

Lecture 2

Neuroscience of Learning and Memory

Monday

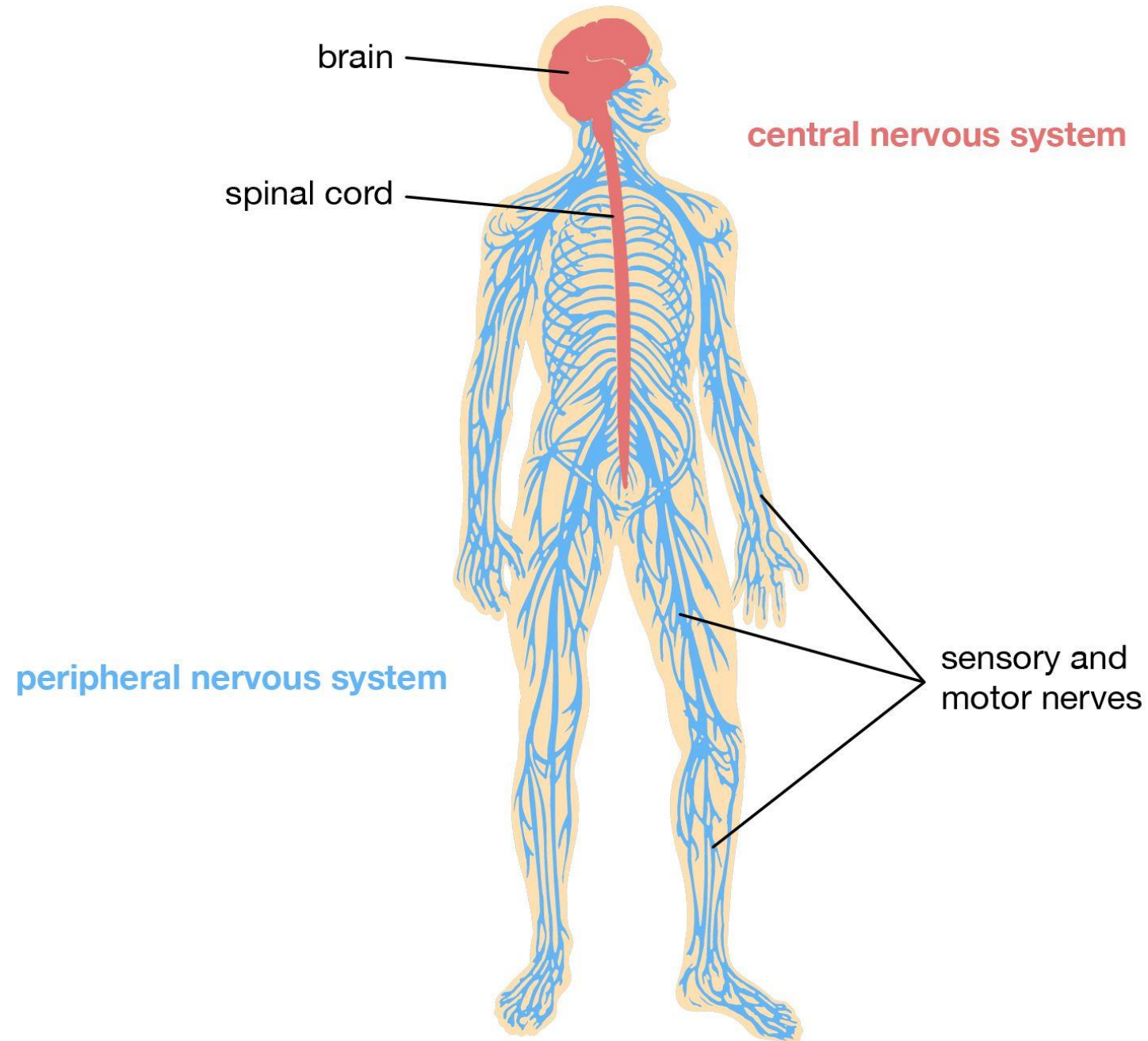
1/8/2022







The nervous system

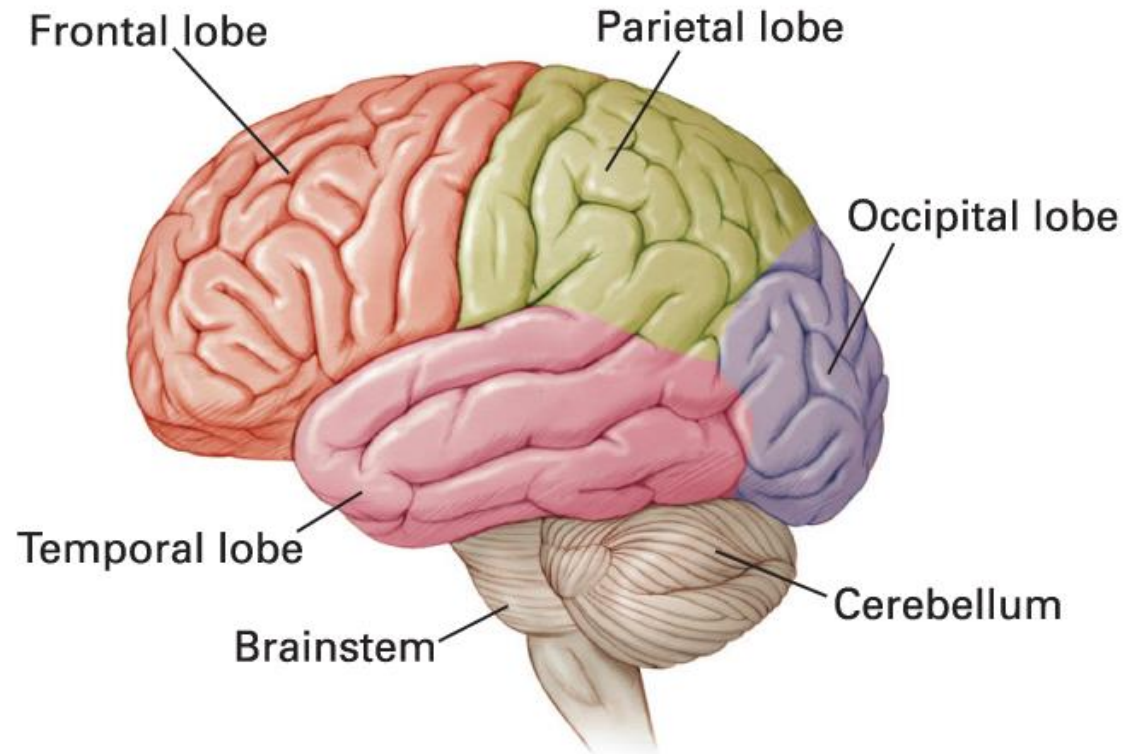


The Human Brain

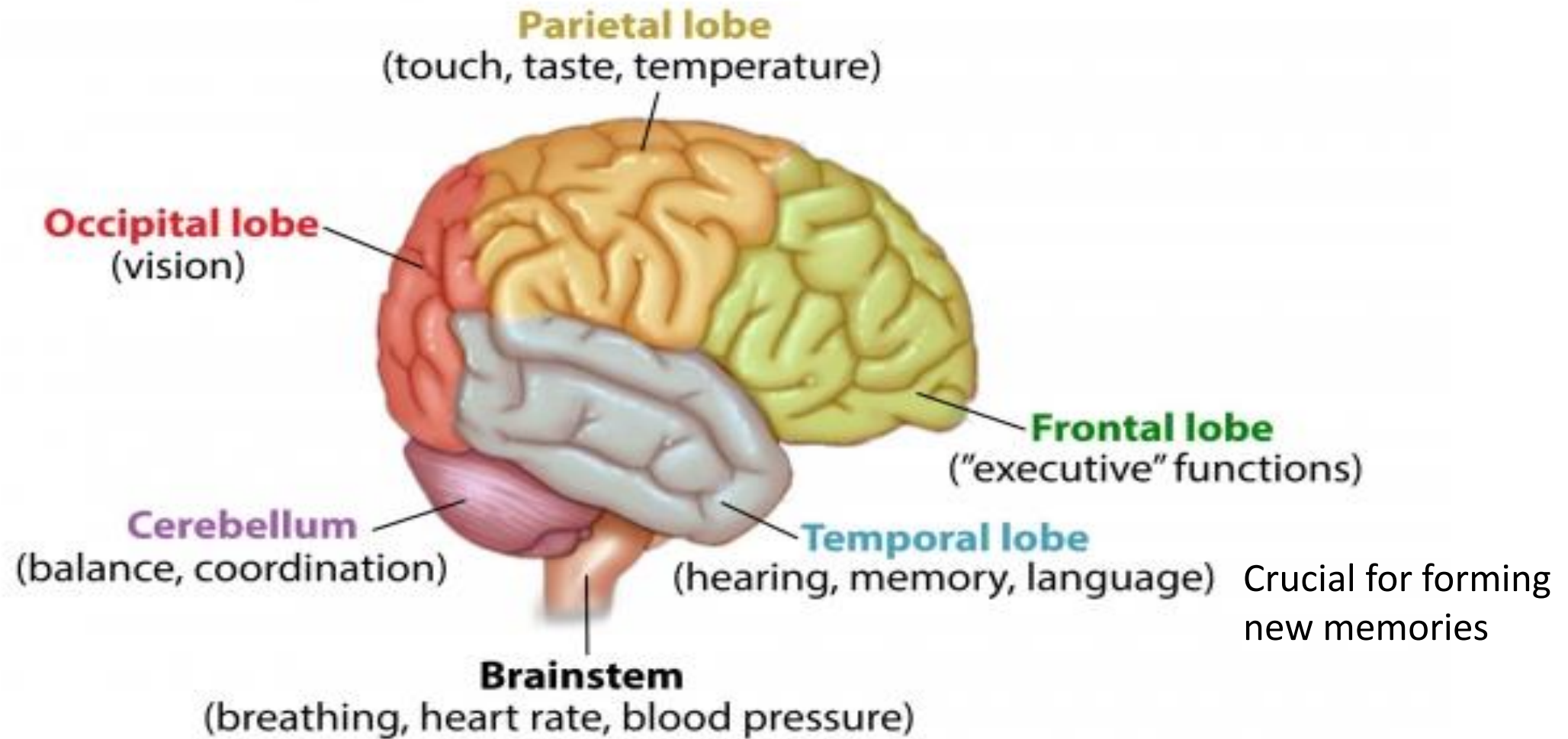
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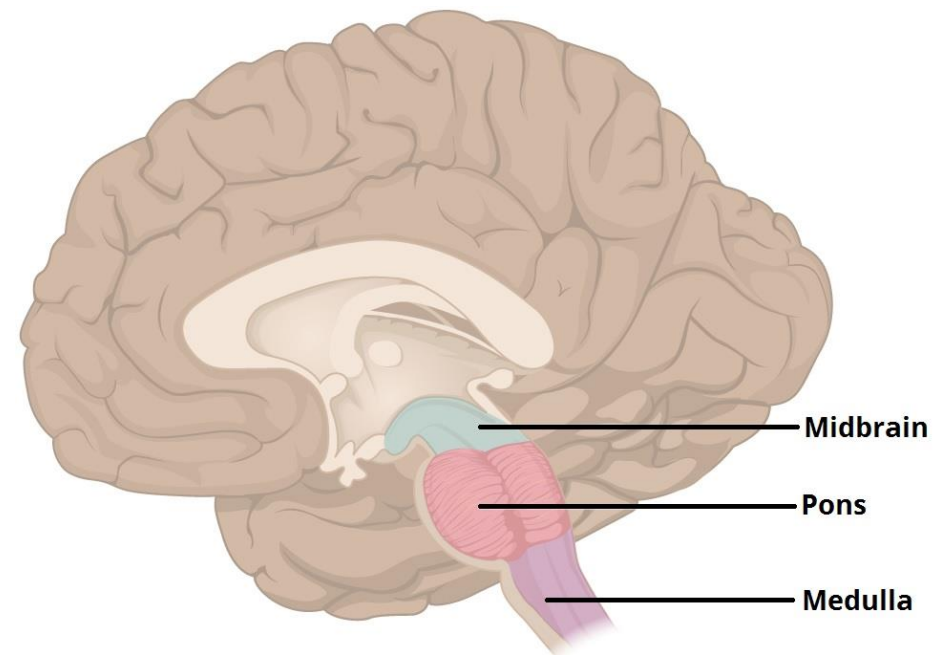
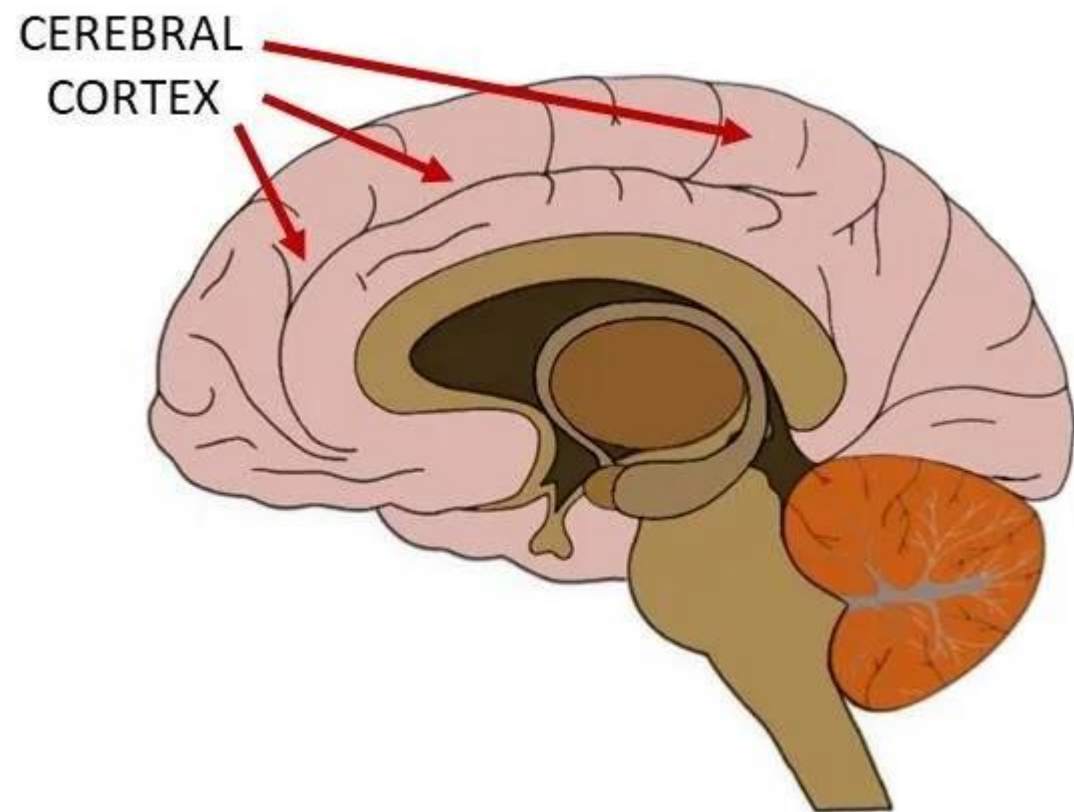


