Solutions for Psychology An Exploration 4th Edition by Ciccarelli

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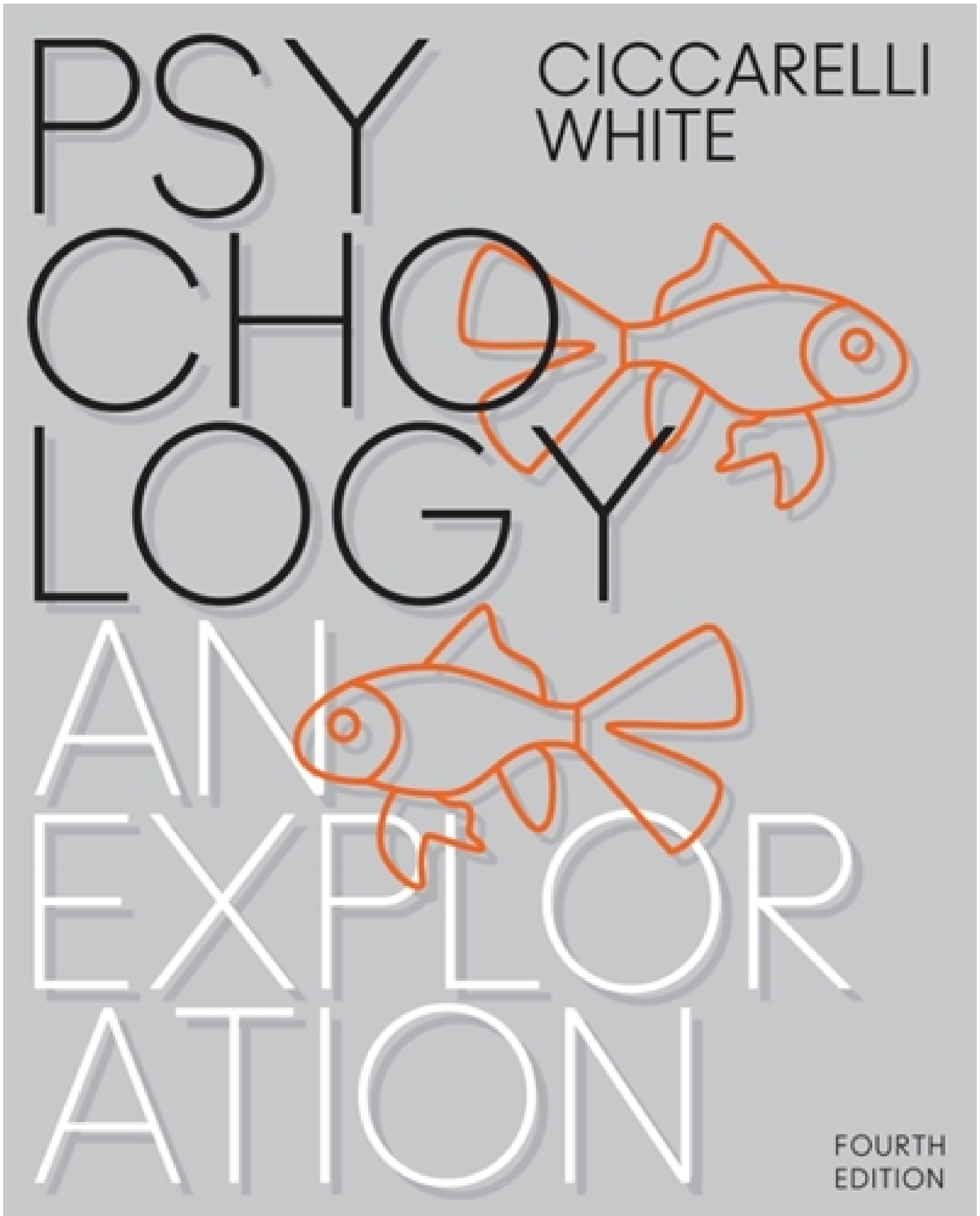

Solutions

the biological perspective

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►LECTURE GUIDE

►FULL CHAPTER RESOURCES

▼CHAPTER-AT-A-GLANCE

Detailed Outline	*Instructor Resources*	*Revel Multimedia*
Neurons and Nerves: Building the Network Structure of the Neuron Generating the Message Neurotransmission	**Learning Objectives:** 2.1, 2.2, 2.3 **Lecture Launchers:** 2.1, 2.2, 2.3, 2.4 **Activities & Exercises:** 2.1, 2.2, 2.3	**Video**: Why Study The Nervous System and the Glands? **Interactive**: The Structure of the Neuron **Interactive**: The Neural Impulse Action Potential **Interactive**: The Synapse **Interactive**: Neurotransmitters – Reuptake
An Overview of the Nervous System The Central Nervous System The Peripheral Nervous System	**Learning Objectives:** 2.4, 2.5 **Lecture Launchers:** 2.5, 2.6 **Activities & Exercises:** 2.4, 2.5, 2.6	**Video**: Overview of Neuroplasticity **Survey**: Do You Fly or Fight? **Interactive**: The Spinal Cord Reflex **Interactive**: Functions of the Parasympathetic and Sympathetic Divisions
The Endocrine Glands The Pituitary Other Endocrine Glands Hormones and Stress	**Learning Objectives:** 2.6, 2.7, 2.8 **Lecture Launchers:** 2.7	**Interactive**: General Adaptation Syndrome
Looking Inside the Living Brain Methods for Studying Specific Brain Regions Neuroimaging Techniques	**Learning Objectives:** 2.9, 2.10 **Lecture Launchers:** 2.8, 2.9, 2.10, 2.11	**Interactive**: Mapping Brain Structure **Interactive**: Mapping Brain Function
Structures of the Brain The Hindbrain The Limbic System The Cortex Association Areas of the Cortex Cerebral Hemispheres	**Learning Objectives:** 2.11, 2.12, 2.13, 2.14, 2.15 **Lecture Launchers:** 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19 **Activities & Exercises:** 2.7, 2.8, 2.9, 2.10 **Handout:** 2.1	**Interactive**: Major Structures of the Human Brain **Interactive**: The Limbic System **Interactive**: Lobes and Cortical Areas of the Brain
Applying Psychology to Everyday Life: Paying Attention to the Causes of ADHD	**Learning Objective:** 2.16	**Interactive**: Phineas Gage's Accident

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▼Lecture Guide

I. NEURONS AND NERVES: BUILDING THE NETWORK

Lecture Launchers and Discussion Topics
➢ *2.1 Neurotransmitters: Chemical Communicators of the Nervous System*
➢ *2.2 Exceptions to the Rules*
➢ *2.3 The Glue of Life: Neuroglial Cells*
➢ *2.4 My Mother, Myself*
Classroom Activities, Demonstrations, and Exercises
➢ *2.1 - Using Dominoes to Understand the Action Potential*
➢ *2.2 - Stemming the Tide of Misinformation*
➢ *2.3 - Environmental Influences on the Brain*

➢ *REVEL Multimedia*
➢ *MyPsychLab Multimedia*

Learning Objective 2.1 - Identify the parts of a neuron and describe the function of each.

A. Structure of the neuron: The nervous system's building block
   1. Neurons: Dendrites, soma, axons
      a. Myelin insulates and protects axons, speeds neural conduction
   2. Glial cells support, separate, and insulate neurons from each other

Learning Objective 2.2 - Explain the action potential.

B. Generating the message within the neuron: The neural impulse
   1. At rest, the neuron is negatively charged inside and positively charged outside
   2. When stimulated, the charge reverses
      a. This is the action potential
   3. Neurons fire in an all-or-nothing manner

Learning Objective 2.3 - Describe how neurons use neurotransmitters to communicate with each other and with the body.

C. Sending the message to other cells: The synapse
   1. Synaptic vesicles release neurotransmitter into the synaptic gap
   2. Neurotransmitter molecules fit into receptor sites
      a. Neurotransmitters may be either excitatory or inhibitory
D. Neurotransmitters: Messengers of the network
   1. Acetylcholine
   2. Norepinephrine
   3. Dopamine
   4. Serotonin
   5. GABA
   6. Glutamate
   7. Endorphins
E. Cleaning up the synapse: Reuptake and enzymes
   1. Most neurotransmitters are taken back into the synaptic vesicles
   2. Acetylcholine is cleared out of the synapse by enzymes that break up the molecules

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II. AN OVERVIEW OF THE NERVOUS SYSTEM

Lecture Launchers and Discussion Topics
- *2.5 Brain Metaphors*
- *2.6 The Cranial Nerves*

Classroom Activities, Demonstrations, and Exercises
- *2.4 - Demonstrating Neural Conduction: The Class as a Neural Network*
- *2.5 - The Dollar Bill Drop*
- *2.6 - Reaction Time and Neural Processing*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.4 - Describe how the components of the central nervous system interact and how they may respond to experience of injury.

A. The central nervous system
  1. Brain
  2. Spinal cord
  3. Neuroplasticity and neurogenesis offer exciting possibilities for cell regeneration

Learning Objective 2.5 - Differentiate the roles of the somatic and autonomic nervous systems.

B. The peripheral nervous system
  1. The somatic nervous system
    a. Sensory pathway
    b. Motor pathway
  2. The autonomic nervous system
    a. Sympathetic division
    b. Parasympathetic division

III. DISTANT CONNECTIONS: THE ENDOCRINE SYSTEM

Lecture Launchers and Discussion Topics
- *2.7 Hormone Imbalances*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.6 - Explain why the pituitary gland is known as the "master gland."

A. Pituitary gland
  1. Just below the hypothalamus
  2. Controls the levels of salt and water in the system
  3. In women, controls the onset of labor and lactation
    a. "Love hormones" and "trust hormones" have popular appeal

Learning Objective 2.7 - Recall the role of various endocrine glands.

B. Other endocrine glands
  1. Pineal gland: secretes melatonin
  2. Thyroid gland: controls metabolism by secreting thyroxin
  3. Pancreas: controls sugar in the blood by secreting insulin and glucagons
  4. Gonads: ovaries and testes regulate sexual growth, activity, reproduction
  5. Adrenal glands: on top of each kidney; control stress reactions

Learning Objective 2.8 - Describe how the autonomic nervous system and body are impacted by stress.

C. The General Adaptation Syndrome
  1. The general adaptation syndrome is the body's reaction to stress
  2. Three stages of reaction: alarm, resistance, and exhaustion

D. Immune system and stress
  1. Stress causes the immune system to react as though an illness or invading organism has been detected, increasing the functioning of the immune system
     a. As the stress continues or increases, the immune system can begin to fail
        i. Psychoneuroimmunologists investigate the causes and consequences of this
           - A complex interplay of duration, hormones, cortisol, immune defenses
        ii. The HPA axis and allostasis play an important role in this regard
  2. Stress puts people at a higher risk for coronary heart disease
     a. Clogged arteries, decreased liver functioning, stroke
     b. A complex interplay of sources of stress, behavioral habits, interpretation
  3. Stress can contribute indirectly to the development of cancer
     a. Stress suppresses the immune system, making cancer growth more likely
        i. Suppresses immune-system cell called a natural killer (NK) cell whose main function is the suppression of viruses and the destruction of tumor cells
  4. Stress can contribute to excessive weight gain, which in turn presages diabetes

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IV. LOOKING INSIDE THE LIVING BRAIN

Lecture Launchers and Discussion Topics
- *2.8 Psychophysiological Measurement*
- *2.9 Berger's Wave*
- *2.10 Lie Detectors 2.0*
- *2.11 Using fMRI and MEG to Study Phantom Limb Pain*

- *REVEL Multimedia*
- *MyPsychLab Multimedia*

Learning Objective 2.9 - Describe how lesioning studies and brain stimulation are used to study the brain.

A. Lesioning studies
  1. Destroy certain areas of the brain in animals
  2. Case studies of human brain damage

B. Brain stimulation
  1. Deep brain stimulation (DBS) is an invasive technique
     a. Optogenetics may offer a comparable alternative
  2. TMS, rTMS, and tDCS are noninvasive methods for stimulating the brain

Learning Objective 2.10 - Compare and contrast neuroimaging techniques for mapping the brain's structure and function.

C. Mapping structure
  1. CT scans are computer-aided X-rays that show the skull and brain structure

2. MRI scans use a magnetic field, radio pulses, and a computer
3. Diffusion tensor imaging (DTI) off to a promising start

D. Mapping function
1. EEG uses electrodes placed on the scalp that are then amplified and viewed
2. ERPs offers a glimpse of activity in response to a stimulus
3. MEG directly identifies areas of brain activation
4. PET scans use a radioactive sugar injected into the bloodstream
5. fMRI allows researchers to look at the activity of the brain over a time period.

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IV. FROM THE BOTTOM UP: STRUCTURES OF THE BRAIN

Lecture Launchers and Discussion Topics
➢ *2.12 - The Importance of a Wrinkled Cortex*
➢ *2.13 - Brain's Bilingual Broca*
➢ *2.14 - A New Look at Phineas Gage*
➢ *2.15 - Freak Accidents and Brain Injuries*
➢ *2.16 - Understanding Hemispheric Function*
➢ *2.17 - Handedness, Eyedness, Footedness, Facedness*
➢ *2.18 – Workplace Problems: Left-handedness*
➢ *2.19 - The Results of a Hemispherectomy*
Classroom Activities, Demonstrations, and Exercises
➢ *2.7 - Mapping the Brain*
➢ *2.8 - Football and Brain Damage*
➢ *2.9 - Hemispheric Lateralization*
➢ *2.10 - Hemispheric Communication and the Split Brain*

➢ *REVEL Multimedia*
➢ *MyPsychLab Multimedia*

Learning Objective 2.11 - Identify the different structures of the hindbrain and the function of each.

A. The hindbrain
1. *Medulla*—regulates breathing and heart rate; automatic functions
2. *Pons*—involved in sleeping, waking, and dreaming
3. *Reticular formation*—responsible for arousal and alertness
4. *Cerebellum*—regulates balance and coordination of movement

Learning Objective 2.12 - Identify the structures of the brain involved in emotion, learning, memory, and motivation.

B. Structures under the cortex
1. *Thalamus*—directs incoming sensory messages to higher centers
2. *Hypothalamus*—associated with drives, such as hunger, thirst, emotion, sex
3. *Hippocampus*—"gateway to memory" that enables us to form new memories
4. *Amygdala*—evaluates sensory information to determine its importance
5. *Cingulate cortex* –regions contribute to different aspects of emotion and cognition

Learning Objective 2.13 - Identify the parts of the cortex that process the different senses and those that control movement of the body.

C. Cortex

1. Connected by band of fibers called corpus callosum
2. Right hemisphere in charge of left side of the body
3. Left hemisphere in charge of right side of the body
4. Lateralization—each hemisphere has somewhat different tasks and talents
5. Divided into four regions
   a. *Occipital lobes*—contain the visual cortex
   b. *Parietal lobes*—contain somatosensory cortex, that receives information about pressure, pain, touch, and temperature from all over the body
   c. *Temporal lobes*—contain auditory cortex
   d. *Frontal lobes*—contain the motor cortex; responsible for making plans, taking initiative, and thinking creatively

Learning Objective 2.14 - Name the parts of the cortex responsible for higher forms of thought, such as language.

D. Association areas of the cortex
   1. Association areas are found in all the lobes but particularly in the frontal lobes
   2. Help make sense of information received from lower areas of the brain
   3. Broca's area is responsible for producing fluent, understandable speech
   4. Wernicke's area is responsible for the understanding of language
   5. Spatial neglect can sometimes occur following a stroke

Learning Objective 2.15 - Explain how some brain functions differ between the left and right hemispheres.

E. The cerebral hemispheres
   1. Left side of the brain seems to control language, writing, logical thought, analysis, and mathematical abilities
   2. The right side of the brain processes information globally and controls emotional expression, spatial perception, and recognition of faces, patterns, melodies, and emotions
   3. Information presented only to the left hemisphere can be verbalized but information only sent to the right cannot
      a. Split-brain research, handedness, provide evidence of these properties

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V. APPLYING PSYCHOLOGY TO EVERYDAY LIFE: PAYING ATTENTION TO ATTENTION-DEFICIT/HYPERACTIVITY DISORDER

➢ *REVEL Multimedia*
➢ *MyPsychLab Multimedia*

Learning Objective 2.16 - Identify some potential causes of attention-deficit/hyperactivity disorder.

A. ADHD may be caused by the interaction of a variety of factors
B. Often persists into adulthood

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VI. CHAPTER SUMMARY

Classroom Activities, Demonstrations, and Exercises
- *Crossword Puzzle*
- *Fill-in-the-Blanks*

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▼LEARNING OBJECTIVES

2.1 Identify the parts of a neuron and describe the function of each.

2.2 Explain the action potential.

2.3 Describe how neurons use neurotransmitters to communicate with each other and with the body.

2.4 Describe how the components of the central nervous system interact and how they may respond to experience of injury.

2.5 Differentiate the roles of the somatic and autonomic nervous systems.

2.6 Explain why the pituitary gland is known as the "master gland."

2.7 Recall the role of various endocrine glands.

2.8 Describe how the autonomic nervous system and body are impacted by stress.

2.9 Describe how lesioning studies and brain stimulation are used to study the brain.

2.10 Compare and contrast neuroimaging techniques for mapping the brain's structure and function.

2.11 Identify the different structures of the hindbrain and the function of each.

2.12 Identify the structures of the brain involved in emotion, learning, memory, and motivation.

2.13 Identify the parts of the cortex that process the different senses and those that control movement of the body.

2.14 Name the parts of the cortex responsible for higher forms of thought, such as language.

2.15 Explain how some brain functions differ between the left and right hemispheres.

2.16 Identify some potential causes of attention-deficit/hyperactivity disorder.

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▼RAPID REVIEW

The **nervous system** is composed of a complex network of cells throughout the body. The cells in the nervous system that carry information are called **neurons**. Information enters at the **dendrites**, flows through the cell body (or **soma**) and down the **axon**. Although neurons are the cells that carry the information, most of the nervous system consists of **glial cells** that provide food, support, and insulation to the neuron cells. The insulation around the neuron is called **myelin** and works in a way similar to the plastic coating on an electrical wire. Bundles of myelin-coated axons are wrapped together in cable-like structures called **nerves**. The movement of an electrical signal across a neuron is called an **action potential**. A neuron fires in an **all-or-none** manner: The neuron either has an action potential or it does not. When the electrical signal travels down the axon and reaches the other end of the neuron called the **axon terminal**, it causes the **neurotransmitters** in the **synaptic vesicles** to be released into the fluid-filled **synapse** between the two cells.

The **central nervous system (CNS)** is made up of the brain and the **spinal cord**. **Afferent (sensory) neurons** send information from the senses to the spinal cord, whereas **efferent (motor) neurons** send commands from the spinal cord to the muscles. **Interneurons** connect sensory and motor neurons and help to coordinate the signals. The **peripheral nervous system (PNS)** is made up of all the nerves and neurons that are NOT in the brain or spinal cord, and is divided into two parts: the **somatic nervous system** and the **autonomic nervous system**. The autonomic nervous system is in turn divided into two parts: the **sympathetic division** and the **parasympathetic division**.

The **endocrine glands** represent a second communication system in the body. The endocrine glands secrete chemicals called **hormones** directly into the bloodstream. The **pituitary gland** is located in the brain and secretes the hormones that control milk production, salt levels, and the activity of other glands. The **pineal gland** is also located in the brain and regulates the sleep cycle through the secretion of melatonin. The **thyroid gland** is located in the neck and releases a hormone that regulates metabolism. The **pancreas** controls the level of blood sugar in the body, whereas the **gonad** sex glands regulate sexual behavior and reproduction. The **adrenal glands** play a critical role in regulating the body's response to stress.

Hans Selye proposed the **general adaptation syndrome**, consisting of alarm, resistance, and exhaustion phases. **Psychoneuroimmunologists**, who study the effects of psychological factors on the immune system, have found that high stress levels are linked to increased risk of heart disease and can decrease **natural killer cells** responsible for fighting cancerous growths.

Two techniques used to study the brain involve either destroying a specific area of the brain (**lesioning**) or stimulating a specific brain area to see the effect. Researchers have developed several methods such as **CT**, **MEG**, **MRI**, **EEG**, **PET**, **fMRI**, or **TMS**.

