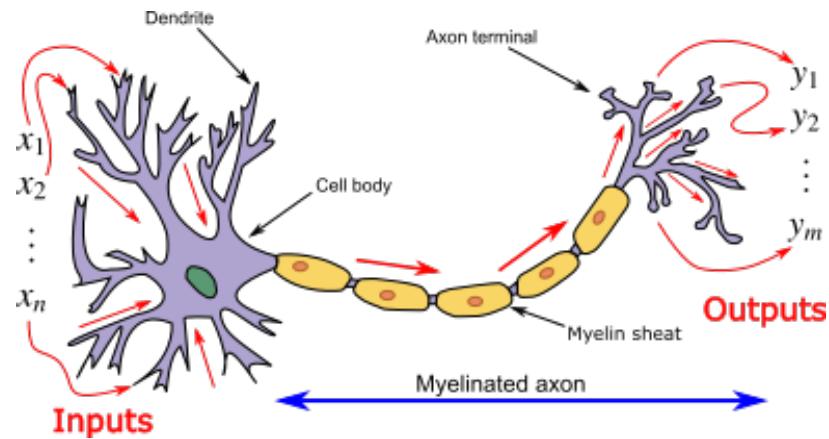


From Biological Neurons to Artificial Neural Networks

James M. Irving, Ph.D.

Updated 10/19/20

TOPICS TO COVER

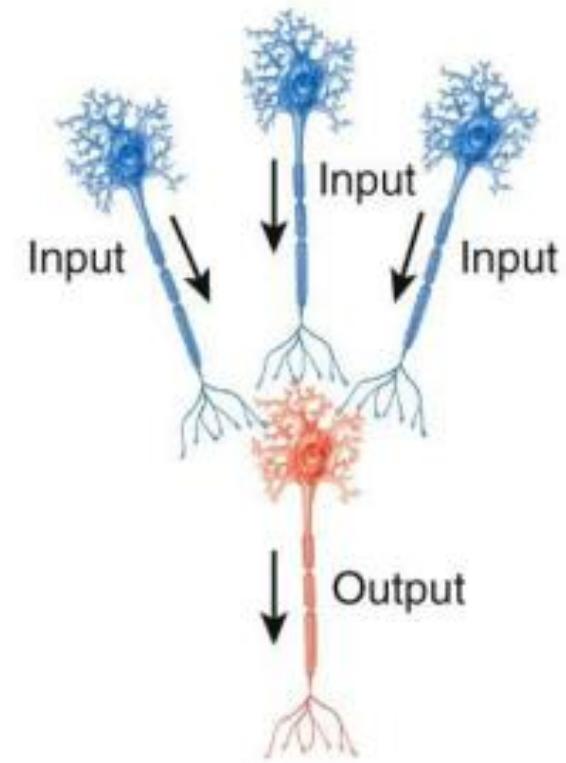
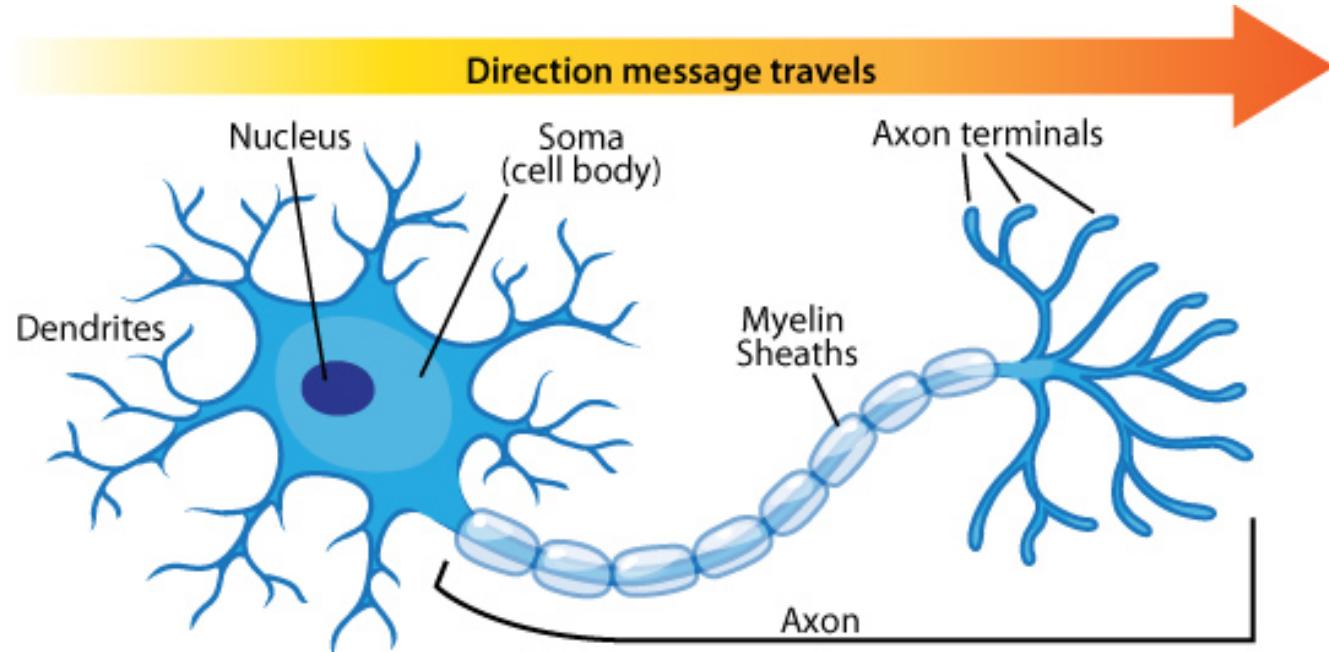