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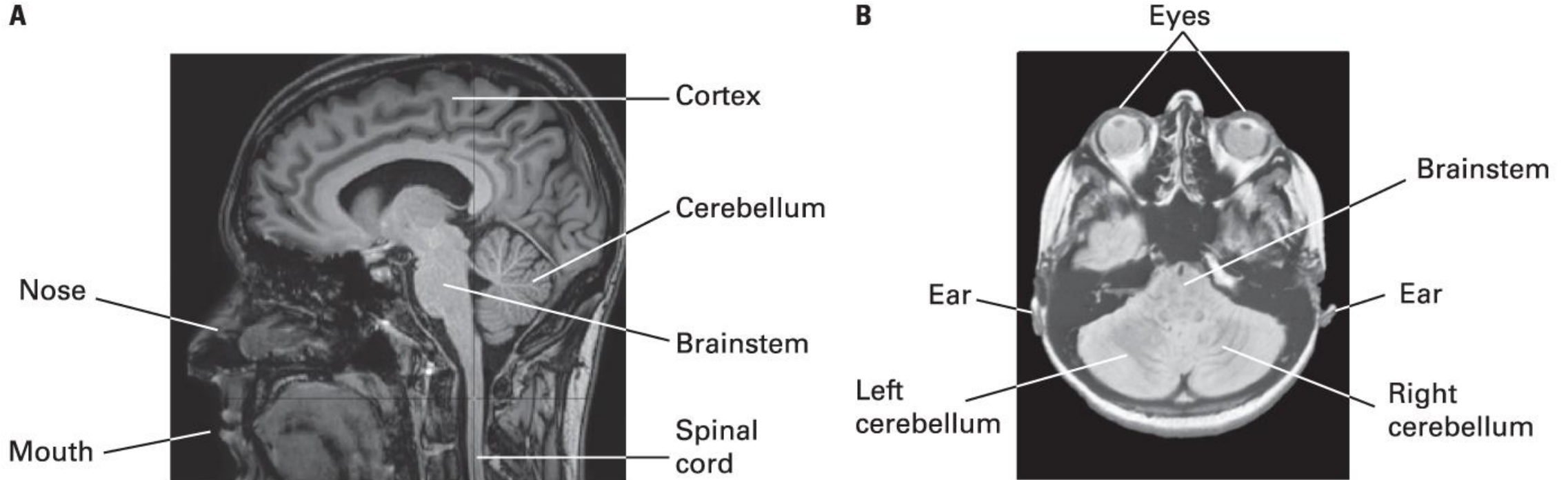


Gluck et al., *Learning and Memory*, 4e, © 2020 Worth Publishers
A: Chris Parsons/Getty Images





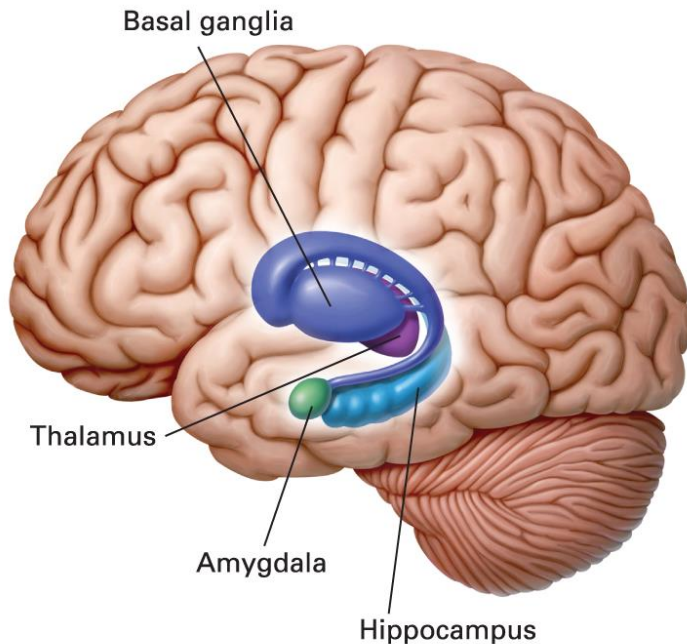
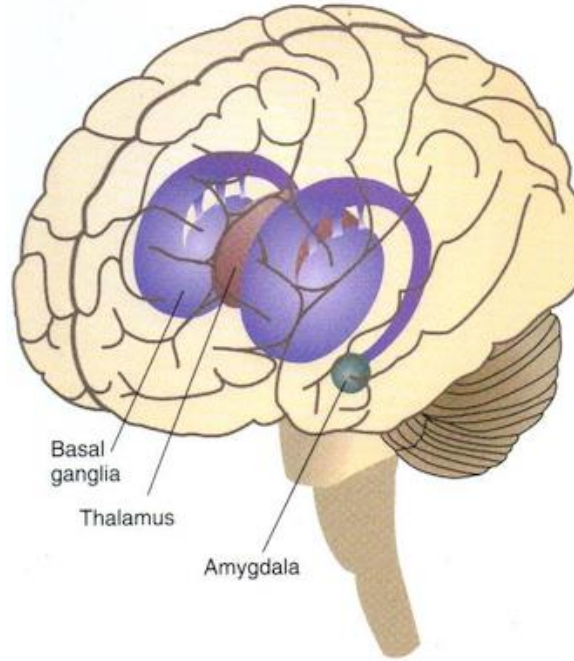
MRI Images



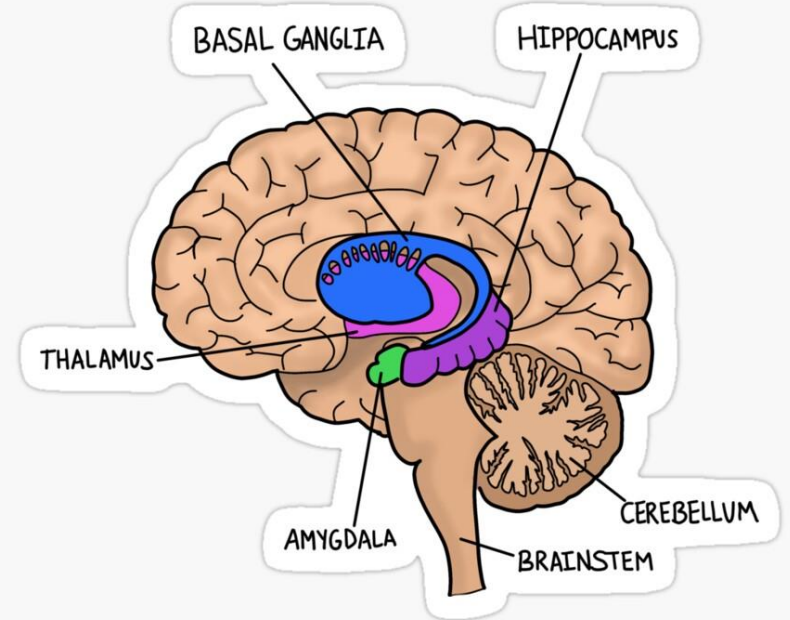
A: Sherbrooke Connectivity Imaging/Cultura Creative (RF)/Alamy; B: Scott Camazine/Science Source

Brain Regions Known to Contribute to Memory

The Location of the Basal Ganglia in the Human Brain

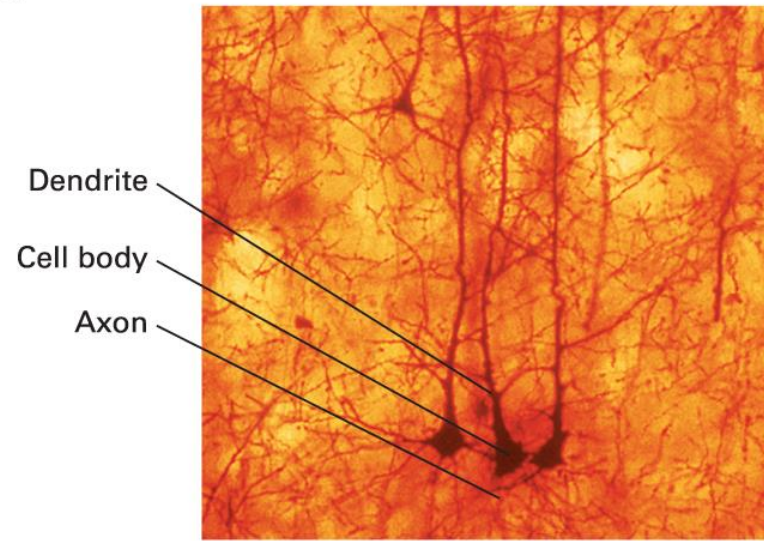


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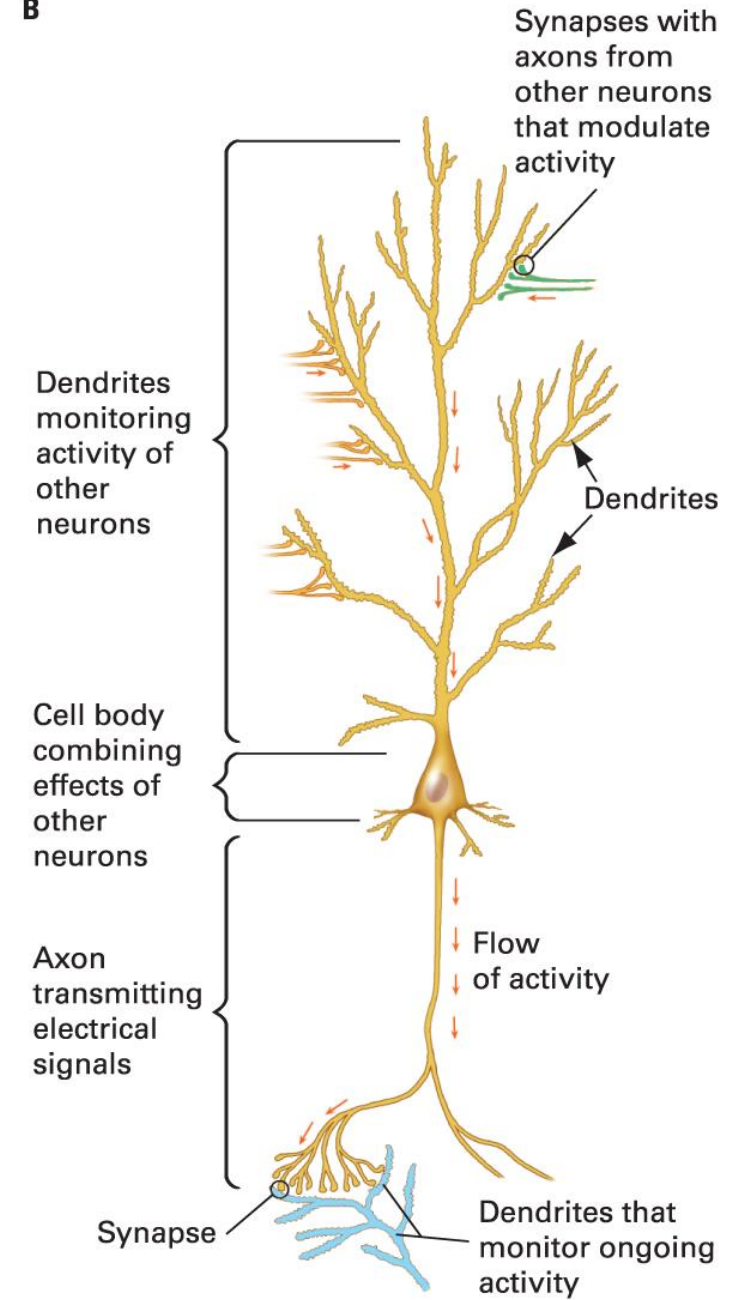


