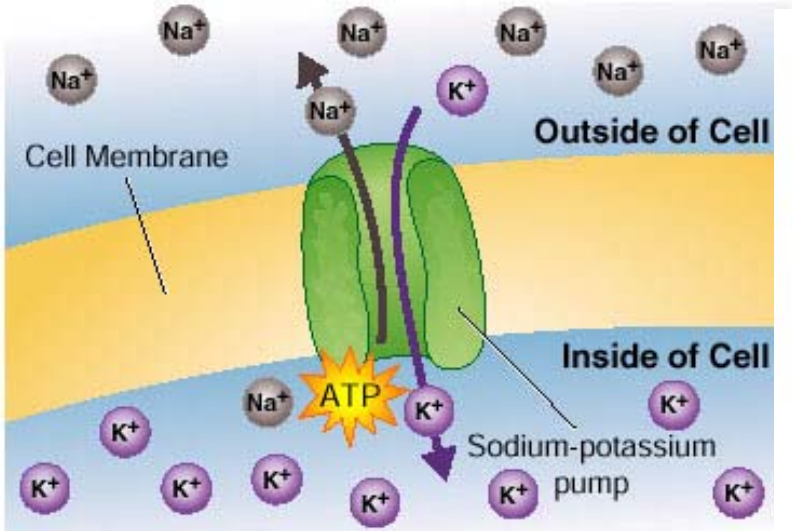
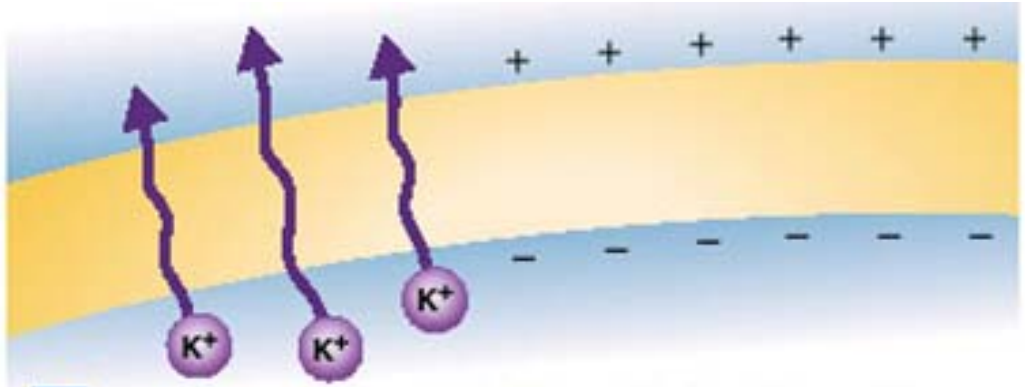
ELECTROCHEMICAL IMPULSE

Resting Membrane Potential

- Inside of neuron more **negative** relative to outside (-70mV).
- Achieved by:
  - Sodium-potassium pump – **active transport** (3 Na^+ **out** for 2 K^+ **in**).
  - Potassium (ungated) channels **opened**.



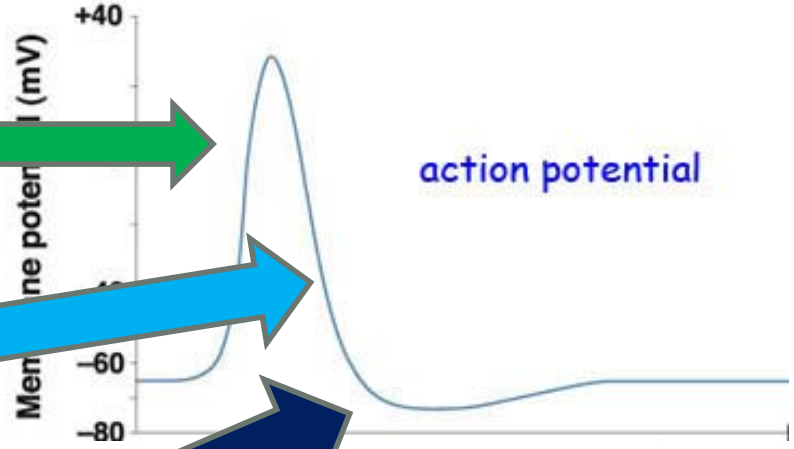
A A protein pump in the neuron cell membrane uses the energy of ATP to pump Na^+ out of the cell, and at the same time to pump K^+ in.