Anatomy of a Neuron

How Neurons Process Info

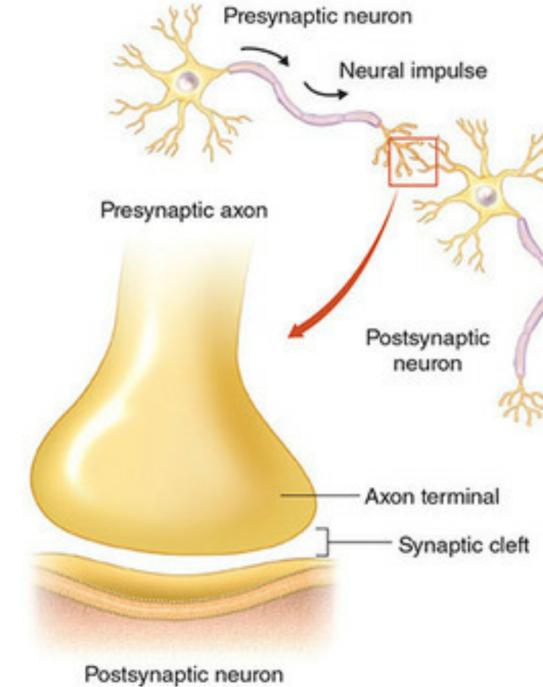
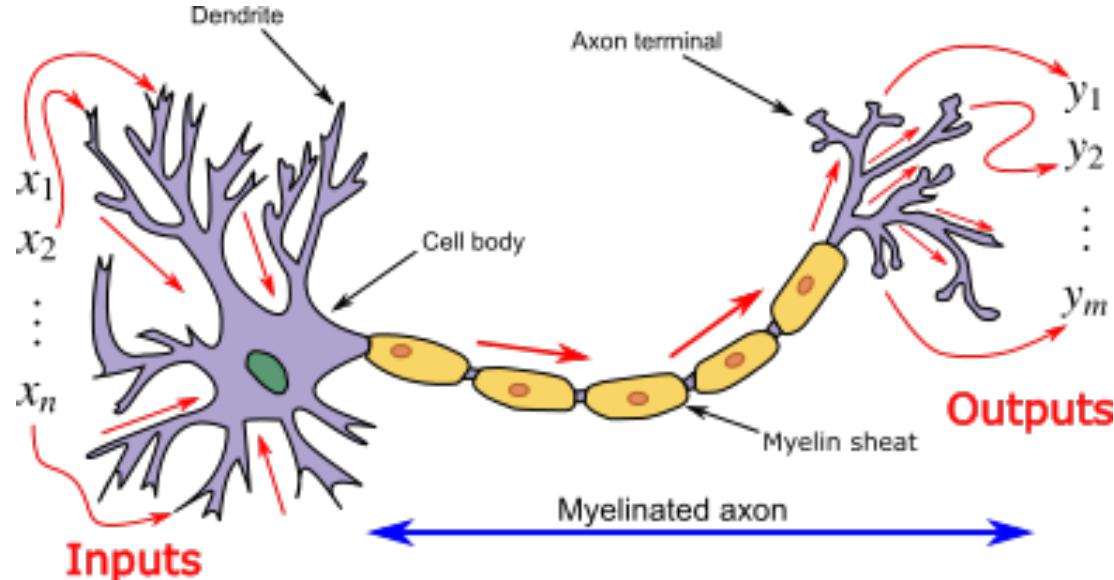
Strengthening / Weakening
Connections

Anatomy of a Neuron I



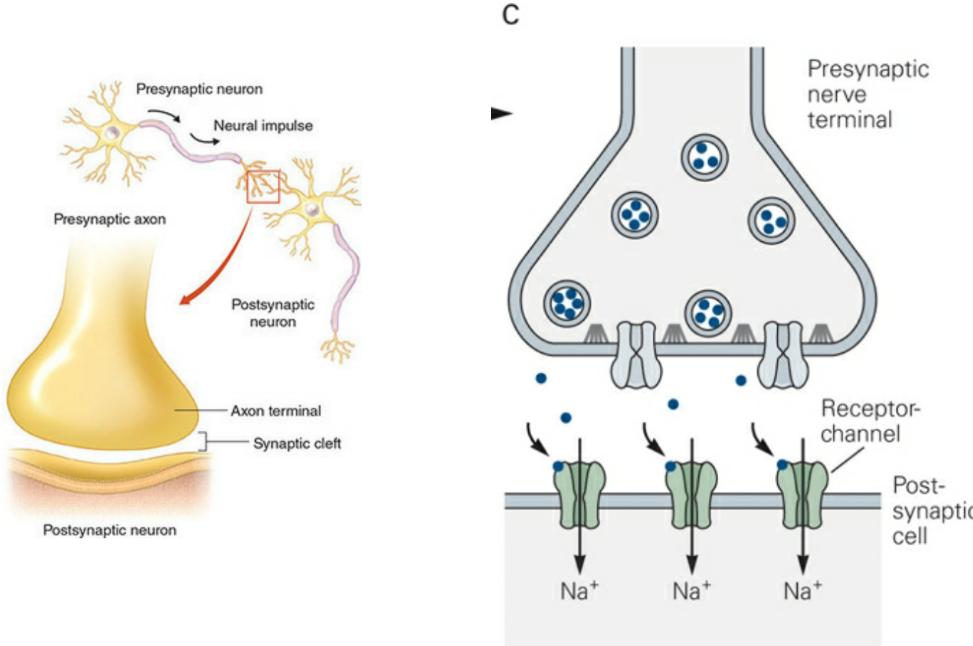
- ▶ Neurons are shaped kind of like a tree.
 - ▶ There are branches with leaves at the top (the dendrites/soma)
 - ▶ It has a long trunk (the axon)
 - ▶ The trunk ends with roots that connect to other neurons (the axon terminals)

Anatomy of a Neuron II

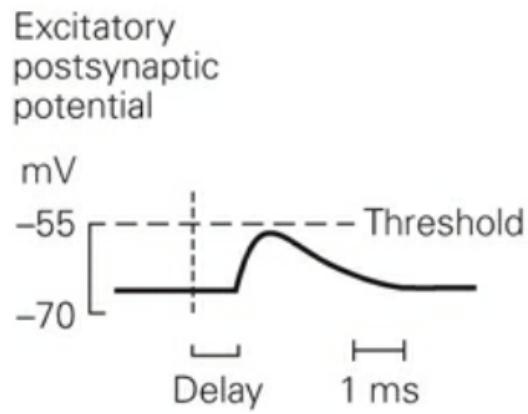
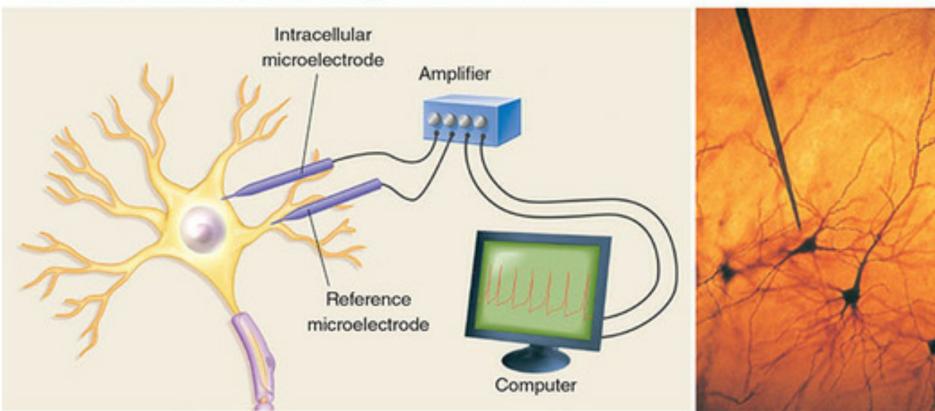


