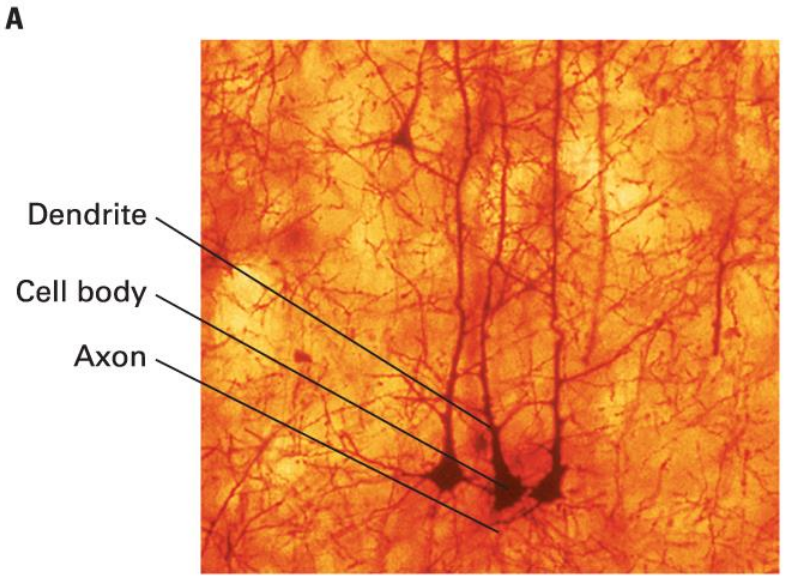
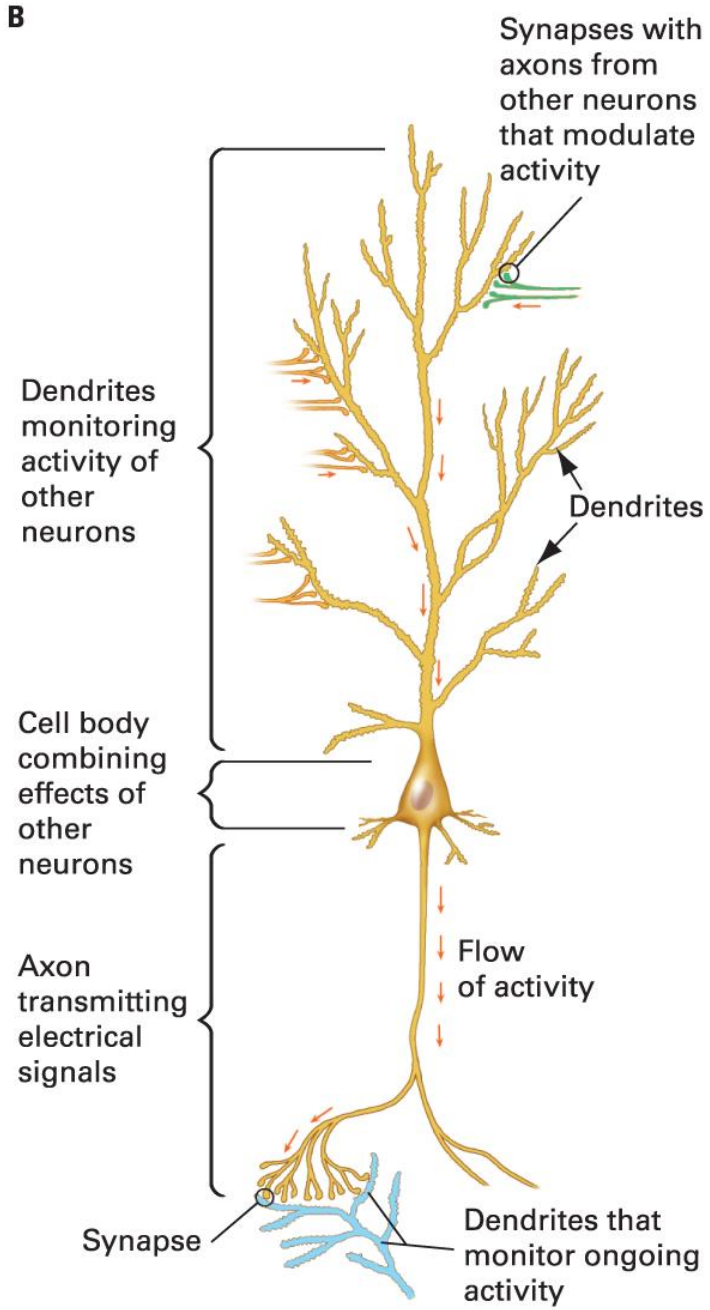
Anatomy of Learning and Memory

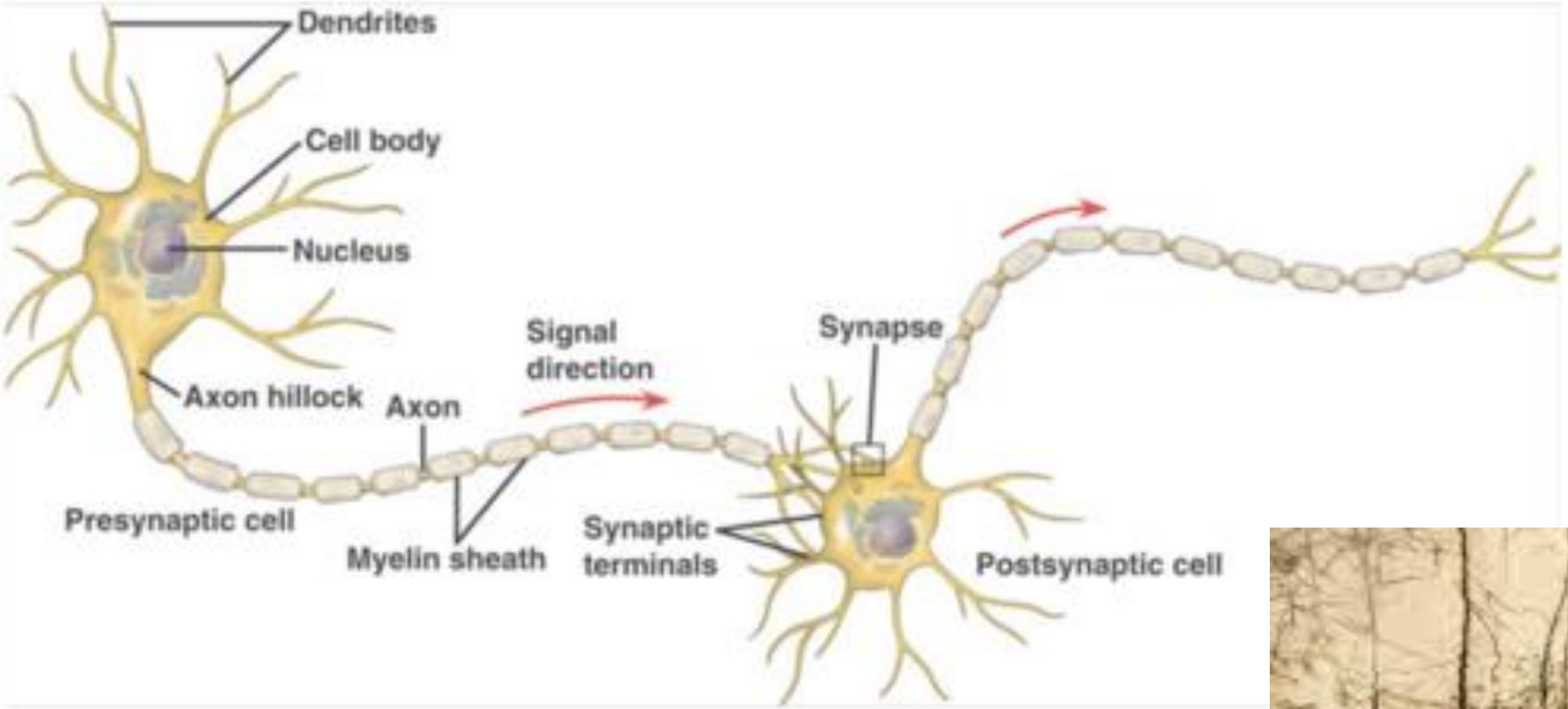
Where is memory stored in the brain?

Neuron

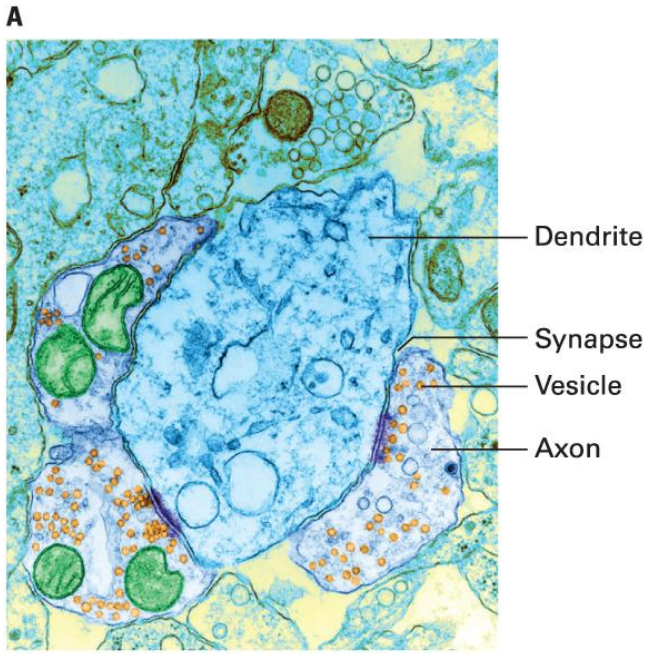


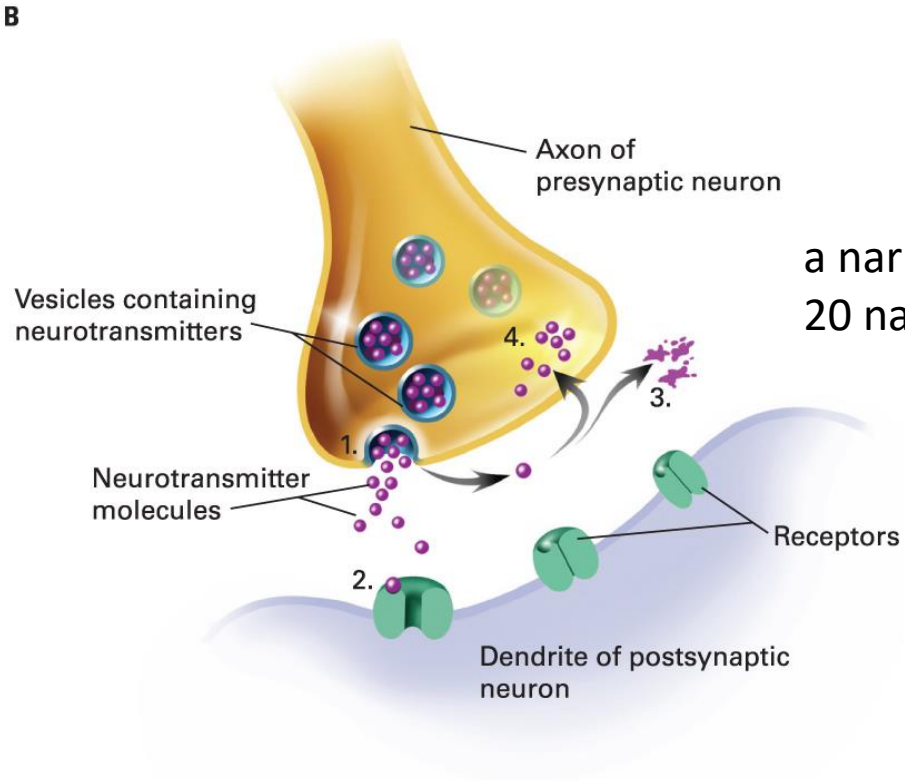


Gluck et al., *Learning and Memory*, 4e, © 2020 Worth Publishers
A: Biophoto Associates/Science Source