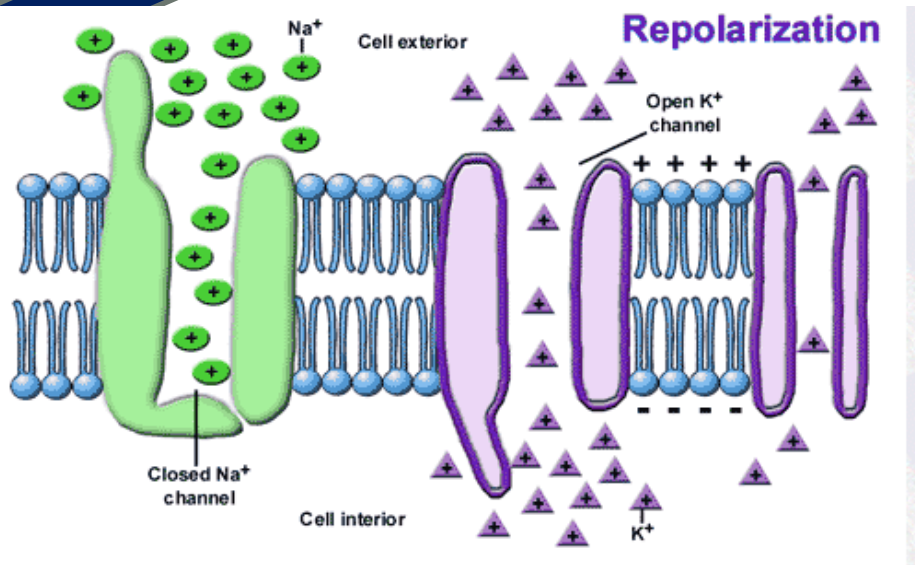


B The cell membrane is leakier to K^+ than it is to Na^+. Because more positive charges leak out of the cell than leak in, the inside of the cell becomes negatively charged with respect to the outside.

Effects of Various Stimuli

- **Depolarization**
  - **Inside more positive.**
- **Repolarization**
  - **Inside more negative**.
- **Hyperpolarization**
  - Inside **more negative** than resting

