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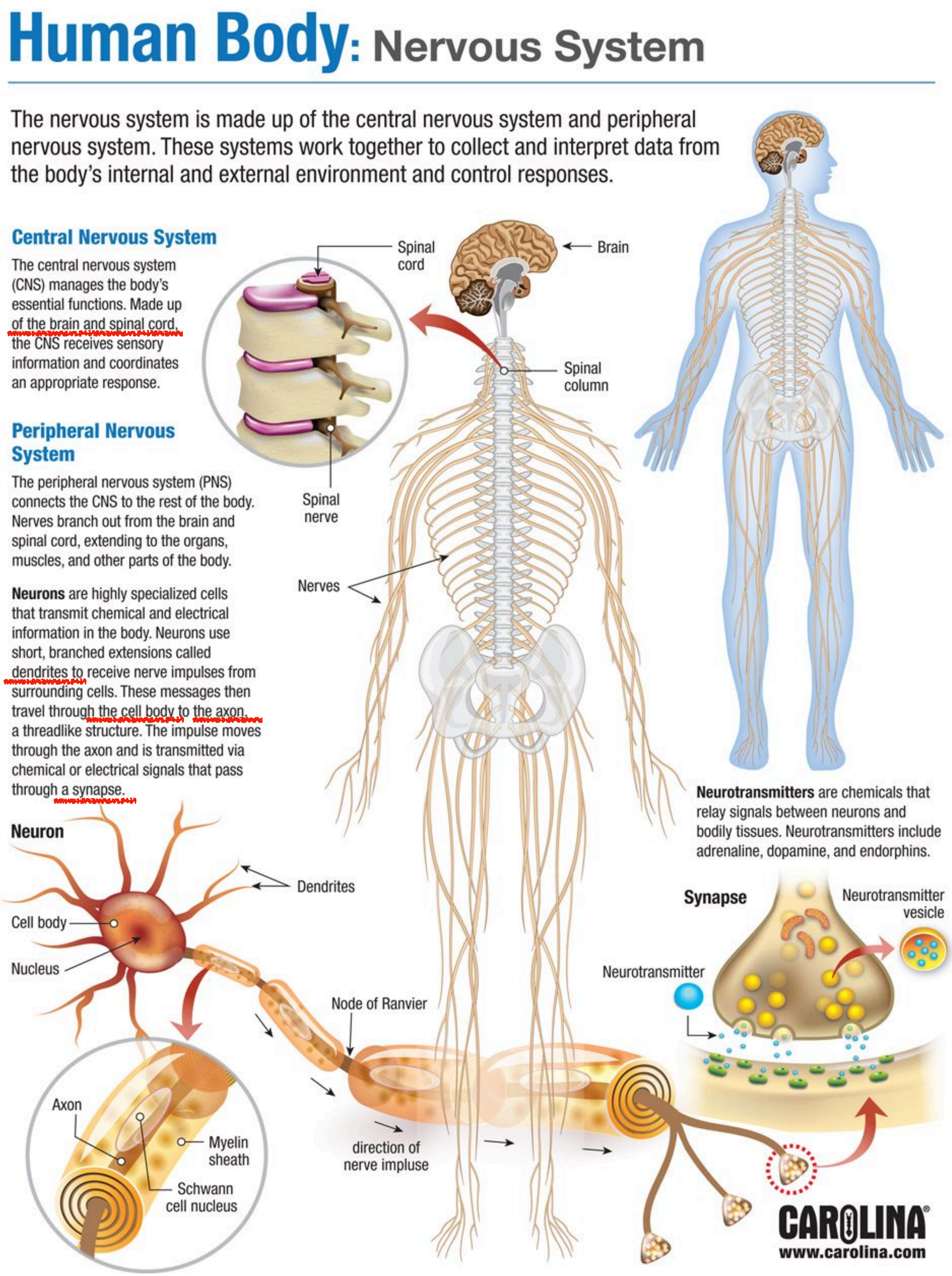
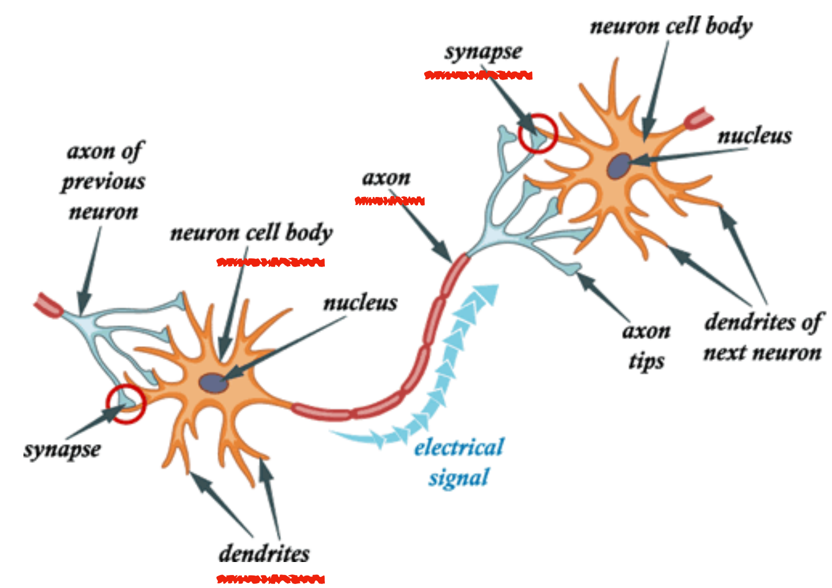
Content



Brain consists of ~10^11 neurons,
building bricks for the central nervous systems

Neurons are interconnected by synapses,
the complexity of the Brian is due to massive highly interconnected neurons working in parallel,
One neuron receives inputs from ~ 10^4 others.

