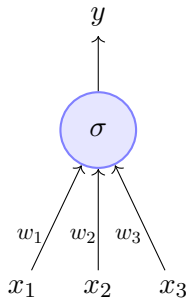
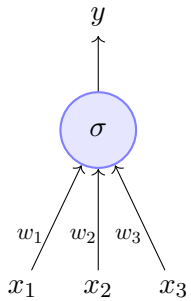
Module 2.1: Biological Neurons



Artificial Neuron

- The most fundamental unit of a deep neural network is called an *artificial neuron*



Artificial Neuron

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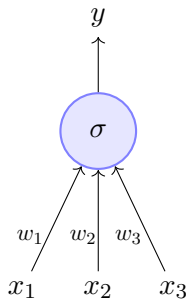
- Why is it called a neuron ? Where does the inspiration come from ?



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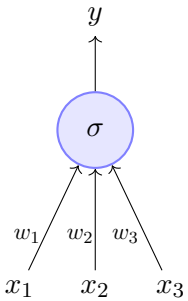

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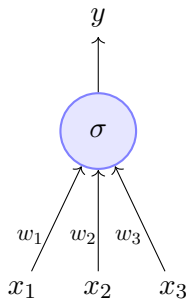

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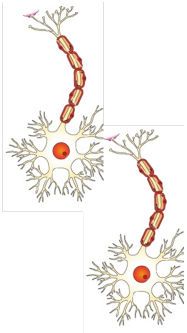
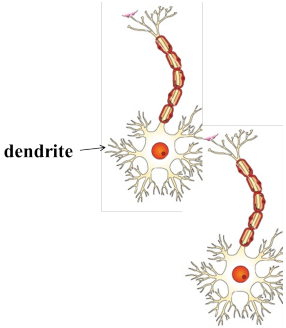
- *biological neurons* = *neural cells* = *neural processing units*
- We will first see what a biological neuron looks like ...



Biological Neurons*

*Image adapted from
https://cdn.vectorstock.com/i/composite/12,25/neuron-cell-vector-81225.jpg



Biological Neurons*

- **dendrite:** receives signals from other neurons

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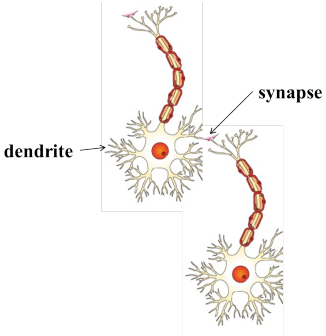

Biological Neurons*

- **dendrite:** receives signals from other neurons
- **synapse:** point of connection to other neurons

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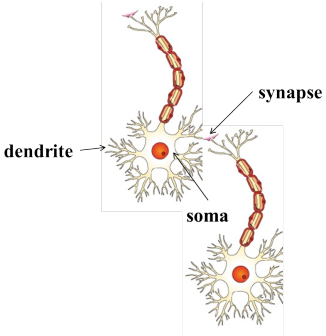

Biological Neurons*

- **dendrite:** receives signals from other neurons
- **synapse:** point of connection to other neurons
- **soma:** processes the information

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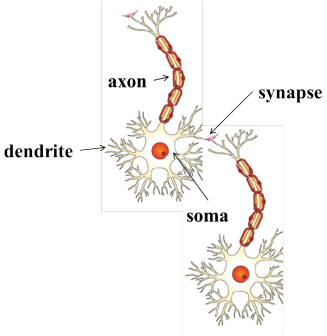

Biological Neurons*

- **dendrite:** receives signals from other neurons
- **synapse:** point of connection to other neurons
- **soma:** processes the information
- **axon:** transmits the output of this neuron

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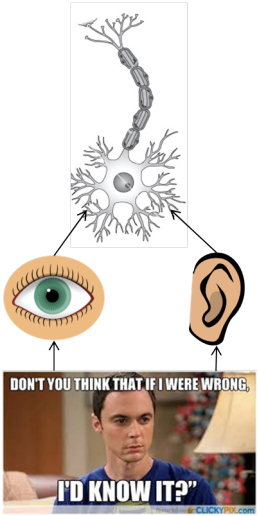

