From Physics to Daily Life

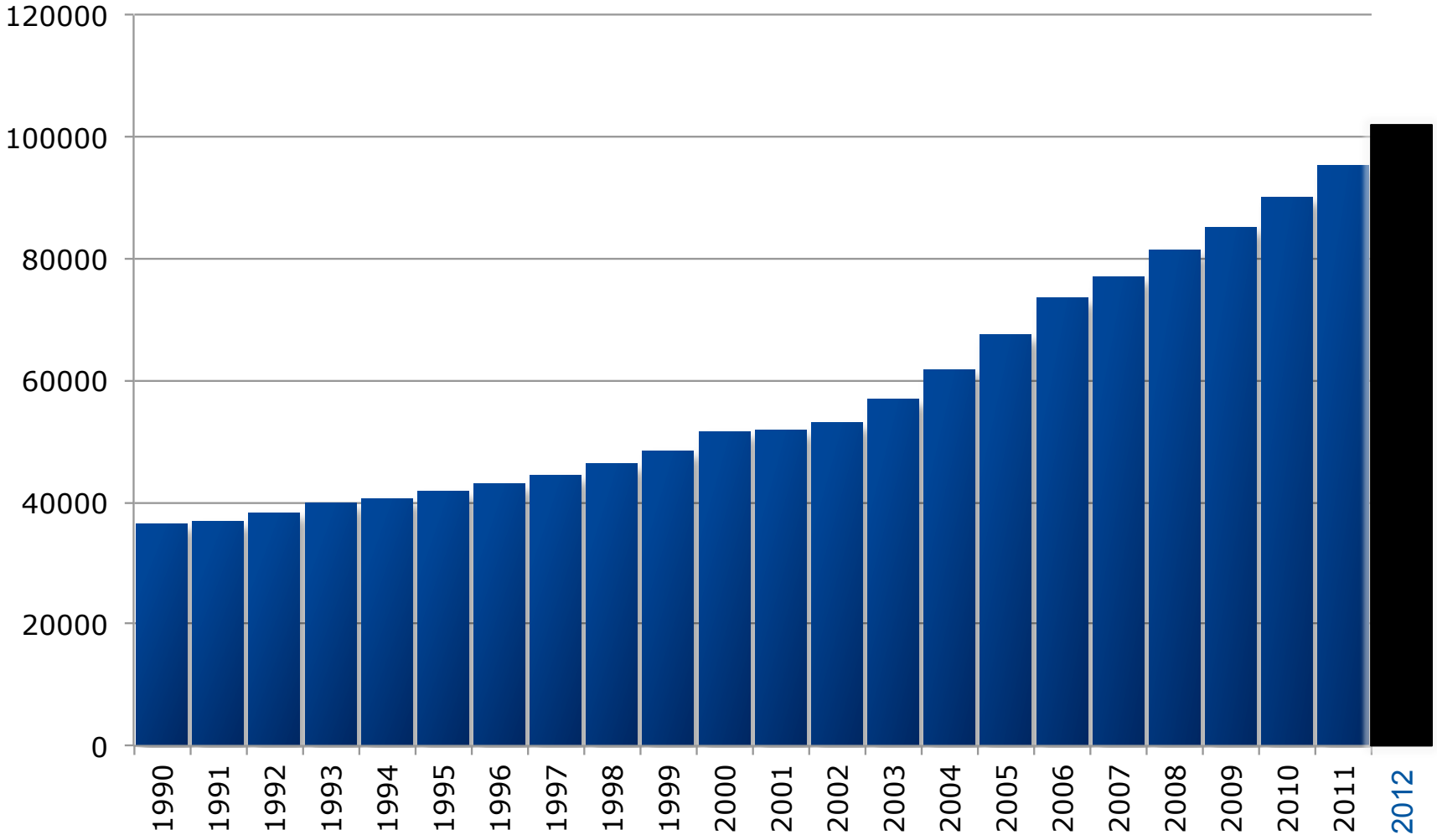
Understanding the Brain

Organizational and Scientific Challenges

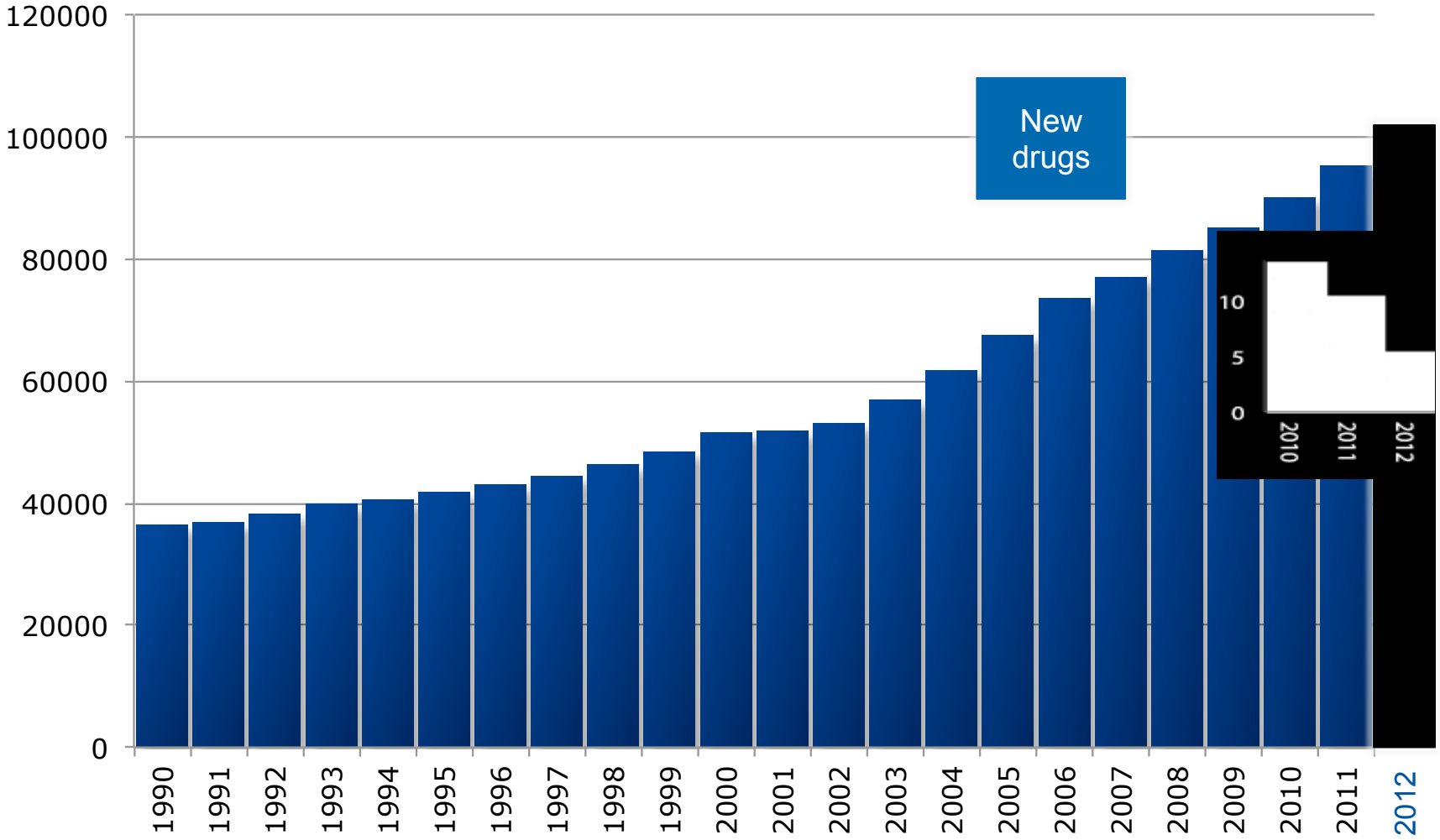
Prof. Henry Markram
Director Blue Brain Project, EPFL
Executive Director Human Brain Project

