Applied Neuroscience

Conclusion of Science Honors Program
Spring 2017

Review

Circle whichever is greater, A or B. If A = B, circle both:

I.
- A. permeability of a neuronal membrane to Na^+ during the rise phase of an action potential
- B. permeability to K^+ at the same time

II.
- A. permeability of the resting membrane to K^+
- B. permeability of the membrane to K^+ during the falling phase of the action potential

III.
- A. concentration of K^+ in the intracellular fluid before the action potential
- B. concentration of K^+ in the intracellular fluid immediately after the action potential

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Circle whichever is greater, A or B. If A = B, circle both:

I.
- A. speed of conduction of nerve impulse in neuron with diameter of 10 microns
- B. speed of conduction of nerve impulse in neuron with diameter of 5 microns

II.
- A. number of directions action potential will travel if stimulated at axon hillock
- B. number of directions action potential will travel if stimulated at dendrite

III.
- A. Na^+ ions moved out by the Na/ K pump
- B. K^+ ions moved in by the Na/ K pump

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Review

Suppose a nerve cell membrane is made less permeable to passive diffusion of K^+ ions, without affecting the Na^+/K^+ ATPase pump.

A. What will happen to the amount of K^+ within the cell?
B. What will happen to the resting potential of the cell?
C. Will it be harder or easier to elicit an action potential?
D. How can a substance produce such an effect on the cell?

Review

Suppose a nerve cell membrane is made less permeable to passive diffusion of K^+ ions, without affecting the Na^+/K^+ ATPase pump.

A. What will happen to the amount of K^+ within the cell?
   Increase, Less K+ would diffuse out of the cell down its concentration gradient
B. What will happen to the resting potential of the cell?
   Increase, More K+ stays in and the potential becomes less negative
C. Will it be harder or easier to elicit an action potential?
   Easier, Potential is closer to threshold
D. How can a substance produce such an effect?
   Block K^+ leak channels

Review

Suppose a nerve cell membrane is made more permeable to passive diffusion of Na^+ ions, without affecting the Na^+/K^+ ATPase pump.

A. What will happen to the amount of Na^+ and the amount of K^+ within the cell?
B. What will happen to the resting potential of the cell?
C. Will it be harder or easier to elicit an action potential?
D. How could a substance produce such an effect on the cell?

Review

Suppose a nerve cell membrane is made more permeable to passive diffusion of Na^+ ions, without affecting the Na^+/K^+ ATPase pump.

A. What will happen to the amount of Na^+ and the amount of K^+ within the cell?
   Na^+ inside the cell increases, K^+ inside the cell decreases (less electrical "pull" back in)
B. What will happen to the resting potential of the cell?
   More positive, Net Na^+ in will be greater than net K^+ out
C. Will it be harder or easier to elicit an action potential?
   Easier
D. How could a substance produce such an effect on the cell?
   Increase the number of ligand-gated channels for Na^+

Review

Hodgkin and Huxley conducted an experiment in which they removed sodium from the fluid surrounding a neuron, and replaced it with choline, a positively charged molecule that doesn't penetrate the membrane. They found that when the neuron was stimulated electrically to threshold, there was no action potential, but after a small delay (about 3 msec) an increase in positive charge could be measured on the outside of the stimulated membrane.

Explain these findings in terms of our current knowledge of neuron function.

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Hodgkin and Huxley conducted an experiment in which they removed sodium from the fluid surrounding a neuron, and replaced it with choline, a positively charged molecule that doesn't penetrate the membrane. They found that when the neuron was stimulated electrically to threshold, there was no action potential, but after a small delay (about 3 msec) an increase in positive charge could be measured on the outside of the stimulated membrane.

Explain these findings in terms of our current knowledge of neuron function.

There was no action potential at first because there was no Na^+ available to enter the cell. An action potential is caused by an influx of Na^+. When the neuron is electrically stimulated, Hodgkin and Huxley increase the membrane potential to threshold. This causes voltage-gated K^+ channels to open after a delay and leave the cell. This resulted in a positive charge outside of cell, which was measured.

Review

Circle whichever is greater, A or B. If A = B, circle both:

I.
- A. time it takes for voltage-gated potassium channels to open after threshold is reached
- B. time it takes for voltage-gated sodium channels to open after threshold is reached

II.
- A. force pushing sodium into neuron at resting potential
- B. force pushing potassium out of neuron at resting potential

III.
- A. voltage-gated Ca^{++} channels in axon hillock
- B. voltage-gated Ca^{++} channels in nerve terminals

Review

Circle whichever is greater, A or B. If A = B, circle both:

I.

A. time it takes for voltage-gated potassium channels to open after threshold is reached

(K^+ channels open more slowly)

B. time it takes for voltage-gated sodium channels to open after threshold is reached

II.

