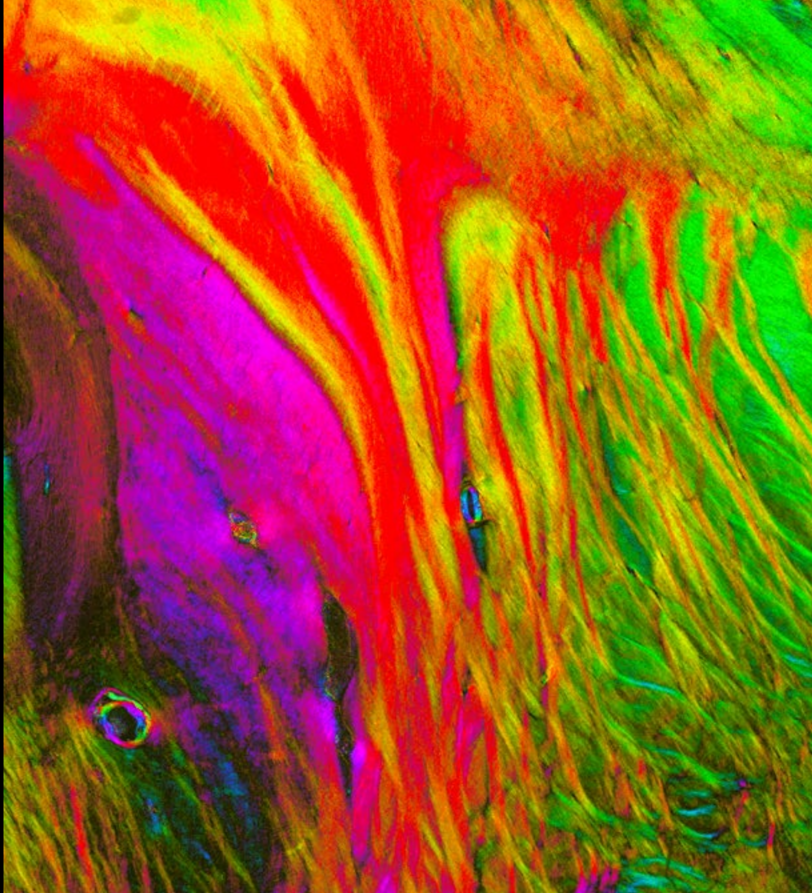
Human Brain Project

Spotlights on latest scientific advances

February 2022



Human Brain Project

500+ Researchers	16 Countries	607 M Euro*	1 Research infrastructure:
123 Institutions	10 Years**	2,000 Publications	EBRAINS

* including partner contributions, ** 2013–2023

Pioneering digital brain research

The Human Brain Project (HBP) is one of the largest research projects in Europe. As a European Future and Emerging Technologies (FET) Flagship, the HBP is a long-term and large-scale research initiative that ambitiously pioneers digital brain research. Its aim is to gain an in-depth understanding of the complex structure and function of the human brain with a unique interdisciplinary approach at the interface of neuroscience and technology.

HBP scientists employ highly advanced methods from computing, neuroinformatics and artificial intelligence to carry out cutting-edge brain research. The acquired knowledge is translated into novel applications in medicine and technological advances. Researchers of the HBP also address the social and ethical implications arising.

To facilitate the integration of brain science across disciplines and national borders, the HBP is building a digital research infrastructure: EBRAINS is an open platform that provides access to a plethora of digital tools, models, data and services, thus enabling collaboration on a very large scale.

Katrin Amunts, Scientific Director of the HBP, Heinrich-Heine-Universität Düsseldorf and Forschungszentrum Jülich, Germany

Spotlights on latest scientific advances

The HBP has driven outstanding advances in the fields of brain research and the development of brain-derived applications in medicine and technology. These spotlights highlight a few of the most recent scientific achievements. Many of these innovations and discoveries were born directly as a result of the HBP's ambitious efforts; for others, the HBP has acted as a catalyst, providing the enabling environment for exceptional breakthroughs.

