Page 1. Introduction
- Synaptic potentials are the incoming signals to the neuron.
- When the neuron is depolarized to threshold, it generates an action potential.
- The action potential is the outgoing signal of the neuron.

Page 2. Goals
- To review the characteristics of the action potential.
- To learn that synaptic potentials are small, variable in amplitude, and decay with distance.
- To understand that synaptic potentials summate.
- To know the difference between temporal and spatial summation.

Page 3. Review of the Action Potential
- Recall that action potentials are all-or-none events.
- For a given cell, the action potential has the same amplitude and duration as it travels along the axon.
- Because the action potential is always the same, it is the signature of the cell.
- The action potential can travel for long distances because it does not decay and is regenerated continuously as it moves along the axon.

Page 4. Synaptic Potentials are Small
- Synaptic potentials are considerably smaller than action potentials.
- Excitatory postsynaptic potentials depolarize neurons.
• Inhibitory postsynaptic potentials depolarize neurons.

* Now is a good time to go to quiz question 1:
  • Click the Quiz button on the left side of the screen.
  • Work through quiz question 1.
  • When you are done return to “Page 5. Synaptic Potentials Vary in Amplitude”.

Page 5. Synaptic Potentials Vary in Amplitude

• The amplitude of a synaptic potential varies and is related to the number of synaptic vesicles releasing neurotransmitter.
• The number of vesicles releasing neurotransmitter in turn is related to the amount of calcium that enters the presynaptic terminal.
• In some neurons, rapid firing of action potentials allows more calcium to enter the terminal. This causes enhanced postsynaptic potentials, or potentiation, for a period of time.
• Signaling at an axoaxonic synapse can decrease the entry of calcium into the presynaptic terminal. This event, called presynaptic inhibition, decreases the amplitude of a subsequent postsynaptic potential.

• When the amount of calcium entering the presynaptic terminal is altered, the synaptic potential may be enhanced, or weakened. Because they vary in amplitude, synaptic potentials are called graded potentials.

Page 6. Synaptic Potentials Decay with Distance

• Synaptic potentials are largest at the synapse where they originate.
• Synaptic potentials decay as they travel away from the synapse.
• Unlike the action potential, the synaptic potential can only travel for short distances because it decays as it moves along the neuronal membrane.
• This effect is true for both excitatory postsynaptic potentials and inhibitory postsynaptic potentials.

Page 7. EPSPs Summate
A single action potential in a presynaptic cell leads to an excitatory postsynaptic potential, which is too small to depolarize a neuron to threshold.

The neuron can summate, or add, excitatory postsynaptic potentials to produce a greater depolarization.

This is an example of temporal summation. Several action potentials are delivered along the same axon but staggered in time.

Click the presynaptic axon again to see what must occur for depolarization to be great enough to produce an action potential in the postsynaptic neuron.

Excitatory postsynaptic potentials from synapses at different sites also summate. This process is an example of spatial summation.

Click a presynaptic axon to see how the activity of synapses at different sites can produce an action potential in the postsynaptic neuron.

Many excitatory postsynaptic potentials are required to depolarize a neuron to threshold.

* Don’t forget to click on the Virtual professor Button.
* Now is a good time to go to quiz questions 2 & 3:
  * Click the Quiz button on the left side of the screen.
  * Work through quiz questions 2 & 3.
  * When you are finished return to page 8 "IPSPs Summate With Each Other and With EPSPs."

Like excitatory postsynaptic potentials, inhibitory postsynaptic potentials also summate.

The overall effect of inhibitory activity is to keep the membrane potential below threshold, thus preventing the postsynaptic cell from generating an action potential.

Inhibitory postsynaptic potentials and excitatory postsynaptic potentials also summate with each other.

When inhibitory potentials are added to excitatory potentials, they reduce the magnitude of the excitatory postsynaptic potentials.
Inhibitory synaptic activity cancels the effects of excitatory activity and can prevent the postsynaptic cell from generating an action potential.

Excitatory activity must travel from the synapse across the cell body to depolarize a neuron to threshold.

The closer a synapse is to the trigger zone or axon hillock, the greater the effectiveness of that synapse. In the brain, inhibitory synapses are often located on the cell body, where they can have the most powerful effect.

Page 9. The Neuron Integrates All Synaptic Information

- Neurons are like democracies.
- Like thousands of voters, the synapses signal their aye or nay votes, and the neuron counts them all.
- If the aye votes prevail, the neuron generates an action potential.
- If the nay votes prevail, the neuron remains silent.
- The process by which a neuron tallies the votes is called cellular integration.
- This process goes on continually as neurons determine whether or not to produce action potentials.
- This neuronal activity is very similar to the fundamental activity of the whole nervous system.
- The integrative activity of the nervous system selects one output from all the competing alternatives.

Page 10. Summary

- Synaptic potentials are small, graded, short-distance signals.
- Many excitatory postsynaptic potentials are needed to depolarize a cell to threshold.
- Inhibitory postsynaptic potentials reduce the magnitude of excitatory postsynaptic potentials.
- The job of the cell, like the job of the whole nervous system, is to select a single output from many competing inputs.

* Now is a good time to go to quiz question 4:
  - Click the Quiz button at the bottom of the screen.
  - Work through quiz question 4.

Notes on Quiz Questions:

Quiz Question #1: Action Potentials vs. Synaptic Potentials
- This question asks you to fill out a chart with respect to action potentials and synaptic potentials. You may want to fill out this chart as you proceed:
Quiz Question #2: Temporal Summation
• This question asks you to stimulate a neuron to determine which dendrite takes the longest to generate an action potential.