Neuron

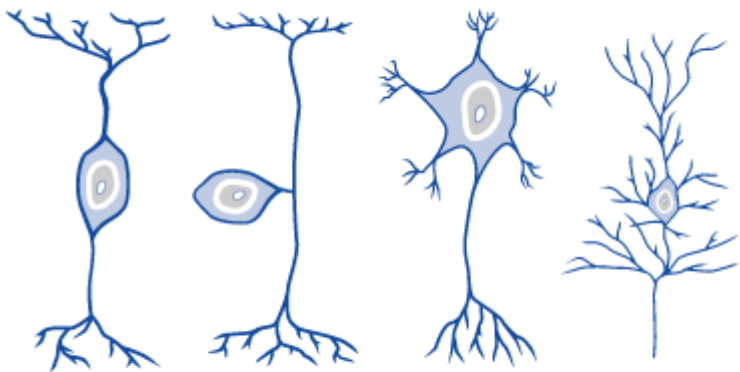
A



B



Basic Neuron Types



Bipolar (Interneuron) Unipolar (Sensory Neuron) Multipolar (Motoneuron) Pyramidal Cell

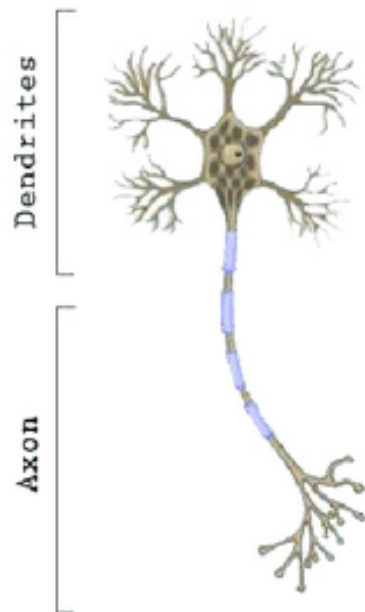
Relays

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information

Multipolar neurons

Motor neuron



Pyramidal neuron



Purkinje cell

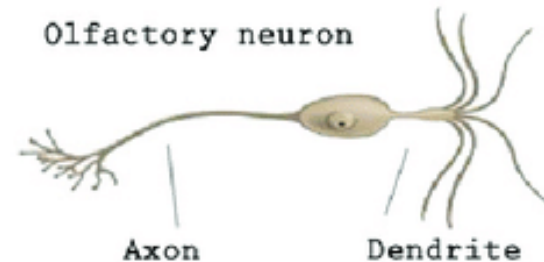


Bipolar neurons

Retinal neuron

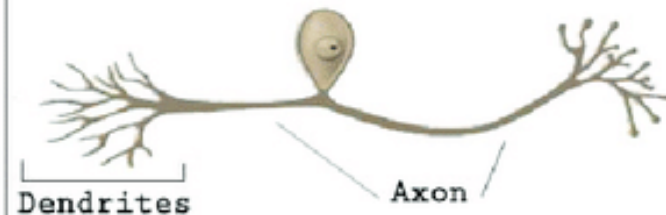


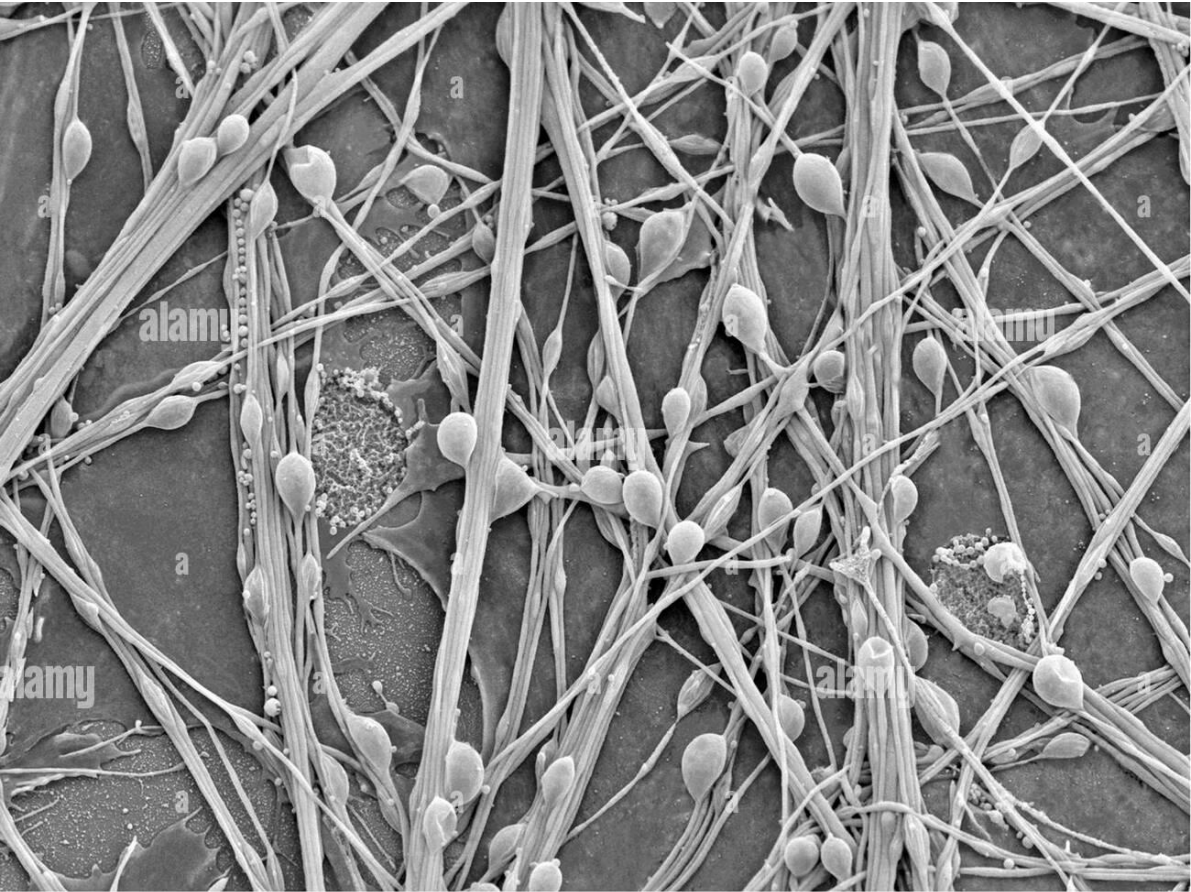
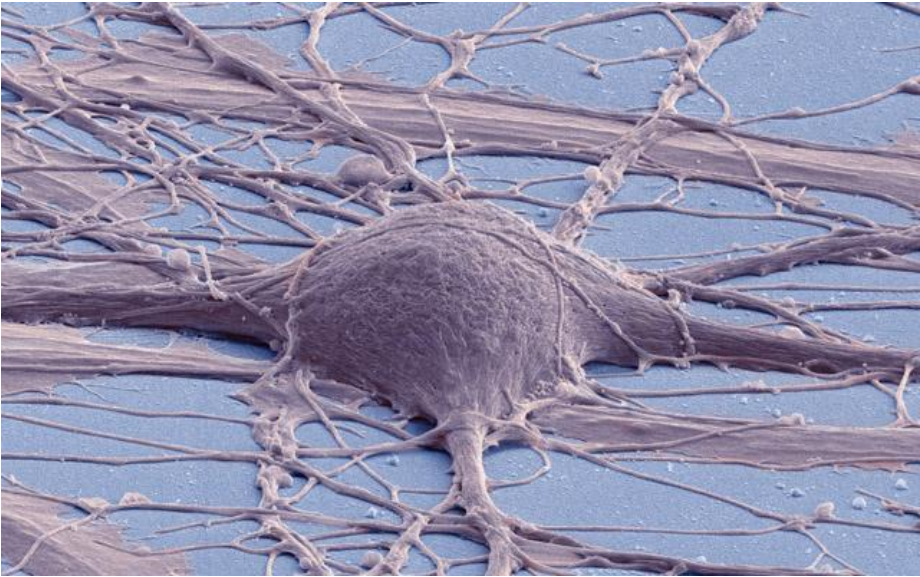
Olfactory neuron