Dendrites
Cell body
Nucleus
Axon hillock
Axon
Signal direction
Synapse
Presynaptic cell
Myelin sheath
Synaptic terminals
Postsynaptic cell

Synapse





a narrow gap of about 20 nanometers

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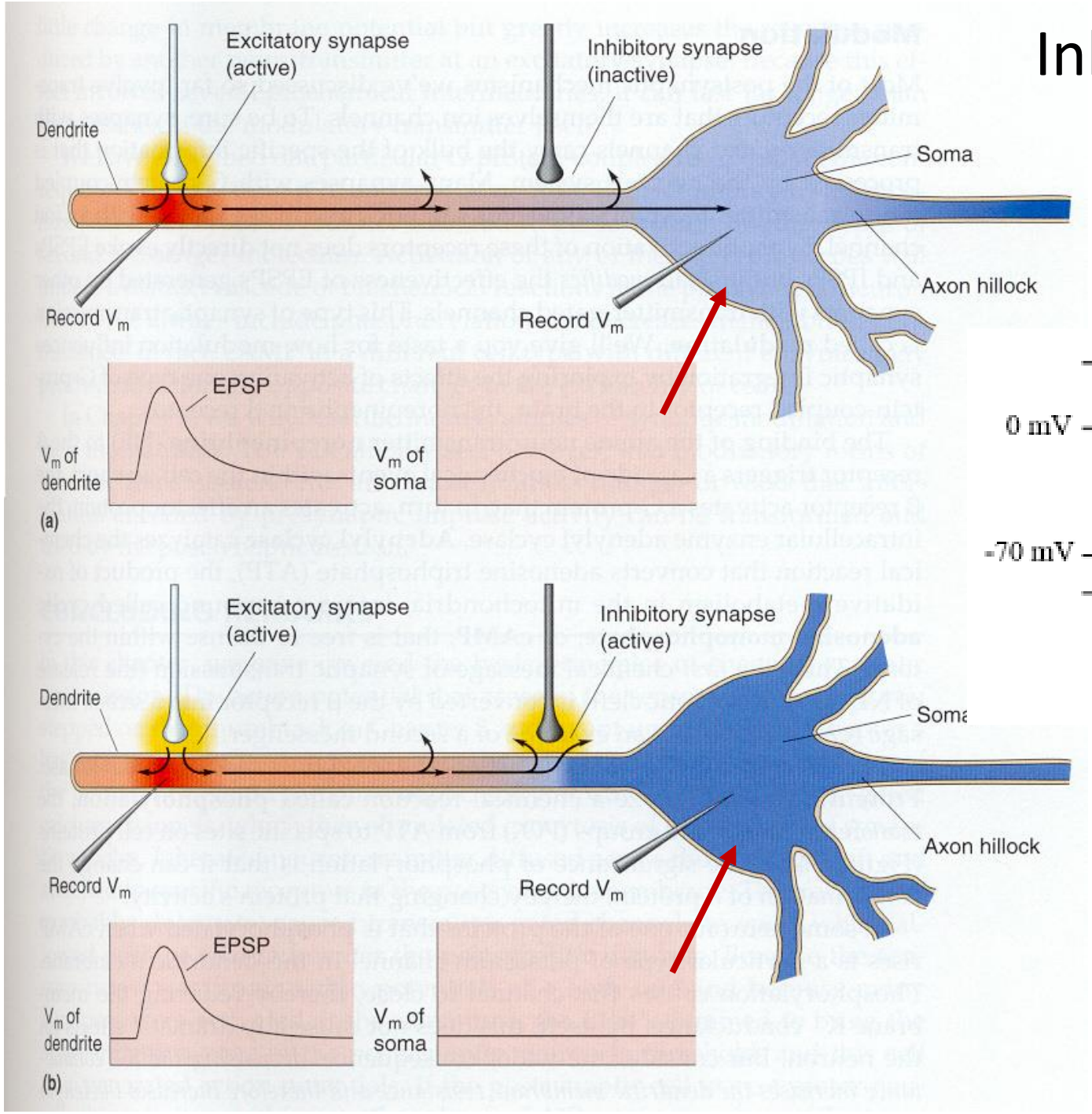
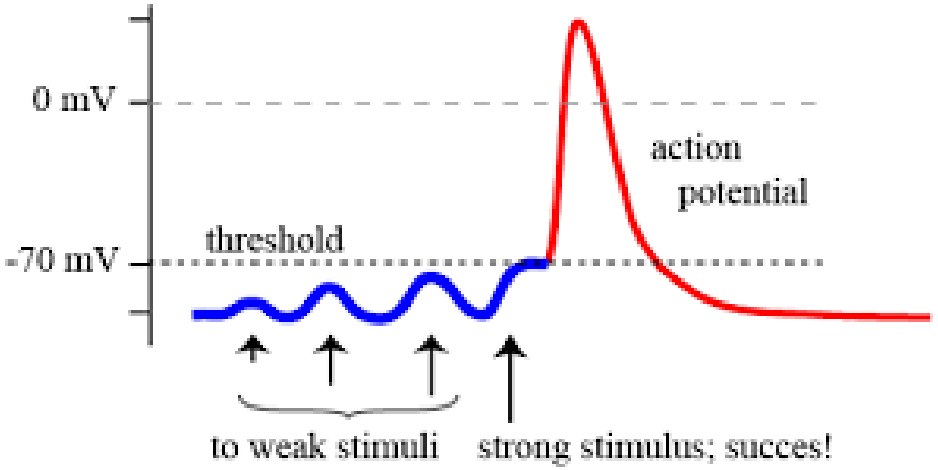
A: OMIKRON/Science Source

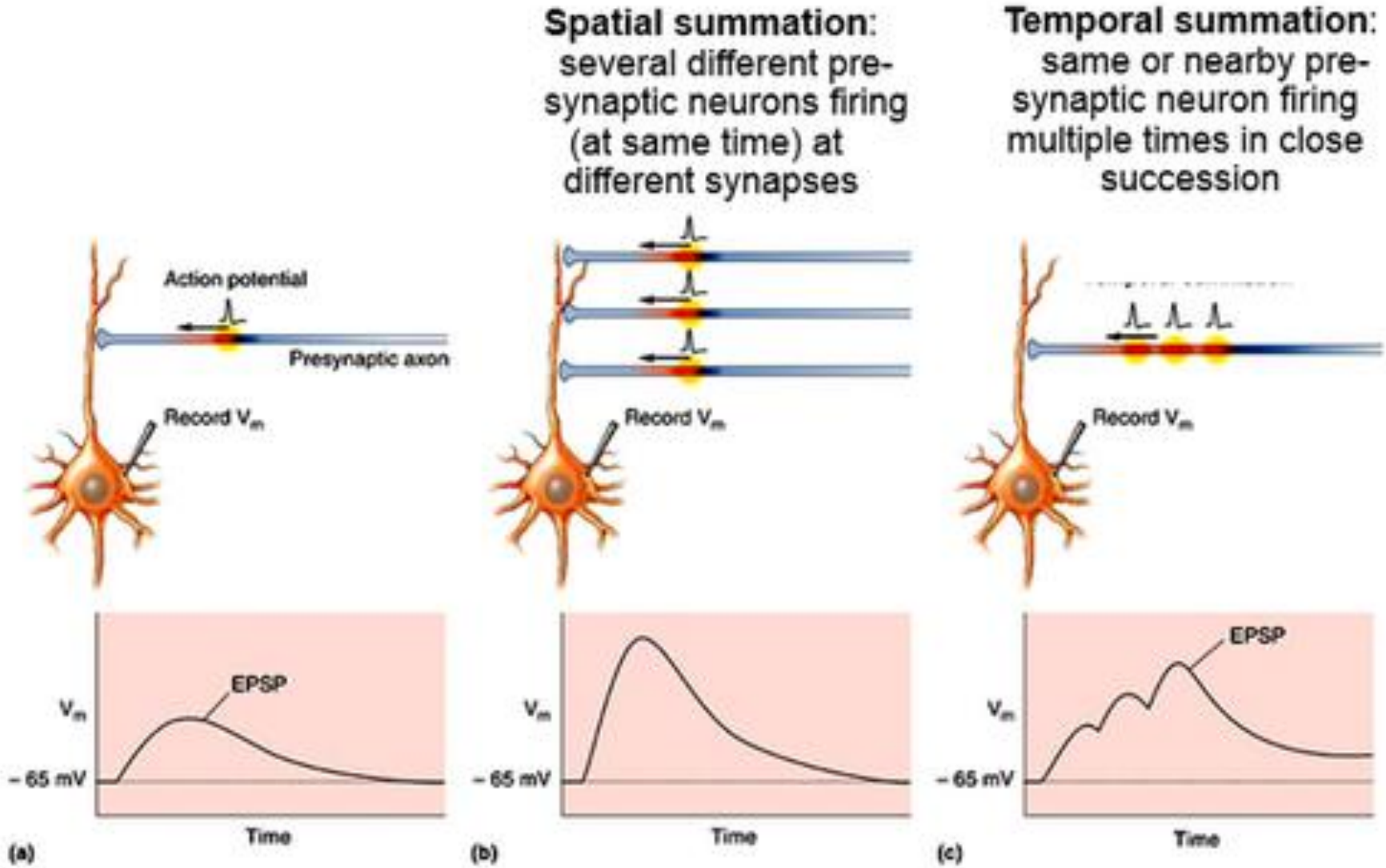
How does a neuron know when to fire?

