

Artificial Neural Networks

Artificial Intelligence and Brain

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Materials are here:

<https://github.com/yungbyun/neuralnetworks>

git clone *link*

Agenda

- Artificial Intelligence
- Brain and neuron
- Synapses, the core of neural networks
- Neuron, equation, and matrix

Intelligence



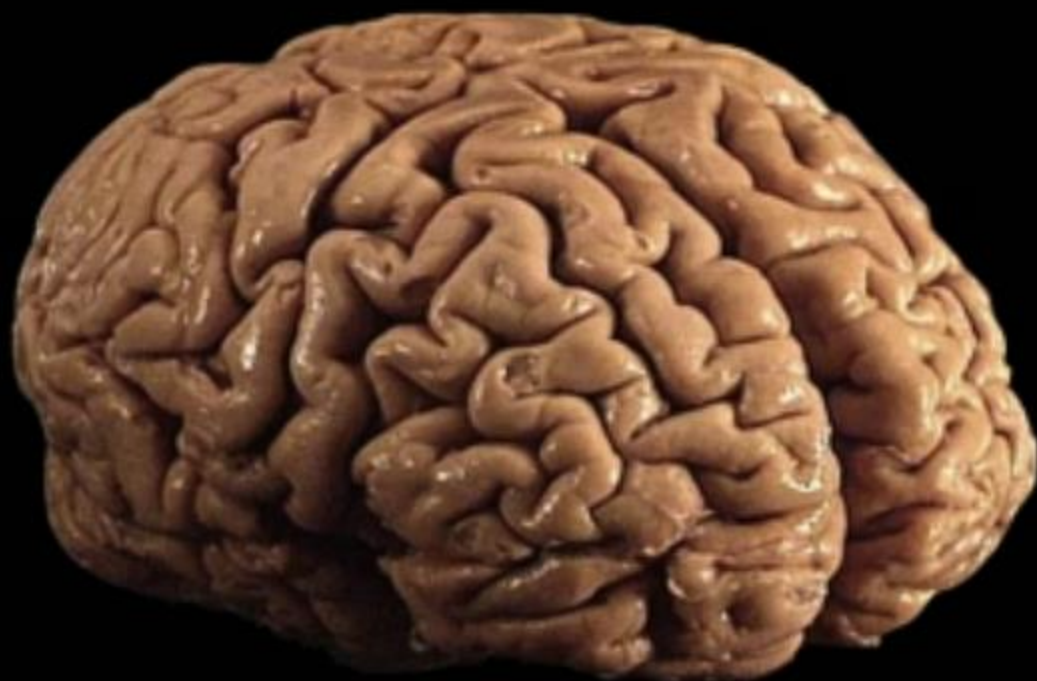
- One's **capability** for logic, understanding, self-awareness, **learning**, planning, creativity, and problem solving
- The **ability** to **perceive** information, and to **retain** it as knowledge to be **applied** towards adaptive behaviors within an environment
- Human Intelligence = Natural Intelligence

Artificial Intelligence

- Intelligence exhibited **by machines**
- A **computerized version** of the human intelligence
- **Theory** and development of computer systems able to perform tasks such as visual perception, voice recognition, decision-making, and translation between languages

How can machines
get *Artificial* Intelligence?

How can human
get *natural* intelligence?



What happens inside
the human brain?

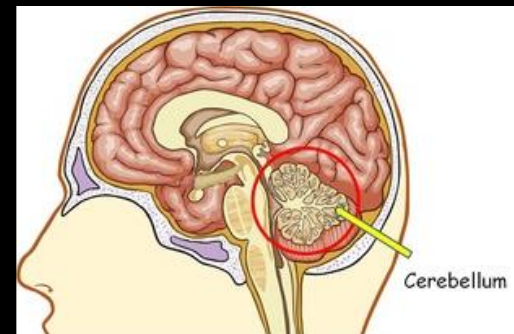
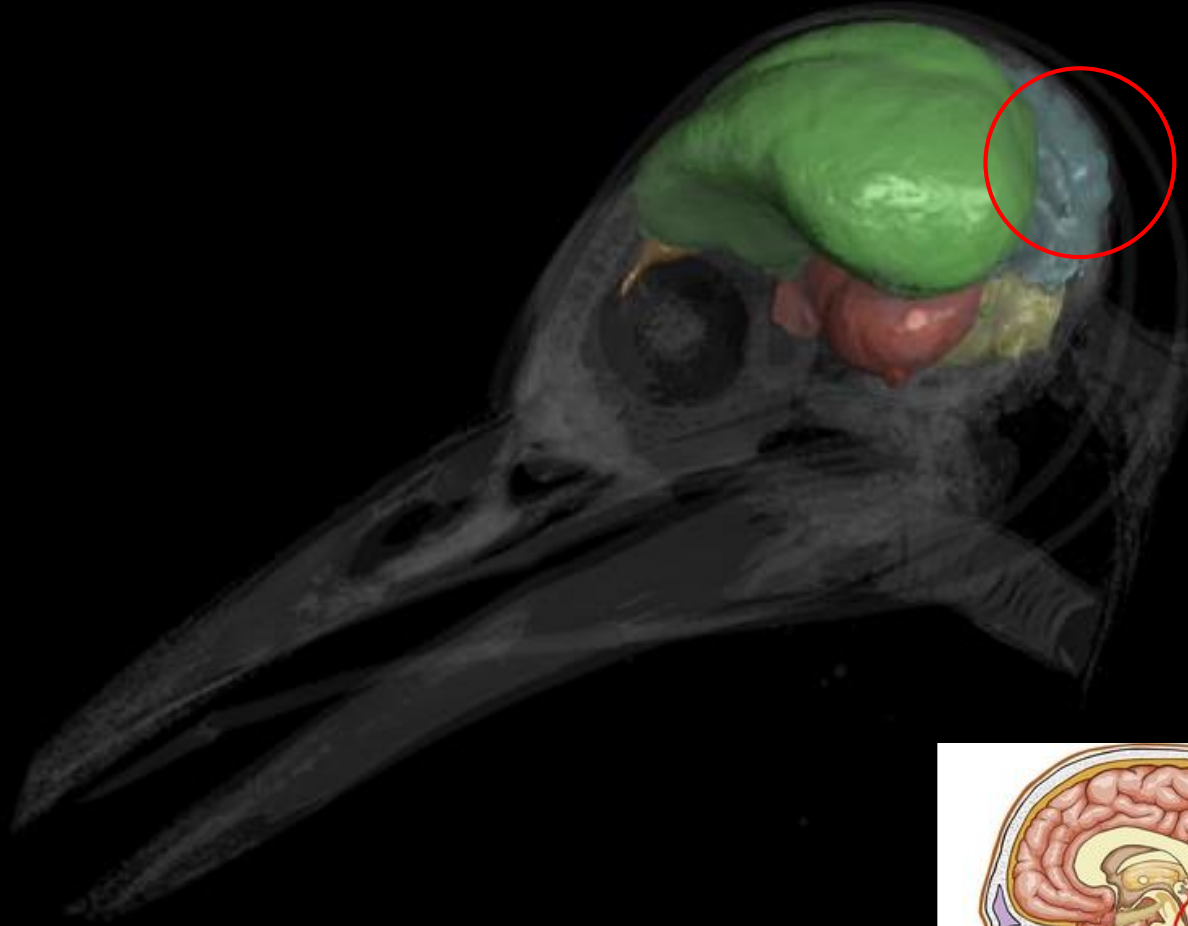
Neuroanatomist

