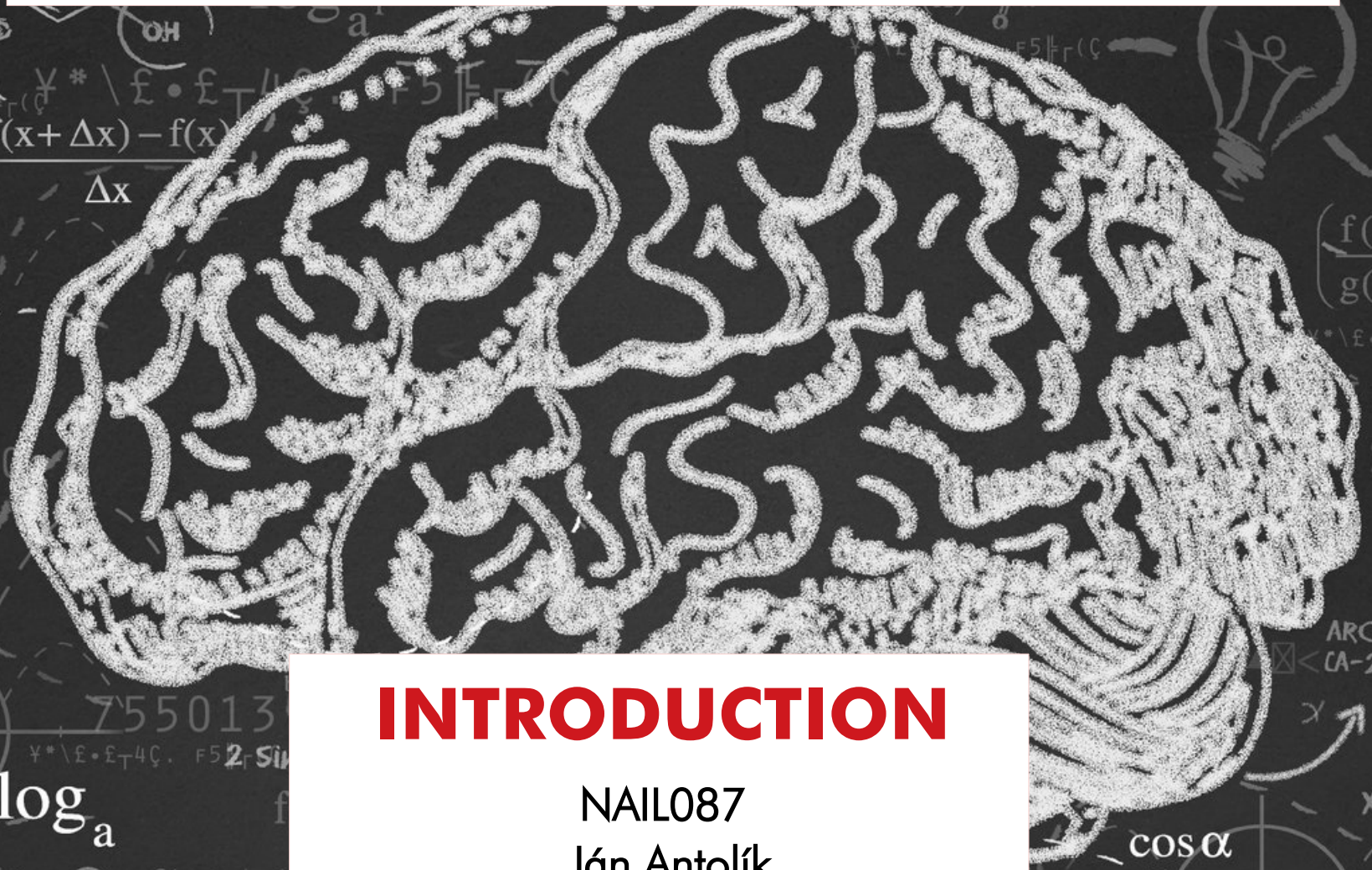
Informatics in Cognitive Science

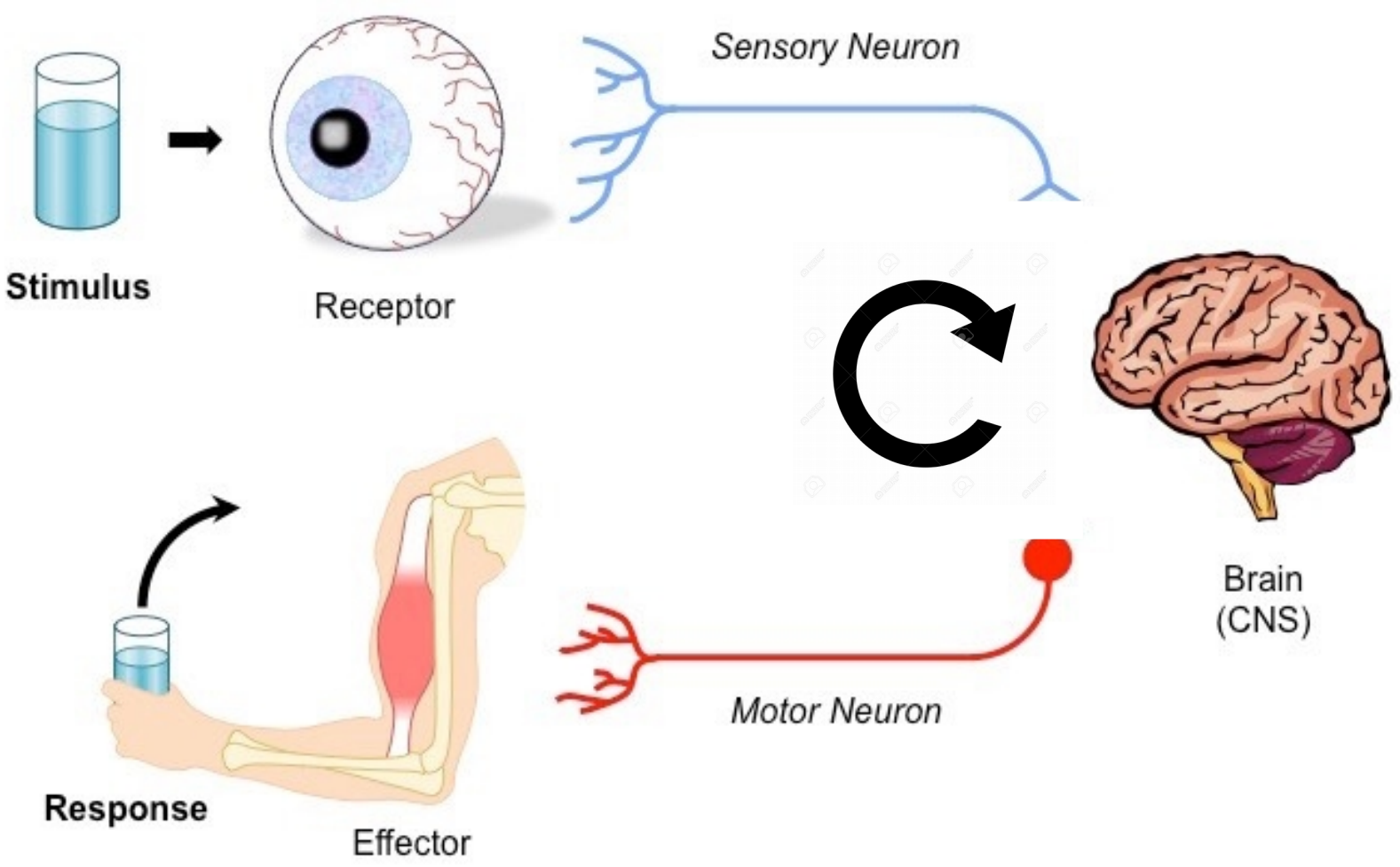


INTRODUCTION

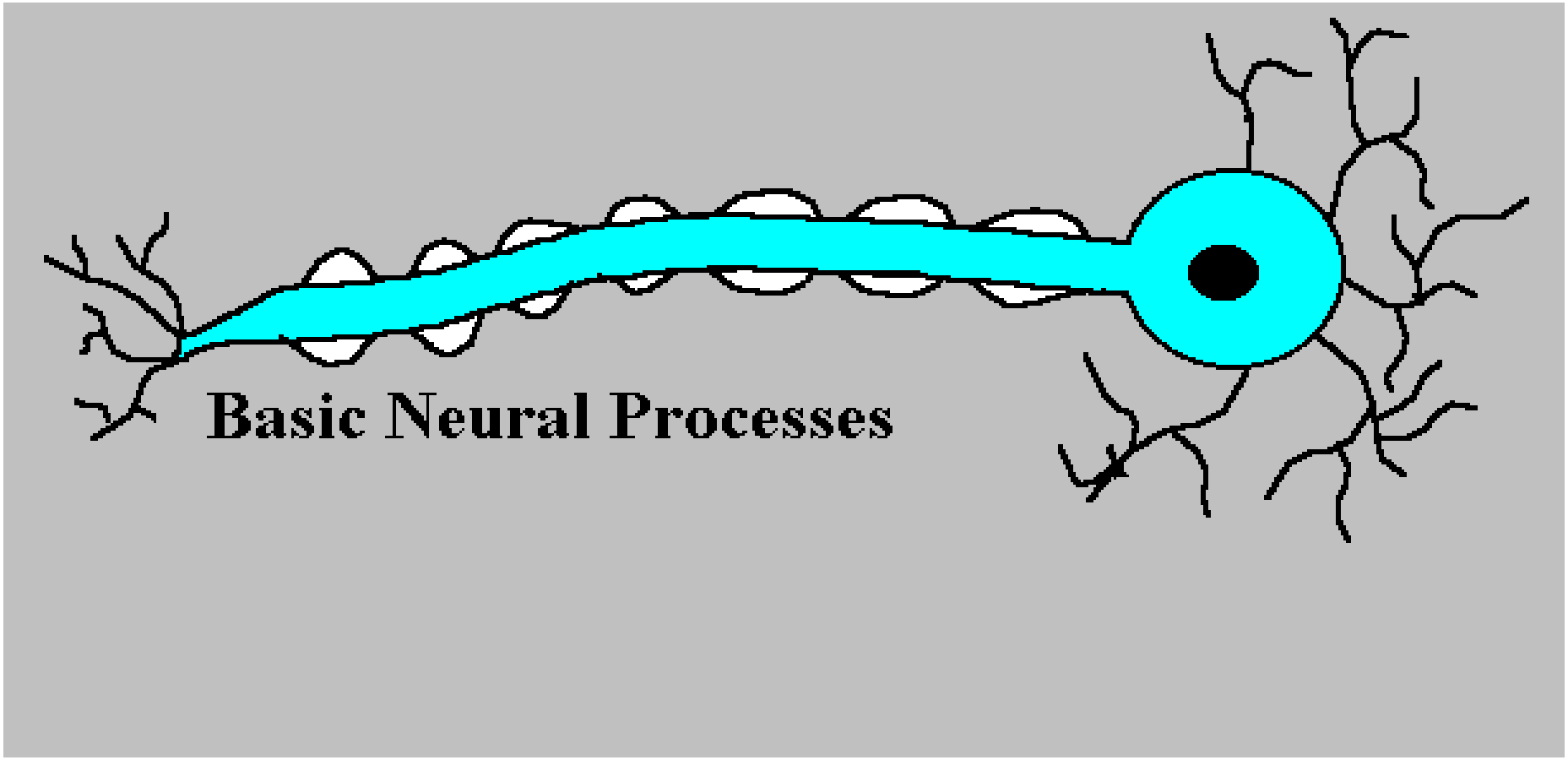
NAIL087

Ján Antolík
MFF UK, 2019

Brain as information processing machine



Neuron

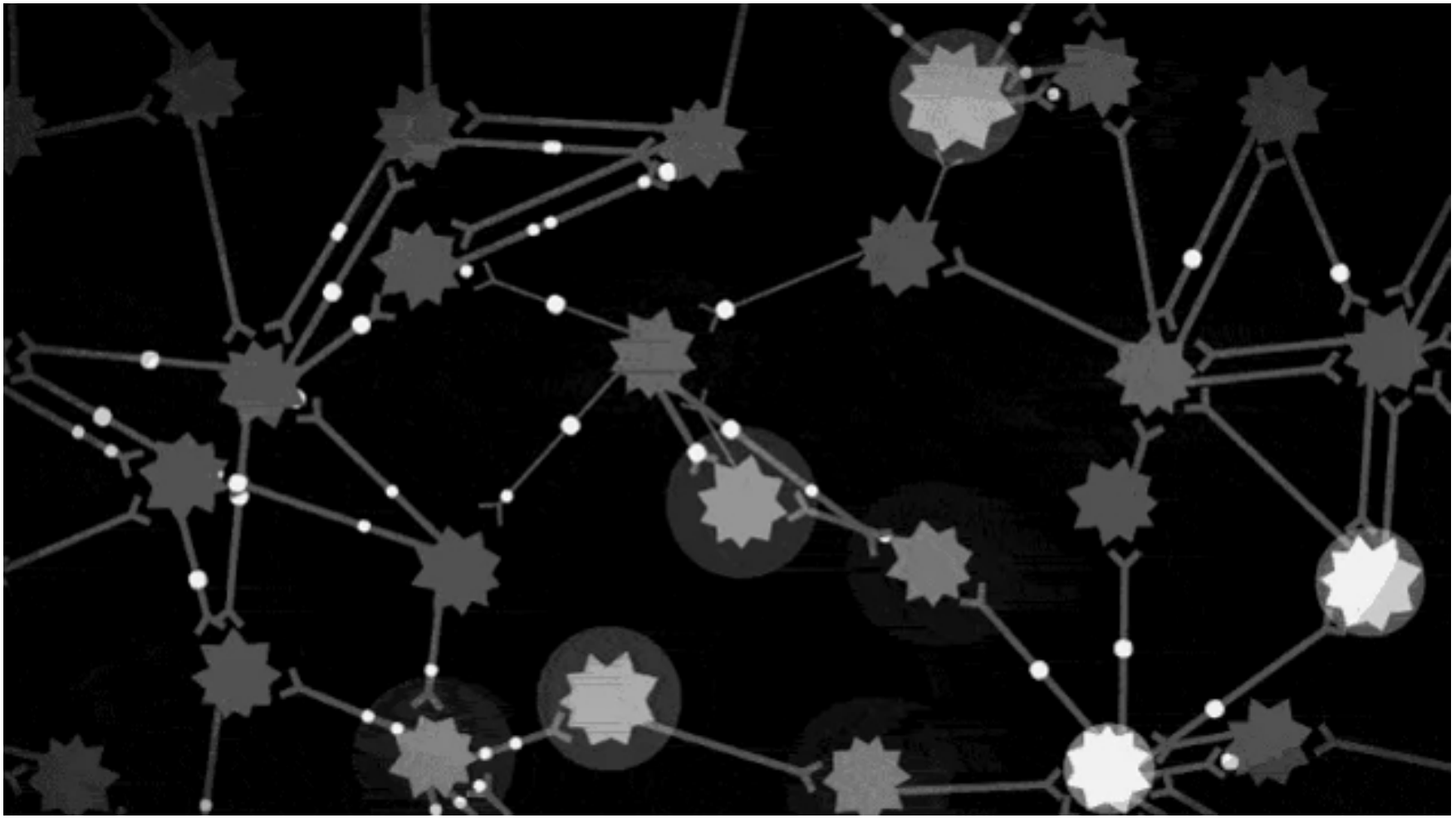


Neural substrate

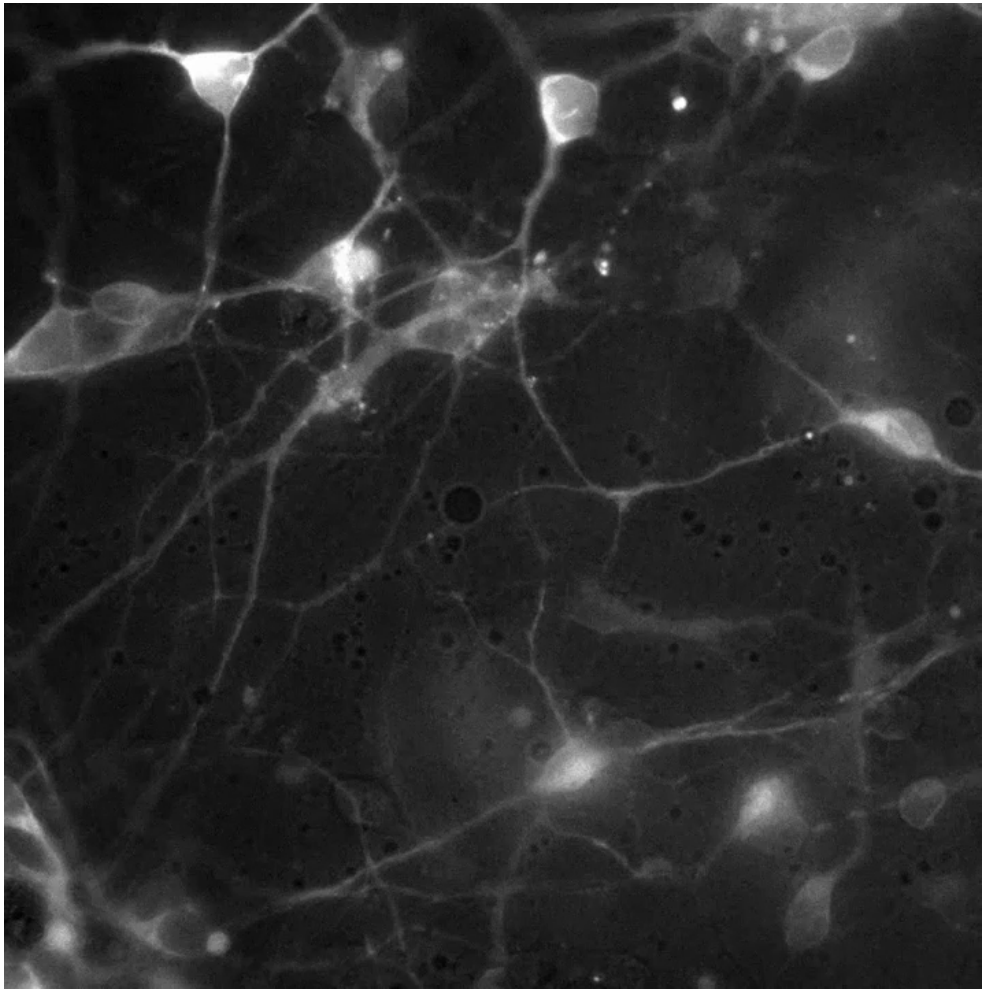
