EBRAINS

# EBRAINS at EnvironMENTAL Seminar Series

**24 June 2022**

Co-funded by the European Union

Twin goals of the Human Brain Project

Our twin goals:

- the scientific work of the Human Brain Project (HBP)
- the ongoing development of the state-of-the art Research Infrastructure for brain studies

HBP Human Brain Project

HBP scientific work

HBP infrastructure: EBRAINS

2023

Co-funded by the European Union
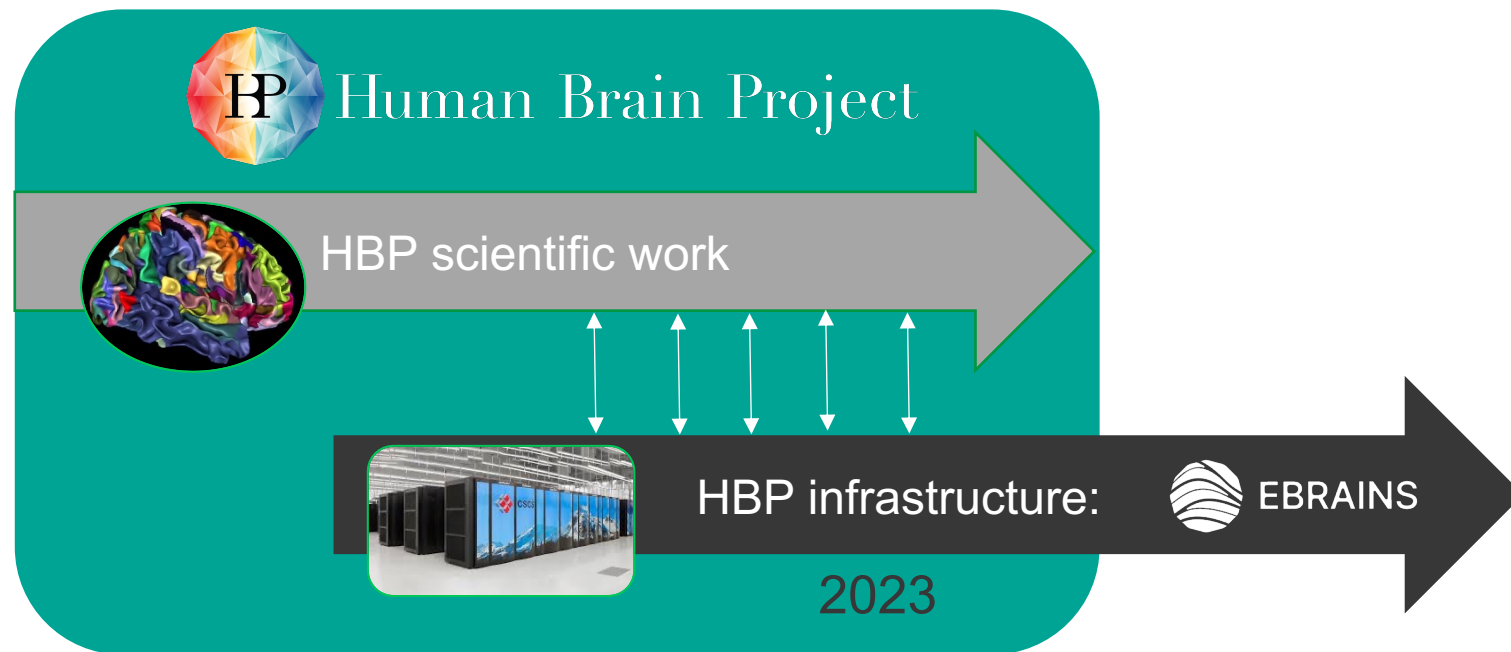
Decoding multiscale organization of the brain
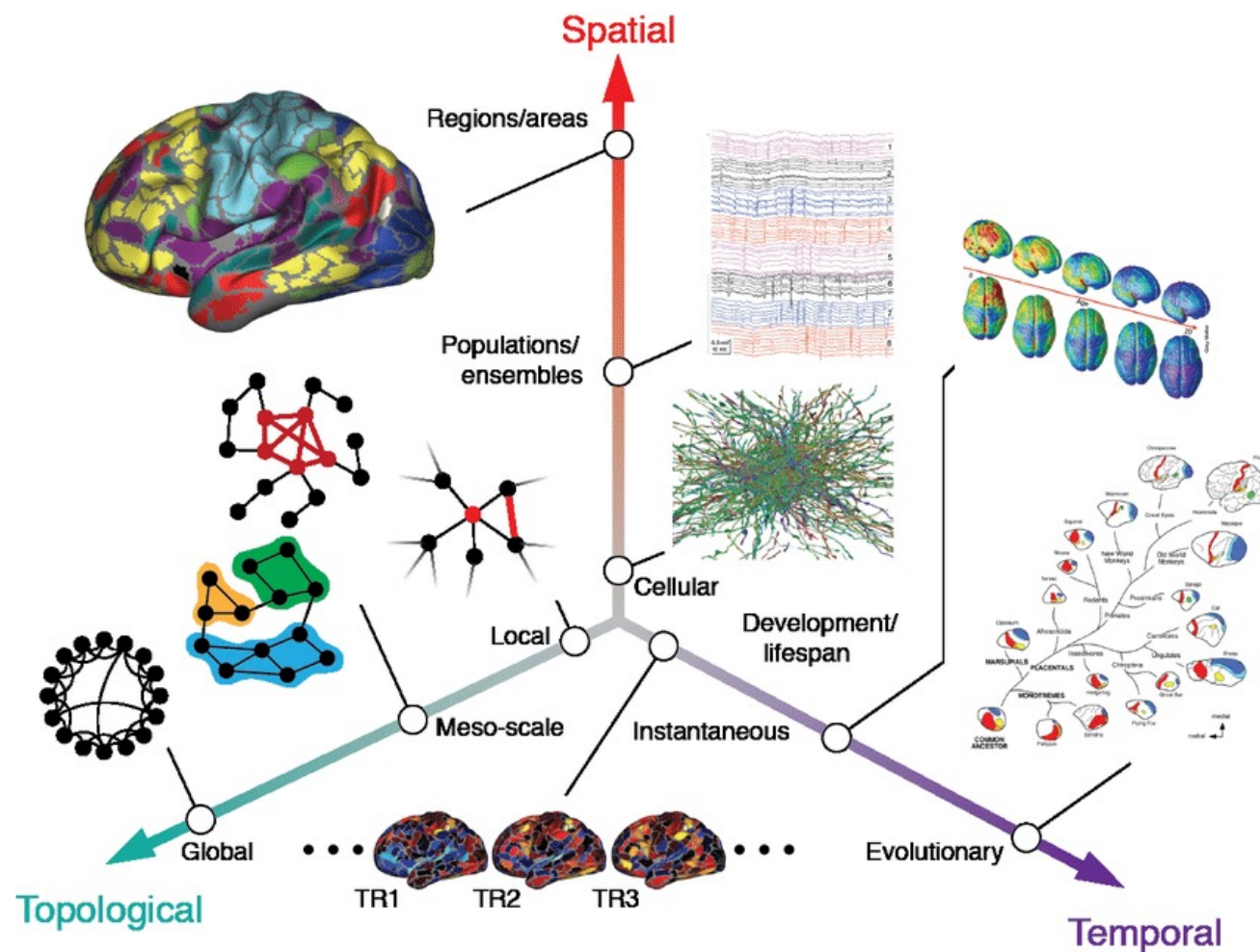
Next decade of digital brain research

Neuroscientific vision at the intersection of technology and computing

- **Starting point:** Neuroscience has firmly entered a new phase, driven by massive methodological advances and digitally enabled data integration and modeling at multiple scales – from molecules to the whole system.

