CHAPTER 2
THE BIOLOGICAL BASIS OF BEHAVIOR

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► LECTURE GUIDE

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►LECTURE GUIDE

NEURONS: THE MESSENGERS (TEXT PAGE 42)

Lecture Launchers/Discussions Topics:
- Leading Off the Chapter
- Neurotransmitters: Chemical Communicators of the Nervous System
- Synaptic Transmission and Neurotransmitters

Classroom Activities, Demonstrations, and Exercises:
- Handout Transparency Master 2.3: The Basic Structure of the Neuron
- Using Reaction Time to Show the Speed of Neurons
- The Dollar Bill Drop
- Using Dominoes to Understand the Action Potential
- Demonstrating Neural Conduction: The Class as a Neural Network
- Human Neuronal Chain

Web Resources:
- General Resources for Biological Psychology
- Neurons/Neural Processes

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Describe a typical neuron. Distinguish between afferent, efferent, and association neurons (text pp. 42-44).

The nervous system is a complex network of cells that carry information to and from all parts of the body.

- The brain is made up of two types of cells, ***neurons*** and ***glial cells***.
  - **Neurons** have **dendrites** --which receive input --a soma or cell body, and **axons** --which carry the neural message to other cells. **(See Figure 2-1 on text page 43.)**
  - **Nerves** (or **tracts**) are groups of axons bundled together. At the end of the axons are ***terminal buttons*** that release ***neurotransmitters***.
  - The **myelin sheath** insulates and protects the axons of neurons that travel in the body. Myelin also speeds up the neural message.
  - **Sensory** (or **afferent**) **neurons** carry messages from sense organs to the spinal cord and brain.
  - **Motor** (or **efferent**) **neurons** carry messages from the brain or spinal cord to the muscles and glands.
  - **Interneurons** (or **association neurons**) carry messages from one neuron to another.
  - **Mirror neurons** are involved in mimicking the behavior of others. **Mirror neurons** are special brain cells that fire not only when we perform a motor action but also when we see someone else perform the same action.
- **Glial cells** separate, support, and insulate the neurons from each other and make up 90% of the brain. Glial cells and ***astrocytes*** (a type of star-shaped glial cell) play a role in neuron regeneration, learning and memory, and in enhancing communication between neurons.

Describe how neurons transmit information including the concepts of resting potential, polarization, action potential, graded potential, threshold of excitation, and the all-or-none law (text pp. 44-45).

The Neural Impulse

- A neuron contains charged particles called **ions**. When at rest, the neuron is negatively charged on the inside and positively charged on the outside (the **resting potential**); at this point, the neuron is in a state of **polarization**.
- When stimulated, this reverses the charge by allowing positive sodium ions to enter the cell, a process called ***depolarization***. The **action potential** is the sequence of electrical charges moving down the cell, also called a "**neural impulse**." **(See Figure 2-2 on text page 45.)**
- Neurons do not fire in response to a single message from another neuron. A single message causes a small, temporary shift in the electrical charge, called a **graded potential**. For a neuron to fire, impulses from many neurons must exceed a certain minimum **threshold of excitation.**
- Neurons fire in an **all-or-none** manner. Each firing produces an impulse of the same strength. It is the speed and number of neurons firing that tells researchers the strength of the stimulus. **(See Figure 2-3 on text page 46.)**
- After firing, neurons enter a ***refractory period*** during which the neuron cannot fire again, followed by a ***relative refractory period*** where the cell is returning to its resting state.

Describe the parts of the synapse and the role of neurotransmitters in the synapse (text pp. 46-48).

The Synapse

- Synaptic vesicles in the end of the axon terminal release neurotransmitter chemicals into the **synaptic space**, or **synaptic cleft**, between one cell and the next. **(See Figure 2-4 on text page 47.)**
- When the nervous impulse travels down to the ***axon terminal***, it causes the **synaptic vesicles** in the **terminal buttons** to release chemicals into the synaptic cleft.
- The **neurotransmitters** fit into specific **receptor sites** on the next cell in a lock-and-key manner, stimulating or inhibiting that cell's firing.
- After they detach from the receptor site, most neurotransmitters are reabsorbed into the synaptic vesicles in a process called reuptake, or they are broken down and recycled or disposed of as waste.

Neurotransmitters

- ***Acetylcholine*** –stimulates muscles and plays a role in arousal, attention and memory formation. Alzheimer's disease has been linked to a degeneration of brain cells that produce and respond to acetylcholine.
- ***Dopamine*** – affects neurons associated with voluntary movement, learning, memory and emotion.
- ***Serotonin*** – involved in emotional experiences.
- ***Glutamate* –** an excitatory neurotransmitter that speeds up synaptic transmission.
- ***Endorphins*** – neural regulators that control our pain response. *Opiates* bind to the same receptor sites as endorphins, producing similar painkilling effects.
- ***GABA (Gamma aminobutyric acid)*** – associated with sleep, eating disorders and increased levels of anxiety.
- See **"Applying Psychology: Drugs and Behavior"** (text p. 49) for a review of how other chemical substances affect the nervous system.

Explain "neural plasticity" and "neurogenesis" (text pp. 48-51).

Neural Plasticity and Neurogenesis

- **Neural Plasticity** – changes in the brain in response to an organism's experiences.
    - Rosenzweig's (1984) classic research on "enriched" environments (versus impoverished environments) revealed that the rats living in the enriched environments generated larger neurons with more synaptic connections. This process occurred with rats of any age. **(See Figure 2-5 on text page 49.)**
    - Neural plasticity is a feedback loop: Experience produces changes in the brain; these changes lead to new learning; this new learning produces further changes in the brain, etc.
    - Repeated stimulation of the same region of the brain (the hippocampus) causes neurons to respond vigorously for weeks after the stimulation. This phenomenon is called *long-term potentiation (LTP)*, and appears to be involved in the learning and storing of new information.
- **Neural networks** – networks composed of thousands of neurons develop in response to experience and are the foundation for all psychological processes. These neural networks vary by culture, reflecting the different influences and emphases of each culture.
- **Neurogenesis** – recent research has revealed that adult brains are capable of producing new brain cells.
    - The discovery of neurogenesis overturned a decades-old belief that organisms were born with all of the brain cells that they would ever have.
    - Neurogenesis raises new possibilities for the treatment of neurological disorders and spinal cord injuries, either through the use of fetal stem cells, mature stem cells, or by stimulating the brain's own stem cells to provide "self-repair."

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THE CENTRAL NERVOUS SYSTEM (TEXT PAGE 52)

Lecture Launchers/Discussion Topics:

- The Perception of Phantom Pain
- The Brain
- The Cranial Nerves
- Berger's Wave
- Freak Accidents and Brain Injuries
- Neural Effects of a Concussion
- The Phineas Gage Story
- Workplace Problems: Left Handedness
- Understanding Hemispheric Function
- Brain's Bilingual Broca
- The Results of a Hemispherectomy

Classroom Activities, Demonstrations, and Exercises:

- Review of Brain Imaging Techniques
- Trip to the Hospital
- The Importance of a Wrinkled Cortex
- Probing the Cerebral Cortex

- Lateralization Activities
- Localization of Function Exercise
- Looking Left, Looking Right
- The Brain Diagram
- Psychology in Literature: *The Man Who Mistook His Wife For a Hat*

APS Reader:

- The Occipital Cortex in the Blind: Lessons about Plasticity and Vision
- Beyond Fear: Emotional Memory Mechanisms in the Human Brain

Forty Studies

- One Brain or Two?
- More Experience = Bigger Brain

Web Resources:

- The Nervous System
- The Brain
- Phineas Gage

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The Organization of the Nervous System (see Figure 2-6 on text page 52)

- The **central nervous system** includes the brain and spinal cord.
- The **peripheral nervous system** consists of nerves that carry messages back and forth between the central nervous system and the sense organs, muscles, and glands. The peripheral nervous system is subdivided into two systems:
    - *Somatic nervous system* – transmits information about body movements and the external environment.
    - *Autonomic nervous system* – transmits information to and from the internal sense organs and glands.

Identify the parts of the brain and their function. Explain what is meant by "hemispheric specialization" and the functional differences between the two cerebral hemispheres (text pp. 52-60).

The Brain (see Figure 2-7 on text page 53)

The Central Core – composed of the *hindbrain* and the *midbrain.*

- **Hindbrain** – located where the spinal cord enters the skull.
    - **Medulla** – controls essential life support functions like breathing, heart rate, and blood pressure.
    - **Pons** – maintains the sleep-wake cycle.
    - **Cerebellum** – controls certain reflexes, sense of balance, and coordinates bodily movements.

- **Midbrain** – located above the hindbrain, the midbrain is important for hearing and sight. It also is one of the places in the brain where pain is registered.
    - **Thalamus** – relays sensory information to appropriate locations in the brain.
    - **Hypothalamus** – governs motivation and emotional responses.

- **Reticular Formation** – network of neurons whose function is to alert and arouse higher parts of the brain in response to incoming messages.

The Cerebrum – covering the central core, the *cerebrum* is what people think of when they talk about "the brain." The cerebrum processes thought, vision, language, memory, and emotions, and is the most recently evolved part of the nervous system. **(See Figure 2-8 on text page 55.)**

- **The Cerebral Cortex** – a thin, convoluted layer of gray matter that covers both hemispheres of the brain, completely enveloping the *cerebrum.* The cerebral cortex is divided into two hemispheres – right and left – and each hemisphere is divided into four lobes (partially divided by a *central fissure* and *lateral sulcus* – see Figure 2-7 on text page 53). Large areas of each lobe of the cortex, called **association areas,** are devoted to integrating information from diverse parts of the cortex and are involved in learning, thinking and remembering.
- **The Lobes of the Cerebral Hemispheres**:
  - **Frontal Lobe** – coordinates messages from the other three lobes of the cortex and serves as the execute control center for the brain. The story of Phineas Gage dramatically illustrates what happens when the frontal lobe is damaged.
    - **Primary Motor Cortex** – part of the frontal lobe responsible for voluntary movement.
    - **Prefrontal Cortex** – involved in goal-directed behavior, impulse control, judgment, and metacognition.
  - **Occipital Lobe –** receives and processes visual information.
  - **Parietal Lobe** – receives sensory information from throughout the body in an area called the **primary somatosensory cortex.**
  - **Temporal Lobe** – involved in face recognition, interpreting emotions, regulating emotions and motivation, and maintaining balance and equilibrium.
  - **Insula –** beneath the temporal lobe and located within the lateral fissure, the *insula* is involved in the expression of emotion and desire and plays a role in addiction.

The Limbic System – fully developed only in mammals, it plays a role in learning and emotional behavior. **(See Figure 2-9 on text page 57.)**

- **Hippocampus** – plays an essential role in the formation of new memories.
- **Amygdala** – governs and regulates emotions and establishes emotional memories.
  - *Williams Syndrome* – a condition associated with amygdala damage in which people are unable to interpret facial expressions of anger or worry in other people.

Hemispheric Specialization

The right and left hemispheres communicate through the **corpus callosum,** a thick band of nerve fibers lying under the cortex. **(See Figure 2-10 on text page 58)**

- The left hemisphere controls movement on the right side of the body and is usually dominant in language and tasks involving symbolic reasoning.
- The right hemisphere controls movement on the left side of the body and is typically superior at nonverbal, visual, and spatial tasks.
- Fascinating research on split-brain patients has taught us much about the specialized functions of each hemisphere **(see Figure 2-11 on text page 59)**, but remind your students that:
  - Not everyone shows the same pattern of differences between the left and right hemispheres;
  - It is tempting to oversimplify and exaggerate differences between the two sides of the brain, resulting in erroneous classifications of people as "left-brain" and "right-brain" thinkers;

- o The brain possesses remarkable levels of plasticity, meaning that both hemispheres have the potential to perform a wide range of tasks.

Language (see Figure 2-12 on text page 60)

- *Wernicke's Area* – located in the temporal lobe, Wernicke's area is responsible for processing and understanding what others are saying.
- *Broca's Area* – located in the frontal lobe, Broca's area is involved in the production of speech.
- **Aphasias –** problems in understanding ("receptive aphasia") or producing ("expressive aphasia") language that usually result from damage to Wernicke's or Broca's areas, respectively.

Handedness

- 90% of humans are right-handed, with slightly more males than females being left-handed.
- Handedness appears to be the product of genetics, environment, and prenatal development.

Discuss how microelectrode techniques, macroelectrode techniques, structural imaging and functional imaging provide information about the brain (text pages 60-63).