신경해부학자

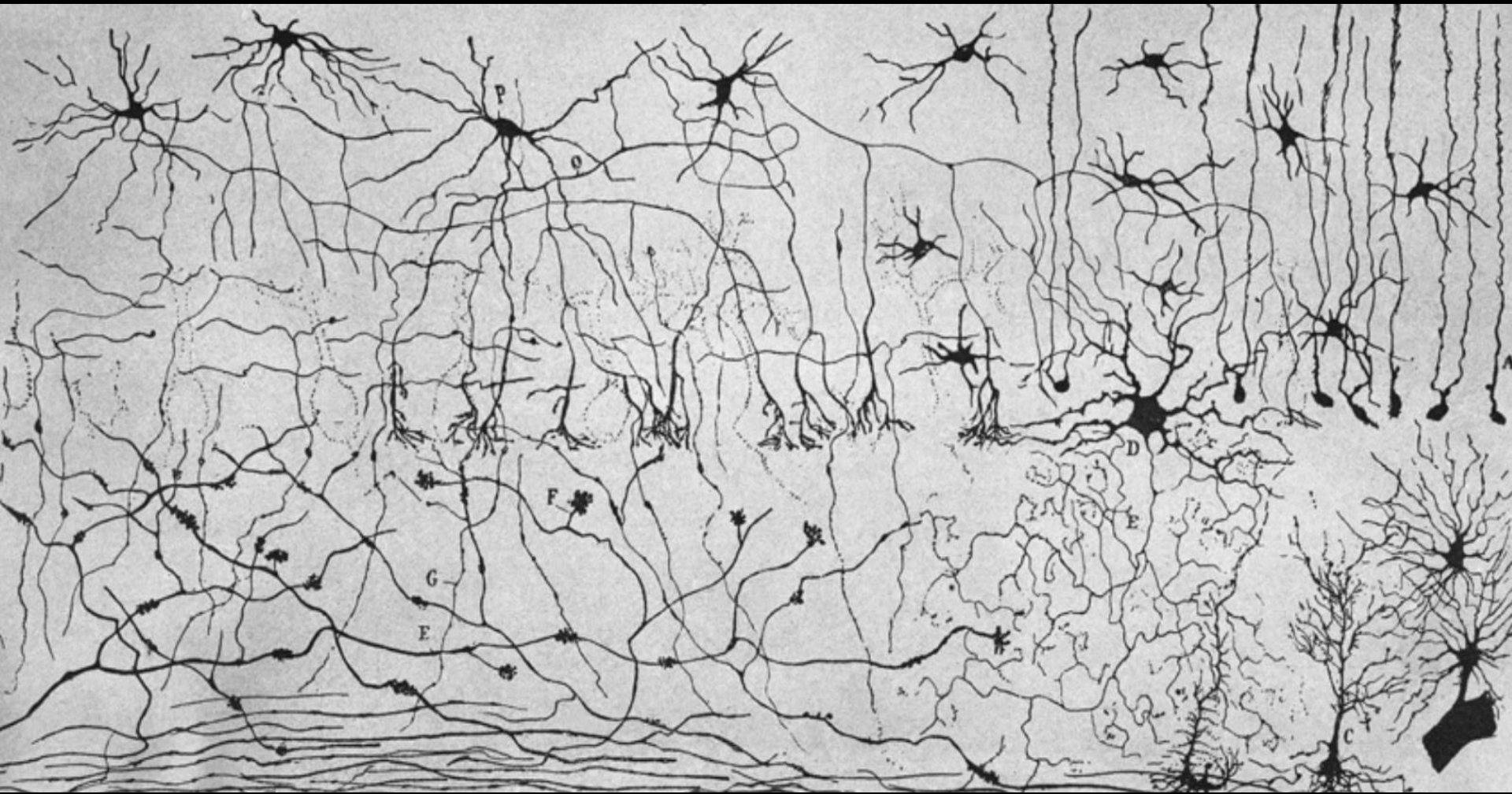


Santiago Ramón y Cajal, 1852-1934

Cerebellum(소뇌) : controls muscles

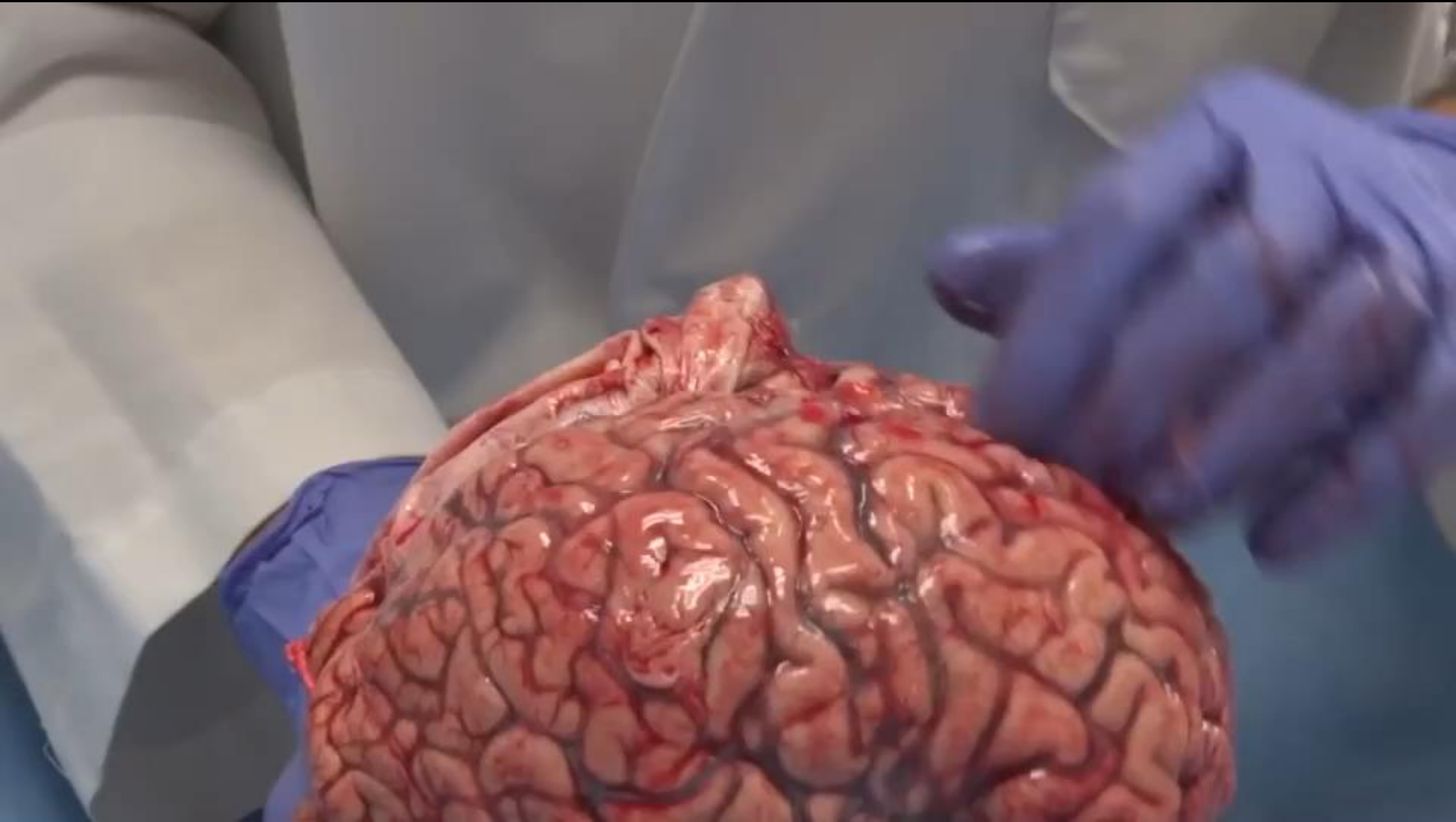


Neurons in a bird's brain



Ramón y Cajal's drawing of **the neurons in a bird's cerebellum** – a part of the brain.

Brain of Human

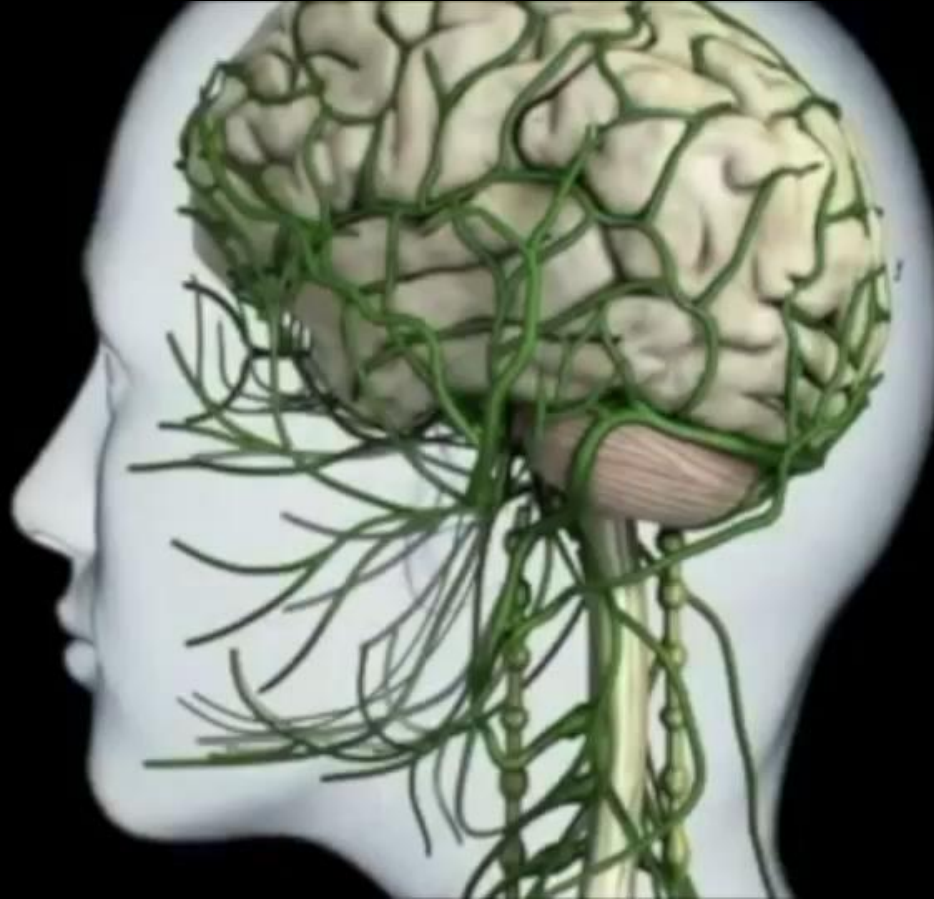






100 billion neurons
more than
the number of stars
in the universe

So, what happens inside?



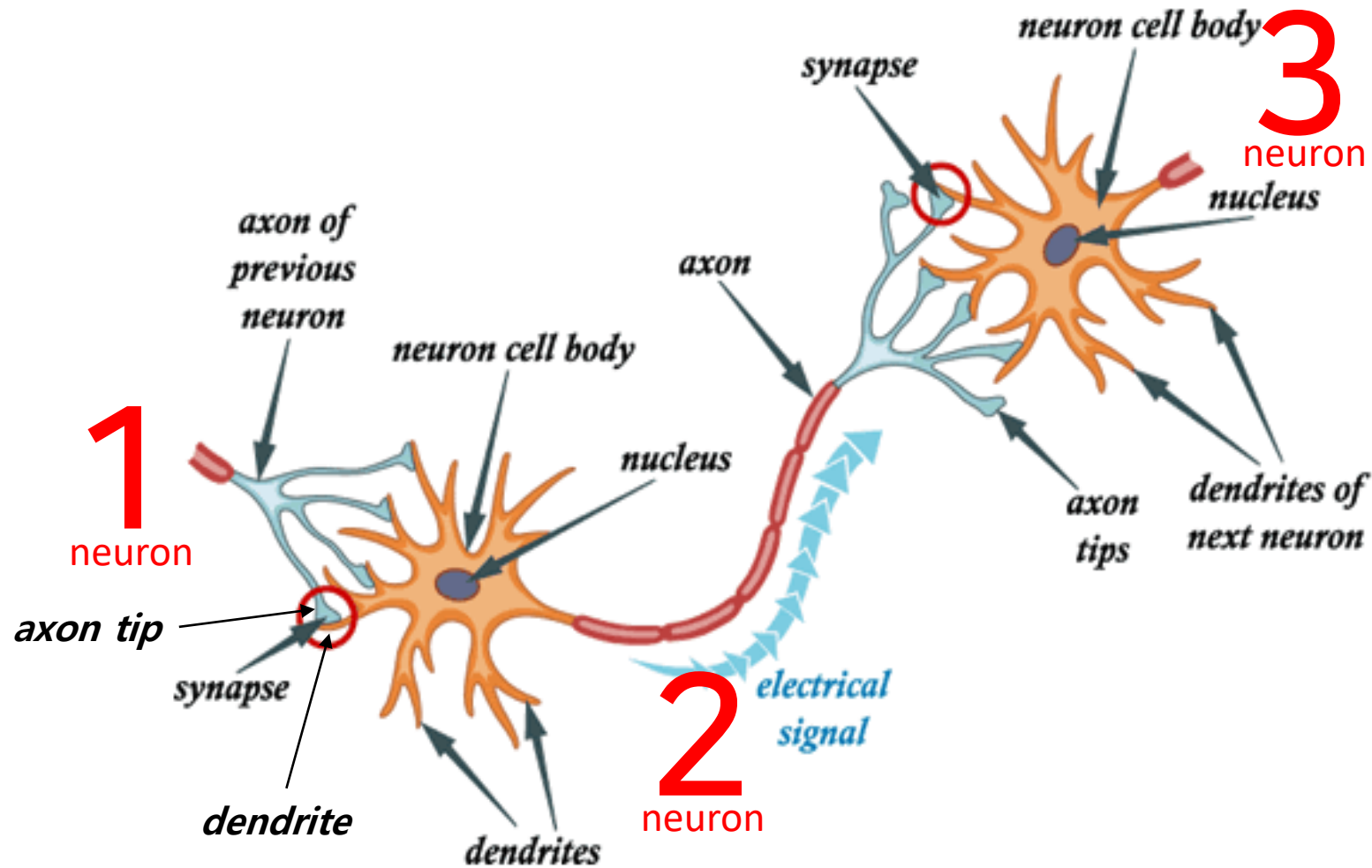
From a DVD that comes with the illustrated medical atlas, The Human Brain, DK Publishing UK.

