967):** Governs the activities of states in exploring and using outer space, including the Moon and other celestial bodies.
- **Rescue Agreement (1968):** Deals with the rescue and return of astronauts and objects launched into outer space.
- **Liability Convention (1972):** Addresses international liability for damage caused by space objects.
- **Registration Convention (1976):** Focuses on the registration of objects launched into outer space.
- **Moon Agreement (1979):** Governs the activities of states on the Moon and other celestial bodies.

#### NOTE

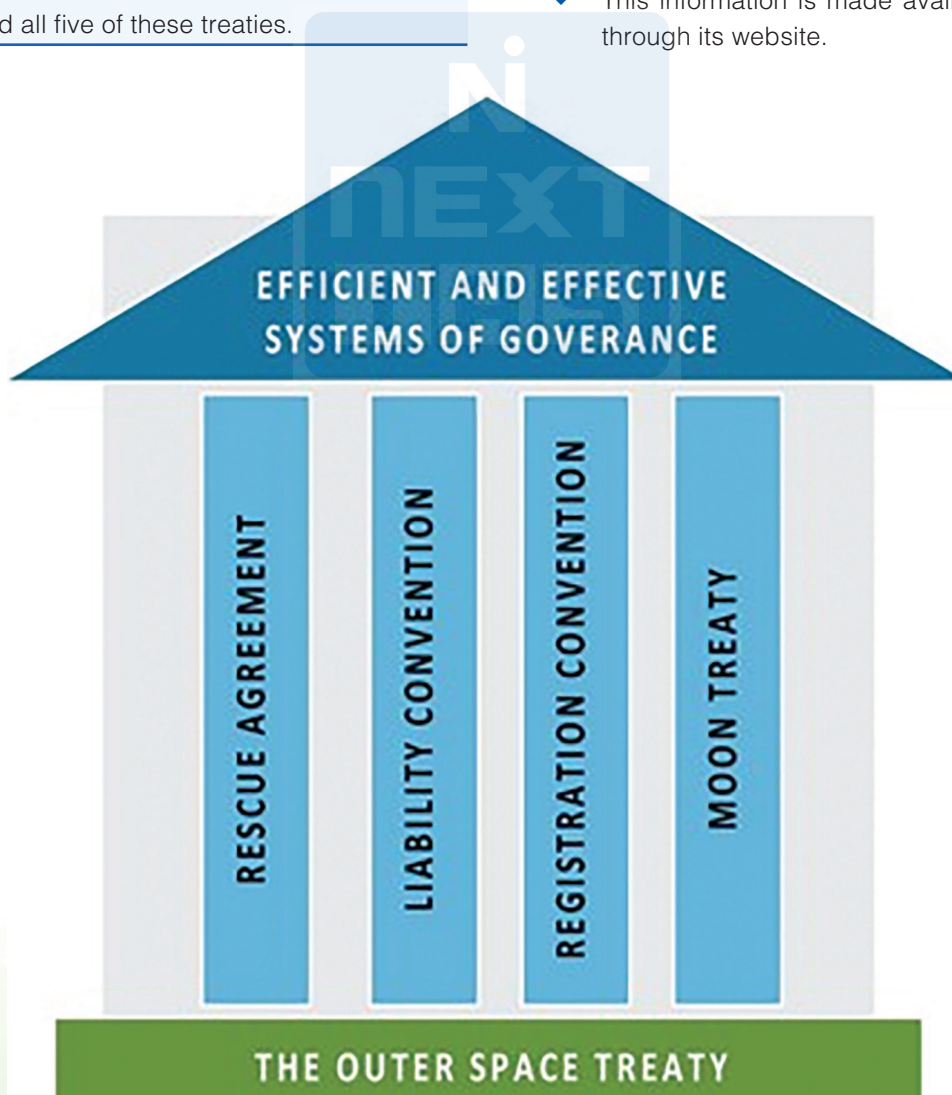
India has signed all five of these treaties.

#### UN Office for Outer Space Affairs (UNOOSA)

- It is in charge of encouraging global cooperation for peaceful space activities.
  - ♦ It serves as the secretariat for the UN General Assembly's Committee on the Peaceful Uses of Outer Space.
- **Members :** 102 including **India**.

#### Main Functions:

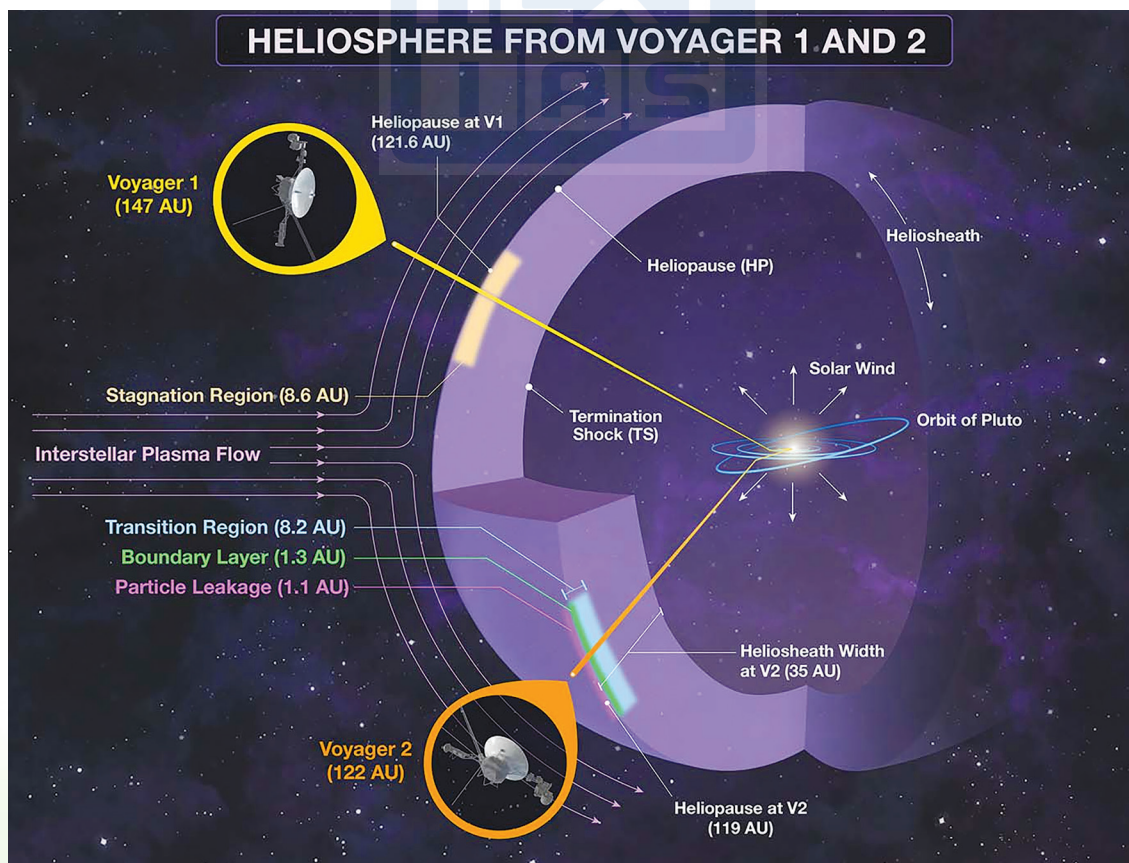
- It carries out the United Nations Programme on Space Applications (PSA), organizing training sessions, workshops, and other events related to space applications.
- UNOOSA manages the Register of Objects Launched into Outer Space on behalf of the UN Secretary-General.
  - ♦ This information is made available to the public through its website.



## VOYAGER 2 MISSION

NASA reestablished communication with its Voyager 2 spacecraft after a communication loss that lasted over a week.

COMPARISON		
Feature	Voyager 1	Voyager 2
Launch Date	September 5, 1977	August 20, 1977
Current Location	Voyager 1 achieved a historic milestone in 2012 by crossing the heliopause, marking its entry into interstellar space as the first human-made object to do so. Exploring Interstellar Space	Exploring Interstellar Space
Primary Mission	Exploration of Jupiter and Saturn	Exploration of Jupiter and Saturn
Extended Mission	Yes, extended after Jupiter-Saturn exploration	Yes, extended to Uranus and Neptune after Jupiter-Saturn exploration
Outer Planets Explored	Jupiter, Saturn	Jupiter, Saturn, Uranus, Neptune
Notable Discoveries	Active volcanoes on Jupiter's moon Io, intricacies of Saturn's rings	Detailed exploration of Uranus and Neptune, only spacecraft to visit these planets
Current Mission	Voyager Interstellar Mission (VIM), exploring the outermost edge of the Sun's domain and beyond	Voyager Interstellar Mission (VIM), exploring the outermost edge of the Sun's domain and beyond



## BLACK HOLE

### About

- It is an astronomical object with a gravitational pull so strong that nothing, not even light, can escape it.
- Black holes are invisible to the naked eye because light cannot escape from them. However, specialized tools on space telescopes can aid in the detection and identification of black holes.

### STRUCTURE OF BLACK HOLES:

- **Singularity:**

The point where whole mass of a black hole is concentrated.

- **Photon Sphere:**

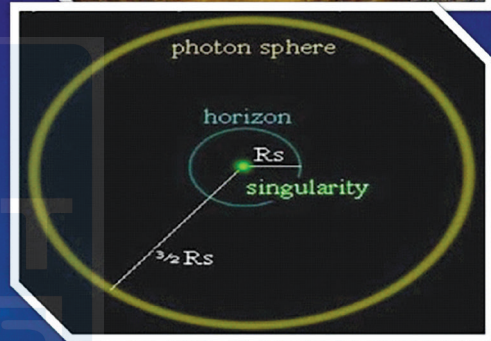
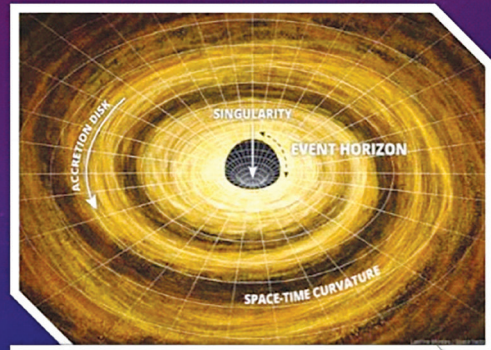
The outer edge where light bends but is still escapable.

- **Event Horizon:**

It is a “point of no return” around a black hole.

- **Accretion Disk:**

It is a disk of gases, dust, stars and planets that fall into the orbit of a black hole.



Types of Black Holes	Formation	Mass Range
<b>Primordial Black Holes</b>	Formed in the first second after the birth of the universe.	Masses ranging from 100,000 times less than a paperclip to 100,000 times more than the Sun's.
<b>Stellar Black Holes</b>	Formed when the center of a very big star falls upon itself or collapses, causing a supernova.	Mass up to 20 times more than the Sun.
<b>Intermediate Black Holes</b>	It Ranges from around one hundred to hundreds of thousands of times the Sun's mass.	It Ranges from around one hundred to hundreds of thousands of times the Sun's mass.
<b>Supermassive Black Holes</b>	Almost every large galaxy, including our Milky Way (Sagittarius A* black hole), has a supermassive black hole at its center.	Mass more than 1 million suns together.

Space Agency	Mission	Objective
NASA	Event Horizon Telescope	Capture images and study the environment around black holes to understand their structure and behavior.
NASA	Chandra X-ray Observatory	Focus on X-ray astronomy, studying high-energy phenomena including black holes.
ESA (European Space Agency)	Euclid Mission	Investigate dark energy, dark matter, and galaxy distribution, including those with black holes.

NASA/European Space Agency(ESA)	Hubble Space Telescope	Observe black holes in various wavelengths, contributing to the understanding of their properties.
NASA, ESA and Canadian Space Agency(CSA)	James Webb Space Telescope (JWST)	It is an ambitious astronomical observatory designed to be the successor to the Hubble Space Telescope. To be the premier observatory of the next decade, studying various phases in the history of the Universe.
ISRO	XPOSat (X-ray Polarimeter Satellite)	Its objective is to decipher complex emission processes from astronomical sources like black holes, neutron stars, and pulsar wind nebulae.

### WORMHOLES

- A wormhole is like a tunnel between two distant points in our universe that cuts the travel time from one point to the other.
- Instead of traveling for many millions of years from one galaxy to another, under the right conditions one could theoretically use a wormhole to cut the travel time down to hours or minutes.

- This process results in the creation of a neutron star, an entity characterized by its extreme density and powerful gravitational pull, approximately **200 billion** times stronger than Earth's gravity.
- During the collapse, the star's angular momentum is conserved, leading to a significant increase in its rotational speed as it shrinks in size.

### PULSAR GLITCHES

#### About:

- **Pulsar Glitches**, characterized by abrupt changes in rotation rate of pulsar followed by gradual relaxation, introduced a new layer of complexity to pulsar dynamics.
- Pulsars are a **type of rapidly rotation neutron star** emitting beams of radiation at intervals that can range from a few milliseconds to several seconds.
- These celestial bodies possess immensely strong magnetic fields, which direct charged particles to move along the magnetic poles at near-light speeds, resulting in the emission of two intense beams of light from the poles.

### FORMATION OF PULSARS

- Pulsars originate from the remnants of massive stars, typically those with **1.4 to 3.2 times the mass of the Sun**. These stars undergo a supernova explosion once they deplete their nuclear fuel.
- This catastrophic event ejects the star's outer layers into space, while the core contracts under the force of gravity.
- The intense gravitational pressure of the contracting core forces electrons and protons to merge, forming neutrons.

### RARE HIGGS BOSON DECAY

Researchers at CERN, home to the Large Hadron Collider, are examining the Higgs boson's properties to validate the Standard Model. They've found indications of the Higgs boson decaying into a Z boson and a photon.

#### About

- **The God particle**, formally known as the Higgs boson, was initially theorized in the 1960s by physicist Peter Higgs.
- Its existence was confirmed in 2012 through experiments at CERN's LHC.
- The Higgs boson is among the 17 elementary particles constituting the Standard Model of particle physics, representing scientists' most **comprehensive theory regarding the behaviors of the fundamental building blocks that compose the universe**.
- **Characteristics:**
  - ♦ The Higgs boson possesses a **mass of 125 billion electron volts**, making it 130 times more massive than a proton.
  - ♦ It lacks charge, exhibiting **zero spin**.
  - ♦ Its lifespan is extremely brief, it swiftly undergoes decay into other particles following its creation in high-energy collisions. Detection involves indirect observation through the examination of the particles resulting from its decay.



**LARGE HADRON COLLIDER (LHC)**

- The Large Hadron Collider (LHC), established in **2008** at CERN near Geneva, is the world's largest and most potent particle accelerator.
- Comprising a **27-kilometer ring of superconducting magnets**, it accelerates particle energy.
- Traveling near the speed of light, particle beams collide within the LHC, enabling the recreation of conditions present within a billionth of a second after the Big Bang.

**EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)**

- CERN is the **world's largest nuclear and particle physics laboratory**.
- It is situated in the North West suburbs of Geneva on the **France-Swiss Border**.
- Established in **1954**, CERN boasts 23 member states. India holds associate membership.
- **Function:** CERN, operating the world's largest particle physics laboratory, primarily facilitates high-energy physics research by providing essential infrastructure such as particle accelerators.

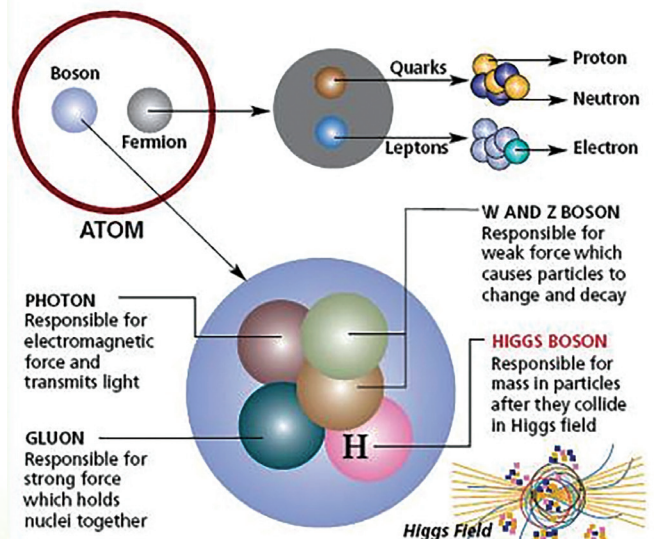
Fundamental Force	Description
Strong Force	The force responsible for holding the nuclei of atoms together. It acts between quarks and gluons, making it the strongest of the four fundamental forces but operates over a very short range.
Electromagnetic Force	Governs the interactions between charged particles. It's responsible for the forces between electrons and protons as well as the behavior of electromagnets, and it has an infinite range but decreases in strength with distance.
Weak Force	A force that is responsible for radioactive decay and certain other processes that occur at the level of subatomic particles. It has a very short range and is weaker than the strong and electromagnetic forces.
Gravitational Force	The force of attraction between all masses in the universe. It has an infinite range but is the weakest of the fundamental forces, noticeable only when at least one mass is very large.

**Standard Model of Physics**

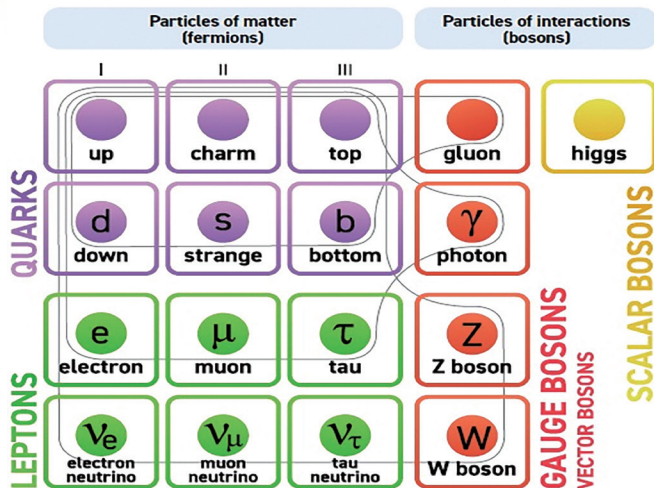
- It is the theory of particles, fields and the fundamental forces that govern them.
- It tells about how families of elementary particles group together to form larger composite particles, how one particle can interact with another, and how particles respond to the fundamental forces of nature.
- The Standard Model describes the behavior of **six types of quarks, six types of leptons, three fundamental forces** (Strong force, electromagnetic force & weak force) and their four associated particles, plus the Higgs boson.
  - ♦ There are four fundamental forces in nature: Strong force, electromagnetic force, weak force and gravitational force.
  - ♦ Quarks and gluons are the **building blocks of protons and neutrons**, which in turn are the building blocks of atomic nuclei. Scientists' current understanding is that quarks and gluons are indivisible—they cannot be broken down into smaller components.

**PARTICLE PHYSICS BASICS**

*How fermions and bosons make up atoms and how they acquire mass*



## Standard Model of Elementary Particles



### MEANING OF BASIC TERMS

- **Fermions:**
  - ♦ These are the building blocks of matter and include both quarks and leptons. They obey Fermi-Dirac statistics and adhere to the Pauli Exclusion Principle, which states that no two fermions can occupy the same quantum state simultaneously.
  - ♦ Quarks combine to form protons and neutrons in atomic nuclei, while leptons, such as electrons and neutrinos, are involved in various fundamental processes.
- **Bosons:**
  - ♦ Bosons are force carriers, mediating interactions between particles. Unlike fermions, they follow Bose-Einstein statistics and do not adhere to the Pauli Exclusion Principle.
  - ♦ The Higgs boson, for instance, imparts mass to other particles, while gauge bosons, like photons and W/Z bosons, are responsible for electromagnetic and weak nuclear forces.
- **Leptons:**
  - ♦ Leptons are a type of fermion that includes particles like electrons, muons, and tau particles, along with their associated neutrinos.
  - ♦ Leptons are not subject to the strong nuclear force and primarily interact through electromagnetism and the weak nuclear force. Electrons, for example, are crucial for chemical processes, forming the basis of electricity and magnetism.

- **Quarks:**
  - ♦ Quarks are another type of fermion, combining to form composite particles called hadrons, like protons and neutrons.
  - ♦ Quarks experience the strong nuclear force, mediated by gluons.
  - ♦ They come in six "flavors": up, down, charm, strange, top, and bottom. Quarks are never found in isolation due to confinement, always existing in groups to form stable particles.
- **Gluons:**
  - ♦ These are elementary particles that play a crucial role in the strong nuclear force, one of the four fundamental forces of nature.
  - ♦ As force carriers, gluons are responsible for mediating the interactions between quarks, which are the building blocks of protons and neutrons in atomic nuclei.

## EUCLID SPACE TELESCOPE

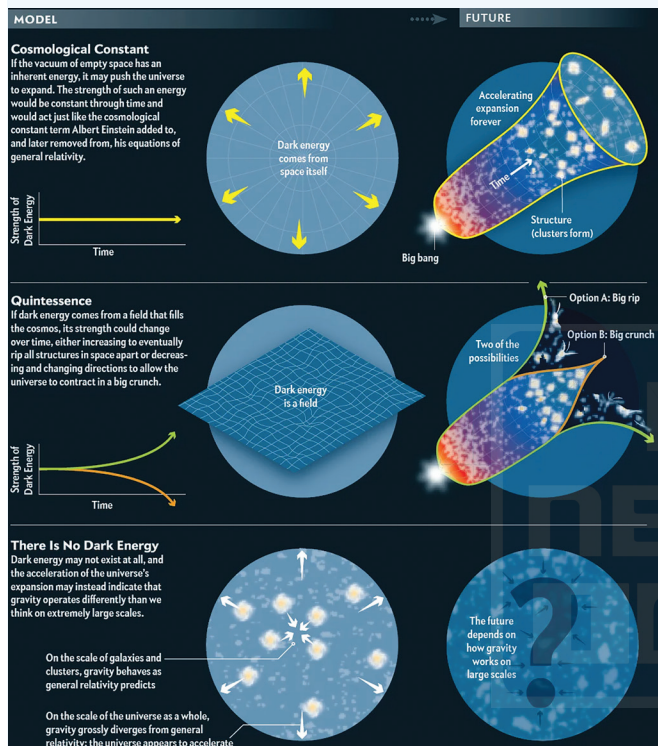
### About

- **Launched by:** European Space Agency's (ESA)
- **Objectives:**
  - ♦ Its primary focus on dark energy and dark matter, aims to provide essential insights into the fundamental forces steering the universe's expansion.
  - ♦ Through precise measurements of galaxy shapes and redshifts, Euclid will unveil the distribution and evolution of dark matter.
  - ♦ Its mission contributes significantly to our understanding of cosmic structures, particularly in the realm of dark matter distribution.

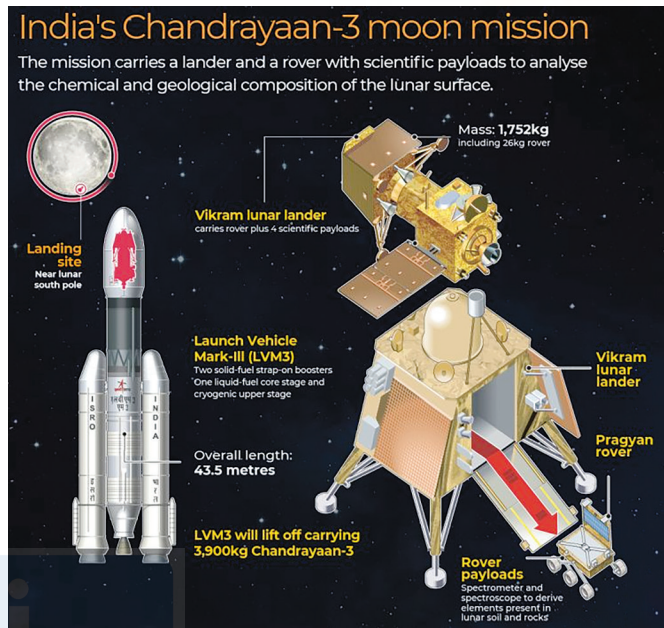
### DARK MATTER AND DARK ENERGY

- The content of the Universe is widely thought to consist of **three types of substance: normal matter, dark matter and dark energy.**
- Roughly **68% of the universe is dark energy. Dark matter** makes up about **27%**. The rest – everything on Earth ever observed adds up to **less than 5% of the universe.**
- **Dark Matter:** Unlike normal matter, dark matter **does not interact with the electromagnetic force.** This means it does not absorb, reflect or emit light, making it extremely hard to spot.

- Dark matter works like an **attractive force** — a kind of cosmic cement that **holds the universe together**. This is because dark matter **does interact with gravity**.
- Dark Energy:** Dark energy is a **repulsive force** — a sort of anti-gravity — that **drives the universe's ever-accelerating expansion**. Dark energy is the far more dominant force than Dark matter.



- To demonstrate Rover roving on the moon and to conduct in-situ scientific experiments.



Lander Payloads	Objectives
Radio Anatomy of Moon Bound Hypersensitive ionosphere and Atmosphere (RAMBHA) - Langmuir Probe (LP)	To measure the near surface plasma (ions and electrons) density and its changes with time
Chandra's Surface Thermo physical Experiment (ChaSTE)	To carry out the measurements of thermal properties of lunar surface near polar region
Instrument for Lunar Seismic Activity (ILSA)	To measure seismicity around the landing site and delineating the structure of the lunar crust and mantle
LASER Retroreflector Array (LRA)	It is a passive experiment to understand the dynamics of the Moon system

Rover Payloads	Objectives
LASER Induced Breakdown Spectroscopy (LIBS)	Qualitative and quantitative elemental analysis. To derive the chemical composition and infer mineralogical composition to further our understanding of Lunar-surface.