Tools for Studying the Brain (see Summary Table on text page 61)

Microelectrode Techniques – used to discover the functions of single neurons.

Macroelectrode Techniques – used to obtain an overall picture of the activity in a particular region of the brain.

Structural Imaging – produces a three-dimensional image of the brain.

- *Computerized axial tomography* (CAT or CT scanning) – X-ray photography unit rotates around the body, producing a 3-D image.
- *Magnetic resonance imaging* (MRI) – a magnetic field captures energy released by different structures of the brain.

Functional Imaging – techniques that look at the brain's activity as it reacts to sensory stimulation.

- *EEG* – the EEG machine allows researchers to look at the activity of the surface of the brain through the use of microelectrodes placed on the scalp and connected to an amplifier and a computer for data recording and analysis.
- *Magnetoencephalography (MEG)* and *magnetic source imaging (MSI)* – similar to EEG but more accurate.
- *Positron Emission Tomography (PET) scanning* – use a radioactive sugar injected into the bloodstream to track the activity of brain cells, which is enhanced and color-coded by a computer.
- *Functional magnetic resonance imaging (fMRI)* – by tracking changes in the oxygen levels of the blood, fMRI can tell researchers what areas of the brain are active.

Explain how the spinal cord works (text pages 63-64).

The Spinal Cord (see Figure 2-13 on text page 63 and Figure 2-14 on text page 64)

- The **spinal cord** is a cable of neurons that runs down the spine, connecting the brain to most of the rest of the body.
- The spinal cord is composed of motor neurons that descend from the brain, controlling internal organs and muscles.
- Ascending, sensory neurons deliver information from the extremities and internal organs to the brain.
- The spinal cord also contains neural circuits involving sensory neurons, *interneurons*, and motor neurons that produce reflex movements that do not require input from the brain.

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THE PERIPHERAL NERVOUS SYSTEM (TEXT PAGE 64)

Classroom Activities, Demonstrations, and Exercises:
- ➢ The Autonomic Nervous System

Web Resources:
- ➢ The Nervous System

MyPsychLab Multimedia Resources:
- ➢ List of Multimedia Resources

PowerPoint Slides:
- ➢ Link to PowerPoint slides

Identify the peripheral nervous system and contrast the functions of the somatic and autonomic nervous systems (text pp. 64-66).

The peripheral nervous system links the brain and spinal cord to the rest of the body. It consists of:
- ***Afferent Neurons*** – carry messages from the sense organs to the spinal cord and brain.
- ***Efferent Neurons*** – carry messages from the spinal cord and brain to the muscles and glands.

The peripheral nervous system is subdivided into:
- **Somatic Nervous System –** contains the sensory pathway, or neurons carrying messages to the central nervous system, and the motor pathway, or neurons carrying messages from the central nervous system to the voluntary muscles.
- **Autonomic Nervous System** – carries messages between the central nervous system and the internal organs, governing involuntary activities.

Explain the differences between the sympathetic and the parasympathetic nervous systems (text pp. 65-66).

The autonomic nervous system consists of the parasympathetic division and the sympathetic division **(see Figure 2-15 on text p. 65)**:
- **Sympathetic Division** – comprises our fight-or-flight system, preparing us to react to stress.
- **Parasympathetic Division** – restores and maintains normal day-to-day functioning of the organs, calming the body after it reacts to stress.

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THE ENDOCRINE SYSTEM (TEXT PAGE 66)

Lecture Launchers/Discussion Topics:

- Too Much or Too Little: Hormone Imbalances
- Would You Like Fries With That Peptide?

Activities, Demonstrations, and Exercises:

- Twenty Questions

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Describe the endocrine glands and the way their hormones affect behavior (text pages 66-68).

The **endocrine glands** release **hormones** that are carried throughout the body by the bloodstream. Hormones, like neurotransmitters, carry messages, but they function more slowly. These chemical messages serve to *organize* the nervous systems and body tissues (governing pubertal development, for example) and they *activate* behaviors, like alertness and sexual behavior.

See Figure 2-16 on text page 67 for a visual overview of the endocrine system.

Endocrine Glands:

- **Pituitary Gland**
  - The pituitary gland is found in the brain just below the hypothalamus. It has two parts, the anterior and the posterior.
  - It controls the levels of salt and water in our system and, in women, the onset of labor and lactation.
  - It also controls the secreting of growth hormones and influences the activity of the other glands.
- **Pineal Gland**
  - The pineal gland is located near the back of the brain.
  - It secretes the hormone melatonin, which regulates the sleep-wake cycle.
- **Thyroid Gland**
  - The thyroid gland is located inside the neck and controls metabolism (the burning of energy) by secreting thyroxin.
  - The thyroid gland determines how alert someone is as well as how thin or heavy they may be.
- **Parathyroids**
  - Four tiny organs that are embedded in the thyroid gland.
  - Control the levels of calcium and phosphate in the body, which influences excitability.
- **Pancreas**
  - The pancreas controls the level of sugar in the blood by secreting insulin and glucagons.
  - Too much insulin produces hypoglycemia, while too little causes diabetes.
- **Adrenal Glands**
  - The adrenal glands, one on top of each kidney, control our stress reaction through the adrenal medulla's secretion of epinephrine and norepinephrine.
  - The adrenal cortex secretes over thirty different corticoids (hormones) controlling salt intake, stress, and sexual development.

- **Gonads**
  - The gonads are the ovaries in women and testes in men.
  - They secrete hormones traditionally classified as masculine (androgens) and feminine (estrogens) to regulate sexual growth, activity, and reproduction.
  - Testosterone has long been linked to aggressive behavior. For example:
    - Violent behavior in males is greatest when testosterone is at its highest level – between the ages of 15 and 25;
    - High levels of testosterone are associated with competitive aggression and risk-taking;
    - In elderly men with dementia, high levels of testosterone are related to increases in aggressive behavior;
    - Married men and married men with children have lower testosterone levels than non-married men, resulting in increases in nurturance.

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GENES, EVOLUTION, AND BEHAVIOR (TEXT PAGE 69)

Lecture Launchers/Discussion Topics:
- Hey, Simpleton!
- Would You Like Fries With That Peptide?

Activities, Demonstrations, and Exercises:
- DEBATE: Are Genetic Explanations for ADHD Faulty?
- Reunited Twins

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Distinguish between genetics, behavior genetics, and evolutionary psychology (text pp. 69-70).

Heredity-Environment: The Pendulum Swings

- The nature versus nurture debate has been waged for many years; psychologists in one camp emphasized genes and heredity (or nature), while psychologists in the other camp emphasized the environment and experience (or nurture).
- Contemporary psychologists view the nature versus nurture debate as artificial and have assumed an “interactionist” perspective: Both genes and environment shape human behavior.
- Strong disagreement exists regarding the relative influence of heredity and environment on our thoughts, abilities, personalities, and behaviors.
  - **Behavior Genetics** – focus on the extent to which heredity accounts for individual differences in behavior and thinking.
  - **Evolutionary Psychology** – studies the evolutionary roots of behaviors and mental processes that all human beings share.

Differentiate between genes, chromosomes, DNA and the human genome. Describe what is meant by dominant and recessive genes, polygenic inheritance, and genotype vs. phenotype (text pp. 70-72).

Genetics

- **Genetics –** the study of how traits are transmitted from one generation to the next.
- **Genes –** elements that control the transmission of traits; they are found on chromosomes and occur in pairs.
- **Chromosomes –** pairs of threadlike bodies within the cell nucleus that contain the genes.
- **DNA –** complex organic molecule in the form of a double-helix from which chromosomes and genes are composed. DNA is the only known molecule that can replicate itself.
- **(See Figure 2-17 on text p. 71)**

- Single-gene Inheritance – some traits, like eye color, are the result or the action of a single gene **(see Figure 2-18 on text p. 72).**
  - **Dominant Gene –** member of a gene pair that controls the appearance of a certain trait.
  - **Recessive Gene –** member of a gene pair that can control the appearance of a certain trait only when paired with another recessive gene.
- **Polygenic Inheritance –** process by which several genes interact to produce a certain trait.
  - **Genotype –** an organism's entire unique genetic makeup.
  - **Phenotype –** the outward expression of a trait, influenced by the interaction of a person's genotype and his or her experience.

- **The Human Genome –** the sum total of all the genes necessary to build a human being; approximately 20,000 to 25,000 genes located on 23 chromosome pairs. In 2000, the Human Genome Project announced the first rough map of the entire human genome.

Compare and contrast strain studies, selection studies, family studies, twin studies and adoption studies as sources of information about the effects of heredity (text pp. 72-73)

Behavior Genetics

The goal of behavioral geneticists is to identify what genes contribute to the traits that humans exhibit.

- **Animal Behavior Genetics**
  - **Strain Studies –** the influence of genetics on behavior can be observed when animals of different strains are raised in the same environment. If their performance differs, it must be the result of differences in genetic strains.
  - **Selection Studies –** heritability of a trait can be investigated by interbreeding animals with the same trait and observing the prevalence of the trait among the offspring. The heritability of physical and psychological traits can be assessed in this manner.

- **Human Behavior Genetics**
  - **Family Studies –** studies of heritability in humans based on the assumption that if genes influence a certain trait, close relatives should be more similar on that trait than distant relatives.
  - **Twin Studies –** studies of **identical** and **fraternal twins** to determine the relative influence of heredity and environment on human behavior.
    - **Identical Twins –** develop from a single egg and ,therefore, are genetically identical.

- **Fraternal Twins –** develop from two separate eggs and, therefore, are no more genetically similar than any other pair of siblings.
- Any differences in identical twins must be due to experience or environmental factors since their genetics are identical. If identical twins who were raised together are no more alike in some specific characteristic than fraternal twins raised under similar environmental conditions, then heredity must not be very important for the characteristic being studied.

- **Adoption Studies –** focus on children who were adopted at birth and raised by parents not genetically related to them. Adoption studies provide additional information about the relative influence of heredity and environment on human behavior.

Identify the key ethical issues that arise as society gains more control over genetics (text p. 74).

Social Implications

Chorionic villus sampling and *amniocentesis* are two procedures for obtaining samples of cells from fetuses in order to analyze their genes. Using these procedures, genetic problems are detected in about 2% of pregnancies. Ethically, how should we use and respond to the information that these procedures yield? Do parents have the right to abort fetuses with genetic defects?

Not only do humans respond to their environments, but humans also shape their environments. Humans inherit predispositions that, in turn, compel them to seek environments that complement their predispositions. Therefore, because genes and environments interact in so many intricate and subtle ways, trying to separate and isolate the effects of heredity and environment is artificial at best, and can perhaps lead to misguided or harmful actions.

Describe how evolutionary psychologists view the influence of natural selection on human social behavior (text pp. 75-76).

Evolutionary Psychology

Evolutionary psychologists try to explain the behavioral traits that people have in common. Shared traits are the result of **natural selection.**

Natural Selection – organisms that adapt best to their environment tend to survive and pass their genetic characteristics to subsequent generations. Those organisms who adapt less successfully to their environment tend to vanish from the earth.

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CHAPTER REVIEW (TEXT PAGE 77)

Classroom Activities, Demonstrations, and Exercises:

- Crossword Puzzle
- Fill in the Blank

MyPsychLab Multimedia Resources:

- List of Multimedia Resources

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▼CHAPTER 2
Learning Objectives

After reading this chapter, students should be able to respond to each of the bulleted objectives below:

Neurons: The Messengers

- Describe a typical neuron. Distinguish between afferent, efferent and association neurons.
- Describe how neurons transmit information, including the concepts of resting potential, polarization, action potential, graded potential, threshold of excitation, and the all-or-none law.
- Describe the parts of the synapse and the role of neurotransmitters in the synapse.
- Explain "neural plasticity" and "neurogenesis."

The Central Nervous System

- Identify the parts of the brain and their function. Explain what is meant by "hemispheric specialization" and the functional differences between the two cerebral hemispheres.
- Discuss how microelectrode techniques, macroelectrode techniques, structural imaging and functional imaging, provide information about the brain.
- Explain how the spinal cord works.

The Peripheral Nervous System

- Identify the peripheral nervous system and contrast the functions of the somatic and autonomic nervous systems.
- Explain the differences between the sympathetic and the parasympathetic nervous systems.

The Endocrine System

- Describe the endocrine glands and the way their hormones affect behavior.

