Artificial Intelligence

Neural Networks

Lesson 1: Biological Background

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Contents

- Motivation
- Biological background
- Computers vs. the human brain

Motivation (1)

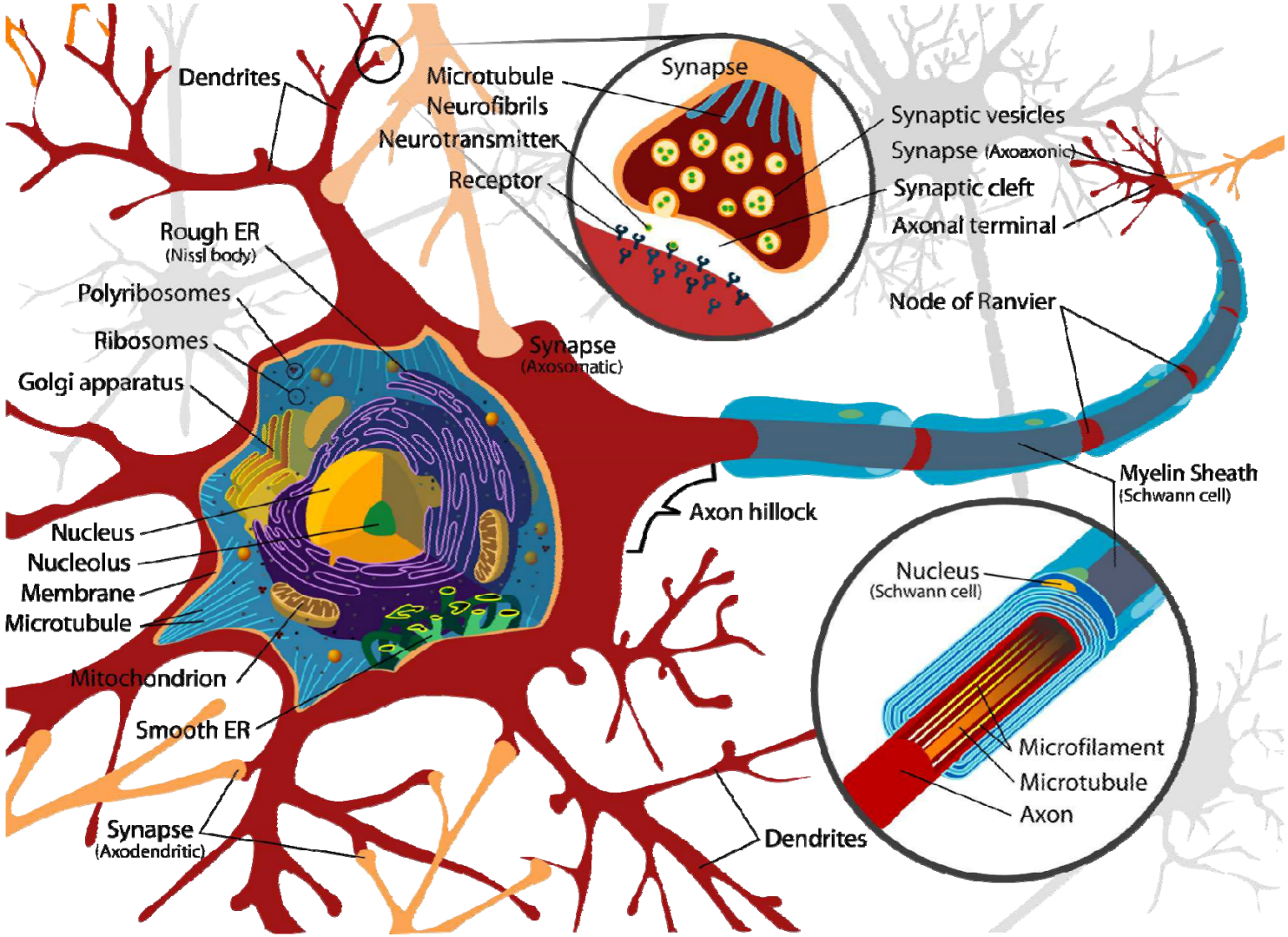
- (Neuro-)Biology / (Neuro-)Physiology / Psychology:
  - Exploit similarity to real (biological) neural networks.
  - Build models to understand nerve and brain operation by simulation.
- Computer Science / Engineering / Economics
  - Mimic certain cognitive capabilities of human beings.
  - Solve learning/adaptation, prediction, and optimization problems.
- Physics / Chemistry
  - Use neural network models to describe physical phenomena.
- Medicine
- ....