## CHANDRAYAAN 3

### About:

- Chandrayaan-3 is a follow-on mission to Chandrayaan-2 to demonstrate end-to-end capability in safe landing and roving on the lunar surface.
- It consists of **Lander and Rover configuration**. The Geosynchronous Satellite Launch Vehicle Mk III deployed the integrated module into an **Elliptic Parking Orbit (EPO)**.
- Chandrayaan-3's** landing point on the Moon will be called '**Shiv Shakti**'. Also, the point where Chandrayaan-2 crash-landed on the lunar surface in 2019 will be named '**Tiranga**'.
- The mission objectives of Chandrayaan-3 are:**
  - To demonstrate Safe and Soft Landing on the Lunar Surface.

Alpha Particle X-ray Spectrometer (APXS)	To determine the elemental composition (Mg, Al, Si, K, Ca, Ti, Fe) of Lunar soil and rocks around the lunar landing site.
<b>Propulsion Module Payload</b>	<b>Objectives</b>
Spectro-polarimetry of HAbitable Planet Earth (SHAPE)	Future discoveries of smaller planets in reflected light would allow us to probe into a variety of Exo-planets, assessing their habitability or the potential presence of life.
<b>Propulsion Module Payload</b>	<b>Objectives</b>
Spectro-polarimetry of HAbitable Planet Earth (SHAPE)	Future discoveries of smaller planets in reflected light would allow us to probe into a variety of Exo-planets, assessing their habitability or the potential presence of life.

### Significance of South Pole

- **Preservation of Lunar History:** Craters at the Moon's south pole remain untouched by sunlight for billions of years, providing an undisturbed record of the solar system's origins.
- **Water Resources:** Permanently shadowed craters in this region are believed to contain significant water reserves, potentially valuable for future missions.
- **Strategic Pit Stop:** The south pole's strategic position makes it an ideal pit stop for upcoming space exploration endeavors.
- **Diverse Resource Potential:** Traces of hydrogen, ammonia, methane, sodium, mercury, and silver in the region present an untapped source of essential resources.

### EJECTA HALO

- **Context:** The ejecta halo phenomenon was observed around the **Chandrayaan-3 mission's Vikram lander** near the moon's south pole.

- **About:**
  - ♦ **Formation:** This feature was created during the descent and landing phase of the mission.
    - The activation of descent stage thrusters caused the ejection and displacement of lunar surface material, known as **epi regolith**.
  - ♦ **Characteristics:** Characterized as an irregular, bright halo around the landing site, it resulted from the reflectance anomaly caused by the displaced lunar material.
  - ♦ **Scale of Displacement:** Approximately 2.06 tonnes of lunar epi regolith were displaced, covering an area of 108.4 square meters around the lander.
- **Understanding Regolith and Epiregolith:**
  - ♦ **Regolith:** Regolith is a layer of unconsolidated, heterogeneous debris covering solid rock.
    - ♦ It encompasses a variety of materials, including dust, soil, broken rock, and other related materials.
  - ♦ **Epiregolith:** Specifically on the moon, the term epiregolith refers to the upper layer of lunar regolith, essentially constituting lunar soil and rock, colloquially known as moon dust.

### ABOUT MOON

- The Moon, Earth's sole natural satellite, lacks an atmosphere.
- Its orbital period matches Earth's rotational period, causing one side, the "**near side**," to consistently face Earth, while the opposite "**far side**" remains hidden. This phenomenon, termed "**tidal locking**" or "**synchronous rotation**," results from prolonged gravitational interaction between the Earth and the Moon, gradually slowing the Moon's rotation over billions of years.

Recent Lunar Missions

MISSION NAME	LAUNCHED BY	OBJECTIVE
Chang'e 4	China (CNSA)	First spacecraft to soft land on the far side of the Moon (South Pole–Aitken basin). Conducted a biological experiment where cotton seeds sprouted on the Moon.
CAPSTONE	United States (NASA)	Lunar orbiting CubeSat testing and verifying the calculated orbital stability planned for the Gateway space station.
Danuri (also known as the Korean Pathfinder Lunar Orbiter or KPLO)	South Korea (KARI)	Lunar Orbiter by the Korea Aerospace Research Institute (KARI) of South Korea. Technology demonstrator surveying lunar resources and producing a topographic map for future lunar landing sites.
Artemis 1	United States (NASA)	Uncrewed test of Orion spacecraft in lunar flyby and lunar Distant retrograde orbit.
Luna 25	Russia (Roscosmos)	failed orbital maneuver in 2023.
Hakuto-R Mission	Japan (ispace)	Lunar lander technology demonstration with a failed landing due to a software bug.
SLIM (Smart Lander for Investigating Moon)	Japan (JAXA)	Lunar lander (Hopper) and rover technology demonstration . Lunar swing-by, lunar orbital phase, and a pin-pointed landing was successful in jan 2024.
LUPEX( Lunar Polar Exploration Mission)	ISRO and JAXA	The mission would send an uncrewed lunar lander and rover to explore the south pole region of the Moon in 2026. JAXA is likely to provide the under-development H3 launch vehicle and the rover, while ISRO would be providing the lander.



EINSTEIN CROSS

A recent discovery where a galaxy about 6 billion light-years away is acting as a lens, magnifying a more distant galaxy over 11 billion light-years away revealed a rare "Einstein cross," a phenomenon predicted by Einstein in 1915.

About

- According to his **Theory of General Relativity**, massive objects in space bend space-time.
  - ♦ Einstein's description of gravity differs from the traditional concept of a force. Instead, it views gravity as the outcome of the curvature of space-time induced by the presence of matter and energy.
  - ♦ In regions where space-time is intensely curved, such as those surrounding massive galaxies, light undergoes bending, resulting in the formation of a halo.

- In the instance of the recently identified Einstein cross, the alignment of the **observer (Earth), the lensing galaxy (foreground elliptical), and the background quasar** is such that it precisely replicates the light emitted by the **quasar**.
  - ♦ A **quasar**, also referred to as a quasi-stellar object, is an exceptionally bright **active galactic nucleus (AGN)**. It features a supermassive black hole, with a mass ranging from millions to billions of times that of the Sun, encircled by a gaseous accretion disk.
- **Einstein Cross:** It occurs when a massive galaxy aligns with a distant object, bending its light and creating a duplicated image along an Einstein ring (produced when two galaxies are almost perfectly aligned, one behind the other).
  - ♦ This alignment is rare and requires precise conditions, known as "**strong gravitational lensing**."
- Gravitational lensing happens throughout the universe, but creating an Einstein Cross needs a specific alignment of the lensing body and light source.
  - ♦ **Gravitational lensing** occurs when a massive celestial body, like a galaxy cluster, bends light, acting as a lens. This phenomenon allows us to observe objects that would otherwise be too faint or distant to see.

## AGNIBAAN SUBORBITAL TECHNOLOGICAL DEMONSTRATED (SORTED)

### About

- Agnibaan SOrTeD, a **single-stage launch vehicle** propelled by AgniKul's patented Agnilet engine, boasts a fully 3D-printed, single-piece, 6-kilonewton (kN) semi-cryogenic engine.
- Diverging from conventional sounding rockets launched from guide rails, Agnibaan SOrTeD will ascend vertically, adhering to a predetermined trajectory to execute a precisely orchestrated sequence of maneuvers in-flight.

### Key Features:

- Customizable as a one or two-stage launch vehicle.
- Stands at a height of 18 meters and weighs 14,000 kg.
- Capable of carrying payloads up to 100 kg to an altitude of 700 km in five different configurations.
- The rocket's first stage may incorporate up to seven Agnilet engines, fueled by Liquid Oxygen and Kerosene, depending on the mission.

### 3D PRINTING

- It is also referred to as **additive manufacturing**, is a process that utilizes materials like plastics and metals to transform digital designs into tangible three-dimensional objects.
- In contrast to **subtractive manufacturing**, which involves cutting or hollowing out materials using tools like milling machines, 3D printing builds up layers to create the final product.

## ADITYA L1 MISSION

- Recently, the Indian Space Research Organisation (ISRO) achieved the successful launch of Aditya-L1, marking its inaugural Solar Mission.
- The launch utilized the **PSLV-C57 rocket**, and notably, ISRO made history by firing the PSLV's fourth stage twice to precisely position the spacecraft into its elliptical orbit.

### About:

- Aditya-L1 stands as India's **first space-based observatory-class solar mission**, designed to study the Sun from a significant distance of 1.5 million kilometers.
- This is ISRO's second astronomy observatory-class mission after **AstroSat (2015)**.
- The spacecraft is planned to be stationed in a halo orbit around Lagrangian point 1 (L1) within the Sun-Earth system.

### The seven payloads:

- **The Visible Emission Line Coronagraph (VELC)** will study the Corona, imaging and spectroscopy, and Coronal mass ejections.
- **The Solar Ultraviolet Imaging Telescope (SUIT)** will focus upon the Photosphere and Chromosphere imaging- narrow and broadband. It will also measure the solar irradiance variations.
- **The Solar Low Energy X-ray Spectrometer (SoLEXS)** and **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)** will study the soft and hard X-ray flares from the Sun over a wide X-ray energy range.
- **The Aditya Solar wind Particle Experiment (ASPEX)** and **Plasma Analyser Package For Aditya (PAPA)** will analyze the electrons and protons in the Solar wind or particles. It will also study the energetic ions.

- The **Advanced Tri-axial High Resolution Digital Magnetometers** will study the interplanetary magnetic field at L1 point.

**Objective:**

- The primary goal of Aditya-L1 is to provide crucial insights into the solar corona, photosphere, chromosphere, and solar wind.
- It aims to deepen our understanding of the Sun's behavior, encompassing aspects such as radiation, heat, particle flow, and magnetic fields, and their impact on Earth.

**ABOUT LAGRANGE POINTS**

- Lagrange Points are positions in space where the gravitational forces of a two body system like the Sun and the Earth produce enhanced regions of attraction and repulsion. These can be used by spacecraft to reduce fuel consumption needed to remain in position.
  - ♦ At Lagrange points, the gravitational pull of two large masses precisely equals the centripetal force required for a small object to move with them.
  - ♦ These points in space can be used by spacecraft to reduce fuel consumption needed to remain in position.
- **L1 (Lagrange Point 1):**
  - ♦ Located along the line connecting the two large bodies and closer to the smaller mass.
  - ♦ In the Sun-Earth system, L1 is positioned between the Earth and the Sun.
  - ♦ Objects placed at L1 experience gravitational forces from both the Earth and the Sun that balance out, allowing them to stay relatively stable in that position.
  - ♦ Ideal for solar observations, as satellites stationed at L1 can continuously observe the Sun without being eclipsed by the Earth.
- **L2 (Lagrange Point 2):**
  - ♦ Also located along the line connecting the two large bodies but on the opposite side of the smaller mass.
  - ♦ In the Sun-Earth system, L2 is positioned beyond the Earth from the perspective of the Sun.
  - ♦ Objects at L2 maintain a stable position relative to the Earth and the Sun, making it suitable for space observatories observing the broader universe without interference from the Earth's shadow.

- **L3 (Lagrange Point 3):**
  - ♦ Positioned opposite the smaller mass, beyond the larger mass in its orbit.
  - ♦ In the Sun-Earth system, L3 is located on the opposite side of the Sun from the Earth.
  - ♦ Offers potential observations of the far side of the Sun but is generally less practical for spacecraft due to the challenges associated with maintaining stability in this region.
- **L4 and L5 (Lagrange Points 4 and 5):**
  - ♦ Form an equilateral triangle with the two larger masses, maintaining stable positions.
  - ♦ In the Sun-Earth system, L4 and L5 are located at 60-degree angles ahead of and behind the Earth in its orbit.
  - ♦ Often used for space observatories, such as those studying asteroids, as objects at these points can orbit in a stable pattern amid the two larger masses.

**LUNCH VEHICLES OF ISRO**

Vehicle	Height	Lift-off weight	Propulsion	Payload mass	Orbit
SLV-3	:22.7m	:17 t	: All Solid	:40 kg	: Low Earth Orbit
ASLV	:23.5m	:39 t	: All Solid	:150 kg	: Low Earth Orbit
PSLV-XL	:44m	:320 t	: Solid & Liquid	:1860 kg	: 475 km Sun Synchronous Polar Orbit (1300 kg in Geosynchronous Transfer Orbit)
PSLV Mk II	:49m	:414 t	: Solid, Liquid & Cryogenic	:2200 kg	: Geosynchronous Transfer Orbit
GSLV Mk III	:43.43 m	:640 t	: Solid, Liquid & Cryogenic	:4000 kg	: Geosynchronous Transfer Orbit

Mission/ Observatory Name	Associated Organization	Objective
Parker Solar Probe	NASA	Investigate the outer corona of the Sun, understand solar wind acceleration, and explore the Sun's magnetic fields.
Solar Orbiter	ESA and NASA	Examine the Sun's polar regions, study solar wind, observe the Sun's heliosphere, and gain a comprehensive understanding of solar processes.
SOHO (Solar and Heliospheric Observatory)	NASA and ESA	Observe the Sun, particularly its outer atmosphere, and monitor solar activities to better understand solar phenomena and their effects on Earth.
Hinode's Solar Optical Telescope	JAXA (Japan Aerospace Exploration Agency)	It is the first space-borne instrument to measure the strength and direction of the Sun's magnetic field on the Sun's surface, the photosphere.
STEREO (Solar Terrestrial Relations Observatory)	NASA	Provide 3D views of the Sun, study solar eruptions, and enhance our understanding of solar phenomena's impact on space weather.
SDO (Solar Dynamics Observatory)	NASA	Monitor the Sun's magnetic fields, observe solar activities, and study the Sun's influence on Earth's space environment.
GONG (Global Oscillation Network Group)	National Solar Observatory (NSO)	It is a worldwide network of six identical telescopes, designed to have 24/7 observations of the Sun. The network serves multiple purposes, including the provision of operation data for use in space weather prediction, and the study of solar internal structure and dynamics.
TRACE (Transition Region and Coronal Explorer)	NASA	Focus on the Sun's transition region and corona, capturing high-resolution images to understand the processes driving solar heating and eruptions.

### About Sun

- The Sun contains the same basic elements that we find on Earth, but in vastly different quantities than what we see around us.
- The Sun contains about **92% hydrogen and 8% helium**, with just a tiny bit of the other common elements we find on Earth.
- The parts of the Sun that we can observe and measure directly are contained in the Sun's atmosphere: the **photosphere, chromosphere and corona**.
- **Photosphere:**
  - ♦ Since the Sun is made up of hot gas, there isn't really a "surface" to it. As you move from space toward the Sun's core, the gas gets denser and denser.
  - ♦ The photosphere represents the depth at which we can see no deeper toward the core of the Sun.
- ♦ The Sun lacks a distinct surface due to its composition of hot gas. The photosphere, approximately **500 kilometers thick**, marks the observable boundary where the Sun's atmosphere transitions from transparent to opaque.
- ♦ With a pressure a few hundredths of Earth's sea level, a density one ten-thousandth of Earth's atmosphere, and temperatures ranging from **4500-6000 Kelvin**, the photosphere is crucial for sunlight emission.
- ♦ Sunspots, temporary dark areas resulting from intense magnetic activity, form in the photosphere, exhibiting temperatures approximately 1500 K cooler than photosphere.
- **Chromosphere:**
  - ♦ The chromosphere is the second layer of the Sun's atmosphere, and extends from the photosphere about 2,000 kilometers out.



- ◆ The density of gas in the chromosphere decreases rapidly as you move away from the photosphere.
- ◆ The chromosphere is essentially transparent to most visible radiation, so that light emitted by the photosphere just passes right through the chromosphere.
- ◆ During a total solar eclipse, when the Moon covers the photosphere from our view, the chromosphere can be seen as a **red rim around the Sun**.
- **Corona:**
  - ◆ The corona is the outermost region of the Sun's atmosphere. It extends for millions of miles into space above the photosphere.
  - ◆ Like the chromosphere, usually we can not see it because of the brightness of the photosphere. However, during a total solar eclipse, the corona shines like a **crown around the Sun**.
  - ◆ Even though the **density of the corona** is very small (it's about 0.0000000001 times that of the Earth's sea-level atmosphere), it is very hot, coming at millions of Kelvin.
  - ◆ Because of this high temperature, most of the radiation emitted by the corona is at **ultraviolet and X-ray wavelengths**.
  - ◆ The reason for the high temperatures of the corona is not well understood. Magnetic fields seem to play a part, but the precise mechanism is an active area of scientific research.

#### KEY TERMS

- **Heliosphere:** The heliosphere encompasses a vast, bubble-like expanse of space governed by the Sun's solar wind and magnetic field, extending well beyond Pluto's orbit. It serves as a protective barrier for the solar system, shielding it from harmful cosmic rays.
- **Solar Wind:** The solar wind results from the outward expansion of plasma, a collection of charged particles, originating from the Sun's corona. Continuously heated, the plasma becomes too energetic for the Sun's gravity to restrain, traveling along radial magnetic field lines.
- **Solar Magnetic Field:** The Sun's intricate magnetic field, generated by the motion of charged particles within its interior, significantly influences solar behavior. It contributes to the formation of phenomena such as sunspots, solar flares, and Coronal Mass Ejections (CMEs).

- **Sunspots:** Sunspots are transient dark spots on the Sun's photosphere, indicating cooler regions caused by substantial shifts in the Sun's magnetic field.
- **Solar Flares:** Intense releases of energy and light from the Sun's surface, solar flares occur due to the discharge of magnetic energy stored in the Sun's atmosphere. They have the potential to disrupt Earth's radio communications and satellite operations.
- **Coronal Mass Ejections (CMEs):** CMEs involve the expulsion of large clouds of plasma and magnetic fields from the Sun's corona into space. Their interaction with Earth's magnetic field can lead to geomagnetic storms, impacting power systems and infrastructure.

### HIGH-ALTITUDE PSEUDO SATELLITE (HAPS) VEHICLE

Recently, the National Aerospace Laboratories (NAL) has successfully conducted the initial test flight of a solar-powered High-Altitude Pseudo Satellite (HAPS) vehicle.

#### Features of HAPS

- **Altitude Performance:** Capable of flying at elevations between **18 and 20 kilometers** above ground level, HAPS vehicles surpass the maximum altitudes achieved by commercial jets by nearly twofold.
- **Solar Power Utilization:** HAPS vehicles are equipped to harness solar energy, enhancing their sustainability and operational efficiency.
- **Extended Air Time:** With the ability to stay airborne for extended periods, ranging from months to years, HAPS vehicles offer functionalities comparable to those of satellites but without necessitating space travel.
- **Cost Efficiency:** Operating a HAPS vehicle incurs significantly lower costs compared to traditional satellites, which orbit at distances **exceeding 200 kilometers** from Earth's surface.

#### Applications of HAPS

- **Disaster Management:** HAPS vehicles can play a critical role in managing and responding to natural disasters.
- **Communication Networks:** These vehicles are capable of establishing mobile communication networks in isolated areas, facilitating connectivity.

- **Border Surveillance:** HAPS can be deployed for continuous monitoring of border regions to detect movements or changes, enhancing security and surveillance capabilities.

#### CSIR-NATIONAL AEROSPACE LABORATORIES (NAL)

- **About:**
  - ◆ It stands as the sole government-owned aerospace research and development facility within India's civilian sector.
  - ◆ As an institution oriented towards high technology, CSIR-NAL dedicates itself to pioneering in advanced aerospace disciplines.
- **Established in :** Bengaluru in **1959** as a part of the Council of Scientific & Industrial Research (CSIR).
- **Primary mission:** It involves the development of cutting-edge aerospace technologies that are heavily science-based, the design and construction of civil aircraft ranging from small to medium sizes, and the provision of support across all national aerospace initiatives.

#### NASA'S PERSEVERANCE ROVER

NASA's Perseverance rover recently accomplished a groundbreaking scientific achievement by generating oxygen on Mars.

#### About:

- This milestone was attained through the utilization of an experimental device known as the **Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE)**, which is integrated into the rover.
- MOXIE effectively converted carbon dioxide from the Martian atmosphere into high-quality, breathable oxygen.
- Operating like a tree on Earth, MOXIE separates oxygen from carbon dioxide molecules through a heat-based process at approximately 800 degrees Celsius.

#### ABOUT MARS:

- Also known as the **Red Planet**.
- It is the fourth planet from the Sun.
- It is the second-smallest planet in the Solar System, bigger than mercury only.
- Has two natural satellites: **Phobos and Deimos**
- Its atmosphere is 100 times thinner than the earth with little oxygen present.
- After the Earth, Mars is the most habitable planet in our solar system
  - ◆ Its gravity is nearly **38% of Earth**.
  - ◆ It is revolving on the edge of the **Goldilock Zone** in the Solar System.
  - ◆ It has protection against cosmic rays and solar flares.

Nation/Agency	Mission	Objectives
ROSCOSMOS	Mars Orbiter	Scientific exploration of Mars
NASA (USA)	Viking Program	Study Martian surface and search for life
	Pathfinder	Demonstrate airbag landing, study Martian geology
	Phoenix	Study water ice and climate of Mars
	Curiosity	Assess habitability, study geology and climate
	Maven	Study Mars' atmosphere and climate
	Perseverance	Search for signs of past life, collect samples.
	Insights (Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport)	focuses on understanding the deep interior of the Red Planet to provide valuable insights into its geology, seismic activity, and internal heat flow.
European Space Agency (ESA)	Mars Express	Study Martian atmosphere and geology

ISRO (India)	Mangalyaan (MOM) (Made India the first Asian nation to reach Martian orbit and the first in the world to do so on its maiden attempt.)	Launched with the objective of studying the Martian surface, morphology, atmosphere, and mineralogy.
UAE	Hope Mission	Study Martian atmosphere and climate.
China	Tianwen 1	Orbital and rover exploration, search for signs of life on mars.

### SUBSURFACE WATER ICE MAPPING (SWIM) PROJECT

This project is funded by NASA and led by the Planetary Science Institute, has unveiled its fourth and most comprehensive map showing potential subsurface water ice locations on the Red Planet, Mars.

#### Significance of New Mars Ice Mapping

- The SWIM project's initial phase, finalized in 2019, concentrated on the northern hemisphere, with the second phase in 2020 encompassing the southern hemisphere of Mars.
- Scientific Insight:** Provides updated data on ice reservoirs using Context Camera (CTX) and High-Resolution Imaging Experiment (HIRISE) instruments for scientific research on Mars.
- Geological Understanding:** Enhances our understanding of Mars' geology and surface features.
- Potential for Life:** Helps identify potential areas for past or present life on Mars.
- Exploration Advancements:** Facilitates exploration and resource utilization on the Red Planet.

### WHAT IS AN EXOPLANET?

- An exoplanet is any planet beyond our solar system.
- All of the planets in our solar system orbit around the Sun. Planets that orbit around other stars are called exoplanets.
- Exoplanets are very hard to see directly with telescopes. They are hidden by the bright glare of the stars they orbit.

Type of Star	Features	Examples
Main Sequence Stars	Fuse hydrogen into helium, stable, found in the main sequence of the Hertzsprung-Russell diagram	Sun, Sirius, Alpha Centauri
Red Giants	Expanded, cool outer layers, helium fusing into heavier elements in the core	Betelgeuse, Arcturus, Aldebaran
White Dwarfs	Very dense, hot remnants of medium-sized old stars, no longer undergoing fusion	Sirius B, Procyon B, Van Maanen's Star
Neutron Stars	Extremely dense, composed mostly of neutrons, formed from the remnants of supernovae	PSR J0348+0432, PSR B1509-58, Crab Pulsar
Supergiants	Very massive, extremely bright, undergo rapid fusion and have a short lifespan	Rigel, Deneb, UY Scuti
Brown Dwarfs	Sub-stellar objects, not massive enough to sustain hydrogen-1 fusion reactions	Teide 1, Luhman 16, WISE 0855-0714

### K2-18 B

NASA's James Webb Space Telescope in its study of K2-18 b discovered the presence of carbon dioxide and methane.

#### About K2-18 b

- K2-18 b is a **super Earth exoplanet** that orbits an M-type star.
- It is 120 light years from earth and orbits the cool dwarf star K2-18 a.
- It is 8.6 times as massive as Earth and the size lies that of between earth and Neptune.
- Its discovery was announced in 2015.

## TOI-715 B

NASA's Transiting Exoplanet Survey Satellite (TESS) mission has identified a super-Earth planet named TOI-715 b, situated 137 light-years away.

### About:

- This planet is approximately 1.5 times wider than Earth and orbits a red dwarf star, completing an orbit every 19 days.
- TOI-715 b is located within its star's "conservative habitable zone," indicating that it has the potential for liquid water to exist on its surface under the right atmospheric conditions.
- This zone's favorable conditions prompt further exploration to determine if TOI-715 b could sustain life.
- The planet's size suggests it could be a "**water world**" with a significant atmosphere, enhancing its habitability prospects.

### Parent Star Properties

- The planet circles a red dwarf star, which is notably smaller and cooler than the Sun.
- Red dwarfs are conducive to hosting small, rocky planets in close orbits, yet their lower temperatures allow these orbits to fall within the habitable zone.
- The proximity of these orbits to the star facilitates more frequent transits, improving the observation and analysis of such planets.

