The Human Brain Project:

Overview of Theoretical Neuroscience

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http://www.humanbrainproject.eu
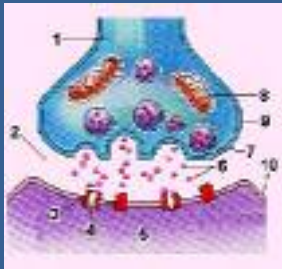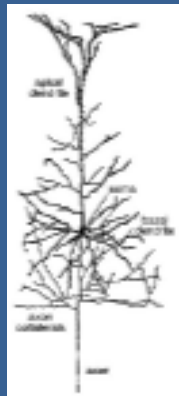
Spatial Scales of the Brain

Molecular (~10 nm)

Sub-cellular (100 nm – 1 μm)

Neuron (10 μm – 1 mm)
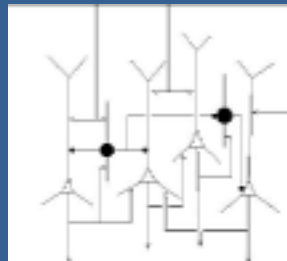
Local circuits (100 μm – 1 mm)
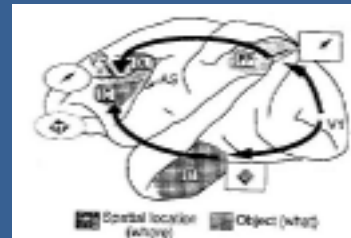
Cortical area (~1 cm)

Whole Brain (~10 cm)

Theoretical Neuroscience in HBP

WP1: Bridging scales, from neurons to networks

WP2: Synaptic plasticity, learning & memory

WP3: Models of cognitive functions

WP4: Principles of brain computations

**WP5: The European Institute for
Theoretical Neuroscience (www.eitn.org)**

Different aspects of Theoretical Neuroscience

WP1: Bridging scales, from neurons to networks
-> Neuroscience, Neuromorphic, Simulation
WP2: Synaptic plasticity, learning & memory
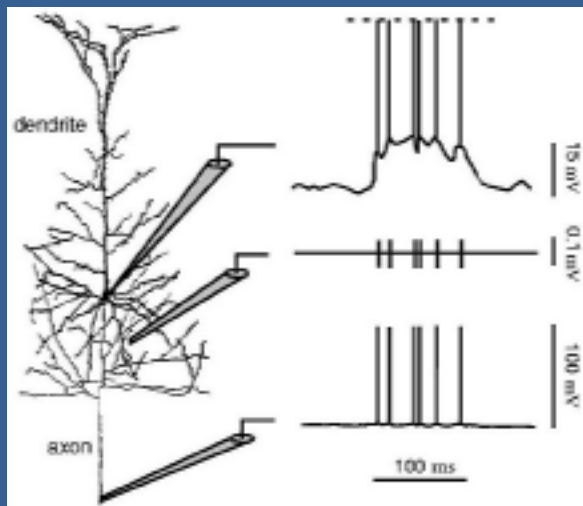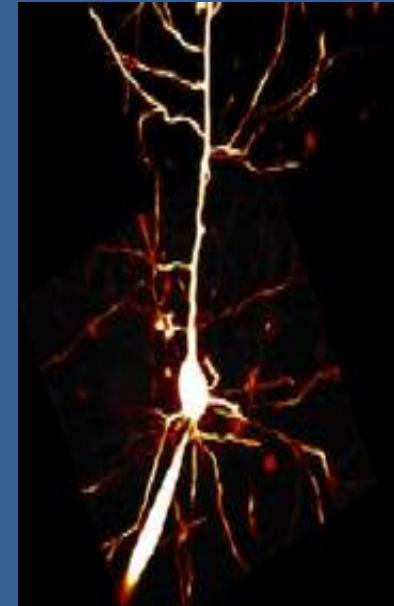**-> Neuroscience, Neuromorphic, Simulation**
WP3: Models of cognitive functions
-> Cognitive, Simulation
WP4: Principles of brain computations
-> Neuromorphic, Robotics
WP5: The European Institute for Theoretical Neuroscience
-> All SPs

