

Deep Learning

14. Brain and biological vision.

Viacheslav Dudar

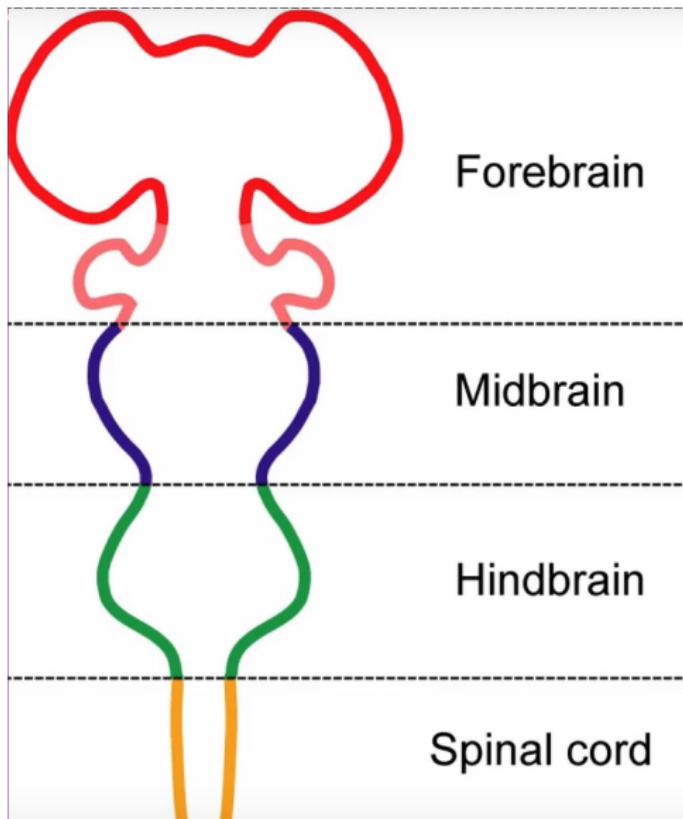
Taras Shevchenko National University of Kyiv

2018

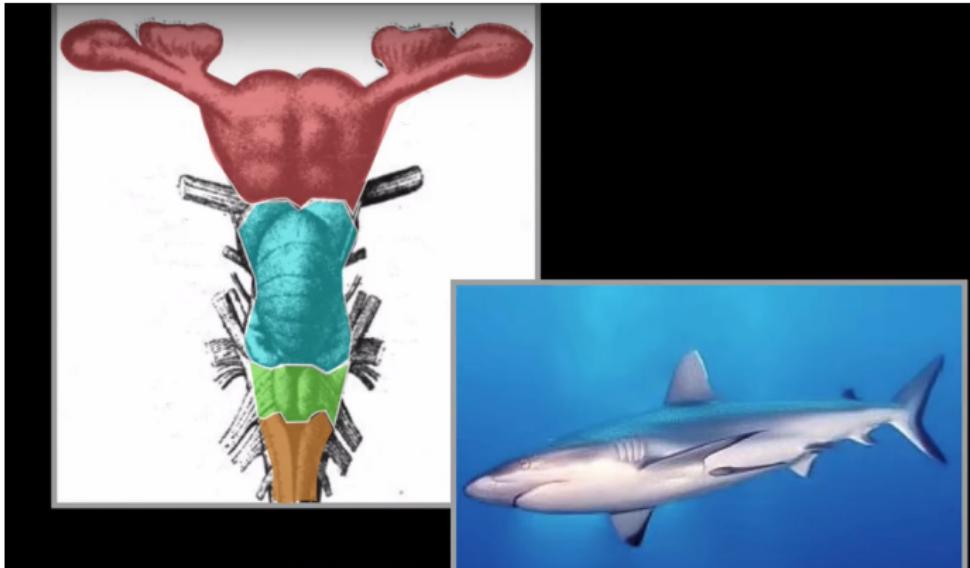
Ways to build smart algorithms

- Bottom-up: simulate networks of artificial neurons that are similar to the neurons in the human brain. They then investigate what aspects of cognition can be recreated in these artificial networks.
- Top-down: intelligence is treated as a high-level phenomenon that is independent of the low-level details of the implementing mechanism.