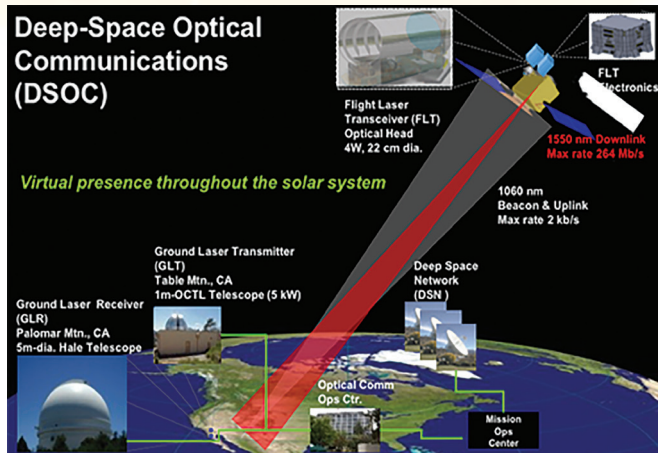
## DEEP SPACE OPTICAL COMMUNICATIONS (DSOC)

NASA's Psyche spacecraft, located a whopping 10 million miles from Earth, has successfully sent a message, marking a significant leap in our ability to communicate across vast distances in space.

### About DSOC

- The experiment represents a groundbreaking step in advancing laser communications into the realm of deep space.
- This innovative technology demonstration was initiated with the launch of the DSOC transceiver on **NASA's Psyche spacecraft**.
  - ♦ Psyche Mission was launched in 2023.
  - ♦ This mission aims to study a metal-rich asteroid with the name **Psyche**, located in the main asteroid belt between **Mars and Jupiter**.
  - ♦ This is NASA's first mission to study an asteroid that has more metal than rock or ice. Psyche launched Oct. 13, 2023,
  - ♦ It also aims to experiment with **high-bandwidth optical communications** between the spacecraft and Earth during its initial two-year voyage towards the main asteroid belt.

Aspect	Radio Communication	Optical Communication
Medium	Electromagnetic waves (radio waves)	Light (laser beams)
Range	Long (can cover vast distances in space)	Shorter compared to radio waves, effective for specific distances
Data Rate	Lower compared to optical communication	Higher, suitable for high-volume data transmission
Energy Efficiency	Less energy-efficient	More energy-efficient for high data rates
Interference	Prone to interference from other radio sources	Less prone to interference from other sources
Weather Dependency	Less affected by weather conditions	Can be affected by atmospheric conditions like clouds and fog
Advantages	Proven technology, more robust to obstructions and atmospheric conditions	Higher data rates, more bandwidth, more secure
Disadvantages	Limited bandwidth, lower data rates, more energy consumption	Requires precise alignment, can be affected by atmospheric disturbances



## LUCY MISSION

NASA is set to launch its first spacecraft to study Jupiter's Trojan asteroids.

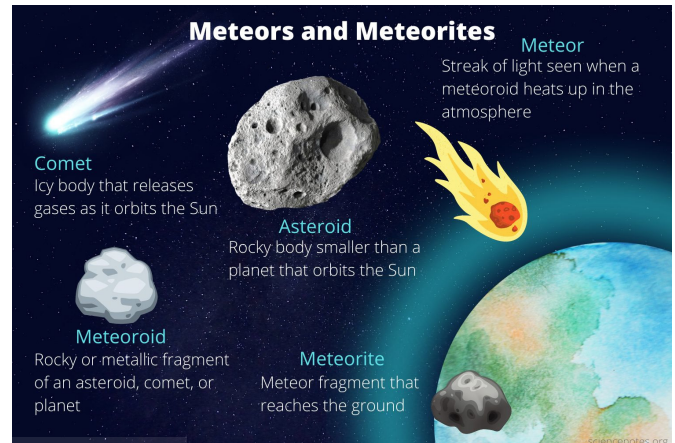
### About

- **Origin:** Named after an ancient fossil 3.2 million-year-old ancestor who belonged to a species of hominins.
- **Aim & Objective:**
  - ♦ To get insights into the formation of the solar system 4.5 billion years ago.
  - ♦ Investigating the group of rocky bodies that are circling the Sun in two swarms- one preceding Jupiter and the other trailing behind it.
- **Duration:** A 12-year journey of eight different asteroids including one in the Main Belt between Mars & Jupiter and seven Trojans.
- **Donald Johnson Asteroid:**
  - ♦ The spacecraft's first encounter will be with an asteroid that lies in the main belt that can be found between Mars and Jupiter.
  - ♦ This asteroid is **named 'Donald Johnson'** after the paleoanthropologist who discovered the **fossilized remains of "Lucy"**.

### Asteroids

- **About:** Rocky objects revolving around the sun that are too small to be called planets.
- **Classification based on their orbits:**
  - ♦ **Main asteroid belt b/w Mars and Jupiter.**
  - ♦ **Trojan asteroids** orbit a larger planet in two special places, known as Lagrange points, where the gravitational pull of the sun and the planet are balanced.

- ♦ NASA reports the presence of Jupiter, Neptune and Mars trojans. In 2011, they reported an Earth trojan as well.
- **Near-Earth Asteroids (NEA),** circle closer to Earth than the sun.



## INTERNATIONAL SPACE STATION (ISS)

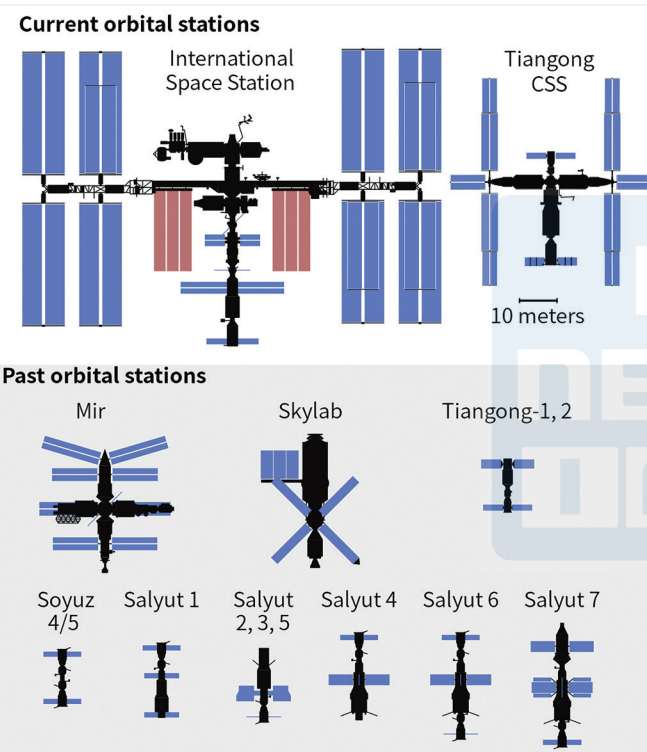
The International Space Station has marked 25 years in orbit since its initial module was launched in 1998.

### About:

- **Collaboration:** A multinational collaborative project involving five space agencies: NASA (United States), Roscosmos (Russia), JAXA (Japan), ESA (European Space Agency), and Canadian Space Agency (Canada).
- **Launch History:** The ISS began its assembly in orbit with the launch of its core modules, **Russia's Zarya** in November 1998 and the **US's Unity Node 1** in December 1998. Through a series of 42 assembly flights, it developed into a fully operational space laboratory.
- **Orbit:** Orbits the Earth approximately every 90 minutes, at an altitude of around 400 km (250 miles).
- **Modules and Components:** Comprises pressurized modules for crew living and working, unpressurized truss segments for structural support, solar arrays for power, and various other components.
- **Research and Impact:** Facilitates research in various fields that benefits humanity, such as medical research, environmental monitoring, and developing technology for future space missions.

### TIANGONG SPACE STATION

- China's inaugural long-term orbital habitat is currently under construction within a low Earth orbit ranging from **340 to 450 kilometers above Earth**.
- This station forms a crucial component of the China Manned Space Program.
- In 2021, China initiated the construction of its permanent space station by launching an **uncrewed module called "Tianhe"**, meaning **"Harmony of the Heavens"**, with plans to finalize the station by the end of 2022.



- **Purpose:** Aimed at examining how atmospheric waves from the lower atmosphere influence conditions in the upper atmosphere and consequently affect space weather.

### AIRGLOW

- It is a weak glow in the Earth's upper atmosphere, produced when air molecules and atoms absorb solar ultraviolet and X-ray radiation selectively.
- This glow predominantly originates from an area stretching between 50 to 300 kilometers above the Earth's surface, with its most intense brightness observed at roughly 97 kilometers altitude.

### Key Research Areas:

- **Airglow Observation:** AWE will focus on observing the colorful bands of light in the Earth's atmosphere, known as airglow, from a unique position above the planet.
- **Atmospheric Dynamics:** The mission seeks to uncover the combined forces that shape space weather in the Earth's upper atmosphere.
- **Mesopause Measurements:** The experiment will measure airglow around the mesopause region, approximately 85 to 87 km above the Earth's surface, where temperatures can drop to around minus 100 degrees Celsius. This region's airglow is particularly bright in the infrared spectrum, facilitating detection.
- **Resolution of Atmospheric Waves:** AWE aims to detect atmospheric waves with greater detail at finer horizontal scales than previously possible with satellite observations at these altitudes, marking a distinctive aspect of the mission.
  - ♦ **Ionosphere's Health:** Understanding the ionosphere's condition, especially its lower layers at the edge of space, is crucial for ensuring uninterrupted communication systems.

## NASA'S ATMOSPHERIC WAVES EXPERIMENT (AWE)

NASA launched AWE to investigate 'airglow' phenomena to enhance our understanding of space weather dynamics.

### About AWE

- **Mission Overview:** AWE represents NASA's innovative effort under its Heliophysics Explorers Programme to explore the interplay between Earth's atmospheric conditions and space weather.
- **Location:** The experiment will be situated on the exterior of the International Space Station (ISS), orbiting Earth.

## PACE MISSION

NASA is going to launch the PACE mission in 2024 to boost our understanding of Earth's atmosphere.

### About

- **Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE)** Mission aims to enhance the understanding of Earth's oceans and atmosphere by studying key components, like light, aerosols, and clouds.

- The mission will make global measurements of ocean color to improve our understanding of the carbon cycle and ocean ecosystem responses to a changing climate.

#### WHAT IS AEROSOL?

- Aerosols are very small particles in the air like those of smoke, dust, sea salt and other pollutants.
- Aerosols absorb as well as scatter sunlight. This decides how much solar energy reaches the surface of Earth.

## INDIAN SPACE POLICY 2023

The policy introduces significant changes to promote private sector engagement in space activities, traditionally dominated by the Indian Space Research Organisation (ISRO).

### Provisions:

- **4 Key Entities Established**
  - ♦ **Indian Space Research Organisation (ISRO):** Continues its focus on research and development, moving away from routine operations to innovate in space technology and applications.
  - ♦ **Indian National Space Promotion and Authorisation Centre (IN-SPACe):** Acts as a single-window agency for the authorization of space activities, setting industry standards, and fostering industry-academia collaborations.
  - ♦ **New Space India Limited (NSIL):** The commercial arm tasked with commercializing technologies developed by government entities, manufacturing, leasing, or purchasing space assets, and providing space-based services.
  - ♦ **Department of Space:** Responsible for policy implementation, clarifying ambiguities, ensuring safe and sustainable space operations, coordinating international cooperation, and dispute resolution.
- **Private Sector Engagement:**
  - ♦ **Scope of Activities:** Private companies can now engage in comprehensive space activities, including satellite launch and operation, rocket development, ground station construction, spaceport creation, and offering services in communication, remote sensing, and navigation both domestically and internationally.

- ♦ **Space Situational Awareness:** Encourages private development of capabilities to monitor space objects and prevent collisions, including satellites and space debris.
- ♦ **Asteroid and Space Resource Recovery:** Opens avenues for private entities to engage in the commercial recovery of space resources, with participation restricted to Indian companies.
- ♦ **Foreign Direct Investment (FDI):** The policy leaves open the question of FDI through the automatic route in space activities, pending government decision.
- **Regulatory and Operational Framework:**
  - ♦ **IN-SPACe Authorization:** Ensures that satellite imagery with a ground sample distance (GSD) greater than five meters is freely available, while imagery with a GSD less than 30 cm requires authorization, considering national security.
  - ♦ **ISRO's Role Transition:** Guides ISRO to prioritize research and innovation, focusing on advancing India's capabilities in space infrastructure, transportation, applications, capacity building, and human spaceflight.
  - ♦ **NSIL's Commercial Role:** Directs NSIL to leverage technologies and platforms for commercial use, offering services to both government and private sectors.
  - ♦ **Department of Space's Oversight:** Mandates the Department of Space to oversee policy implementation, international cooperation, and the establishment of a framework for safe and sustainable space operations, including an appropriate mechanism for dispute resolution.

## JUICE (JUPITER ICY MOONS EXPLORER) MISSION

The JUICE mission will be the first time that the European Space Agency (ESA) has sent a spacecraft beyond the asteroid belt.

### About:

- JUICE is the first large-class mission in the ESA Cosmic Vision 2015-2025 programme.
- The mission launched successfully on April 14, 2023, aboard an Ariane 5 rocket from Europe's Spaceport in French Guiana on an eight-year journey including gravity assist flybys of Earth and Venus before arriving in the Jupiter system in 2031.

• **Goals:**

- ◆ It will spend at least three years making detailed observations of the giant gaseous planet Jupiter and three of its largest moons, Ganymede, Callisto and Europa.
- ◆ It will understand if the oceans of these icy moons could have ever been suitable habitats for life.

Mission Name	Agency	Objectives
Pioneer 10	NASA	First spacecraft to pass through the asteroid belt and make direct observations of Jupiter
Pioneer 11		Studied Jupiter's atmosphere and magnetic field
Voyager 1		Detailed images of Jupiter and its moons
Voyager 2		Detailed study of Jupiter's atmosphere and moons
Galileo		Orbited Jupiter for several years, studying the planet and its moons
Juno		Detailed study of Jupiter's composition, gravity field, magnetic field, and polar magnetosphere

## EMERGING TECHNOLOGIES

### DEEPAKES

In reaction to the Deep Fake video of an Indian actress, the Union Minister for Electronics & Technology highlighted that deep fakes represent a new, "more harmful and destructive type of misinformation.

**About:**

- Deep Fakes are created by **altering media** — images, video, or audio using technologies such as **AI and machine learning**, thereby blurring the lines between fiction and reality.
- This technology employs deep learning, a type of artificial intelligence that falls under machine learning.
  - ◆ It utilizes **artificial neural networks**, modeled after the human brain, to learn from vast amounts of data, thereby creating realistic images of events that never actually occurred.

### Working of Deep Fake

- Deepfake technology utilizes advanced deep learning algorithms, notably **Generative Adversarial Networks (GANs) and Variational autoencoder models**, to accurately study and replicate human features, including faces, voices, and movements.
- Through the examination of extensive collections of images and videos, these algorithms acquire the ability to imitate human facial expressions, speech intonations, and mannerisms. This process facilitates the production of compelling and misleading digital media.

## GANs AND VAEs

- **Generative Adversarial Networks (GANs):** GANs consist of two neural networks, the Generator and the Discriminator, which are trained simultaneously through a competitive process:
  - ◆ **Generator:** This network takes random noise as input and generates data (such as images). The goal of the Generator is to produce data that is indistinguishable from real data.
  - ◆ **Discriminator:** This network attempts to distinguish between real data (from the training dataset) and fake data produced by the Generator.
- **Variational Autoencoders (VAEs):**VAEs are a type of autoencoder that produces a probabilistic representation of the input data. They are composed of two main parts:
  - ◆ **Encoder:** This part of the network compresses the input data into a smaller, dense representation called the latent space.
  - ◆ Unlike traditional autoencoders, VAEs produce a distribution over the latent space that represents the input data.
  - ◆ **Decoder:** The Decoder takes the representation from the latent space and attempts to reconstruct the input data from this compressed form.

### Applications of Deepfake Technology

- **Entertainment and Media:** Film Dubbing and Editing: Deep fake technology can be used to dub films in different languages, making it appear as if the actors



are naturally speaking the dubbed language. For example, "The Irishman" used deep fake technology to de-age its actors.

- **Content Creation:** Creators use deep fakes to generate new episodes of TV shows, movies, or create virtual celebrities. An example is the use of deep fake in the creation of new content for characters like **Princess Leia in the "Star Wars" series** after the passing of Carrie Fisher.
- **Education and Training:** Educators can use deep fakes to recreate historical speeches or events for a more immersive learning experience. For instance, bringing historical figures like **Abraham Lincoln to life to deliver their famous speeches**.
- **Politics and Social Campaigns:** Deep fakes can be used in campaigns to raise awareness about social issues by depicting scenarios that haven't happened but could. For example, a campaign showing the effects of climate change through realistic future scenarios.
- **Security and Law Enforcement:** Deep fakes can be used to create realistic training videos for law enforcement and military personnel, simulating various scenarios they might face in the field.

### Challenges

- **Misinformation and Manipulation:** Deepfakes can be exploited to generate fabricated videos of politicians or public figures, potentially leading to misinformation and the manipulation of public opinion.
- **Privacy Infringement:** The creation of damaging content without individuals' consent raises serious privacy concerns, violating personal data and infringing upon the right to privacy. This can result in harm to reputations and well-being.
- **Detection Dilemma:** Developing effective tools to identify deepfakes remains an ongoing challenge. The constant evolution of the technology used to create deep fakes makes it difficult to stay ahead in the detection game. This poses a substantial hurdle in mitigating the risks associated with the misuse of deepfake technology.

### Legal Provisions in India

In India, **there is no specific legislation directly targeting deepfake technology**. However, certain laws indirectly touch upon aspects of deep fakes:

- **Section 66E of the IT Act of 2000:** This section pertains to acts involving the capturing, publishing, or

transmitting of a person's images in mass media, constituting a violation of privacy.

- **Section 66D of the IT Act of 2000:** This provision enables the prosecution of individuals using communication devices or computer resources with malicious intent, particularly those engaging in cheating or impersonation.
- **Indian Copyright Act of 1957:** This act includes penalties for copyright infringement, which could be applicable to cases involving deep fake content.

### Global Measures Against Deep Fakes:

- **Bletchley Declaration:** More than 25 major countries, including India, the United States, China, Japan, and the UK, have joined the Bletchley Declaration, emphasizing the need to address the potential risks associated with AI technologies.
- **Digital Services Act of EU:** The European Union's Digital Services Act imposes obligations on social media platforms, requiring them to adhere to labeling requirements. This enhances transparency and assists users in determining the authenticity of media content.
- **Google's Announcements:** Google has introduced tools such as **watermarking** to identify synthetically generated content, contributing to efforts aimed at mitigating the impact of deep fakes on online platforms.
- **US senators propose DEFIANCE Act :** To address non-consensual, sexualised images created by AI that invades people's privacy and causes harm. The proposed legislation aims to provide legal protection for victims of **"digital forgeries" or non-consensual pictures** that depict them in nude or sexually explicit situations.

### ARTIFICIAL INTELLIGENCE (AI)

- The inaugural **AI Safety Summit**, a historic event, took place at Bletchley Park, located near London in Buckinghamshire, United Kingdom.
  - ♦ At the inaugural AI Safety Summit, eight leading nations, comprising the United States, China, India, and the European Union, endorsed the Bletchley Park Declaration.

### About Bletchley declaration

- **Misuse Awareness:** Recognizes the significant threats arising from either deliberate misuse or accidental control issues related to advanced AI, highlighting

particular concerns in cybersecurity, biotechnology, and the spread of disinformation.

- **Risk Assessment:** Points out the possibility of serious harm, whether intentional or accidental, from the advanced capabilities of AI models. It also acknowledges additional concerns like bias and privacy issues extending beyond the realm of cutting-edge AI.
- **International Collaboration:** Stresses that addressing these challenges effectively requires global cooperation. The agreement sets the groundwork for annual summits focused on international collaboration for the safety of advanced AI.
- **Core Principles:** Underlines the necessity of upholding human rights and ensuring AI systems are transparent, understandable, fair, accountable, well-regulated, safe, under human oversight, ethical, free from bias, and protective of privacy and data.

### About AI:

- It is a branch of **computer science** dedicated to creating systems that can perform tasks which typically require human intelligence. It's a broad field that encompasses various types and applications, and as its influence grows, both India and the global community have been developing regulations to govern its use.

### Types of Artificial Intelligence

- **Narrow or Weak AI:** AI systems designed to perform a specific task without the consciousness or self-awareness that a human might have.
  - ♦ *Example:* **chatbots** and **recommendation systems**.
- **Generative AI:** Generative AI refers to models that have the ability to generate new content, such as images, text, or other data, often indistinguishable from real, human-created content.
  - ♦ *Example:* **Generative models like GPT-3** (Generative Pre-trained Transformer 3) by OpenAI.
- **Frontier AI:** Frontier AI represents the **cutting-edge and innovative aspects** of artificial intelligence that push the boundaries of what's currently possible. It involves exploring new and groundbreaking technologies and approaches in AI.
  - ♦ *Example:* Quantum AI is an example of frontier AI. Quantum computing, combined with machine learning algorithms, has the potential to solve complex problems at speeds far beyond what classical computers can achieve.

- **Multimodal AI:** It refers to artificial intelligence systems that can process and understand information from multiple modalities or sources, such as text, images, videos, and audio.

### PROJECT GEMINI

- Launched by Google as an artificial intelligence (AI) model crafted to mimic human behavior closely.
- This initiative is likely to accelerate the competition in AI technology while sparking discussions on its advantages and potential drawbacks.
- The goal of Gemini is to improve the responsiveness and effectiveness of Google's AI-driven chatbot, Bard, especially in tasks that require careful planning.
- Developed by Google DeepMind, the team highlights Gemini's capabilities in solving complex problems in mathematics and physics, hinting at possible significant advancements in scientific research.

### Applications of AI

- **Healthcare:** From diagnosis and predictive analytics to robotic surgery and personal health management.
- **Finance:** For fraud detection, trading algorithms, and personalized banking services.
- **Manufacturing:** Through predictive maintenance, supply chain optimization, and enhanced quality control.
- **Education:** Customized learning experiences, grading automation, and predictive analytics to identify student needs.
- **Agriculture:** AI-driven drones for crop monitoring, predictive analytics for crop health, and automated farming equipment.
- **Transportation:** Autonomous vehicles, traffic management, and predictive maintenance for vehicles and infrastructure.

### REGULATIONS

- **National Strategy for Artificial Intelligence:** NITI Aayog Outlines the framework for AI ethics, development, and use in critical sectors.
- **Digital Personal Data Protection Act, 2023:** Proposes regulations for data protection that impact AI development by safeguarding personal information.
- **European Union's AI Act:** Proposes strict rules for high-risk AI applications, emphasizing transparency, safety, and fundamental rights.

## Artificial Intelligence and India

**AI refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem-solving and decision-making.**

- The Government of India expects AI to be the **kinetic enabler** of the nation's digital economy and make governance more data-driven and smarter.
- AI is expected to add **\$ 967 billion** to the Indian economy by **2035** and **\$450-\$500 billion** to India's **GDP by 2025**, accounting for 10% of the country's \$5 trillion GDP target.\*

### AI: Benefits

- Lesser chances of human error
- Lesser exposure of humans to risks
- Lesser cost on human resources
- Round-the-clock availability
- Greater work efficiency
- Greater accuracy

### AI: Risks

- Job loss triggered by AI-spurred automation
- Deepfakes
- Violation of privacy
- Technology going beyond human control
- Volatility in market
- Embedded algorithmic bias
- Automation of weapon systems
- Aggravated socioeconomic inequality

### October 30, 2023

- **US President Joe Biden Issues Executive Order on Safe, Secure, and Trustworthy AI.**

It requires that developers of the most powerful AI systems share their safety test results and other critical information with the US government.

### November 1-2, 2023

- The UK government hosted the first AI Safety Summit at Bletchley Park in Milton Keynes (Buckinghamshire).
- India, 27 other nations and the European Union adopted The Bletchley Declaration, which...
  - ...called for international cooperation to manage the risks of AI,
  - ...expressed concerns over risks in domains such as cybersecurity and biotechnology, as well as where Frontier AI systems may amplify risks such as disinformation.

### December 12-14, 2023

- India hosts the Global Partnership on Artificial Intelligence (GPAI) summit.
- Prime Minister Narendra Modi urges "extreme caution" while moving forward with AI, highlighting challenges, like deepfake, data theft and terrorist organizations getting their hands on AI tools.
- 29 nations adopt the Delhi Declaration, with consensus on advancing safe, secure, and trustworthy AI.

\*SOURCE: INDIA AI 2023 BY MINISTRY OF ELECTRONICS AND INFORMATION TECHNOLOGY



## GLOBAL PARTNERSHIP ON ARTIFICIAL INTELLIGENCE (GPAI)

The Prime Minister of India launched the Global Partnership on Artificial Intelligence (GPAI) Summit. The PM also talked about AIRAWAT and YUVAi initiatives.

### About

- In 2024, India will be at the forefront of GPAI, serving as the primary chair. This partnership, which consists of 28 countries along with the European Union, endorsed the **'New Delhi Declaration' of the GPAI**.

### NEW DELHI DECLARATION' OF THE GPAI

- It recognizes the necessity to exploit opportunities and mitigate risks associated with AI's development, deployment, and use.
- Reaffirms commitment to human dignity, rights, and democratic values.
- Highlights the need for trust, transparency, accountability, and inclusiveness in AI.
- Acknowledges AI's potential to support the UN Sustainable Development Goals and solve global challenges.
- Calls for global cooperation and coordination in AI research, innovation, and policy.
- Advocates for a comprehensive framework with shared principles for safe and trustworthy AI.
- Endorses India's proposal for a **Global Digital Public Infrastructure Repository (GDPIR)** to distribute digital public goods.