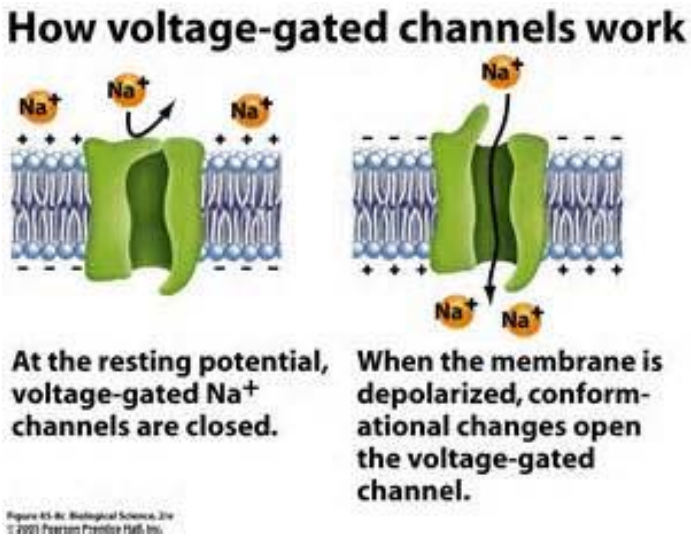


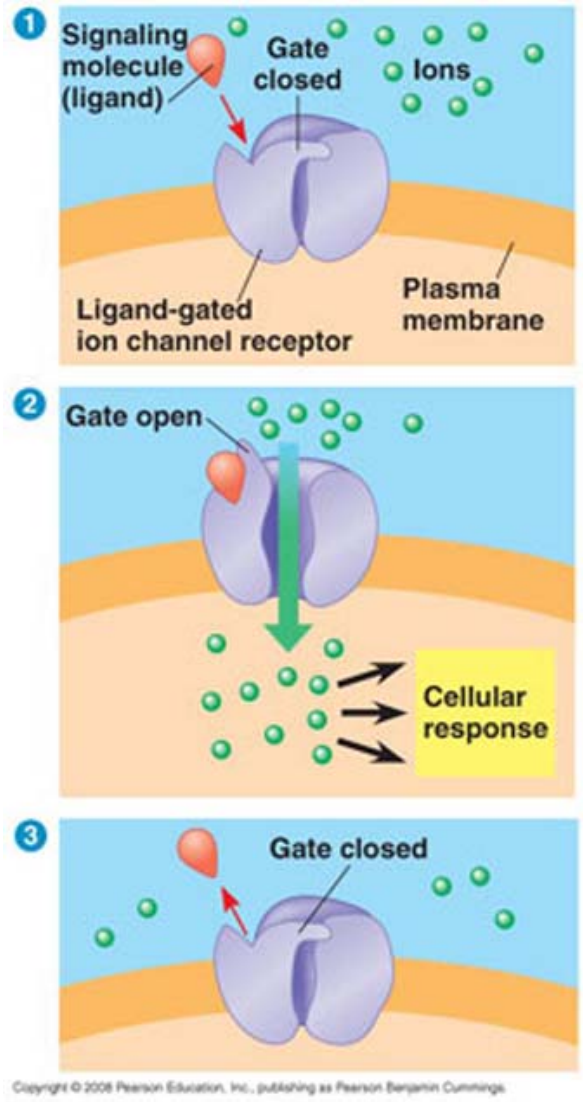


Gated Ion Channels

- **Ligand-gated ion channels:**
  - **Found at dendrites and open/close when bound to neurotransmitters.**

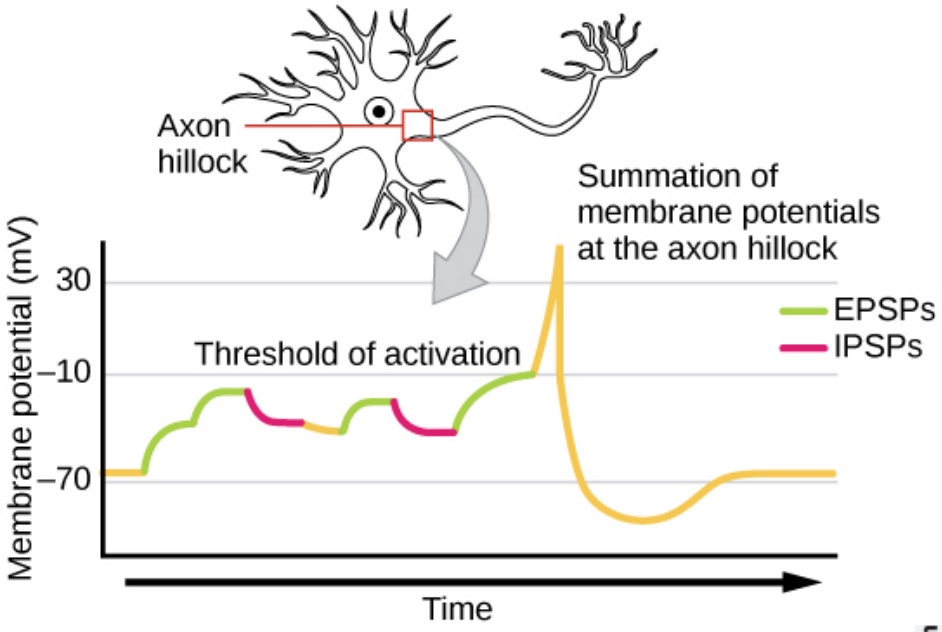
- **Voltage-gated ion channels:**
  - **Found in axons.**
  - **Open/close when membrane potential changes.**