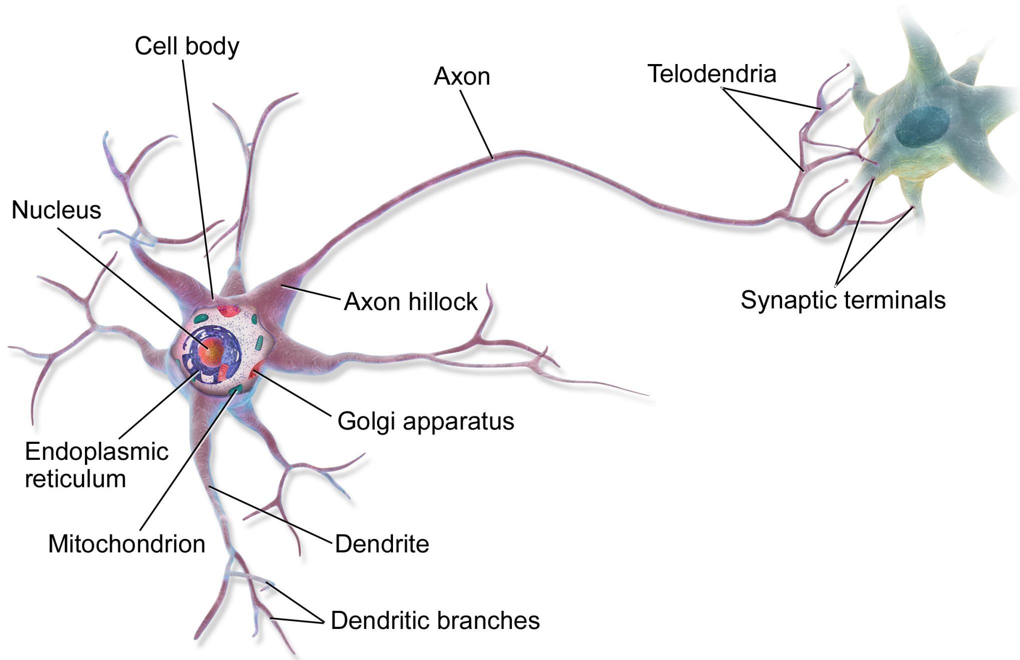


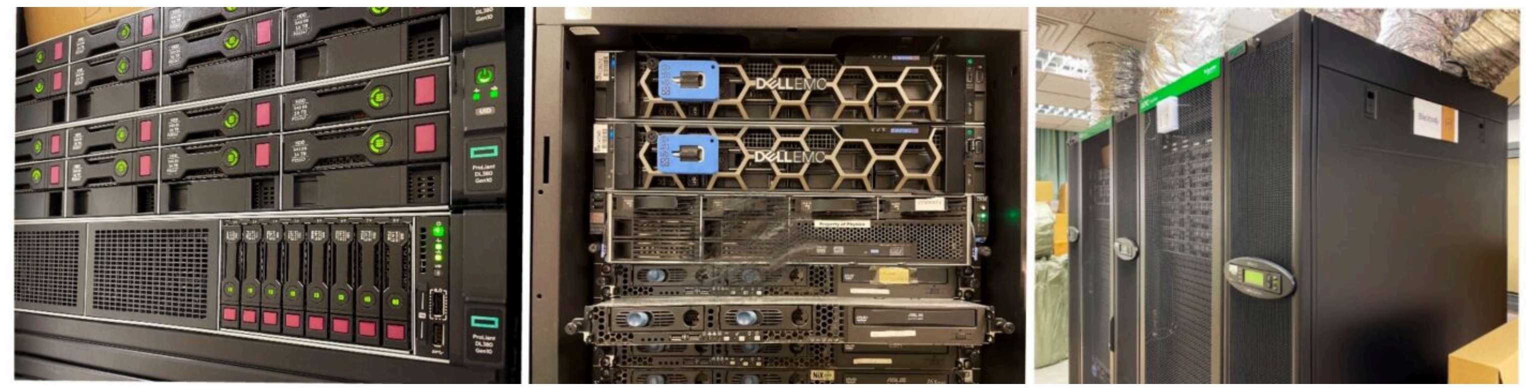
All the inputs to the neuron, are summed up.
The input sum is processed by a threshold function and produces an output signal.
The processing time ~ 1ms per cycle

Brian works in both a parallel and serial way.
Picture recognition of human ~ 100 ms
Around 100 neurons are in involved in serial
Complexity requires parallel processing

Biological neural systems have high fault tolerance
People with brain injuries can perform normally

AI & Machine Learning Basics

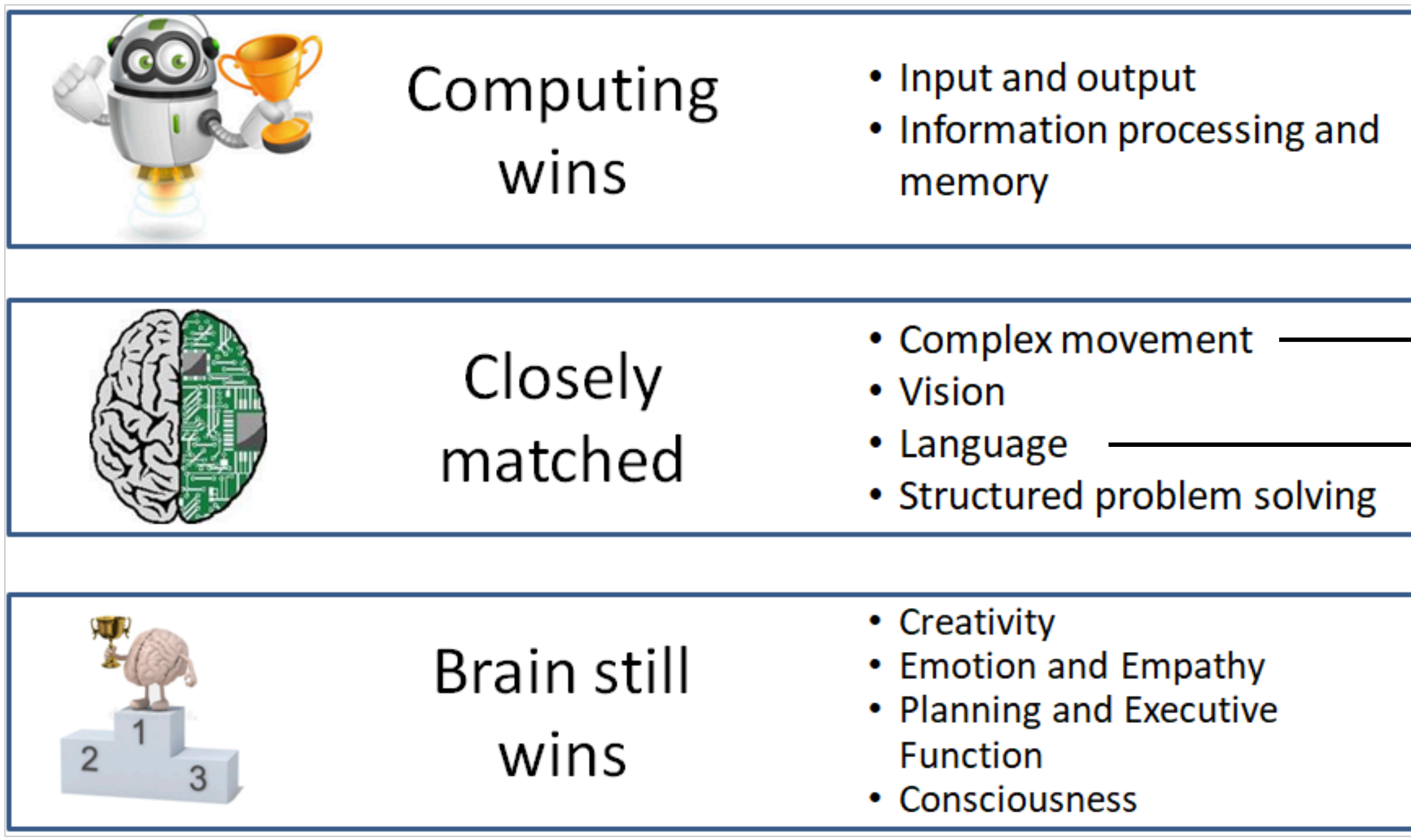




	Supercomputer	Personal Computer	Human Brain
Computational Units	4,000 Xeon/AMD CPUs 10^12 transistors	4 CPUs, 10^9 transistors	10^11 neurons
Storage units	10^14 bits RAM 10^15 bits Storage	10^11 bit RAM 10^13 bit Storage	10^11 neurons 10^14 synapses
Cycle time	10^-9 sec	10^-9 sec	10^-3 sec
Operations/sec	10^15	10^10	10^17
Memory updates/sec	10^14	10^10	10^14
Weight / Space	150 tons / Basketball court	1 Kg / A4 Paper	1.5 Kg / 1/6 basketball
Power consumption	500 megawatt	100 watt	20 watt