- ▶ Lots of neurons (hundreds-thousands) act as Inputs to the neuron by connecting to the neuron's branches.
 - ▶ These are called “synapses”
 - ▶ Neurons released Neurotransmitters to send information across a synapse

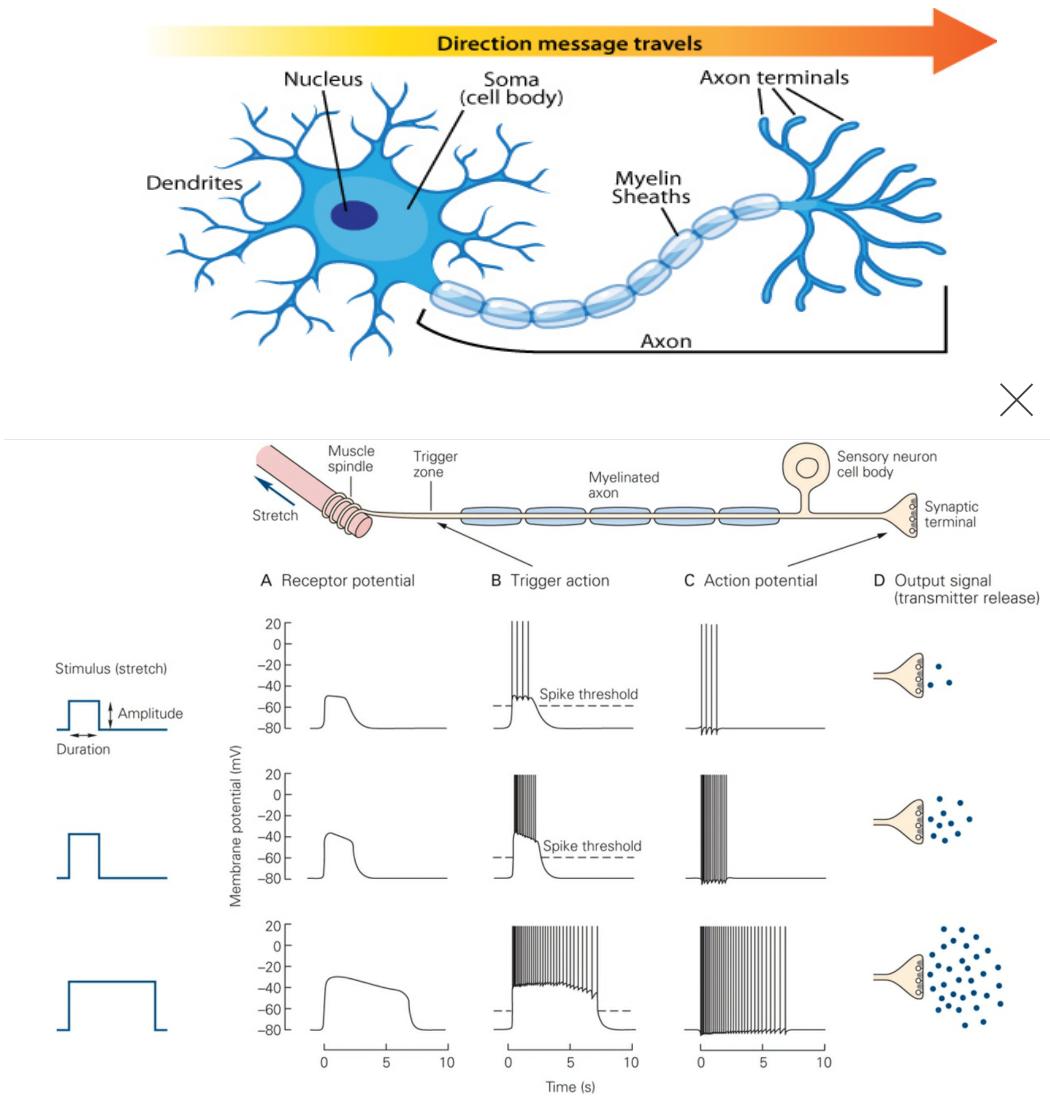
How Neurons communicate



Potentials are being recorded in the axon of a neuron, with an electrode inside the cell and one in the fluid outside. Due to the size of neurons, the electrodes have microscopically small tips. On the right, a highly magnified view shows the size of a microelectrode relative to that of neurons. Electrodes for recording inside neurons are even smaller.