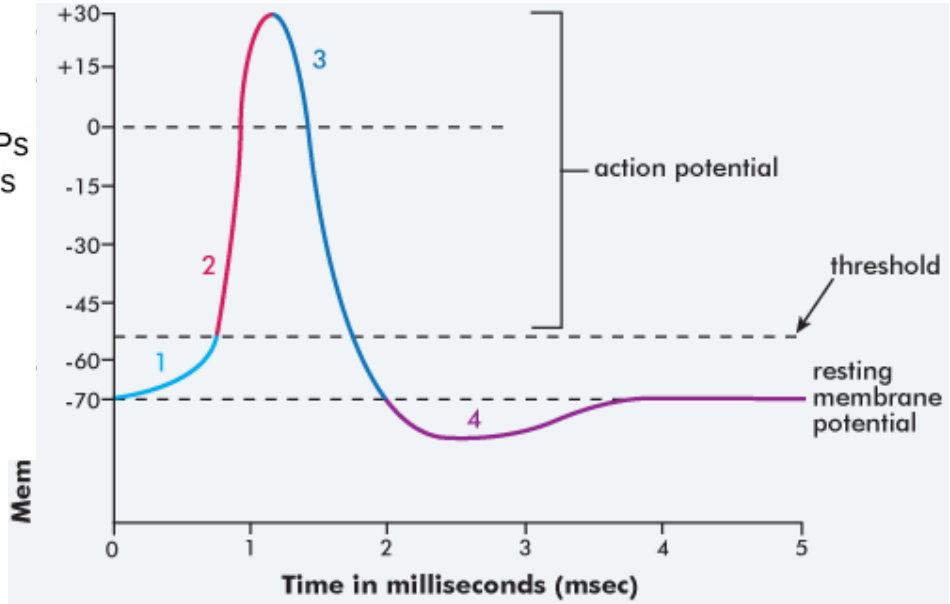




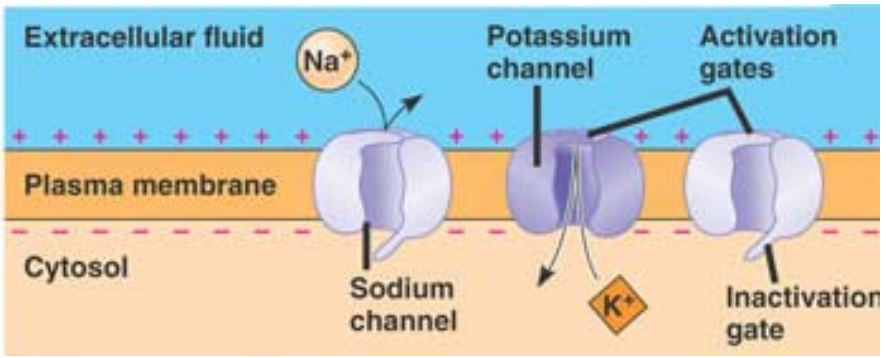
Action Potential (AP)

- A **moving depolarization**
- Triggered by a stimulus strong enough to produce a **depolarization** to **threshold**.





Action Potential Generation



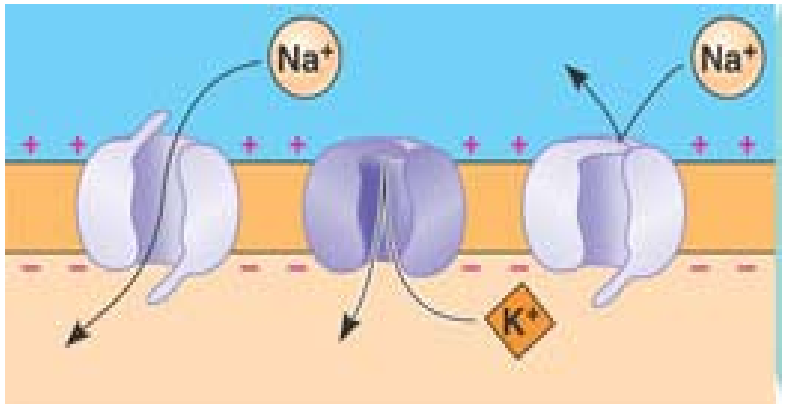
1. **Resting State**:

   -**70mV** within cell due to **sodium-potassium pumps**

   - All voltage-gated channels inactive/closed

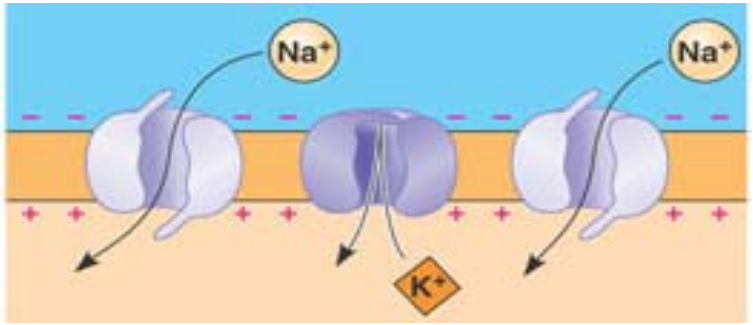
2. **Excitation:**

   - Stimulus causes **Na^+ voltage-gated channels** to **open**, **Na^+ into c**ell
   - **Charge** difference **decreases**
   - If threshold reached AP continues, if not back to resting state



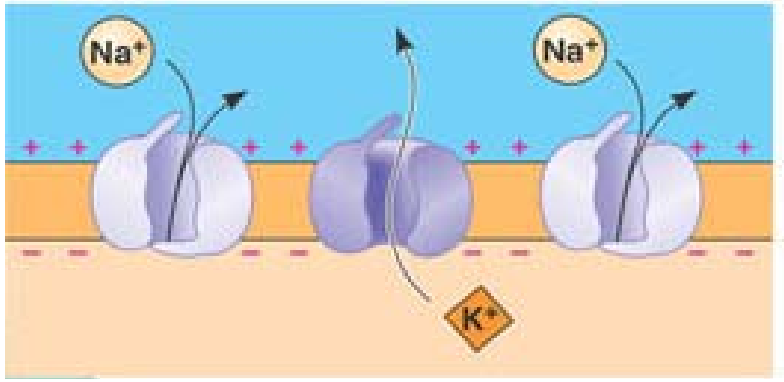
3. Depolarization:

- **Na^+ influx** causes further depolarization, opening **more Na^+ voltage-gated** channels.



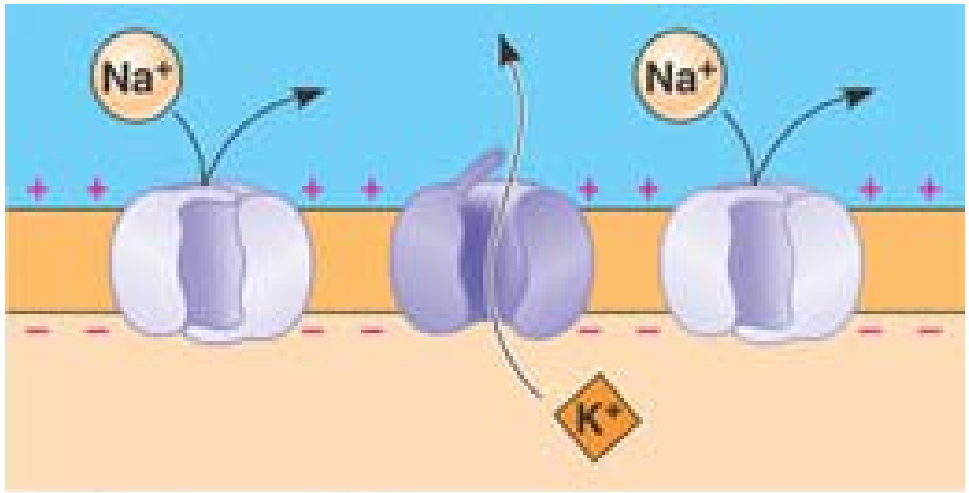
4. Repolarization:

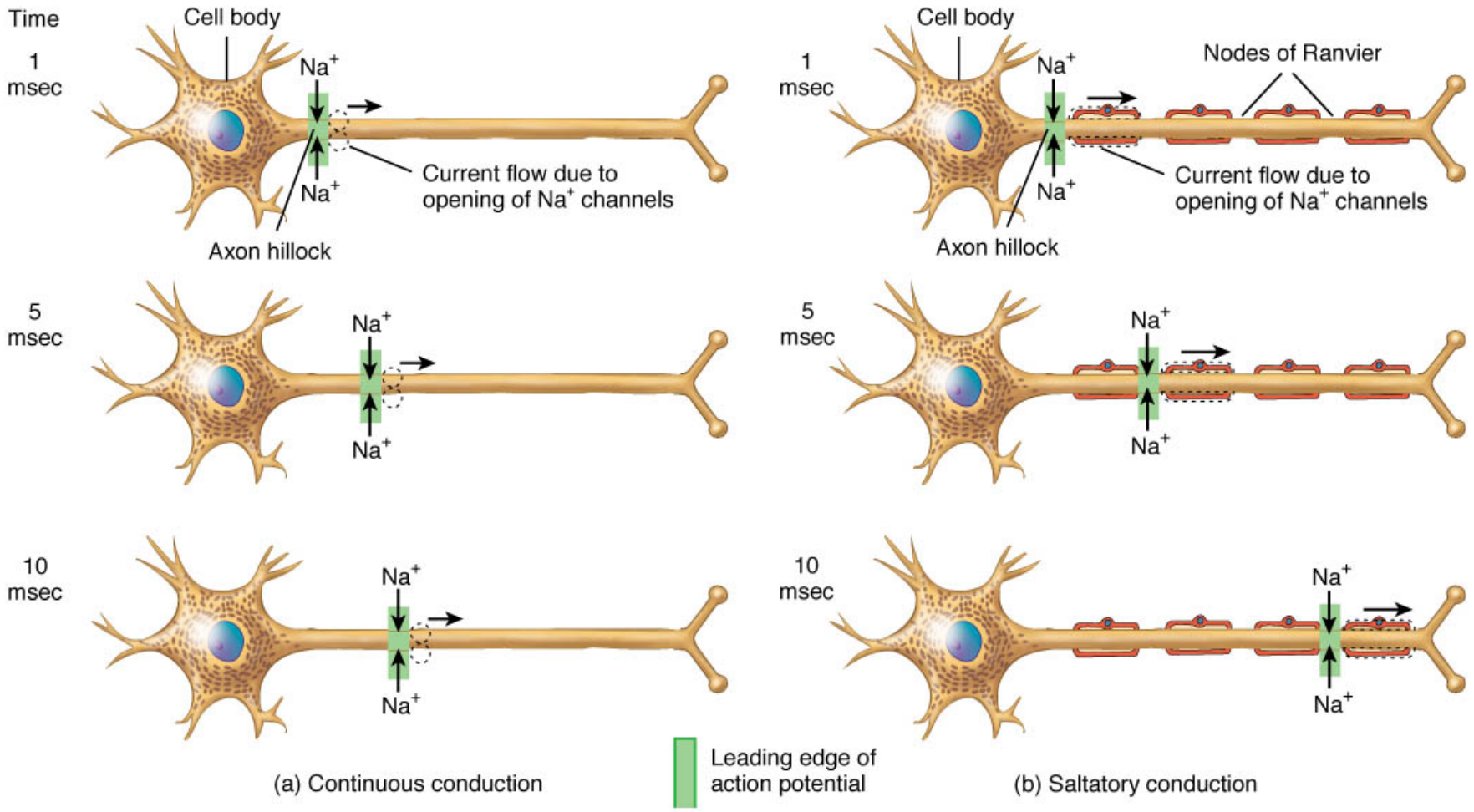
- **Na^+ voltage-gated channels inactivating.**
- **K^+ voltage-gated channels open**, **K^+ flows out** of cell.