Peripheral nervous system

- Touching a hot object
- Sensory nerves carry information about the heat to the brain
- Brain, via motor nerves, tells the muscle of the hand to withdraw
- The whole process takes less than a second



Boston Dyanmics
SPOT/ATLAS

Auditory processing
Script in zoom
Chat-GPT

https://becominghuman.ai/brains-vs-computers-f769548010f1

Neuroscience For Kids

http://faculty.washington.edu/chudler/neurok.html

Biological neurons (nerve cell)

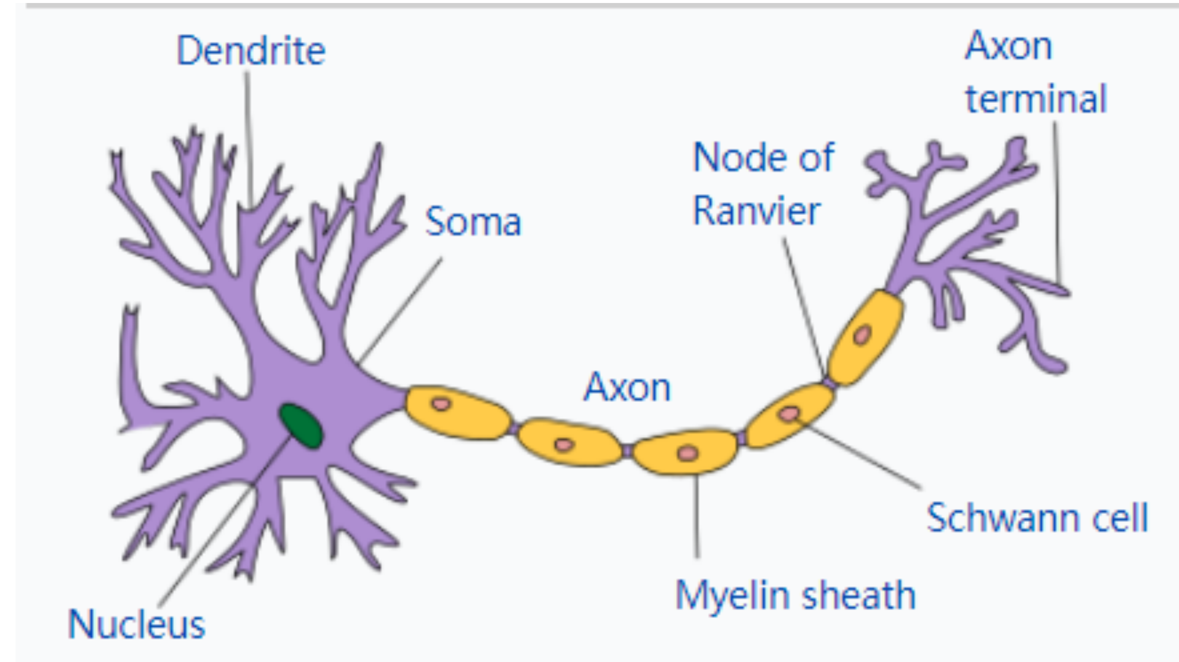
Functional and structural units of nervous system
10^{11} in human body
80% in human Brain

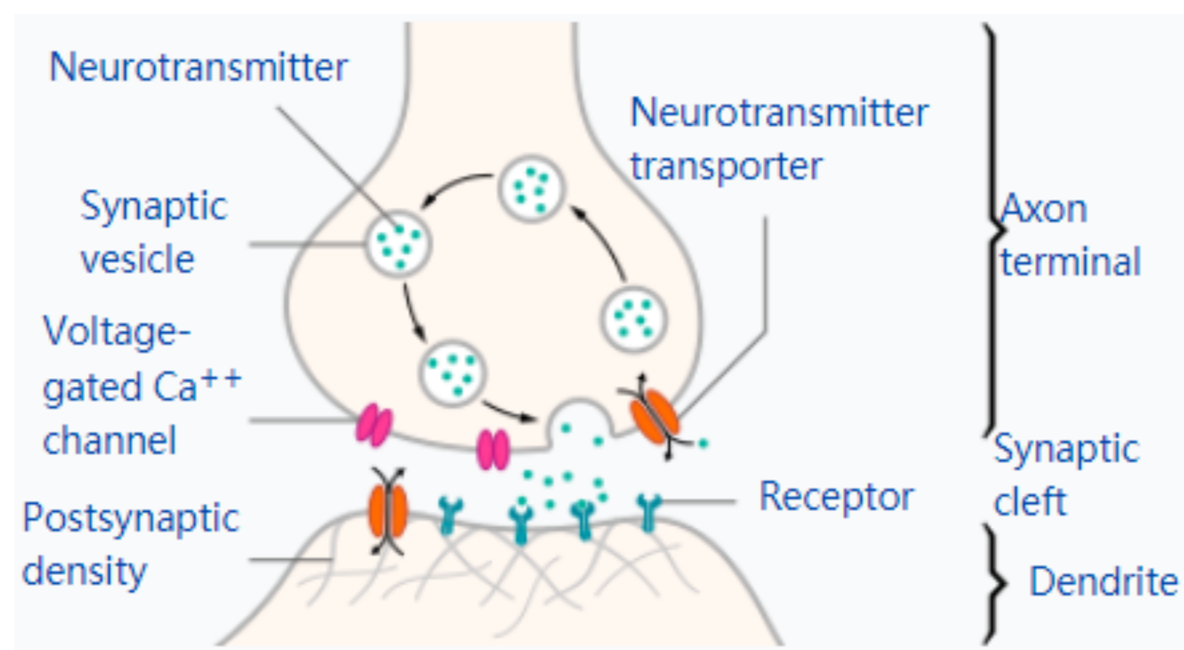
Input: Dendrites:
neuron receives one or more inputs through dendrites

