

BIOLOGICAL BASES OF BEHAVIOR

a seven-day unit lesson
plan for high school
psychology teachers

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This unit is a revision of the original TOPSS Unit Lesson Plan on *Biological Bases of Behavior*, written by Blaine Adams, Elizabeth Berry, Gerald Blackstone, Betsy Fuqua, Lorrilee Geraci, Roger Hazzard, Joseph Lamas, Rhinehart Lintonen, Laura Maitland, Bates Mandel, Michael Riley, Pat Rowan, Ron Thornton, and Robert Windemuth; original unit edited by Laura Lincoln Maitland, W. C. Mephram High School, Bellmore, NY.

The unit is aligned to the following content standards of the *National Standards for High School Psychology Curricula* (APA, 2011):

Standard Area: Biological Bases of Behavior

Content Standards

After concluding this unit, students understand:

1. Structure and function of the nervous system in human and nonhuman animals
2. Structure and function of the endocrine system
3. The interaction between biological factors and experience
4. Methods and issues related to biological advances

Please refer to Appendix A to see how sections of this unit lesson plan align with APA's *National Standards* (APA, 2011).

The authors of this unit lesson plan want to mention that high school psychology teachers need not present all the content in this document in the high school course. Please refer to the *National Standards* as to which content should be presented in the high school psychology course.

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procedural timeline

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LESSON 1: TECHNIQUES TO LEARN ABOUT THE BRAIN AND NEURAL FUNCTION

As technology has improved, scientists have used a wide range of techniques to learn about the brain and neural function. There are three fundamental ways to study how the brain functions: lesion, stimulation, and recording.

I. Greek philosophers and physicians linked the mind with the brain.

- A. Hippocrates (460-377 B.C.) said that emotions, thought, and mental health arise from the brain (Plato agreed 427-347 B.C.).
- B. Galen (circa 130-200 A.D.) thought that fluids of the brain in ventricles were responsible for sensations, reasoning, judgment, memory, and movement.

II. Franz Gall (1758-1828) and Johann Spurzheim (1776-1832) incorrectly related bumps and depressions on the surface of the skull with personality traits and moral character. This study was known as phrenology. Later researchers explored localization of functions in the brain with more systematic research.

III. Studying patients with brain damage linked loss of structure with loss of function.

- A. Phineas Gage was the level-headed, calm foreman of a railroad crew (1848) until an explosion hurled a tamping iron through his head. After the injury destroyed major parts of his prefrontal lobes, thereby severing connections with his limbic system, Gage became volatile.

His localized brain injury and subsequent change in behavior helped researchers identify areas of the frontal lobes as being instrumental to the mediation and control of emotional behavior.

B. Paul Broca (1824-1880) performed an autopsy on the brain of a patient named Leborgne (aka Tan) who had lost the capacity for speech with no paralysis of the articulatory tract and no loss of verbal comprehension or intelligence. Tan's brain showed damage to the left frontal lobe, as did the brains of several similar cases, relating destruction of "Broca's area" to expressive aphasia (1861). Carl Wernicke (1848-1905) similarly found that an area in the temporal lobe of the left cerebral hemisphere is important for language comprehension.

C. Gunshot wounds, tumors, strokes, Alzheimer's disease, Korsakoff's syndrome (amnesia caused by B1 deficiency related to malnutrition or alcoholism), and so on enabled further mapping of the brain.

IV. Producing lesions (damaging the structure) at specific brain sites enabled systematic study of loss of function resulting from surgical removal, severing of neural connections, or destruction by chemical or electrical applications.

Ablation is the removal of a structure. The vast majority of lesion studies are with laboratory animals (although occasionally, surgeons must remove some brain structure in humans to remove a tumor). The procedures in nonhuman animals are done only after thorough review by Institutional Animal Care and Use Committees (IACUCs), which ensure that the work is ethical and pain will be minimized.

V. Examination of neural tissue led to the understanding of the neuron as the basic unit of structure and function of the nervous system.

Santiago Ramon y Cajal (1852-1934) perfected a selective silver staining technique developed by Camillo Golgi (1843-1926) to examine single neurons. Cajal described the structure of a neuron and noted that each cell was distinct from the next instead of merging into it.

VI. Direct electrical stimulation of the brain provides another way to test the functions of certain brain areas.

A. Wilder Penfield (1952) used an electrode to localize the origin of seizures in patients. Stimulating different cortical areas, such as the back of the frontal cortex, at particular sites caused movement for different body parts, enabling mapping of the motor cortex.

B. Walter Hess (1955) inserted electrodes more deeply into the brain of nonhuman animals that were under anesthesia. After they recovered from the surgery, he related start/stop functions with specific brain structures. Examples are the "start eating and stop eating" functions associated with areas of the hypothalamus.

VII. An EEG (electroencephalogram) is an amplified tracing of the activity of a region of the brain produced when electrodes positioned in direct contact with the scalp transmit signals about the brain's electrical activity ("brain waves") to an electroencephalograph machine. The amplified tracings are referred to as evoked potentials when the recorded change in voltage is the result of a response to a specific stimulus presented to the subject.

EEGs have been used to study the brain during various states of arousal (such as sleeping and dreaming), detect abnormalities (such as deafness and visual disorders in infants or epilepsy), and study cognition.

VIII. Imaging techniques in widespread use provide images of brain anatomy.

A. CAT scan (also called CT)—computerized axial tomography

1. A CAT scan creates a computerized image of X-rays passed through various angles of the brain showing two-dimensional “slices” that can be arranged to show the extent of a lesion.
2. The procedure may involve injection of a contrast dye and involves shorter periods of scanning than MRI. Because it does not use magnets, it can be used with patients who have pacemakers or metallic implants.

B. MRI—magnetic resonance imaging

1. The giant circular magnet in the MRI machine causes the hydrogen nuclei in the water of cells to orient in a single direction. Pulses of radio waves cause the atoms to spin at a frequency and in a direction dependent on the type of tissue. The computer constructs images based on these signals.
2. MRI images are more detailed than CAT or PET scans and can be produced for any plane of view.

IX. Some imaging techniques in widespread use have enabled neuroscientists to observe the activity of the brain as it functions.

A. fMRI—functional magnetic resonance imaging

1. fMRIs capitalize on the ability of MRI scanners to detect a change in oxygen that occurs in an area of heightened neuronal activity. Heightened activity causes the brain to use more oxygen. Therefore, hemoglobin in that area has less oxygen bound to it. Hemoglobin with oxygen reacts to a magnetic field in a different way from hemoglobin not bound to oxygen.
2. fMRI is generally considered preferable to PET because fMRI does not expose the brain to radioactivity. Powerful magnetic fields can pose a mild risk, too, especially if repeated rapidly, but they are less dangerous than radioactivity.

B. PET scans—positron emission tomography

1. When neurons are active, an automatic increase in blood flow to the active region of the brain brings more oxygen and glucose necessary for respiration. Blood flow changes are used to create brain images when tracers (such as radioactively labeled glucose) injected into the blood of the subject emit particles called positrons, which are converted into signals detected by the PET scanner (or more specifically, the positrons almost immediately are destroyed and produce pairs

of gamma particles, and the gamma radiation is detected by the scanner). Glucose concentrates in the areas of greatest activity, and the concentration of labeled substances taken up by brain tissue (revealed in colored computer graphics) depends on the amount of metabolic activity in the imaged brain region. This technique tracks complex series of interactions in different brain areas associated with specific mental processes.

2. PET scans expose the subject to radioactivity (a low amount), so their use is limited.

X. Other advances in technology have enabled neuroscientists to learn more about the relationship of neurological function to behavior.

A. BEAM—brain electrical activity mapping

This feeds EEG information from numerous recording sites into a computer that constructs an image of the brain showing areas with different gradations of voltage in different colors or shades so that more accurate diagnoses of brain tumors, epilepsy, and learning disorders can be made.

B. MEG—magnetoencephalography and SQUID—superconducting quantum interference device

Based on the fact that whenever an electrical current is present there is an accompanying magnetic field, MEG detects neural activity too brief to be detected by PET or fMRI. This technique has been used to locate seizure-producing regions in epileptic patients. It's similar to EEG. MEG measurements use a SQUID, an extremely sensitive device, which detects magnetic fields.

C. PRONG—parallel recording of neural groups

Electrodes that can measure many individual neurons in close proximity have uncovered information about communication among neurons in a region.

D. SPECT—single-photon emission computerized tomography

This tracks cerebral blood flow as an indicator of neural activity in specific brain regions during performance of various tasks. SPECT is faster but has lower resolution than PET.

E. TMS—transcranial magnetic stimulation

The coils of wire around the head let scientists either depress or enhance activity in one area of the brain. This allows them to learn more about the different brain functions.

F. Gene knock-out technology

Breakthroughs in genetics have allowed scientists to remove specific genes from mice (and some other organisms) to help them understand the link between genes and behavior. For example, mice that are lacking one of the genes responsible for regulating the neurotransmitter dopamine act as if they are permanently high on cocaine.

- G. Optogenetics allows neuroscientists to insert genes into neurons of nonhuman animals that cause the neurons to become sensitive to (and be excited by) light. Shining light on that part of the brain will then activate those neurons. This allows specific activation of only the modified neurons, allowing their functions to be better understood.

LESSON 2: THE NEURON—UNIT OF STRUCTURE AND FUNCTION OF THE NERVOUS SYSTEM

The neuron is the basic cell of the nervous system. There are many types of neurons, each performing different functions, but they are structured similarly.

I. The neuron, or nerve cell, sends and receives signals that affect many aspects of behavior and motor control.

A. Three major structures of the neuron enable the cell to communicate with other cells.

1. The cell body (or *soma*) contains *cytoplasm* and the nucleus, which includes the chromosomes. Mitochondria in the cell body perform metabolism. Ribosomes synthesize proteins.
2. Extending outward from the soma are *dendrites* (Greek=little trees), the receiving/input branches of the neuron.
3. The *axon* emerges from the soma as a single conducting fiber.
4. The axon branches and ends in tips called presynaptic terminals (also known as terminal buttons, boutons, or telodendria). *Neurotransmitters* are stored in structures of the presynaptic terminal known as vesicles.
5. The axon may be covered by an insulating *myelin sheath* (think insulation on an electrical cord), made of specialized cells such as oligodendrocytes (central nervous system, or CNS) and Schwann cells categorized as glial cells (peripheral nervous system, or PNS). Glial cells (from Greek word meaning glue") were once thought of as cells that simply hold the neurons together. We know now that they play important roles in neural function. Spaces between segments of myelin are called *nodes of Ranvier*. One function of the myelin sheath is to speed up neural impulses.