- Glogi's method of silver staining
- S.R. Cajal stainings of neurons
- 1 mm^3 contains 3km of wires

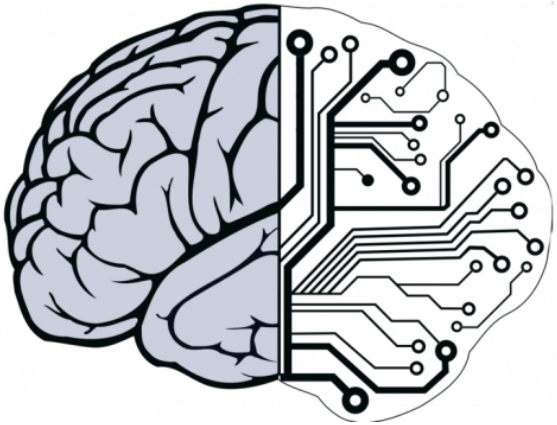
Santiago Ramón y Cajal

It’s all about connections



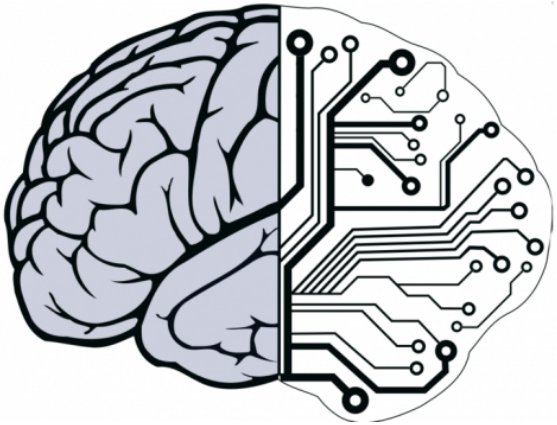
It’s all about connections



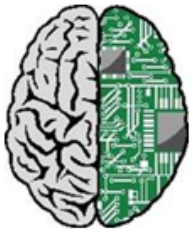


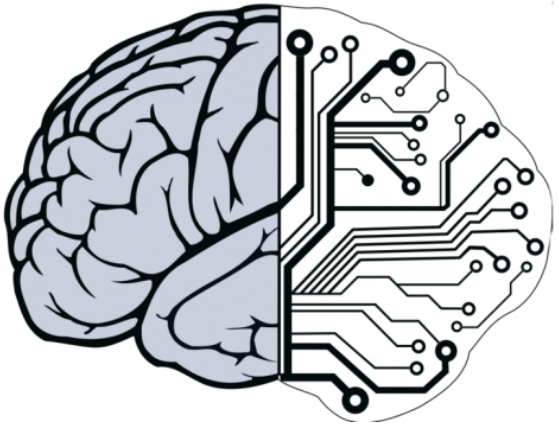
Computer vs. Brain (THE SPECS)