The brain can be roughly divided into three sections: the forebrain, the midbrain, and the hindbrain. The many structures within each division are discussed, such as the **brainstem**, **medulla**, **reticular formation**, **limbic system**, **thalamus**, **hypothalamus**, **hippocampus**, **amygdala**, **cortex**, **cerebral hemispheres**, **corpus callosum**, **occipital lobes**, **parietal lobes**, **temporal lobes**, and **frontal lobes**. **Mirror neurons**, neurons that fire when we perform an action and also when we see someone else perform that action, may explain a great deal of the social learning that takes place in humans from infancy on. **Association areas** are the areas within each of the lobes that are responsible for "making sense" of all the incoming information.

Broca's area is located in the left frontal lobe and **Wernicke's area** is located in the left temporal lobe; both play a role in language. The **cerebrum** is made up of the two cerebral hemispheres and the structures connecting them. **Split-brain research** helped scientists understand that the two cerebral hemispheres are not identical.

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▼CHANGES FROM THE THIRD EDITION TO THE FOURTH EDITION

Chapter 2: The Biological Perspective

- Updated art and animations appear throughout the chapter, and interactive visual brain figures are included as well
- Some headings were updated and shortened to better accommodate mobile users
- Research on the functions of glial cells and myelin was updated
- Coverage of neurogenesis and discussion of neuroplasticity were expanded, with research on new methods of repairing spinal cord damage and brain damage
- A new discussion of epigenetics (key term) is included
- New research on the relationship between sex hormones and cognitive changes during aging is present
- Research on oxytocin's effects was added
- A discussion of optogenetics, a developing area in brain stimulation, is included
- New research showing the connection between the cerebellum and disorders characterized by perceptual disturbances is discussed
- New research suggesting activity in the amygdala impacts hippocampal neuroplasticity has been incorporated
- A revised discussion of Broca's area and its connection to speech appears
- Statistics on the rates of handedness have been added
- A new APA Goal 2 feature on Phineas Gage is included
- New research in the *Applying Psychology to Everyday Life* feature on ADHD is presented
- A discussion of allostasis and allostatic load was added to the material on the immune system and stress

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▼LECTURE LAUNCHERS AND DISCUSSION TOPICS

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Lecture Launcher 2.1 –
Neurotransmitters: Chemical Communicators of the Nervous System

In 1921, Otto Loewi put two living hearts in a fluid bath that kept them beating. He stimulated the vagus nerve of one of the hearts. This is a bundle of neurons that serves the parasympathetic nervous system and causes a reduction in the heart's rate of beating. A substance was released by the nerve of the first heart and was transported through the fluid to the second heart. The second heart reduced its rate of beating. The substance released from the vagus nerve of the first heart was later identified as *acetylcholine*, one of the first neurotransmitters to be identified. Although many other neurotransmitters have now been identified, we continue to think of acetylcholine as one of the most important neurotransmitters. For example, curare is a poison that was discovered by South American Indians, who put it on the tips of the darts they shoot from their blowguns. Curare blocks acetylcholine receptors, and paralysis of internal organs results. The victim is unable to breathe and eventually dies. As another example, a substance in the venom of black widow spiders stimulates release of acetylcholine at synapses. More commonly, botulism toxin, found in improperly canned foods, blocks release of acetylcholine at the synapses and has a deadly effect. It takes less than one millionth of a gram of this toxin to kill a person. Finally, a deficit of acetylcholine is associated with Alzheimer's disease, which afflicts a high percentage of older adults.

Many neurotransmitters have been identified in the years since 1921, and there is increasing evidence of their importance in human behavior. Psychoactive drugs affect consciousness because of their effects on synaptic transmission. For example, cocaine and the amphetamines prolong the action of certain neurotransmitters and opiates imitate the action of natural neuromodulators called endorphins. It appears that the neurotransmitters dopamine, norepinephrine, and serotonin are associated with some of the most severe forms of mental illness.

Loewi, O. (1921). Über humorale übertragbarkeit der herznervenwirkung. [About humoral transmissibility of the heart nervous system] *Pflüger's Archiv für die gesamte Physiologie des Menschen und der Tiere*, [Pflüger's Archive for the Whole Physiology of Man and Animals], *189*(1), 239-242.
Loewi, O. (1960). An autobiographic sketch. *Perspectives in Biology and Medicine*, *4*(1), 3-25.

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Lecture Launcher 2.2 - Exceptions to the Rules

In an introductory psychology class, students learn the basic rules that generally govern neuronal communication. In many cases, however, the exceptions to these rules may be as important as the rules themselves. Several of these exceptions are described below.

Rule #1: Neuron to neuron signaling is chemical, not electrical.
Exception: Gap junctions

Although it is generally the case that a neuron's electrical signal must first be converted to a chemical signal in order excite or inhibit another neuron, this is not always the case. Some neurons have gap junctions, which connect their intracellular fluids. This means that the electrical signal can flow directly from one neuron to another. Unlike chemical synapses, most electrical synapses formed by gap junctions are bi-directional, meaning that electrical signals can travel in both directions through the gap junctions. Gap junctions also contain gates, which can be closed to prevent the electrical signal from being passed to the neighboring neuron.

Rule #2: Axons always synapse on dendrites.
Exception: Axo-axonic and axosomatic synapses

Axons can form synapses on all parts of a postsynaptic neuron. Synapses located on the soma (i.e., cell body) of a neuron are often inhibitory. In other words, transmitters released at these axosomatic synapses make it harder for the postsynaptic neuron to reach the threshold for generating an action potential. When an axon synapses on the axon of another neuron, it is called an axo-axonic synapse. Because these synapses usually occur near the end of the axon, they have no effect on whether the post synaptic cell generates an axon potential or not. Instead, axo-axonic synapses usually modulate how much neurotransmitter is released from the postsynaptic neuron.

Rule #3: Action potentials only travel in one direction.
Exception: Back-propagating action potentials

Action potentials begin at the axon hillock, where the axon emerges from the soma. From there, the action potential travels down the axon, and away from the soma. At the same time however, a back-propagating action potential can travel from the axon hillock, through the soma, and into the dendrites. Back-propagating action potentials are thought to affect the functioning of receptors located in the soma and dendrites.

Kandel, E., Schwartz, J., & Jessell, T. (2012). *Principles of neural science* (5th ed.). New York, NY: McGraw-Hill.

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Lecture Launcher 2.3 - The Glue of Life: Neuroglial Cells

Glia is derived from the Greek word for glue and is an appropriate name for the cells that surround all neurons, sealing them together. Glial cells outnumber neurons ten to one, and, although tiny in size, still make up half of the brain's bulk. Unlike neurons, glia do not possess excitable membranes and so cannot transmit information in the way neurons do. Yet so many thousands of cells must be there for some purpose.

Researchers studying the brain have suggested that glia can take up, manufacture, and release chemical transmitters, and so may help to maintain or regulate synaptic transmission. Other researchers suggest that glia can manufacture and possibly transmit other kinds of molecules, such as proteins. The anatomy of some glial cells is striking in this regard, for they seem to form a conduit between blood vessels and neurons, and so may bring nourishment to the neurons. It is thought that these cells may have important functions during prenatal development and recovery from brain injury. One role of the glia is known definitely: certain kinds of glia, called by the tongue-twisting name of *oligodendroglia,* form the myelin sheath that insulates central nervous system axons and speeds conduction of the nerve impulse. A counterpart called a Schwann cell performs the same role for the neurons that make up peripheral nerves.

The study of glia is difficult because these tiny cells are inextricably entwined with neurons. As the most numerous type of cell in the brain, their potential importance is vast, and investigation of their function seems likely to yield exciting results in the near future.

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Lecture Launcher 2.4 - My Mother, Myself

Many people feel that their mothers are "a part of them." Recent findings suggest that there may be considerable truth to that phrase.

Many adults apparently still have cells in their bodies that they picked up from their mothers during the gestation period. Similarly, many mothers still have cells in their bodies that came from their own children during pregnancy. Technically speaking, these "guest cells" are actually the product of stem cells that got planted in the "host's" body and started reproducing decades later. And, technically speaking, there aren't too many of them. Some estimates put the number of foreign cells at less than one in a million, a comforting thought for anyone conjuring up images of parasitic offspring or alien-like entities living happily rent-free.

The meaning of these *microchimeras* is less clear. There is some evidence that these cells might contribute to autoimmune diseases, although there is also speculation that these cells might confer a health benefit. Because this area of study is relatively young, there remain more questions than answers (such as, what about women who have cells from both their mothers and their own offspring?). It's comforting to know, though, that in some small way a parent is always with us.

Boddy, A. M., Fortunato, A., Sayres, M. W., & Aktipis, A. (2015). Fetal microchimerism and maternal health: A review and evolutionary analysis of cooperation and conflict beyond the womb. *Bioessays*, 37(10), 1106-1118.
Gammill, H. S., & Nelson, J. L. (2010). Naturally acquired microchimerism. *International Journal of Developmental Biology, 54,* 531-543.
Ritter, M. (2003, May 9). Moms, you've got a little of your kids inside you. *Austin American-Statesman*, A1, A16.
Shute, N. (2010, Apr. 3). Beyond birth: A child's cells may help or harm a mother long after delivery. *Scientific American*.
http://www.microchimerism.org/

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Lecture Launcher 2.5 - Brain Metaphors

Metaphors are a toolbox of handiness in psychology, because they help us to understand systems that aren't directly observable through reference to things that are more familiar and perhaps better understood (Weiner, 1991). Our understanding of the human brain and its activity has been helped through a reliance on metaphor. The metaphors used, however, have changed over time.

- *Hydraulic models*. Thinkers such as Galen and Descartes described the brain as a pneumatic/hydraulic system, relying on the "new-fangled" plumbing systems dominant during their lifetimes. Galen, for example, believed that the liver generated "spirits" or gases that flowed to the brain, where they then formed "animal spirits" that flowed throughout the nervous system. Descartes expanded on this view, adding that the pineal gland (the supposed seat of the soul) acted on the animal spirits to direct reasoning and other behaviors. In short, the brain was a septic tank; storing, mixing, and directing the flow of spirit gases throughout the body for the purposes of behavior and action.

- *Mechanical and telephone models*. With the advent of new technology came new metaphors for the brain. During the Industrial Revolution machine metaphors dominated, and in particular the brain was conceived as a complex mechanical apparatus involving (metaphorical) levers, gears, trip hammers, and pulleys. During the 1920s, the brain developed into a slightly more sophisticated machine resembling a switchboard; the new technology of the telephone provided a new metaphor. Inputs, patch cords, outputs, and busy signals (though no "call waiting") dominated explanations of brain activity. This metaphor, however, faltered by viewing the brain as a system that shut down periodically, as when no one was dialing a number. We now know, of course, that the brain is continually active.

- *Computer models*. Starting in the late 1950s, metaphors for the brain relied on computer technology. Input, output, memory, storage, information processing, and circuitry were all terms that seemed equally suited to talking about computer chips or neurons. Although perhaps a better metaphor than plumbing or telephones, the computer model eventually showed its shortcomings. As a descriptive device, however, this metaphor can at least suggest limits in our understanding and point the way to profitable areas of research.

Weiner, B. (1991). Metaphors in motivation and attribution. *American Psychologist*, *46*, 921-930.

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Lecture Launcher 2.6 - The Cranial Nerves

The textbook discusses various divisions of the nervous system. You may want to add a description of the cranial nerves to your outline of the nervous system. Although the function of the cranial nerves is not different from that of the sensory and motor nerves in the spinal cord, they do not enter and leave the brain through the spinal cord. There are 12 cranial nerves (numbered 1 to 12 and ordered from the front to the back of the brain) that primarily transmit sensory information and control motor movements of the face and head. The 12 cranial nerves are:

1. *Olfactory*. A sensory nerve that transmits odor information from the olfactory receptors to the brain.

2. *Optic*. A sensory nerve that transmits information from the retina to the brain.

3. *Oculomotor*. A motor nerve that controls eye movements, the iris (and therefore pupil size), lens accommodation, and tear production.

4. *Trochlear*. A motor nerve that is also involved in controlling eye movements.

5. *Trigeminal*. A sensory and motor nerve that conveys somatosensory information from receptors in the face and head and controls muscles involved in chewing.

6. *Abducens*. Another motor nerve involved in controlling eye movements.

7. *Facial*. Conveys sensory information and controls motor and parasympathetic functions associated with facial muscles, taste, and the salivary glands.

8. *Auditory-vestibular*. A sensory nerve with two branches, one of which transmits information from the auditory receptors in the cochlea and the other conveys information concerning balance from the vestibular receptors in the inner ear.

9. *Glossopharyngeal*. This nerve conveys sensory information and controls motor and parasympathetic functions associated with the taste receptors, throat muscles, and salivary glands.

10. *Vagus*. Primarily transmits sensory information and controls autonomic functions of the internal organs in the thoracic and abdominal cavities.

11. *Spinal accessory*. A motor nerve that controls head and neck muscles.

12. *Hypoglossal*. A motor nerve that controls tongue and neck muscles.

As is their custom, medical students have developed several mnemonics for memorizing the cranial nerves. Some of the family-friendly ones include:

On Old Olympus' Tiny Tops, A Friendly Viking Grew Vines And Hops
Oh Once One Takes The Anatomy Final Very Good Vacations Are Heavenly
One Of Our Two Timing Adults Found Very Good Values At Home
On Occasion Our Trusty Truck Acts Funny. Very Good Vehicle Any How
Orlando's Overweight Octopuses Try To Avoid Fuddrucker's And Grabbing Vienna Sausage Hamburgers
On Our Overseas Trip To Argentina Found Very Grand Villas And Huts

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Lecture Launcher 2.7 - Hormone Imbalances

Various problems are caused by imbalances within the endocrine system. The following disorders and medical problems are associated with abnormal levels within the pituitary, thyroid, and adrenal glands.

Pituitary malfunctions

Hypopituitary Dwarfism
If the pituitary secretes too little of its growth hormone during childhood, the person will be very small, although normally proportioned.

Giantism
If the pituitary gland over-secretes the growth hormone while a child is still in the growth period, the long bones of the body in the legs and other areas grow very, very long—a height of 9 feet is not unheard of. The organs of the body also increase in size, and the person may have health problems associated with both the extreme height and the organ size.

Acromegaly
If the over-secretion of the growth hormone happens after the major growth period is ended, the person's long bones will not get longer, but the bones in the face, hands, and feet will increase in size, producing

abnormally large hands, feet, and facial bone structure. The famous wrestler/actor, Andre the Giant (Andre Rousimoff), had this condition, as did the great actor Rondo Hatton.

Thyroid malfunctions

Hypothyroidism
In hypothyroidism, the thyroid does not secrete enough thyroxin, resulting in a slower than normal metabolism. The person with this condition will feel sluggish and lethargic, have little energy, and tend to be obese.

Hyperthyroidism
In hyperthyroidism, the thyroid secretes too much thyroxin, resulting in an overly active metabolism. This person will be thin, nervous, tense, and excitable. He or she will also be able to eat large quantities of food without gaining weight (oh, if only we came equipped with thyroid control knobs!).

Adrenal Gland Malfunctions

Among the disorders that can result from malfunctioning of the adrenal glands are Addison's Disease (which is caused by adrenal insufficiency) and Cushing's Syndrome (caused by elevated levels of cortisol). In the former, fatigue, low blood pressure, weight loss, nausea, diarrhea, and muscle weakness are some of the symptoms, whereas for the latter, obesity, high blood pressure, a "moon" face, and poor healing of skin wounds is common. John F. Kennedy, Helen Reddy, and (perhaps) Osama bin Laden were well-known Addisonians.

If there is a problem with over-secretion of the sex hormones in the adrenals, virilism and premature puberty are possible problems. Virilism results in women with beards on their faces and men with exceptionally low, deep voices. Premature puberty, or full sexual development while still a child, is a result of too many sex hormones during childhood. (Puberty is considered premature if it occurs before the age of 8 in girls and 9 in boys.) Treatment is possible using hormones to control the appearance of symptoms, but must begin early in the disorder.

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Lecture Launcher 2.8 - Psychophysiological Measurement

There are various strategies for measuring activity in the brain, especially recently developed techniques such as PET, TMS, or MRI. There are, of course, other bodily systems and other techniques for measuring them, many of which rely on the electrophysical activity of the body.

■ *EMG—Electromyography*. An electromyogram records the action potential given off by contracting muscle fibers. A common example is the recording of facial EMG, in which either inserted electrodes or surface electrodes record the activity of muscles as they pose various expressions.

■ *EGG—Electrogastrography*. Electrogastrograms provide a record of smooth muscle activity in the abdomen. The contractions of the stomach or intestines, for example, can be measured by comparing the readings from a surface electrode attached to the abdomen with those of an electrode attached to the forearm. In the special case of measuring contractions in the esophagus, surface electrodes are attached to a balloon, which is "swallowed" by the person being measured. EGG may be used successfully to gain information about fear, anxiety, or other emotional states.

■ *EOG—Electrooculography*. Readings from electrodes placed around the posterior of the eyes are the basis for EOG. Electrical signals result from small saccadic eye movements as well as more gross movements that can be directly observed. EOG can be used for measuring rapid eye movements during sleep.

■ *EKG—Electrocardiography*. EKG records changes in electrical potential associated with the heartbeat. Electrodes are placed at various locations on the body, and their recordings yield five waves that can be analyzed: P-waves, Q-waves, R-waves, S-waves, and T-waves. EKG may be used by psychologists to supplement observations relevant to stress, heart disease, or Type A behavior patterns.

■ *EDA—Electrodermal activity*. Formerly called *galvanic skin response*, *skin resistance*, and *skin conductance*, EDA refers to the electrical activity of the skin. As activity in the sympathetic nervous system increases it causes the eccrine glands to produce sweat. This activity of the eccrine glands can be measured by EDA, regardless of whether or not sweat actually rises to the skin surface. The folklore of "sweaty palms" associated with a liar might be measured using this technique.

■ *EEG—Electroencephalography*. As discussed in the text, EEG provides information about the electrical activity of the brain, as recorded by surface electrodes attached to the scalp. EEG has been used in a variety of ways to gather information about brain activity under a wide range of circumstances.

■ *Pneumography*. Pneumographs measure the frequency and amplitude of breathing, and are obtained through a relatively straightforward procedure. A rubber tube placed around the chest expands and contracts in response to the person's inhalations and exhalations. These changes can then be recorded with either an ink pen or electrical signal.

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Lecture Launcher 2.9 - Berger's Wave

Ask if anyone knows what is meant by the term *Berger's wave*. Explain that the study of electrical activity in the brain was once limited to studies in which different kinds of measuring devices were attached to the exposed brains of animals. Studies involving humans were rare; researchers could only measure the electrical activity of the living human brain in individuals who had genetic defects of their skull bones that caused the skin of their scalps to be in direct contact with the surfaces of their brains. Yuck!

All this changed when a German physicist named Hans Berger, after several years of painstaking research, discovered that it was possible to amplify and measure the electrical activity of the brain by attaching special electrodes to the scalp which, in turn, sent impulses to a machine that graphed them. In his research, Berger discovered several types of waves, one of which he called the "alpha" wave for no other reason than being the first one he discovered ("alpha" is the first letter of the Greek alphabet). He kept his research a secret until he published an article about it in 1929. The alpha wave is also sometimes called *Berger's wave* in honor of Berger's discovery.

Obviously, Berger achieved one of the most important discoveries in the history of neuroscience. However, his life was not a happy one. Shortly after his article was published, the Nazis rose to power in Germany, which greatly distressed him. In addition, his work wasn't valued in Germany; he was far better known in the United States. As a result, Berger fell into a deep depression in 1941 and hanged himself.

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Lecture Launcher 2.10 - Lie Detectors 2.0

A staple of police and lawyer television shows is the "lie detector" scene, in which the suspect is hooked up to polygraph machine and asked a series of questions about a crime. As the questions are asked, the needles on the polygraph record the suspect's heart rate, breathing, skin conductance, and other physiological responses to the questions. Polygraph machines have been used in this way by various law enforcement agencies for many years. The principle behind the test is that the act of lying causes an involuntary change in the autonomic nervous system, which can be detected by the polygraph. The accuracy of polygraph machines, however, is controversial, and in many courts they are inadmissible evidence. More recently, some researchers have tried to create a new generation of lie detectors, which can measure activity in the brain directly. These techniques look for patterns in the brain that, at least in theory, correlate with lying.