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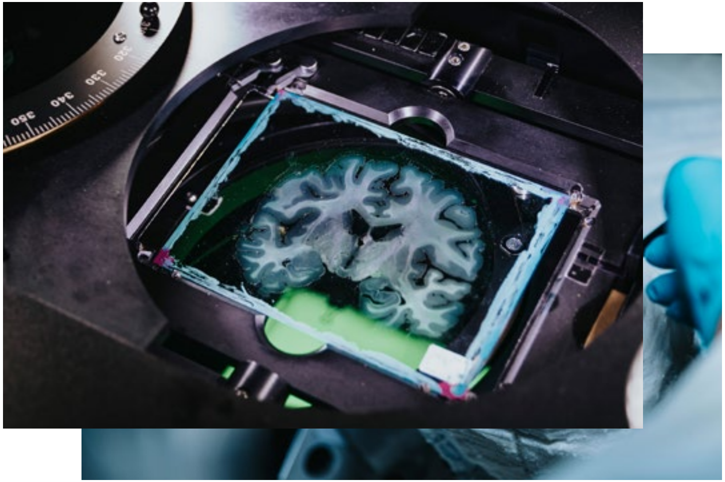
New methods to look into the brain

Watch Video

HBP researchers including teams from Italy, Germany and the UK have developed novel, high-resolution methods to image the brain in exceptional detail. These include a technique that for the first time enables imaging of intact mouse brains at subcellular resolution and a new method that allows comparing the connectome of different species in extremely high resolution (picture). In parallel, novel deep-learning methods have been established for rapid analysis of the huge volumes of brain data on supercomputers.

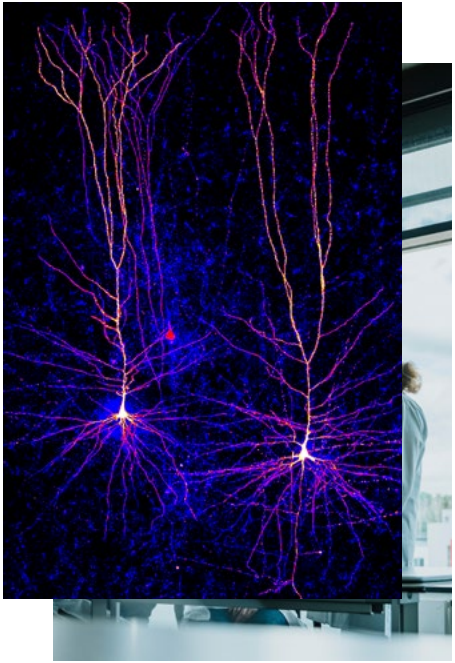


Human brain section in a Polarized Light Microscope

Silvestri et al. Nature Methods 18, 953–958 (2021). → Press release
Stacho, Herold et al. Science 369, eabc5534 (2020). → Press release
Schiffer et al. NeuroImage 240, 118327 (2021).

The tiny secret to the brain's computing power

Neurons have long tree-like appendages called dendrites that send and receive electrochemical signals. HBP researchers from Germany have discovered that in humans the dendrites of certain neurons may hold the secret to our brain's unique processing power: their unexpectedly complex activities allow single nerve cells to solve computational problems that were previously considered to require multi-layered neural networks.