Parts of the brain

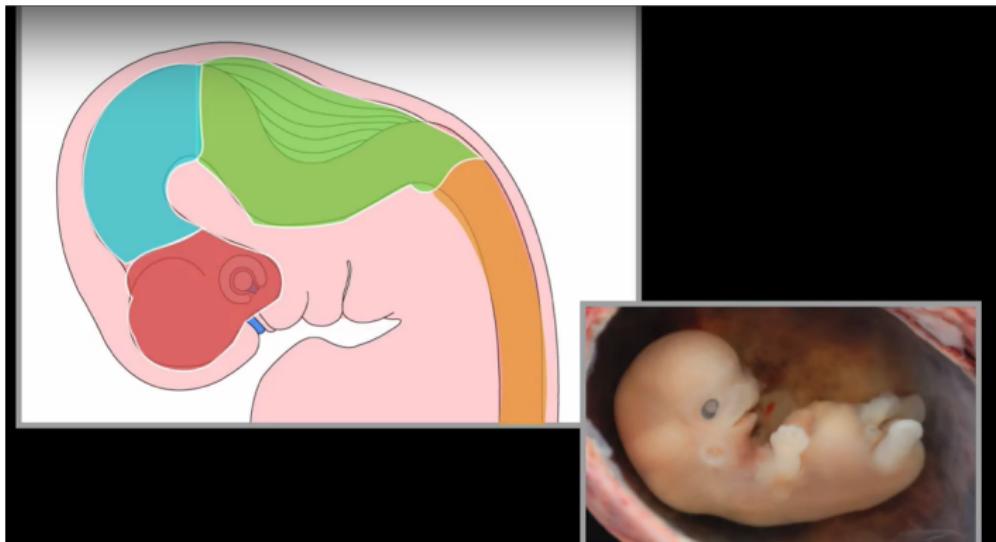


Animal brain



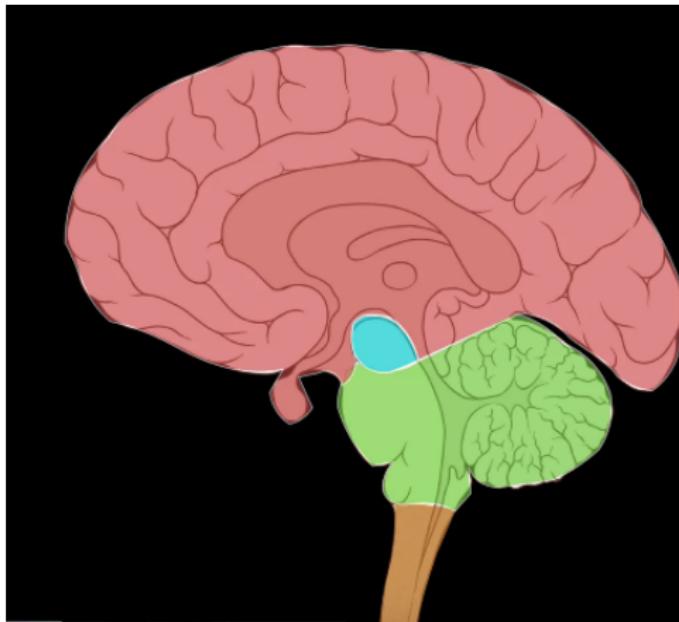
Has the same parts as human brain.

Baby brain



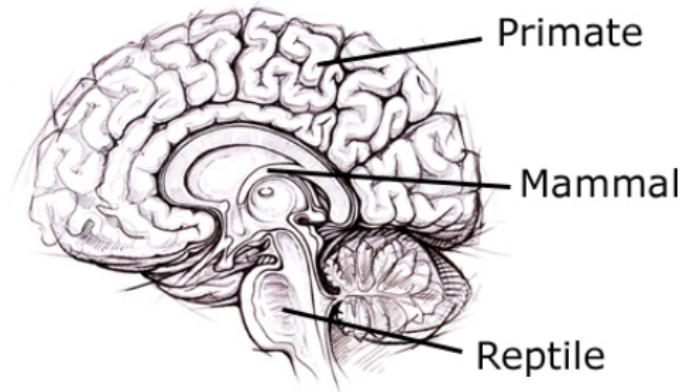
Very similar to animal brain.

Adult brain



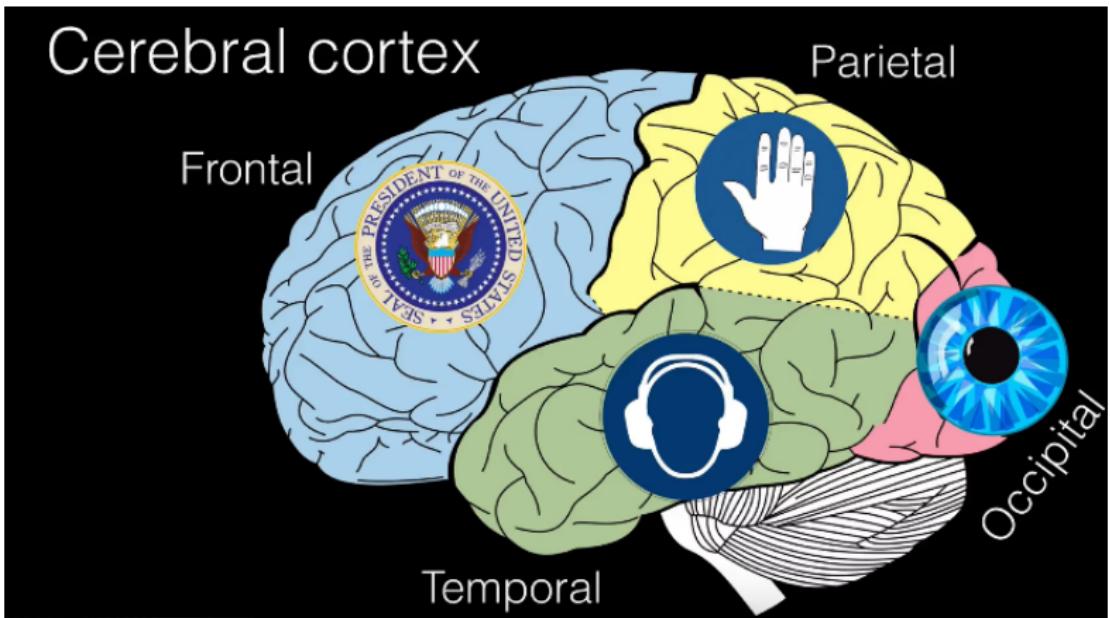
Human forebrain develops during life.

Hierarchical brain



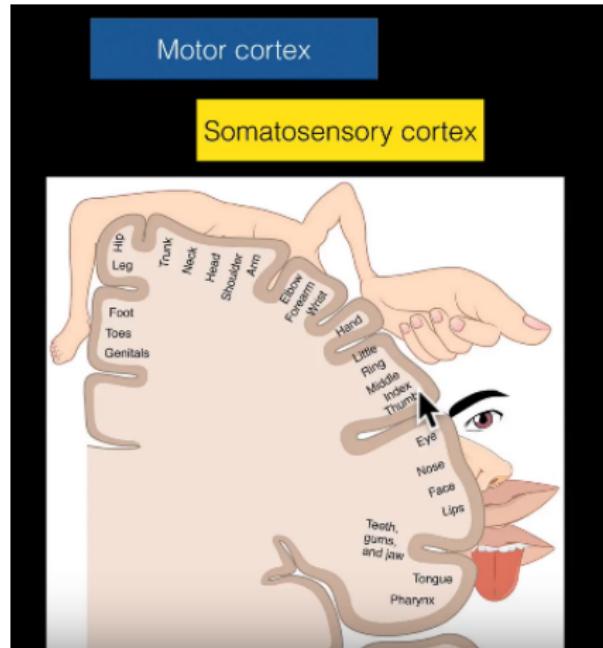
New brain levels appear on top of previous during evolution.