B. Many neurotransmitters have been identified that have a variety of chemical structures and hypothesized functions.

1. *Acetylcholine* (ACh) causes contraction of the skeletal muscles, helps regulate heart muscles, promotes arousal in the brain, and transmits messages between the brain and spinal cord. Low ACh means low arousal and low attention; its depletion is associated with Alzheimer's disease.
2. *Glutamate* and *aspartate* stimulate receptors associated with learning and memory, as well as many sensory and

motor functions. Glutamate is the most abundant excitatory neurotransmitter in the brain. An overabundance of glutamate may lead to migraine headaches; often connected with MSG (monosodium glutamate) in foods, a result of overstimulation.

3. *GABA (gamma-aminobutyric acid)* inhibits the firing of neurons. It is the most abundant inhibitory neurotransmitter in the brain. GABA is associated with calming effects. A lack of GABA is connected to seizures, tremors, insomnia, anxiety, epilepsy, and Huntington's disease.
4. *Dopamine (DA)* is primarily involved in processing smooth and coordinated gross motor movements and in attention, learning, and reinforcing effects of several often-abused drugs. Parkinson's disease is associated with the death of DA-producing neurons. Dopamine release in the nucleus accumbens is linked to addictive drugs, sex, and attention-grabbing experiences in general, including videogame playing.
5. *Norepinephrine (NE)* is found in neurons in the autonomic nervous system (ANS). NE governs sympathetic arousal by activating the heart and blood vessels, thus giving rise to the "fight or flight" syndrome as well as other excitatory actions. It is also released in the brain to enhance attention and memory for emotionally charged events.
6. *Serotonin (SE or 5-HT, for 5-hydroxytryptamine)* plays a role in the regulation of mood; control of eating, sleep, arousal; the regulation of pain; and control of dreaming. Most of the drugs that relieve depression increase activity at serotonergic synapses.
7. *Opioid peptides*, such as *endorphins*, are often considered the brain's own painkillers. These are endogenous chemicals that modulate the experience of pain or pleasure.
8. Dozens of *peptide neuromodulators* are released by small groups of brain neurons. These peptides produce long-lasting, wide-spread effects, much like hormones, to alter hunger, thirst, and other long-lasting behaviors.

C. Relationship of neurotransmitters and abused drugs: See Appendix B.

II. The nature of the neural impulse, known as an action potential, is electrochemical. It is an all-or-nothing action, as an axon either fires or does not.

A. An impulse is transmitted down the length of the axon bioelectrically.

1. A resting neuron is more negative inside the cell membrane than outside. The resting neural membrane potential is about -70mV (on average). (Physiologists refer to voltage differences as "potential" because they represent potential energy.)
2. When sufficiently stimulated to threshold, the cell membranes admit sodium, creating a *depolarization* (loss of potential) that "kicks" the electrical charge down the axon to the presynaptic terminals. The brief change in potential is called the *action potential*.

3. The action potential reverses the charge across the membrane—it changes from -70 mV to about +50 mV for about 1 msec.
4. After the peak of the action potential, the sodium channels close. However, the potassium channels are open wider than usual, and potassium exits from the cell to the outside, carrying a positive charge and returning the membrane to its original condition (or a slightly increased hyperpolarization).
5. The more intense a stimulus, the more frequently a neuron fires, but the amplitude and velocity of the action potentials do not change.
6. When the axon is myelinated, conduction speed is increased. Depolarizations occur only at the nodes of Ranvier, and, therefore, the action potential jumps from one node to the next. This is called saltatory conduction.
7. The message now arrives at the presynaptic terminals and prepares to release neurotransmitters (chemicals) from sacs (*vesicles*).
8. After a brief period of time—the *refractory period*—the neuron is ready to fire again.

B. Neurons signal by transmitting chemical messages to adjacent neurons, gland cells, or muscle cells (*synaptic transmission*).

1. Tiny gaps between neurons are called *synaptic clefts*. A particular terminal button of an axon, the synaptic cleft itself, and the receiving portion of another neuron, gland cell, or muscle cell together constitute the *synapse*.
2. When action potentials arrive at the terminal, they trigger the release of neurotransmitter molecules from *synaptic vesicles* into the synaptic cleft.
3. A signal is transmitted from one neuron to the next when the neurotransmitter molecules from the presynaptic neuron bind with the postsynaptic neuron (at its dendrites), much like a “lock-and-key” mechanism, thus changing the potential of the postsynaptic neuron.
4. If the binding of the neurotransmitter to the postsynaptic receptor site makes the neuron more likely to fire, the effect is called excitatory.
5. If the binding of the neurotransmitter to the postsynaptic receptor site prevents or lessens the likelihood of the firing of the neuron, the effect is called inhibitory.

See Activity 2: Neurons and Impulse Conduction.

III. The simplest form of behavior, called a reflex, involves impulse conduction over a few neurons. This path is called a reflex arc.

- A. Sensory or *afferent* neurons transmit impulses from sensory receptors to the spinal cord or brain.

- B. Motor or *efferent* neurons conduct impulses (motor commands) away from the brain or spinal cord to the muscles and glands. Muscle and gland cells acting on motor commands are called *effectors*.
- C. *Interneurons*, located entirely within the brain and spinal cord, intervene between one neuron and another.

LESSON 3: THE ORGANIZATION OF THE NERVOUS SYSTEM

I. Patterns of behavior are generally related to the functioning of structures of neural tissue or regions within the brain rather than single or small groups of neurons. Neural tissue can be categorized in a variety of ways.

A. Appearance by shade/color of neural tissue

1. Gray matter is composed of neural cell bodies mixed with capillaries. A large number of cell bodies grouped together constitute a nucleus (within the central nervous system) or ganglion (in the peripheral nervous system).
2. White matter is composed of myelinated fibers. A large collection of myelinated axons constitutes a fiber pathway, or tract (within the central nervous system), or nerve (within the peripheral nervous system).
3. Reticular matter is composed of cell bodies and axons mixed together, giving a netlike appearance.

B. Description by location in the organism with respect to three axes

1. From the back or dorsal portion to the belly or ventral portion: With respect to the human brain, superior is synonymous with dorsal, and inferior is synonymous with ventral.
2. From the head or anterior portion to the tail or posterior portion
3. From the midline or medial portion to the side or lateral portion

II. General divisions of the nervous system are anatomical and physiological.

A. Most of the peripheral nervous system lies outside the brain and spinal cord, carrying sensory information to and motor information away from the central nervous system via spinal and cranial nerves.

1. One subdivision is the somatic nervous system (SNS) whose motor neurons innervate skeletal muscle.
2. The other subdivision is the autonomic nervous system, whose motor neurons innervate glands or smooth or cardiac muscle.
 - a. The autonomic nervous system is subdivided into the sympathetic and parasympathetic nervous systems, whose functions are antagonistic in many cases.

b. Autonomic fibers emerge from the central nervous system and typically synapse with a second neuron. All synapses and cell bodies in the sympathetic nervous system are at about the same location causing a bulge in the nerve called a sympathetic ganglion. Nerves of the parasympathetic system project to ganglia very close to the organs they control.

i. Sympathetic stimulation results in responses that help the body deal with stressful events.

- dilation of pupils
- dilation of bronchi
- acceleration of heart rate
- acceleration of breathing rate
- release of glucose from liver
- inhibition of digestive functions
- secretion of adrenalin from adrenal glands
- inhibition of secretion of tear glands

ii. Parasympathetic stimulation results in maintenance of homeostasis, digestive processes, and calming following sympathetic stimulation.

- constriction of pupil size
- normal bladder contractions
- return to normal breathing rate
- stimulation of tear glands
- return to normal heart rate
- stimulation of digestive functions (salivation, peristalsis, enzyme secretion)

B. The central nervous system (CNS) consists of the spinal cord and the brain.

1. The spinal cord is protected by membranes called meninges (collectively made up of the dura, arachnoid, and pia mater) and the spinal column of bony vertebrae. In adults, the spinal cord ends at the upper part of the curvature of the lower back and extends upward to the base of the skull where it joins the brain.

- a. Sensory fibers enter dorsally, and motor fibers exit ventrally.
- b. The cord itself is an H-shaped area of gray cell bodies surrounded by transverse, ascending, and descending white myelinated fibers.
- c. The cord itself is composed mainly of interneurons and glial cells which are bathed by cerebrospinal fluid extracted from the blood by tissue called choroid plexus located within the ventricles (hollow spaces) in the brain. Cerebrospinal fluid surrounds the spinal cord.

2. The brain has the consistency of soft-serve yogurt or semi-soft cheese, covered by meninges and housed in the skull.

a. Species comparisons in brain anatomy:

- i. The general organization of the brain is similar for all vertebrates. One can recognize the forebrain, midbrain, and hindbrain for any fish, reptile, amphibian, bird, or mammal.
- ii. Mammals are distinguished from other vertebrates mainly by their larger, more elaborate forebrain, including the development of a cerebral cortex, which nonmammals lack.
- iii. Among mammals, the organization of the cerebral cortex is the same across species. (The relative locations of primary visual cortex, primary auditory cortex, primary motor cortex, and so forth are the same for all species.)
- iv. The differences among species pertain mostly to total size. If you know the size of one brain area of a mammalian species, you can predict with reasonable accuracy the size of every other major brain area, except for the olfactory bulbs, which are much larger in some species than in others.
- v. Brains differ somewhat based on the sensory capacities needed for an animal's way of life. For example, the auditory cortex is larger in echolocating bats, because of their reliance on echolocation (not all bats echolocate though).
- vi. Humans and other primates have a larger brain-to-body ratio than most other mammals, as well as deeper sulci (folds) in the cortex, enlarging the surface area of the cortex and, therefore, the number of neurons.

b. The developmental approach describes changes in structure and relates that to changes in function during the development of an individual. The infant brain has features specifically adapted to infant life (e.g., grasping or rooting reflexes).

- i. The embryonic hindbrain develops into the medulla, pons, and cerebellum. The midbrain is relatively small in mammals, although larger in other kinds of vertebrates. The forebrain grows and elaborates during development, becoming the cerebral cortex and various subcortical structures, including the thalamus and hypothalamus. The term *brain stem* refers to a series of structures extending from the medulla and pons through the midbrain and the hypothalamus and thalamus in the forebrain.

- ii. The embryonic endbrain (also called forebrain) gives rise to the neocortex, basal ganglia, limbic system, and olfactory bulb.

See Activity 3: Brain & Nervous System Metaphors.

LESSON 4: LOCALIZATION OF FUNCTION OF THE HUMAN BRAIN

Multiple representations of information can be located within different areas of the human brain, yet specific regions of the brain seem most critical in handling particular functions. This localization of structure and function has been identified for numerous regions.