### GLOBAL PARTNERSHIP ON ARTIFICIAL INTELLIGENCE (GPAI)

- It is a multi-stakeholder initiative of global experts bridging AI theory and practice, promoting research and practical efforts across science, industry, civil society, and governments.
- It was established in **June 2020** with 15 member countries and currently it has 29 member states including **India**.
- It has a Council, Steering Committee and an Executive Council supported by a Secretariat hosted by the OECD.

- **It has two Centers of Expertise:**

- ♦ **Montreal:** The International Centre of Expertise in Montreal for the Advancement of Artificial Intelligence (ICEMAI);
- ♦ **Paris:** The French National Institute for Research in Digital Science and Technology (INRIA).

### AIRAWAT (AI Research, Analytics, and Knowledge Assimilation Platform)

- **Initiative by:** NITI Aayog, announced in June 2018.
- **Purpose:**
  - ♦ This platform integrates cloud computing and big data analytics with a robust, power-efficient AI computing infrastructure.
  - ♦ Designed for advanced AI processing, AIRAWAT aims to facilitate cutting-edge research and development in various AI domains.
- **Key Features**
  - ♦ Equipped for leading-edge machine learning, deep learning, and supercomputing capabilities to store, process, simulate, and analyze extensive data sets including images, videos, text, sound, and speech.
  - ♦ The platform is tailored to enhance AI-driven projects in image and speech recognition, natural language processing, and more, fostering innovation across sectors.

### 'YUVAi - Youth for Unnati and Vikas with AI' Scheme

- **Launched by:** National e-Governance Division (NeGD) in partnership with Intel India.
- **Objective:**
  - ♦ To enhance the understanding of Artificial Intelligence (AI) among school students in classes 8 to 12 nationwide, preparing them as human-centric AI designers and users.
  - ♦ Focuses on equipping students with the mindset and skill sets relevant to AI.
  - ♦ Offers practical learning experiences for students to explore how AI can address critical issues and contribute to the nation's inclusive growth.

## WI-FI 7 TECHNOLOGY

Recently, **Wi-Fi Alliance**, a non-profit consortium dedicated to promoting Wi-Fi technology, unveiled 'Wi-Fi Certified 7'.

### WI-FI

- **Wi-Fi, also known as Wireless Fidelity**, is a technology that enables devices to connect to the internet and communicate wirelessly.
- Utilizes Radio Waves for the delivery of high-speed internet and network connectivity.
- Wi-Fi signal transmission requires three components: a Base Station, a Router, and Access Devices (e.g., smartphones, laptops).
- Wi-Fi 7 represents the forthcoming generation of Wi-Fi standards, operating under the **IEEE 802.11b** specification for **Extremely High Throughput (EHT)**.
  - ◆ EHT in simple terms, refers to the capability of Wi-Fi networks to handle a very large amount of data being transmitted at extremely high speeds.
  - ◆ The IEEE (Institute of Electrical and Electronics Engineers) is the largest global technical professional organization committed to advancing technology for human benefit.

Wi-Fi Standard	Release Year	Frequency Band	Key Features
Wi-Fi 1	1999	2.4 GHz	<b>Data rate:</b> up to 11 Mbps Uses DSSS Technique (Direct-Sequence Spread Spectrum) modulation
Wi-Fi 2	1999	2.4 GHz	<b>Data rate:</b> up to 54 Mbps Uses OFDMA Technique (Orthogonal Frequency-Division Multiplexing)
Wi-Fi 3	2003	2.4 GHz	<b>Data rate:</b> up to 54 Mbps Uses OFDMA Technique
Wi-Fi 4	2009	2.4 GHz, 5 GHz	<b>Data rates :</b> up to 600 Mbps Uses MIMO (Multiple Input Multiple Output) Technique
Wi-Fi 5	2014	5 GHz	<b>Data rates:</b> up to 3.46 Gbps Uses MU-MIMO (Multi-User MIMO) Technique
Wi-Fi 6	2019	2.4 GHz, 5 GHz	<b>Data rates:</b> up to 9.6 Gbps Uses OFDMA Technique (Orthogonal Frequency-Division Multiple Access)
Wi-Fi 6E	2020	6 GHz	<b>Data rate:</b> up to 9.6 Gbps Same key features as Wi-Fi 6 with the addition of access to the 6 GHz band for less interference and congestion
Wi-Fi 7	2024	2.4 GHz, 5 GHz, 6 GHz	<b>Data Rate:</b> 36 Gbps Enhanced use of MU-MIMO and OFDMA Introduction of new features like 320 MHz channel bandwidth, 4K-QAM, and Multi-Link Operation (MLO) for improved efficiency and latency

### MEANING OF TERMS RELATED TO WIFI

- **Direct-Sequence Spread Spectrum (DSSS) Modulation**
  - ◆ It is a technique used in wireless communications where the signal is spread over a wider bandwidth than necessary for sending the information.
  - ◆ This is achieved by mixing the data signal with a higher rate bit sequence (known as a chipping code) that spreads the data over a wider frequency range.
  - ◆ This spreading makes the signal more resistant to interference and eavesdropping, and allows multiple users to share the same frequency band by using different codes.
- **Orthogonal Frequency-Division Multiplexing Access (OFDMA)**
  - ◆ It is a method of encoding digital data on multiple carrier frequencies. OFDM splits the data into several parallel data streams or channels, each of which is transmitted on its own distinct frequency.
  - ◆ This approach reduces interference and can handle high data rates, making it highly efficient for broadband communications.

- OFDM is used in various applications, including Wi-Fi, LTE, and digital television broadcasting.
- **MIMO (Multiple Input Multiple Output)**
  - ◆ It is a wireless technology that uses multiple antennas at both the transmitter and receiver to improve communication performance.
  - ◆ MIMO enables the transmission of more than one data signal simultaneously over the same radio channel, which can significantly increase the network's capacity and speed without requiring additional bandwidth or increased transmit power.
    - This technology enhances data throughput and the range of wireless networks.
- **MU-MIMO (Multi-User MIMO)**
  - ◆ It is an advanced version of MIMO technology that allows a Wi-Fi router to communicate with multiple devices simultaneously.
  - ◆ Unlike traditional MIMO, which is designed to improve the bandwidth efficiency for a single user, MU-MIMO divides the available bandwidth into separate, individual streams that share the connection equally among multiple users.

Feature	Bluetooth	Wi-Fi
Range	Typically up to 10 meters (33 feet) for most devices, with Bluetooth 5 extending up to 40 meters (131 feet) in clear line of sight.	Typically up to 100 meters (164 feet) indoors, but can extend further with advanced equipment and outdoors.
Speed	Lower than Wi-Fi. Bluetooth 5 offers speeds up to 2 Mbps.	Much higher. Wi-Fi 6, for example, can achieve speeds up to 9.6 Gbps under optimal conditions.
Connectivity	Supports point-to-point connections between devices, with newer versions allowing for connections to multiple devices simultaneously.	Supports multiple device connections over a network, with routers facilitating numerous simultaneous connections.
Applications	Ideal for personal area networks, wearable devices, and IoT applications where low power and close proximity communications are key.	Suited for providing high-speed internet access, streaming, gaming, and connecting multiple devices in a networked environment.

### PRIME MINISTER'S WI-FI ACCESS NETWORK INTERFACE (PM-WANI)

- **About:** It was approved by the Union Cabinet in December 2020.
- **Nodal Ministry:** Department of Telecom (DoT), Ministry of Communications is the nodal agency to proliferate Broadband through Public Wi-Fi networks under the framework of Prime Minister's Wi-Fi Access Network Interface (PM-WANI)
  - ◆ This was first recommended by the Telecom Regulatory Authority of India (TRAI) in 2017.
- **Objective:** To provide public Wi-Fi service through Public Data Offices (PDOs) spread across the length and breadth of the country just like what PCOs (Public Call Offices) did for telephone spread in India.
- The Public Wi-Fi Networks will be set up by Public Data Office Aggregators (PDOAs).
- The Public Data Offices (PDOs) will be there with no requirement of the license, registration, or any other fees.

#### Other Features:

- The PM-WANI ecosystem will be operated by different players such as Public Data Office (PDO); Public Data Office Aggregator (PDOA); App Provider; Central Registry.
- The PDOs will either provide internet on their own or will lease from some other Internet Service Provider (ISP).
- A central registry will be set-up which will maintain details of all app providers, PDOAs and PDOs. It will be handled by the Centre for Development of Telematics (C-DoT).
- It will also have an app developer who will build a platform to register users and discover Wani-compliant Wi-Fi hotspots in an area and display them on the app.

#### MU-MIMO (Multi-User MIMO)

- ◆ It is an advanced version of MIMO technology that allows a Wi-Fi router to communicate with multiple devices simultaneously. Unlike traditional MIMO, which is designed to improve the bandwidth efficiency for a single user, MU-MIMO divides the available bandwidth into separate, individual streams that share the connection equally among multiple users.

### NON FUNGIBLE TOKENS (NFTS)

Google has recently announced its decision to permit developers to offer games on the Play Store, enabling players to purchase, sell, and earn tokenized digital assets, such as non-fungible tokens (NFTs).

#### About

- These are unique cryptographic tokens that exist on a blockchain and are inimitable. They represent a range of digital and real-world assets, providing a novel means for artists and creators to monetize their work.
- **Nature and Uniqueness:** NFTs are inherently unique, marked by distinct identifiers and metadata that differentiate one NFT from another. This non-fungibility contrasts with fungible assets like traditional currency, where units are identical and interchangeable.

#### FUNGIBILITY

- Fungibility is the ability of a good or asset to be readily interchanged for another of like kind.
- Goods and assets such as cars and houses that aren't interchangeable are non-fungible.
- Money is a prime example of a fungible asset because a \$1 bill is easily convertible into four quarters or 10 dimes.
- **Representation of Assets:** NFTs can represent a wide array of assets, both digital and tangible. This includes artwork, photographs, music, videos, real estate, personal identities, and property rights.
- **Trade and Exchange:** NFTs can be bought, sold, or traded on various platforms. Their value is determined by market demand and the perceived value of their owners, enabling transactions in cash, cryptocurrencies, or other NFTs.
- **Blockchain Integration:** Transactions and ownership details of NFTs are securely recorded on blockchains, predominantly on the Ethereum blockchain.
  - ◆ This digital ledger technology ensures transparency, security, and immutability of records, making NFT transactions trustworthy and verifiable.
- **Legal Aspects:** Currently, in India, there are no specific laws governing the commercial transactions of NFTs. The sole legal reference comes from the Income Tax Act, 1961, which has been updated to categorize NFTs as Virtual Digital Assets (VDAs).
  - ◆ As a result, the revenue earned from NFT transactions is subject to a 30% tax rate.

### Difference Between Fungible and Non-Fungible Tokens

Fungible	Non-Fungible
<b>Interchangeable</b> A token can be exchanged to any other token of the same type. If we make an analogy with the fiat currency - a dollar bill can be exchanged for any other dollar bill and that makes no difference for the holder.	<b>Not Interchangeable</b> Non-fungible token cannot be replaced with another non-fungible token of the same type. If you lend a token to somebody else you expect that person to return you the same token and not another of the same type. You cannot exchange your birth certificate for a birth certificate of another person.
<b>Uniform</b> All tokens of the same type are identical in specification, each token is identical to another.	<b>Unique</b> Each Token is unique and different to all other tokens of the same type.
<b>Divisible</b> Fungible tokens are divisible into smaller units and it doesn't matter which units you get as long as the value is the same. In an analogy with dollar, it's the same if you get 1 dollar bill or two 50 cents or 4 quarters.	<b>Non-Divisible</b> Non-fungible tokens cannot be divided. The elementary unit is one token and one token only.
<b>ERC-20 Standard</b> The well known standard on the Ethereum blockchain that allows the issuance of tokens like OMG, SNC, TRX...	<b>ERC-721 Standard</b> The new standard on the Ethereum blockchain that gives the possibility to issue unique, non-fungible tokens. Most well known use cases at the moment are CryptoKitties and other crypto collectibles.

### BLOCKCHAIN TECHNOLOGY

- A blockchain functions as a digital ledger for transactions, replicated and shared across the blockchain's entire network of computers.
- Each block within the chain stores numerous transactions, and with each new transaction on the blockchain, a record of that transaction is added to the ledger of every participant.
- Being decentralized, blockchains are immutable, meaning once data is entered, it cannot be altered.
- This immutability ensures that any alteration of a block in a chain would be immediately noticeable, indicating tampering.

### VIRTUAL DIGITAL ASSETS (VDA)

- Under the **Income Tax Act**, a 'virtual digital asset' encompasses any data, code, number, or token (excluding Indian or foreign currency) created via cryptographic methods or other means, regardless of the name it is given.
- These assets are capable of being electronically transferred, held, or exchanged. Furthermore, this definition explicitly covers Non-Fungible Tokens (NFTs) and any similar types of tokens, irrespective of their designated name.

### NOBEL PRIZE IN CHEMISTRY


- **Moungi G. Bawendi, Louis E. Brus, and Alexei I. Ekimov** has been awarded the **2023 Nobel Prize** in Chemistry for their pioneering work in the discovery and synthesis of **quantum dots**.
- These tiny particles are highly valued across various sectors, including electronics, advanced medical procedures, and quantum computing, due to their wide range of applications.

#### About Quantum Dots:

- Quantum dots are minuscule particles, typically only a few nanometers in diameter. Their diminutive size endows them with unique optical properties.
- While their structure and atomic makeup mirror those of larger, bulk materials, the behavior of quantum dots is influenced by their dimensions.
- By modifying the size of these quantum dots, one can alter their properties, resulting in quantum dots that display a variety of colors based on their size.

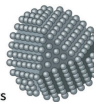
**NOBEL PRIZE FOR CHEMISTRY 2023**  
 Alexei Ekimov, Louis Brus and Moungi Bawendi were awarded the Nobel prize for chemistry for the discovery and synthesis of quantum dots

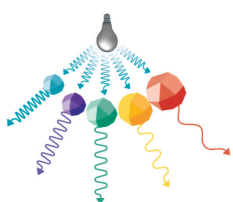
Quantum dots are tiny crystals, often consisting of just a few thousand atoms, made from semiconductor materials



The size ratio of a quantum dot to a football is about the same as a football to the Earth

Because their size is reduced to the nanometre scale, they exhibit quantum effects that determine their characteristics





By manipulating their size, scientists can precisely control their properties and make them emit light of specific colours when they are excited by light

**SOME APPLICATIONS**

- TV screens / illumination sources
- Biomedical imaging
- Producing photons for quantum communication
- Making better and cheaper solar cells

#### Applications

- They are employed to illuminate computer monitors, television screens, and LEDs, enhancing color range and brightness through color combination.
- In biochemistry, quantum dots of nanoscale dimensions are used to label and visualize biological tissues.
- In the field of solar energy, quantum dots contribute to the enhanced efficiency and absorption rates of photovoltaic cells, aiding in the conversion of solar energy to electricity.
- Within cancer therapy, quantum dots facilitate targeted drug delivery and other therapeutic interventions.



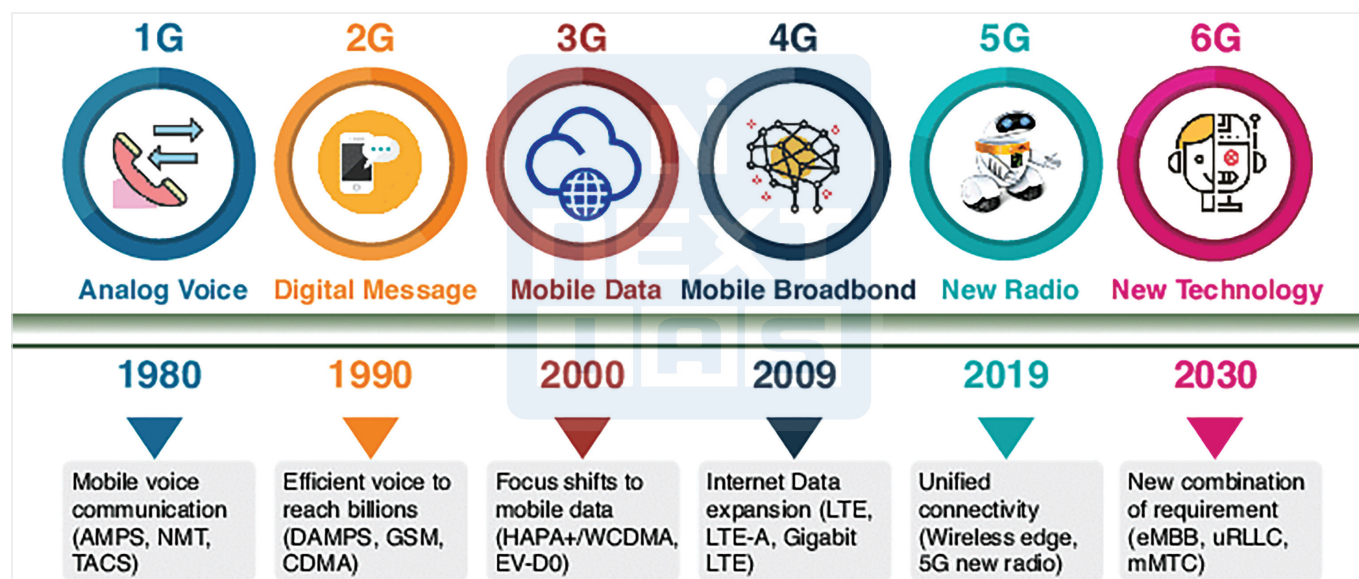
TYPES OF DISPLAY SCREENS

Attribute	LCD (Liquid Crystal Display)	LED (Light Emitting Diode)	AMOLED (Active Matrix Organic Light Emitting Diode)	OLED (Organic Light Emitting Diode)	QLED (Quantum Dot LED)
<b>Technology</b>	Uses liquid crystals and a backlight to produce images.	LED is a type of LCD that uses LED backlights instead of traditional CCFL backlighting.	Utilizes organic materials that emit light when an electric current is applied, with an active matrix.	Similar to AMOLED but without the active matrix technology for individual pixel illumination.	Uses LED backlighting but with a quantum dot film to enhance brightness and color.
<b>Brightness</b>	Good, but depends on the backlight's strength.	Better than traditional LCD due to LED backlighting, offering more brightness.	Excellent, can achieve high brightness and true blacks since pixels can be turned off completely.	Similar to AMOLED, offering excellent brightness levels and true blacks.	Exceptionally bright due to quantum dot technology enhancing the LED backlight.
<b>Color Accuracy</b>	Good, but can be affected by the angle of view.	Improved over traditional LCD due to better backlight, but similar color accuracy.	Superior, offers more vibrant colors and deeper blacks.	Superior, with a wide color gamut and high contrast ratio.	Superior quantum dots provide a wide color gamut and vibrant colors.
<b>Viewing Angles</b>	Limited color and contrast can degrade at wide angles.	Similar to LCD but slightly improved in some models.	Excellent, maintains color and contrast at wide angles.	Excellent, maintains integrity of display at wide angles.	Very good, but can vary depending on the implementation.
<b>Power Consumption</b>	Generally efficient, but can be higher with brighter backlights.	More energy-efficient than traditional LCD due to LED backlighting.	More efficient than LCD/LED in displaying true blacks but can consume more power with bright white screens.	Similar to AMOLED in efficiency, excellent for power saving with dark themes.	Similar to LEDs, but efficiency can be improved with quantum dot technology.
<b>Lifespan</b>	Long, but can be affected by the backlight's life.	Longer than traditional LCD due to the durability of LEDs.	Shorter than LCD/LED due to organic material degradation.	Similar to AMOLED, organic materials may degrade over time.	Long, quantum dots enhance the longevity of LED backlights.
<b>Cost</b>	Generally the most affordable option.	More expensive than traditional LCD, but cost is decreasing.	More expensive due to organic materials and manufacturing complexity.	Similar to AMOLED, with a premium price tag.	More expensive than LCD/LED but can offer better performance for the price.

## 5G AND 6G TECHNOLOGY

In India, the introduction of 5G services took place in October 2022. Since then, the deployment of the 5G network has expanded across all 28 states and 8 Union Territories, marking it as one of the swiftest 5G deployments globally.

Comparison between 5G and 6G		
Feature	5G	6G
Peak Data Speed	Up to 10 Gbps	Expected to be up to 100 Gbps or more
Latency	As low as 1-10 ms	Expected to be less than 1 ms
Frequency Band	450 MHz to 52.6 GHz	above 100 GHz
Network Efficiency	High efficiency in energy and spectrum use	Expected to be significantly more efficient
Application Areas	Enhanced mobile broadband, IoT, industrial automation, smart cities, remote healthcare	Advanced IoT, smart cities and infrastructures, 3D holographic communication, high-fidelity mobile hologram, and augmented realities



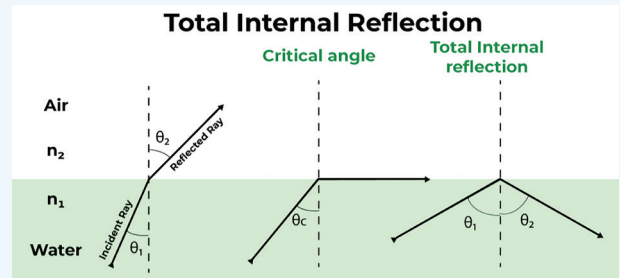
### Advantages of 5G Technology

- **Unprecedented Speeds:** 5G offers peak data rates up to 20 Gbps, allowing for ultra-fast downloads and uploads, significantly reducing the time required for streaming and downloading large files.
- **Lower Latency:** With a potential reduction to as low as 1 millisecond, 5G drastically cuts down the response time between devices and servers, enabling real-time applications, such as gaming and autonomous driving, to operate more efficiently.
  - ♦ **Latency:** It is a networking term to describe the total time it takes a data packet to travel from one node to another. In other contexts, when a data packet is transmitted and returned back to its source, the total time for the round trip is known as latency.
- **Increased Connectivity:** 5G can support a more significant number of connected devices per square kilometer, making it ideal for densely populated areas and for powering IoT (Internet of Things) ecosystems, from smart homes to smart cities.
- **Enhanced Capacity:** 5G networks can handle many more high-demand applications simultaneously, from high-resolution video streaming and virtual reality to massive machine-type communications in industrial applications.

### Disadvantages of 5G Technology

- **Limited Coverage:** Currently, 5G deployment is concentrated in urban areas, with extensive coverage and rural penetration still in progress, leading to a digital divide between different regions.
- **Infrastructure Costs:** The rollout of 5G technology requires substantial investment in new infrastructure, including cell towers and updated networking equipment, making it an expensive endeavor.
- **Device Compatibility:** Only the latest smartphones and devices are 5G-enabled, requiring consumers to upgrade their devices to take advantage of the new network, which can be costly.
- **Battery Consumption:** 5G devices tend to consume more battery life due to the higher data rates and processing power required, potentially leading to shorter device battery life.

- **Total Internal Reflection (TIR)** is a physical phenomenon that occurs when a light wave traveling through a medium arrives at the boundary with another medium at an angle greater than the critical angle, with respect to the normal to the surface.
- For TIR to occur, the light must be in the medium with a higher refractive index and be heading towards a medium with a lower refractive index.



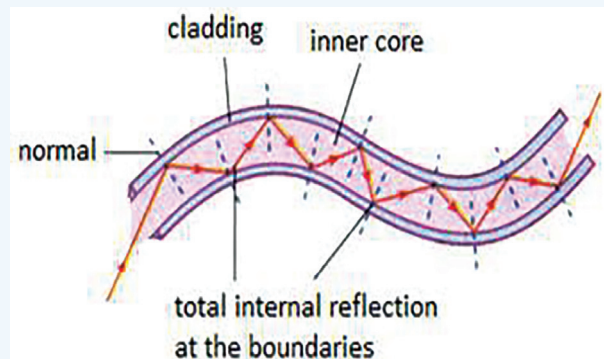
### THE BHARAT 6G ALLIANCE (B6GA)

- It is a pioneering initiative launched by the **Department of Telecommunications (DoT)**, under the Ministry of Communications, aimed at advancing innovation and establishing leadership in the realm of 6G wireless communication technology.
- This collaborative platform brings together a diverse group of stakeholders, including public and private companies, academic institutions, research organizations, and entities involved in developing standards.
- Its inclusive approach ensures a comprehensive coverage of expertise and resources necessary for the advancement of 6G technology.
- **Objectives:** The B6GA is committed to identifying and addressing both the commercial and societal implications of 6G technology. Its goal is to build consensus among stakeholders, drive impactful research, and development activities, and ensure that India is at the forefront of the 6G technology curve.

### Optical Fibre

- Optical fibre is the cornerstone of digital infrastructure, facilitating data transfer via light pulses along slender, flexible strands.
- Contrary to this method, metal wires are often selected for signal transmission due to their reduced signal degradation.
- The operation of optical fibre is governed by the principle of Total Internal Reflection (TIR).

- optical cables are engineered to redirect all light rays inward using TIR, ensuring effective data transmission.
- **Optical fibre is typically composed of the following materials:**
  - **Core:** The central part of the optical fibre where light is transmitted. It is usually made of glass (silica) or plastic. The core's high purity allows light to travel with minimal loss.
  - **Cladding:** A layer of material that surrounds the core. The cladding is made of glass or plastic with a lower refractive index than the core. This difference in refractive index causes the total internal reflection that allows light to propagate through the fibre without escaping.
  - **Buffer Coating:** A protective layer that surrounds the cladding. It is made of a plastic coating that protects the fibre from moisture and physical damage.