Cerebral cortex



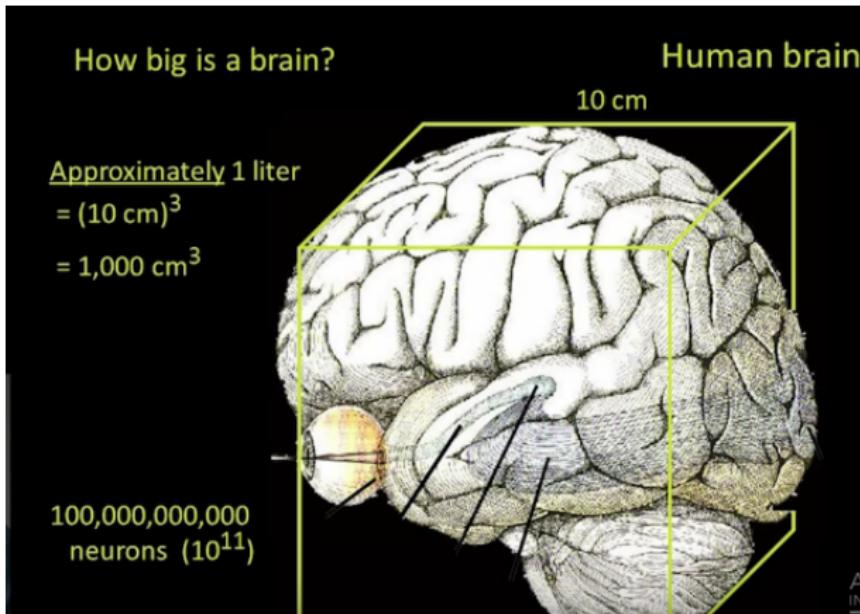
Responsible for higher activity such as thinking.
80% of brain weight.

Motor cortex

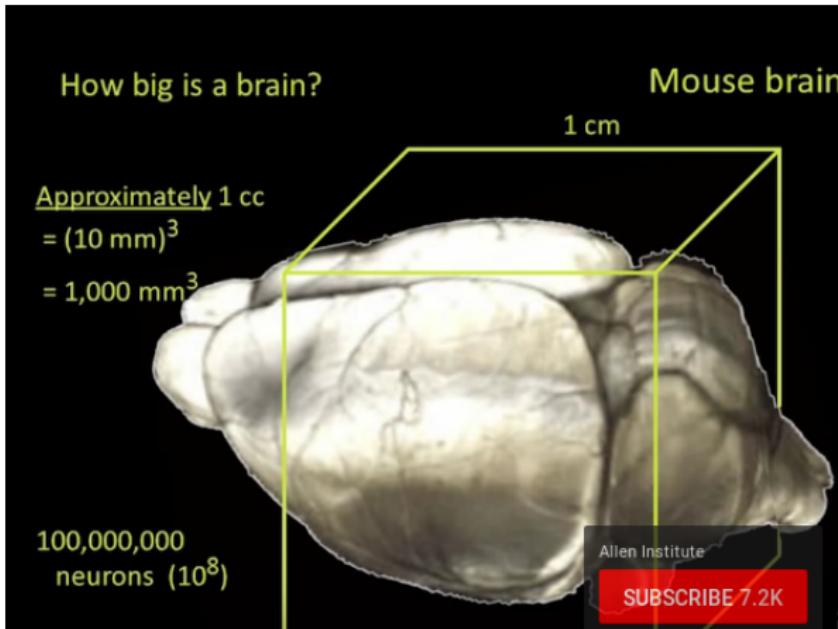


Sends connections to muscles.

