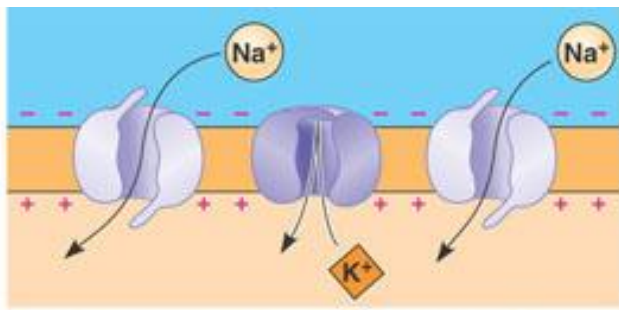


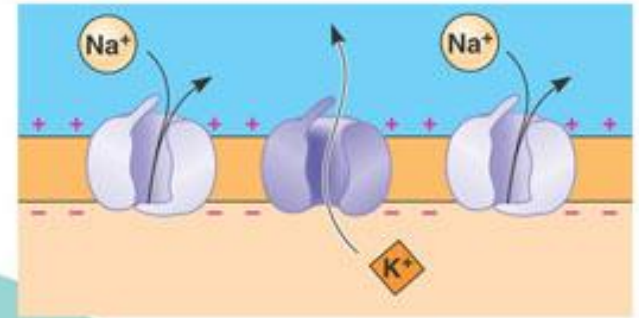
# Transport of ions across plasma membranes

## Plasma Membranes of Excitable tissues

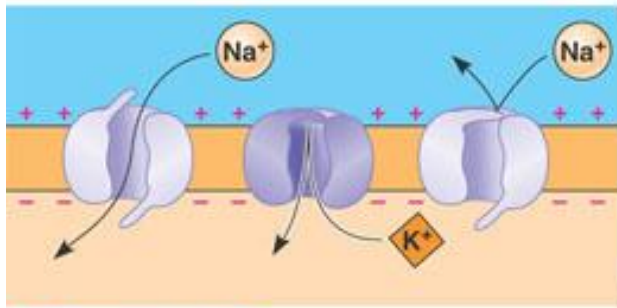
Ref: Guyton, 14<sup>th</sup> ed: 63-76. 13<sup>th</sup> ed: pp: 61-71. 12<sup>th</sup> ed: pp: 57-69,



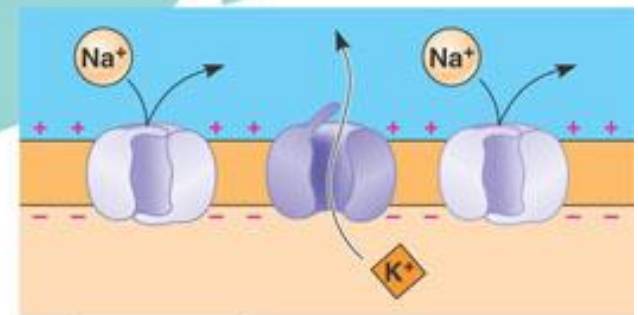
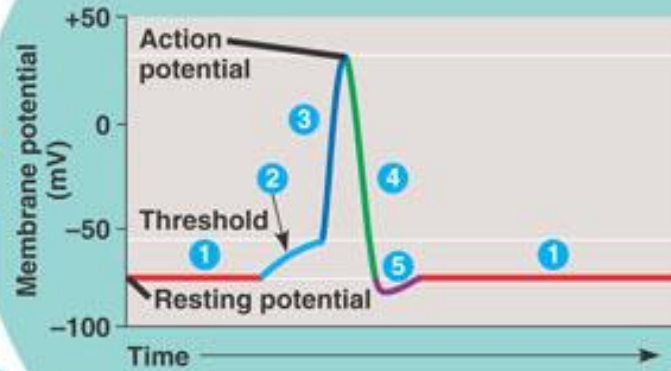
3 Rising phase of the action potential