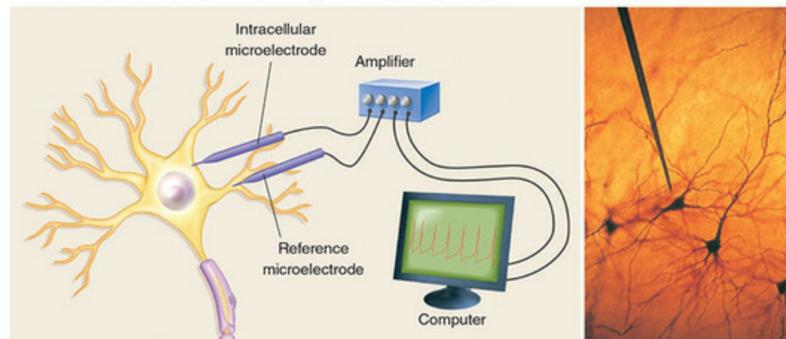


Example Information Processing

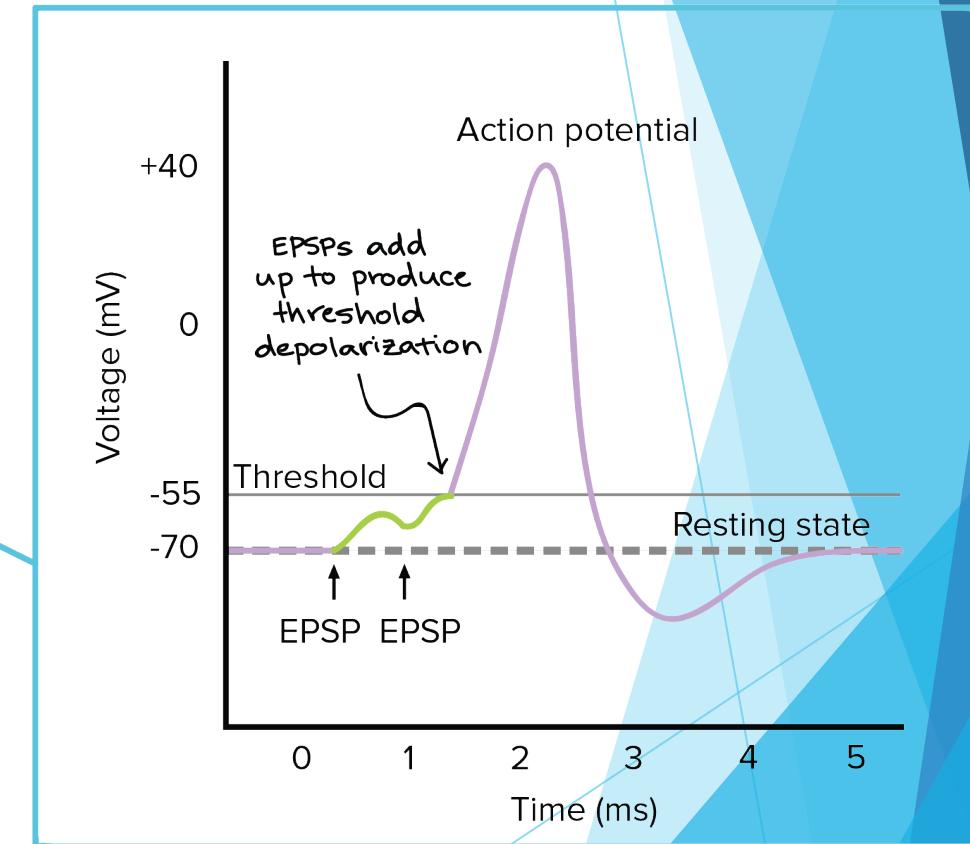
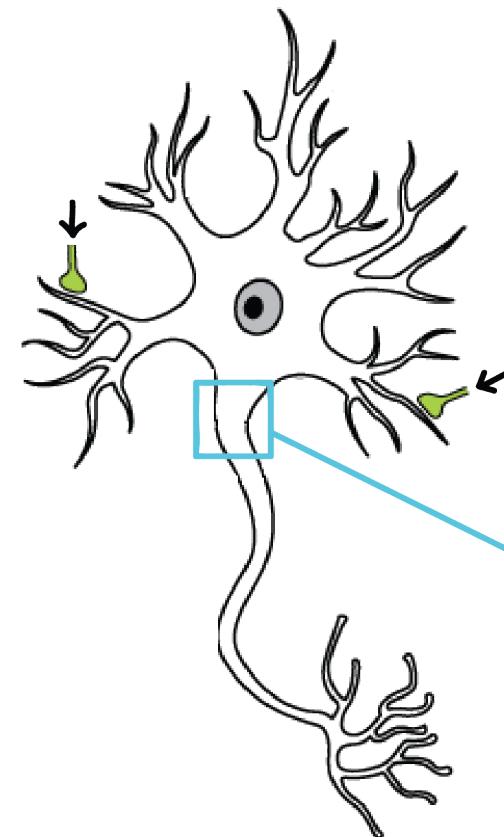
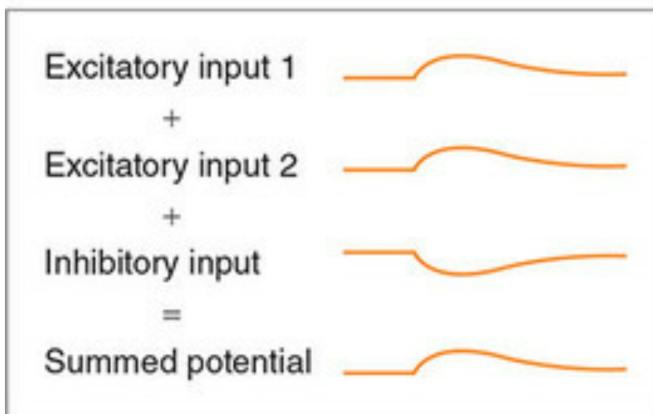


How Neurons Process Information

Potentials are being recorded in the axon of a neuron, with an electrode inside the cell and one in the fluid outside. Due to the size of neurons, the electrodes have microscopically small tips. On the right, a highly magnified view shows the size of a microelectrode relative to that of neurons. Electrodes for recording inside neurons are even smaller.