	BRAIN	COMPUTER
# elements	10^{10}-10^{12} neurons	10^{7}-10^{8} transistors
# connections/element	10^{3}-10^{4}	10
clocking	10^{3} Hz	10^{9} Hz
energy/operation	10^{-16}J	10^{-6}J
power consumption	10 Watt	100-500 Watt
reliability of elements	low	reasonable
reliability of system	high	reasonable
memory vs. cpu	multiplexed	separate
processing architecture	parallel	serial



Computer vs. Brain (CAPABILITY)

	Computing wins	• Input and output • Information processing and memory
	Closely matched	• Complex movement • Vision • Language • Structured problem solving
	Brain still wins	• Creativity • Emotion and Empathy • Planning and Executive Function • Consciousness



Computer vs. Brain (CAPABILITY)

Computing wins

- Input and outp
- Infor

Structured problem solving

Brain still wins

- Creativity
- Emotion and Empathy
- Planning and Executive Function
- Consciousness

GENERALIZATION

LEARNING FROM FEW EXAMPLES

Why to follow this course?

- **Learn critical thinking about neuroscience**
- Gain inspiration for artificial intelligence systems or artificial agents
- Learn about applications in industry
  - Neuro-prosthetics
  - Neuro-morphic engineering
  - Medical imaging
  - Cognitive Mechanisms in DNNs
  - Brain-computer interface
  - …

Most read on Blesk.cz

Disgusting Parents from Wife Exchange: Cruelly Abused Ondra Finished at the Institution!

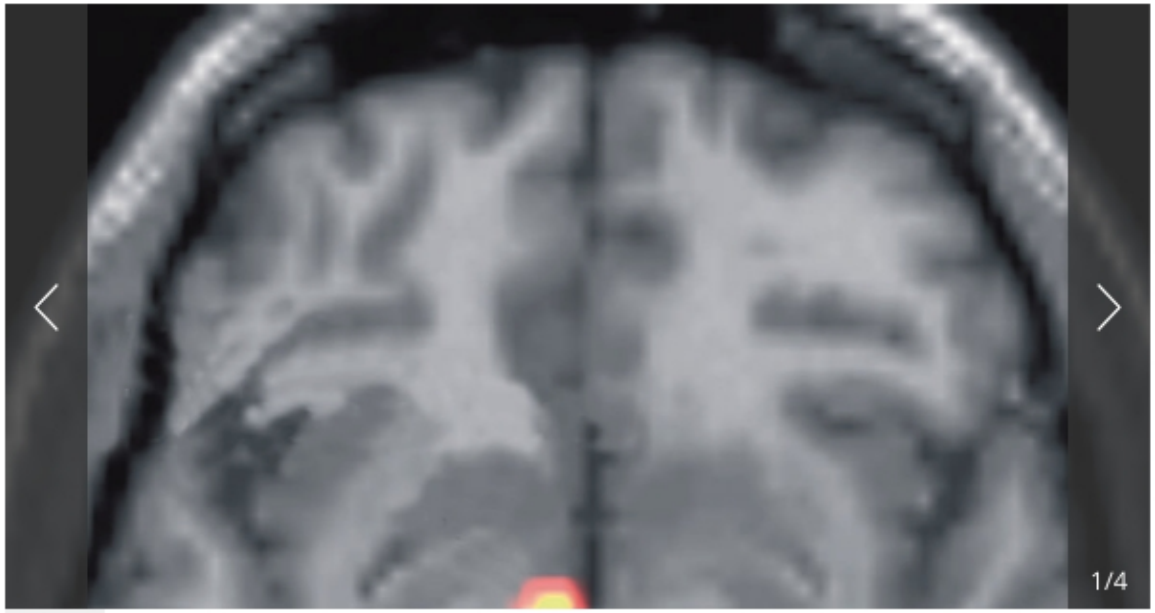
What is Korn's father? Ex-wife Kateřina Kornová told the truth!

Funeral of General James, killed by Mustang: Weather has ruined military honors!

Vondráčková's first words after divorce from Plekance: She admitted a health problem!

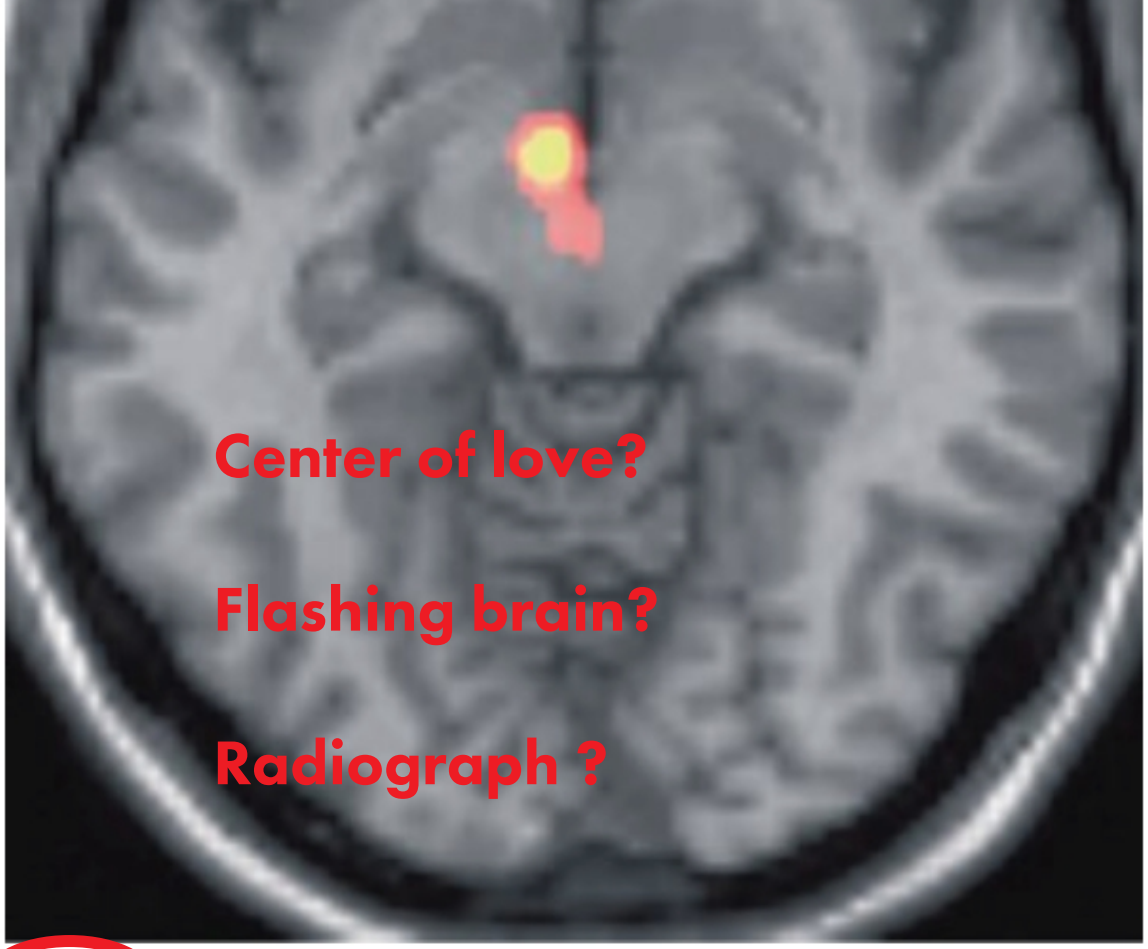
Aleš Cibulka with partner Jagelka: Collapsing household and labor disputes!

Scientists have discovered a center of love in the brain



Thomas Cook's Expert: Wrong decisions and missing hearts

"Czechs are a great nation." Babiš at the UN also mentioned the wasted time after 1989



Radiograph of the brain, where it is shown where nacházícentrum Love | Keystone, AP

Love

That you feel your love in your heart? Error! Scientists examined the brain activity of individuals who claimed to be in love at the moment. When the photographers and their counterpart showed them, an area in their brain flashed, which they marked not very romantic - the ventral tegmental area, or center of love. Here and there an element, a little acid, not to stir, shake and love is born.

Why to follow this course?