I. The following areas compose the *hindbrain*.

A. The *medulla* lies immediately anterior to the spinal cord. The medulla:

1. Is where ascending and descending tracts of many fibers cross, resulting in contralateral control
2. Regulates heart rate and force of contraction
3. Regulates distribution of blood flow
4. Sets the pace of respiratory movements
5. Controls vomiting
6. Regulates reflexes such as coughing, salivating, and sneezing
7. Includes sensory and motor nuclei of five cranial nerves. Cranial nerves control sensations and movement of the head and control much of the activity of the parasympathetic nervous system's control of the organs.

B. The *pons* lies immediately anterior to the medulla. The pons:

1. Includes ascending and descending tracts and nuclei of cranial nerves
2. Helps coordinate movements and is involved in sleep and arousal

C. The *cerebellum* ("little brain") is dorsal to the medulla and the pons. The cerebellum:

1. Represents one-eighth the mass of the brain but includes about 90% of the neurons in the nervous system
2. Coordinates motor function based upon the integration of motion and positional information from the inner ear and individual muscles
3. Does not initiate muscle movement

4. Is important for all sensory and motor functions that depend on accurate timing of short (less than 2 seconds) intervals

II. The *midbrain* lies anterior to the pons between the hindbrain and forebrain.

A. The midbrain:

1. Integrates sensory processes
2. Includes ascending and descending tracts and nuclei of cranial nerves
3. Is involved in control of eye movement
4. Is responsible for reflexive responses during vision (e.g., pupil reflex)
5. Is responsible for involuntary control of muscle tone

B. The reticular formation runs through the hindbrain and midbrain. It contributes to sleep and arousal regulation.

III. The following areas compose the *forebrain*. The forebrain encompasses the area from the top of the brain stem through the cerebrum.

A. The *thalamus* lies anterior to the midbrain. The thalamus:

1. Relays for sensory pathways carrying visual, auditory, and somatosensory information to appropriate regions of the cerebral cortex (neocortex)
2. Integrates different sensory information
3. Is probably involved in determining what sensory input is attended to at any point in time

B. The *hypothalamus* lies underneath the thalamus. It manages basic body functions. The hypothalamus:

1. Controls autonomic functions such as body temperature and heart rate via control of sympathetic and parasympathetic centers in the medulla
2. Sets appetitive drives (such as thirst, hunger, sexual desire) and behaviors
3. Sets emotional states with the limbic system
4. Integrates with the endocrine system by the secretion of peptide hormones that regulate the secretion of tropic hormones from the anterior pituitary (These hormones control the rate of activity by other endocrine glands. The pituitary gland is attached to the hypothalamus.)
5. Produces antidiuretic hormone (ADH) and oxytocin, which are stored in and released from the posterior pituitary

C. The *limbic system* consists of a number of structures surrounding the brain stem. The limbic system is involved in motivation, emotion, and memory, though its role in memory is a topic of deliberation among researchers. It also provides a link between the intellectual functions of the cerebral cortex and the autonomic functions of the brain stem.

1. The amygdala is critical for processing information with emotional content, such as understanding other people's facial expressions of emotions and understanding descriptions of situations that might produce emotional consequences.
2. The hippocampus is involved in aspects of learning, especially spatial learning and learning the relationships among objects. It also plays a role in storing (consolidating) information into long-term memory.

D. The *cerebrum* is the largest part of the human brain. It conducts more complex mental activities.

1. The surface of the cerebrum (the cerebral cortex) has many convolutions that increase the surface area of the brain and provide a means of mapping regions.
 - a. Gyri (rolls) form the folding out portion of the cortex.
 - b. Sulci are valleys in the convolutions.
 - c. Fissures are deeper than sulci.
2. Lobes are four large regions of the cerebral cortex of each of the two hemispheres.
 - a. The left and right frontal lobes are anterior to the central sulcus and above the lateral sulcus.
 - b. The left and right temporal lobes are inferior to the lateral sulcus.
 - c. The left and right parietal lobes are posterior to the central sulcus, anterior to the parietal-occipital sulcus, and superior to the lateral sulcus.
 - d. The left and right occipital lobes are posterior to the parietal-occipital fissure.
3. Regions in each of the lobes receive information related to sensations and process the information.
 - a. The occipital lobes process visual information.
 - b. The somatosensory region is the anterior strip of the parietal lobes where information regarding stimulation of various body parts is received.
 - c. The motor cortex is located in the posterior area of the frontal lobes just anterior to the central sulcus that separates it from the somatosensory cortex. The motor cortex is concerned with integration of activities performed by skeletal muscles and initiates movements.

- d. The auditory cortex is partially buried within the lateral sulcus in the temporal lobes. Sensations of smell and taste are processed anteriorly in the temporal lobes.
- e. Multiple representations of information can be illustrated with respect to speech. The temporal cortex is important for understanding language, especially spoken language. The left frontal cortex is important for language production (speaking and writing). (Recall the earlier mention of Wernicke's area and Broca's area.) The occipital cortex contributes to reading or to any other instance in which someone talks about what he or she sees.

4. Specialized deficits can occur after localized brain damage in the cerebral cortex. Examples: People with damage to part of the inferior temporal cortex lose the ability to recognize faces, although they otherwise have good vision. People with damage to part of the middle temporal cortex lose the ability to perceive visual motion. People with damage to part of the somatosensory cortex in the parietal lobe get the emotion aspect of a sensation without the touch sensation (they may not feel their arm, but if gently stroked, they may say they feel good).

See Activity 4.1: Mini-Project: The Brain.

See Activity 4.2: Biopsychology BINGO.

LESSON 5: LATERALIZATION OF FUNCTION OF THE HUMAN BRAIN (SPLIT BRAIN)

Although similarly located regions in both cerebral hemispheres generally have similar functions, differences or lateralization of function has been shown to exist.

I. Methods of studying information regarding brain lateralization:

- A. Electrical stimulation (EBS) is done by sending a weak electrical current to a specific part of the brain to activate it. Most of this research is done with animals.
- B. Transcranial magnetic stimulation (TMS) lets scientists either depress or enhance activity in one area of the brain. This allows them to learn more about the different brain functions.
- C. PET scans reveal information regarding brain activity during tasks.
- D. Deficits resulting from cerebral vascular accidents ("strokes"), injury, or lesioning can be studied.
- E. Brain wave patterns can be studied.
- F. Split-brain patients (patients who have undergone a commissurotomy, a procedure when a surgeon surgically severs the corpus callosum, which is the bundle of nerve fibers which join the two hemispheres of the brain) can be studied. This is done in some people to control epilepsy.

- G. Drugs are administered so they affect activity of half of the brain (i.e., sodium amytal in carotid artery) and can be studied.
- H. Dichotic listening is used to investigate selective attention in the auditory system (laterality can be studied by presenting two stimuli, one to each ear) and the ability to accurately identify the sounds.

II. Left hemisphere specialization

- A. The left hemisphere is specialized for verbal processing, such as speaking, reading, and writing.
 - 1. Wernicke's area, which controls language reception, is located in the left temporal lobe.
 - a. Damage to this area can result in problems with language comprehension.
 - b. Wernicke's aphasia results from damage to this and related areas of the brain. People with Wernicke's aphasia are characterized by impairment in remembering nouns and verbs and their meaning. Their language comprehension is impaired and slow, while spontaneous speech is fluent and grammatical but short on meaning.
 - 2. Broca's area, which controls expressive language function, is located in the left frontal lobe.
 - a. Damage to this area can result in problems with the production of speech.
 - b. Broca's aphasia results from damage in the left frontal cortex, including but extending beyond Broca's area. Broca's aphasia is characterized by slow, inarticulate language production, including not only speech but also writing and gesturing. Speech is meaningful, but lacks the prepositions, conjunctions, and word endings of smooth, grammatical speech. Language comprehension is usually satisfactory, except when the meaning of a sentence critically depends on syntax.
 - c. Almost all right-handed people and about two-thirds of left-handed people show the specialization of speech function in their left hemisphere. Most other left-handers show about equal representation of language in both hemispheres. Only a few people have complete right hemisphere control of language.
- B. Contralateral (opposite-side) representation
 - 1. The left somatosensory cortex registers tactile (touch) sensations from the right side of the body, while the right somatosensory cortex registers tactile sensations from the left side.
 - 2. The left motor cortex initiates movements in the right side of the body, while the right motor cortex initiates movements on the left side.

3. The left temporal cortex receives auditory information from both ears, but more strongly from the right ear. (Receiving input from both ears is essential for auditory localization because localization depends on comparing the sounds from the two ears.)
4. The left occipital cortex processes visual information from the right visual field of both retinas, while the right occipital cortex processes visual information from the left visual field of both retinas.

C. Some psychologists characterize the left hemisphere as dominant because of its responsibility in language function, and conscious thought is usually expressed in language. Some psychologists characterize the left hemisphere as specialized for attention to detail, including remembering, reasoning, planning, and problem solving.

III. Right hemisphere specialization

- A. The right hemisphere is specialized for important roles in nonverbal processing such as spatial tasks and musical and visual recognition (pattern and configuration).
- B. Some psychologists characterize the right hemisphere as predisposed to deal with large overall patterns, totalities or organized wholes (gestalten), and diffused representations.
- C. Recent research supports that the right hemisphere is important to perceptions of others' emotions.
- D. Lateralization of experience and expression of emotions are more complex. Negative emotions seem to activate the right hemisphere, while positive emotions are associated with great activity in the left hemisphere.
- E. In most people, the right hemisphere is apparently critical in understanding the emotional content of speech. People with right hemisphere damage have trouble understanding jokes, sarcasm, irony, tone of voice, and so on.

IV. Corpus callosum and split-brain subjects

- A. The corpus callosum routes information from one hemisphere to the other. Each hemisphere primarily controls connections to and communicates with the opposite side of the body.
- B. When the corpus callosum is severed, the functional specialization of each hemisphere is evident.
- C. Visual stimuli in the right half of the visual field are received by receptors in the left side of each eye and signals are sent to the left hemisphere.
- D. An object in the right visual field of split-brain patients reaches only the left hemisphere (responsible for speaking, reading, and writing) and is unable to integrate (because of the severed corpus callosum) with any information in the right hemisphere. Subjects are able to name and describe the object. They can draw or point to a picture of the object with the right hand but not the left hand.

- E. Visual stimuli in the left half of the visual field are received by receptors in the right side of each eye and sent to receptors in the right hemisphere.
- F. An object in the left visual field of split-brain patients reaches only the right hemisphere and is unable to integrate (because of the severed corpus callosum) with any information in the left hemisphere. Subjects are able to draw or point to a picture of the object name with the left hand but not the right hand. They cannot name or describe the object in words.

See Activity 5: *The Split-Brain Students*.

