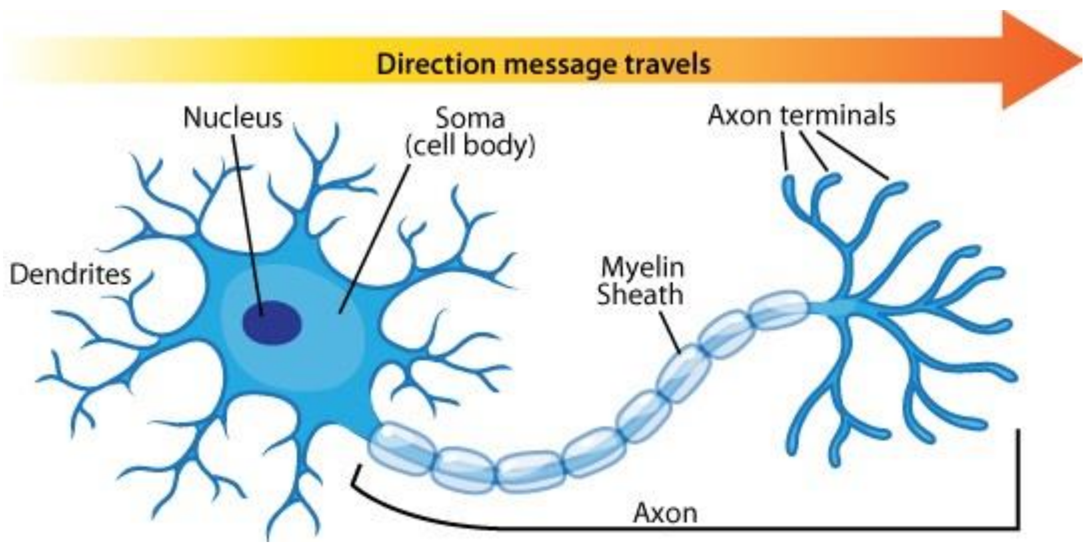
Biological Bases of Behavior

Chapter 2: The Biology of Mind
AP Objective 3: Biological Bases of Behavior (8-10%)

An effective introduction to the relationship between physiological processes and behavior—including the influence of neural function, the nervous system and the brain, and genetic contributions to behavior—is an important element in the AP course.

AP Objective: Identify basic processes and systems in the biological bases of behavior, including parts of the neuron and the process of transmission of a signal between neurons.



- **<u>Neuron</u>:** a nerve cell; the basic building block of the nervous system.
  - Human brain contains about 100 billion neurons.
  - The average neuron is a complex structure with as many as 10,000 physical connections with other cells.

- **<u>Cell body (soma):</u>** The part of the neuron that contains the nucleus, which directs the manufacture of substances that the neuron needs for grown and maintenance.

- **<u>Dendrites:</u>** a neuron's busy, branching extensions that receive messages and conduct impulses toward the cell body.
  - Most neurons have numerous dendrites, which increase their surface area, allowing each neuron to receive input from many other neurons.

- **<u>Axon:</u>** the part of the neuron that carries information away from the cell body toward other cells.
  - Although extremely thin (1/10,000th of an inch—a human hair by comparison is 1/1000th of an inch), axons can be very long.
    - Some extend more than 3 feet through the body.
  - **<u>Myelin sheath:</u>** a layer of fatty tissue that insulates axons and speeds their impulses.
    - As myelin is laid down up to about age 25, neural efficiency, judgment, and self-control grows.

        - If myelin degenerates, *multiple sclerosis* results: communication to muscles slows, with eventual loss of muscle control.

- **Glial cells (glia):** provide support, nutritional benefits, and other functions, and keep neurons running smoothly.
    - Are not specialized to process information the way neurons do.
    - There are far more glial cells than neurons (approximately 10 for every 1 neuron)
        - This is where the myth that we only use 10% of our brains comes from. It's not that we only use 10% of our brain, it's that only around 10% of our brain is made up of neurons.

NEURAL TRANSMISSION:

- Neurons communicate and transmit information from one to the other via electrical impulses.
    - Happens in response to signals from our senses or chemical signals from neighboring neurons.