- **Major advances** are emerging at the intersection of neuroscience with technology and computing. This new science of the brain integrates strong basic research, systematic data-integration across multi scales, a new culture of large-scale collaboration, and translation into applications.

- **Aims:**

- To develop a Concept and Roadmap for the **Next decade of digital brain research**
- To discuss it with the research community at large, with the aim to identify points of convergence and common goals – "*Living Paper*"
- To provide a scientific framework for current and future development of EBRAINS
- To inform and to convince stakeholders, funding organizations and research institutions

Science vision paper on Zenodo

June 10, 2022

Working paper   **Open Access**

The coming decade of digital brain research - A vision for neuroscience at the intersection of technology and computing

Amunts, Katrin; Axer, Markus; Bitsch, Lise; Bjaalie, Jan; Brovelli, Andrea; Caspers, Svenja; Changeux, Jean-Pierre; Costantini, Irene; D'Angelo, Egidio; De Bonis, Giulia; Deco, Gustavo; DeFelipe, Javier; Destexhe, Alain; Dickscheid, Timo; Diesmann, Markus; Duqué, Julie; Düzel, Emrah; Eickhoff, Simon B.; Engel, Andreas K.; Evers, Kathinka; Fousek, Jan; Furber, Stephen; Goebel, Rainer; Günterkün, Onur; De Kerchove d'Exaerde, Alban; Hellgren Kotaleski, Jeanette; Krsnik, Zeljka; Hilgetag, Claus C.; Hölter, Sabine M.; Ioannidis, Yannis; Jirsa, Viktor; Klijn, Wouter; Kämpfer, Julia; Lippert, Thomas; Maquet, Pierre; Marinazzo, Daniele; Meyer-Lindenberg, Andreas; Migliore, Michele; Morel, Yannick; Morin, Fabrice; Nagels, Guy; Oden, Lena; Panagiotaropoulos, Fanis; Paolucci, Pier Stanislao; Pennartz, Cyriel; Peeters, Liesbet M.; Petkoski, Spase; Petrovici, Mihai A.; Roelfsema, Pieter; Ris, Laurence; Ritter, Petra; Rotter, Stefan; Rowald, Andreas; Ruland, Sabine; Ryvlin, Philippe; Salles, Arleen; Sanchez-Vives, Maria V.; Schemmel, Johannes; Thirion, Betrand; Van Albada, Sacha Jennifer; Vanduffel, Wim; De Vos, Winnok

Brain research has in recent years indisputably entered a new epoch, driven by substantial methodological advances and digitally enabled data integration and modeling at multiple scales – from molecules to the whole system. Major advances are emerging at the intersection of neuroscience with technology and computing. This new science of the brain integrates high-quality basic research, systematic data integration across multiple scales, a new culture of large-scale collaboration and translation into applications. A systematic approach, as pioneered in Europe's Human Brain Project (HBP), will be essential in meeting the pressing medical and technological challenges of the coming decade. The aims of this paper are

- To develop a concept for the coming decade of digital brain research
- To discuss it with the research community at large, with the aim of identifying points of convergence and common goals
- To provide a scientific framework for current and future development of EBRAINS
- To inform and engage stakeholders, funding organizations and research institutions regarding future digital brain research
- To identify and address key ethical and societal issues

5

EBRAINS is the result of the work of

500 scientists and engineers

FROM

200 academic institutions and international partners
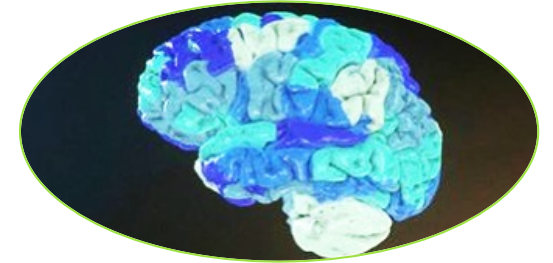
WHO DELIVERED

1450 scientific publications

HBP/EBRAINS: recent achievements

New EBRAINS-enabled tool to help guide surgery in drug-resistant epilepsy patients

Ultra-high-definition predictive brain tool seeks to give surgeons a sharp eye to spot epilepsy in a patient's brain.


Contribution to a new treatment for spinal cord injury

A team of scientists has developed a treatment that allows patients to regain control of their blood pressure, using targeted electrical spinal-cord stimulation.


HBP-supported innovation: A brain prosthesis for the blind

Human Brain Project research has helped lay the foundation for a brain implant that could one day give blind people their sight back.
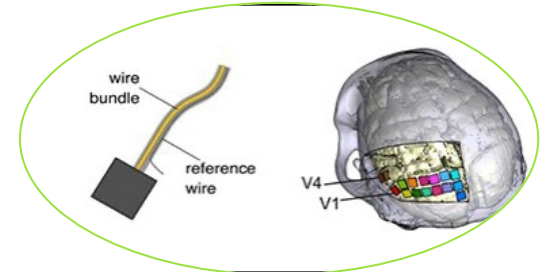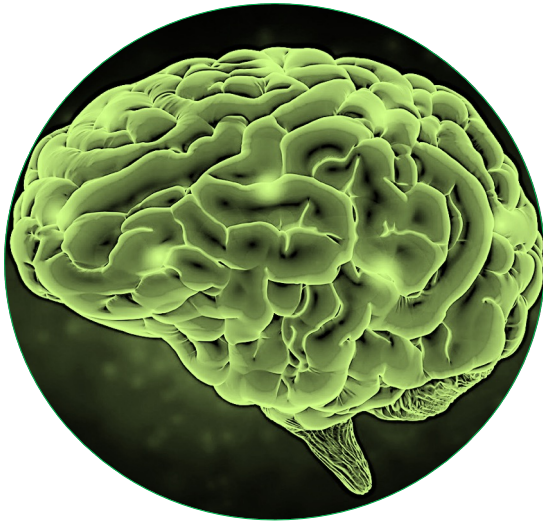

Awakened by a sleeping pill

A patient with severe brain injury was temporarily able to talk, walk, and recognize family members after being treated with sleeping medication.
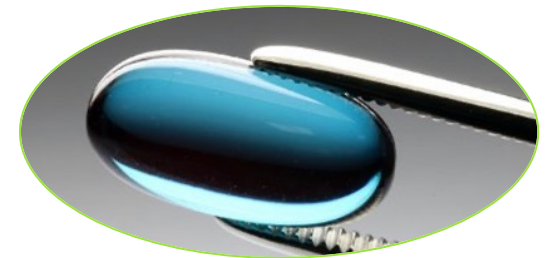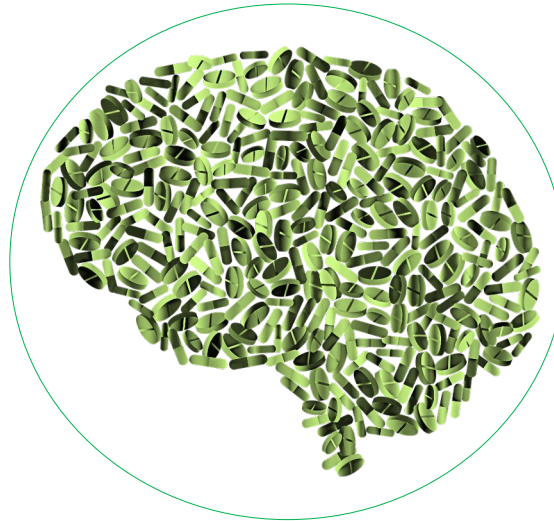
EBRAINS Focus areas