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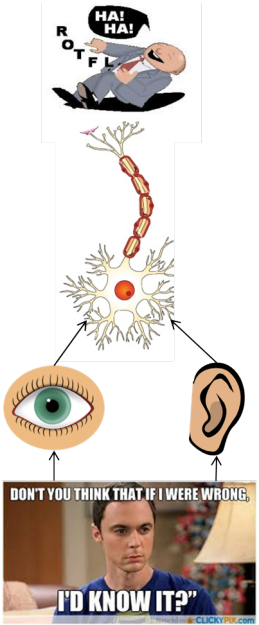
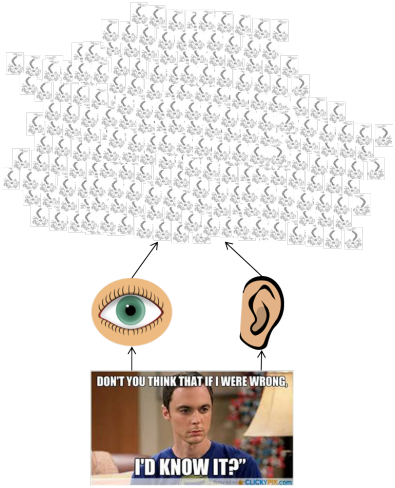
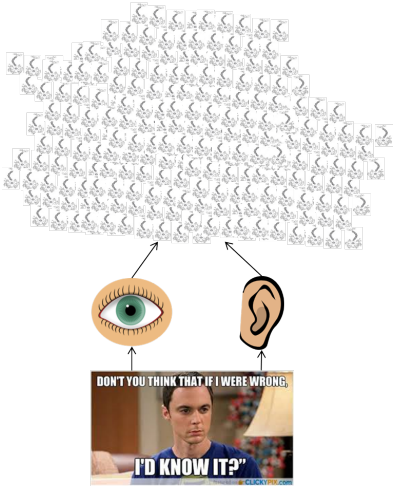
- Our sense organs interact with the outside world
- They relay information to the neurons



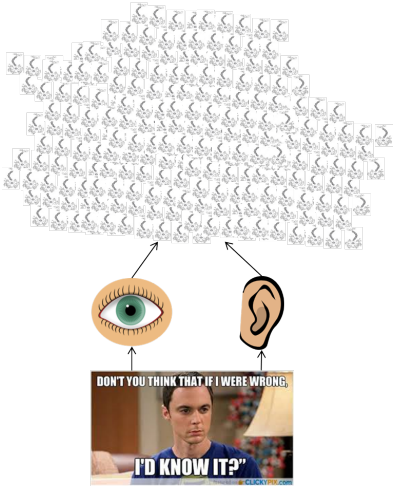
- Let us see a very cartoonish illustration of how a neuron works
- Our sense organs interact with the outside world
- They relay information to the neurons
- The neurons (may) get activated and produces a response (laughter in this case)

- Of course, in reality, it is not just a single neuron which does all this





- Of course, in reality, it is not just a single neuron which does all this
- There is a massively parallel interconnected network of neurons