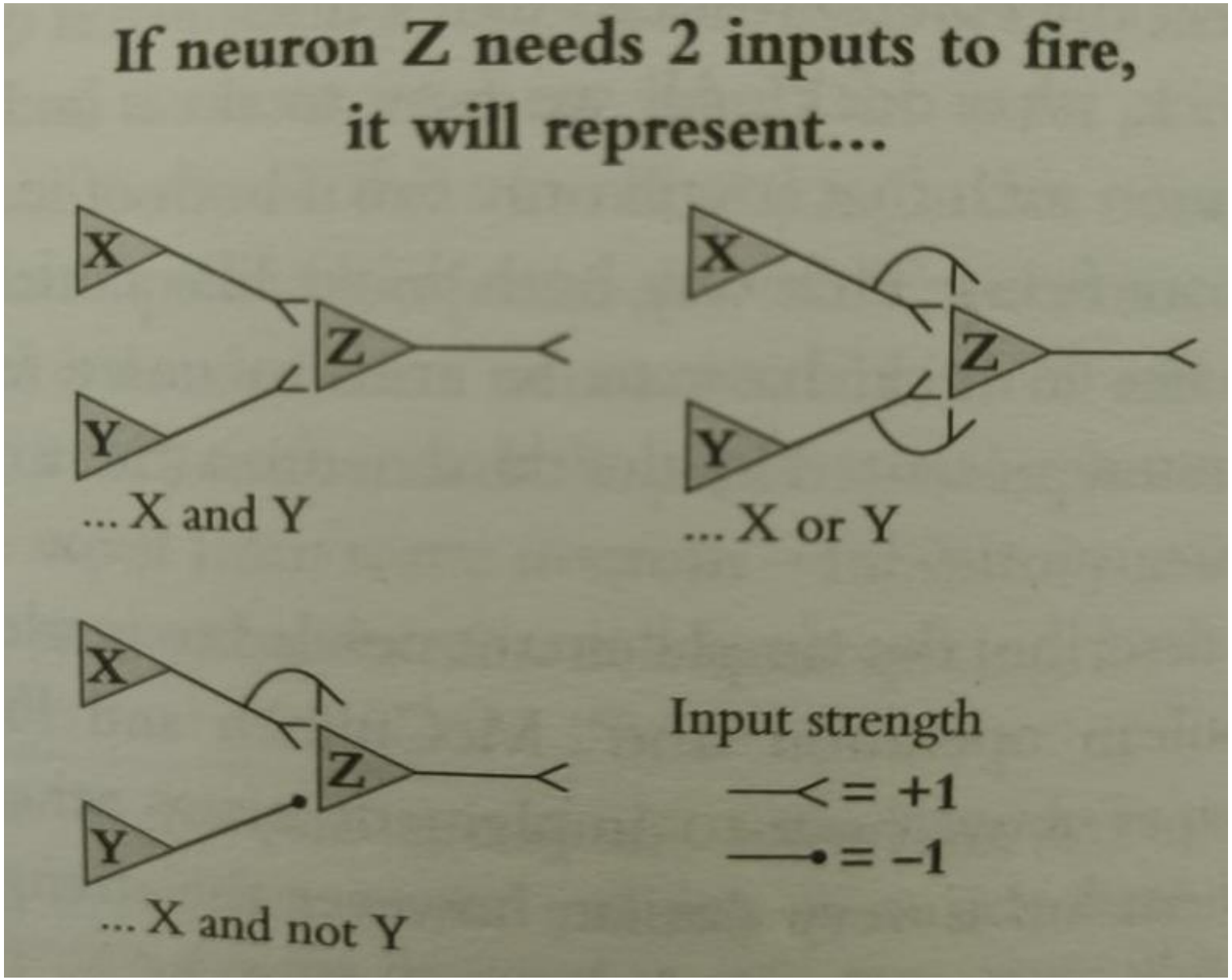
Inhibition and Excitation





Temporal Vs Spatial Summation of PSP





NOT

x	F
0	1
1	0

AND

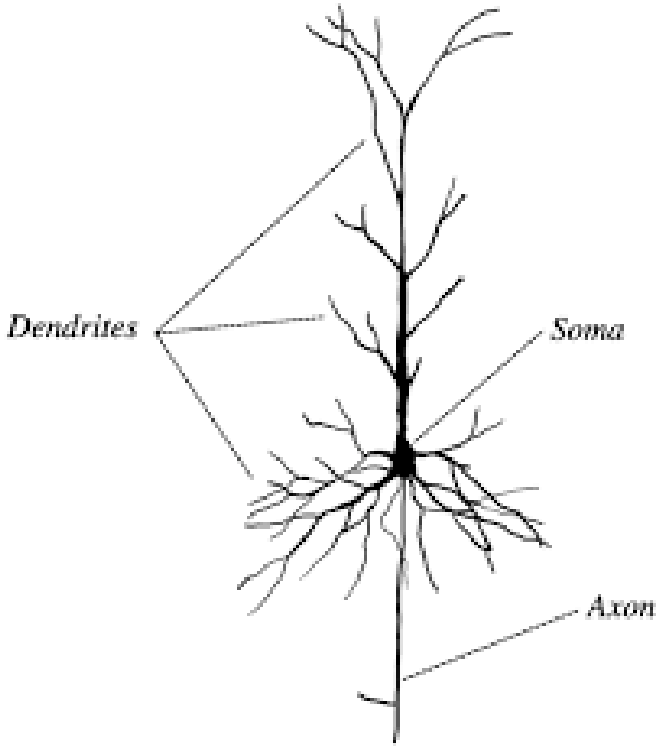
x	y	F
0	0	0
0	1	0
1	0	0
1	1	1

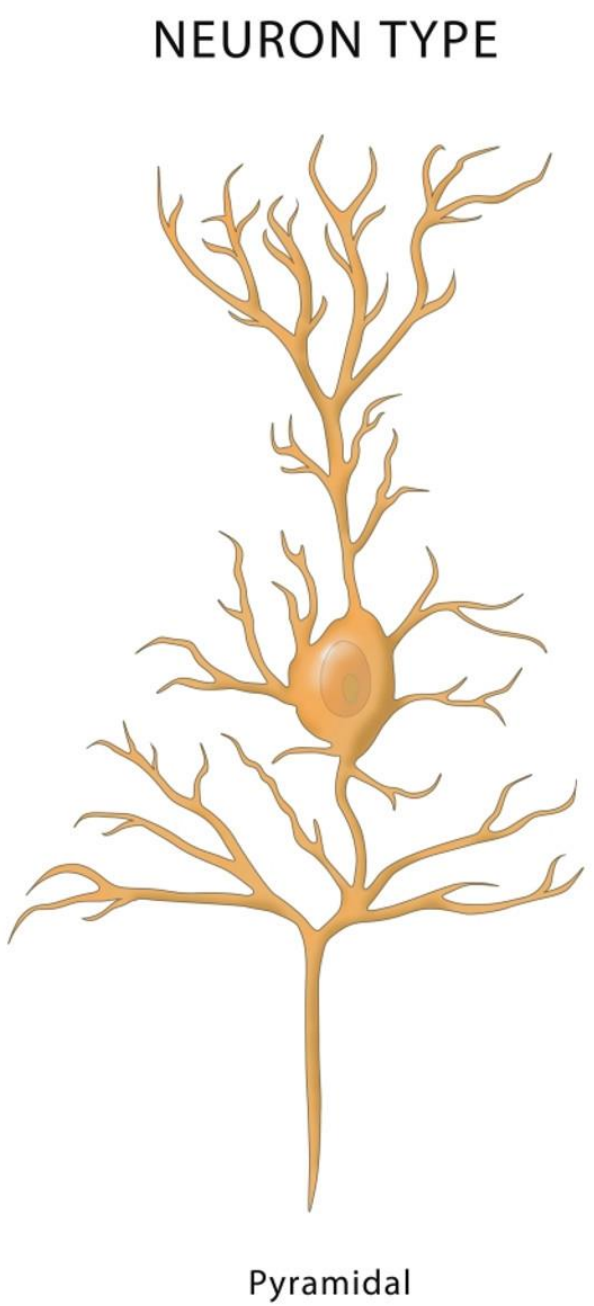
OR

x	y	F
0	0	0
0	1	1
1	0	1
1	1	1

Neurons function similar to Boolean Operators

Neurons are not so simple – thousands of inputs





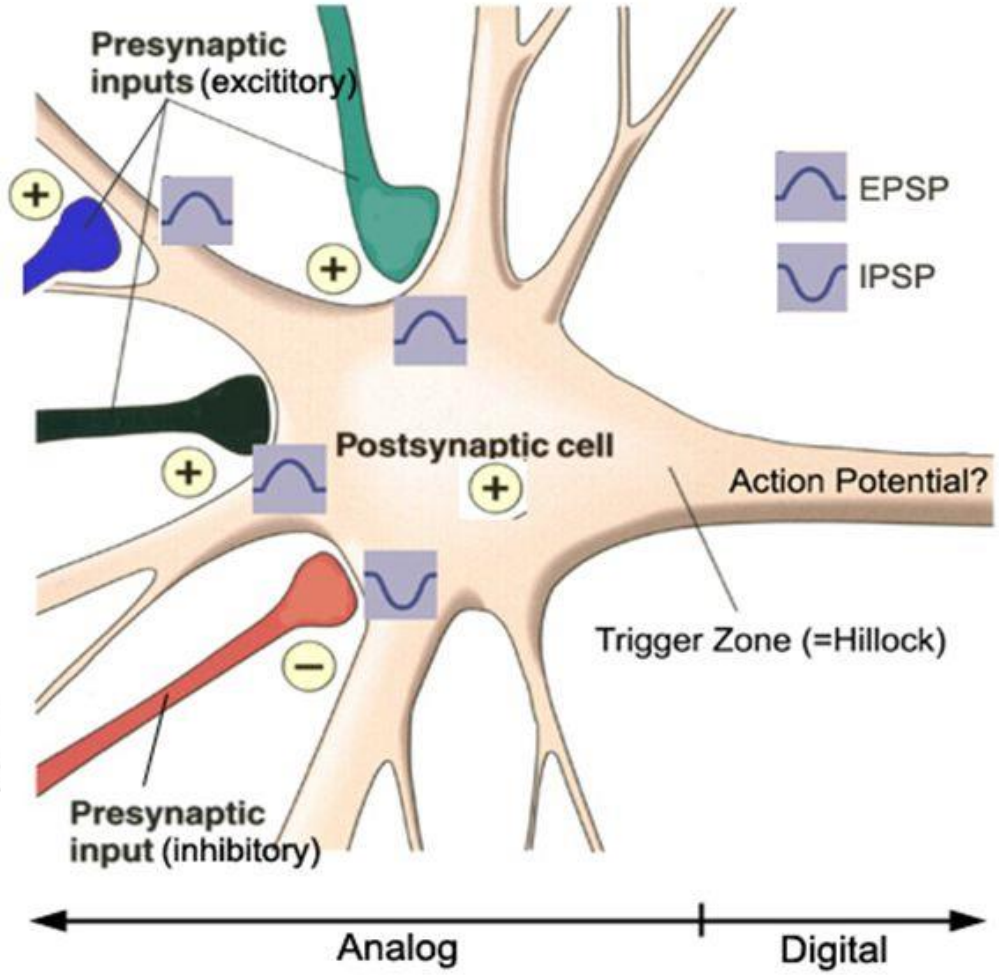
How does a neuron incorporate Boolean logic?

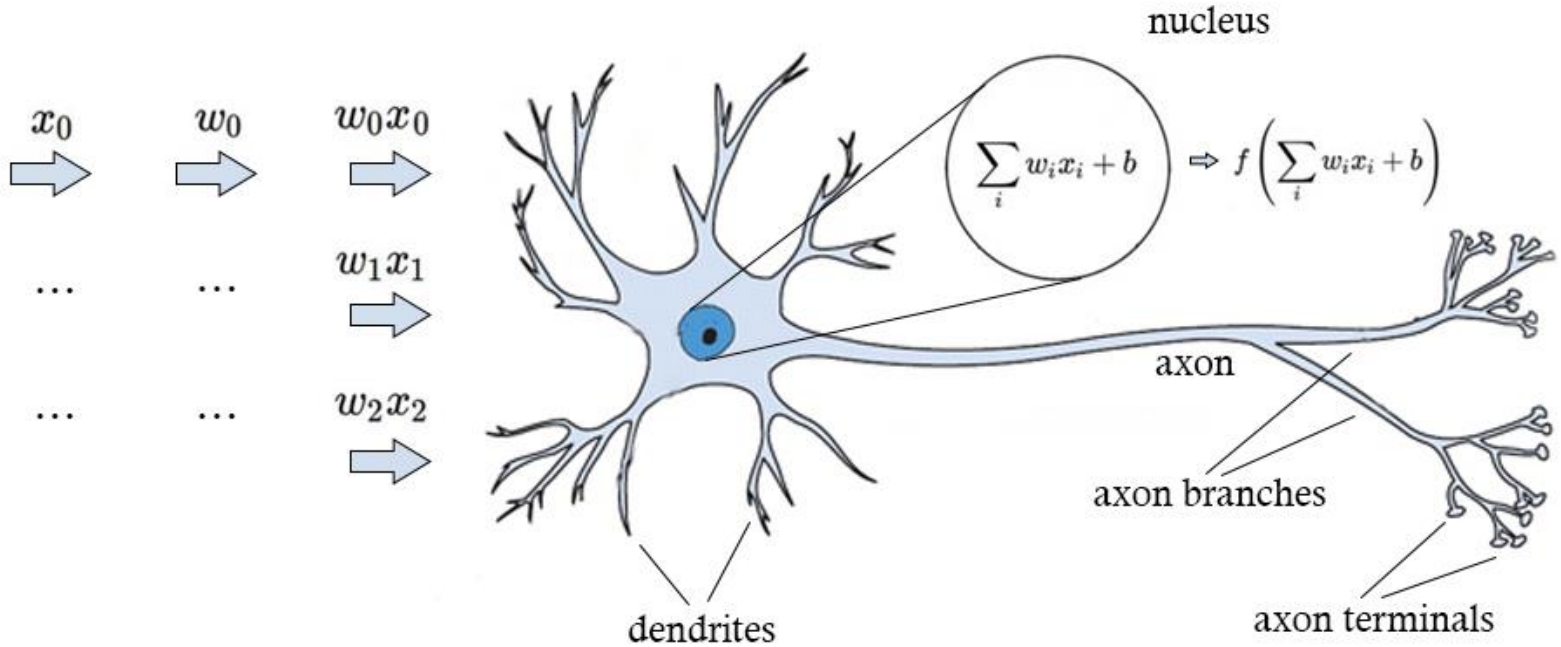
Spatial summation of PSP Post synaptic potential