One technique that might be adapted to lie-detection is electroencephalography, more commonly referred to as EEG. During an EEG recording, electrodes are placed at various locations on the scalp. These electrodes are capable of picking up the electrical activity produced by neurons located in different parts of the brain. While the activity of individual neurons cannot be identified, the patterns of electrical activity produced by thousands of neurons working together can be a sign that the brain is functioning in a particular way. One way EEGs may be useful as lie detectors, is by identifying event-related potentials or (ERPs). An ERP is a brief electrical change that occurs at a reliable time point relative to a specific event. For example, it has been found that 300 to 500 ms after a person has been shown something that is unexpected or novel, there is a brief electrical change in that person's EEG. Theoretically, this ERP could be used to determine if a subject has previous knowledge of a piece of evidence. For instance, an ERP occurring 300 ms after being shown a picture of the murder weapon might indicate that the suspect had not seen the murder weapon before.

More recently, fMRIs have been suggested as potential lie-detectors. fMRI, or functional magnetic resonance imaging, works by detecting the increase in blood flow to more active regions in the brain. This is not to be confused with structural MRIs, which can only create an image of tissues, bones, etc. When a person performs a task in an fMRI, adding two numbers together for example, the brain regions required to perform the task will become active. This activity will cause a change in blood flow, which the fMRI can detect. It is possible that, because different brain regions are involved in recounting an actual event than are involved in making up a story, an fMRI is capable of determining whether someone is lying or telling the truth. Some researchers have found that, even if a lie is well rehearsed, it still appears to activate different brain regions than telling the truth does.

Despite media interest in new forms of lie-detection, many experts agree that the EEG and fMRI approaches currently suffer from the same issues that polygraphs do. For example, although the newer techniques measure brain activity much more directly, there is concern about their reliability. While certain brain activity might suggest that a person is lying, unless the technology can be made almost 100% accurate, innocent people may be accused of crimes they did not commit. Also, it is unclear whether people could find ways to "trick" the machines by performing certain mental tasks during testing. Until these questions can be answered, it is unlikely that the polygraph will be replaced anytime soon.

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Lecture Launcher 2.11 – Using fMRI and MEG to Study Phantom Limb Pain

The concept of *pain sensation* means different things to different people. Many students are aware of phantom pain sensations and are actually very curious as to what it is. Medical professionals have recorded many cases of what has come to be called "phantom limbs." Phantom limb phenomenon occurs when a person who has had an amputation of some body part, such as an arm or leg, reports "feeling" sensations from the now-missing limb. Phantom limb refers to the subjective sensory awareness of an amputated body part, and may include numbness, itchiness, temperature, posture, volume, or movement. For example, one man whose left arm was amputated just above the elbow during a horrific car accident claimed that he could still feel the arm as a kind of ghostly presence. He could feel himself wiggling nonexistent fingers and "grabbing" objects that would have been in his reach had his arm still been there (Ramachandran & Blakeslee, 1998). Phantom sensations may take years to fade, and usually do so from the end of the limb up to the body—in other words, one's phantom arm seems to get shorter and shorter until it can no longer be felt. In addition to legs and arms there have been cases of phantom breasts, bladders, rectums, vision, hearing, and internal organs.

Phantom limb pain refers to the specific case of painful sensations that appear to reside in the amputated body part. Patients have variously reported pins-and-needles sensations, burning sensations, shooting pains that seem to travel up and down the limb, or cramps, as though the severed limb was in an uncomfortable and unnatural position. Many amputees often experience several types of pain; others report that the sensations are unlike other pain they've experienced. Unfortunately, some estimates suggest that over 70% of amputees still experience intense pain, even 25 years after amputation. Most treatments for phantom limb pain (there are over 50 types of therapy) help only about 7% of sufferers.

What causes these phantom sensations? A recent study has shed light on the causes of phantom limb sensations. Researchers at Humboldt University in Berlin suggest that the most severe type of this pain occurs in amputees whose brains undergo extensive sensory reorganization. Magnetic responses were measured in the brains of 13 arm amputees in response to light pressure on their intact thumbs, pinkies, lower lips, and chins. These responses were then mapped onto the somatosensory cortex controlling that side of the body. Because of the brain's contralateral control over the body, the researchers were able to estimate the location of the somatosensory sites for the missing limb. They found that those amputees who reported the most phantom limb pain also showed the greatest cortical reorganization. Somatosensory areas for the face encroached into regions previously reserved for the amputated fingers.

Renowned neuroscientist Dr. V. S. Ramachandran has investigated many cases of phantom limb sensations in his career. He believes that examination of people who experience these phenomena, using the noninvasive techniques of magnetoencephalograms and fMRIs, can teach us much about the relationship between sensory experience and consciousness. Researchers have long known that touching certain points on the stump of the amputation (and in some cases on the person's face) can produce phantom sensations in a missing arm or fingers (Ramachandran & Hirstein, 1998). Older explanations of phantom limb sensations have called it an illusion brought on by the irritation of the nerve endings in the stump due to scar tissue. But using anesthesia on the stump does not remove the phantom limb sensations or the pain experienced by some patients in the missing limb, so that explanation is not adequate. Ramachandran and colleagues suggest instead that phantom limb sensations may occur because areas of the face and body near the stump "take over" the nerve functions that were once in the control of the living limb, creating the false impression that the limb is still there, feeling and moving. This "remapping" of the limb functions, together with the sensations from the neurons ending at the stump and the person's mental "body image" work together to produce phantom limb sensations.

Although these findings do not by themselves solve the riddle of phantom limb pain, they do offer avenues for future research. For example, damage to the nervous system may cause a strengthening of connections between somatosensory cells and the formation of new ones. Phantom limb pain may result due to an imbalance of pain messages from other parts of the brain. As another possibility, pain may result from a remapping of somatosensory areas that infringes on pain centers close by.

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Lecture Launcher 2.12 - The Importance of a Wrinkled Cortex

At the beginning of your lecture on the structure and function of the brain, ask students to explain why the cerebral cortex is wrinkled. There are always a few students who correctly answer that the wrinkled appearance of the cerebral cortex allows it to have a greater surface area while fitting in a relatively small space (i.e., the head). To demonstrate this point to your class, hold a plain, white sheet of paper in your hand and then crumple it into a small, wrinkled ball. Note that the paper retains the same surface area, yet is now much smaller and is able to fit into a much smaller space, such as your hand. You can then mention that the brain's actual surface area, if flattened out, would be roughly the size of a newspaper page. Laughs usually erupt when the class imagines what our heads would look like if we had to accommodate an unwrinkled, newspaper-sized cerebral cortex!

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Lecture Launcher 2.13 - Brain's Bilingual Broca

Se potete parlare Italiano, allore potete capire questa sentenza. Of course, if you only speak English, you probably only understand *this* sentence. If you speak both languages, then by this point in the paragraph you should be really bored.

Bilingual speakers who come to their bilingualism in different ways show different patterns of brain activity. Joy Hirsch (now at the Yale School of Medicine) and her colleagues at Memorial Sloan-Kettering Cancer Center in New York monitored the activity in Broca's area in the brains of bilingual speakers who acquired their second language starting in infancy and compared it to the activity of bilingual speakers who adopted a second language in their teens. Participants were asked to silently recite brief descriptions of an event from the previous day, first in one language and then in the other. An fMRI was taken during this task. All of the 12 adult speakers were equally fluent in both languages, used both languages equally often, and represented speakers of English, French, and Turkish, among other tongues.

Hirsch and her colleagues found that among the infancy-trained speakers, the same region of Broca's area was active, regardless of the language they used. Among the teenage-trained speakers, however, a different region of Broca's area was activated when using the acquired language. Similar results were found in Wernicke's area in both groups. Although the full meaning of these results is a matter of some debate (do they reflect sensitivity in Broca's area to language exposure or pronounced differences in adult versus childhood language learning?), they nonetheless reveal an intriguing link between la testa e le parole.

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Lecture Launcher 2.14 - A New Look at Phineas Gage

For over 30 years, Jack and Beverly Wilgus had a daguerreotype portrait—a type of early photograph—of a well-dressed young man with one eye closed. Because the photo showed the young man holding what appeared to be part of a harpoon, the Wilguses believed that the man was a 19th-century whaler who had lost his eye, perhaps in a whaling accident. It was only after a copy of the portrait was posted online that the couple was told that the object in the man's hands did not appear to be a harpoon. Then, in 2008, a person viewing the image online posted a comment that the young man may be Phineas Gage, making the "harpoon," the infamous tamping rod that was blasted through his skull and brain. By carefully examining the rod in the daguerreotype, and by comparing the young man's face to the cast made of Gage's head after his death, the Wilguses were able to confirm that the portrait is almost certainly that of Phineas Gage, made sometime after his accident. Importantly, this is the only known photograph of the man who became one of the most famous case studies in psychology.

One of the consequences of the portrait's discovery has been a renewed debate about how Gage's injuries affected his personality and behavior. Many psychology textbooks explain that the accident left Gage a permanently changed man following the accident, with his once well-balanced, gregarious, and hard-working personality replaced with profane, inconsiderate, and impulsive behavior for the rest of his life. This, however, is not necessarily supported by the few original sources researchers have to go on. For example, although the evidence clearly indicates that Gage had major psychological changes for a period after his accident, we also know that Gage later spent many years driving stagecoaches before he died in 1860, 12 years after the accident. Many have questioned whether the postaccident Phineas Gage commonly described in introductory psychology classes could have performed the tasks required to drive a stagecoach, interact with passengers, and be reliable enough to maintain employment for long periods at a time. Does this indicate that many of the psychological changes Gage suffered were temporary? Certainly the newly discovered daguerreotype of a healthy-looking and well-kept Phineas Gage lends further support to the idea that Phineas was able to largely recover from his accident, both physically and mentally. If true, this may mean that the case of Phineas Gage may be as much a story about the incredible plasticity of the brain and its ability to compensate for the loss of specific brain regions, as it is about the localization of specific functions.

The newly discovered portrait of Phineas Gage can be found at: brightbytes.com/phineasgage or by searching the Internet for "Phineas Gage daguerreotype."

Jarrett, C. & Sutton, J. (2009, July 20). Face to face with Phineas Gage. http://www.thepsychologist.org.uk/blog/11/blogpost.cfm?threadid=1035&catid=48
Macmillan, M. (2008). Phineas Gage–Unravelling the myth. *The Psychologist, 21(9)*, 828-831.
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Lecture Launcher 2.15 - Freak Accidents and Brain Injuries

Students may be interested in the unusual cases of individuals who experience bizarre brain injuries due to freak accidents with nail guns. The most fascinating example involved Isidro Mejias, a construction worker in Southern California, who had six nails driven into his head when he fell from a roof onto his coworker who was using a nail gun. (X-ray images of the embedded nails can be found at several sites on the Internet.) Incredibly, none of the nails caused serious damage to Mejia's brain. One nail lodged near his spinal cord, and another came very close to his brain stem. Immediate surgery and treatment with antibiotics prevented deadly infections that could have been caused by the nails. In a similar accident, a construction worker in Colorado ended up with a nail lodged in his head due to a nail gun mishap. Unlike Mejia, Patrick Lawler didn't realize he had a nail in his head for six days. The nail was discovered when he visited a dentist due to a "toothache." It appears that Lawler fired a nail into the roof of his mouth. The nail barely missed his brain and the back of his eye.

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Lecture Launcher 2.16 - Understanding Hemispheric Function

A variation on the rather dubious statement that "we only use one-tenth of our brain" is that "we only use one-half (hemisphere) of our brain." Research suggests that each cerebral hemisphere is specialized to perform certain tasks (e.g., left hemisphere/language; right hemisphere/visuospatial relationships), with the abilities of one hemisphere complementary being to the other. From this came numerous distortions, oversimplifications, and unwarranted extensions, many of which are discussed in two interesting reviews of this trend toward "dichotomania" (Corballis, 1980; Levy, 1985). For example, the left hemisphere has been described variously as logical, intellectual, deductive, convergent, and "Western," while the right hemisphere has been described as intuitive or creative, sensuous, imaginative, divergent, and "Eastern." Even complex tasks are described as right- or left-hemispheric because of their language component. In every individual one hemisphere supposedly dominates, affecting that person's mode of thought, skills, and approach to life. One commonly cited but questionable test for dominance is to note the direction of gaze when a person is asked a question (left gaze signaling right hemisphere activity; right gaze showing left hemisphere activity). Advertisements have claimed that artistic abilities can be improved if the right hemisphere is freed, and the public schools have been blamed for stifling creativity by emphasizing left-hemisphere skills and by neglecting to teach the children's right hemisphere.

Corballis and Levy explode these myths and trace their development. In reality, the two hemispheres are quite similar and can function remarkably well even if separated by split-brain surgery. Each hemisphere does have specialized abilities, but the two hemispheres work together in all complex tasks. For example, writing a story involves left-hemispheric input concerning syntax but right-hemispheric input for developing an integrated structure and for using humor or metaphor. The left hemisphere is not the sole determinant of logic, nor is the right hemisphere essential for creativity. Disturbances of logic are more prevalent with right-hemisphere damage, and creativity is not necessarily affected. Although one hemisphere can be somewhat more active than the other, no individual is purely "right brained" or "left brained." Also, eye movement and hemispheric activity patterns poorly correlate with cognitive style or occupation. Finally, because of the coordinated, interactive manner of functioning of both hemispheres, educating or using only the right or left hemisphere is impossible (without split-brain surgery).

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Lecture Launcher 2.17 – Handedness, Eyedness, Footedness, Facedness

Although the title sounds like a Dr. Seuss rhyme, it actually denotes something sensible to neuropsychologists. Most people are familiar with the concept of handedness. The human population is distributed across many people who are adept at using their right hands for most tasks, some who have greater skill using the left hand, and a smaller proportion of those who are equally skilled using either hand (or who alternate hands for certain tasks). The concepts of footedness, leggedness, eyedness, and facedness may be less familiar to the layperson, although they stem from the same principle as handedness.

The basis of these distinctions lies in the concept of laterality. Just as the cerebral hemispheres show specialization (e.g., left hemisphere language functions, right hemisphere visual–spatial functions), so too are there preferences or asymmetries in other body regions. The concept of eyedness, then, refers to the preference for using one eye over another, such as when squinting to site down the crosshairs of a rifle or to thread a needle. Footedness and leggedness similarly refer to a preference for one limb over the other; drummers and soccer players will attest to the importance of being equally adept at using either foot and to the difficulty in achieving that. Finally, facedness refers to the strength with which information is conveyed by the right or left side of the face. It has been suggested that verbal information shows a right-face bias, whereas emotional expressions are more strongly shown on the left side of the face, although these conclusions remain somewhat controversial.

Why are these distinctions useful? They play their largest role in the areas of sensation and perception, engineering psychology, and neuropsychology. Studies of reaction time, human–machine interaction, ergonomic design, and so on take into account the preferences and dominance of some body systems over others. In the case of facedness and emotional expression, researchers are working to illuminate the link between facial expressions and cerebral laterality. Given the right hemisphere's greater role in emotional activities, the contralateral control between the right hemisphere and the left hemiface becomes an important proving ground for investigating both brain functions and the qualities of expression.

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Sackheim, H. A., Gur, R. C., & Saucy, M. C. (1978). Emotions are expressed more intensely on the left side of the face. *Science*, *202*, 434-436.
Wang, Z., & Newell, K. M. (2013). Footedness exploited as a function of postural task asymmetry. *Laterality: Asymmetries of Body, Brain and Cognition*, *18*(3), 303-318.

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Lecture Launcher 2.18 - Workplace Problems: Left-Handedness

Within Canada and the United States, there are approximately 33 million people who are left handed. This presents a severe detriment to the workplace. It has been shown that left-handed individuals are more likely to have accidents at work than are right-handed individuals, in fact 25% more likely (and if they are working with tools and machinery, 51% more likely). Accommodations such as being able to rearrange the work area and having tools available that are either left- or right-hand adapted would make the workplace a safer place to be. Have students suggest ways that the workplace could be made safer or even what could be done in the classroom that would make it easier for students who are left handed to take notes or tests. What about the mouse on computers? The mouse is actually made for people who are right handed. How adaptable must a left-handed person become in order not to be frustrated by using a right-handed mouse?

Gunsch, D. For Your Information: Left-handed workers struggle in a right-handed work world. *Personnel Journal, 93*, 23–24.
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Lecture Launcher 2.19 - The Results of a Hemispherectomy

When Matthew was 6 years old, surgeons removed half of his brain.

His first three years of life were completely normal. Just before he turned 4, however, Matthew began to experience seizures, which did not respond to drug treatment. The seizures were both life threatening and frequent (as often as every 3 minutes). The eventual diagnosis was Rasmussen's encephalitis, a rare and incurable condition of unknown origin.

The surgery, a hemispherectomy, was performed at Johns Hopkins Hospital in Baltimore. A few dozen such operations are performed each year in the United States, usually as a treatment for Rasmussen's and for forms of epilepsy that destroy the cortex but do not cross the corpus callosum. After surgeons removed Matthew's left hemisphere, the empty space quickly filled with cerebrospinal fluid.

The surgery left a scar that runs along one ear and disappears under his hair; however, his face has no lopsidedness. The only other visible effects of the operation are a slight limp and limited use of his right arm and hand. Matthew has no right peripheral vision in either eye. He undergoes weekly speech and language therapy sessions. For example, a therapist displays cards that might say "fast things" and Matt must name as many fast things as he can in 20 seconds. He does not offer as many examples as other children his age. However, he is making progress in the use of language, perhaps as a result of fostering and accelerating the growth of dendrites.

The case of Matthew indicates the brain's remarkable plasticity. Furthermore, it is interesting to note that Matt's personality never changed through the seizures and surgery.

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Vining, E. P., Freeman, J. M., Pillas, D. J., Uematsu, S., Carson, B. S., Brandt, J., Boatman, D., Pulsifer, M. B., & Zuckerberg, A. (1997). Why would you remove half a brain? The outcome of 58 children after hemispherectomy-the Johns Hopkins

experience: 1968 to 1996. *Pediatrics*,*100(2 Pt 1)*, 163-171.

Find more hemispherectomy stories and information at: http://hemifoundation.intuitwebsites.com/

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▼CLASSROOM ACTIVITIES, DEMONSTRATIONS, AND EXERCISES

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Activity 2.1 - Using Dominoes to Understand the Action Potential

Walter Wagor suggests using real dominoes to demonstrate the so-called "domino effect" of the action potential as it travels along the axon. For this demonstration, you'll need a smooth table-top surface (at least 5 feet long) and one or two sets of dominoes. Set up the dominoes beforehand, on their ends and about an inch apart, so that you can push the first one over and cause the rest to fall in sequence. Proceed to knock down the first domino in the row and students should clearly see how the "action potential" is passed along the entire length of the axon. You can then point out the concept of refractory period by showing that, no matter how hard you push on the first domino, you will not be able to repeat the domino effect until you take the time to set the dominoes back up (i.e., the resetting time for the dominoes is analogous to the refractory period for neurons). You can then demonstrate the all-or-none characteristic of the axon by resetting the dominoes and by pushing so lightly on the first domino that it does not fall. Just as the force on the first domino has to be strong enough to knock it down before the rest of the dominoes will fall, the action potential must be there in order to perpetuate itself along the entire axon. Finally, you can demonstrate the advantage of the myelin sheath in axonal transmission. For this demonstration, you'll need to set up two rows of dominoes (approximately 3 or 4 feet long) next to each other. The second row of dominoes should have foot-long sticks (e.g., plastic rulers) placed end-to-end in sequence on top of the dominoes. By placing the all-domino row and the stick-domino row parallel to each other and pushing the first domino in each, you can demonstrate how much faster the action potential can travel if it can jump from node to node rather than having to be passed on sequentially, single domino by single domino. Ask your students to discuss how this effect relates to myelinization.

Wagor, W. F. (1990). Using dominoes to help explain the action potential. In V. P. Makosky, C. C. Sileo, L. G. Whittemore, C. P. Landry, & M. L. Skutley (Eds.), *Activities handbook for the teaching of psychology: Vol. 3* (pp. 72-73). Washington, DC: American Psychological Association.

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Activity 2.2 - Stemming the Tide of Misinformation

Although there's a lot of promise in stem cell research, it comes with a lot of controversy as well. Consider these statements from various political figures over the years:

"While we must devote enormous energy to conquering disease, it is equally important that we pay attention to the moral concerns raised by the new frontier of human embryo stem cell research. Even the most noble ends do not justify any means."

GEORGE W. BUSH, speech, Aug. 9, 2001

"I think we can do ethically guided embryonic stem cell research. We have 100,000 to 200,000 embryos that are frozen in nitrogen today from fertility clinics. These weren't taken from abortion or something like that. They're from a fertility clinic, and they're either going to be destroyed or left frozen. And I believe if we have the option, which scientists tell us we do, of curing Parkinson's, curing diabetes, curing, you know, some kind of a ... you know, paraplegic or quadriplegic or, you know, a spinal cord injury — anything — that's the nature of the human spirit. I think it is respecting life to reach for that cure."