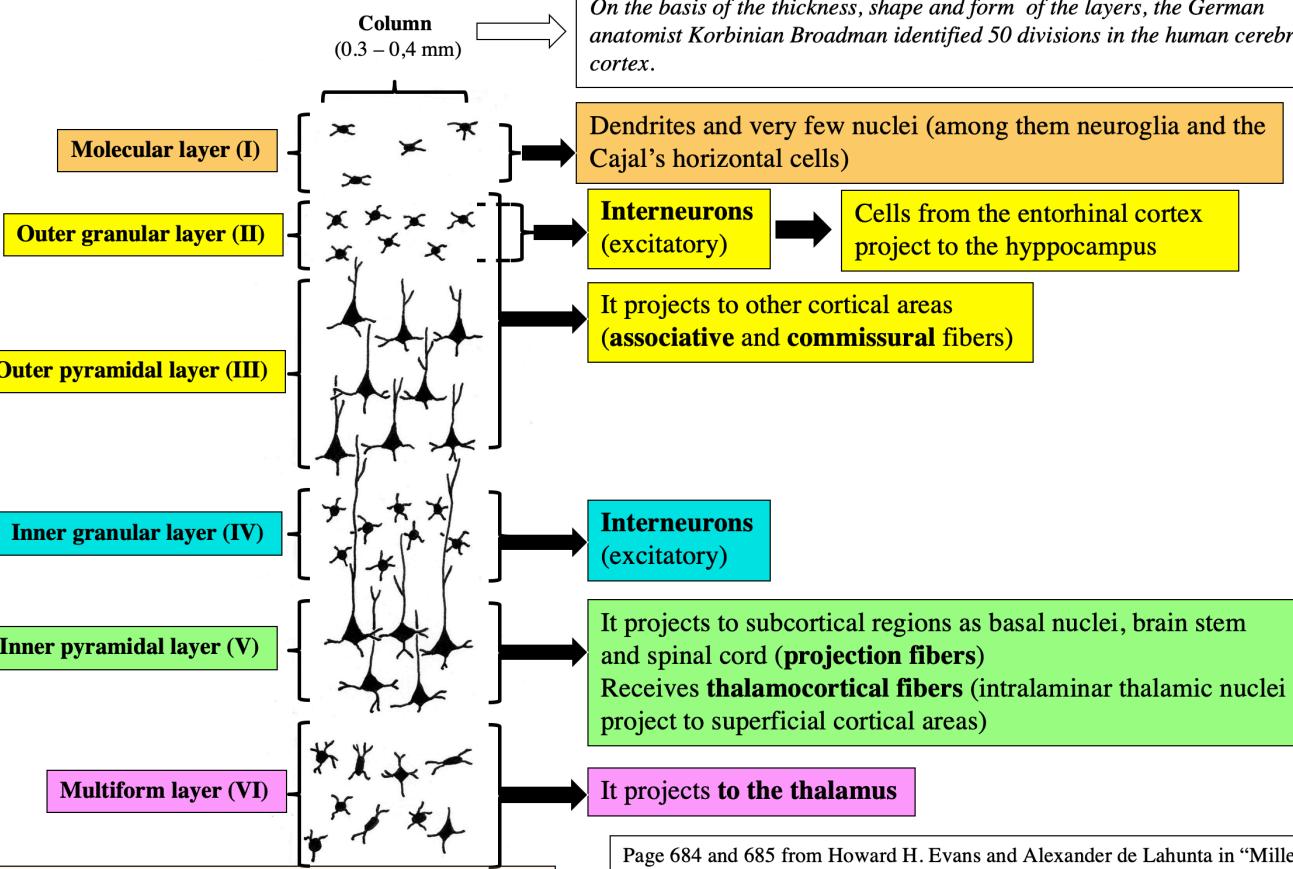


Note that inhibitory potentials cancel out excitatory potentials of equal strength (and vice versa).



Neurons are Organized into Networks

Cerebral cortex – Neocortical layers



All the neurons in a column respond to the same type of stimulus.
Depending on its function, the thickness of each layer varies.
On the basis of the thickness, shape and form of the layers, the German anatomist Korbinian Brodmann identified 50 divisions in the human cerebral cortex.

Dendrites and very few nuclei (among them neuroglia and the Cajal's horizontal cells)

Interneurons (excitatory)
Cells from the entorhinal cortex project to the hippocampus

It projects to other cortical areas
(associative and commissural fibers)

Interneurons (excitatory)

It projects to subcortical regions as basal nuclei, brain stem and spinal cord (**projection fibers**)
Receives **thalamocortical fibers** (intralaminar thalamic nuclei project to superficial cortical areas)