V. Plasticity

- A. Recent research has provided the insight that the structure and organization of the brain are somewhat changeable or “plastic,” not “hard-wired” as previously thought.
- B. Studies have shown that experience can refine brain development.
- C. Damage or destruction of brain tissue can result in neural restructuring.
- D. The adult mammalian brain is able to generate new neurons in the areas of the olfactory system and hippocampus.
- E. Growing evidence suggests that plastic changes, such as the development of new neurons in the hippocampus, the addition of new connections between neurons, or the strengthening or weakening of existing synapses, provide the mechanism for memory storage. A non-plastic nervous system would be a nervous system that cannot learn.

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LESSON 6: THE ENDOCRINE SYSTEM

Integration and control is achieved through interaction of the nervous system with the endocrine system of glands and hormones. The endocrine glands secrete chemical messengers called hormones that are produced in one tissue and travel through the blood system to affect other bodily tissues including the brain.

I. Comparison of endocrine and nervous system regulation

- A. Endocrine gland cells secrete hormones directly into the bloodstream, whereas neurons transmit signals over a neural network in general.
- B. Endocrine transport may take minutes to hours, whereas in nervous control, the process may take a fraction of a second to minutes. However, not all endocrine effects build up slowly; epinephrine, for example, can produce quick effects. Likewise, the effects of neurotransmitters in the nervous system will begin quickly, but the duration of effects can range from a fraction of a second to minutes, hours, or longer. Many chemicals are used as both neurotransmitters and hormones, with similar effects. For example, the hypothalamus uses shorter versions of cholecystokinin (a hormone that facilitates digestion) and insulin as transmitters; these are both important hormones in the digestive system.

- C. Endocrine effects are typically long lasting, whereas most neural effects are short lived.
- D. Both hormones and neurotransmitters interact with specific receptors on or in the target cells. Again, many chemicals are used as both neurotransmitters and hormones. The difference is that when released as a hormone, the chemical diffuses throughout the body, whereas when released as a neurotransmitter, it is released in small amounts near its receptor.
- E. Overlap between systems is evidenced by:
 - 1. Neurotransmitters that are chemically identical to hormones (such as noradrenaline),
 - 2. Neurons that are neurosecretory cells that release signal molecules into the bloodstream, and
 - 3. Neurosecretory cells in endocrine glands (such as the adrenal medulla) that transmit signals through the blood and neurons.

II. Hormones are the signal molecules of the endocrine system.

- A. Hormones are of three general chemical types: steroids, peptides or proteins, and amino acid derivatives.
- B. Hormones are active in very small amounts.
- C. Some hormones are under tight negative feedback control.
- D. Hormones are rapidly degraded in the body.
 - 1. Steroids, peptides, and proteins are broken down by the liver.
 - 2. Amino acid derivatives are broken down by enzymes in the blood.

III. Endocrine glands are specialized in function.

- A. The pineal gland lies near the thalamus. The pineal gland:
 - 1. Produces melatonin, which is involved in the regulation of circadian rhythms
 - 2. Is controlled by light-dark cycles
 - 3. May be associated with seasonal affective disorder
- B. The hypothalamus is superior to the pituitary gland and has endocrine gland properties. The hypothalamus:
 - 1. Secretes at least nine hormones that stimulate (such as thyrotropin-releasing hormone and gonadotropin-releasing hormone) or inhibit (such as somatotropin) the secretion of hormones by the anterior pituitary
 - 2. Contains neurons that make ADH, which controls water excretion, and oxytocin, which stimulates uterine contractions and milk ejection. Both hormones are transmitted to the

posterior lobe of the pituitary through nerve fibers and released into the blood from the posterior pituitary

3. Negative feedback systems link the hypothalamus and pituitary with the thyroid, adrenal cortex, and gonads to maintain homeostasis and permit response to changing conditions.

C. The pituitary gland is located at the base of the brain in the geometric center of the skull inferior to the hypothalamus. The pituitary gland and the hypothalamus are connected. The pituitary gland:

1. Was once considered the master gland because it is the source of hormones that stimulate reproductive organs, the adrenal cortex, and thyroid
2. Stimulates or inhibits production of pituitary hormones
3. Produces the growth hormone, also called somatotropin, which stimulates growth of bone, inhibits oxidation of glucose, and promotes breakdown of fatty acids and is controlled by the hypothalamus
4. Produces prolactin, which stimulates milk production and secretion controlled by hypothalamus
5. Produces TSH (thyroid-stimulating hormone) and thyrotropin regulated by hypothalamus and concentration of thyroxine in blood
6. Produces ACTH (adrenocorticotropic hormone), which stimulates the adrenal cortex to secrete cortisol and other steroids regulated by hypothalamus and cortisol in blood. Cortisol can impair immune responses, making the body more prone to infection.
7. Produces FSH (follicle-stimulating hormone), which stimulates egg production or sperm production regulated by hypothalamus and estrogen in blood
8. Produces LH (luteinizing hormone), which stimulates ovulation and corpus luteum in females and cells of testes in males regulated by progesterone or testosterone in blood and hypothalamus
9. Releases oxytocin
10. Releases ADH (antidiuretic hormone, also known as vasopressin) regulated by osmotic concentration of blood, blood volume, and the nervous system.

D. The thyroid gland is an H-shaped gland in the neck. The thyroid gland:

1. Produces iodine-containing thyroxine, which stimulates and maintains metabolic activities and is regulated by the hypothalamus (A lack of iodine results in a goiter (a swelling of the thyroid gland).)
2. Produces calcitonin that inhibits release of calcium from bone and is regulated by the concentration of calcium ions in the blood

E. The parathyroid glands are pea-sized glands generally embedded in the thyroid. The parathyroid glands:

1. Produce the parathyroid hormone, also called parathormone, which is regulated by the concentration of calcium ions in the blood
2. Help maintain calcium ion level in blood necessary for normal functioning of neurons by stimulating release of calcium from bone and stimulate conversion of vitamin D to active form that promotes calcium uptake from gastrointestinal tract and inhibits calcium excretion

F. The adrenal glands lie atop the kidneys.

1. The adrenal cortex, the outer layer, is the source of a number of steroid hormones.
 - a. Glucocorticoids such as cortisol affect carbohydrate, protein, and lipid metabolism and are regulated by ACTH.
 - b. Mineral corticoids such as aldosterone affect salt and water balance and are regulated by potassium ion concentration in the blood and kidney processes.
2. The adrenal medulla, the core of the adrenal gland, is a large cluster of neurosecretory cells. The adrenal medulla:
 - a. Secretes adrenaline (epinephrine) and noradrenaline (norepinephrine), which increases blood sugar by influencing the breakdown of glycogen to glucose, dilates or constricts specific blood vessels, increases rate and strength of heartbeat, stimulates respiration, and/or dilates respiratory passages
 - b. Reinforces sympathetic nervous system effects and is stimulated by sympathetic nerve fibers

G. The pancreas, dorsal to the stomach, regulates blood sugar.

1. Some secretory cells, called islet cells or Isles of Langerhans, release insulin that lowers blood sugar and increases the storage of glycogen, which is controlled by the concentration of glucose and amino acids in blood and somatostatin.
2. Other islet cells secrete glucagon, which stimulates the breakdown of glycogen to glucose in the liver, which is controlled by the concentration of glucose and amino acids in blood and somatostatin.
3. Still other islet cells secrete somatostatin (also secreted by hypothalamus), which helps regulate the rate at which glucose and other nutrients are absorbed into the bloodstream and may control synthesis of insulin and glucagon.
4. Imbalances associated with diabetes and hypoglycemia can affect behavior because the brain metabolizes glucose almost exclusively and is immediately affected by low blood sugar.

H. The ovaries and testes are the gonads in females and males, respectively, and are necessary for reproduction and secondary sex characteristics.

1. Estrogen hormones secreted by ovarian follicles develop and maintain sex characteristics in females, initiate buildup of uterine lining, and are regulated by FSH.
2. Progesterone secreted by the corpus luteum in the ovary promotes continued growth of the uterine lining and is regulated by LH.
3. Androgens, such as testosterone secreted by testes, support spermatogenesis, develop and maintain sex characteristics of males, and are regulated by LH.
4. Smaller quantities of estrogens and androgens are produced by the gonads of the opposite sex and by the adrenal gland.

IV. Prostaglandins are fatty acids produced by cell membranes in organs of the body.

They act like hormones in very low concentrations stimulating contractions in smooth muscle (especially uterus) and are associated with dysmenorrhea, the medical term for menstrual cramps.

LESSON 7: BEHAVIORAL GENETICS

The nature–nurture issue deals with the extent to which heredity and the environment influence our behavior. The field of behavioral genetics studies the role played by inheritance in mental ability, temperament, emotional stability, and so on.

I. Transmission of hereditary characteristics is achieved by biological processes (including gametogenesis, fertilization, embryonic development, and protein synthesis).

A. Chromosomes carry information stored in genes to new cells during reproduction.

1. Human body cells have a constant number of chromosomes = 46 in normal cells.
2. Cells of the ovaries and testes produce eggs (ova) and sperms (spermatozoa), which normally have 23 chromosomes each by a process (gametogenesis) that involves the disjunction of pairs of chromosomes that have genes for the same traits.
3. Of the 23 pairs of chromosomes in human body cells, 22 pairs are non-sex chromosomes (autosomes), and one pair constitutes the sex chromosomes.
 - a. A female has 22 pairs of autosomes and two X sex chromosomes. Thus, normal eggs have 22 autosomes + X.

- b. A male has 22 pairs of autosomes and one X and one Y sex chromosome. Thus, normal sperms have 22 autosomes + either X or Y.
4. At fertilization the chromosomes from the egg and sperm recombine to form a zygote (fertilized egg) with 46 chromosomes that will develop into a new individual.
5. The sex of the new individual is determined by the sperm that fertilizes the egg.
 - a. If the sperm carries an X chromosome, the baby will be a female.
 - b. If the sperm carries a Y chromosome, the baby will be a male.
 - c. Without the presence of a Y chromosome, zygotes develop into females.
6. The new individual gets about half his/her hereditary material from the mother and half from the father, one chromosome from each pair.
7. Genes, carried by chromosomes, are the units of inheritance that are sequences of DNA (deoxyribonucleic acid) that indirectly produce proteins such as enzymes, hormones, and structural proteins.
 - a. DNA is a molecule shaped like a double stranded helix that looks like a twisted ladder.
 - i. The two uprights (strands) of the DNA "ladder" are composed of phosphate and sugar.
 - ii. The rungs are composed of pairs of nitrogenous bases (either adenine (A) and thymine (T) or guanine (G) and cytosine (C)).
 - b. The sequence of bases along a strand constitutes the genetic code, which gives instructions to perform a specific function, such as to manufacture a particular protein.
 - i. Because of the huge number of possible base sequences, DNA can specify almost unlimited genetic messages for characteristics of organisms.
 - ii. All the cells in the body carry the same genes, except that a sperm or egg cell has only one set of chromosomes instead of a pair. Also, mature red blood cells contain no chromosomes.
 - iii. Only a fraction of the genes in any given cell are active, and some are active at certain times and not others.