Presented by Prof. Felix Schürmann

Peer-Reviewed Neuroscientific Articles

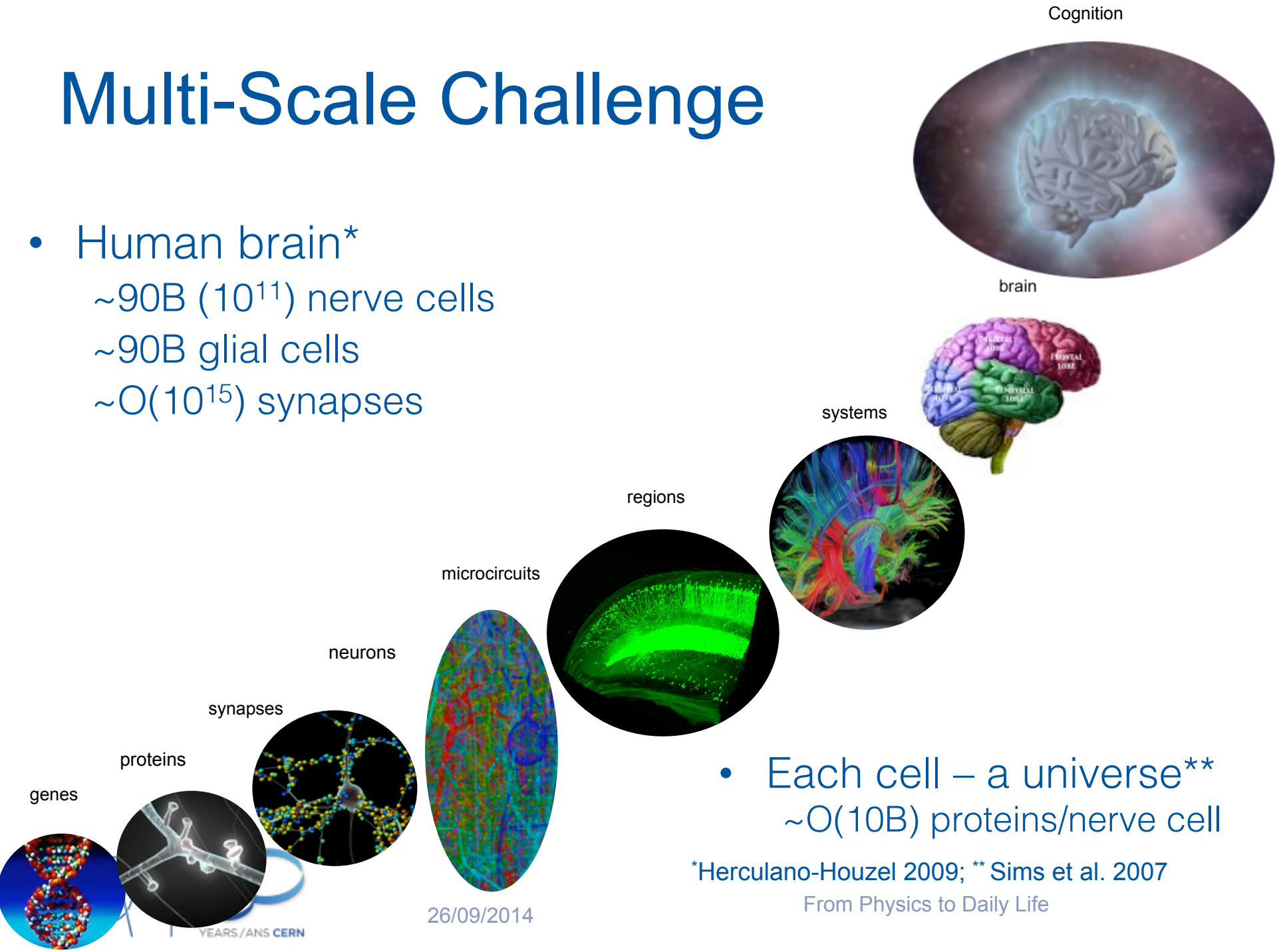


Number of newly released CNS drugs



Multi-Scale Challenge

- Human brain*
  - ~90B (10^{11}) nerve cells
  - ~90B glial cells
  - ~O(10^{15}) synapses