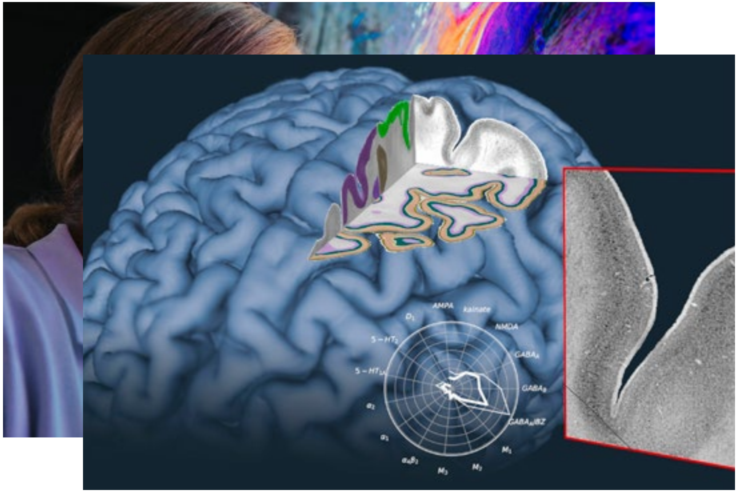


Layer 2/3 neurons of the human neocortex

Gidon et al. Science 367, 83–87 (2020). → Press release

The most detailed atlas of the human brain

HBP researchers from Germany have generated an atlas of the human brain that contains maps of more brain areas than ever identified before. The atlas shows the brain's cellular architecture in a three-dimensional space and reflects variability between individual brains. The massive amounts of data require supercomputers and AI. The atlas is openly available on EBRAINS, where new data is constantly integrated. This enables researchers to collaboratively decode the brain and clinicians to improve treatments of patients suffering from neurological disease.



The multi-level human brain atlas of the HBP

Amunts et al. Science 369, 988–992 (2020). → Press release
Amunts & Lippert. Science 374, 1054–1055 (2021). → Press release

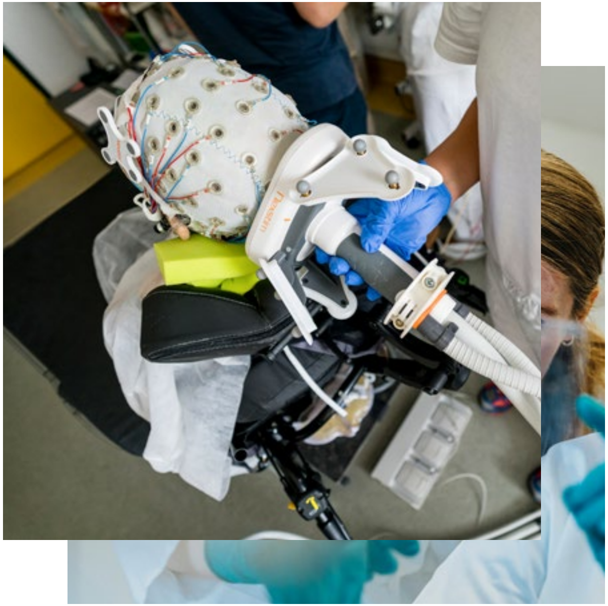
„Our method to detect consciousness has been tested across many scales and models within the HBP. Such a thorough multiscale exploration is unique and provides a solid mechanistic background."

Marcello Massimini, Leader of the HBP's Perturbational Complexity Index Team, University of Milan, Italy

Measuring consciousness

Read Interview

After severe brain injury, unresponsive patients are commonly declared unconscious, but this diagnosis is not always correct, as some patients may be unable to show that they are in fact conscious. HBP scientists from Italy and Belgium have established a new method with unprecedented sensitivity to assess the level of consciousness.
It involves magnetic stimulation of the brain non-invasively and measuring the complexity of the brain's response with an electroencephalogram (EEG). The team is now preparing a large, multi-centric clinical study.



Simultaneous EEG recording and magnetic stimulation

Lutkenhoff et al. Brain Stimulation 13, 1426–1435 (2020). → Press release

Improving epilepsy surgery with digital brain models

Watch Video

EBRAINS Atlas

In millions of epilepsy patients, pharmacological treatment is not effective and surgical intervention is the only option. HBP scientists from France have developed personalised brain models to identify the areas where seizures emerge in a patient's brain (picture). A 400-patient clinical trial is currently ongoing in France with the aim of providing surgeons with a precise tool to help individual surgery decisions and improve outcomes. The EBRAINS human brain atlas built by the HBP now serves to further enhance accuracy.