Covering and ensuring equilibrium between three areas:

Neuroscience | Brain Medicine | Brain-inspired technologies

Ambition: EBRAINS as an infrastructure of reference for brain research

Solution provider for an extensive community of researchers

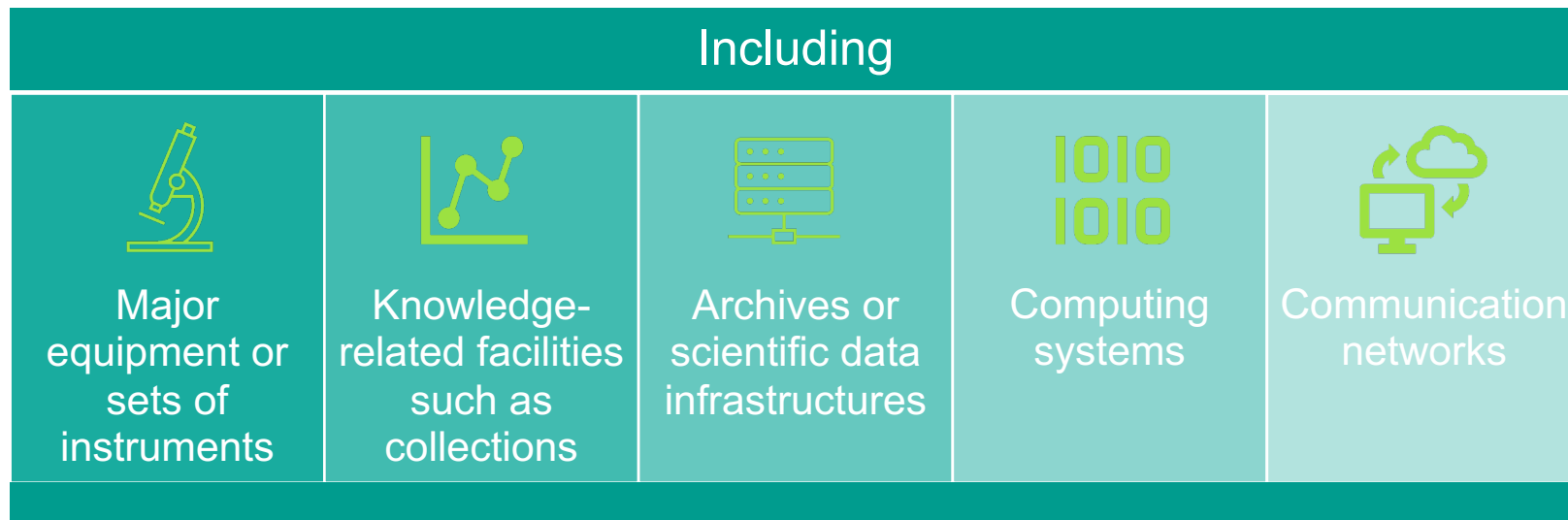Enabler of state-of-the art multi-scale research via customized workflows

Suite of unique add-on tools such as those for reinforced inference

To deliver holistic solutions, science needs research infrastructures

Research infrastructures are facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields.[1]

Including				
Major equipment or sets of instruments	Knowledge-related facilities such as collections	Archives or scientific data infrastructures	Computing systems	Communication networks

[1] European Commission, https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/research-infrastructures_en

Value added of EBRAINS as a Research Infrastructure

Fair & high-quality data

- Unique degree of data findability
- Both, machine and human readable metadata
- Use of OpenMINDS meta data schemas
- Curation by expert neuroscientists
- Access restriction to be defined by individual
- Links to interactive Brain Atlas

Collaboration, co-design and user support

- Technological development is driven by concrete scientific questions and use cases
- More documentation and higher TRL than most of the scientific software
- Efficient support of users through the High-Level Support Team
- Partnering projects
- Systematic analysis of feedback and updates
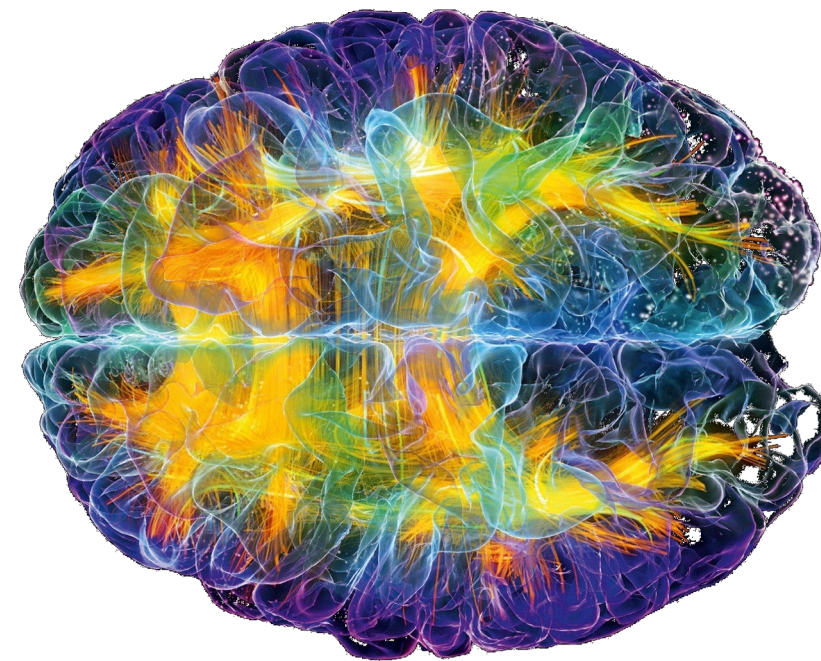
EBRAINS

EBRAINS offers a focused and deep range of services

Data and Knowledge

- Online solutions to facilitate sharing of and access to research data, computational models and software

Atlases

- Navigate, characterise and analyse information on the basis of anatomical location

Simulation

- Solutions for brain researchers to conduct sustainable simulation studies and share their results

Brain-Inspired Technologies

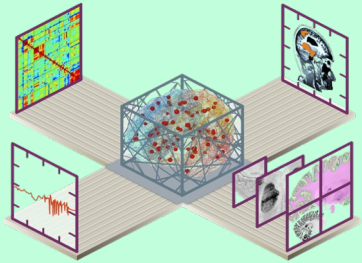- Understand and leverage the computational capabilities of spiking neural networks

Medical Data Analytics

- The Medical Data Analytics service provides two unique EBRAINS platforms, covering key areas in clinical neuroscience research
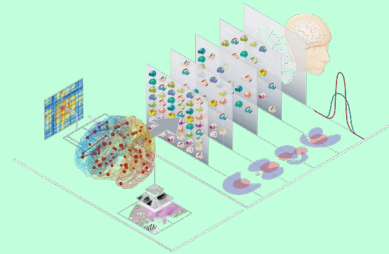
EBRAINS amplification capacity

Example: **The Virtual Brain** closing the gap between model and brain imaging data

Maximal predictive power through workflows integrating heterogeneous data

- post-mortem brain data (full brain)
- clinical data (tissue resections)
- individual brain imaging (MRI, PET, ...)

