ST. CATHERINE UNIVERSITY

Nervous Tissue

Nervous Tissue: Cells

Nervous tissue is composed of two main classes of cells: **neurons** and **neuroglia.** Neurons are cells that carry out the communicative role of the nervous system, while neuroglia play varying supportive roles to help the neurons function effectively.

Nervous Tissue: Neurons

Universal Properties of Neurons:

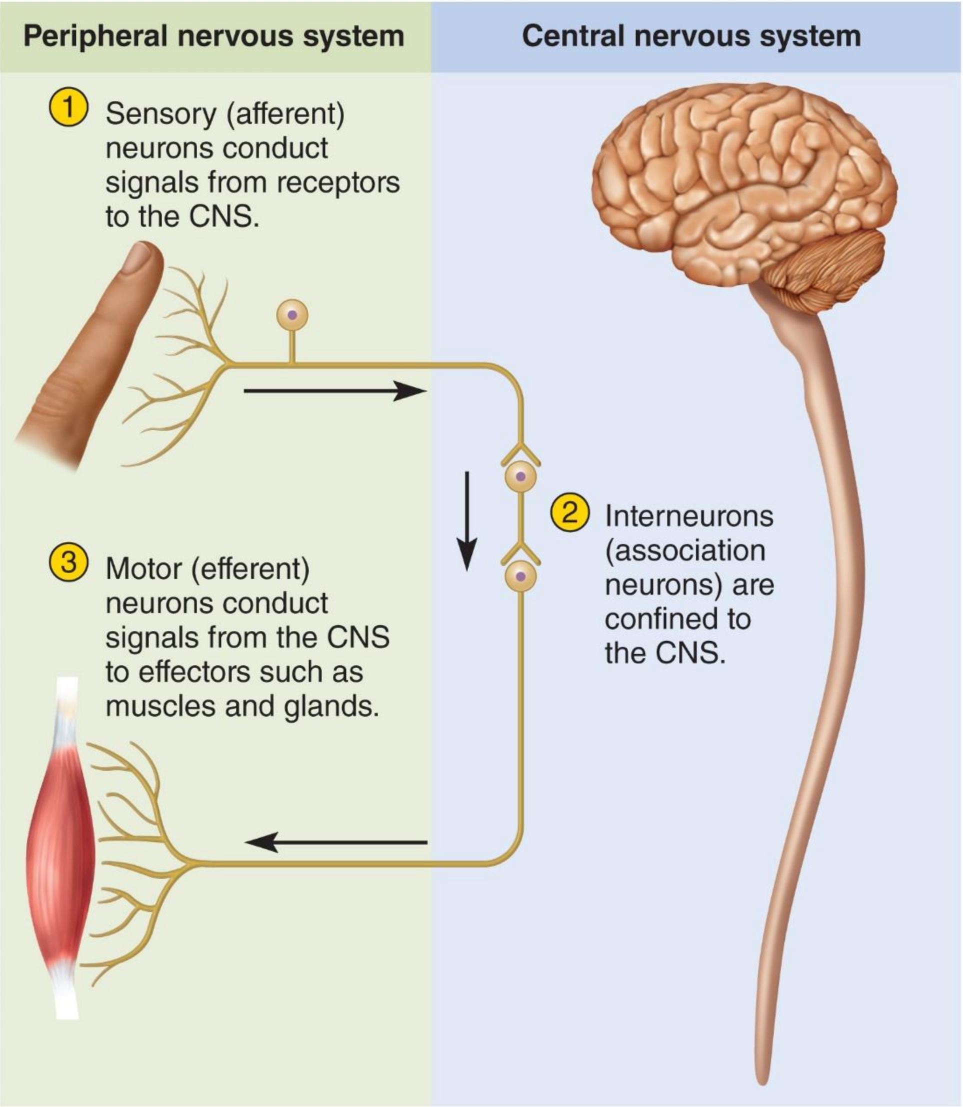
- Excitability
- Conductivity
- Secretion

Nervous Tissue: Neurons

Three major classes of neurons:

- Sensory Neurons
- Interneurons
- Motor Neurons

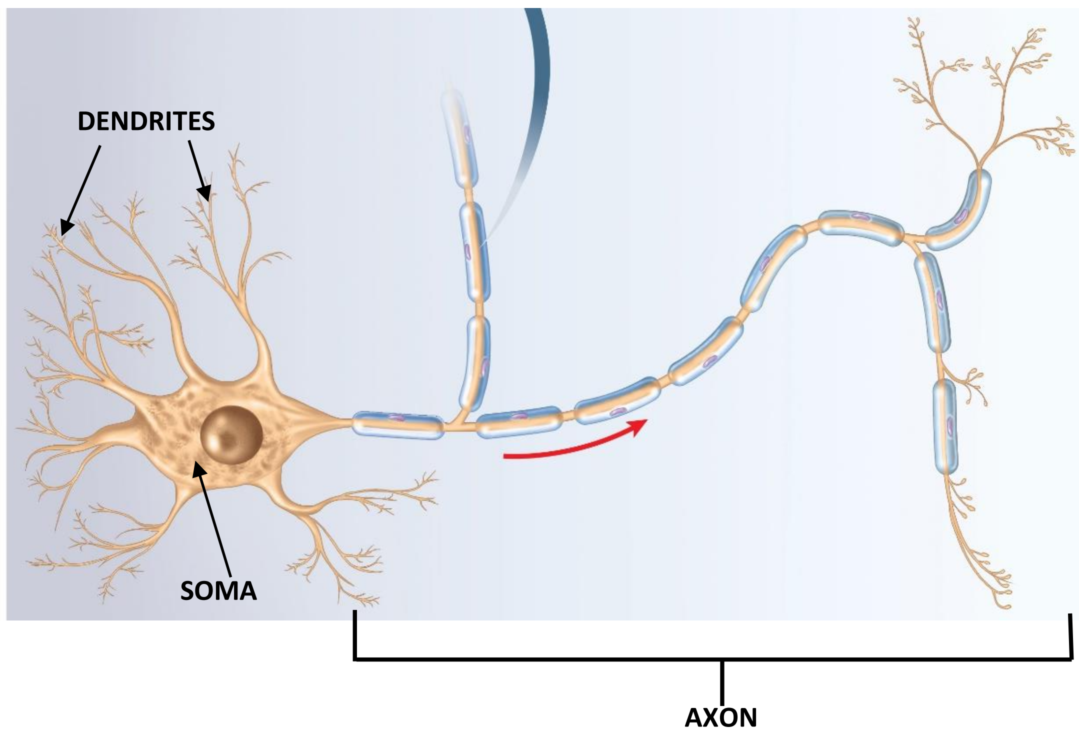
Nervous Tissue: Neurons



Nervous Tissue: Neurons

Motor neuron structures:

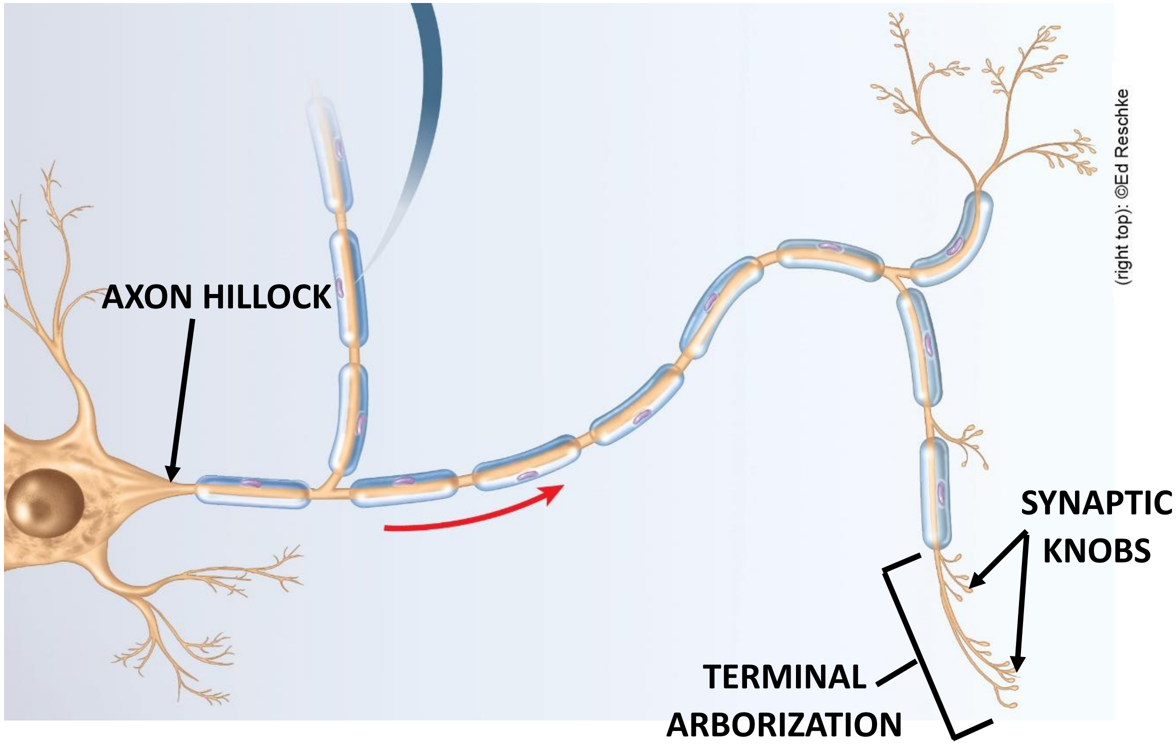
- Soma
- Dendrites
- Axon



Nervous Tissue: Neurons

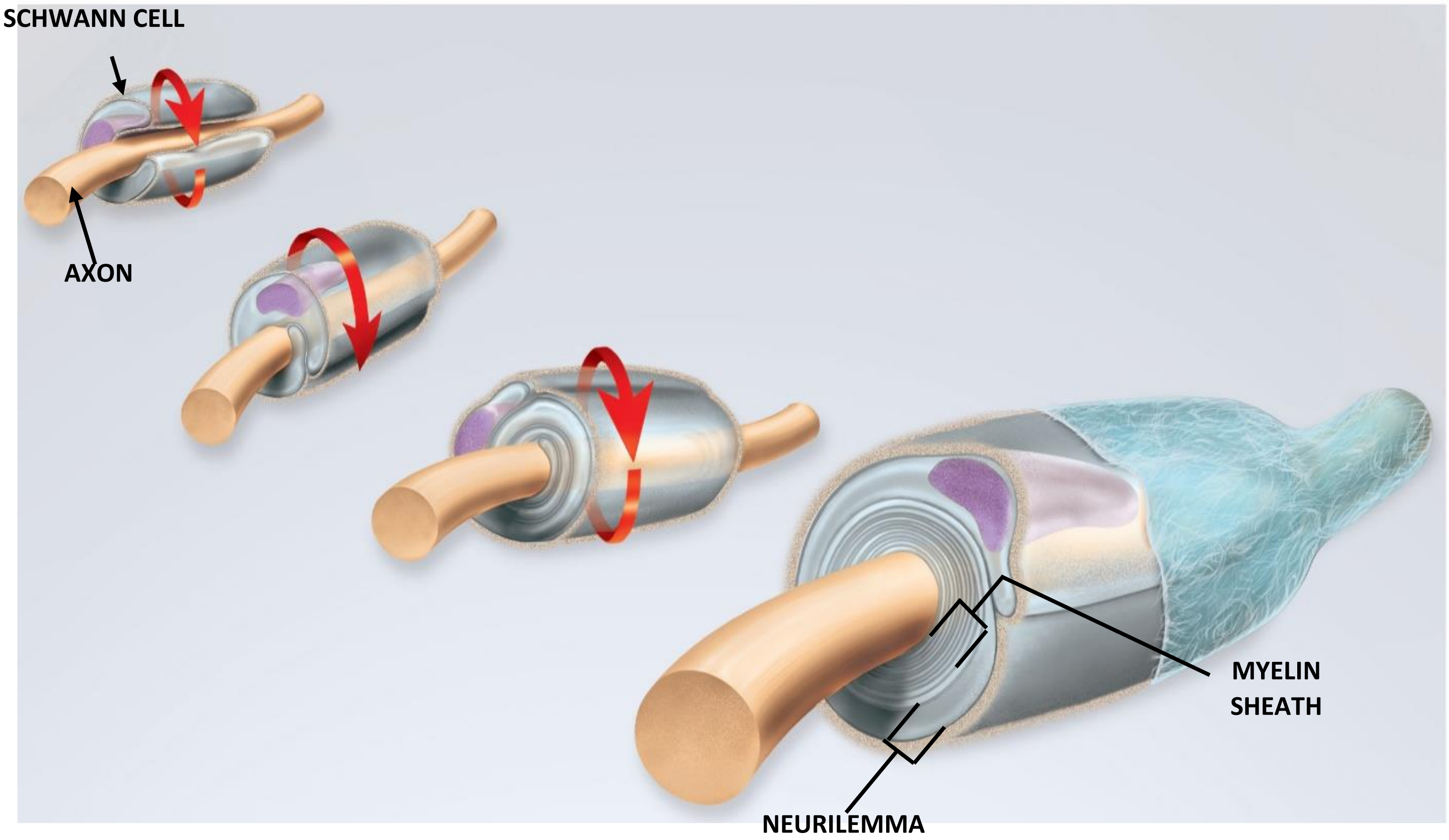
Axon:

- –axon hillock
- –terminal arborization
- –synaptic knobs



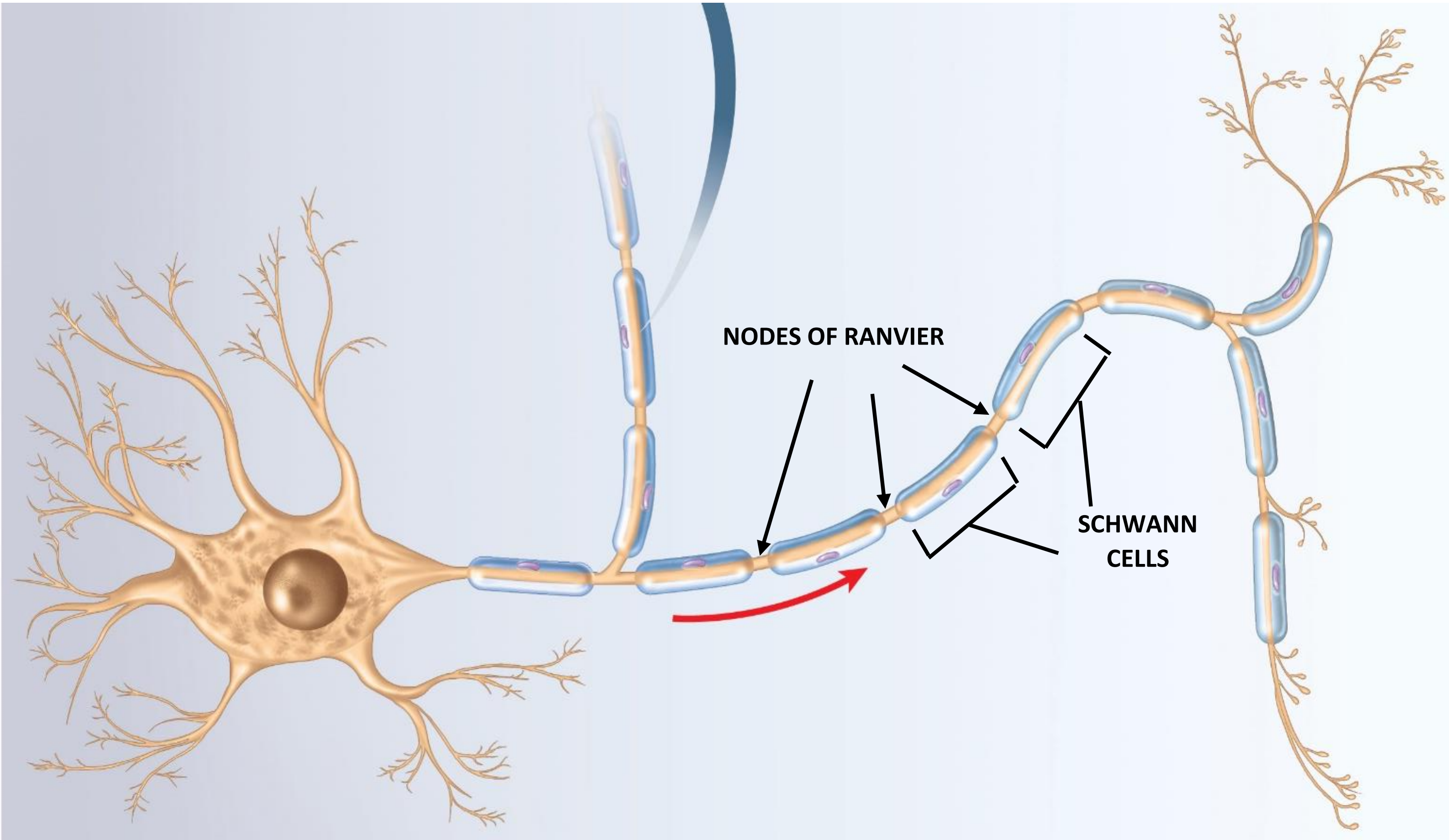
Nervous Tissue: Neurons

Associated Structures



Nervous Tissue: Neurons

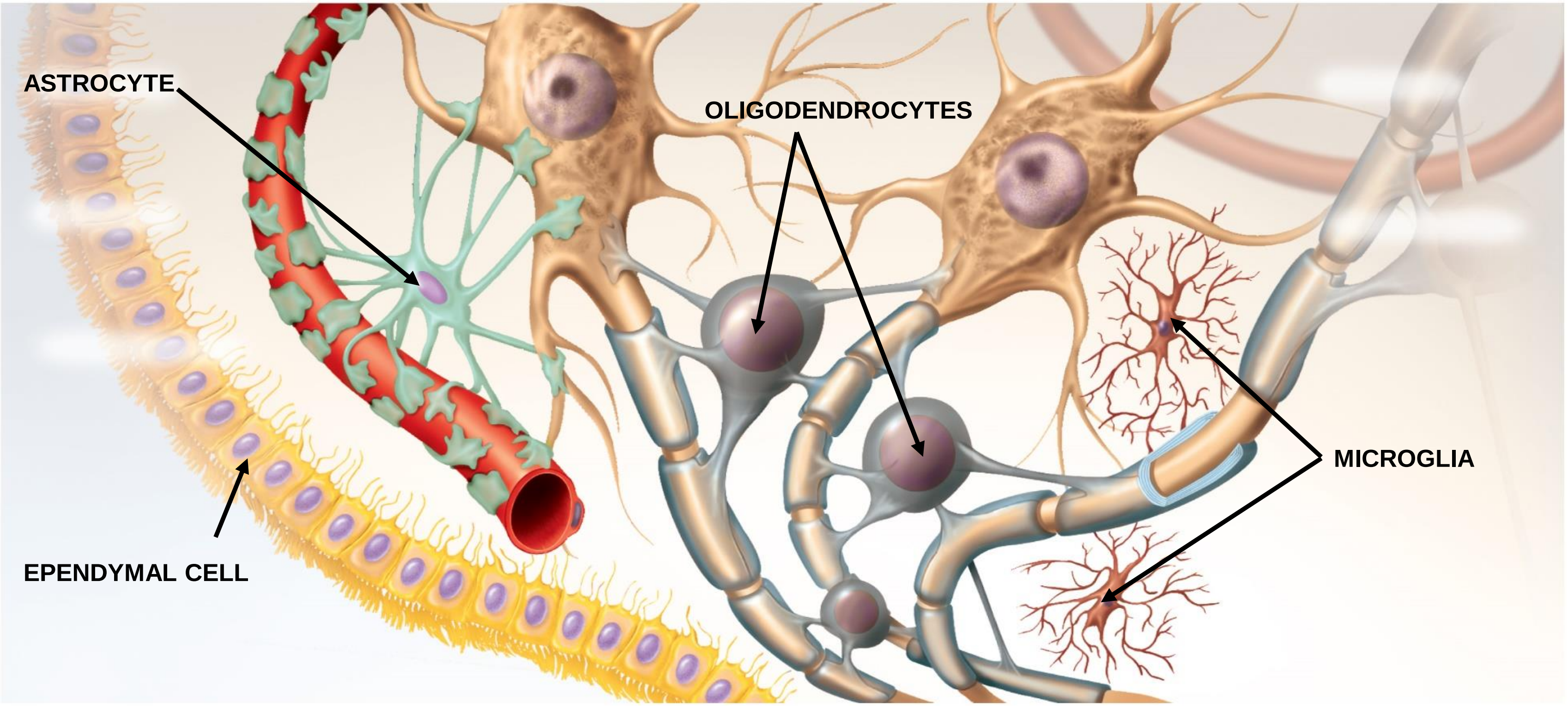
Associated Structures



Nervous Tissue: Neuroglia

- Oligodendrocytes
- Ependymal Cells
- Microglia
- Astrocytes
- Schwann cells
- Satellite cells