Synaptic integration

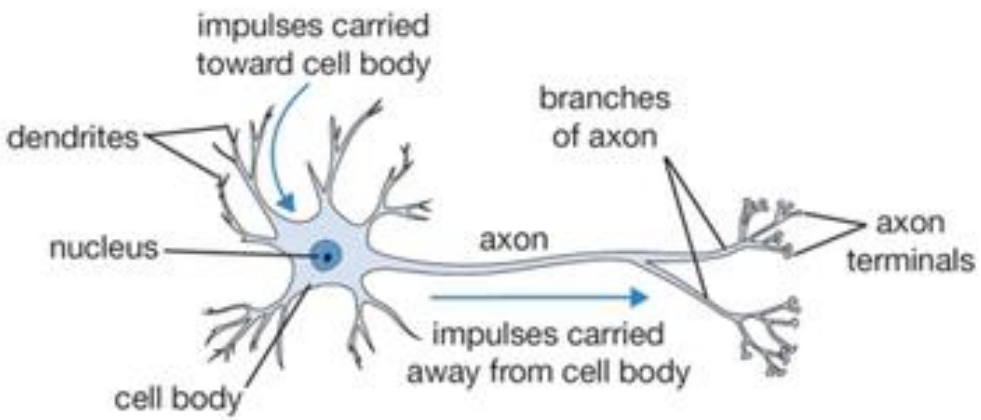
- The combining of excitatory and inhibitory signals acting on adjacent membrane regions of a neuron.

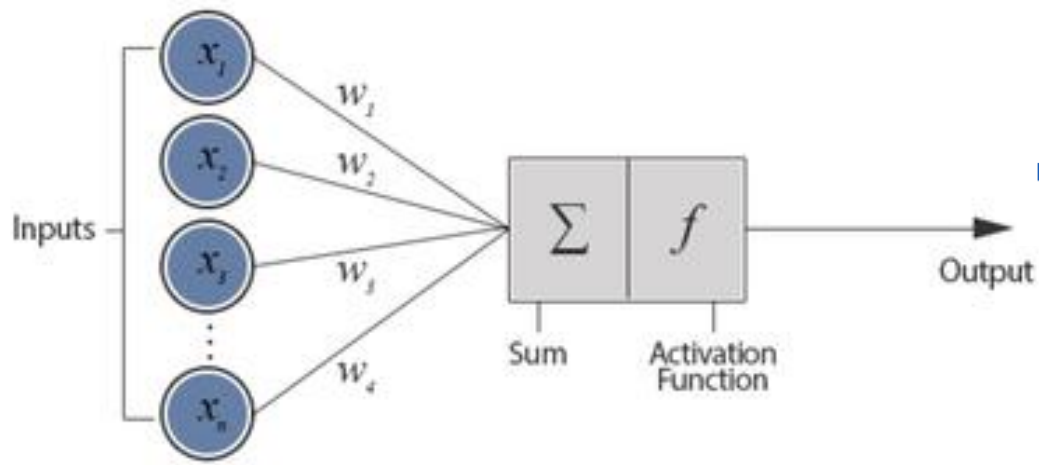
In order for an action potential to occur, the sum of excitatory and inhibitory postsynaptic potentials (local responses) must be greater than a threshold value.

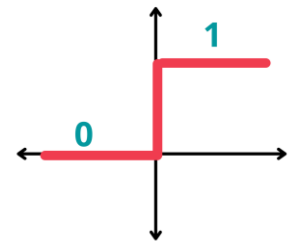




Biological Neuron versus Artificial Neural Network



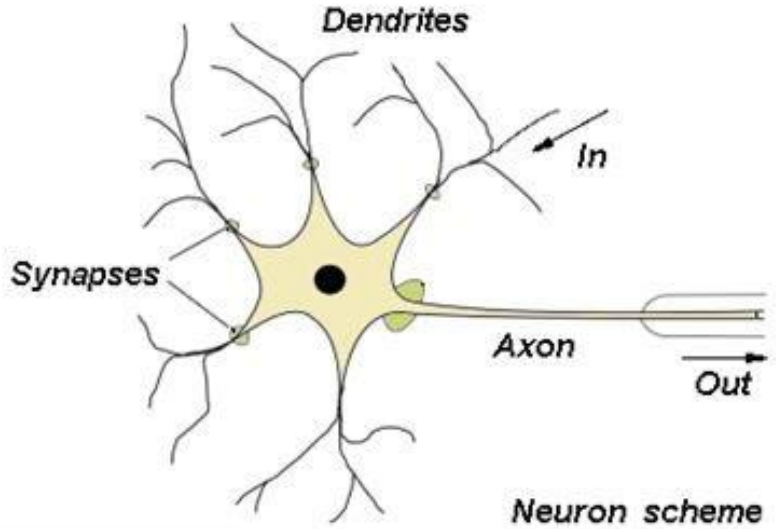


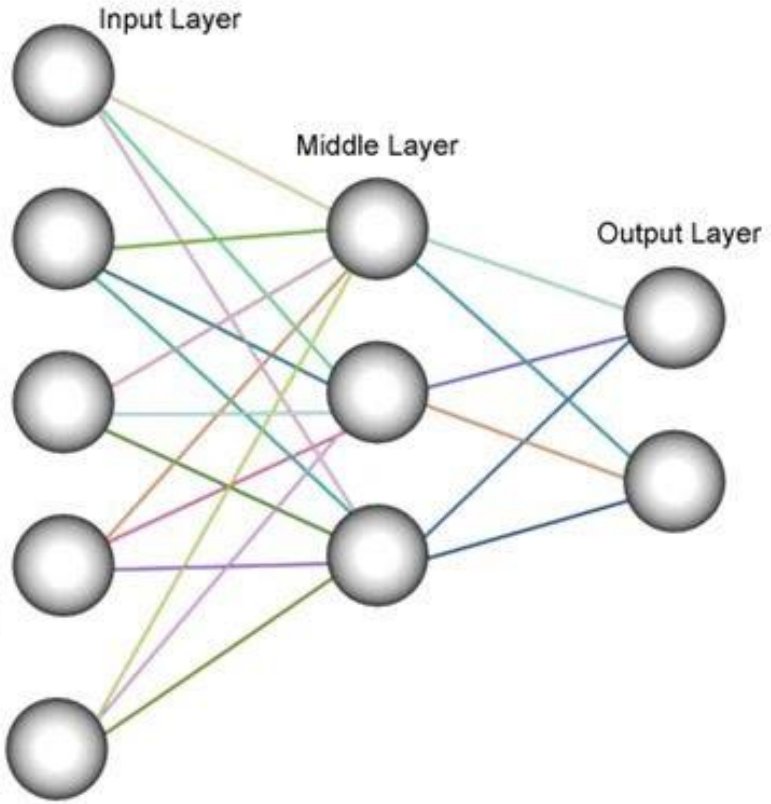


Binary Step Activation Function

When both inputs to a firing neuron are inhibitory, how does a neural network model incorporate that?

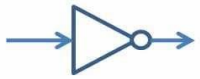
Inhibitory input does not mean absence of a signal – by inhibition the output has to be lowered by a certain magnitude





NOT

x	F
0	1
1	0



AND

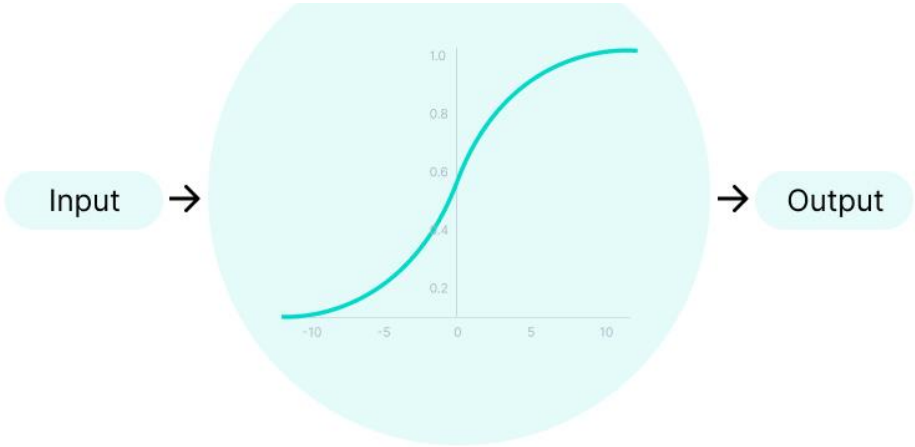
x	y	F
0	0	0
0	1	0
1	0	0
1	1	1

OR

x	y	F
0	0	0
0	1	1
1	0	1
1	1	1

XOR

x	y	F
0	0	0
0	1	1
1	0	1
1	1	0



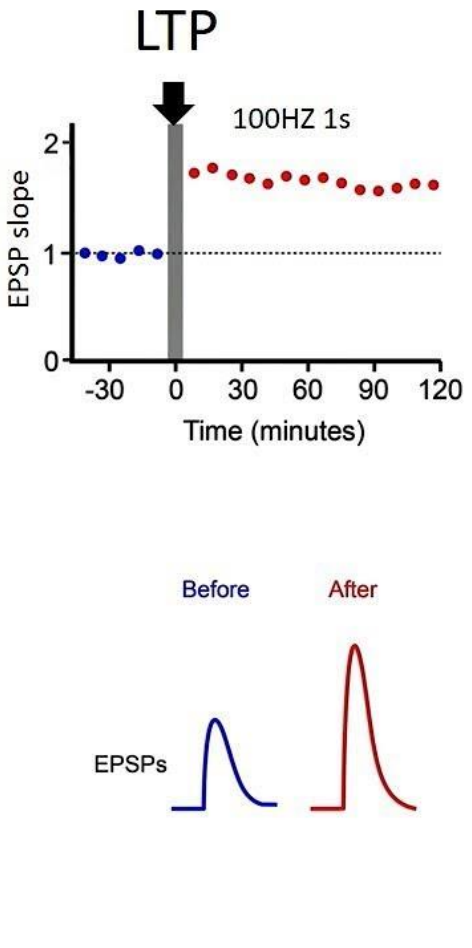
Activation Function

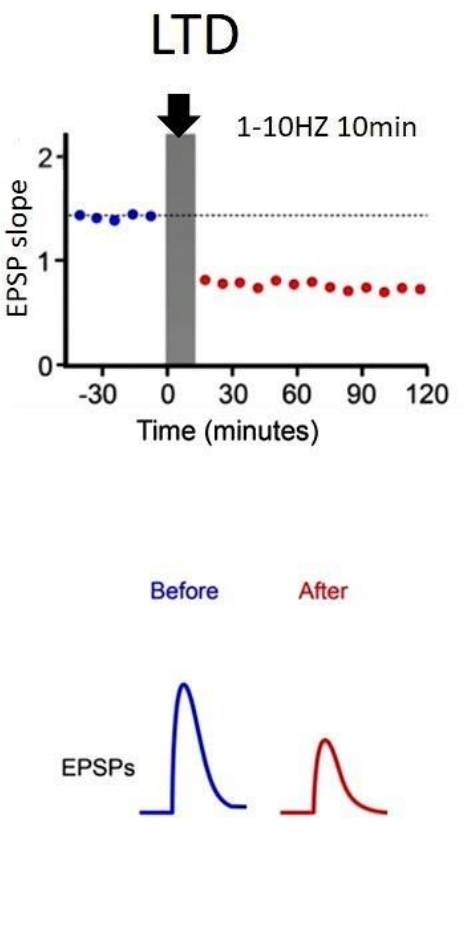
So how does a neuron store an experience?