Hypothesis: Cell Body (Soma):
Processing the information

Output: Axon:
Send output through axon
Neurons do not touch each other, they form tiny gaps called synapses,
pass electrical or chemical signal to another neuron or target cell

https://en.wikipedia.org/wiki/Synapse



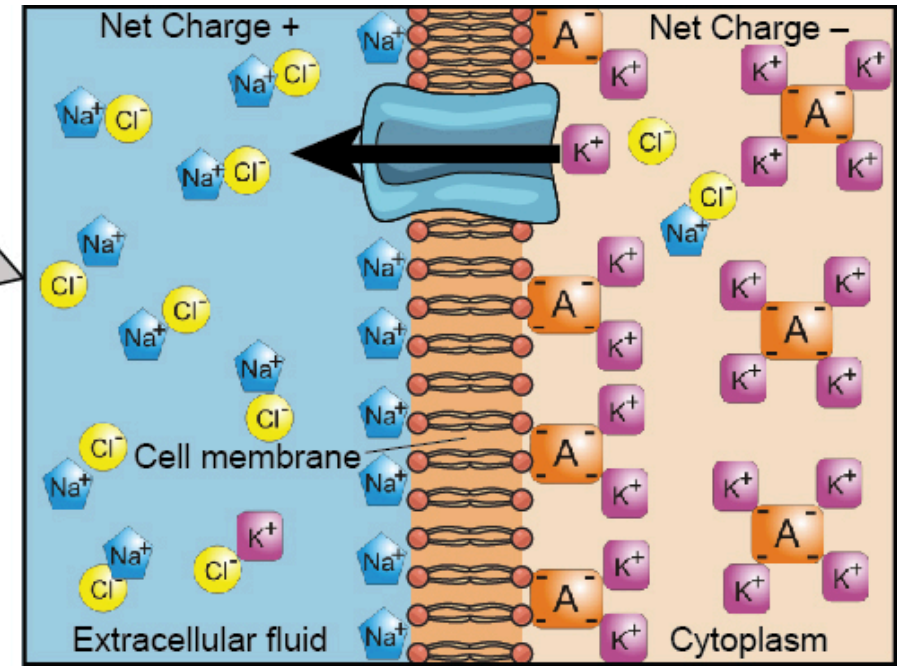


Chemical synapse

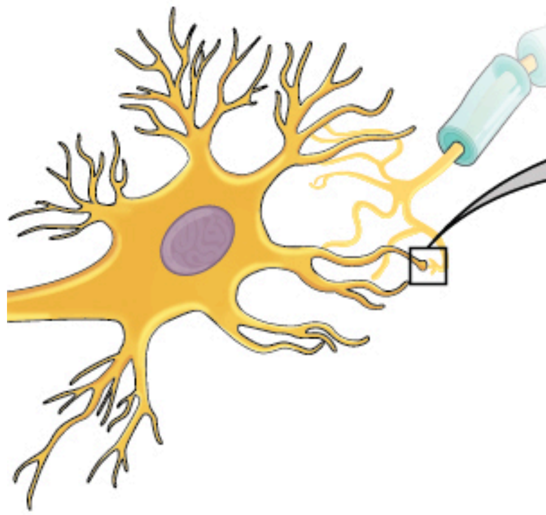
Biological neurons

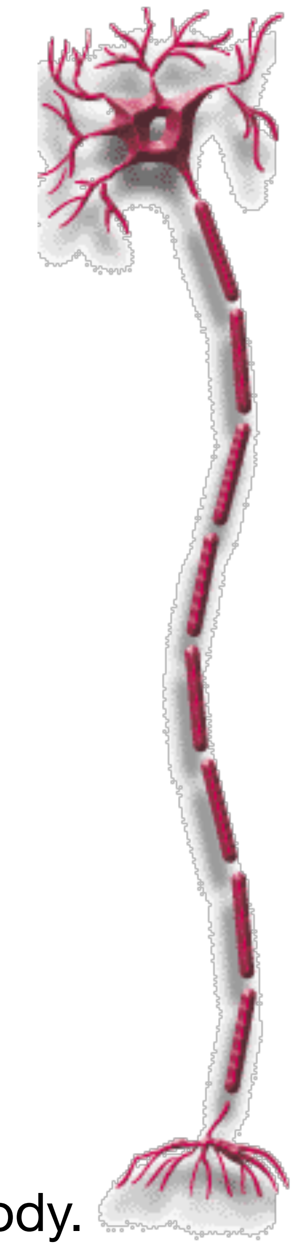
Neurons send message **electrochemically**

Semi-permeable membrane



Sodium Na+ ion
Potassium K+ ion
Calcium Ca++ ion
Chloride Cl- ion
Protein molecules A-