- There is fluid both inside and outside of the axon.
    - Electrically charged sodium and potassium **ions** are floating in that fluid.
    - Membrane surrounding the axon contains thousands of gates called **ion channels** that prevent negative and positive ions from randomly flowing into or out of the cell.
        - This membrane is **selectively permeable** because fluids and ions can sometimes flow into and out of it, but the process is controlled.

- **Resting Potential:** the resting state of a neuron when it is not transmitting information.
    - Neuron is negatively charged at this state
    - Ion channels are closed
    - Slight negative charge present along the inside of the cell membrane
    - Outside of cell membrane contains mostly positively charged ions
    - **Sodium-potassium pumps** increase potassium inside of the cell and decrease sodium to help maintain the resting potential

- **Depolarization:** when an incoming impulse raises the neuron's voltage and opens the ion channels, causing potassium ions to flow out and sodium ions to flow in.
    - The channels open up one after the other like falling dominos
    - Neuron becomes positively charged

- **Action Potential:** the brief wave of positive electrical charge that travels down the axon.
    - Abides by the **all-or-nothing principle**, meaning that once the electrical impulse reaches a certain level of intensity, called its **threshold**, it fires and moves all the way down the axon without losing any of its intensity.
        - A strong stimulus can trigger *more* neurons to fire and to fire more often, but it does not affect the action potential's strength or speed.
    - Only lasts 1/1000th of a second, because the ion channels can only stay open for a very brief time.
        - They quickly close again and become reset for the next action potential.

- **Refractory period:** the recovery time during which another stimulus given to the neuron (no matter how strong) will not lead to a second action potential.
    - The neuron pumps positively charged sodium ions back outside the cell membrane and the neuron becomes negatively charged once again.

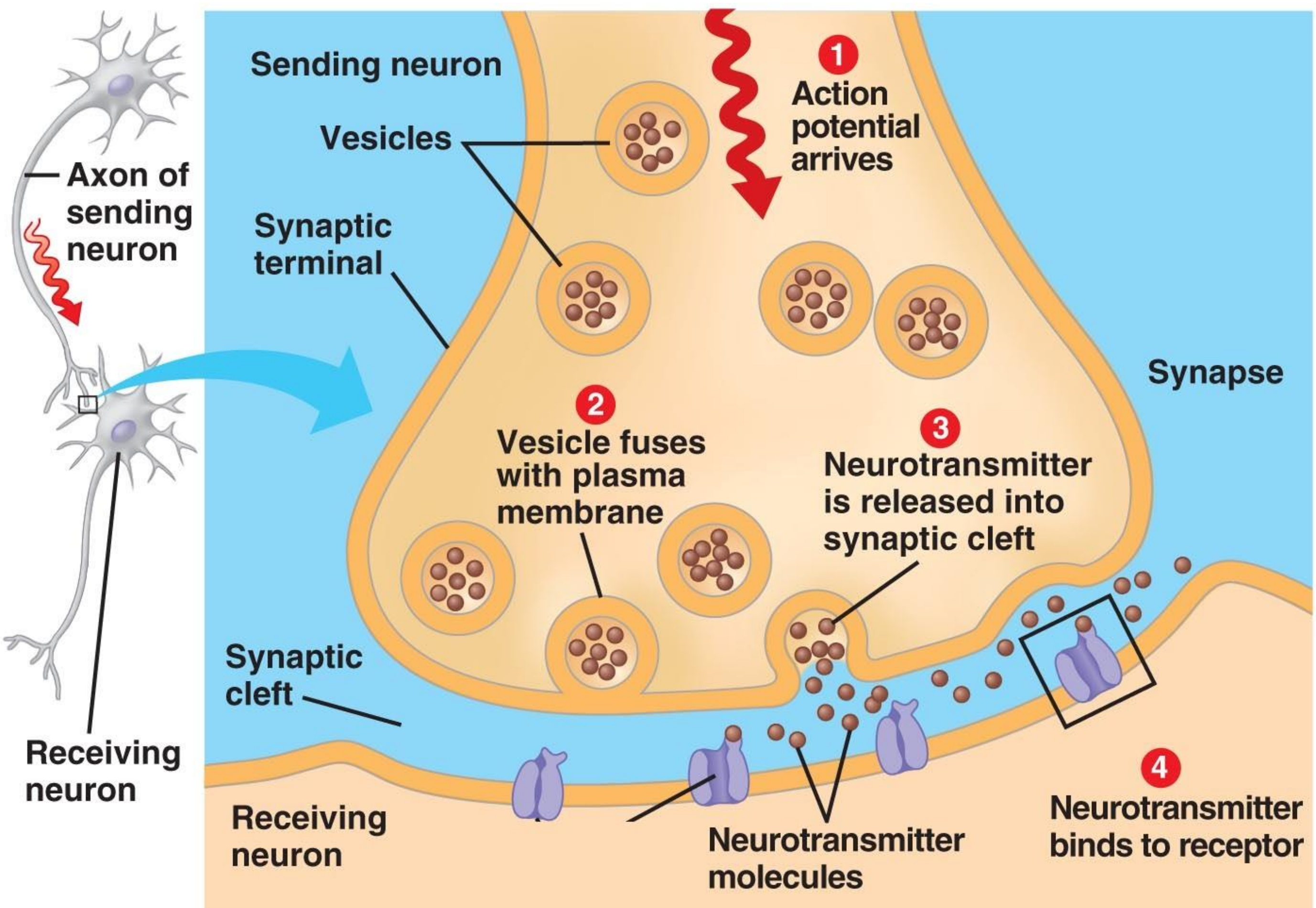
- The electrochemical process from resting period to action potential to refractory period happens up to 100 or even 1000 times per second.