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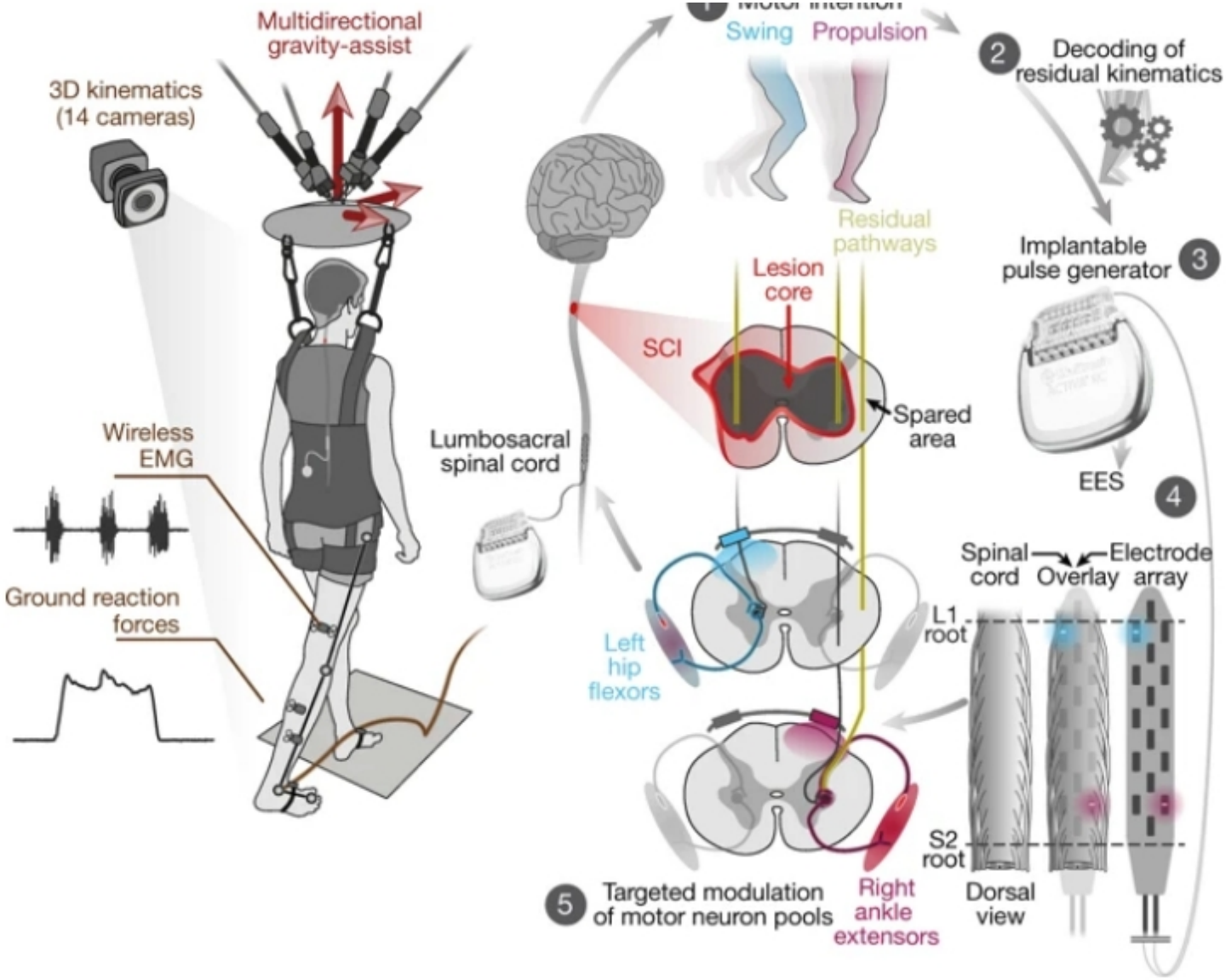
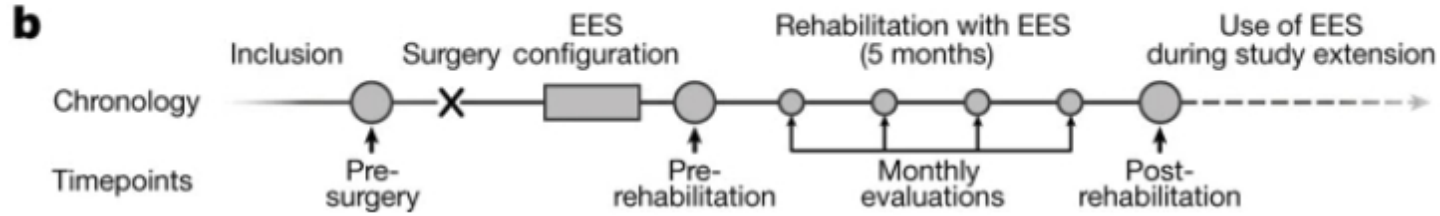

Multidirectional gravity-assist
3D kinematics (14 cameras)
Wireless EMG
Ground reaction forces
Swing
Propulsion
2
Decoding of residual kinematics
Residual pathways
Lesion core
SCI
Spared area
Lumbosacral spinal cord
Implantable pulse generator
3
EES
4
Spinal cord
Overlay
Electrode array
L1 root
S2 root
Dorsal view
Left hip flexors
Right ankle extensors
5
Targeted modulation of motor neuron pools


b
Inclusion
Surgery
EES configuration
Rehabilitation with EES (5 months)
Use of EES during study extension
Chronology
Timepoints
Pre-surgery
Pre-rehabilitation
Monthly evaluations
Post-rehabilitation

Locomation restoration via neural prosthetics.

Why to follow this course?

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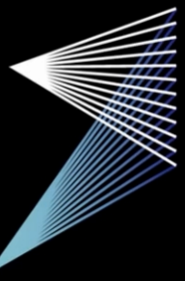
  - **Neuro-morphic engineering**
  - Medical imaging
  - Cognitive Mechanisms in DNNs
  - Brain-computer interface
  - …

Event-based Vision for Autonomous High-Speed Robotics

Robotics and Perception Group

University of Zurich[UZH]

Department of Informatics



ROBOTICS & PERCEPTION GROUP

rpg.ifi.uzh.ch

Why to follow this course?

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  - Neuro-prosthetics
  - Neuro-morphic engineering
  - **Medical imaging**
  - Cognitive Mechanisms in DNNs
  - Brain-computer interface
  - …
-

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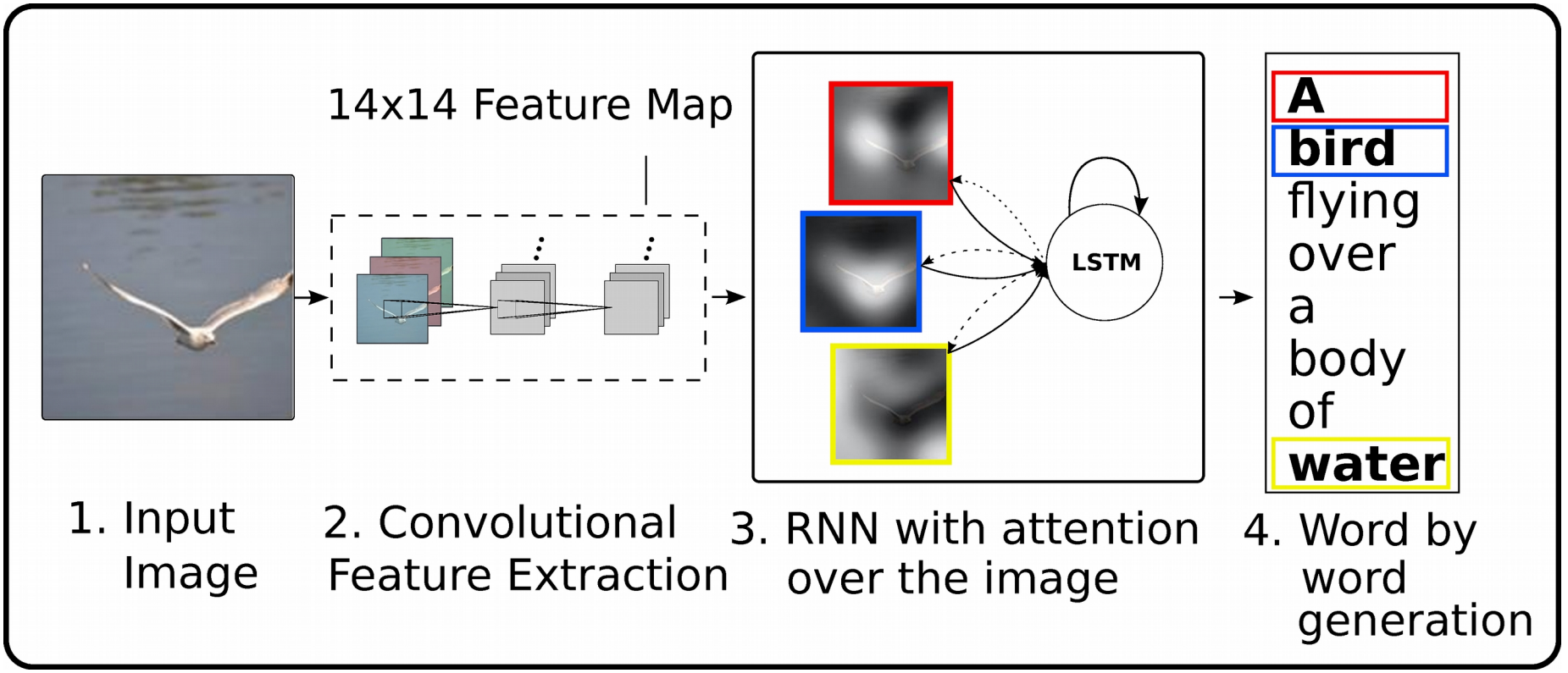
  - Neuro-prosthetics
  - Neuro-morphic engineering
  - Medical imaging
  - **Cognitive mechanisms in DNNs**
  - Brain-computer interface
  - …