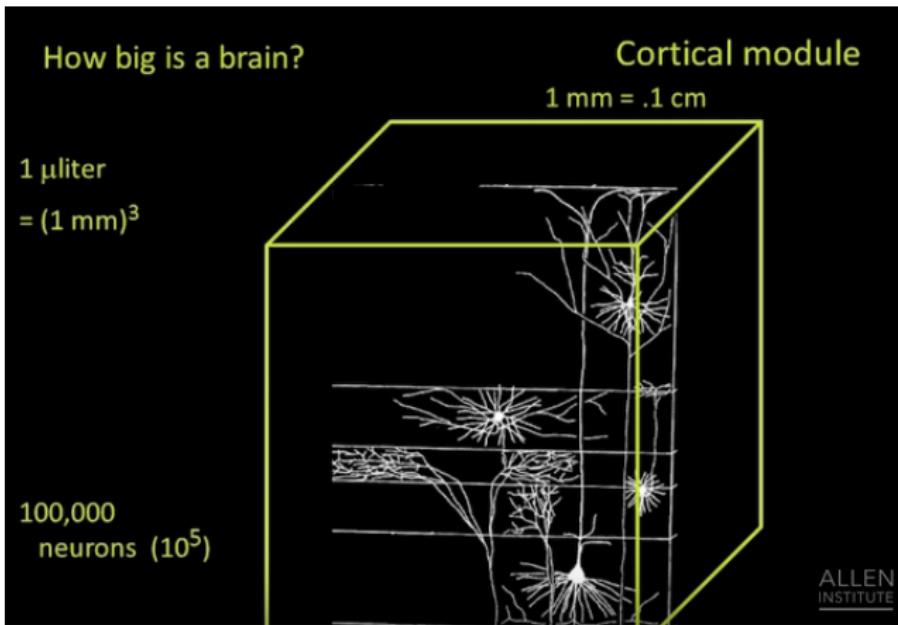
Brain scale



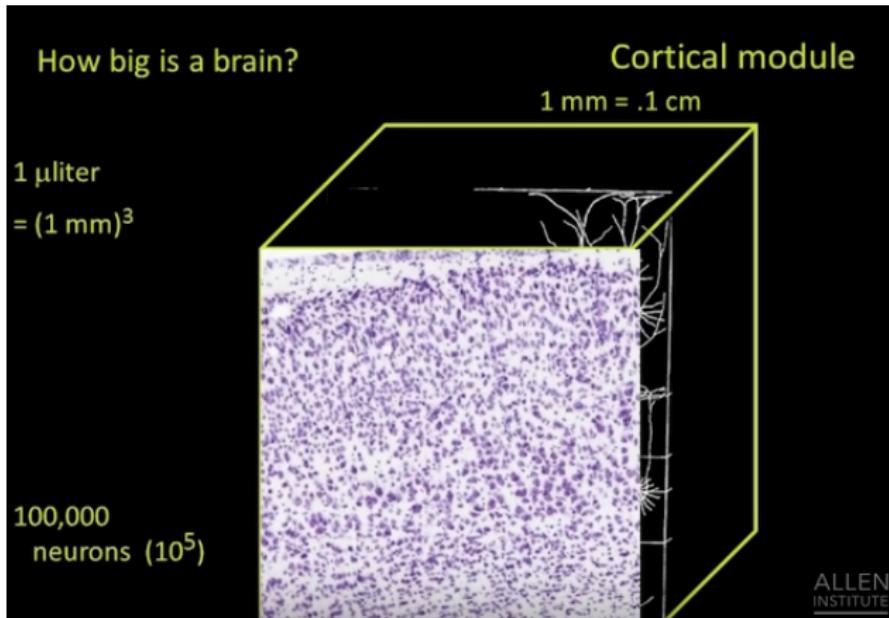
Mouse brain



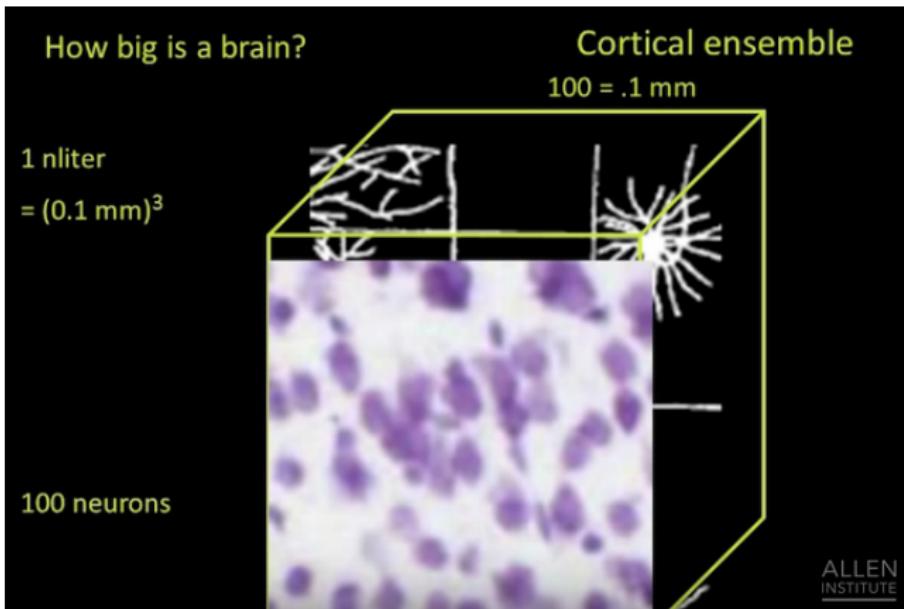
Smaller scale



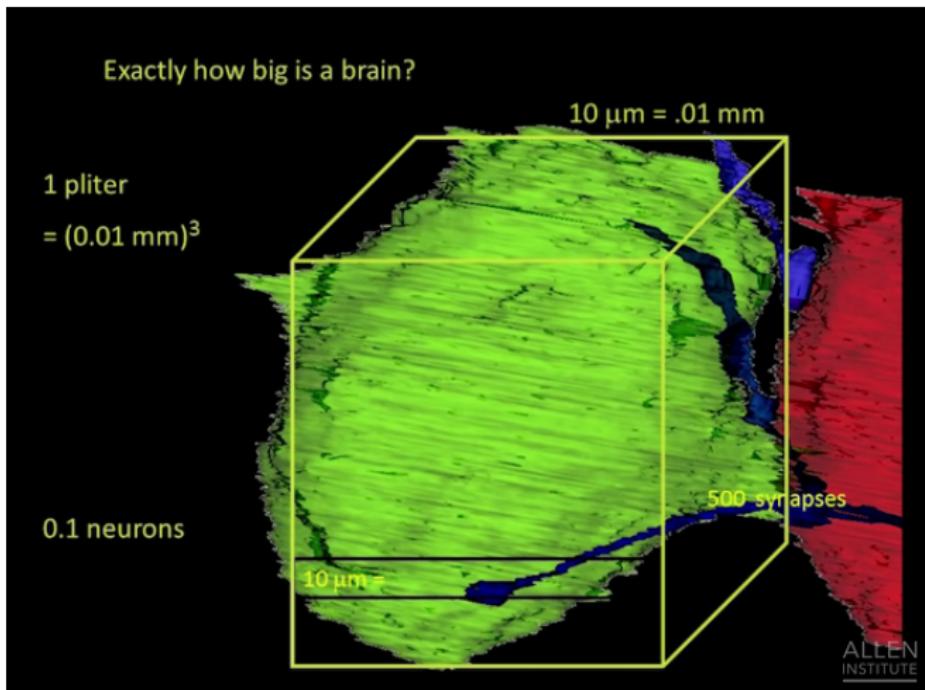
Smaller scale



Even smaller scale

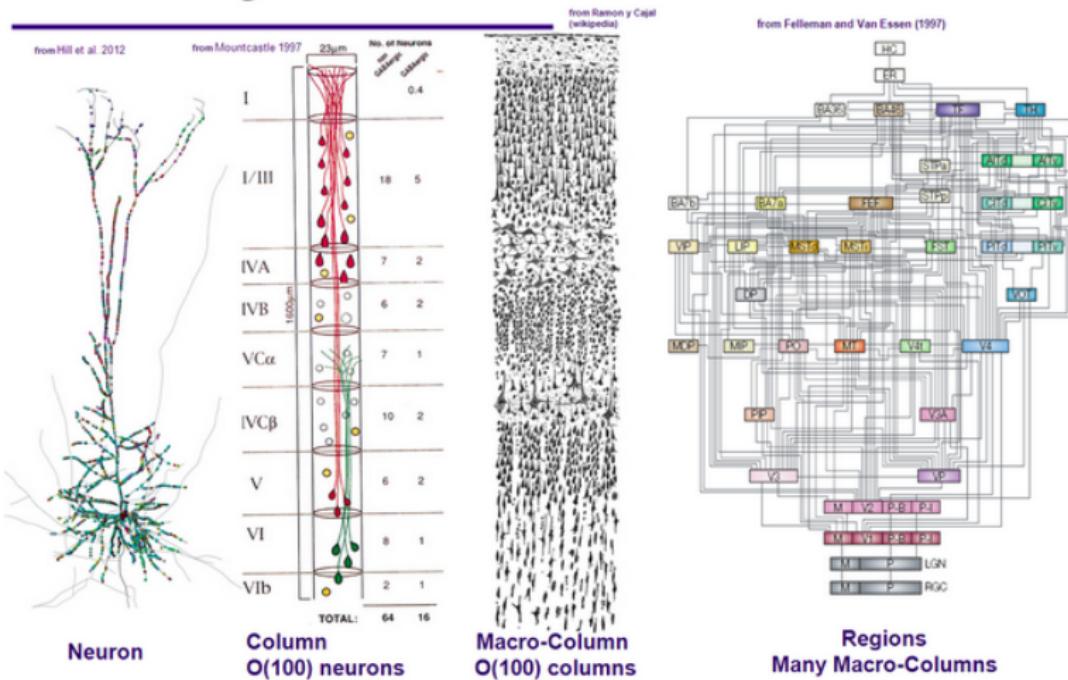


Even smaller scale