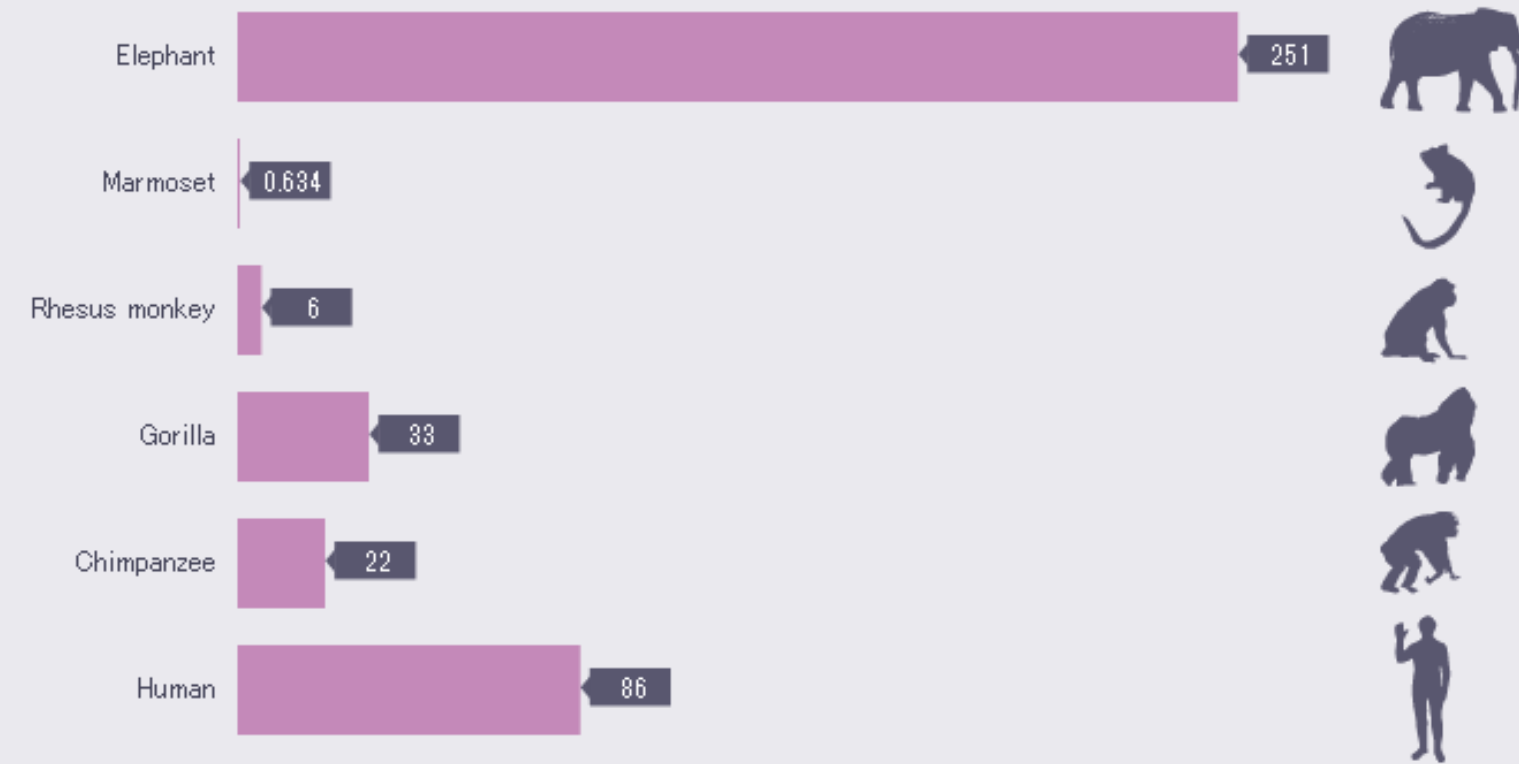
Pseudounipolar neuron

Sensory neuron

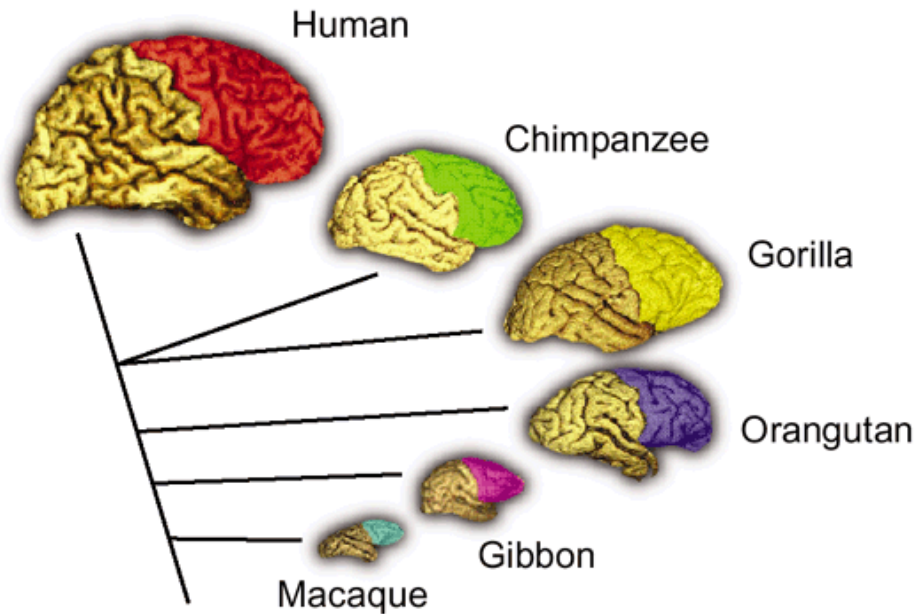
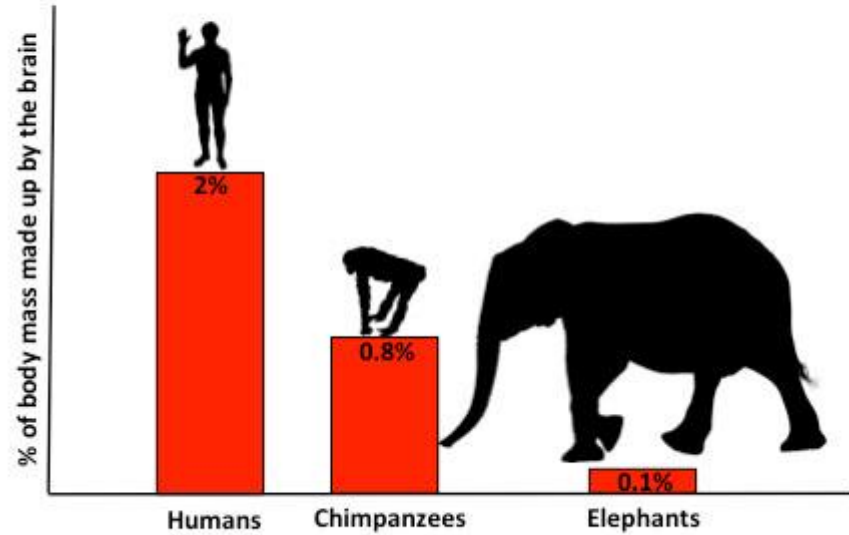




Brain neurons (billions)



Sources: Suzana Herculano-Houzel; Marino, L. Brain Behav Evol 1998;51;230-238



Brain size → intelligence (non-linear relationship)

Humans → larger cerebral cortex

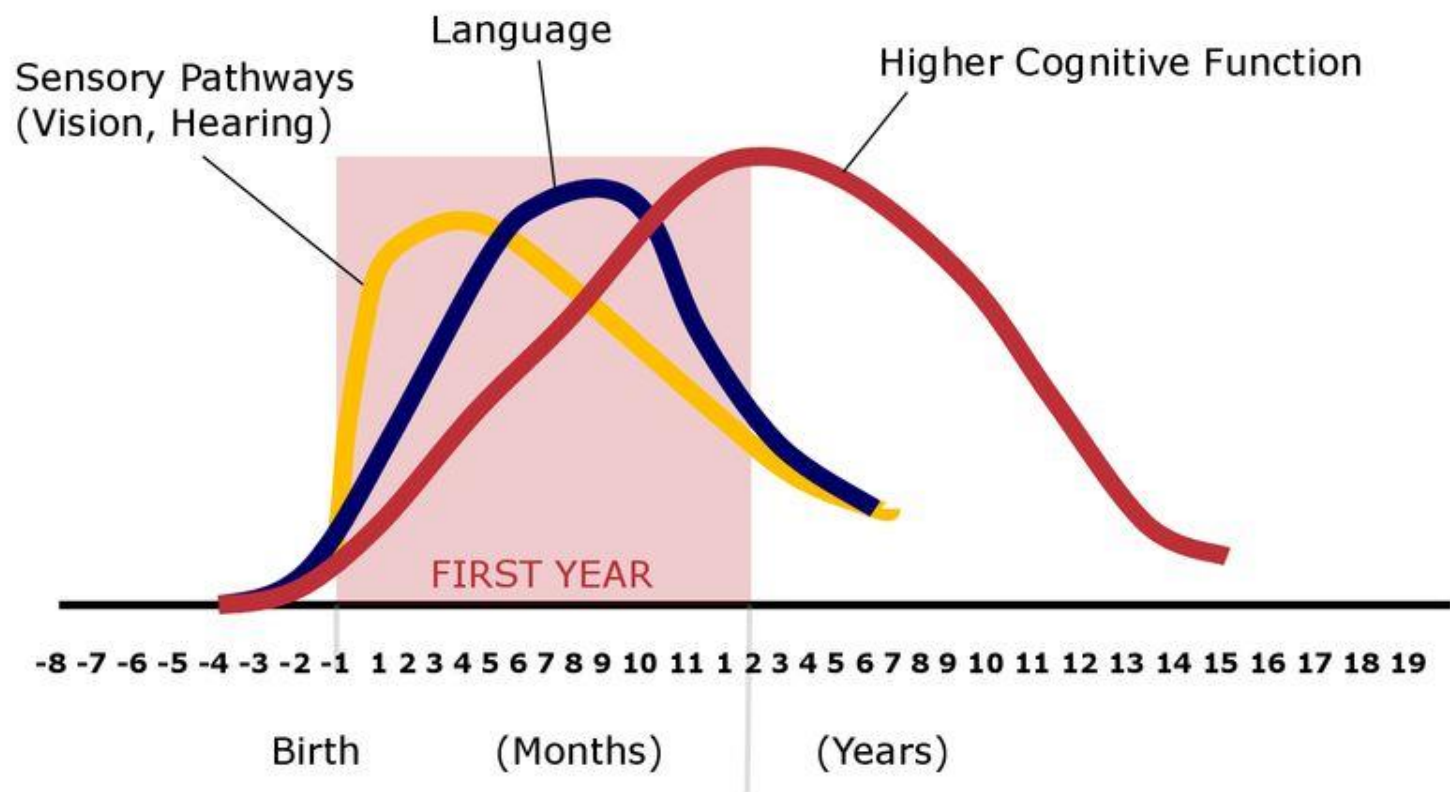
Elephants → larger cerebellum (trunk- sensory powerhouse)

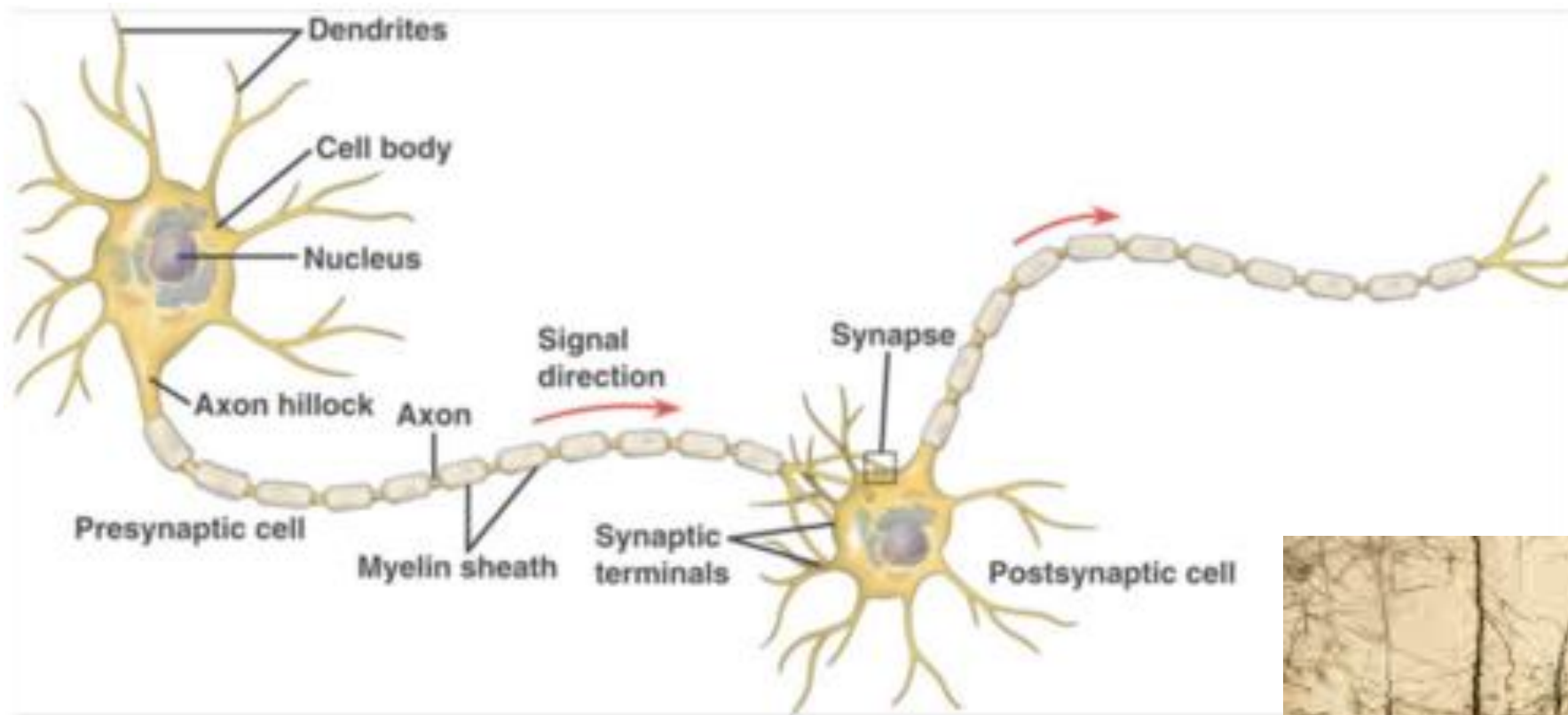
- What makes us relatively smarter than other animals?
 - Larger surface area
 - Higher neuronal density
 - Higher ratio of brain size to body size