Nervous Tissue: Neuroglia

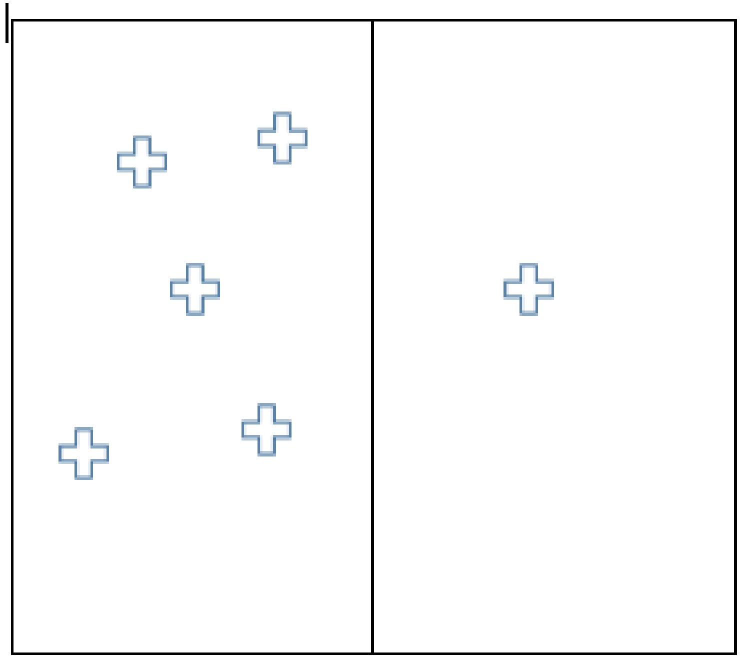


Nervous Tissue: Electrophysiology

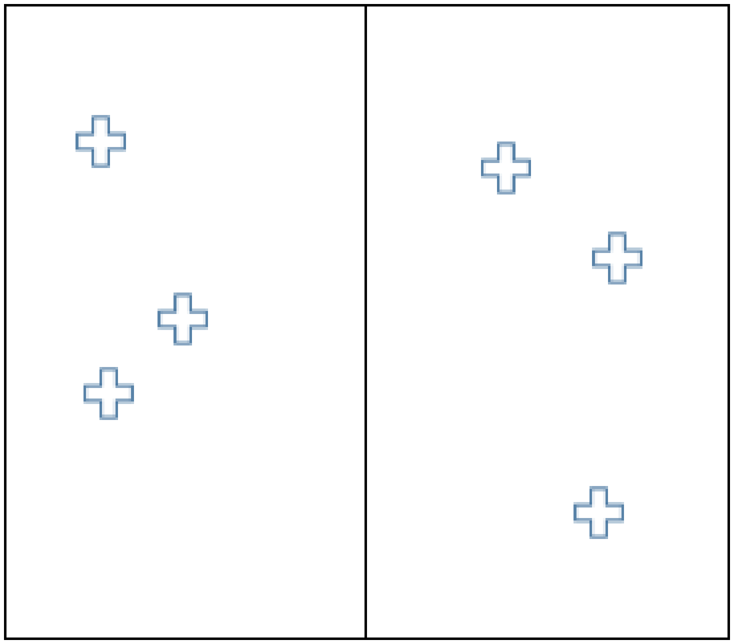
How do neurons generate and transmit electrical signals? The answers to this question are related to the electrophysiology of the neuron. First, we have to understand what an **electrical potential** is and what a **current** is.

An **electrical potential** is <u>a difference between the concentration of charged particles between one point and another</u>. If there is no difference in charged particles between two points, then there is no electrical potential.

Nervous Tissue: Electrophysiology



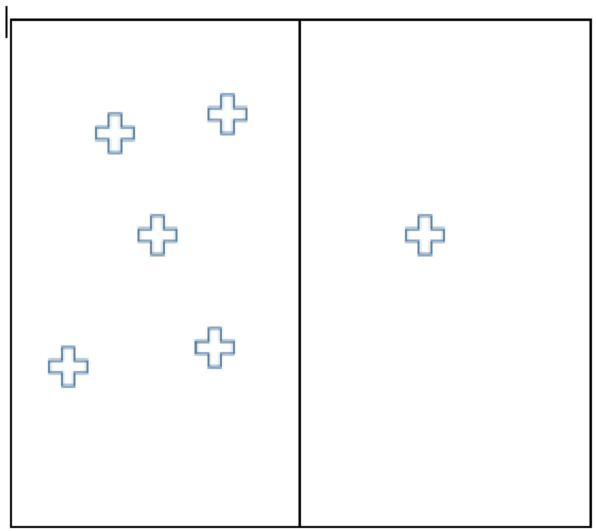
Electrical potential exists, because there is a difference in the concentration of charged particles between the left chamber and the right.



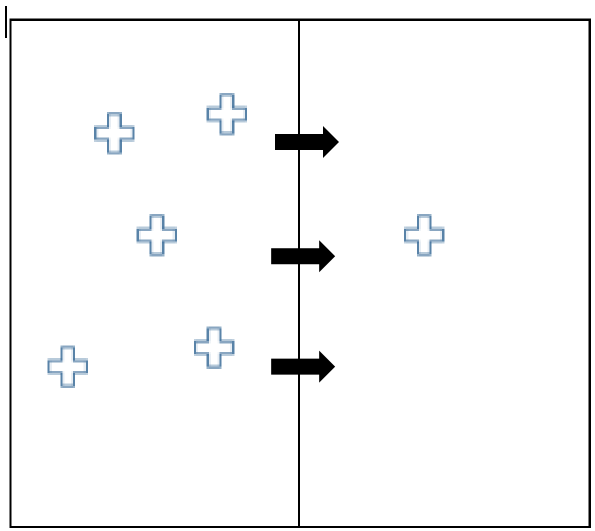
Electrical potential is absent, because there is no difference in the concentration of charged particles between the left chamber and the right.

Nervous Tissue: Electrophysiology

An **electrical current** is a flow, or movement, of charged particles from one point to another.

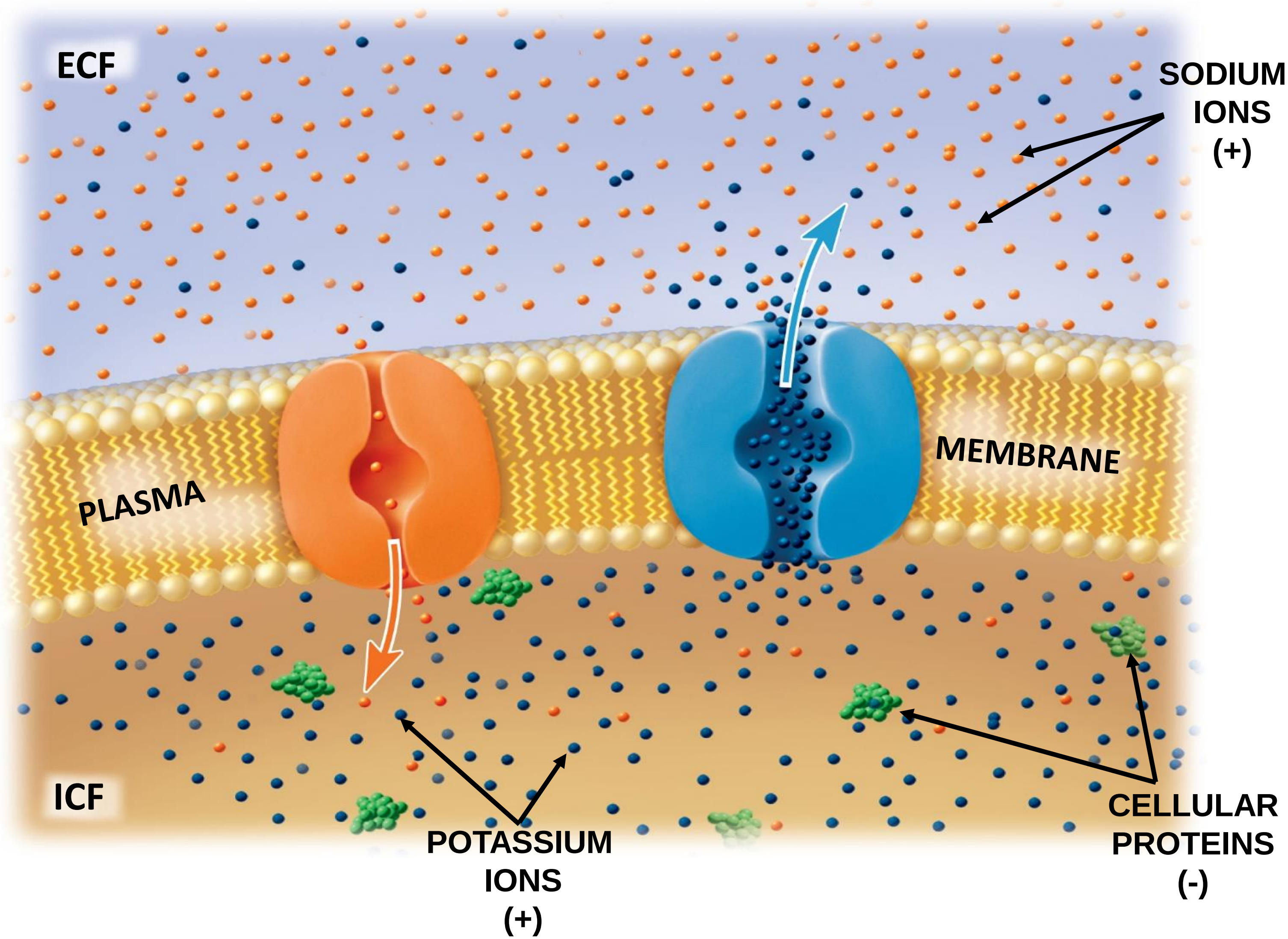


Electrical potential exists but no current.