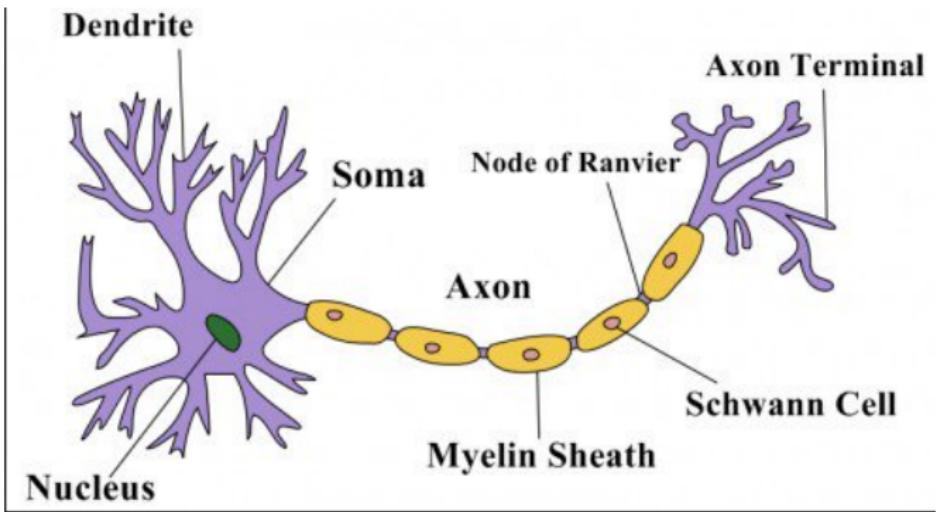


Columns

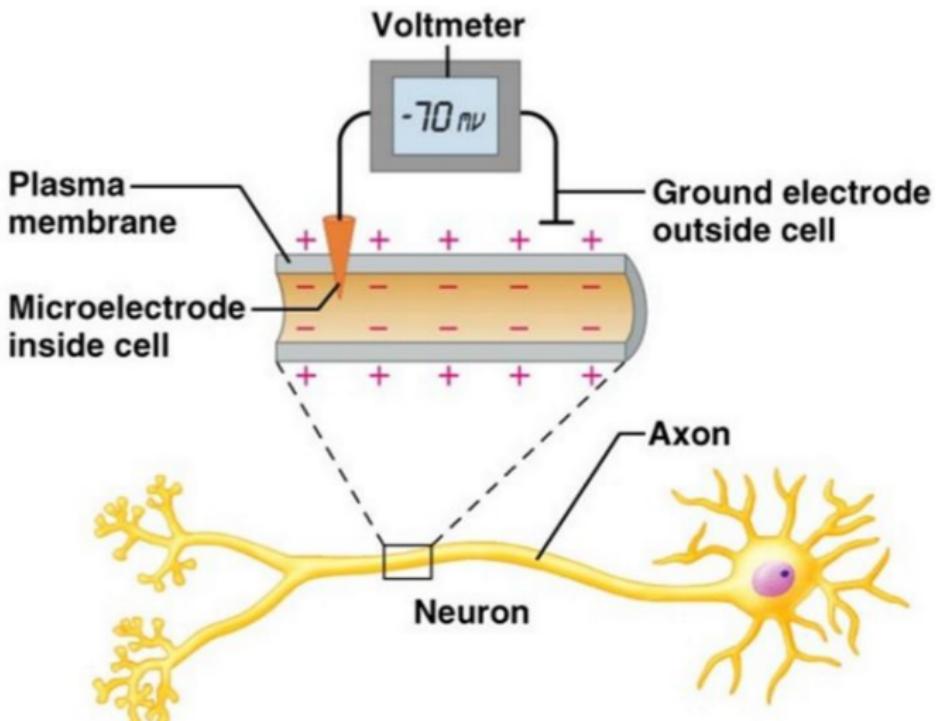
Hierarchy



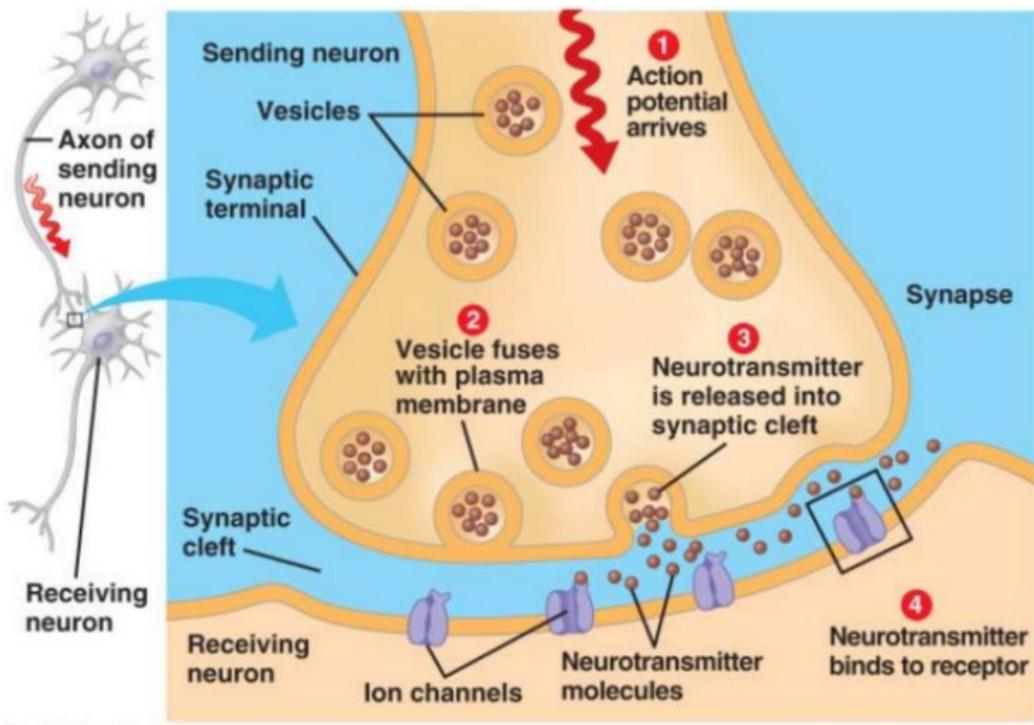
Neuron structure



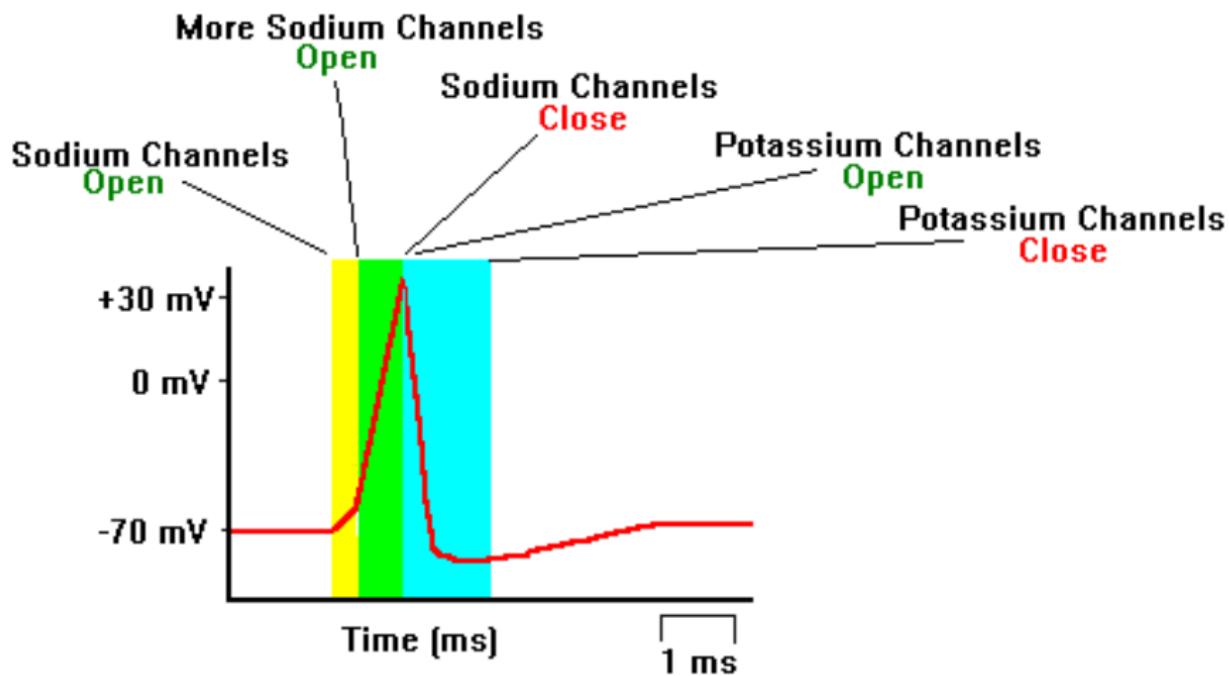
Action potential



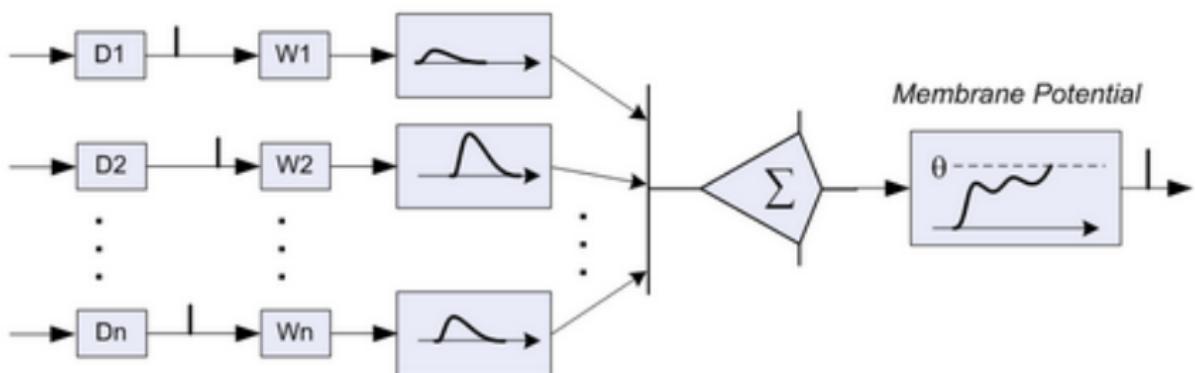
Synapse