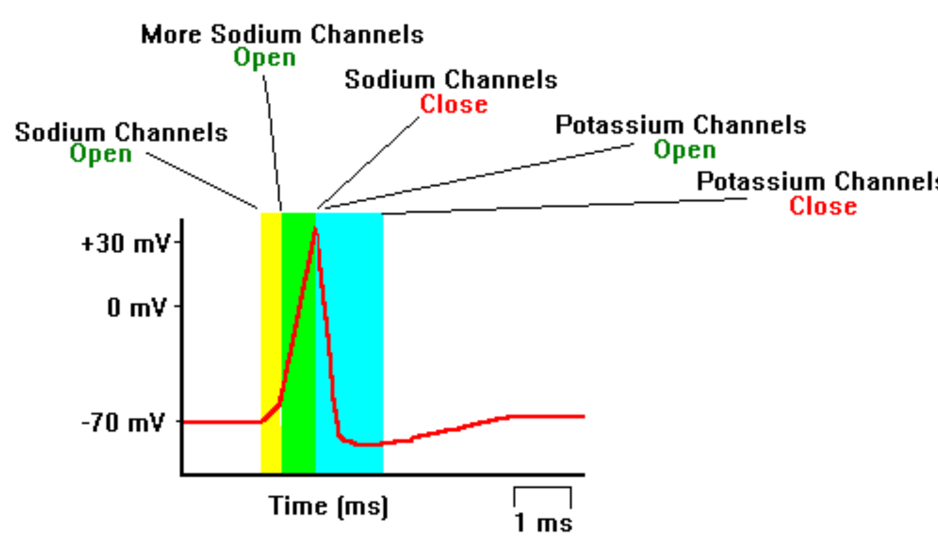


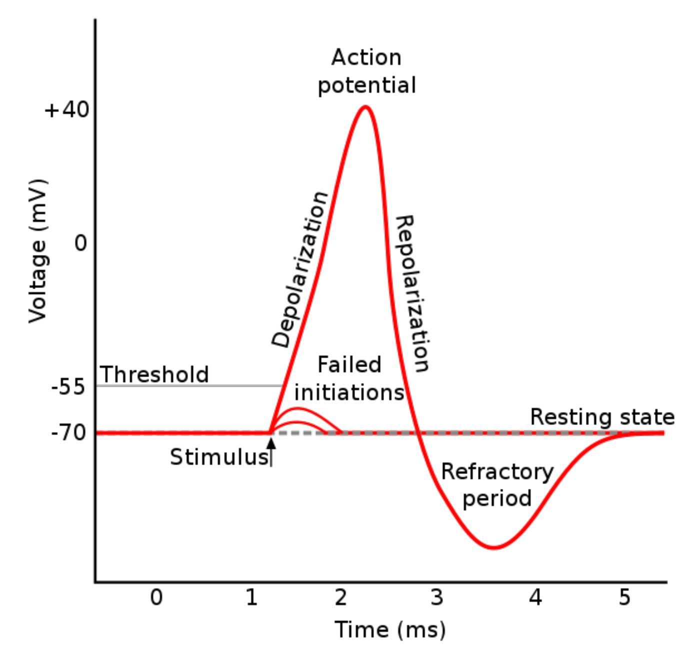


When a neuron at rest (not sending a signal)
Inside is negative relative to the outside
Resting potential about -70 mV (millivolt)
More solidum outside and more potassium inside

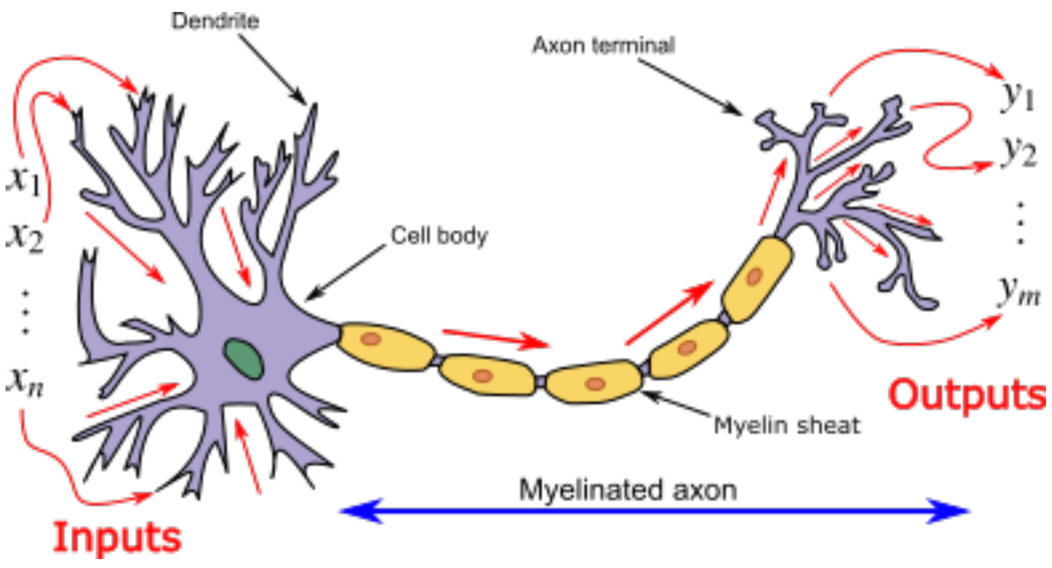
Action potential occurs when a neuron sends information down an axon, away from the cell body.
An explosion of electrical activity created by depolarizing current
A stimulus causes the resting potential to move towards 0 mV.
Depolarisation reaches about -55 mV (threshold), neuron will fire an action potential

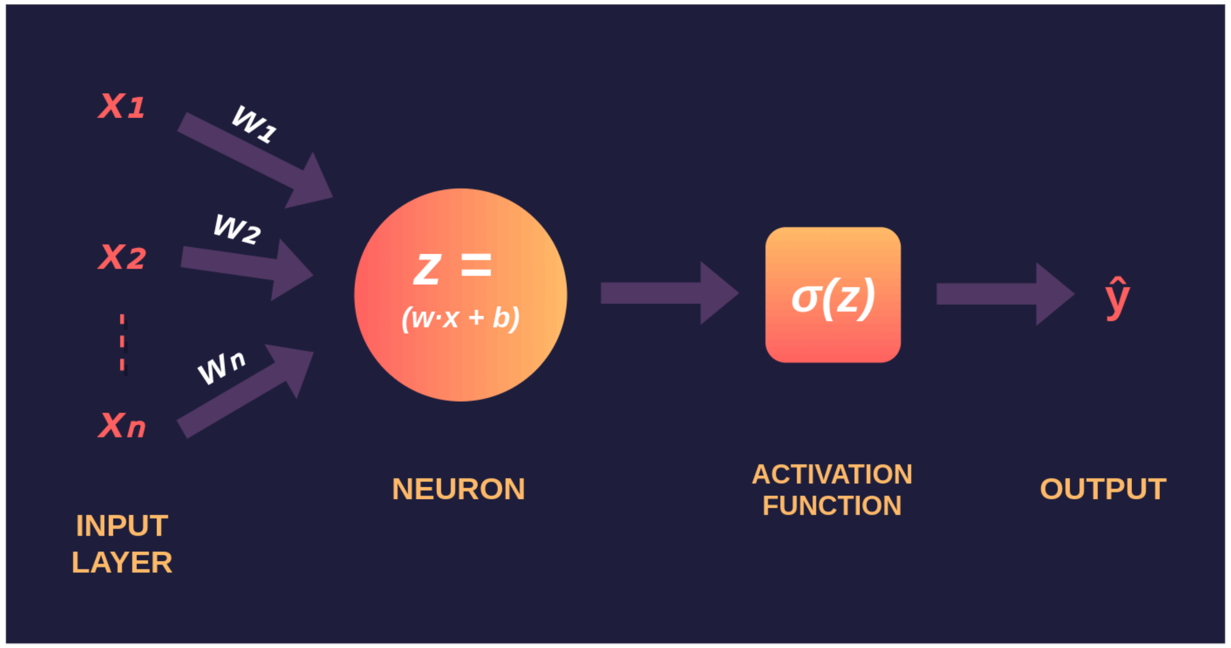
Spike or impulse
Depolarization
Repolarization





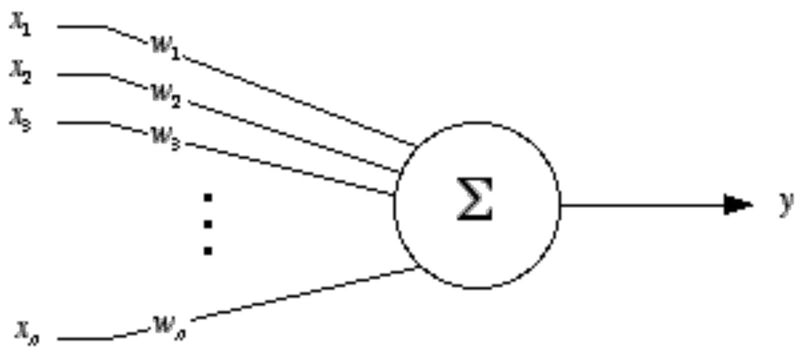
Mathematical representation for neutrons: Linear model





- Brain contains neurons, each neuron can be thought of as a device having inputs and outputs.
- Inputs consist of 10^3-10^4 synapses on the dendritic tree, outputs consist of action potential carried by the axon sent to other neurons.
- The input currents are (roughly) summed together into the cell body, whose voltage rises and decays with the fluctuations in current.
- When the cell body voltage exceeds a certain threshold, an action potential is fired, propagates down the axon.