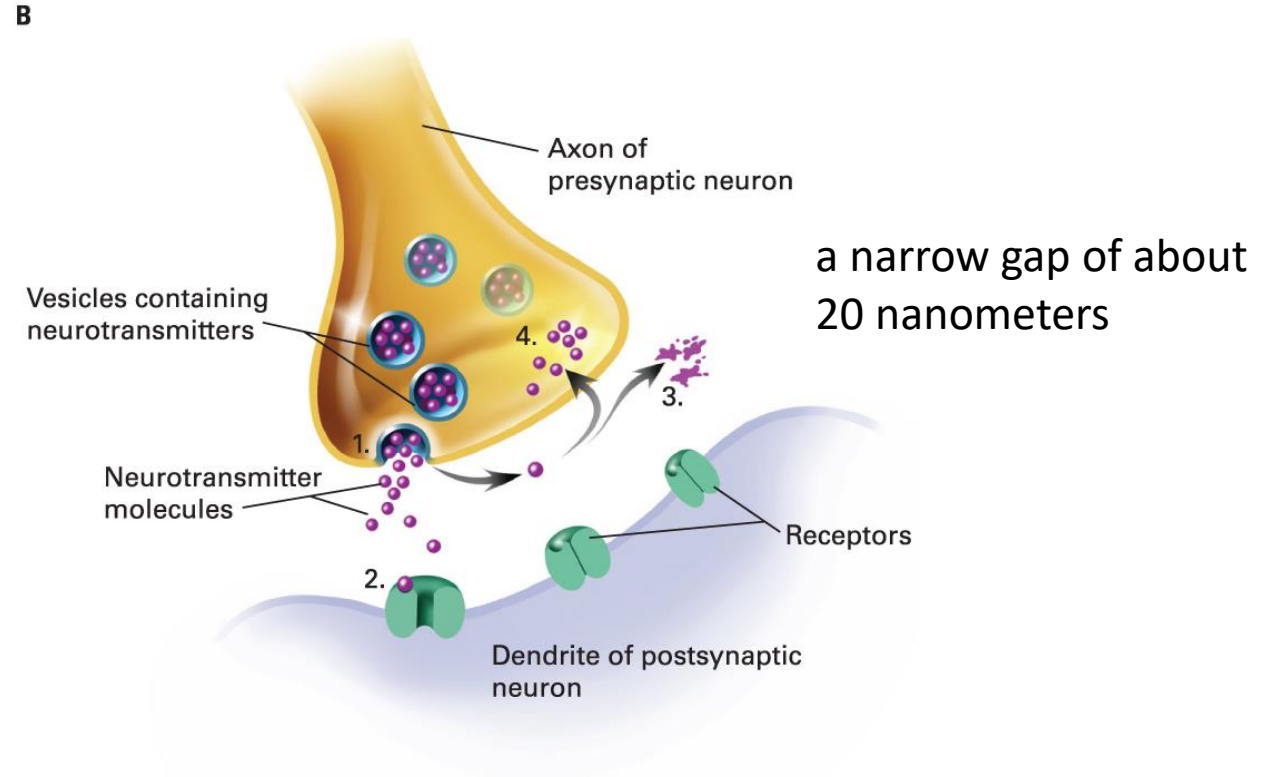
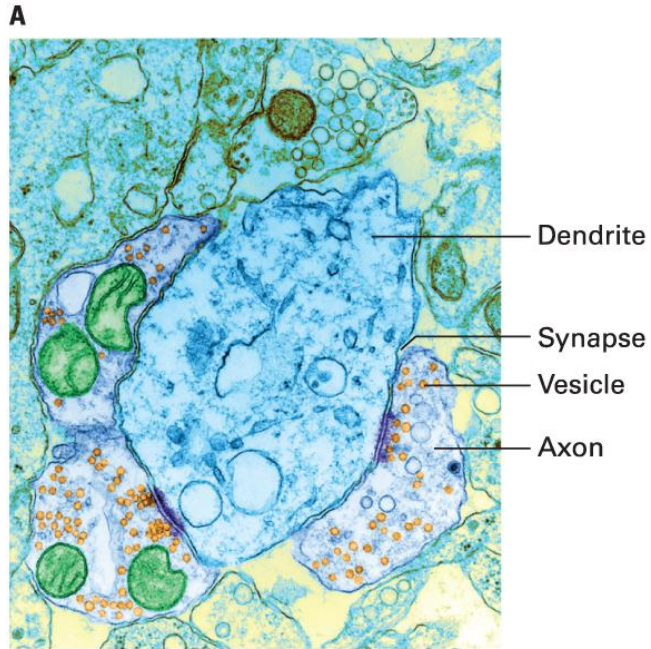
Human Brain Development

Synapse Formation Dependent on Early Experiences

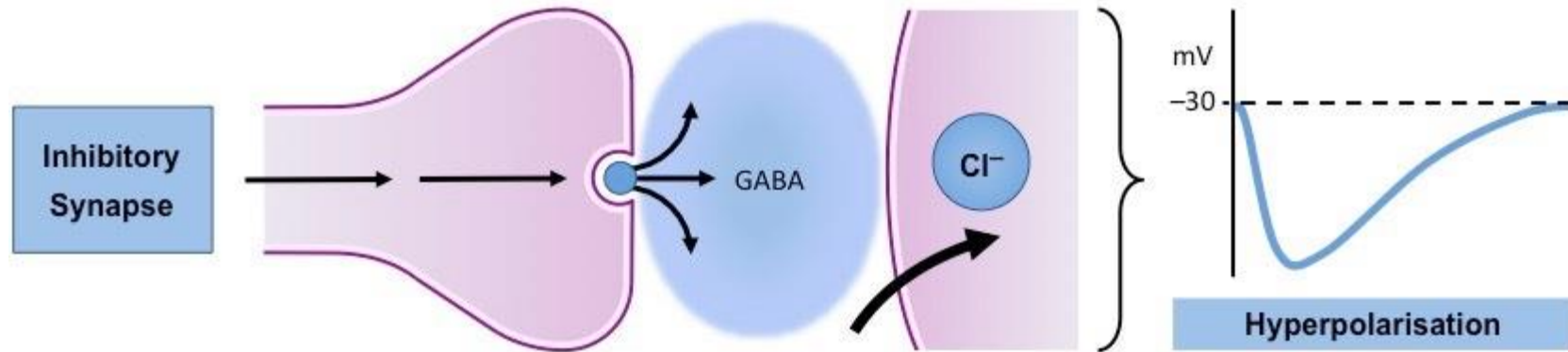
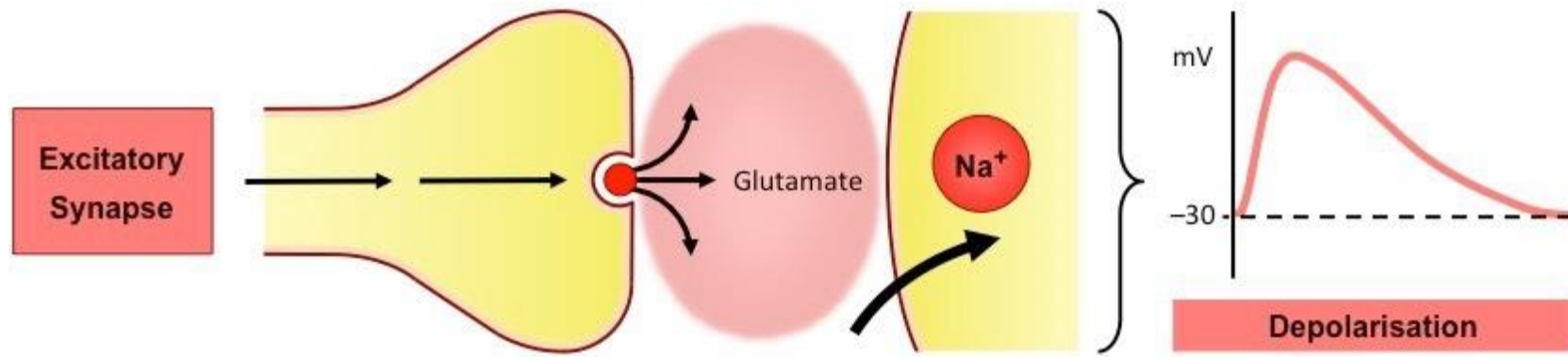




Synapse

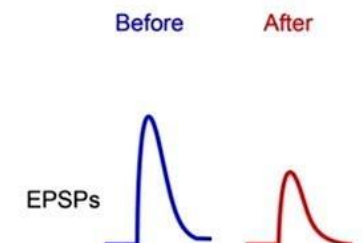
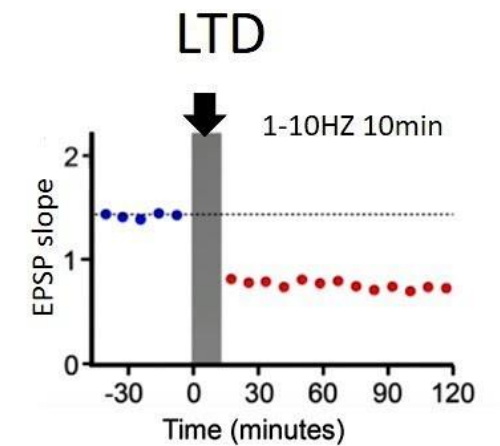
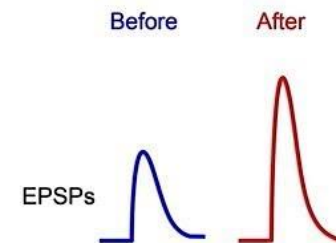
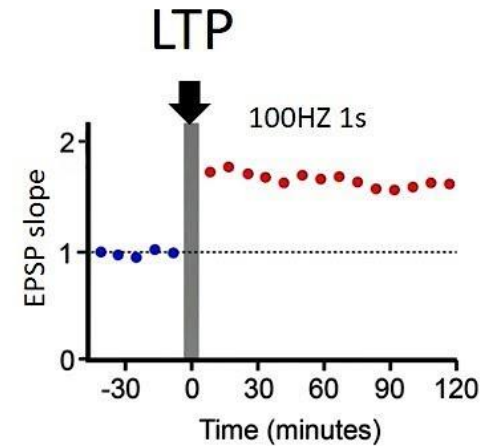


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A: OMIKRON/Science Source



- Some neurotransmitters—glutamate, for example—are *excitatory*, activating receptors that tend to increase the likelihood of the postsynaptic neuron firing
- Other neurotransmitters— such as GABA—are *inhibitory*, activating receptors that tend to decrease the likelihood of the postsynaptic neuron firing

- **Long-term potentiation (LTP):** a process in which synaptic transmission becomes more effective as a result of recent activity
- **Long-term depression (LTD):** a process in which synaptic transmission becomes less effective as a result of recent activity

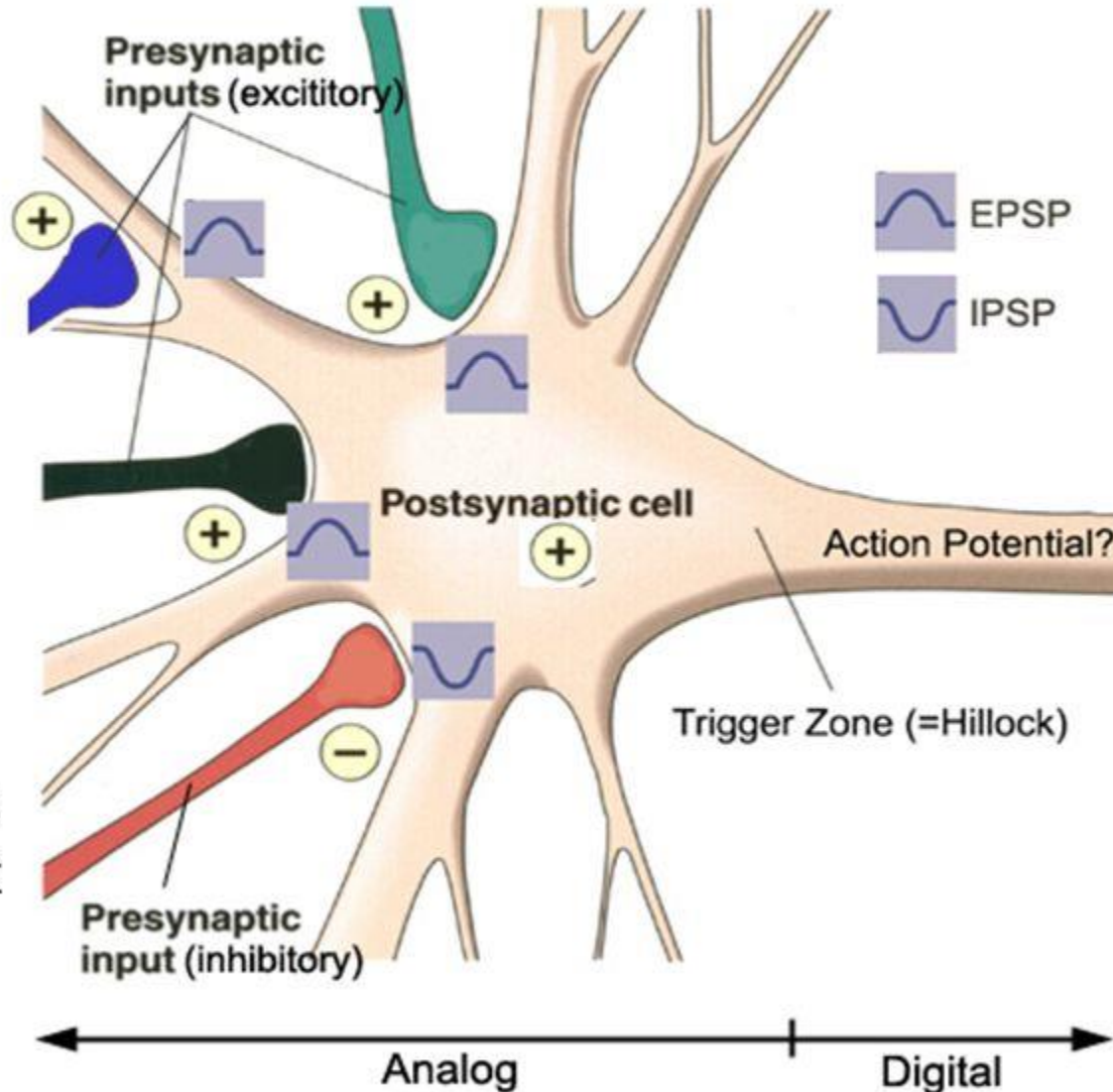


Spatial summation of PSP

Post synaptic potential

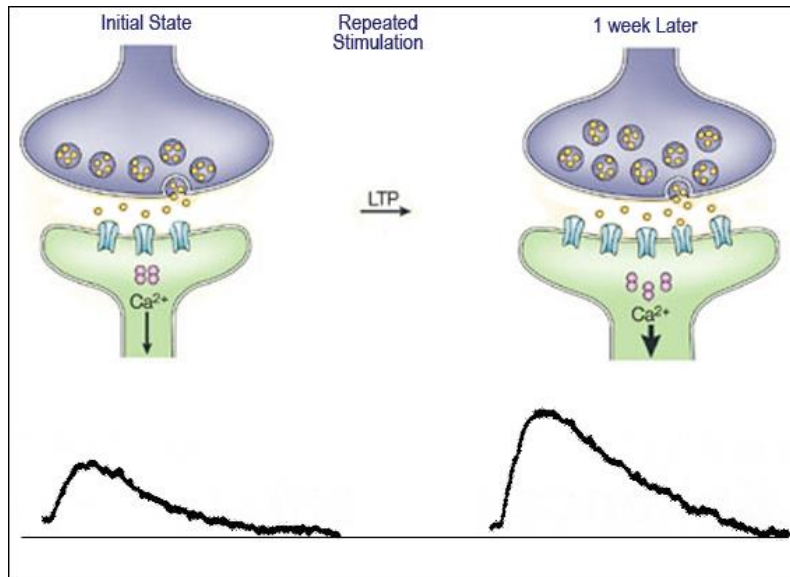
Synaptic integration

- The combining of excitatory and inhibitory signals acting on adjacent membrane regions of a neuron. In order for an action potential to occur, the sum of excitatory and inhibitory postsynaptic potentials (local responses) must be greater than a threshold value.