Synaptic Plasticity

- **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

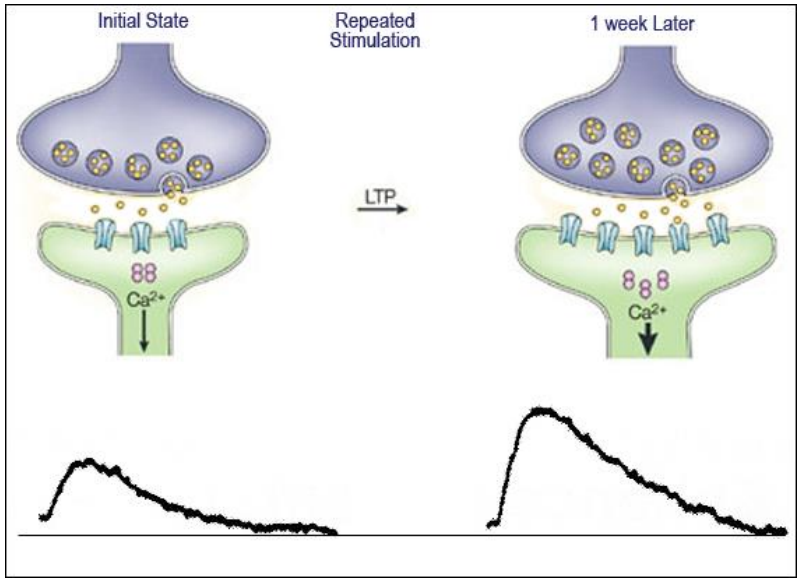


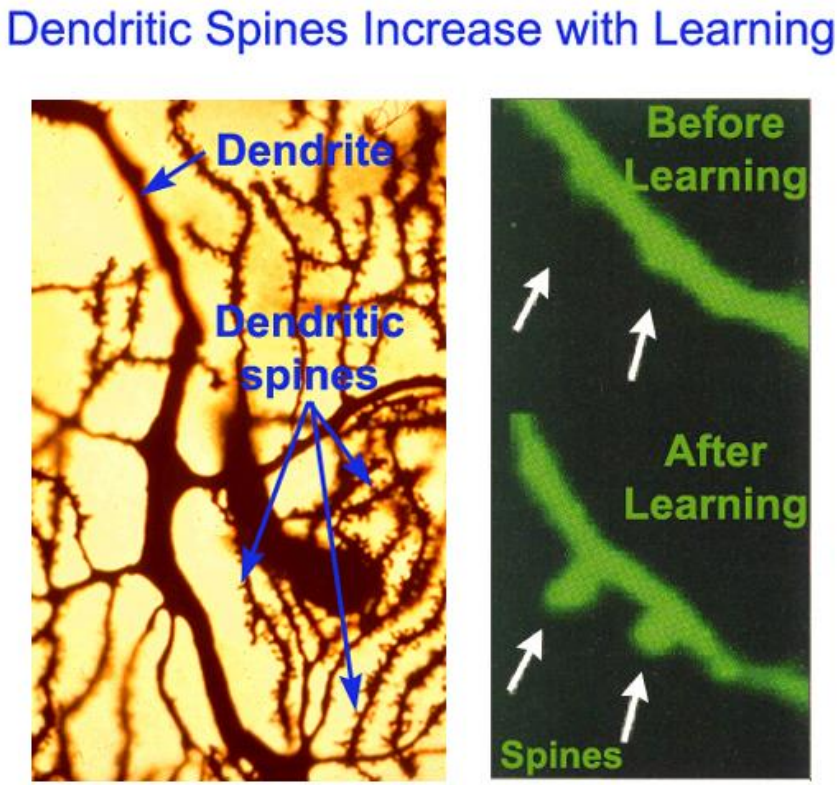


https://www.youtube.com/watch?v=4Hm08ksPtMo&ab_channel=AlilaMedicalMedia

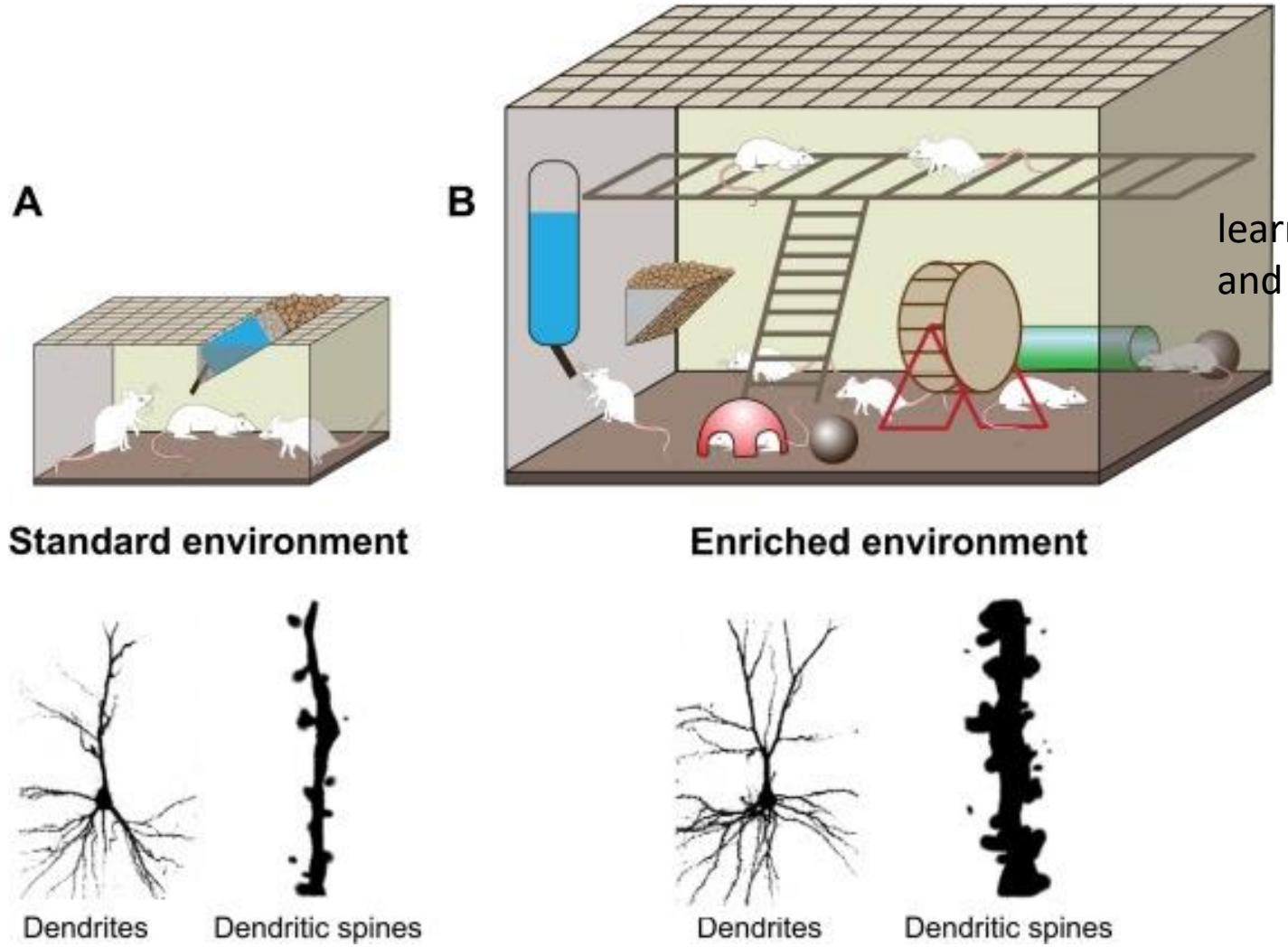
When synapses get strengthened, what changes occur in a neuron that increase magnitude of LTP?

More receptors on the postsynaptic membrane





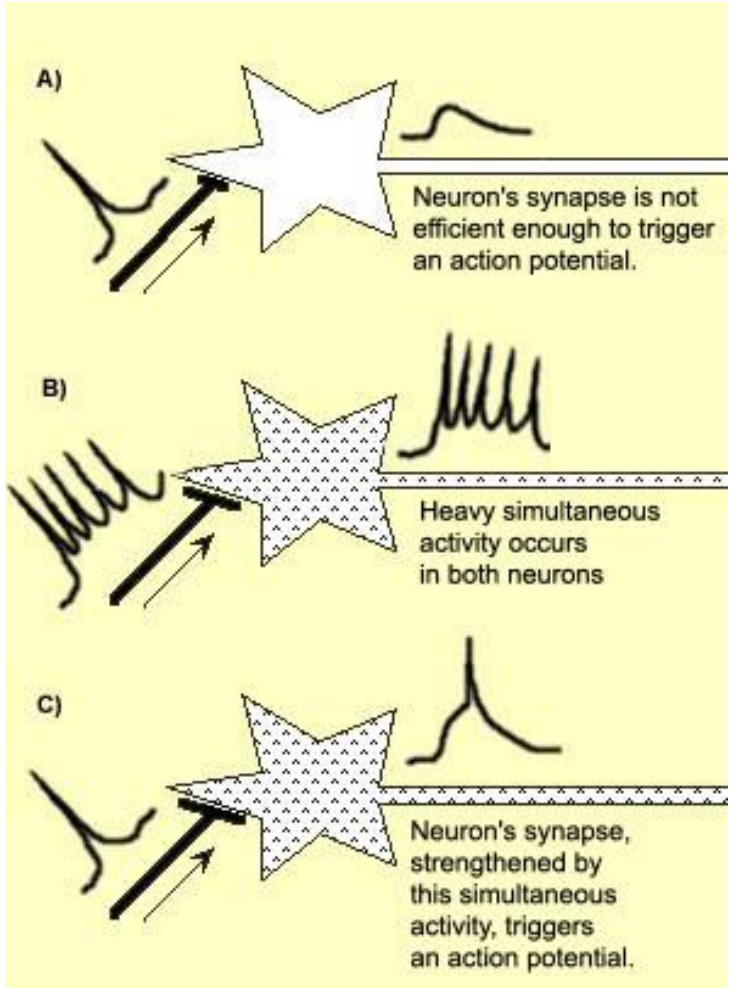
More dendrites



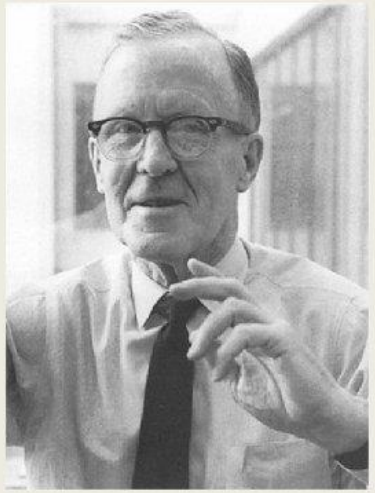
learning, social interactions, and exercise

Under what conditions does synaptic plasticity occur?