Genes, Evolution, and Behavior

- Distinguish between genetics, behavior genetics, and evolutionary psychology.
- Differentiate between genes, chromosomes, DNA, and the human genome. Describe what is meant by dominant and recessive genes, polygenic inheritance, and genotype vs. phenotype.
- Compare and contrast strain studies, selection studies, family studies, twin studies, and adoption studies as sources of information about the effects of heredity.
- Identify the key ethical issues that arise as society gains more control over genetics.
- Describe how evolutionary psychologists view the influence of natural selection on human social behavior.

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▼CHAPTER 2
Rapid Review

(From the Study Guide accompanying Morris/Maisto, *Understanding Psychology, 10th edition*)

The chapter opens with the compelling story of 5-year-old Nico, a child who had radical surgery to remove the entire right side of his brain. The journey through the brain taken in this chapter is part of the branch of psychology known as **psychobiology**, which deals with the biological bases of behavior and mental processes. Psychobiology overlaps with a much larger interdisciplinary field of study called **neuroscience**, which specifically focuses on the brain and nervous system.

Biological processes are the basis of our thoughts, feelings, and actions. All of our behaviors are kept in tune with our surroundings and coordinated with one another through the work of two interacting systems: the nervous system and the endocrine system.

The basic building block of the nervous system is the **neuron**, or nerve cell. Neurons have several characteristics that distinguish them from other cells. Neurons receive messages from other neurons through short fibers called **dendrites**. A longer fiber, called an **axon**, carries outgoing messages from the cell. A group of axons bundled together forms a nerve or tract. Some axons are covered with a fatty **myelin sheath** made up of **glial cells**; this increases neuron efficiency and provides insulation. There are many different types of neurons including: **sensory** or **afferent neurons**, **motor** or **efferent neurons**, **interneurons** or **association neurons**, and **mirror neurons**, which are involved in imitation.

When a neuron is at rest (a state called the **resting potential**), there is a slightly higher concentration of negatively charged ions inside its membrane than there is outside. The membrane is said to be **polarized—**that is, the electrical charge inside it is negative relative to its outside. When an incoming message is strong enough, this electrical imbalance abruptly changes (the membrane is depolarized), and an **action potential** (**neural impulse**) is generated. Incoming messages cause **graded potentials**, which, when combined, may exceed the minimum **threshold of excitation** and make the neuron "fire." After firing, the neuron briefly goes through the **absolute refractory period**, when it will not fire again, and then through the relative refractory period, when firing will occur only if the incoming message is much stronger than usual. According to the **all-or-none law**, every firing of a particular neuron produces an impulse of equal strength. More rapid firing of neurons is what communicates the strength of a message. **Neurotransmitter** molecules, released by **synaptic vesicles**, cross the tiny **synaptic space** (or **cleft**) between an **axon terminal** (or **terminal button**) of a sending neuron and a dendrite of a receiving neuron. Here they latch on to **receptor sites**, much as keys fit into locks, and pass on their excitatory or inhibitory messages. Psychologists need to understand how **synapses** function because neurotransmitters affect an enormous range of physical and emotional responses.

Research demonstrates that experiences in our environments can produce changes in the brain, a principle called **neural plasticity**. Neural plasticity leads to the development of **neural networks—** neurons that are functionally connected to one another. Human brains also are capable of **neurogenesis—**the production of new brain cells. The study of neurogenesis may help treat neurological disorders, but also raises ethical questions.

The chapter next turns to the central nervous system. The nervous system is organized into two parts: the **central nervous system (CNS)**, which consists of the brain and spinal cord, and the **peripheral nervous system (PNS)**, made up of nerves that radiate throughout the body, linking all of the body's parts to the CNS.

Physically, the brain has three more-or-less distinct areas: the central core, the limbic system, and the cerebral hemispheres.

The central core consists of the hindbrain, cerebellum, midbrain, thalamus and hypothalamus, and reticular formation. The **hindbrain** is made up of the **medulla**, a narrow structure nearest the spinal cord that controls breathing, heart rate, and blood pressure, and the **pons**, which produces chemicals that maintain our sleep–wake cycle. The medulla is the point at which many of the nerves from the left part of the body cross to the right side of the brain and vice versa. The **cerebellum** controls the sense of balance and coordinates the body's actions. The **midbrain**, which is above the cerebellum, is important for hearing and sight and is one of the places in which pain is registered. The **thalamus** is a relay station that integrates and shapes incoming sensory signals before transmitting them to the higher levels of the brain. The **hypothalamus** is important to motivation, drives, and emotional behavior. The **reticular formation**, which is woven through all of these structures, alerts the higher parts of the brain to incoming messages.

The **cerebrum** takes up most of the room inside the skull. The outer covering of the cerebral hemispheres is known as the cerebral cortex. They are the most recently evolved portion of the brain, and they regulate the most complex behavior. Each cerebral hemisphere is divided into four lobes, delineated by deep fissures on the surface of the brain. The **occipital lobe**, located at the back of the head, receives and processes visual information. The **temporal lobe**, located roughly behind the temples, helps us perform complex visual tasks, such as recognizing faces. The **parietal lobe**, which sits on top of the temporal and occipital lobes, receives sensory information from all over the body and oversees spatial abilities. Messages from sensory receptors are registered in the **primary somatosensory cortex**. The frontal lobe receives and coordinates messages from the other lobes and keeps track of past and future body movement. The **prefrontal cortex** is primarily responsible for goal-directed behavior, the ability to control impulses, judgment, and metacognition. The **primary motor cortex** is responsible for voluntary movement. The **insula**, which lies between the temporal and parietal lobes, is involved in the conscious expression of emotion, desire, and addiction. The **association areas—**areas that are free to process all kinds of information—make up most of the cerebral cortex and enable the brain to produce behaviors requiring the coordination of many brain areas.

The **limbic system**, a ring of structures located between the central core and the cerebral hemispheres, is a more recent evolutionary development than the central core. It includes the **hippocampus**, which is essential to the formation of new memories, and the **amygdala**, which, together with the hippocampus, governs emotions related to self-preservation. Other portions of the limbic system heighten the experience of pleasure. In times of stress, the limbic system coordinates and integrates the nervous system's response.

The two cerebral hemispheres are linked by the **corpus callosum**, through which they communicate and coordinate their activities. Nevertheless, each hemisphere appears to specialize in certain tasks (although they also have overlapping functions). The right hemisphere excels at visual and spatial tasks, nonverbal imagery, and the perception of emotion, whereas the left hemisphere excels at language and perhaps analytical thinking, too. The right hemisphere controls the left side of the body, and the left hemisphere controls the right side.

An increasingly sophisticated technology exists for investigating the brain. Among the most important tools are microelectrode techniques, macroelectrode techniques (EEG), structural imaging (CT scanning and MRI), and functional imaging (EEG imaging, MEG, and MSI). Two new functional imaging techniques, PET scanning and fMRI, allow us to observe not only the structure, but also the functioning of parts of the brain. Scientists often combine these techniques to study brain activity in unprecedented detail—information that can help in the treatment of medical and psychological disorders.

The **spinal cord** is a complex cable of nerves that connects the brain to most of the rest of the body. It is made up of bundles of long nerve fibers and has two basic functions: to permit some reflex movements and to carry messages to and from the brain. When a break in the cord disrupts the flow of impulses from the brain below that point, paralysis occurs.

The chapter next looks at the peripheral nervous system. The peripheral nervous system (PNS) contains two types of neurons: *afferent neurons,* which carry sensory messages to the central nervous system, and *efferent neurons,* which carry messages *from* the CNS. Neurons involved in making voluntary movements of the skeletal muscles belong to a part of the PNS called the **somatic nervous system**, whereas neurons involved in governing the actions of internal organs belong to a part of the PNS called the autonomic nervous system. The **autonomic nervous system** is itself divided into two parts: the **sympathetic division**, which acts primarily to arouse the body when it is faced with threat, and the **parasympathetic division**, which acts to calm the body down, restoring it to normal levels of arousal.

The chapter moves into a discussion of the endocrine system, and the interest psychologists have in hormones and their effects. The endocrine system is the other communication system in the body. It is made up of **endocrine glands** that produce **hormones**, chemical substances released into the bloodstream to either *trigger* developmental changes in the body or to activate certain behavioral responses. The **thyroid gland** secretes thyroxin, a hormone involved in regulating the body's rate of metabolism. Symptoms of an overactive thyroid are agitation and tension, whereas an underactive thyroid produces lethargy. The **parathyroids** control and balance the levels of calcium and phosphate in the blood and tissue fluids. This process in turn affects the excitability of the nervous system. The **pineal gland** regulates activity levels over the course of the day and also regulates the sleep–wake cycle. The **pancreas** controls the level of sugar in the blood by secreting insulin and glucagon. When the pancreas secretes too much insulin, the person can suffer *hypoglycemia.* Too little insulin can result in *diabetes mellitus.* Of all the endocrine glands, the **pituitary gland** regulates the largest number of different activities in the body. It affects blood pressure, thirst, uterine contractions in childbirth, milk production, sexual behavior and interest, and the amount and timing of body growth, among other functions. Because of its influences on other glands, it is often called the "master gland." The **gonads—**the testes in males and the ovaries in females—secrete hormones called androgens (including testosterone) and estrogens. Testosterone plays an important role during critical periods of prenatal development to organize sex-typed behaviors, and has long been linked to aggressive behavior. Each of the two **adrenal glands** has two parts: an outer covering, the *adrenal cortex,* and an inner core, the *adrenal medulla.* Both affect our response to stress, although the adrenal cortex affects other body functions, too. One stress-related hormone of the adrenal medulla is epinephrine, which amplifies the effects of the sympathetic nervous system.

The chapter concludes with an examination of genes, evolution, and behavior—how genes are passed from one generation to the next, methods psychologists use to study their effects (and those of natural selection) on behavior, as well as some of the ethical issues that arise as society gains more control over genetics.

The related fields of **behavior genetics** and **evolutionary psychology** explore the influences of heredity on human behavior. Both are helping to settle the nature-versus-nurture debate over the relative contributions of genes and the environment to human similarities and differences. **Genetics** is the study of how traits are passed on from one generation to the next via genes. This process is called heredity. Each **gene**, or basic unit of inheritance, is lined up on tiny threadlike bodies called **chromosomes**, which in turn are made up predominantly of a complex molecule called **deoxyribonucleic acid (DNA)**. The human genome is the full complement of genes necessary to build a human body—approximately 20,000 to 25,000 genes. The *Human Genome Project* has produced a rough map of the genes on the 23 pairs of human chromosomes. Each member of a gene pair can be either **dominant** or **recessive**. In **polygenic inheritance** a number of genes interact to produce a trait.

Psychologists use a variety of methods to study *heritability*—that is, the contribution of genes in determining variations in certain traits. **Strain studies** approach the problem by observing strains of highly inbred, genetically similar animals, whereas **selection studies** try to determine the extent to which an animal's traits can be passed on from one generation to another. In the study of humans, **family studies** tackle heritability by looking for similarities in traits as a function of biological closeness. Also useful in studying human heritability are **twin studies** and **adoption studies**.

Manipulating human genes in an effort to change how people develop is a new technology that makes many people uneasy, but their concerns may be exaggerated because genes are not all-powerful. Both heredity and environment play a part in shaping most significant human behaviors and traits.

The theory of evolution by **natural selection** states that organisms best adapted to their environment tend to survive, transmitting their genetic characteristics to succeeding generations, whereas organisms with fewer adaptive characteristics tend to die off. Evolutionary psychology analyzes human behavioral tendencies by examining their adaptive value from an evolutionary perspective. While not without its critics, it has proved useful in helping to explain some of the commonalities in human behavior that occur across cultures.

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▼ LECTURE LAUNCHERS AND DISCUSSION TOPICS

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Lecture/Discussion: Leading Off the Chapter

Your students may find the presence of a chapter on "biology" puzzling in a psychology textbook. An effective lead off for the chapter is to point out our tendency to take for granted the integrity and normal functioning of the nervous system. Only when there is damage through stroke, disease, or brain trauma do we realize its importance. If there is an example from your personal life that is apropos here, such as a family member with a neurological disease, consider sharing it with your students. Students may add their own stories as well to highlight the importance of studying "biology" in a psychology class.