## RADIO ACCESS NETWORK (RAN)

C-DOT has entered into a partnership with Galore Networks to jointly develop a comprehensive range of products and solutions for a 5G Radio Access Network.

### About:

- It is a critical component of wireless telecommunications, facilitating the connection between mobile devices, such as smartphones, and the broader network infrastructure.
- It operates by transmitting data through radio waves from devices to the network's transceivers, which then relay this information to the core network, linking to the internet at large.
- The RAN is responsible for granting access and managing resources across its radio sites, enabling devices to wirelessly connect to the core network.
- This system allows a device to communicate with multiple RANs simultaneously, a feature seen in dual-mode handsets, thereby enhancing connectivity.

### Key Elements of RAN

- **Antennas:** These devices are responsible for converting electrical signals into radio waves, facilitating the transmission of data through the air.
- **Radios:** They convert digital data into a form that can be transmitted wirelessly, ensuring that the signals are broadcast within the appropriate frequency bands and at the correct power levels.
- **Baseband Units (BBUs):**
  - ♦ BBUs perform a variety of signal processing tasks essential for wireless communication. This includes error detection, encryption of signals for security, and efficient allocation of wireless resources.
  - ♦ Traditional BBUs utilize specialized hardware and extensive programming to achieve these functions, primarily operating within licensed radio frequency spectrums.

### RAN TYPES

- **Open RAN:** This trend focuses on creating cellular wireless networks that are built on **interoperable and open hardware, software, and interfaces**. It utilizes generic, standardized equipment, such as white-box servers, instead of the proprietary hardware typically found in base stations.

- **C-RAN (Centralized RAN):** C-RAN architecture decentralizes the radio components of a base station, employing **Remote Radio Heads (RRHs)** placed on cell towers to optimize radio coverage.
  - ♦ These RRHs are linked to central baseband controllers through either fiber optic or microwave radio connections, with the majority of baseband processing being carried out on generic white-box servers.

## 3D PRINTING

India has taken a groundbreaking step in technological advancement with the unveiling of its **first 3D-printed post office in Bengaluru** constructed by Larsen & Toubro Limited in partnership with IIT Madras.

### About

- 3D printing, or **additive manufacturing**, is a process that creates three-dimensional objects by adding material layer by layer, based on digital models.
- This method stands out from traditional manufacturing techniques, which typically remove material to shape an object.
- 3D printing uses a variety of materials, including plastics, metals, and bio-materials, to precisely construct objects with specific shapes, sizes, and properties.

### Key Concepts of 3D Printing

- **Layered Construction:** Objects are built layer by layer, contrasting with the subtractive process of traditional manufacturing.
- **Digital Blueprint:** Objects start as 3D models designed in CAD software, which are then sliced into thin layers to guide the printing process.
- **Material Choices:** A wide range of materials can serve as the "ink" for 3D printers, allowing for diverse applications.

### Applications of 3D Printing

- **Manufacturing:** Enables rapid prototyping, complex designs, and reduced waste.
- **Healthcare:** Produces custom implants, prosthetics, and models for surgical planning.
- **Aerospace:** Creates lightweight, durable parts for aircraft, enhancing fuel efficiency.
- **Fashion and Design:** Supports the creation of unique, intricate designs in fashion and accessories.

## e-SIM CARD

### About:

- It is a SIM card that is embedded in a mobile device and can connect you to any operator offering eSIM services.
- Furthermore, the e-SIM works the same way as a traditional SIM card, but you don't need a physical SIM card to use it.
- It is actually pre-installed in the device and you can activate it by installing the "eSIM profile" of a new operator.
  - ♦ *Examples:* iPhone 15 Pro, iPhone 14 Plus etc.

### Advantages of eSIMs

- **Convenience:** It will also save a trip to a telecom store/ service center when you visit a different state or country where you may want to switch to another operator.
- **Security:** When a phone with a physical SIM card is lost or stolen, the SIM card can be used in illegal activities.
  - ♦ An eSIM prevents this, as there is no physical element to pull out and use in another device.
- **One less opening on your phone:** Having an eSIM also means there is one less opening on the frame of your phone, in theory, which should reduce the likelihood of elements like dust and water entering the phone from yet another slot.

## DIGITAL INDIA RISC-V MICROPROCESSOR (DIR-V) PROGRAM

Recently, the Minister of State for Electronics and Information Technology launched the Digital India RISC-V Microprocessor (DIR-V) Program.

### About

- Its overall aim is to enable the creation of Microprocessors for the future in India, for the world and achieve industry-grade silicon and Design wins by December 2023.
- The government has set a timeline to commercially roll out the first indigenous chipsets by 2023-24 and future generation of microprocessors under the programme to meet the surging demand in semiconductors in the automotive, mobility and computing segments.

### Features:

- ♦ It will consolidate and leverage the ongoing efforts in the country with an integrated multi-institutional and multi-location team.
- ♦ It will finalize the formal architecture and target performance of chipsets, support original equipment makers and design wins in India and abroad.
- ♦ It is part of the government's Rs 76,000 crore effort to build a semiconductor ecosystem in the country.

## FLEX-FUEL VEHICLES (FFVS) AND FFV-SHEVS

### About:

#### Flex-Fuel Vehicles (FFVs):

- ♦ FFVs are vehicles equipped with engines that can operate on a mixture of petrol and **ethanol**, with the ethanol component varying up to 100%.
  - Ethanol is a significant biofuel obtained by **fermenting sugars using yeast** or through petrochemical processes.
  - These engines are designed to adjust to any proportion of the petrol-ethanol blend, offering versatility in fuel choice.

#### Flex Fuel Strong Hybrid Electric Vehicles (FFV-SHEVs)

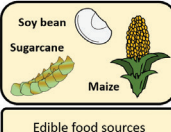
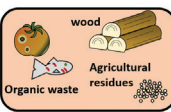
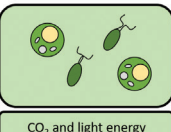
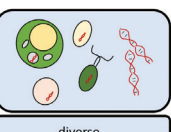
- ♦ FFV-SHEVs combine the flexible fuel capability of FFVs with strong hybrid electric technology.
- ♦ A strong hybrid, also known as a full hybrid, is a vehicle that can function entirely on electric power or petrol, offering a dual mode of operation.
- ♦ Unlike **mild hybrids**, which cannot operate solely on electric power and use it only to assist the primary petrol engine, **strong hybrids** can independently run on electric power, making them more versatile and efficient in fuel usage.

#### Ethanol Blending Programme (EBP) in India:

- ♦ **Objective:** The EBP aims to reduce oil imports, lower emissions, enhance energy independence, and support farmers' income by transitioning them into energy producers ('urjadata') while they continue to be food providers ('annadata'). This initiative also focuses on environmental betterment.
- ♦ **Updated Target:** The Indian government has revised its goal for achieving **20% ethanol** blending in petrol (**referred to as E20**) to 2025, moving it up from the initial target year of 2030.

- ◆ **Progress:** India has seen a significant increase in its ethanol blending rates, going from 1.53% in the fiscal year 2013-14 to 11.8% by August 2023.

### Four Generations of Biofuels:

	Advantages	Disadvantages
<b>1st Generation Biofuels</b>  Edible food sources	<ul style="list-style-type: none"> <li>• Simple processes</li> <li>• Cost efficient</li> <li>• Well established</li> <li>• No intensive pretreatments</li> </ul>	<ul style="list-style-type: none"> <li>• Food vs fuel conflict</li> <li>• High land use, high fresh water use</li> </ul>
<b>2nd Generation Biofuels</b>  Lignocellulosic biomass and other waste streams including industrial waste	<ul style="list-style-type: none"> <li>• Valorization of waste streams (circular economy)</li> <li>• Bypasses food vs fuel conflict</li> </ul>	<ul style="list-style-type: none"> <li>• Limited amounts of biomass</li> <li>• More extensive pretreatment necessary, due to complex feedstocks</li> </ul>
<b>3rd Generation Biofuels</b>  CO <sub>2</sub> and light energy	<ul style="list-style-type: none"> <li>• Direct capture of CO<sub>2</sub></li> <li>• No land use change, reduced fresh water use</li> <li>• Bypasses food vs fuel conflict</li> </ul>	<ul style="list-style-type: none"> <li>• Higher downstream costs</li> </ul>
<b>4th Generation Biofuels</b>  diverse	<ul style="list-style-type: none"> <li>• Higher yields/increased efficiency due to genetic engineering</li> <li>• Often includes direct use of CO<sub>2</sub> and syngas</li> </ul>	<ul style="list-style-type: none"> <li>• Higher regulation due to safety issues</li> </ul>

## BRAIN-COMPUTER INTERFACE

Recently, Elon Musk announced a successful Neuralink device implantation in a human.

### About:

- The Neuralink device, approximately the size of a large coin, is intended for implantation in the skull to enable a brain-computer interface.
- The wireless device implanted by Neuralink contains a chip and arrays of electrodes, which are meant to register thoughts related to movement.
- **Brain-Computer Interface (BCI):**
  - ◆ Technology that allows for direct communication between the brain and external devices (e.g., computers, prosthetics) without relying on traditional neuromuscular pathways.
  - ◆ Involves the use of sensors to capture brain activity.
  - ◆ Translates brain activity into commands or actions, permitting control of devices or interaction with the external world through thought.

### Applications:

- **Medical Rehabilitation:**Assisting patients with paralysis or motor neuron diseases to regain control over their limbs or prosthetic devices.
- **Neuroprosthetics:**Enabling amputees to control artificial limbs using their thoughts.
- **Assistive Technologies:**Developing communication aids for individuals unable to speak or use traditional input devices.
- **Neurogaming and Virtual Reality:**Integrating BCI with Virtual Reality (VR) and gaming for more immersive experiences.
- **Research and Neuroscience:**Advancing our understanding of the brain by mapping neural activity during various cognitive tasks.

### Potential Applications

- Terrestrial, aerial, and marine navigation.
- Disaster management.
- Vehicle tracking and fleet management for mining and transport sectors.
- Integration with mobile phones for precise timing and location services.
- Mapping and geodetic data capture.

### Significance of NavIC Integration in Smartphones

- Reduces reliance on foreign navigation systems like GPS.
- Showcases India's capacity in technology development and deployment.
- Ensures control over critical navigation infrastructure for national security.
- Provides accurate and reliable positioning in the Indian subcontinent.

### NVS-01

- Recently, a Geosynchronous Satellite Launch Vehicle (GSLV) mission deployed the NVS-01 navigation satellite, weighing about 2232 kg, into a **Geosynchronous Transfer Orbit**.
- NVS-01 is the **first of the second-generation satellites** envisaged for the Navigation with Indian Constellation (NavIC) services.
- NVS series of satellites will sustain and augment the NavIC with enhanced features. This series incorporates L1 band signals additionally to widen the services. For the first time, an indigenous atomic clock will be flown in NVS-01.

## NavIC SYSTEM

The recently unveiled Apple iPhone 15 now features integration with the navigation system (NavIC) created by the Indian Space Research Organisation (ISRO) within its hardware.

### About:

- NavIC, also known as the Indian Regional Navigation Satellite System (IRNSS) is developed by ISRO.
- Autonomous satellite navigation system for real-time positioning and timing.
- Covers India and regions extending **about 1500 km** around it.
- Consists of a **constellation of 7 satellites** and a network of ground stations.
- Although the system initially included eight satellites, currently, **only seven are operational**. This setup includes **three satellites positioned in geo-stationary orbit** and **four in geosynchronous orbit**.
- In 2020, the **International Maritime Organization (IMO)** acknowledged it as a component of the **World-Wide**

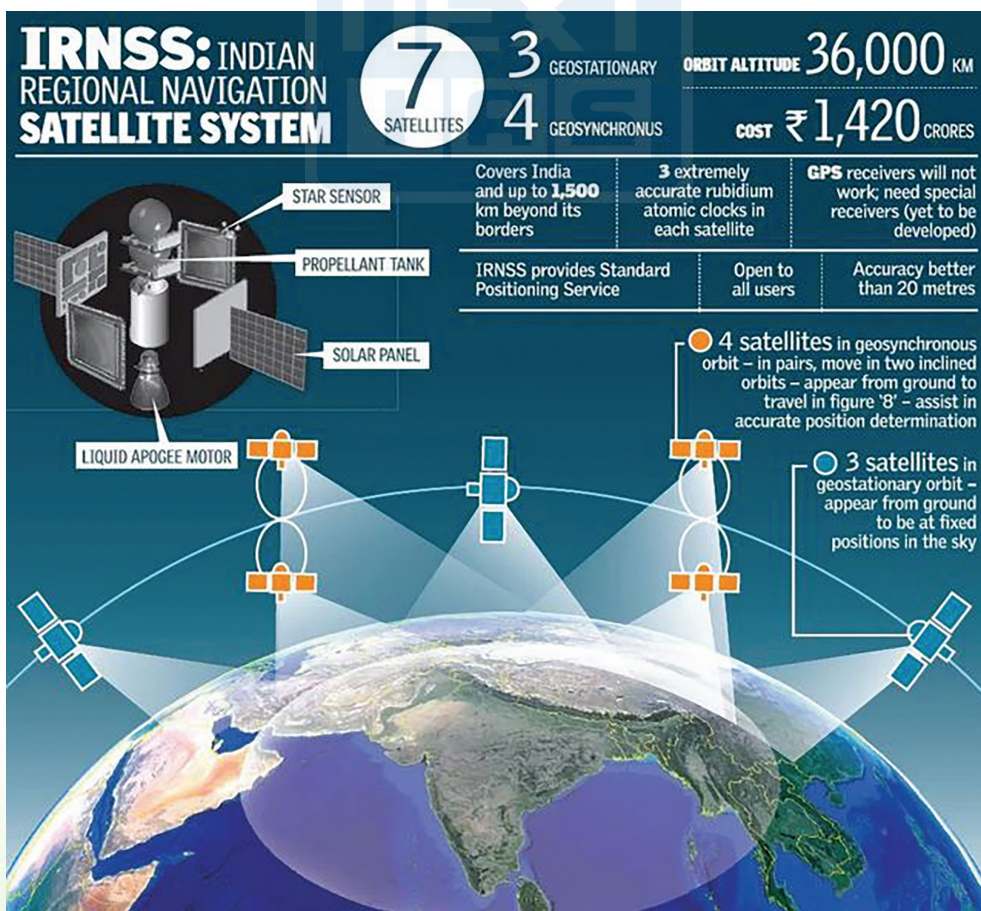
**Radio Navigation System (WWRNS)** for use within the Indian Ocean Region.

### GEOSYNCHRONOUS ORBITS

- Match the Earth's rotational period (about 24 hours).
- Return to the same position in the sky at the same time every day.
- Can have various inclinations and eccentricities.
- Not necessarily stationary relative to the Earth's surface.
- Useful for communication, meteorology, and surveillance.

### GEO-STATIONARY ORBITS

- A special case of geosynchronous orbits.
- Located directly above the Earth's equator.
- Maintain a constant position relative to the Earth's surface.
- Have an orbital period of exactly one sidereal day.
- Ideal for telecommunications, broadcasting, and weather forecasting.



**HEALTH ISSUES**

**STEM CELLS**

Recently, researchers in the US and the UK have successfully developed the world's first synthetic structures resembling human embryos by utilizing stem cells, eliminating the requirement for eggs and sperm.

**About Stem Cell**

- Stem cells possess the unique capability to evolve into various cell types within the body. When subjected to appropriate conditions, either within the body or in a laboratory setting, stem cells can proliferate, giving rise to daughter cells.
- These offspring can either maintain their stem cell identity or transform into specialized cells through a process known as differentiation.
- This transformation leads to the formation of specific cell types, including blood cells, brain cells, heart muscle cells, or bone cells, a capability no other cell in the body naturally possesses.
  - ♦ Essentially, stem cells act as the body's repair mechanism, replenishing and regenerating tissues as needed.



**INHERITANCE OF SICKLE CELL**

**PARENTS**  
Sickle Cell Trait (Carrier father)      Sickle Cell Trait (Carrier mother)

**CHILDREN**  
No Sickle Cell      Sickle Cell Trait (Carrier children)      Sickle Cell Anaemia

Normal haemoglobin A gene      Sickle haemoglobin S gene

**ABOVE, each parent has one normal haemoglobin A gene and one haemoglobin S gene. This means each of their children has:**  
**25% CHANCE** of inheriting two normal A genes. This child will not have either sickle cell trait or sickle cell disease  
**50% CHANCE** of inheriting one normal A gene and one S gene. This child will have sickle cell trait, and be a carrier  
**25% CHANCE** of inheriting two S genes. This child will have sickle cell disease  
**EACH TIME** the couple has a child, chances of the child having sickle cell disease remain same

**IMPACT ON RED BLOOD CELLS**

**Normal red blood cells**  
Normal red blood cell (RBC)  
RBCs flow freely within blood vessel  
Normal haemoglobin

**Abnormal, sickled, RBC (sickle cells)**  
Sickle cells blocking blood flow  
Sticky sickle cell  
Abnormal haemoglobin form strands that cause sickle shape

US National Institutes of Health (NIH)

**TYPES OF STEM CELLS**

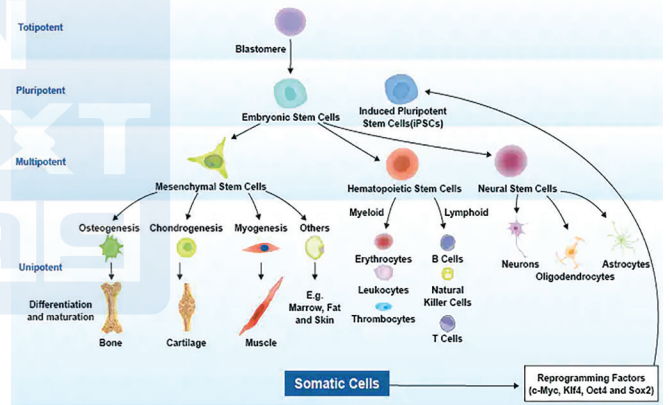
Feature	Totipotent Stem Cells	Pluripotent Stem Cells (PSCs)	Multipotent Stem Cells	Oligopotent Stem Cells	Unipotent Stem Cells
Definition	Can differentiate into all types of cells in an organism, including embryonic and extraembryonic structures.	Can form cells of all three germ layers (ectoderm, mesoderm, endoderm) but not extraembryonic structures like the placenta.	Can develop into cells of a specific lineage or tissue type.	Limited to differentiating into a few closely related cell types.	Can produce only one cell type, but possess high self-renewal capacity.
Examples	Zygote	Embryonic stem cells (ESCs), induced pluripotent stem cells (iPSCs).	Hematopoietic stem cells (blood cells), mesenchymal stem cells (bone, cartilage, fat).	Myeloid stem cells (certain types of white blood cells).	Dermatocytes (skin cells).



Differentiation Potential	Highest, with the ability to create an entire organism.	High, capable of giving rise to nearly any cell type in the body.	Moderate, restricted to specific cell types within a particular tissue or lineage.	Low, limited to several related cell types.	Very low, restricted to a single cell type.
Source	Early embryos.	Inner cell mass of the blastocyst for ESCs; adult cells reprogrammed for iPSCs.	Various tissues throughout the body.	Specific tissues, depending on the cell type.	Specific tissues, producing one type of cell.
Applications	Fundamental research on early human development.	Regenerative medicine, disease modeling, drug testing.	Regenerative therapies specific to tissues like blood, bone, and cartilage.	Limited therapeutic applications focused on specific cell types.	Targeted therapies, such as skin repair and regeneration.

### Applications

- Tissue Repair and Regeneration:** Stem cells can be used to repair or replace damaged tissues and organs, offering potential treatments for conditions such as heart disease, diabetes, and spinal cord injuries.
- Transplants:** Hematopoietic stem cells (HSCs) from bone marrow, peripheral blood, or umbilical cord blood are used in transplants to treat blood and immune system disorders, including leukemia and lymphoma.
- Disease Modeling:** Scientists can create disease models using patient-specific induced pluripotent stem cells (iPSCs) to study the progression of diseases and identify potential treatment pathways.
- Drug Safety and Efficacy Testing:** Before clinical trials, drugs can be tested on differentiated stem cells to assess their safety and effectiveness, reducing the reliance on animal testing.
- Genetic Research:** They are instrumental in studying the effects of genetic mutations and understanding genetic diseases, potentially leading to gene therapies.
- Gene Therapy:** Combining stem cell therapy with gene editing technologies like CRISPR could correct genetic defects in stem cells before transplantation, offering a potential cure for genetic disorders.



### CRISPR-CAS9 MECHANISM

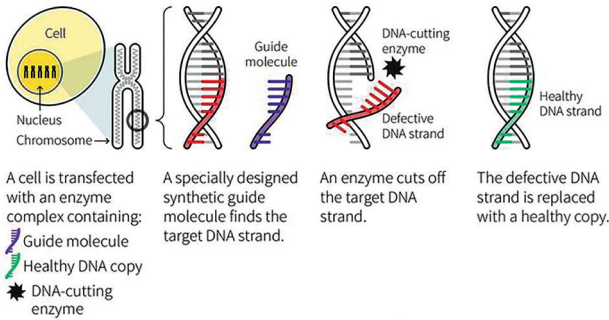
It employs two critical components to alter DNA:

- Cas9 enzyme:** Functions as molecular shears, capable of slicing through both strands of DNA at a designated spot within the genome.
  - This allows for the insertion or deletion of DNA segments.
- Guide RNA (gRNA):** Comprises a short, specifically engineered RNA sequence (roughly 20 bases in length) embedded within a longer RNA structure.
  - The longer portion attaches to the DNA, while the engineered sequence directs the Cas9 to the precise location in the genome where the cut should be made, ensuring the enzyme targets the correct section of DNA for editing.

## DNA editing

A DNA editing technique, called CRISPR/Cas9, works like a biological version of a word-processing programme's "find and replace" function.

### HOW THE TECHNIQUE WORKS



## Procedure

- In this therapy, T cells are extracted from the patient's blood.
- These cells are then engineered in the lab by introducing a gene that codes for a **Chimeric Antigen Receptor (CAR)**, which is designed to bind to a particular protein present on the cancer cells.
- This modification allows the T cells to specifically target and attack the cancer cells.
- Afterward, these engineered CAR T cells are multiplied in large numbers in the lab and administered back to the patient through an infusion.

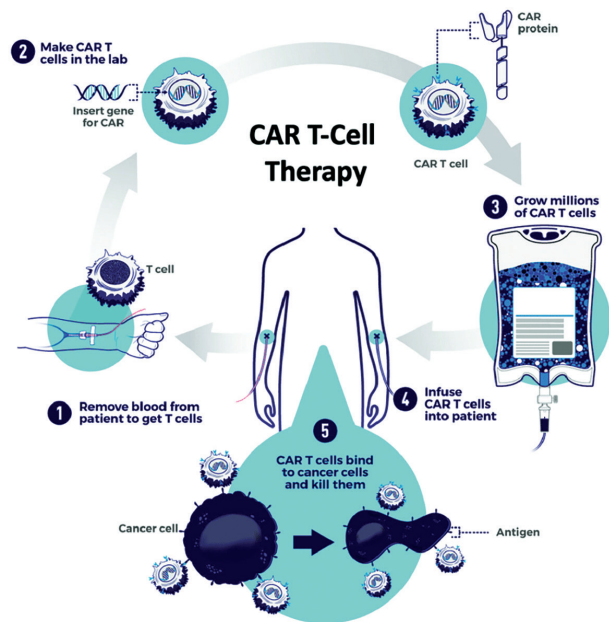
## Significance

- CAR T-cell therapies offer a more precise mechanism of action than other targeted therapies by directly engaging the patient's immune system to combat cancer, thus exhibiting superior clinical effectiveness.
- This innovation has led to their characterization as "living drugs," underlining the dynamic and personalized nature of this treatment approach.

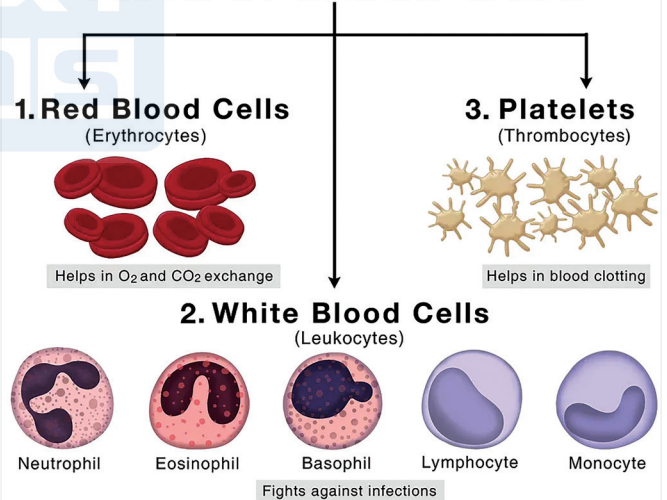
## CART CELL

### About:

- CAR T-cell therapies represent a significant advancement in the **realm of cancer treatment**.
- This innovative approach differs from traditional treatments like chemotherapy or immunotherapy, which rely on drugs.
- Instead, CAR T-cell therapy utilizes the patient's own cells, specifically modified in the lab to enhance T-cells' ability to recognize and destroy cancer cells.
- This form of therapy has gained approval for treating specific cancers such as leukemias, which originate from the cells responsible for generating white blood cells, and lymphomas, which develop from the lymphatic system.