Simulation(signaling)

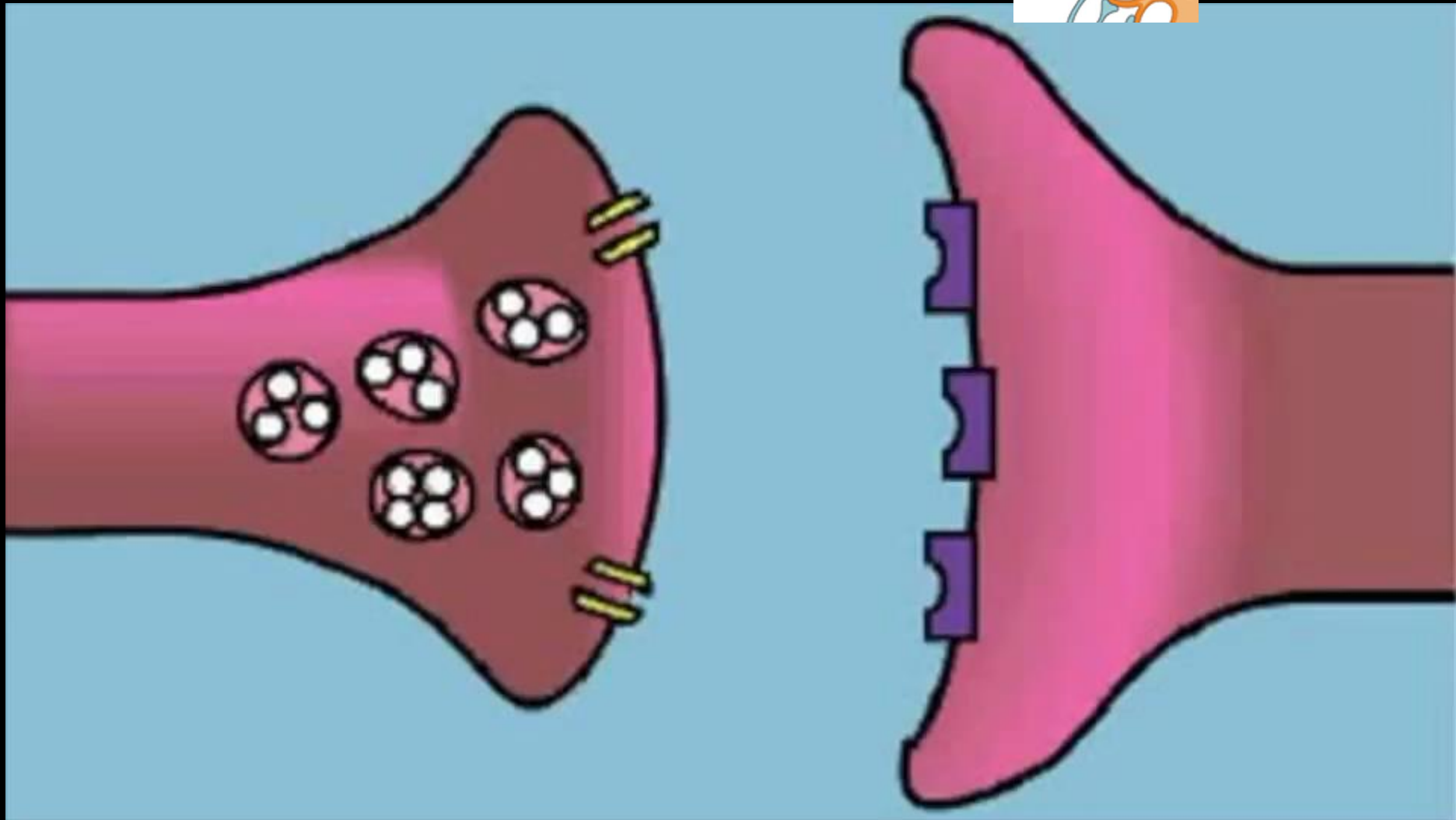
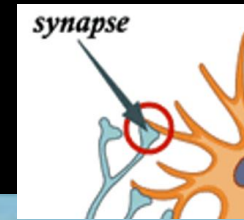


A brain in a supercomputer | Henry Markram

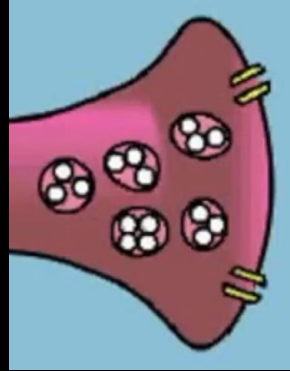
Connection between neurons



Synapse



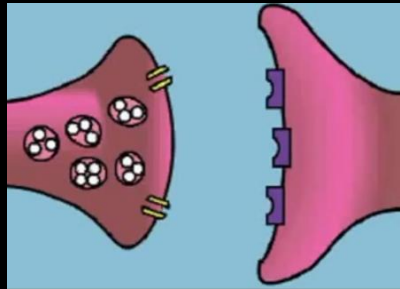
The Brain—Lesson 2—How Neurotransmission Works