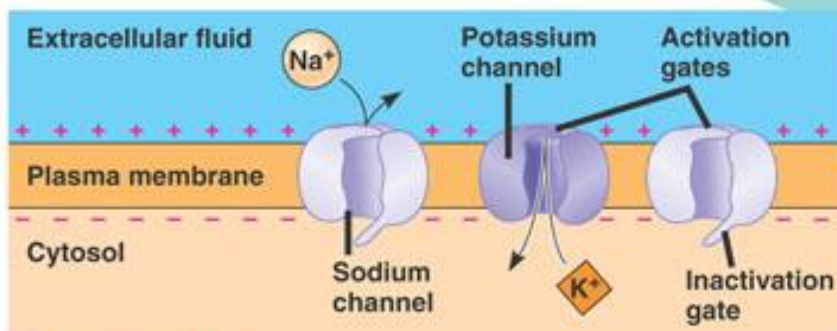
4 Falling phase of the action potential



2 Depolarization

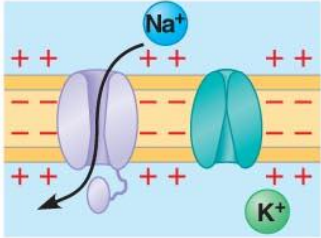


5 Undershoot

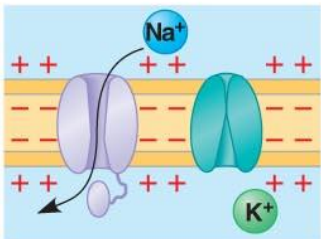


1 Resting state

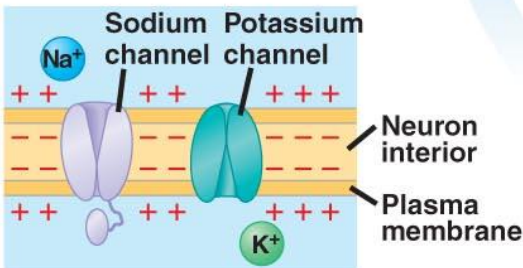
# Generation of action potentials



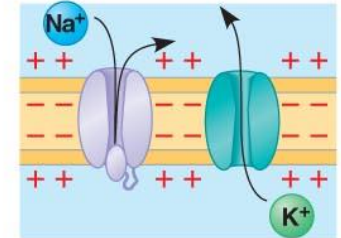
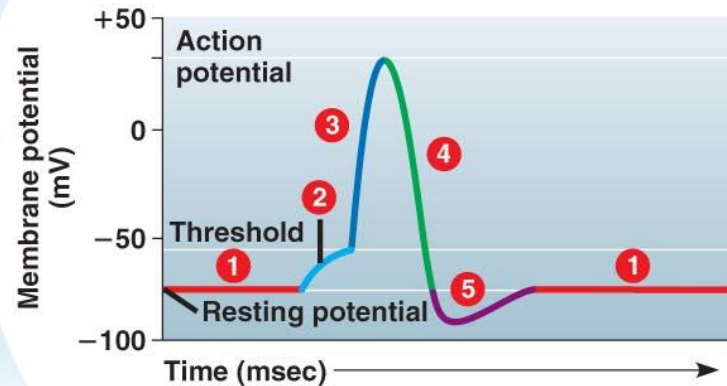
- 3** Additional Na<sup>+</sup> channels open, K<sup>+</sup> channels are closed; interior of cell becomes more positive.



- 2** A stimulus opens some Na<sup>+</sup> channels; if threshold is reached, action potential is triggered.

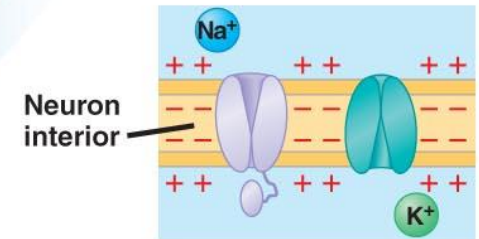


- 1** Resting state: voltage-gated Na<sup>+</sup> and K<sup>+</sup> channels closed; resting potential is maintained.



- 4** Na<sup>+</sup> channels close and inactivate. K<sup>+</sup> channels open, and K<sup>+</sup> rushes out; interior of cell more negative than outside.

- 5** The K<sup>+</sup> channels close relatively slowly, causing a brief undershoot.



- 1** Return to resting state.