- Each cell – a universe**
  - ~O(10B) proteins/nerve cell

*Herculano-Houzel 2009; ** Sims et al. 2007

Position Statement

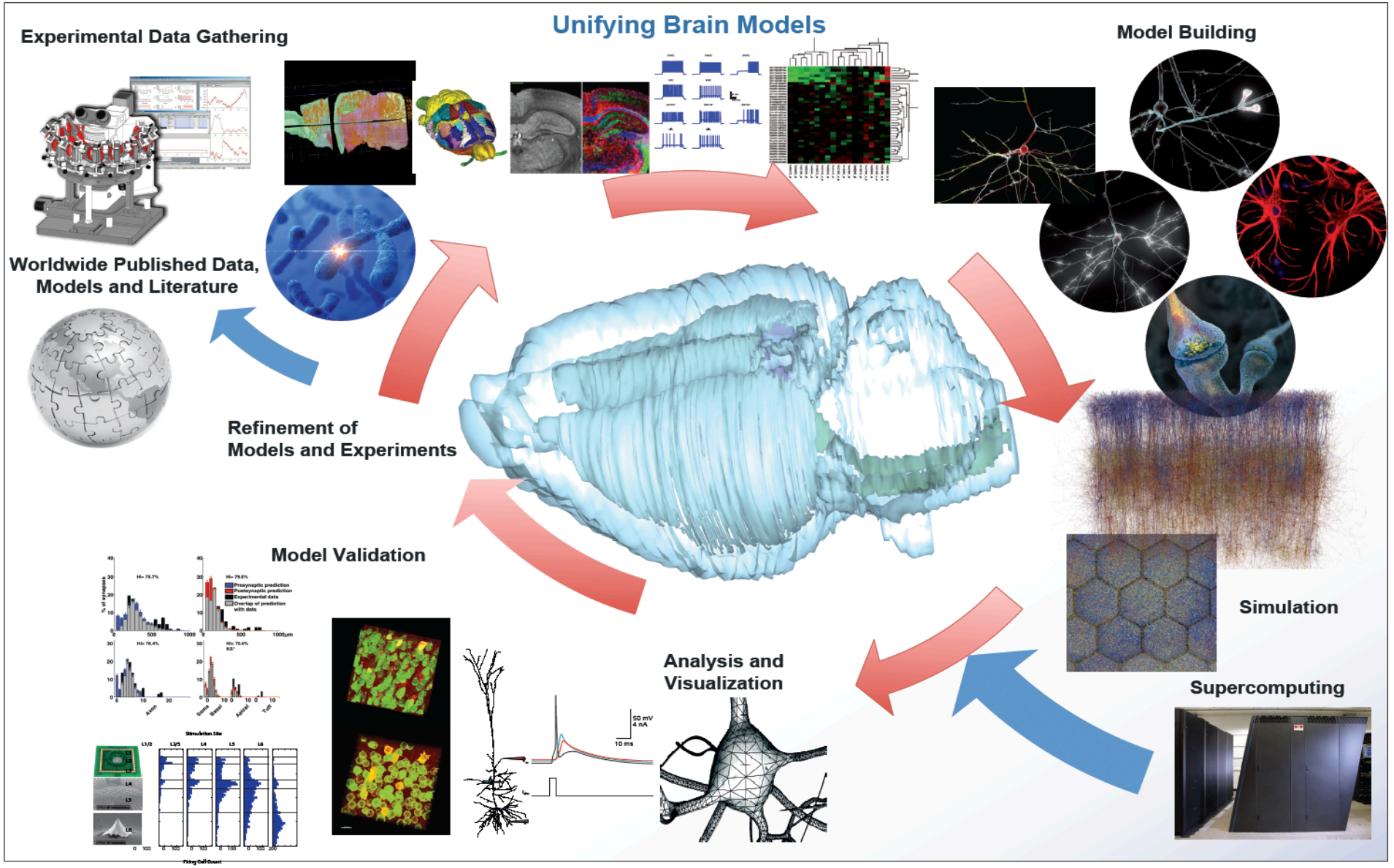
Status

1. Exponential increase in data
2. Increasingly fragmented
3. Benefits for society decreasing
4. Economic burden increasing