Motivation (2)

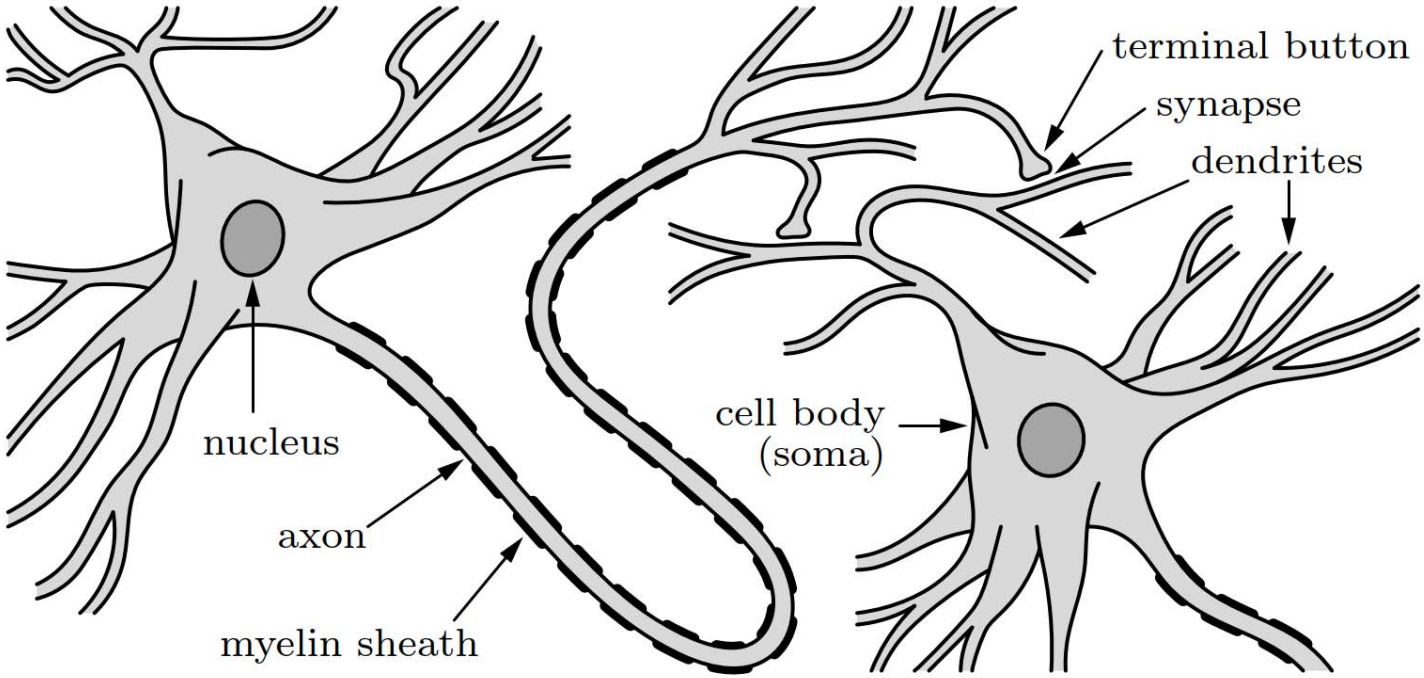
Why study neural networks in Artificial Intelligence?

- Neural networks allow for highly parallel information processing.
- There are several successful applications in industry, environment, medicine, finance...