## TYPES OF BLOOD CELLS



## T CELLS, OR T LYMPHOCYTES

- It represents a crucial category of white blood cells essential to the body's immune defense mechanisms.
- Their primary function is to facilitate cell-mediated immunity, enabling the body to identify and counteract external pathogens like viruses and bacteria, as well as internal threats such as cancerous cells.

- T cells are broadly classified into **two main types: helper T cells and cytotoxic T cells.**
  - Helper T cells play a supportive role by enhancing the functions of other immune system cells.
  - Cytotoxic T cells are involved in the direct destruction of cells infected by viruses and cancer cells.

## NEGLECTED TROPICAL DISEASES (NTDS)

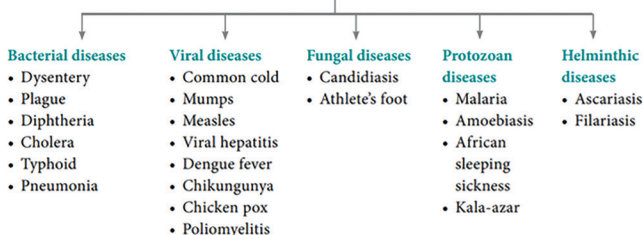
### About:

- These are a diverse group of conditions caused by a variety of pathogens (including **viruses, bacteria, parasites, fungi and toxins**) and associated with devastating health, social and economic consequences.
- NTDs are mainly prevalent among impoverished communities in tropical areas, although some have a much larger geographical distribution
- They are '**neglected**' because they are almost absent from the global health agenda.

### NTDS INCLUDE

- Buruli ulcer; Chagas disease; dengue and chikungunya; dracunculiasis; echinococcosis; foodborne trematodiasis;
- Human African trypanosomiasis; leishmaniasis; leprosy; lymphatic filariasis; mycetoma, chromoblastomycosis and other deep mycoses;
- Noma; onchocerciasis; rabies; scabies and
- Schistosomiasis; soil-transmitted helminthiasis; snakebite envenoming; taeniasis/cysticercosis; trachoma; and yaws.

### Common human diseases



Bacteria vs Viruses		
	Bacteria	Viruses
<b>DEFINITION</b>	Bacteria are single-celled ubiquitous microorganisms.	Viruses are non-living particles which are obligate parasites.
<b>CELL STRUCTURE</b>	Have a cellular structure	Have no cellular structure
<b>LIVING AND NON-LIVING</b>	Bacteria are living things	Possess both living and non-living characteristics but consider as non-living particles.
<b>STRUCTURE</b>	Composed of a single cell	Have just RNA, DNA and proteins, and use this genetic information to multiply in host cells.
<b>KINGDOM</b>	Kingdom Monera	Viruses do not belong to any of the five kingdoms
<b>CELL WALL</b>	Present	No cell wall, possess a protein coat.
<b>HARMFULNESS</b>	Most bacteria are beneficial to human beings and only some harm us.	All viruses are harmful to human beings..
<b>CONTROL</b>	Bacteria can be killed easily using antibiotics.	Antiviral drugs can only slow down the reproduction of viruses and cannot destroy them.

## VACCINES

- UNICEF, WHO, and Gavi announced the outcome of the first malaria vaccine supply allocation.
- The available supply of 18 million doses of RTS,S/AS01 vaccine has been allocated among twelve countries.

### About:

- This vaccine, the first of its kind against malaria, is designed to prevent P. falciparum malaria infections.
- Mosquirix is classified as a recombinant protein vaccine (RPV), marking a significant advancement in the fight against malaria.

### Recombinant Protein Vaccines (RPVs):

- These are a subset of Recombinant Subunit Vaccines (RSVs), focusing on using specific proteins as antigens to stimulate the immune system.

- These vaccines leverage targeted antigens, such as proteins, peptides, or DNAs from a pathogen, to provoke the body's immune response and build immunity against the disease-causing organism.
- **Safety of RPVs:**
  - ♦ RPVs are regarded as safer alternatives to live virus vaccines.
  - ♦ Their non-replicating nature means they do not contain any infectious elements of the virus, thus eliminating the risk of the vaccine inducing the disease it is designed to prevent.

ABOUT MALARIA
<ul style="list-style-type: none"> <li>• Malaria is a life-threatening, vector-borne disease caused by the <b>Plasmodium parasite</b>, transmitted through the bite of infected <b>female Anopheles</b> mosquitoes. The disease manifests through symptoms like high fever, shaking chills, and flu-like illness.</li> <li>• Humans can be infected by four types of malaria parasites: <b>P. falciparum, P. vivax, P. ovale, and P. malariae</b>.                     <ul style="list-style-type: none"> <li>♦ Additionally, <b>P. knowlesi</b>, a parasite that typically infects macaques in Southeast Asia, can also infect humans, resulting in a form of zoonotic malaria.</li> </ul> </li> </ul>

Type of Vaccine	Mechanism	Examples
Live Attenuated Vaccines	Use a weakened form of the germ that causes a disease to prompt a natural immune response.	Measles, Varicella (chickenpox) vaccine
Inactivated Vaccines	Use the killed version of the germ that causes a disease.	Polio vaccine, influenza vaccine. Bharat Biotech's Covaxin and Sinovac-CoronaVac
Viral Vector Vaccines	Viral vector-based vaccines use a harmless virus (like Adenovirus) to smuggle the instructions for making antigens from the disease-causing virus into cells, triggering protective immunity against it	Johnson & Johnson, Sputnik V and AstraZeneca
RNA Vaccines	Use messenger RNA (mRNA) to instruct cells to produce a protein that is part of the pathogen, triggering an immune response.	Pfizer and Moderna vaccines
DNA Vaccines	Use genetically engineered DNA to produce an immune response. They introduce a piece of DNA containing the genes for the pathogen's antigens.	ZyCoV-D
Conjugate Vaccines	Combine a weak antigen with a strong antigen as a carrier so that the immune system has a stronger response to the weak antigen.	Haemophilus influenzae type b (Hib) vaccine, Pneumococcal vaccine (PCV13), and Meningococcal vaccine.

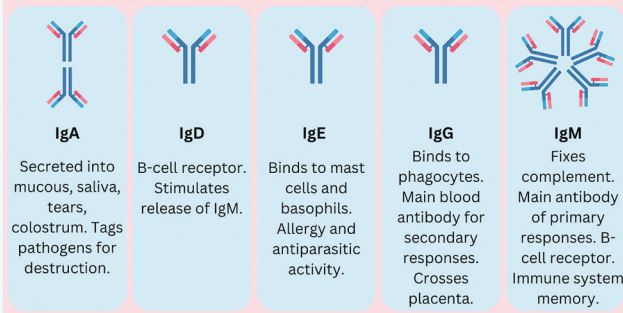
OTHER DISEASE IN NEWS			
Disease	Caused By	Transmission	Remarks
Zika Virus	Virus (Flavivirus)	Mosquito bites, sexual transmission, from mother to child.	No vaccine available. Associated with birth defects when pregnant women are infected.
Dengue Fever	Virus (Flavivirus)	Mosquito bites (Aedes aegypti)	Vaccine available but with limitations.
Kyasanur Forest Disease (Monkey Fever)	Virus (Flavivirus)	Tick bites, contact with an infected animal (mainly monkeys)	No Vaccine available till now. High fever, headache, severe muscle pain, vomiting, gastrointestinal symptoms, hemorrhagic symptoms in severe cases
Hepatitis C	Virus (HCV)	Blood-to-blood contact	No vaccine, treatment available that can cure most cases.
Chikungunya	Virus (Togaviridae family)	Mosquito bites (Aedes aegypti)	No vaccine; treatment focuses on relieving symptoms.
Japanese Encephalitis	Virus (Flavivirus)	Mosquito bites (Culex species)	Mild symptoms in most cases; severe cases can cause headache, high fever, neck stiffness, seizures, coma, and possibly death.

**KEY TERMS**

- **Antibody:** It is a specific type of protein synthesized by the immune system in response to the presence of antigens, which are harmful or foreign substances in the body. These antibodies play a crucial role in identifying and neutralizing such threats.
  - ♦ Antibodies are categorized based on the structure of their heavy chain constant regions into five main classes: **IgG, IgM, IgA, IgD, and IgE**. Each class serves distinct functions within the body's immune response.
  - ♦ Notably, IgG is the only class of antibody that can cross the placenta, allowing maternal IgG to provide essential protection to the newborn.

**5 Types of Antibodies**

Antibodies or immunoglobulins (Ig) are Y-shaped proteins that recognize unique markers (antigens) on pathogens.



- **Antigen:** It refers to any substance that triggers the immune system to generate antibodies in response to it, indicating that the immune system perceives this substance as unfamiliar and mounts a defense against it.
  - ♦ Antigens can originate from external sources, such as environmental chemicals, bacterial and viral pathogens, or pollen. Additionally, antigens can also develop internally within the body.

cells. Phage therapy utilizes these phages to combat bacterial infections.

- ♦ Unlike broad-spectrum antibiotics, which can kill off good bacteria in the microbiome along with harmful ones, potentially leading to additional health issues, phages are highly specific, typically attacking only certain strains or species of bacteria.

**Characteristics:**

- **Specificity:** Bacteriophages display a high degree of specificity, infecting only certain bacterial species or strains. This specificity stems from the ability of phage proteins to recognize and bind to specific receptors on the surface of bacterial cells.
- **Structure:** The structure of bacteriophages typically includes a nucleic acid core, which may be DNA or RNA, encased within a protein shell. Many bacteriophages also possess additional features like tail fibers or spikes, which facilitate the attachment to and penetration of bacterial cells.
- **Replication Process:** After infecting a compatible bacterial host, a bacteriophage hijacks the host's cellular machinery to replicate its own genetic material and produce new phage particles. The infected bacterial cell eventually bursts (lyses), releasing new bacteriophages that can then infect additional bacterial cells.
- **Prevalence:** Bacteriophages are the most numerous life forms on the planet, with estimates suggesting they outnumber bacteria by a factor of at least 10 to 1. They are pivotal in maintaining bacterial population dynamics across diverse ecosystems.

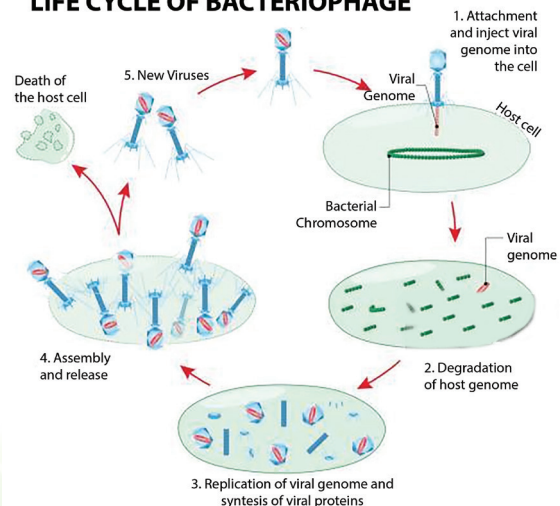
**BACTERIOPHAGE**

Researchers are investigating the use of bacteriophages as a treatment for infections caused by antibiotic-resistant bacteria.

**About:**

- The discovery of bacteriophages is credited to Frederick William Twort in 1915 in Great Britain and Felix d'Herelle in 1917 in France.
- Bacteriophages, also known as phages, are viruses that specifically infect and multiply within bacterial

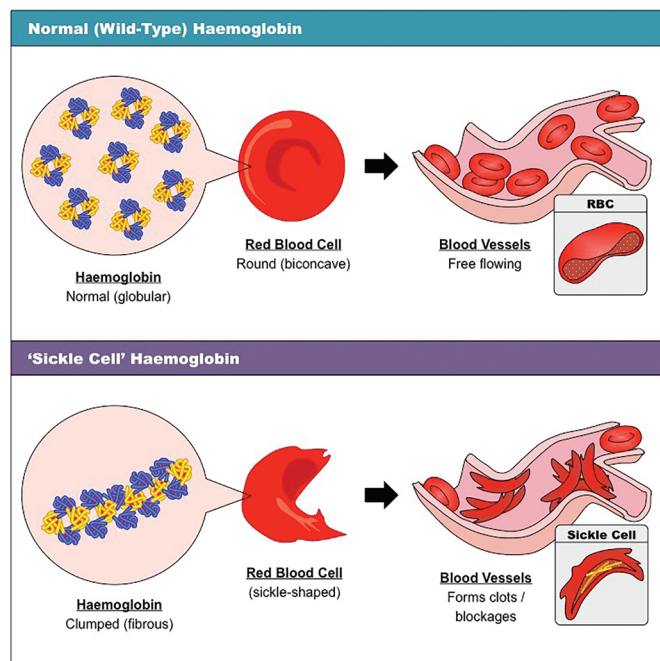
**LIFE CYCLE OF BACTERIOPHAGE**



## SICKLE CELL ANEMIA

### About:

- Sickle cell Disease (SCD) is a group of inherited (genetic) red blood cell disorders.
  - ♦ Red blood cells (RBCs) contain hemoglobin, a protein that carries oxygen.
  - ♦ Healthy red blood cells are round, and they move through small blood vessels to carry oxygen to all parts of the body.
  - ♦ In SCD, the hemoglobin is abnormal, which causes the RBCs to become hard and sticky and look like a C-shaped farm tool called a "sickle."
- It is transmitted by parents carrying a defective 'beta globin' gene.
- The sickle cells die early, which causes a constant shortage of RBCs.
- When they travel through small blood vessels, they get stuck and clog the blood flow. This can cause pain and other serious complications (health problems) such as infection, acute chest syndrome and stroke.



### Treatment

- **Gene Therapy:** The DNA inside the hemoglobin gene is edited to stop the disease.
- **Stem cells Transplant:** The bone marrow affected by sickle cell anaemia is replaced with healthy bone marrow from a donor.

- **Blood Transfusion:** RBCs are removed from donated blood and given to a patient, but challenges include a scarcity of donors, fears around safe supply of blood, risk of infection etc.

## WHO'S GONE INITIATIVE

### About

- The Global Onchocerciasis Network for Elimination (GONE) was launched in 2023 by WHO
- Its goal is to empower countries to accelerate progress towards the achievement of the road map targets for onchocerciasis elimination.
- Key focus area is to strengthen communication and partnerships and empower countries to achieve the onchocerciasis targets for 2030.

### ABOUT ONCHOCERCIASIS

- Onchocerciasis (river blindness) is the second leading infectious cause of blindness worldwide. It is classified by WHO as a Neglected Tropical Diseases.
- River blindness mostly affects people living in isolated and underserved rural communities in some of the world's poorest regions.
- The infection is spread by black flies that live near fast-flowing rivers; it causes severe skin irritation, itching and, eventually, irreversible blindness.

### WORLD HEALTH ORGANIZATION (WHO)

- **Establishment:** Founded in 1948 as the United Nations' specialized agency for health.
- **Headquarter:** located in Geneva, Switzerland.
- **Membership:** Comprises 194 Member States including India
- **Nature:** An intergovernmental organization that collaborates primarily with member states through their Ministries of Health.
- **Functions:**
  - ♦ Leads on global health issues.
  - ♦ Shapes the health research agenda.
  - ♦ Sets health norms and standards.
  - ♦ Offers evidence-based policy options.
  - ♦ Provides technical support to countries.
  - ♦ Monitors and assesses health trends.

## BIOSIMILARS

The health ministry plans to revamp guidelines for approving biosimilar drugs.

### About

- **Definition:** Biosimilars are biologic medicines highly similar to an existing biologic (the reference product), with minor differences in inactive components.
  - ♦ *Examples:* Biologic drugs with biosimilars include **etanercept, infliximab, and adalimumab.**
- **Manufacturing Process:** Biosimilars are produced using the same amino acids and processes as the reference drug, ensuring high similarity.
- **Regulatory Approval:** Undergo thorough evaluation to ensure they meet the necessary criteria for similarity to the reference biologic.
- **Distinction from Generics:** Unlike generic drugs, biosimilars are not identical copies due to the complexities of biological materials, but they are closely similar and meet stringent approval standards.

### ABOUT BIOLOGICS

- **Definition:** Biologics are complex proteins derived from living organisms, contrasting with traditional drugs that are chemical compounds.
- **Size and Complexity:** They are significantly larger and more complex than "small molecule" drugs like aspirin.
- **Types of Biologics:** Includes gene and cell therapies, therapeutic proteins, monoclonal antibodies, and vaccines.
- **Applications:** Used to prevent, treat, or cure various diseases such as cancer, chronic kidney disease, diabetes, cystic fibrosis, and autoimmune disorders.


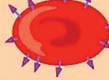
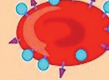
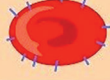
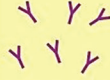

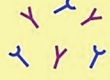
## BOMBAY BLOOD GROUP

In recent times, the spike in demand of Bombay Blood Group has been witnessed due to the rarity of its presence.

### About:

- The Bombay blood type, also known as hh, is characterized by its inability to express the H antigen.
- This results in red blood cells of the hh group lacking the H antigen.
- It is commonly mistaken for the O blood group; however, the key distinction lies in the presence of the H antigen in the O group, which is absent in the hh group.

- Discovered in Mumbai (formerly known as Bombay) in 1952 by Dr. Y M Bhende, the Bombay blood group is notably rare.

	Type A	Type B	Type AB	Type O
Antigen (on RBC)	Antigen A 	Antigen B 	Antigens A + B 	Neither A or B 
Antibody (in plasma)	Anti-B Antibody 	Anti-A Antibody 	Neither Antibody	Both Antibodies 
Blood Donors	Cannot have B or AB blood Can have A or O blood	Cannot have A or AB blood Can have B or O blood	Can have any type of blood Is the universal recipient	Can only have O blood Is the universal donor

## COMPLETE SEQUENCE OF Y CHROMOSOME

A recent international research endeavor has successfully produced the first truly complete sequence of the human Y chromosome using the innovative "long-read" sequencing method.

### About:

- The Y chromosome, alongside the X chromosome, constitutes one of the **two sex chromosomes** in humans, playing a crucial role in **determining sex**.
- It forms part of the **23 chromosome pairs** found in human cells, being notably smaller and comprising approximately **2% of a cell's total DNA**, with an estimated 50 to 60 genes.
- In human genetics, males possess one Y and one X chromosome, while females have two X chromosomes.

### Genetic Significance of the Y Chromosome:

- The Y chromosome is **exclusive to males**, harboring genes primarily associated with the determination and development of male characteristics.
- Its smaller size and fewer gene content, relative to the X chromosome, have branded it as the determinant of male sex, focusing predominantly on male-specific biological functions.
- Among its critical genes, the **Sex-Determining Region Y (SRY) gene** stands out for its pivotal role in male sex determination, guiding the fetal development towards male characteristics.
  - ♦ It directs the development of a ridge of cells into a **testis** in the embryo.

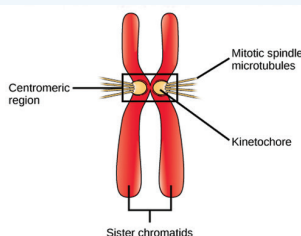
- Additionally, other genes on the Y chromosome play essential roles in male fertility, enabling men to father biological offspring.

### DNA Sequencing:

- DNA sequencing techniques have evolved to decode the sequence of DNA, revealing genetic information critical for research and medicine.
- **Sanger Sequencing:** As one of the earliest DNA sequencing methods, Sanger sequencing is capable of sequencing short DNA fragments, typically up to 900 base pairs. This method laid the groundwork for DNA sequencing technologies.
- **Long-Read Sequencing:** Also known as third-generation sequencing, long-read sequencing is a technique that sequences **much longer fragments of DNA, ranging from 10,000 to 100,000 base pairs**. This capability marks a significant advancement over traditional short-read sequencing methods.
- **Advantages of Long-Read Sequencing**
  - ♦ **Sequencing Capacity:** It can read the DNA sequence of substantially longer fragments, providing a more comprehensive view of the genome.
  - ♦ **Detecting Complex Variants:** Long-read sequencing excels at identifying complex structural variants that are challenging or impossible to detect with short-read sequencing. This ability is crucial for understanding genetic diversity and disease mechanisms.

### CHROMOSOMES

- Within the nucleus of every cell, the **DNA molecule is organized into structures resembling threads**, known as chromosomes.
- These chromosomes consist of DNA that is tightly wound around proteins known as **histones**, which provide structural support. Under normal conditions, chromosomes cannot be seen within the cell's nucleus, even when using a microscope.



Chromosome:  
composed of  
proteins and  
DNA

## MISCELLANEOUS

### TITAN SUBMERSIBLES

The Titan disappeared near the Titanic wreck site in the North Atlantic on June 19, 2023. This incident highlights the challenges and risks associated with deep-sea exploration using submersibles.

#### About

- A **submersible** is an underwater vehicle designed for temporary operations beneath the surface.
- **Unlike submarines**, submersibles cannot sustain long underwater missions on their own and require a support vessel for deployment and retrieval. They lack the autonomy to navigate to and from ports independently.

#### Features of Titan

- **Capacity:** The Titan was equipped to transport one pilot and four passengers, making it suitable for a range of underwater activities.
- **Depth Range:** It was capable of descending to depths of up to 4,000 meters (13,123 feet), allowing for deep-sea exploration and research.
- **Construction:** Built from titanium and carbon fiber, the Titan combined durability with a lightweight design, weighing approximately 9.5 tons. Its dimensions were 6.7 by 2.8 by 2.5 meters (22 by 9.2 by 8.3 feet).
- **Life Support:** The submersible provided up to 96 hours of life support for its crew, ensuring safety during extended dives.

### SIGHT PROGRAMME

Union government announced Strategic Interventions for Green Hydrogen Transition (SIGHT) Programme.

#### Objectives and Implementation

- **Parent Mission:** National Green Hydrogen Mission
- **Goals:** Enhance local manufacturing of electrolyzers and increase green hydrogen production.
- **Financial Incentives:** Initially, the programme introduces two types of financial incentives aimed at electrolyser manufacturing and green hydrogen production, with a budget of ₹17,490 crore extending until the fiscal year 2029-30.



- **Executing Body:** Solar Energy Corporation of India (SECI) is designated to manage and execute the programme.

**NATIONAL GREEN HYDROGEN MISSION**

- **Implemented by:** Ministry of New and Renewable Energy
- **Objectives:** The Mission will facilitate demand creation, production, utilization and export of Green Hydrogen.
  - ♦ It aims to make India a 'global hub' for using, producing and exporting green hydrogen.
  - ♦ It aims to incentivise the commercial production of green hydrogen and make India a net exporter of the fuel.
  - ♦ The mission has laid out a target to develop green hydrogen production capacity of at least **5 MMT (Million Metric Tonne) per annum**. This is alongside adding renewable energy capacity of about 125 GW (gigawatt) in the country.

**Solar Energy Corporation of India Ltd (SECI)**

- It is a **CPSU** under the administrative control of the **Ministry of New and Renewable Energy (MNRE)**, set up in 2011 to facilitate the implementation of National Solar Mission (NSM) and achievement of targets set therein.
- It is the only CPSU dedicated to the renewable energy sector. It was originally incorporated as a **section-25** (not for profit) company under the **Companies Act, 1956**.
  - ♦ However, through an amendment by the Government of India, the company has been converted into a **Section-3 company**, in 2015, under the **Companies Act, 2013**.
- The mandate of the company has also been broadened to cover the entire renewable energy domain.

	Terminology	Technology	Feedstock / Electricity source	GHG footprint*
PRODUCTION VIA ELECTRICITY	Green Hydrogen	Electrolysis	Wind   Solar   Hydro Geothermal   Tidal	Minimal
	Purple/Pink Hydrogen		Nuclear	
	Yellow Hydrogen	Mixed-origin grid energy	Medium	
PRODUCTION VIA FOSSIL FUELS	Blue Hydrogen	Natural gas reforming + CCUS Gasification + CCUS	Natural gas   coal	Low
	Turquoise Hydrogen	Pyrolysis	Natural gas	Solid carbon (by-product)
	Grey Hydrogen			Medium
	Brown Hydrogen	Gasification	Brown coal (lignite)	High
	Black Hydrogen		Black coal	

\*GHG footprint given as a general guide but it is accepted that each category can be higher in some cases.

**SAMUDRAYAAN MISSION**

India is planning to explore deep sea resources with its Samudrayaan mission which is expected to be realized by year 2026. The Indian Government launched the Samudrayaan mission in 2021.

**About**

- India will send three personnel to 6,000 meter depth in a vehicle called Matsya 6000 for the exploration of deep-sea resources like minerals.
  - ♦ **MATSYA 6000** vehicle is being designed and developed by Chennai-based **National Institute of Ocean Technology (NIOT)** which is an autonomous society under the Ministry of Earth Sciences.
- **Participation:** Indian Space Research Organization (ISRO), IITM, and Defence Research and Development Organisation (DRDO) will actively participate in this mission.
- **Elite club of nations:** India will be joining the elite club of nations such as the US, Russia, Japan, France, and China to have niche technology and vehicles to carry out subsea activities.