A. force pushing sodium into neuron at resting potential

(Na^+ has both electrical and chemical gradients pushing it in)

B. force pushing potassium out of neuron at resting potential

III.

A. voltage-gated Ca^{++} channels in axon hillock

B. voltage-gated Ca^{++} channels in nerve terminals

(Ca^{++} channels in nerve terminals needed for neurotransmitter release)

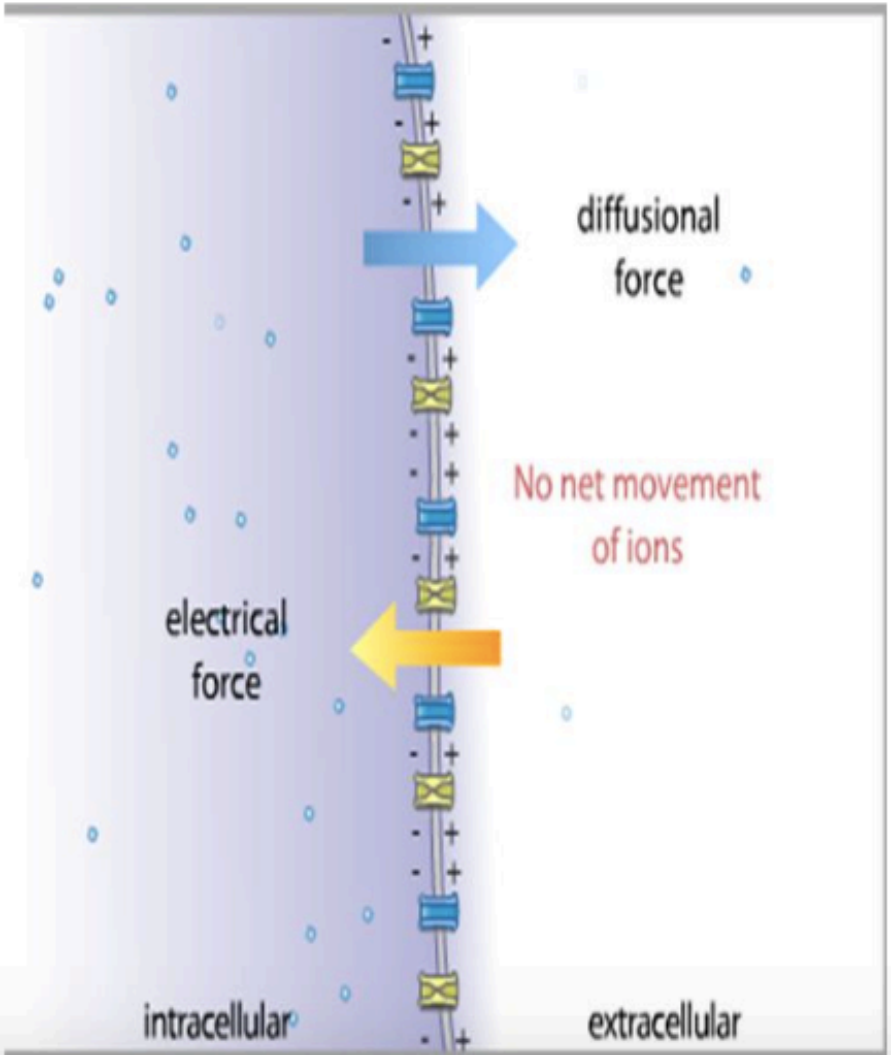
Nernst potential

Diffusion potential / equilibrium potential)

- The potential level across the membrane that exactly opposes net diffusion of a particular ion through the membrane

- EMF (electromotive force) = ± 61 log conc. inside / conc. outside

  - Potassium (Ek) = - 94 millivolts (negativity inside)
  - Sodium (ENa) = + 61 millivolts (positivity inside)
  - Chloride (Ecl) = - 70 millivolts (nerve fiber)
    = - 90 millivolts (muscle fiber)



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I.
- A. number of axon K+ channels open the threshold potential
- B. number of axon K+ channels open at the resting potential

II.
- A. chance of finding a graded potential at the pre-synaptic membrane
- B. chance of finding a graded potential at the post-synaptic membrane

III.
- A. number of neurotransmitter receptors on post-synaptic membrane
- B. number of neurotransmitter receptors on pre-synaptic membrane

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B. number of axon K+ channels open at the resting potential

Depolarization is due to opening of Na^+ channels, not closing of K^+ channels.

II.

A. chance of finding a graded potential at the pre-synaptic membrane

B. chance of finding a graded potential at the post-synaptic membrane

There is no graded potential on the pre-synaptic side.

III.

A. number of neurotransmitter receptors on post-synaptic membrane

B. number of neurotransmitter receptors on pre-synaptic membrane

Neurotransmitter release is unidirectional.