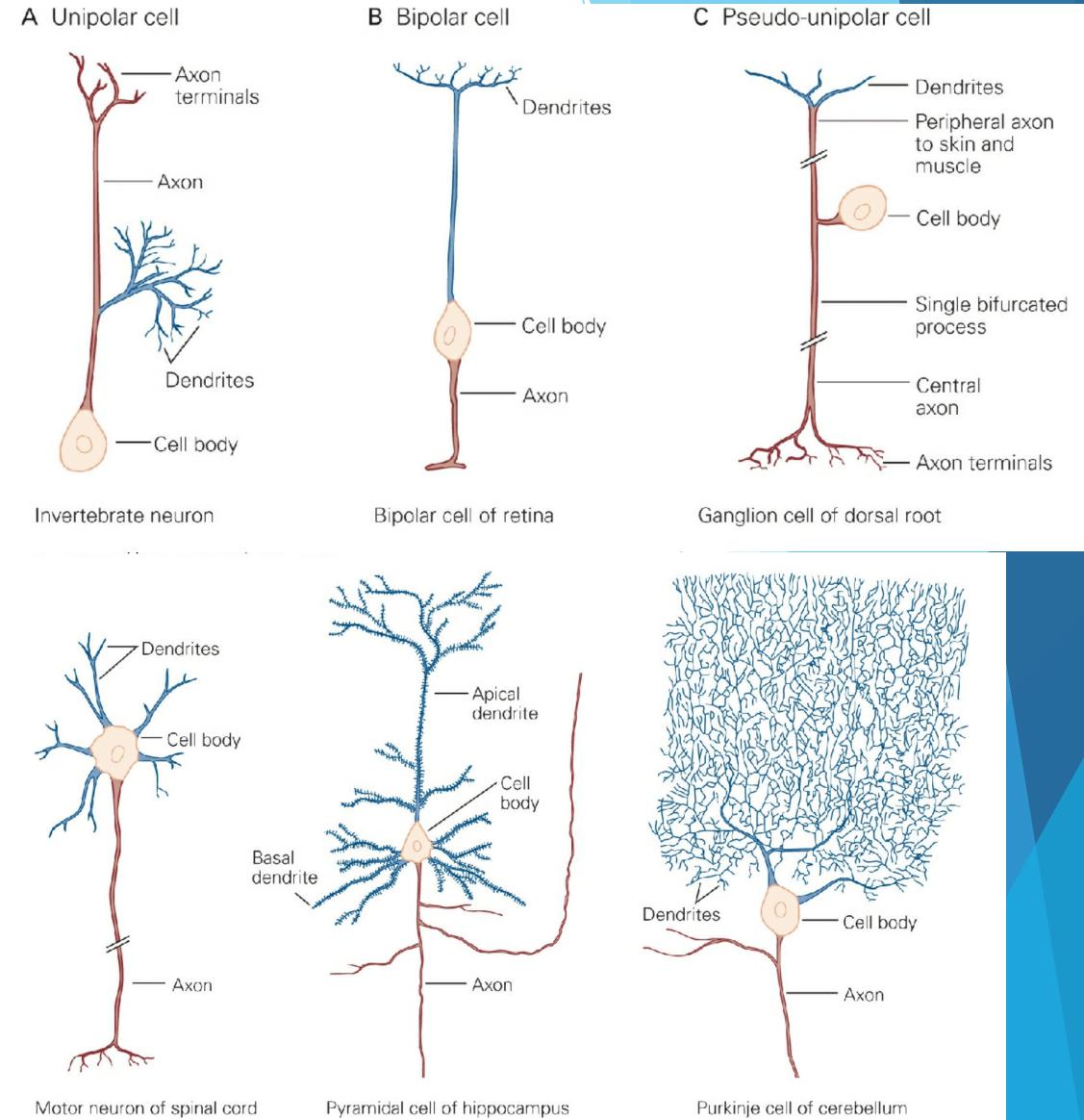
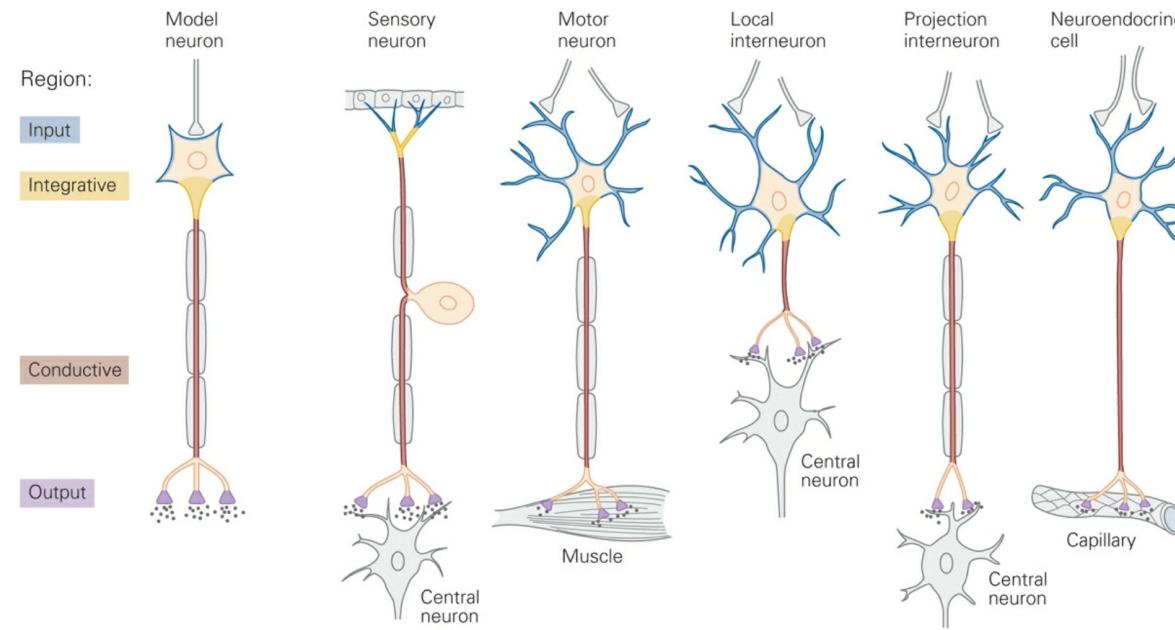
It projects to the thalamus

Page 684 and 685 from Howard H. Evans and Alexander de Lahunta in "Miller's anatomy of the dog" (4th edition)

Page 439 from Lennart Heimer in "The human brain and spinal cord" (2nd edition)
Page 82 to 84 from John H. Martin in "Neuroanatomy" (2nd edition)

Except for the basal nuclei, the newly formed neurons migrate from the mantle layer, close to the lumen of the neural tube, to form the cerebral cortex. The cortex forms inside out, the first neurons to migrate form the layer VI. The rest of the neurons pass through the formed layer to form layer V and so on. So the last is the molecular layer.

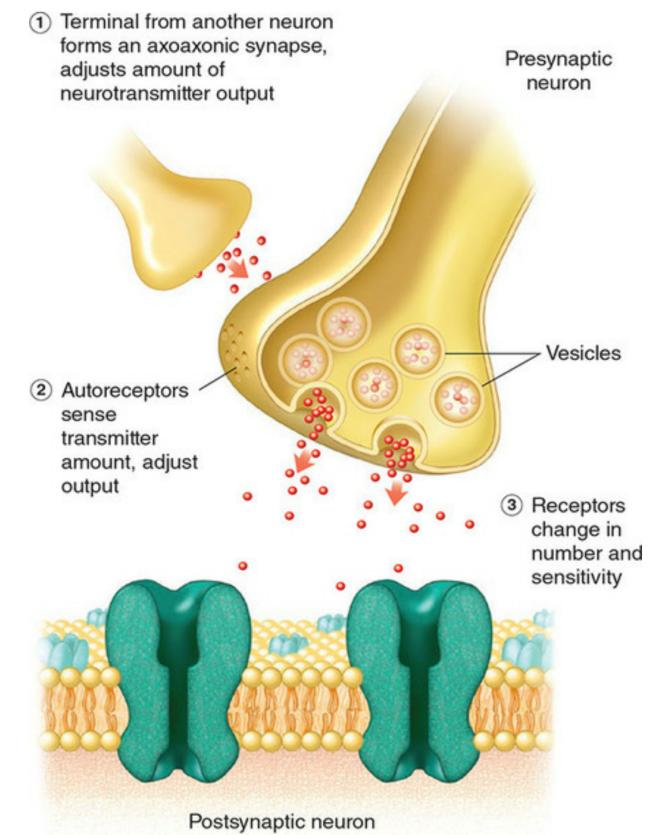
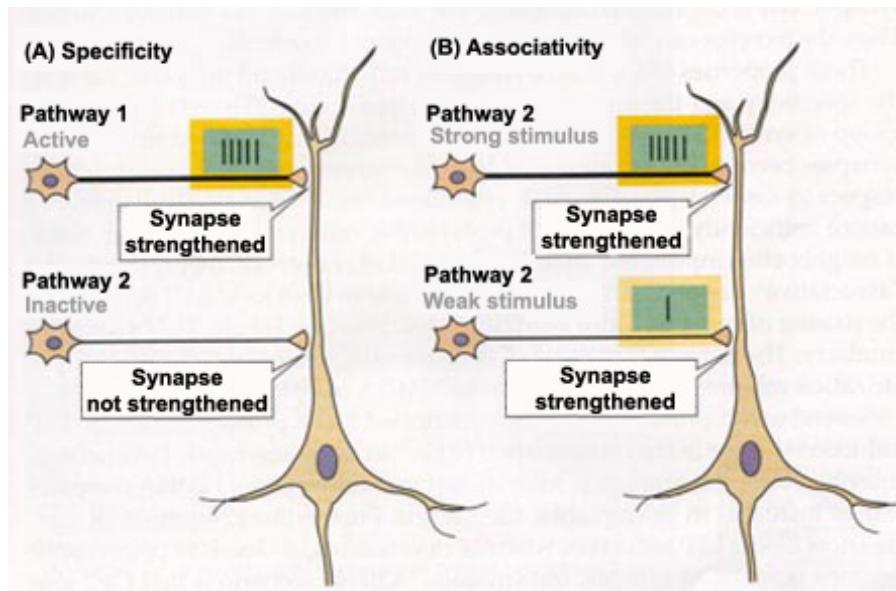
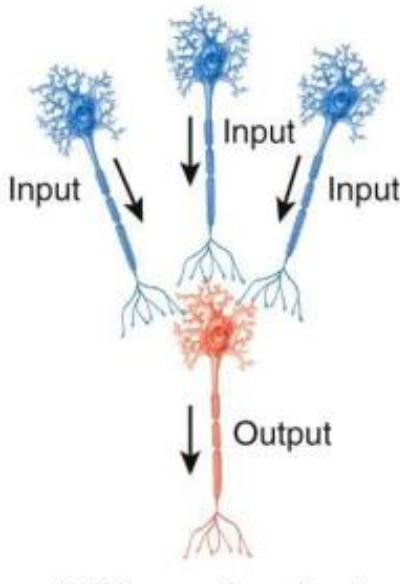
Many Types of Neurons