Lacking

1. No integration plan
2. No data curation plan
3. No plan to bridge levels
4. No plan from animal to human

Unifying Brain Models



ICT

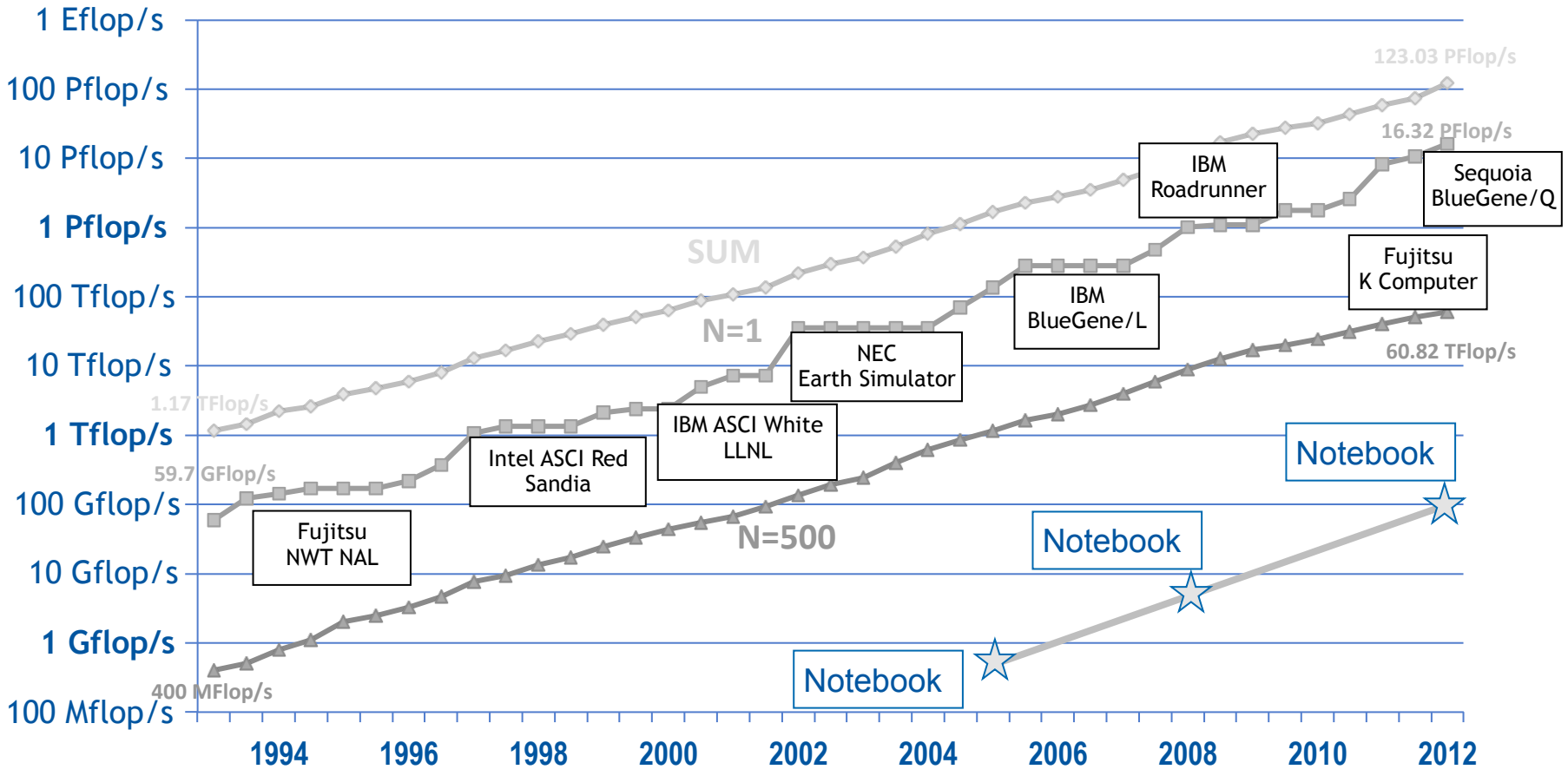
NEUROSCIENCE		MEDICINE		COMPUTING
Allen Institute launches $300 million mouse brain project and commits $1B for brain research	2012	Whole exome sequencing and informatics reveals new genetic key to autism	2012	More than 612 million websites; more than 900 million Facebook users
One Mind for Research; $6B targetted funding; Active transposons in the human brain	2011	> 350 biotechnology-based products resulting from Human Genome Project in clinical trial	2011	IBM Watson wins Jeopardy; BrainScaleS; ARM shipments exceed 30 billion; IBM Neuro Chip
NIH Human Connectome Project; MIT Intelligence Intiative	**2010**	Cancer Genome Project; Synthetic cell	**2010**	PRACE, Brain-I-Nets, DARPA Neovision II
First single cell transcriptome	2009	Large genome-wide association studies identify new Alzheimer's disease genes	2009	HPC driven real-time realistic global illumination algorithm
Janelia Farms founded; NIH Open Access Policy to enhance knowledge dissemination	2008	First Eukarya interactome; deep brain stimulation to move muscles	2008	Cray XT5 Petaflop on superconductive materials; DARPA SyNAPSE project started
Decade of the Mind	2007	Visual prosthetics, HT-DNA sequencing; embryonic stem cells from human skin	2007	Apple iPhone
Optogenetics technology	2006	First pluripotent stem cells; 23andMe launch personal genomics; BrainGate System for paraplegics	2006	Amazon Cloud, SpiNNaker Project; real-time animation of digital human bodies
International Neuroinformatics Coordinating Facility (INCF) founded; Blue Brain Project launched	2005	HapMap and First Genome Wide Association Study; identification of human mircoRNA genes	2005	FACETS, DAISY, COLAMN, DARPA Aug Cognition; IBM Cell Processor; Assisted GPS for cell phones
Champalimaud Foundation launches new brain research institute, commits €500M	2004	ADNI founded; comparative genomic analysis identifies cause for Bardet-Biedl syndrome	2004	INTEL Dual Core; DARPA Neovision I; Facebook triggers social networking phenomenon
Paul Allen founds the Allen Institute to map the mouse transcriptome; commits $100M	2003	Human genome completed	2003	About 1 billion PCs sold
	2002		2002	Earth simulator
NEST Large-scale neural network simulator	2001	Telesurgery; 1000 Genomes Project;artificial liver	2001	
Institute of Systems Biology	**2000**	First draft human and mouse genome; human testing of an Alzheimer's disease vaccine	**2000**	
	1999	Structural Genomics Project; fruit fly sequenced	1999	
