

# Neuroscience Tutorial I

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# What is Neuroscience?

Neuroscience is the study of the processes by which we perceive, act, learn, and remember.

Kandel et al. 2015

# What is Neuroscience?

Neuroscience is the study of the nervous system.

Flores, today.

# What is the nervous system?

- Most living organisms have a **sensory surface** and a **motor surface**.
- Some multicellular organisms developed a **neuron-based link** between the sensory and motor surfaces.
- We call this link the **nervous system**.
- The role of the nervous system is to perform **sensory-motor integration**.

# Unicellular: Protozoa.



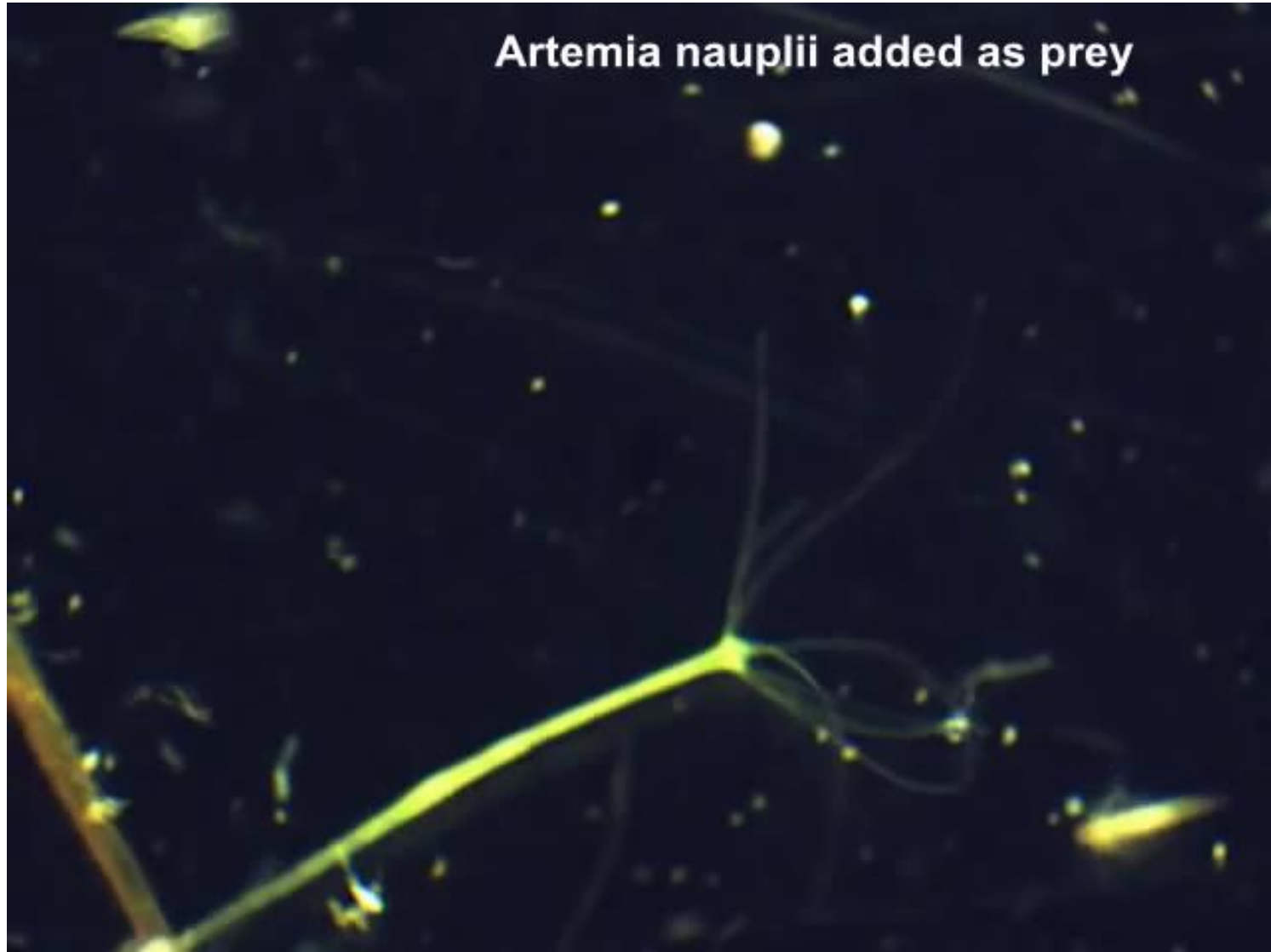
# Unicellular: Protozoa.



# Unicellular: Bacteria.

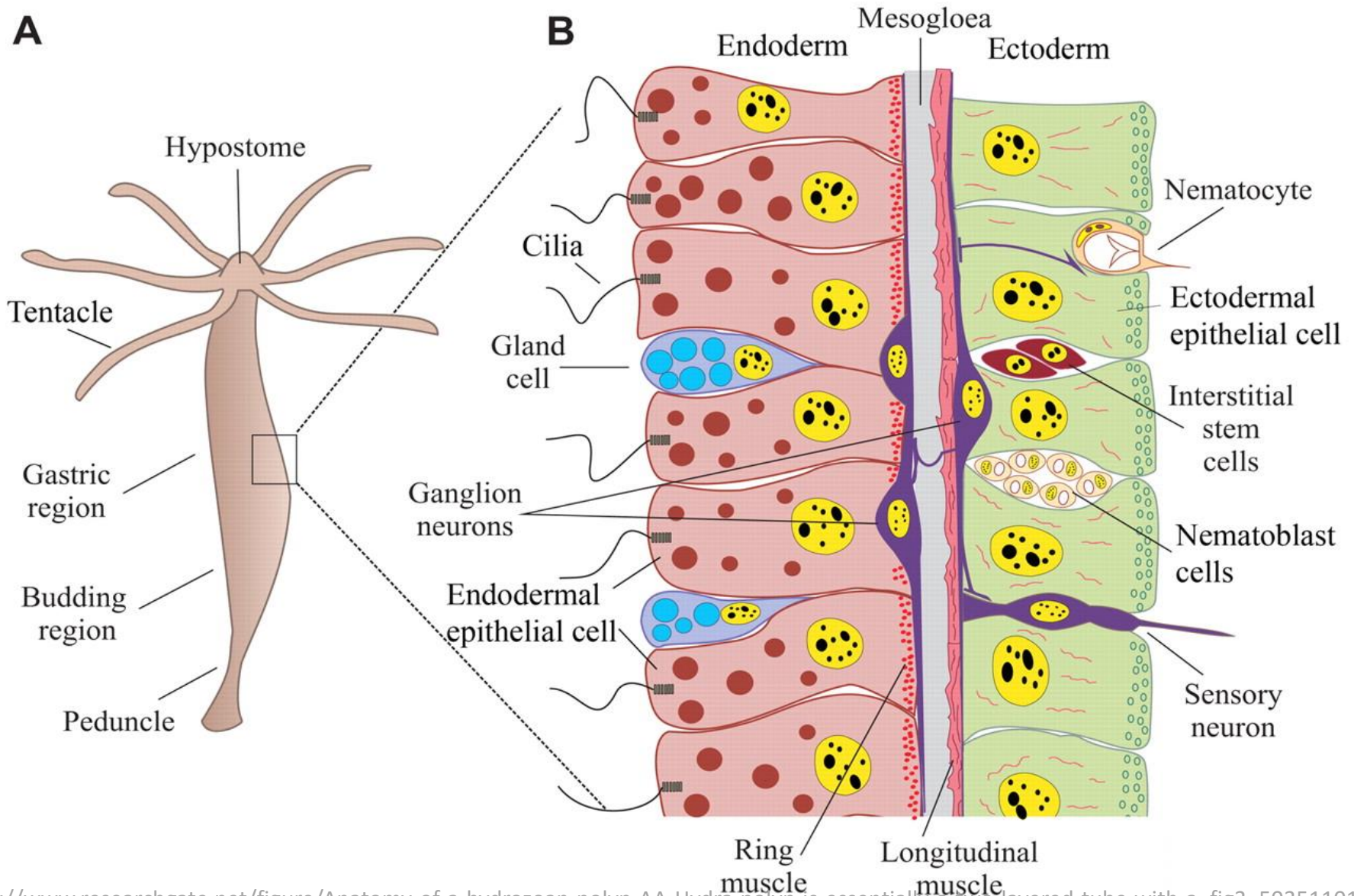


# Multicellular: Hydra.

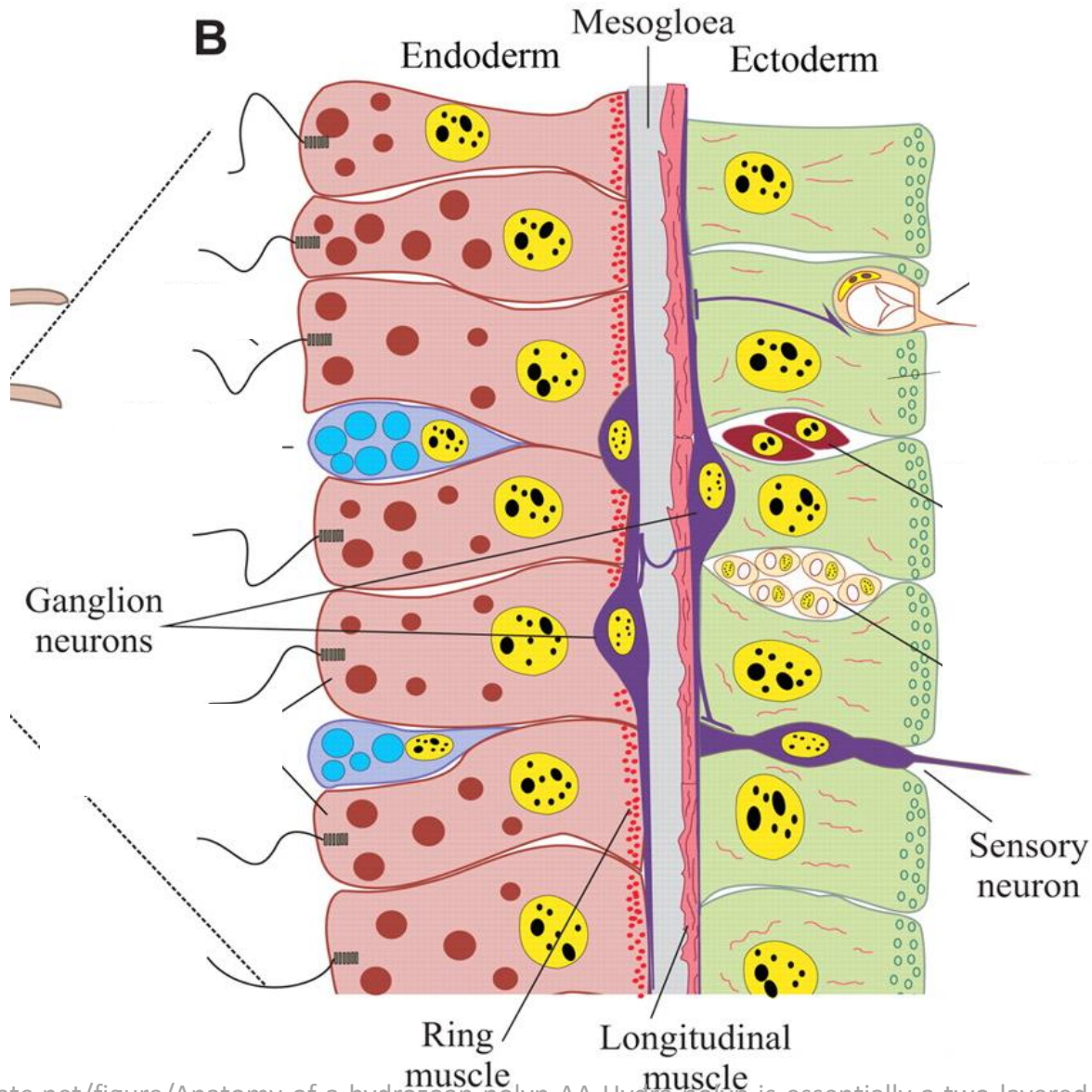




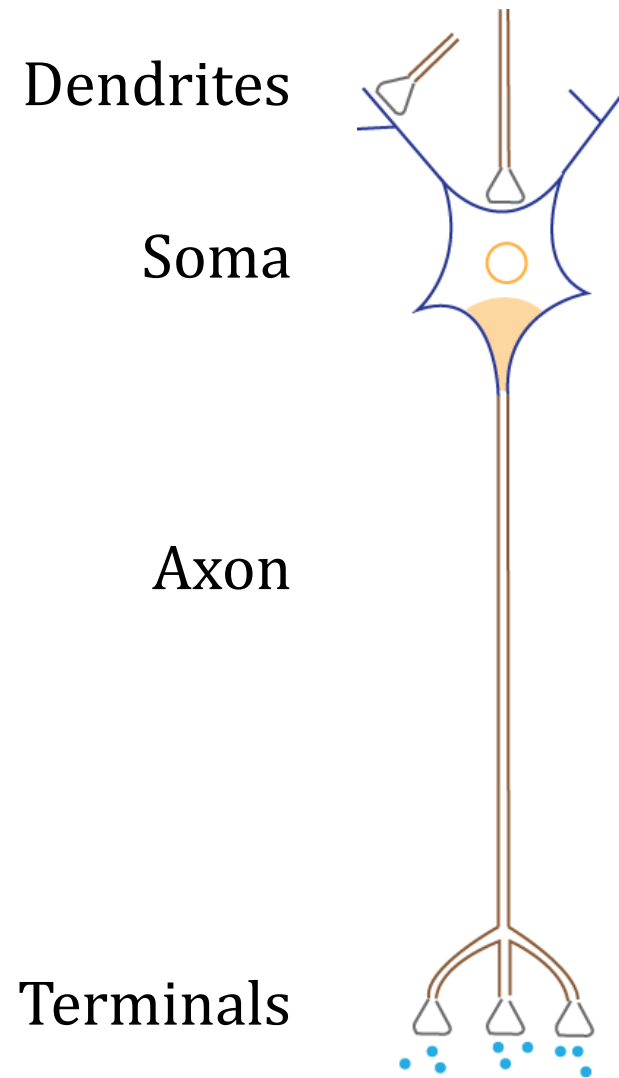
# Multicellular: Hydra.



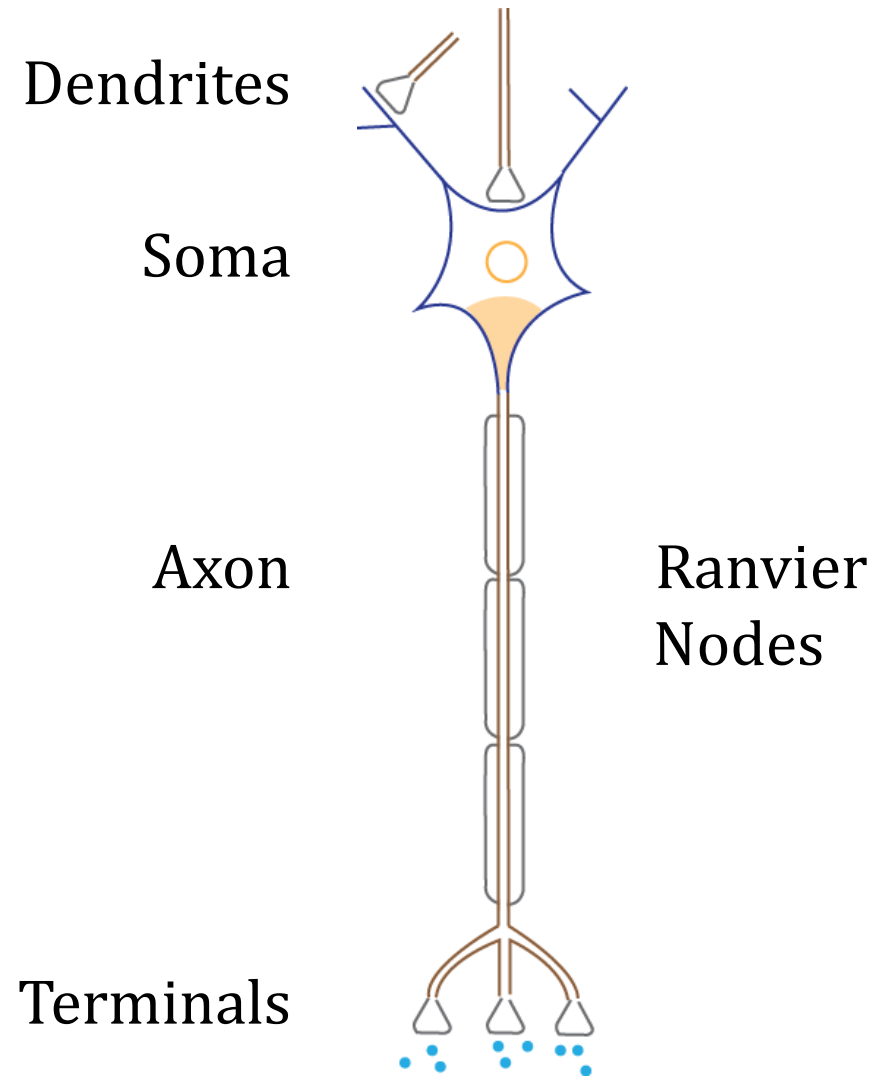
# Multicellular: Hydra.



# The Neuron.

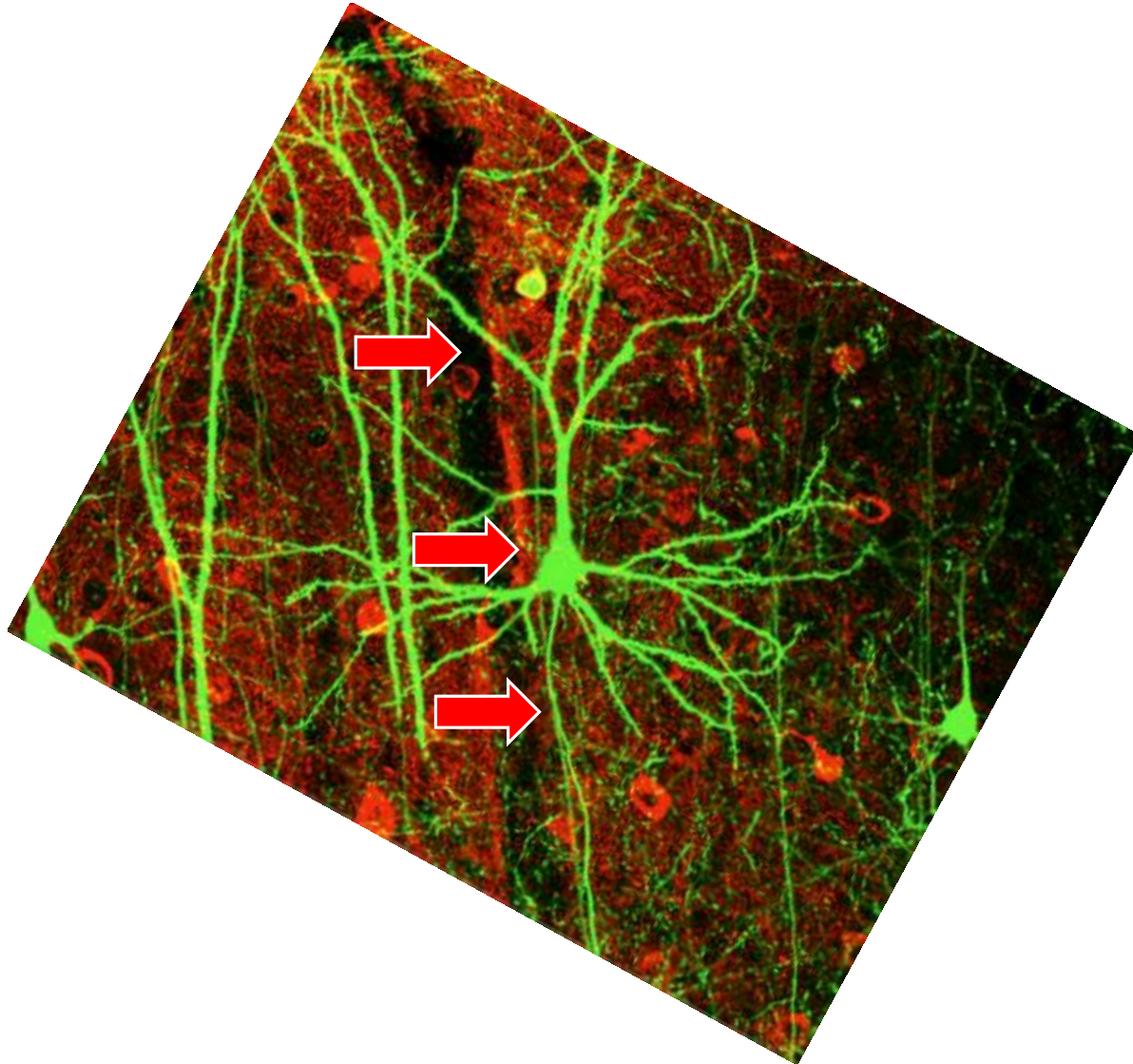


# The Neuron.

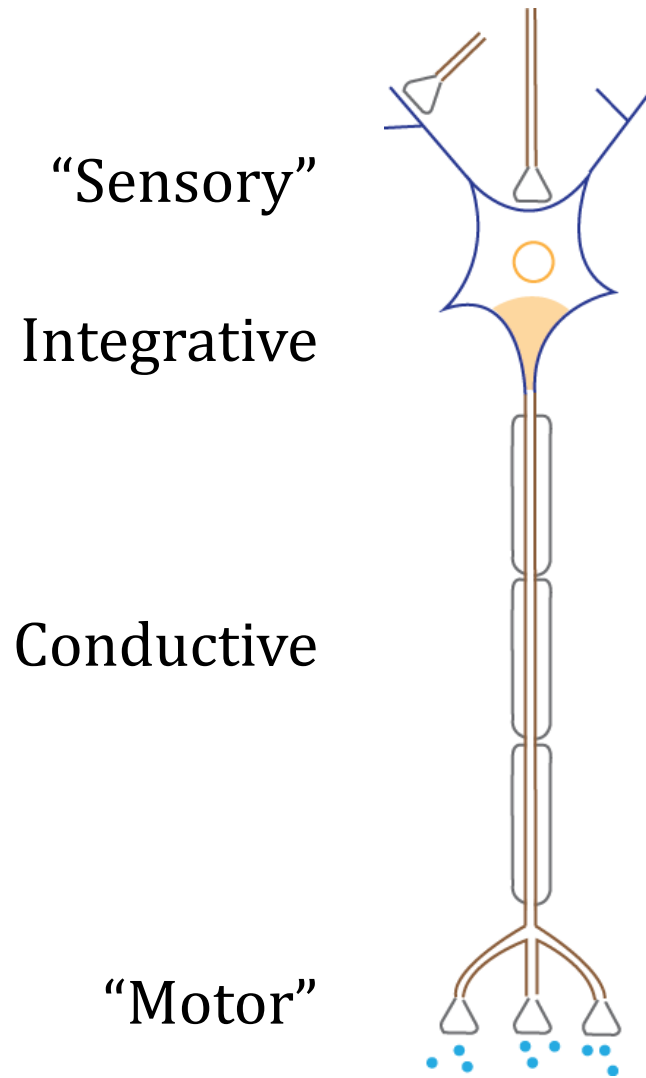




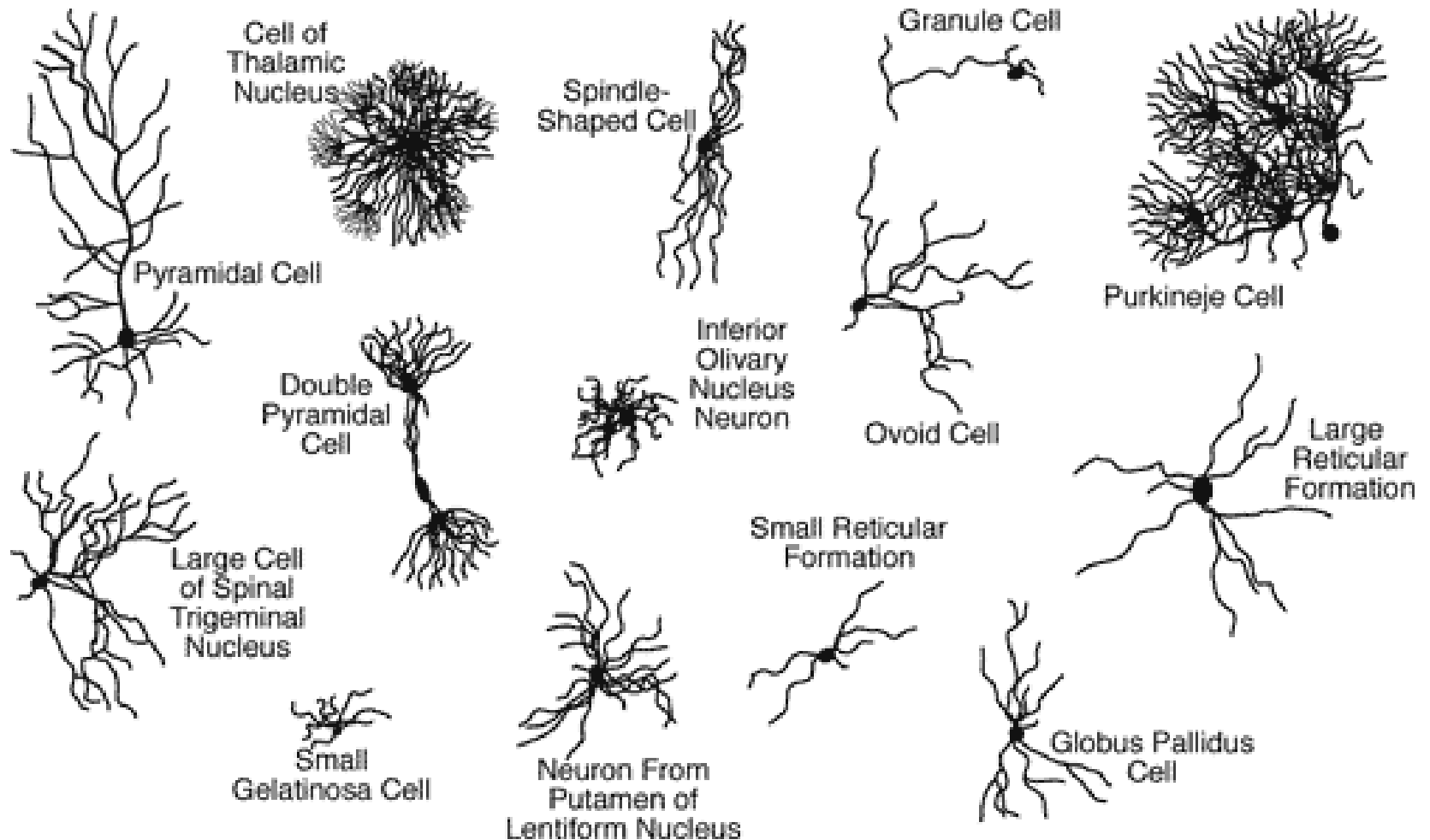
# Mouse cortical neuron.