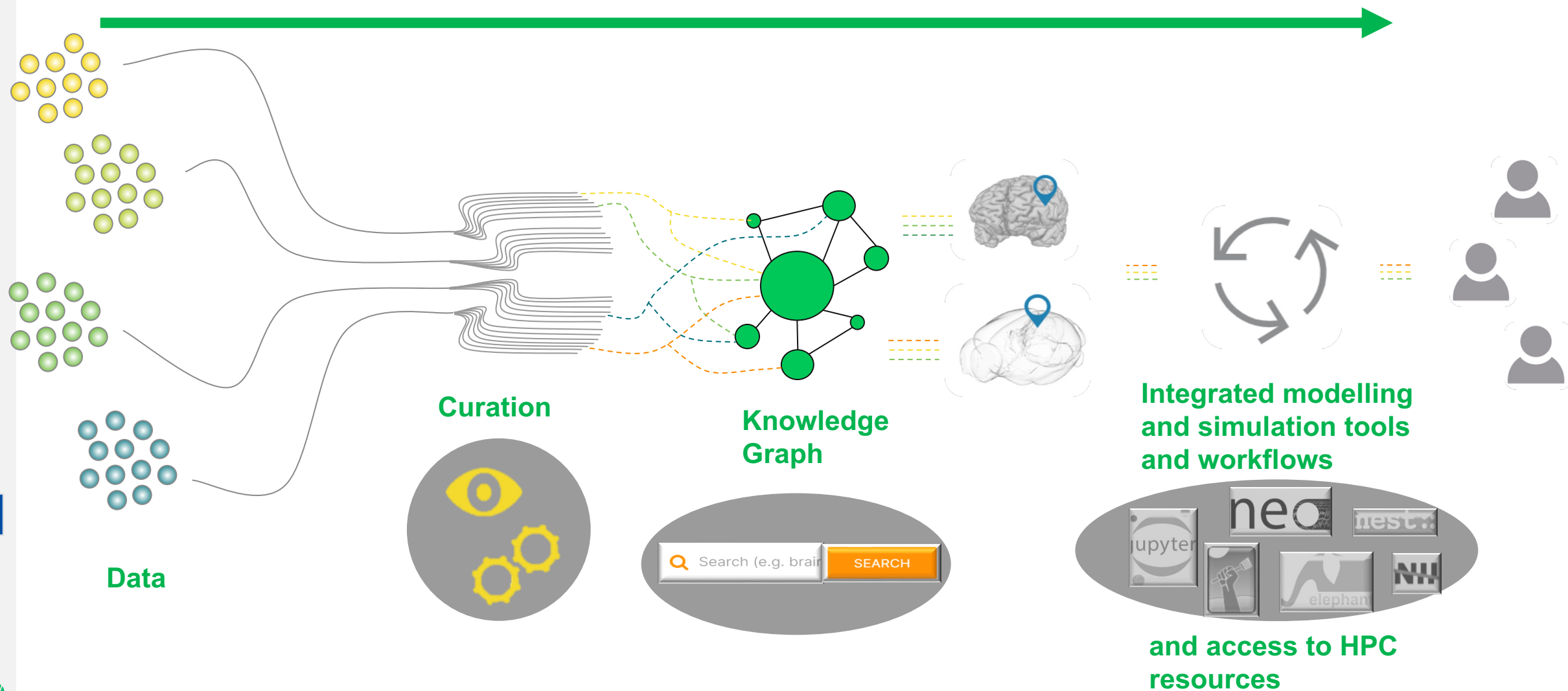**Personalization** workflows for in-silico brain modeling

- Monte Carlo Markov Chain technology
- High fidelity: diagnostics for performance and reliability
- High resolution

Causal inference exploits patient-specific brain models to develop diagnostic solutions for early detection of neurodegeneration

https://ebrains.eu/service/the-virtual-brain

An integrated platform with cutting-edge workflows

www.ebrains.eu

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EBRAINS

Data

Curation

Knowledge
Graph

Search (e.g. brain   SEARCH

Integrated modelling
and simulation tools
and workflows
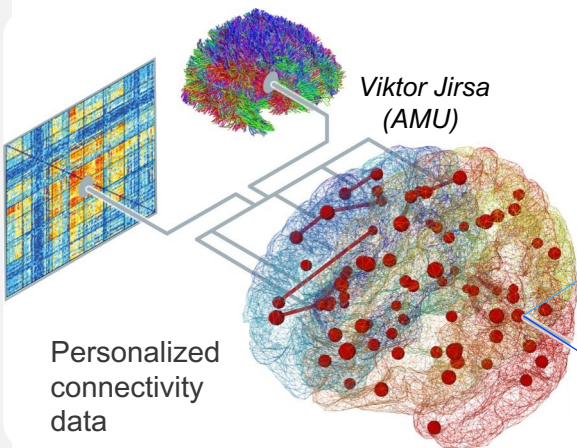
and access to HPC
resources

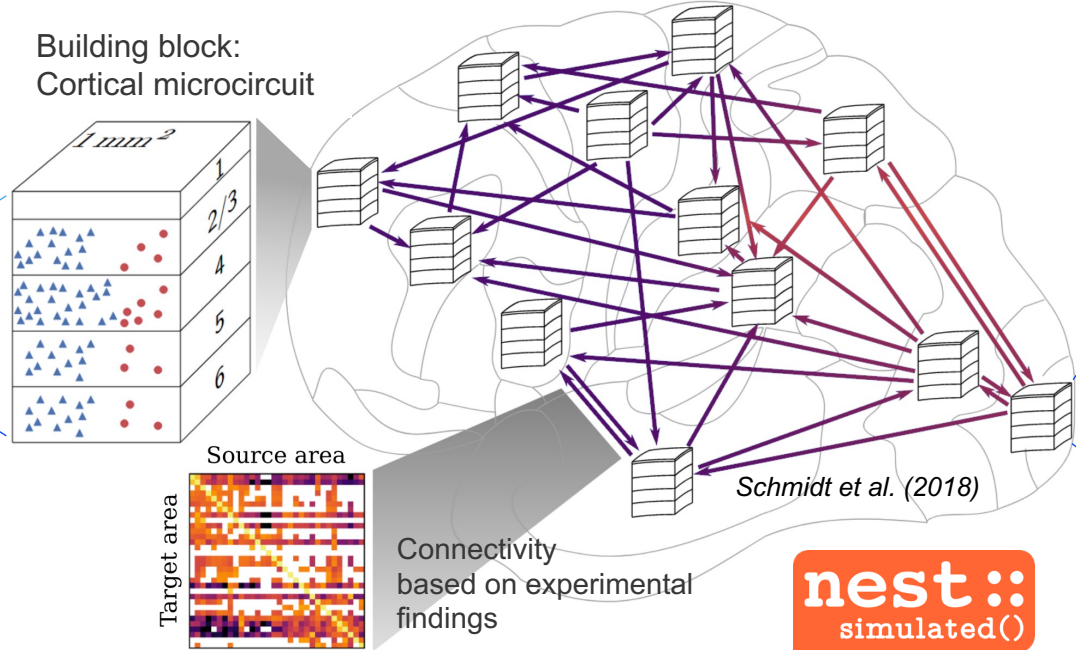# Ecosystem of neuroinformatics tools to enable complex in-silico experiments

Multi-simulator interaction

Multi-simulator interaction

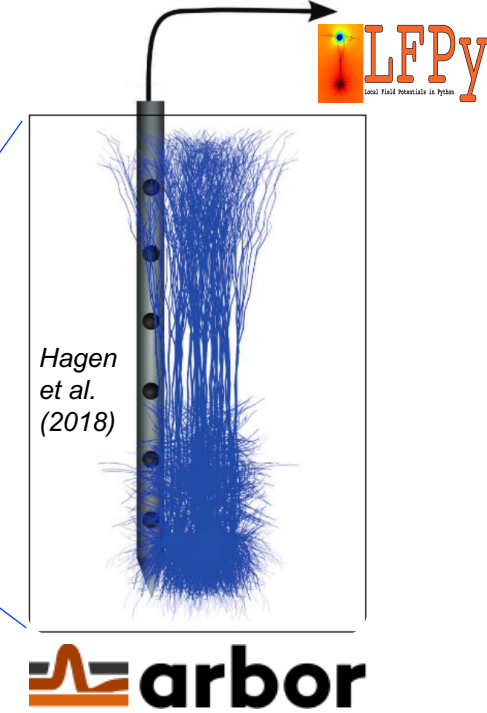Brain models at brain-region resolution

Brain-scale models at single neuron resolution

Cortical circuits with morphological details

Viktor Jirsa (AMU)

Personalized connectivity data

THEVIRTUALBRAIN.