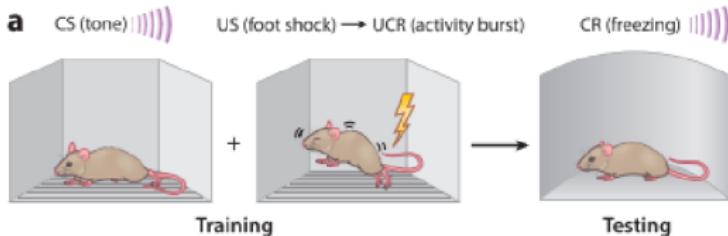
Action potential changes



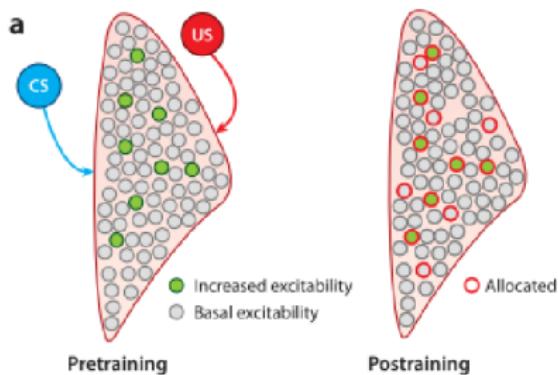
Action potential changes



Associations



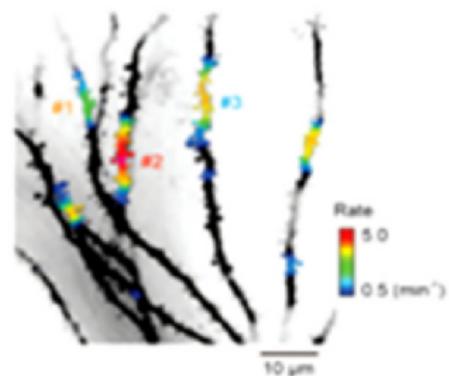
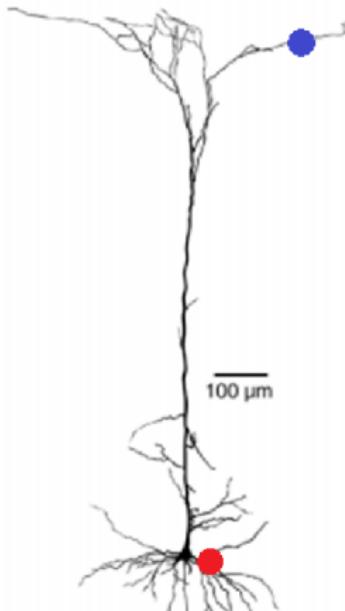
We can selectively:
Write
Delete
Change
memories



Josselyn, S. A., & Frankland, P. W.