Attention in DNNs



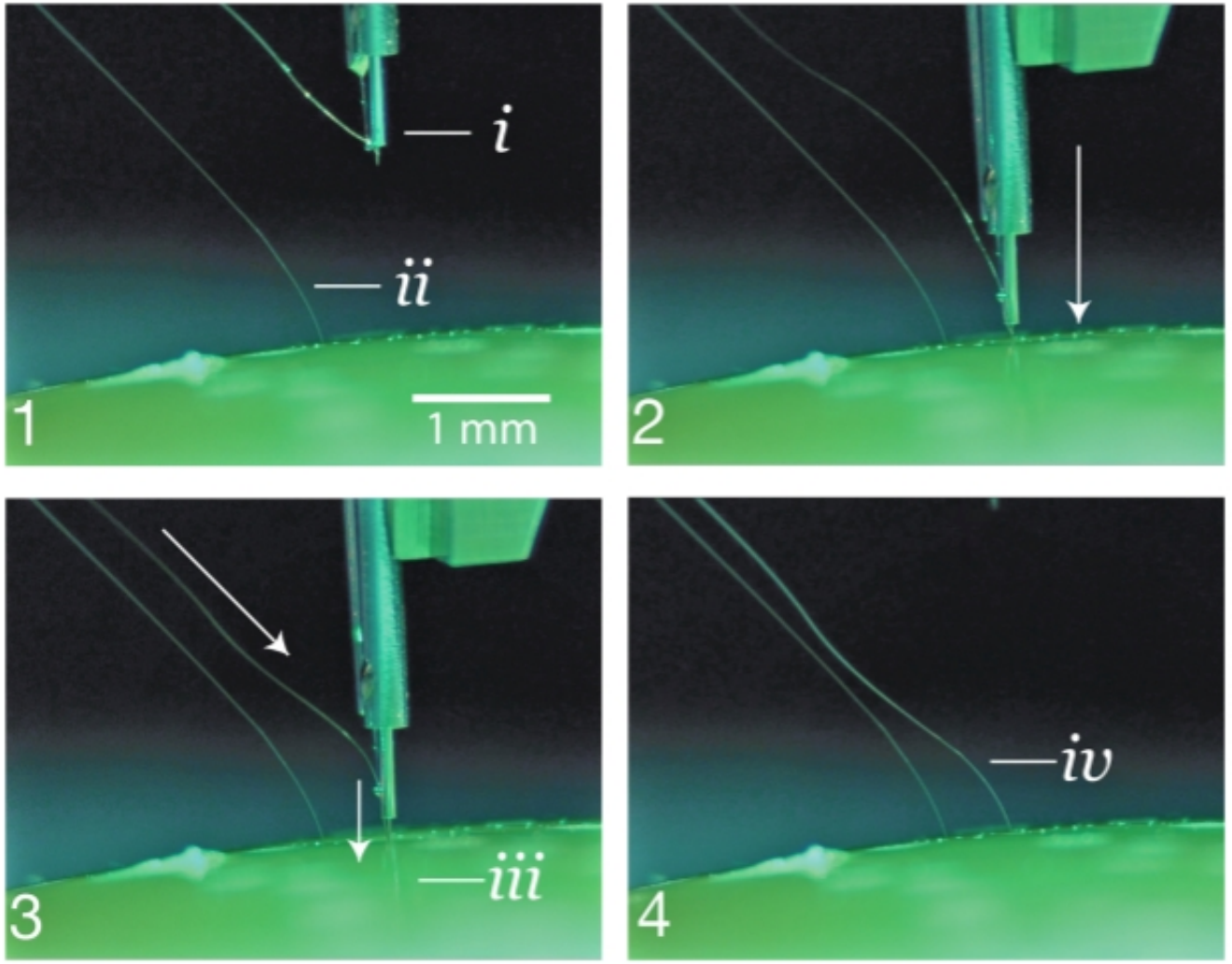
(Show et al. 2015)

Why to follow this course?

- Learn critical thinking about neuroscience
- Gain inspiration for artificial intelligence systems or artificial agents
- Applications of neuroscience in industry
  - Neuro-prosthetics
  - Neuro-morphic engineering
  - Medical imaging
  - Design of deep neural networks
  - **Brain–computer interface**
  - …

Nueralink (Elon Musk)

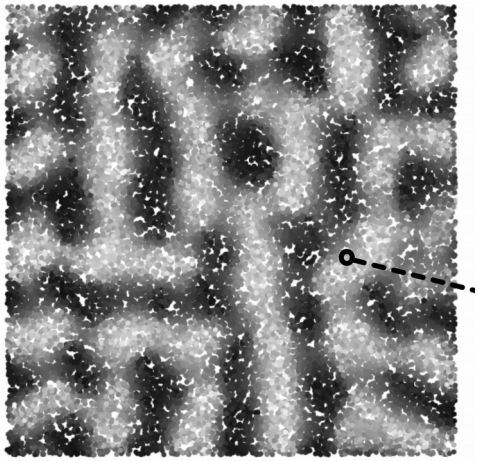
Nueralink (Elon Musk)



WHO

- **Ján Antolík**
- Jirka Lukavský
- Filip Dechterenko
- Matej Hoffman

Computational neuroscience
Visual system modelling
Sensory development modelling
Machine learning in neuroscience



http://antolik.net

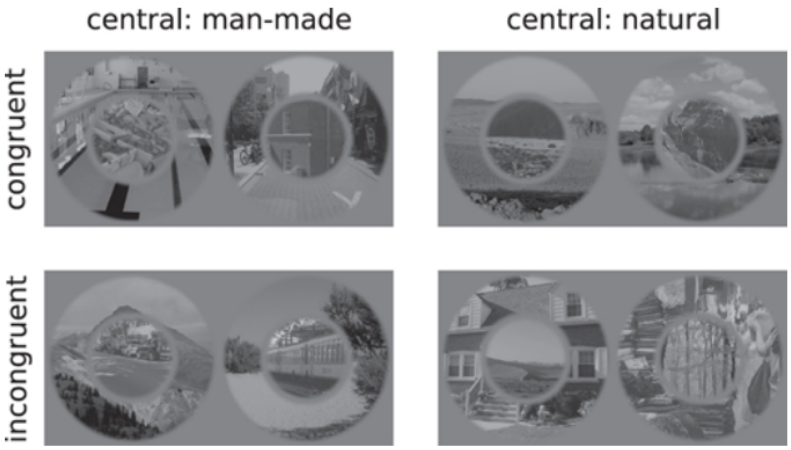
WHO

- Ján Antolík
- **Jirka Lukavský**
- Filip Dechterenko
- Matej Hoffman

http://www.lukavsky.info

Czech Academy of Sciences

Visual perception, attention, memory
Eye movement tracking
Psychophysics
Perception and action



WHO

- Ján Antolík
- Jirka Lukavský
- **Filip Dechterenko**
- Matej Hoffman

Czech Academy of Sciences

Vision science
Experimental psychology
Cognitive science
Eye movement tracking

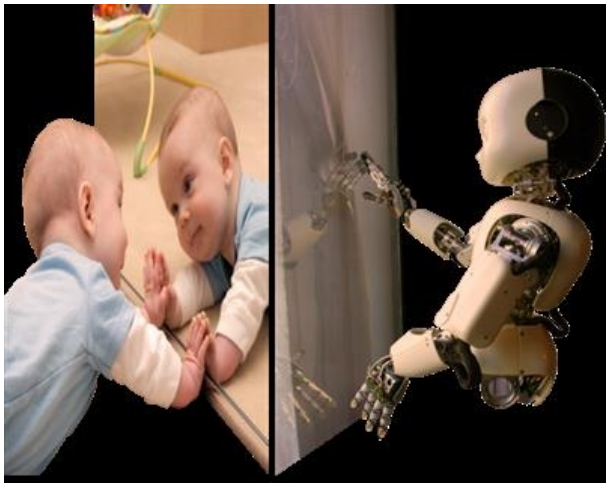
http://www.ms.mff.cuni.cz/~dechf7am/

WHO

- Ján Antolík
- Jirka Lukavský
- Filip Dechterenko
- **Matej Hoffman**

Robotics
Body representations
Embodiment and morphological computation
Minimally cognitive robotics

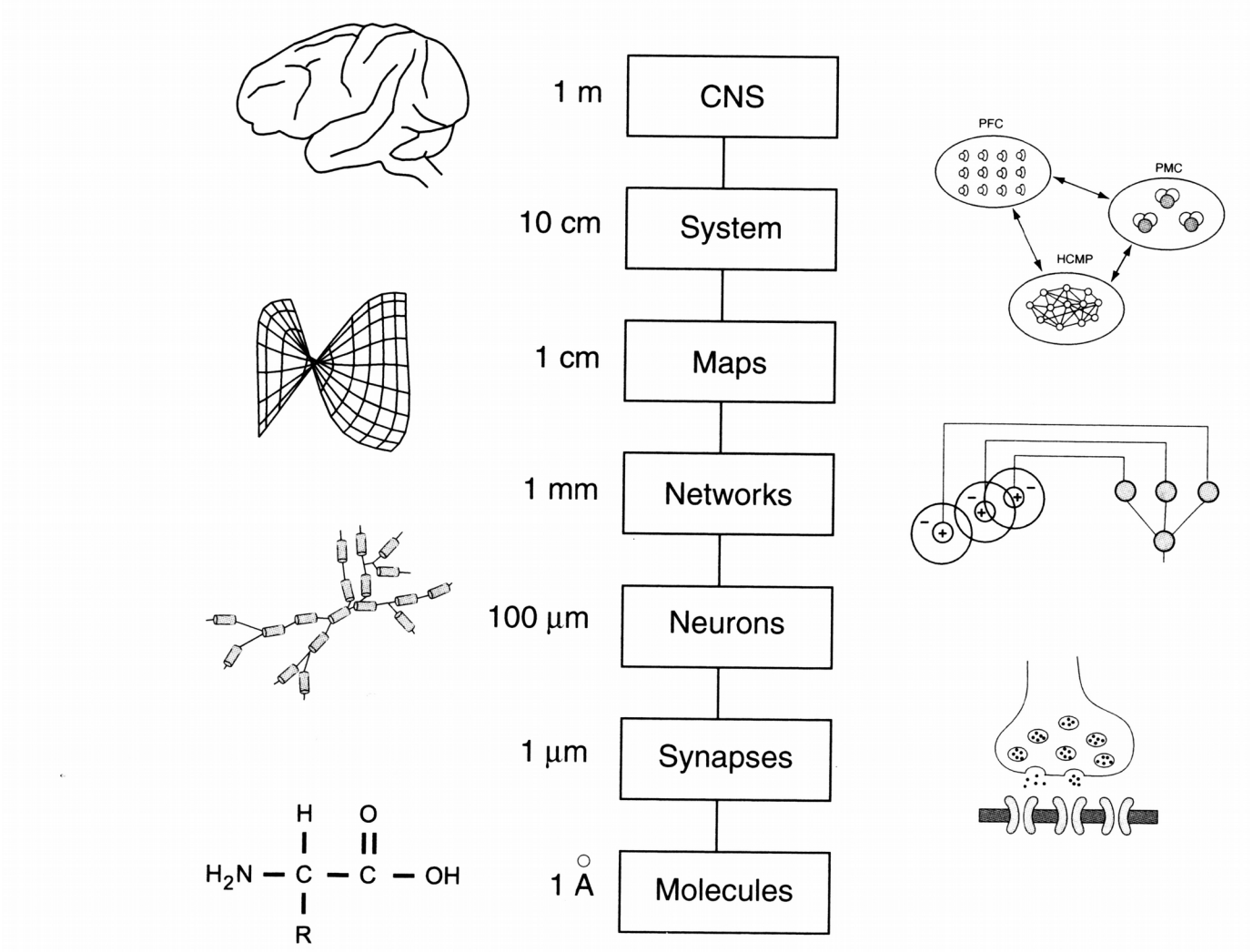
https://sites.google.com/site/matejhof/home