# The Neuron.



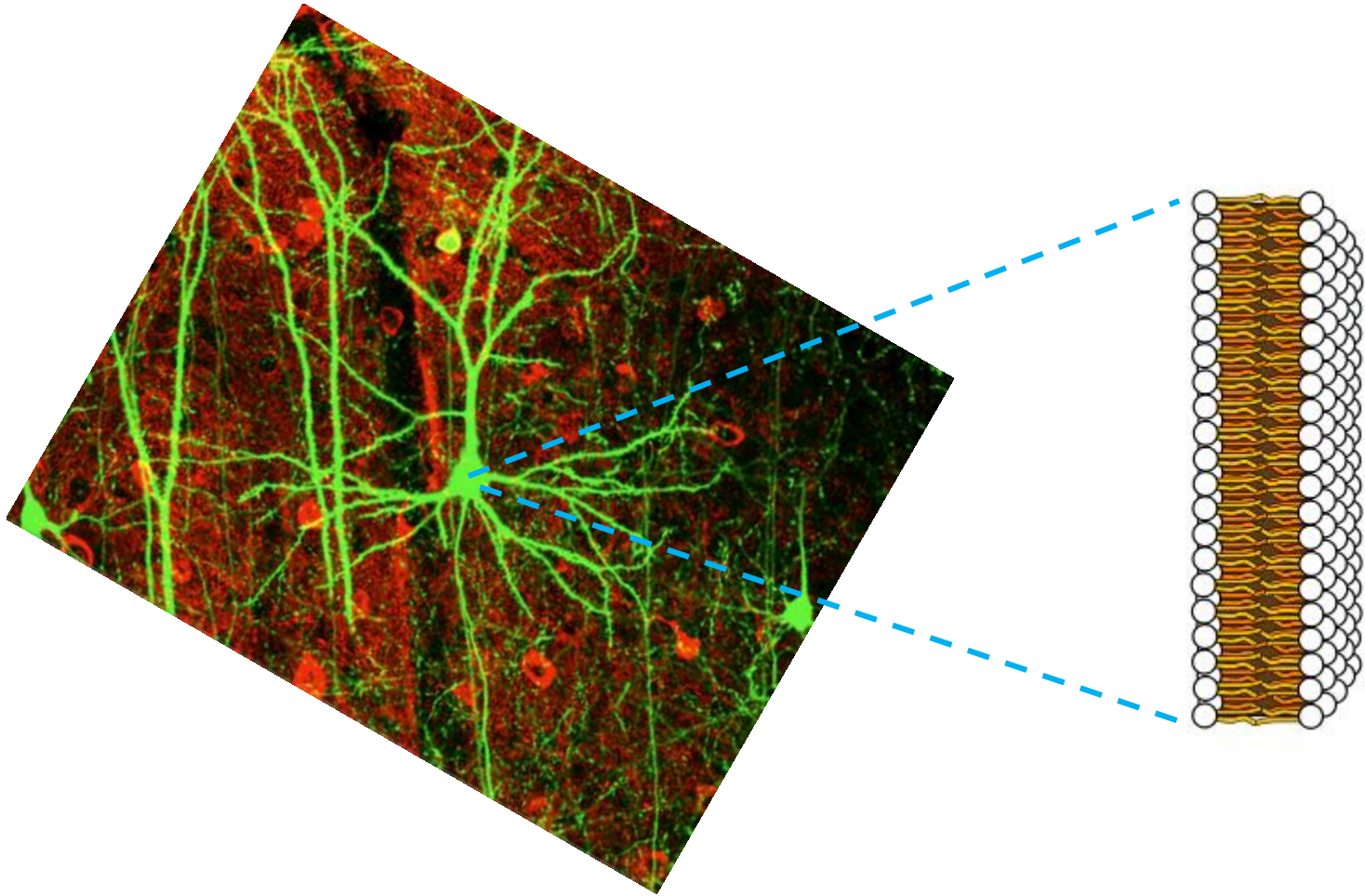
# Diversity of neurons.