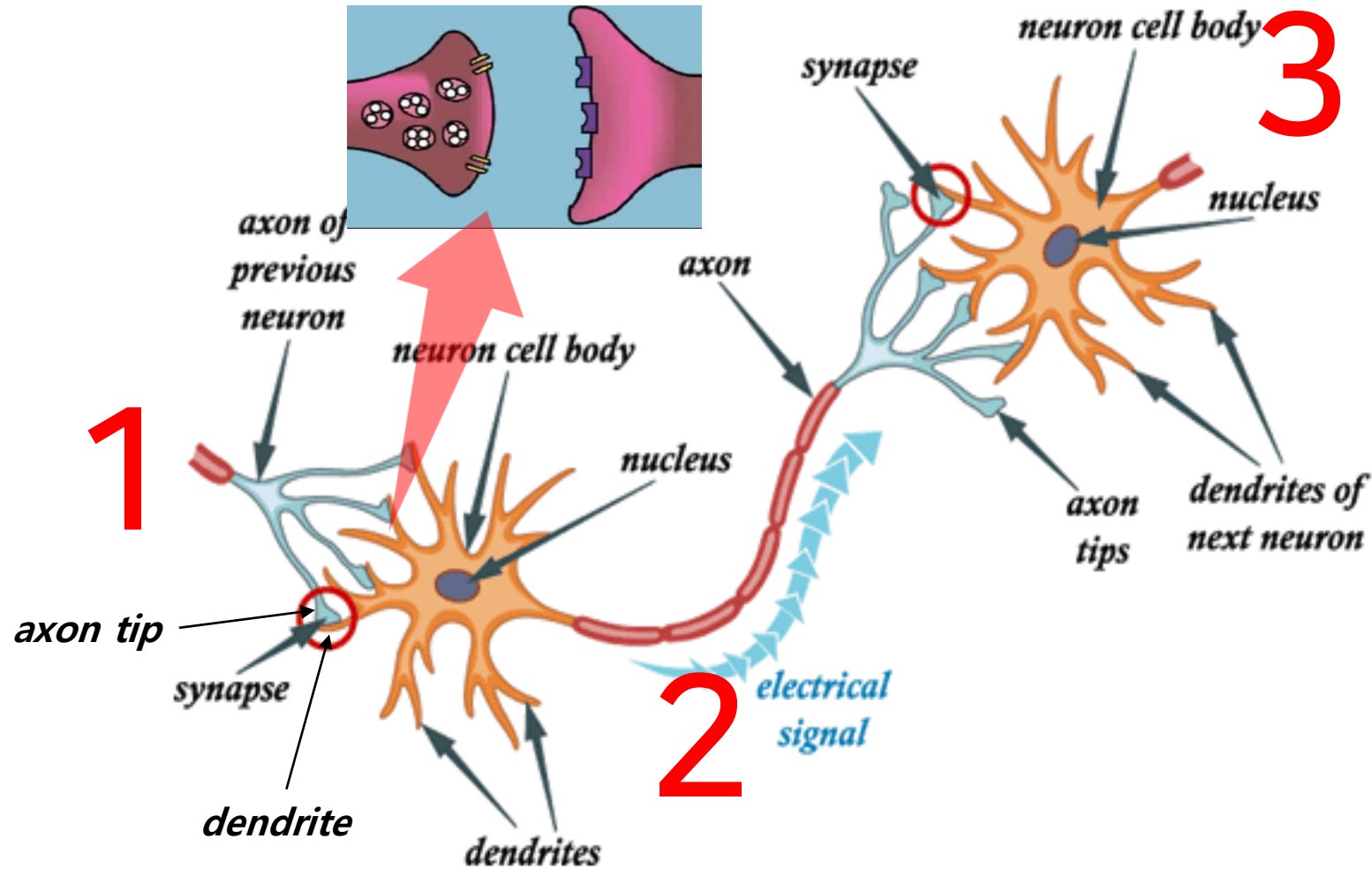
Neurotransmitter in synapse

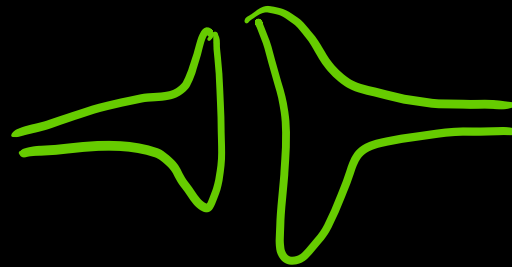
신경전달물질

Various amount of
neurotransmitter in
each synapse

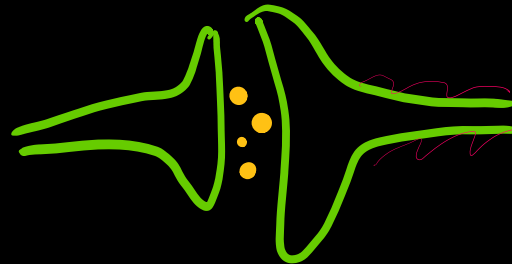


Connection between neurons

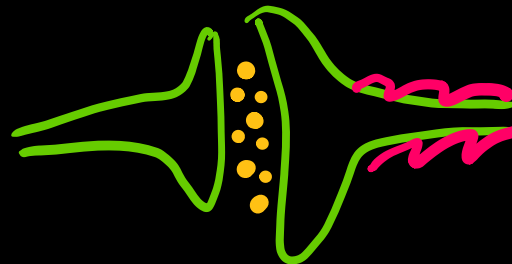




No neurotransmitter
No signal to the
nucleus
No connection

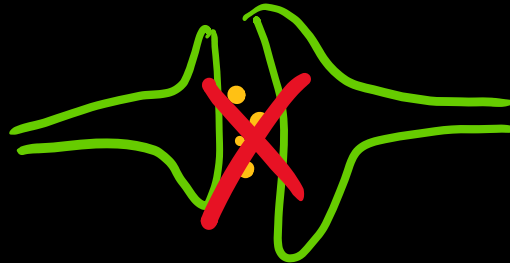
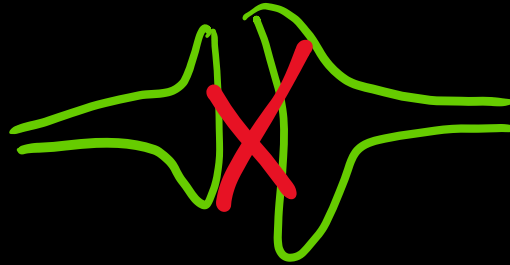


small
week



big
strong

What happens if



Alzheimer's

Loss of memory, Paralysis

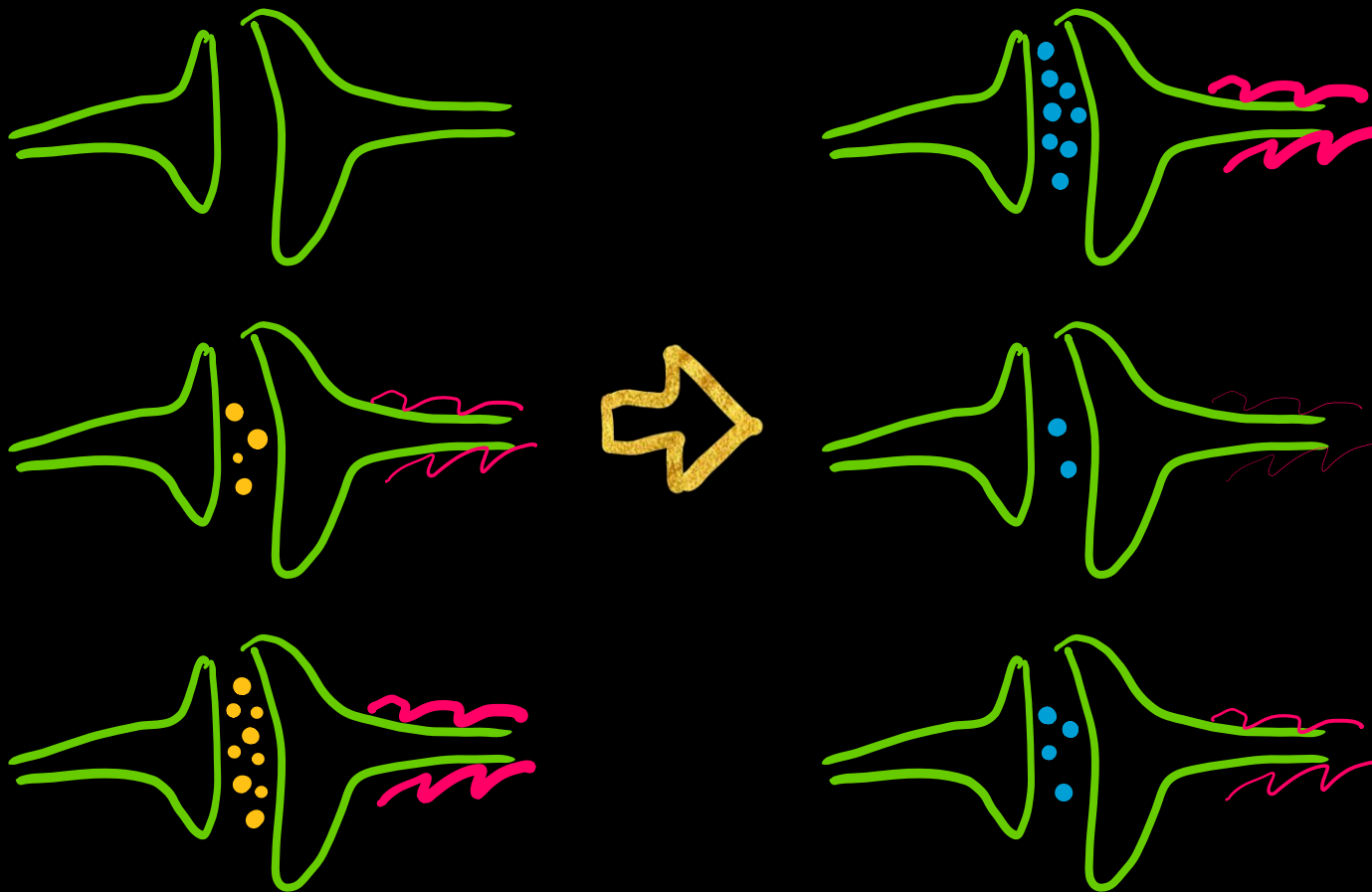
Our memory
thinking
moving
emotion
and everything



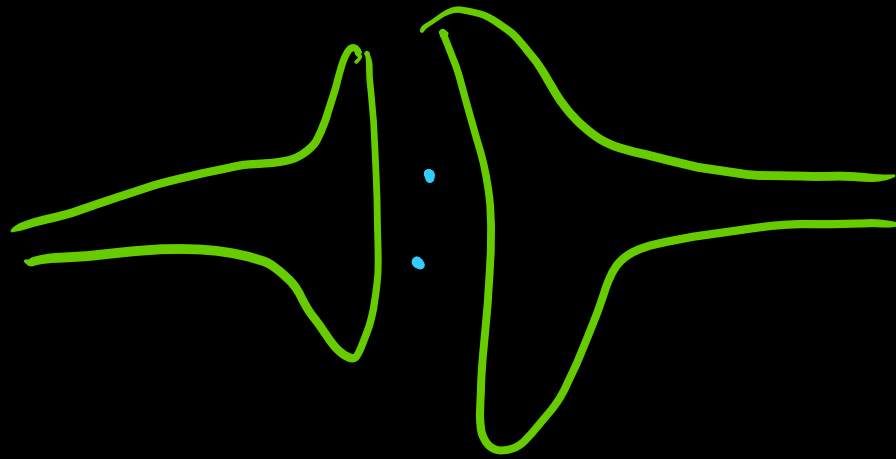
Experience and
the adjusting of the
amount of
neurotransmitter