Hebbian Learning

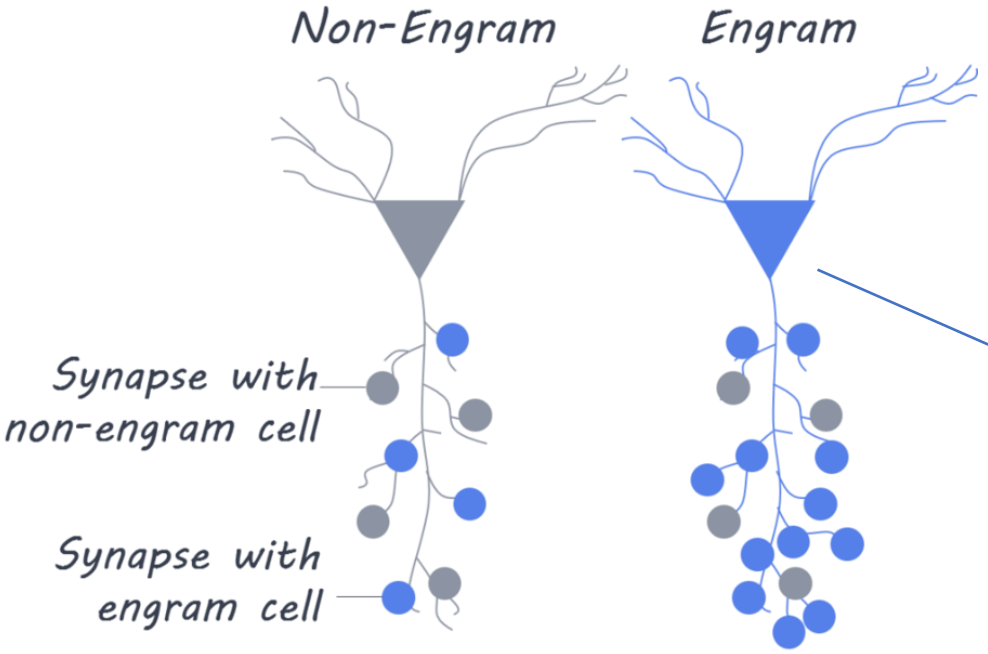


Donald Hebb

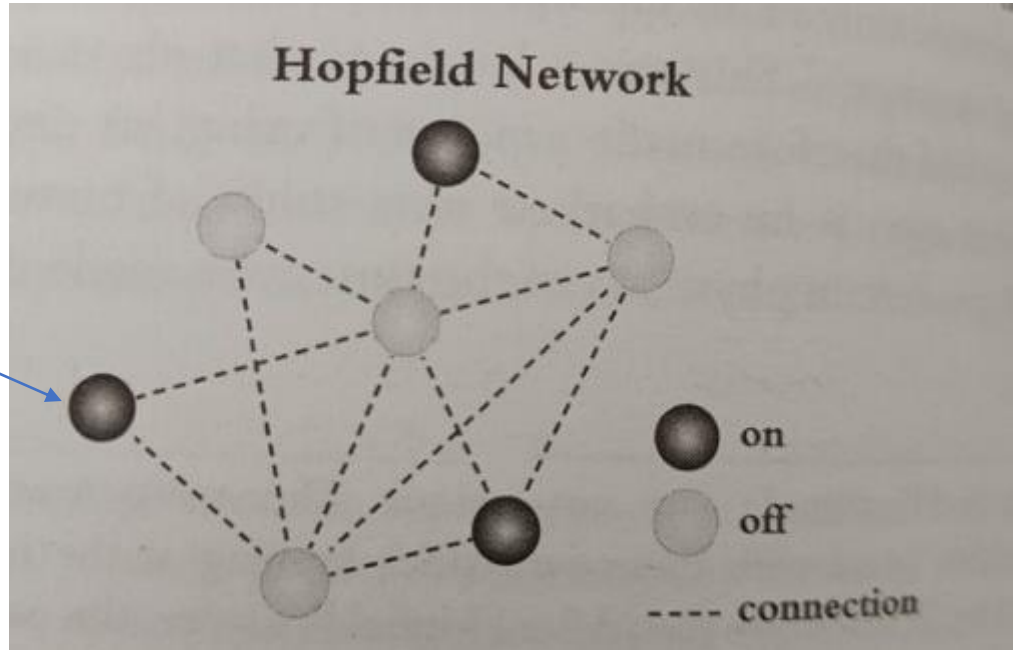


Neurons that fire together, wire together.

Engram?



Mathematical model of a memory network – John Hopfield (physicist)

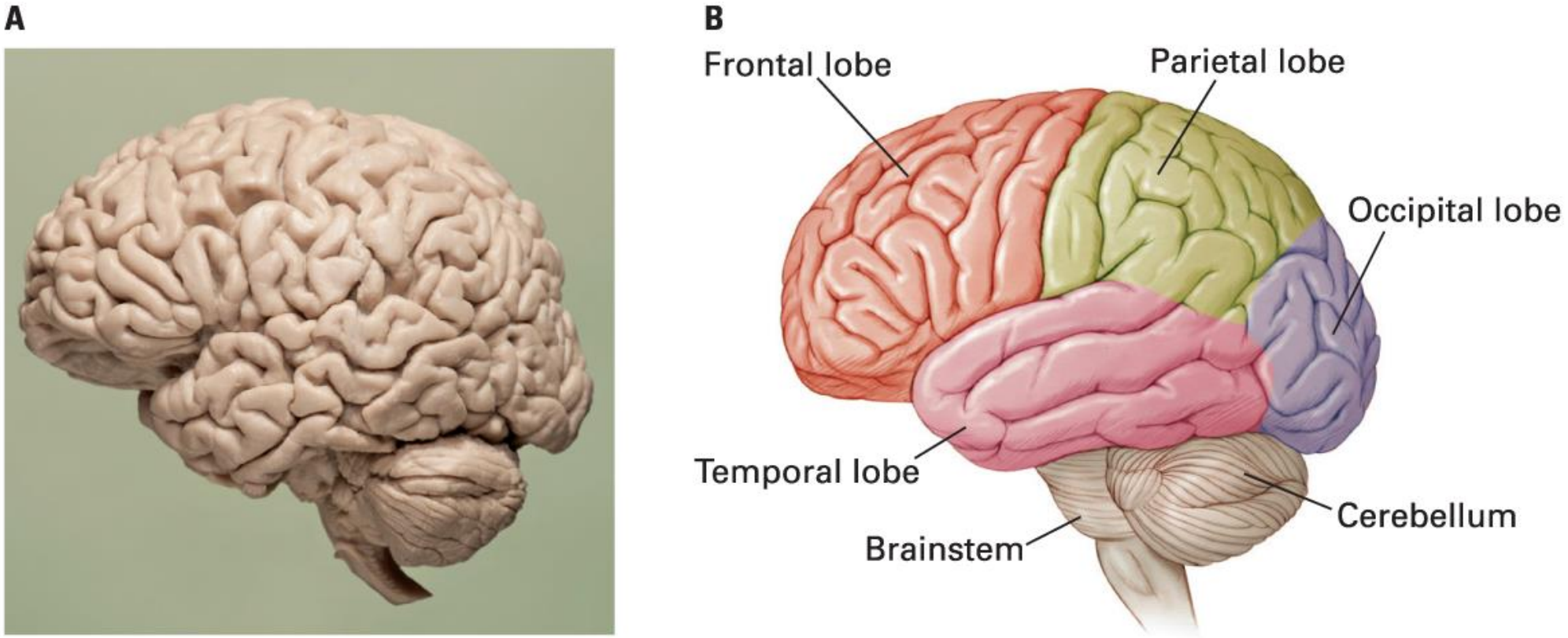


- Can learning related changes in a neuron be reversed?

Neurons are important units of information processing

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

The Human Brain



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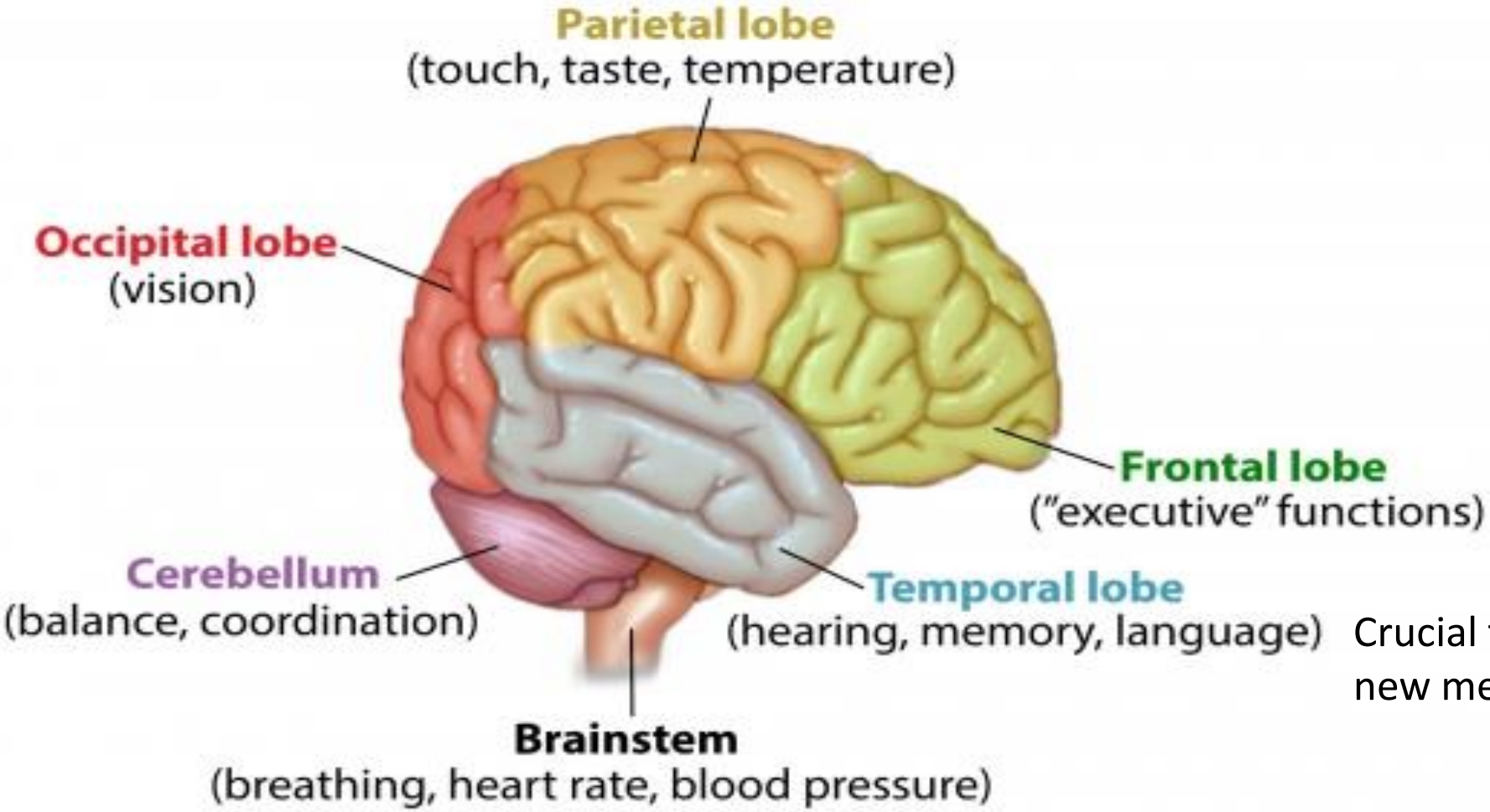
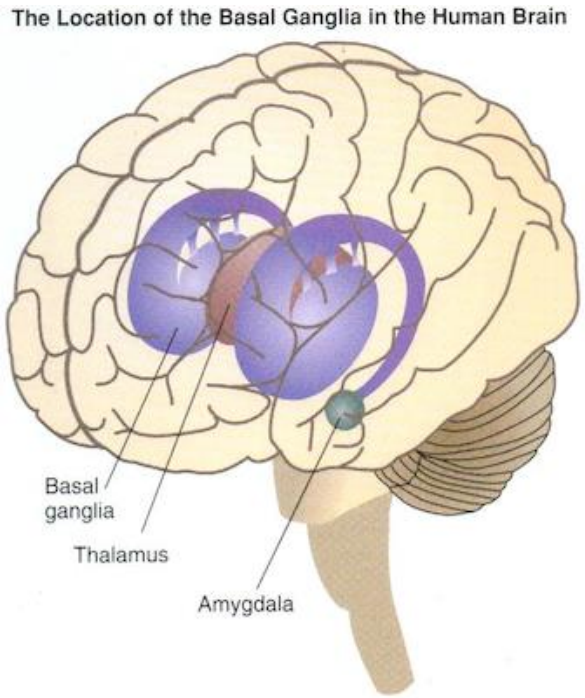
A: Chris Parsons/Getty Images