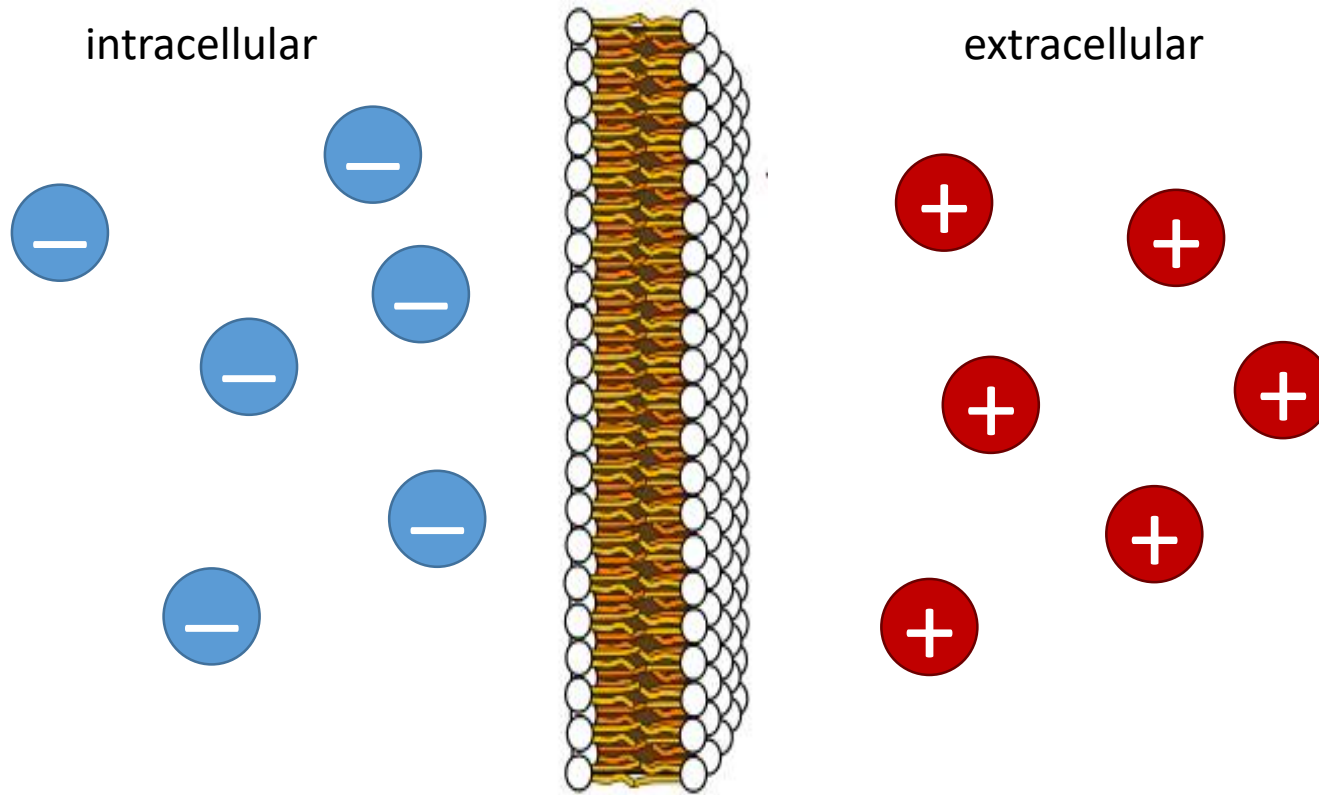
# Membrane Potential



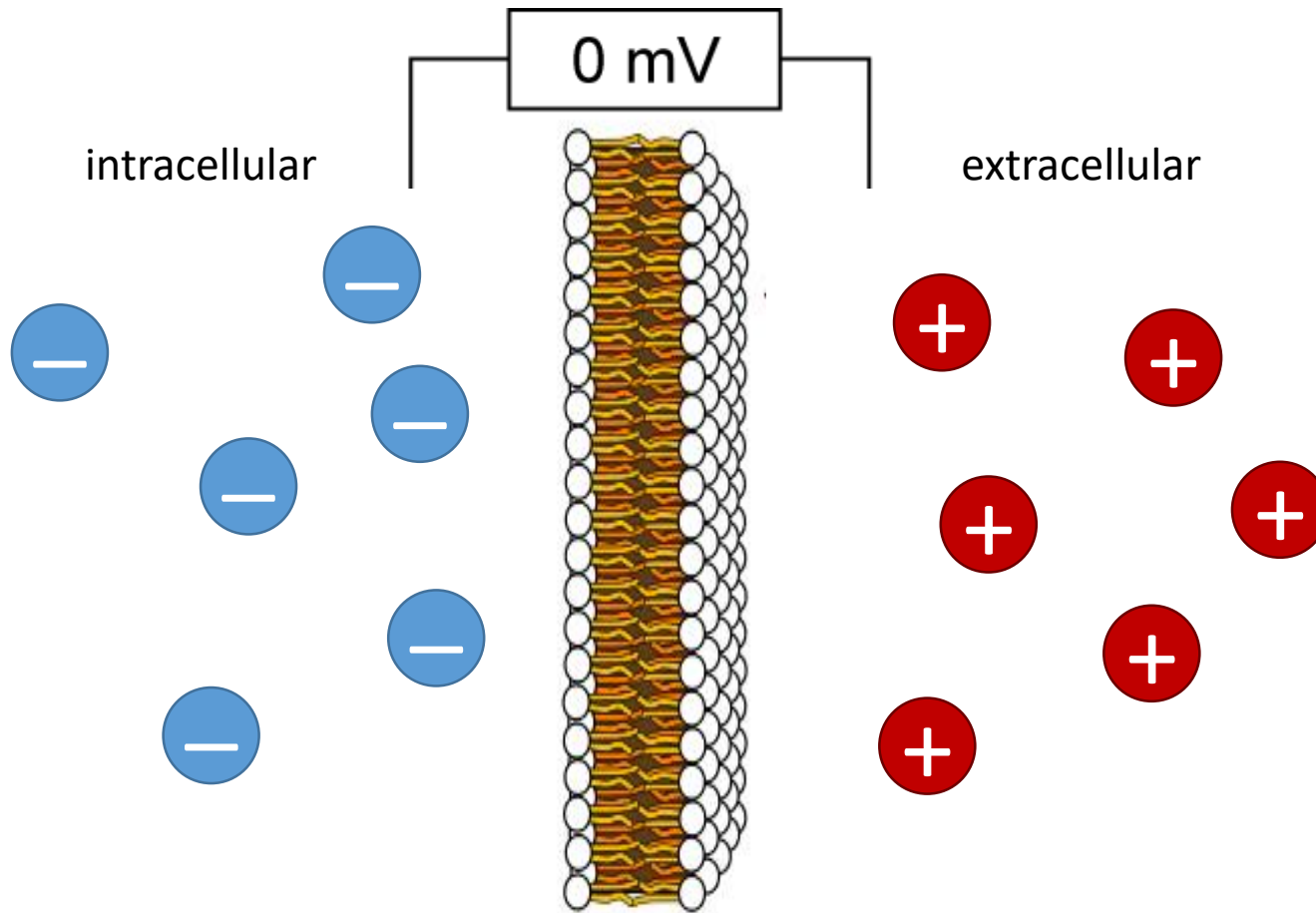
# Membrane potential



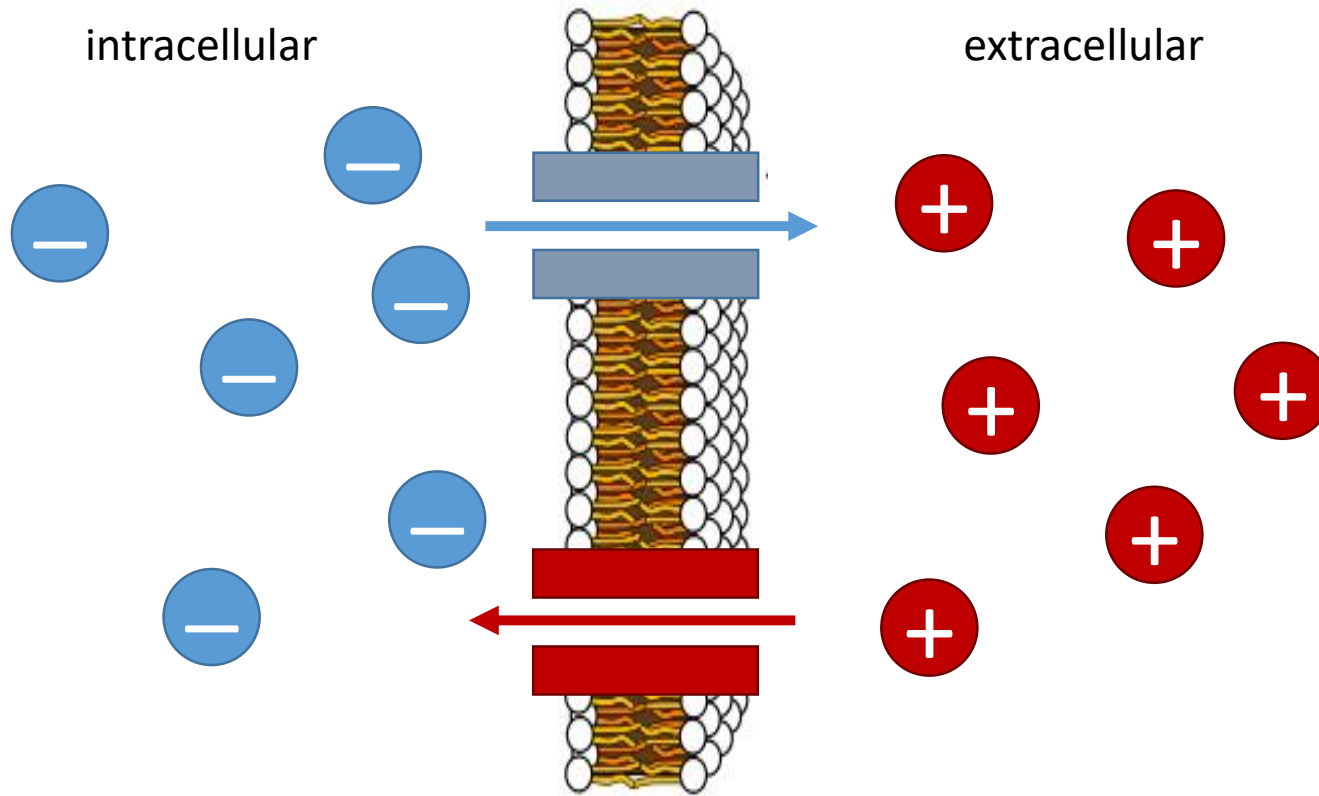
# Membrane potential



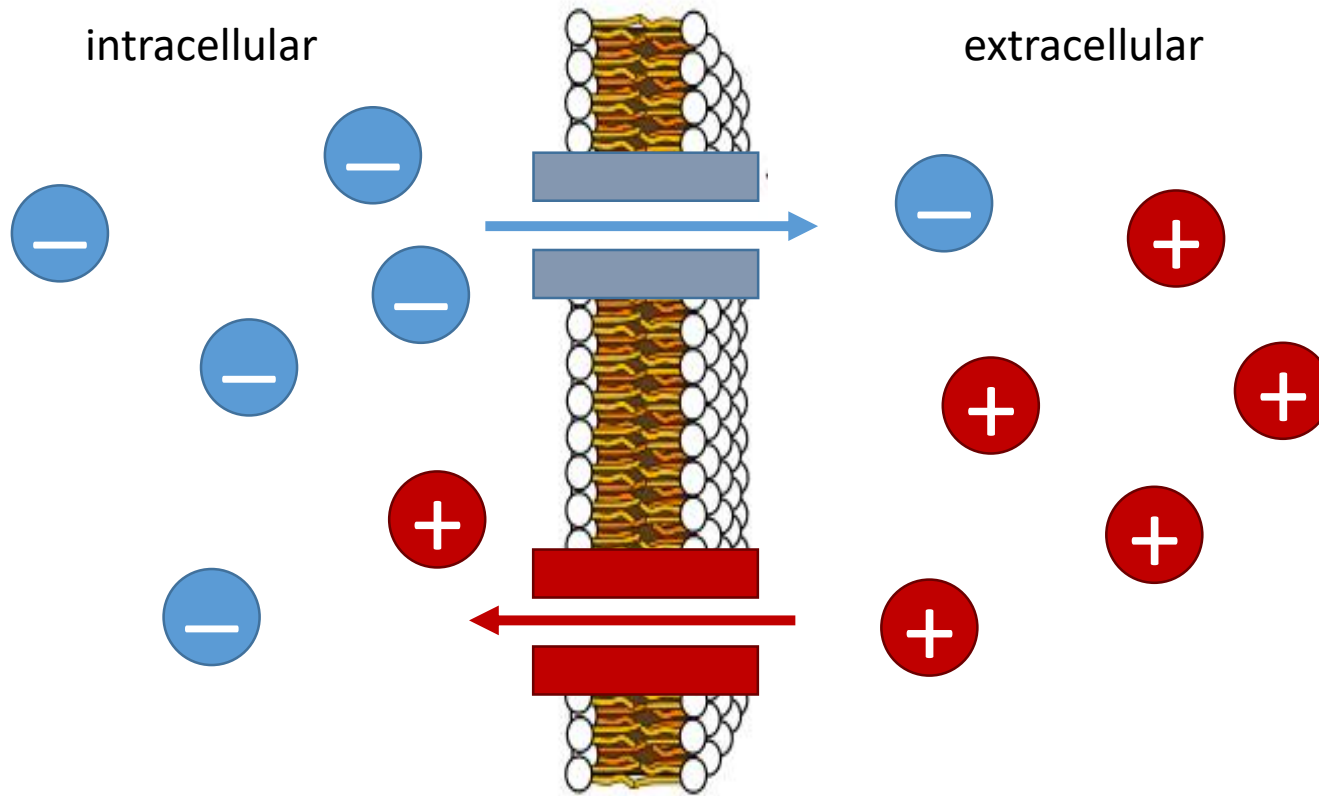
# Membrane potential



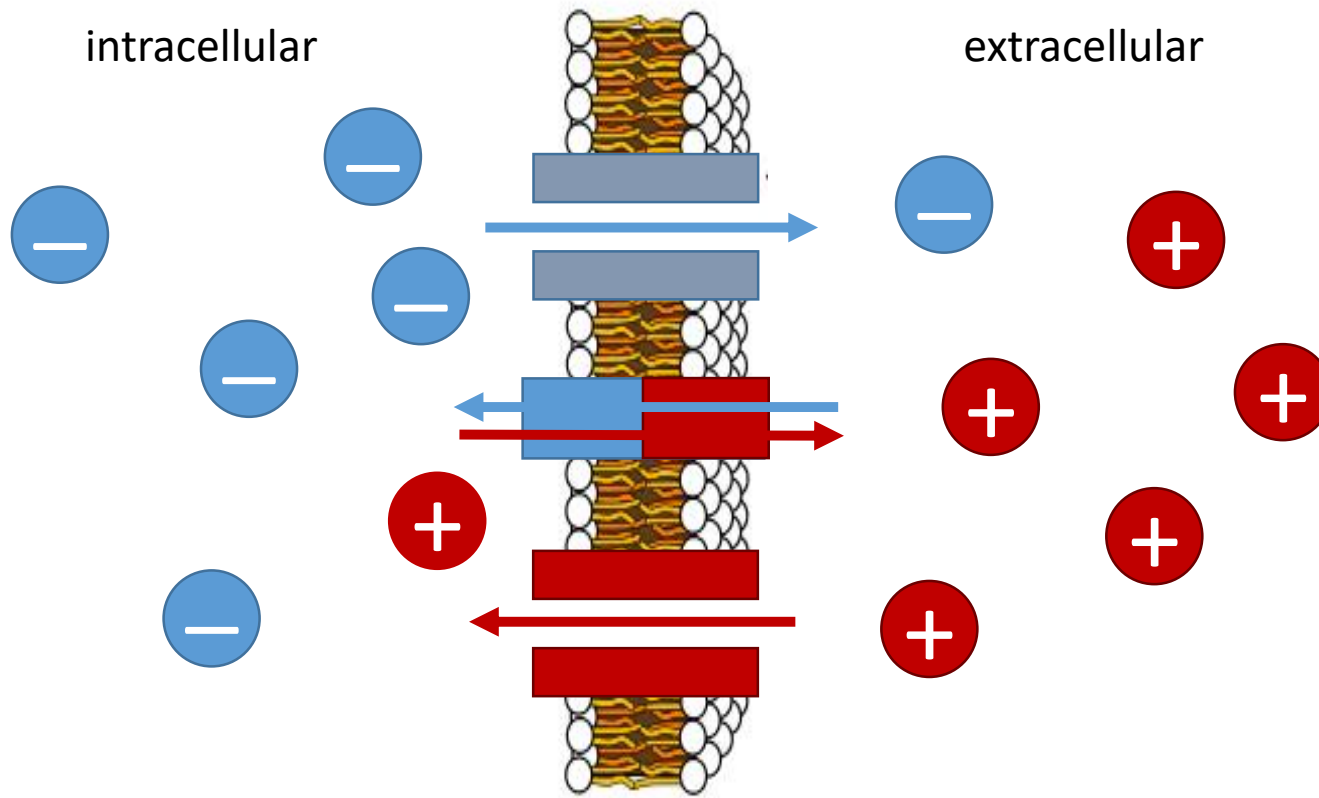
# Membrane potential



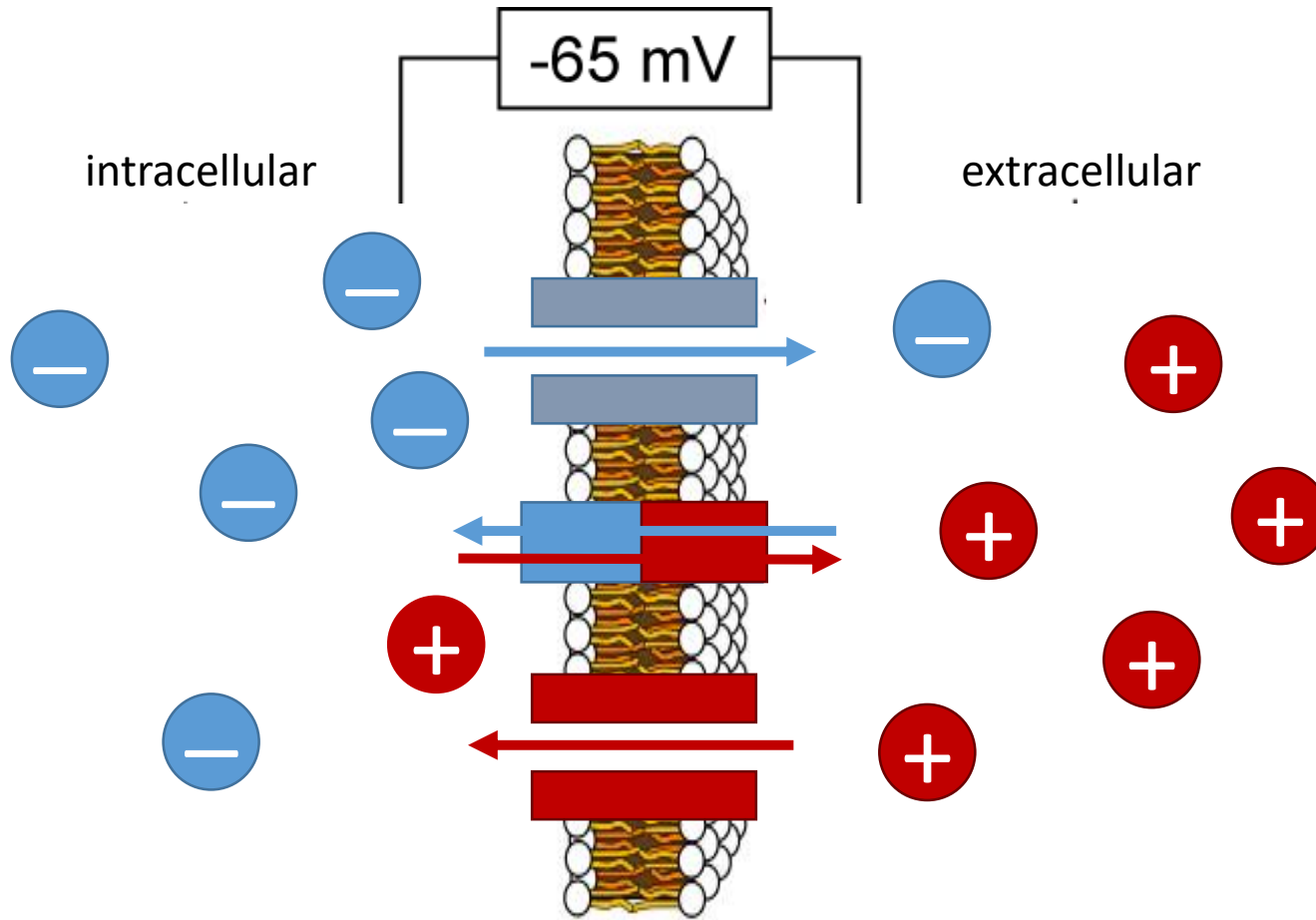
# Membrane potential



# Membrane potential

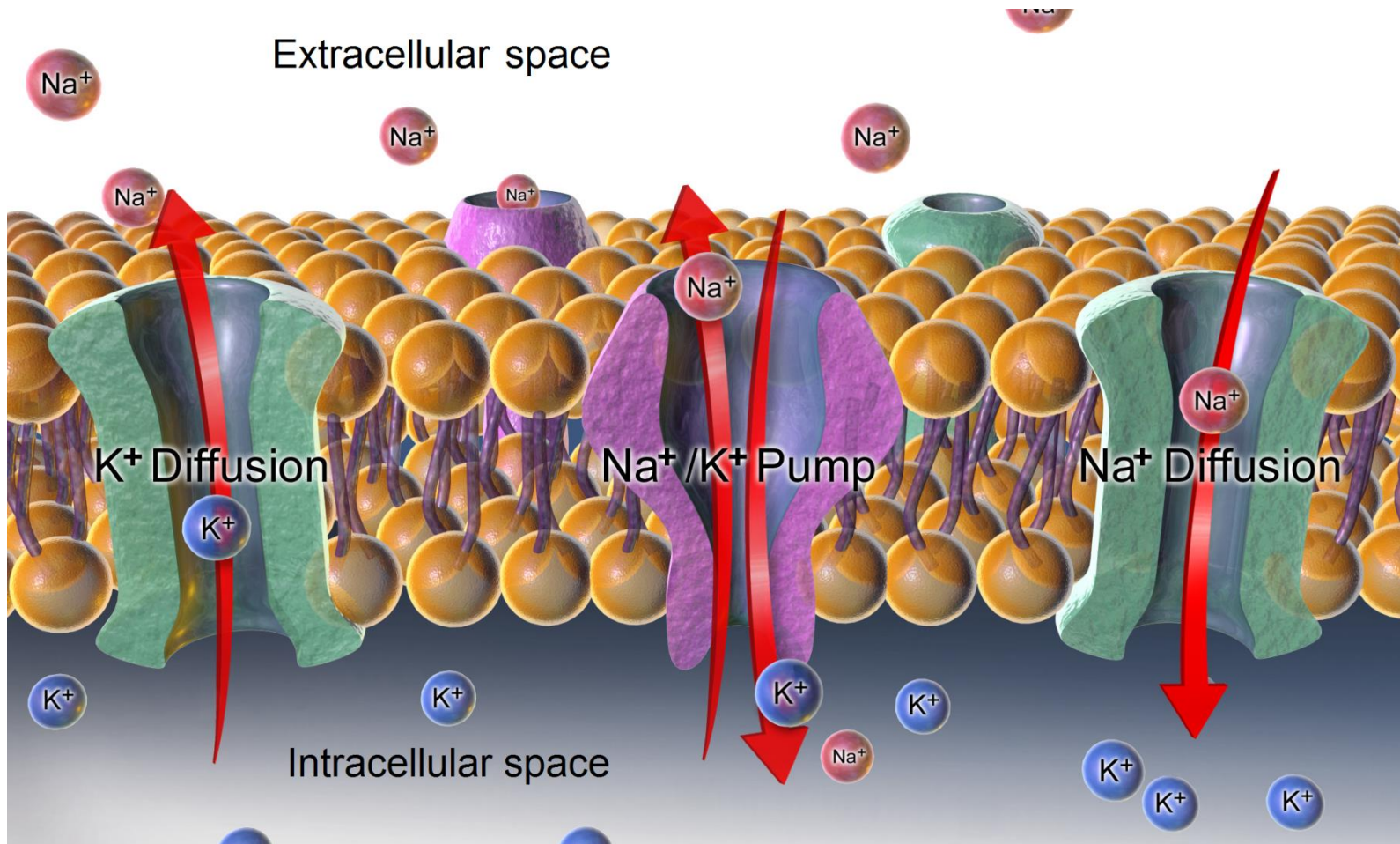


# Membrane potential





# Resting Ion Channels.



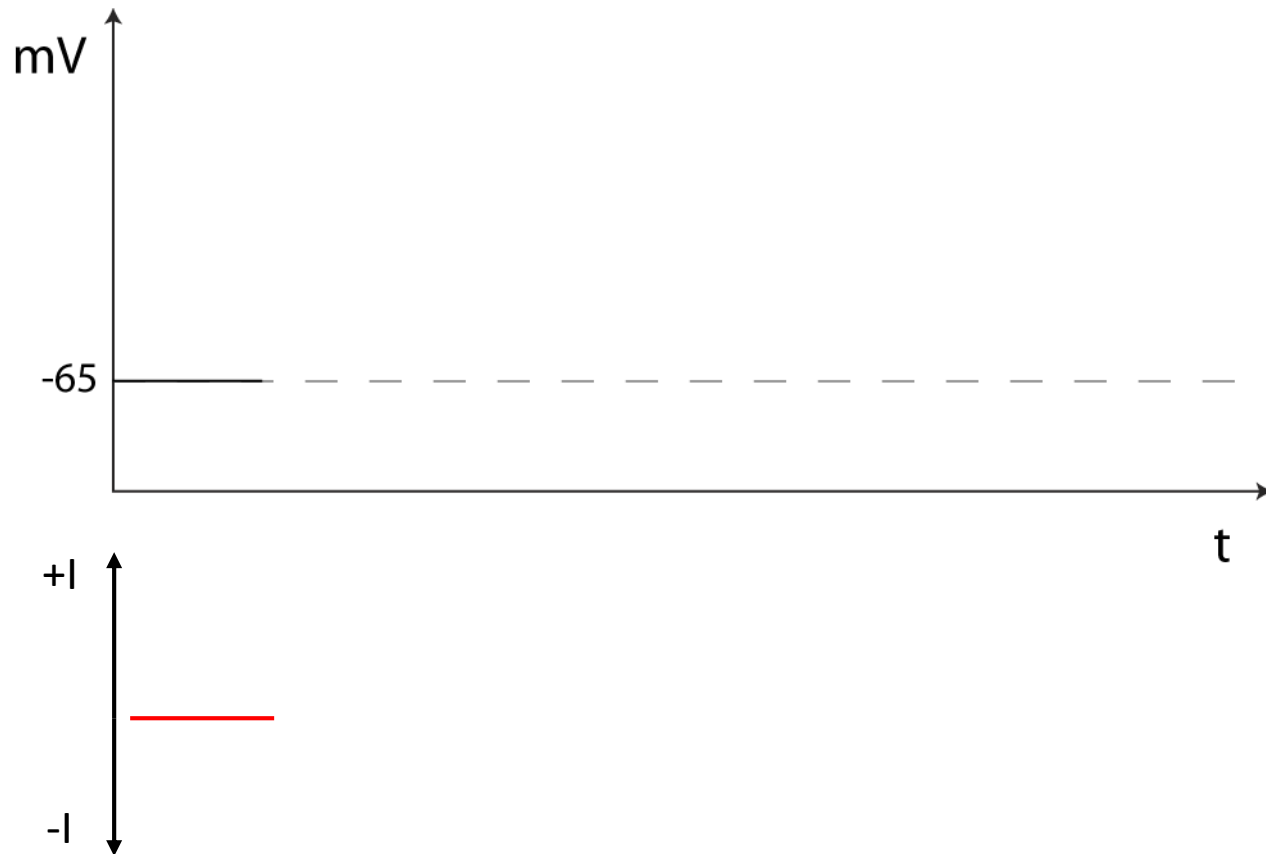
The inside is negative because of the imbalance between  $\text{Na}^+$  and  $\text{K}^+$  ions



