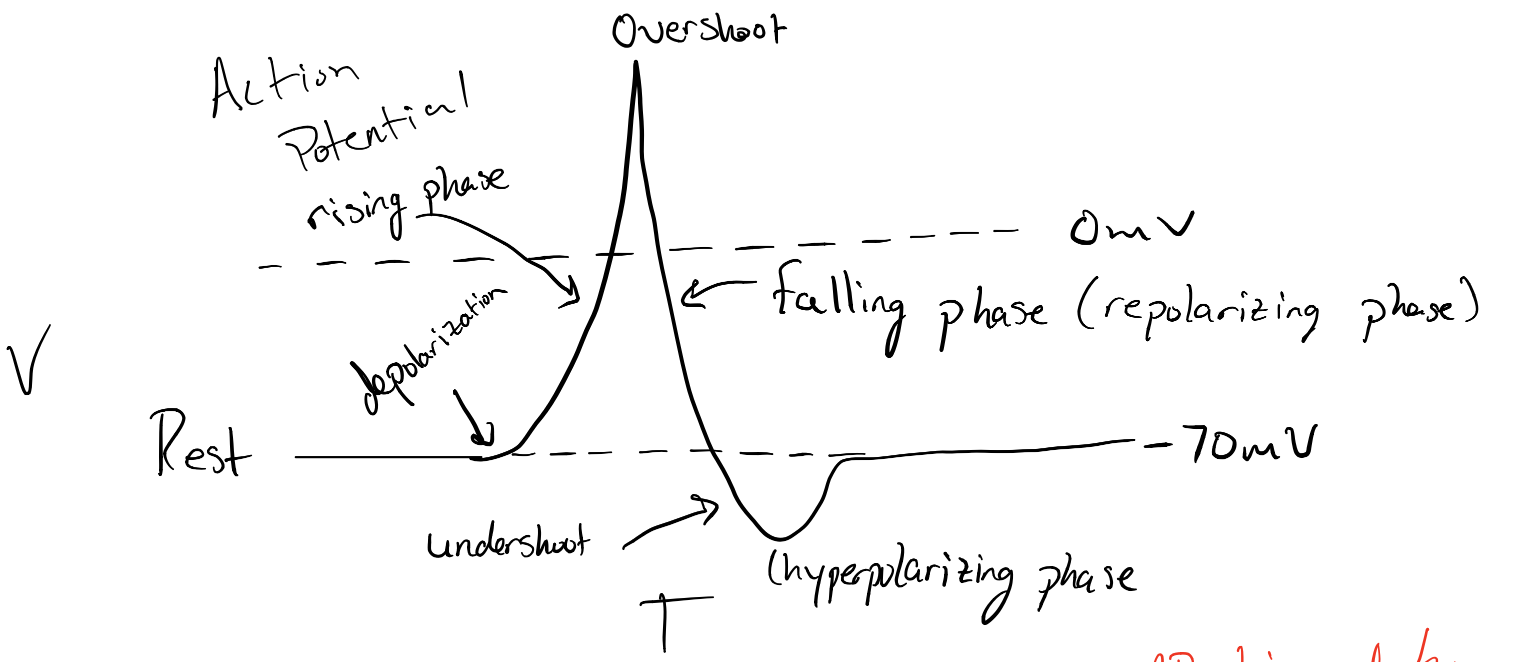
Pre-lecture Video



AP triggered by depolarization

- Injecting positive current depolarizes the cell
- There's a threshold for amount of current added that seperates no action potential from action potential.

- Action potential is **ALL or NONE!**
- A neuron that just fired an action potential can't immediately fire another one!
  - There's a refractory period!

- Propogation w/o decrement (10-100 m/s)

Lecture 06. Action Potential and Propagation II

Watch the Pre-class video! Reading (less important than video)

Bear et al., pp. 100-105.

Learning Objectives:

1. To finish learning how the main features of the action potential, such as threshold, arise. See last outline for relevant goals.

2. To learn how action potentials are propagated along axons and how the speed of this propagation can be increased.

  a. To be able to explain the current flows and voltage dependent conductances that propagate the action potential

  b. To be able to explain what features of an axon affect the speed of propagation and why.