Building block: Cortical microcircuit

$1\ mm^2$

1
2/3
4
5
6

Source area

Target area

Connectivity based on experimental findings

Schmidt et al. (2018)

nest::
simulated()

Hagen et al. (2018)

LFPy
Local Field Potentials in Python

arbor

Controlled workspaces connected to the Federated HPC, Cloud, storage & network infrastructure

- Self-hosted storage

- Access to supercomputing power

- Workspace = the collaboratory
  - Public (accessible without an account)
  - Private
  - Team permissions: admins, editors, viewers
  - Versioning

- Document your work
  - Wiki pages
  - Office with collaborative edition

- Share data
  - 1 collab = 1 drive
  - File versioning

FENIX sites
- CSCS, Lugano CH
- BSC, Barcelona ES
- CEA, Paris FR
- Cineca, Bologna IT
- JSC, Jülich DE

EBRAINS Collaboratory

Co-funded by
the European Union

EBRAINS

11 July 2022   16
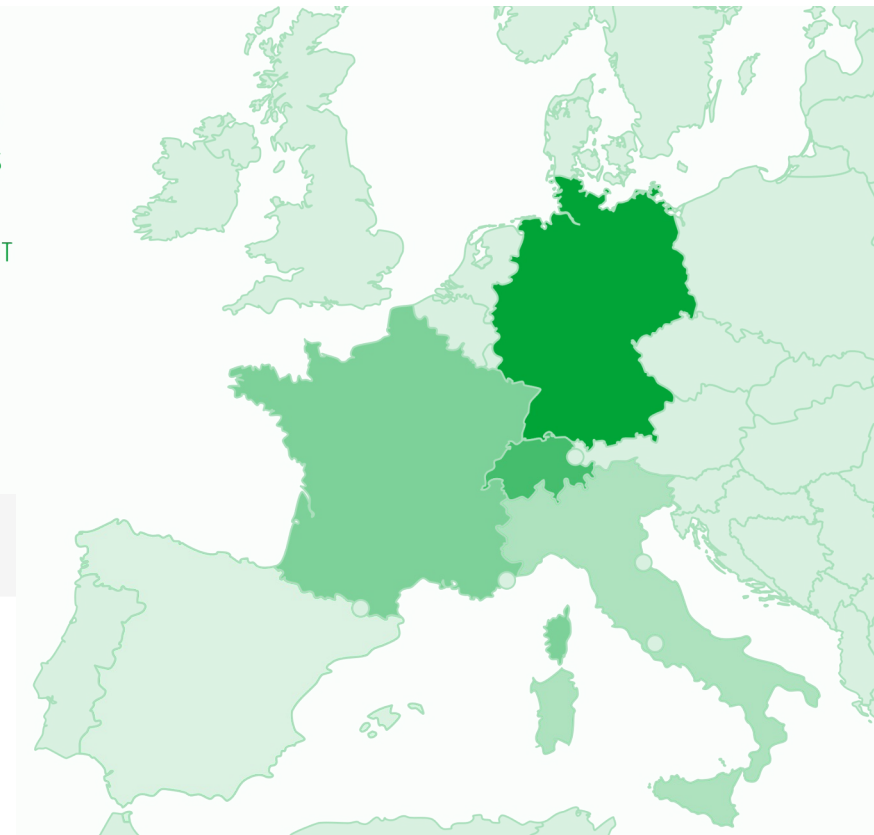
Large-scale, cross-disciplinary collaboration is key to drawing benefits

By joining forces and expertise, trans-disciplinary teams will succeed in creating a paradigm shift in brain science

From these scientific breakthroughs should emerge unparalleled societal benefits, with innovative treatment solutions for brain diseases and revolutionary brain-inspired technologies
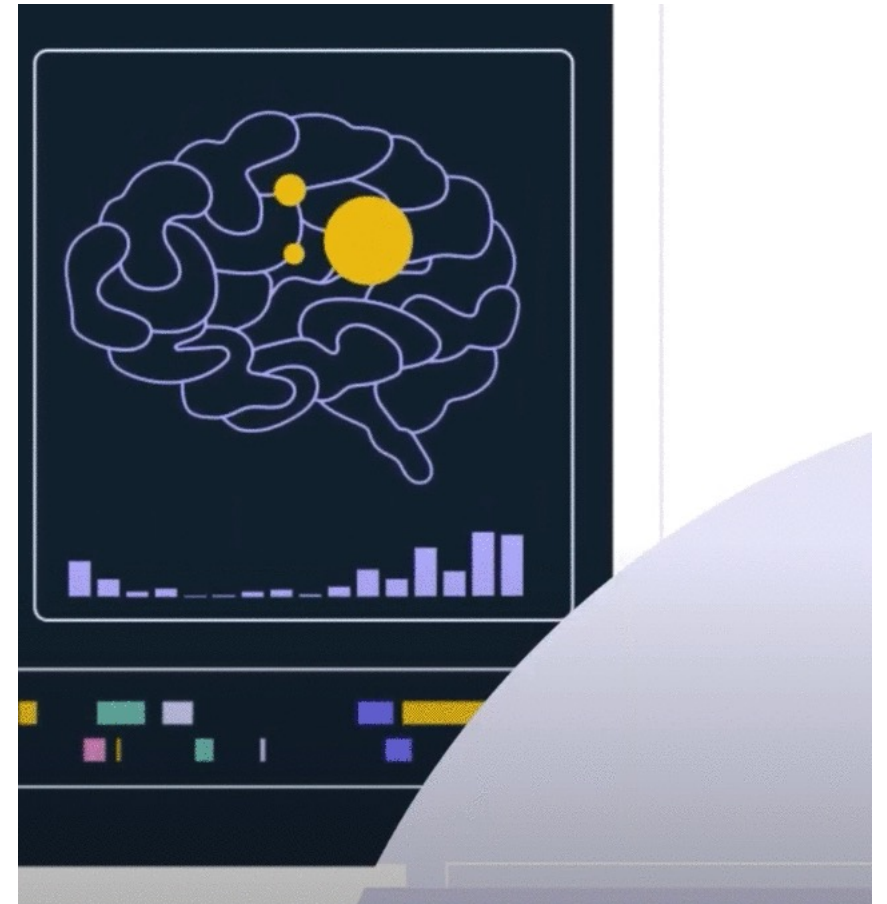
EBRAINS

EBRAINS in the RI landscape

EBRAINS is addressing an existing need of researchers in several European Countries for solid research tools and services

- **341** "research infrastructures" providing services to support "Biological and Medical Sciences"[1]