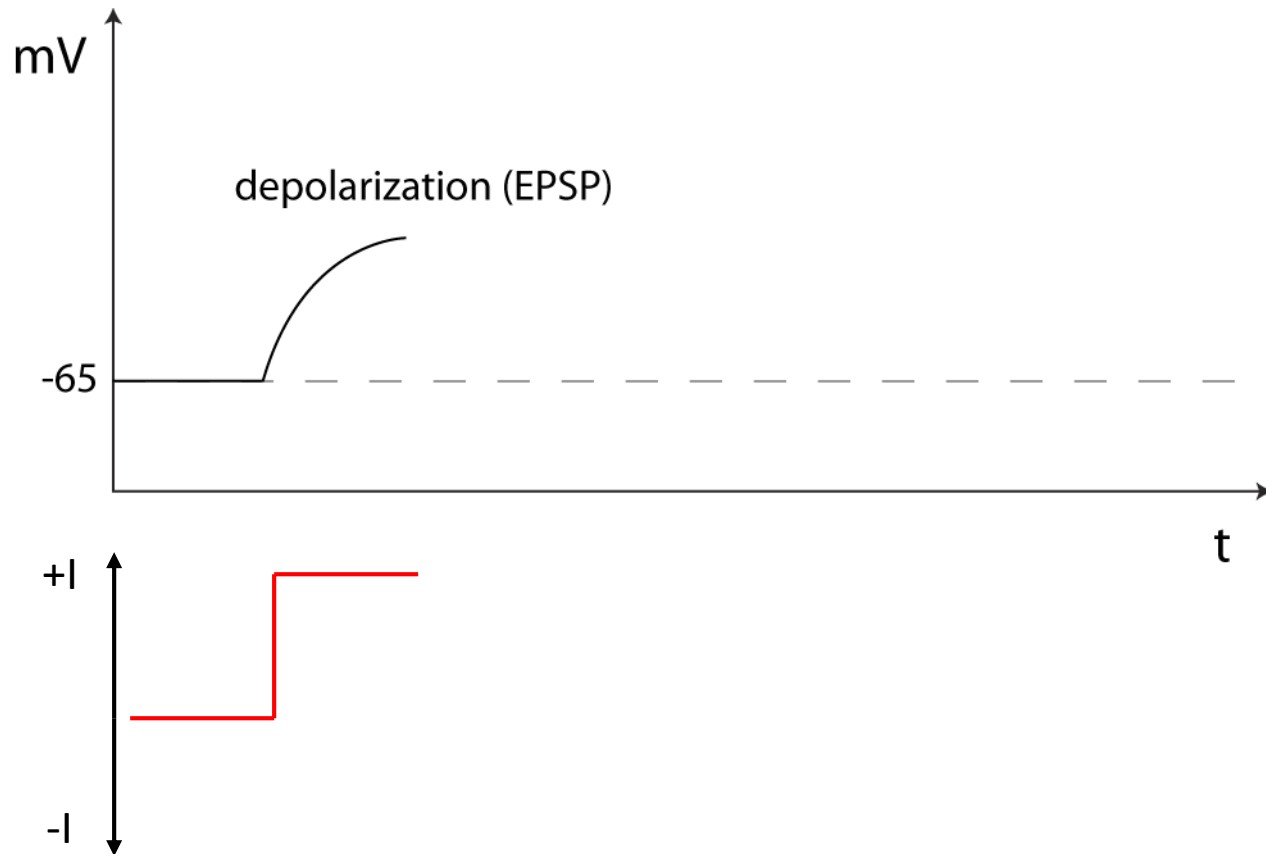
# Membrane potential



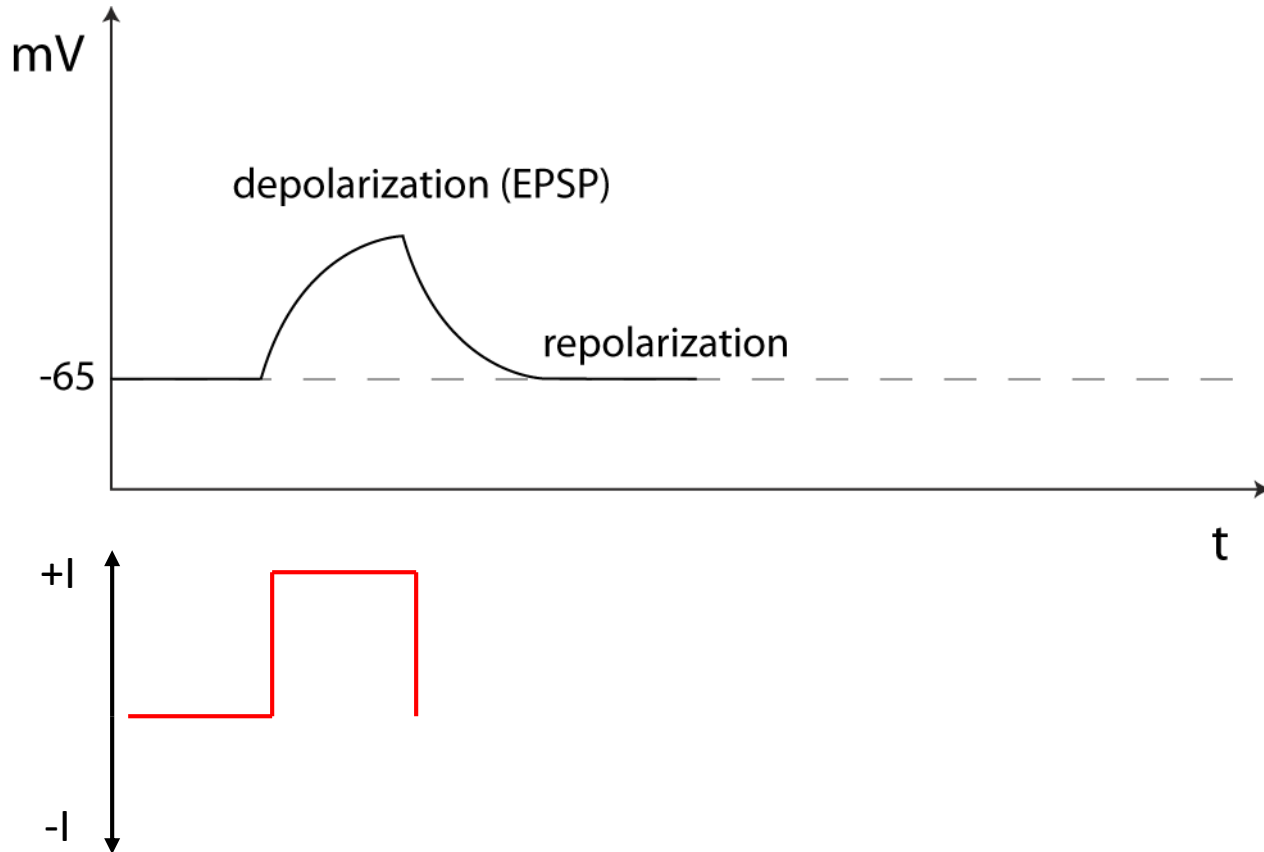
# Membrane potential



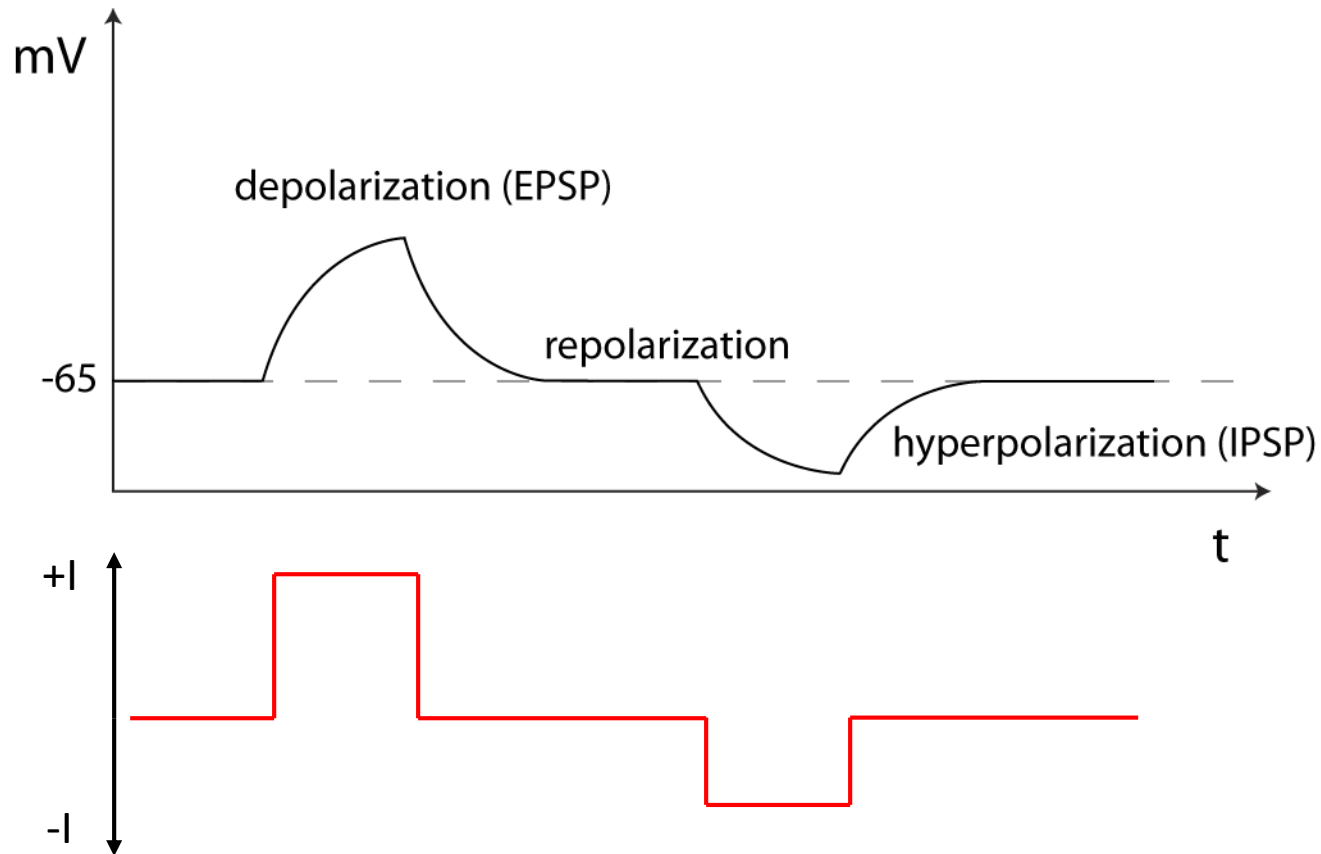
# Membrane potential



# Membrane potential

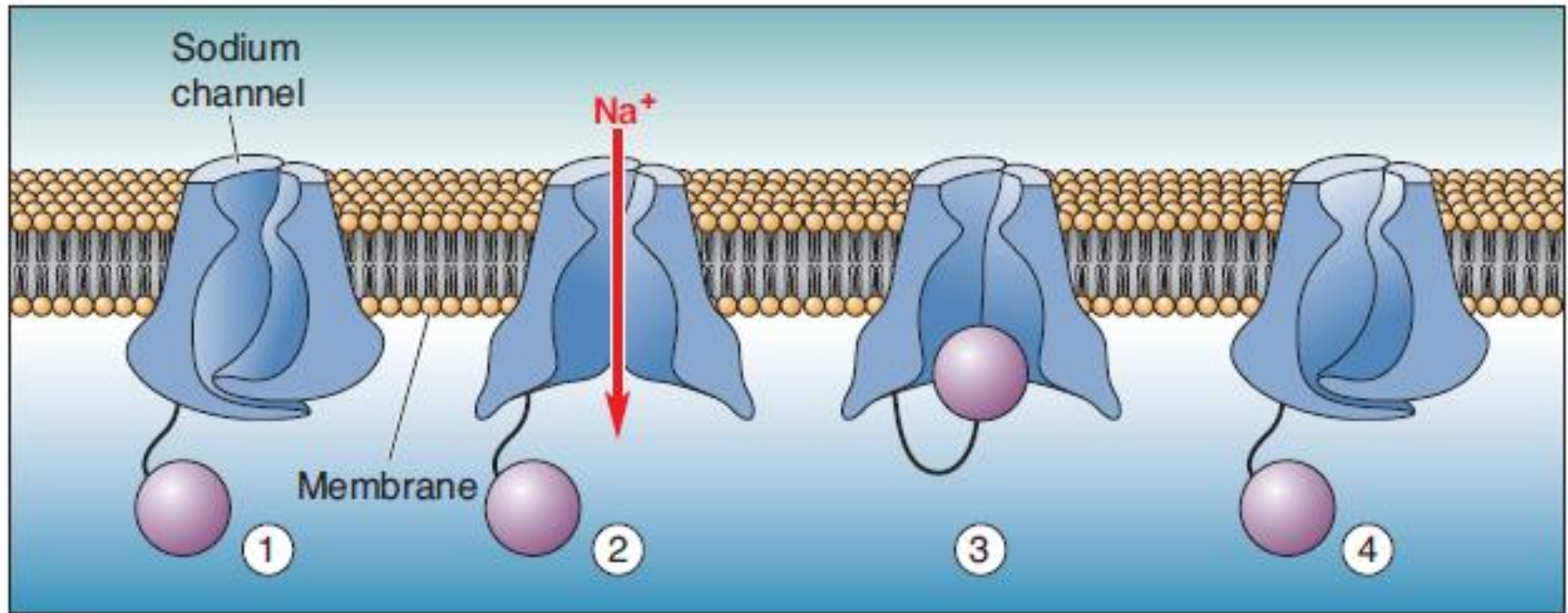


# Membrane potential



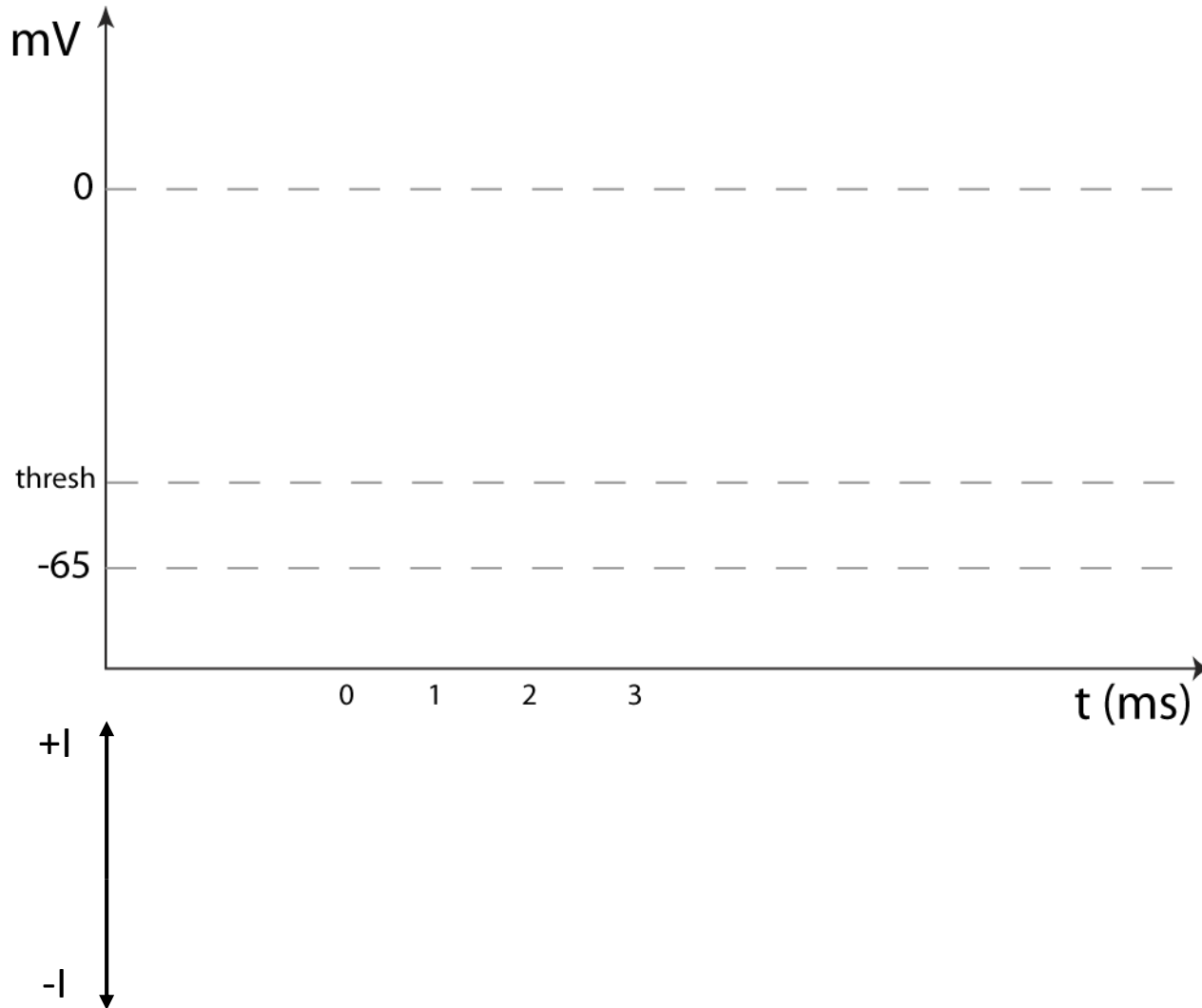
# Action Potential

# Voltage-gated ion channels.



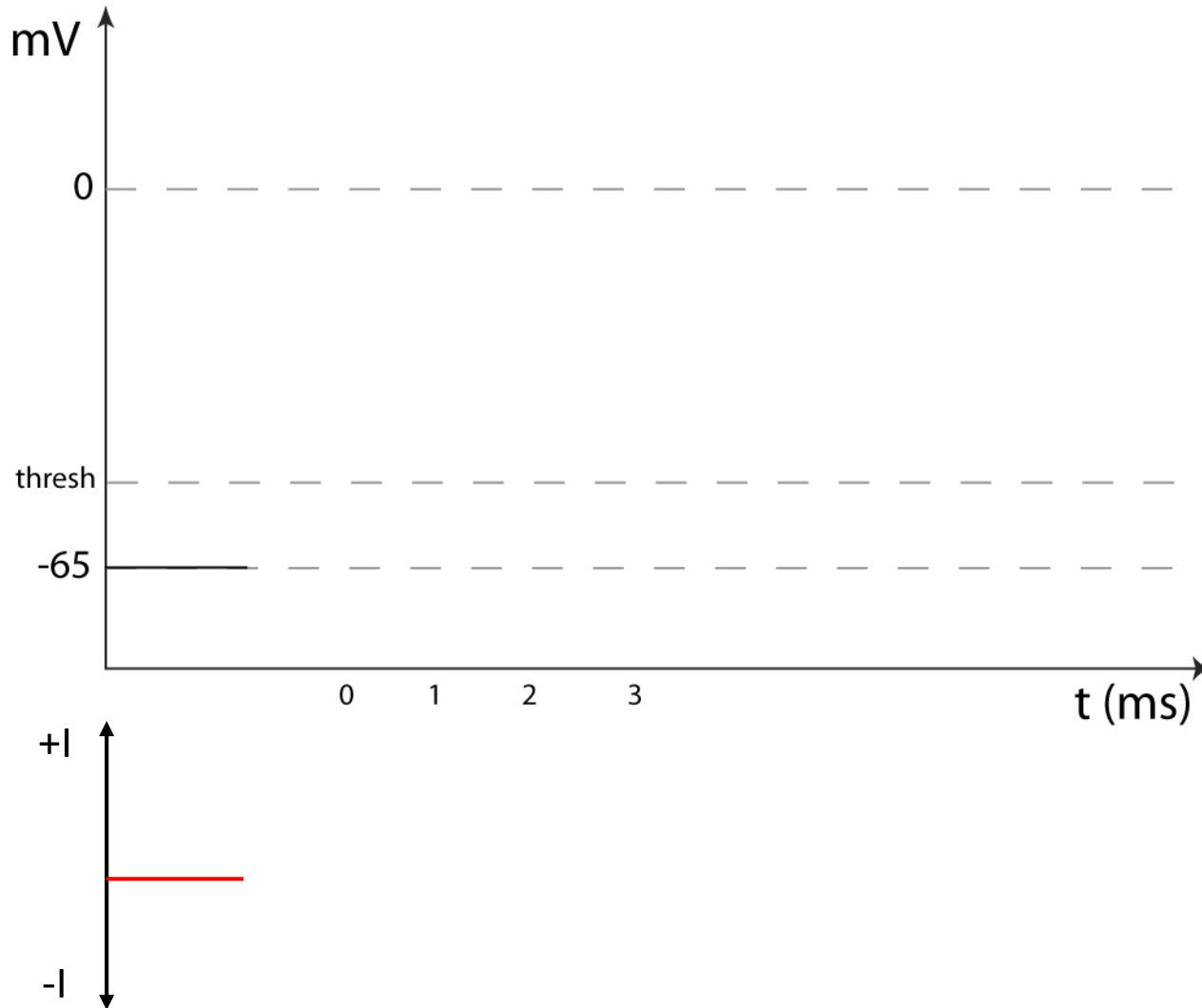
(c)

# Action potential

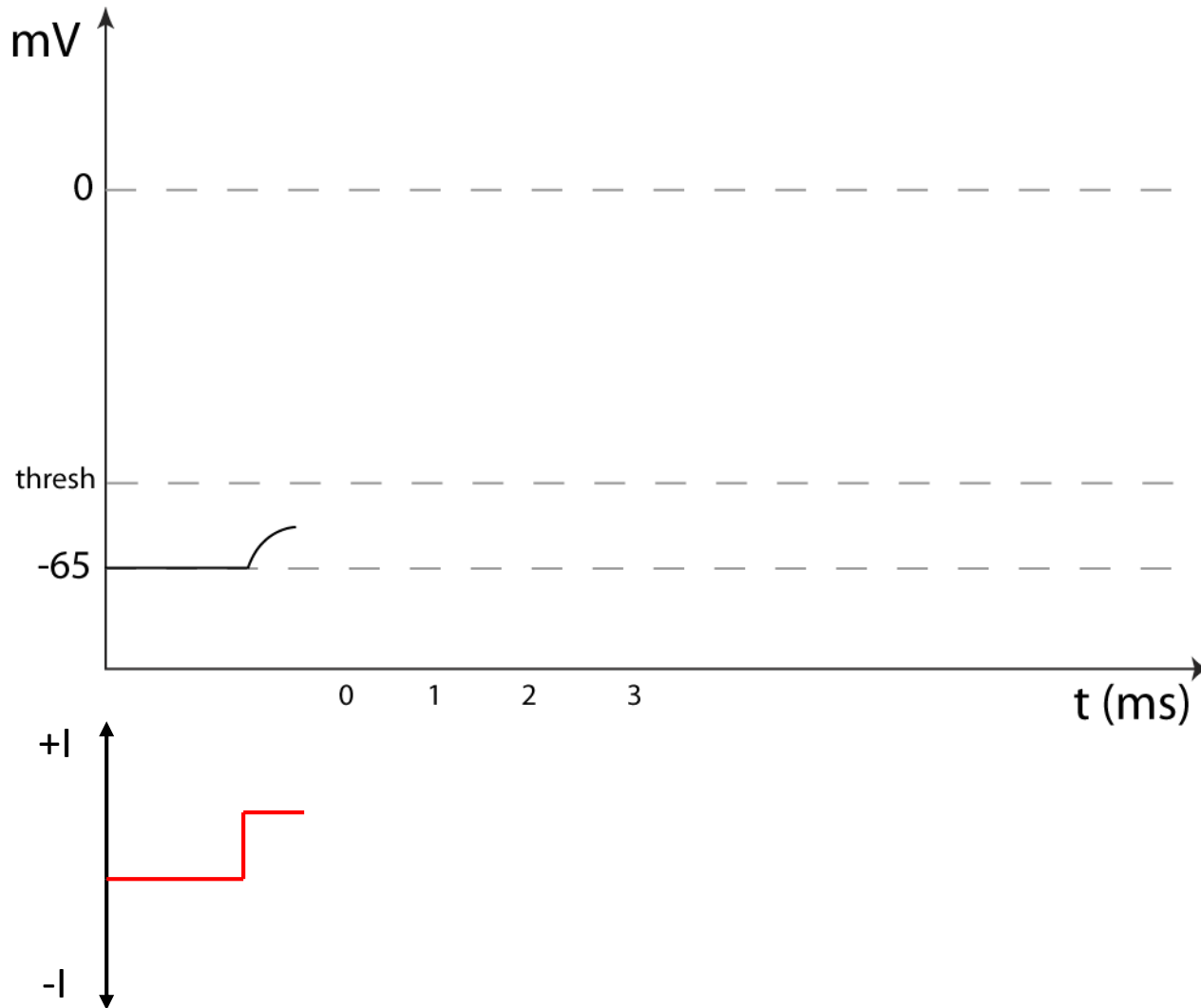




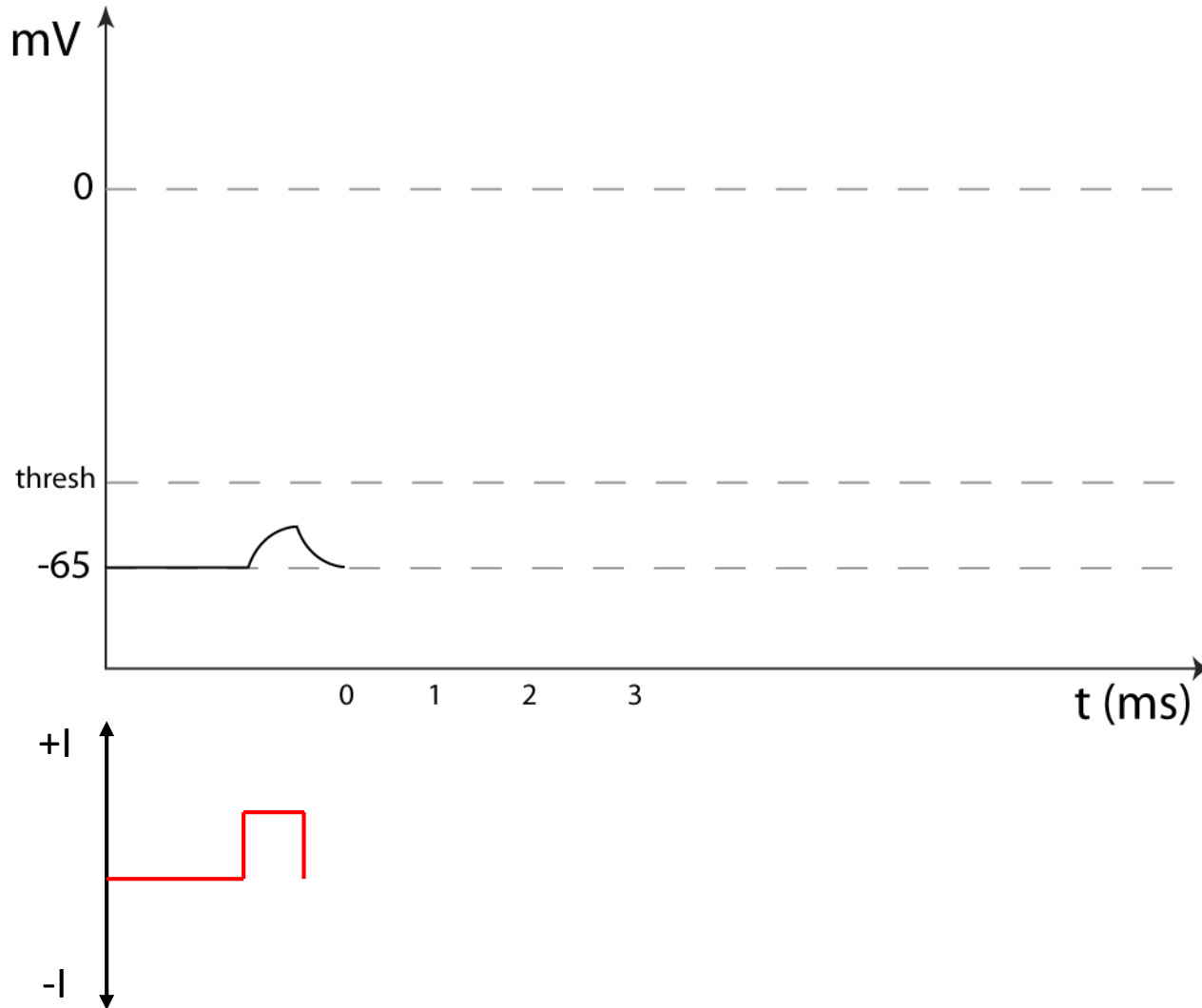
# Action potential



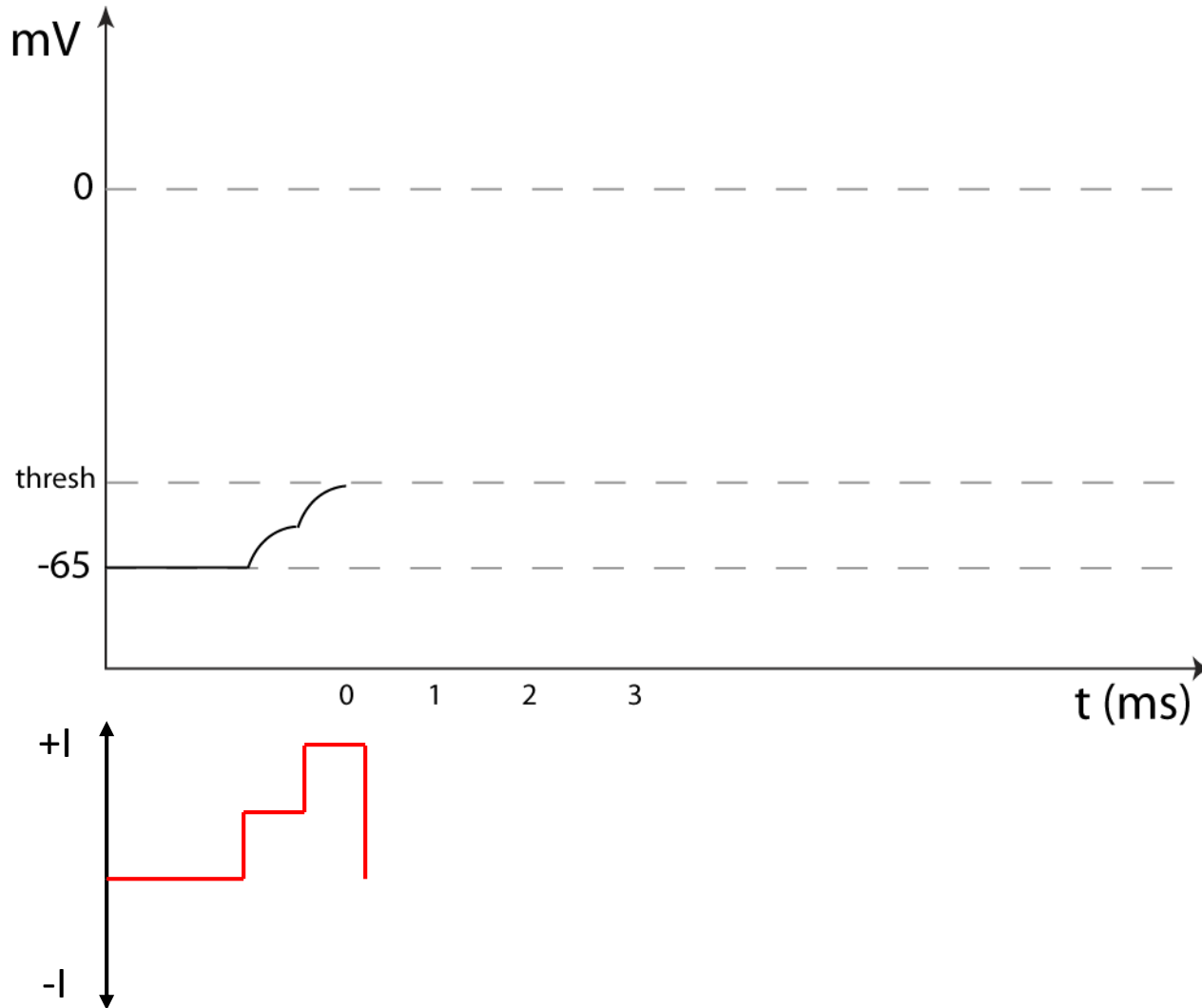
# Action potential



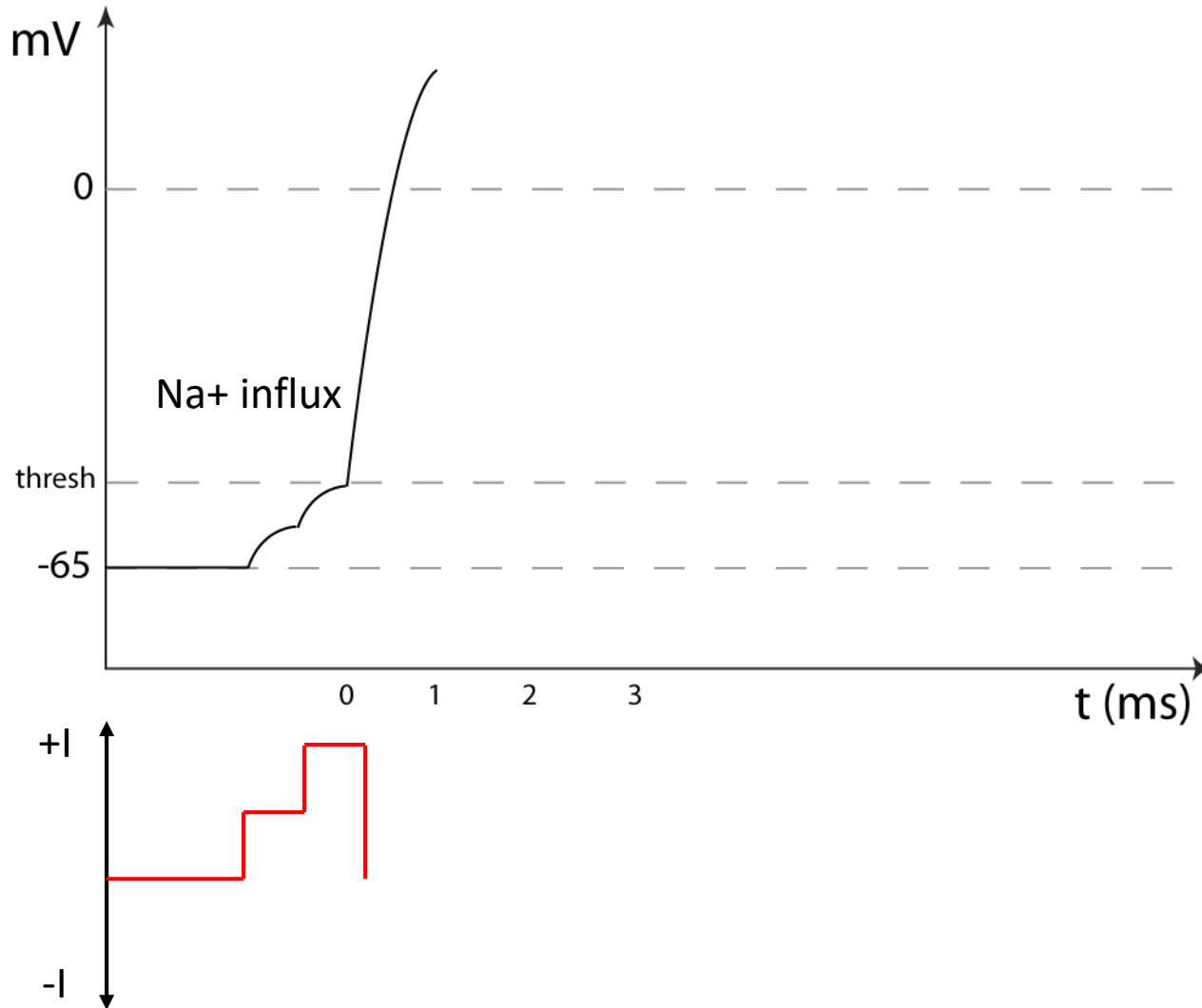
# Action potential



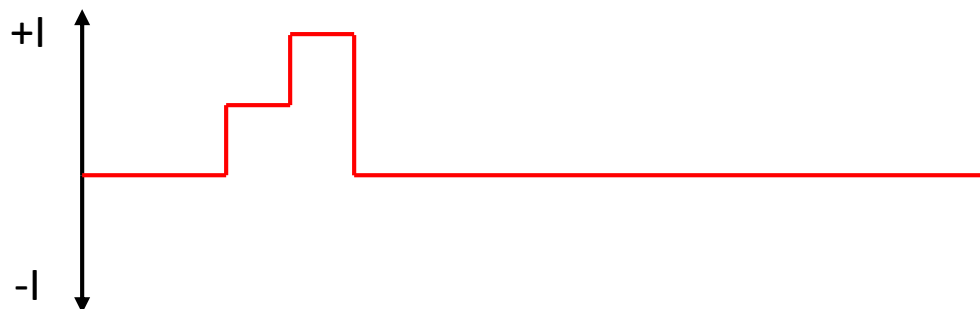
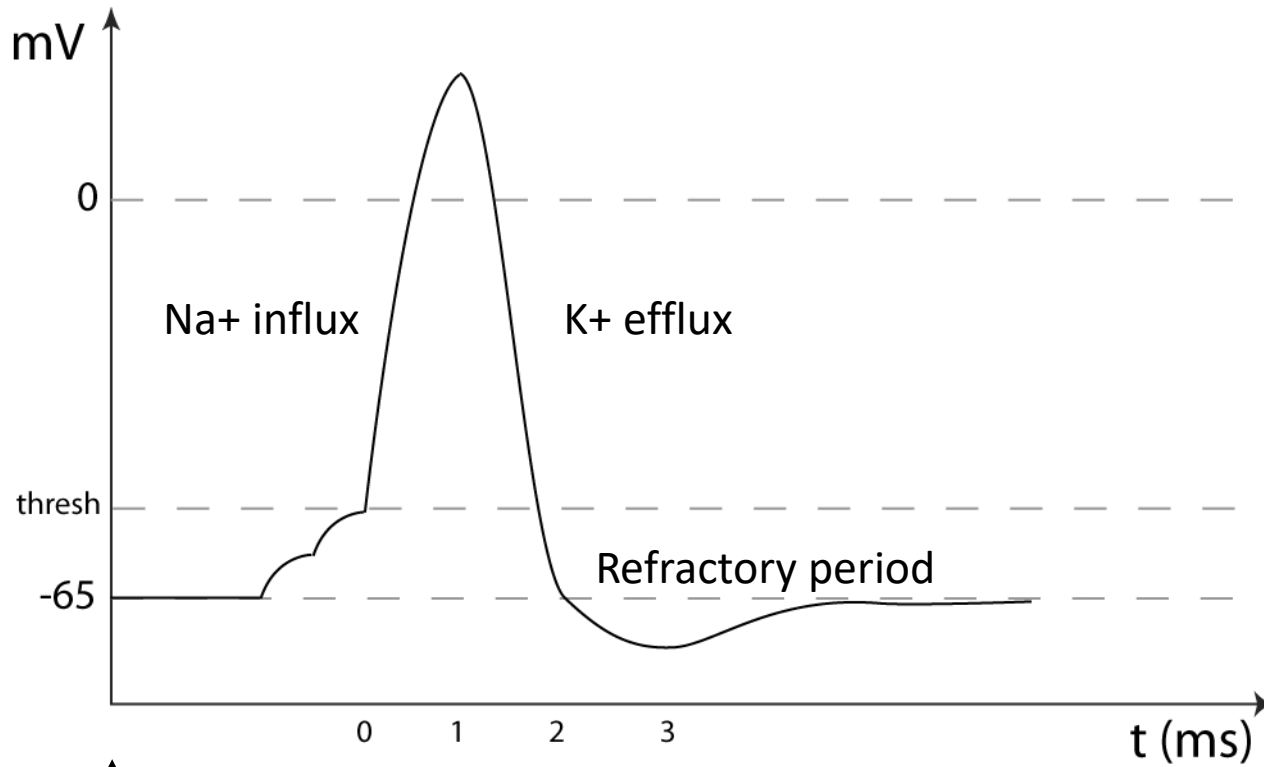
# Action potential