Experience \rightarrow Adjusting



3 variables implementation with Python



Learning



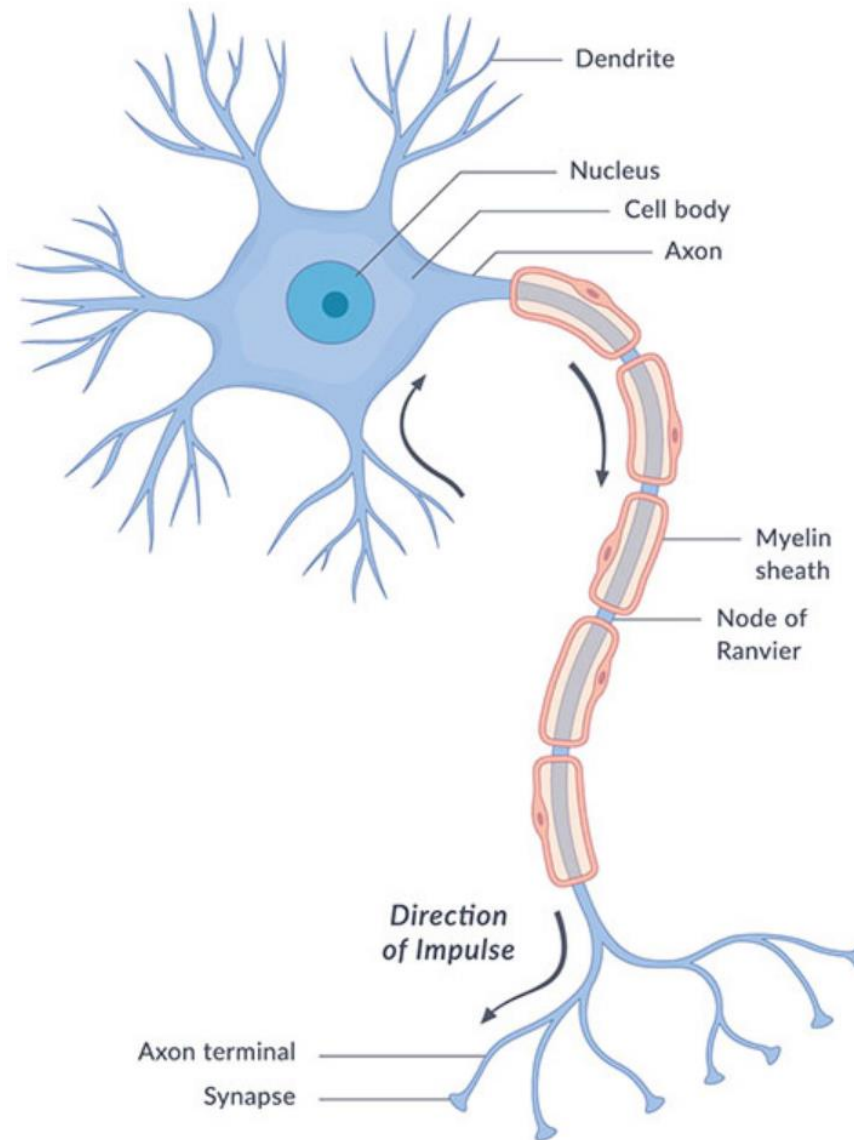
Happiness



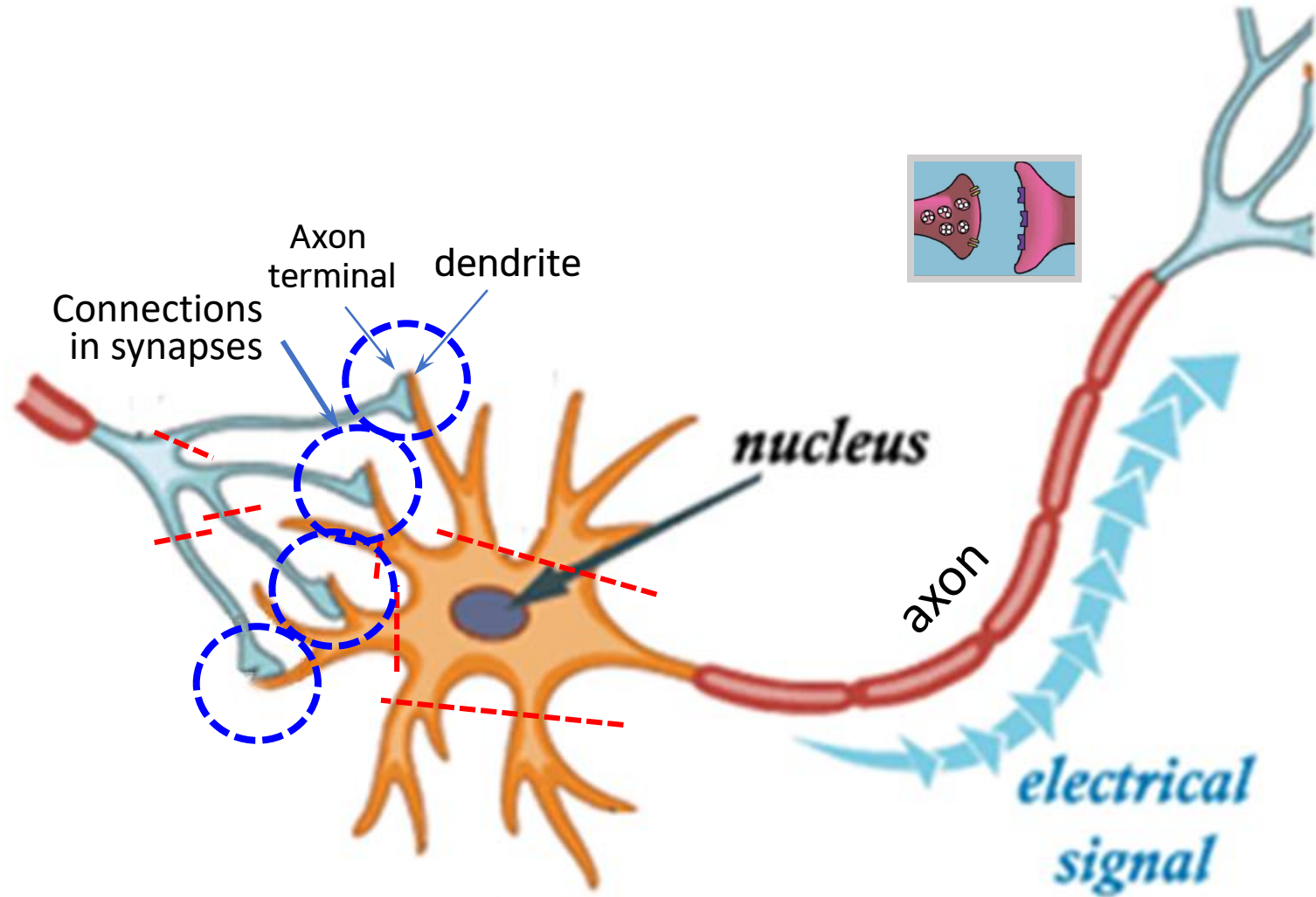
Stress

Stress/Error/Cost/Loss function

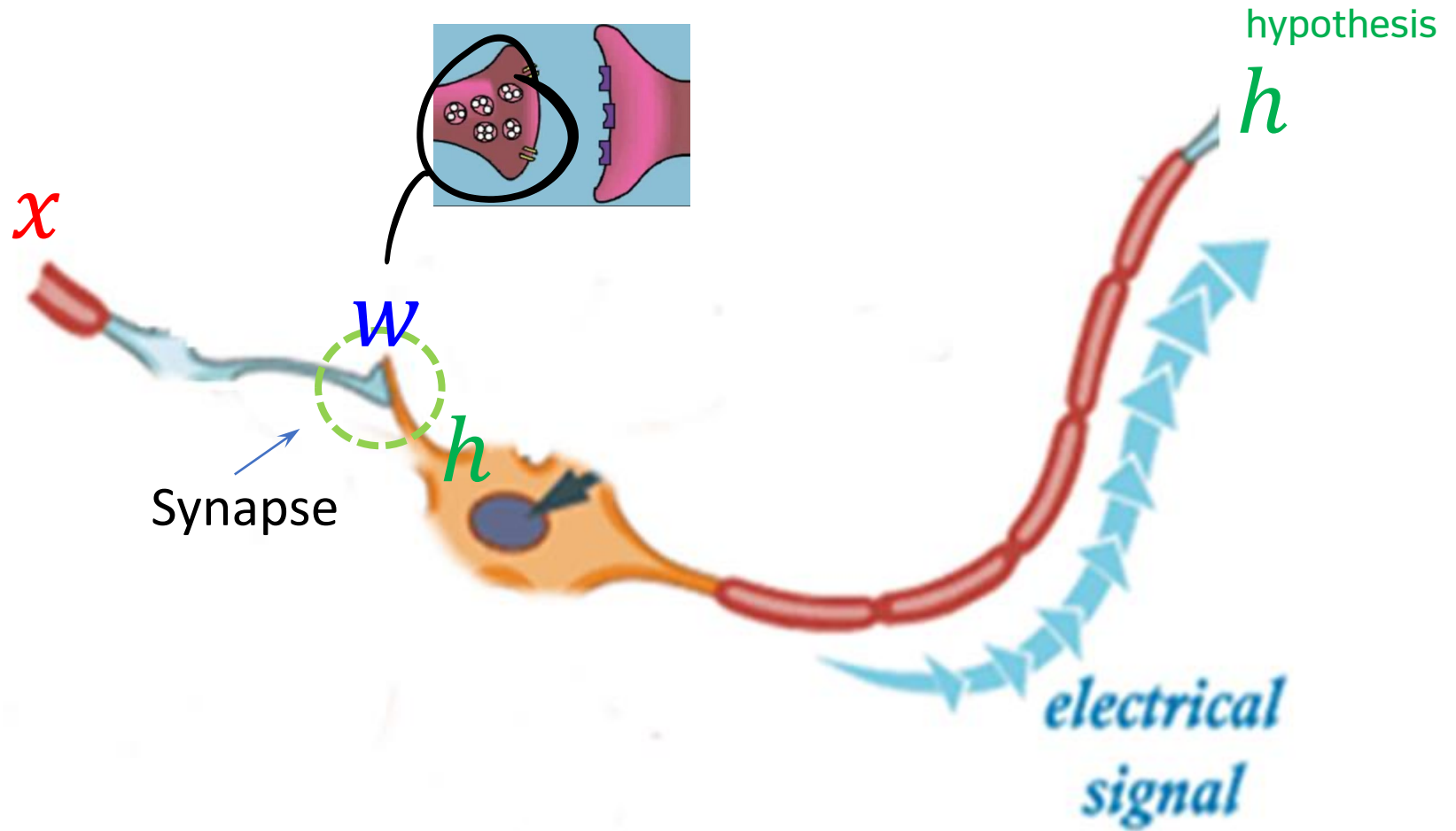
S/W implementation
→ AI



A Neuron with Multiple Inputs



A Neuron with 1 Input



h, Hypothesis

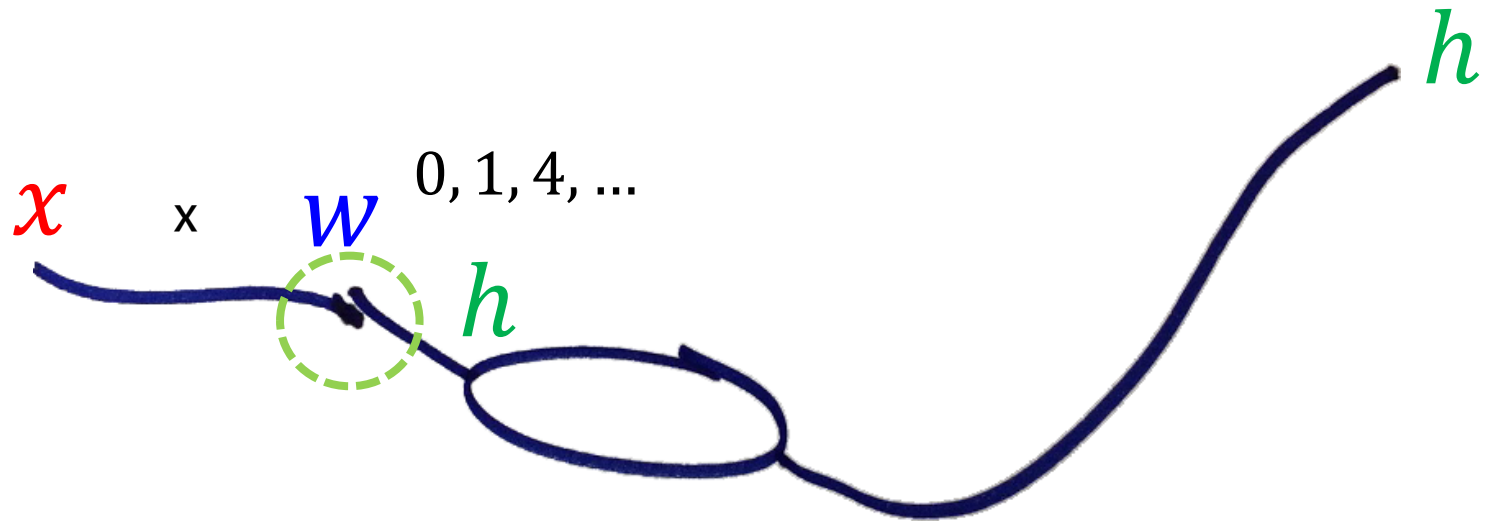


A **hypothesis** (plural **hypotheses**) is a proposed explanation for a phenomenon.

Explanation about **the way a neuron works in**.