- **8 of the 341** are explicitly concerned with neuroscience, and all are **single-site, national bodies**
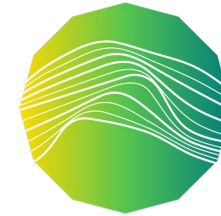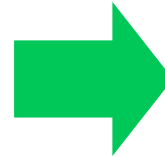
EBRAINS complements the landscape and promotes **synergies across the still fragmented neuroscience activities in Europe**

EBRAINS is the only pan-European digital distributed infrastructure in Brain Science

EBRAINS

EBRAINS selected for the ESFRI Roadmap 2021

The ESFRI Roadmap arguably contains the **best European science facilities** based on a thorough evaluation and selection procedure

ESFRI's mission is to develop the scientific integration of Europe, to strengthen its international outreach, and to provide Europe with the most up-to-date Research Infrastructures, responding to the rapidly evolving Science frontiers, also advancing the knowledge-based technologies and their extended use

One of the core objectives of ESFRI is to ensure that *excellent scientists have access to Europe's best research infrastructures irrespective of borders*

https://www.esfri.eu/latest-esfri-news/new-ris-roadmap-2021

New RIs for Roadmap
2021 announced

Strategy Report on Research Infrastructures
ROADMAP 2021
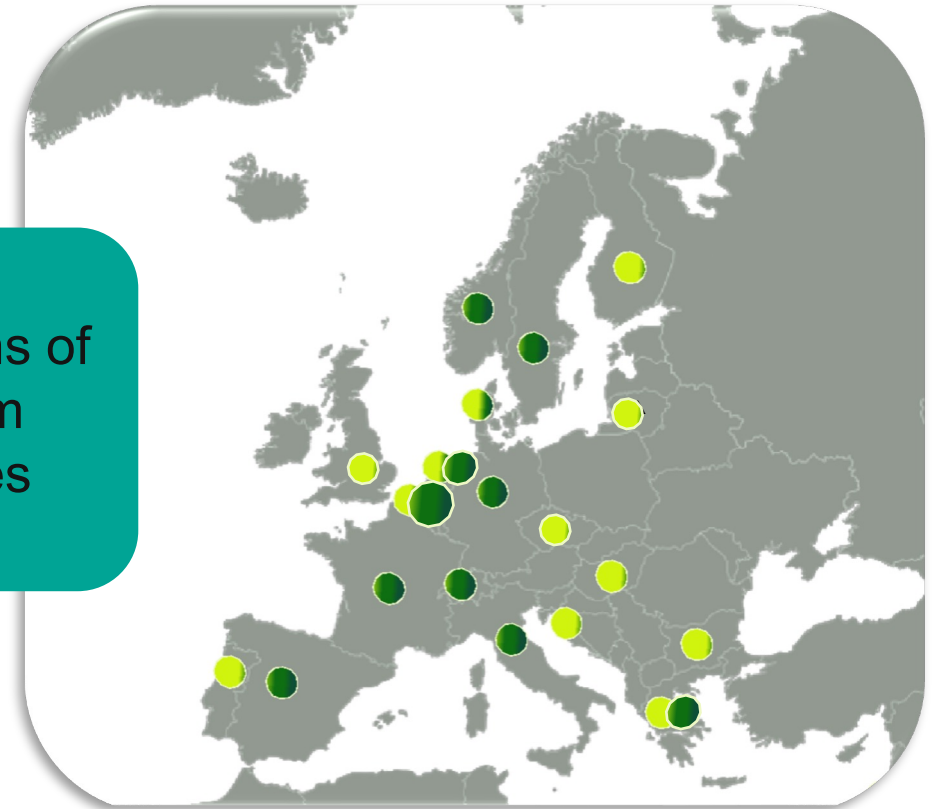
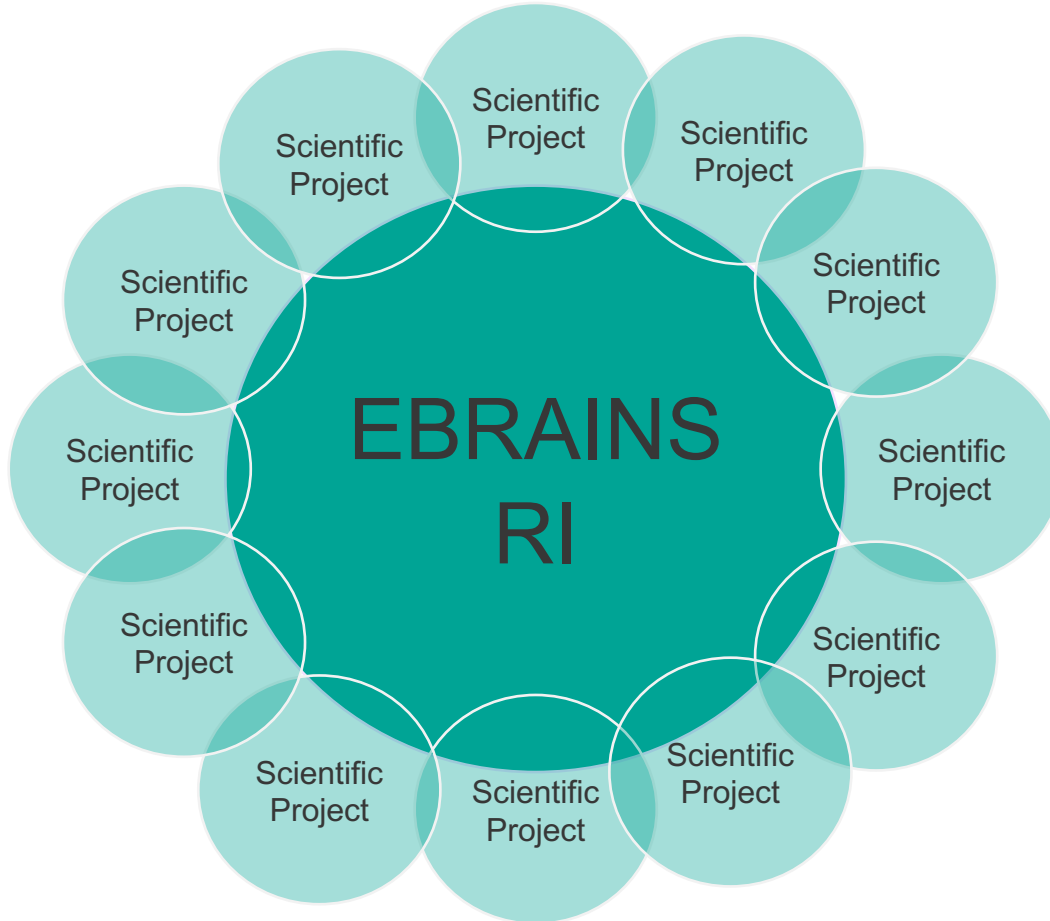# Emerging system of National Nodes of EBRAINS

2021-2022

2023- onwards

France
Italy
Norway
Spain
Sweden
Switzerland
Germany
Belgium
Netherlands
Greece

Denmark
Bulgaria
Croatia
Czech Republic
Finland
Hungary
Israel
Lithuania
Portugal
UK