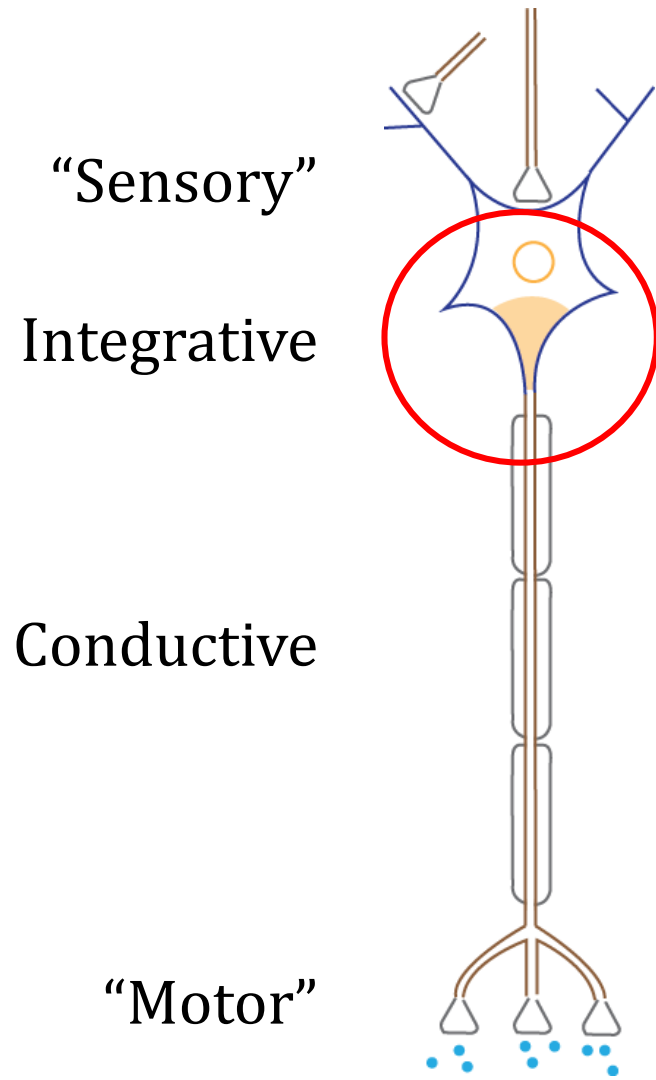
# Action potential



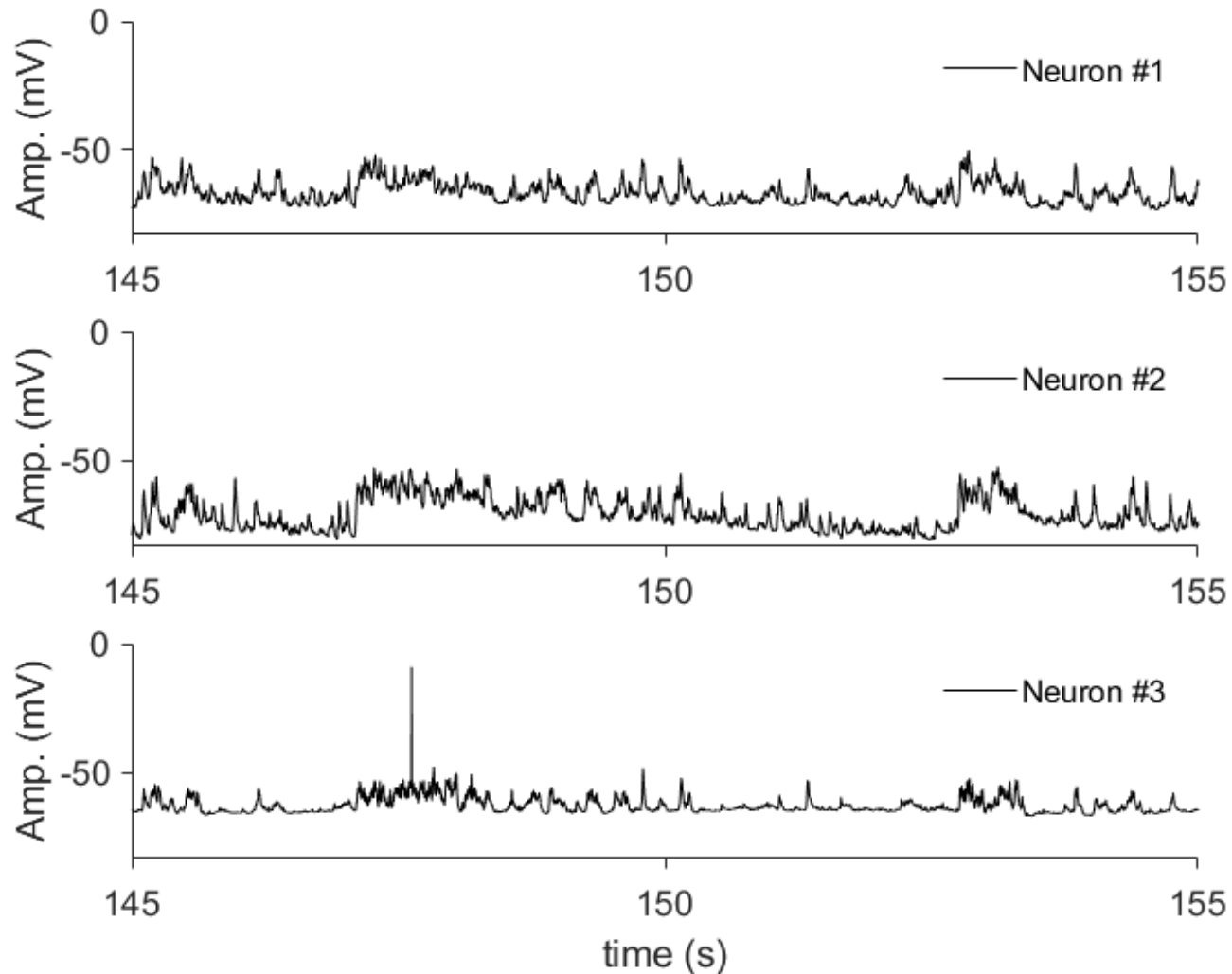
# Action potential



# The Neuron.

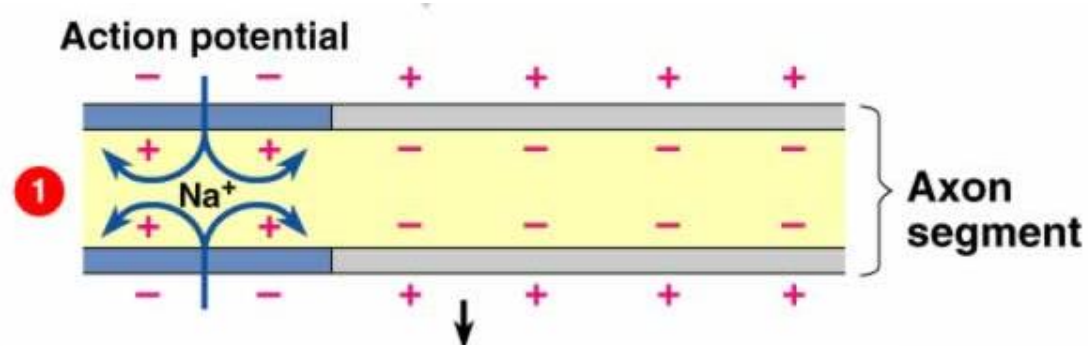


# Membrane and action potentials



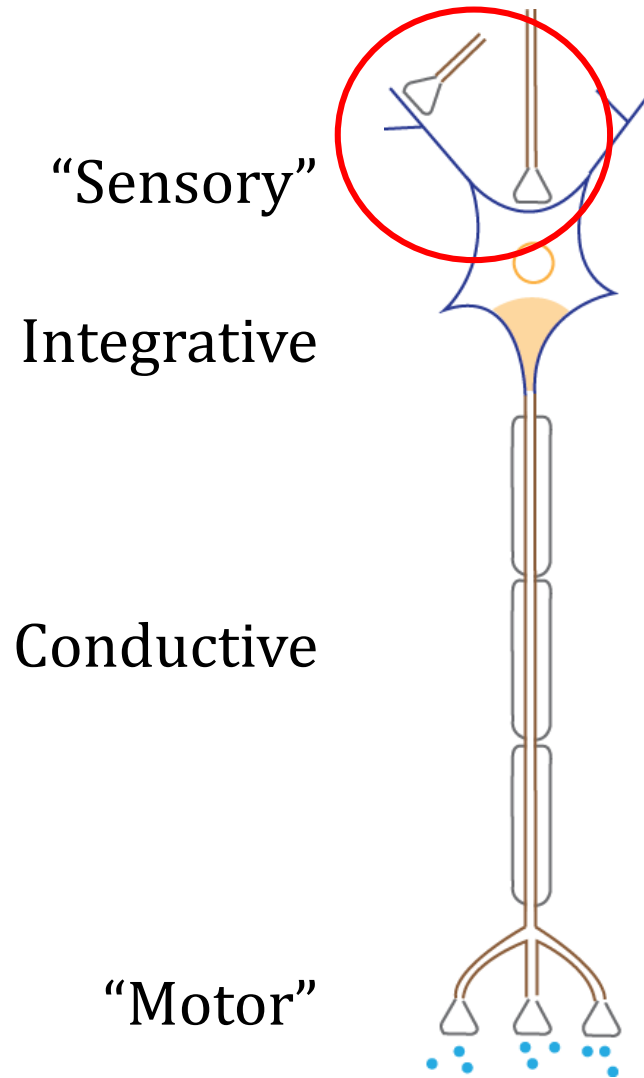


# AP propagation

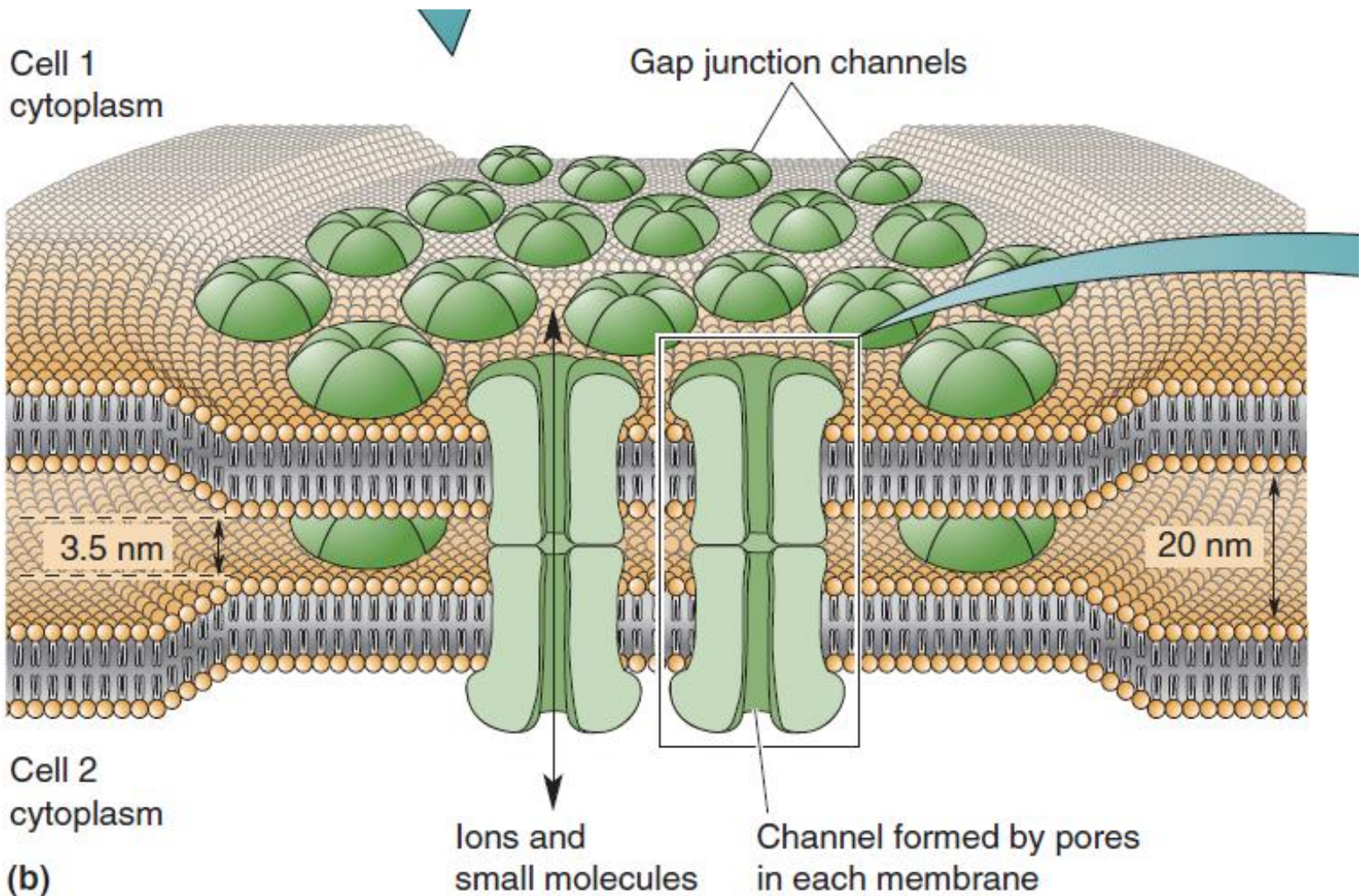


Synapses.

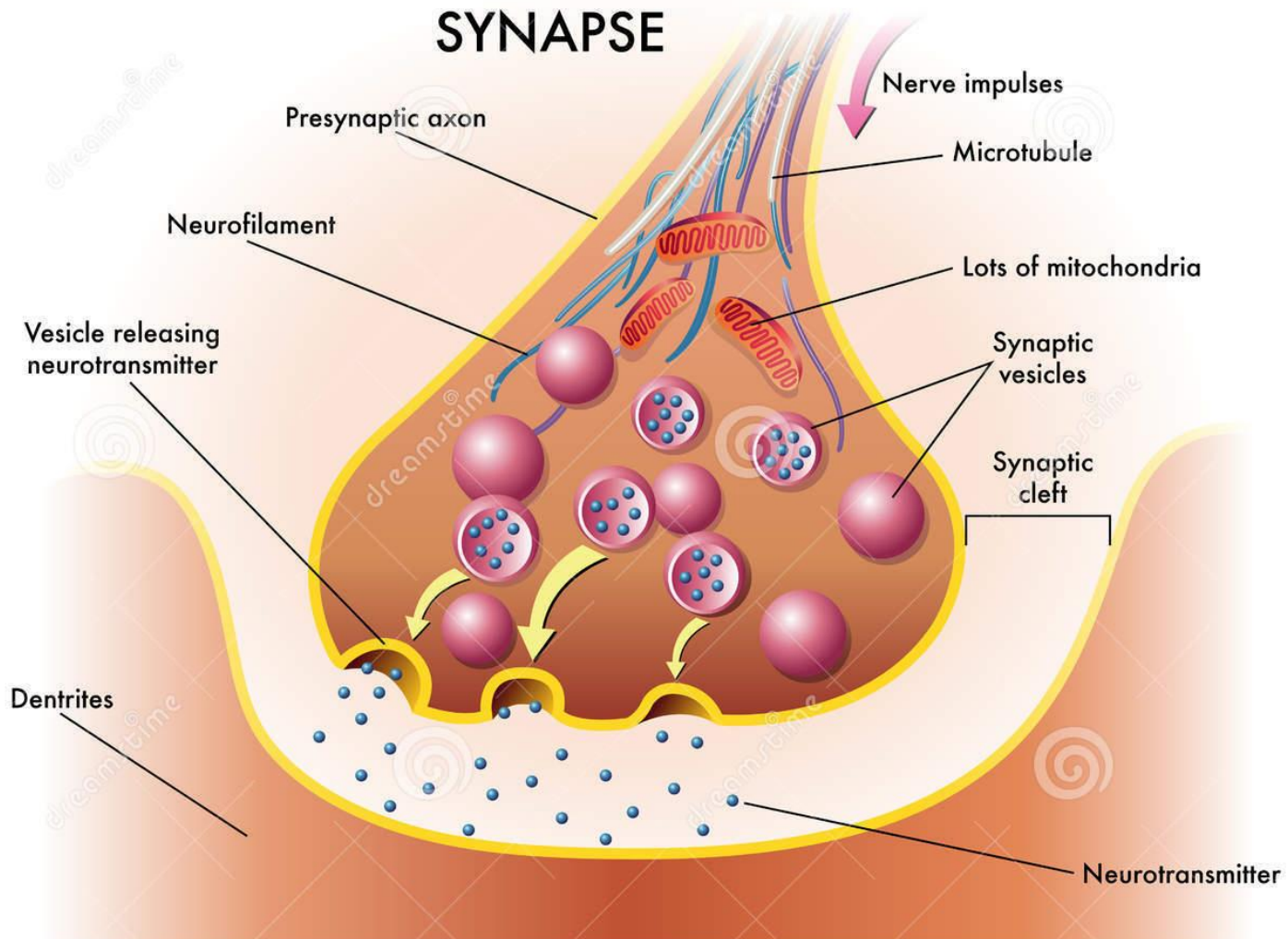
# The Neuron.



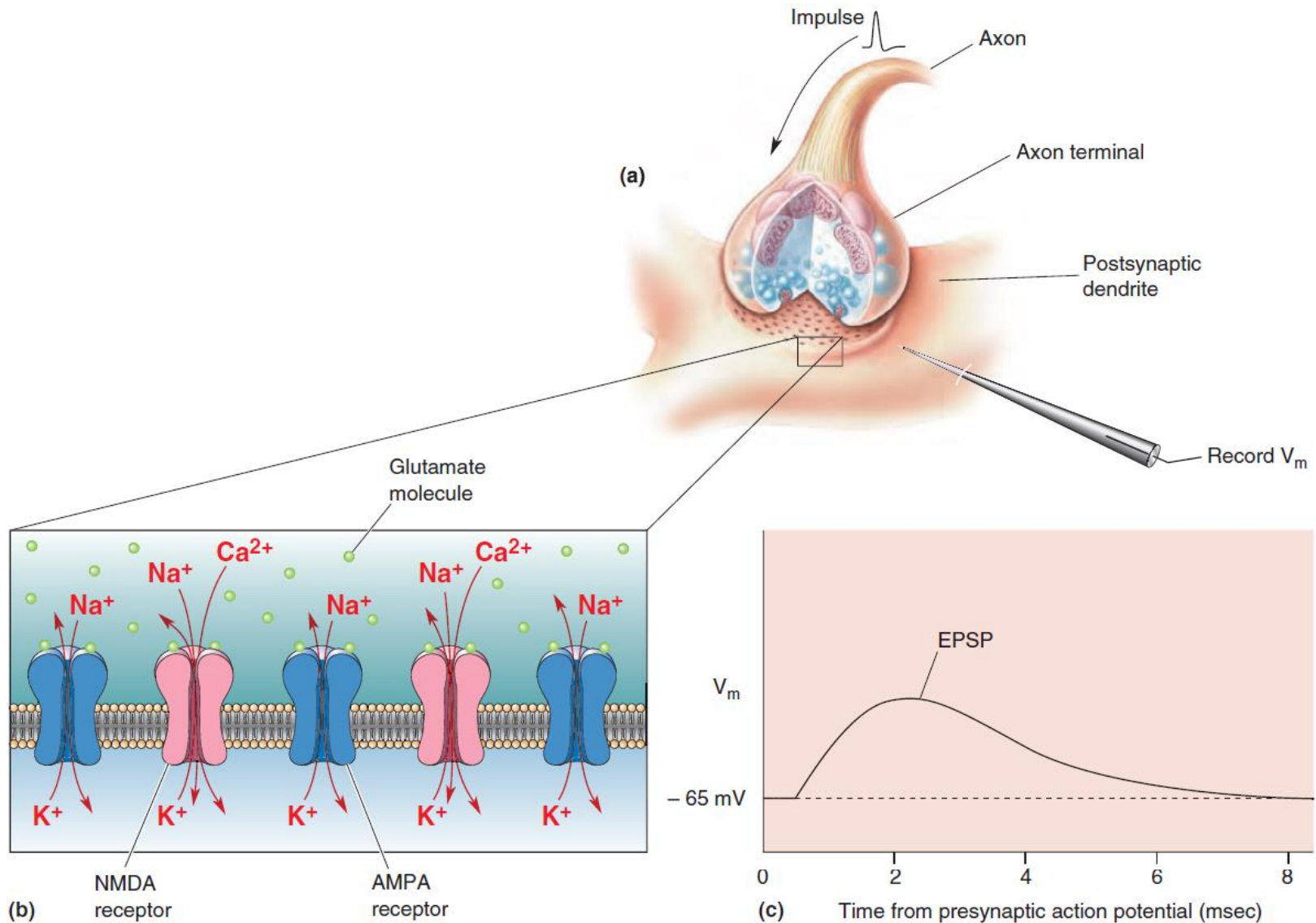
# Electrical Synapse



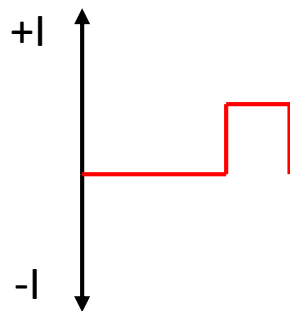
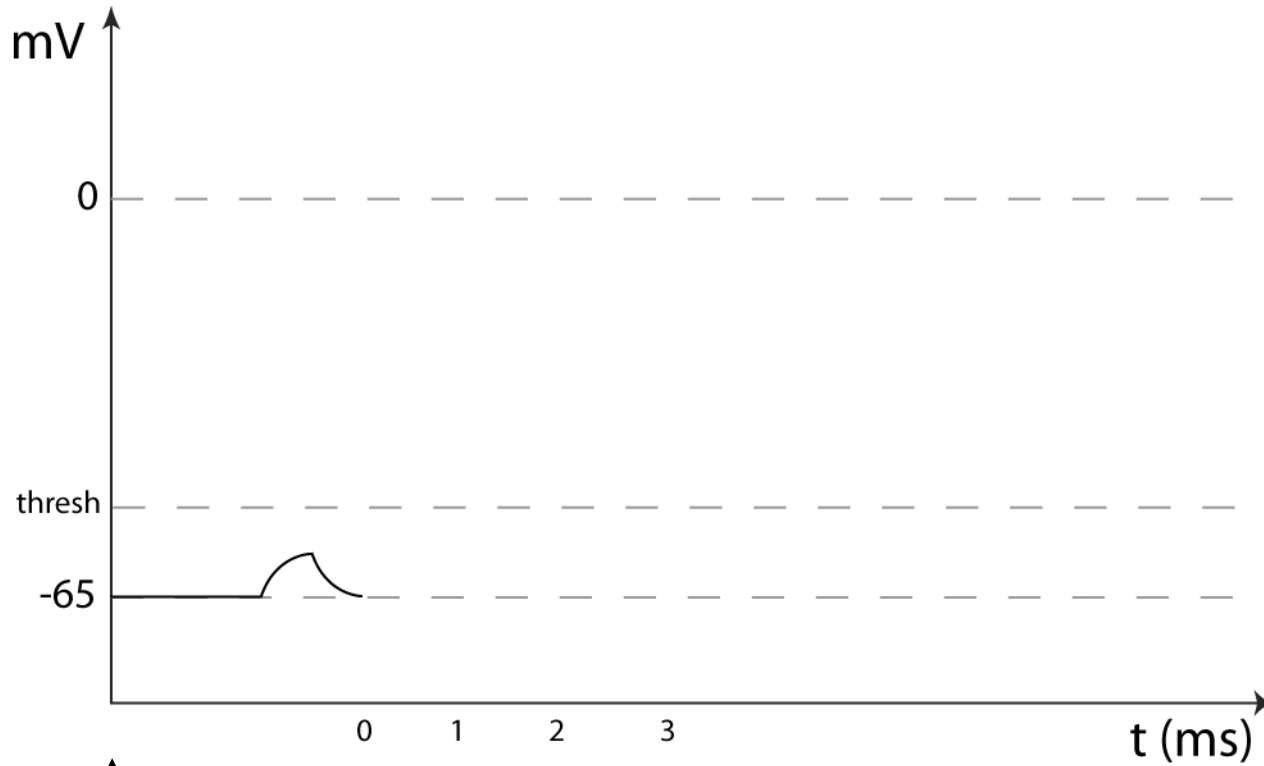
# Chemical Synapse