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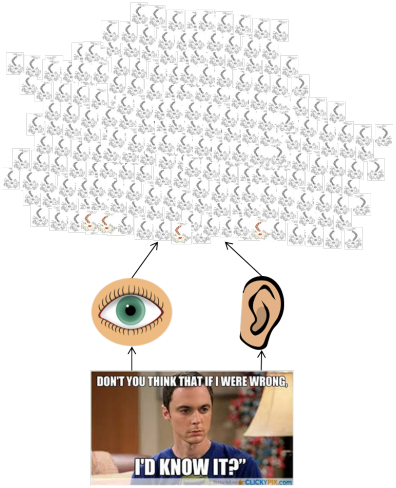
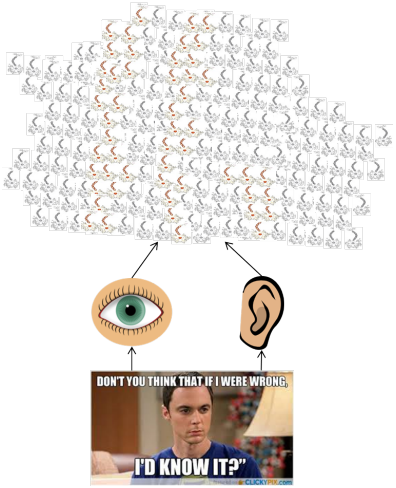
- The sense organs relay information to the lowest layer of neurons



- Of course, in reality, it is not just a single neuron which does all this
- There is a massively parallel interconnected network of neurons
- The sense organs relay information to the lowest layer of neurons
- Some of these neurons may fire (in red) in response to this information and in turn relay information to other neurons they are connected to



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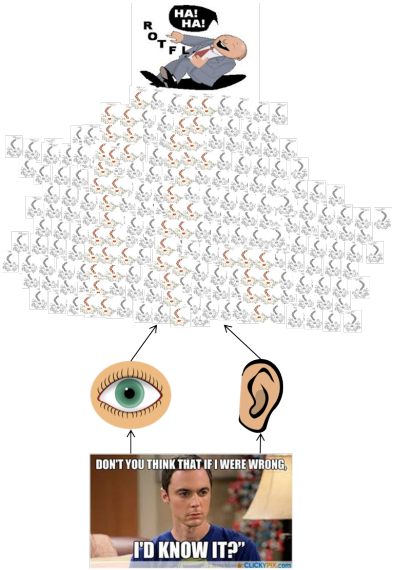
- These neurons may also fire (again, in red) and the process continues



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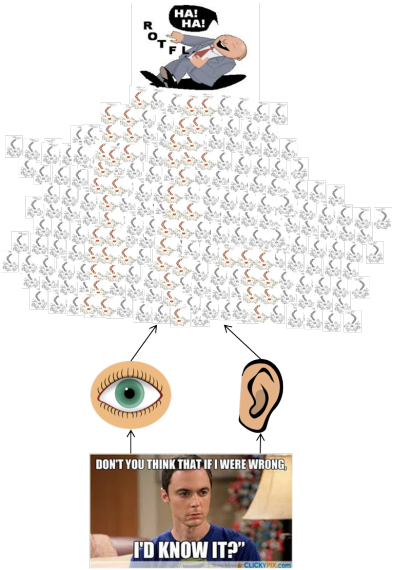

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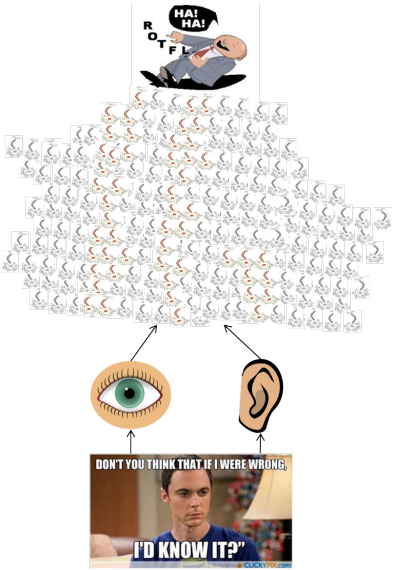
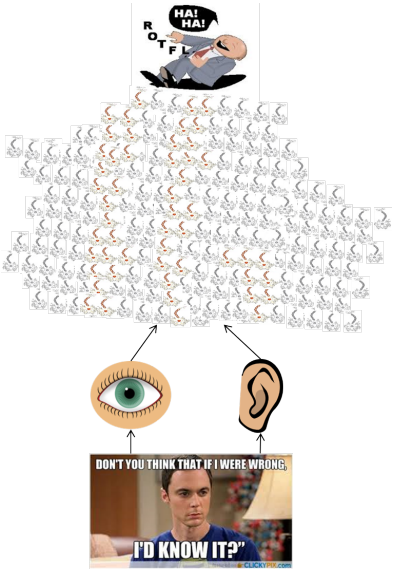
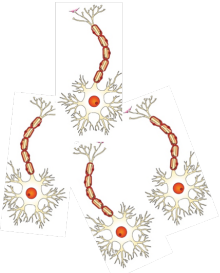
- An average human brain has around 10^{11} (100 billion) neurons!