HOW NEURONS COMMUNICATE

- **Synaptic gap/synaptic cleft:** the tiny space between the axon of one neuron and the dendrite of another.

- **Terminal button/Axon Terminal:** the knoblike structure at the end of an axon.
  - Contains **vesicles (sacs)** that store chemicals called neurotransmitters.

- **Neurotransmitter:** chemical substances that are stored in very tiny sacs within the terminal buttons and transmit information across a synaptic gap to the next neuron.
  - When released by the sending neuron, they travel across the synapse and bind to receptor sites on the receiving neuron.
    - **Excitatory neurotransmitters:** increase the likelihood that the receiving neuron will produce an action potential.
    - **Inhibitory neurotransmitters:** decrease the likelihood that the receiving neuron will produce an action potential.
  - Once the message has been received, the neurotransmitters are released from the receptor sites and reabsorbed into the axon in a process called **reuptake.**



TYPES OF NEURONS:

- **Sensory neurons (afferent neurons):** neurons that carry incoming information from the sensory receptors in the body to the brain and spinal cord for processing.

- **Motor neurons (efferent neurons):** neurons that carry outgoing information from the brain and spinal cord to the muscles and glands.

- **Interneurons:** acts as a middle man between neurons, allowing efferent neurons, afferent neurons, and other interneurons to communicate with one another.

- **Mirror neurons:** neuron that fires both when someone acts and when someone observes the same action performed by another. Thus, the neuron "mirrors" the behavior of the other, as though the observer were itself acting. Such neurons have been directly observed in primate species. May help explain why people experience feelings of empathy.

TYPES OF NEUROTRANSMITTERS

There are many different neurotransmitters. Each plays a specific role and functions in a specific pathway. Most neurons secrete only one type of neurotransmitter, but often many different neurons are simultaneously secreting different neurotransmitters into the synaptic gaps of a single neuron. At any given time, a neuron is receiving a mixture of messages from the neurotransmitters.

Scientists do not know exactly how many neurotransmitters exist, and more are discovered all the time.

- **Acetylcholine (ACh):** involved in muscle action, learning, and memory.
  - ACh is the messenger at every junction between motor neurons and skeletal muscles.
  - When ACh is released to our muscle cell receptors, the muscles contract.
  - If ACh transmission is blocked, as happens during some kinds of anesthesia, the muscles become paralyzed.
  - The venom from the bite of the black widow spider causes ACh to gush out of the synapses between the spinal cord and skeletal muscles, producing violent muscle spasms and weakness.
  - Individuals with Alzheimer's disease have an acetylcholine deficiency.
    - Some of the drugs that alleviate Alzheimer's symptoms do so by compensating for the loss of the brain's supply of ACh.