II. Transmission of an incorrect number of chromosomes can result from nondisjunctional errors, which occur when pairs of chromosomes do not separate correctly during cell division.

- A. Chromosomes from a normal body cell can be photographed and arranged in pairs numbered from largest to smallest (1=largest, 22=smallest, sex chromosomes not numbered).
- B. Sperms and eggs with the wrong number of chromosomes can be produced as a result of the failure of pairs of chromosomes to disjoin during gametogenesis.
 - 1. Eggs can be produced with 21 or 23 autosomes plus an X chromosome.
 - 2. Eggs can be produced with 22 autosomes without an X or with two X chromosomes.
 - 3. Sperms can be produced with 21 or 23 autosomes plus an X or a Y chromosome.
 - 4. Sperms can be produced with 22 autosomes without a sex chromosome or with two X, two Y or both X and Y chromosomes.
- C. Fertilization that includes a gamete with the wrong number of chromosomes results in a zygote and subsequently an individual with chromosomal abnormalities.
 - 1. Most nondisjunctional fertilizations result in spontaneous abortion (miscarriages); only a small number of nondisjunctional individuals involving the smallest autosomes, or sex chromosomes, survive.
 - 2. Trisomy-21 (the presence of 3 copies of autosome 21) results in expression of Down syndrome.
 - a. Down syndrome individuals are typically mentally retarded with a mean IQ of 50 at age 5 and a mean life expectancy of 23 years.
 - b. Down syndrome individuals typically have a round head, flat nasal bridge, protruding tongue, small round ears, spots in the iris of the eye, an epicanthal fold in the eyelid, and poor muscle tone and coordination.
 - 3. Sex chromosome nondisjunctional conditions are more common than autosomal ones.
 - a. The XXX condition is not a true syndrome. Only a small percentage express one or more clinical/behavioral problems, such as irregularity in menstruation, retardation, sterility, or disturbed personalities.
 - b. The XYY condition is probably not a true syndrome. XYY males are typically over 6 feet tall and have acne beyond adolescence. Prison studies conducted in the 1960s that indicated that XYY males tend to

be aggressive/violent and tend to have behavioral disorders have not been substantiated. Some XYY males are sterile, and some are mentally retarded.

- c. Turner syndrome females have only one X sex chromosome (XO). Girls with Turner syndrome are typically short with a webbed neck; they lack ovaries and fail to develop secondary sex characteristics at puberty. Although usually of normal intelligence, they evidence specific cognitive deficits in arithmetic, spatial organization, and visual form perception.
- d. Klinefelter syndrome males arise from an XXY zygote. Although the XXY male may have a small penis at birth, the syndrome is not evident until puberty when male secondary sex characteristics such as development of chest hair, deepening of voice, and further development of the testes and penis fail to occur. Breast tissue develops, and fat distribution characteristic of females becomes evident. Klinefelter syndrome is characterized by sterility.

III. The genetic make-up of an individual is called the *genotype*. The expression of the genes is called the *phenotype*. Basic principles of genetics are applicable to human inheritance and expression of genes.

A. Pairs of chromosomes (homologous chromosomes) each have a gene for the same trait at the same locus on each of the chromosomes (alleles).

1. For traits determined by one pair of genes, if the alleles are the same, the individual is homozygous for the trait and expresses that phenotypic characteristic. Whether both genes are dominant genes or both genes are recessive genes, the alleles will be expressed.

a. Numerous recessive genes are responsible for syndromes in the homozygous condition.

i. Tay-Sachs syndrome produces progressive loss of nervous function in a baby, which becomes obvious from about 6 months of age when the baby fails to sit up, becomes blind, suffers seizures, becomes paralyzed, and dies (usually by age 5).

ii. Albinism arises from a failure to synthesize or store melanin and also involves abnormal nerve pathways to the brain resulting in quivering eyes and the inability to perceive depth or three-dimensionality with both eyes.

iii. Phenylketonuria (PKU) results in severe brain damage and mental retardation unless the baby is fed a special diet low in phenylalanine beginning in infancy and continuing into adulthood. Mental retardation occurs because the individual cannot metabolize phenylalanine. This amino acid accumulates

to levels that impair brain functioning. U.S. hospitals routinely test newborns for this disorder.

iv. Most recessive disorders involve enzyme defects of metabolism.

b. A small number of dominant genes are responsible for syndromes and will be expressed in the homozygous or heterozygous condition. They are usually involved in tissue development. Huntington's disease is an example that involves degeneration of the nervous system. Progressive symptoms involve forgetfulness, tremors, jerky motions, loss of the ability to talk, personality changes such as temper tantrums or inappropriate accusations, blindness, and death. The onset of the disease occurs after 30, but can occur earlier. Laboratories today test not for a marker, but for the gene itself, which has been identified.

2. For alleles on the X chromosome, with no corresponding allele on the Y chromosome, the allele on the X chromosome will be expressed in males whether it is dominant or recessive. Recessive genes for color vision deficiency (color blindness), hemophilia, and Lesch-Nyhan syndrome are located on the X chromosome with no corresponding allele on the Y chromosome. As a result, males show sex-linked traits much more frequently than females.

a. Color vision deficiency affects about 6% of males in the population by affecting the cones of the retina so that in most cases red and green cannot be discerned clearly.

b. Hemophilia affects the ability of the blood to clot.

c. Lesch-Nyhan is a metabolic disorder that results in self-mutilation. It affects a very small number of males.

d. For females to show the sex-linked recessive trait, they would need two recessive genes, one on each X chromosome.

e. Females with one allele for a sex-linked trait are carriers and can pass the gene on to sons who will express the trait or to daughters who could be carriers or in the homozygous condition express the trait.

3. For traits determined by one pair of genes, if the alleles are different, the individual is heterozygous for the trait.

a. The dominant gene is the one that is expressed when alleles are different and only one of the genes is expressed.

b. The recessive gene is the one that is masked when alleles are different and only one of the genes is expressed. An individual who is heterozygous for a trait is called a carrier (for the recessive trait).

c. For some traits, both genes may be expressed as for type AB blood.

d. For some traits, an intermediate form of inheritance may be expressed, as for the sickle-cell trait.

4. Most human traits are polygenic, influenced by more than one pair of genes. All complex behavioral characteristics such as musical, artistic, athletic, and intellectual aptitudes are influenced by more than one pair of genes and show continuous variation rather than distinct categories. What happens to genetic potential depends upon environmental conditions.

5. Phenotypic characteristics, such as hair color, may change over time or may be modified by environmental factors.

6. Behaviors and diseases may have variations only some of which are genetically based. A form of familial Alzheimer's disease has been attributed to a gene on chromosome 21, but not all cases of Alzheimer's disease are associated with that gene.

IV. Behavioral genetics research is accomplished by a variety of techniques.

A. Extrapolation from selective breeding experiments in rats, dogs, and other animals has yielded information regarding the genetic and environmental contributions to excitability, aggression, intelligence, and so on. Animals showing the highest value of a given trait are bred, and animals showing the lowest value of the given trait are bred. With environmental conditions held constant, if two different "strains" develop after several generations, a genetic component for the characteristic under study has been established.

B. Twin studies have been conducted to assess the influence of heredity on expression of a behavior or constellation of behaviors.

1. Monozygotic (MZ) twins develop from a single fertilized egg that has split to form two embryos early in development. Thus, they share the same heredity. MZ twins are often referred to as identical, although they are not truly identical and can sometimes be mirror images of each other.

2. Dizygotic (DZ) twins develop from two different fertilized eggs. Thus, like other siblings, or each parent and child, they share about 50% of their genes. DZ twins are often referred to as fraternal.

3. In twin studies, a particular trait is studied for appearance in sets of monozygotic twins and sets of dizygotic twins. If there is more similarity in monozygotic twins than in dizygotic twins, researchers infer a genetic component for the trait. Some traits such as schizophrenia and general intelligence have shown greater similarity in monozygotic twins than in dizygotic twins, for example. These studies are not controlled experiments.

C. Adoption studies assess genetic influence by comparing resemblance of adopted children to both their adoptive and biological parents. The

children must have been adopted as infants without prolonged contact with their biological parents. If the children resemble their biological parents, but not their adoptive families, with respect to a given trait, researchers infer a genetic component for that trait.

1. Behaviors such as alcoholism, schizophrenia, and general intelligence have shown both genetic and environmental components.
 2. One problem with adoption studies: The biological mother contributes not only her genes, but also the prenatal environment. Studies have found positive correlations between adopted children and their biological parents with regard to alcoholism and criminality. If mothers with a background of alcoholism and criminality drank alcohol and perhaps used other drugs during pregnancy, their offspring might be impaired by prenatal environment, independent of genetic contributions.
- D. The Human Genome Project is an international effort that succeeded in 2003 in its quest to map the loci of all of the genes on the 23 chromosome pairs in humans. This greatly facilitates efforts to close in on locations for genes for Alzheimer's, Huntington's, and Duchenne muscular dystrophy. The DNA sequence for some genes has already been established.

activities

In addition to the five activities that follow, teachers are encouraged to go to the APA TOPSS website (<http://www.apa.org/ed/precollege/topss/lessons/index.aspx>) to access a free online module on *Classroom Demonstrations in Biological Psychology*, featuring James Kalat, PhD, of North Carolina State University. In this hour-long video, recommended classroom activities to accompany this unit plan are presented. A second module on *Key Points to Remember in Biological Psychology* is also available through the website above. Upon completion of the online module(s), teachers can access and print a certificate of professional development hours.

activity 2

neurons and impulse conduction

From original TOPSS unit lesson plan
on *Biological Bases of Behavior*

CONCEPT

Neurons transmit electrochemical impulses along the neuron and across the synapse through release of a neurotransmitter, which excites or inhibits impulse transmission in the postsynaptic neuron. Neurons can stimulate muscle cells to contract or gland cells to secrete. This activity is a simulation of impulse conduction.

MATERIALS

In addition to 16 students, you will need 5 spray bottles (preferably insulated) containing very warm water, 1 spray bottle containing cold water, another type of squeeze bottle or sponge with water, door of the classroom or closet, and worksheets.

