Biological Psychology International Edition 14th edition Kalat Solutions Manual

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Instructor Manual

James W. Kalat, Biological Psychology, 2024, 9780357798126;
Chapter 1: The Cellular Foundations of Behavior

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Purpose and Perspective of the Chapter

The purpose of this chapter is to describe biological explanations of behavior, outline how neurons and other cells conduct signal transmission, and provide students with an understanding of how an action potential takes place.

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Chapter Objectives

The following objectives are addressed in this chapter:

1. State the mind–brain problem and contrast monism with dualism.
2. List three points that are important to remember from this text.
3. Give examples of physiological, ontogenetic, evolutionary, and functional explanations of behavior.
4. Discuss the ethical issues of research with laboratory animals.
5. Describe neurons and glia, the cells that constitute the nervous system.
6. Contrast axons with dendrites.
7. Summarize how the blood–brain barrier relates to protection and nutrition of neurons.
8. State the chemicals necessary for the brain's nutrition.
9. Describe the importance of bacteria in the intestines.
10. Contrast action potentials with electrical transmission.
11. Explain what causes the resting potential of a neuron.
12. Discuss how the movement of sodium and potassium ions produces the action potential and recovery after it.
13. State the all-or-none law of the action potential.
14. Explain how the action potential propagates along the axon.
15. Describe the importance of the refractory period, the myelin sheath, and local neurons.

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Complete List of Chapter Activities and Assessments

The following table organizes activities and assessments by objective, so that you can see how all this content relates to objectives and make decisions about which content you would like to emphasize in your class based on your objectives. For additional guidance, refer to the Teaching Online Guide.

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Chapter Objective	Activity/Assessment	Source (i.e., PPT slide, Workbook)	Duration	Certification Standard
LO 1.3	Stop and Check	Text p. 8	5 minutes	
LO 1.4	Stop and Check	Text p. 10	5 minutes	
LO 1.4	Stop and Check	Text p. 11	10 minutes	
LO 1.7	Stop and Check	Text p. 12	5 minutes	
LO 1.7	Discussion	PPT Slide 30	15 minutes	
LO 1.12	Discussion	PPT Slide 46	15 minutes	

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KEY TERMS

Biological psychology: the study of the physiological, evolutionary, and developmental mechanisms of behavior and experience

Dualism: the idea that minds are one type of substance and matter is another

Mind–body problem: how and why certain types of brain activity are conscious

Monism: mental activity and certain types of brain activity are inseparable

Physiological explanation: relates a behavior to the activity of the brain and other organs

Ontogenetic explanation: describes how something develops

Evolutionary explanation: reconstructs the evolutionary history of a structure or behavior

Functional explanation: describes why a structure or behavior evolved as it did

Neurons: receive information and transmit it to other cells

Membrane: a structure that separates the inside of the cell from the outside environment.

Nucleus: structure that contains the chromosomes

Ribosomes: structures that synthesize new protein molecules

Endoplasmic reticulum: a network of thin tubes that transport newly synthesized proteins to other locations

Mitochondrion: performs metabolic activities, providing the energy that the cell use for all activities

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Motor neuron: receives excitation through its dendrites and conducts impulses along its axon to a muscle

Sensory neuron: is specialized at one end to be highly sensitive to a particular type of stimulation

Dendrites: are branching fibers that get narrower near their ends

Dendritic spines: short outgrowths that increase the surface area available for synapses

Cell body or soma: contains the nucleus, ribosomes, and mitochondria

Axon: conveys an impulse to other neurons, an organ, or a muscle

Myelin sheath: an insulating material that covers axons

Nodes of Ranvier: interruptions in the myelin sheaths

Presynaptic terminal: swellings at the ends of axons

Afferent axon: brings information into a structure

Efferent axon: carries information away from a structure

Interneuron or intrinsic neuron: a cell's dendrites and axon are entirely contained within a single structure

Glia: a Greek word meaning "glue"

Astrocytes: star-shaped glia

Microglia: act as part of the immune system, removing viruses and fungi from the brain

Oligodendrocytes and Schwann cells: build the myelin sheaths that surround and insulate certain vertebrate axons

Radial glia: guide the migration of neurons and their axons and dendrites during embryonic development

Blood–brain barrier: the mechanism that excludes most chemicals from the vertebrate brain

Electrical gradient, also known as polarization: a difference in electrical charge between the inside and outside of the cell

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Resting potential: The inside of the membrane has a slight negative charge compared to the outside, mainly because of negatively charged proteins inside the cell. This difference in voltage is called the resting potential

Selectively permeable: the cell membrane is selectively permeable, letting some chemicals pass more freely than others

Sodium–potassium pump: a protein complex that repeatedly transports three sodium ions out of the cell while drawing two potassium ions in.