Quiz Question #3: Spatial Summation
• This question asks you to stimulate neurons in order to determine how many EPSPs are needed for threshold.

Quiz Question #4: Cellular Integration
• This question asks you to find a location for an IPSP that will inhibit an EPSP.

Study Questions on Synaptic Potentials & Cellular Integration:
1. (Page 1.) __________ __________ are the incoming signals to the neuron.
   a. synaptic potentials  b. action potentials

2. (Page 1.) When the neuron is depolarized to threshold, it generates an ________ _________. The action potential is the outgoing signal of the neuron.
   a. synaptic potentials  b. action potentials

3. (Page 1.) Recall that action potentials are all-or-none events. For a given cell, the action potential has the same ________ and ________ as it travels along the axon.
   a. amplitude and duration  b. decay and fizzle out

4. (Page 4.) __________ __________ are considerably smaller than ________ _________.
   a. synaptic potentials, action potentials  b. action potentials, synaptic potentials

5. (Page 4.) Excitatory postsynaptic potentials ________ neurons.
   a. depolarize  b. hyperpolarize

6. (Page 4.) Inhibitory postsynaptic potentials ________ neurons.
   a. depolarize  b. hyperpolarize

7. (Page 4.) Which of these is a depolarization and which is a hyperpolarization?
   a.  
   b. 
8. (Page 5.) The amplitude of a synaptic potential varies and is related to the number of synaptic vesicles releasing _____________.
   a. calcium    b. neurotransmitter    c. sodium

9. (Page 5.) The number of vesicles releasing neurotransmitter in turn is related to the amount of _____ that enters the presynaptic terminal.
   a. calcium    b. neurotransmitter    c. sodium

10. (Page 5.) In some neurons, rapid firing of action potentials allows more calcium to enter the terminal. This causes enhanced ____________, or potentiation, for a period of time.
    a. EPSP    b. IPSP    c. postsynaptic potentials    d. presynaptic inhibition

11. (Page 5.) Signaling at an axoaxonic synapse can decrease the entry of calcium into the presynaptic terminal. This event, called ____________, decreases the amplitude of a subsequent postsynaptic potential.
    a. EPSP    b. IPSP    c. postsynaptic potentials    d. presynaptic inhibition

12. (Page 5.) When the amount of _____ entering the presynaptic terminal is altered, the synaptic potential may be enhanced, or weakened. Because they vary in amplitude, synaptic potentials are called graded potentials.
    a. calcium    b. neurotransmitter    c. sodium

13. (Page 6.) Synaptic potentials are largest at the synapse where they originate. Synaptic potentials ______ as they travel away from the synapse.
    a. potentiate    b. decay    c. remain as is

14. (Page 6.) Unlike the action potential, the synaptic potential can only travel for _______ because it decays as it moves along the neuronal membrane. This effect is true for both excitatory postsynaptic potentials and inhibitory postsynaptic potentials.
    a. short distances    b. long distances

15. (Page 6.) Which of these shows a graded potential and which shows an action potential?
   a. [Image A]    b. [Image B]
16. (Page 7.) A single action potential in a presynaptic cell leads to an ____________ ___________ __________, which is too small to depolarize a neuron to threshold.
   a. EPSP  b. IPSP  c. postsynaptic potentials  d. presynaptic inhibition

17. (Page 7.) The neuron can summate, or add, excitatory postsynaptic potentials to produce a greater ____________ _____________.
   a. depolarization  b. hyperpolarization  c. EPSP  d. IPSP

18. (Page 7.) This is an example of ________ _________. Several action potentials are delivered along the same axon but staggered in time.
   a. depolarize  b. hyperpolarize  c. temporal summation  d. spatial summation

19. (Page 7.) Excitatory postsynaptic potentials from synapses at different sites also summate. This process is an example of ________ _________.
   a. depolarize  b. hyperpolarize  c. temporal summation  d. spatial summation

20. (Page 7.) Many __________ __________ ____________ are required to depolarize a neuron to threshold.
   a. depolarization  b. hyperpolarization  c. EPSP  d. IPSP

21. (Page 8.) Like excitatory postsynaptic potentials, inhibitory postsynaptic potentials also ________.
   a. depolarization  b. hyperpolarization  c. summate

22. (Page 8.) The overall effect of inhibitory activity is to keep the membrane potential below threshold, thus preventing the postsynaptic cell from generating an ______ ________.
   a. synaptic potentials  b. action potentials

23. (Page 8.) Inhibitory postsynaptic potentials and excitatory postsynaptic potentials also ________ with each other.
   a. depolarization  b. hyperpolarization  c. summate  d. reduce

24. (Page 8.) When inhibitory potentials are added to excitatory potentials, they ______ the magnitude of the excitatory postsynaptic potentials.
   a. depolarization  b. hyperpolarization  c. summate  d. reduce

25. (Page 8.) Excitatory activity must travel from the synapse across the cell body to depolarize a neuron to ____________.
   a. threshold  b. depolarize  c. hyperpolarize

26. (Page 8.) The closer a synapse is to the ________ ________ , the greater the effectiveness of that synapse. In the brain, inhibitory synapses are often located on the cell body, where they can have the most powerful effect.
   a. trigger zone  b. depolarization  c. hyperpolarization  d. EPSP  e. IPSP

27. (Page 9.) Neurons are like democracies. Like thousands of voters, the synapses signal their aye or nay votes, and the neuron counts them all. If the aye votes prevail, the neuron generates an ______ _________. If the nay votes prevail, the neuron remains silent.
   a. synaptic potentials  b. action potentials

28. (Page 9.) The process by which a neuron tallies the votes is called ______ ________________.
   a. cellular integration  b. temporal summation  c. spatial summation