- **GABA (gamma aminobutyric acid):** plays a key function in the brain by inhibiting many neurons from firing. Serves as the brain's brake pedal, helping to regulate neuron firing and control the precision of the signal being carried from one neuron to the next.
  - Low levels linked with anxiety, seizures, tremors, and insomnia.
  - Valium and other antianxiety drugs increase the inhibiting effects of GABA.
  - Alcohol acts on GABA receptors, inhibiting neural signaling.

- **Glutamate:** has a key role in exciting many neurons to fire and is especially involved in learning and memory.
  - The most prevalent neurotransmitter.
  - Too much glutamate can overstimulate the brain and trigger migraine headaches or even seizures.
  - Thought to be a factor in anxiety, depression, and schizophrenia.

- **Norepinephrine:** helps control alertness and arousal.
    - Used for arousal in the fight-or-flight response.
    - Stress stimulates the release of norepinephrine.
    - Oversupply triggers agitation or jumpiness.
    - Amphetamines and cocaine cause hyperactive, manic states of behavior by rapidly increasing norepinephrine levels in the brain.
    - Undersupply is associated with depression.

- **Dopamine:** helps control voluntary movement and affects sleep, mood, attention, learning, and the ability to recognize opportunities for rewarding experiences.
    - Stimulant drugs such as cocaine and amphetamines produce excitement, alertness, elevated mood, decreased fatigue, and sometimes increased motor activity mainly by activating dopamine receptors.
    - Low levels associated with Parkinson's disease, a degenerative neurological disorder in which a person develops jerky physical movements and tremors and has difficulty with speech and walking.
    - Oversupply linked to schizophrenia.

- **Serotonin:** involved in the regulation of sleep, mood, attention, and learning. Also affects hunger and aggression.
    - Low levels associated with depression.
    - Medications used to treat depression often act upon serotonin, slowing down its reuptake into terminal buttons and thereby increasing brain levels of serotonin.

- **Endorphins:** the body's natural opiates—substances that reduce or eliminate pain.
    - Shield the body from pain and elevate feelings of pleasure.
    - Released during aerobic exercise.

AP Objective: Discuss the influence of drugs on neurotransmitters (e.g., reuptake mechanisms, agonists, antagonists).

- Drugs and other chemicals affect brain chemistry at synapses, often by either exciting or inhibiting a neuron's firing.

- **Agonists:** chemicals that bind to receptors and mimic the effects of neurotransmitters.
    - Some opiate drugs (pain pills) are agonists and produce a temporary "high" by amplifying normal sensations of arousal or pleasure.

- **Antagonists:** chemicals that bind to receptors and block the functioning of neurotransmitters.
    - Botulin, a poison that can form in improperly canned food, causes paralysis by blocking the release of acetylcholine (ACh).
    - Small injections of botulin—Botox—smooth wrinkles by paralyzing the underlying facial muscles.

- **Selective Serotonin Reuptake Inhibitors (SSRI):** a medication that treats depression and anxiety by preventing the reuptake of serotonin, thereby increasing the brain's supply of serotonin.

AP Objective: Discuss the effect of the endocrine system on behavior.

- **Endocrine system:** the body's "slow" chemical communication system; a set of glands that secrete hormones into the bloodstream.
  - The endocrine glands consist of the following:
    - Pituitary gland
    - Thyroid and parathyroid glands
    - Adrenal glands
    - Pancreas
    - Ovaries in females
    - Testes in males

- **Glands**: organs or tissues in the body that create and secrete hormones.

- **Hormones:** chemical messengers that are produced by the endocrine glands and carried by the bloodstream to all parts of the body.
  - When hormones act on the brain, they influence our interest in sex, food, and aggression.
  - Some hormones are chemically identical to neurotransmitters.
    - Both produce molecules that act on receptors elsewhere.
  - Hormones move much more slowly through the body than neurotransmitters
  - Endocrine messages tend to last longer than neural messages which is why it takes a while for their effects to wear off.