JOHN KERRY, presidential debate, Oct. 8, 2004

"The best that can be said about embryonic stem cell research is that it is scientific exploration into the potential benefits of killing human beings."

TOM DeLAY, *Washington Post,* May 25, 2005

"I am pro-life. I believe human life begins at conception. I also believe that embryonic stem cell research should be encouraged and supported."

BILL FRIST, speech, Jul. 29, 2005

"I'm very grateful that President Obama has lifted the restrictions on federal funding for embryonic stem cell research."

NANCY REAGAN, commentary, March 8, 2009

"The majority of Americans - from across the political spectrum, and of all backgrounds and beliefs - have come to a consensus that we should pursue this research. That the potential it offers is great, and with proper guidelines and strict oversight, the perils can be avoided."

BARACK OBAMA, executive order, March 9, 2009

Unfortunately, there's also a lot of misinformation about stem cells and stem cell research…in fact, one might question the scientific credentials of Mr. DeLay, whose noteworthy accomplishments (apart from a chequered political career) include running a pest control business and competing on *Dancing With the Stars*.

Encourage your students to examine the evidence and decide for themselves. Ask them to prepare a brief report on some aspect of stem cell research -- it's current legal status in the United States and worldwide; options for gathering stem cells; potential cures indicated by the current scientific evidence, and so on. You might ask different groups of students to tackle different issues, or ask all students to investigate a small set of issues. Similarly, you might structure this as a brief discussion exercise, or you might want to stage it as a more formal debate. There are many possible ways to implement this exercise. The important underlying aspect, however, is to get students to think critically and discuss openly the facts associated with stem cell research.

http://stemcells.nih.gov/research/pages/current.aspxhttp://www.tellmeaboutstemcells.org/
http://www.stemcells.com/view/0/index.html
http://www.physorg.com/news172072614.html
http://www.wilsoncenter.org/index.cfm?event_id=161696&fuseaction=topics.event_summary&topic_id=116811
http://www.biotech.ucdavis.edu/TBCWebsites/TBC07/StemCells&TissueEngineering/Li-MiraLoma/Biotech%20Website%20Design/index.html
http://www.notable-quotes.com/s/stem_cells_quotes.html

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Activity 2.3 - Environmental Influences on the Brain

You might want to remind students that brain function and structure are subject to environmental influences. Ask students to identify the behaviors that are important for keeping the brain healthy and functioning well. The following are some possibilities:

Good nutrition, especially during childhood Adequate nutrition is vital for proper brain development. Even in adults, diet may influence brain function. Studies are showing that although high levels of cholesterol may be bad for your heart, low levels of cholesterol may be bad for the brain. Low cholesterol may be associated with low levels of the neurotransmitter serotonin, that can result in higher levels of aggression and depression.

Mental stimulation High levels of stimulation help to form neural connections that in turn enhance brain function.

Physical fitness Studies have shown that aerobic fitness has an impact on the density of capillaries in the brain. More capillaries result in greater blood flow to the brain.

Maternal health during pregnancy The uterine environment can have an enormous impact on the brain development of a fetus. Women who do not have adequate nutrition, or drink, smoke, or do drugs, and who are exposed to certain environmental toxins are more likely to have children with lower IQs and learning disabilities.

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Activity 2.4 –
Demonstrating Neural Conduction: The Class as a Neural Network

In this engaging exercise (suggested by Paul Rozin and John Jonides), students in the class simulate a neural network and get a valuable lesson in the speed of neural transmission. Depending on your class size, arrange 15 to 40 students so that each person can place his or her right hand on the right shoulder of the person in front of them. Note that students in every other row will have to face backwards in order to form a snaking chain so that all students (playing the role of individual neurons) are connected to each other. Explain to students that their task as a neural network is to send a neural impulse from one end of the room to the other. The first student in the chain will squeeze the shoulder of the next person, who, upon receiving this "message," will deliver (i.e., "fire") a squeeze to the next person's shoulder and so on, until the last person receives the message. Before starting the neural impulse, ask students (as "neurons") to label their parts; they typically have no trouble stating that their arms are axons, their fingers are axon terminals, and their shoulders are dendrites.

To start the conduction, the instructor should start the timer on a stopwatch while simultaneously squeezing the shoulder of the first student. The instructor should then keep time as the neural impulse travels around the room, stopping the timer when the last student/neuron yells out "stop." This process should be repeated once or twice until the time required to send the message stabilizes (i.e., students will be much slower the first time around as they adjust to the task). Next, explain to students that you want them to again send a neural impulse, but this time you want them to use their ankles as dendrites. That is, each student will "fire" by squeezing the ankle of the person in front of them. While students are busy shifting themselves into position for this exercise, ask them if they expect transmission by ankle-squeezing to be faster or slower than transmission by shoulder-squeezing. Most students will immediately recognize that the ankle-squeezing will take longer because of the greater distance the message (from the ankle as opposed to the shoulder) has to travel to reach the brain. Repeat this transmission once or twice and verify that it indeed takes longer than the shoulder squeeze.

This exercise -- a student favorite -- is highly recommended because it is a great ice-breaker during the first few weeks of the semester, and it also makes the somewhat dry subject of neural processing come alive.

Rozin, P., & Jonides, J. (1977). Mass reaction time measurement of the speed of the nerve impulse and the duration of mental processes in class. *Teaching of Psychology, 4*, 91-94.

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Activity 2.5 - The Dollar Bill Drop

After engaging in the neural network exercise, follow it up with the "dollar bill drop" (Fisher, 1979), which not only delights students but also clearly illustrates the speed of neural transmission. Ask students to get into pairs and to come up with one crisp, flat, one-dollar bill (or something larger, if they trust their fellow classmates!) between them. First, each member of the pair should take turns trying to catch the dollar bill with their nondominant (for most people, the left) hand as they drop it from their dominant (typically right) hand. To do this, they should hold the bill vertically so that the top, center of the bill is held by the thumb and middle finger of their dominant hand. Next, they should place the thumb and middle finger of their nondominant hand around the dead center of the bill, as close as they can get without touching it. When students drop the note from one hand, they should be able to easily catch it with the other before it falls to the ground.

Now that students are thoroughly unimpressed, ask them to replicate the drop, only this time one person should try to catch the bill (i.e., with the thumb and middle finger of the nondominant hand) while the other person drops it (i.e., from the top center of the bill). Student "droppers" are instructed to release the bill without warning, and "catchers" are warned not to grab before the bill is dropped. (Students should take turns playing dropper and catcher.) There will be stunned looks all around as dollar bills whiz to the ground. Ask students to explain why it is so much harder to catch it from someone other than themselves. Most will instantly understand that when catching from ourselves, the brain can simultaneously signal us to release and catch the bill, but when trying to catch it from someone else, the signal to catch the bill can't be sent until the eyes (which see the drop) signal the brain to do so, which is unfortunately a little too late.

Fisher, J. (1979). *Body Magic*. Briarcliff Manor, NY: Stein and Day.

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Activity 2.6 - Reaction Time and Neural Processing

Yet another exercise that illustrates the speed of neural processing is suggested by E. Rae Harcum. The point made by this simple but effective exercise is that reaction times increase as more response choices become available (i.e., because more difficult choices in responses involve more neuronal paths and more synapses, both of which slow neural transmission). Depending on your class size, recruit two equal groups of students (10 to 20 per group is ideal) and have each group stand together at the front of the room. First, explain that all subjects are to respond as quickly as possible to the name of a U.S. President. Then give written instructions to each group so that neither group knows the instructions given to the other. One group should be instructed to raise their right hands if the president served before Abraham Lincoln and to raise their left hands if the president served after Lincoln. The other group should be instructed simply to raise their left hands when they hear a president's name. Ask participants and audience members to note which group reacts more quickly. When all students are poised and ready to go (i.e., hands level with shoulders and ready to raise), say "Ready" and then "Reagan." The group with the simpler reaction time task should be faster than the group whose task requires a choice.

Harcum, E. R. (1988). Reaction time as a behavioral demonstration of neural mechanisms for a large introductory psychology class. *Teaching of Psychology, 4*, 208-209.

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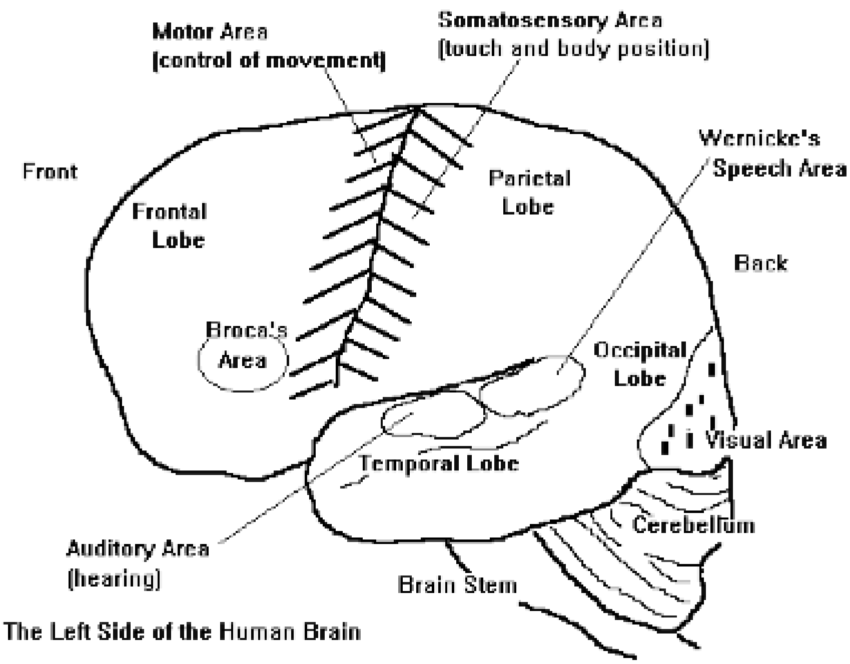
Activity 2.7 - Mapping the Brain

Many students, especially those with little background in the sciences, will find it a challenge to keep track of the location of all the parts of the brain outlined in the text. One simple way to reinforce their learning of brain structure is to have students locate the various parts on a diagram of the brain. The brain diagram and the student instructions for this exercise are included as **Handout Master 2.1**. The day before you present this activity, ask students to bring colored pencils or markers to the next class meeting. On the day of the activity, divide students into small groups and distribute copies of the diagram of the brain and the accompanying questions in the student handouts. Within their groups students can help each other locate each part of the brain and then color code them using their pencils or markers. They can also indicate the function of each part on the diagram. This exercise is very useful for helping students to memorize brain anatomy, and the color-coded diagram serves as a helpful study guide.

For your convenience, a completed diagram and suggested answers to the questions are furnished here.



The Left Side of the Human Brain

1. This is a diagram of the left side of the brain.

   Left side functions: The left hemisphere controls touch and movement of the right side of the body, vision in the right half of the visual field, comprehension and production of speech, reading ability, mathematical reasoning, and a host of other abilities.

   Right side functions: The right hemisphere controls touch and movement of the left side of the body, vision in the left half of the visual field, visual-spatial ability, map-reading, art and music appreciation, analysis of nonverbal sounds, and a host of other abilities.

2. The front of the brain is on the left side of the diagram; the back of the brain is on the right.
3. The cerebrum is the sum of the frontal, parietal, temporal, and occipital lobes. The cerebellum is labeled on the diagram above. The cerebrum is responsible for higher forms of thinking, including a variety of specific abilities described under motor cortex, visual cortex, somatosensory cortex, and auditory cortex. The cerebral cortex also contains vast association areas, whose specific functions are poorly defined but may include reasoning and decision making, planning appropriate behavior sequences, and knowing when to stop. The limbic system, which appears to be strongly involved in regulating emotions, is also part of the cerebrum. The cerebellum aids in the sense of balance and motor coordination.

4. The frontal, parietal, temporal, and occipital lobes are labeled on the diagram above.

5. The motor cortex is labeled on the diagram above. The motor cortex in each hemisphere controls movements on the opposite side of the body.

6. The visual cortex is labeled on the diagram above. The visual cortex in each hemisphere receives information from the visual field on the opposite side.

7. The auditory cortex is labeled on the diagram above. The auditory cortex is responsible for processing sounds.

8. The somatosensory cortex is labeled on the diagram above. The somatosensory cortex on each side receives information about touch, joint position, pressure, pain, and temperature from the opposite side of the body.

9. Broca's and Wernicke's areas are labeled on the diagram above. Broca's area is often referred to as the motor speech area. It is responsible for our ability to carry out the movements necessary to produce speech. Wernicke's area is often referred to a sensory speech area. It is mainly involved in comprehension and planning of speech.

10. Neurons would be found all over the drawing. (The brain is made up of billions of neurons.) Each neuron is very tiny compared to the size of the brain, so no single neuron would be visible to the naked eye in a drawing at this scale. The cell bodies of the largest neurons in the brain are about 1/20 of a millimeter in diameter!

11. The brain stem is labeled on the diagram above. Different parts of the brain stem are involved in regulation of sleep and wakefulness, dreaming, breathing, heart rate, and attentional processes.

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Activity 2.8 - Football and Brain Damage

Coaches and medical experts have known for a while that the severe hits that football players take on the field can lead to concussions, blacking out, and even permanent damage. More recently, however, there has been increasing concern that the effects of repeated hits to the head may not manifest themselves until decades later. Early studies suggest that former NFL players suffer high rates of memory and other cognitive problems years after retiring, and that they also may develop these problems earlier than non-football players do. NFL players may also be vulnerable to higher rates of depression and Alzheimer's disease.

To investigate this problem, groups like the Sports Legacy Institute have begun to encourage former NFL players to donate their brains to science when they die. Already, the brains of a handful of players have been examined, with shocking results. Almost all of the brains show high levels of a protein called *tau,* which is suspected of being involved in several neurodegenerative disorders, including Alzheimer's disease. The presence of high levels of tau may explain why football players have a tendency to develop cognitive impairments long after their playing days are over. More disturbing still, high levels of tau have also been found in the brain of an 18 year-old high school football player who died.

After introducing students to this issue, have the class discuss the possible implications for social and sports policy. Should football playing be stopped? Should the rules of the game be changed to eliminate hard hitting? If necessary, pose the following additional questions to stimulate discussion: Everyone knows football is dangerous, but does the fact that these cognitive impairments may take decades to develop make them somehow different? Is the risk of permanent cognitive disability somehow different than the risk of permanent physical disability? Wrestlers, soccer players, boxers, and other types of athletes are also at risk for long term brain damage. Should these sports be changed of banned?

After discussing the issue in class, have students respond to the following writing prompt.

Writing Prompt: Describe a longitudinal and then a cross-sectional study that could be used to determine if professional football players show higher than normal rates of cognitive impairment. Explain some of the advantages and disadvantages of the two designs.

Sample answer: *A longitudinal study might choose a few football players and then test them every 10 years using the same cognitive tests to see how their abilities change over time. A cross-sectional study, on the other hand, might find a group of 65 year old retired football players and compare their cognitive functioning to 65 year olds who did not play football. The longitudinal study would provide a more complete view of how cognitive function might decline, but would take decades to complete, and may suffer from attrition. The cross-sectional study would be a lot easier to perform, but would only offer a "snap-shot" of cognitive function. You could not tell, for example, if football players develop cognitive impairment earlier than non-football players typically do.*

Miller, G. (2009). A late hit for pro football players. *Science, 7*, 670–672.

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Activity 2.9 - Hemispheric Lateralization

Hemispheric lateralization results in eyedness, handedness, footedness, earedness, facedness, and other silly-sounding words with important implications (see the related Lecture Launcher in this chapter). Lateralization results from the specialization of each hemisphere for different tasks, such as reading facial expressions, speaking, solving spatial problems, or performing analytic tasks. Although neuropsychologists use sophisticated measures to determine these lateralization, this simple exercise allows students to gauge their own brain organization.

With both eyes open, have students hold up their right thumbs at arm's length under an object across the room directly in front of them. As they alternately close their left and right eyes, their thumbs should appear to jump to the right or to the left with respect to the distant object. For those who are right-eyed, their thumbs should jump to the right when they close their right eyes, but stay as is when they close their left eyes. The opposite pattern should occur among those who are left-eyed. Students who see little or no jumping are among the 41% of the population who are neither strongly left-eyed nor right-eyed.

As a second test, ask for a volunteer. Present the student with the first paragraph of this exercise (or any suitable short passage) to memorize, a broom, a clock with a second hand, a pencil, and a pad of paper. First, time how long the volunteer can balance the broom on the tip of his or her right index finger while standing on the right foot. Next, measure the time as the volunteer balances the broom on his or her left index finger while standing on the left foot. Finally, repeat these tests while the volunteer recites the memorized passage. Speech will be localized on the side of the brain opposite the hand that is most disrupted by the memorization task.

Another demonstration, suggested by Morton Ann Gernsbacher, requires students to move their right hand and right foot simultaneously in a clockwise direction for a few seconds. Next ask that the right hand and left foot be moved in a clockwise direction. Then, have students make circular movements in opposite directions with right the hand and the left foot. Finally, have students attempt to move the right hand and right foot in opposite directions. This generally produces laughter as students discover that this procedure is most difficult to do even though they are sure – before they try it – that it would be no problem to perform. A simple alternative activity is to ask students to pat their heads and to rub their stomachs clockwise and then switch to a counterclockwise motion. The pat will show slight signs of rotation as well.

The brain is lateralized to some extent, and this makes some activities difficult to perform. Challenge your students to explain why activities of these types are difficult to execute. This will generally lead to interesting discussions and the assertion by some students that this type of behavior is no problem. Generally students who have been trained in martial arts, dance and/or gymnastics have less difficulty completing these activities due to their rigorous physical training.

Haseltine, E. (1999, June). Brain works: Your better half. *Discover,* 112.
Kemble, E. D. (1987). Cerebral lateralization. In V. P. Makosky, L. G. Whittemore, and A. M. Rogers (Eds.). *Activities handbook for the teaching of psychology* (Vol. 2) (pp. 33–36). Washington, D.C.: American Psychological Association.
Kemble, E. D., Filipi, T., & Gravlin, L. (1985). Some simple classroom experiments on cerebral lateralization. *Teaching of Psychology, 12*, 81–83.

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Activity 2.10 - Hemispheric Communication and the Split Brain

Even after reading the textbook and listening to your lecture, many students may have difficulty conceptualizing the effects of a split-brain operation on an individual's behavior. Morris (1991) described five activities designed to simulate the behavior of split-brain patients. All of the activities have the same basic setup. You will need to solicit two right-handed volunteers and seat them next to each other at a table, preferably in the same chair. The volunteer on the left represents the left hemisphere, and the other student is the right hemisphere. The students are instructed to place their outer hand behind their back and their inner hands on the table with their hands crossed, representing the right and left hands of the split-brain patient. Finally, the student representing the right hemisphere is instructed to remain silent for the remainder of the activity. In one of the activities described by Morris, both students are blindfolded and a familiar object (Morris suggested a retractable ball-point pen) is placed in the left hand of the "split-brain patient" (the hand associated with the right hemisphere). Then ask the "right hemisphere" student if he or she can identify the object, reminding him or her that they must do so nonverbally. Next, ask the "right hemisphere" to try to communicate, without using language, what the object is to the "left hemisphere." Your more creative volunteers may engage in behaviors that attempt to communicate what the object is through sound or touch. If your "right hemisphere" has difficulty in figuring out how to communicate, ask the class for suggestions. This demonstration can be used to elicit discussion about why only the "left hemisphere" student can talk, the laterality of the different senses, and how split-brain patients are able to adjust their behavior to accommodate. You should refer to Morris's original article for descriptions of the other activities.

Morris, E. J. (1991). Classroom demonstration of behavioral effects of the split-brain operation. *Teaching of Psychology, 18*, 226-228.

► Return to Lecture Guide
◄ Return to complete list of Classroom Activities, Demonstrations, and Exercises for Chapter 2
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Activity 2.11 - Crossword Puzzle

Copy and distribute **Handout Master 2.2** to students as a homework or in-class review assignment.