10 Expressions of Interest to form National Nodes

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EBRAINS

From decoding brain connectivity to brain health

Scientific work on the human multiscale brain connectome and its variability can contribute to progress in **personalized and precision medicine for brain diseases**

from synapses to large-scale networks and function

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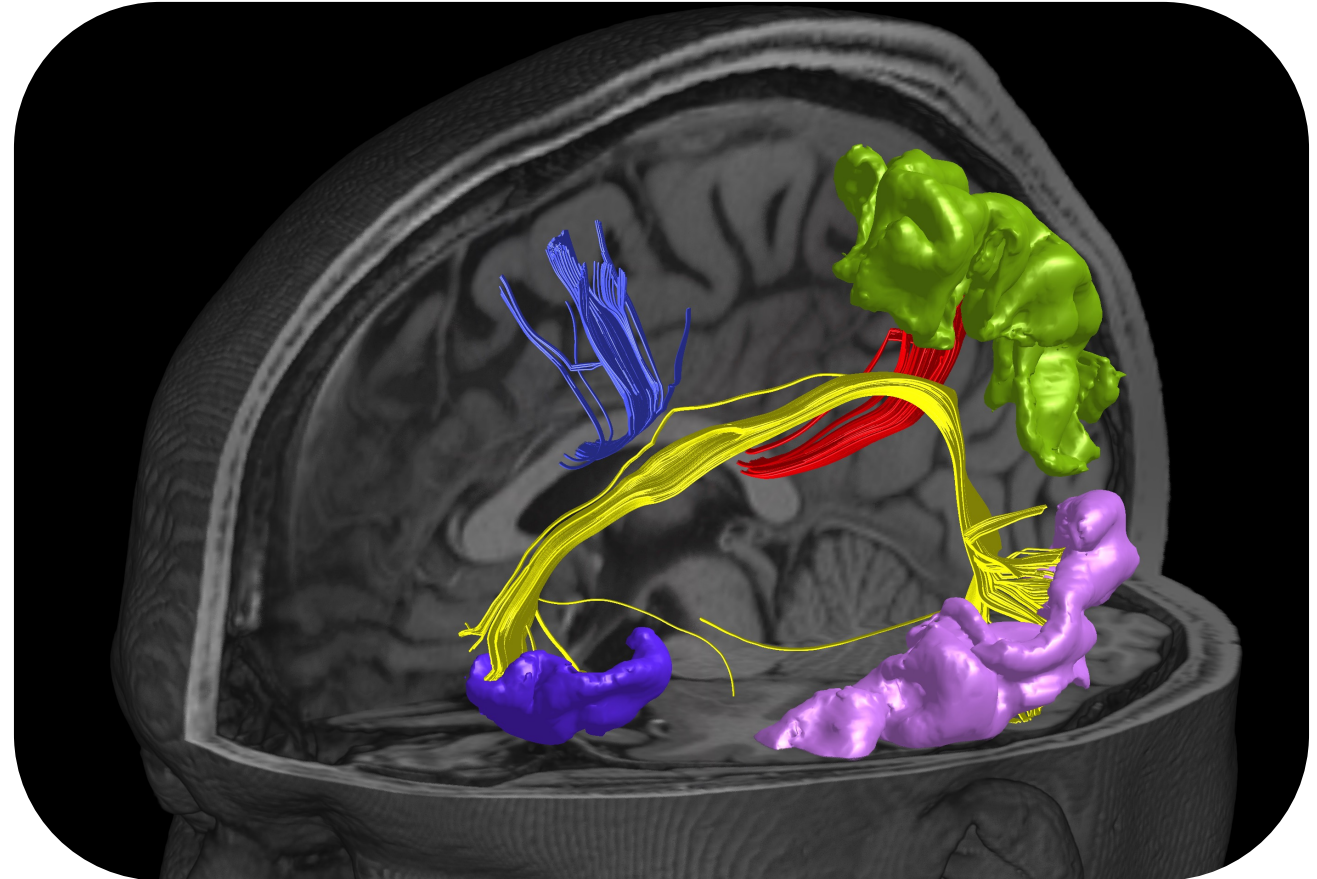
Growing centrality of brain health

✓ Focus on a healthy and a diseased brain

✓ Neurological disorders: leading cause of disability and second leading cause of deaths worldwide

✓ Number of people with MS: 2.8 mln globally with prevalence rising in every region

✓ Number of people with AD expected to triple to 2050

✓ Deaths from stroke increased by 43% between 1990 and 2019

✓ Globally: 2.5 trillion USD lost in productivity due to poor brain health

✓ Mental health and neurological diseases are likely to be the single largest medical and societal cost in Europe in the next 2 decades
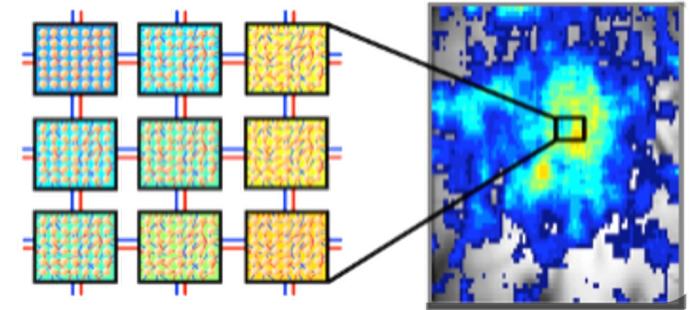

TIPS FOR GOOD BRAIN HEALTH

1. KEEP PHYSICALLY ACTIVE
2. EAT A HEALTHY DIET
3. GET ENOUGH SLEEP
4. STIMULATE YOUR MIND
5. LOOK AFTER YOUR HEART
6. WEAR A HELMET

World Health Organization

Convergence of policy initiatives

✓Forthcoming Global Action Plan on epilepsy and other neurological disorders of WHO

✓Non-Communicable Diseases Initiative of the EU: to be presented on 22 June

✓Result of community efforts: OneNeurology in particular
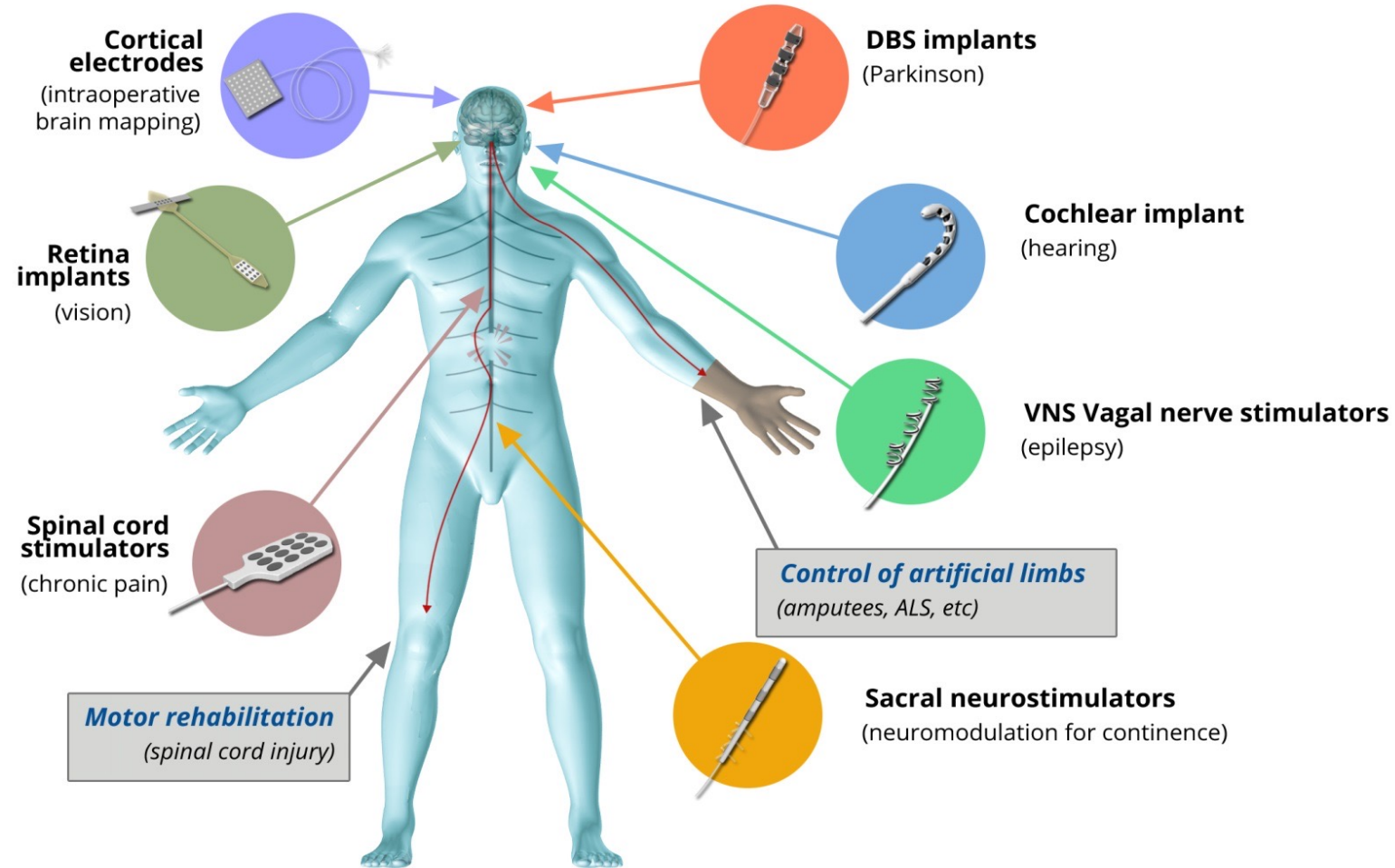
✓Emerging national Brain Plans