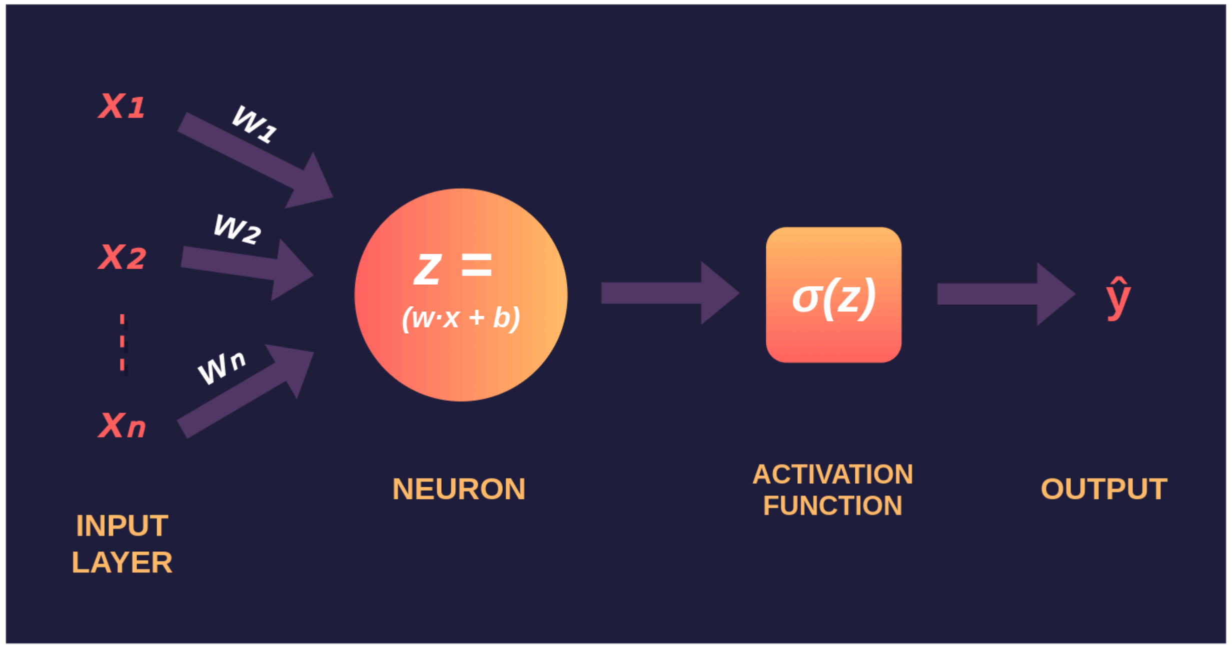
Linear neuron models



$$y = \sum_{i=1}^{n} w_i x_i = \theta^T x$$

w_i weight for each input

Mathematical representation for neutrons: Perceptrons



- Frank Rosenblatt in 1958
- n inputs, n weights, one neuron, one output
- Passing data through via forward propagation

$$w \cdot x + b = \theta^T x \; = z$$

$$\begin{bmatrix} 1 & x_1^{(1)} & x_2^{(1)} & \cdots & x_N^{(1)} \\ 1 & x_1^{(2)} & x_2^{(2)} & \cdots & x_N^{(2)} \\ & \vdots & & \vdots & \\ 1 & x_1^{(M)} & x_2^{(M)} & \cdots & x_N^{(M)} \end{bmatrix} \cdot \begin{bmatrix} \theta_0 \\ \theta_1 \\ \vdots \\ \theta_N \end{bmatrix} = \underline{\underline{X}} \cdot \underline{\Theta}$$

$\mathbb{R}^{M \times 1}$ vector

Binary activation function

$$y = 0 \quad \text{if} \quad \theta^T x \leq 0$$

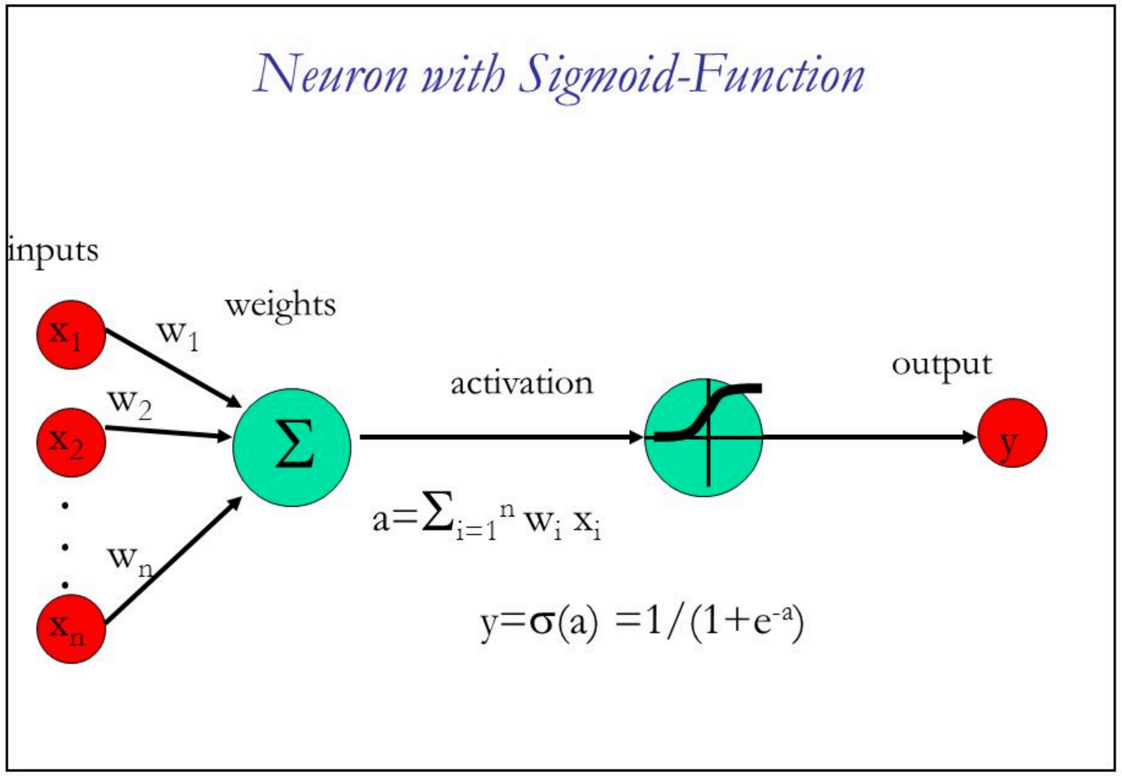
$$y = 1 \quad \text{if} \quad \theta^T x > 0$$