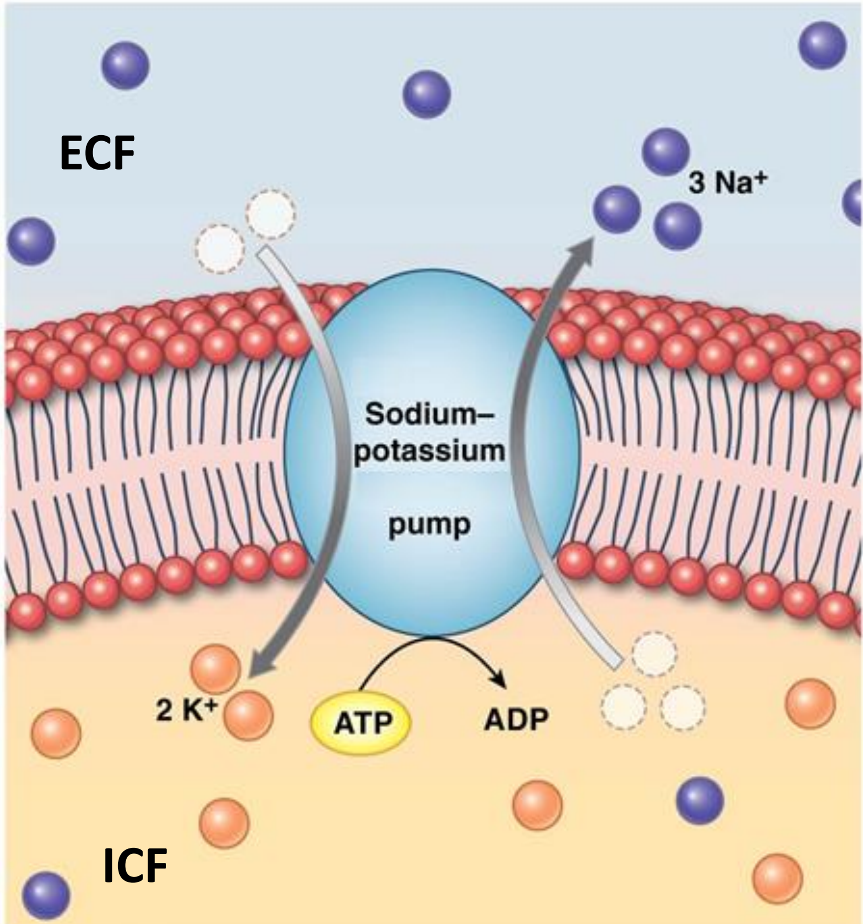
A current exists as charged particles move from the left chamber to the right.

Nervous Tissue: Electrophysiology



Nervous Tissue: Electrophysiology

How the electrical potential gets created:



Nervous Tissue: Electrophysiology

Resting Membrane Potential

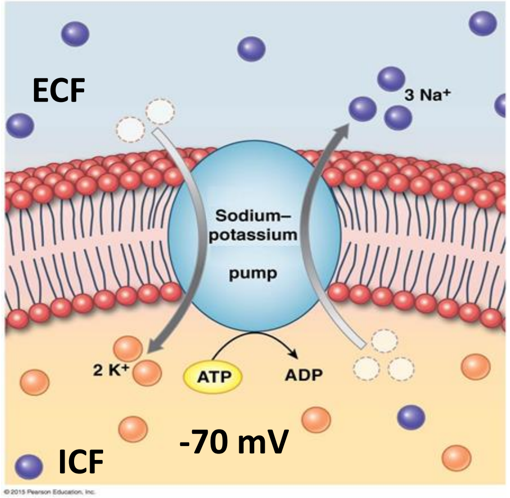
- describes the actual value of the electrical potential of the plasma membrane when it is "at rest" and ready to send a signal down its length

- the ICF's measured value in this state is **–70 mV**

Nervous Tissue: Electrophysiology

What we know so far:

1. A neuron uses sodium/potassium pumps to continually make sure that sodium ions exist in a higher concentration in the ECF and that potassium ions exist in a higher concentration in the ICF.
2. While these ions are both positive, the potassium ions in the ICF contend with negatively-charged proteins, which means that the ECF has a positive nature to it, and the ICF has a negative nature to it. In addition, the ECF is more positive due to the diffusion of potassium ions to some degree through the plasma membrane.
3. This difference on the two sides on the plasma membrane means an electrical potential exists at the membrane, called the resting membrane potential, which leads to a -70 mV value for the ICF while the neuron is in this ready/at rest state.



Nervous Tissue: Electrophysiology

State of the Membrane While at Rest

Polarized – describes the plasma membrane when it is at rest and the ICF is at −70 mV.

For example, when the resting membrane potential has been established, meaning the ICF has a voltage value of −70 mV, the membrane is said to be in a polarized state.