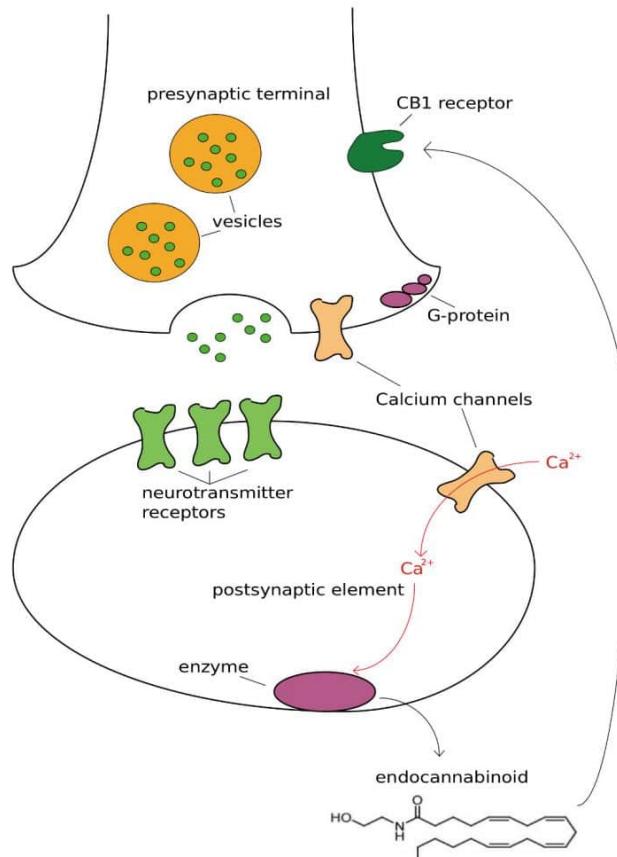
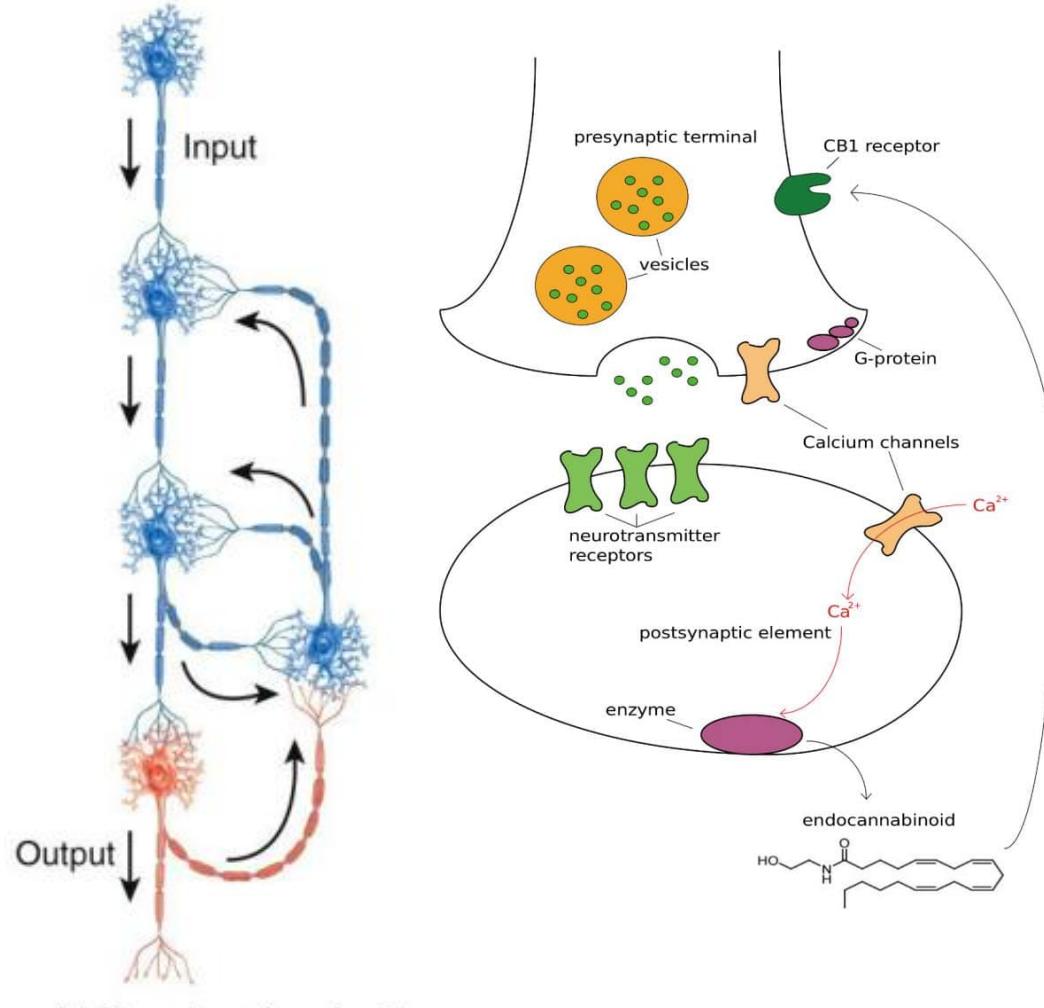
Strengthening of Connections