Realistic models, Biophysical models

- Single cell, Hodgkin-Huxley, dendrites

- Modeling integrative properties in vivo

Objectives:

- Understand the integrative properties of neurons (I/O function)

- Understand how integrative properties change according to activity (in vivo)

- Design simplified models for networks

Models of synaptic plasticity and learning

- Biophysical and simplified models of synaptic plasticity
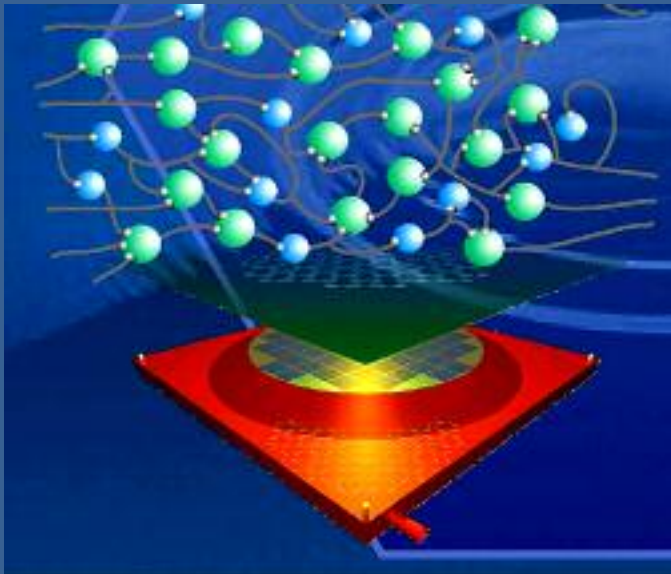
- Link learning rules to connectivity
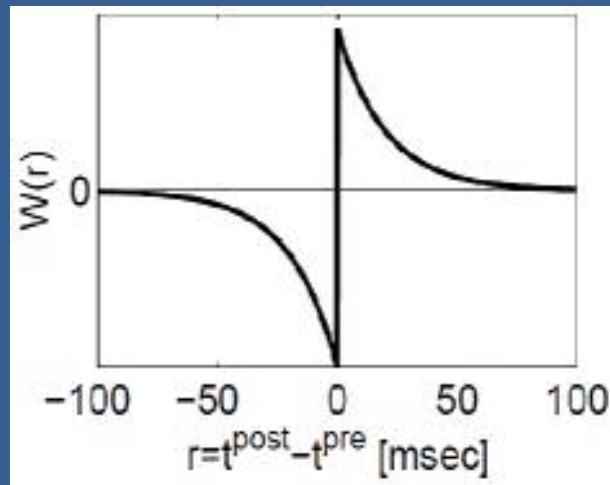
Objectives:

- Develop learning rules that are consistent with experiments

- Transfer learning rules to network simulations

Neuro-engineering models

- Models for VLSI neurons

- Brain-computer interfaces

Objectives:

- Design analog or digital harware to emulate principles of biological computation in neuronal networks

