

Synaptic Potentials & Cellular Integration

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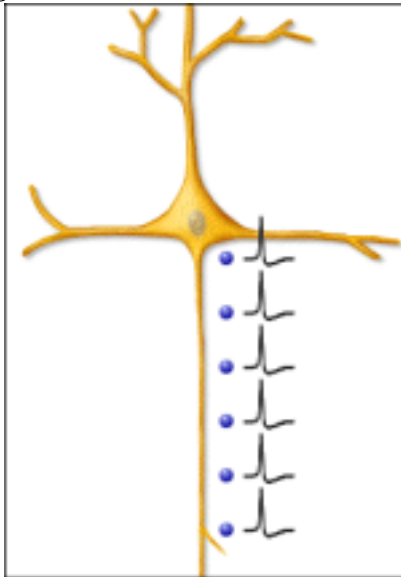
Page 1. Introduction

- 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

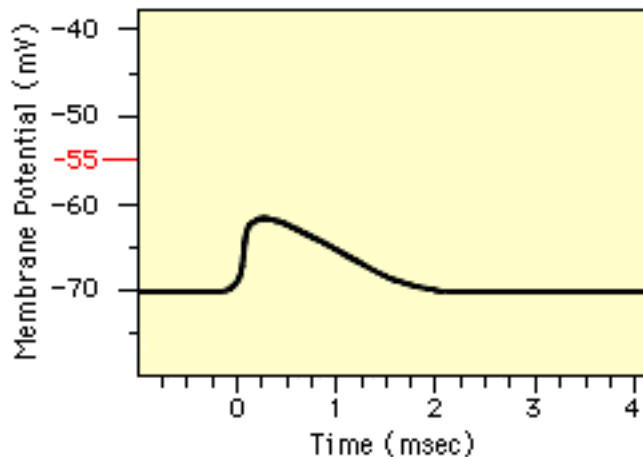
- To review the characteristics of the action potential.
- To learn that synaptic potentials are small, variable in amplitude, and decay with distance.
- To understand that synaptic potentials summate.
- To know the difference between temporal and spatial summation.

Page 3. Review of the Action Potential

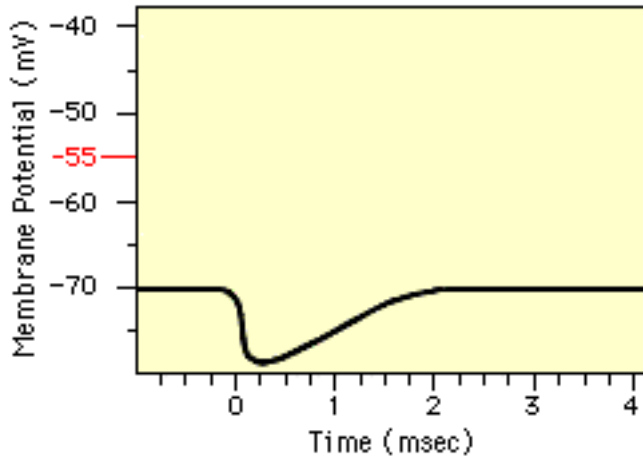


- Recall that action potentials are all-or-none events.
- For a given cell, the action potential has the same amplitude and duration as it travels along the axon.
- Because the action potential is always the same, it is the signature of the cell.
- The action potential can travel for long distances because 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.

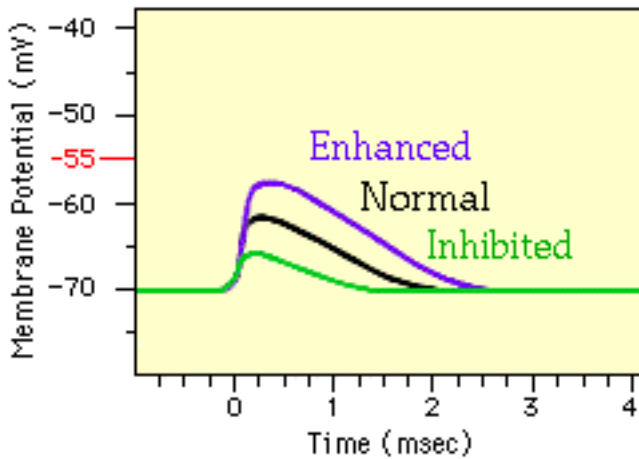


- Inhibitory postsynaptic potentials depolarize neurons.