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Lecture/Discussion: Neurotransmitters: Chemical Communicators of the Nervous System

In 1921, a scientist in Austria put two living, beating 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. Many poisonous or toxic substances impact the functioning of neurotransmitters. Curare is a poison that was discovered by South American Indians. They put it on tips of the darts they shoot from their blowguns. Curare blocks acetylcholine receptors; paralysis of internal organs results. The victim is unable to breathe, and dies. A substance in the venom of black widow spiders stimulates release of acetylcholine at the synapses. Botulism toxin, found in improperly canned foods, blocks release of acetylcholine at the synapses and has a deadly effect. It takes less that one millionth of a gram of this toxin to kill a person. 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 the endorphins. It appears that the neurotransmitters dopamine, norepinephrine, and serotonin are associated with some of the most severe forms of mental illness.

There are probably only a few ounces of these substances in the body, but they may have a profound effect on mood, memory, perception, and behavior. Could intelligence be primarily a matter of having plenty of the right neurotransmitter at the right synapses?

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Lecture/Discussion: Synaptic Transmission and Neurotransmitters

Point out to students that neurons do not touch each other. Instead, two neurons are connected through a small space called a *synapse*, into which flow substances called *neurotransmitters* that either enhance or impede impulses moving from one neuron to the next. During the first half of the 1900s, there was controversy over whether synaptic transmission was primarily chemical or electric. By the 1950s, it was apparent that the communication between the neurons was chemical. During this period, some synapses showed what was termed *gap junction* or electrical transmission between neurons at the synapse. Recent research has shown that electrical synaptic transmission may be more frequent than neuroscientists once believed (Bennett, 2000). Even though the transmission of information between neurons at the synapses is primarily chemical, some electrical synapses are known to exist in the retina, the olfactory bulb, and the cerebral cortex (Bennett, 2000).

To illustrate how an action potential functions, use "The Wave," an activity at sports arenas, as an analogy for the action potential. Like "The Wave," the action potential travels the length of the neuron; the neuron doesn't experience the action potential all at once. To extend the analogy, mention that right after people stand up in "The Wave," they are somewhat tired and must recover (i.e., refractory period) to be prepared for the next go-round (i.e., action potential).

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Lecture/Discussion: The Perception of Phantom Pain

The idea 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 non-existent 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 amputated 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 percent 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 percent 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 non-invasive techniques of magnetoencephalograms and functional MRIs, 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/Discussion: The Brain

To set the mood for your discussion of the brain, try the following: (1) talk about the relatively small size of the brain; (2) discuss its role in humankind's most amazing accomplishments; (3) discuss its role in humankind's most destructive actions; and (4) note that, to our knowledge, the brain is probably the only thing in the universe that can ponder its own existence (by asking your students to think about it, the statement is supported).

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Lecture/Discussion: 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 twelve 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 twelve 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.

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Lecture/Discussion: 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 because researchers could only measure the electrical activity of the living human brain in individuals who had genetic defects of their skull bones that cause the skin of their scalps to be in direct contact with the surfaces of their brains.

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 its having been 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.

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.

The alpha wave is also sometimes called Berger's wave in honor of Berger's discovery.

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Lecture/Discussion: 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 imbedded nails can be found at the *USA Today* link below. Incredibly, none of the nails caused serious damage to Mejia's brain. One nail lodged near his spinal cord, while 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.

http://www.usatoday.com/news/nation/2004–05–05-nail-head_x.htm
Nail Gun /Victim Lives. *Current Science*, A Weekly Reader publication, Sept. 10, 2004, v90 (1), Page 14.
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Lecture/Discussion: Neural Effects of a Concussion

During the fall term, when college football is in season, it is especially appropriate to stress the discussion of the neuronal and behavioral effects of concussion. Chances are good that in any given class, you will have several students who will report having had a concussion in the past, usually as a result of participation in football or other sports activities, or as a result of an automobile accident. You can ask the students to discuss their experiences with the class, asking what kind of physiological and cognitive effects occurred. The most common effects include loss of vision ("black out"), blurred vision, ringing in the ears, nausea/vomiting, and not being able to think clearly. However, the physiological and cognitive effects vary between individuals; some may not have experienced nausea at all, whereas others have only experienced blurred vision. It is important to point out the variability between individuals, because it can be inferred that concussions vary greatly in terms of the severity of brain damage and the brain areas affected.

The brain sits in the cranium surrounded by cerebral fluid. When a severe blow to the head occurs, the brain may collide with the cranium, then "bounce back" and collide with the opposite side of the cranium. For example, if a football player falls and hits the back of his or her head, the brain may hit the back of the cranium, then the front. At this point, you might ask students what brain areas would be affected in this example ("occipital and frontal lobes" are an acceptable answer). Therefore, both vision and some cognitive functioning may be affected. At the neuronal level, a concussive blow to the head results in a twisting or stretching of the axons, which in turn creates swelling. Eventually, the swelling may subside and the neuron may return to its normal functioning. However, if the swelling of the axon is severe enough, the axon may disintegrate. A more severe blow to the head may even sever axons, rendering those neurons permanently damaged. Either way, neuronal signaling is disrupted, either temporarily or permanently. Depending on the brain areas where the damaged axons are located, different physiological symptoms may occur.

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Lecture/Discussion: The Phineas Gage Story

Recently, the journal *History of Psychiatry* reprinted the original presentation of the case study of Phineas P. Gage, noteworthy in psychology for surviving having an iron tamping rod driven through his skull and brain. The case notes, by physician John M. Harlow, reveal aspects of the event that provide greater detail about Gage and his unfortunate accident.

Phineas Gage stood five feet six inches tall, weighed 150 pounds, and was 25 years old at the time of the incident. By all accounts this muscular foreman of the Rutland and Burlington Railroad excavating crew was well liked and respected by his workers, due in part to "an iron will" that matched "his iron frame." He had scarcely known illness until his accident on September 13, 1848, in Cavendish, Vermont. Here is an account of the incident, in Harlow's own words:

"He was engaged in charging a hold (sic) drilled in the rock, for the purpose of blasting, sitting at the time upon a shelf of rock above the hole. His men were engaged in the pit, a few feet behind him... The powder and fuse had been adjusted in the hole, and he was in the act of 'tamping it in,' as it is called...While doing this, his attention was attracted by his men in the pit behind him. Averting his head and looking over his right shoulder, at the same instant dropping the iron upon the charge, it struck fire upon the rock, and the explosion followed, which projected the iron obliquely upwards...passing completely through his head, and high into the air, falling to the ground several rods behind him, where it was afterwards picked up by his men, smeared with blood and brain."

The tamping rod itself was three feet seven inches in length, with a diameter of 1¼ inches at its base and a weight of 13¼ pounds. The bar was round and smooth from continued use, and it tapered to a point 12 inches from the end; the point itself was approximately ¼ inch in diameter.

The accounts of Phineas' frontal lobe damage and personality change are well known, and are corroborated by Harlow's presentation. Details of Phineas' subsequent life (he lived 12 years after the accident) are less known. Phineas apparently tried to regain his job as a railroad foreman, but his erratic behavior and altered personality made it impossible to do so. He took to traveling, visiting Boston and most major New England cities, and New York, where he did a brief stint at Barnum's sideshow. He eventually returned to work in a livery stable in New Hampshire, but in August, 1852, he turned his back on New England forever. Gage lived in Chile until June of 1860, then left to join his mother and sister in San Francisco. In February, 1861, he suffered a series of epileptic seizures, leading to a rather severe convulsion at 5 a.m. on February 20. The family physician unfortunately chose bloodletting as the course of treatment. At 10 p.m., May 21, 1861, Phineas eventually died, having suffered several more seizures. Although an autopsy was not performed, Phineas' relatives agreed to donate his skull and the iron rod (which Phineas carried with him almost daily after the accident) to the Museum of the Medical Department of Harvard University.

Miller (1993) also briefly notes that John Martyn Harlow himself had a rather pedestrian career, save for his association with the Gage case. Born in 1819, qualifying for medical practice in 1844, and dying in 1907, he practiced medicine in Vermont and later in Woburn, Massachusetts, where he engaged in civic affairs and apparently amassed a respectable fortune as an investor. Like Gage himself, Harlow was an unremarkable person brought into the annals of psychology by one remarkable event.

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Lecture/Discussion: Workplace Problems: Left Handedness

Between 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 suggest 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/Discussion: 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 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). (Note: Suggestions for a student activity on this topic are given in the following Demonstrations and Activities section of this manual).

Corballis, M.C. (1980). Laterality and myth. *American Psychologist, 35*, 284–295.
Levy, J. (1985). Right brain, left brain: Fact or fiction? *Psychology Today, 19*, 38–45.

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Lecture/Discussion: 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 of Memorial Sloan-Kettering Cancer Center in New York and her colleagues 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. A functional magnetic resonance image (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.*

Bower, B. (1997, July 12). Brains show signs of two bilingual roads. *Science News, 152,* 23.

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Lecture/Discussion: The Results of a Hemispherectomy

Matthew is eight years old now. Two years ago surgeons removed half of his brain.

His first three years were completely normal. Just before he turned four, however, Matthew began to experience seizures, which did not respond to drug treatment. The seizures were severe (life threatening) and frequent (as often as every three 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 U.S., 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. It is interesting to note that Matt's personality never changed through the seizures and surgery.

Boyle, M. (1997, August 1). Surgery to remove half of brain reduces seizures. *Austin American-Statesman*, A18.
Swerdlow, J. L. (1995, June). Quiet miracles of the brain. *National Geographic, 87*, 2-41.
Adapted from Davis, S. F., & Palladino, J. J. (1996) *Interactions: A newsletter to accompany Psychology, 1(Spr)*, 4.

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Lecture/Discussion: Too Much or Too Little: Hormone Imbalances

Students may find it interesting to hear more about the various problems caused by problems within the endocrine system. The following disorders/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.

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.

Adrenal Gland Malfunctions

Among the disorders that can result from malfunctioning of the adrenal glands are **Addison's Disease (caused by low** levels of cortisol) and **Type I diabetes** (caused by a deficiency or absence of insulin production by the pancreas). In the former, fatigue, low blood pressure, weight loss, nausea, diarrhea, and muscle weakness are some of the symptoms; while, for the latter, obesity, high blood pressure, a "moon" face, and poor healing of skin wounds is common.

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. There is a documented case of a 5-year old Peruvian girl who actually gave birth to a son (Strange, 1965). 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/Discussion: Would You Like Fries With That Peptide?

Toast and juice for breakfast. Pasta salad for lunch. An orange, rather than a bagel, for an afternoon snack. These sound like reasonable dietary choices, involving some amount of deliberation and free will. However, our craving for certain foods at certain times of the day may be more a product of the brain than of the mind.

Sarah F. Leibowitz, Rockefeller University, has been studying food preferences for over a decade. What she has learned is that a stew of neurochemicals in the paraventricular nucleus, housed in the hypothalamus, plays a crucial role in helping to determine what we eat and when. Two in particular – Neuropeptide Y and galanin – help guide the brain's craving for carbohydrates and for fat.

Here's how they work. Neuropeptide Y (NPY) is responsible for turning on and off our desire for carbohydrate. Animal studies have shown a striking correlation between NPY and carbohydrate intake; the more NPY produced, the more carbohydrates eaten, both in terms of meal size and duration. Earlier in the sequence, the stress hormone cortisol seems responsible, along with other factors, for upping the production of Neuropeptide Y. This stress ⇨ cortisol ⇨ Neuropeptide Y ⇨ carbohydrate craving sequence may help explain overweight due to high carbohydrate intake. But weight and craving rely on fat intake as well. Leibowitz has found that the neuropeptide galanin plays a critical role in this case. Galanin is the on/off switch for fat craving, correlating positively with fat intake; the more galanin produced, the heavier an animal will become. Galanin also triggers other hormones to process the fat consumed into stored fat. Galanin itself is triggered by metabolic cues resulting from burning fat as energy, but also from another source: estrogen.

Neuropeptide Y triggers a craving for carbohydrate, galanin triggers a craving for fat, but the two march to different drummers throughout a day's cycle. Neuropeptide Y has its greatest effects in the morning (at the start of the feeding cycle), after food deprivation (such as dieting), and during periods of stress. Galanin, by contrast, tends to increase after lunch and peaks toward the end of our daily feeding cycle.

The implications of this research are many. For example, the findings suggest that America's obsession with dieting is a losing proposition. Skipping meals, gulping appetite suppressers, or experiencing the stress of dieting will trigger Neuropeptide Y to encourage carbohydrate consumption, which in turn can foster overeating. Paradoxically, then, by trying to fight nature we may stimulate it even more. As another example, the onset and maintenance of anorexia may be tied to the chemical cravings in the hypothalamus. Anorexia tends to develop during puberty, a time when estrogen is helping to trigger galanin's craving for fat consumption. Some women (due to societal demands, obsessive-compulsive tendencies, or other pressures) react to this fat trigger by trying to accomplish just the opposite; subsisting on very small, frequent, carbohydrate-rich meals. The problem is that the stress and starvation produced by this diet cause Neuropeptide Y to be released, confining dietary interest to carbohydrates, but also affecting the sex centers nearby in the hypothalamus. Specifically, neuropeptide Y may act to shut down production of gonadal hormones.