Answers for the Crossword puzzle:

Across
1. neurotransmitter that causes the receiving cell to stop firing. **Inhibitory**
3. the cell body of the neuron, responsible for maintaining the life of the cell. **Soma**
4. endocrine gland located near the base of the cerebrum which secretes melatonin. **Pineal**
7. glands that secrete chemicals called hormones directly into the bloodstream. **Endocrine**
8. long tube-like structure that carries the neural message to other cells. **Axon**
10. chemical found in the synaptic vesicles which, when released, has an effect on the next cell. **Neurotransmitter**
13. bundles of axons coated in myelin that travels together through the body. **nerves**
14. branch-like structures that receive messages from other neurons. **Dendrites**
15. endocrine gland found in the neck that regulates metabolism. **Thyroid**
17. thick band of neurons that connects the right and left cerebral hemispheres. **Corpus Callosum**
19. part of the nervous system consisting of the brain and spinal cord. **Central**

Down
2. part of the limbic system located in the center of the brain, it acts as a relay from the lower part of the brain to the proper areas of the cortex. **Thalamus**
4. endocrine gland that controls the levels of sugar in the blood. **Pancreas**
5. fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse. **Myelin**
6. the basic cell that makes up the nervous system and which receives and sends messages within that system. **Neuron**
8. chemical substances that mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell. **Agonists**
9. part of the lower brain that controls and coordinates involuntary, rapid, fine motor movement. **Cerebellum**
11. process by which neurotransmitters are taken back into the synaptic vesicles. **Reuptake**
12. a group of several brain structures located under the cortex and involved in learning, emotion, memory, and motivation. **Limbic**
16. chemicals released into the bloodstream by endocrine glands. **Hormones**
18. brain structure located near the hippocampus, responsible for fear responses and memory of fear. **Amygdala**

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Activity 2.12 - Fill-in-the-Blanks

Copy and distribute **Handout Master 2.3** to students as a homework or in-class review assignment.

Answers for Fill-in-the-Blanks—Chapter 2

nervous system
neuron
axon
dendrites

soma
myelin
nerves
ions
resting potential
synaptic vesicles
neurotransmitters
excitatory
agonists
spinal cord
sensory
peripheral nervous
somatic nervous
autonomic nervous
sympathetic division
electroencephalograph
cerebellum
thalamus
pons
reticular formation
hippocampus
amygdala
cortex
corpus callosum
occipital cortex
parietal cortex
temporal lobes
frontal lobes
endocrine
adrenal glands
General Adaptation Syndrome
psychoneuroimmunology

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▼HANDOUT MASTERS

- Handout Master 2.1 Mapping the Brain
- Handout Master 2.2 Crossword Puzzle
- Handout Master 2.3 Fill-in-the-Blanks

◄ Return to complete list of Classroom Activities, Demonstrations, and Exercises for Chapter 2
▲ Return to Chapter 2: Table of Contents

Handout Master 2.1

Mapping the Brain

Label the diagram of the brain to show or answer the following questions.

1. Is this a drawing of the left side or the right side of the brain? What are the particular functions of that side of the brain as compared to the other hemisphere?

   Left side functions: Right side functions:

2. Where is the front of the brain? Where is the back?

3. Label the cerebrum and cerebellum and describe their functions.

   Cerebral functions: Cerebellar functions:

4. Label the four lobes of the cerebral cortex.

5. Label the motor cortex and describe its function.

6. Label the visual cortex and describe its function.

7. Label the auditory cortex and describe its function.

8. Label the somatosensory cortex and describe its function.

9. Label Broca's and Wernicke's areas and describe their functions.

10. Where would you expect to find neurons in this drawing and how big would they be if they were drawn?

11. Label the brain stem. What is its function?

► Return to Activity: Mapping the Brain
◄ Return to complete list of Handout Masters for Chapter 2
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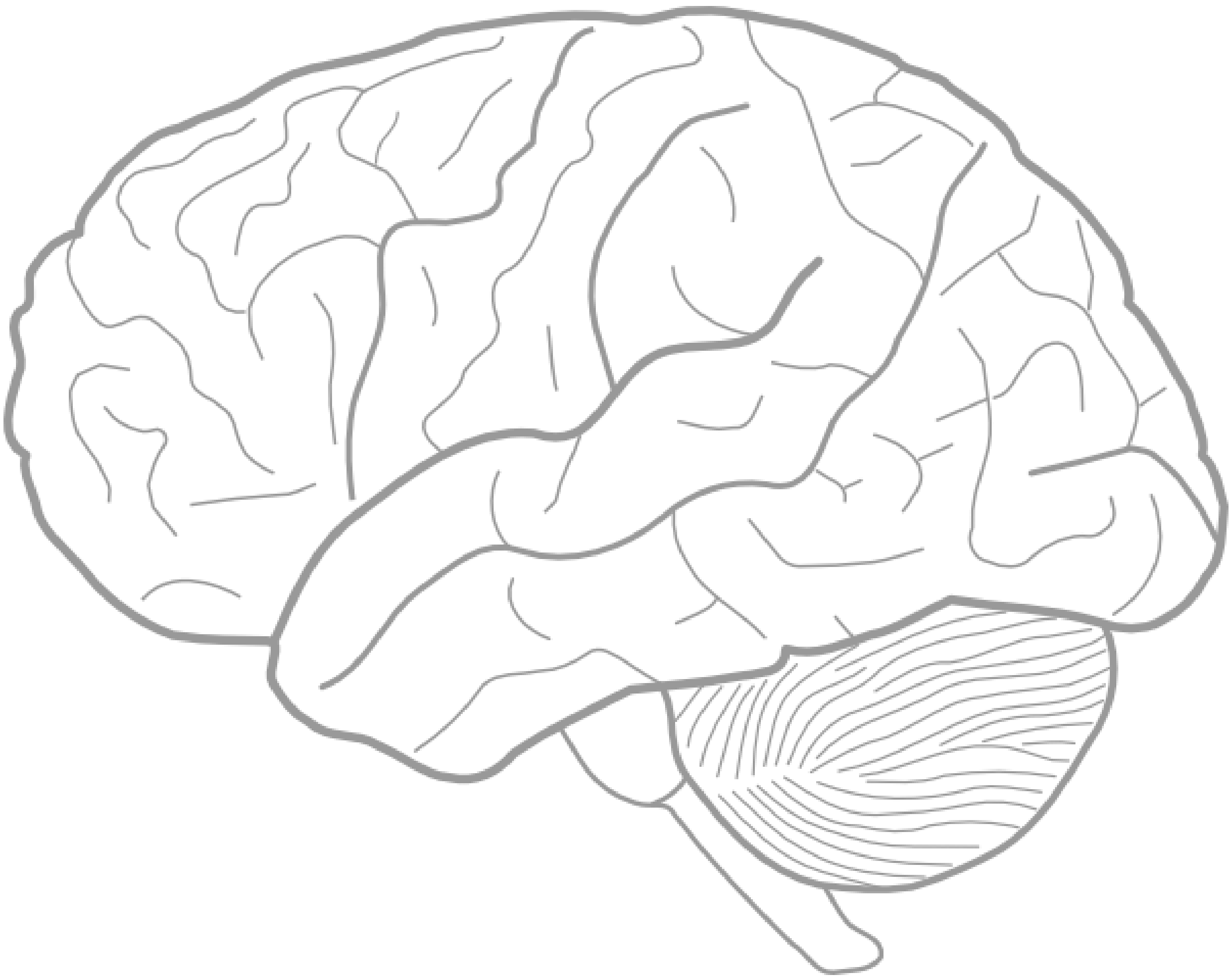
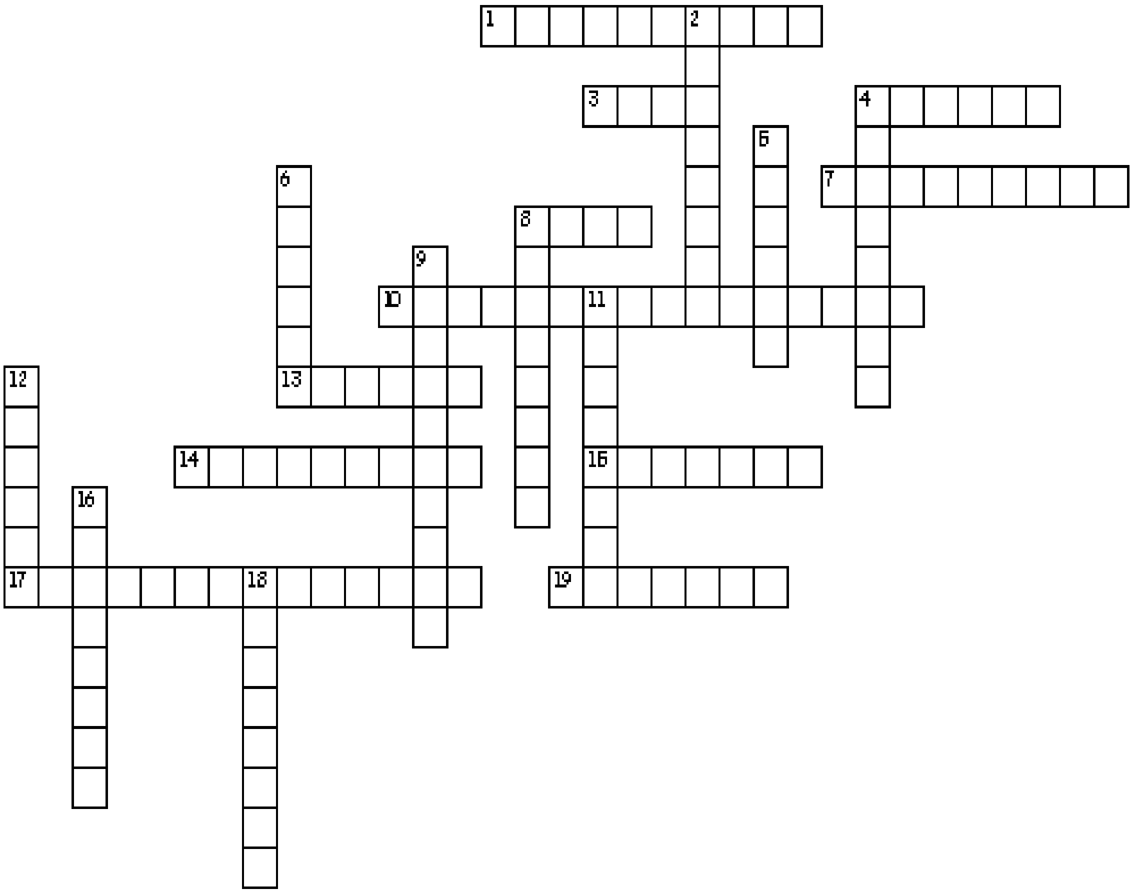


Handout Master 2.2

Crossword Puzzle



Across
1. neurotransmitter that causes the receiving cell to stop firing
3. the cell body of the neuron, responsible for maintaining the life of the cell
4. endocrine gland located near the base of the cerebrum which secretes melatonin
7. glands that secrete chemicals called hormones directly into the bloodstream
8. long tube-like structure that carries the neural message to other cells
10. chemical found in the synaptic vesicles which, when released, has an effect on the next cell
13. bundles of axons coated in myelin that travel together through the body
14. branch-like structures that receive messages from other neurons
15. endocrine gland found in the neck that regulates metabolism
17. thick band of neurons that connects the right and left cerebral hemispheres
19. part of the nervous system consisting of the brain and spinal cord

Down
2. part of the limbic system located in the center of the brain, it acts as a relay from the lower part of the brain to the proper areas of the cortex
4. endocrine gland that controls the levels of sugar in the blood
5. fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse
6. the basic cell that makes up the nervous system and which receives and sends messages within that system
8. chemical substances that mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell
9. part of the lower brain that controls and coordinates involuntary, rapid, fine motor movement.
11. process by which neurotransmitters are taken back into the synaptic vesicles
12. a group of several brain structures located under the cortex and involved in learning, emotion, memory, and motivation
16. chemicals released into the bloodstream by endocrine glands
18. brain structure located near the hippocampus, responsible for fear responses and memory of fear

► Return to Activity: Crossword Puzzle
◄ Return to complete list of Handout Masters for Chapter 2
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Handout Master 2.3

Fill-in-the-Blanks

1. An extensive network of specialized cells that carry information to and from all parts of the body is called the _________________ ______________.
2. The basic cell that makes up the nervous system and which receives and sends messages within that system is called a __________________.
3. The long tube-like structure that carries the neural message to other cells on the neuron is the _______________
4. On a neuron, the branch-like structures that receive messages from other neurons is the ___________________.
5. The cell body of the neuron, responsible for maintaining the life of the cell and contains the mitochondria is the _________________.
6. The fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse is the _________________.
7. The bundles of axons in the body that travel together through the body are known as the ______________.
8. The charged particles located inside and outside of the neuron are called ____________.
9. The state of the neuron when not firing a neural impulse is known as the ________________ ____________________.
10. The _____________ _____________ are sack-like structures found inside the synaptic knob containing chemicals.
11. __________________________ are chemicals found in the synaptic vesicles which, when released, has an effect on the next cell.
12. The ______________________ neurotransmitter causes the receiving cell to fire.
13. The __________________________ mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell, increasing or decreasing the activity of that cell.
14. The __________________ _______________ a long bundle of neurons that carries messages to and from the body to the brain that is responsible for very fast, lifesaving reflexes.
15. A neuron that carries information from the senses to the central nervous system and is also known as the afferent is called a ____________________ ________________.
16. All nerves and neurons that are not contained in the brain and spinal cord but that run through the body itself are in the __________________ ____________________ system.
17. The division of the PNS consisting of nerves that carry information from the senses to the CNS and from the CNS to the voluntary muscles of the body is the ______________ ________________ system.
18. The ___________________ _________________ system division of the PNS consisting of nerves that control all of the *involuntary* muscles, organs, and glands sensory pathway nerves coming from the sensory organs to the CNS consisting of sensory neurons.
19. The part of the ANS that is responsible for reacting to stressful events and bodily arousal is called the _______________________ __________________ of the nervous system.
20. A machine designed to record the brain wave patterns produced by electrical activity of the surface of the brain is called an _________________________.
21. The part of the lower brain located behind the pons that controls and coordinates involuntary, rapid, fine motor movement is called the ______________________.
22. The part of the limbic system located in the center of the brain, this structure relays sensory information from the lower part of the brain to the proper areas of the cortex and processes some sensory information before sending it to its proper area and is called the _______________________.

23. The larger swelling above the medulla that connects the top of the brain to the bottom and that plays a part in sleep, dreaming, left–right body coordination, and arousal is called the ____________________.
24. The ____________________ ________________ is an area of neurons running through the middle of the medulla and the pons and slightly beyond that is responsible for selective attention.
25. The ______________________ is a curved structure located within each temporal lobe, responsible for the formation of long-term memories and the storage of memory for location of objects.
26. The ___________________ is a brain structure located near the hippocampus, responsible for fear responses and memory of fear.
27. The ______________ is the outermost covering of the brain consisting of densely packed neurons, responsible for higher thought processes and interpretation of sensory input.
28. The thick band of neurons that connects the right and left cerebral hemispheres is called the ________________ ______________.
29. The section of the brain located at the rear and bottom of each cerebral hemisphere containing the visual centers of the brain is the called the _______________ _______________.
30. The sections of the brain located at the top and back of each cerebral hemisphere containing the centers for touch, taste, and temperature sensations is called the ______________________ ___________________________.
31. The _________________ ________________ is the area of the cortex located just behind the temples containing the neurons responsible for the sense of hearing and meaningful speech.
32. The ___________________ _____________________ are areas of the cortex located in the front and top of the brain, responsible for higher mental processes and decision making as well as the production of fluent speech.
33. The ____________________ glands secrete chemicals called hormones *directly* into the bloodstream.
34. The endocrine glands located on top of each kidney that secrete over 30 different hormones to deal with stress, regulate salt intake, and provide a secondary source of sex hormones affecting the sexual changes that occur during adolescence are called the __________________ ___________________.

35. The three stages of the body's physiological reaction to stress, including alarm, resistance, and exhaustion, is called the __________ __________ __________ or GAS.

36. __________ is the study of the effects of psychological factors such as stress, emotions, thoughts, and behavior on the immune system.

Words for Fill-in-the-Blanks

adrenal glands
agonists
amygdala
autonomic nervous
axon
cerebellum
corpus callosum
cortex
dendrites
electroencephalograph
endocrine
excitatory
frontal lobes
General Adaptation Syndrome
hippocampus
ions
myelin
nerves
nervous system
neuron
neurotransmitters
occipital cortex
parietal cortex
peripheral nervous
pons
psychoneuroimmunology
resting potential
reticular formation
sensory
soma
somatic nervous
spinal cord
sympathetic division
synaptic vesicles
temporal lobes
thalamus

► Return to Activity: Fill-in-the-Blanks
◄ Return to complete list of Handout Masters for Chapter 2
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▼REVEL Multimedia Resources

More than 5,000 Revel instructors are connecting and sharing ideas. They're energizing their classrooms and brainstorming teaching challenges via Pearson's growing network of faculty communities. The Revel community is an open, online space where members come together to collaborate and learn from each other. If you're currently teaching with Revel or considering Revel for use in your class, we invite you to join the Revel community.

If you are a Revel user, VIDEOS and ANIMATIONS are embedded in the interactive chapters, along with JOURNAL PROMPTS and SHARED WRITING activities. All EXPERIMENT SIMULATIONS are in the Appendix in your Revel course. Access your Revel course at http://www.pearson.com/revel

Chapter 2 REVEL Multimedia Content available:

Video: Why Study The Nervous System and the Glands?
Video: Overview of Neuroplasticity

Survey: Do You Fly or Fight?

Interactive: The Structure of the Neuron
Interactive: The Neural Impulse Action Potential
Interactive: The Synapse
Interactive: Neurotransmitters – Reuptake
Interactive: The Spinal Cord Reflex
Interactive: Functions of the Parasympathetic and Sympathetic Divisions
Interactive: General Adaptation Syndrome
Interactive: Mapping Brain Structure
Interactive: Mapping Brain Function
Interactive: Major Structures of the Human Brain
Interactive: The Limbic System
Interactive: Lobes and Cortical Areas of the Brain
Interactive: Phineas Gage's Accident

Additional Revel Videos: Methods for Studying the Brain

Thinking Critically Journal Prompt 2.1: What do you see as the brain's role in our behavior? How much do you think your behavior is influenced by hormones and chemicals in the nervous system?

Thinking Critically Journal Prompt 2.2: 1. What type of questions should you ask yourself when referring to case studies? Do the questions differ based on the case studies being modern or historical? 2. What kind of supports and structure might have been provided to Phineas through his post-accident jobs that would have possibly helped him with his recovery? 3. How might the modern study of psychology help us better understand other historical case studies?

Shared Writing Prompt: Dr. Z is conducting research on ADHD and is requiring members of his psychology class to participate. As part of the study, students are learning to control their brain activity by using feedback during an EEG. In doing so, half of the class is learning to enhance brain activity associated with improved attention. The other half is learning to increase brain activity associated with the inattentive symptoms of ADHD. He asks both groups to complete tests of attention, and he shares the individual results with students in class, calling them by name and displaying their individual results. He did not gain approval from his university's institutional review board to conduct this study, claiming it simply a pilot investigation. Refer back to the APA Ethical Guidelines discussed in Chapter 1. What guidelines and standards are being violated?

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▼MyPsychLab Multimedia Resources

MyPsychLab features a variety of content to enhance your course. To access these resources, go to www.MyPsychLab.com, and select **Videos**, **Simulations**, or **Writing Space**.

Chapter 2 Videos

Video: The Basics: How the Brain Works, Part 1 (5:04)
Find out about neurons: their parts, how they communicate, and their function in the brain.

Video: The Basics: How the Brain Works, Part 2 (6:11)
Find out about the nervous system: how it's divided and processes information, the significance of each brain structure, and how neuronal transmission works.

Video: The Big Picture: My Brain Made Me Do It. (4:59)
Learn about the function of different parts of the nervous system and how it integrates multiple signals to create experience.

Video: In the Real World: Neurotransmitters (3:10)
Learn about the neurotransmitter dopamine and what happens when there is an imbalance of dopamine as a result of natural causes or drugs.

Video: Special Topics: The Plastic Brain (7:04)
Learn specifics about how the human brain grows and develops throughout the lifespan and how the brain can remarkably repair itself or compensate after being damaged.

Video: Thinking Like a Psychologist: The Pre-Frontal Cortex (3:28)
See how certain areas of the brain contribute to different behaviors, and how both biological and environmental factors can lead a person to become a violent criminal later in life.