Output of a neuron, prediction

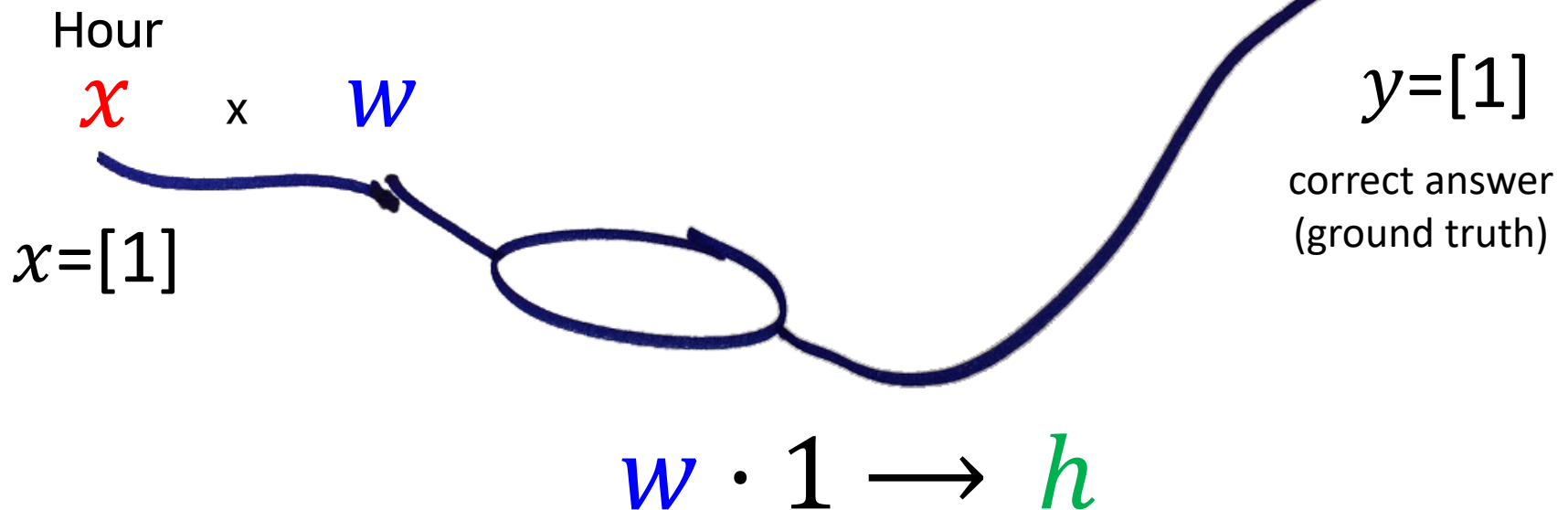
Action of a neuron



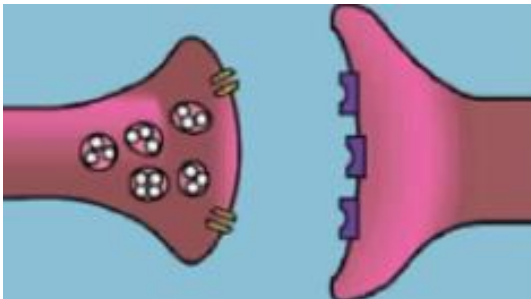
$$h = wx$$

Application: Wage Calculator NN

- Knowledge: 1 hour working(**input** x) \rightarrow 1USD(**groundtruth** y) payment
- How much you get for 3 hours? (**prediction**)
- Finding the correct value of $W \rightarrow$ Learning



x (hour)	w	Output of a neuron	y (wage)	Error	Reaction
1	4(random)	4	1	4-1	scolding seriously
1	2	2	1	2-1	ordinarily
1	1.5	1.5	1	1.5-1	not bed
1	1.3	1.3	1	1.3-1	good but not enough
1	1.1	1.1	1	1.1-1	acceptable



Scolding a dog/dolphin/child
 automatically updates the connection
 strength(w)

to make the error smaller in
 the next step.

Learning

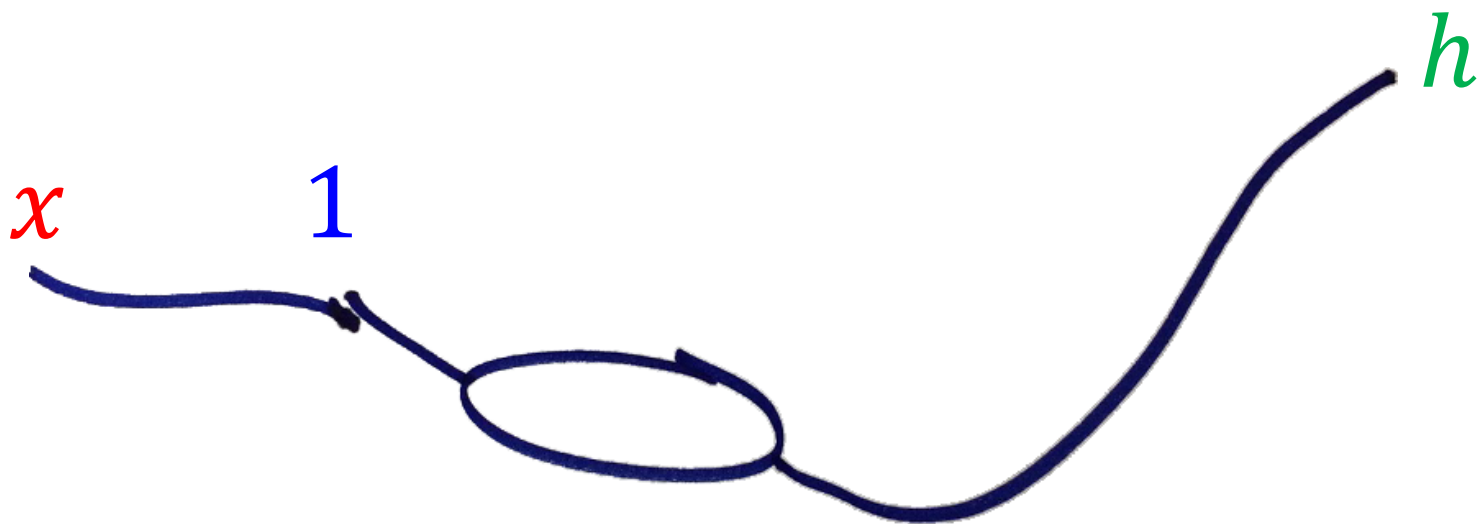
is to find the optimal value of parameter (w) to predict correctly.

the amount of
neurotransmitter

Drawing a neuron

Representing the below equation:

$$h = 1x$$

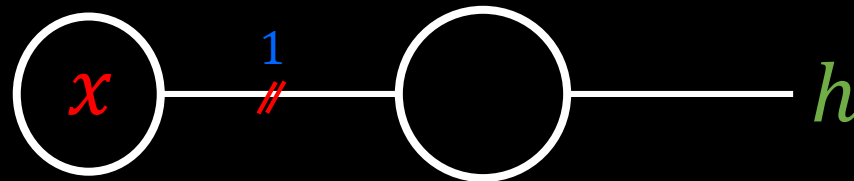


$$h = 1x$$

Matrix notation

$$(x)(1) \rightarrow (h)$$

Simplified version



$$(1)(1) \rightarrow (h)$$

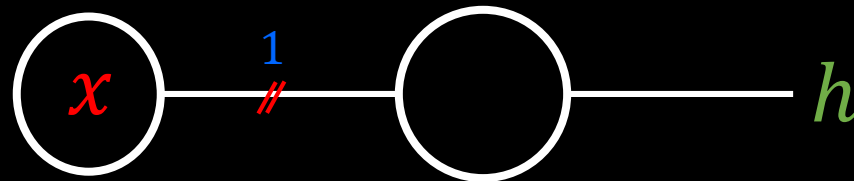
Where is the synapse/connection?



Matrix notation

$$\begin{pmatrix} x \end{pmatrix} \begin{pmatrix} 1 \end{pmatrix} \rightarrow \begin{pmatrix} h \end{pmatrix}$$

Simplified version



$$\begin{pmatrix} 1 \\ 2 \end{pmatrix} \begin{pmatrix} 1 \end{pmatrix} \rightarrow \begin{pmatrix} h_1 \\ h_2 \end{pmatrix}$$

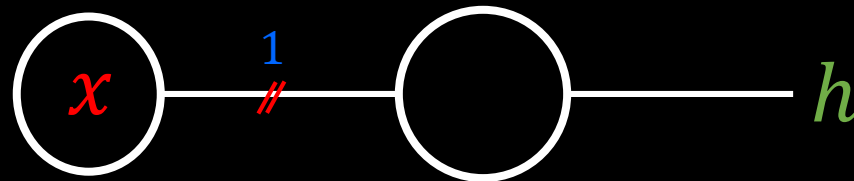
Where is the synapse/connection?