Concentration gradient: the difference in distribution of ions across the membrane.

Action potentials: when an axon send a message

Hyperpolarization: an increase the negative charge of a neuron

Threshold: the point at which the cell membrane opens

All-or-none law: the amplitude and velocity of an action potential are independent of the intensity of the stimulus that initiated it, provided that the stimulus reaches the threshold

Voltage-gated channels: open or close depending on the voltage across the membrane

Local anesthetic: drugs, such as Novocain and Xylocaine, attach to the sodium channels of the membrane, preventing sodium ions from entering.

Propagation of the action potential: describes the transmission of an action potential down an axon

Absolute refractory period: the time when the membrane cannot produce an action potential, regardless of the stimulation

Relative refractory period: when a stronger-than-usual stimulus is necessary to initiate an action potential

Saltatory conduction: from the Latin word saltare, meaning “to jump”

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What’s New in This Chapter

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- *A new section on Neuroethics, including issues in dealing with human participants.*
- *The important contributions of gut bacteria and mitochondrial genes, two topics historically overlooked.*

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CHAPTER OUTLINE

The following outline organizes activities (including any existing discussion questions in PowerPoints or other supplements) and assessments by chapter (and therefore by topic), so that you can see how all the content relates to the topics covered in the text.

I. Biological Explanations of Behavior (LO 1.1–1.4, PPT 7–14)
   a. Biological explanations of behavior fall into four categories:
      I. Physiological – relates a behavior to the activity of the brain and other organs.
      II. Ontogenetic – describes how something develops.
      III. Evolutionary – reconstructs the evolutionary history of a structure or behavior.
      IV. Functional – describes why a structure or behavior evolved as it did.
   b. Career Opportunities
      I. A research position ordinarily requires a PhD degree.
      II. Fields of therapy include clinical psychology, counseling psychology, school psychology, medicine, and allied medical practice such as physical therapy.
      III. Anyone who pursues a career in research needs to stay up to date on new developments.
   c. Neuroethics
      I. Why do biological psychologists study nonhumans?
         (1) Many of the mechanisms of behavior are similar across species, and sometimes, they are easier to study in a nonhuman species.
         (2) We are interested in animals for their own sake.
         (3) What we learn about animals sheds light on human evolution.
         (4) Legal or ethical restrictions prevent certain kinds of research on humans.
      II. The legal standard emphasizes “the three Rs.”

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(1) Reduction of animal numbers (using fewer animals)
(2) Replacement (using computer models or other substitutes for animals when possible)
(3) Refinement (modifying the procedures to reduce pain and discomfort)

III. Research with humans raises different types of ethical concerns.
(1) Sometimes, a patient undergoing surgery is invited to participate in a study.
(2) A successful procedure may have negative effects.
(3) Most research has been done in North America or Europe, and most studies of humans have used relatively prosperous people, mostly people of European ancestry, not a representative sample of all humanity.

IV. **Knowledge Check Activity: 5 minutes total.** Students will review the three "Rs" for animal research.

II. Neurons and Other Cells (LO 1.5–1.9, PPT 15–30)
a. Santiago Ramón y Cajal, a Pioneer of Neuroscience
I. In the late 1800s, the Spanish investigator Santiago Ramón y Cajal (1852–1934) was the first to demonstrate that the individual cells comprising the nervous system remained separate.
II. He showed that they did not merge into each other as previously believed.
b. The Structures of an Animal Cell
I. Like other cells in the body, neurons contain the following structures:
(1) Membrane
(2) Nucleus
(3) Mitochondria
(4) Ribosomes
(5) Endoplasmic reticulum
II. Membrane: separates the inside of the cell from the outside environment
III. Nucleus: contains the chromosomes
IV. Mitochondrion: performs metabolic activities and provides energy that the cells require
V. Ribosomes: sites at which the cell synthesizes new protein molecules