Neuroplasticity: “Cells that fire together wire together.”

- Cells that interact strongly will make their connection stronger.

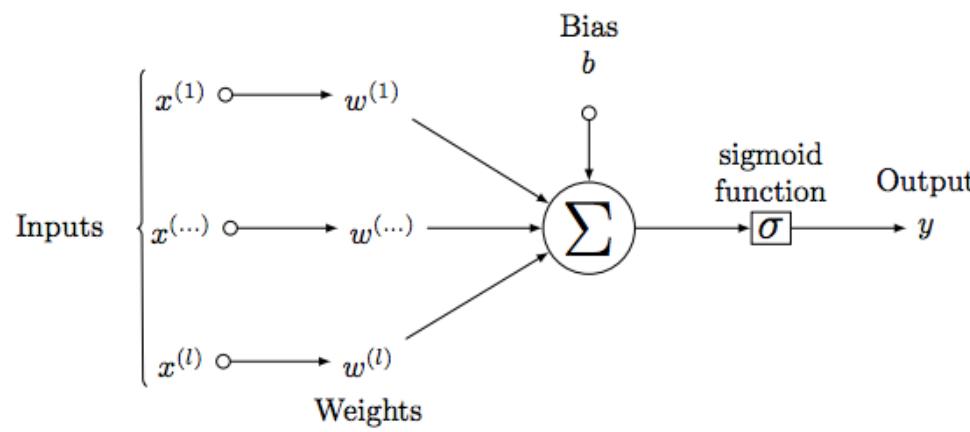
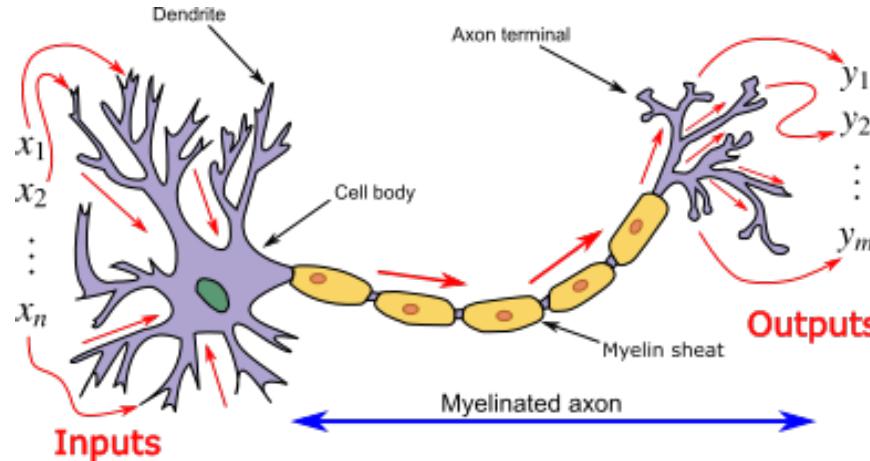


Weakening of Connections / Negative Feedback

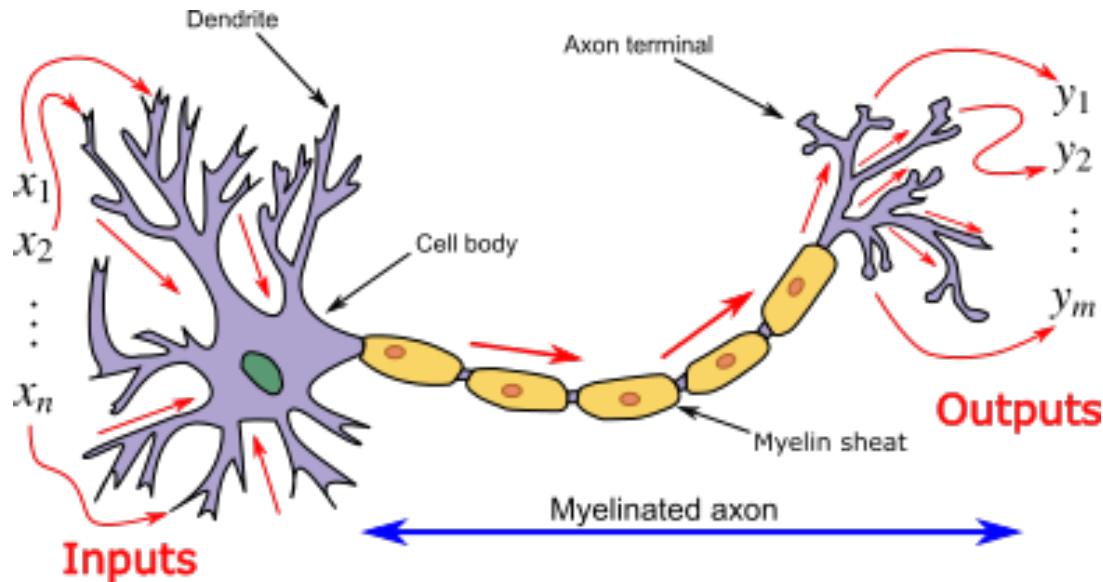


- Weakly/poorly activated neurons will weaken their connections

From Bio to Artificial



- ▶ Artificial Neural Networks mimic the activity of bio neurons:
- ▶ They take in lots of inputs from other neurons.
- ▶ They sum up the input signal inside their cell bodies and then depending on the signal and then pass that message onto the next neurons.
- ▶ The different properties of the cells (like activation functions) result in different information being shared.



Now Back to the Notebook...