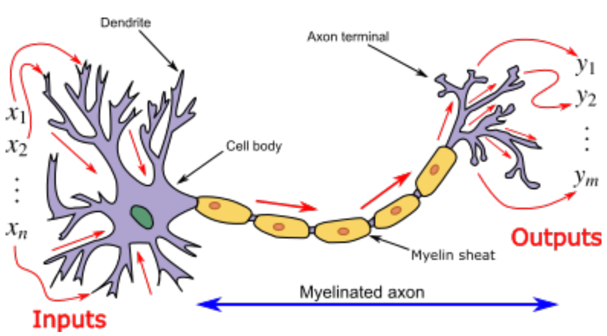
Logistic/Sigmoid activation function

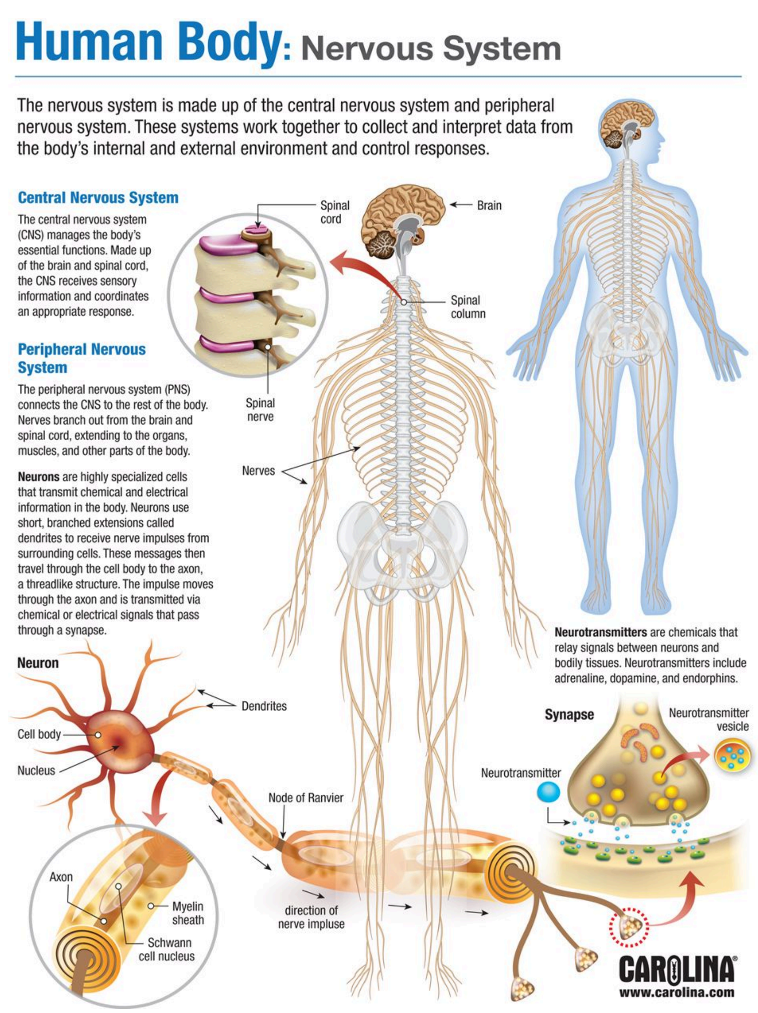
$$y = \frac{1}{1 + \exp(-\theta^T x)}$$

https://towardsdatascience.com/introduction-to-math-behind-neural-networks-e8b60dbbdeba
https://towardsdatascience.com/nns-aynk-c34efe37f15a