Difference between real and artificial neurons

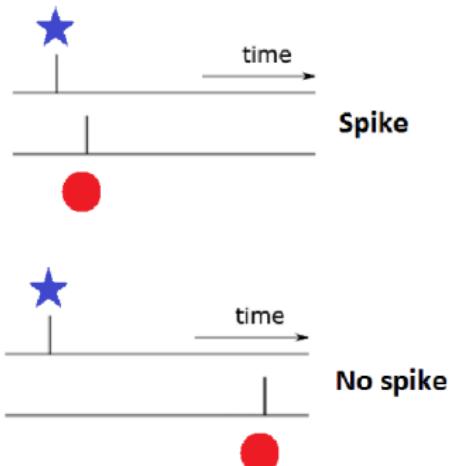
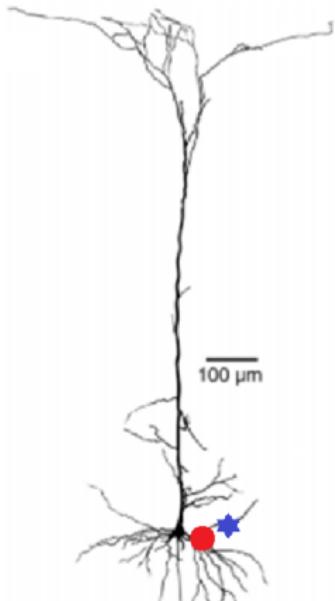
Dendrite location matters:



Takahashi, N., et.al. 2012

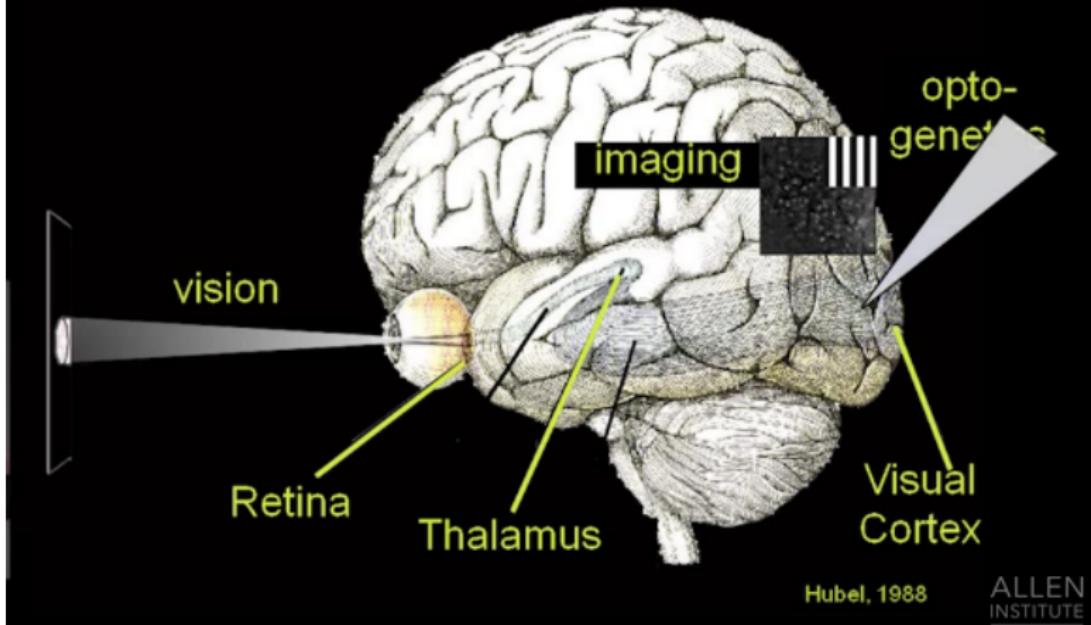
Difference between real and artificial neurons

Time matters:



Visual system

A great time to study the brain, and vision

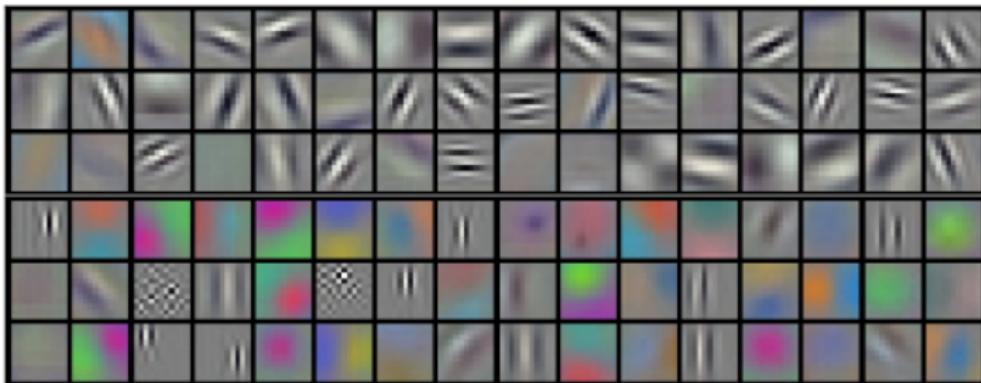


Hubel, 1988

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Cat visual cortex

- First neuron layers detect edges of different orientations
- Later layers detect more complex shapes: combinations of lines, shapes
- Very similar to convolutional neural net



Learning

What is the Engram, or memory trace?