Lecture Outline

1. **What is responsible for threshold?** It is the point at which influx of sodium exceeds the efflux of potassium. At this point a positive feedback develops because the extra positivity inside from the sodium ions depolarizes the neuron more, which opens more sodium channels, which depolarizes the neuron more and opens more channels…

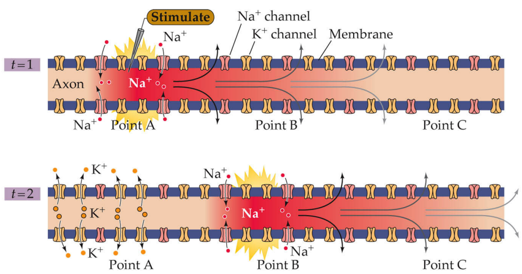
2. **The positive feedback loop also explains the all or nothing behavior of the action potential and the "overshoot" to positive potentials.** The feedback drives the membrane potential to near the sodium equilibrium potential by a massive opening of sodium channels.

3**. Some other important bits about action potentials.**

A. Not many sodium ions need to move into the cell to depolarize it. Still, after very many action potentials, the concentration of sodium would rise inside the cell and the ability to generate action potentials would go away. The cell needs to prevent this…

B. The high sodium outside and high potassium inside are maintained by pumps, powered by ATP, that work on a slower time scale than action potentials. In effect, the cell uses the pump to store the energy for generating an action potential in a concentration gradient.

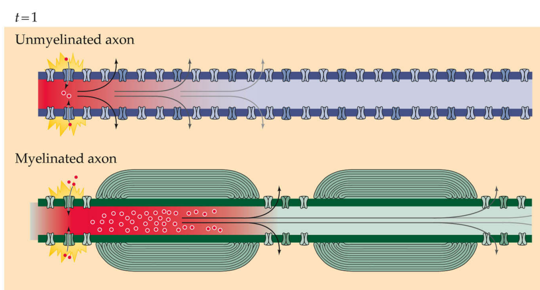
4. **Propagation of Action potentials along an axon.** See animation on Blackboard.



NEUROSCIENCE, Third Edition, Figure 3.12 (Part 1) © 2004 Sinauer Associates, Inc.

An action potential brings the neighboring regions of the membrane above threshold, propagating the action potential rapidly along the axon, much like a fuse burns along its length as energy from the lit region ignites regions further along.

5. What influences the speed of the action potential?



NEUROSCIENCE, Third Edition, Figure 3.14 (Part 1) © 2004 Sinauer Associates, Inc.

A. The length constant. Increase speed by decreasing r_i and increasing r_m.

B. Myelinated versus unmyelinated axons.

3. **Review of the explanation of features of action potentials.**

A. *Waveform of the action potential. Rising phase (depolarizing), overshoot, falling phase (repolarizing), undershoot (hyperpolarizing).* Depends on voltage dependent changes in sodium and potassium conductances and movements toward the equilibrium potentials of the different ions.

B. *Triggered by a depolarization…* because of the voltage dependence of the sodium channels.

C. *The membrane needs to be depolarized to a certain level, or threshold, and then suddenly a full blown action potential is produced…* because at the threshold the sodium current flowing in exceeds the potassium efflux to depolarize the cell and open even more sodium channels producing a positive feedback loop.

D. *Action potentials are all or none…* because the positive feedback loop drives the membrane potential consistently near to the sodium equilibrium potential.

E. *At the peak of the action potential the inside of the neuron is positive…* because the membrane is near the sodium equilibrium potential, which is very positive.

F. *After an action potential there is a brief time (about 1 millisecond), called the refractory period. when it is impossible to trigger another action potential…* because of inactivation of the voltage dependent sodium channels.

G. *Action potentials propagate without decrement along axons, although at fairly low speeds (10-100m/sec) …* because an action potential at one location brings the neighboring regions to threshold. The process is not super fast because it depends on channel openings and ions flows, which take some time.

Study Questions:

1. Explain what properties of an axon give rise to the key features of an action potential such as its waveform, threshold, all-or-none character, short duration, and propagation without decrement.

2. What influences the speed of an action potential and why?

3. Why do myelinated axons generally conduct faster than unmyelinated ones of the same diameter?