- **Pituitary gland:** a pea-sized gland just beneath the hypothalamus that controls growth and regulates other glands.
  - Is a sort of "master gland" that influences the release of hormones by other endocrine glands.
    - Example: triggers sex glands to release sex hormones which in turn influence the brain and behavior.
  - Releases **oxytocin**, a hormone that promotes bonding, group cohesion, and social trust.

- **Adrenal glands:** a pair of endocrine glands that sit just above the kidneys and secrete hormones that help arouse the body in times of stress or emergency.
  - Releases **epinephrine (adrenaline)** and **norepinephrine (noradrenaline)**.
  - The hormones secrete by the adrenal glands increase heart rate, blood pressure, and blood sugar, providing a surge of energy.
  - When the emergency passes, the hormones—and feelings of excitement—linger a while.

- **Pancreas:** a dual-purpose gland that performs both digestive and endocrine functions.
  - Located under the stomach.
  - Produces insulin, an essential hormone that controls glucose (blood sugar) levels in the body and is related to metabolism, body weight, and obesity.

- **Ovaries:** sex-related endocrine glands that produce hormones involved in female sexual development and reproduction.

- **Testes:** sex-related endocrine glands that produce hormones involved in male sexual development and reproduction.

AP Objective: Describe the nervous system and its subdivisions and functions.
--central and peripheral nervous systems
--major brain regions, lobes, and cortical areas
--brain lateralization and hemispheric specialization

- **<u>Nervous system:</u>** the body's speedy, electrochemical communication network, consisting of all the nerve cells of the peripheral and central nervous systems.

- **<u>Central nervous system (CNS):</u>** the brain and spinal cord.
    - More than 99% of all nerve cells in the body are located in the CNS.

- **<u>Peripheral nervous system (PNS):</u>** the network of nerves that connects the brain and spinal cord to other parts of the body.
    - **<u>Nerves:</u>** electrical cables formed of bundles of axons.

    - **<u>Somatic nervous system:</u>** the division of the peripheral nervous system that controls voluntary movement of the body's skeletal muscles.
        - Conveys information from the skin and muscles to the central nervous system about conditions such as pain and temperature.
        - Sends information to the central nervous system for processing. The CNS then sends instructions back to the muscles causing them to flex and move.

    - **<u>Autonomic nervous system (ANS):</u>** the division of the peripheral nervous system that controls the glands and the muscles of the internal organs (such as the heart).
        - Influences the functions such as glandular activity, heartbeat, and digestion.
        - Like automatic pilot, this system may be consciously overridden, but usually operates on its own (autonomously).

            - **<u>Sympathetic nervous system:</u>** the division of the autonomic nervous system that arouses the body to mobilize it for action in stressful situations.
                - When stressed or alarmed, accelerates heartbeat, raises blood pressure, slows digestion, raises blood sugar, and cools with perspiration, making you alert and ready for action.

            - **<u>Parasympathetic nervous system:</u>** the division of the autonomic nervous system that calms the body and conserves its energy after stressful situations.
                - Restores the body's internal activities to normal.

<u>MAJOR BRAIN REGIONS, LOBES, AND CORTICAL AREAS</u>

- **<u>Brainstem:</u>** the oldest part and central core of the brain, beginning where the spinal cord swells as it enters the skull.
    - Responsible for automatic survival functions.
    - Is a crossover point where most nerves to and from each side of the brain connect with the body's opposite side.
        - Information from the left side of the body is routed to the right side of the brain.
        - Information from the right side of the body is routed to the left side of the brain.

- **Medulla:** controls heartbeat and breathing
    - Begins where the spinal cord enters the skull.

- **Pons:** plays a key role in sleeping and dreaming.

- **Cerebellum:** coordinates voluntary movement.
    - Two rounded structures extending from the rear of the brainstem.
    - Damage to the cerebellum impairs the performance of coordinated movements.
        - Causes difficulty walking, keeping your balance, or shaking hands.
        - Movements would be jerky and exaggerated.
    - Alcohol's influence on the cerebellum causes impaired coordination.