INSTRUCTIONS

1. Single neuron simulation—Five students line up one behind the other. The one in the back of the line and the one in the front each hold a spray bottle of warm water. Students are directed that the student at the back of the line should squirt the hand of the student in front of him/her with warm water (the student whose hand is being sprayed should extend his/her hand behind him/her so that it is near, but not touching the spray bottle). When the next-to-the-last student in line feels the spray of water, he/she should tap the shoulder of the student in front of him/her. The next two students should tap the shoulder of the students in front of them when they, in turn, are tapped. When the student in the front is tapped, he/she should squirt his/her spray bottle forward. The rear student squirts the hand of the student in front of him/her with the spray bottle to start the sequence. After the sequence is completed, students answer Part I on the worksheet and discuss results.

2. Impulse conduction across an excitatory synapse—A second group of four students line up behind one another, but in front of the first group. The student in

the front holds a spray bottle of warm water. The rear person of the second group should extend his/her hand behind him/her so that it is near, but not touching the spray bottle of the person in the original group. Students are directed that the original sequence of events will be repeated, ending with the hand of the rear person in the second group getting sprayed. When the person feels warm water, he/she should tap the shoulder of the student in front of him/her. The next two students should tap the shoulder of the student in front of them when they, in turn, are tapped. When the student in the front is tapped, he/she should squirt the spray bottle forward. The rear student from the original group sprays water at the hand of the student in front of him/her. After the sequence is completed, students answer Part II on the worksheet and discuss results.

3. Impulse conduction to an effector (muscle)—An additional student grabs the handle of a door that opens (the classroom or a cabinet). The first and second groups of students line up behind the one holding the door handle. The student holding the door extends his/her hand behind him/her so that it is near, but not touching the spray bottle of the first person in the second group. At the end of the sequence of events described in #2, when the student holding the door handle feels the spray of warm water, he/she should pull the door open.

4. Impulse conduction to an effector (gland)—A student with a wet sponge or different type of squeeze bottle substitutes for the student who grabbed the door handle in #3. The first and second groups of students line up behind the one with the sponge or squeeze bottle. He/she extends his/her hand behind him/her so that it is near, but not touching the spray bottle of the first person in the second group. At the end of the sequence of events described in #2, when the student with the sponge or squeeze bottle feels the spray of warm water, he/she should squeeze the sponge or bottle releasing some water at a chalk board, pail, or window that students can see. After the sequence is completed, students answer Part III on the worksheet and discuss results.

5. Excitation/Inhibition—An additional group of five students is selected to line up next to the first group of students, also behind the second group of students. The one in the back is given a spray bottle with warm water, and the one in front is given a spray bottle with cold water. The rear groups are positioned so that each of the spray bottles is aimed at one of the hands of the rear person in the second group. If that student feels cold spray, he/she should NOT tap the shoulder of the student in front of him/her. If he/she feels warm spray, he/she should tap the shoulder of the student in front of him/her to continue the sequence of #4. Direct the rear student in the newest group to spray the hand of the student in front of him/her to initiate the sequence previously described. The sequence should end when the rear student in the second group senses cold water. Then direct the rear student in the first group to initiate the sequence. After the sequence is completed, students answer Part IV on the worksheet and discuss results.

DISCUSSION

Students generally clear up some misconceptions as a result of this simulation. They can “see” that inhibition results when the reception of a neurotransmitter blocks transmission of an impulse in the postsynaptic neuron. They can also “see” that a neuron can receive either inhibitory neurotransmitters, excitatory neurotransmitters, or both. They can also predict the result of repeated excitation accompanied by weak inhibition.

activity 2—student worksheet neurons and impulse conduction



(Website for above clip art: <http://www.clker.com/disclaimer.html>)

PART I

1. Label the parts of the neuron in the diagram above.
2. What did each of the students in the simulation represent?
3. What does the spray bottle represent?
4. What does the water represent?

PART II

1. What does the space between the two groups of students represent?
2. What relationship is represented by the warm water sprayed on the hand?
3. What is simulated when the sprayed-upon student taps the student in front of him/her?

PART III

1. What was represented by the spraying of the student holding the door?
2. What was represented by the student opening the door?
3. What was represented by the student squeezing the sponge or bottle?
4. Muscle contraction and gland secretion are very different. Why are the muscle cells and gland cells both considered effectors?

PART IV

1. Draw a diagram to show what you think this simulation represented.
Label all structures.
2. What do you think represented the:
 - (a) inhibitory transmission?
 - (b) excitatory transmission?
3. How should the simulation have proceeded in the last demonstration if the warm water bottle held by the front student in the original row had been sprayed several times, and the cold water bottle only once? Explain your answer.

activity 3

brain & nervous system metaphors

Adapted from materials by
Eric Chudler, PhD
University of Washington

CONCEPT

Students will demonstrate a deeper understanding of the parts of the nervous system and their functions through the creation of original metaphors.

MATERIALS

Prepare a set of 10-12 photos of common objects such as Legos, cell phone, junk drive, computer, video game, a flushing toilet, a cookbook, etc.

INSTRUCTIONS

Provide students with copies of photos individually or in groups and instruct them to develop analogies for how the object pictured is like the nervous system and ways in which it is not. The students could also explain how the objects presented form effective metaphors for the brain and nervous system and list the ways in which the metaphors are limited.

OPTIONAL ACTIVITIES

Brain Models: Have students create a brain model. This can be done in a variety of ways. Ideas include clay, play dough, cakes, paper maché,, mobiles, and so on. Another possible idea would be for students to create “Green Brain Models” made from recycled materials. (This could also prevent high costs). Students may create these in class or as an out of class project. Display the models in the classroom and have groups present their designs.

Neuron Models: Students create model neurons in class using a variety of supplies such as pipe cleaners, play dough, or candy. The website Neuroscience for Kids (<http://faculty.washington.edu/chudler/neurok.html>) has excellent instructions for a variety of student- created neuron models, including a working room size rope model.

activity 4.1

mini-project: the brain

Developed by

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and

Hilary Rosenthal

Glenbrook South High School, Glenview, IL

CONCEPT

The purpose of this exercise is to familiarize students with the various parts of the brain, their location, and functions.

MATERIALS

You will need a group of index cards or pieces of paper, each with either a different brain area or structure on it, and research materials either online or in print format.

INSTRUCTIONS

Have students randomly choose a brain structure to research. Choices may be written on slips of paper or index cards and drawn out of a container or handed out as students enter the classroom. Research may be conducted in the library or computer lab during a class period or given as homework (or a combination of the two). Students should be asked to answer questions such as the following about the structure they have selected:

- Where is it located?
- What does it look like? (Include illustration.)
- What are its major functions?
- What techniques are used to view or measure it?
- What happens when it is damaged?
- What other structures is it near?
- What other structures help or perform similar functions?

Once students have researched and answered these knowledge-level questions, the assignment should extend to more creative and constructive work. Examples include the following:

- Create a mnemonic device that will help classmates remember the most important information about your structure.

(activity 4.1 continued on next page)

(activity 4.1 continued from previous page)

- Design a T-shirt with an illustration of structure and function.
- Compose a motto/bumper sticker your structure might adopt.
- Create a cartoon featuring your structure.

Finally, as a class activity, you might want to have students arrange a brain taxonomy. Give them (or have them make) name tags depicting their structures. Each will then “collect” three or four other students that are related to them in some way. At the end of the collection phase, groups will explain the principle by which they are related. These principles may relate to location, function, or any other system they can justify.

activity 4.2

biopsychology bingo

Adapted by
Hilary Rosenthal
Glenbrook South High School, Glenview, IL

CONCEPT

Students will participate actively in a review game of key terms and concepts in biopsychology.

MATERIALS

You will need Biopsychology Bingo questions, Biopsychology Bingo terms list, bingo cards, an overhead projector or PowerPoint slide, and candy prizes (optional). The following websites provide free sample customized or blank bingo cards:

www.print-bingo.com

www.teach-nology.com/web_tools/materials/bingo (requires membership)

INSTRUCTIONS

Provide students with blank or customized bingo cards and present the biopsychology bingo terms either on an overhead, the white board, or a PowerPoint slide. If you are using a blank card, ask students to choose any 24 terms from the provided list to fill in their own bingo card. You may also choose to create your own varied bingo cards to present to the students. For each round, the teacher reads questions from the provided biopsychology bingo list, and students attempt to complete their bingo cards. After a student shouts bingo, have them read their answers and award them candy if they are a winner (always check with students about possible allergies before distributing food in class). Before moving on to another round, be certain to review the correct answers.

BIOPSYCH BINGO QUESTIONS

What is/are the...

1. Connection between cerebral hemispheres (corpus callosum)
2. Part of the limbic system, important in the fear response (amygdala)

(activity 4.2 continued on next page)

3. Collection of forebrain structures mainly involved in emotion (limbic system)
4. Structures most involved in producing speech, located in the left hemisphere for most people (Broca's area)
5. Brain and spinal cord (central nervous system)
6. Sensory and motor neurons found outside the central nervous system (peripheral nervous system)
7. Specialized cells that communicate information in the nervous system (neurons)
8. A threadlike structure that action potential travels along (axon)
9. Postsynaptic structures in a neuron that receive messages (dendrites)
10. Small gap between neurons crossed by neurotransmitters (synapse)
11. Coating that may develop on an axon that speeds neural transmission (myelin)
12. Neurotransmitter whose imbalance is involved in schizophrenia and Parkinson's disease (dopamine)
13. Neurotransmitter involved in mood regulation, target of many antidepressant drugs (serotonin)
14. Major inhibitory neuroregulator (GABA)
15. Major excitatory neuroregulator (glutamate)
16. Neurotransmitter most critical for memory, also used for muscle contraction (acetylcholine)
17. Cerebral region that is the primary processing area for vision (occipital lobe)
18. Cerebral region that is the primary processing area for hearing (temporal lobe)
19. Cerebral region that is the primary processing area for higher brain functions and motor messages (frontal lobe)
20. Cerebral region that is the primary processing area for skin senses (parietal lobe)
21. Division of the peripheral nervous system that includes sympathetic and parasympathetic branches (autonomic)
22. Connection between the brain and the peripheral nervous system (spinal cord)
23. Representation on the brain of the relative sensitivity of various regions of sense receptors (sensory homunculus)
24. The body's natural opiate-like pain killer (endorphin)
25. Area of the limbic system that is important in storage of memories (hippocampus)
26. Brain structure that regulates many important functions through stimulation of the pituitary "master gland" (hypothalamus)
27. Structure that relays information from all senses except smell (thalamus)
28. The electrical potential at which an action potential fires (threshold)
29. Hormones that are used by the nervous system to communicate messages through the body (endocrine system)
30. Structure at the back of the brain involved in balance, fine motor skills, and sequencing (cerebellum)
31. Brain-imaging technique that uses powerful magnets to create sharp pictures (MRI)
32. Measurement that tracks brain waves (EEG)
33. Interneuron loop that results in automatic action before brain processing (reflex)
34. Nervous system component that provides support for neurons (glia)
35. Thin layer of cells covering the forebrain, site of most brain activity (cortex)
36. Division of brain structures that include functions most critical to living (hindbrain)

BIOPSYCH BINGO TERMS

Review the following terms dealing with the nervous system.
Choose any 24 from the list to fill in your Biopsych Bingo card in any order.