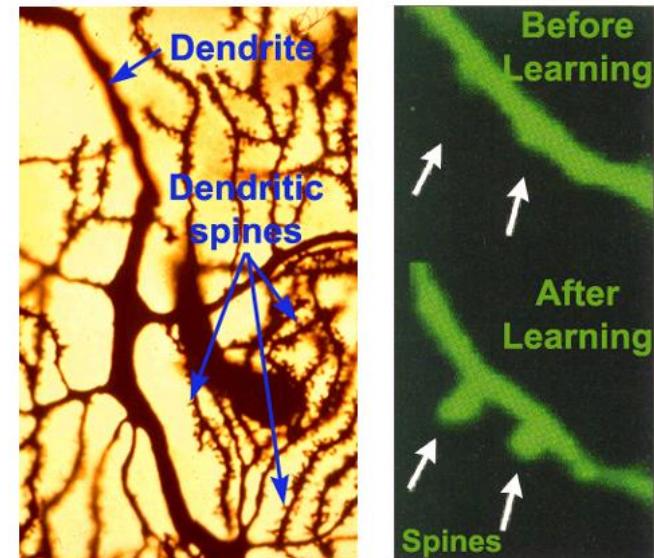


When synapses get strengthened, what changes occur in a neuron that increase magnitude of LTP?

More receptors on the postsynaptic membrane



Dendritic Spines Increase with Learning

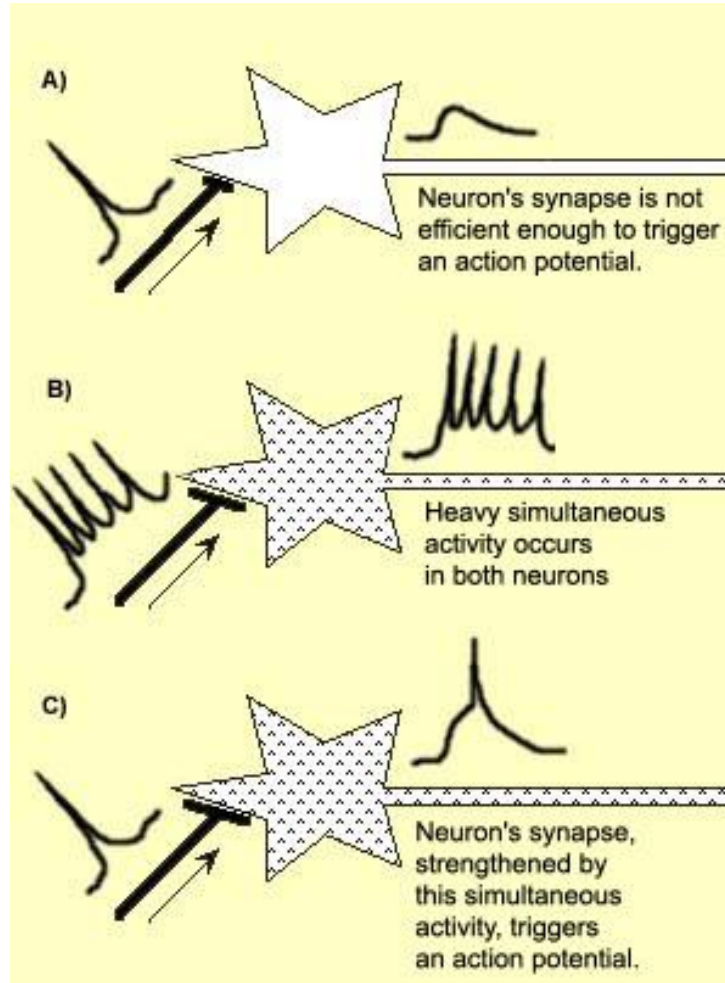


More dendrites

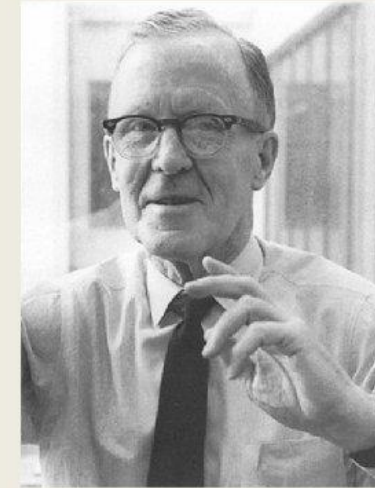
Under what conditions does synaptic plasticity occur?

Hebb's Law

Hebbian Learning

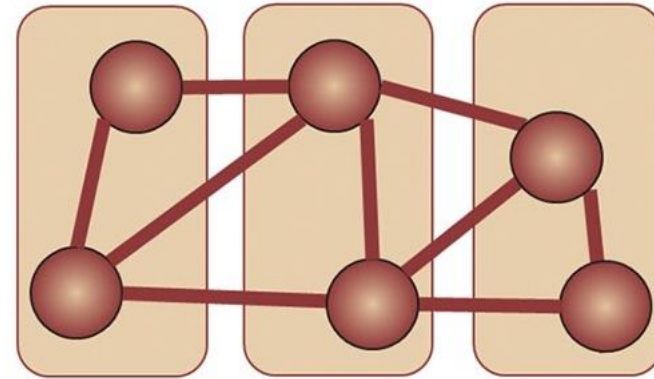
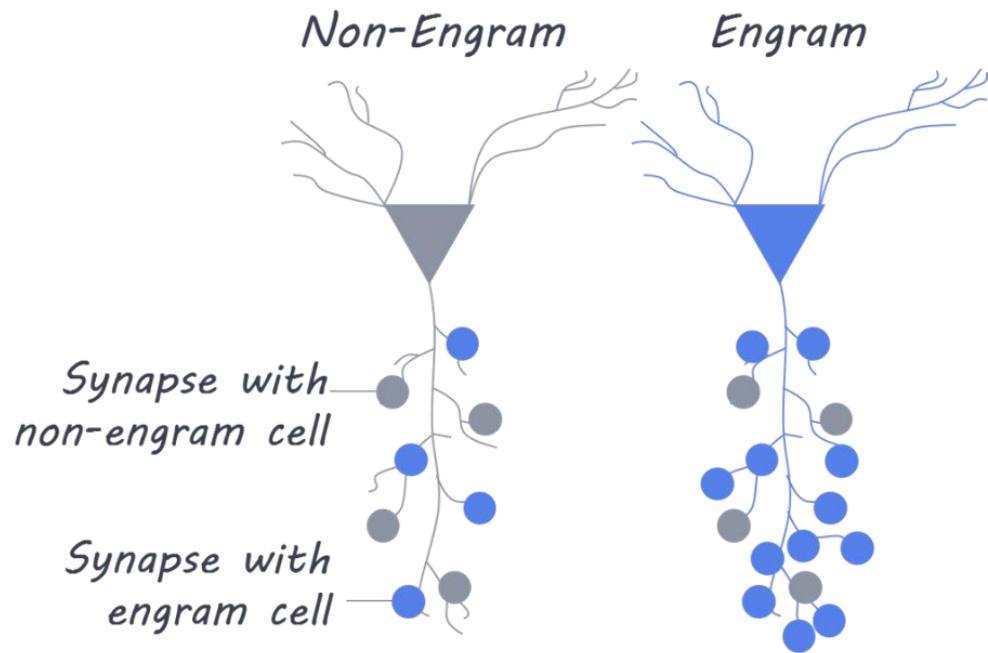


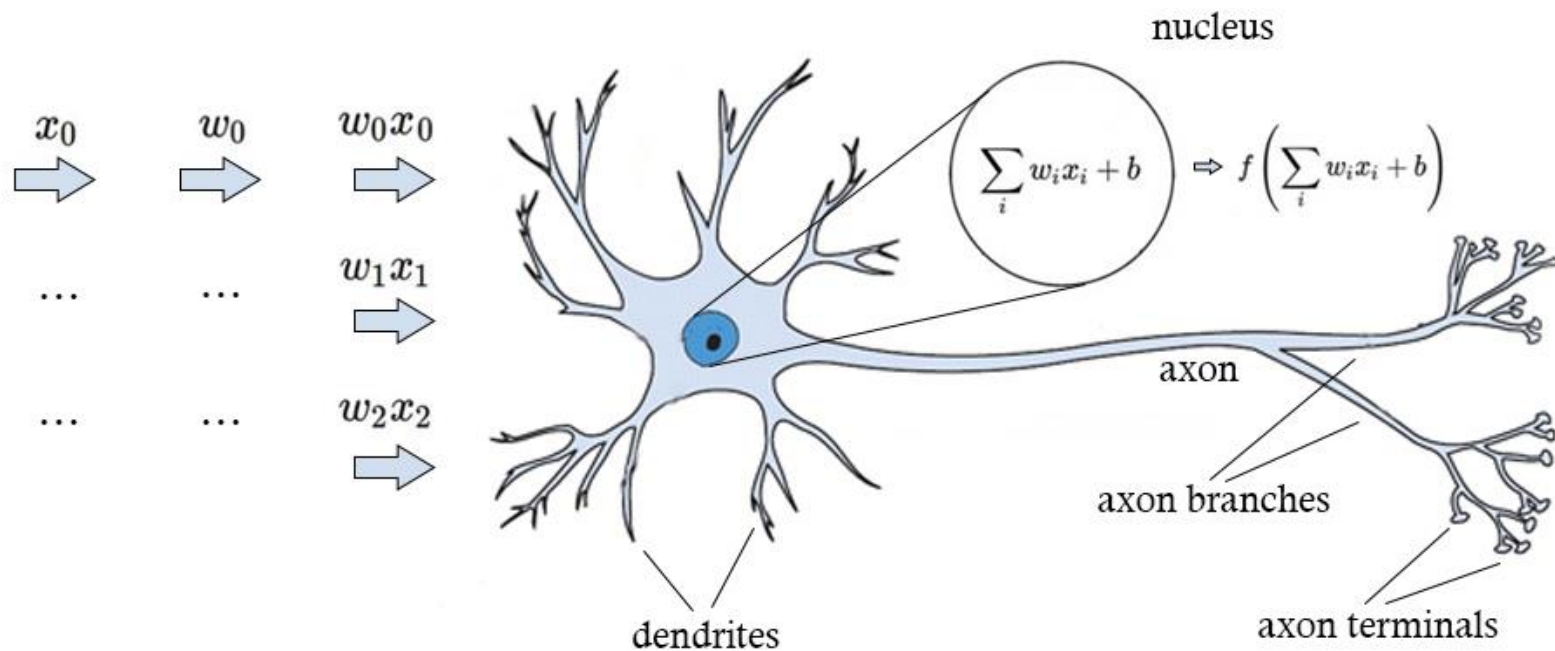
Donald Hebb



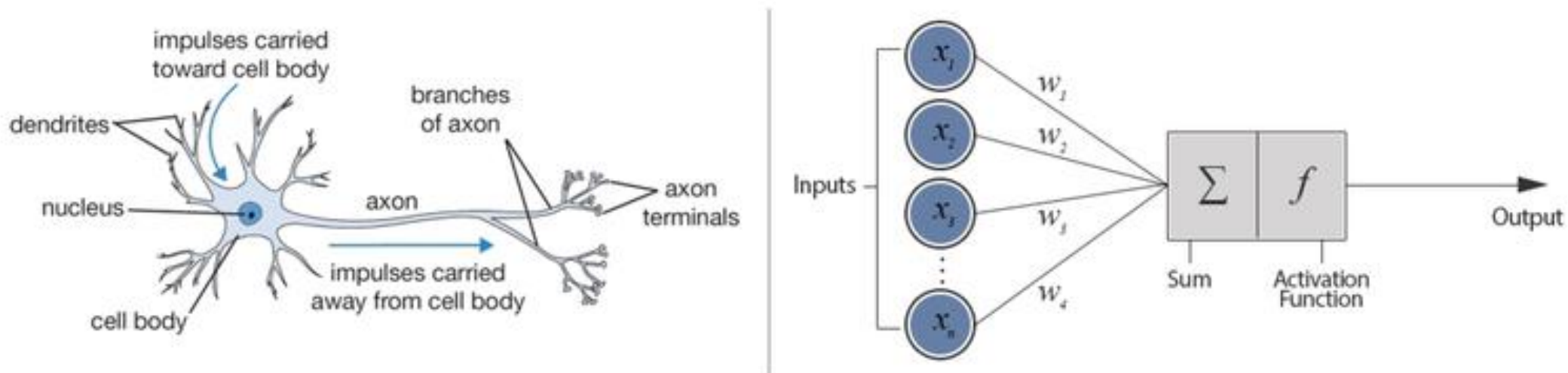
Neurons that fire together, wire together.