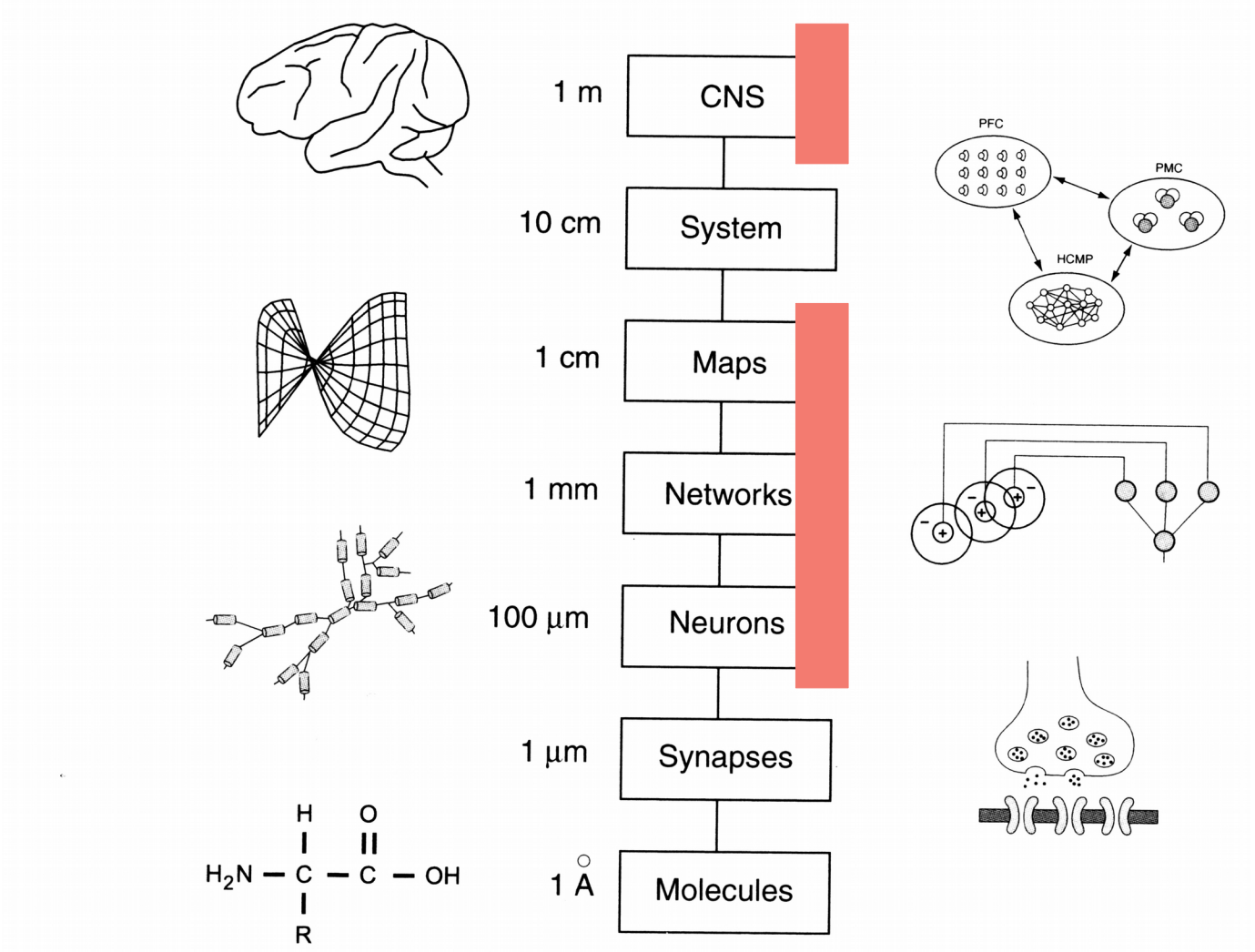
Multiple scales in:

Substrate
Models
Measurments

Brain as a multi–scale system



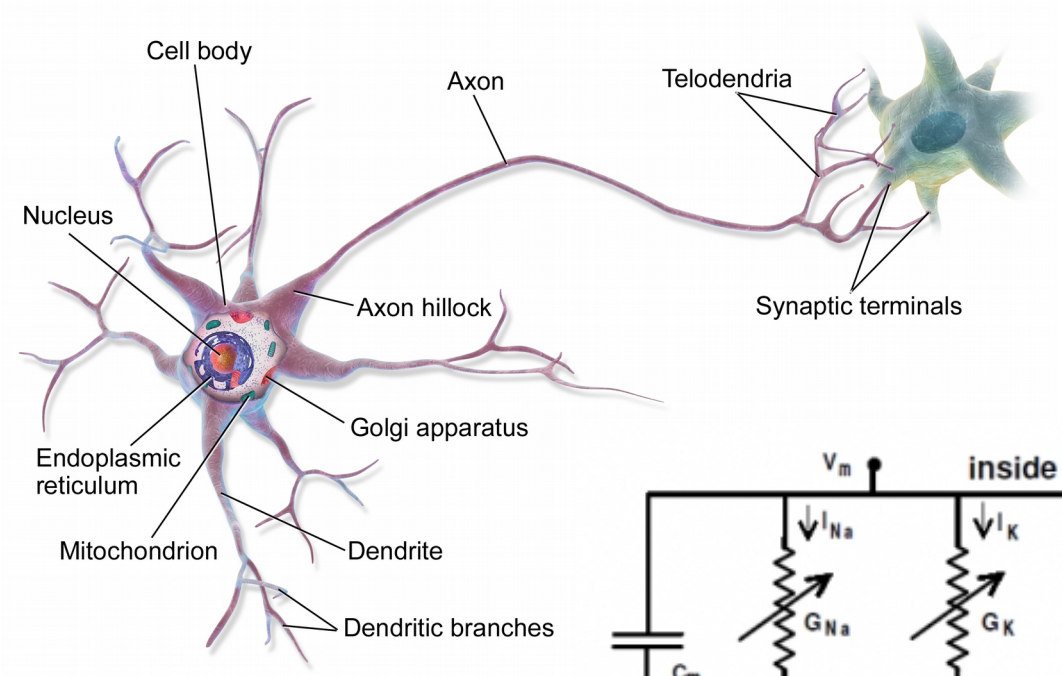
Brain as a multi–scale system

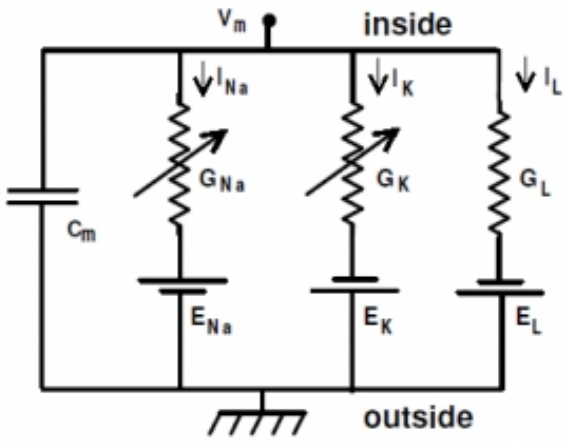


What kind of models?

- **Descriptive**
- Mechanistic
- Functional

…





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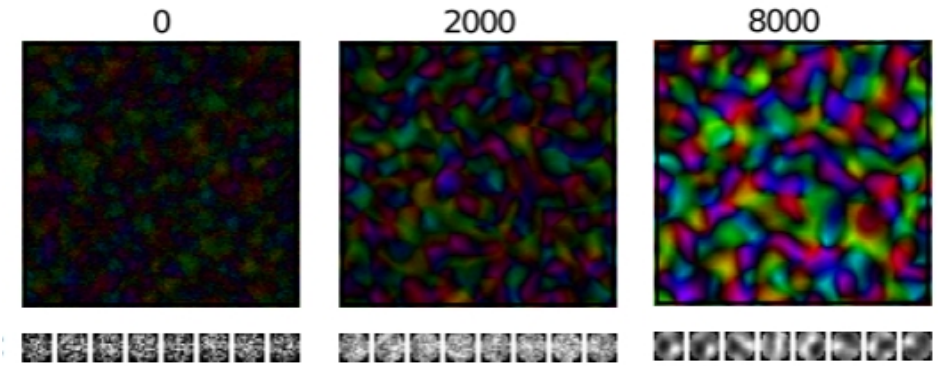
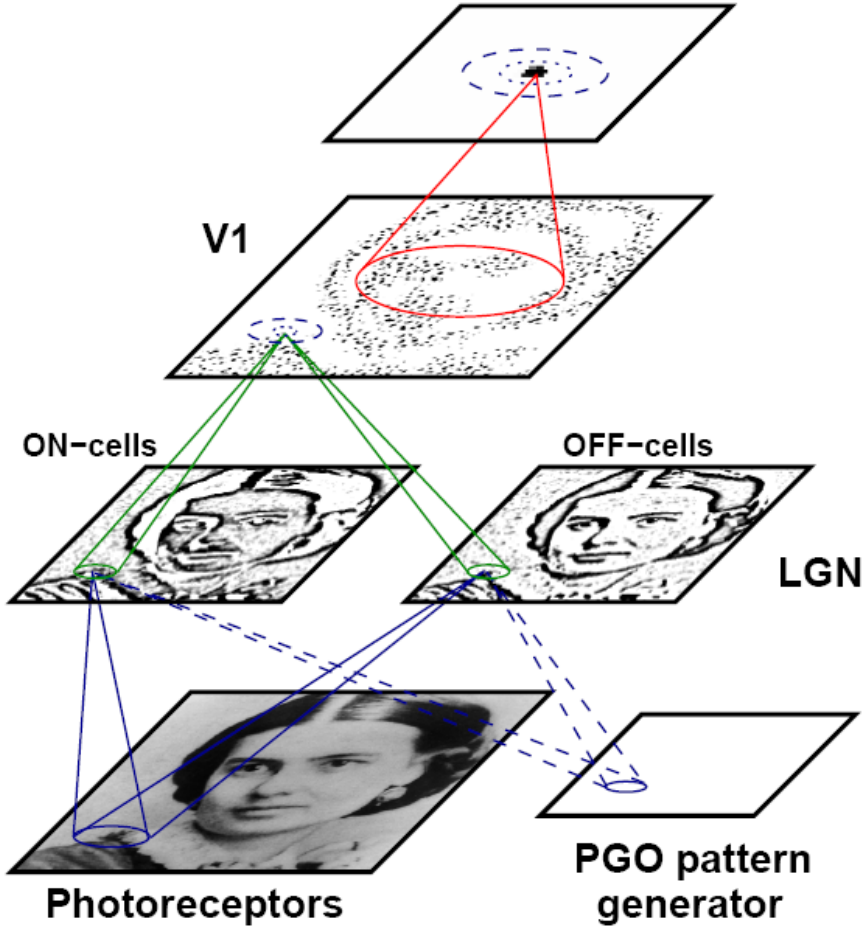
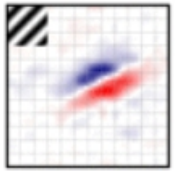