1. Acetylcholine
2. Amygdala
3. Axon
4. Autonomic nervous system
5. Broca's area
6. Central nervous system
7. Cerebellum
8. Corpus callosum
9. Cortex
10. Dendrite
11. Dopamine
12. EEG
13. Endocrine system
14. Endorphin
15. Frontal lobe
16. GABA
17. Glia
18. Glutamate
19. Hindbrain
20. Hippocampus
21. Hypothalamus
22. Limbic system
23. MRI
24. Myelin
25. Neuron
26. Occipital lobe
27. Parietal lobe
28. Peripheral nervous system
29. Reflex
30. Sensory homunculus
31. Serotonin
32. Spinal cord
33. Synapse
34. Temporal lobe
35. Thalamus
36. Threshold

activity 5

the split-brain students

Edward J. Morris, PhD
Owensboro Community College

CONCEPT

The purpose of this exercise is to allow students an opportunity to experience the frustrations and deficits of patients who have had the split-brain operation. During the demonstration, participants explore the interesting limitations caused by the procedure known as the commissurotomy, giving them insight into the functioning of the hemispheres of the brain in a way impossible through reading and lecture alone.

MATERIALS

Materials are simple: Collect blindfolds, a shoe with a shoelace, a few coins, a pen or a pencil, and some toy blocks.

INSTRUCTIONS

Have students sit together in twos as closely as can be arranged (in the same chair, if possible). They then interlock their inside arms and put their outside arms behind them. With their inside arms together, it will be as if they are one person, one of the pair using their left hand and the other using their right. Instruct the student on the left that he/she must be the voice for the pair. The student on their right is not allowed to speak from this point on. The student on the right communicates through nonverbal means.

While in this configuration, have students tie the shoelace. They will have some difficulty with this, but will eventually accomplish it. Then repeat the task with both students blindfolded. They will find this very difficult and the left student who is using his/her right hand may spontaneously talk the other through the task.

With the students still blindfolded, place one of the objects in the left hand and ask if they are able to identify the object. The “left-brain” student will say no while the “right-brain” student will possibly nod “their” head affirmatively. While the voice of the pair will be unable to correctly identify the object, the left hand will be able to correctly select the object from several placed before him/her

when the blindfolds are removed. When asked why a correct response could not be produced before the blindfolds were removed, the “voice” will come up with interesting rationalizations such as “I can’t feel what is in my left hand.”

You may also place other objects in the pair’s hands in different combinations to demonstrate how a correct response is possible under certain conditions. If a retractable ballpoint pen is used, a correct response may be forthcoming if the left hand clicks the pen allowing the other side to hear the sound of it.

The differences in the abilities of the two hands may be demonstrated by having the students use the blocks to reproduce a pattern in a picture or a model created by you. Handedness may play a part in how well they are able to do this task.

The manner in which the right and left visual fields are processed by the hemispheres is demonstrated by having the students in each pair fix their gazes in opposite directions. In this situation, each “hemisphere” is only aware of what happens in his/her sight and will be unable to answer questions about objects displayed in the other “hemisphere’s” visual field.

DISCUSSION

After the demo, students can be led in a discussion about the localization of language in the left hemisphere in most people and how vision and hearing are processed by the brain. Students can be encouraged to think about the conditions under which this operation would be worth the difficulties it causes.

Video Tip: Scientific American Frontiers with Alan Alda, which is available free online, includes an episode featuring an individual who has had split-brain surgery.

<http://www.pbs.org/saf/>

Choose the episode “The Man with Two Brains” from the 1997 Season 7.

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- Gazzaniga, M. S. (1987). Perceptual and attentional processes following callosal section in humans. *Neuropsychologia*, 25, 119-133.
- Hay, J. C. (1985). *Psychworld*. New York: McGraw-Hill.
- Nebes, R. D., & Sperry, R. W. (1971). Hemispheric disconnection syndrome with cerebral birth injury in the dominant arm area. *Neuropsychologia*, 9, 247-259.

Note. A similar article appeared previously in *Teaching of Psychology*, Vol. 18, No. 4, December 1991. Used by permission of Lawrence Erlbaum Associates, Inc., Hillsdale, NJ. The above activity was originally published in the Jan/Feb 1995 issue of the *Psychology Teacher Network*. The activity is reprinted here with the permission of the Education Directorate of the APA. Further publication of the activity is not permitted without the express written consent of the Education Directorate.

WEBSITES FOR CONTENT AND ACTIVITIES

American Psychological Association (APA)

<http://www.apa.org>

The mission of the APA is to advance the creation, communication, and application of psychological knowledge to benefit society and improve people's lives.

APA Division 6: Behavioral Neuroscience and Comparative Psychology

<http://www.apadivisions.org/division-6/index.aspx>

APA Division 6 members are devoted to studying the biology of behavior.

APA Division 38: Health Psychology

<http://www.health-psych.org/>

Division 38, Health Psychology, seeks to advance contributions of psychology to the understanding of health and illness through basic and clinical research, education, and service activities and encourages the integration of biomedical information about health and illness with current psychological knowledge.

APA Online Psychology Laboratory

<http://opl.apa.org>

The APA Online Psychology Laboratory (**OPL**) provides highly interactive resources for the teaching of psychological science. The peer-reviewed materials include online studies and correlational studies, large data sets, demonstrations, and teaching aids. OPL is a web-based resource for further learning about psychological phenomena and the scientific process. Several of the resources on OPL can be useful for teaching biopsychology:

1. Action Potential (<http://opl.apa.org/contributions/ITL/ap.htm>): In this interactive animation, view what happens to ions during an action potential. *Courtesy of Ian Winship, University of Alberta.*

2. The Homunculus (<http://opl.apa.org/contributions/EC/Hom.htm>): This flash program shows how the body's touch receptors are mapped onto the cerebral cortex. *Courtesy of Eric Chudler, University of Washington, Neuroscience for Kids.*
3. Human Brain Fly-Through (<http://opl.apa.org/contributions/EC/BrainFly.htm>): With this flash program, move through coronal sections of a labeled diagram of the human brain. *Courtesy of Eric Chudler, University of Washington, Neuroscience for Kids.*
4. Penfield Research Replication (<http://opl.apa.org/contributions/UAlberta/Penfield.htm>): Experience a replication of Penfield's classic brain-mapping research. *Courtesy of the University of Alberta.*
5. Who Wants to Be a Mill-Neuron-Aire? (<http://opl.apa.org/contributions/EC/Million.htm>): In the style of "Who Wants to Be a Millionaire?" test your knowledge of neurons. *Courtesy of Eric Chudler, University of Washington, Neuroscience for Kids.*

Bio Motion Lab

<http://www.biomotionlab.ca/Demos/BMLwalker.html>

Delightful demonstration of how highly prepared we are to detect biological motion, even from minimal stimuli

BrainLine

<http://www.BrainLine.org>

BrainLine is a national multimedia project dedicated to traumatic brain injury (TBI). The website includes information and resources about preventing, treating, and living with TBI.

Comparative Mammalian Brain Collections

<http://www.brainmuseum.org/sections/index.html>

Photographs of the brain, including internal structures, from a wide variety of mammalian species

Dana Foundation

<http://www.dana.org/>

Dedicated to brain research and education—Sign up here for a free newsletter on cutting-edge brain research.

Genes to Cognition (g2c) Online

<http://www.g2conline.org/?gclid=CMBLucWM9KcCFYHb4Aod3WMmbg>

A 3D-brain model website also available as an iPhone/iPod/iPad app, or as an app for an Android or Windows 7 phone

Genetic Science Learning Center (The University of Utah)

<http://learn.genetics.utah.edu/>

Useful website from the University of Utah with many interesting genetics-related activities, including Mouse party—an activity for neurotransmitter discussion (worksheets and interactive demo), which may be used in the neuroscience unit or the unit on states of consciousness

The center has also developed two websites to advance the teaching of genetics, bioscience, and health topics. One of the websites is called Learn. Genetics, and the other one is called Teach.Genetics. Links to some of the topics on these websites are provided below.

Neural communication

<http://learn.genetics.utah.edu/content/addiction/reward/index.html>

Glial cells

<http://learn.genetics.utah.edu/content/addiction/reward/cells.html>

Interactive Brain http://www.brainline.org/multimedia/interactive_brain/the_human_brain.html?gclid=CLaZ78LloKQCFR5N5QodNUXJ6w
Brain basics from BrainLine (see above)

Journal for Undergraduate Neuroscience Education (JUNE)

<http://www.funjournal.org/>

Published by Faculty for Undergraduate Neuroscience (FUN), the *Journal for Undergraduate Neuroscience Education (JUNE)* is an online journal for undergraduate neuroscience faculty. The journal publishes peer-reviewed articles about laboratory exercises, curricular topics, and teaching methods.

Library of Congress podcasts: Music and the Brain

<http://www.loc.gov/podcasts/musicandthebrain/index.html>

The Library of Congress website has podcasts on *Music and the Brain* featuring the latest research at the intersection of cognitive neuroscience and music.

Memory Loss and the Brain

<http://www.memorylossonline.com/glossary/anterogradeamnesia.html>

Brief overview of amnesia and its link to brain damage, with links to further information

Neural Messages Module Map

<http://bcs.worthpublishers.com/myers7e/content/psychsim/chapter01.htm>

Web Activity: "Neural Messages" PsychSim; Worth Publishers

Neuroscience for Kids

<http://faculty.washington.edu/chudler/neurok.html>

An amazing collection of information, illustrations, and activities created by Eric Chudler at the University of Washington

Sugar as an Addiction

<http://www.futurity.org/health-medicine/had-your-sugar-fix-today/#more-382>

Describes Bart Hoebel's research and theory linking sugar craving to other addictions

Synapses

<http://www.biologymad.com/NervousSystem/synapses.htm>

Good coverage of how synapses work, with effective illustrations

Teaching High School Psychology Blog

<http://teachinghighschoolpsychology.blogspot.com/>

Teacher-generated website that compiles activities, YouTube videos, and current research in an easy-to-search format

This Week in the History of Psychology

<http://www.yorku.ca/christo/podcasts/TWITHOP-Sep11.mp3>

This podcast series by Christopher D. Green, York University, Toronto, Canada, includes an interview with Malcolm Macmillan on the life and myth of Phineas Gage. Macmillan is the author of *An Odd Kind of Fame: Stories of Phineas Gage*. (Access full podcast website at <http://www.yorku.ca/christo/podcasts/>.)