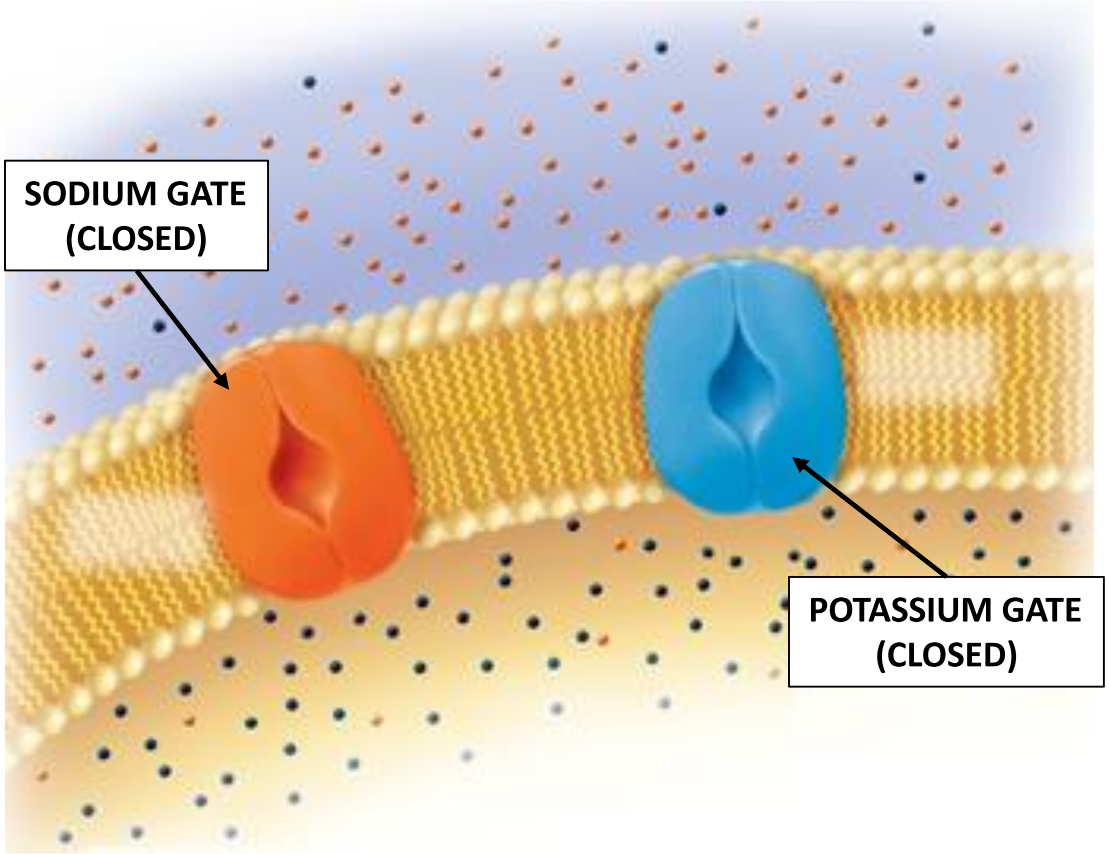
Nervous Tissue: Electrophysiology

Electrical Signals

- are disruptions to the membrane's polarized state and the resting membrane potential
- involve the movements of sodium and potassium ions between the ECF and ICF
- are triggered by stimulation such as chemicals, light, temperature change, pressure, etc.

Nervous Tissue: Electrophysiology

Sodium Gates and Potassium Gates



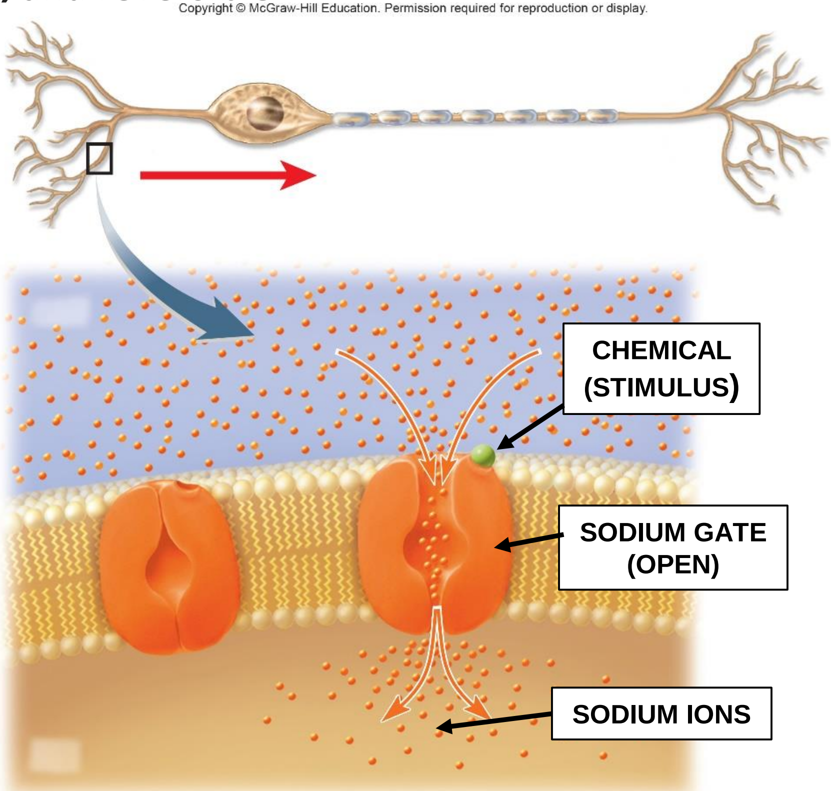
Nervous Tissue: Electrophysiology

Depolarization

- description of the state of the plasma membrane any time it experiences a shift in its voltage in a positive direction

Local Potential

- a short-range change in voltage along the plasma membrane
- graded, decremental, and reversible



Nervous Tissue: Electrophysiology

Action Potential

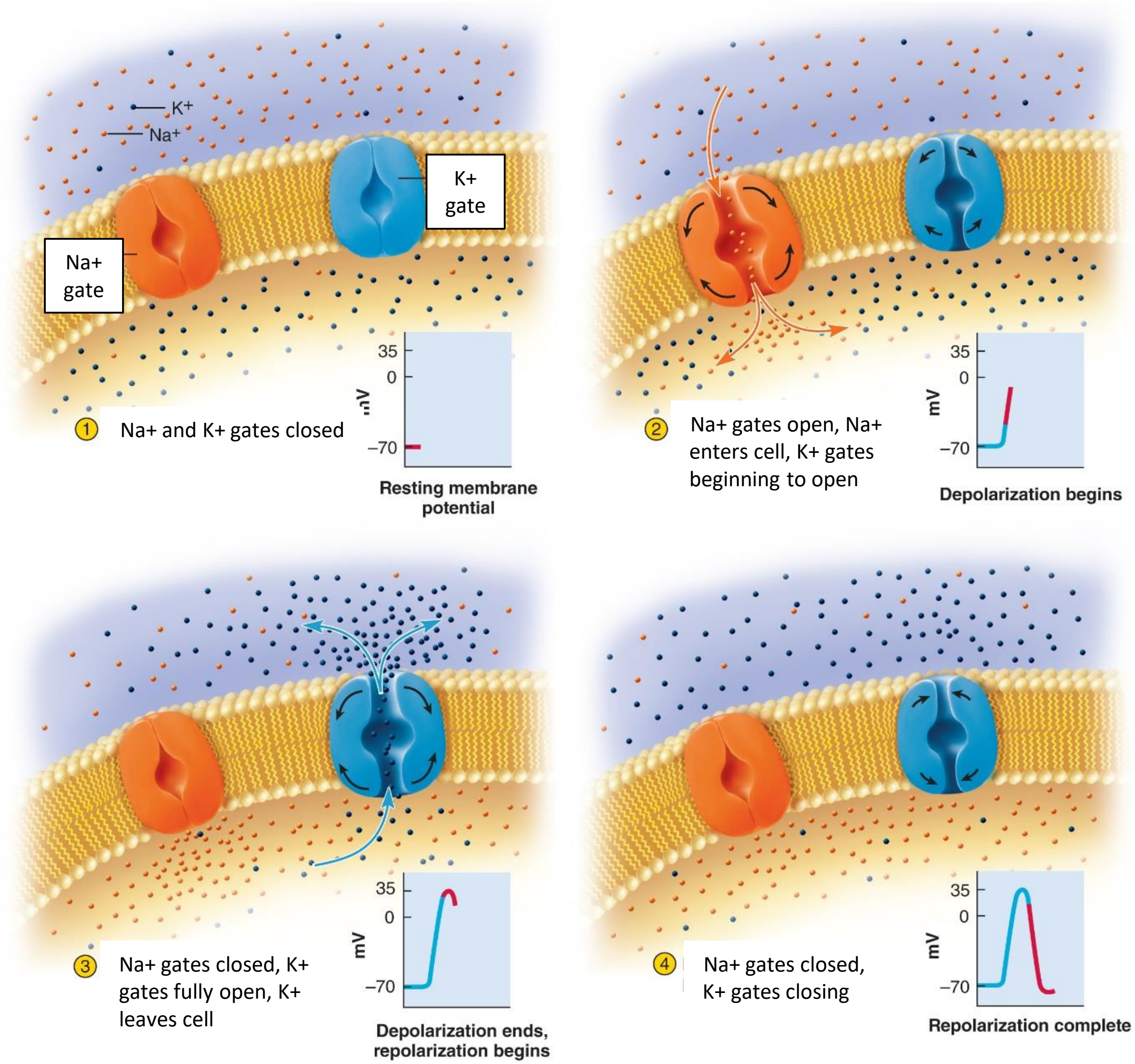
- a more dramatic change in the state of the plasma membrane
- can occur at the axon hillock and along the axon's length
- will occur at either full strength or not at all (**all-or-none law**)
- **nondecremental**
- **irreversible**