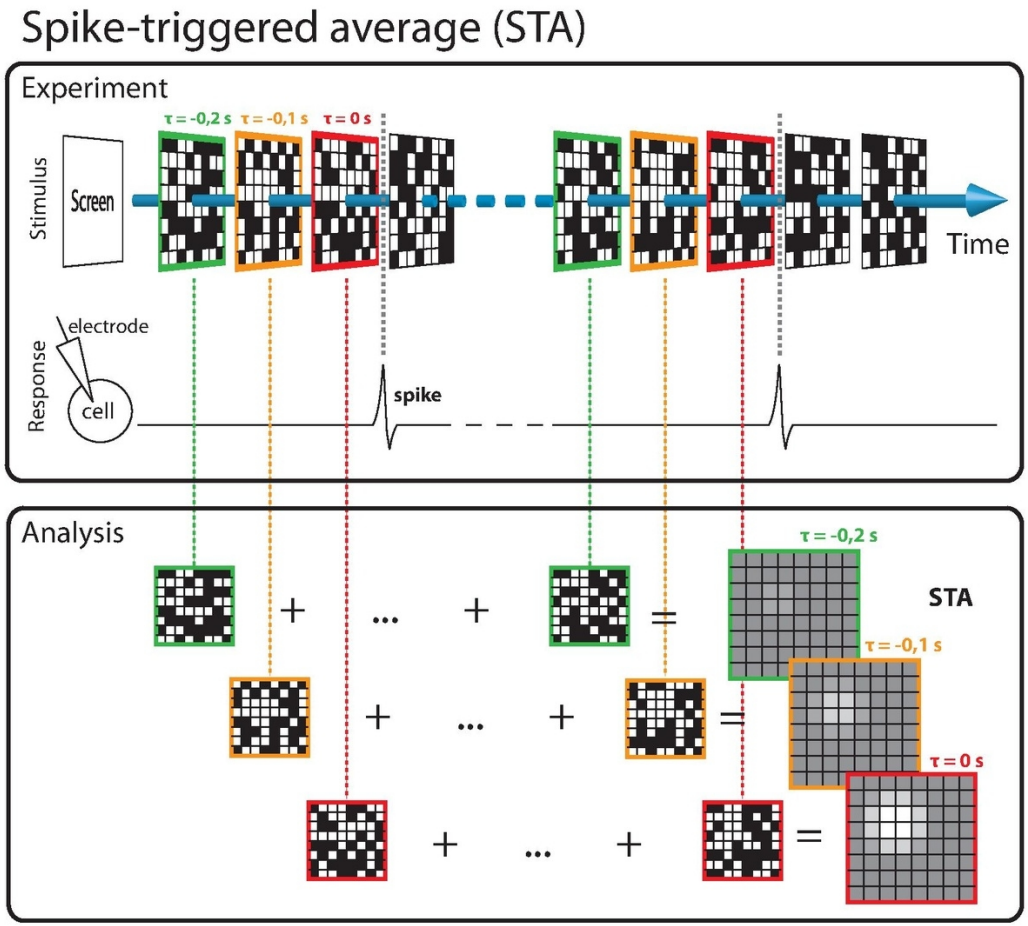


What kind of models?

- Descriptive
- Mechanistic
- **Functional**
- Normative

…





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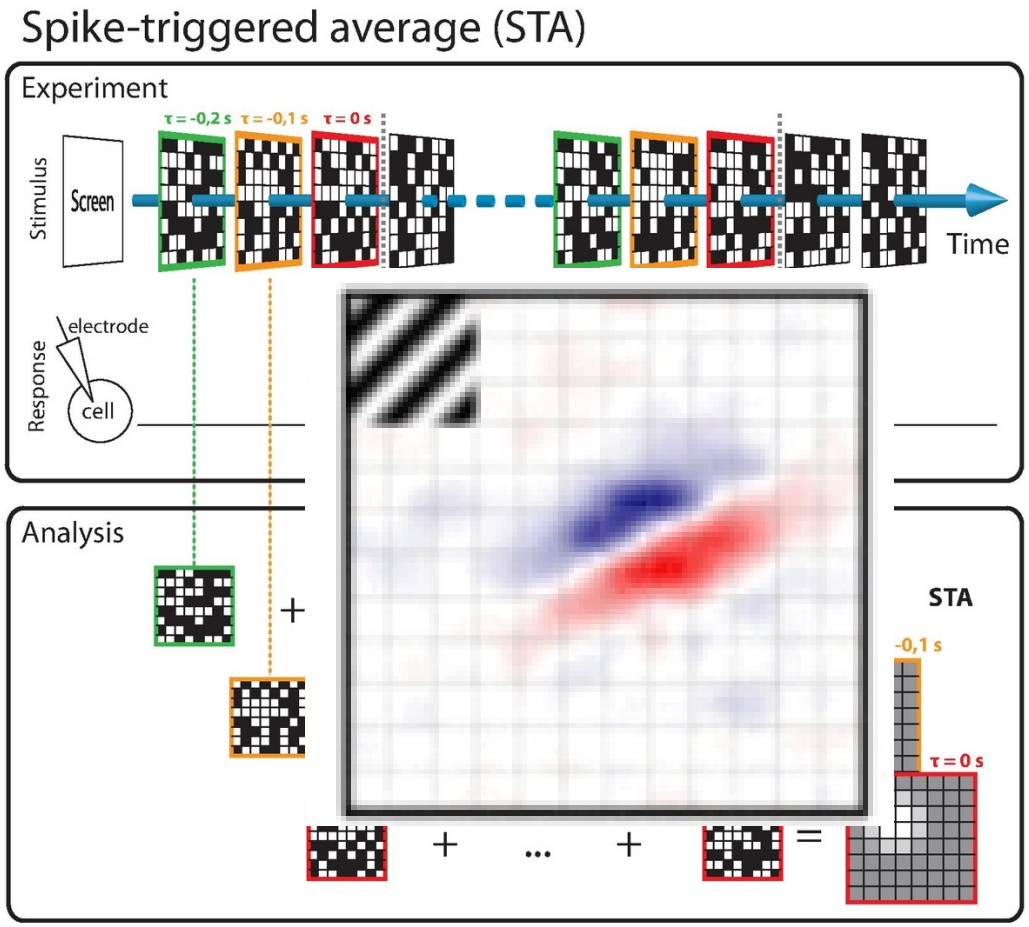

What kind of models?

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- Mechanistic
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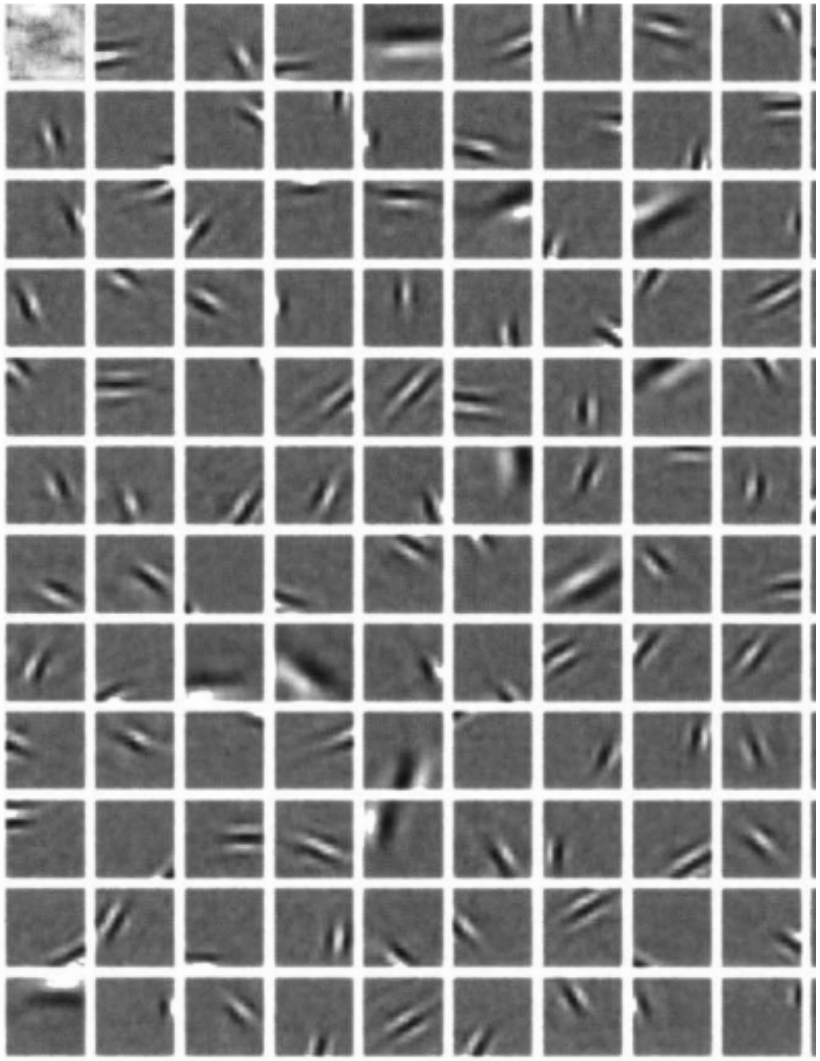
- **Normative**