- **Reticular formation:** responsible for the sleep-wake cycle.
    - Finger-shaped network of neurons inside the brainstem, between the ears.
    - Damage can cause someone to lapse into a coma from which they might never wake up.

- **Thalamus:** receives almost all incoming sensory information, organizes it, and relays it to the cortex.
    - Receives information from all of the senses except smell.
    - Think of it as a hub through which traffic passes en route to various destinations.

- **Basal Ganglia:** works with the cerebellum and cerebral cortex to control voluntary movements.
    - Enables people to engage in habitual activities such as riding a bicycle.

- **Limbic System:** a group of interconnected structures that are crucial for emotion, motivation, and many aspects of learning and memory.
    - Comprised of the hypothalamus, amygdala, and hippocampus.

- **Hypothalamus:** plays a vital role in controlling many motivated behaviors, like eating, drinking, and sexual activity.
    - Controls autonomic functions such as body temperature and heart rate.
    - Sets appetite drives (such as thirst, hunger, and sexual desire) and behaviors
    - Sets emotional states
    - Helps determine biological rhythms such as the menstrual cycle
    - Controls the pituitary gland

- **Amygdala:** Influences aggression and fear.
    - Almond shaped structure.
    - Coordinates the fight-or-flight response.
    - Is active in response to unpredictable stimuli (makes us cautious).
    - Involved in emotional awareness and expression.
    - Helps us recognize expressions of aggression and fear in others.
    - Damage to this area can reduce aggressive behavior and the ability to feel fear.

- **Hippocampus:** Involved in learning and the storage of long-term memories.
    - Animals or humans who lose their hippocampus to surgery or injury also lose their ability to form new memories of facts and events.
    - The hippocampus seems to help us recall things by waking up the areas of the brain that were used when we originally encountered the information.

- **Broca's Area:** involved in speech production.

    - Damage to this area may result in telegraphic speech with very simple grammatical structure. The ability to form grammatically complex sentences is impaired.
        - Example: "Here… head… operation… here… speech… none… talking."

- **Wernicke's Area:** involved in understanding spoken language.
    - Individuals with damage to this area cannot comprehend words; they hear the words but do not know what they mean. They also produce incoherent sentences.

THE CORTEX AND MAJOR CORTICAL AREAS

- **Cerebral cortex:** the outer layer of the brain, responsible for the most complex mental functions, such as thinking and planning.
    - The wrinkly outer layer of the brain.
    - Split into the left and right hemispheres
        - Each hemisphere is divided into four lobes:
            - Frontal lobes (behind the forehead)
            - Parietal lobes (at the top and to the rear)
            - Occipital lobes (at the back of the head)
            - Temporal lobes (below the parietal lobes)
        - Each lobe is separated by prominent **fissures**, or folds.

- **Frontal Lobes:** involved in personality, intelligence, and the voluntary control of muscles.
    - Damage can alter personality and remove a person's inhibitions. Can also impair moral judgments.

    - **Motor cortex:** controls voluntary movements.
        - Located at the rear of the frontal lobe.
        - Body areas that require precise control, such as the fingers and mouth, occupy the greatest amount of cortical space.

    - **Prefrontal cortex:** involved in higher cognitive functions such as planning, reasoning, and self-control.
        - Located in front of the motor cortex and directly behind the forehead.

- **Parietal Lobes:** processes sensory information that has to do with taste, temperature, and touch. Also involved in registering spatial location (relating to physical space), attention, and motor control.

    - **Somatosensory cortex:** detects and interprets information on touch, temperature, pain, and pressure and allows us to perceive the size, shape, and texture of an object via touch.
        - Located directly behind the motor cortex
        - Structured like the motor cortex: body areas that require precise control, such as the fingers and mouth, occupy the greatest amount of cortical space.
        - Somatosensory cortex interprets the information; motor cortex tells the body to physically move

- **Occipital lobes:** process and respond to visual stimuli.
    - Process information about aspects of visual stimuli such as color, shape, and motion.
    - Eyes only perceive incoming information; the occipital lobes process and interpret it.
    - A stroke or lesion to this area can cause blindness or damage to the vision field.