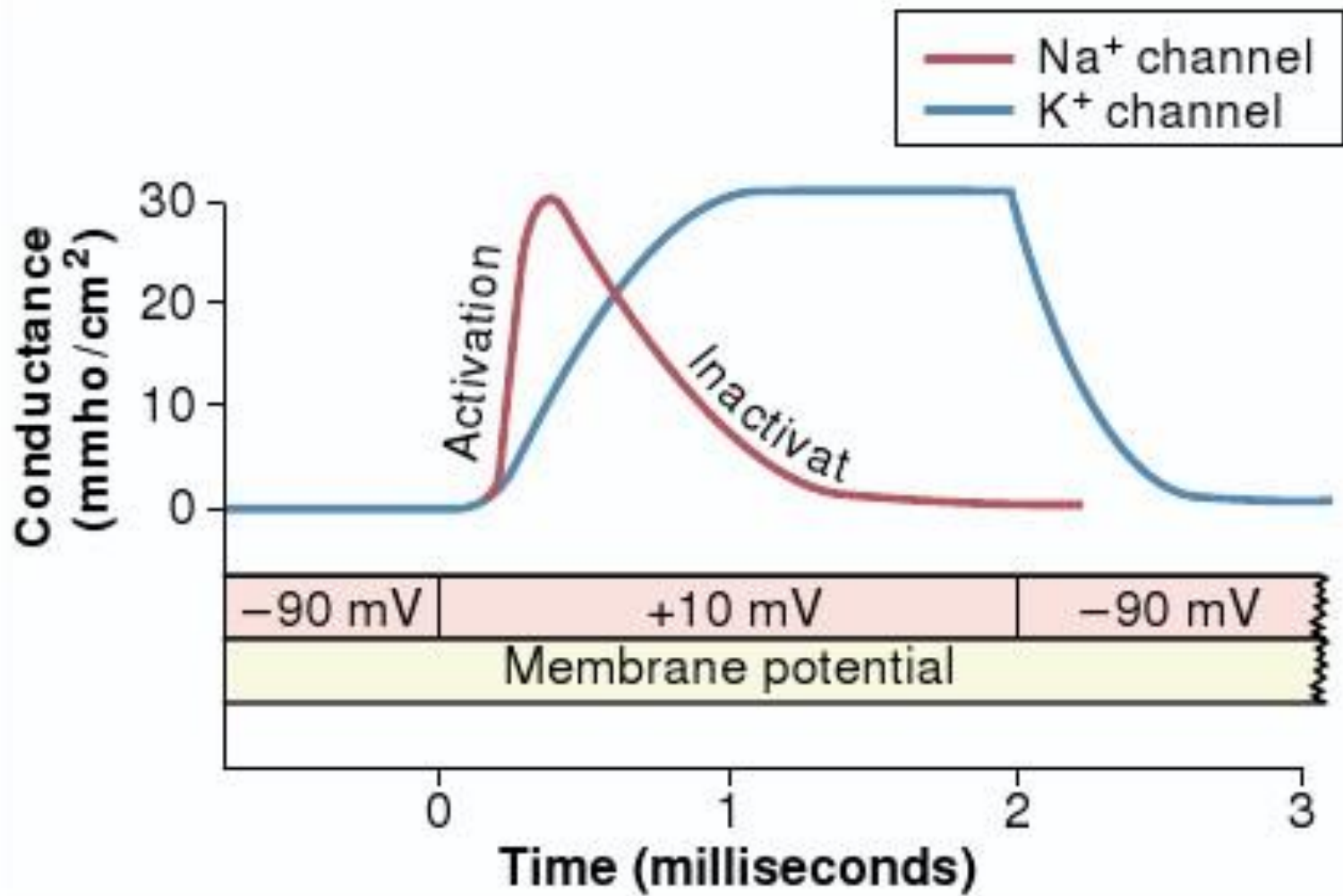
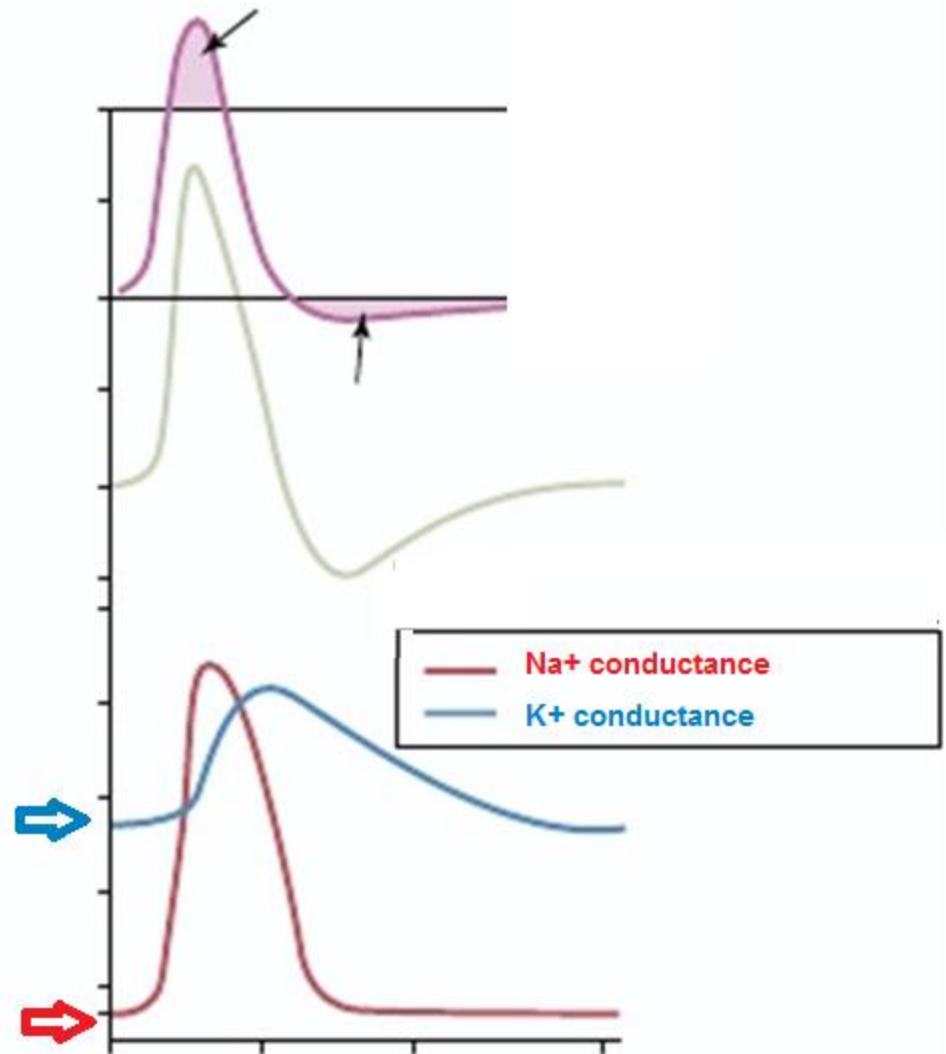