# Excitatory synapses.

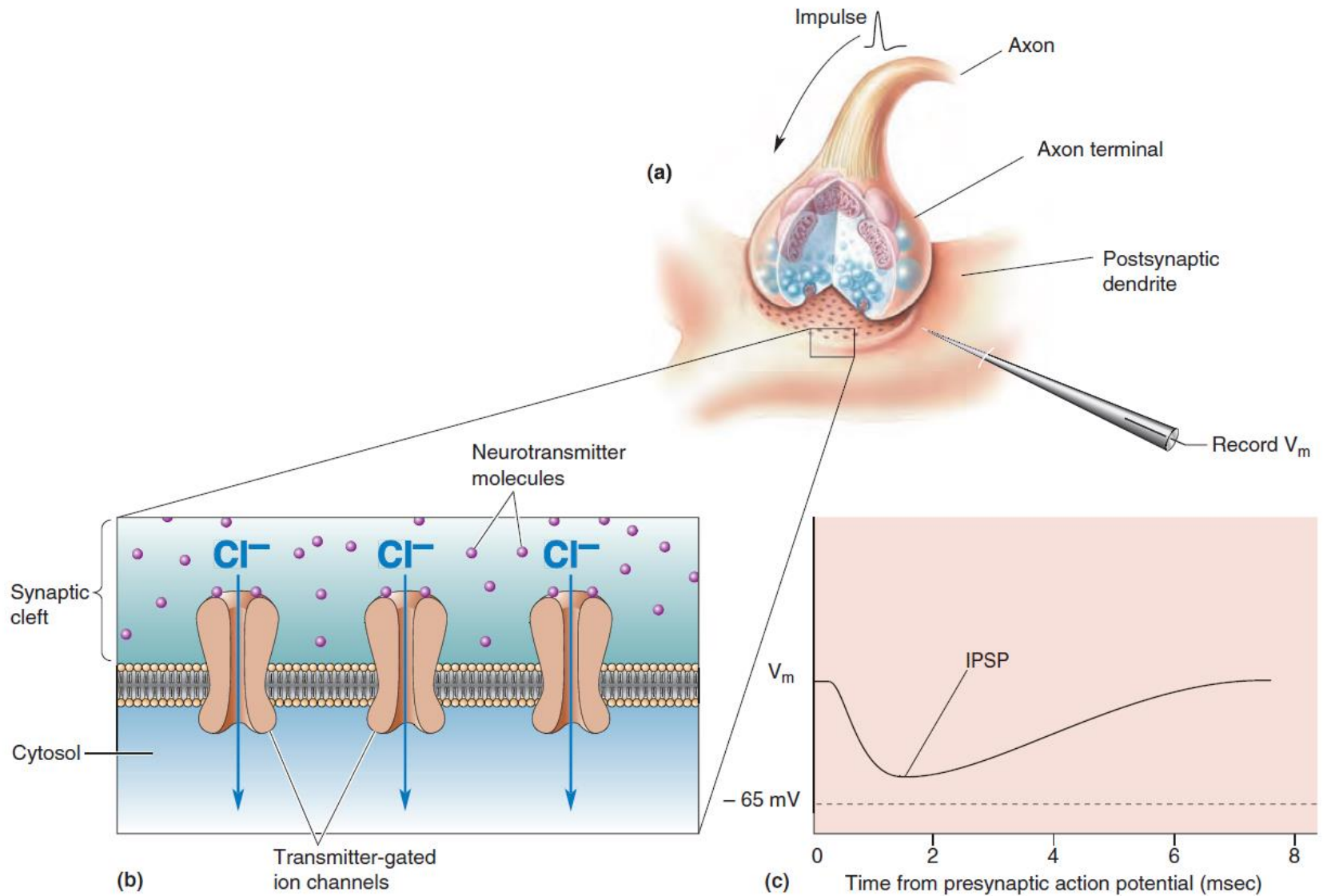


# EPSP



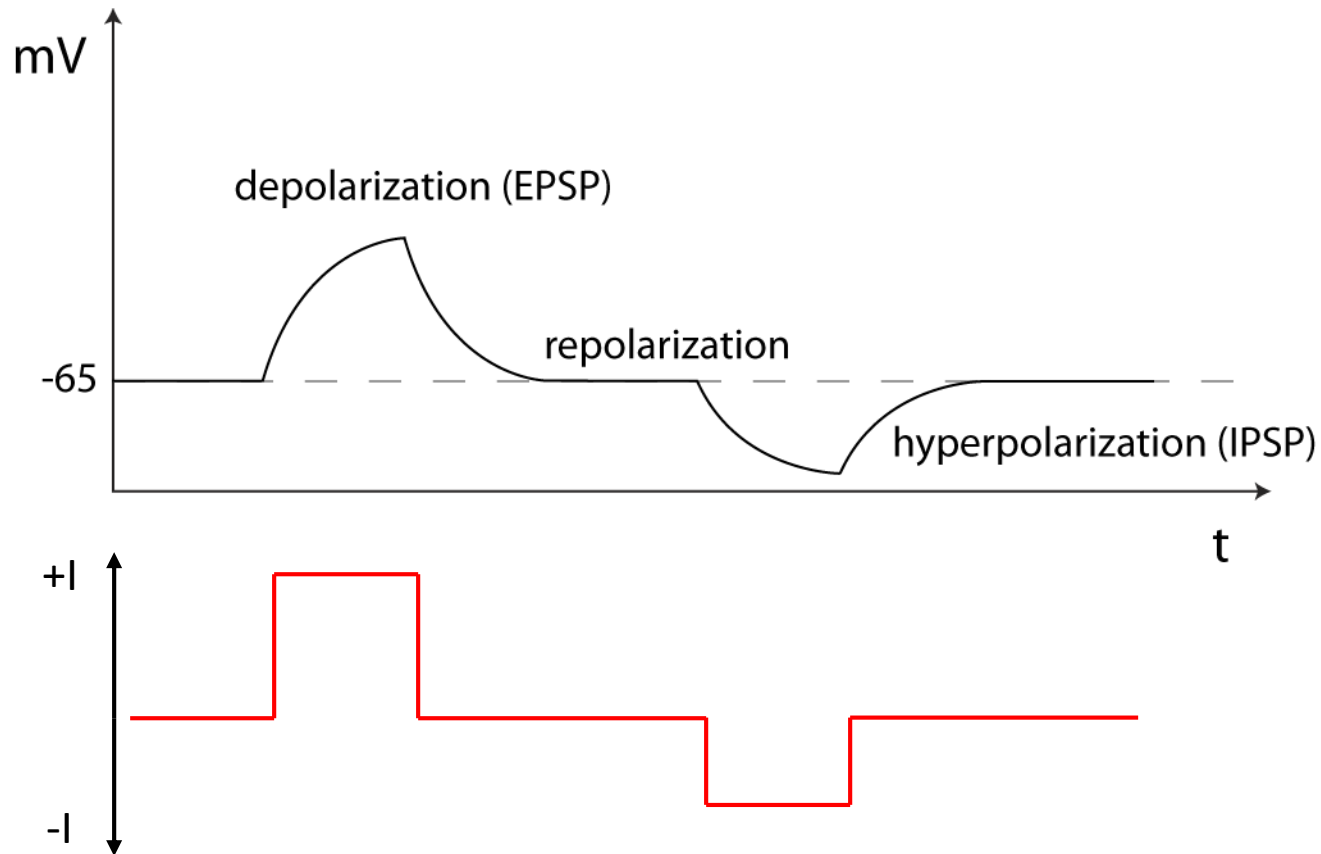


# Inhibitory synapse.





# Membrane potential



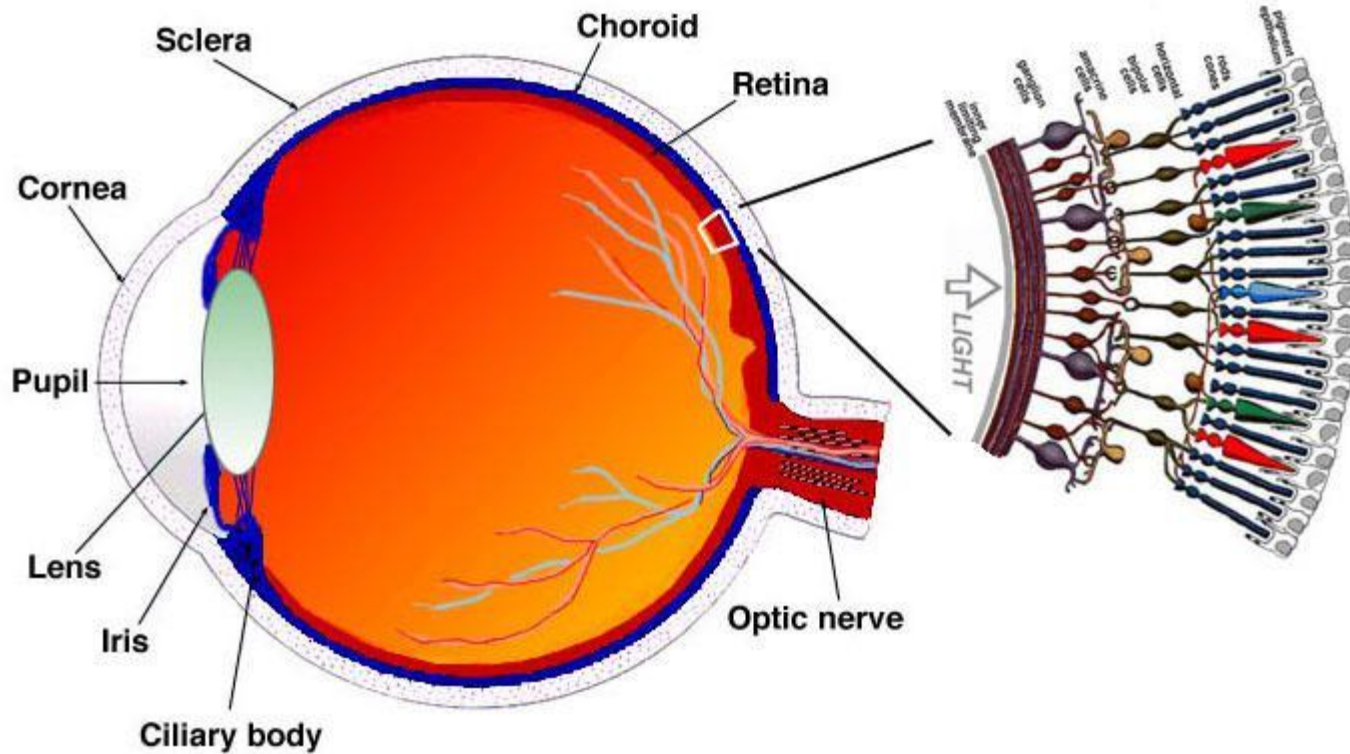
# Real Neural Networks.

## A. Feedforward excitation

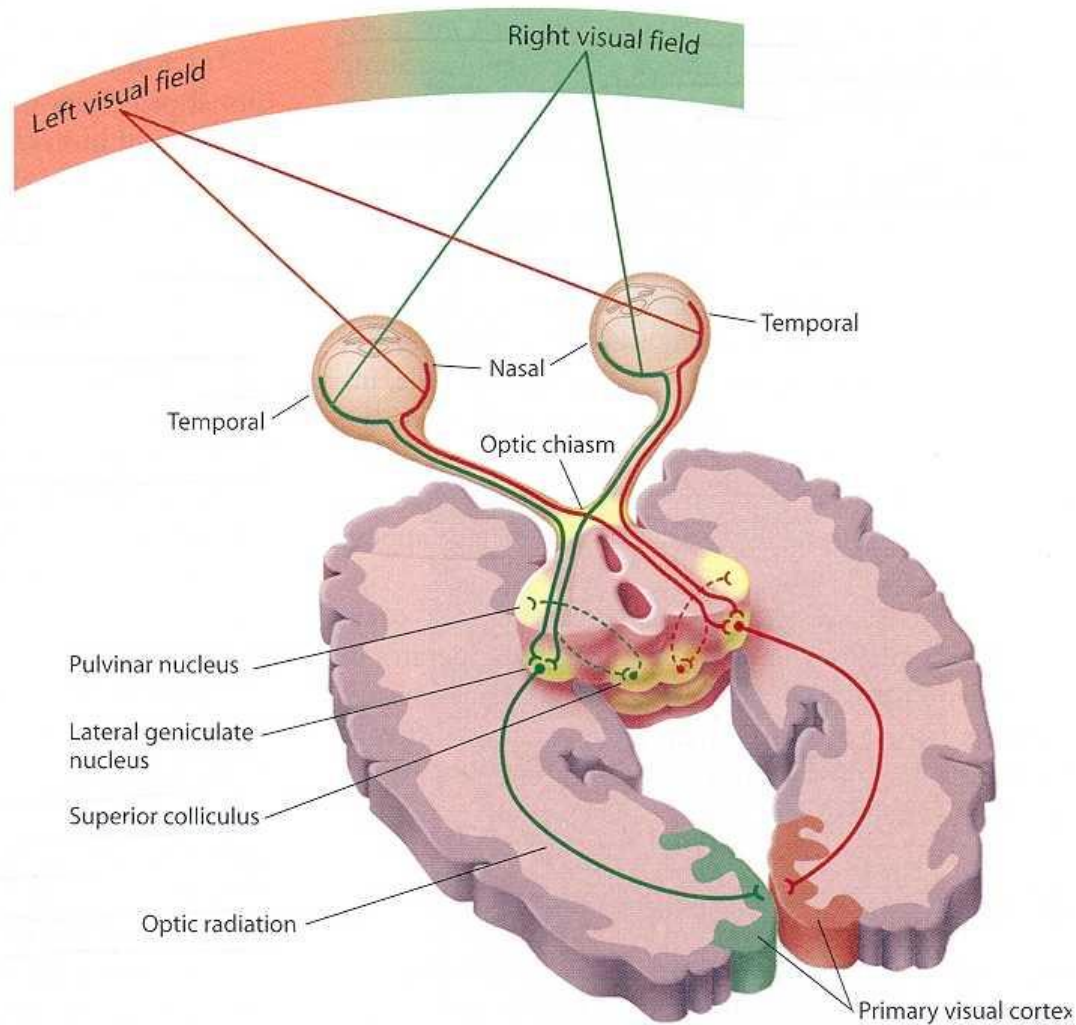


Sensory Systems.

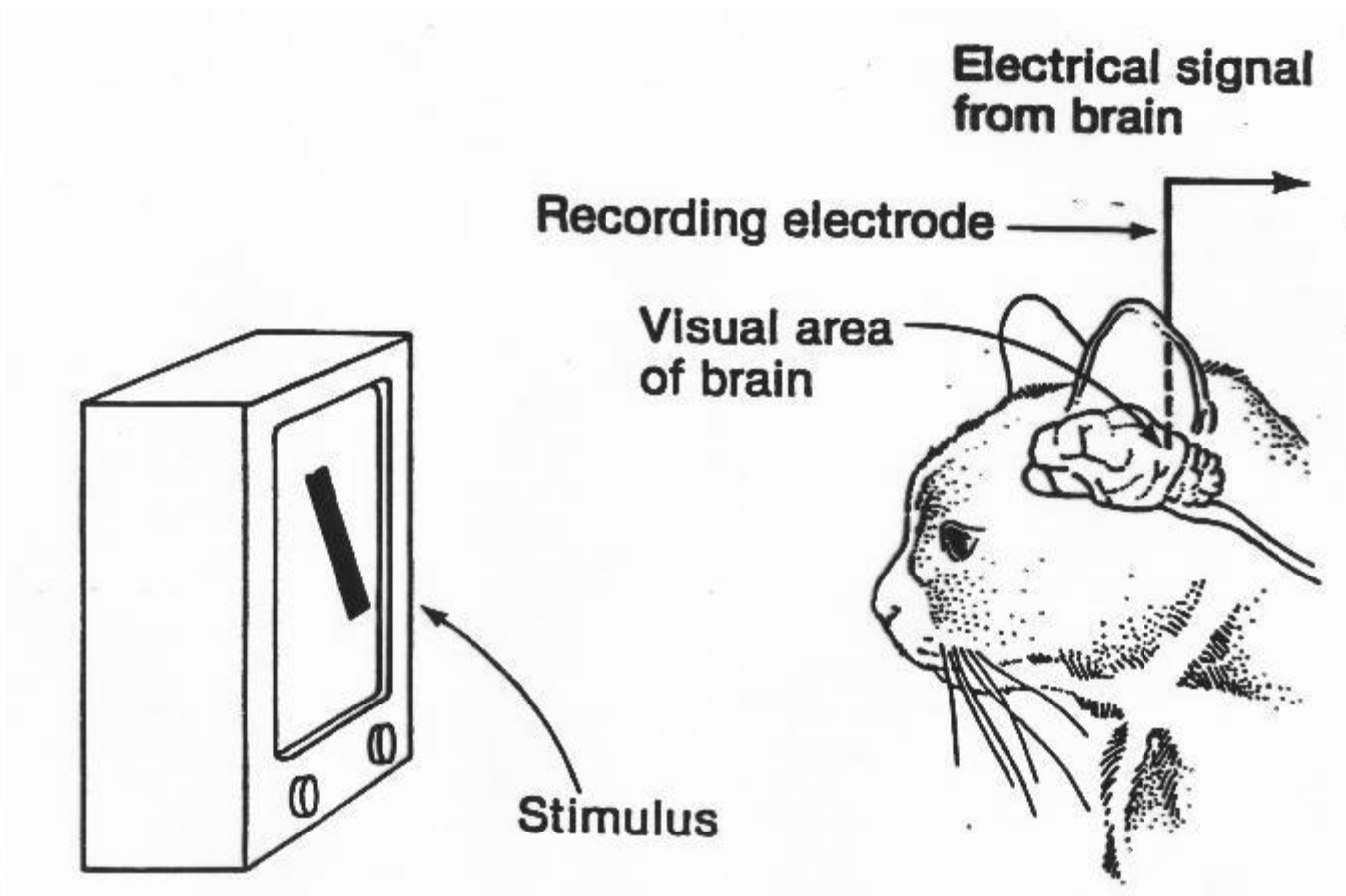
# Eye and Retina.



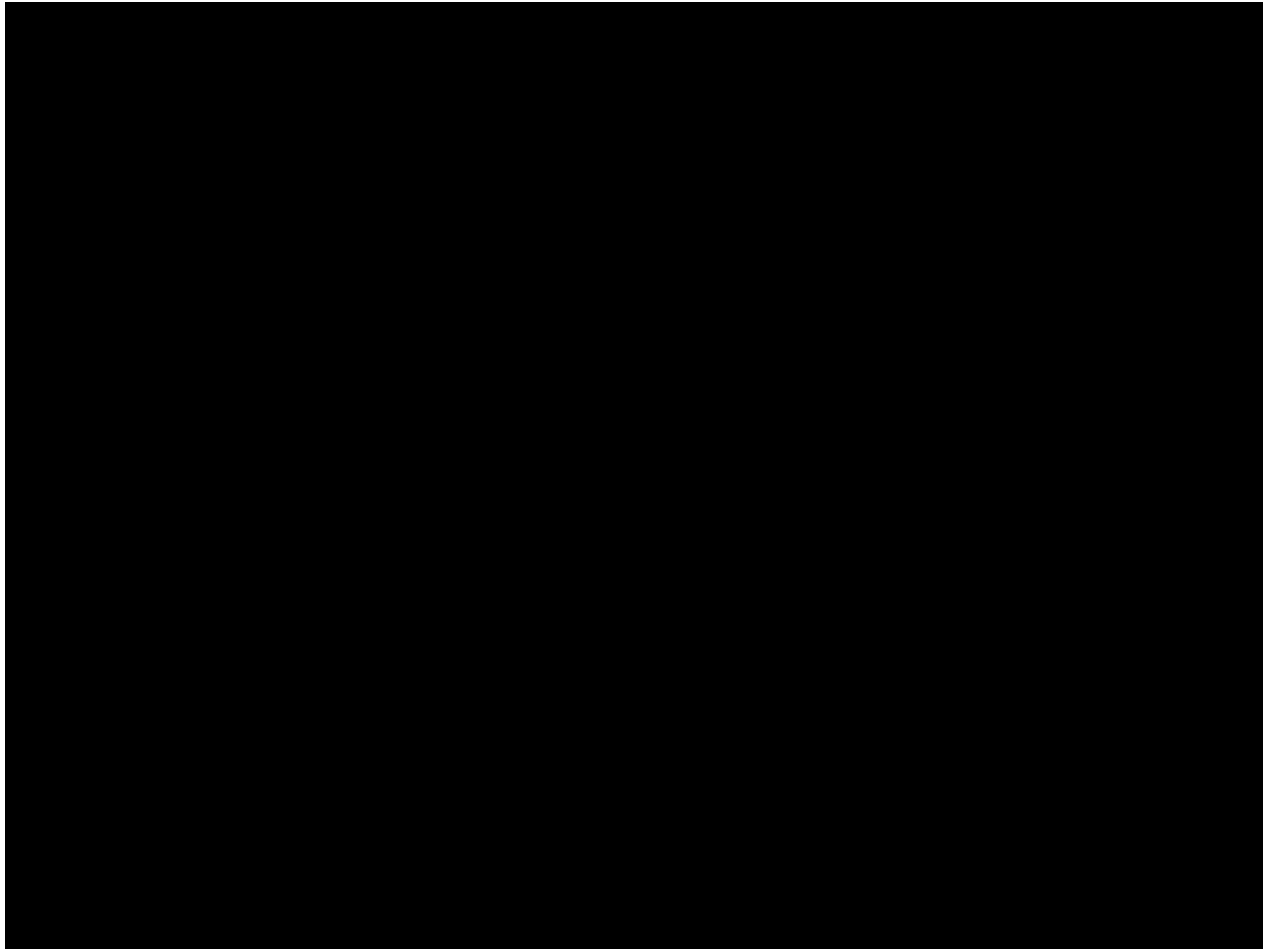
# Visual pathway.



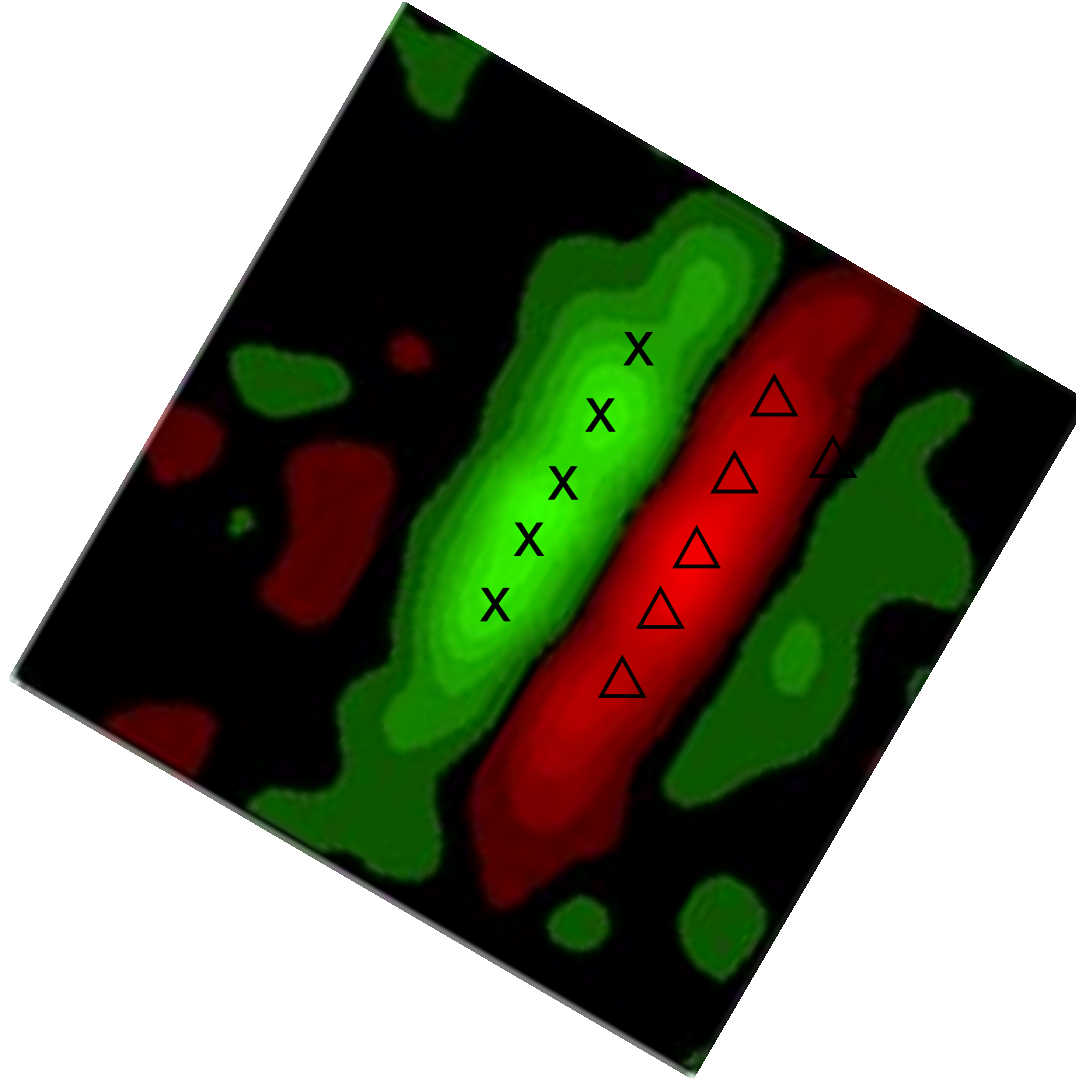
# Neurons in Primary Visual Cortex.



Receptive field of V1  
neurons.