Video: What's In It For Me? Your Brain on Drugs (3:51)
Neurotransmitter imbalances can occur from chemicals that we willingly ingest, such as drugs or alcohol.

Chapter 2 Simulations

Simulation: Hemispheric Specialization
Judge whether a string of letters in your peripheral vision is a real word and test whether language functions are lateralized in the brain.

Survey: Do You Fly or Fight?
Participate in a survey to discover if you flee or fight under stressful conditions.

Writing Space

Writing Practice prompts within Writing Space offer immediate automated feedback. Each student submission receives feedback based on the following characteristics: Development of Ideas, Organization, Conventions, Voice, Focus, and Coherence. Instructors can provide additional feedback and can adjust the auto-generated grade.

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▼Practice Quizzes and *Test Yourself* Answer Keys

Chapter 2

Practice Quiz page 52
1. b; 2. b; 3. c; 4. a; 5. a; 6. a

Practice Quiz page 59
1. a; 2. a; 3. c; 4. a; 5. d

Practice Quiz page 66
1. a; 2. a; 3. c; 4. c

Practice Quiz page 71
1. c; 2. c; 3. a; 4. a

Practice Quiz page 82
1. a; 2. a; 3. a; 4. b; 5. b

Test Yourself page 88
1. d; 2. d; 3. a; 4. c; 5. b; 6. a; 7. a;
8. c; 9. d; 10. b; 11. a; 12. a; 13. a; 14. a;
15. b; 16. d; 17. a; 18. b; 19. a; 20. a

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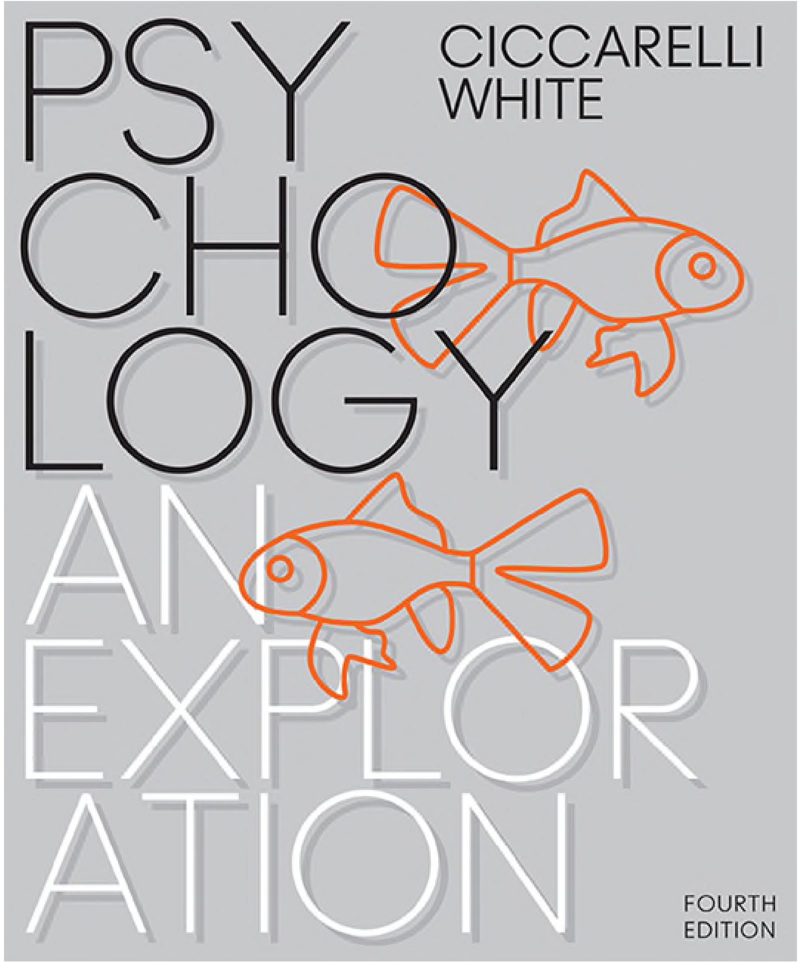
Psychology An Exploration

Fourth Edition



Chapter 2

The Biological Perspective

Learning Objectives

2.1 Identify the parts of a neuron and the function of each.

2.2 Explain the action potential.

2.3 Describe how neurons use neurotransmitters to communicate with each other and with the body.

2.4 Describe how the components of the central nervous system interact and how they may respond to experience or injury.

2.5 Differentiate the roles of the somatic and autonomic nervous systems.

2.6 Explain why the pituitary gland is known as the "master gland."

2.7 Recall the role of various endocrine glands.

Learning Objectives (2 of 3)

2.8 Describe how the autonomic nervous system and body are impacted by stress.

2.9 Describe how lesioning studies and brain stimulation are used to study the brain.

2.10 Compare and contrast neuroimaging techniques for mapping the brain's structure and function.

2.11 Identify the different structures of the hindbrain and the function of each.

2.12 Identify the structures of the brain that are involved in emotion, learning, memory, and motivation.

Learning Objectives (3 of 3)

2.13 Identify the parts of the cortex that process the different senses and those that control movement of the body.

2.14 Name the parts of the cortex that are responsible for higher forms of thought, such as language.

2.15 Explain how some brain functions differ between the left and right hemispheres.

2.16 Identify some potential causes of attention-deficit/ hyperactivity disorder.

Neurons and Nerves: Building the Network

Nervous system

- An extensive network of specialized cells that carry information to and from all parts of the body

Neuroscience

- Deals with the structure and function of neurons, nerves, and nervous tissue
- Relationship to behavior and learning

Structure of the Neuron: The Nervous System's Building Block (1 of 3)

Learning Objective 2.1 Identify the parts of a neuron and the function of each.

Neuron

- The basic cell that makes up the nervous system and receives and sends messages within that system

Structure of the Neuron: The Nervous System's Building Block (2 of 3)

Parts of a neuron

- Dendrites: branch-like structures that receive messages from other neurons
- Soma: the cell body of the neuron, responsible for maintaining the life of the cell
- Axon: long, tube-like structure that carries the neural message to other cells
- Axon terminals: rounded areas at the end of the branches at the end of the axon
  - Responsible for communicating with other nerve cells

Structure of the Neuron: The Nervous System's Building Block (3 of 3)

Glial Cells

- Provide support for neurons to grow on and around
- Deliver nutrients to neurons
- Produce myelin to coat axons

Myelin: fatty substances produced by certain glial cells that coat the axons of neurons to insulate, protect, and speed up the neural impulse

- Clean up waste products and dead neurons

Generating the Message Within the Neuron: The Neural Impulse (1 of 2)

Learning Objective 2.2 Explain the action potential.

Ions: charged particles

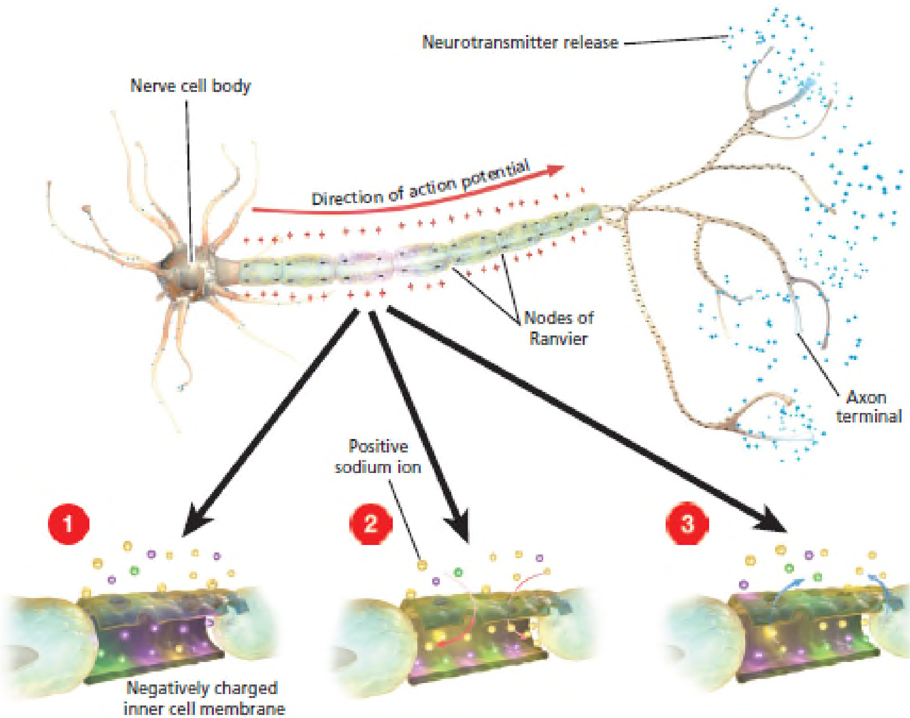
- Inside neuron: negatively charged
- Outside neuron: positively charged

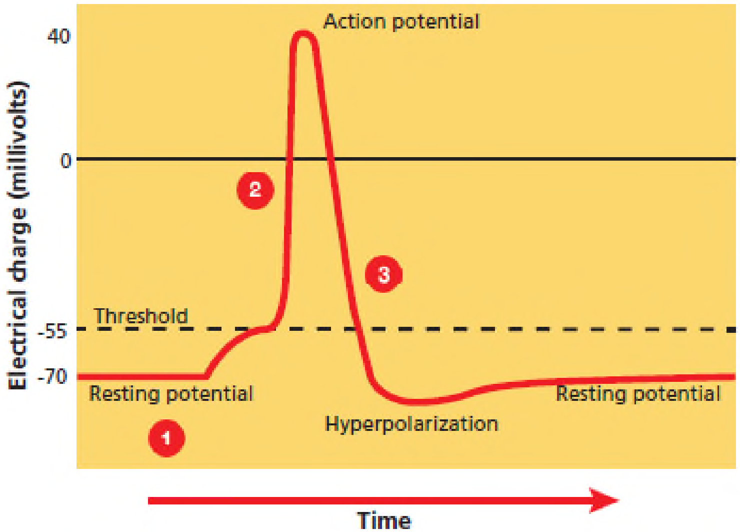
Resting potential: the state of the neuron when not firing a neural impulse

Generating the Message Within the Neuron: The Neural Impulse (2 of 2)

- Action potential: the release of the neural impulse consisting of a reversal of the electrical charge within the axon
  - Allows positive sodium ions to enter the cell
- All-or-none: a neuron either fires completely or does not fire at all

Figure 2.2
The Neural Impulse Action Potential





In the graph, voltage readings are shown at a given place on the neuron over a period of 20 or 30 milliseconds (thousandths of a second). At first the cell is resting; it then reaches threshold and an action potential is triggered. After a brief hyperpolarization period, the cell returns to its resting potential.

Neurotransmission (1 of 5)

Learning Objective 2.3 Describe how neurons use neurotransmitters to communicate with each other and with the body.

Sending The Message To Other Cells: The Synapse

- Synaptic vesicles: sack-like structures found inside the axon terminal containing chemicals
- Neurotransmitter: chemical found in synaptic vesicles which, when released, has an effect on the next cell

Neurotransmission (2 of 5)

Synapse/Synaptic Gap

- Microscopic fluid-filled space between the rounded areas on the end of the axon terminals of one cell and the dendrites or surface of the next cell

Receptor Sites

- Holes in surface of dendrites or certain cells of the muscles and glands, which are shaped to fit only certain neurotransmitters

Neurotransmission (3 of 5)

Neurons must be turned ON and OFF

- Excitatory neurotransmitter: neurotransmitter that causes the receiving cell to fire
- Inhibitory neurotransmitter: neurotransmitter that causes the receiving cell to stop firing

Neurotransmission (4 of 5)

Neurotransmitters: Messengers of the Network

- Agonists: mimic or enhance the effects of a neurotransmitter on the receptor sites of the next cell, increasing or decreasing the activity of that cell
- Antagonists: block or reduce a cell's response to the action of other chemicals or neurotransmitters

Table 2.1
Neurotransmitters and Their Functions

Neurotransmitters	Functions
Acetylcholine (ACh)	Excitatory or inhibitory; involved in arousal, attention, memory, and controls muscle contractions
Norepinephrine (NE)	Mainly excitatory; involved in arousal and mood
Dopamine (DA)	Excitatory or inhibitory; involved in control of movement and sensations of pleasure
Serotonin (5-HT)	Excitatory or inhibitory; involved in sleep, mood, anxiety, and appetite
Gaba-aminobutyric acid (GABA)	Major inhibitory neurotransmitter; involved in sleep and inhibits movement
Glutamate	Major excitatory neurotransmitter; involved in learning, memory formation, nervous system development, and synaptic plasticity
Endorphins	Inhibitory neural regulators; involved in pain relief

Neurotransmission (5 of 5)

Cleaning Up the Synapse: Reuptake and Enzymes

- Reuptake: process by which neurotransmitters are taken back into the synaptic vesicles
- Enzyme: complex protein that is manufactured by cells

Figure 2.4 Neurotransmitters: Reuptake

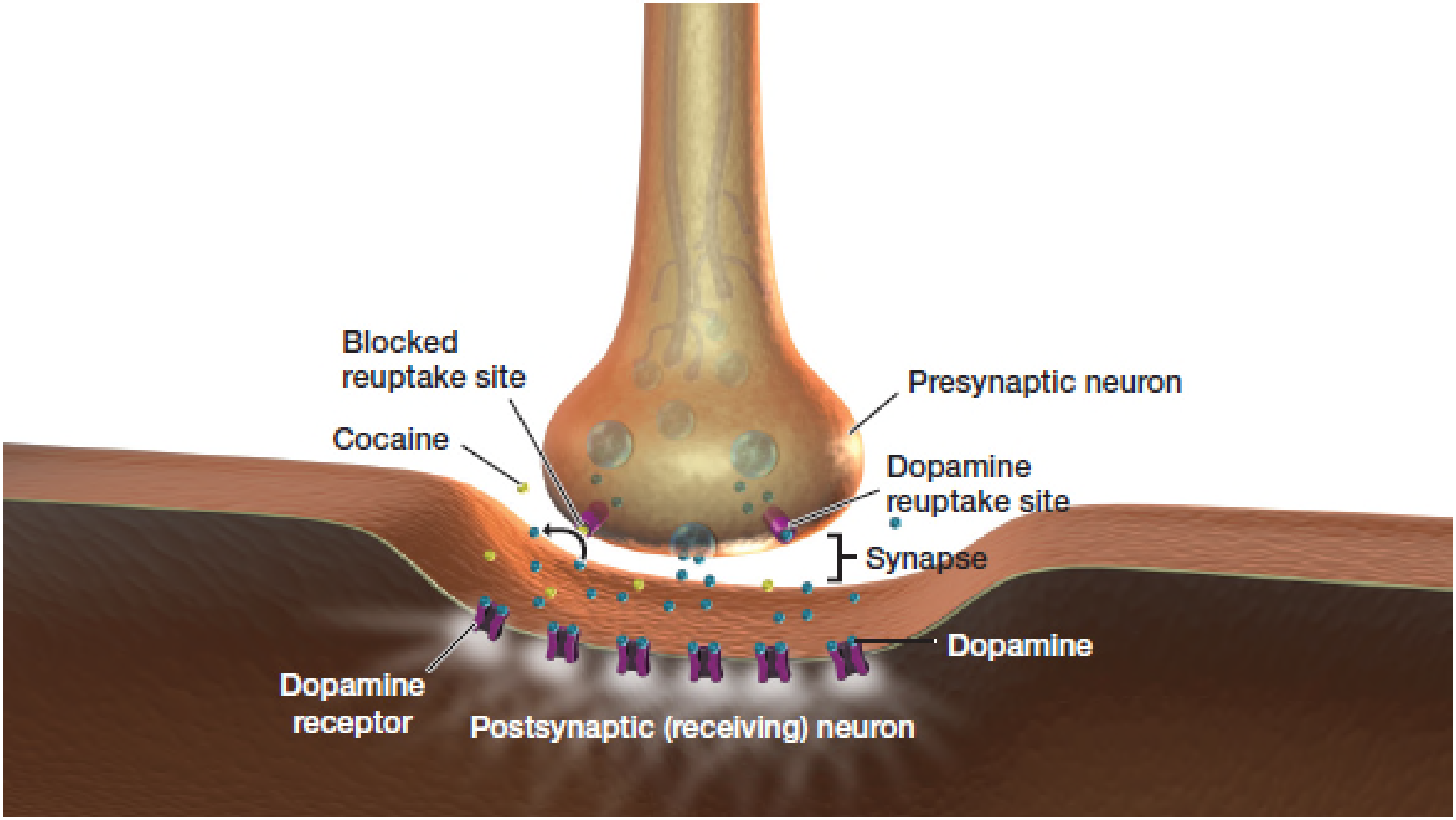
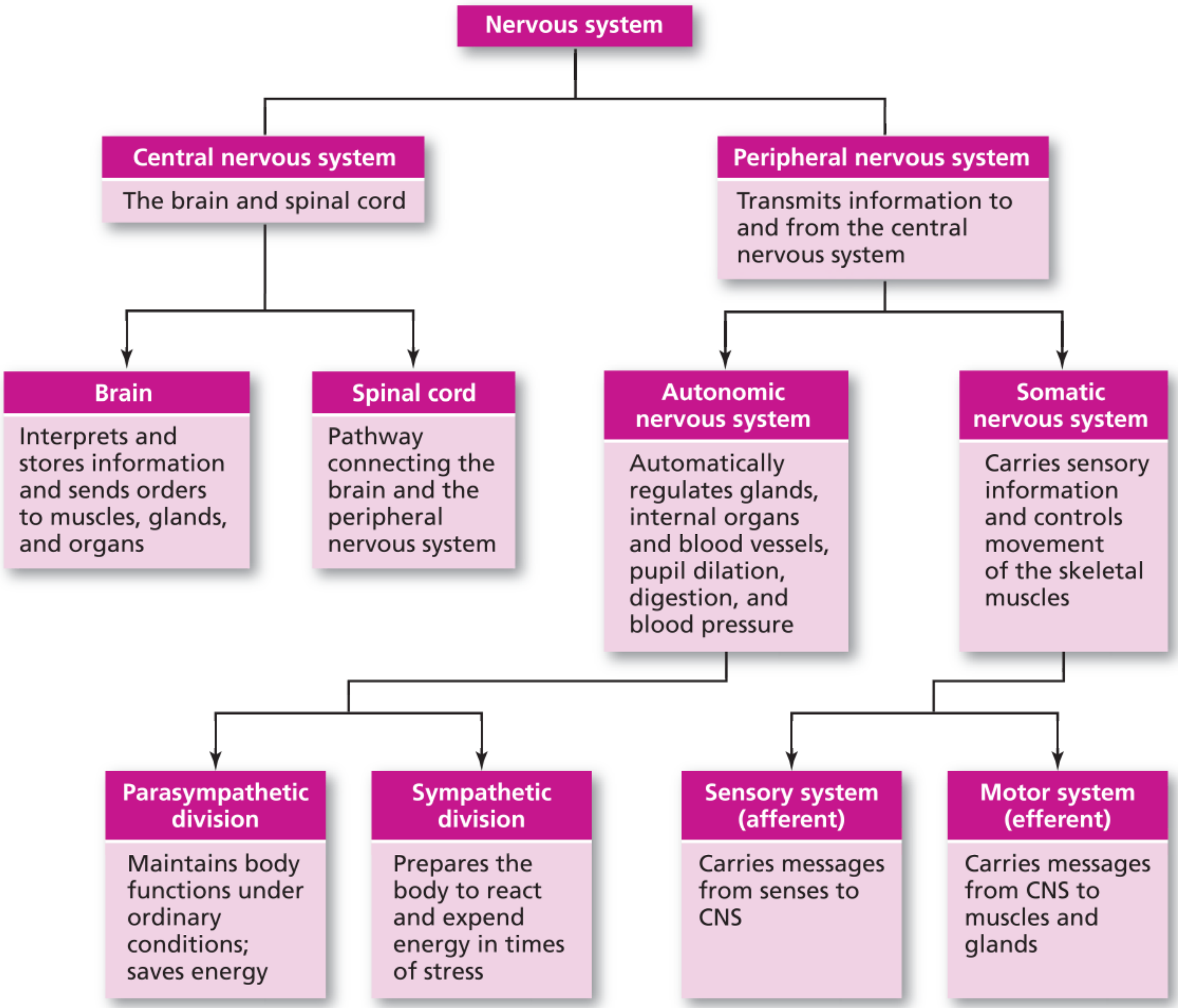