Whole Brain Atlas

<http://www.med.harvard.edu/AANLIB/home.html>

An amazing source of information about brain anatomy

Your Amazing Brain

www.youramazingbrain.org.uk

Large interactive site with a variety of activities and background information

WEBSITES FOR FREE VIDEOS

Annenberg Media

<http://www.learner.org/index.html>

Annenberg media—free video streaming of numerous psychology-related videos, including the three series *The Brain*, *The Mind*, and *Discovering Psychology*

Brain Development

<http://www.youtube.com/watch?v=FugrcVhi2tg>

A videotaped lecture about brain development and its relation to behavior

The Fearless Gene

<http://www.youtube.com/watch?v=r7eIYYpEB4g&feature=fvwrel>

A short video about research on genetic variations in anxiety

Musiophilia

<http://www.youtube.com/watch?v=S4aJXcoiNK0&feature=related>

This describes a unique case in which a man struck by lightning developed a fascination with music. A neurologist speculates on possible explanations.

NOVA: Body & Brain

<http://www.pbs.org/wgbh/nova/body/>

Information on the body and brain from NOVA, including articles, videos, and more

Scientific American Frontiers

<http://www.pbs.org/saf/>

Episodes are available free online for use in the classroom.

TED Talks

www.TED.com

Free online videos, including:

Ed Boyden

On optogenetics

http://www.ted.com/talks/ed_boyden.html

Christopher Decharmes

Scanning the Brain in Real Time

http://www.ted.com/talks/christopher_decharmes_scans_the_brain_in_real_time.html

Allan Jones

Mapping the Brain

http://www.ted.com/talks/allan_jones_a_map_of_the_brain.html

V. S. Ramachandran

What brain damage can do

http://www.ted.com/talks/lang/en/vilayanur_ramachandran_on_your_mind.html

Jill Bolte Taylor

http://www.ted.com/talks/jill_bolte_taylor_s_powerful_stroke_of_insight.html

This is an 18-minute TED talk with neuroscientist and stroke survivor Jill Bolte Taylor. Search TED for more relevant talks regarding neuroscience.

Daniel Wolpert

The Real Reason for Brains

http://www.ted.com/talks/daniel_wolpert_the_real_reason_for_brains.html

WEBSITES FOR STUDY OR REVIEW

The Psych Files

<http://www.thepsychfiles.com>

Free podcasts including great episodes on mnemonics for memorizing the parts of the brain as well as resources for other units

Quizlet

www.quizlet.com

Create electronic flash cards for student online review

PRINT RESOURCES

American Psychological Association. (2011). *National Standards for High School Psychology Curricula*. Washington, DC: Author.

Benjamin, L. T. (Ed.). (2008). *Favorite Activities for the Teaching of Psychology*. Washington, DC: American Psychological Association.

Benjamin, L. T., Nodine, B. F., Ernst, R. M., & Blair-Broeker, C. (Eds.). (1999). *Activities Handbook for the Teaching of Psychology: Volume Four*. Washington, DC: American Psychological Association.

MAGAZINES

Discover Magazine

<http://discovermagazine.com/>

Monitor on Psychology

<http://www.apa.org/monitor>

New York Times Science Section

<http://www.nytimes.com/pages/science/index.html> (published on Tuesdays)

Scientific American Mind magazine

<http://www.scientificamerican.com/sciammind/>

VIDEO RESOURCES

ABC, Nightline Prime (Producer). (2011). *Secrets of Your Mind Series* [Video/DVD]. Available online at <http://abcnews.go.com/Nightline/>

Colorado State University (Producer). (1999). *The Mind: Teaching Modules* [Video/DVD]. Available online at <http://www.learner.org/resources/series150.html>

Educational Broadcasting Corporation and David Grubin Productions, Inc. (Producers). (2001). *The Secret Life of the Brain* [Video/DVD]. Available online at <http://www.pbs.org/wnet/brain/>

History Channel. (Producer). (2008). *The Brain* [Video/DVD]. Available online through <http://shop.history.com>

critical thinking questions

1. As you may know, alcohol is considered a depressant drug, yet often individuals do not act depressed while under the influence. How does neuroscience explain this? What is the difference between a central nervous system depressant and a mood depressant? While under the influence of alcohol, how is behavior affected when the following brain structures are depressed: medulla, cerebellum, frontal lobe (impulse control), Broca's area, and the hippocampus?
2. Should sports (like football) that have high incidences of concussions be banned especially for teens and children since we now know the long-term negative neural impact of these injuries?
3. Laboratory research with rats has shown that dendrites develop more complex and intricate branching when subjects are exposed to enriched and variable external stimulation than when raised in more impoverished environments. What might this mean for children who are reared in deprived or limited environments? What should we do to enable individuals to develop their potential?
4. The nature of neural messages is both electrical and chemical. Explain the electrical nature of the action potential and the chemical nature of communication across the synapse.
5. A frail elderly woman had managed to save enough money for a large and very heavy flat screen television. When a fire breaks out in her apartment, she is somehow able to push the television out of her apartment. After the fire is extinguished, it takes two very strong firemen to push the television back into the apartment. How would you account for the woman's ability to push the television out? In your answer, be certain to reference the endocrine system and the autonomic nervous system.

APPENDIX A

ALIGNMENT OF *BIOLOGICAL BASES OF BEHAVIOR* UNIT LESSON PLAN TO THE *NATIONAL STANDARDS FOR HIGH SCHOOL PSYCHOLOGY CURRICULA* (APA, 2011)

53

Standard Area: Biological Bases of Behavior

Content Standards

After concluding this unit, students understand:

1. Structure and function of the nervous system in human and nonhuman animals
2. Structure and function of the endocrine system
3. The interaction between biological factors and experience
4. Methods and issues related to biological advances

Content Standards With Performance Standards

CONTENT STANDARD 1: Structure and function of the nervous system in human and nonhuman animals

Students are able to (performance standards):

- 1.1 Identify the major divisions and subdivisions of the human nervous system

Lesson 3 (Part II)

- 1.2 Identify the parts of the neuron and describe the basic process of neural transmission

Lesson 2

- 1.3 Differentiate between the structures and functions of the various parts of the central nervous system

Lesson 3, Part II–B; Lesson 4

- 1.4 Describe lateralization of brain functions

Lesson 5

- 1.5 Discuss the mechanisms and importance of plasticity of the nervous system

Lesson 5, Part V

CONTENT STANDARD 2: Structure and function of the endocrine system

Students are able to (performance standards):

2.1 Describe how the endocrine glands are linked to the nervous system

Lesson 6

2.2 Describe the effects of hormones on behavior and mental processes

Lesson 6, Part I–D; Part II

2.3 Describe hormone effects on the immune system

Lesson 6, Part III

CONTENT STANDARD 3: The interaction between biological factors and experience

Students are able to (performance standards):

3.1 Describe concepts in genetic transmission

Lesson 7

3.2 Describe the interactive effects of heredity and environment

Lesson 7, Part IV

3.3 Explain how evolved tendencies influence behavior

Appendix C

CONTENT STANDARD 4: Methods and issues related to biological advances

Students are able to (performance standards):

4.1 Identify tools used to study the nervous system

Lesson One, Parts VII–IX

4.2 Describe advances made in neuroscience

Lesson One, Part X

4.3 Discuss issues related to scientific advances in neuroscience and genetics

Lesson One, Part X

APPENDIX B

COMMENTS ON THE RELATIONSHIP BETWEEN NEUROTRANSMITTERS AND ABUSED DRUGS

Prepared by James Kalat, PhD, North Carolina State University

Amphetamine increases the release of mainly dopamine, but also serotonin and other neurotransmitters. The reuptake of dopamine and serotonin is blocked by cocaine. (The presynaptic neuron releases dopamine or serotonin, the transmitter attaches to its receptor on the postsynaptic neuron and then detaches, and finally the presynaptic neuron reabsorbs the transmitter for later use.) Because cocaine blocks the reuptake, the transmitter remains in the synaptic cleft longer, where it may restimulate its receptor several times. Eventually, some of released amount gets reabsorbed, but much of it washes away from the synapse, showing up in the blood and urine. Because the neurotransmitters wash away faster than the presynaptic neuron can synthesize more, the long-term effect (hours later) is decreased availability of these neurotransmitters. So the user goes into a withdrawal state, which is mildly unpleasant.

Methylphenidate (Ritalin) works exactly the same way as cocaine does, at the same sites. The only difference is that Ritalin pills cause a slow buildup of the drug over about an hour and a half, instead of a rush of effects in a few seconds.

Heroin and morphine act by stimulating the same synaptic receptors as the endorphins.

The effects of cannabinoids (from marijuana) were discovered more recently and are still less clearly understood, but cannabinoids act in a different way from all other abused drugs: After either glutamate excites or GABA inhibits the postsynaptic neuron, in many parts of the brain the postsynaptic neuron sends a reverse message that means "I got your message, so stop sending it." Cannabinoids mimic this reverse message, thus slowing or deterring neurons from sending both excitatory and inhibitory messages.

APPENDIX C

EVOLUTIONARY INFLUENCES ON BEHAVIOR

Prepared by W. Jeffrey Wilson, PhD, Albion College

The idea that behavior might evolve is sometimes hard to grasp—after all, organisms inherit their biology, not their behavior. However, the nervous system controls behavior, and the nervous system's structure and function are subject to evolutionary (Darwinian) pressures.

In general, as the brain has evolved, most elaboration has occurred anteriorly (near the front). All vertebrate hindbrains are nearly identical; mammals have highly elaborated forebrains including structures such as the limbic system and cerebral cortex that are not present in reptiles. The addition of these brain structures has resulted in behavioral or mental capabilities for mammals that reptiles must have in only a rudimentary form (e.g., emotions and cognitive processing).

Brain areas near the anterior end of the brain often function to inhibit areas further posterior; thus newer brain areas function to inhibit older brain areas.

As an example of the way that Darwinian pressures shape the nervous system and thus behavior, consider the ganglia of the sympathetic nervous system. These ganglia are close to the spinal cord and are interconnected. The interconnection allows the sympathetic ganglia to communicate with each other, ensuring coordinated activation of the sympathetic responses that typically deal with stressful events. Parasympathetic ganglia do not communicate with each other—coordination of the restorative effects controlled by the parasympathetic system is less important to survival. The organism that starts running fast to escape from a predator before the heart starts beating fast will not survive as well as the one who coordinates these two sympathetic effects. The adaptive value of this coordination has drawn the sympathetic ganglia together.