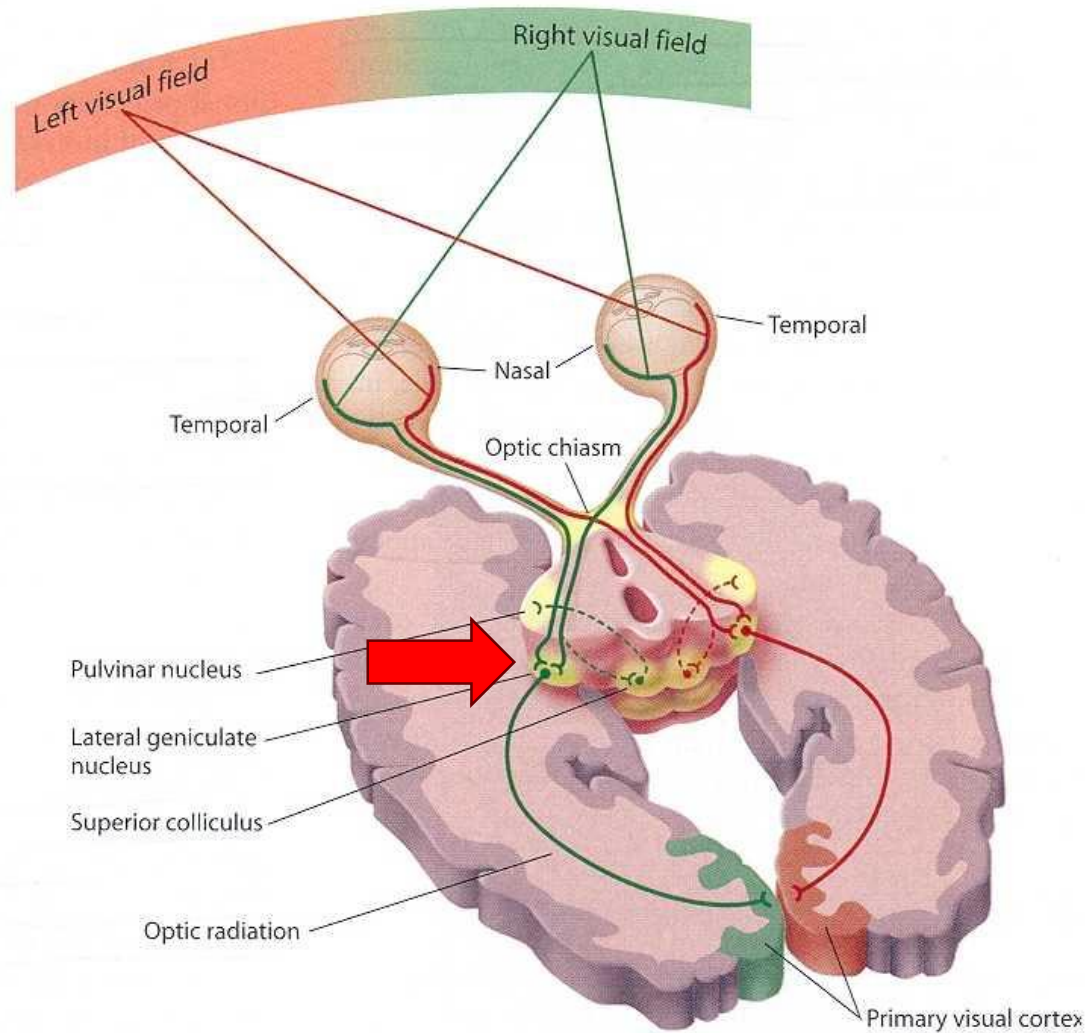


# Receptive field of V1 neurons.

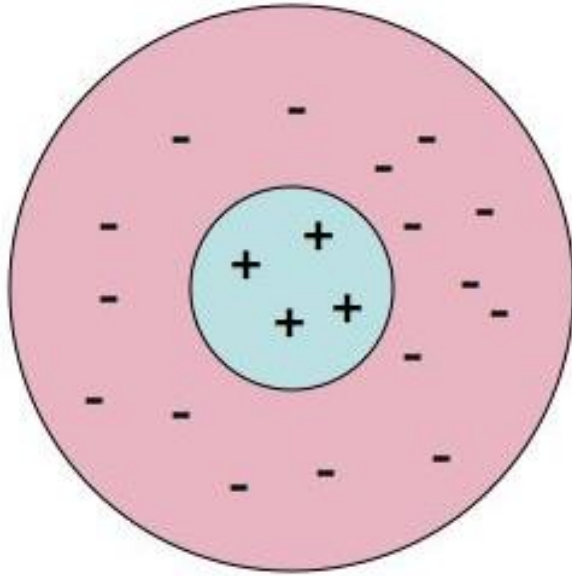




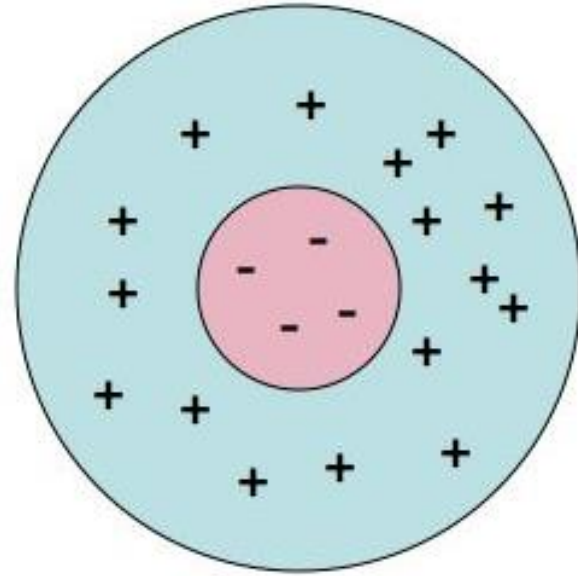
# Lateral geniculate nucleus (LGN).



# Receptive field of thalamic neurons.

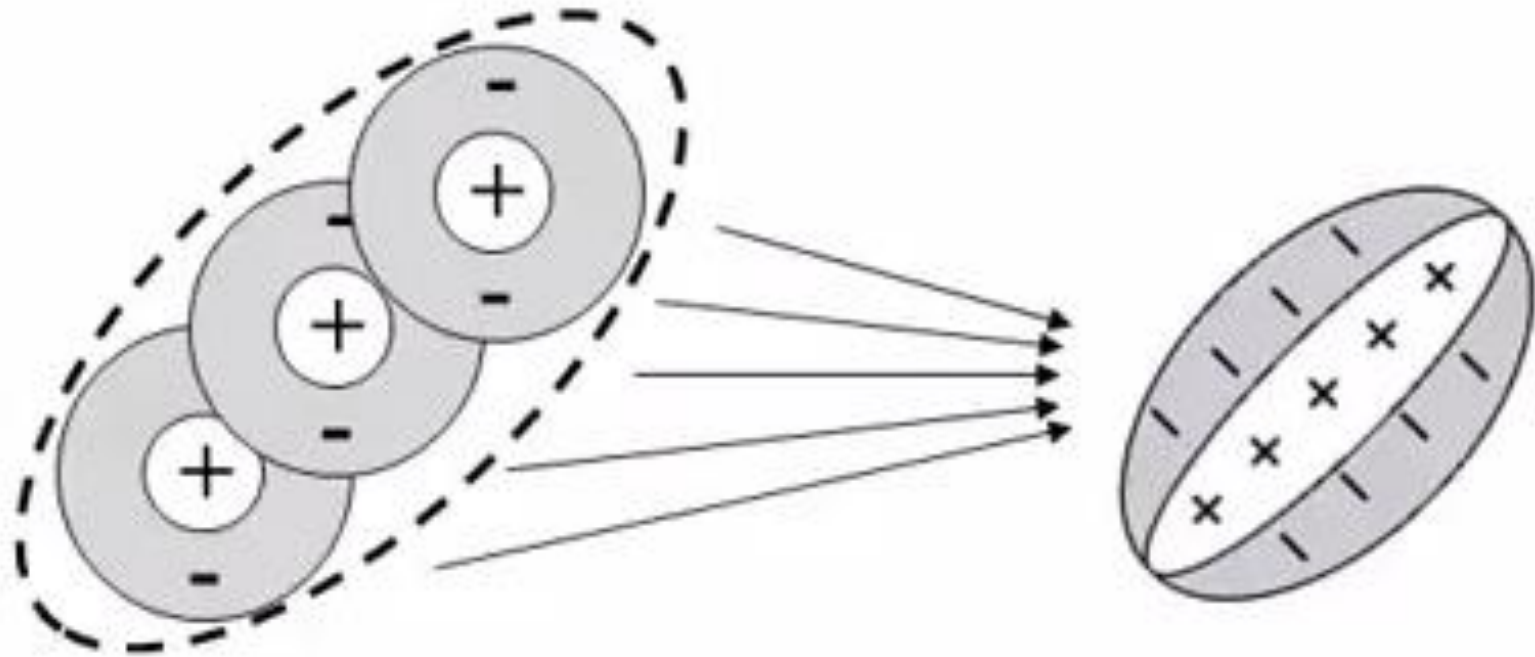


On-center, Off-surround



Off-center, On-surround

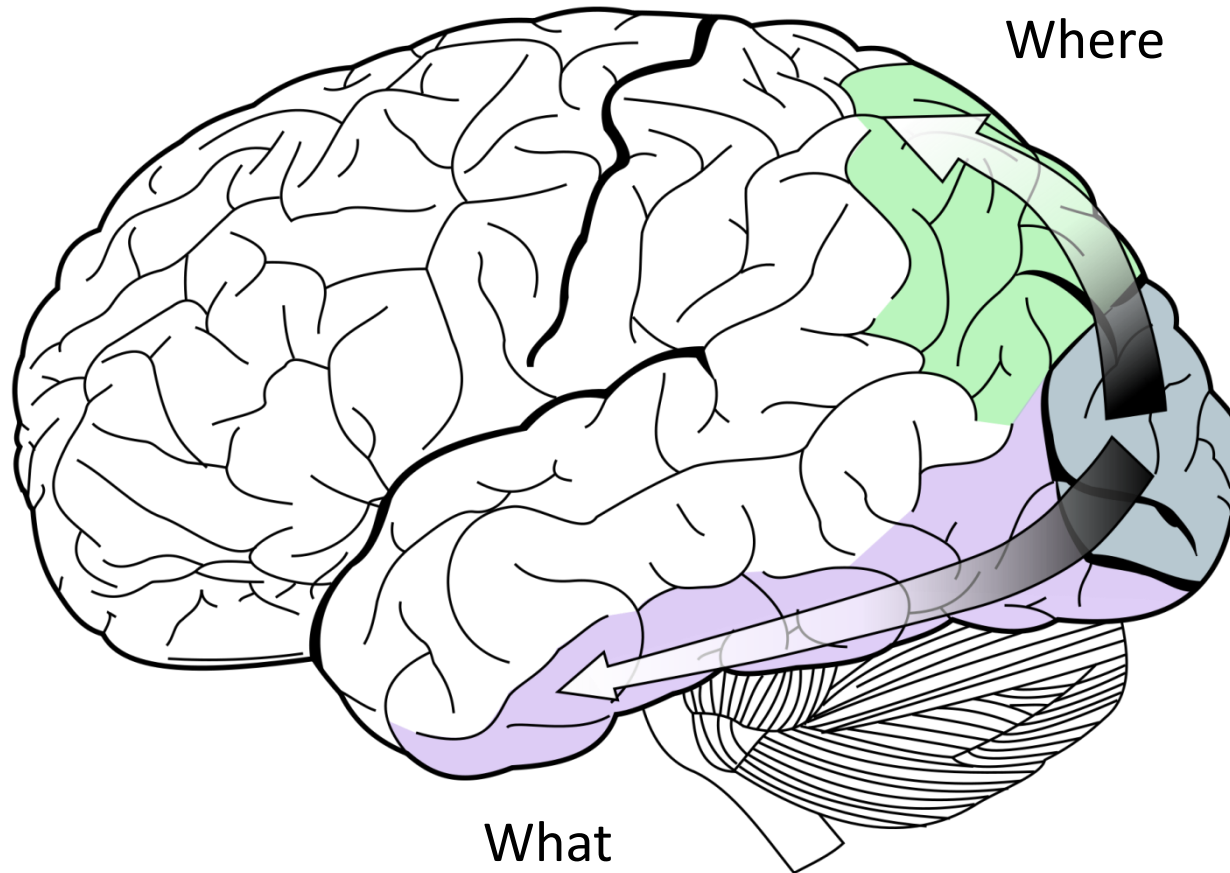
# Feedforward model.



LGN Cells

V1 Cell

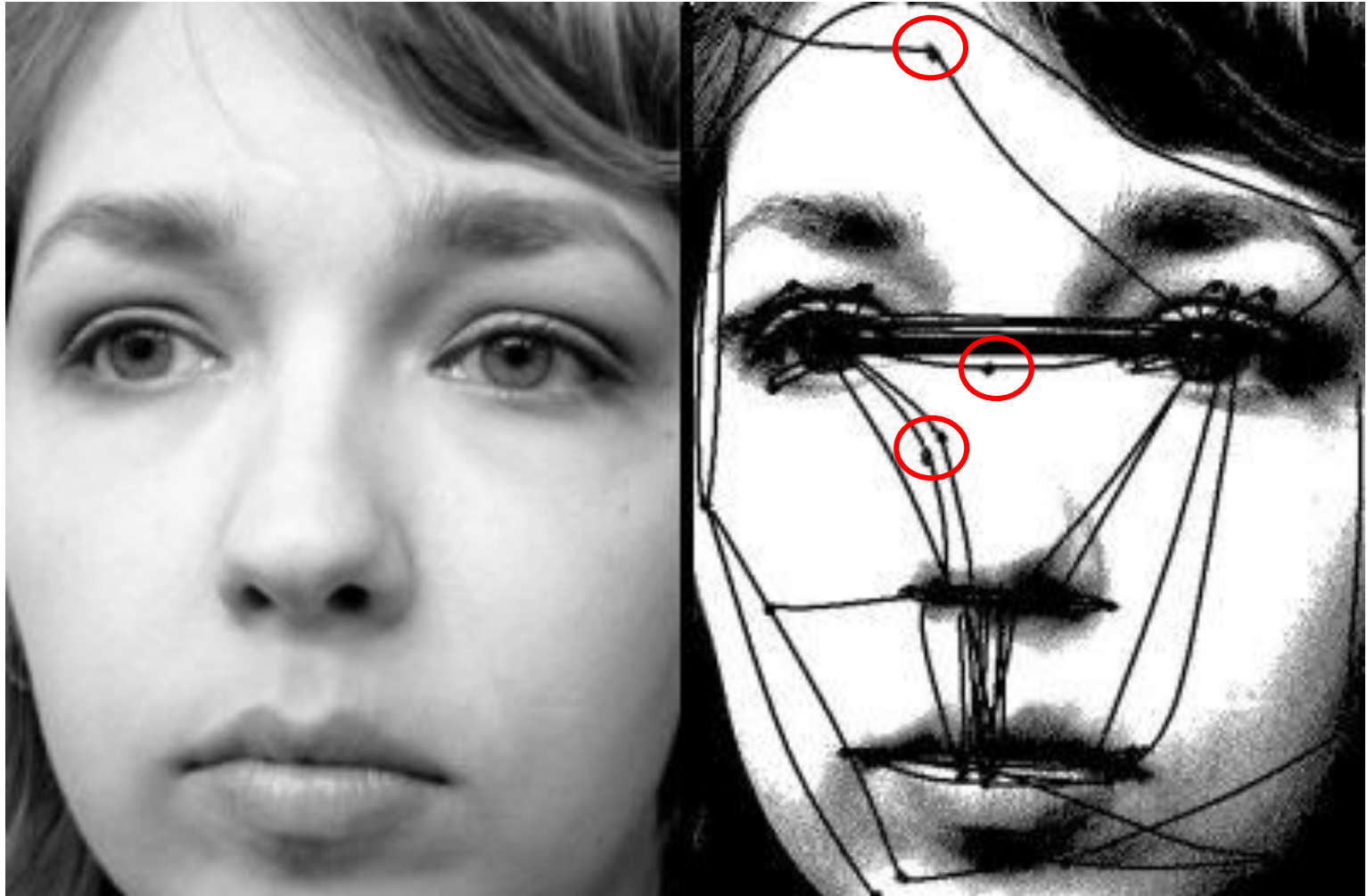
# Visual system.