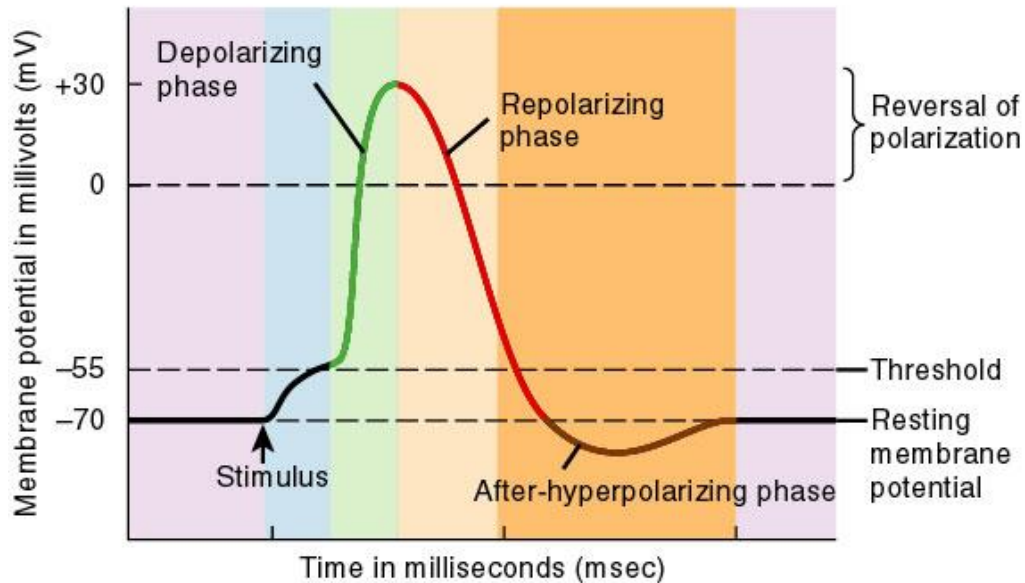
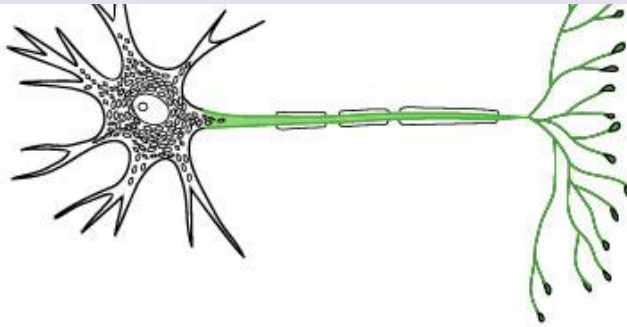