Biological Background (1)

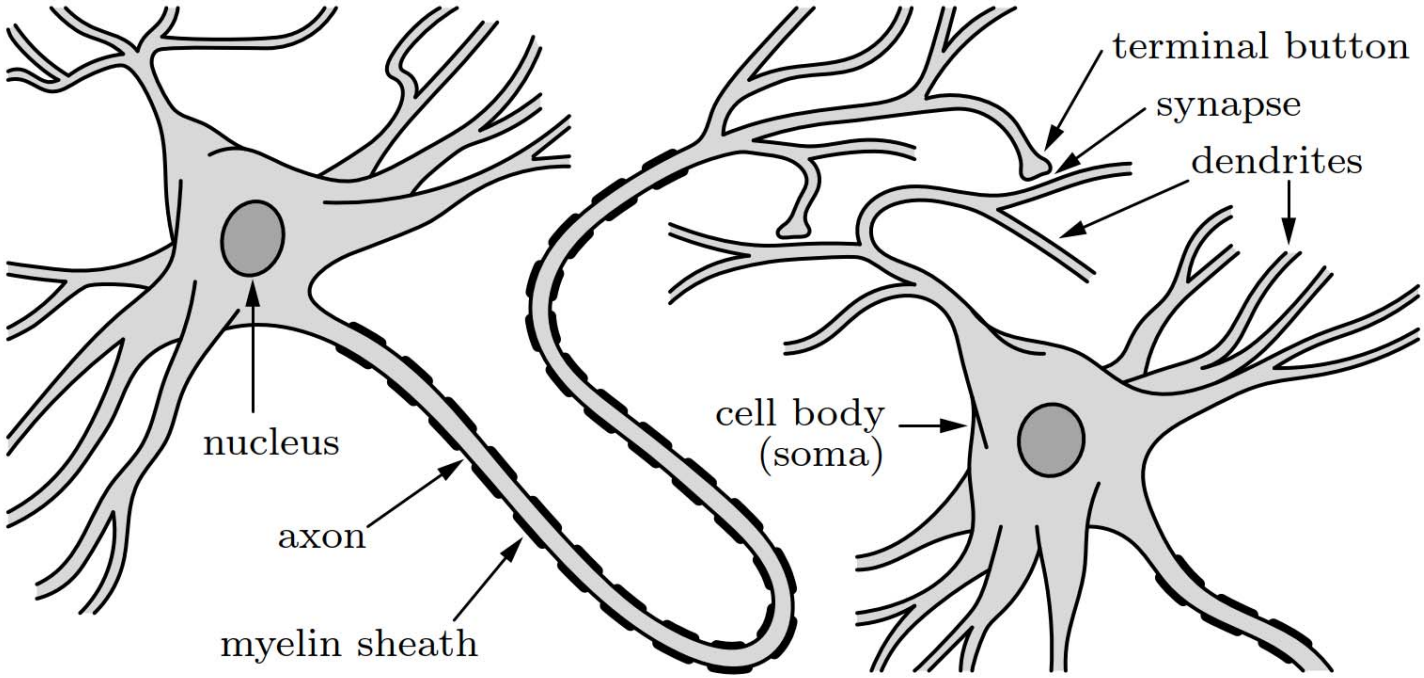


Biological Background (2)