Crystal structure of an ion channel; Gatsby Comp. Neurosc. Institute launched, Lord Sainsbury commits £500M	1998	Stem cell therapy	1998	Cray T3E Teraflop modelling metallic magnets; MDA Silicon Brain Program
	1997	Protein accumulation in human neurodegenerative diseases	1997	Google founded
	1996	Dolly, the sheep cloned	1996	MDA Silicon Neuron Program
	1995	First bacterial genome	1995	Real-time image-based rendering; JAVA; Support Vector Machines
	1994	First HIV (anti-AIDS) treatment; gene therapy via implanted transformed fibroblasts	1994	WWW Foundation launched; GPS goes live with 24 satellites
Int. Consortium for Brain Mapping; NIH Human Brain Project	1993	Huntington's disease gene identified; interferon for multiple sclerosis	1993	50 websites in the world
First whole head MEG system; fMRI	1992	Self-folding prion proteins	1992	
	1991	Amyloid hypothesis of Alzheimer's Disease; term "evidence-based medicine" coined	1991	Motion capture technology for guiding virtual robots
Two-photon microscope US "Decade of the brain"	**1990**	First human viral gene therapy	**1990**	WWW technology
DNA microarray technology for transcriptomics	1989		1989	INTEL Electrically Trainable Artificial Neural Network chip
	1988		1988	Silicon retina published; 45 million PCs in the USA; TAT-8, first transatlantic fiber optic cable
	1987	Deep-brain electrical stimulation; laser surgery on human cornea; meningitis vaccine developed	1987	Cray YMP Gigaflop on finite element analysis Thinking Machine with 65536 processors
Mapping of the structure of C.elegans nervous system	1986		1986	Radiosity rendering for scene illumination
	1985	TMS - Transmagnetic stimulation; automated DNA sequencer; surgical robots	1985	First Gigaflop supercomputer; First ARM processor
Transgenic mouse produced; Boltzman machine	1984		1984	
Cylindric PET scan; Polymerase Chain Reaction technology (PCR)	1983	Automated DNA sequencers (ABI 380A); discovery of HIV	1983	
The Hopfield Artificial Neural Network; Statistical Mechanics of Artifical Neural Networks	1982	Interferon cloning; commercial protein sequencers	1982	First 32 bit microprocessor
Magnetic Resonance Imaging (MRI)	1981	Artificial Skin; Applied Biosystems founded by two HP engineers	1981	IBM Personal Computer
	1980	WHO declares smallpox eradicated	**1980**	Recursive ray tracing and new algorithms for realistic scene rendering
	1979	Anti-viral drugs	1979	
Patch Clamp technique	1978	Test-tube baby born; first cochlear implant	1978	
First Molecular Dynamics simulation of a protein	1977	First DNA sequencing method; first virus sequenced	1977	

CERN

60 YEARS / ANS CERN

From Physics to Daily Life

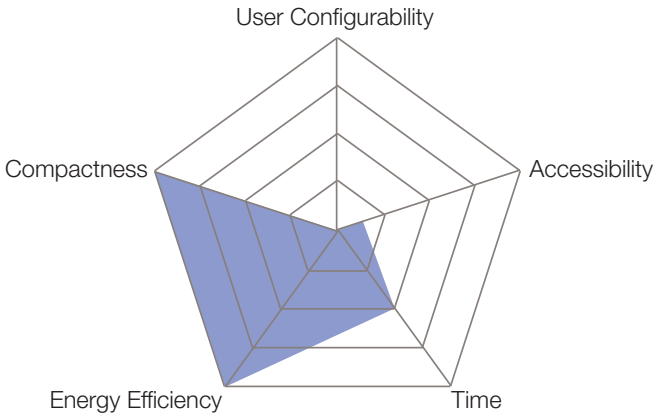
Performance Development of Supercomputers