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VI. Endoplasmic reticulum: network of thin tubes that transports newly synthesized proteins to their location.
VII. Compared to other cells, the most distinctive feature of neurons is their highly variable shape.
VIII. All neurons include a soma (cell body), and most also have dendrites, an axon, and presynaptic terminals.

c. Motor Neurons and Sensory Neurons
   I. A motor neuron
      (1) Has its soma in the spinal cord
      (2) Receives excitation from other neurons
      (3) Conducts impulses along its axon to a muscle or gland
   II. A sensory neuron
      (1) Is specialized at one end to be highly sensitive to a particular type of stimulation (touch, light, sound, etc.)

d. Other terms associated with neurons are afferent, efferent, and intrinsic.
   I. An afferent axon brings information into a structure.
   II. An efferent axon carries information away from a structure.
   III. If a cell's dendrites and axon are entirely contained within a single structure, the cell is an interneuron or intrinsic neuron of the structure.

e. Glia
   I. Astrocytes
      (1) Help synchronize the activity of the axon by wrapping around the presynaptic terminal and taking up chemicals released by the axon
      (2) Responsible for dilating blood vessels to bring more nutrients into brain areas with heightened activity
   II. Microglia
      (1) Remove waste material, viruses, and fungi from the brain
      (2) Also remove dead, dying, or damaged neurons
   III. Oligodendrocytes (in the brain and spinal cord) and Schwann cells (in the periphery of the body)
      (1) Build the myelin sheath that surrounds and insulates certain vertebrate axons
   IV. Radial glia
      (1) Guide the migration of neurons and the growth of their axons and dendrites during embryonic development

f. The Blood–Brain Barrier

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I. A mechanism that surrounds the brain and blocks most chemicals from entering
   (1) The immune system destroys damaged or infected cells throughout the body.
   (2) Because neurons in the brain generally do not regenerate, it is vitally important for the blood–brain barrier to block incoming viruses, bacteria, or other harmful material from entering.
II. Active Transport
   (1) The protein-mediated process that expends energy to pump chemicals from the blood into the brain
      (a) Glucose, certain hormones, amino acids, and a few vitamins are brought into the brain via active transport.
   (2) The blood–brain barrier is essential to health, but can pose a difficulty in allowing chemicals such as chemotherapy for brain cancer to pass the barrier.

g. Nourishment of Vertebrate Neurons
I. Vertebrate neurons depend almost entirely on glucose.
   (1) A sugar that is one of the few nutrients that can pass through the blood–brain barrier
II. Neurons need a steady supply of oxygen.
   (1) 20 percent of all oxygen consumed by the body is used by the brain.
III. The body needs a vitamin, thiamine, to use glucose.
IV. Prolonged thiamine deficiency leads to death of neurons as seen in Korsakoff's syndrome, a result of chronic alcoholism.
   (1) Korsakoff's syndrome is marked by severe memory impairment.

h. Other Cells: The Gut Bacteria
I. Another influence on your behavior comes from cells that are not really you, genetically. They are "guests" in your body—the bacteria in your gut.
II. Bacteria influence brain activity in several ways.
   (1) Stimulate the vagus nerve
   (2) Release chemicals that cross the lining of the intestines and enter the blood
III. Stress increases the type of bacteria that cause inflammation and mitochondrial damage.

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i. **Discussion Activity: 15 minutes total.** In a small group, discuss the advantages and disadvantages of having a blood–brain barrier.

III. The Action Potential (LO 1.10–1.15, PPT 31–45)

a. The Resting Potential of the Neuron

I. Messages in a neuron develop from disturbances of the resting potential.

II. At rest, the membrane maintains an electrical gradient known as polarization.

(1) A difference in the electrical charge inside and outside of the cell

III. The inside of the membrane is slightly negative with respect to the outside (approximately 70 millivolts).

IV. The resting potential of a neuron refers to the state of the neuron prior to the sending of a nerve impulse.

b. Forces Acting on Sodium and Potassium Ions

I. The membrane is selectively permeable, allowing some chemicals to pass more freely than others.

II. Sodium, potassium, calcium, and chloride pass through channels in the membrane.

III. When the membrane is at rest:

(1) Sodium channels are closed

(2) Potassium channels are partially closed allowing the slow passage of potassium

c. Ion Channels

I. The sodium–potassium pump is a protein complex.

(1) Continually pumps three sodium ions out of the cells while drawing two potassium ions into the cell

(2) Helps to maintain the electrical gradient

(3) Uses active transport (requires ATP)

II. The electrical gradient and the concentration gradient—the difference in distributions of ions—work to pull sodium ions into the cell.