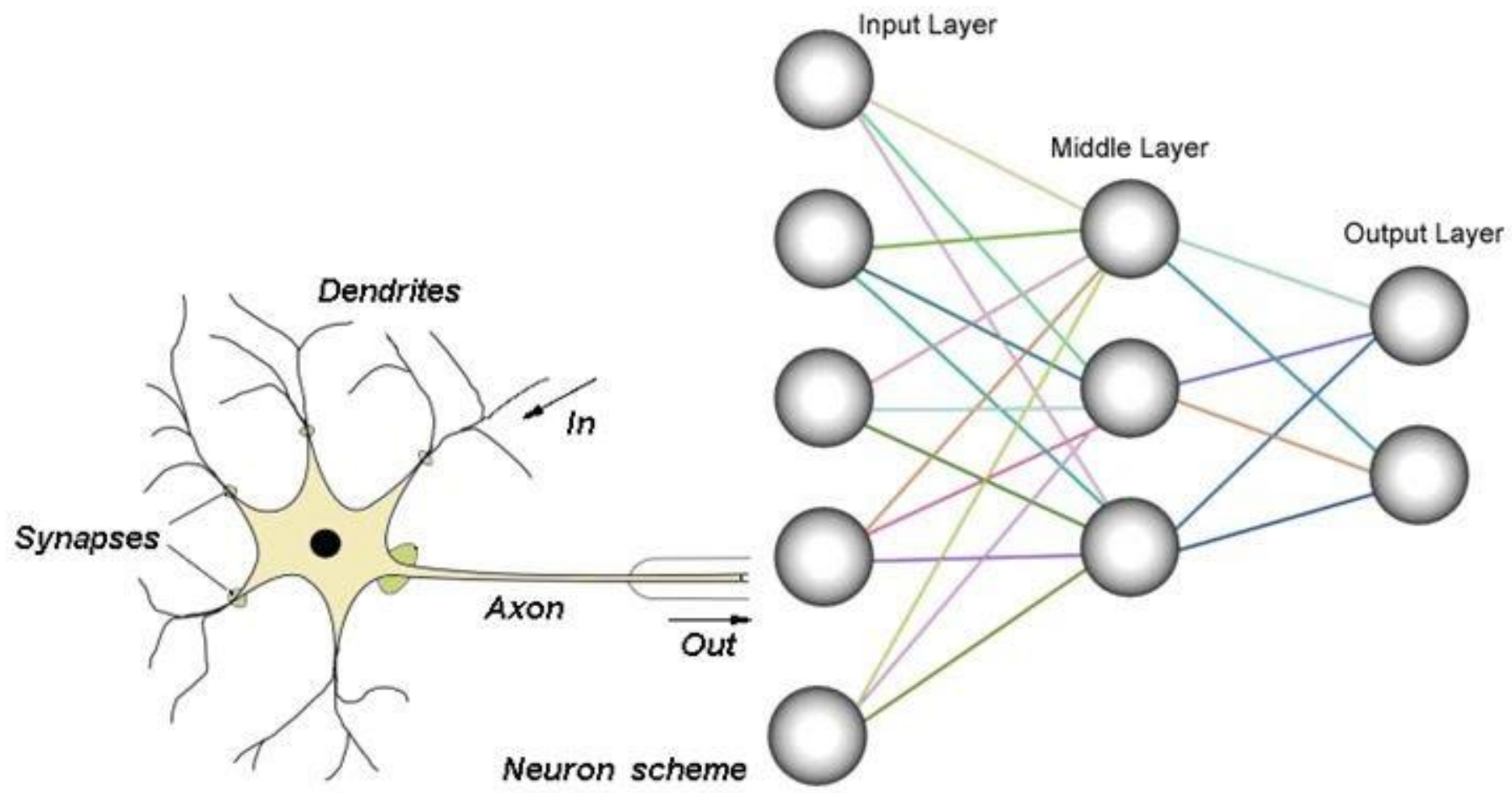
Engram?



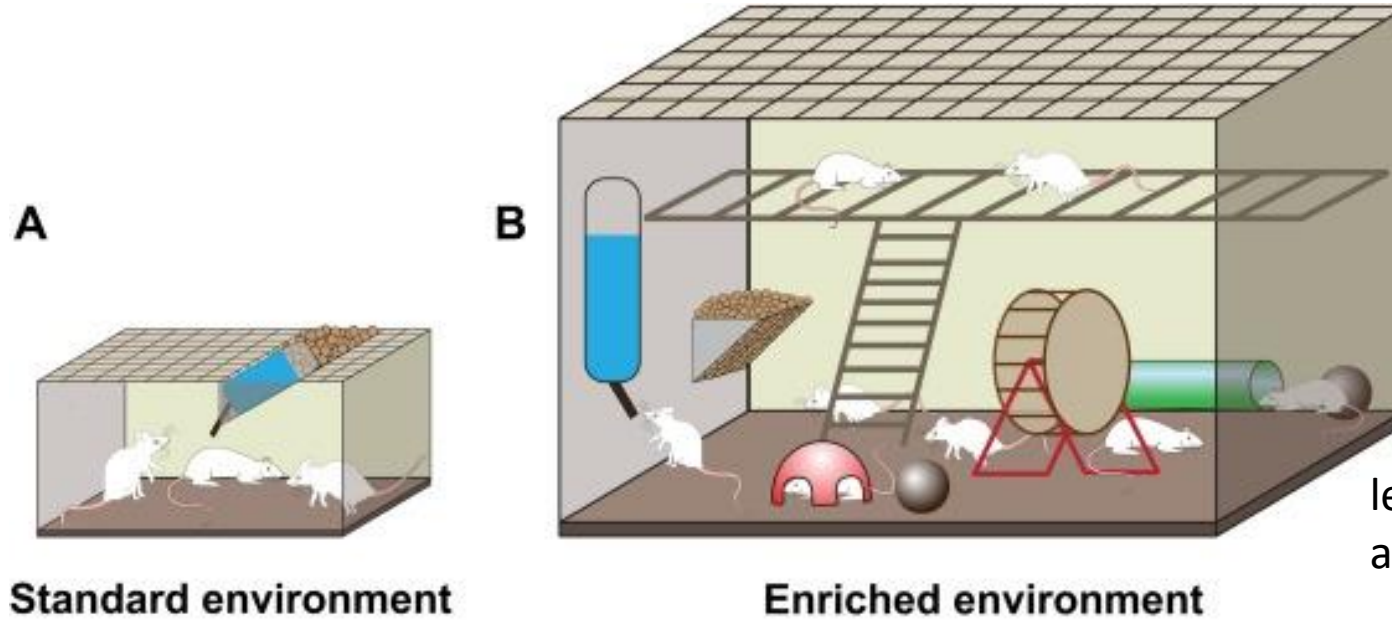


Biological Neuron versus Artificial Neural Network

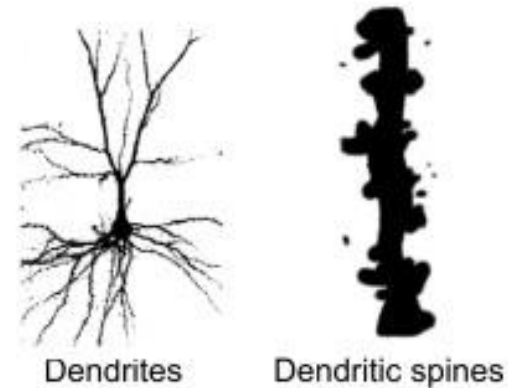
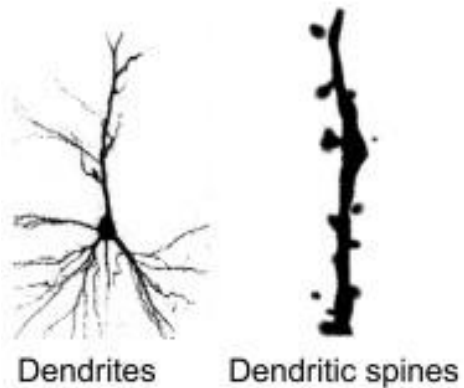




How can we learn through-out our lives → neurons are limited?



learning, social interactions,
and exercise



- Can learning related changes in a neuron be reversed?

Neurons are important unit of information processing

- Which is the most important region for helping the brain to form new memories?



















Old items - Target



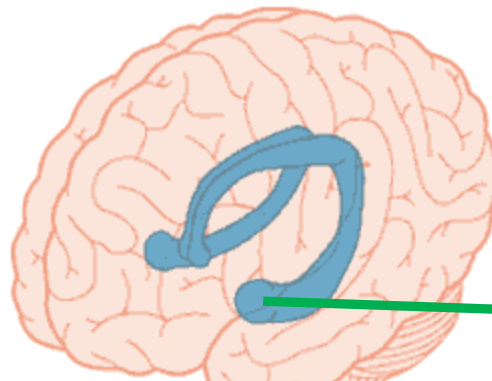
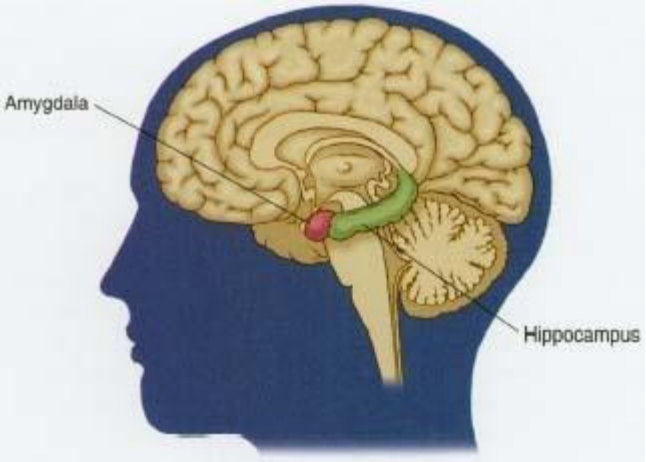
Similar items - Lures