# Action in visual perception.

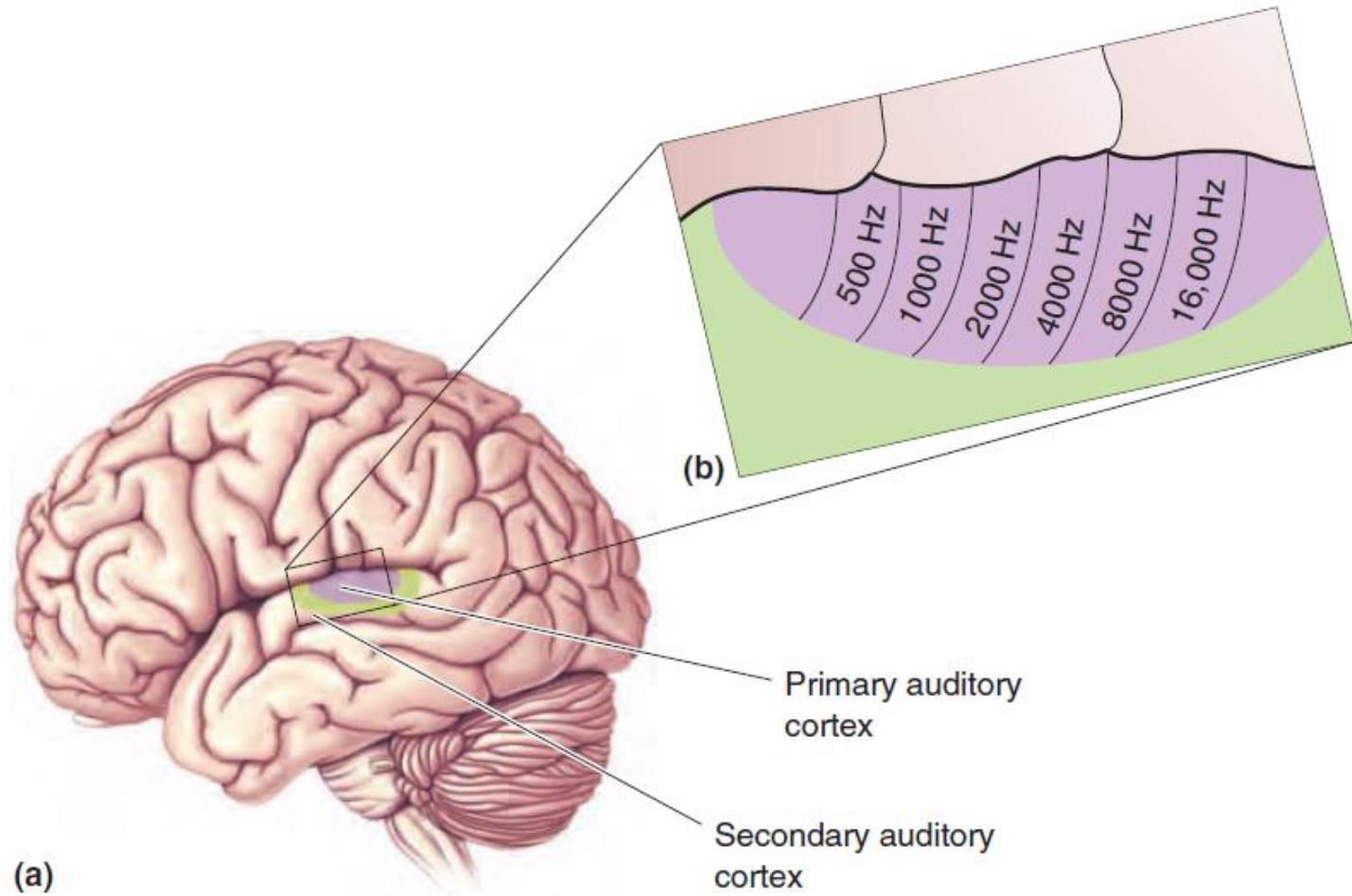


# Action in Visual Perception.

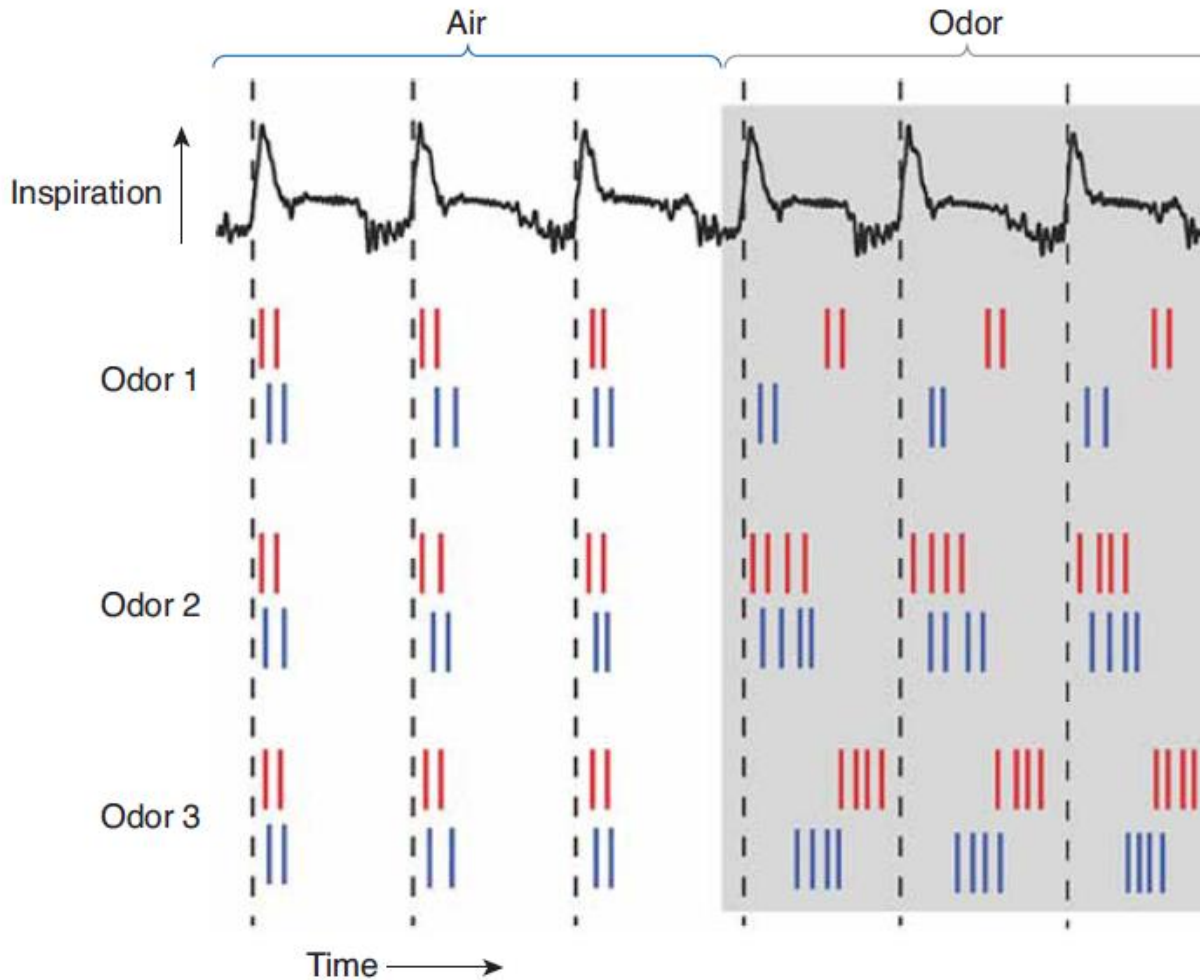




# Auditory system.

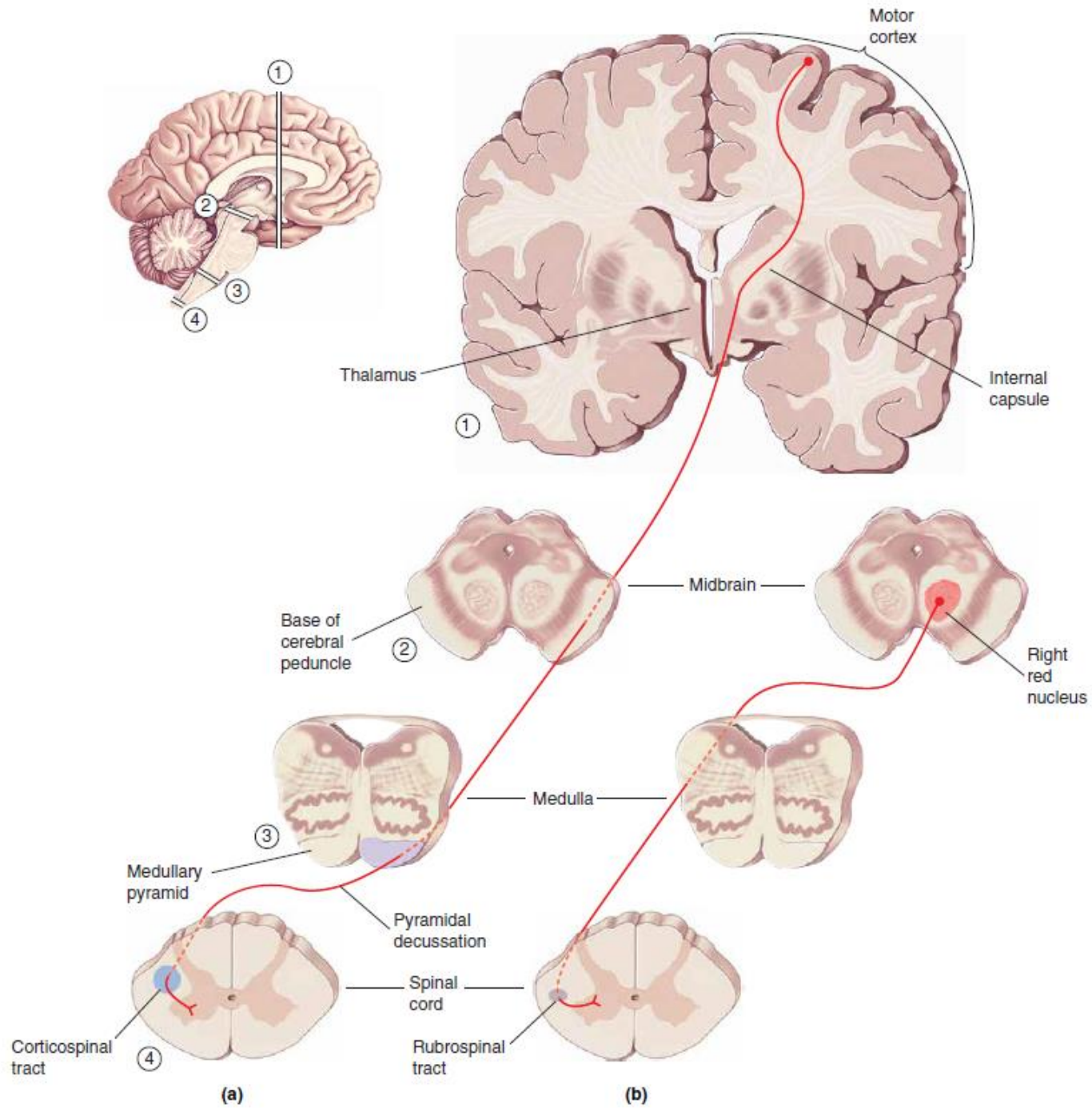


# Olfactory system.

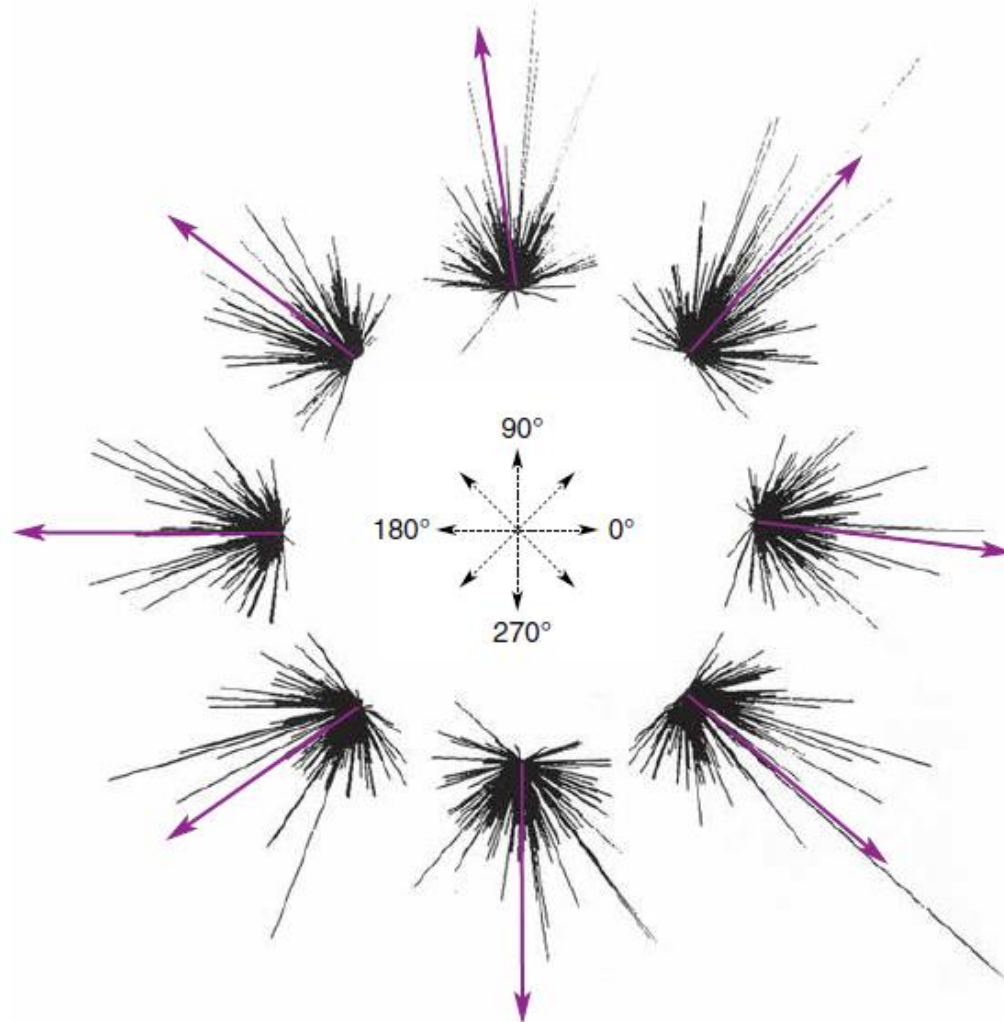




Motor system

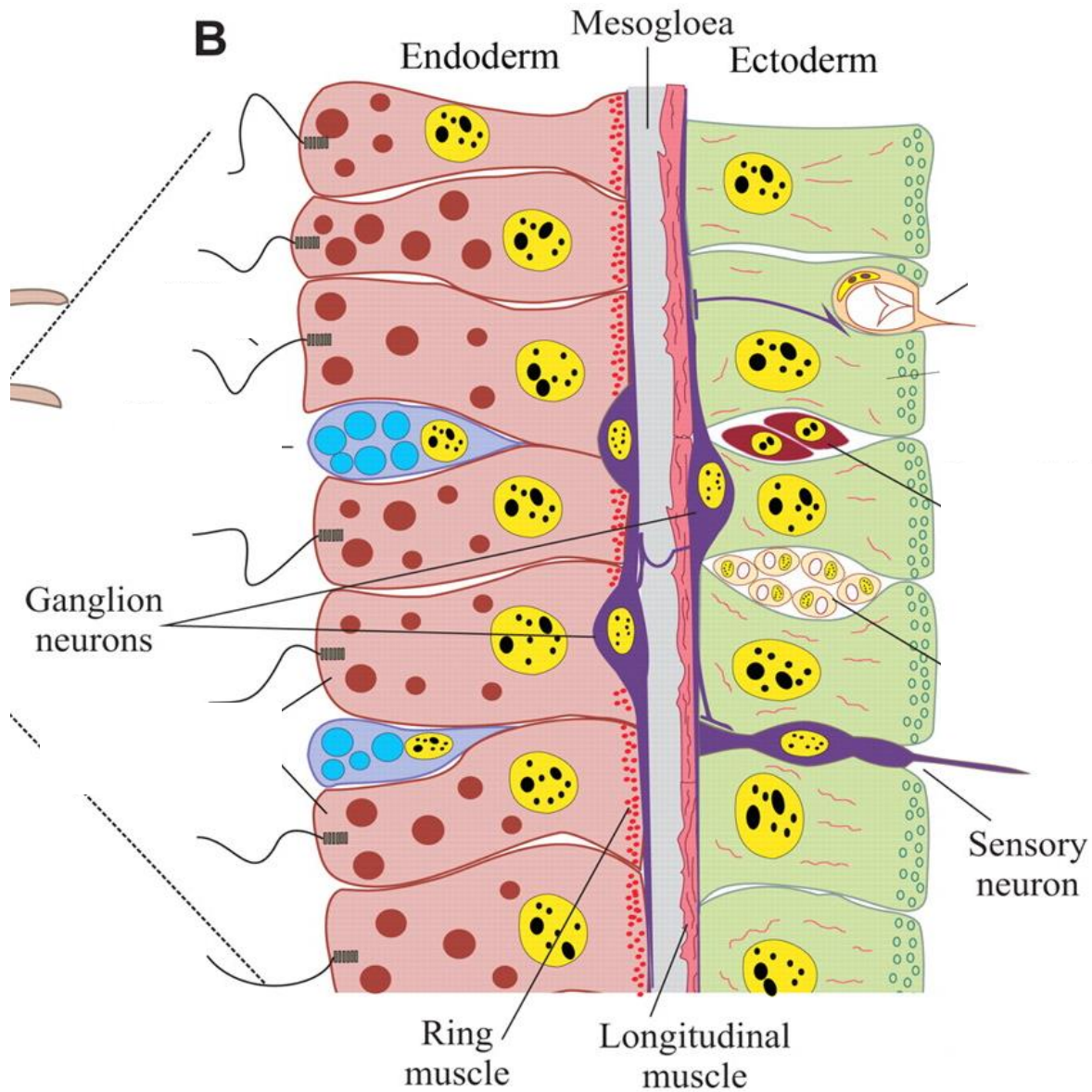


# Neuronal tuning to movement direction.

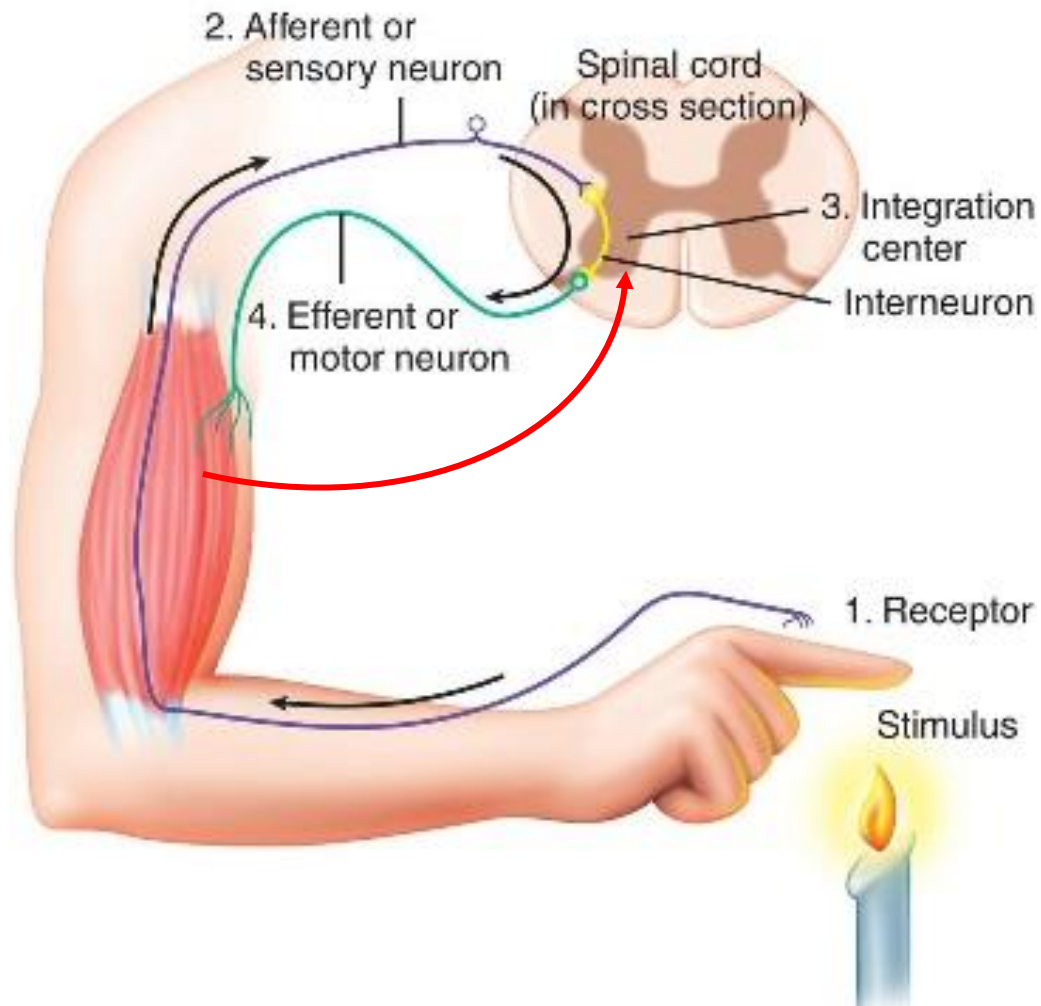


Sensory-motor  
integration.

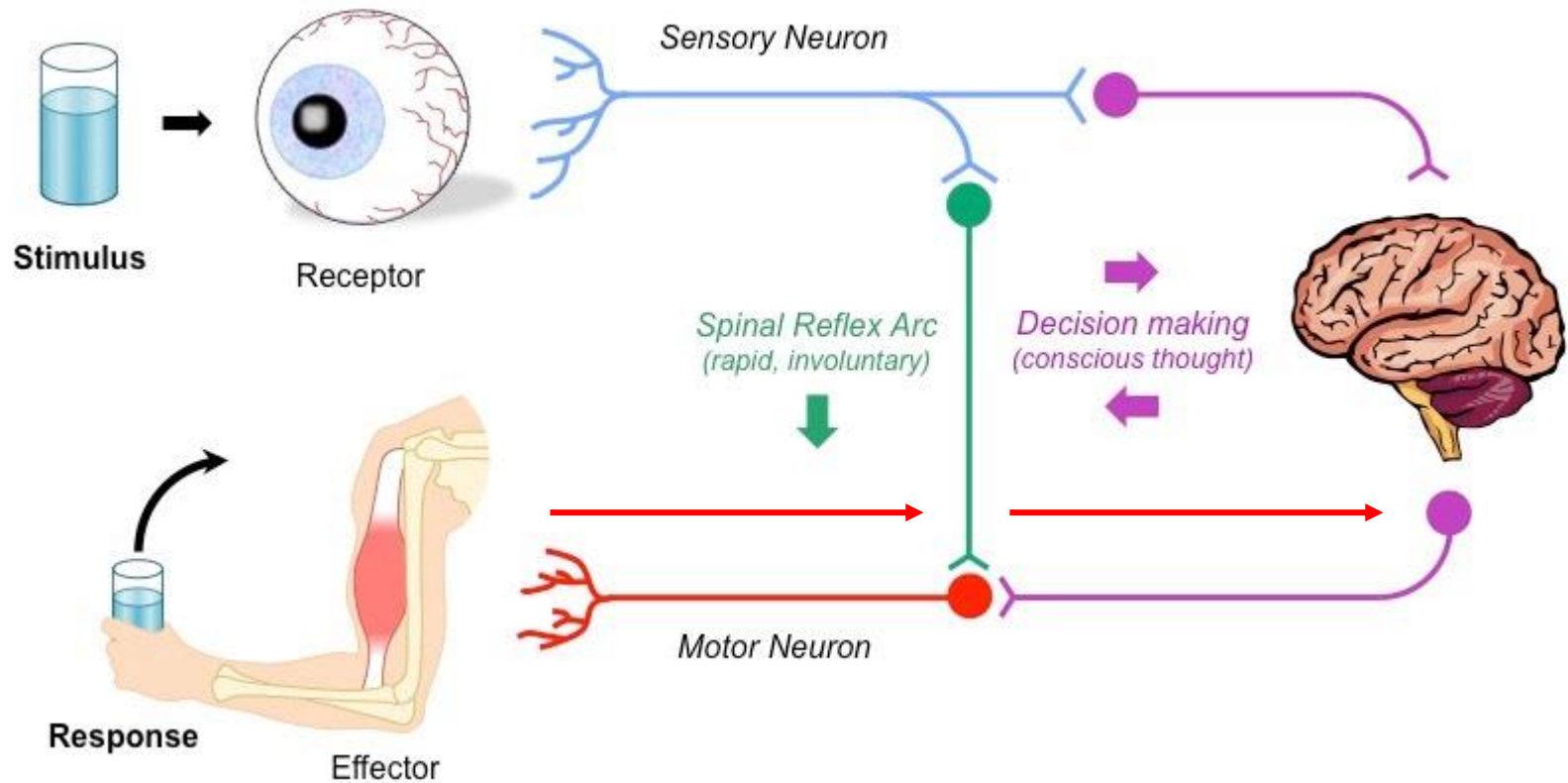
# Hydra.



# The reflex arc

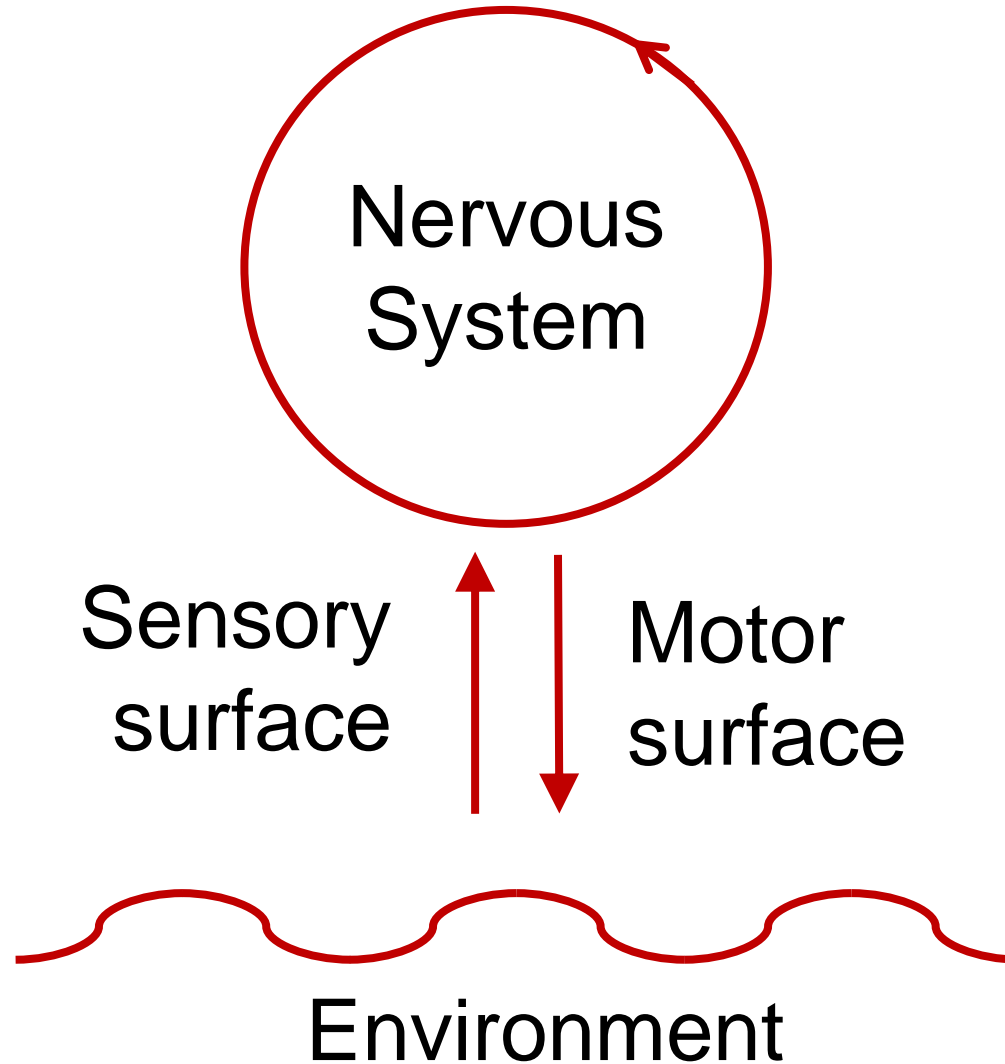


# Sensory-motor integration.



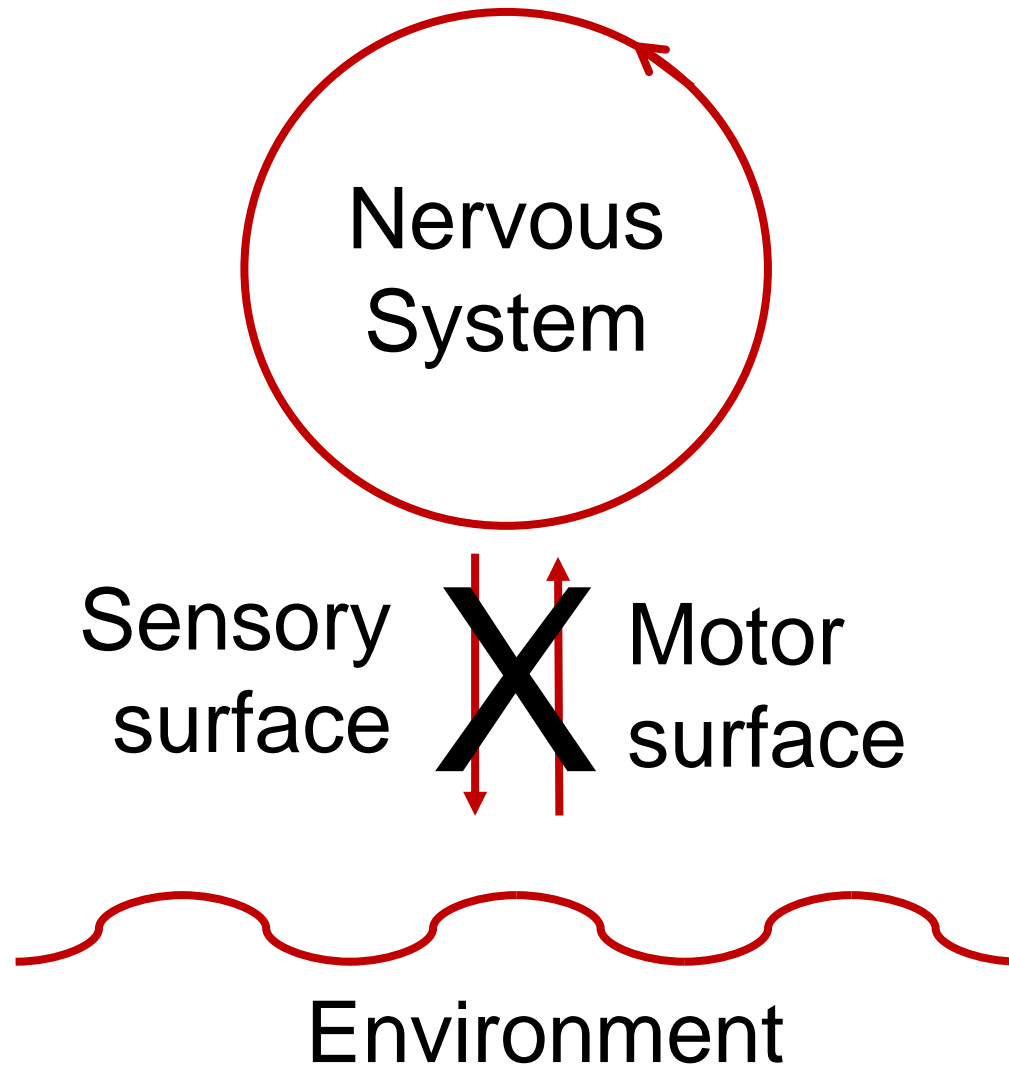


# Functional closure.





# Sensory-motor decoupling.

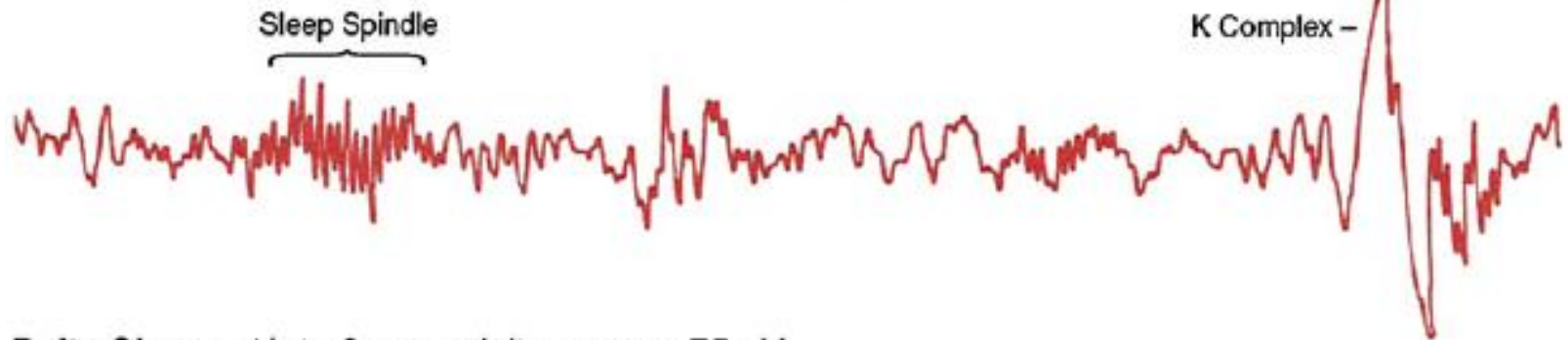


# Sleep

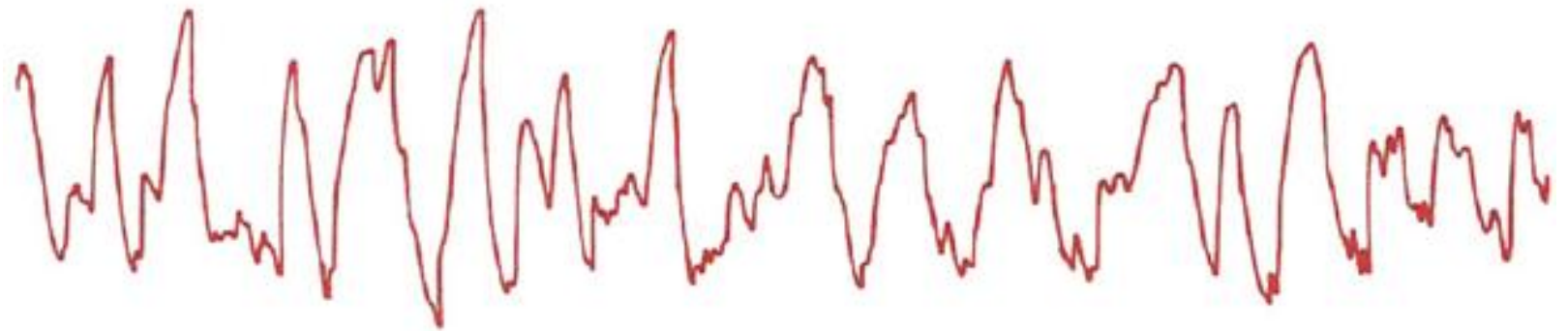


# Self-generated activity.

**Stage 2 – 12 to 14 cps – sleep spindles and K complexes**



**Delta Sleep – 1/2 to 2 cps – delta waves >75  $\mu$ V**



# Final remarks.

- Neuroscience is the study of the nervous system.
- In animals, the nervous system provides a fast and sophisticated link for sensory-motor integration.
- Learning, memory, attention, etc. emerge in the nervous system within the process of sensory-motor integration.