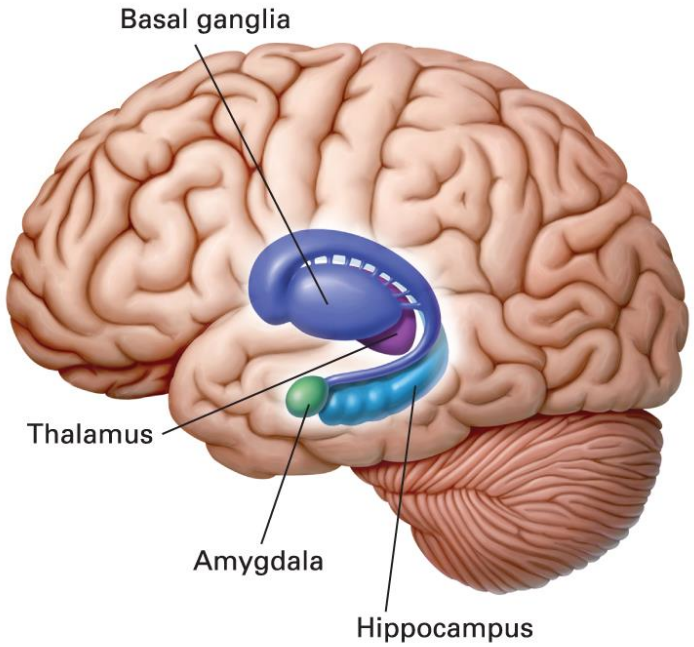


Crucial for forming new memories

Brain Regions Known to Contribute to Memory



Habit based, motor memories



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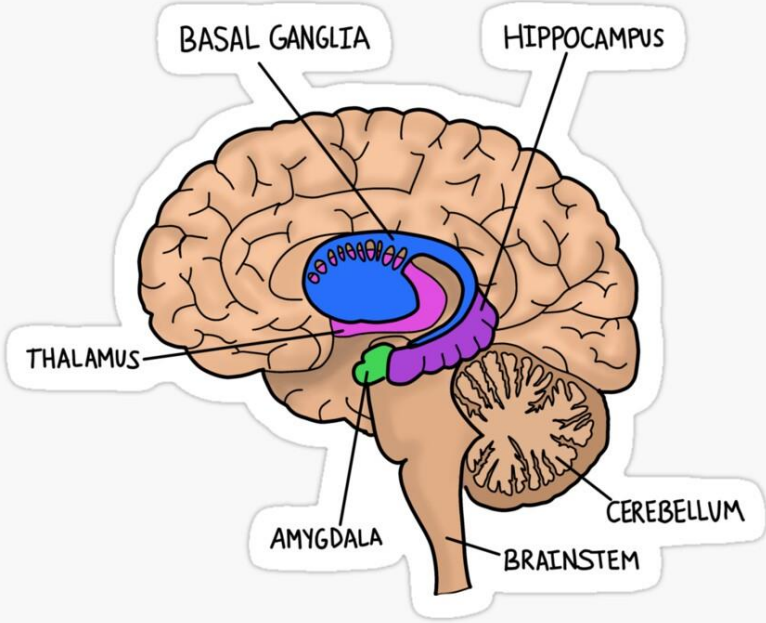
Declarative memories, knowledge networks



Surprise Quizzes – Laptops/phones

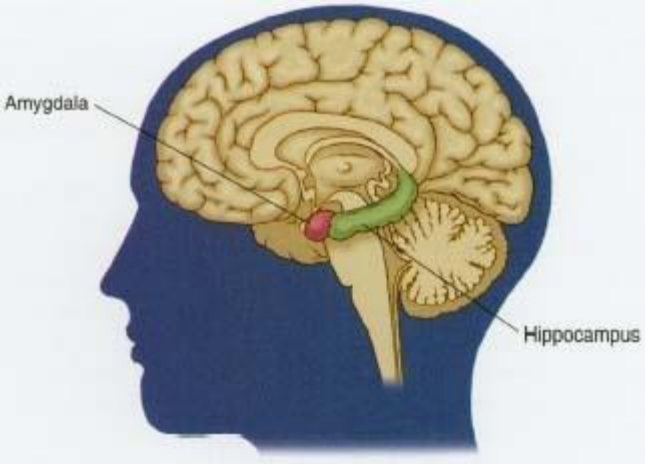

Community Helpers: DOCTORS
IT FEELS GOOD TO
BELONG!