Marano, H. E. (1993, January/February). Chemistry and craving. *Psychology Today*, pp. 30–36, 74.
http://www.rockefeller.edu/labheads/leibowitz/research.php

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Lecture/Discussion: Hey, Simpleton!

"The culmination of evolution." "Master of the universe." "Erect-walking swell young fops." There's no shortage of appellations humans heap upon themselves in recognition of their arguably advanced position among the species. Some genetic research suggests, however, that the praise might be premature.

Francis Collins and Eric Lander, researchers working with data from the National Human Genome Research Institute, led a team that discovered that humans have about 20,000 to 25,000 genes, fewer than the 30,000 to 40,000 they had previously estimated in 2001. Why is this significant? A flowering houseplant has about 20,000 to 25,000 genes, as does a small worm. Therefore,we're about as genetically complex as other not-so-complex living things.

So why isn't a worm writing this piece? Because clearly it's not just the parts, but rather how those parts are assembled, that makes a difference. Granted, these are only the genes that tell cells how to make proteins, but some of those genes make multiple proteins, and some make more complex proteins. Some of our biological complexity, then, comes from combinations of proteins rather than from individual proteins, so it's somewhat a case where "less is more."

By the way, in case you're curious: Rice has about 40,000 genes; corn, about 50,000. But at least we've got the fruit fly's 13,600 genes beat ... by a little.

Ritter, M. (October 21, 2004). Human complexity built with fewer genetic bricks. Austin American-Statesman, A1, A13.

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▼CLASSROOM ACTIVITIES, DEMONSTRATIONS, AND EXERCISES

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Activity: Using Reaction Time to Show the Speed of Neurons

I always begin this demonstration by asking students if they believe that there is a difference in reaction time if the impulse has to travel farther. Most frequently students answer in the affirmative. Here is a simple demonstration of the time required to process information along sensory neurons in the arm and can be done by asking students to form a line by holding hands. Ask a student to start and stop a stopwatch. Then begin by asking for volunteers. The number of students who volunteer is irrelevant. Instruct the students to close their eyes and to squeeze the hand of the person next to them when they feel the person on the opposite side squeeze their hand. The last person in line should signal the timekeeper that his or her hand has been squeezed by raising a free hand. Have the student stop the watch and record the elapsed time. Repeat the process until the reaction times appear to be stable. Take the final reaction time and divide by the number of students in the line to obtain the average reaction time.

Next, ask the students to squeeze the next person's shoulder instead of hand. The average reaction time should now decrease since the sensory information has a shorter distance to travel. The difference in average reaction time obtained from the two procedures represents—roughly—the average conduction time for sensory information between the hand and shoulder.

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Activity: The Dollar Bill Drop

After engaging in the neural network exercise, try following 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 bigger, if necessary) 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 else. 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: 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: 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 him or her. 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 until 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: Human Neuronal Chain

Objective: To illustrate that the transmission of messages in the nervous system is not instantaneous
Materials: 20 students standing, facing forward, in a line; a stopwatch
Procedure: Ask the first student to tap either shoulder of the next person and each subsequent person to continue the process through the entire line, always using the same shoulder and never crossing the body (i.e., left hand to right shoulder). Use the stopwatch to time how long it takes for the last person to receive the stimulus.

Harcum, E. R. (1988). Reaction time as a behavioral demonstration of neural mechanisms for a large introductory psychology class. *Teaching of Psychology, 15*, 208–209.

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Activity: Review of Brain-Imaging Techniques

Objectives: To review information on brain-imaging techniques

Materials: None

Procedures: Ask students to tell which brain-imaging technique could answer each of the following questions:

1. How do the brains of children and adults differ with regard to energy consumption? (PET)
2. In what ways do brain waves change as a person falls asleep? (EEG)
3. In which part of the brain has a stroke patient experienced a disruption of blood flow? (CT, MRI)
4. What is the precise location of a suspected brain tumor? (CT, MRI)
5. How can brain structures be examined without exposing a patient to radiation? (MRI)
6. How can scientists view structures and their functions at the same time? (fMRI)
7. What techniques allow scientists to view changes in the magnetic characteristics of neurons as they fire? (SQUID, MEG)

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Activity: Trip to the Hospital

Objective: To demonstrate brain imaging techniques

Materials: Local or regional hospital

Procedure: Arrange a trip to the local or regional hospital to see their CAT, PET, MRI and fMRI facilities. Being able to see and hear about this equipment firsthand far exceeds what students can gain from the text. Such a trip can be undertaken only if you have a small class, recitation, or laboratory section. A voluntary sign-up list also can be used. You will have to make your plans well in advance and at the convenience of the hospital staff. If the size of your class precludes this field trip, you could invite a local physician or one of the technicians to discuss these procedures. It will be helpful if he or she can arrange to bring examples of the records or scans that are produced for evaluation of neurological disorders. You should plan to ask your guest speaker to compare modern procedures to earlier evaluations of neurological disorders.

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Activity: 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 (Myers, 1995). Laughs usually erupt when the class imagines what our heads would look like if we had to accommodate an unwrinkled, newspaper-sized cerebral cortex!

Myers, D. G. (1995). *Psychology* (4th ed.). New York: Worth.

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Activity: Probing the Cerebral Cortex

Use: Pearson Introductory Psychology Teaching Films

SYNOPSIS: This clip contains commentary by Wilder Penfield, a pioneer in mapping the areas of the cerebral cortex. Penfield discusses the work that led to electrode-stimulation of the cortex. He also interviews a brain surgery patient about her experiences during surgery: Stimulation of various areas of her cortex produced memories of past events and the perception of music playing.

Form a Hypothesis
Q: What happens when Penfield stimulates a small area of the temporal lobe, called the auditory cortex?
A: The patient "hears" sounds.

Test Your Understanding
Q: What are the four lobes of the cerebral cortex?
A: The four lobes of the cerebral cortex are occipital, parietal, temporal, and frontal.

Q: What are the functions of the somatosensory cortex, motor cortex, and association cortex areas?
A: Somatosensory cortex interprets sensations and coordinates the motor behavior of skeletal muscles. Association areas, located on all four cortical lobes, are involved in the integration of various brain functions, such as sensation, thought, memory, planning, etc.

Q: What two areas of the association cortex specialize in language?
A: Wernicke's area, located toward the back of the temporal lobe, is important in understanding the speech of others. Broca's area is essential to sequencing and producing language.

Thinking Critically
Q: What four types of research methods are commonly used in the study of behavioral neuroscience?
A: Microelectrode techniques are used to study the functions of individual neurons.

Macroelectrode techniques, such as an EEG, record activities of brain areas. Structural imaging, such as computerized axial tomography or CAT scans, is useful for mapping brain structures. Functional imaging, in which specific brain activity can be recorded in response to tasks or stimulation, offers the potential to identify specific brain areas and functions.

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Activity: Lateralization Activities

Procedure:
There are several demonstrations that illustrate the lateralization of the brain. Several have been described by Filipi, and Gravlin (1985). A variant by Morton 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's is to ask students to pat their head and to rub their stomach 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 rigorous physical training.

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: Localization of Function Exercise

This exercise has several functions. It is designed to get students to review the methods that are used to study the brain and the locations of particular functions. It is also intended to make students think critically about how we know what we know about functional localization. The examples included are based on real-life examples of situations that have provided information about localization of functions in the brain. Some of the situations described may be difficult for students to conceptualize. Be prepared to assist students in conceptualizing each situation. Students can do this exercise individually or in small groups. Group work is probably preferable because students can learn by bouncing ideas off each other. The student handout for this activity is included as **Handout Master 2.1**. Suggested answers are included below.

1. The lesion method is being used to study brain function. Students may be puzzled by this, thinking that the lesion method always involves *intentionally* damaging part of the brain to study its function. This is not the case; much of the information we have about functional localization comes from fairly old studies of veterans who received gunshot wounds to their brains.

   This part of the brain controls movement on the opposite side of the body. It is the *motor* area of the cerebral cortex.

   By looking at the drawing we can see that damage high up on the brain results in paralysis which is lower down on the body and vice versa. It is as if the body is "mapped" upside down and backwards on the motor cortex. (If you have a drawing of the "motor homunculus," it would be helpful to share this with the students after they have completed this exercise.)

2. The lesion method is being used to study brain function.

   Based on the information provided, the part of the brain labeled J is responsible for the ability to speak.

   The area marked J controls the ability to speak; it is on the left side of the brain. The equivalent area on the right side of the brain must be doing something else, since damage to this area does not produce any effect on speech.

3. The function of this part of the brain is being studied with the electrical stimulation method. Students may be surprised, and horrified, to find out that people are often awake during surgery on their brains. This is necessary because in real life the brain is not color coded, nor does it come with nice little labels saying what its different parts do. During surgery, surgeons have a general idea where they are, but one part looks pretty much the same as the next. When the surgeon is planning to remove a part of the brain, for example, an area where a tumor is located or an area where a patient's epileptic seizures tend to start, he or she does not want to remove a part which would result in a marked decrement in the patient's quality of life (for example, a speech area). Therefore, it is fairly routine to stimulate an awake patient's brain during surgery, to verify the function of the areas the surgeon is working near. During surgery, the scalp, bone, and membranes covering the brain must be anesthetized, so that the patient does not feel pain. The brain itself does not have pain receptors, so that working on the brain is not physically painful.

   This part of the brain appears to process visual information; in fact, it is the *visual* cortex. When this part of the brain is stimulated electrically, neurons are activated in much the same way that they would be by natural visual stimulation. Therefore, the patient reports seeing a visual stimulus that is not actually there.

   The information provided suggests that there is an upside-down and backwards map of the visual world on the visual cortex (note the similarity to the upside-down and backwards map of the body on the motor cortex in the first example). Note that the left side of the brain is being stimulated. Yet, when the patient fixates on the cross in the middle of the screen, all of the points of light that he reports are to the right of the fixation point. Therefore, the information from the right side of the visual field is relayed to the left side of the brain. Note also, that when points that are higher up on the cortex are stimulated, the patient reports seeing flashing lights in the lower part of the visual field; conversely, when points lower down on the visual cortex are stimulated, the patient reports flashing lights in the upper part of the visual field. Hence, there is the notion of an upside-down and backwards map of the visual world in the visual cortex.

4. The function of this part of the brain is being studied through the electrical stimulation method.

   This part of the brain is responsible for the sense of touch (among other things) on the opposite side of the body. The area being stimulated is the *somatosensory* cortex.

   By looking at the drawing we can see that stimulation high up on the brain results in a tingling sensation which is lower down on the body and vice versa. It is as if the body is "mapped" upside down and backwards on the somatosensory cortex. (If you have a drawing of the "sensory homunculus," it would be helpful to share this with the students after they have completed this exercise.) 5. The method being used is positron emission tomography (PET scanning).

This area is responsible for processing information concerning sounds; it is the *auditory* cortex.

6. A needle electrode is being used to record the electrical activity of this part of the brain.

The evidence suggests that this part of the brain may be responsible for triggering eating behavior; alternately, it may be responsible for the sensation of hunger.

7. The lesion method is being used to study brain function, but this time, in contrast to examples 1 and 2, the damage to the brain was created intentionally.

The corpus callosum relays information from one side of the brain to the other when it is intact. In this example, because the corpus callosum is cut, information cannot be relayed from one side of the brain to the other. This explains the two specific deficits noted in this example.

The patient is unable to name an object placed in her left hand because the sensory information from that hand is relayed to the right side of her brain, which has little or no language or speech ability.

The patient is unable to pick out an object with her right hand that she has already felt with her left hand because that would require comparison of sensory information relayed to the two sides of the brain, which is no longer possible with the corpus callosum cut.

Students may wonder why it is important that the patient kept her eyes closed in these two examples. This was done because each eye, when open, sends information to both sides of the brain. If the patient had had her eyes open in these examples, information would have been sent to both sides of the brain, and the patient would not have had difficulty with these tasks.