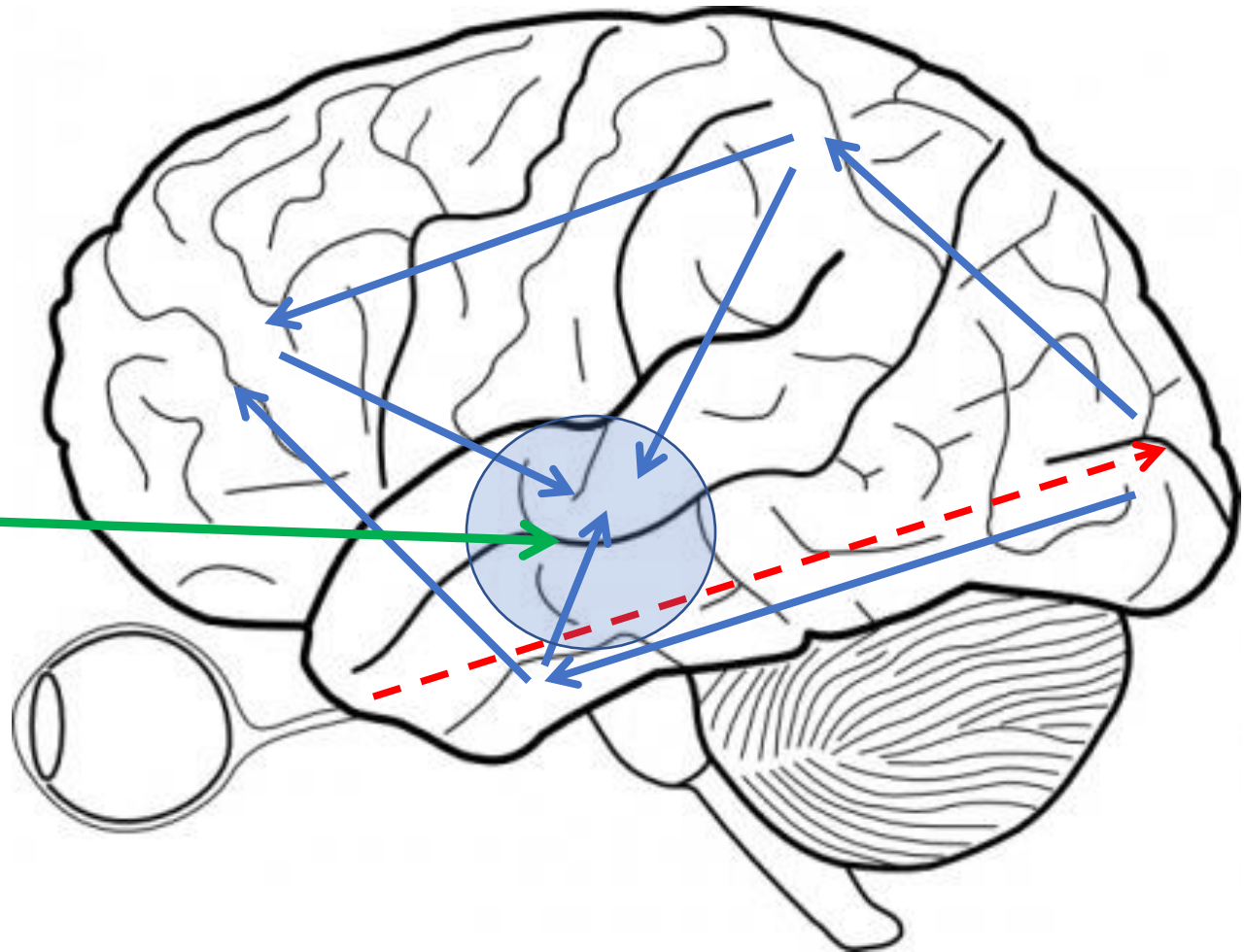
New items - Foils

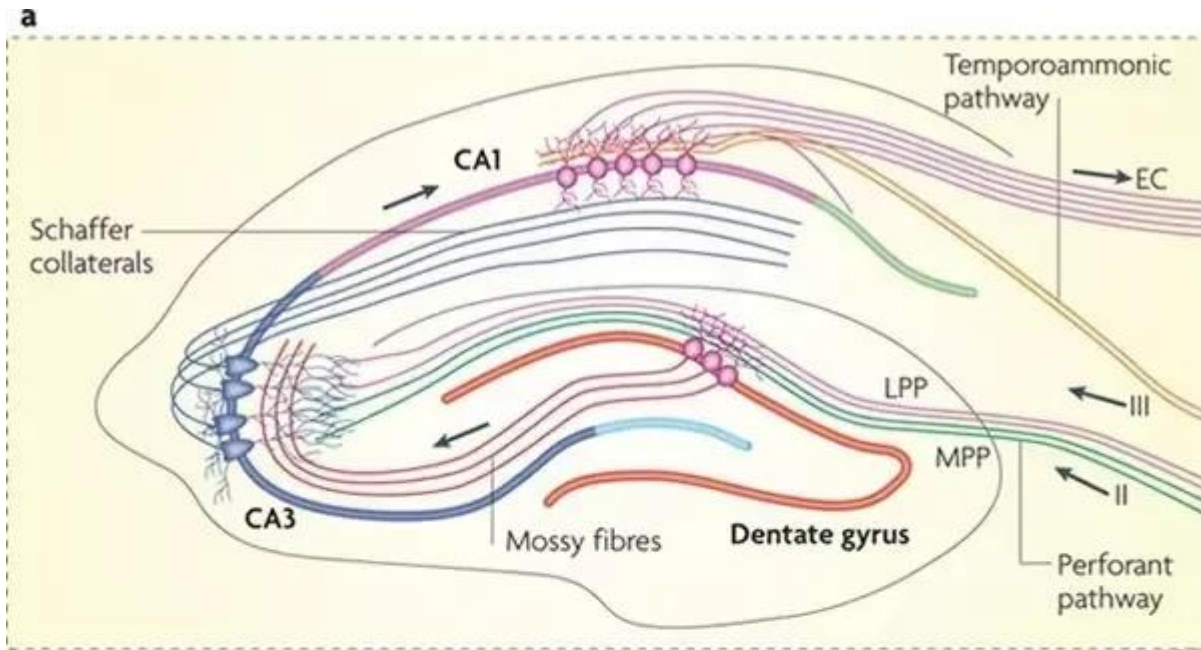


- How does our brain achieve such a level of computation?

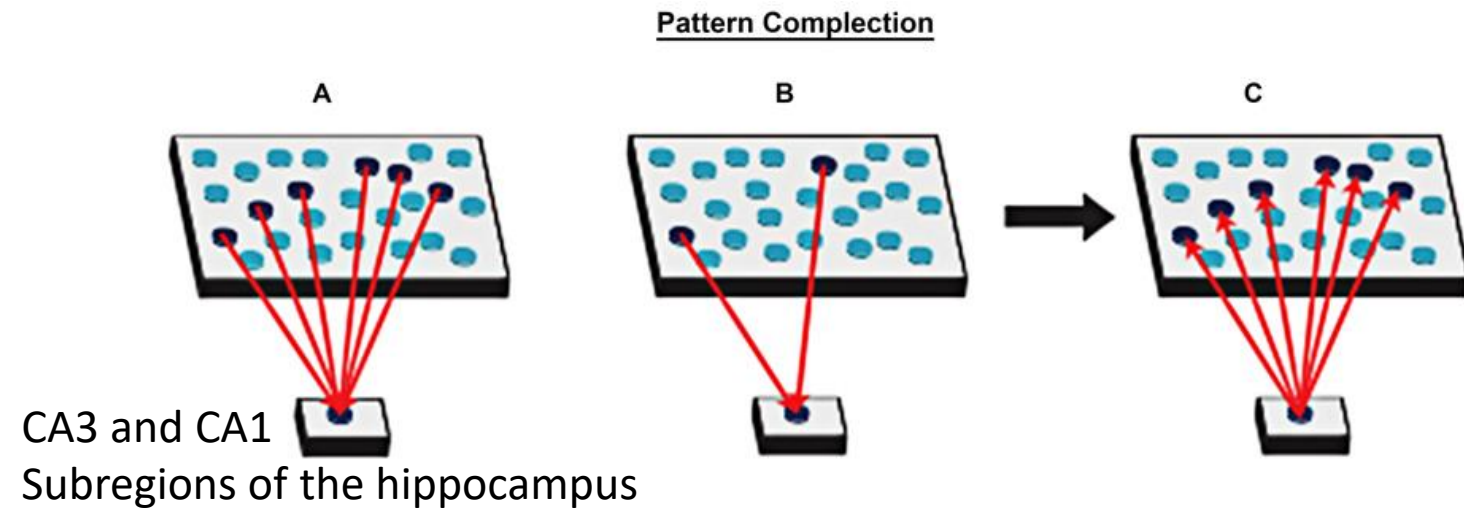


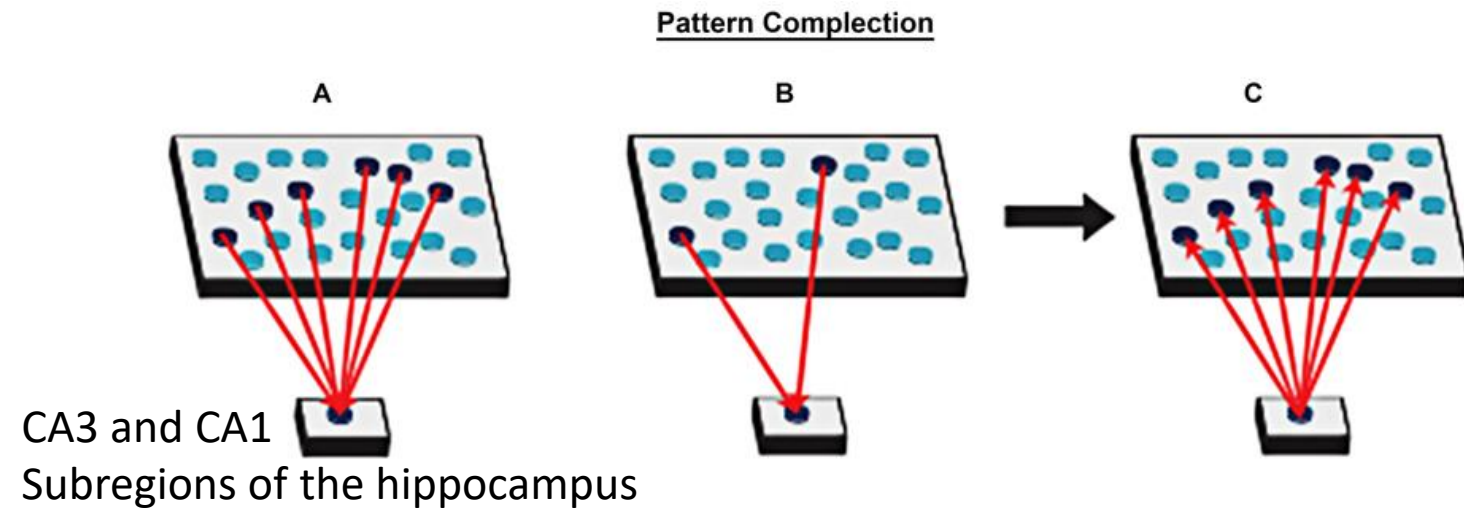
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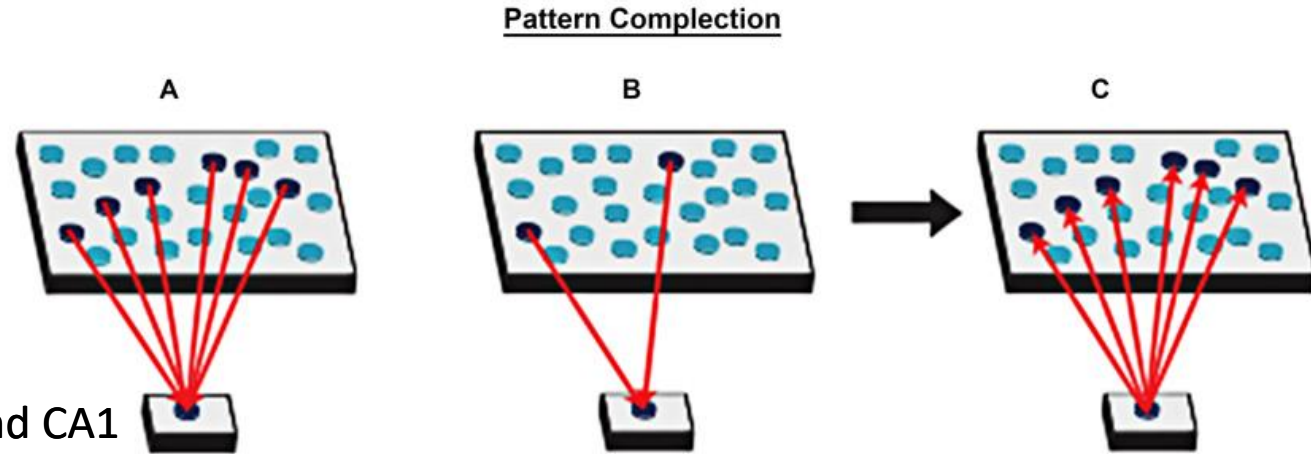
Unidirectional
flow of
information



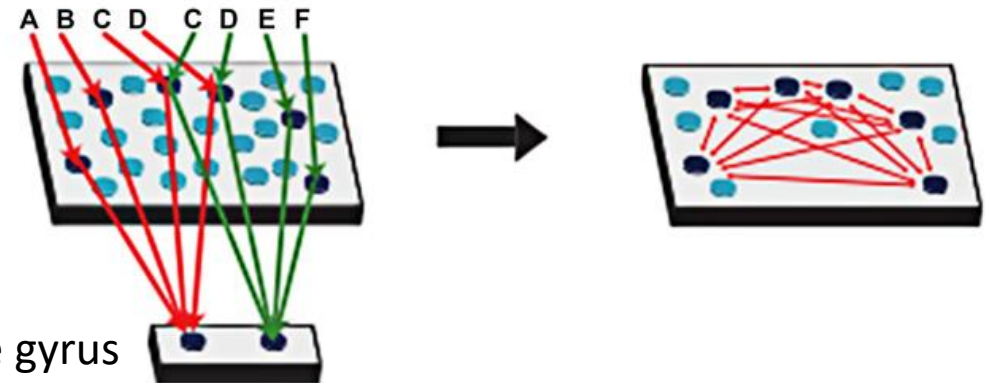




CA3 and CA1
Subregions of the hippocampus



Pattern Separation



Dentate gyrus
Sub-region of the hippocampus



Pattern discrimination and completion are recognized as complementary processes, requiring a fine balance between establishing and dissociating new memories and reconstructing old ones

- What if somebody loses their hippocampus?