**INDIA'S DEEP OCEAN MISSION**

**MATSYA 6000**  
Manned submersible for deep-sea exploration; a major technology project under Deep Ocean Mission

**ESTIMATED COST**  
₹4,077 crore (for 2021-2026 period)

**OPERATION ENDURANCE**  
12 hours

**EMERGENCY LIFE SUPPORT**  
96 hours

**GOALS**

- Explore deep ocean for resources
- Develop deep-sea technologies for sustainable use of resources

**CAPABILITIES**

- Deep ocean resource exploration
- Scientific observations in deep waters
- Search and rescue support

**CAPACITY**  
Pilot +2

**DIVE DEPTH**  
6,000m

**Weight**  
24 tonnes

**RECORD HOLDER**  
**TRITON 36000/2**

- World's deepest diving manned submersible

**Weight**  
12.5 tonnes

**Capacity**  
Pilot + 1

**Depth reached**  
10,927m

**COUNTRIES WITH DEEP WATER SUBMERSIBLES**

- USA**  
Alvin (1964)  
Pisces (1972)  
Triton (2019)
- France**  
Nautilus (1985)
- Japan**  
Shinkai (1990)
- Russia**  
Mir (1990)  
Rus (2002)  
Consu (2009)
- China**  
Jiaolong (2009)  
Deep Sea Warrior (2018)  
Fendouzhe (2020)
- Australia**  
Deep Sea Challenger (2012)

### DEEP OCEAN MISSION (DOM)

- Launched by the **Ministry of Earth Sciences (MoES)** to foster the development of deep-sea exploration technologies and capabilities.
- Supported by the **Prime Minister's Science, Technology, and Innovation Advisory Council (PMSTIAC)**.

#### Fundamental Aspects of the Mission:

- Focusing on creating advanced tools and vehicles for exploring and exploiting deep-sea resources.
- Offering insights and guidance on the impacts of climate change on oceanic environments.
- Encouraging new methods and technologies to explore and protect the vast biodiversity found in deep-sea ecosystems.
- Conducting surveys to discover and characterize mineral deposits in the deep ocean.

## Batteries and its Types

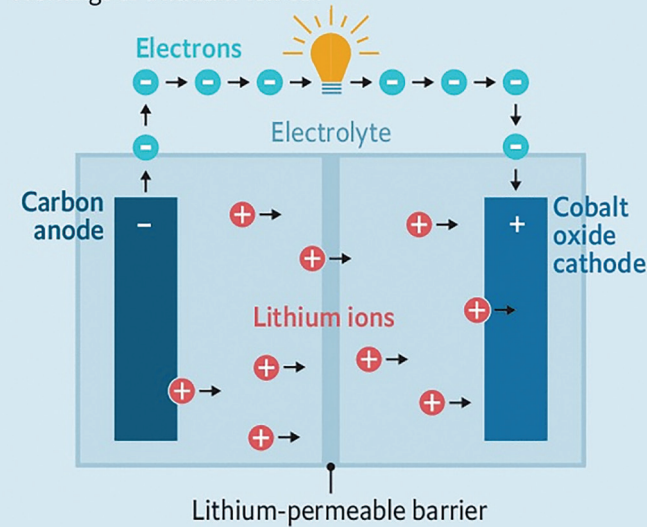
### LI-ION BATTERY (LIB)

#### About

- Lithium-ion (Li-ion) batteries are a type of **rechargeable battery** that primarily relies on lithium ions to function. These batteries are prevalent in portable electronics, electric vehicles, and energy storage solutions due to their efficient energy storage capabilities.

#### A better battery

Workings of a lithium-ion cell



#### Composition and Structure

- **Components:** A Li-ion battery consists of an **anode** (negative electrode), **cathode** (positive electrode), separator, electrolyte, and current collectors (positive and negative).
- **Electrode Materials:** The anode is usually made from graphite, while the cathode materials can vary, including **lithium cobalt oxide (LiCoO<sub>2</sub>)**, **lithium manganese oxide (LiMn<sub>2</sub>O<sub>4</sub>)**, and **lithium iron phosphate (LiFePO<sub>4</sub>)**.
- **Mechanism:** While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other. When plugging in the device, the opposite happens: Lithium ions are released by the cathode and received by the anode.

#### Applications

- Li-ion batteries dominate the portable electronics market, including in smartphones and laptops.
- They are also integral to powering electric vehicles and are used in aerospace applications, notably in the **Boeing 787**, to reduce weight and enhance efficiency.

#### Advantages

- **Energy Density:** Li-ion batteries have one of the highest energy densities, allowing them to store more energy relative to their size and weight.
- **Low Self-Discharge:** They have a lower self-discharge rate than other rechargeable batteries, retaining their charge for longer periods.
- **Voltage Capacity:** Capable of delivering up to 3.6 Volts, Li-ion batteries can provide high current for power-intensive applications without the memory effect, making them suitable for a wide range of uses.
- **Eco-Friendly:** They are free from toxic cadmium, making disposal less harmful compared to Ni-Cd batteries.

#### Disadvantages

- **Safety Concerns:** Li-ion batteries are prone to overheating and can cause thermal runaway and fires if damaged or charged excessively.
- **Aging and Cost:** These batteries undergo aging, reducing their capacity over time, and are relatively costly, being about 40% more expensive than Ni-Cd batteries, which can limit their broader adoption despite their advantages.

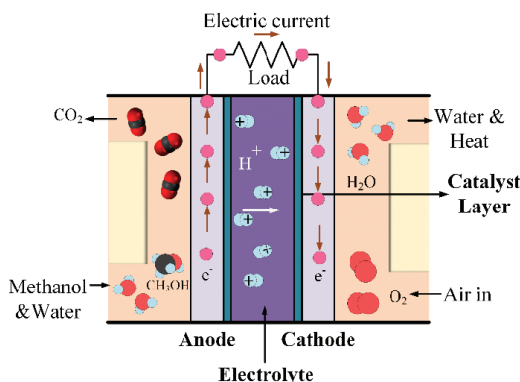
### SODIUM-ION BATTERY (SIB)

- It represents a rechargeable battery technology similar to lithium-ion batteries (LIBs), utilizing sodium ions (Na+) for charge transport.
- This type of battery comprises several key components: an anode, cathode, electrolyte (which can be either non aqueous or aqueous), and a separator.
- Its operational mechanism is similar to that of LIBs, with sodium ions moving from the cathode (positive electrode) to the anode (negative electrode) during discharge, and vice versa during charging.

Comparison	Sodium-ion Batteries	Lithium-ion Batteries
Anode Material	Hard Carbon, Sodium Titanate	Graphite
Cathode Material	Sodium-containing Compounds	Lithium-containing Compounds
Energy Density	Lower	Higher
Raw Material Abundance	Sodium (Abundant)	Lithium (Less Abundant)
Safety and Stability	Safer, More Stable	Sensitive to Overcharging, Heating
Cycle Life	Shorter	Longer
Applications	Stationary, Grid Storage	Portable Electronics, EVs
EV Usage	Limited Due to Lower Energy Density	Common for Higher Energy Density
Environmental Impact	Lower Environmental Impact	Environmental Concerns
Cost-effectiveness	Cost-effective Due to Abundance	Potentially Higher Costs

### DIRECT METHANOL FUEL CELLS (DMFCs)

It represents a cutting-edge technology that stands out for being lightweight, potent, and durable. These fuel cells operate on DMFC technology, utilizing direct methanol as a fuel source to generate electricity.



### Working Principles

- The design of DMFCs closely resembles that of a battery, featuring two electrodes divided by a membrane: an anode on one side and a cathode on the other.
- In the presence of oxygen, the methanol fuel cell converts methanol fuel into energy, which is why it's named as such.
- The chemical reaction within the DMFC produces only direct current (DC) electricity, heat, water, and a minimal amount of CO2 as its by-products.

### How Energy is Produced

- In this, energy is produced through an electrochemical reaction where methanol and water are oxidized at the anode, resulting in the formation of carbon dioxide, protons, and electrons.
- The protons produced at the anode pass through the polymer electrolyte membrane to reach the cathode, where they combine with oxygen to create water.
- Meanwhile, the electrons generated during the oxidation process at the anode are transported through an external circuit.
- This movement of electrons through the circuit is what generates electricity, harnessing the free energy change from the chemical reaction.

### Advantages

- **Methanol Handling:** Methanol's ease of transport and storage, due to its liquid state and lower requirements compared to hydrogen, combined with its cost-effectiveness and availability, enhances its practical use in DMFCs.
- **Clean Energy Production:** DMFCs efficiently utilize by-products, excluding CO2, for additional applications like heating and hydrogen production, offering a clean energy solution with minimal emissions and direct electricity generation for external use.
- **Durability:** DMFCs operate quietly without moving parts, reducing wear and maintenance. This leads to lower operational costs and highlights their reliability and longevity in comparison to traditional combustion engines or turbines.

### Disadvantages

- **Lower Energy Density:** Compared to some other fuel cell types and lithium-ion batteries, DMFCs possess a lower energy density. This can limit their effectiveness in applications requiring compact energy solutions with high power output.

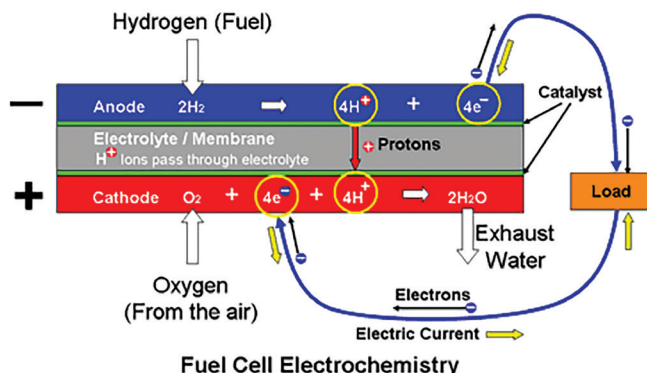
- **Methanol Crossover:** One technical challenge of DMFCs is methanol crossover, where methanol leaks from the anode to the cathode through the membrane. This not only wastes fuel but also reduces the cell's efficiency and power output.
- **Cost of Catalysts:** Although methanol itself is relatively inexpensive, the catalysts required for the DMFC reaction, typically platinum-based, are costly. This increases the overall cost of DMFC systems and impacts economic viability.
- **CO2 Emissions:** While DMFCs produce fewer emissions compared to fossil fuel-based systems, they still emit CO2 as a by-product of methanol oxidation. This poses challenges for applications where zero-emission solutions are preferred.

## GREEN HYDROGEN FUEL CELLS

Recently, the Union Minister of Petroleum & Natural Gas Launched the country's first Green Hydrogen Fuel Cell Bus in New Delhi.

### About

- Green Hydrogen Fuel Cells represent an innovative and clean energy technology, offering a sustainable and efficient method for generating high-quality electric power.
- These cells operate by utilizing green hydrogen, derived from renewable resources, to initiate an electrochemical reaction that generates electricity, with only water and heat as by-products.
- **Fuel Cell Mechanics:** A fuel cell is a device that transforms the chemical energy of a fuel, such as hydrogen, into electrical energy through an electrochemical reaction, involving two electrodes (an anode and a cathode) and an electrolyte.



- **Electricity Generation Process:**
  - ♦ Green hydrogen is directed to the fuel cell's anode side.
  - ♦ At the anode, hydrogen molecules are ionized, releasing electrons and forming positively charged ions.
  - ♦ Electrons travel to the cathode through an external circuit, creating an electric current.
  - ♦ Oxygen is introduced to the cathode, where it reacts with electrons and hydrogen ions to produce water vapor.

### Benefits

- **Zero-Emission:** The sole by-products of this process are water and heat, positioning green hydrogen fuel cells as an environmentally friendly energy solution.
- **Quick Refueling:** Similar to conventional vehicles, hydrogen fuel cell vehicles can be quickly refueled.

### Challenges

- **Cost Factors:** The production of green hydrogen is currently costly, though research is underway to make it more economical.
- **Infrastructure Development:** Establishing a comprehensive hydrogen infrastructure, encompassing production, storage, and distribution systems, is crucial for its broad adoption.

## PROJECT TAARA

### About:

- An initiative by Alphabet, the parent company of Google, is at the forefront of deploying innovative internet technology globally, including in India and Africa.
- The project harnesses **Free Space Optical Communication (FSOC)** technology to create a novel communication channel that operates in the free space between line-of-sight transceivers.
- **Communication Medium:** Unlike traditional communication technologies that rely on cables or radio waves, FSOC uses free space as its medium, leveraging beams of light to facilitate connectivity.
- **Capabilities:** Project Taara's FSOC technology enables high-speed, high-capacity data transmission, achieving bidirectional speeds of up to 20 Gbps over distances up to 20 kilometers.

Feature	FSOC (Free Space Optical Communication)	LiFi (Light Fidelity)
Definition	A technology that uses light beams to transmit data through free space as a communication channel between transceivers in line-of-sight.	A technology that uses visible light communication (VLC) for high-speed wireless communication within a short range.
Application	Designed for outdoor environments to provide high-speed internet connectivity over long distances.	Primarily used for indoor applications, offering high-speed data transmission in a local area network.
Speed	Can achieve bidirectional speeds of up to 20 Gbps.	Speeds can vary, with some systems offering up to 224 Gbps under laboratory conditions.
Distance	Effective over distances up to 20 km.	Effective within shorter ranges, typically within a room or visible light range.

## XRISM PROJECT

### About

- The X-Ray Imaging and Spectroscopy Mission (XRISM) is a joint project involving the Japan Aerospace Exploration Agency (JAXA) and the National Aeronautics and Space Administration (NASA), with contributions from the European Space Agency (ESA) and the Canadian Space Agency (CSA).
- Primary Objective:** To capture and accurately determine the wavelengths of X-rays originating from deep space, providing insights with unparalleled precision.
- Advanced Spectroscopy:** Employs cutting-edge spectroscopy techniques to monitor the fluctuation in brightness of space objects across various wavelengths.

- Energy Detection Range:** XRISM is equipped to detect X-rays with energy levels ranging from 400 to 12,000 electron volts, extending beyond the energy spectrum of visible light (2 to 3 electron volts).
- Astrophysical Insights:** The mission aims to offer new data about the universe's extremely hot regions, its largest cosmic structures, and entities exhibiting the strongest gravitational forces.

## DARK-SKY RESERVE

Ladakh is poised to establish India's inaugural Dark Night Sky Reserve in the Hanle village, located within the Changthang region.

### About:

- It is an area whose sky is free of light pollution. It is a designation given to a place that has policies in place to ensure that a tract of land or region has minimal artificial light interference.
- The authorities safeguard telescopes' access to dark skies by actively lowering light pollution around their sites. Several such reserves exist around the world but none so far in India.
- Nomination by:** The **International Dark Sky Association is a U.S.-based non-profit** that designates places as International Dark Sky Places, Parks, Sanctuaries and Reserves, depending on the criteria they meet.
- Significance:**
  - The reserve will boost astro tourism in India and will be one of the world's highest-located sites for optical, infrared, and gamma-ray telescopes.
  - The astronomical observatories located in the area particularly to keep the skies dark.

## INDIA'S FIRST INDIGENOUSLY DEVELOPED NUCLEAR POWER REACTOR

India's indigenously developed 700 MW nuclear power reactor, situated at the Kakrapar Atomic Power Project (KAPP) in Gujarat, has commenced its commercial operations.

### Kakrapar Atomic Power Station

- Located near Mandvi, Surat, and the Tapi river in Gujarat, is at the forefront of India's nuclear expansion efforts.

- The projects are spearheaded by Larsen & Toubro (L&T) and operated by the Nuclear Power Corporation of India (NPCIL), aiming to elevate India's nuclear power plant capacity from 7,480 MWe to 22,480 MWe by 2031.
- Nuclear power currently represents about 2 percent of India's total installed capacity of 417,668 MW.

## DIFFERENT TYPES OF NUCLEAR REACTORS

### Pressurised Heavy Water Reactor (PHWR)

- **Coolant and Moderator:** The PHWR uses deuterium oxide, commonly known as **heavy water**, for both moderation and cooling purposes.
- This substance is effective in slowing down neutrons, facilitating the nuclear fission process.
- **Fuel:** Utilizes natural uranium.
- **Cooling System:** Incorporates a dual cooling system utilizing both heavy and light water.
- The primary loop's heavy water transfers heat to a secondary loop, generating steam to power turbines.
- **Control Rods:** Employs boron or cadmium rods to absorb excess neutrons, thus regulating the nuclear reaction.
- **Annual Fuel Requirement:** A 700 MW PHWR, operating at an 85% capacity factor, requires approximately 125 tons of UO<sub>2</sub> fuel annually.

### Light Water Reactor (LWR)

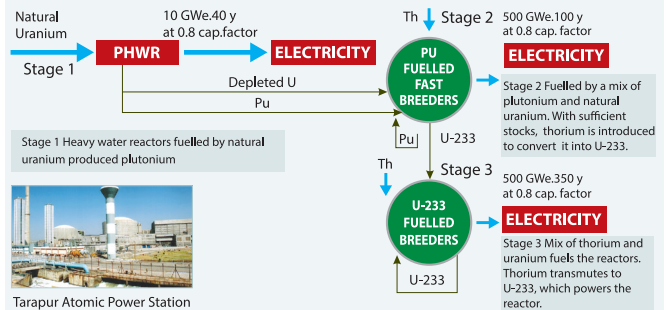
- **Coolant and Moderator:** Regular light water (H<sub>2</sub>O) is used for cooling and moderation.
  - ◆ However, as a less efficient moderator compared to heavy water, LWRs require enriched uranium for effective fission reactions.
- **Fuel:** Needs low-enriched uranium.
- **Cooling System:** Features a pressurized water cooling system that transfers heat from the reactor core to a secondary loop, subsequently generating steam for turbine operation.
- **Control Rods:** Utilizes boron or other materials capable of absorbing neutrons to control the nuclear reaction.
- **Annual Fuel Requirement:** For a 1000 MW LWR with a 90% capacity factor, about 25 tons of UO<sub>2</sub> fuel is needed annually.

### Fast Breeder Reactor (FBR)

- **Fuel Composition:** The FBR uses Mixed Oxide (MoX) fuel, which typically blends 3-5% Plutonium Oxide with 95-97% natural or depleted Uranium Oxide, leveraging the potential to breed more fuel than it consumes.

## INDIA'S THREE-STAGE NUCLEAR PROGRAMME

Homi Bhabha envisioned India's nuclear power programme in three stages to suit the country's low uranium resource profile.



## JT-60SA: LARGEST NUCLEAR FUSION REACTOR

Japan has unveiled the world's largest operational experimental nuclear fusion reactor, JT-60SA, in Naka, near Tokyo.

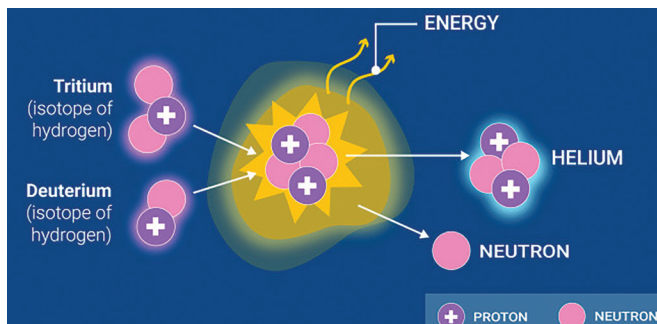
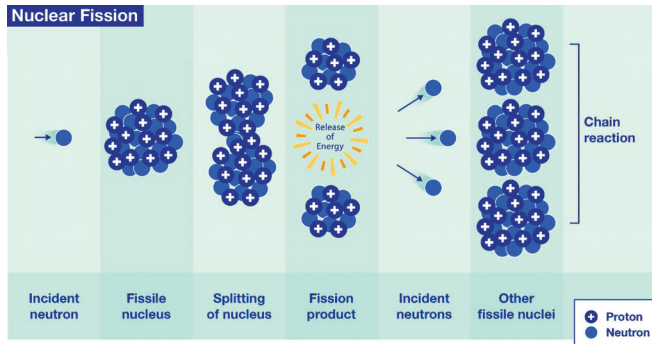
### About:

- JT-60SA is a joint international fusion experiment being built and operated by Japan and the European Union.
- It is a six-story-high tokamak, designed to contain and control plasma heated to a staggering 200 million degrees Celsius.
  - ◆ It is an upgrade to the previous JT-60. SA stands for 'Super, Advanced'.
- **Objective of JT-60SA:** To investigate the feasibility of fusion as a safe, large-scale and carbon-free source of net energy – with more energy generated than is put into producing it.

### Nuclear Energy

- It is a form of energy released from the nucleus, the core of atoms, made up of protons and neutrons.
- **This source of energy can be produced in two ways:**
  - ◆ **Fission:** when nuclei of atoms split into several parts, and
  - ◆ **Fusion:** when nuclei fuse together.

- The fusion of two nuclei of a heavier isotope of hydrogen, called tritium produces at least four times as much energy as the fission of a uranium atom which is the normal process of generating electricity in a nuclear reactor.



- Fusion differs from fission, the technique currently used in nuclear power plants, by fusing two atomic nuclei instead of splitting one.

### INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR (ITER)

- It is the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
  - The tokamak is an experimental machine designed to harness the energy of fusion.
  - The ITER Members: China, the European Union, India, Japan, Korea, Russia and the United States.
- Objective:** To investigate and demonstrate burning plasmas in which the energy of the helium nuclei produced by the fusion reactions is enough to maintain the temperature of the plasma, thereby reducing or eliminating the need for external heating.

## NOBEL PRIZE IN PHYSICS 2023

The 2023 Nobel Prize for Physics was awarded to **Pierre Agostini, Ferenc Krausz, and Anne L'Huillier** for their pioneering work in experimental physics, which led to the development of **attosecond pulses**.

### About:

- These ultrafast pulses have revolutionized our ability to directly observe and analyze the swift dynamics of electrons within matter, marking a significant breakthrough in the field of electron dynamics.
- Electron dynamics explores the behaviors and movements of electrons within atoms, molecules, and solid materials.
- This field covers the electrons' trajectories, their interactions with electromagnetic fields, and how they respond to different external stimuli.
- It delves into the fundamental aspects of electron activity, including their motion around the atom's nucleus and the forces that influence their behavior.

### Time Scales of Electron Activity

- The movements of atoms in molecules occur on **femtosecond** timescales, where a femtosecond is one **quadrillionth** (one millionth of one billionth) of a second.
- Electrons, which are lighter and move even faster, operate within **attoseconds** - one **quintillionth** (one billionth of one billionth) of a second ( $1 \times 10^{-18}$  seconds).
- This incredibly brief time frame signifies the **attosecond** realm in which electron interactions and dynamics take place, offering a glimpse into the ultrafast processes that were previously beyond our observational capabilities.

## NOBEL PRIZE IN MEDICINE

### About:

- Karikó and Weissman made a pivotal observation that dendritic cells could distinguish in vitro transcribed mRNA as foreign, leading to activation and release of inflammatory signals.
- This response contrasted with the non-reactive nature of mRNA originating from mammalian cells, suggesting a fundamental difference in how these mRNA types were recognized by the immune system.

## Exploring the Distinction

- Upon further investigation, they pinpointed that mammalian mRNAs' lack of immunogenicity stemmed from its cellular origin.
- Mammalian cells, which are complex eukaryotic entities belonging to the animal kingdom, house their genetic material within a nucleus and possess membrane-bound organelles.
- This complexity hinted at inherent differences in the mRNA produced by these cells compared to synthetic mRNA.

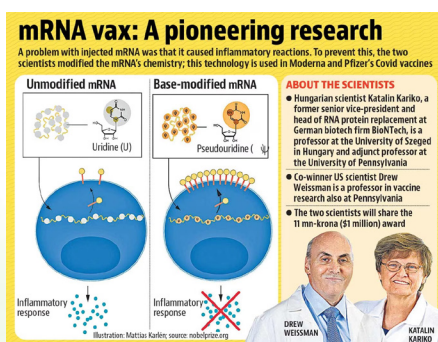
## Breakthrough in Understanding mRNA

### Chemical Modifications in RNA

- Karikó and Weissman's research revealed that RNA, akin to DNA, is composed of four nucleotide bases: adenine (A), uracil (U), guanine (G), and cytosine (C).
- A key observation was that RNA from mammalian cells often undergoes chemical modifications, a feature absent in synthetic mRNA, potentially explaining the differential immune response.
- The researchers hypothesized that the inflammatory reactions triggered by synthetic mRNA were due to the lack of natural base modifications.
- By creating mRNA variants with specific chemical changes and introducing them to dendritic cells, they demonstrated that these modifications could significantly diminish inflammatory responses.

## Implications

- This discovery has significantly advanced our comprehension of how cells differentiate between various mRNA types and the implications for mRNA's therapeutic use.
- Karikó and Weissman's subsequent research in 2008 and 2010 further showed that modified mRNA led to enhanced protein production, largely by reducing the activation of a key enzyme involved in protein synthesis.



## KRUTRIM

### About

- Ola has recently introduced the Krutrim, a specialized large language model (LLM) tailored for Indian languages.
- Krutrim is designed to comprehend 22 Indian languages and is capable of generating content in approximately 10 of these languages.
  - ♦ LLMs, which are advanced deep learning algorithms, possess the ability to understand, summarize, translate, predict, and create content by analyzing extensive datasets.
  - ♦ These models are essentially neural networks (NNs), which mimic the neural structure of the human brain.
- Notable examples of LLMs include OpenAI's ChatGPT and Google's Gemini.

## CODEX ALIMENTARIUS COMMISSION (CAC)

CAC has approved India's submission for establishing international standards for millets, including specifications for Finger millet, Barnyard millet, Kodo millet, Proso millet, and Little millet under collective standards.

### About:

- The Food Safety and Standards Authority of India (FSSAI) has introduced these group standards, detailing eight quality criteria such as moisture and uric acid content limits for 15 varieties of millets.
- This approval aligns with the celebration of the International Year of Millets 2023.