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▲ Return to Chapter 2: Table of Contents

Activity: Looking Left, Looking Right

Objective: To demonstrate that lateral eye movements are associated with thinking
Materials: Left and Right Hemisphere Questions (**Handout 2.1**)
Procedure: It has been theorized that when language-related tasks are being performed in the left hemisphere, the eyes look to the right; when nonlanguage, spatial abilities are being used in the right hemisphere, the eyes look to the left. This is a relatively easy class activity. After pairing up, one student asks the questions and records lateral eye movements, while the other attempts to answer the questions.

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Assignment: The Brain Diagram

Students often have trouble encoding the location and function of the different parts of the brain, both because (a) they glance too quickly over the colorful textbook illustrations and (b) their eyes tend to glaze over during class discussion of the brain's structure and function. As an easy remedy to this problem, try asking students to draw their own colorful rendition of the human brain, an active learning strategy that ensures that they encode and think about the parts of the brain rather than passively glossing over them in the text. Prior to the class period in which you will be discussing the brain, ask students to read Chapter 2 and to hand draw a diagram of the brain (in a cross-section) on a clean white sheet of unlined paper. For each of the following sections of the brain, students should color and label the appropriate structure, and also list at least one or two of its major functions: (a) the cerebral cortex, including the four lobes, (b) the thalamus, (c) the hypothalamus, (d) the hippocampus, (e) the amygdala, (f) the cerebellum, (g) the pons, and (h) medulla. Added benefits of this assignment are that it is easy to grade, students enjoy doing it (and it is an easy and fun way for them to get points), and it can be used by students as a study aid for the exam.

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Activity: Psychology in Literature

The Man Who Mistook His Wife For a Hat

Oliver Sacks's national bestseller chronicles over 20 case histories of patients with a variety of neurological disorders. His compassionate retelling of bizarre and fascinating tales include patients plagued with memory loss, useless limbs, violent tics and jerky mannerisms, the inability to recognize people or objects, and unique artistic or mathematical talents despite severe mental deficits. A reading of this absorbing book will surely increase your students' understanding of the connection between the brain and the mind, and will also give them invaluable insights into the lives of disordered individuals. Ask your students to write a book report focusing on a few of the cases that most interest them, and to apply principles from the text and lecture to the stories. As a more elaborate project, you might consider assigning this book at the end of the semester, as many of the cases are ripe with psychological principles that may be encountered later in the course (e.g., perception, memory, mental retardation).

Sacks, O. (1985). *The man who mistook his wife for a hat*. New York: Harper Collins.
Staff (1995, May/June). PT interview: Oliver Sacks; the man who mistook his wife for a ... what? *Psychology Today*, 28–33.

► Return to Lecture Guide: The Central Nervous System
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Activity: Twenty Questions

Objective: To review information about hormones
Materials: None
Procedures: Play a round of the Twenty Questions game. Tell students that you are thinking of a certain hormone. The students are to determine which hormone by asking you questions to which you can respond only "yes" or "no."

► Return to Lecture Guide: The Endocrine System
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Activity: DEBATE – Are Genetic Explanations for ADHD Faulty?

Attention Deficit Hyperactivity Disorder (ADHD), like Attention Deficit Disorder (ADD), has been increasingly diagnosed among schoolchildren, adolescents, and even adults. The origins of ADHD remain a matter of some debate. Although there is evidence that genetics plays a substantial role in the development of ADHD, not all researchers agree on the extent of its influence. Some writers, in fact, prefer to devote more attention to exploring social and psychological explanations for the disorder. Given that many disorders (e.g., schizophrenia, depression) have revealed their genetic underpinnings (and that substantial research money and time have been allocated to pursuing these explanations), the origins of ADHD offer a case for further discussion. Ask your students to become conversant with the arguments on both sides of this issue.

Slife, B. (2003). Taking sides: Clashing views on controversial psychological issues (13th ed.). Guilford, CT: Dushkin Publishing Group.

► Return to Lecture Guide: Genes, Evolution, and Behavior
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Activity: Reunited Twins

Although twin studies (particularly studies of identical twins reared apart) seem to confirm genetic links to intelligence, psychological disorder, and some complex personality traits, critics become skeptical when the same research reveals eerie (and ostensibly genetically-based) similarities between twins on such things as aftershave brand, selection of hobbies, attraction to tattoos, and even child name preferences. Although amazing behavioral similarities do indeed turn up between identical twins raised apart (see Rosen, 1987), Wyatt and his colleagues (1994) suggest that, rather than being genetically based, these similarities are merely selected examples of coincidences that are inevitable given the hundreds or even thousands of questions typically asked of reunited twins by eager researchers. In other words, it is likely that similar "amazing" coincidences would be found if genetically unrelated people were asked a large number of questions about their behavior.

To illustrate this point, Lester Sdorow (1994) designed the "Identical Twins Reunited Questionnaire" and accompanying exercise. For this assignment, students should first read the articles by Rosen (1987) and Wyatt et al. (1994); you can put these on reserve in the library. Next, you'll need to distribute one copy of the ITRQ to each student. **Handout 2-1** contains the questionnaire (which, as you can see, asks students about their behaviors, relationships, and characteristics) along with instructions for the assignment. After students have completed their surveys, you should collect them and identify pairs of students who are the most similar. [Note: You may want to take the surveys home with you and present the results during the next class period.] Once you have described for your class the "reunited twins" among them, instruct them to write a 2–3 page paper discussing how the results from the class study bear on the rationale for reunited twin studies. Ask students to incorporate into their papers insights from the Wyatt et al. study and an additional reference of their choosing from *Psychological Abstracts*. [Note: This assignment can also be used in Chapter 10, which covers personality.]

Rosen, C. M. (1987, September). The eerie world of reunited twins. *Discover*, pp. 36–46.
Sdorow, L. (1994). The Frankenstein course: Teaching assistants, laboratory exercises, and papers in introductory psychology. Paper presented at the Southwest Regional Conference for Teachers of Psychology, Fort Worth. Used by permission of the author.
Wyatt, W. J., Posey, A., Welker, W., & Seamonds, C. (1984). Natural levels of similarities between identical twins and between unrelated people. *The Skeptical Inquirer*, 9, 62–66.

► Return to Lecture Guide: Genes, Evolution, and Behavior
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Activity: Crossword Puzzle

Frequently instructors want an activity that is interactive for their students as well as a reinforcer of the material just covered in the lecture. An activity, such as a crossword puzzle, can fulfill both criteria. Copy and distribute **Handout Master 2.5** to students as a homework or in-class review assignment.

The answers for the crossword puzzle are:

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 travel 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. **CorpusCallosum**
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. t**halamus**
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 that 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: Fill in the Blank

Copy and distribute **Handout Master 2.6** to students as a homework or in-class review assignment.

Answer Key: Chapter 2 -- The Biological Basis of Behavior – Fill in the Blank

1. nervous system
2. neuron
3. axon
4. dendrites
5. soma
6. myelin
7. nerves
8. ions
9. resting potential
10. All or none
11. synaptic vesicles
12. Neurotransmitters
13. excitatory
14. agonists
15. spinal cord
16. sensory
17. peripheral nervous
18. somatic nervous
19. autonomic nervous
20. sympathetic division
21. electroencephalograph
22. cerebellum
23. thalamus
24. pons
25. reticular formation
26. hippocampus
27. amygdala
28. cortex
29. corpus callosum
30. occipital cortex
31. parietal cortex
32. temporal lobes
33. frontal Lobes
34. endocrine
35. adrenal glands
36. chromosomes
37. dominant; recessive
38. genotype; phenotype
39. identical; fraternal
40. Evolutionary; natural selection

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▼HANDOUT MASTERS

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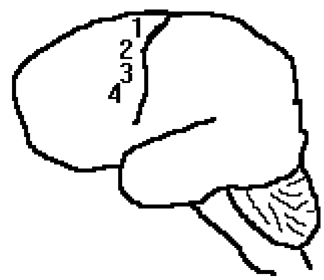
Handout Master 2.1

Localization of Function Exercise

Case 1. Dr. Holmes sees a series of patients with gunshot injuries to parts of their frontal lobes. The location of the damage to each person's brain is indicated in the drawing. Patient 1 has some paralysis of his right hip and thigh muscles. Patient 2 has paralyzed trunk muscles on his right side. Patient 3's right arm is paralyzed. Patient 4 shows paralysis of the muscles on the right side of her face.

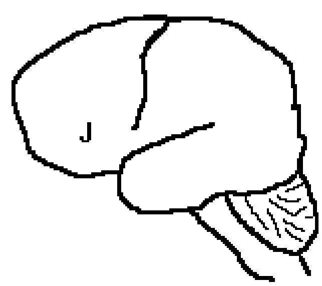


Case 1: a. What method is being used to study brain function?

b. What does this part of the brain do?

c. What can you say about the representation of this function in the brain based on this information (what are the rules of organization)?

Case 2. Dr. Broca's patient (J) has suddenly lost his ability to speak, apparently due to a stroke. After J dies, Dr. Broca studies the brain and discovers an area of damage in the location marked with J in the drawing below. Later another patient (K) dies and Dr. Broca is amazed to discover that this patient has damage to the comparable area of the brain on the right side, with NO effect on speech.

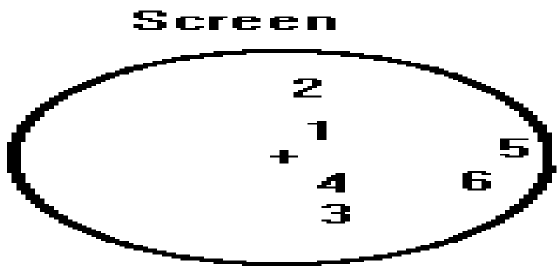


Case 2: a. What method is being used to study brain function?

b. What does the area of the brain marked J do?

c. What can we say about the lateralization of this function based on the information provided?

Case 3. Dr. Brightman is doing surgery on a patient to remove a rapidly growing tumor in the patient's brain. The patient is awake during the surgery. To check out where he is, Dr. Brightman applies a brief pulse of electricity to various areas of the brain and asks the patient to describe the sensation. The patient is looking up at a screen with a cross in the middle of it; he is fixating on the cross. After each point on the brain is touched, the patient reports seeing flashing lights and points to the area on the screen where he sees the lights.

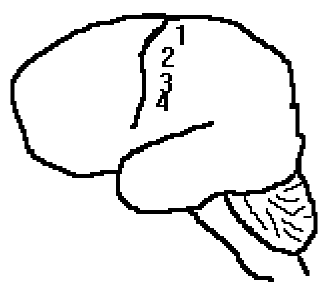


Case 3: a. What method is being used to study brain function?

b. What does this area of the brain do?

c. What can we say about how this function is mapped on the brain based on the information provided?

Case 4. Dr. Penfield is operating on the brain of a young woman with intractable epilepsy. He is going to remove the part of the brain where the seizure starts. He does not want to remove the wrong part, so the patient is awake during surgery, and Dr. Penfield identifies where he is in the brain by applying brief pulses of electricity to various parts of her brain. As Dr. Penfield touches each part of her brain, the patient reports feeling a tingling sensation on various parts of her body. At point 1, she feels tingling on her right thigh. At point 2, she feels tingling on the right part of her rib cage. At point 3, she reports a tingling on her right hand. At point 4, she feels a sensation on the right side of her face.

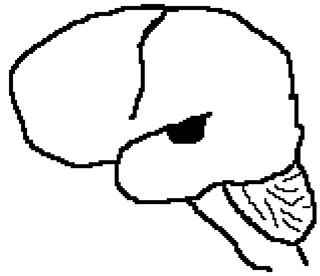


Case 4: a. What method is being used to study brain function?

b. What function is localized in this part of the brain?

c. How is this function mapped on the brain (how is it organized)?

Case 5. Dr. Lashley is doing experiments on brain function. He persuades a Doe College student to participate in his experiment. The student is injected with radioactive glucose and then asked to listen to recordings of various sounds for half an hour in a darkened room. Then the student's head is scanned to determine where in the brain the radioactivity has collected. The most intensely radioactive area is indicated on the drawing below.



Case 5: a. What method is being used to study brain function?

b. What does this area do?

Case 6. Dr. Gross places an electrode in part of the hypothalamus of a rat and measures the electrical activity in the hypothalamus during various activities. She finds that the part of the hypothalamus where the electrode is located is most active just before the rat eats.

Case 6: a. What method is being used to study brain function?

b. What does this part of the hypothalamus do?

