W6: Neurophysiology of Nerve Impulses

# A C T I V I T Y 2 Receptor Potential

1. Sensory neurons have a resting potential based on the efflux of potassium ions (as seen in Activity 1). What passive channels are likely found in the membrane of the olfactory receptor, in the membrane of the Pacinian corpuscle, and in the membrane of the free nerve ending?
2. What is meant by the term *graded potential*?
3. Identify which of the stimulus modalities induced the largest amplitude receptor potential in the Pacinian corpuscle. How well did the results compare with your prediction?
4. Identify which of the stimulus modalities induced the largest-amplitude receptor potential in the olfactory receptors. How well did the results compare with your prediction?
5. The olfactory receptor also contains a membrane protein that recognizes isoamyl acetate and, via several other molecules, transduces the odor stimulus into a receptor potential. Does the Pacinian corpuscle likely have this isoamyl acetate receptor protein? Does the free nerve ending likely have this isoamyl acetate receptor protein?
6. What type of sensory neuron would likely respond to a green light?

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# A C T I V I T Y 3 The Action Potential: Threshold

1. Define the term *threshold* as it applies to an action potential.
2. What change in membrane potential (depolarization or hyperpolarization) triggers an action potential?
3. How did the action potential at R1 (or R2) change as you increased the stimulus voltage above the threshold voltage? How well did the results compare with your prediction?
4. An action potential is an “all-or-nothing” event. Explain what is meant by this phrase.
5. What part of a neuron was investigated in this activity?

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# A C T I V I T Y 4 The Action Potential: Importance of Voltage-Gated Na+ Channels

1. What does TTX do to voltage-gated Na+ channels?
2. What does lidocaine do to voltage-gated Na+ channels? How does the effect of lidocaine differ from the effect of TTX?
3. A nerve is a bundle of axons, and some nerves are less sensitive to lidocaine. If a nerve, rather than an axon, had been used in the lidocaine experiment, the responses recorded at R1 and R2 would be the sum of all the action potentials (called a compound action potential). Would the response at R2 after lidocaine application necessarily be zero? Why or why not?
4. Why are fewer action potentials recorded at R2 when TTX is applied between R1 and R2? How well did the results compare with your prediction?
5. Why are fewer action potentials recorded at R2 when lidocaine is applied between R1 and R2? How well did the results compare with your prediction?
6. Pain-sensitive neurons (called nociceptors) conduct action potentials from the skin or teeth to sites in the brain involved in pain perception. Where should a dentist inject the lidocaine to block pain perception?

# A C T I V I T Y 5 Action Potential: Measuring Absolute and Relative Refractory Periods

1. Define *inactivation* as it applies to a voltage-gated sodium channel.
2. Define the *absolute refractory period.*
3. How did the threshold for the second action potential change as you further decreased the interval between the stimuli? How well did the results compare with your prediction?
4. Why is it harder to generate a second action potential during the relative refractory period?

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# A C T I V I T Y 6 The Action Potential: Coding for Stimulus Intensity

1. Why are multiple action potentials generated in response to a long stimulus that is above threshold?
2. Why does the frequency of action potentials increase when the stimulus intensity increases? How well did the results compare with your prediction?
3. How does threshold change during the relative refractory period?
4. What is the relationship between the interspike interval and the frequency of action potentials?

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# A C T I V I T Y 7 The Action Potential: Conduction Velocity

1. How did the conduction velocity in the B fiber compare with that in the A fiber? How well did the results compare with your prediction?
2. How did the conduction velocity in the C fiber compare with that in the B fiber? How well did the results compare with your prediction?
3. What is the effect of axon diameter on conduction velocity?
4. What is the effect of the amount of myelination on conduction velocity?
5. Why did the time between the stimulation and the action potential at R1 differ for each axon?
6. Why did you need to change the timescale on the oscilloscope for each axon?

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# A C T I V I T Y 8 Chemical Synaptic Transmission and Neurotransmitter Release

1. When the stimulus intensity is increased, what changes: the number of synaptic vesicles released or the amount of neurotransmitter per vesicle?
2. What happened to the amount of neurotransmitter release when you switched from the control extracellular fluid to the extracellular fluid with no Ca2+? How well did the results compare with your prediction?
3. What happened to the amount of neurotransmitter release when you switched from the extracellular fluid with no Ca2+ to the extracellular fluid with low Ca2+? How well did the results compare with your prediction?
4. How did neurotransmitter release in the Mg2+ extracellular fluid compare to that in the control extracellular fluid? How well did the result compare with your prediction?
5. How does Mg2+ block the effect of extracellular calcium on neurotransmitter release?

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# A C T I V I T Y 9 The Action Potential: Putting It All Together

1. Why is the resting membrane potential the same value in both the sensory neuron and the interneuron?
2. Describe what happened when you applied a very weak stimulus to the sensory receptor. How well did the results compare with your prediction?
3. Describe what happened when you applied a moderate stimulus to the sensory receptor. How well did the results compare with your prediction?
4. Identify the type of membrane potential (graded receptor potential or action potential) that occurred at R1, R2, R3, and R4 when you applied a moderate stimulus. (View the response to the stimulus.)
5. Describe what happened when you applied a strong stimulus to the sensory receptor. How well did the results compare with your prediction?