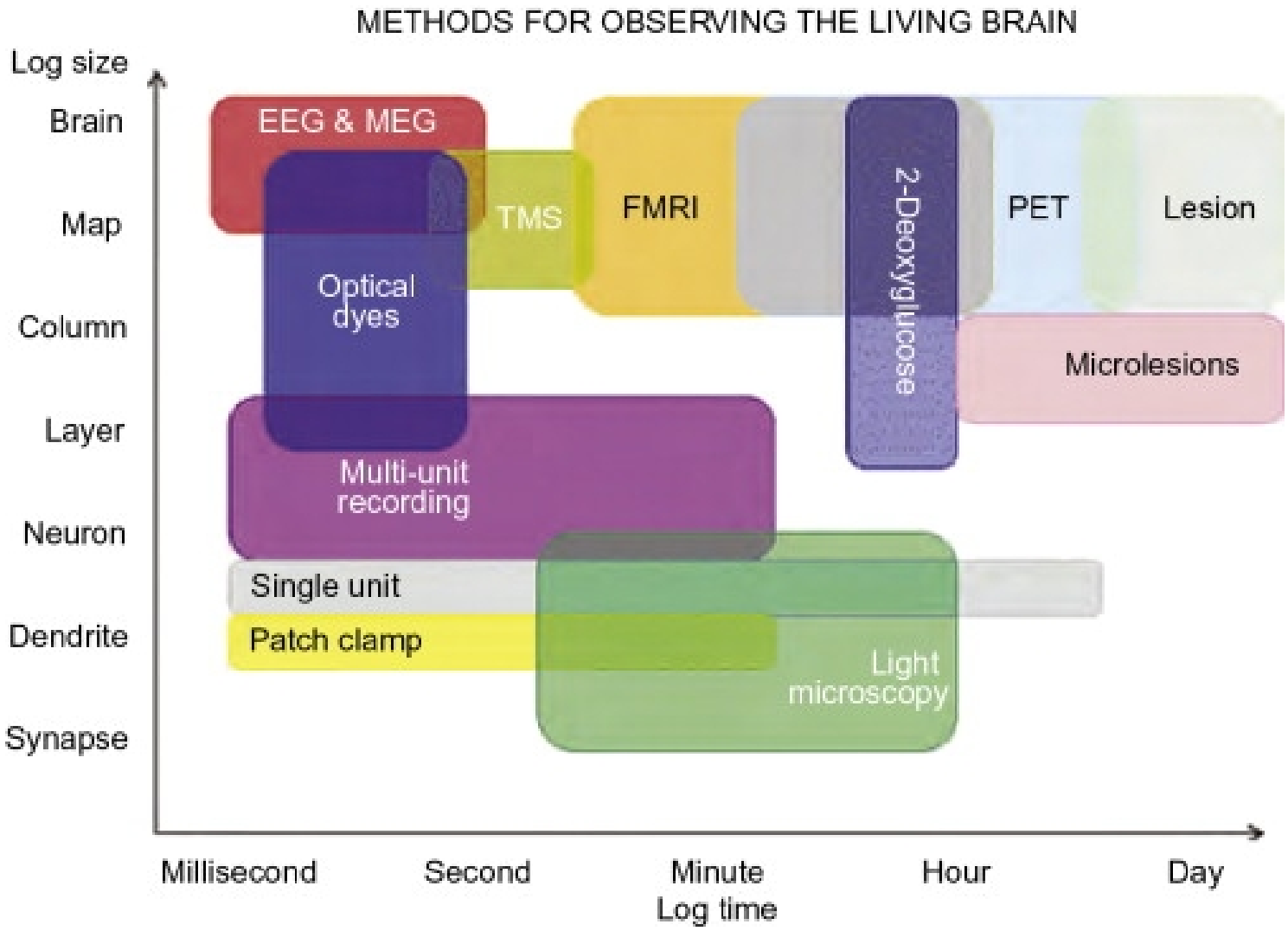
…

$$[\text{preserve information}] = -\sum_{xy}\left[I(x,y) - \sum_i a_i \phi_i(x,y)\right]^2$$

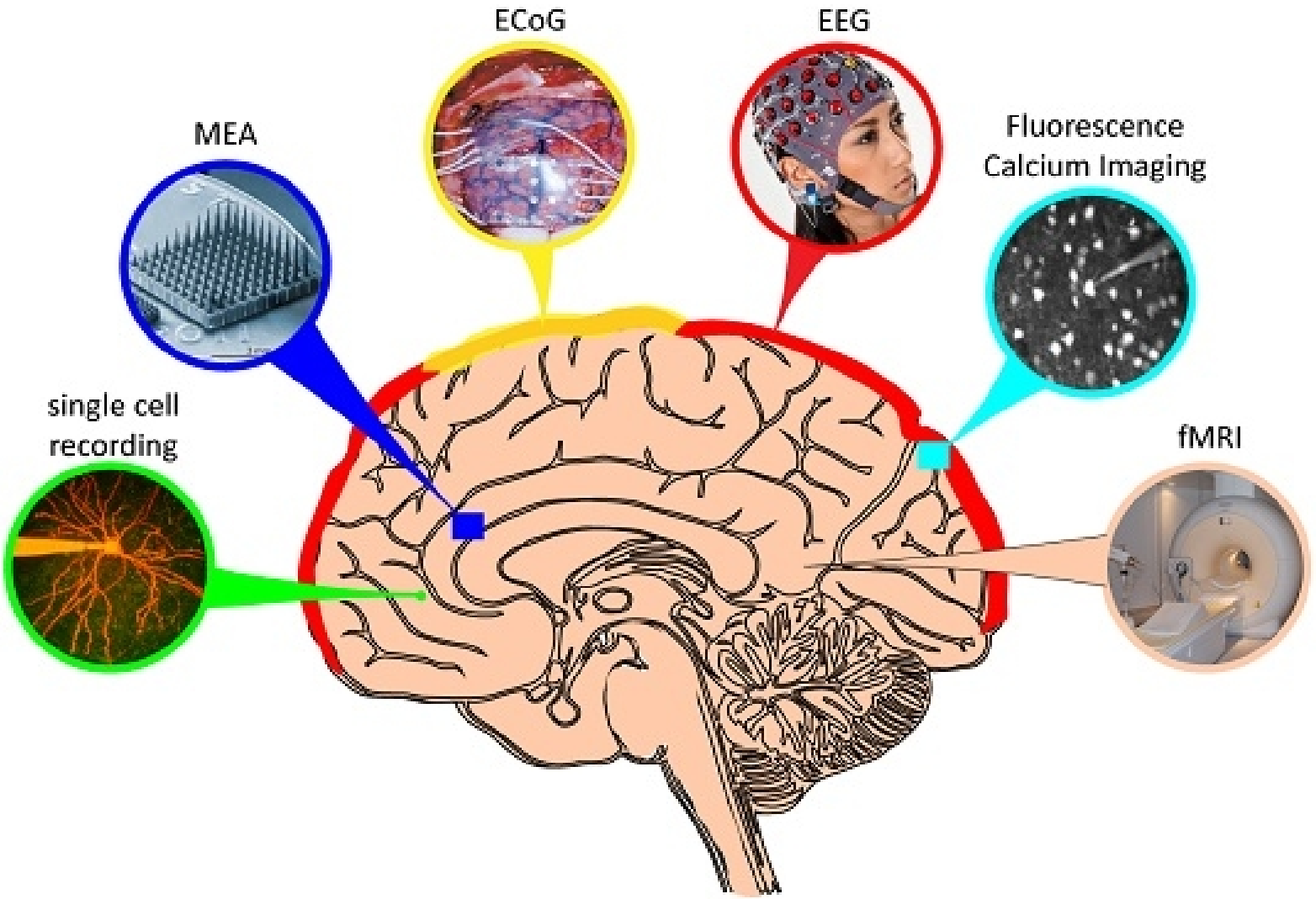
$$[\text{sparseness of } a_i] = -\sum_i S\left(\frac{a_i}{\sigma}\right)$$



Measuring brain



Measuring brain



Lecture Outline

- 2.10. Ján Antolík – Introduction
- 9.10. Ján Antolík - Neurons I
- 16.10. Ján Antolík - Neurons II
- 23:10. Jiři Lukavský - Cognitive psychology I
- 30.10. Ján Antolík - Cortical architecture
- 6.11. Jan Antolik - Introduction to Visual Systems
- 13.11. Ján Antolík - TEST , Filip Dechterenko - Seminar I
- 20.11. Jiři Lukavský - Cognitive psychology II
- 27.11. Jiři Lukavský - Cognitive psychology III
- 4.12. Jiři Lukavský - Cognitive psychology IV
- 11.12. Matej Hoffman - Motor system
- 18.12., Filip Dechterenko - Seminar II
- 8.1. Filip Dechterenko - Seminar III

Requirements

- Test
  - Compulsory readings from Bear book
    - Neuroscience: Exploring the Brain, 3rd Edition (Mark F. Bear, Barry W. Connors, Michael A. Paradiso)
    - If not successful oral exam
- Excercise sessions
    - Participation in experiment
    - Own mini-experiment (deliver a short report)
    - An excercsie with neural model

More info on my website

http://antolik.net

Password: IKV