Case 7. Dr. Sperry cuts the corpus callosum of a young woman to stop the spread of intractable epilepsy from one side of the brain to the other. After the woman has had time to recover from the surgery, Dr. Sperry tests her on various tasks. Dr. Sperry finds no impairment on most tasks. There are two exceptions. When the patient is asked to close her eyes and name an object placed in her hand, she can do so correctly for things placed in her right hand, but not for things placed in her left hand. (She has no problems with paralysis or lack of sensation, however.) When she is given a task where she is asked to close her eyes and feel something with her left hand, then pick it out of a group of objects using her right hand, she is also unable to do so.

Case 7: a. What method is being used to study function?

b. What does the corpus callosum do?

c. What accounts for the two specific impairments described here?

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► Return to Activity: Localization of Function Exercises
▼ Return to List of Handout Masters for Chapter 2
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Handout Master 2.2

The Autonomic Nervous System

Describe how each organ is affected by the sympathetic and parasympathetic nervous system.

Organ	*Sympathetic*	*Parasympathetic*
Adrenal Medulla		
Bladder		
Blood Vessels Abdomen Muscles Skin		
Heart		
Intestines		
Liver		
Lungs		
Pupil of Eye		
Salivary Glands		
Sweat Glands		

► Return to Lecture Guide: The Peripheral Nervous System
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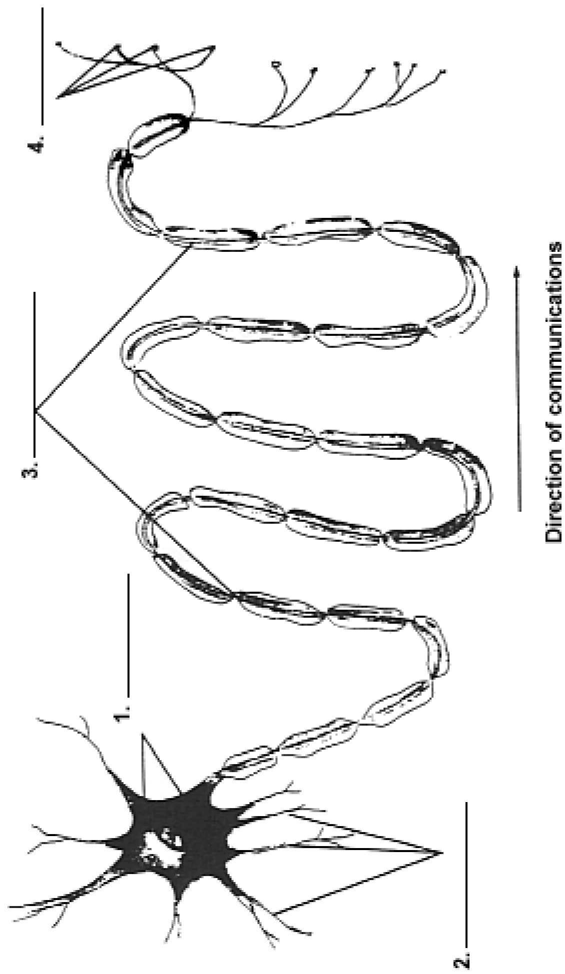
Handout Master 2.3

The Basic Structure of the Neuron

Identify the parts of the neuron discussed in the text.



► Return to Lecture Guide: Neurons: The Messengers
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Handout Master 2.4

IDENTICAL TWINS REUNITED QUESTIONNAIRE

Instructions: Give your response to the following questions; if you prefer not to answer a particular question, feel free to leave it blank.

1. Academic major: ______________________________
2. Favorite musical group/performer: ______________________________
3. Mother's name: ______________________________
4. Favorite dessert: ______________________________
5. Boyfriend's/girlfriend's first name: ______________________________

6. Favorite television show: ______________________________
7. Political affiliation: (Dem/Rep/Ind/Other): ______________________________
8. Favorite food: ______________________________
9. Favorite actor: ______________________________
10. Favorite actress: ______________________________

11. Favorite movie: ______________________________
12. Favorite hobby: ______________________________
13. Favorite sport to watch: ______________________________
14. Favorite sport to play: ______________________________
15. Favorite professional sports team: ______________________________

16. Favorite author: ______________________________
17. Father's name: ______________________________
18. Most distinctive habit: ______________________________
19. Favorite politician: ______________________________
20. Favorite professional athlete: ______________________________

21. Most disliked food: ______________________________
22. Favorite automobile: ______________________________
23. Favorite kind of pet animal: ______________________________
24. Professional goal: ______________________________
25. Most recent non-course book read: ______________________________

Sdorow, L. (1994). The Frankenstein course: Teaching assistants, laboratory exercises, and papers in introductory psychology. Paper presented at the Southwest Regional Conference for Teachers of Psychology, Fort Worth. Reprinted by permission of the author.

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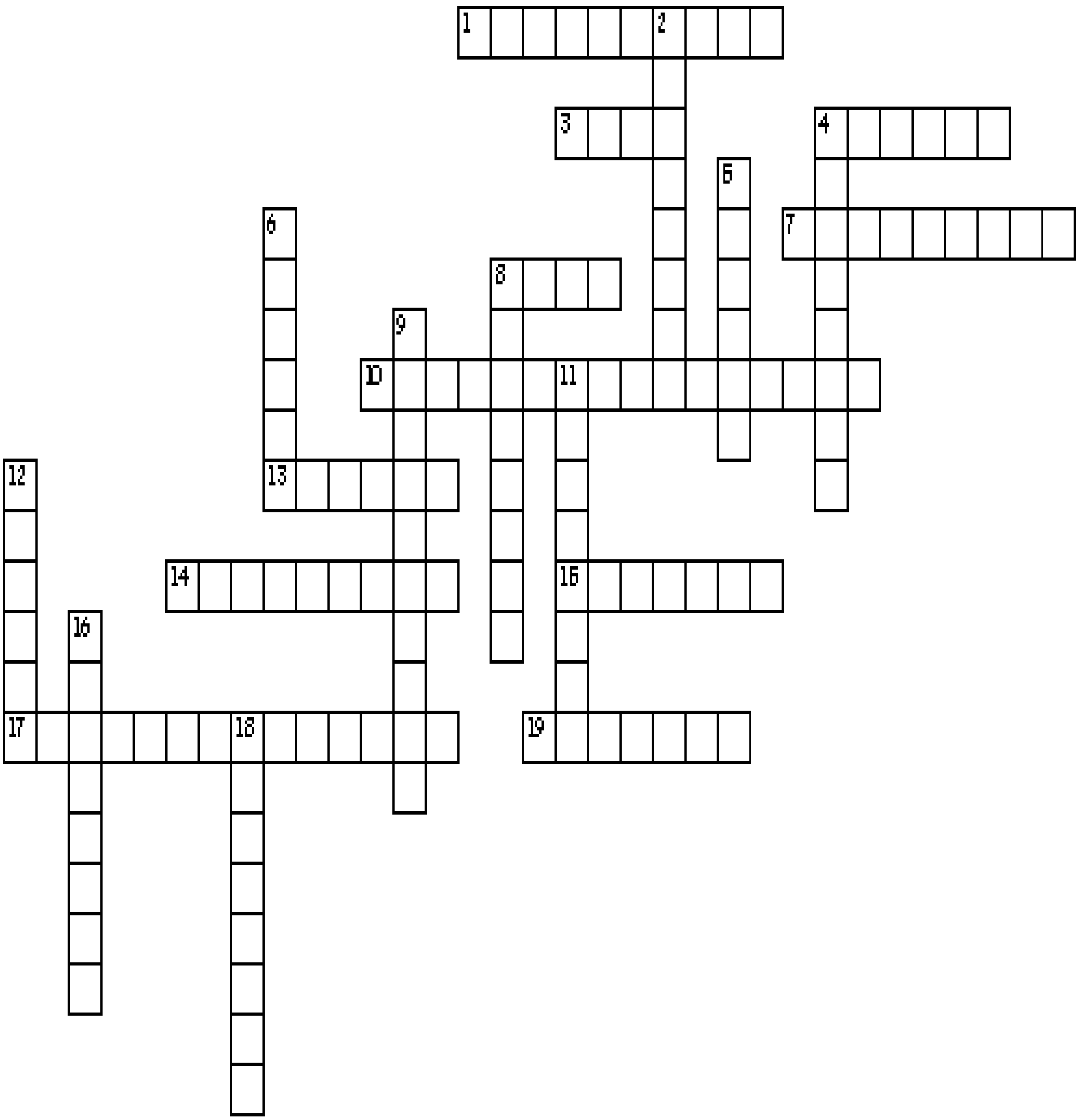
Handout Master 2.5

Crossword Puzzle Activity

Chapter 2: The Biological Basis of Behavior



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 that 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 Chapter 2 (answers)
► Return to Activity: Crossword Puzzle
▼ Return to List of Handout Masters for Chapter 2
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Handout Master 2.6

Fill in the Blank Class Activity

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 that 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 are the ________________.

5. The cell body of the neuron, responsible for maintaining the life of the cell and containing 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 the neuron are called ________________.

9. The state of the neuron, when not firing a neural impulse, is known as the ________________ ________________.

10. ________________ ________________ ________________ refers to the fact that a neuron either fires completely or does not fire at all.

11. The ______________ ______________ are sack-like structures found inside the synaptic knob containing chemicals.

12. ________________ are chemicals found in the synaptic vesicles which, when released, have an effect on the next cell.

13. The ________________ neurotransmitter causes the receiving cell to fire.

14. 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.

15. The ________________ ________________ is a long bundle of neurons that carries messages to and from the body to the brain; this bundle of neurons is responsible for very fast, lifesaving reflexes.

16. A neuron that carries information from the senses to the central nervous system and is also known as the afferent is called a ________________ neuron.

17. 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.

18. 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.

19. The _______________ _______________ system division of the PNS consists of nerves that control all of the *involuntary* muscles, organs, glands, and sensory pathway nerves.

20. The part of the ANS that is responsible for reacting to stressful events and bodily arousal is called the _______________ _______________ of the nervous system.

21. A machine designed to record the brain wave patterns produced by electrical activity of the surface of the brain is called a(n) _______________.

22. The part of the lower brain located behind the pons that controls and coordinates involuntary, rapid, fine motor movement is called the _______________.

23. 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 _______________.

24. 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 _______________.

25. _______________ _______________ is an area of neurons running through the middle of the medulla and the pons, and slightly beyond, that is responsible for selective attention.

26. 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.

27. The _______________ is a brain structure located near the hippocampus, responsible for fear responses and memory of fear.

28. The _______________ is the outermost covering of the brain, consisting of densely packed neurons, responsible for higher thought processes and interpretation of sensory input.

29. The thick band of neurons that connects the right and left cerebral hemispheres is called the _________________ _______________.

30. 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 _______________ _______________.

31. 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 _______________ _______________.

32. The _______________ _______________ are the areas of the cortex located just behind the temples, containing the neurons responsible for the sense of hearing and meaningful speech.

33. The _______________ _______________are the 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.

34. The _______________ glands secrete chemicals called hormones directly into the bloodstream.

35. 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 _______________ _______________.

36. The nucleus of each cell contains _______________, tiny threadlike bodies that carry genes, the basic units of heredity.

37. A _______________ gene is a member of a gene pair that controls the appearance of a certain trait, while a _______________ gene can influence the appearance of a certain trait only if it is paired with a similar gene.

38. A _______________ is an organism's entire unique genetic inheritance, while a _____________ is the actual characteristics of the person.

39. _______________ twins develop from a single fertilized ovum, while _______________ twins develop from two separate eggs.

40. ____________ psychologists try to explain the behavioral traits that people have in common. To address these shared characteristics, these psychologists rely on Charles Darwin's notion of _______________ _______________.