Figure 2.5 An Overview of the Nervous System



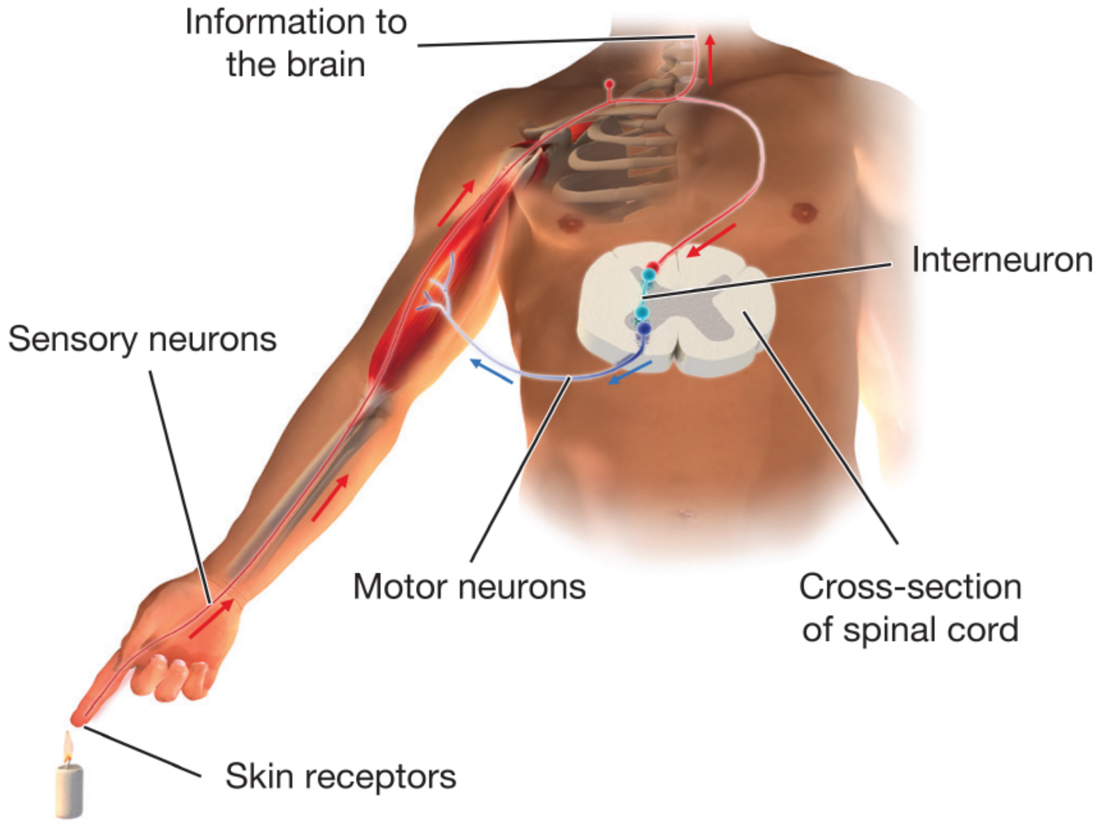
The Central Nervous System (1 of 4)

Learning Objective 2.4 Describe how the components of the central nervous system interact and how they may respond to experience or injury.

Central nervous system (CNS): part of the nervous system consisting of the brain and spinal cord

- Brain: core of the nervous system
- Spinal cord: a long bundle of neurons that carries messages to and from the body to the brain that is responsible for very fast, lifesaving reflexes

Figure 2.6 The Spinal Cord Reflex



The pain from the burning heat of the candle flame stimulates the afferent nerve fibers, which carry the message up to the interneurons in the middle of the spinal cord. The interneurons then send a message out by means of the efferent nerve fibers, causing the hand to jerk away from the flame.

The Central Nervous System (2 of 4)

Sensory neuron: a neuron that carries information from the senses to the central nervous system

- Also called an afferent neuron

Motor neuron: a neuron that carries messages from central nervous system to muscles of body

- Also called an efferent neuron

The Central Nervous System (3 of 4)

Interneuron: a neuron found in the center of the spinal cord that receives information from the sensory neurons and sends commands to the muscles through the motor neurons

- Interneurons also make up bulk of neurons in brain

The Central Nervous System (4 of 4)

Neuroplasticity and Neurogenesis in the Central Nervous System

- –Damage once thought to be permanent
- –Neuroplasticity: ability to constantly change both the structure and function of cells in response to experience or trauma
- –Neurogenesis: formation of new neurons

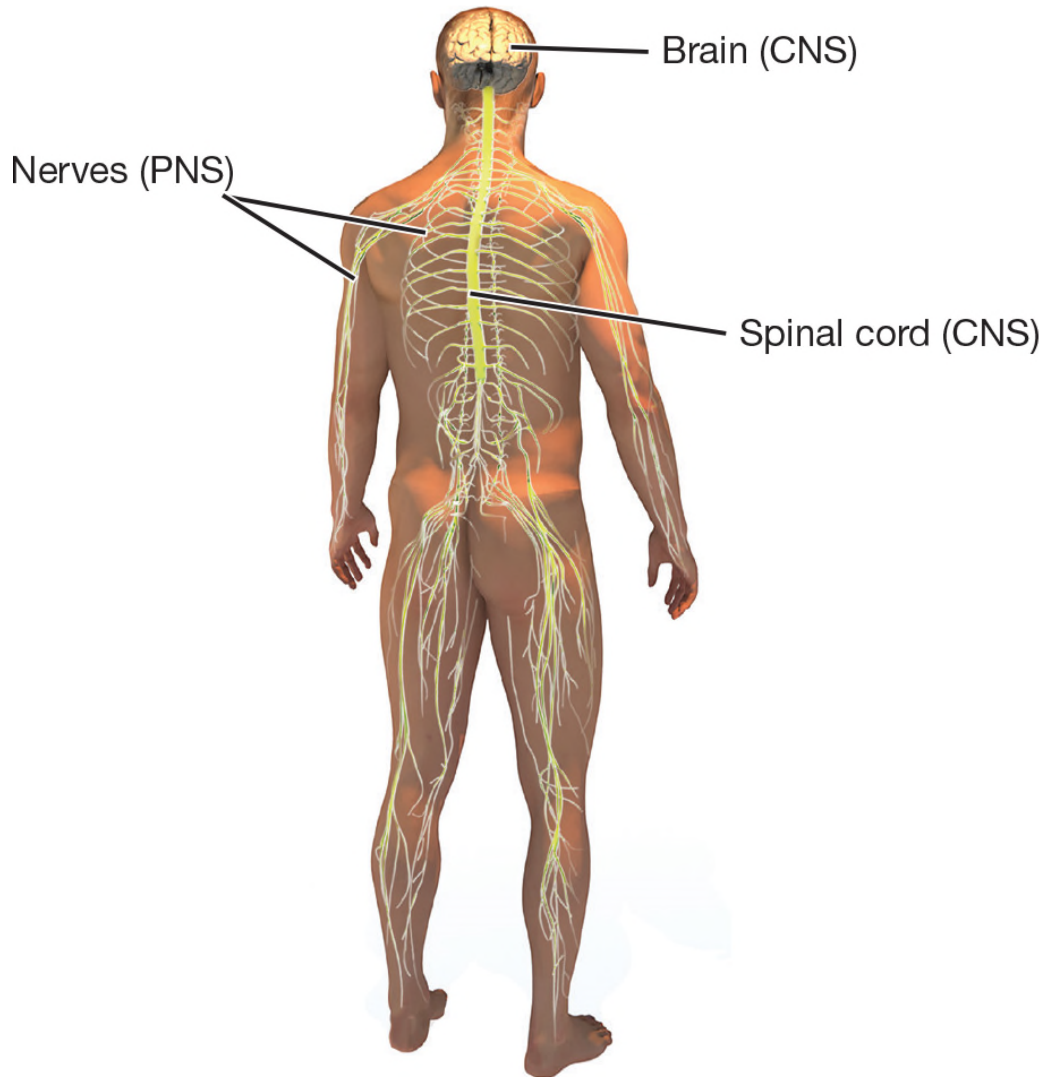
The Peripheral Nervous System (1 of 3)

Learning Objective 2.5 Differentiate the roles of the somatic and autonomic nervous systems.

Peripheral nervous system (PNS): all nerves and neurons that are not contained in the brain and spinal cord but that run through the body itself

- Somatic nervous system
- Autonomic nervous system

Figure 2.7 The Peripheral Nervous System



The Peripheral Nervous System (2 of 3)

Somatic nervous system: division of the PNS consisting of nerves that carry information from the senses to the CNS and from the CNS to the voluntary muscles of the body

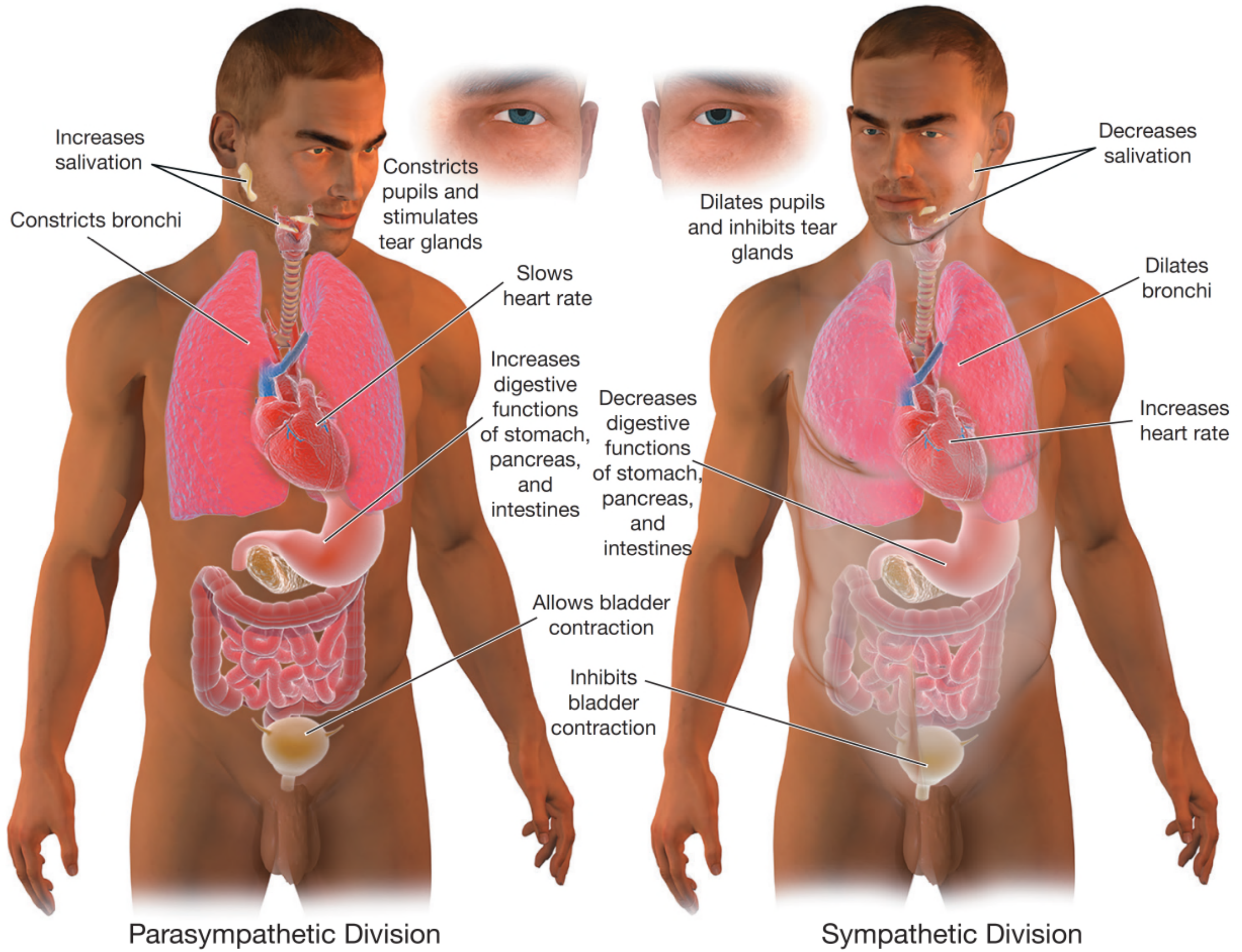
- Sensory pathway: nerves coming from the sensory organs to the CNS consisting of sensory neurons
- Motor pathway: nerves coming from the CNS to the voluntary muscles, consisting of motor neurons

The Peripheral Nervous System (3 of 3)

Autonomic nervous system (ANS)

- Division of the PNS consisting of nerves that control all of the involuntary muscles, organs, and glands; sensory pathway nerves coming from the sensory organs to the CNS consisting of sensory neurons
- Sympathetic division (fight-or-flight system): part of ANS is responsible for reacting to stressful events/bodily arousal
- Parasympathetic division: part of the ANS that restores the body to normal functioning after arousal and is responsible for the day-to-day functioning of the organs and glands

Figure 2.8 Functions of the Parasympathetic and Sympathetic Divisions of the Nervous System

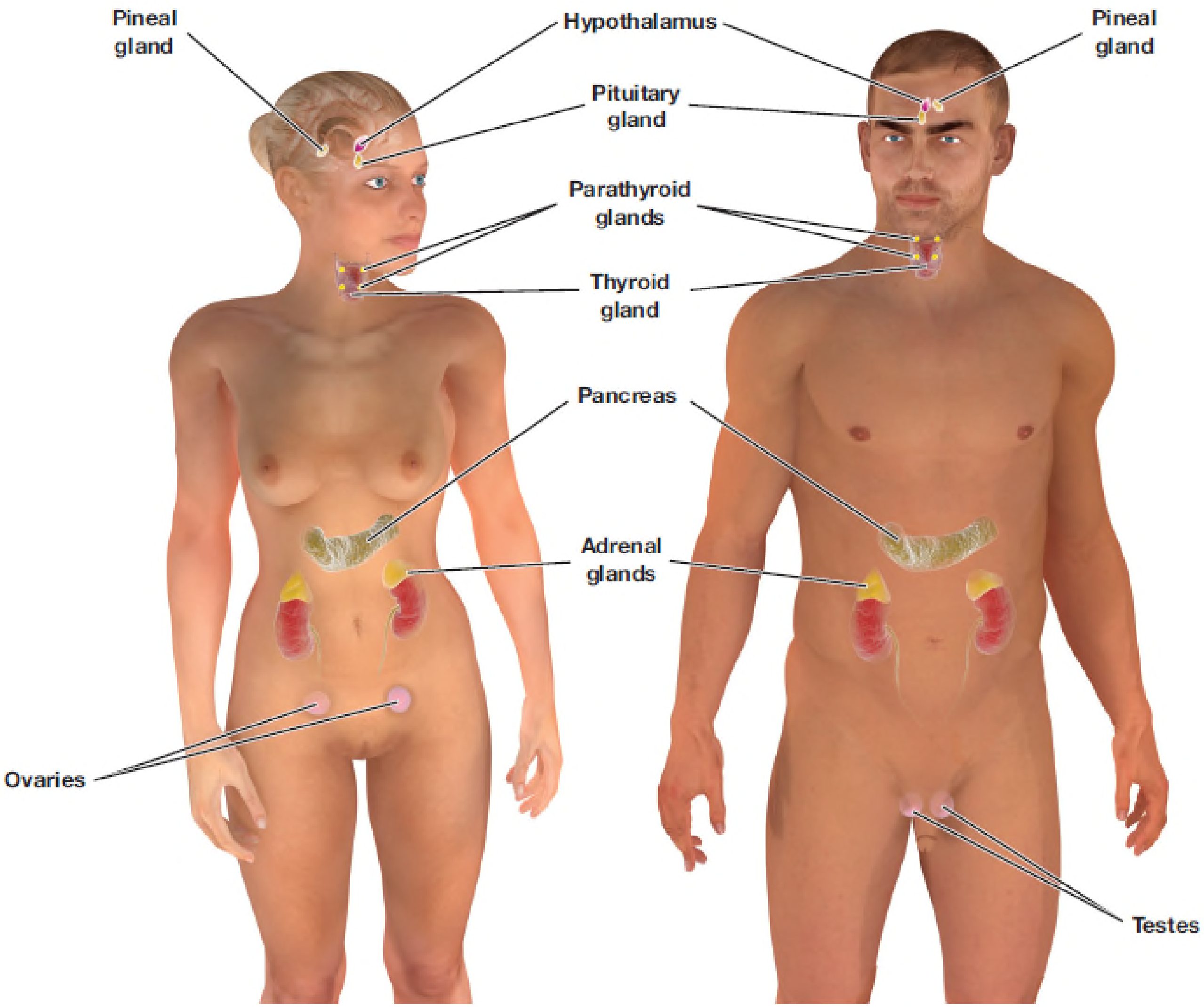


The Endocrine Glands

Endocrine glands: glands that secrete chemicals called hormones directly into the bloodstream

- Hormones: chemicals released into the bloodstream by endocrine glands

Figure 2.9 The Endocrine Glands



The endocrine glands secrete hormones directly into the bloodstream, which carries them to organs in the body, such as the heart, pancreas, and sex organs.

The Pituitary, Master of the Hormonal Universe

Learning Objective 2.6 Explain why the pituitary gland is known as the "master gland."

Pituitary gland: gland located in the brain that secretes human growth hormone and influences all other hormone-secreting glands

- Also known as the master gland

Other Endocrine Glands (1 of 2)

Learning Objective 2.7 Recall the role of various endocrine glands.

- Pineal gland: endocrine gland located near the base of the cerebrum that secretes melatonin
- Thyroid gland: endocrine gland found in the neck that regulates metabolism
- Pancreas: endocrine gland that controls the levels of sugar in the blood

Other Endocrine Glands (2 of 2)

- Gonads: the sex glands; secrete hormones that regulate sexual development and behavior as well as reproduction
  - Ovaries: the female gonads
  - Testes: the male gonads
- Adrenal glands: endocrine glands located on top of each kidney
  - Secretes over thirty different hormones to deal with stress, regulate salt intake
  - Provide a secondary source of sex hormones affecting the sexual changes that occur during adolescence

Hormones and Stress (1 of 4)

Learning Objective 2.8 Describe how the autonomic nervous system and body are impacted by stress.

General Adaption Syndrome

- Sequence of reactions the body goes through when adapting to a stressor
  - Alarm
  - Resistance
  - Exhaustion

Hormones and Stress (2 of 4)

Immune system

- The system of cells, organs, and chemicals of the body that responds to attacks from diseases, infections, and injuries
- Psychoneuroimmunology
- Positive effects of stress work only when it is not continual, chronic condition

Hormones and Stress (3 of 4)

Allostasis and allostatic load

- Maintaining stability through change
- Allostasis used to help body protect itself from internal and external stress
- Prolonged exposure to stress hormones leads to allostatic load and damage to body

Hormones and Stress (4 of 4)

Heart disease

- Stress puts people at higher risk for coronary heart disease; liver function affected

Cancer

- Collection of diseases that can affect any part of body in which cells divide without stopping
- Stress affects effectiveness of cancer treatments

Type 2 diabetes

Methods for Studying Specific Regions of the Brain (1 of 2)

Learning Objective 2.9 Describe how lesioning studies and brain stimulation are used to study the brain.

Lesioning Studies

- Insertion of a thin, insulated wire into the brain through which an electrical current is sent that destroys the brain cells at the tip of the wire

Brain Stimulation

- Electrical stimulation of the brain (ESB): milder electrical current that causes neurons to react as if they had received a message

Methods for Studying Specific Regions of the Brain (2 of 2)

Invasive Techniques

- Deep brain stimulation (DBS), impulse generator implanted and sends impulses to implanted electrodes, stimulating brain areas of interest.

Noninvasive Techniques

- Transcranial magnetic stimulation (TMS), magnetic pulses are applied to the cortex using special copper wire coils that are positioned over the head
- Tepetitive TMS (rTMS)
- Transcranial direct current stimulation (tDCS)

Neuroimaging Techniques (1 of 3)

Learning Objective 2.10 Compare and contrast neuroimaging techniques for mapping the brain's structure and function.