- This massively parallel network also ensures that there is division of work



- This massively parallel network also ensures that there is division of work
- Each neuron may perform a certain role or respond to a certain stimulus



A simplified illustration

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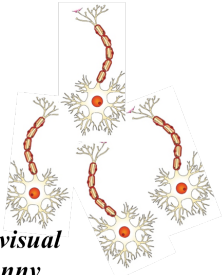

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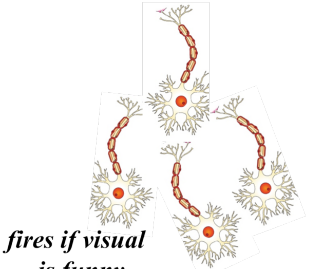

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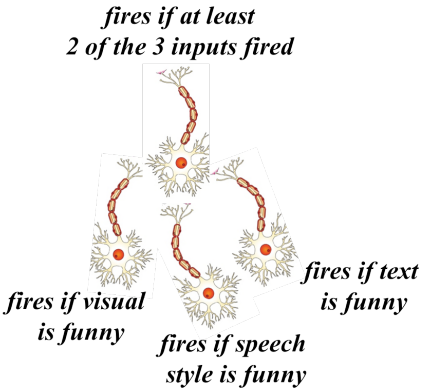

A simplified illustration

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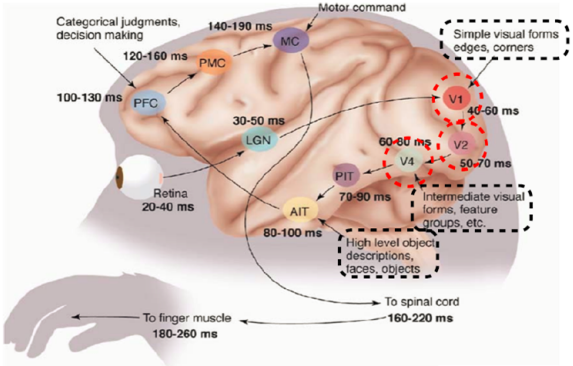
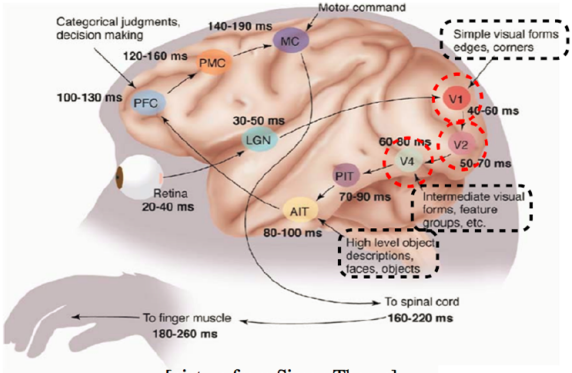
- The neurons in the brain are arranged in a hierarchy



[picture from Simon Thorpe]

- The neurons in the brain are arranged in a hierarchy
- We illustrate this with the help of visual cortex (part of the brain) which deals with processing visual information