- **<u>Temporal lobes:</u>** involved in hearing, language processing, and memory.
  - People with temporal lobe damage have problems filing experiences into long-term memory.
  - Damage can also impair a person's ability to recognize faces.
    - **<u>Prosopagnosia:</u>** the inability to recognize faces, even one's own face.

- **<u>Association cortex/Association Areas:</u>** areas in all four lobes of the brain that are involved in higher mental functions such as learning, remembering, thinking, and speaking.
  - Interpret, integrate, and act on sensory information and link it with stored memories.

<u>BRAIN LATERALIZATION AND HEMISPHERIC SPECIALIZATION</u>

- **<u>Lateralization:</u>** the separation of the brain into two hemispheres—left and right—that serve different functions.
  - The right hemisphere of the brain receives information from the left side of the body.
    - When you hold an object in your right hand, only the left hemisphere of your brain detects the object.
  - The left hemisphere of the brain receives information from the right side of the body.

  - **<u>Left hemisphere:</u>** specializes in language (except in <u>some</u> left-handed people where language is mainly processed on the right side of the brain.)

  - **<u>Right hemisphere:</u>** specializes in processing nonverbal information such as spatial perception, visual recognition, and emotion.
    - Plays a role in processing the meaning of language.

- **<u>Corpus callosum:</u>** the large band of neural fibers connecting the two brain hemispheres and carrying messages between them.
  - Data received by either hemisphere are quickly transmitted to the other across the corpus callosum.

- **<u>Split brains:</u>** a condition resulting from surgery that isolates the brain's two hemispheres by cutting the fibers (mainly those of the corpus callosum) connecting them.
  - Data received by the right hemisphere cannot be transported to the left and vice versa.
  - Michael Gazzinga conducted an experiment on split-brain patients that went as follows:
    - He had split-brain patients stare at a dot while he flashed HE-ART on a screen.
      - HE appeared in their left visual field
      - ART appeared in their right visual field
    - When he asked them to <u>say</u> what they had seen, they reported they had seen ART.
    - When he asked them to <u>point</u> to the word they had seen, their <u>left hand</u> pointed to HE.
      - The right hemisphere (controlling the left hand) intuitively knew what it could not verbally report.
    - When a picture of a spoon was flashed to their right hemisphere, the patients could not <u>say</u> what they had viewed.
    - When asked to <u>identify</u> what they had viewed by feeling an assortment of hidden objects with their <u>left hand</u>, they easily selected the spoon.
      - If the experimenter said "Correct!" the patient might reply, "What? Correct? How could I possibly pick out the correct object when I don't know what I saw?"

        - It is the left hemisphere doing the talking here, bewildered by what the nonverbal right hemisphere intuitively knows.

    - Can help reduce seizures.
    - People with split brains are surprisingly normal; their personality and intellect are hardly affected.

AP Objective: Discuss the role of neuroplasticity in traumatic brain injury.

Some of the effects of brain damage can be traced to two hard facts:

1. Severed neurons usually do not regenerate.
2. Some brain functions seem preassigned to specific areas.
    - One newborn who suffered damage to the temporal lobe facial recognition areas later remained unable to recognize faces.

Still, some neural tissue can <u>reorganize</u> in response to damage.

- **<u>Brain lesion:</u>** damage to brain tissue

- **<u>Neuroplasticity:</u>** the brain's ability to change, especially during childhood, by reorganizing after damage or by building new pathways based on experience.
    - Damaged brain functions can sometimes migrate to other brain regions.

- **<u>Neurogenesis:</u>** the formation of new neurons.
    - Occurs only in restricted brain regions.

AP Objective: Recount historic and contemporary research strategies and technologies that support research (e.g., case studies, split-brain research, imagine techniques).

- **<u>Phrenology:</u>** the detailed study of the shape and size of the cranium as a supposed indication of character and mental abilities.
    - Developed in the early 1800s.
    - Was not an accurate way to study the brain.

- **<u>EEG (electroencephalogram):</u>** a record of the brain's electrical activity.
    - Waves are measured by electrodes placed on the scalp.