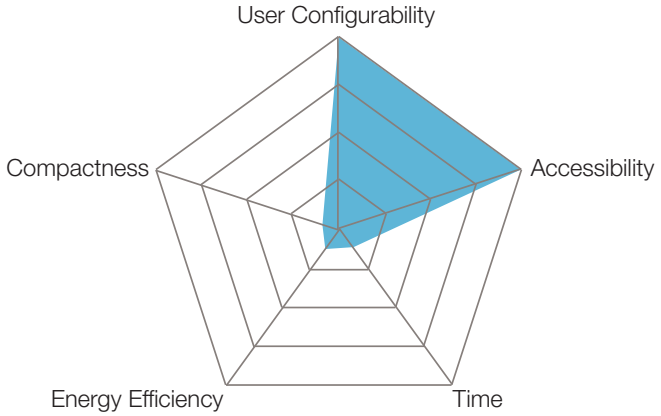
Slide courtesy of Horst Gietl

Learning from the Brain

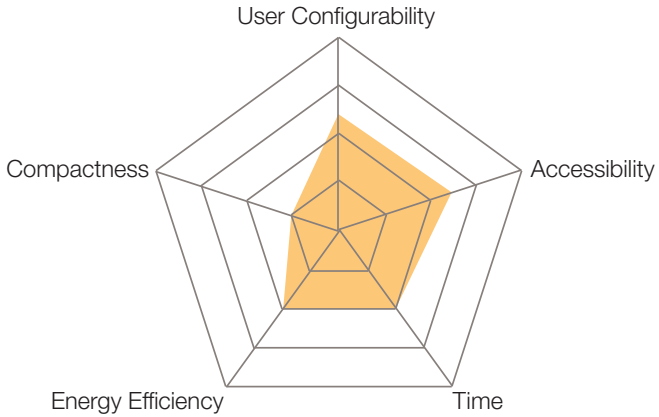
Biological Brain



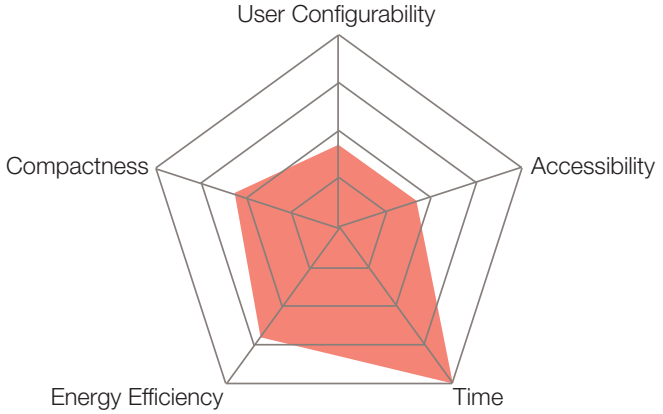
Numerical Simulation



Numerical Neuromorphic

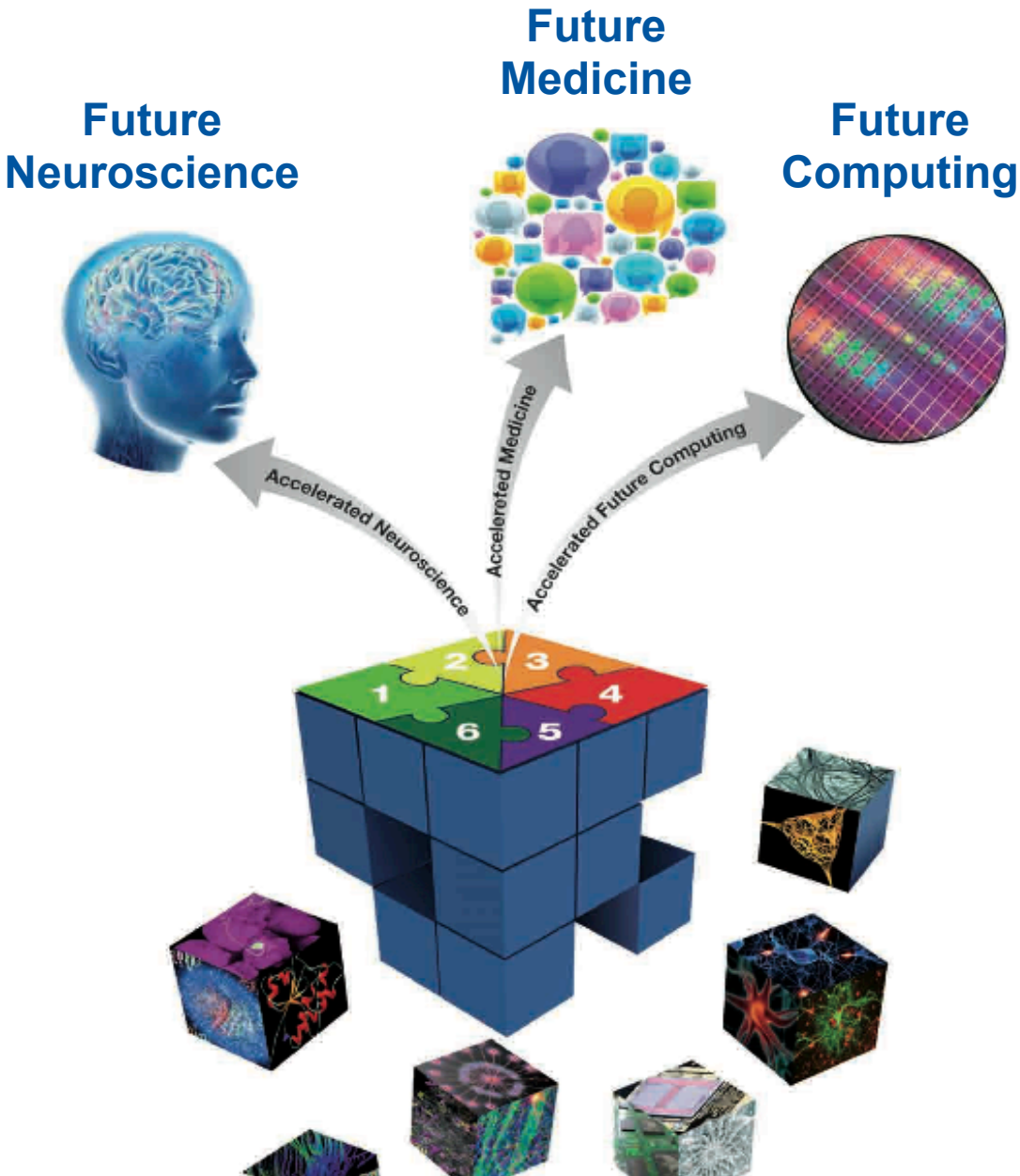