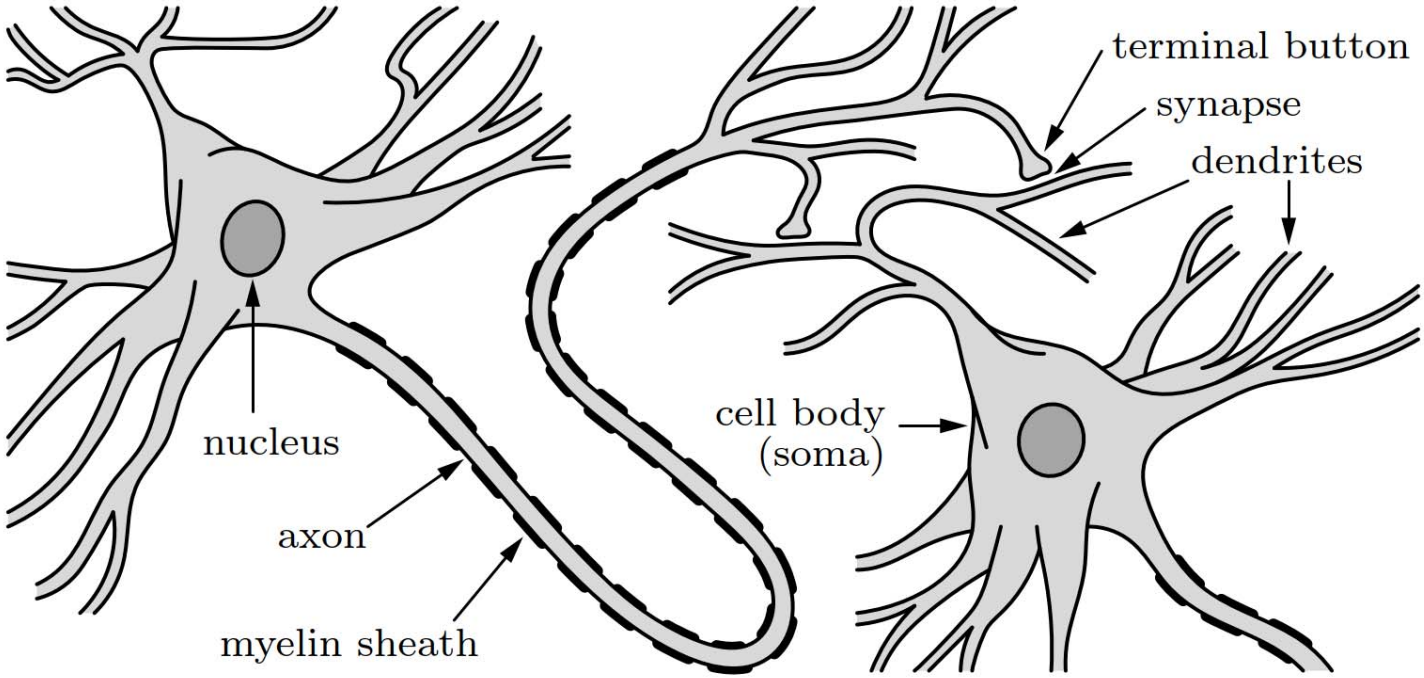
- Axon terminal releases chemicals, called neurotransmitters.
  - These act on the membrane of the receptor dendrite to change its polarization.

Biological Background (3)



- If there is enough net excitatory input, the axon is depolarized.
  - The resulting action potential travels along the axon.

Biological Background (4)



- When the action potential reaches the terminal buttons, it triggers the release of neurotransmitters.

Computer vs. the Human Brain (1)

	Personal computer	Human brain
Processing units	1 CPU, 2–10 cores 10^{10} transistors 1–2 graphics cards/GPUs, 10^{3} cores/shaders 10^{10} transistors	10^{11} neurons
Storage capacity	10^{10} bytes main memory (RAM) 10^{12} bytes external memory	10^{11} neurons 10^{14} synapses
Processing speed	10^{-9} seconds 10^{9} operations per second	$>10^{-3}$ seconds < 1000 per second
Bandwidth	1012 bits/second	10^{14} bits/second
Neural updates	106 per second	10^{14} per second

Computer vs. the Human Brain (2)

Advantages of Neural Networks:

- High processing speed due to massive parallelism.
- Fault Tolerance:
  - Remain functional even if (larger) parts of a network get damaged.
- "Graceful Degradation":
  - Gradual degradation of performance if an increasing number of neurons fail.
- Well suited for inductive learning
  - (learning from examples, generalization from instances).

Computer vs. the Human Brain (3)

It appears to be reasonable to try to mimic or to recreate these advantages by constructing artificial neural networks.