* 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".

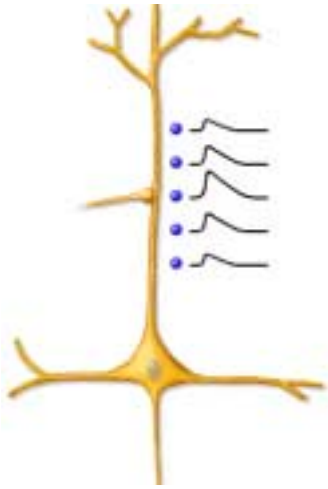
Page 5. Synaptic Potentials Vary in Amplitude



- 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.

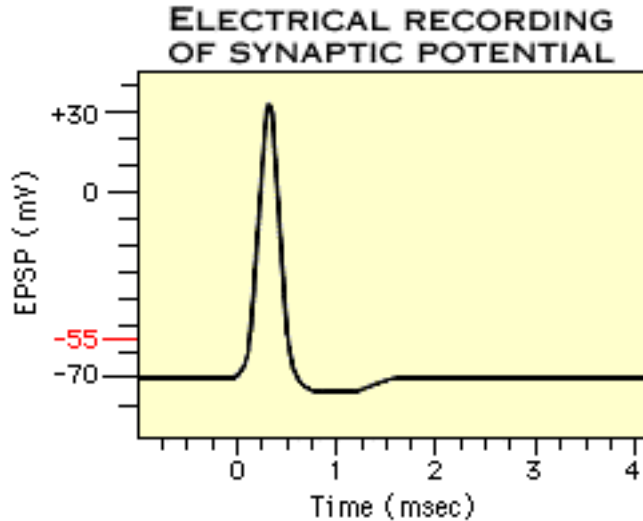
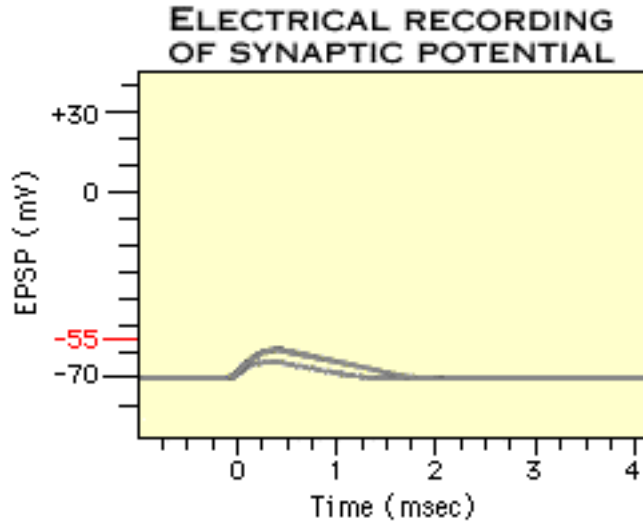
- When the amount of calcium entering the presynaptic terminal is altered, the synaptic potential may be enhanced, or weakened. Because they vary in amplitude, synaptic potentials are called graded potentials.

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.