- Obtain new generations of hardware to emulate neuronal networks

- Ultimately, interface brains with computers

Computing paradigms

- Liquid computing, reservoir computing

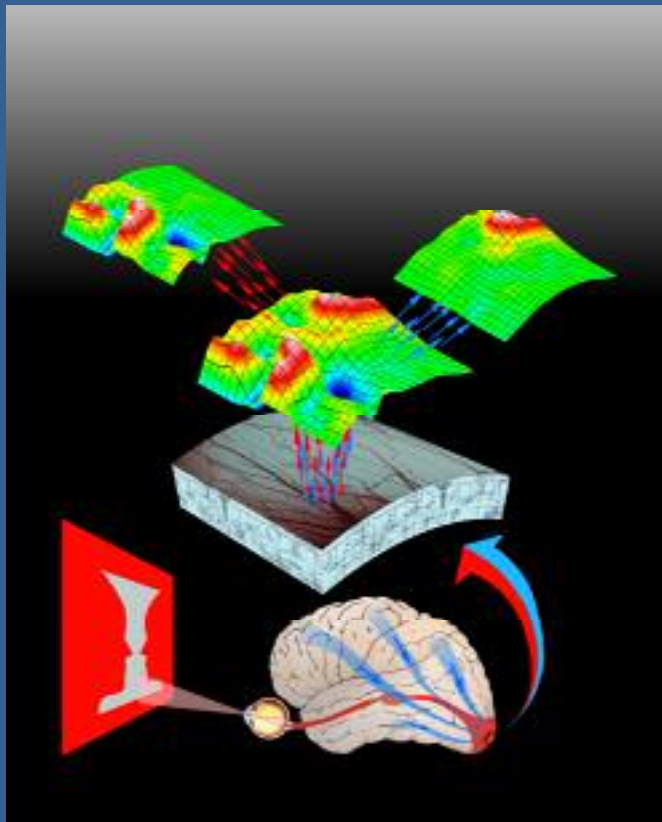- Bayesian models

- Spike-based computation
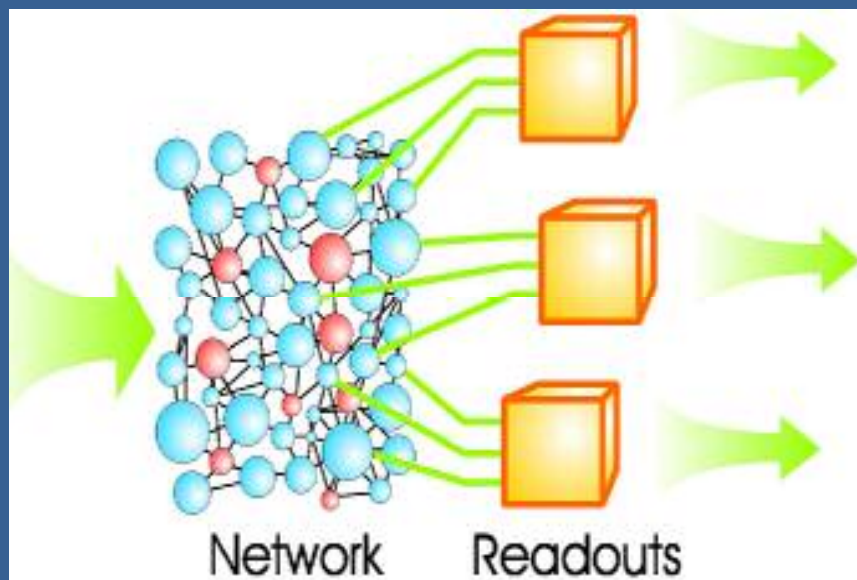
Objectives:

- Obtain and study new computational paradigms based on the properties of biological networks

- Determine how such paradigms can explain neural computations in sensory and motor systems

Cognitive models

Modeling high-level cognitive processes (decision making, perception-action, consciousness...)

Objectives:

- Understand low-level cognitive processes such as sensory perception

- Understand high-level cognitive processes such as language, decision making, ...

- Ultimately understand the mechanisms of consciousness

The European Institute for Theoretical Neuroscience (www.eitn.org)

- 200 m2 in central Paris (*Institut de la Vision*)
- 4 postdocs + 1 administrator + 2 co-directors
- Conference and workshop program
- Visitor program
- Strong participation of HBP members
- Permanent space offered by Neuro-Saclay in 2018

Objective:

To involve the theoretical neuroscience community in HBP and bring new theoretical ideas to the project

Key Participants

Neil Burgess (UCL)
Gustavo Deco (UPF, **WP leader**)
Markus Diesmann (Julich)
Alain Destexhe (CNRS, **SP Director**)
Gaute Einevoll (UMB)
Olivier Faugeras (INRIA)
Wulfram Gerstner (EPFL, **SP co-Director**)
Marc-Oliver Gewaltig (EPFL)
Wolfgang Maass (TU Graz, **WP leader**)
Benjamin Schrauwen (U Gent, **Task leader**)
Idan Segev (Hebrew U, **Task leader**)
Walter Senn (U Bern, **Task leader**)
Misha Tsodyks (Weizmann I, **Task leader**)

+ Paris Theoretical Neuroscience community
+ DeepMind Technologies (London)
+ Nicolas Brunel (U Chicago)