Matrix notation

$$(\textcolor{red}{x})(\textcolor{blue}{1}) \rightarrow (h)$$

Simplified version



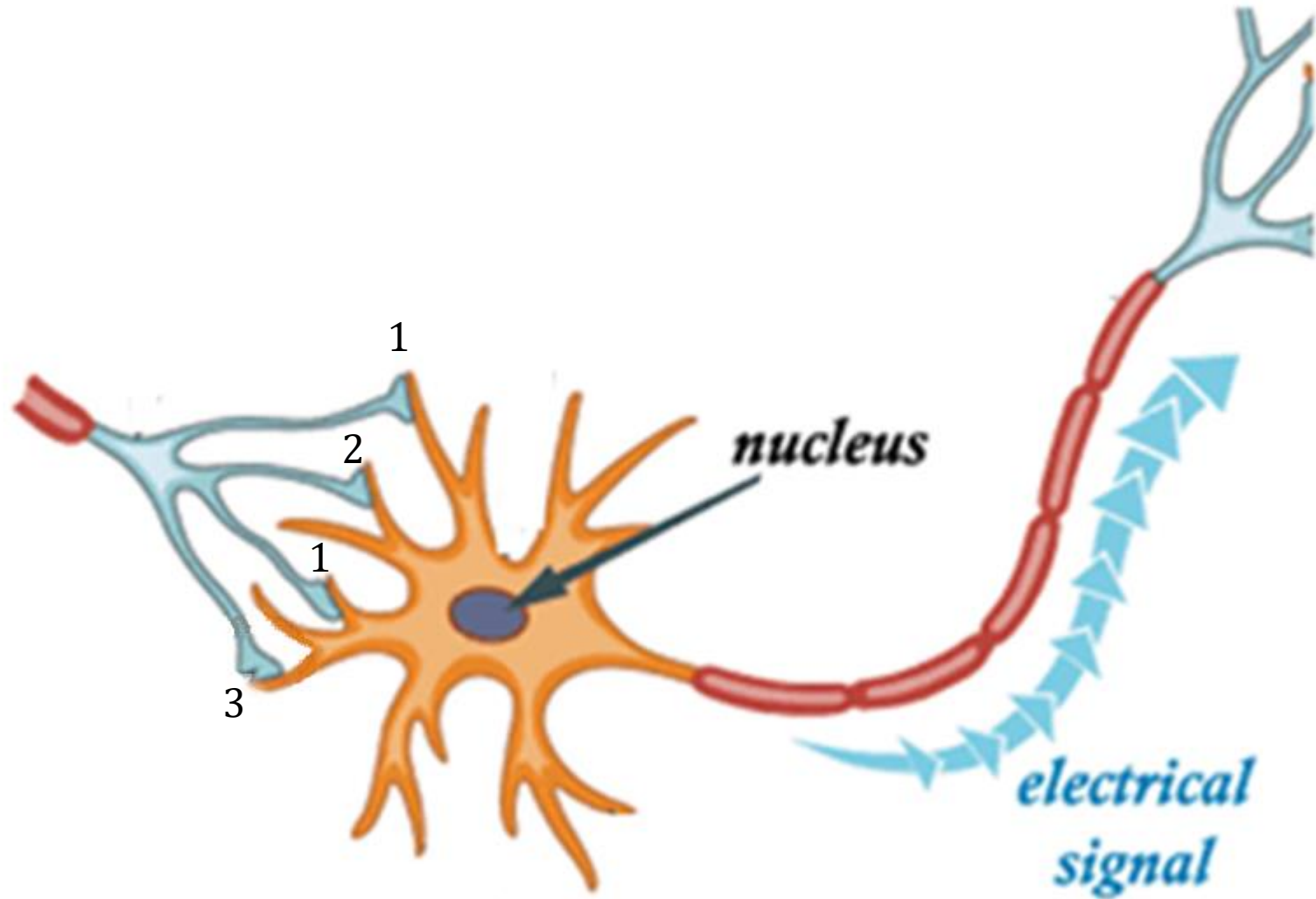
Where is the synapse/connection?

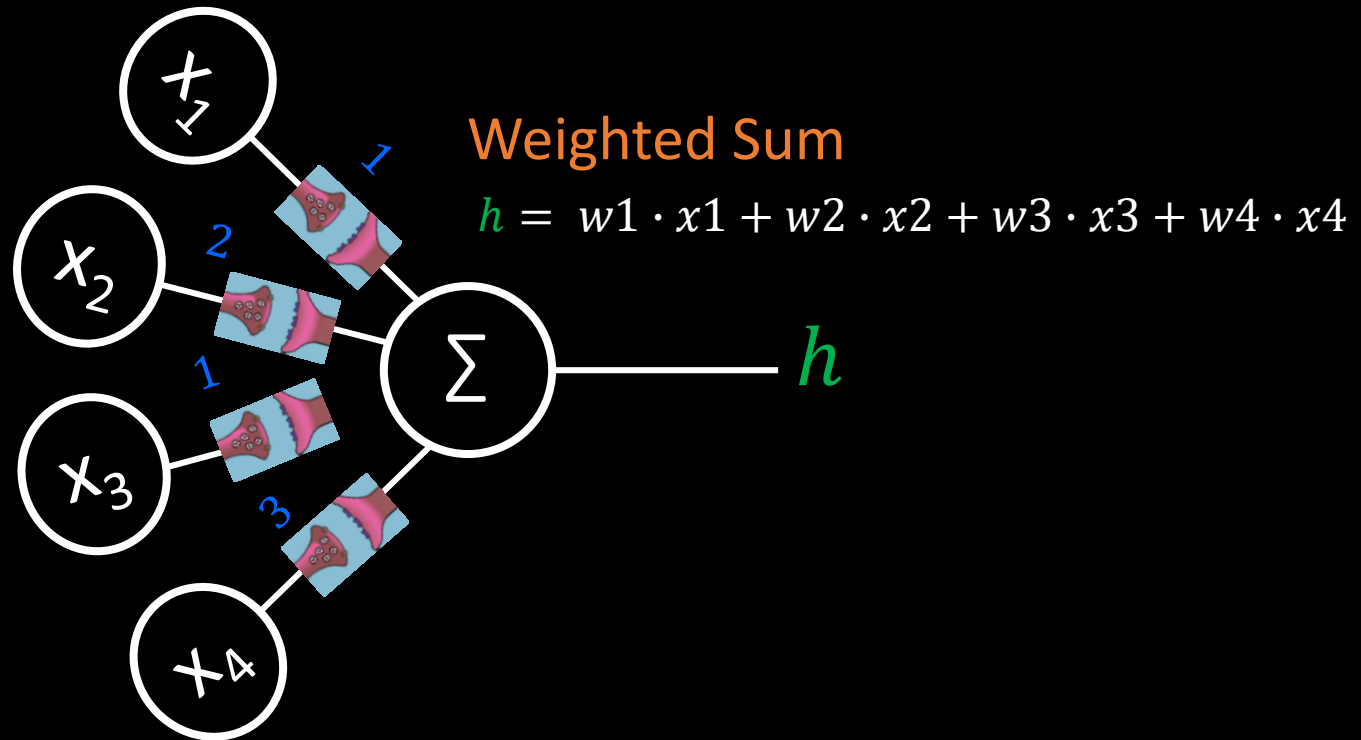
$$\begin{pmatrix} 1 \\ 2 \\ \textcolor{red}{3} \end{pmatrix} (\textcolor{blue}{1}) \rightarrow \begin{pmatrix} h_1 \\ h_2 \\ h_3 \end{pmatrix}$$



A neuron and the **matrix** to describe the action of it.

A Neuron with Multiple Inputs





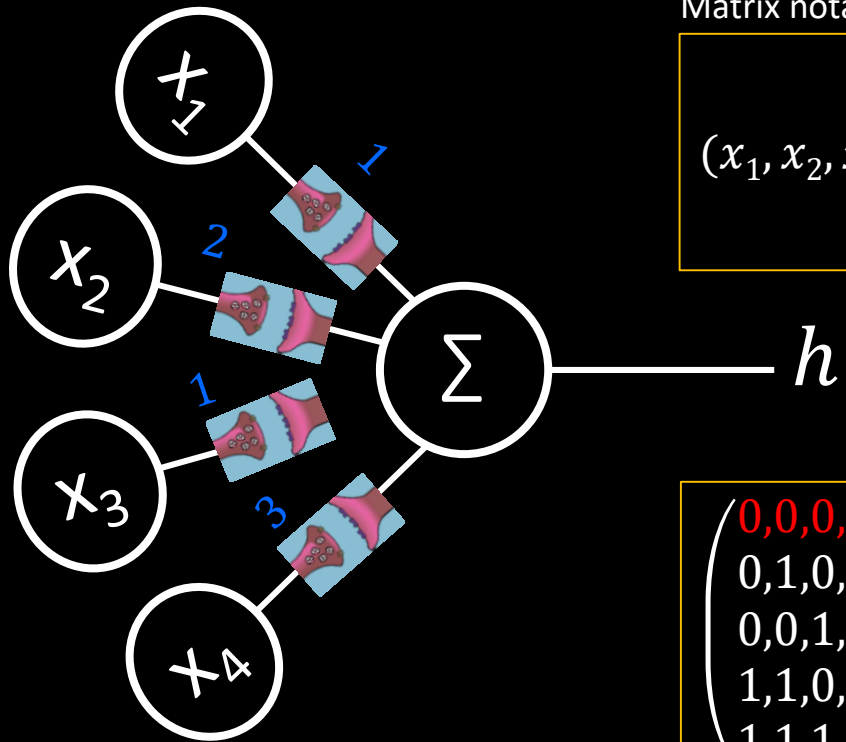
if the input values are (0,0,0,1), then h is ..

$$h = 1 \cdot x_1 + 2 \cdot x_2 + 1 \cdot x_3 + 3 \cdot x_4$$



Matrix notation

$$(x_1, x_2, x_3, x_4) \begin{pmatrix} 1 \\ 2 \\ 1 \\ 3 \end{pmatrix} \rightarrow (h)$$



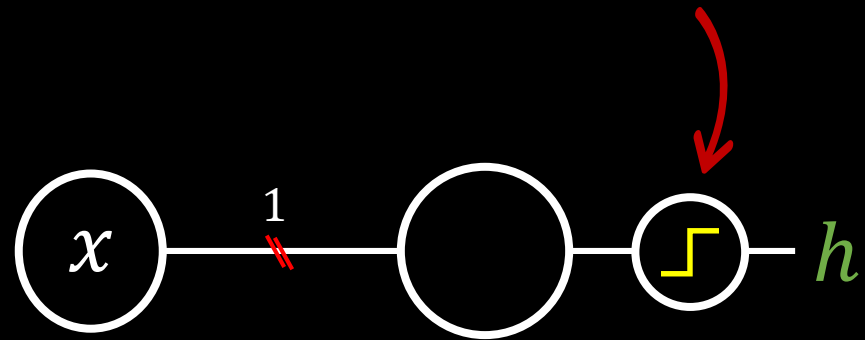
Matrix notation

$$(x_1, x_2, x_3, x_4) \begin{pmatrix} 1 \\ 2 \\ 1 \\ 3 \end{pmatrix} \rightarrow (h)$$