Nervous Tissue: Electrophysiology

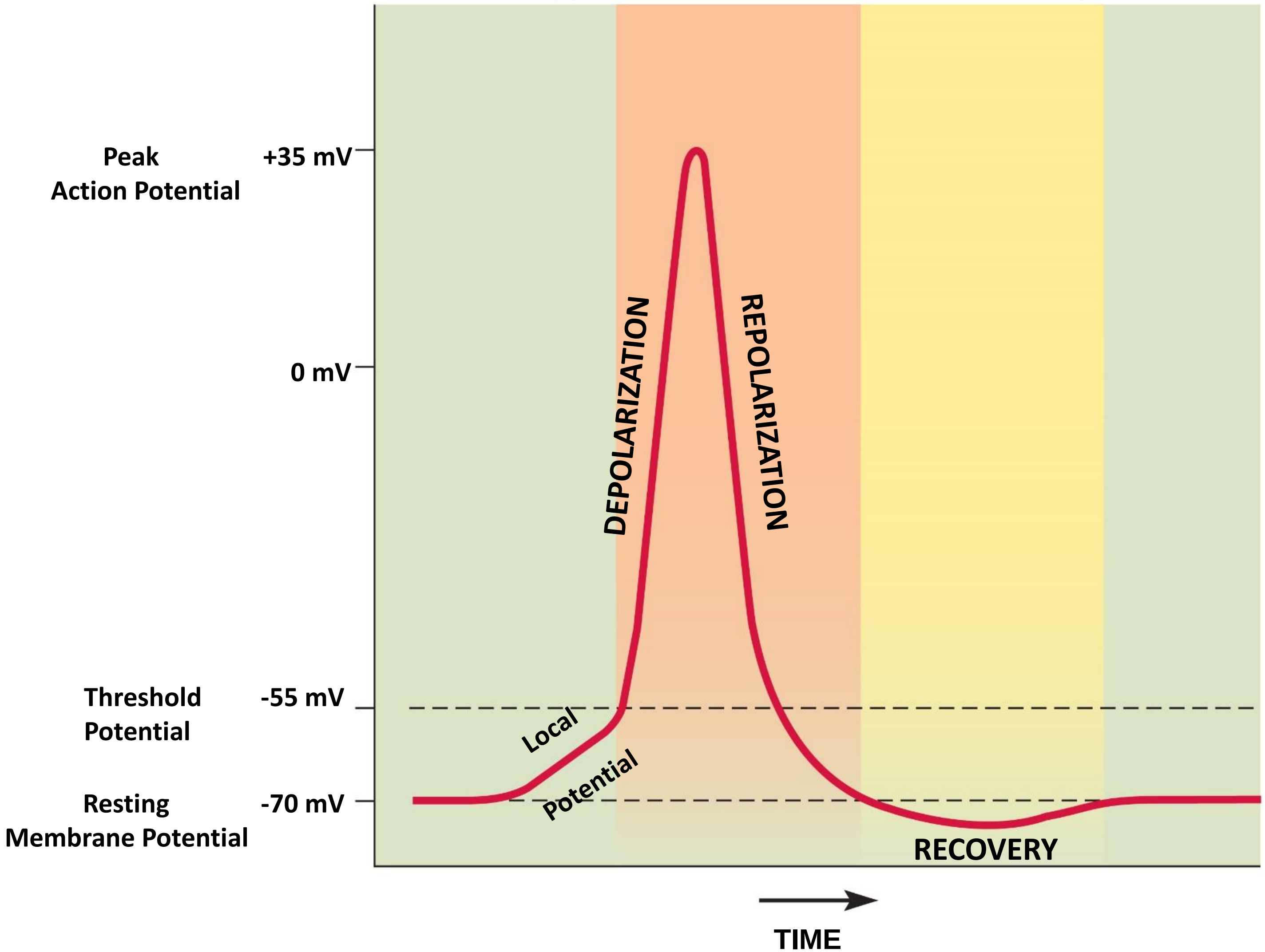
Action Potential Process:

1. Local potential at action hillock is strong enough to cause a current that depolarizes the membrane to its threshold value (−55 mV).
2. Sodium gates open, and sodium ions rapidly diffuse from the ECF to the ICF, causing the membrane potential to rapidly depolarize from −55 mV, through 0 mV, and eventually to +35 mV.
3. Sodium gates close, and the potassium gates open, causing potassium ions to rapidly diffuse from the ICF to the ECF. The membrane potential now rapidly repolarizes as the exiting cations cause the membrane potential to become more negative, eventually returning to −70 mV.
4. Potassium gates close, and now with both gates closed, the sodium/potassium pumps can return the cations to their original locations.