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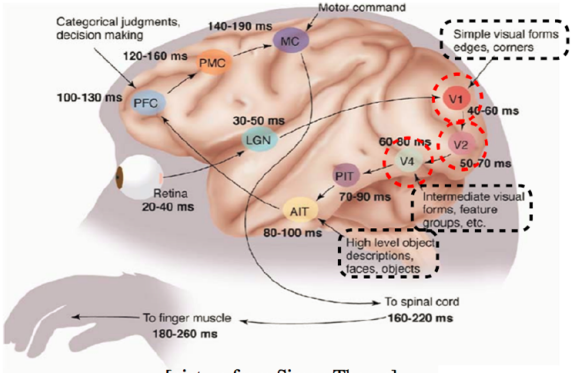
- Starting from the retina, the information is relayed to several layers (follow the arrows)



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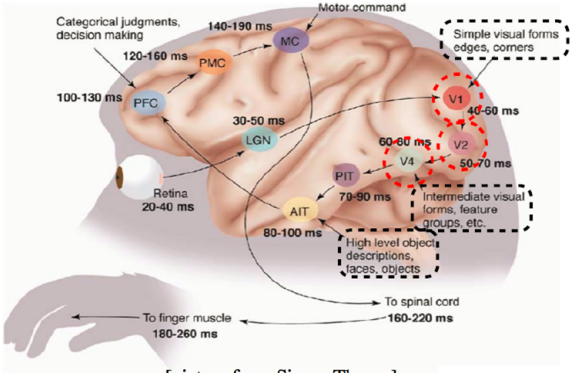
- The neurons in the brain are arranged in a hierarchy
- We illustrate this with the help of visual cortex (part of the brain) which deals with processing visual information
- Starting from the retina, the information is relayed to several layers (follow the arrows)
- We observe that the layers $V1$, $V2$ to AIT form a hierarchy (from identifying simple visual forms to high level objects)

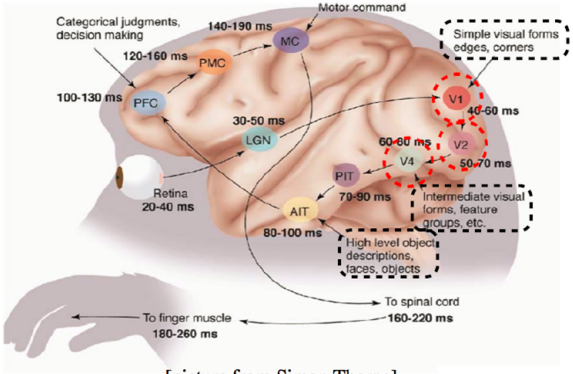


[picture from Simon Thorpe]

Layer 1: detect edges & corners

Sample illustration of hierarchical processing*

*Idea borrowed from Hugo Larochelle's lecture slides



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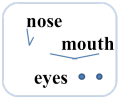

Layer 2: form feature groups

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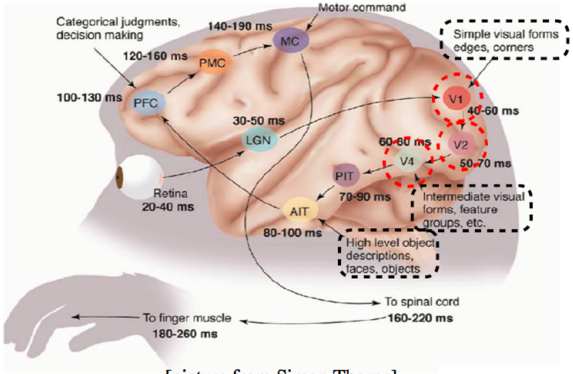

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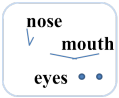

Layer 2: form feature groups

Layer 3: detect high level objects, faces, etc.

Sample illustration of hierarchical processing*

*Idea borrowed from Hugo Larochelle's lecture slides

Disclaimer

- I understand very little about how the brain works!
- What you saw so far is an overly simplified explanation of how the brain works!
- But this explanation suffices for the purpose of this course!