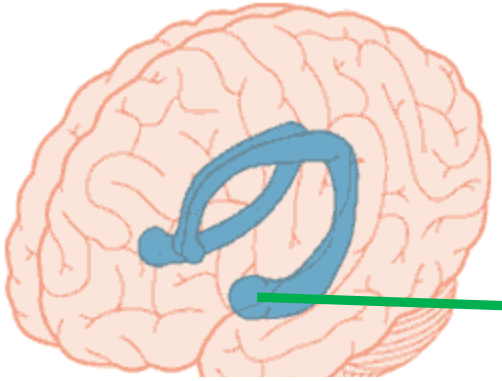
Old items - Target

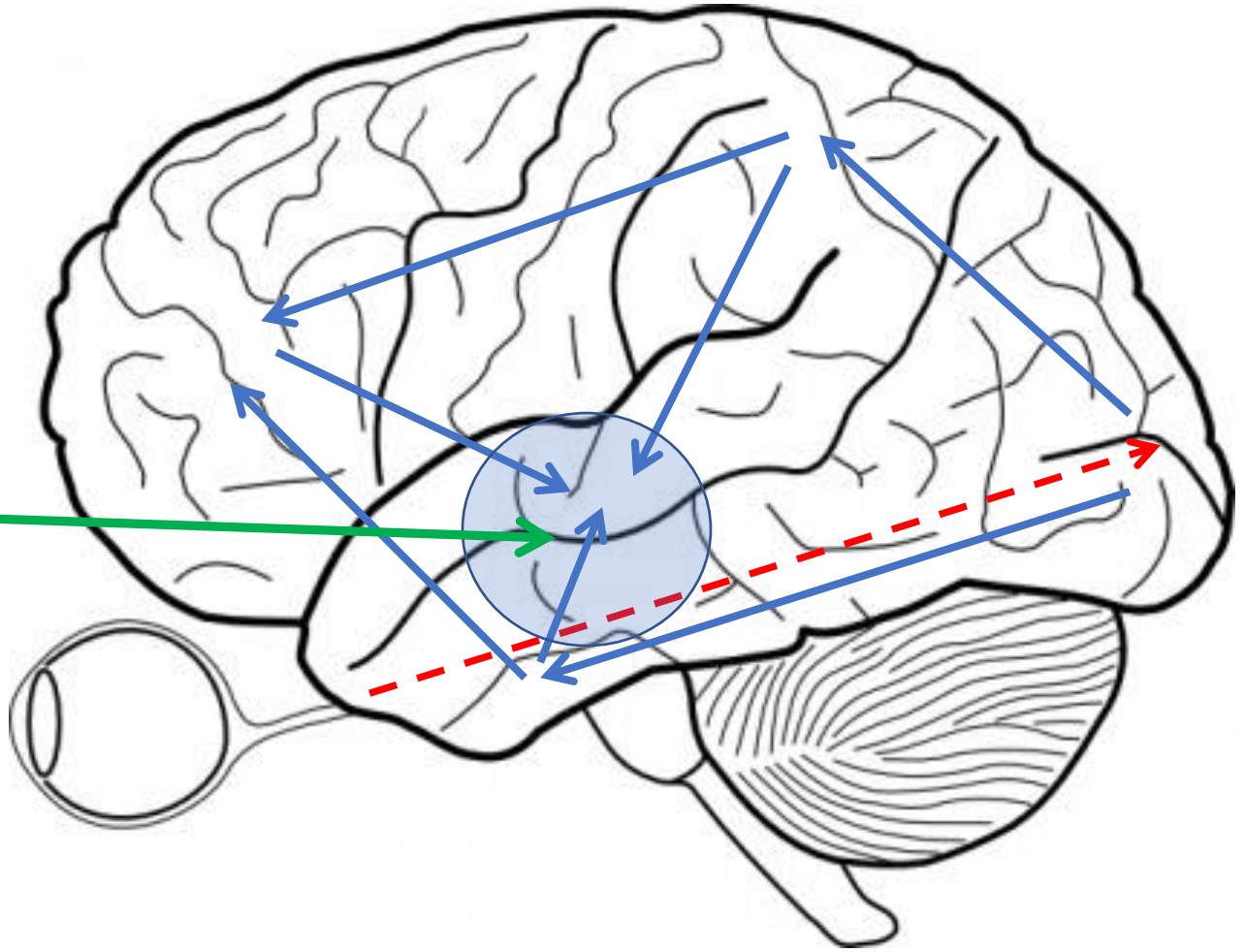
Similar items - Lures

New items - Foils

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


Amygdala
Hippocampus



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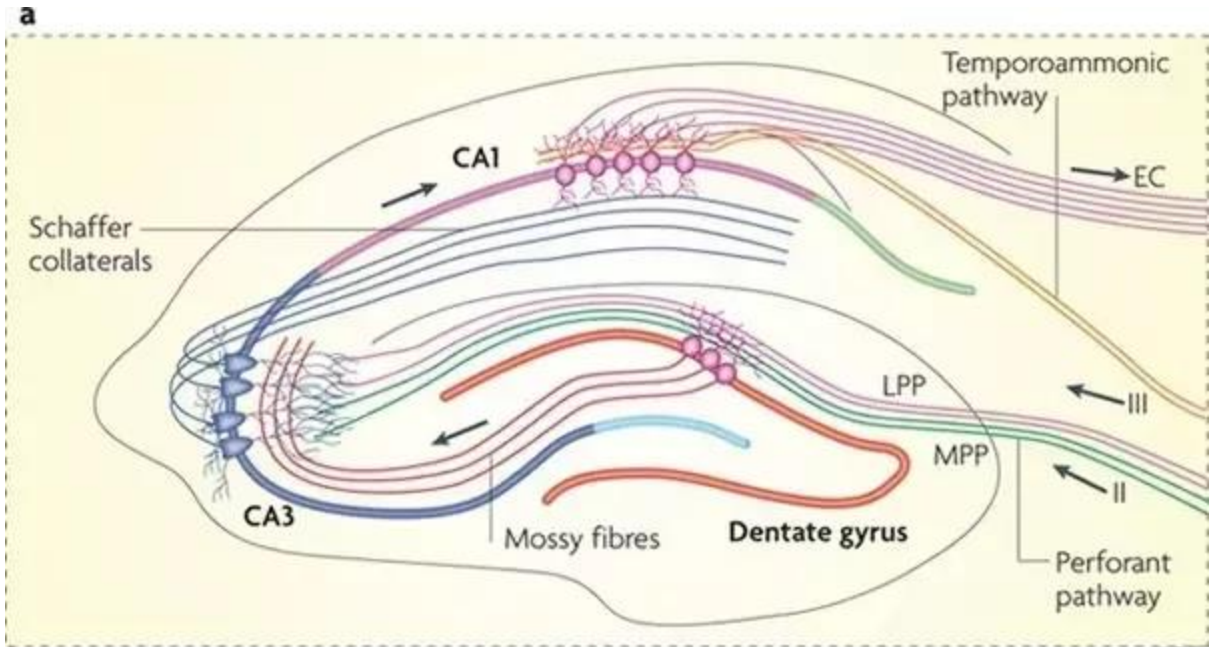
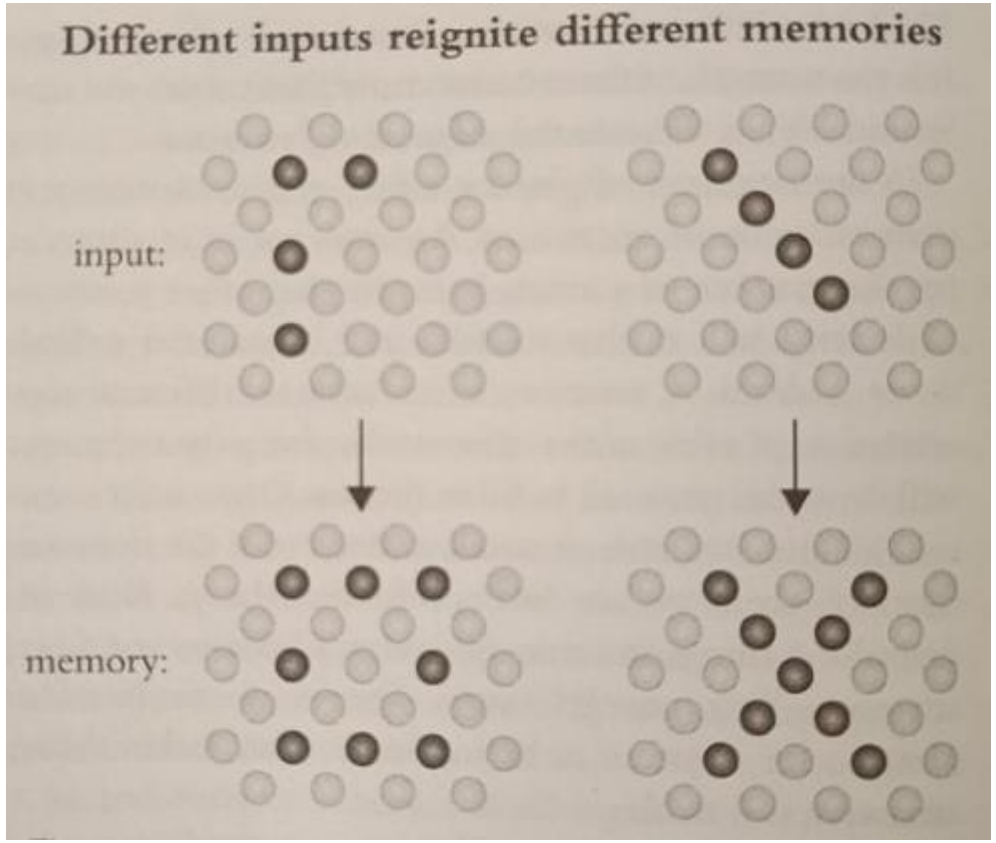
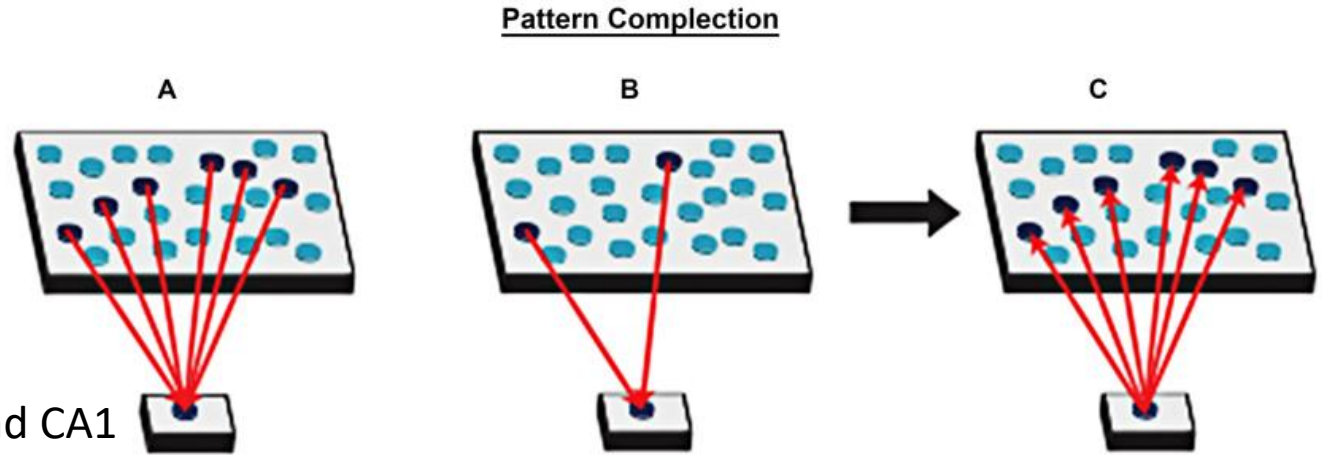
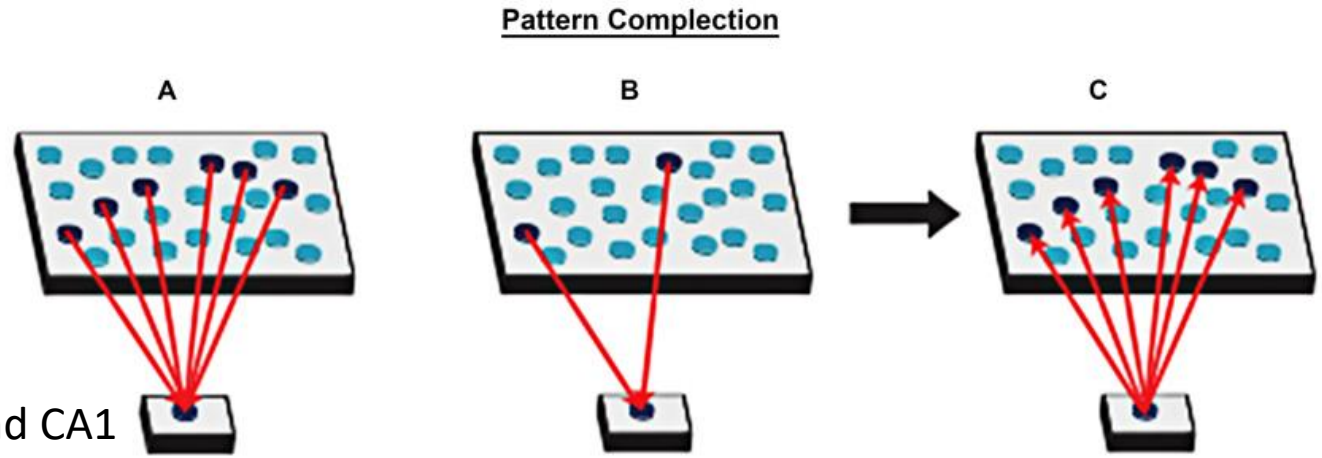
Unidirectional flow of information



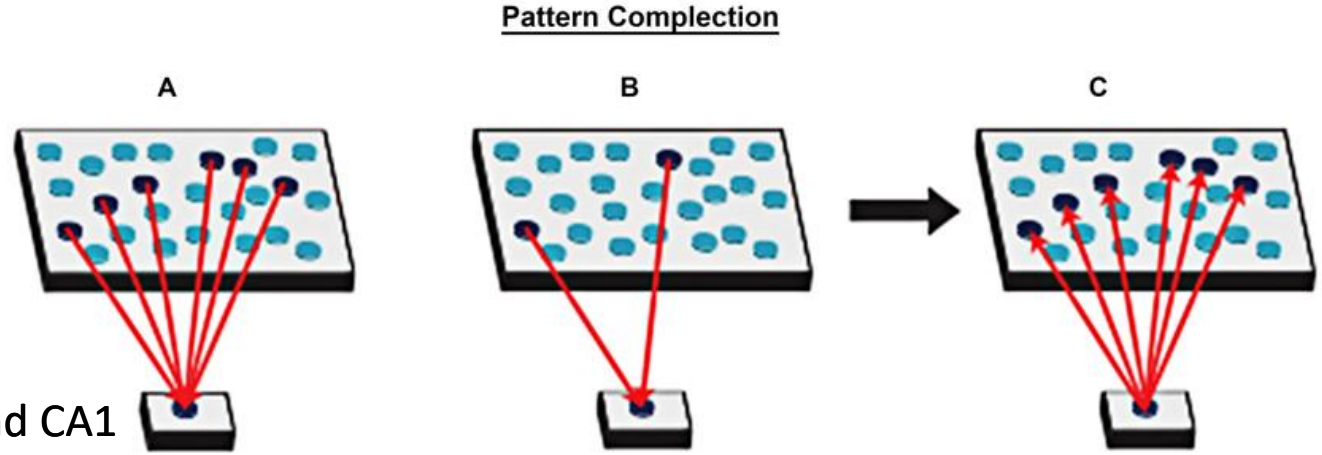




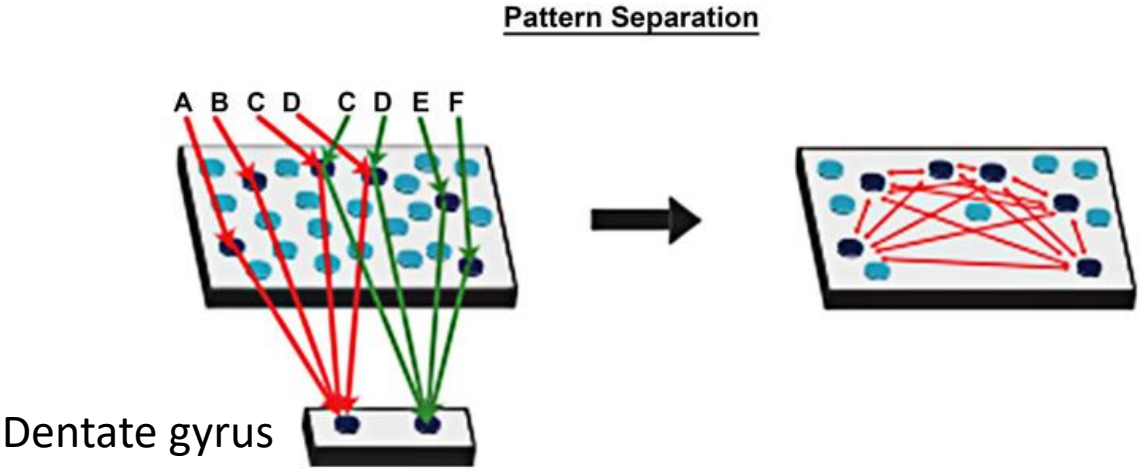
CA3 and CA1
Subregions of the hippocampus



CA3 and CA1
Subregions of the hippocampus



CA3 and CA1
Subregions of the hippocampus



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?