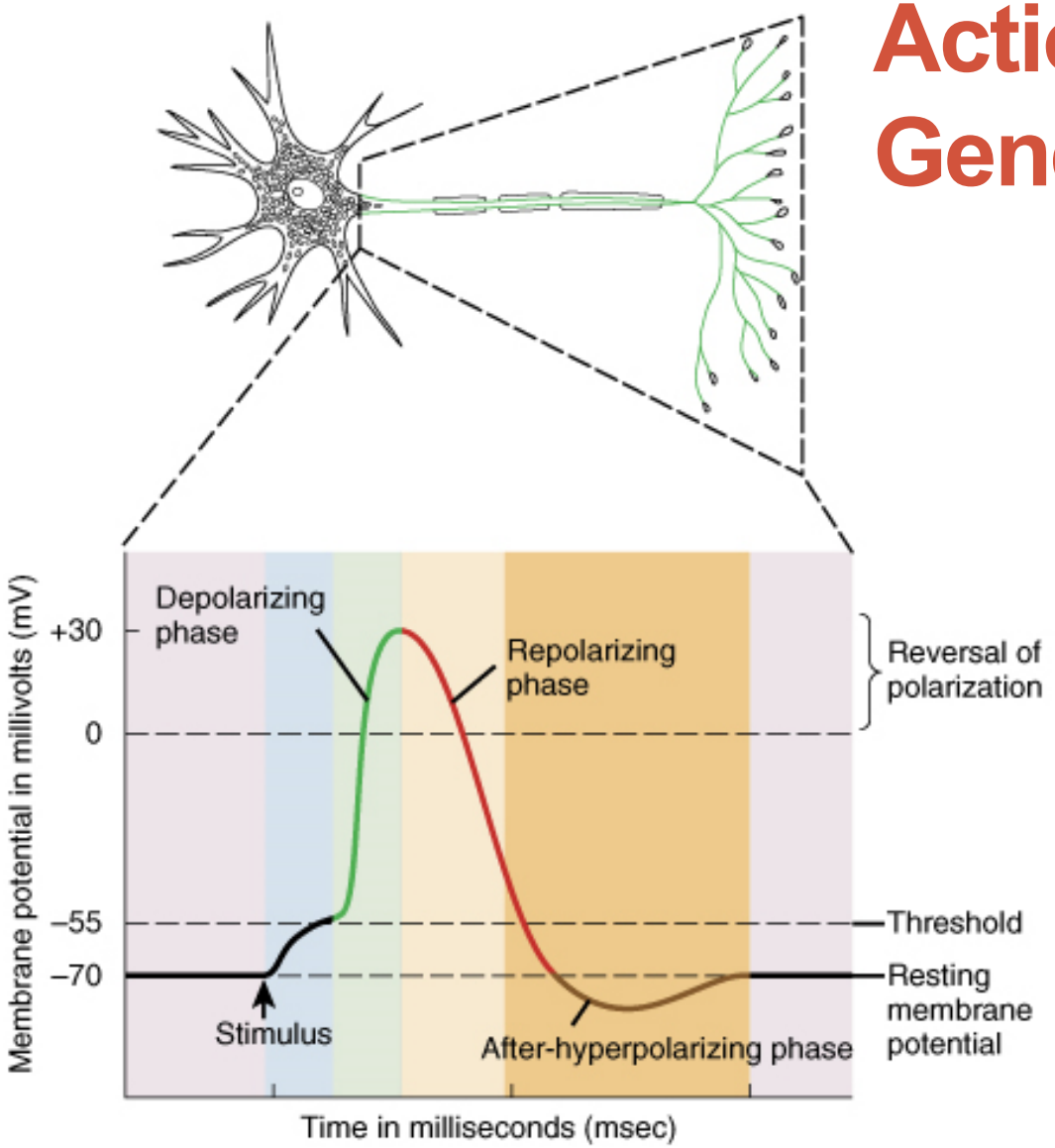
5. Undershoot:

- **K^+ voltage-gated channels open longer** than needed, creating an “undershoot”.
- **Na^+ channels** are in **resting** state
- Prevents a second stimulus from depolarizing membrane.
- This is known as the **relative refractory period.**
  - Limits the maximum frequency at which APs can be generated.
  - Ensures AP only moves in **one direction**




Time
1 msec
5 msec
10 msec
Cell body
Na+
Na+
Current flow due to opening of Na+ channels
Axon hillock
Nodes of Ranvier
(a) Continuous conduction
Leading edge of action potential
(b) Saltatory conduction

Action Potential Generation



Key:

- Resting membrane potential: Voltage-gated Na^+ channels are in the resting state and voltage-gated K^+ channels are closed
- Stimulus causes depolarization to threshold
- Voltage-gated Na^+ channel activation gates are open
- Voltage-gated K^+ channels are open; Na^+ channels are inactivating

(Absolute refractory period)

- Voltage-gated K^+ channels are still open; Na^+ channels are in the resting state

(Relative refractory period)

Watch This!!!