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I.
- A. potassium channels open during an EPSP
- B. potassium channels open during an IPSP

II.
- A. rate of substance moving down axon through the cytoplasm by simple diffusion
- B. rate of substance moving down axon by vesicular transport

III.
- A. sodium ions crossing the membrane during an EPSP
- B. sodium ions crossing the membrane during an IPSP

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Review

Consider two nerve cells that produce action potentials.
Cell #1 is a post-ganglionic cell of the parasympathetic nervous system.
Cell #2 is a sensory receptor in the olfactory cell.

Note: Pre-ganglionic cells are from brainstem or spinal cord. Post-ganglionic cells are from outside the central nervous system.

A. Which cell moves toward the central nervous system?

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A. Which cell moves toward the central nervous system?
   Cell #2, Sensory neurons move toward the CNS.

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B. Which cell should have voltage-gated Na+ channels?
    - Cell #1
    - Cell #2
    - Both
    - Neither

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Test Your Understanding

Select the statement that is false:

A.
Optogenetics is a technique that manipulates neural activity using light.

B.
Exogenous ligands are chemicals not made in the body that can bind to receptors in our nervous system.

C.
Ionotropic receptors are mechanically-gated.

D.
Influx of Ca^{2++} promotes exocytosis of neurotransmitters in the axon terminal.

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Explanation:

Ionotropic receptors are ligand-gated.

Test Your Understanding

The process by which a neuron summates synaptic excitation and inhibition is called:

A. Plasticity
B. Integration
C. Convergence
D. Pulse Frequency Modulation
E. Dis-inhibition

In the nervous system, the strength of the stimulus is coded into:

A. Frequency of Action Potentials Generated
B. Amplitude of Action Potentials Generated
C. Both Frequency and Amplitude of Action Potentials Generated

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Test Your Understanding

This term best represents a neural circuit where one pre-synaptic neuron synapses with several post-synaptic neurons in order to amplify a sensory signal:

A. Feed-Forward Excitation
B. Convergence
C. Divergence
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Explanation:

Diverging circuits allows one neuron to communicate with many neurons (i.e. skeletal muscle contractions). On the other hand, converging circuits allows one neuron to receive many inputs (i.e. spinal cord to brain).

Test Your Understanding:

During emotional states, epinephrine and norepinephrine are released because of activation of which of the following?

A. Cortex
B. Thalamus
C. Amygdala
D. Sympathetic Nervous System

What is the part of the limbic system involved in regulating emotion?

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Test Your Understanding:

What is the name for information sent from robot sensors to robot controllers?

A. Temperature
B. Pressure
C. Feedback
D. Signal
E. Output

Which of the basic parts of a robot unit would include the computer circuitry that could be programmed to determine what the robot would do?

A. Sensor
B. Controller
C. Arm
D. End Effector
E. Drive

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Test Your Understanding:

Which of the following terms is **not** one of the five basic parts of a robot?

A. Peripheral tools
B. Effectors
C. Controller
D. Drive
E. Sensor

The number of moveable joints in the base, the arm, and the end of the effectors of the robot determines:

A. Payload Capacity
B. Operational Limits
C. Flexibility
D. Degrees of Freedom
E. Cost

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Test Your Understanding

Which of the following systems mimics human thinking?

A. Artificial Intelligence
B. Intelligent Agent
C. Bot
D. Database Management System

Which AI System finds and identifies patterns, for instance, in the words you use?

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Test Your Understanding

True or False:

- The activation values of the hidden layer units in a neural network, with the sigmoid function applied at every layer, are always in the range (0,1).
- The outputs of a neural network represent probabilities and must sum to 1.
- Any logical function over binary-valued (0 or 1) inputs x_1 and x_2 can be *approximately* represented using some neural network.

Test Your Understanding

Which of the following statements are true?

- The activation values of the hidden layer units in a neural network, with the sigmoid function applied at every layer, are always in the range (0,1).
- The outputs of a neural network represent probabilities and must sum to 1.
- Any logical function over binary-valued (0 or 1) inputs x_1 and x_2 can be *approximately* represented using some neural network.

  Explanation: Since we can build the basic AND, OR, and NOT functions with the two layer network, we can approximately represent any logical function by composing these basic functions over multiple layers.

Test Your Understanding:

EEG activity is thought to arise from which of the following?

A. Cortical layers I and VI
B. Axonal action potentials
C. Horizontal dipoles
D. Excitatory and inhibitory post-synaptic potentials

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Explanation: EEG activity arises from the outermost cortex layer I and does not directly capture axonal action potentials. EEG is most sensitive to post-synaptic potentials generated in the superficial layers of the cortex.

KEEP
CALM
AND
GOOD
LUCK