Network of European Neurotechnology Platforms

✓ **Pharmaco-molecular approaches have often not been enormously successful**, including because of the anatomical resistance of the blood-brain barrier

✓ Now **major progress in the field of neuro-engineering**, including **Brain Computer Interfaces** for modulation of brain activity and neuro-prosthetics with significant clinical impact.

✓ As a result: **major advances in the management of several neurological, and even certain psychiatric diseases**, have become possible

Neuroelectronic medicine

Cortical electrodes
(intraoperative brain mapping)

DBS implants
(Parkinson)

Retina implants
(vision)

Cochlear implant
(hearing)

VNS Vagal nerve stimulators
(epilepsy)

Spinal cord stimulators
(chronic pain)

Control of artificial limbs
(amputees, ALS, etc)

Motor rehabilitation
(spinal cord injury)

Sacral neurostimulators
(neuromodulation for continence)

- stroke rehabilitation
- support of memory
- alleviate depression
- brain computer interfaces (speech)

EBRAINS

EBRAINS in the European Health Data Space

✓ Common European approach for the use and re-
use of health data
✓ Complements and builds on the GDPR
✓ Towards step change in accessibility of health data
✓ 15 mandatatory categories of data to be defined
✓ Data access bodies to be set up to provide access
in a secure environment
✓ One request to be sufficient for all required data
sets in the different European countries
✓ Pilot project plannned to test infrastructural support

Tackling the sensitive data challenge in brain research

HDC
HealthDataCloud

Large data-science approaches to the brain, and to health in general, need to solve an important problem: **all research needs to strictly protect privacy** - and thus the freedom and rights of each individual, and comply with European GDPR rules.
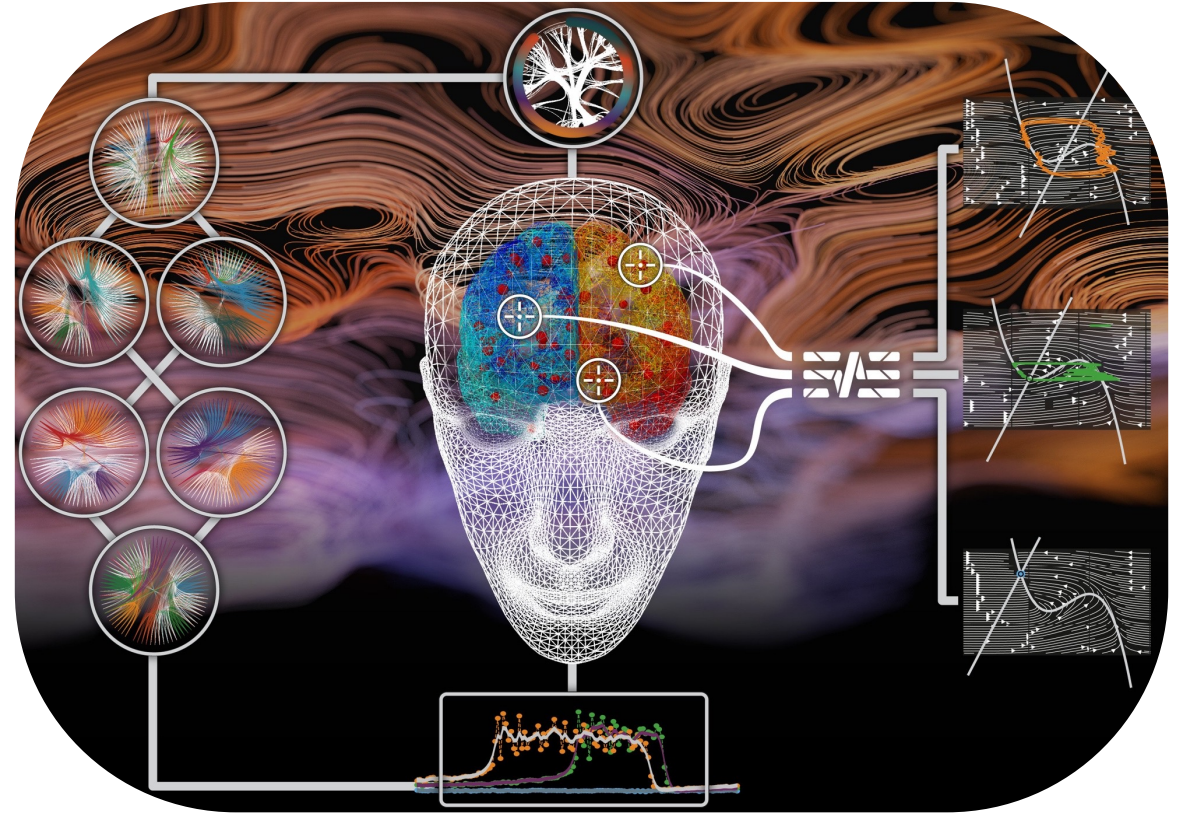
To this end, **EBRAINS HealthDataCloud** will provide a GDPR-compliant, federated research data ecosystem that enables neuroscience research consortia across Europe and beyond to work with sensitive neuroscience data originating from human subjects, as well as defined routes for sharing of the data and results.

Causal inference exploits patient-specific brain models to develop diagnostic solutions for early detection of neurodegeneration

EBRAINS

Towards federated infrastructure for brain health data

- Create a governance and business model for capturing brain health data and exploitation

- Form a federated network of data sources and tools for distributed data analysis

- Ensure support by AI, HPC and cloud tools

- Support the creation of new data sets and extension of existing ones

- Make tools developed in other EU projects available and ensure their sustainability

- Align with developments in the European Health Data Space

Thank you

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