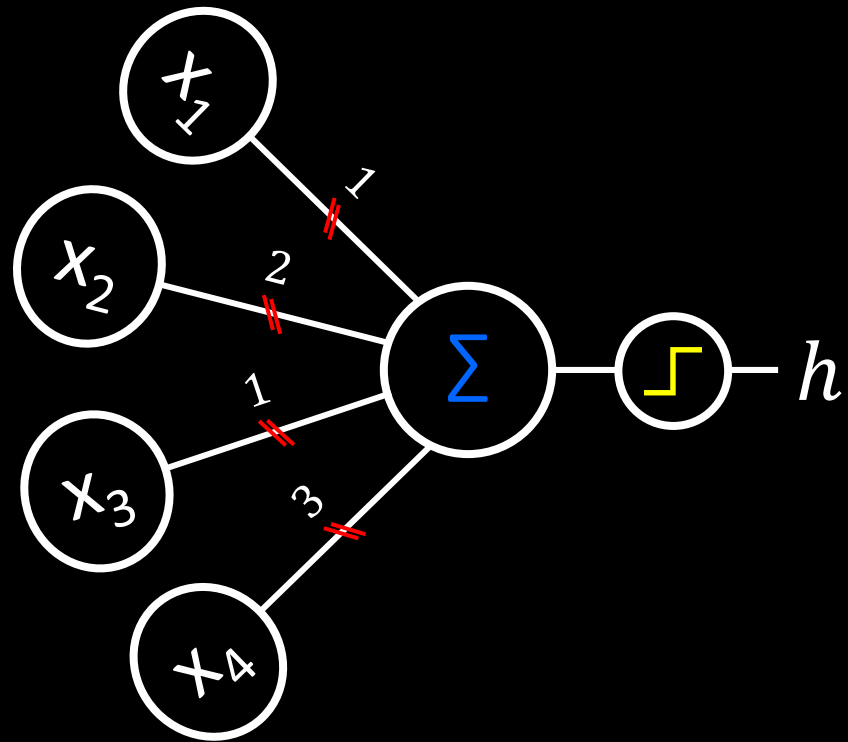
$$\begin{pmatrix} 0,0,0,1 \\ 0,1,0,1 \\ 0,0,1,1 \\ 1,1,0,0 \\ 1,1,1,1 \end{pmatrix} \begin{pmatrix} 1 \\ 2 \\ 1 \\ 3 \end{pmatrix} \rightarrow \begin{pmatrix} h_1 \\ h_2 \\ h_3 \\ h_4 \\ h_5 \end{pmatrix}$$

Real operation of a neuron

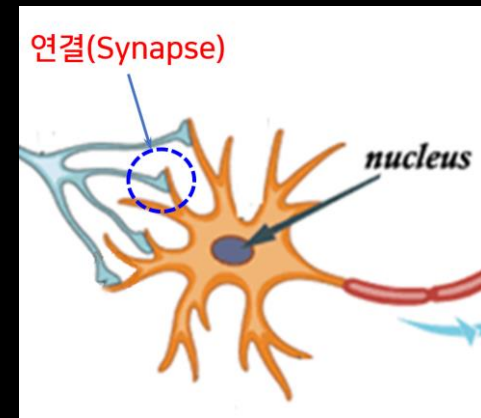
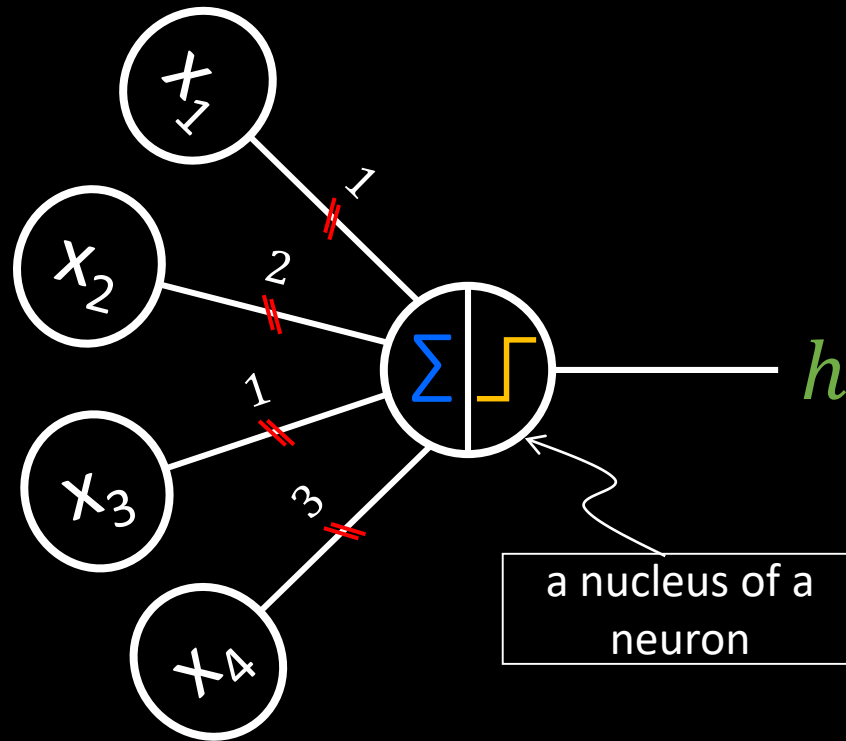
- More than weighted sum
- Thresholding
- signal ON if the weighted sum is greater than T
- otherwise signal OFF



Thresholding



Weighted sum and thresholding



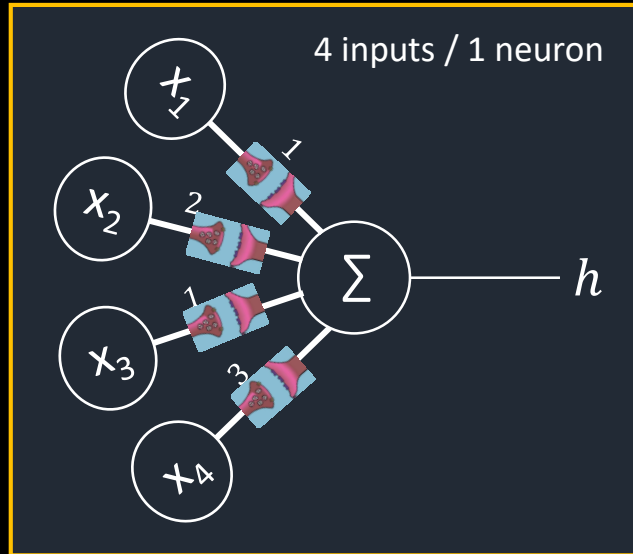
$$h = \begin{cases} 1 & \text{if } x_1 + 2x_2 + x_3 + 3x_4 > T \\ 0 & \text{otherwise} \end{cases}$$

Drawing
of a neuron

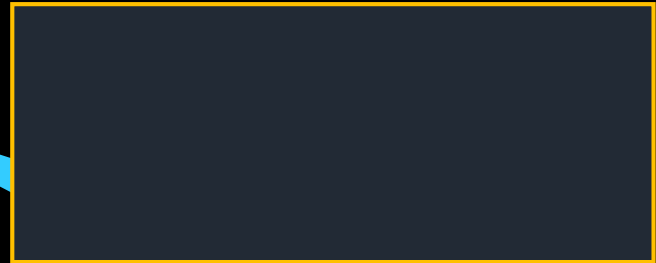
Matrix Notation

Equation

Drawing



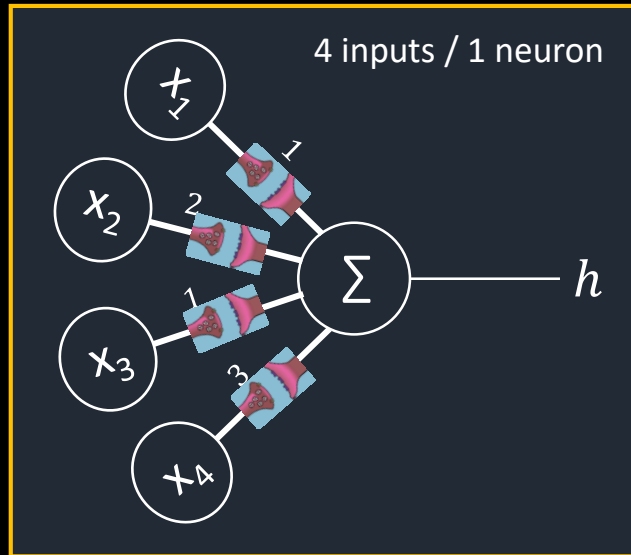
Matrix notation



Equation



Drawing



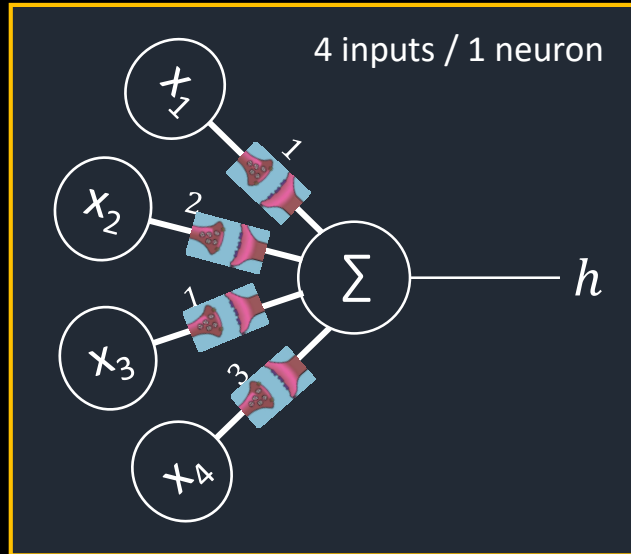
Matrix notation



Equation

$$h = 1 \cdot x_1 + 2 \cdot 1 + 1 \cdot x_3 + 3 \cdot x_4$$

Drawing



Matrix notation

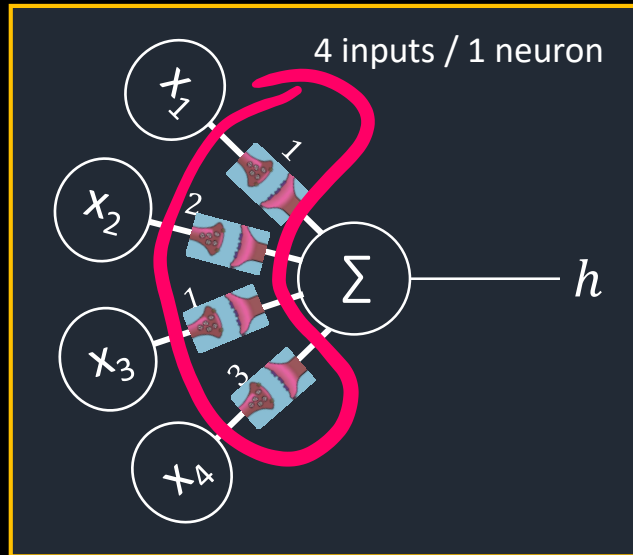
$$(x_1, x_2, x_3, x_4) \begin{pmatrix} 1 \\ 2 \\ 1 \\ 3 \end{pmatrix} \rightarrow (h)$$

Equation

$$h = 1 \cdot x_1 + 2 \cdot 1 + 1 \cdot x_3 + 3 \cdot x_4$$

What is learning again?

Drawing



Matrix notation

$$(x_1, x_2, x_3, x_4) \begin{pmatrix} 1 \\ 2 \\ 1 \\ 3 \end{pmatrix} \rightarrow (h)$$

Equation

$$h = 1 \cdot x_1 + 2 \cdot 1 + 1 \cdot x_3 + 3 \cdot x_4$$

How do we update it?