Karl Lashley (1890-1958)

IN SEARCH OF THE ENGRAM

K. S. Lashley 1950

SUMMARY

This series of experiments has yielded a good bit of information about what and where the memory trace is not. It has discovered nothing directly of the real nature of the engram. I sometimes feel, in reviewing the evidence on the localization of the memory trace, that the necessary conclusion is that learning just is not possible. It is difficult to conceive of a mechanism which can

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Hebb rule

Hebb rule: if cell A takes part in activation of cell B, then connection between them is strengthen.

$$\omega_i(n+1) = \omega_i(n) + \eta y(n)x_i(n)$$

Normalization:

$$\omega_i(n+1) = \frac{\omega_i(n) + \eta y(n)x_i(n)}{\sqrt{\sum_{i=1}^m (\omega_i(n) + \eta y(n)x_i(n))^2}}$$

Oya rule:

$$\omega_i(n+1) = \omega_i(n) + \eta y(n)(x_i(n) - y(n)\omega_i(n))$$

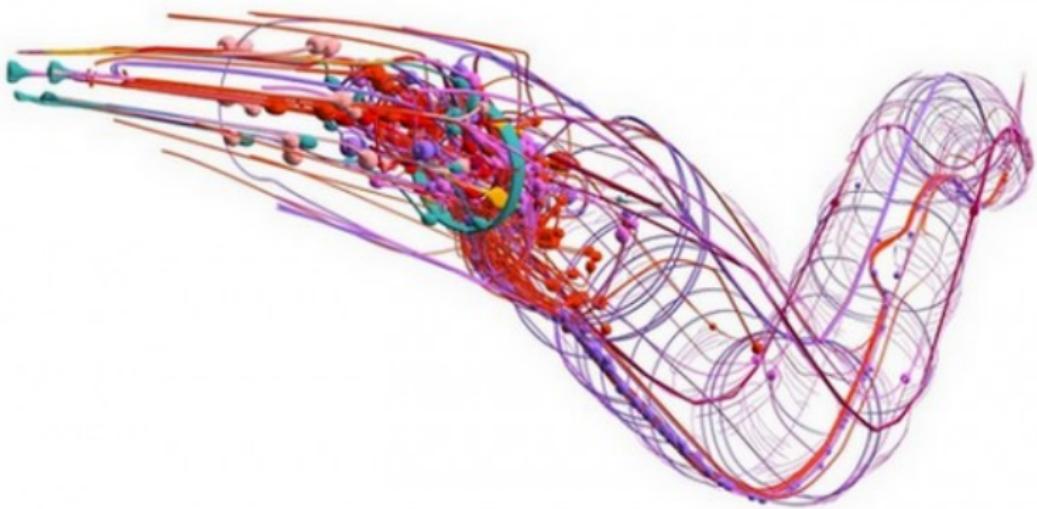
Oya rule corresponds to finding the first principal component of the input data.

Origins of brain

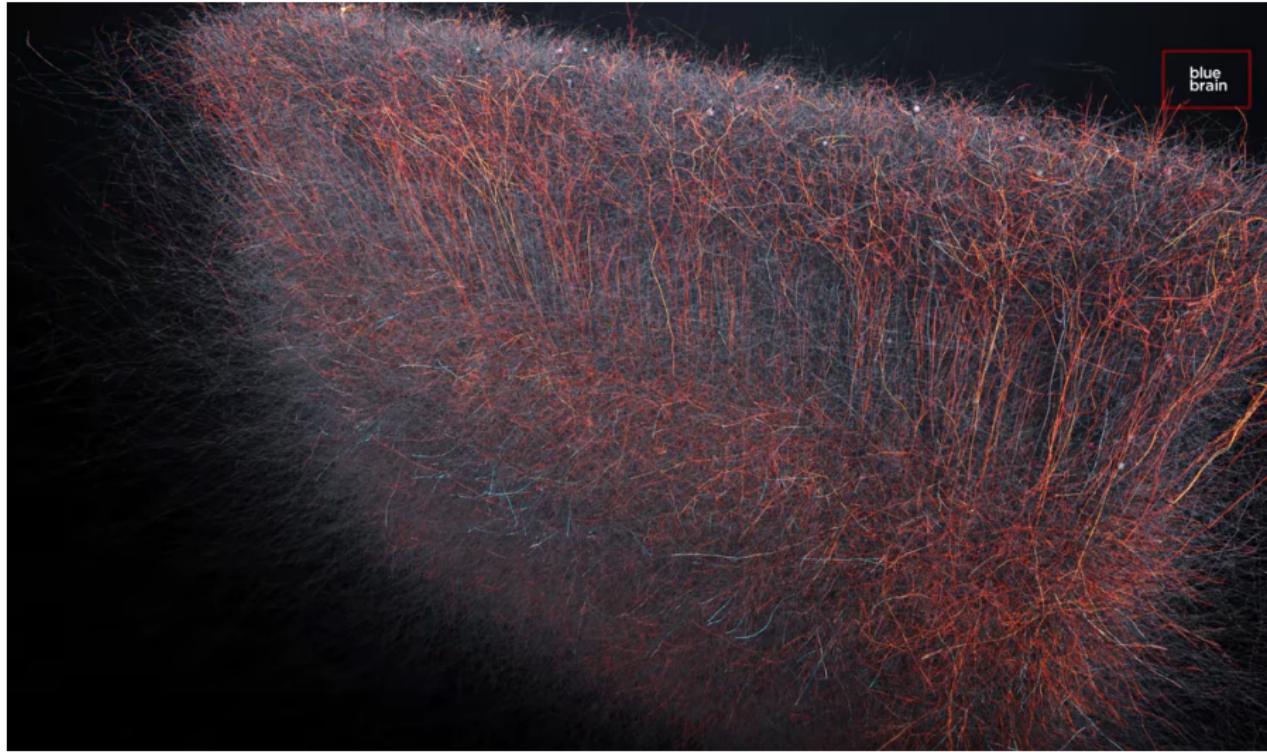
Full video "Origin of brain:"

<https://www.youtube.com/watch?v=6RbPQG9WTZM>

OpenWorm



BlueBrain



Top - down approach

Computer science defines AI research as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.

AI tasks:

- Reasoning
- Knowledge representation
- Planning
- Learning
- NLP
- Perception

"AI is whatever hasn't been done yet."

Tools

- Search and optimization
- Logic
- Probabilistic methods for uncertain reasoning
- Classifiers and statistical learning methods

Read more: book "Artificial intelligence: modern approach" by Russel, Norwig.

Read more

Blue brain project: <https://bluebrain.epfl.ch/>

Origins the Series: [Link](#)

Coding and Vision Lectures: [Link](#)

Simulation neuroscience course: [Link](#)

Hierarchical temporal memory model:

<https://www.numenta.org/>

Artificial Intelligence: A Modern Approach (Russel, Norvig)