III. Information

d. The Action Potential

I. The resting potential remains stable until the neuron is stimulated.

(1) Hyperpolarization

(2) Depolarization

(3) The threshold of excitation

(4) The all-or-none law

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II. The Molecular Basis of the Action Potential
(1) The chemical events behind the action potential make sense if you remember three principles:
(a) At the start, sodium ions are mostly outside the neuron, and potassium ions are mostly inside. Depolarizing the membrane opens the sodium and potassium channels (voltage-gated channels).
(b) At the peak of the action potential, the sodium channels close.

e. Propagation of the Action Potential
I. In a motor neuron, the action potential begins at the axon hillock (a swelling where the axon exits the soma).
II. Propagation of the action potential: the transmission of the action potential down the axon
(1) The action potential does not directly travel down the axon.
III. After an action potential, a neuron has a refractory period during which time the neuron resists the production of another action potential.
(1) The absolute refractory period
(2) The relative refractory period

f. The Myelin Sheath and Saltatory Conduction
I. The myelin sheath of axons is interrupted by short unmyelinated sections called nodes of Ranvier.
(1) Myelin is an insulating material composed of fats and proteins.
(2) At each node of Ranvier, the action potential is regenerated by a chain of positively charged ions pushed along by the previous segment.
II. The “jumping” of the action potential from node to node
(1) Provides rapid conduction of impulses

g. Local Neurons
I. Have no axons, exchange information with only close neighbors, and do not produce action potentials
II. When stimulated, produce graded potentials—membrane potentials that vary in magnitude and do not follow the all-or-none law
III. Depolarize or hyperpolarize in proportion to the stimulation
IV. Difficult to study due to their small size

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h. **Discussion Activity: 15 minutes total.** In a small group, discuss if a drug partly blocks a membrane's potassium channels, how does it affect the action potential?

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Additional Discussion Questions

The following are discussion questions that do not appear in the text, PPTs, or courseware (if courseware exists) – they are for you to use as you wish. You can assign these questions several ways: in a discussion forum in your LMS; as whole-class discussions in person; or as a partner or group activity in class.

1. Discussion: How does the form of a neuron relate to its function? Duration 10 minutes.
2. How are neurons different from other body cells? Duration 10 minutes.
3. How do ions relate to neurons, membrane potential, and thoughts? Duration 10 minutes.
4. What is diffusion and why is it important for neurons? Duration 10 minutes.
5. What would be the effect on the neuron if there was no refractory period? Duration 10 minutes.

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Additional Activities and Assignments

The following are activities and assignments developed by Cengage but not included in the text, PPTs, or courseware (if courseware exists) – they are for you to use if you wish.

1. **Concentration Gradient**: To visually demonstrate how particles will passively move from an area of high concentration to an area of low concentration, add dye to a large container of water and let the color disperse.
    a. A large flask (4 L) and about 1 mL of blue food coloring work very well.
2. **Demonstrating the Action Potential**: With the use of dominos, explain how the action potential works. Dominos and a stick or a thin wooden ruler are required. Arrange dominos in a straight line, and tell your students that this represents a neuron. After pushing the first domino, all others fall in sequence:

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This provides an example of how an action potential begins in one area of a neuron (axon hillock) and travels down the axon.

   a. The concept of the refractory period is demonstrated when you cannot knock over the dominos again until you reset them. In addition, by giving the first domino a slight touch (which is not strong enough to knock it over), you can allow students to conceptualize the all-or-none principle (an action potential will not occur unless the stimulus, which creates it forces the neuron to reach its threshold).