Figure 5-9

- Na<sup>+</sup> and K<sup>+</sup> conductance at resting potentials



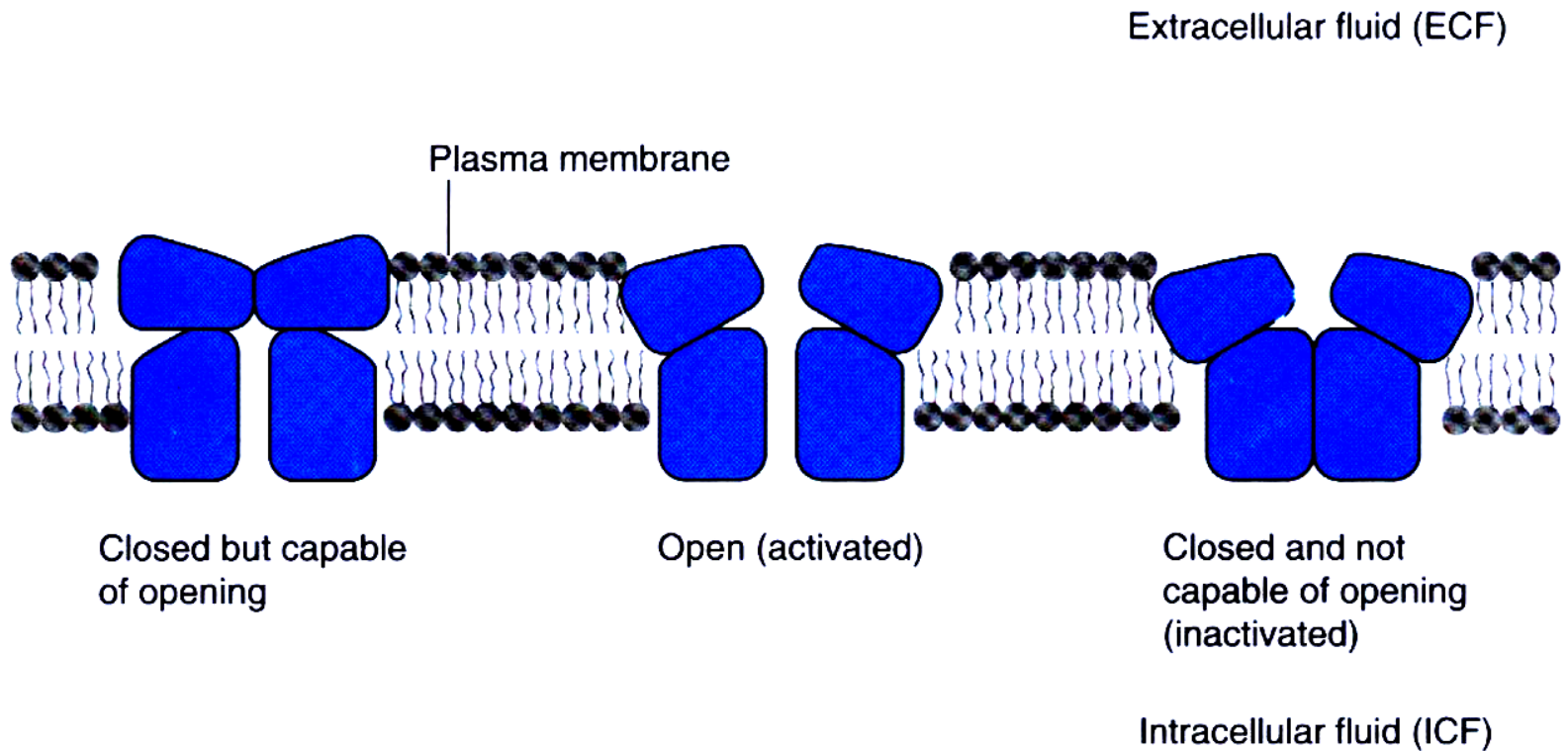
# Refractory periods



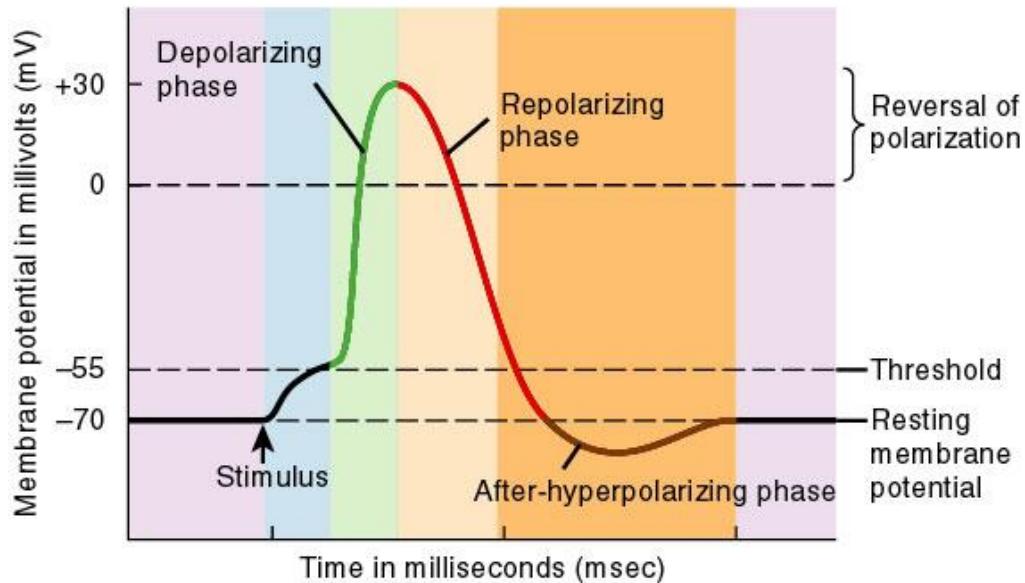
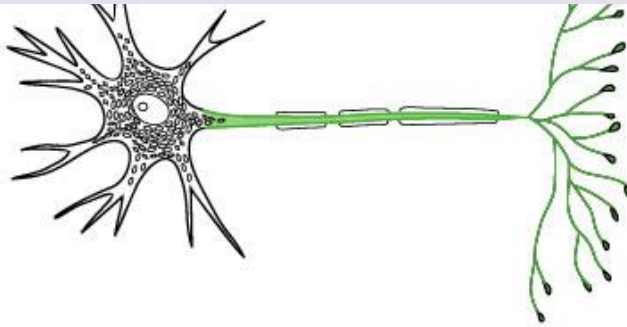
## Key:

- Resting membrane potential: Voltage-gated  $\text{Na}^+$  channels are in the resting state and voltage-gated  $\text{K}^+$  channels are closed
  - Stimulus causes depolarization to threshold
  - Voltage-gated  $\text{Na}^+$  channel activation gates are open
  - Voltage-gated  $\text{K}^+$  channels are open;  $\text{Na}^+$  channels are inactivating
  - Voltage-gated  $\text{K}^+$  channels are still open;  $\text{Na}^+$  channels are in the resting state
- } Absolute refractory period
- } Relative refractory period

# Refractory periods and Na<sup>+</sup> Channels



# Refractory periods



## Key:

- Resting membrane potential: Voltage-gated  $\text{Na}^+$  channels are in the resting state and voltage-gated  $\text{K}^+$  channels are closed
  - Stimulus causes depolarization to threshold
  - Voltage-gated  $\text{Na}^+$  channel activation gates are open
  - Voltage-gated  $\text{K}^+$  channels are open;  $\text{Na}^+$  channels are inactivating
  - Voltage-gated  $\text{K}^+$  channels are still open;  $\text{Na}^+$  channels are in the resting state
- } Absolute refractory period
- } Relative refractory period