- **<u>CT scan/CAT scan (computerized axial tomography):</u>** a technique for examining brain structure by constructing a composite of x-ray images taken from many different angles.
    - These scans, which yield precise information about the exact shape and position of structures within a brain, are immensely useful for medical diagnosis of tumors or structural abnormalities.

- **<u>PET scan (positron emission tomography):</u>** a technique for examining brain function by observing the amount of metabolic activity in different brain regions.
    - Participants are injected with a safe does of some radioisotope. The PET scan then keeps track of how this radioactivity is distributed across the brain.
    - Shows which brain regions are particularly active at the time.

- **MRI (magnetic resonance imaging):** documents the effects of strong magnetic pulses on the molecules that make up brain tissue. A computer then assembles this information into a picture of brain structure.
  - Safer than CT scans because they don't involve x-rays.
  - Can show healthy tissue as well as tumors, tissue degeneration, and blood clots or leaks that may signal strokes.

- **fMRI (functional magnetic resonance imaging):** a technique for examining brain function by measuring blood flow and oxygen use within the brain.
  - Are much more precise than PET scans.

- **Split brain research:** examines people and animals with a severed corpus callosum.
  - Helps researchers understand the functions of the left and right brain hemispheres.

- **Twin studies:** allow researchers to examine the overall role of genes in the development of a trait or disorder.

AP Objective: Discuss psychology's abiding interest in how heredity, environment, and evolution work together to shape behavior.

- **Nature vs nurture:** the debate over whether human thought and behavior are caused primarily by nature (genetics/biology) or nurture (environmental/social-cultural influences).
  - The simple answer is both, although how much of a role each one plays varies by person and by circumstances.

- **Behavior genetics:** the study of the relative power and limits of genetic and environmental influences on behavior.

- **Environment:** every external influence, from prenatal nutrition to the people and things around us.

- **Chromosomes:** threadlike structures made of DNA molecules that contain an organism's genes.

- **DNA (deoxyribonucleic acid):** a complex molecule containing the genetic information that makes up the chromosomes.

- **Genes:** the biochemical units of heredity that make up the chromosomes.
  - **Dominant trait:** a trait that will appear in the offspring if one of the parents contributes it.
  - **Recessive trait:** traits that can be carried in a person's genes without appearing in that person. Only becomes a person's phenotype if they inherent recessive genes from both parents.
  - **Phenotype:** the set of observable characteristics of an individual
    - Example: blue eyes, brown hair, attached earlobes

- **Genome:** the complete instructions for making an organism, consisting of all the genetic material in that organism's chromosomes.

- **<u>Heritability:</u>** the extent to which variation among individuals can be attributed to their differing genes.

- Human thought and behavior is best understood as **biopsychosocial**: we are influenced by our biology, by evolutionary processes, but psychological experiences, and by our social-cultural circumstances.

AP Objective: Predict how traits and behavior can be selected for their adaptive value.

- **<u>Evolutionary psychology:</u>** the study of the evolution of behavior and the mind, using principles of natural selection.

- **<u>Natural selection:</u>** the principle that, among the range of inherited trait variations, those contributing to reproduction and survival will most likely be passed on to succeeding generations.
  - As mobile gene machines, we are designed to prefer whatever worked for our ancestors in their environments because we inherited their genes.

- **<u>Mutations:</u>** a random error in gene replication that leads to a change.

AP Objective: Identify key contributors (e.g., Paul Broca, Charles Darwin, Michael Gazzaniga, Roger Sperry, Carl Wernicke).

- **<u>Paul Broca:</u>** French surgeon whose study of brain lesions contributed to our understanding of how language is processed in the brain.
  - **<u>Broca's area:</u>** area of the frontal lobe involved in speech production.

- **<u>Charles Darwin:</u>** argued that natural selection shapes bodies and behaviors.

- **<u>Michael Gazzaniga</u>** and **<u>Roger Sperry:</u>** conducted split-brain research.

- **<u>Carl Wernicke:</u>** German neurologist who contributed to our understanding of language disorders called aphasias.
  - **<u>Wernicke's area:</u>** involved in understanding spoken language.