3. **The Colossal Neuron: Acting out Physiological Psychology**: This is an interesting class demonstration that works well even in large lecture classes. The demonstration involves 30 students joining to construct a "functional" colossal neuron. Principles such as the movement of ions during the action potential and synaptic transmission are demonstrated.
   a. The full instructions for this exercise can be found in the article: Hamilton, S. B., & Knox, T. A. (1985). The colossal neuron: acting out physiological psychology. Teaching of Psychology, 12, 153–156.
4. **Action Potential-Epilepsy**: In this activity, students simulate how an action potential starts in a neuron using dried peas and beans to represent ions.
   a. The activity provides students with a better understanding of how Na+ and K+ ions move across the membrane and the mechanisms that allow a neuron to remain at rest. It also allows students to apply knowledge of how the action potential works under normal conditions to what may be occurring during epilepsy. The exercise was developed by Thomas Conley and Beth Shepley for the Neuroscience Laboratory and Classroom Activities Manual. The full instructions can be found at **https://www.nabt.org/files/galleries/12NLCAchp10.pdf.**
5. **Neuron Slide Show:** To demonstrate the many unique shapes of neurons in the nervous system, supplement the images from the text with images downloaded from the following website:
   a. **http://faculty.washington.edu/chudler/gall1.html**
6. **Anatomy of a Neuron:** To demonstrate the anatomy of a neuron, take an arm-length latex glove and blow it up (or simply use your forearm.) The fingers represent the multiple dendrites that convey information to the cell body (the hand). Information is consolidated at the cell body, and an action potential will be initiated at the axon hillock (the wrist).
   a. The arm is the axon, which carries the action potential away from the cell body.
7. **Myelination:** To illustrate the difference between propagation of the action potential along unmyelinated and myelinated axons, use the graphic found on **http://www.brainviews.com/abFiles/AniSalt.htm.**

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a. The class can discuss other factors that affect the speed of propagation along a neuron, such as the diameter of the neuron and why some neurons are myelinated, and some are unmyelinated.

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ADDITIONAL RESOURCES

CENGAGE VIDEO RESOURCES

- Refer to MindTap Video Resources

EXTERNAL VIDEOS OR PLAYLIST

- The Ethics of Human Brain Surrogates Research: When does a surrogate brain become a moral agent? In this webinar, we try to unpack some of the interesting and complicated issues related to the ethics of brain surrogate research. **https://www.youtube.com/watch?v=INMhmIYGut4**
- The ethics behind your neurogenetics: Dr. Emma Yhnell, an alumna and now working in the Neuroscience and Mental Health Research Institute (NMHRI), discusses research into genetic disorders and the challenging ethical dilemmas that are associated with this area of research. She is a Health and Care Research Wales Fellow working in the Neuroscience and Mental Health Research Institute (NMHRI). My fellowship is focused on exploring computerized cognitive training (brain training) for people with Huntington's disease. This talk was given at a TEDx event using the TED conference format but independently organized by a local community. **https://www.youtube.com/watch?v=8yhEd5cMGTk**

INTERNET RESOURCES

- This site developed by Dr. John H. Krantz at Hanover College provides an excellent review of the forces involved in the action potential. **http://psych.hanover.edu/Krantz/neural/actionpotential.html**
- This site was designed by Dr. Eric Chudler at the University of Washington and is one of the best resources for teaching basic biological psychology on the web. Although developed for secondary students, it provides a great overview for both the neuronal structure and neurophysiology discussed in this chapter. **http://faculty.washington.edu/chudler/introb.html#bb**

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- This electronic textbook, The Nerve Impulse, is written by F. Bezanilla and gives a thorough overview of the molecular basis of the action potential and other membrane properties. **http://nerve.bsd.uchicago.edu/med98a.htm**
- This online biology textbook is written by J.W. Kimball. The section on excitable cells gives a concise overview of the signaling properties of neurons. **http://www.biology-pages.info/E/ExcitableCells.html**
- This website provides information on the ethical issues surrounding using animals for research. **https://www.americanbraincoalition.org/page/AnimalsInResearch**
- Towards an antiracist (neuro)science: This web article addresses issues surrounding racism and brain research. **https://www.nature.com/articles/s41562-021-01075-y**

Primary Sources

- APA Guidelines for research with Nonhuman animals **https://www.apa.org/science/leadership/care/guidelines**

Cengage Audio Resources

- Refer to MindTap Audio Resources

External Audio Resources

- StarTalk Podcast: Science of the Brain with Neil deGrasse Tyson: Psychedelic drugs, dreams, mental health awareness, understanding our reality, and more – Neil deGrasse Tyson, neuroscientist Heather Berlin, PhD, and first-time comic co-host Jackie Hoffman answer fan-submitted questions about neuroscience. **https://www.youtube.com/watch?v=vRxyCoquhmI**
- Neuroscience of Everyday Life: Audible: https://www.audible.com/pd/Neuroscience-of-Everyday-Life-Audiobook/1629976695

List of Transcripts for Audio Assignments

- Refer to Cengage for all available audio transcripts.

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