Physical Neuromorphic



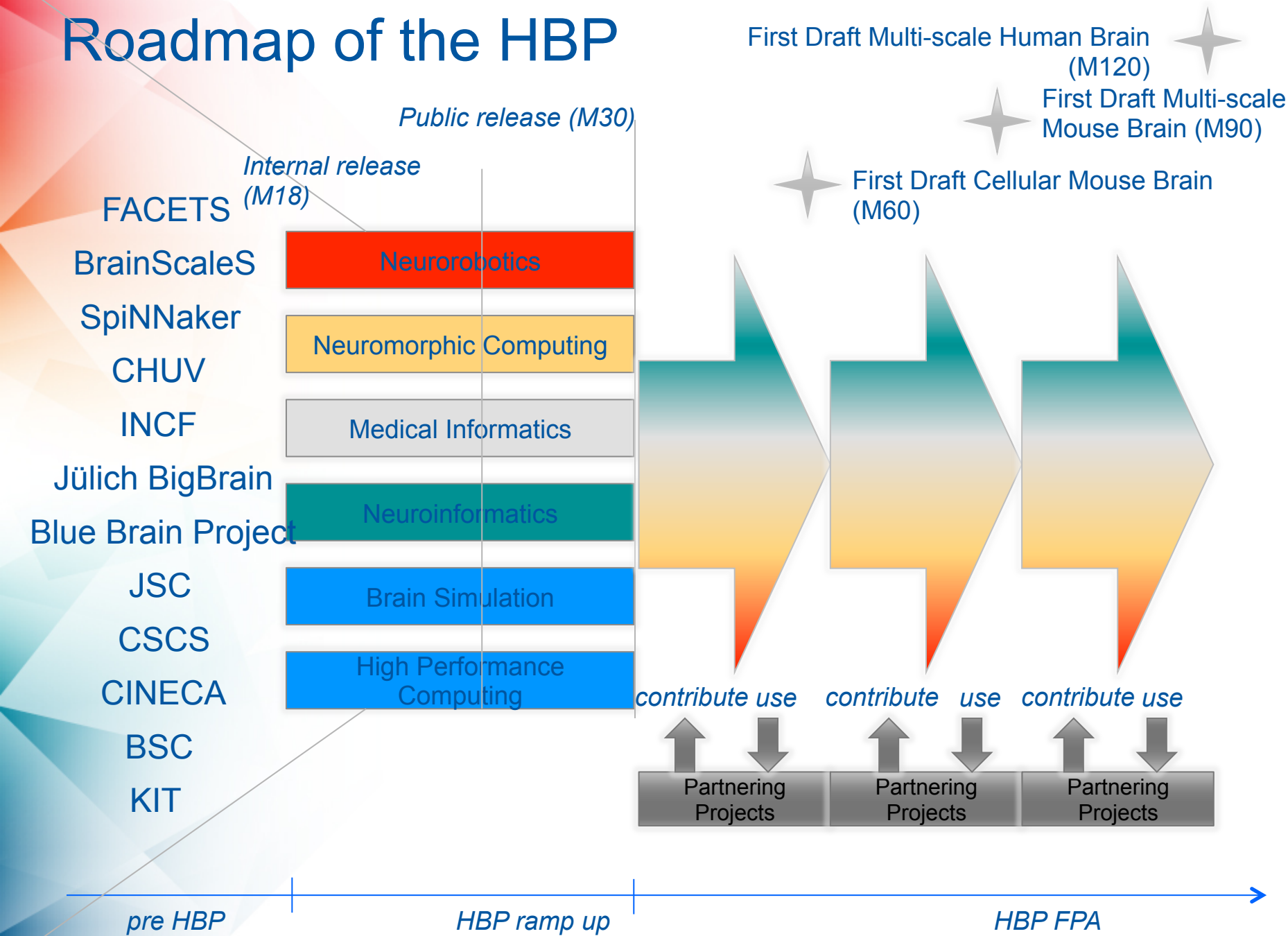
The Human Brain Project

Use ICT as a catalyst for *a global collaborative effort* to understand the human brain, its diseases and ultimately to emulate its computational capabilities.