Mapping structure

- Computed tomography (CT): brain-imaging method using computer-controlled X-rays of the brain
- Magnetic resonance imaging (MRI): brain-imaging method using radio waves and magnetic fields of the body to produce detailed images of the brain

Neuroimaging Techniques (2 of 3)

Mapping Function

- Electroencephalogram (EEG): records electric activity of the brain below specific areas of the skull
- Magnetoencephalography (MEG)
- Positron emission tomography (PET): radioactive sugar is injected into the subject and a computer compiles a color-coded image of brain activity of the brain; lighter colors indicate more activity

Neuroimaging Techniques (3 of 3)

Mapping Function continued

- Single photon emission computed tomography (SPECT): similar to PET, but uses different radioactive tracers
- Functional MRI (fMRI): a computer makes a sort of “movie” of changes in the activity of the brain using images from different time periods

From the Bottom Up: The Structures of the Brain

Exploring Areas of the Brain

- Focus on areas of interest to psychologists
- Many areas have multiple roles

The Hindbrain (1 of 2)

Learning Objective 2.11 Identify the different structures of the hindbrain and the function of each.

Medulla: first large swelling at the top of the spinal cord, forming the lowest part of the brain

- Responsible for life-sustaining functions such as breathing, swallowing, and heart rate

Pons: larger swelling above the medulla that connects the top of the brain to the bottom

- Plays a part in sleep, dreaming, left–right body coordination, and arousal

The Hindbrain (2 of 2)

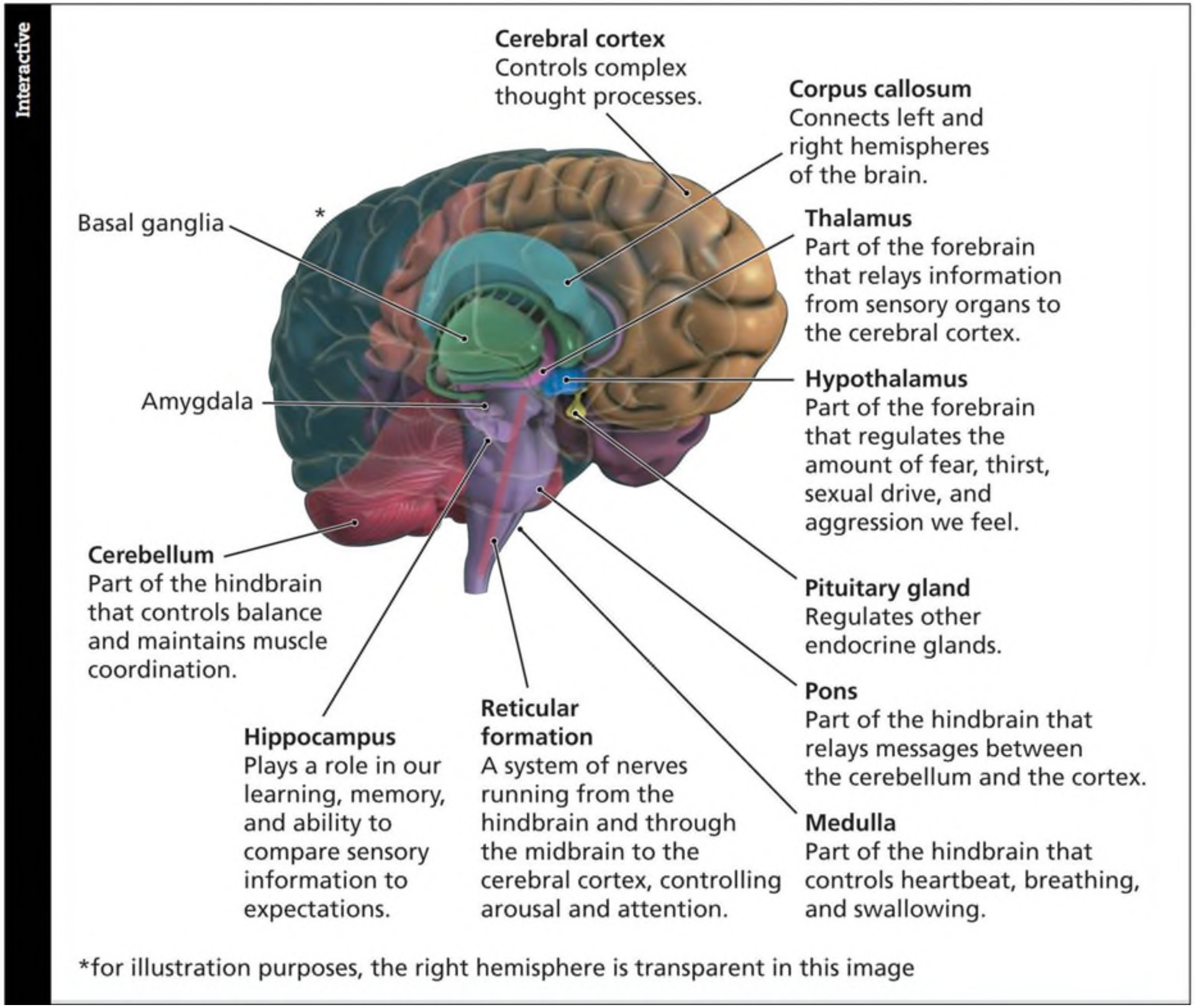
Reticular formation (RF): area of neurons running through the middle of the medulla and the pons and slightly beyond

- Responsible for selective attention

Cerebellum: part of the lower brain located behind the pons

- Controls and coordinates involuntary, rapid, fine motor movement

Figure 2.13
Major Structures of the Human Brain



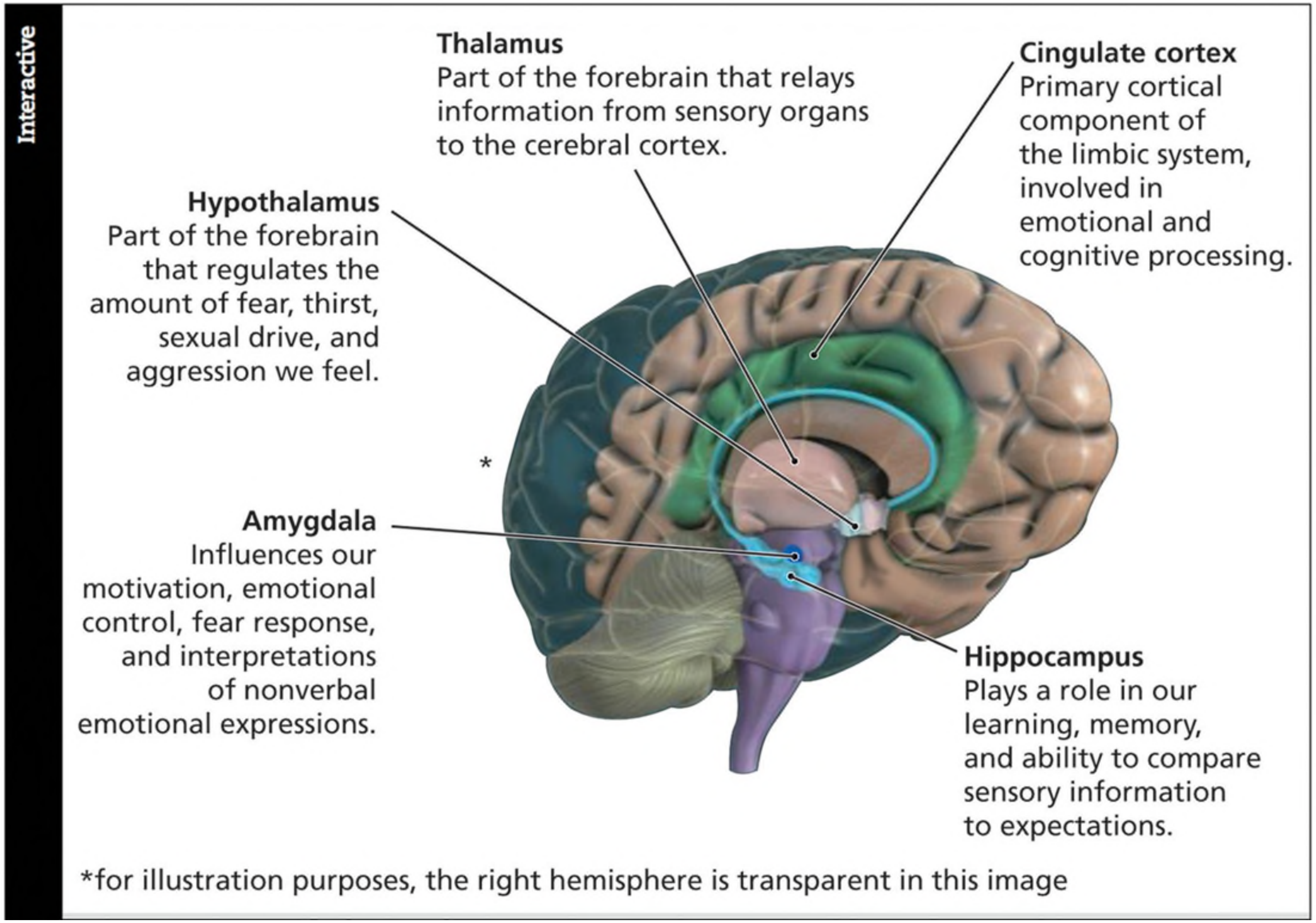
Structures Under the Cortex: The Limbic System (1 of 3)

Learning Objective 2.12 Identify the structures of the brain that are involved in emotion, learning, memory, and motivation.

A group of several brain structures located under the cortex and involved in learning, emotions, and motivation

- Thalamus: part of the limbic system located in the center of the brain
  - Relays sensory information from the lower part of the brain to the proper areas of the cortex
  - Processes some sensory information before sending it to its proper area

Figure 2.14 The Limbic System



Structures Under the Cortex: The Limbic System (2 of 3)

Hypothalamus: small structure in the brain located below the thalamus and directly above the pituitary gland

– Responsible for motivational behavior such as sleep, hunger, thirst, and sex

Hippocampus: curved structure located within each temporal lobe

– Responsible for the formation of long-term memories and the storage of memory for location of objects

Structures Under the Cortex: The Limbic System (3 of 3)

Amygdala: brain structure located near the hippocampus

- Responsible for fear responses and the memory of fear

Cingulate cortex: the limbic structure actually found in the cortex

- Plays important roles in cognitive and emotional processing

The Cortex (1 of 6)

Learning Objective 2.13 Identify the parts of the cortex that process the different senses and those that control movement of the body.

Cortex: outermost covering of the brain consisting of densely packed neurons

- Responsible for higher thought processes and interpretation of sensory input
- Corticalization: wrinkling of the cortex
  - Allows a much larger area of cortical cells to exist in the small space inside the skull

The Cortex (2 of 6)

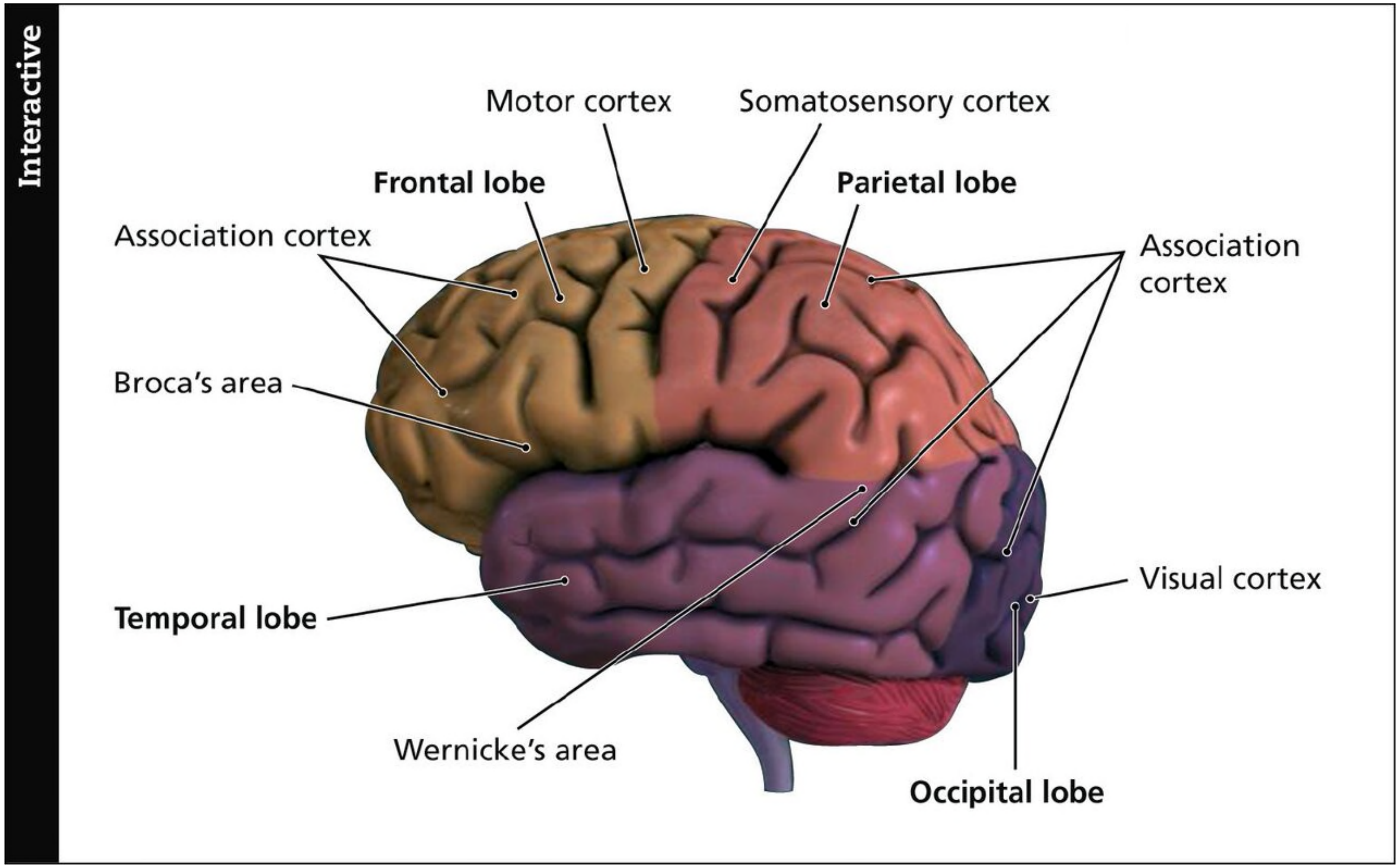
Cerebral hemispheres: the two sections of the cortex on the left and right sides of the brain

Corpus callosum: thick band of neurons that connects the right and left cerebral hemispheres

Comparing the Cortex

From top to bottom, a rat brain, sheep brain, and human brain (not to scale!). Note the differences in the amount of corticalization, or wrinkling, of the cortex between these three brains. Greater amounts of corticalization are associated with increases in size and complexity.

Figure 2.15
Lobes and Cortical Areas of the Brain



The Cortex (3 of 6)

Occipital lobe: section of the brain located at the rear and bottom of each cerebral hemisphere containing the visual centers of the brain

- Primary visual cortex: processes visual information from the eyes
- Visual association cortex: identifies and makes sense of visual information

The Cortex (4 of 6)

Parietal lobes

- Sections of the brain located at the top and back of each cerebral hemisphere containing the centers for touch, taste, and temperature sensations
- Somatosensory cortex: area of neurons running down the front of the parietal lobes
  - Responsible for processing information from the skin and internal body receptors for touch, temperature, body position, and possibly taste

The Cortex (5 of 6)

Temporal lobes: areas of the cortex located just behind the temples containing the neurons responsible for the sense of hearing and meaningful speech

- Primary auditory cortex: processes auditory information from the ears
- Auditory association cortex: identifies and makes sense of auditory information

The Cortex (6 of 6)

Frontal lobes: areas of the cortex located in the front and top of the brain; responsible for higher mental processes and decision making as well as the production of fluent speech

- Motor cortex: section of the frontal lobe located at the back; responsible for sending motor commands to the muscles of the somatic nervous system

The Association Areas of the Cortex (1 of 2)

Learning Objective 2.14 Name the parts of the cortex responsible for higher forms of thought, such as language.

Association areas: areas within each lobe of the cortex responsible for the coordination and interpretation of information, as well as higher mental processing

Broca's aphasia: condition resulting from damage to Broca's area (usually in left frontal lobe)

- Causes affected person to be unable to speak fluently, to mispronounce words, and to speak haltingly

The Association Areas of the Cortex (2 of 2)

Wernicke's aphasia: condition resulting from damage to Wernicke's area (usually in left temporal lobe)

- Causes the affected person to be unable to understand or produce meaningful language

Spatial neglect: condition produced by damage to the association areas of the right hemisphere

- Results in an inability to recognize objects or body parts in the left visual field

The Cerebral Hemispheres (1 of 3)

Learning Objective 2.15 Explain how some brain functions differ between the left and right hemispheres.

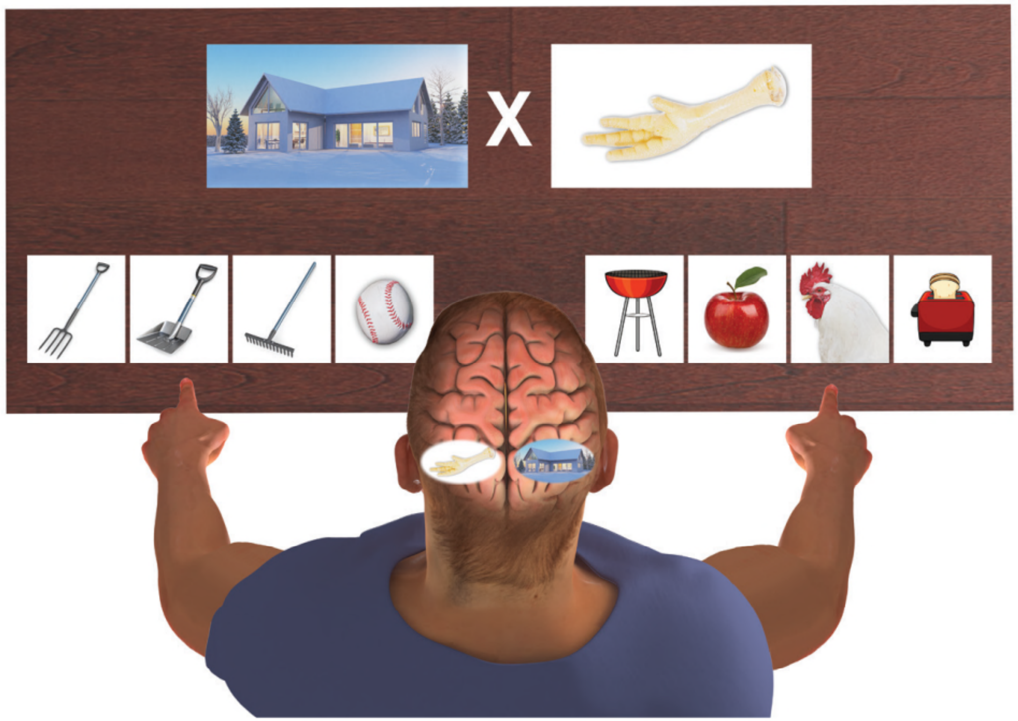
Cerebrum: the upper part of the brain consisting of the two hemispheres and the structures that connect them

The Cerebral Hemispheres (2 of 3)

Split-Brain Research

- Study of patients with severed corpus callosum
- Involves sending messages to only one side of the brain
- Demonstrates right and left brain specialization

Figure 2.17 The Split-Brain Experiment



Building off methods designed by Roger Sperry, Michael Gazzaniga and Joseph LeDoux used this simultaneous concept test to further investigate functions of the left and right hemispheres of the brain.

The Cerebral Hemispheres (3 of 3)

- Left side of the brain
  - Seems to control language, writing, logical thought, analysis, mathematical abilities
- Right side of the brain
  - Controls emotional expression, spatial perception, recognition of faces, patterns, melodies, emotions
- Handedness
  - Left and right side functions often confused with handedness

Table 2.2
Specialization of the Two Hemispheres

Left Hemisphere	Right Hemisphere
Controls the right hand	Controls the left hand
Spoken language	Nonverbal
Written language	Visual-spatial perception
Mathematical calculations	Music and artistic processing
Logical thought processes	Emotional thought and recognition
Analysis of detail	Processes the whole
Reading	Pattern recognition
Blank cell	Facial recognition

Paying Attention to Attention-Deficit/ Hyperactivity Disorder

Learning Objective 2.16 Identify some potential causes of attention-deficit/ hyperactivity disorder.

Likelihood of more than one cause and more than one brain route to ADHD

Current research looking at a variety of areas

- Environmental factors such as low-level lead exposure
- Genetic influences
- Role of heredity and familial factors
- Personality factors

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