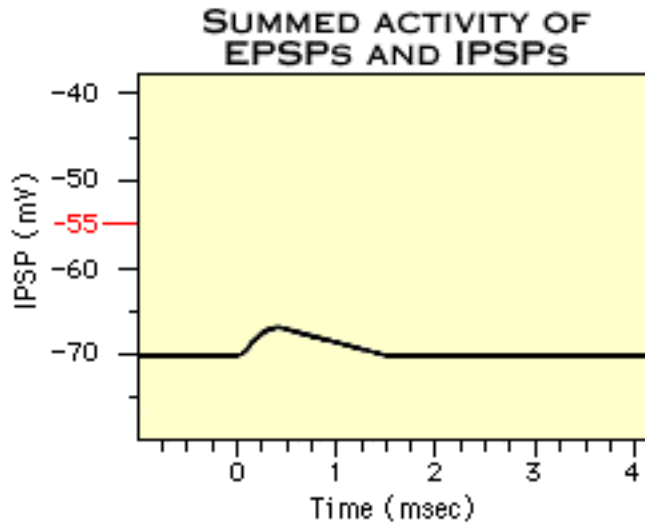
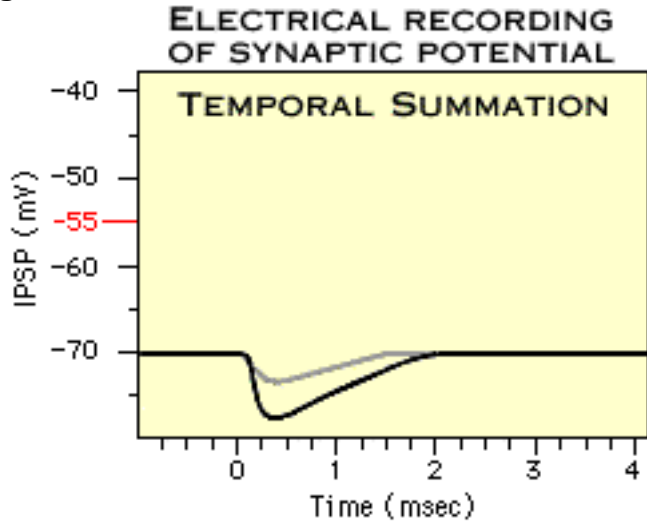
- Excitatory postsynaptic potentials from synapses at different sites also summate. This process is an example of **spatial summation**.
- Click a presynaptic axon to see how the activity of synapses at different sites can produce an action potential in the postsynaptic neuron.
- Many excitatory postsynaptic 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:

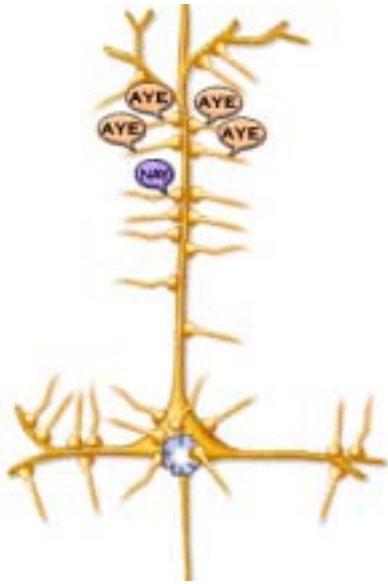
- Click the Quiz button on the left side of the screen.
- Work through quiz questions 2 & 3.
- When you are finished return to page 8 "IPSPs Summate With Each Other and With EPSPs."

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:

	Action Potential	Synaptic Potential
Function		
Conduction Distance		
Stimulus for opening Ion Channels		
Mechanism of neuron repolarization		
Comparative amplitude		

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.

event, called _____, decreases the amplitude of a subsequent postsynaptic potential.

a. EPSP

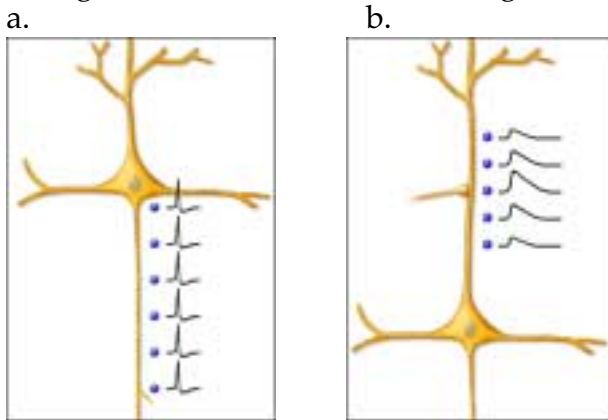
b. IPSP

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?



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