The Virtual Brain

Hashemi et al. NeuroImage 217, 116839 (2020). → Press release
Proix et al. Nature Communications 9, 1088, (2018).

„The tools for personalisation of our epilepsy models could have only emerged from the HBP. Without the HBP, we would not be in clinical trial today.“

Viktor Jirsa, Leader of the HBP's multiscale connectome focus area, Institut de Neurosciences des Systèmes Aix- Marseille University, France

Neural implants to overcome blindness and paralysis

Chen et al. Science 370, 1191–1196 (2020).
→ Press release
Wagner et al. Nature 563, 65–71 (2018).
Squair et al. Nature 590, 308–314 (2021).
Rowald, Komi, Demesmaeker, et al. Nature Medicine 28, 260–271. (2022).
→ Press release

Dutch HBP researchers have developed a brain implant that may help blind people see. The implant electrically stimulates the brain's visual cortex with high precision and successfully induced visual perception in monkeys. The EBRAINS atlas built by the HBP will empower the transfer of the technology into human medicine. In Switzerland, HBP researchers used neural implants stimulating the spinal cord to help paraplegics walk again. The team simulated the spinal cord of each patient in order to design and place the implants.

David Mzee is now able to walk all by himself – even without stimulation.

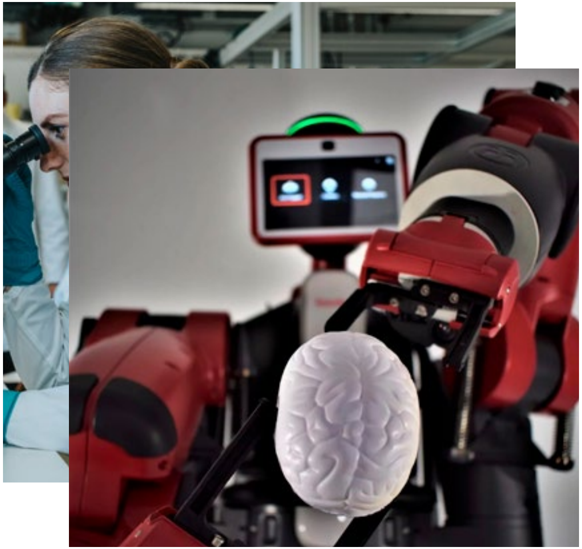
Watch Video

EBRAINS Atlas

Building robots with brain-inspired movement and cognition

Abadía, Naveros et al. Science Robotics 6, eabf2756 (2021). → Press release
Pearson et al. Frontiers in Robotics and AI 8, 732023 (2021). → Press release

HBP researchers connect brain-inspired deep learning to biomimetic robots to teach them more human-like capabilities. A team from Spain has equipped a robot with a detailed simulation of the cerebellum, a part of the brain that is involved in motor control. Their system surpasses traditional AI in learning to perform precise movements and safely interacting with humans, while dealing with unpredictable natural time delays. Researchers from the Netherlands and the UK have used the EBRAINS Neurorobotics Platform to teach robots how to remember places and improve autonomous navigation.



Watch Video

EBRAINS Neurobotics

Robot controlled
by artificial cerebellum

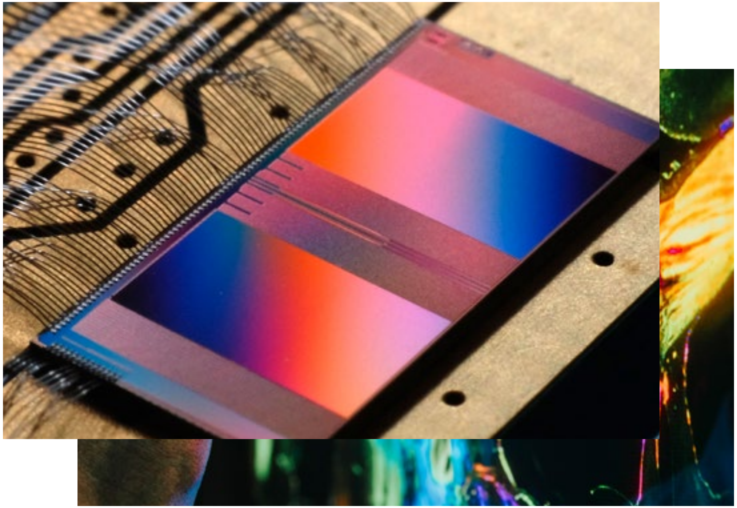
„The EBRAINS neuromorphic platform Brain-ScaleS is a versatile system, especial-ly, when you have dedicated experts running it for you in close collaboration. This is one of the crucial and much needed links that the HBP has made possible.“