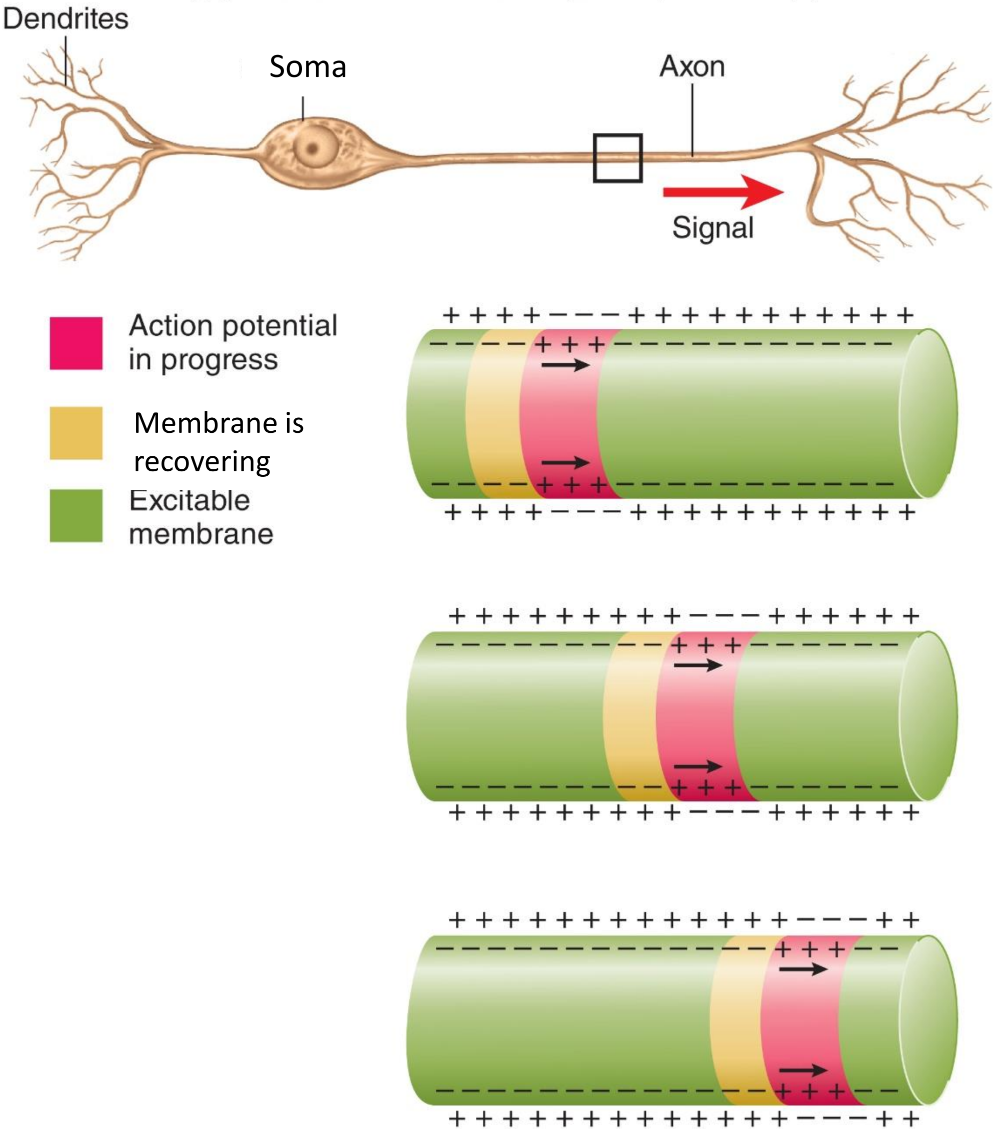
Nervous Tissue: Electrophysiology



Nervous Tissue: Electrophysiology



Nervous Tissue: Electrophysiology



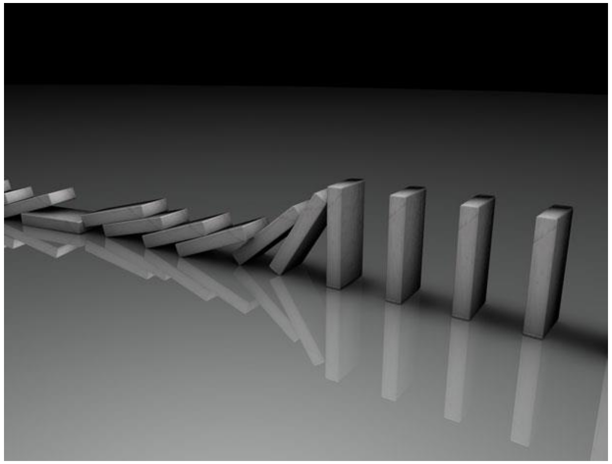
Nervous Tissue: Electrophysiology

Signal Conduction

1. **Unmyelinated Neurons**

- starting with the axon hillock, a single action potential triggers a neighboring, downstream region of the plasma membrane to undergo an action potential.
- eventually the original action potential event is conducted through the plasma membrane to the synaptic knobs.

Example: dominoes falling in a line

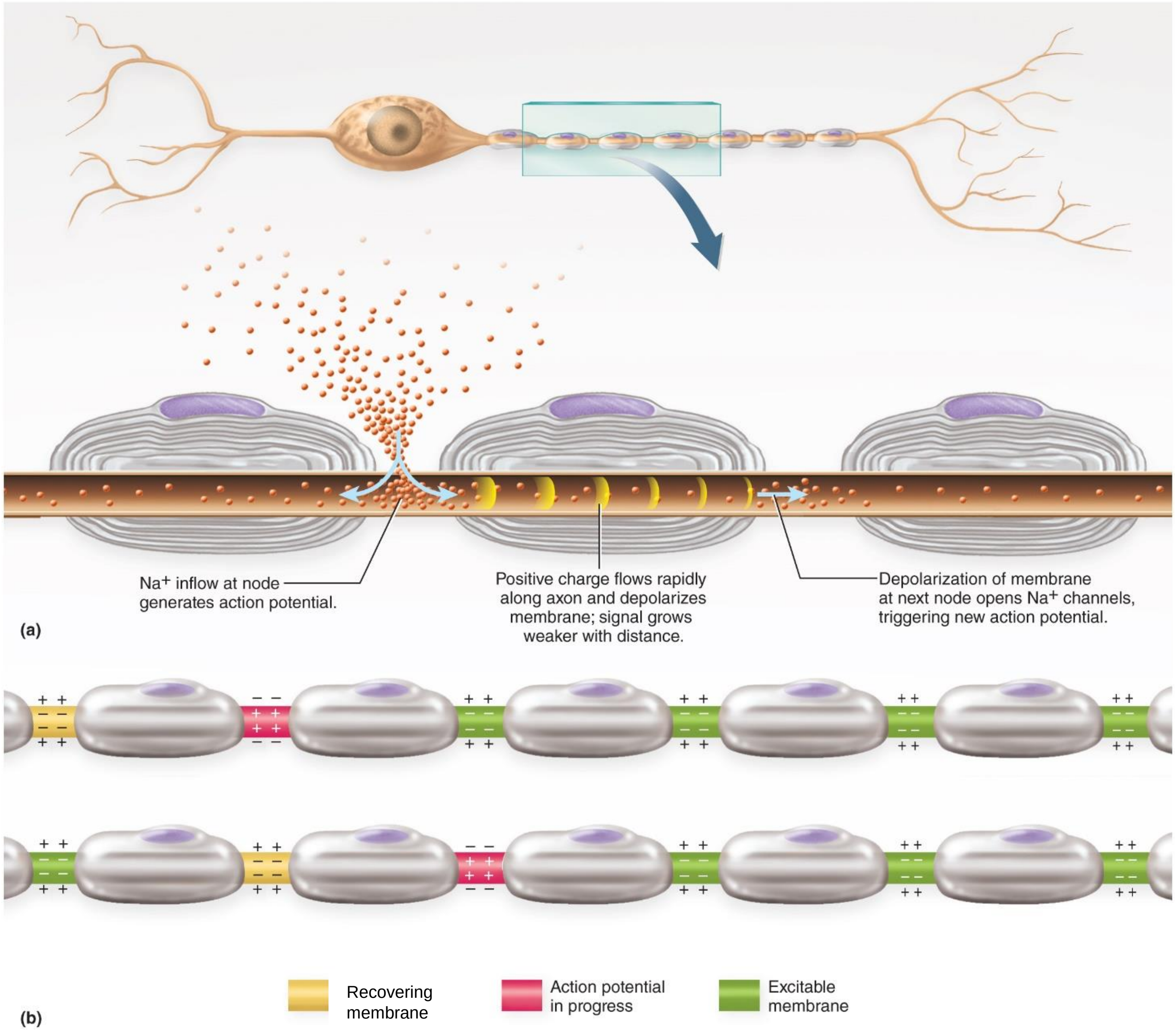


Signal Conduction

2. Myelinated Neurons

- ions can’t pass through the plasma membrane in areas that are coated with myelin
- action potentials can occur at the hillock and at each node of Ranvier
- in myelinated areas, sodium ions diffuse rapidly through the ICF to the next node, bringing the electrical current with them internally
- signal is faster during myelinated stretches but weakens
- signal is restrengthened at each node
- referred to as **saltatory conduction**

Nervous Tissue: Electrophysiology



Nervous Tissue: Electrophysiology

Synapses

- Region where a neuron carries info toward a target cell (muscle, gland, or another neuron).
- 3 components:
  - Pre-synaptic structure
  - Synaptic cleft
  - Post-synaptic structure
- Neurotransmitters are used to carry the neuron’s signal across the cleft to the post-synaptic target cell.

Nervous Tissue: Electrophysiology