Human Brain Project

Roadmap of the HBP

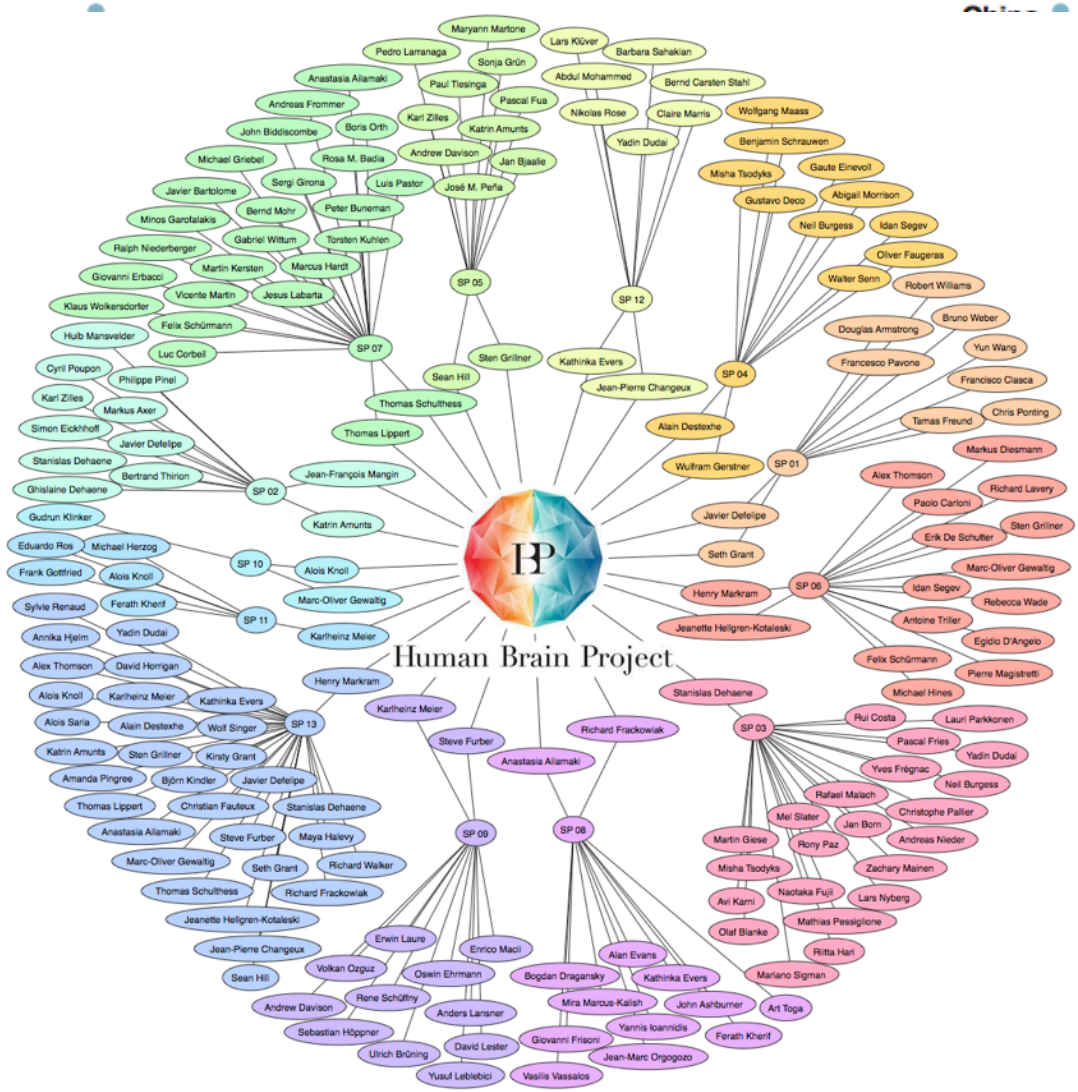


The Human Brain Project

FET Flagship Idea
- Funded from ICT branch
- 100MEuro/a for 10 years

Ramp-up Phase (2 ½ years)
- FP7 (54MEur)
- 112 partner institutions
- 24 countries

Operational Phase (7 ½ years)
- H2020
- FPA+Partner Projects



Human Brain Project

Commission européenne

Contacts

The Human Brain Project Consortium

http://www.humanbrainproject.eu

Contacts:
Prof. Henry Markram
Director Blue Brain Project
Coordinator Human Brain Project
Email: henry.markram@epfl.ch

Prof. Felix Schürmann
Blue Brain Project – Co-Director, Head of Computing
Email: felix.schuermann@epfl.ch

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