Words to Use:

adrenal glands
agonists
All or none
amygdala
autonomic nervous
axon
cerebellum
chromosomes
corpus callosum
cortex
dendrites
dominant
electroencephalograph
endocrine
Evolutionary
excitatory
frontal lobes
genotype
hippocampus
Identical
ions
myelin
natural selection
nerves
nervous system
neuron
neurotransmitters
occipital cortex
parietal cortex
peripheral pervous
phenotype
pons
recessive
resting potential
reticular formation
sensory
soma
somatic nervous
spinal cord
sympathetic division
synaptic vesicles
temporal lobes
thalamus

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▼APS: READINGS FROM THE ASSOCIATION OF PSYCHOLOGICAL SCIENCE
Current Directions in Introductory Psychology, Second Edition **(0137143508)**
Edited by Abigail A. Baird, with Michele M. Tugade and Heather B. Veague

Amir Amedi, Lotfi B. Merabet, Felix Bermpohl, Alvaro Pascual-Leone
The Occipital Cortex in the Blind: Lessons About Plasticity and Vision. (Vol. 14, No. 16, 2005, pp. 306—311) p. 47 of the APS reader
Studying the brains of blind individuals provides a unique opportunity to investigate how the brain changes and adapts in response to afferent (input) and efferent (output) demands. We discuss evidence suggesting that regions of the brain normally associated with the processing of visual information undergo remarkable dynamic change in response to blindness. These neuroplastic changes implicate not only processing carried out by the remaining senses but also higher cognitive functions such as language and memory. A strong emphasis is placed on evidence obtained from advanced neuroimaging techniques that allow researchers to identify areas of human brain activity, as well as from lesion approaches (both reversible and irreversible) to address the functional relevance and role of these activated areas. A possible mechanism and conceptual framework for these physiological and behavioral changes is proposed.

Kevin S. LaBar
Beyond Fear: Emotional Memory Mechanisms in the Human Brain. (Vol. 16, No. 4, 2007, pp. 173—177) 64 of the APS reader
Neurobiological accounts of emotional memory have been derived largely from animal models investigating the encoding and retention of memories for events that signal threat. This literature has implicated the amygdala, a structure in the brain's temporal lobe, in the learning and consolidation of fear memories. Its role in fear conditioning has been confirmed, but the human amygdala also interacts with cortical regions to mediate other aspects of emotional memory. These include the encoding and consolidation of pleasant and unpleasant arousing events into long-term memory, the narrowing of focus on central emotional information, the retrieval of prior emotional events and contexts, and the subjective experience of recollection and emotional intensity during retrieval. Along with other mechanisms that do not involve the amygdala, these functions ensure that significant life events leave a lasting impression in memory.

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▼*Forty Studies that Changed Psychology: Explorations into the History of Psychological Research, Sixth Edition* (013603599X)
By Roger Hock

Studies examined in Biology and Human Behavior:

One Brain or Two?
Gazzaniga, M. S. (1967). The split brain in man. *Scientific American, 217*(2), 24—29.

More Experience = Bigger Brain
Rosenzweig, M. R., Bennett, E. L., & Diamond, M. C. (1972). Brain changes in response to experience. *Scientific American, 226*(2), 22—29.

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▼WEB RESOURCES

General/Comprehensive

Biological and Physiological Resources: http://psych.athabascau.ca/html/aupr/biological.shtml
Links to several sites and interesting topical articles relevant to biological and physiological psychology. A good starting point for a number of assignments, such as writing short papers or assembling study guide terms. Maintained by the Centre for Psychology Resources at Athabasca University, Alberta, Canada.

Neuroguide.com – Neurosciences on the Internet: http://www.neuroguide.com/
A resource for all things related to neuroscience: databases, diseases, research centers, software, biology, psychology, journals, tutorials, and much more.

Neuropsychology Central: http://www.neuropsychologycentral.com/
Links to resources related to neuropsychology, including brain images, and extensive, well-organized, links to other sites.

Neuroscience for Kids: http://faculty.washington.edu/chudler/neurok.html
This site can be enjoyed by people of all ages who want to learn about the brain. Fun, superbly organized site, providing information and links to other neuroscience sites. Includes informative pages regarding Brain Basics, Higher Functions, Spinal Cord, Peripheral Nervous System, The Neuron, Sensory Systems, Methods and Techniques, Drug Effects, and Neurological and Mental Disorders. Even includes a nice answer to the perennial question "Is it true that we only use 10% of our brain?"
http://faculty.washington.edu/chudler/tenper.html

Whole Brain Atlas: http://www.med.harvard.edu:80/AANLIB/home.html
Prepared by Keith Johnson, M.D. and J. Alex Becker at Harvard University. Site includes brain images, information about imaging techniques, and information about specific brain disorders.

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Neurons/Neural Processes

Basic Neural Processes Tutorials: http://psych.hanover.edu/Krantz/neurotut.html
A good site for your students to learn about basic brain functioning.

How do Nerve Cells Communicate?
http://www.sfn.org/index.aspx?pagename=core_concepts
Information prepared by the Society for Neuroscience.

Making Connections – The Synapse: http://faculty.washington.edu/chudler/synapse.html
Clear, comprehensible, explanation of how synapses work, with nice illustrations, prepared by Eric Chudler.

Neural Processes Tutorial: http://psych.hanover.edu/Krantz/neurotut.html
An excellent interactive animated tutorial.

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Nervous System

Autonomic Nervous System: http://faculty.washington.edu/chudler/auto.html
Succinct summary of information about the structure and function of the autonomic nervous system, prepared by Eric Chudler.

Self-Quiz for Chapter on the Human Nervous System:
http://www.psychwww.com/selfquiz/ch02mcq.htm
Self-quiz prepared by Russ Dewey at Georgia Southern University. Covers material typically found in an introductory psychology textbook chapter with a title like "Brain and Behavior" or "Neuropsychology."

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The Brain

Brain and Behavior: http://serendip.brynmawr.edu/bb/
This mega-site contains lots of links to information about the brain, behavior, and the bond between the two. Students can complete several interactive exercises to learn more about brain functions.

Brain Connection: The Brain and Learning: http://www.brainconnection.com/
A newspaper-style web page that contains interesting articles, news reports, activities, and commentary on brain-related issues.

Brain Function and Pathology: http://www.waiting.com/brainfunction.html
Concise table of diagrams of brain structures, descriptions of brain functions, and descriptions of signs and symptoms associated with brain structures and functions.

Brain Model Tutorial: http://pegasus.cc.ucf.edu/~Brainmd1/brain.html
This tutorial teaches students about the various parts of the human brain and allows them to test their knowledge of brain structures.

Brain Reorganization: http://www.sfn.org/index.aspx?pagename=brainfacts
Brief information on how the brain changes with experience, prepared by the Society for Neuroscience.

Brain: Right Down the Middle: http://faculty.washington.edu/chudler/sagittal.html
Useful drawing and succinct information about the location and functions of brain structures that can be seen on the midsagittal plane, presented by Eric Chudler.

***Conversations with Neil's Brain* (1994):** http://www.williamcalvin.com/index.html
An online book by William H. Calvin & George A. Ojemann of University of Washington. Teachers are allowed to print and photocopy chapters for educational use.

Cross Sections of the Human Brain: http://www.neuropat.dote.hu/caud.gif
A cross-sectional image of the human brain. Good to have on hand if you need one. Show your students and help them identify the various structures.

Drugs, Brains, and Behavior: http://www.rci.rutgers.edu/~lwh/drugs/
An online textbook detailing the effects of various substances on the brain, authored by C. Robin Timmons & Leonard W. Hamilton.

History of Phrenology: http://pages.britishlibrary.net/phrenology/

Follow the bumpy road to discovering phrenology's past from a professor of history at the University of Cambridge.

Human Corpus Callosum: http://www.indiana.edu/~pietsch/callosum.html
Information and links about the corpus callosum and "split-brain surgery" by Paul Pietsch.

Lobes of the Brain: http://faculty.washington.edu/chudler/lobe.html
Succinct information about the location and functions of the four lobes of the cerebrum, presented by Eric Chudler. Includes link to "Lobes of the Brain Review," a very brief quiz on functions associated with major lobes of the brain. Answers provided online: http://faculty.washington.edu/chudler/revlobe.html

One Brain…or Two?: http://faculty.washington.edu/chudler/split.html
Information on lateralization of function and how the functions of the hemispheres may be studied, presented by Eric Chudler.

She Brains/He Brains
http://faculty.washington.edu/chudler/heshe.html: Nice summary of evidence for sex-related differences in brain structure, prepared by Eric Chudler.

What Does Handedness Have to Do with Brain Lateralization (and Who Cares?):
http://www.indiana.edu/~primate/brain.html
Very nice page on lateralization of function in the brain.

How do we move? http://www.sfn.org/skins/main/pdf/brainfacts/2008/movement.pdf
Information about the areas of the motor cortex and the cerebellum that are responsible for controlling movement. Prepared by the Society for Neuroscience.

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Phineas Gage

Phineas Gage Information Page: http://www.deakin.edu.au/hbs/GAGEPAGE
Everything you ever wanted to know about Phineas Gage is on this page, prepared by Malcolm Macmillan at Deakin University, Victoria, Australia.

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▼ MyPsychLab VIDEO CLIPS AVAILABLE FOR CHAPTER 2: THE BIOLOGICAL BASIS OF BEHAVIOR

The ***MyPsychLab Video Series*** includes current introductory video content that takes viewers into research laboratories, inside the body and brain, and onto the streets for real-world applications of chapter content. Each video is approximately 5 minutes long, and the videos are accompanied by assessments so that they may be turned into assignments for students.

Within each chapter (or "episode"), the viewer can find video clips that serve the following purposes:

- ***The Big Picture*** – introduces the topic of the chapter/episode.
- ***The Basics*** – presents foundational topics from the chapter/episode, especially ones that students find challenging.
- ***Special Topics*** – shows research in action as specific topics are explored more deeply.
- ***Thinking Like a Psychologist*** – demonstrates critical thinking and the uses of various research methods.
- ***In the Real World*** – illustrates the practical applications of psychological research.
- ***What's in It for Me?*** – conveys the relevance of psychological research to the lives of students.

Episode 3: Biological Psychology

- **The Big Picture: My Brain Made Me Do It, 4:59**
  This video explains the function of different parts of the brain and how the brain processes multiple signals at once.
- **The Basics: How the Brain Works, Part 1, 5:05**
  In this video, we are introduced to the neuron and what purpose neurons serve in the brain. We also learn about the different parts of the neuron and how neurons communicate with each other.
- **The Basics: How the Brain Works, Part 2, 6:11**
  This video explains how the nervous system is divided and how it processes information, the significance of each of the different brain structures, and how neuronal transmission works.
- **Special Topics: The Plastic Brain, 7:04**
  In this video, we 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.
- **Thinking Like a Psychologist: The Prefrontal Cortex: The Good, The Bad, and The Criminal, 3:28**
  In this video we learn about how different parts of the brain control different types of behavior, and how both biological and environmental factors can lead a person to become a violent criminal later in life.
- **In the Real World: Neurotransmitters: Too Much, or Too Little of a Good Thing, 3:10**
  In this video we learn about how neurotransmitters function and how an imbalance in neurotransmitters, specifically dopamine, can affect the body.
- **What's in It for Me? Your Brain on Drugs, 3:51**
  In this video we learn about neurotransmitter imbalance, the different categories of drugs, and how drugs interrupt the natural neurological processes in our bodies to change the way we feel and function.

Episode 4: Genes and Evolution

- **The Big Picture: Genes, Evolution, and Human Behavior, 1:46**
  In this video, the history of the nature versus nurture debate is introduced and explained in a way that helps viewers understand why there is cause for disagreement and what scientists are currently trying to determine about nature versus nurture.
- **The Basics: Genetic Mechanisms and Behavioral Genetics, 7:52**
  In this video, we learn about the types of things that behavioral geneticists study; we are given a review of basic genetics and inheritance, what correlation of traits means, and what family studies, adoption studies, and twin studies can determine.
- **Special Topics: Epigenetics: A Revolutionary Science, 5:47**
  In this video, we learned about epigenetics and how strong an influence the environment can be on our genetic development, gene expression, and behavior.
- **Thinking Like a Psychologist: Evolutionary Psychology: Why We Do the Things We Do, 6:53**
  This video explains what evolutionary psychologists study, how human behavior, particularly mating strategy, is influenced by evolutionary history, and why some groups are offended by evolutionary psychology.
- **In the Real World: Taking Control of Our Genes, 5:26**
  In this video, we dig deeper into the field of epigenetics and hear how one researcher conducted his experiment on gene expression and addiction. This video also explains how epigenetic research can lead to the prevention of a number of different diseases.

MyPsychLab videos can be accessed at **www.mypsychlab.com** and are also available on DVD (visit **www.pearsonhighered.com**).

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▼MyPsychLab MULTIMEDIA RESOURCES

Multimedia Content applicable to this chapter is available at www.mypsychlab.com

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▼POWERPOINT SLIDES

Three different sets of PowerPoint slides are available for this chapter and can be accessed by clicking on the links below:

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Click on the *Resources* tab

Interactive PowerPoint Slides
Click on the *Resources* tab

Art Only PowerPoint Slides
Click on the *Resources* tab

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