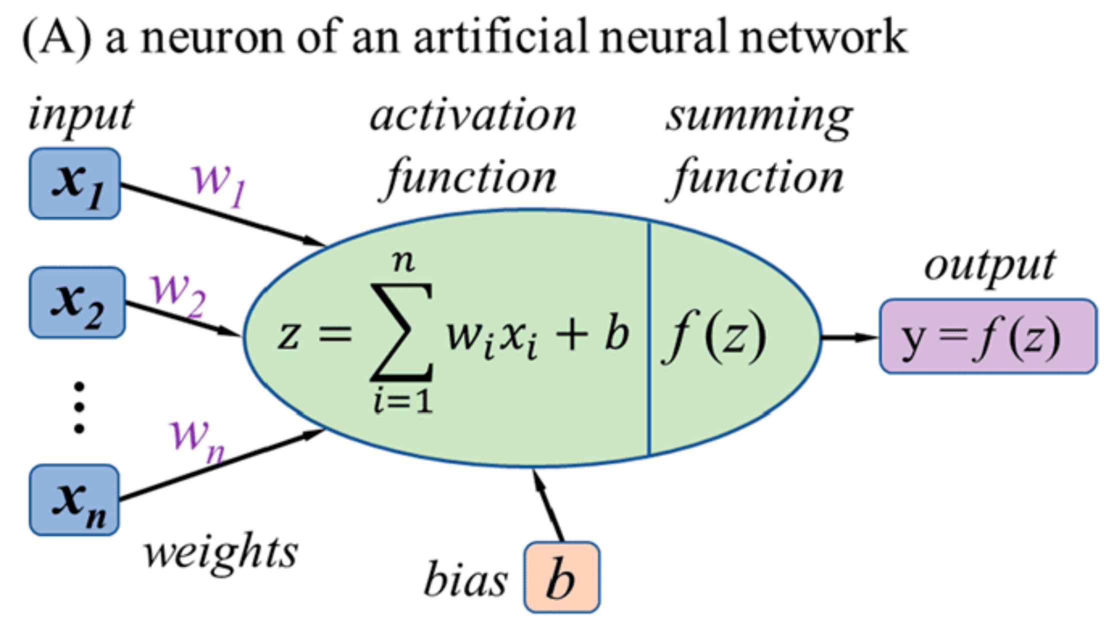
Perceptron

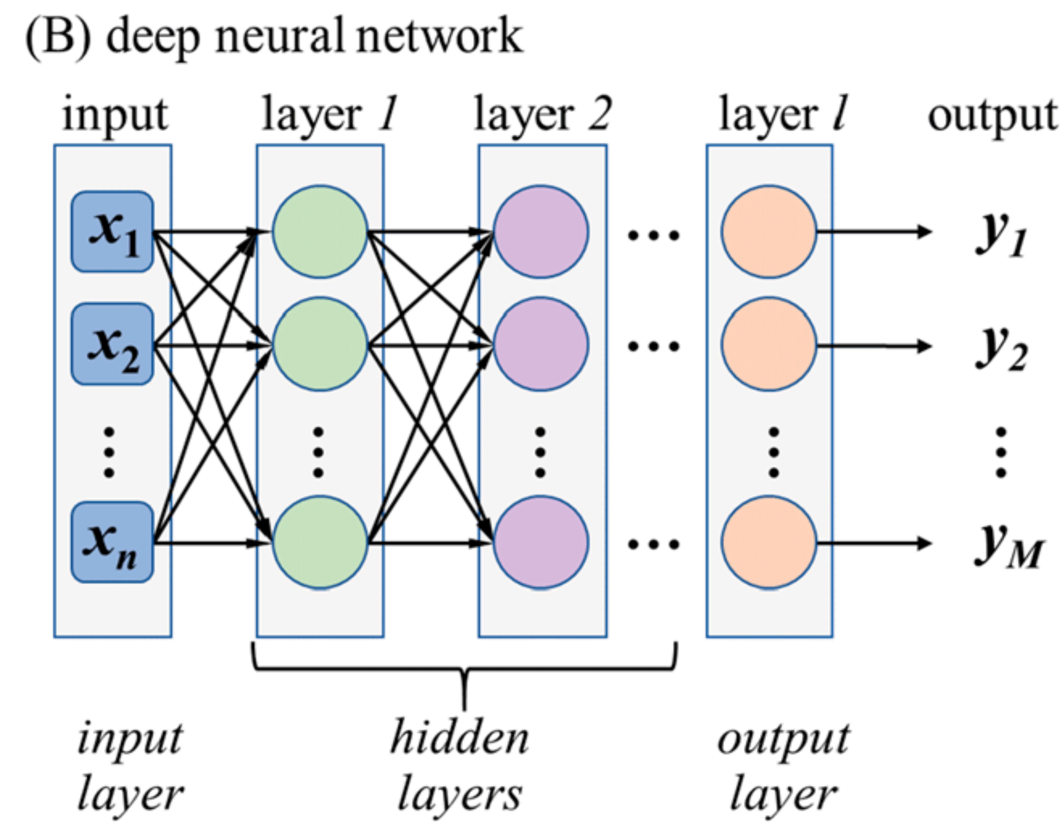




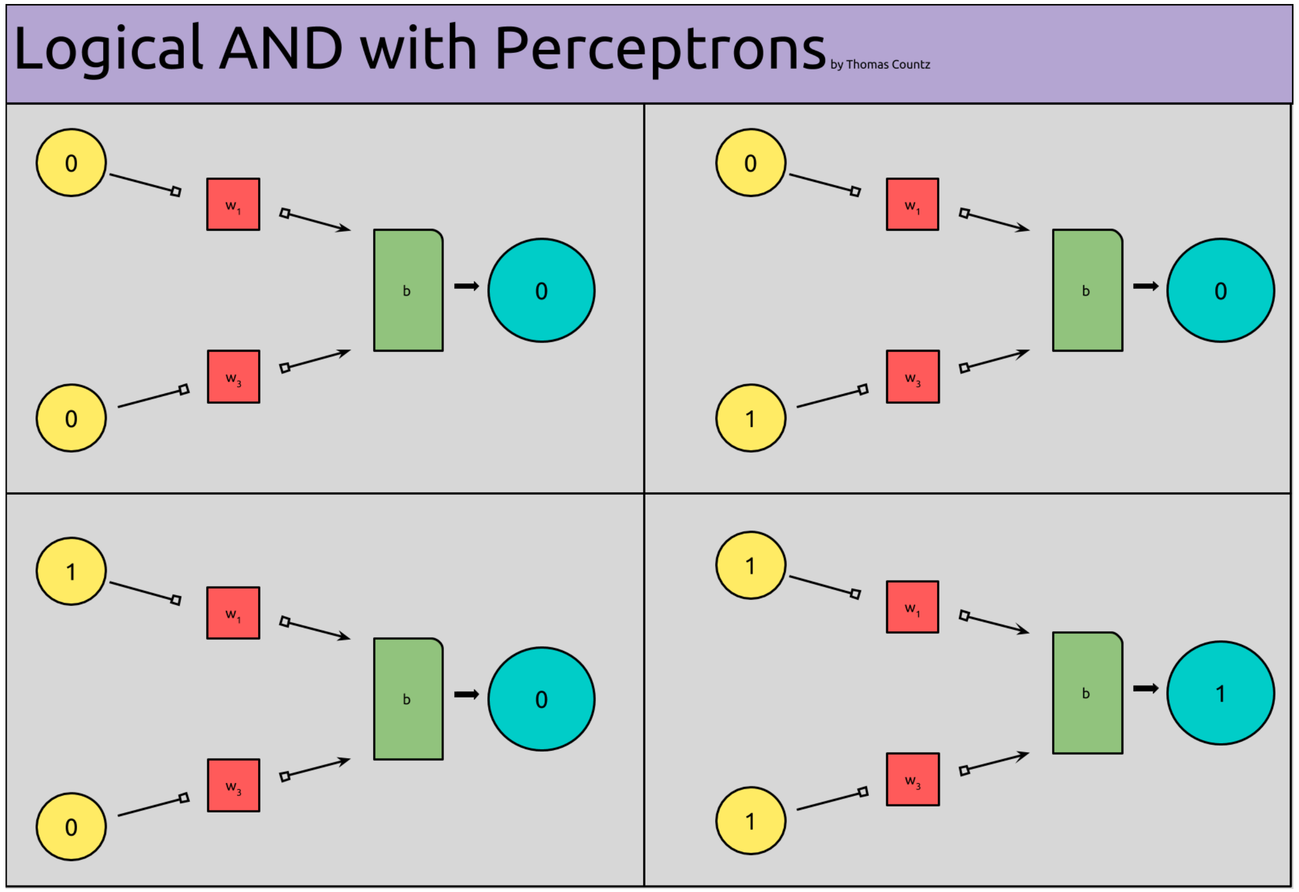


Neural network





A Simple Example of Perceptron AND



A	B	AND
0	0	0
0	1	0
1	0	0
1	1	1

f(x)=1 if w.x + b > 0
f(x)=0 if otherwise

y	f(x)	y - f(x)
1	1	0
0	0	0
1	0	1
0	1	-1

How to adjust the weights

- If perceptron outputs 0 (f(x)=0), when we want 1 (y=1), adjust by making w.x+b larger
  y - f(x) == 1, then w + x —> w

- If perceptron outputs 1 (f(x)=1), when we want 0 (y=0), adjust by making w.x+b smaller
  y - f(x) == -1, then w - x —> w

- If perceptron outputs expected value, f(x) == y, adjust nothing
  y - f(x) == 0, then w —> w

Since y-f(x) only produces 1,-1,0, simplify w + (y-f(x)) * x —> w

https://medium.com/@thomascountz/perceptron-implementing-and-part-2-84bfb1f46597
https://medium.com/@thomascountz/19-line-line-by-line-python-perceptron-b6f113b161f3