Viola Priesemann, Leader of HBP Voucher Project, Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Mimicking the brain to make AI more energy-efficient

Göltz, Kriener et al. Nature Machine Intelligence 3, 823–835 (2021). → Press release
Stöckl & Maass. Nature Machine Intelligence 3, 230–238 (2021). → Press release
Cramer et al. Nature Communications 11, 2853 (2020). → Press release
Bellec et al. Nature Communications 11, 3625 (2020). → Press release

HBP scientists from Austria, Germany and Switzerland have taken inspiration from the human brain to make artificial intelligence more energy-efficient. The teams have developed and optimized a number of powerful brain-inspired algorithms that demonstrate advantages over traditional deep-learning approaches. The resulting spiking neural networks are implemented in the two large-scale neuromorphic systems that have been developed within the HBP and are accessible via EBRAINS: SpiNNaker and BrainScaleS-2.



Close-up of a BrainScaleS-2 chip

EBRAINS Neuromorphic Computing

Final sprint of Europe's largest brain research initiative

In April 2020, the HBP launched its final phase as an EU-funded FET Flagship, which will conclude in 2023. In this end phase, the project is focussing on three core scientific areas – brain networks, their role in consciousness and artificial neural networks – as well as on expanding its innovative EBRAINS infrastructure. With this strategy, the HBP is driving further advances in neuroscience, medicine and neuro-inspired technologies alike.

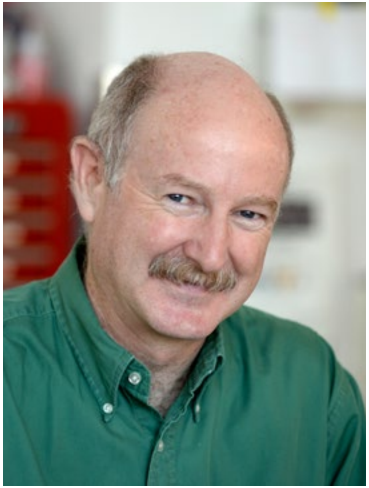
The HBP has permanently changed the way brain research is carried out. It is bringing communities from different disciplines together to work collaboratively on common goals. With its open access infrastructure EBRAINS, the HBP facilitates cross-border collaboration not only within Europe but also between large-scale initiatives from different continents. In 2021, EBRAINS was added to the influential ESFRI Road-map for Research Infrastructures – a strong demonstration that it is on track to becoming a fixture in the European research landscape.

EBRAINS is now transitioning into a sustainable infrastructure that will remain available to the scientific community as a lasting contribution of the HBP to global scientific progress.

EBRAINS offers open access to state-of-the-art tools and services. All researchers are welcome to join the community.

Discover EBRAINS

What others say about the HBP



Rafael Yuste, Co-initiator of the US BRAIN Initiative and Professor of Biological Sciences and Neuroscience at Columbia University

„The HBP has greatly advanced neuroscience and was a founding partner of the International Brain Initiative. The joint international developments will likely have a major impact on science, the clinic and society at large.“

Linda J. Richards, Australian Brain Alliance, Edison Professor and Chair, Department of Neuroscience; Director, McDonnell Center for Cellular & Molecular Neurobiology, Washington University School of Medicine

„Integrated interdisciplinary collaboration across many countries is highly challenging. The HBP has shown how this can be done on an unprecedented scale.“

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