### CAC

- **About:** It is a global food standards authority, a collaborative effort between the World Health Organization (WHO) and the Food and Agriculture Organization (FAO).
- **Founded:** in 1963
- **HQ:** Based in Rome
- **Members:** CAC comprises 189 members, including India.
- **Functions:**
  - ♦ Its primary aim is to safeguard consumer health and promote equitable practices in the global food trade.



- ◆ The CAC oversees the Codex Alimentarius, or "Food Code," a compendium of standards, guidelines, and practices designed to guide the international food industry.
  - However, adherence to Codex standards is voluntary.

## LK-99

According to a paper released recently, the South Korean team has created a groundbreaking new material, LK-99, a room-temperature superconductor working at ambient pressure.

### About

- Named after two scientists, Lee and Kim, and the year of its discovery — 1999 — LK-99 is a compound which is a copper-doped lead apatite.
  - ◆ Apatites are a group of phosphate minerals that have a phosphate scaffold with a tetrahedral, or pyramidal motif: one phosphorus atom is surrounded by four oxygen atoms. Other atoms can sit in between these pyramids.
- The work of the Korean group's involves filling the space between the phosphate pyramids with lead and oxygen ions. Then, some of the lead atoms are replaced with those of copper, a process called substitution.
- The group reported that at 10% copper substitution, the wonder material LK-99 arises: copper-substituted lead appetite.
- Superconductivity Evidence: LK-99 exhibits zero electrical resistance and maintains superconductivity under an external magnetic field up to a critical threshold.

## SUPERCONDUCTORS

### About

- Superconductors are materials that can conduct electricity without any energy loss when cooled below a certain temperature.
- Discovered in 1911 by Kamerlingh Onnes in mercury, leading to the phenomenon known as superconductivity.
  - ◆ **Examples:** Known superconductors include Lanthanum-Barium-Copper Oxide and Yttrium-Barium-Copper Oxide.

### Applications of Superconductors:

- ◆ **Energy Transmission:** Lossless electricity transmission over long distances.
- ◆ **Medical Imaging:** Used in MRI machines for detailed imaging through strong magnetic fields.
- ◆ **Particle Accelerators:** Essential for achieving high particle velocities in facilities like the LHC.
- ◆ **Transportation:** Enable high-speed maglev trains by reducing friction through magnetic levitation.
- ◆ **Quantum Computing:** Explored for potential in quantum computing due to unique quantum states.

## DARK PATTERNS

The Ministry of Consumer Affairs, Food and Public Distribution of the Government of India has formed a 17-member task force aimed at creating consumer protection guidelines to tackle the issue of dark patterns.

### About:

- Coined by **Harry Brignull, a UX designer, in 2010**, these strategies exploit cognitive biases through various manipulative tactics like creating **false scarcity, imposing forced choices, concealing extra charges etc.**
- Dark patterns, also known as **deceptive design techniques**, are tactics used by websites and applications to **manipulate users** into making **unintended decisions** or **discourage actions that do not benefit the service providers.**

### Different Types

- **False Urgency:** Generating a fake sense of urgency or scarcity to coerce consumers into immediate purchases or actions.
- **Subscription Traps:** Making subscriptions easy to enter but challenging to exit, often through obscured or complicated cancellation processes.
- **Bait & Switch:** Promoting a specific product/service but providing a different, often inferior, one.
- **Hidden Costs:** Concealing additional fees until the consumer is deep into the purchase process.
- **Basket Sneaking:** Secretly adding extra products or services to the shopping cart without the user's approval.

- **Confirm Shaming:** Employing guilt-tripping tactics to compel users to comply; demeaning users for not subscribing to a specific belief or action.
- **Nagging:** Repeatedly bothering users with criticisms, complaints, or demands for action.
- **Disguised Ads:** Presenting advertisements in a manner that mimics genuine content, such as articles or user posts.

### Implications:

- Dark patterns jeopardize internet user experiences, exposing them to increased risks of financial loss and data misuse by major technology companies.
- These tactics mislead users, create online barriers, prolong simple online activities, entice users into unwanted subscriptions/products, and coerce them into spending more money or disclosing more personal information than intended.

### REGULATIONS INITIATED

- **California Consumer Privacy Act:** The state of California in the United States enacted amendments to said act which outlawed dark patterns that obstructed consumers' ability to assert their privacy rights.
- **Guidelines under the Data Protection Act of 2018:** By United Kingdom released, aiming to prevent companies from employing deceptive strategies to entice underage users into opting for settings with less privacy protection.

### GM MUSTARD

The Genetic Engineering Appraisal Committee (GEAC) has given its approval for the environmental release of **Dhara Mustard Hybrid-11 (DMH-11)**, a genetically modified variant of mustard.

#### About:

- DMH-11 is a domestically developed genetically modified (GM) variant of mustard, characterized as Herbicide Tolerant (HT). It is created through the hybridization of the Indian mustard variety 'Varuna' and the East European variety 'Early Heera-2'.
- **Genetic Modification:** Incorporates two foreign genes, 'barnase' and 'barstar', from the soil bacterium **Bacillus amyloliquefaciens**, facilitating the creation of high-yielding mustard hybrids.

- **Yield Enhancement:** Demonstrates an approximate 28% higher yield compared to the national check and 37% more than zonal checks, as recognized and sanctioned by the GEAC.

### Bt COTTON

- Bt cotton is a genetically engineered cotton variant that produces an insect-killing protein, originating from a gene sourced from the soil-dwelling bacterium called *Bacillus thuringiensis*, or Bt.
- This bacterium, found in various subspecies in soil, is known for its toxicity to several insect species while being harmless to other organisms.
- Bt has been employed as an insecticidal spray in numerous countries, including India, for managing pests in stored grains and as part of cotton's Integrated Pest Management (IPM) strategies for insect control.
- In March 2002, Bt cotton became the **first genetically modified crop** to receive approval for commercial cultivation in India.

### GENETIC ENGINEERING APPRAISAL COMMITTEE (GEAC)

- **Operates under:** The Ministry of Environment, Forest and Climate Change (MoEF&CC).
- **Established as: Statutory** committee constituted under the "Rules for the Manufacture, Use/Import/Export and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells (Rules, 1989)" framed under **Environment (Protection) Act, 1986**.
- **Responsibilities:**
  - ♦ Assesses activities that involve extensive use of hazardous microorganisms and recombinant technologies in research and industrial production, considering environmental impacts.
  - ♦ Evaluates proposals for the environmental release of genetically engineered (GE) organisms and products, including experimental field trials.
- **Chairman:** Special Secretary/Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC).

### PRECISION FERMENTATION

#### About

- **Definition:** Precision fermentation is a revolutionary technology that marries traditional fermentation practices with the precision of modern biology.

- It entails the **genetic modification of microorganisms**, such as yeast, to enable them to produce specific proteins. This is achieved by introducing **specific DNA sequences into their cells**, turning these organisms into highly efficient producers of desired substances.

#### Applications:

- This technology is versatile, enabling the production of a wide range of products including enzymes, fats, vitamins, flavorings, natural pigments, and alternative proteins. For instance:
  - ♦ **Dairy Alternatives:** Products like milk protein, animal fats, and collagen are created without using animals.
  - ♦ **Egg Whites:** Engineered yeast cells produce proteins identical to those found in chicken eggs.
  - ♦ **Vitamins:** Bacteria are optimized to produce essential nutrients such as vitamin B12 in large quantities.

#### Advantages of Precision Fermentation

- **Efficiency and Scalability:** It surpasses traditional farming and agriculture in speed and scalability, requiring less land, water, and resources.
- **Food Security and Nutrition:** Offers a sustainable, affordable protein and nutrient source to meet global demands.
- **Environmental Benefits:** Generates lower greenhouse gas emissions, consumes less energy, and produces less waste than conventional food production methods.
- **Ethical Considerations:** Eliminates the need for animal farming, aligning with ethical food production values.
- **Global Application:** Can be adopted worldwide, utilizing various local biomass sources for fermentation.

#### Concerns Surrounding Precision Fermentation

- **Cost:** High initial technology costs could lead to more expensive end products.
- **Regulatory and Safety:** The use of genetically modified organisms (GMOs) involves regulatory approvals and safety assessments.
- **Agricultural Impact:** Has the potential to disrupt traditional farming sectors.
- **Consumer Acceptance:** May face skepticism or resistance from consumers wary of genetically engineered foods and unfamiliar technologies.

## INDIAN SCIENCE CONGRESS

Lovely Professional University (LPU) decided to withdraw from hosting the 109th Indian Science Congress (ISC), casting doubts on the event's feasibility.

#### About:

- **Establishment:** The Indian Science Congress Association (ISCA) was established in **1914**.
- **Governing Body:** It operates under the **Department of Science & Technology**, Ministry of Science & Technology.
- **Founders:** Founded by two British chemists, **Professor J. L. Simonsen and Professor P.S. MacMahon**.
- **Purpose:** ISCA organizes the annual Indian Science Congress, a premier gathering for researchers across India.
- **Inaugural Session:** The first meeting took place from January 15-17, 1914, at the premises of the Asiatic Society in Calcutta.
- **Coverage:** The Congress includes fourteen sections, such as:
  - ♦ Agriculture and Forestry Sciences
  - ♦ Earth System Sciences
  - ♦ Engineering Sciences
  - ♦ Environmental Sciences
  - ♦ Mathematical Sciences
  - ♦ Medical Sciences, etc.

## RADIOCARBON DATING

Radiocarbon dating helped establish the age and authenticity of the famous Dead Sea.

#### About:

- Radiocarbon dating, or carbon-14 dating, is a scientific method that can accurately determine the age of organic materials.
- It was developed in the late 1940s by Willard Libby, the technique is based on the decay of the carbon-14 isotope.

#### Working of radiocarbon dating

- It starts with cosmic rays—subatomic particles of matter that continuously rain upon Earth from all directions.
- When cosmic rays reach Earth's upper atmosphere, physical and chemical interactions form the radioactive isotope carbon-14.

- Living organisms absorb this carbon-14 into their tissue. Once they die, the absorption stops, and the carbon-14 begins very slowly to change into other atoms at a predictable rate.
- By measuring how much carbon-14 remains, scientists can estimate how long a particular organic object has been dead.

### Limitations of carbon-14 dating

- Radiocarbon dating works on organic materials up to about 60,000 years of age.
- Conventional radiocarbon dating requires samples of 10 to 100 grams (0.35 to 3.5 ounces) of an object, depending on the material in question.
  - ♦ Newer forms of dating can use much smaller amounts, down to 20 to 50 milligrams or 0.0007 to 0.0018 ounces.
- Radiocarbon samples are also easily contaminated, so to provide accurate dates, they must be clean and well-preserved.

### Improvement in Radiocarbon Dating

- Technological and analytical advances have made radiocarbon dating faster and much more precise—and expanded its range of uses by reducing the size of the sample needed.
- The latest form of radiocarbon dating, called accelerator mass spectrometry, needs samples of only 20 to 50 milligrams; however, it is also more expensive.
- Another newer development is Bayesian statistical modeling, which applies probability analytics to radiocarbon dates, which always involve an error margin.

## SOLAR GEOENGINEERING

### About:

- It is also known as solar radiation modification, and **aims to cool the Earth by reflecting absorbed sunlight back into space.**
- This approach seeks to counteract global warming by artificially enhancing the Earth's natural heat dissipation process.

### Methods

- **Stratospheric Aerosol Injection (SAI):** This method involves dispersing large quantities of reflective

particles, such as sulfur dioxides or calcium carbonate, into the stratosphere to reflect sunlight away from the Earth.

- **Marine Cloud Brightening:** This technique aims to enhance the reflectivity of low-lying clouds by spraying sea salt into them, increasing their ability to reflect sunlight.

### GLOBAL WARMING

- The Earth's surface temperature increases as it absorbs solar energy (**short wave radiation**) and emits part of this heat back as infrared radiation (**long wave radiation**), which warms the atmosphere.
- However, at higher altitudes, this heat escapes into space, regulating the Earth's temperature. Greenhouse gasses, such as carbon dioxide, trap infrared radiation, leading to an energy imbalance and global warming.
- Solar geoengineering intends to artificially boost the reflection of heat back into space to cool the Earth's surface.

### Concerns

- **Temporary Solution:** It does not address the root causes of climate change but offers a temporary cooling effect. The effectiveness of methods like SAI diminishes over time, potentially leading to a net warming effect.
- **Moral Hazard:** There's a risk that reliance on solar geoengineering could detract from essential efforts to reduce greenhouse gas emissions, as it might be seen as an easier or immediate fix.
- **Environmental and Social Impacts:** The potential for unintended consequences on global and regional weather patterns, including precipitation and temperature, raises concerns. These adverse effects might disproportionately affect the global south.
- **Governance Challenges:** An international group of scientists and scholars has called for a moratorium on solar geoengineering research and development, citing the lack of understanding about its risks and the absence of a global governance framework capable of managing its deployment fairly and inclusively.

## OPERATION AMRITH

The Drug Control Department of Kerala has launched Operation AMRITH aimed at reducing the misuse of antibiotics.

**About:**

- As part of this operation, pharmacies are required to maintain detailed records of antibiotic sales and display a notice that antibiotics will not be sold without a prescription from a doctor.
- Additionally, the public is encouraged to report any instances where these regulations are not followed to the Drug Control Department.
- **Antimicrobial Resistance (AMR)** develops when microorganisms such as bacteria, viruses, fungi, and parasites evolve over time to the point where they no longer respond to medications.
  - ◆ This resistance makes infections more difficult to manage, heightens the risk of disease transmission, and escalates the severity of illness and mortality rates.

**Reasons Behind AMR**

- **Inappropriate Prescriptions:** Prescribing antibiotics for viral infections against which they are ineffective. Individuals taking antibiotics without a prescription or medical advice.
- **Misuse in Agriculture and Livestock:** Antibiotics are used to promote growth in healthy livestock, not just to treat illness.
- **Poor Infection Control and Hygiene Practices:** Insufficient infection control measures can lead to the spread of resistant microorganisms. Inadequate hygiene practices contribute to the transmission of infections.
- **Lack of Awareness and Education:** Limited understanding among the public about the correct use of antibiotics and the risks of AMR. Need for ongoing education on antimicrobial stewardship and resistance.
- **Environmental Contamination:** Improper disposal of antibiotics leads to environmental contamination. Antibiotics used in agriculture can enter water systems, promoting resistance in wild microorganisms.

**STEPS TAKEN****National Action Plan on AMR**

- Launched in 2017 by the Union Health Ministry.
- This plan advocates for a comprehensive strategy that includes the involvement of various stakeholder ministries and departments. It emphasizes the interconnectedness of human, animal, and environmental health in addressing AMR i.e **One Health Approach**.

- By engaging different ministries and departments, the plan fosters a collaborative effort to tackle AMR from multiple fronts.

**Red Line campaign:**

- MoHFW launched Red Line awareness campaign on Antimicrobials Resistance, urging people not to use medicines marked with a red vertical line, including antibiotics, without a doctor's prescription.

**Global Antimicrobial Resistance and Use Surveillance System (GLASS)**

- Launched by **WHO** in 2015
- GLASS aims to fill existing knowledge gaps and support the development of strategies to combat AMR at all levels.
- The system is designed to gradually include data on AMR surveillance in humans, the use of antimicrobial medicines, AMR in the food chain, and environmental AMR.
- This comprehensive approach allows for a more detailed understanding of AMR's spread and impact.

**FOOD FORTIFICATION****About:**

- **According to WHO**, the practice of adding vitamins and minerals to commonly consumed foods during processing improves their nutritional value. For example, Rice fortification.
  - ◆ **Rice Fortification:** It is a process of adding micronutrients like **iron, folic acid and vitamin B12**, which is an effective, preventive and cost-efficient complementary strategy to address the nutrition problem within a short period.
- It allows food manufacturers to voluntarily fortify foods available in the marketplace.

**Benefits/Advantages of Fortification**

- Eliminates malnutrition and nutritional deficiencies.
  - ◆ India has slipped to the **111st position** in the **Global Hunger Index (GHI) 2023** of 125 countries.
- Provides extra nutrition at affordable costs.
- The inherent characteristics of the food remain the same even after fortification. This means that the original taste, texture, and appearance are unchanged.

- Wide-scale production of fortified foods can help improve the overall nutritional problem of a country, by catering to both the poor and the wealthy.
- It does not require any changes in the food habits and patterns of people.
- The **Copenhagen Consensus** estimates that every 1 Rupee spent on fortification results in 9 Rupees in benefits to the economy.

### GOVERNMENT STEPS

- In 2018, **FSSAI** had notified standards of fortification for five staple product categories — milk, edible oil, rice, flour and salt (**'F+' logo** to be displayed on labels).
- **Milk Fortification Project:** By the **National Dairy Development Board (NDDB)** in collaboration with the World Bank.

#### Food Safety and Standards Authority of India (FSSAI)

- Established as a statutory body under the Food Safety and Standards Act, 2006, under the Ministry of Health.

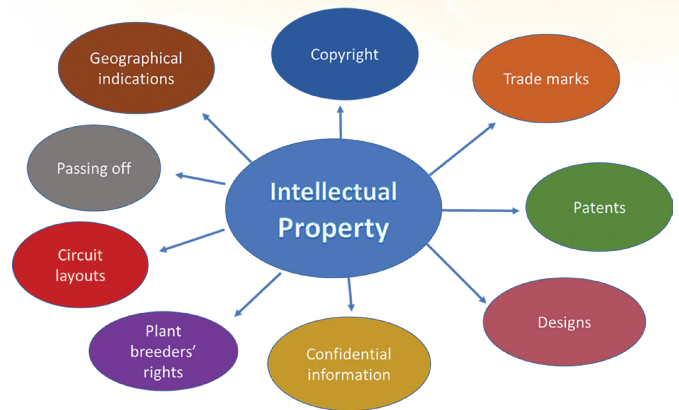
#### Powers or Functions of FSSAI

1. Framing of regulations to lay down food safety standards
2. Laying down guidelines for accreditation of laboratories for food testing
3. Providing scientific advice and technical support to the Central Government
4. Contributing to the development of international technical standards in food
5. Collecting and collating data regarding food consumption, contamination, emerging risks etc.
6. Disseminating information and promoting awareness about food safety and nutrition in India.

## INTELLECTUAL PROPERTY RIGHTS (IPR)

### About:

- Intellectual property (IP) refers to a group of property rights concerning the non-physical creations of the human mind.
- These rights encompass various forms of protection for inventors and creators, such as patents, copyrights, rights related to industrial designs, trademarks, rights for plant varieties, trade dress, and geographical indications.
- These rights, recognized under **Article 27 of the Universal Declaration of Human Rights**, allow creators or their assignees exclusive rights to exploit their creations.



### Objectives of IPR

- Financial gain and recognition for creators.
- Encouragement of a creative and innovative environment by balancing innovator interests with public welfare.
- Protection of traditional knowledge.

### Types of IPR

- **Copyright:**
  - ♦ Copyright is a legal mechanism that protects the exclusive right to reproduce and distribute creative works, including written, artistic, and musical compositions, as well as films.
  - It automatically safeguards a creation upon its inception. While copyright registration is not obligatory, it is crucial for enforcing rights in case of infringement.
- **Trademark:**
  - ♦ Trademarks consist of words, symbols, or combinations thereof, identifying and distinguishing a manufacturer's or merchant's goods from those of others.
  - ♦ Notable examples include logos of Apple, LG, and Audi.
  - ♦ Trademark categories in India cover product and service marks, among others, with registration strengthening exclusive rights to use.
- **Geographical Indication:**
  - ♦ Geographical Indications (GIs) denote the origin of agricultural, natural, or manufactured products, reflecting the quality or reputation linked to their geographical locale.
  - ♦ Examples include Darjeeling tea and Kashmir Pashmina. GIs emphasize the heritage and collective reputation of a region's products.

- **Patent:**
  - ♦ A patent is granted to inventors for novel devices or ideas, offering exclusive rights to utilize and commercialize the invention. It differentiates between inventions and discoveries, such as the telephone's invention by Alexander Graham Bell, which is patentable, unlike the discovery of gravity.
- **Design:** In a market flooded with functionally similar products, design plays a pivotal role in consumer choice. Design rights protect the aesthetic aspects of industrial and handmade products, controlling their commercial production, import, and sale to maintain uniqueness.
- **Plant Variety:** Special rights are awarded to breeders of new plant species or varieties, recognizing the skill and selection involved in breeding. Key legislations include The Plant Variety Protection Act and The Utility Patent Act, safeguarding breeders' interests.
- **Semiconductor Integrated Circuits Layout Design:** This pertains to the unique layout designs of semiconductors, essential for electronic circuitry in computers. Protection rights prevent competitors from copying and selling these designs, ensuring the original creator's exclusivity.

### International Conventions and Bodies on IPR

- **World Intellectual Property Organization (WIPO):** WIPO is the principal agency overseeing global IPR protection, managing international treaties like the **Paris Convention for the Protection of Industrial Property (1883)** and the **Berne Convention for the Protection of Literary and Artistic Works (1886)**
- **Budapest Treaty:** Facilitates patent procedure through the recognition of microorganism deposits.
- **Marrakesh Treaty:** Aids in producing and transferring adapted books for visually impaired individuals.
- **TRIPS Agreement (1994):** A comprehensive WTO agreement covering a broad spectrum of IPR, including patents, copyrights, and trademarks.

### Legal Provisions in India

- **The Copyright Act, 1957**
  - ♦ The Copyright Act safeguards the form in which ideas are expressed rather than the ideas themselves.
  - ♦ Section 13 specifies that copyright can protect original works including literary, dramatic,

musical, artistic creations, cinematograph films, and sound recordings. Notably, this protection extends to computer programs as well.

- **The Trade Marks Act, 1999:**
  - ♦ According to the act, a 'trade mark' is any mark that can be graphically represented and distinguishes the goods or services of one entity from those of another.
  - ♦ This may encompass the shape of goods, their packaging, and combinations of colors, among others, offering protection for various symbols, words, and designs associated with products or services.
- **The Patents Act, 1970:**
  - ♦ A 'Patent' grants an inventor exclusive rights to a new invention, ensuring that others cannot use or replicate the patented invention without authorization.
  - ♦ This right is crucial for protecting the inventor's interests against unauthorized use or misappropriation.
- **The Design Act, 2000**
  - ♦ Under the Design Act, a 'design' refers to the aspects of shape, configuration, pattern, ornamentation, or composition of lines or colors applied to any article, visible and appealing to the eye.
  - ♦ These features can be created through any industrial process and are protected in both two-dimensional and three-dimensional forms.
- **The Geographical Indications of Goods (Registration and Protection) Act, 1999**
  - ♦ This Act recognizes products known for their geographic origin and the unique qualities, reputation, or characteristics derived from that place.
  - ♦ Examples include 'Darjeeling Tea', known for its origin, the expertise of Darjeeling's tea farmers, and the region's climate, as well as 'Banarasi Sarees' and 'Basmati Rice'.
- **Protection of Plant Varieties and Farmers' Rights Act, 2001:**
  - ♦ The Protection of Plant Varieties and Farmers' Rights Act aims to acknowledge the rights of Indian farmers and protect plant varieties to stimulate the development of new plant varieties, enhancing agricultural progress.

- **The Semiconductor Integrated Circuits Layout-Design Act, 2000:**

- ♦ This Act defines a 'semiconductor integrated circuit' as a product featuring transistors and circuit elements, formed on or within a semiconductor material, designed to execute an electronic function.
- ♦ It provides protection for the layout designs of semiconductor integrated circuits to prevent unauthorized replication or use.

#### OTHER STEPS TAKEN

- **KAPILA:** A program for promoting IP literacy and awareness among students and faculty in higher education.
- **International Membership:** India is committed to the TRIPS Agreement and is a member of WIPO.
- **CIPAM (Cell for IPR Promotion & Management):** Established under the National IPR Policy 2016 to promote and manage intellectual property rights within the country.
- **Office of the Controller General of Patents, Designs and Trade marks:** The Office of the Patents, Designs and Trade Marks (CGPDTM) is a subordinate office under the Department of Industrial Policy and Promotion.
  - ♦ The Controller General administers the working of the Patents Act, 1970, the Trade Marks Act, 1999, the Geographical Indications of Goods (Registration and Protection) Act, 1999 and the Designs Act, 2000 and also renders advice to the Government on matters relating to Intellectual Property Rights.
- **Copyrights Office:** Section 9 of the Copyright Act mandates the creation of an office, known as the

Copyright Office, subordinate office under the Department of Industrial Policy and Promotion. This office is placed directly under the management of a Registrar of Copyrights, who is appointed by the Central Government.

#### Protection of Plant Varieties and Farmers' Rights Authority:

- It is a **Statutory body** created under **The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001**
- It **works under the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare.**
- **Formation:** In order to provide for the establishment of an effective system for the protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants, the of India enacted "The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001" adopting sui generis system.

#### Semiconductor Integrated Circuits Layout-Design Registry (SICLDR)

- It is the office where the applications on Layout-Designs of integrated circuits are filed for registration of created IPR.
- The jurisdiction of this Registry is the whole of India. The Registry, as per the guidelines laid down in the Semiconductor Integrated Circuits Layout Design (SICLD) Act 2000 and the Semiconductor Integrated Circuits Layout-Design (SICLD) Rules 2001.
- Examines the layout-designs of the Integrated Circuits and issues the Registration Certificate to the original layout-designs of the Semiconductor Integrated Circuits.

