

A European Center for Brain Simulation

Henry Markram, EPFL, Switzerland

Goals & Ambition

Build an ICT facility to simulate the brain across species, ages & diseases

- **Neuroscience:**
 - Understand the brain at all levels of organization (genes to whole brain); simulate the brain in any species at any age with any disease; heal the diseases of the brain
- **Industrial Screening:**
 - Screen the brain at all -omics levels (genes to whole brain); develop new ICT for screening
- **Neuroinformatics:**
 - Federate experimental data from all over the world; design and build an exa-scale database for the brain and brain models; database the brain; *Predictive Reverse Engineering* to build detailed brain models from non-invasive data.
- **Brain Probes:**
 - Build new ICT technologies to probe the structure and function of the brain and biological organisms in greater depth, with more detail and faster than ever before
- **Diseasome:**
 - Federate clinical data on the Human Brain; study the *Diseasome* as a complex system;
- **Modeling:**
 - Generate mathematical models for all levels of biological organization of the brain (structure/geometry/function/computation); establish parameters, generate equations, build libraries, develop algorithms, enable multi-scale models
- **Simulation:**
 - Build software applications to model, simulate, visualize and diagnose biologically detailed brain models; build simulation engines, libraries, procedures, workflows; build an internet accessible European facility for simulation-based brain research.
- **Supercomputing:**
 - Establish an *European Exascale HPC Facility* for brain simulation; build a *European HPC Design & Optimization Centre* to design and optimize HPC for any simulation challenge; enable hardware-software co-design & co-development for supercomputers;
- **Visualization:**
 - Enable interactive, collaborative and visual steering of supercomputing (HPC as a desktop virtual environment); build remotely accessible *virtual laboratories*; build a *simulation cockpit for the brain*; create a *European Facility for Scientific Multimedia Production* (for science, education & society).
- **Analytics:**
 - Build a suite of analytics applications to process brain data (signal analytics, visual analytics, real-time analytics, auto-analytics); build data display applications for complex data (multidimensional data; visualizing complexity)
- **Computational Intelligence:**
 - Discover the essential mathematical, physical and chemical principles of neural information processing, emergent functions, complex behavior & cognition.
- **BrainICT:**
 - Build a *European Facility for Neuromorphic Engineering*; design and build neural computers, intelligent devices and software
- **Neurorobotics:**
 - Enable a real-time closed loop between virtual and physical robots and brain simulations on supercomputers
- **Education:**
 - Create virtual centers for education; create 3D internet technologies; produce multimedia & internet based training programs & workshops;

Impact

- **Impact on ICT (Screening Life)**
 - Advanced ICT technologies for high throughput multiomics screening
- **Impact on ICT (Data Deluge)**
 - New strategies to store manage and mine exascale volumes of data
 - New strategies to predict unknown data from data at other levels of biological information or in other species (*Predictive Reverse Engineering*)
- **Impact on ICT (Computing)**
 - Boost Europe's role in global HPC
 - Create a European design & configuration center for exascale HPC
 - Intelligent software & hardware devices
 - Neuromorphic computers
- **Impact on ICT (Global Collaboration)**
 - A new generation of virtual laboratories for collaborative and interactive research
 - Remotely accessible immersive environments
- **Impact on Neuroscience**
 - A unifying agenda
 - A new way of integrating data and knowledge and of testing hypotheses
 - Insight into the structural and functional design of biological intelligence
- **Impact on mental health**
 - A systems view of all brain diseases
 - A strategy to study the causes of any brain disorder
 - New prospects for prevention, diagnosis and treatment.
 - reduce the incidence and impact of brain disease; contribute to individual and family well-being, reduce the impact on national economies and health services.
- **Impact on Industry**
 - ICT methods for pharmaceutical companies (disease and drug simulation); simulation for drug screening and for rational design of new drugs
 - ICT tools for high-tech SMEs offering high throughput screening services.
 - Simulation of neuroprosthetics, and surgery
 - New Brainprobes for clinical diagnostics
 - New role for simulation-based science
- **Impact on education and skill base**
 - Development of key skills in life sciences (multiomics) and simulation based science.
 - New immersive multimedia tools for education

Integration

- **Disciplines**
 - ICT (transform & enable),
 - Life Science (data & knowledge; computation),
 - Health & Medicine (mental health),
 - Materials (research & development; screening, diagnostics),
 - Physics, Mathematics, Chemistry (models of all levels of biology)
 - Science & Society (3D internet education, psychology, philosophy, ethics)
- **Countries**
 - All EU countries
 - USA, Japan, China, Russia, Australia, Latin America, Africa
- **EU Industries**
 - ICT (HPC, visualization and analytics, neuromorphic and brain-inspired computing, Internet)
 - Bio-tech,
 - Bio-services,
 - Medical devices
 - Pharmaceuticals
 - Robotics.

