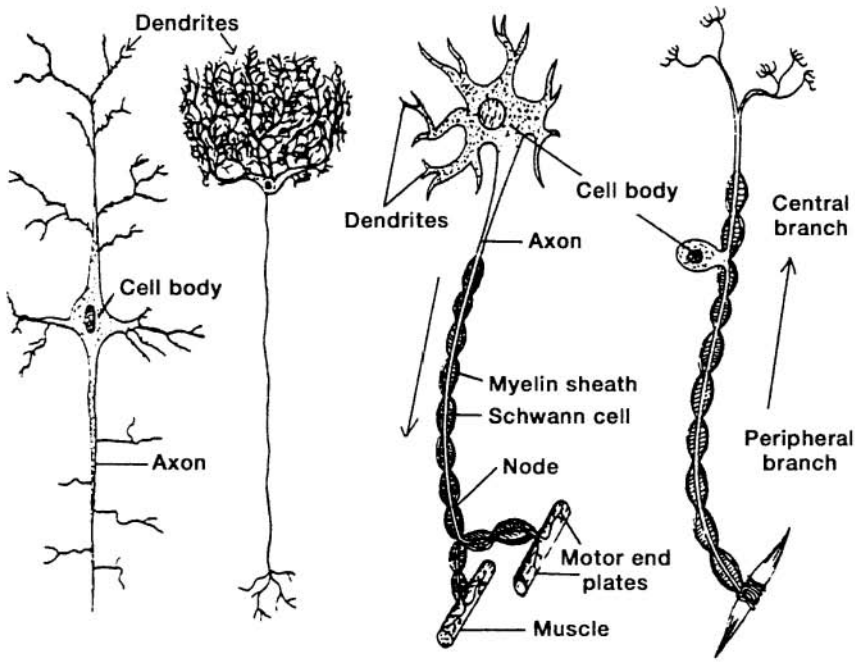

# The Biological Bases of Behavior

KEY CONTENT REVIEW

## I. Neural Communication

### A. THE NEURON

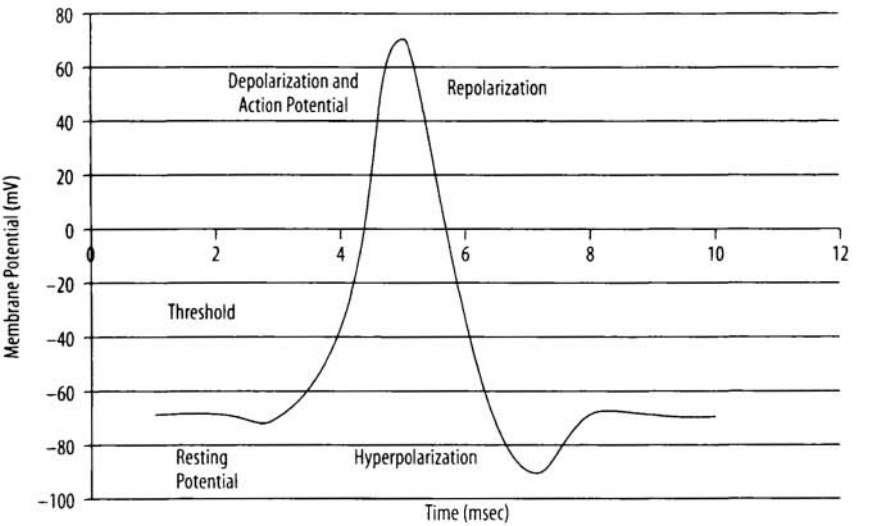
1. The neuron is the fundamental building block of the nervous system. It uses both chemical and electrical signals to communicate messages to other neurons or muscles.
2. There are several components of the neuron:
    - *Cell body or soma—the large portion of the neuron that contains the nucleus and the organelles; receives messages from the dendrites*
    - *Dendrites—branch-like portions of a neuron that receive and communicate the nervous signal from the tips of neuron to the cell body.*
    - *Axon—conduit that communicates the signal down the neuron and away from the cell body*
    - *Myelin sheath—lipid/fat based insulation around the Schwann cells that stops the leaking of the electrical signal. The myelin sheath is formed by the Glial cells. The disease multiple sclerosis (MS) is caused by a deterioration of the myelin sheath which results in the loss of controlling muscle movement.*
    - *Schwann cell—chain of cells that propagates the nervous signal*
    - *Nodes of Ranvier—space or gap between the Schwann cells*




## B. ACTION POTENTIAL

1. A brief electrical impulse by which information is transmitted along the axon of a neuron.
2. All neurons have a charge associated with them because of the concentration of various ions being transported into and out of the cell. A cell at rest has a resting membrane potential of approximately a -70mV. Both sodium and potassium channels are closed.
3. Depolarization—reduction in the absolute value of membrane potential because sodium channels open and flood inside the cell. Potassium channels are closed.
4. Action potential—if depolarization reaches the threshold, an action potential will be created and the neuron will fire. This is an example of the all-or-none response. It is important to note that the myelin sheath increases the velocity of conduction of the action potential along the axon.
5. Saltatory conduction—propagation of the chemical signal down the neuron from one node to the next.

6. Repolarization and hyperpolarization—decrease in membrane potential (more negative) because potassium channels open and potassium leaves the cell. Sodium channels are closed. Returns the membrane potential from positive (caused by depolarization) to negative.

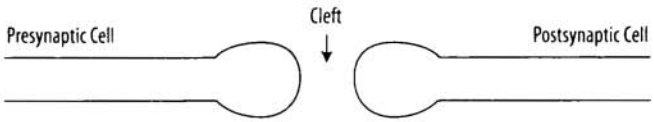





## C. PASSAGE OF A NERVE TO A REFLEX ACTION

1. Synapse—the gap between nerve cells or a nerve cell and a muscle cell.
2. Synaptic vesicle—a small membrane-bound organelle that holds the neurotransmitter at the presynaptic membrane. The vesicle will eventually release the neurotransmitter into the synapse.
3. Presynaptic membrane—the surface of the synaptic terminal that faces the synaptic cleft or the space between neurons. The neurotransmitter (packaged in a vesicle) will be released across the cleft to the postsynaptic cell via the presynaptic membrane.
4. Postsynaptic Membrane—the surface of the cell body/axon that is on the opposite side of the synapse. It receives the

neurotransmitter and depolarization of the neuron will take place, thus propagating the signal.





*Knowing the structure and function of the neuron is very important. Be sure you can identify and explain the function of dendrites, the myelin sheath, and the axon. It is interesting to note that the largest number of sensory neurons is found on our lips.*

## D. NEUROTRANSMITTERS

1. Neurotransmitters are chemical messengers manufactured by a neuron. They are released at the synaptic vesicles, which are tiny sacs located in the axon terminals.
2. The human body contains hundreds of substances known (or suspected) to function as neurotransmitters.
3. Endorphins are the best-known neurotransmitters. These chemicals can reduce pain or produce feelings of pleasure. For example, endorphins can help athletes overcome pain from an injury. They can also produce a boosted mood, which is often called "runner's high."
4. Neurotransmitters play a role in your eating habits and body weight. When levels of norepinephrine, dopamine, serotonin, leptin and other neurotransmitters are low, hunger and or eating results. When levels of these substances are high, satiety, or fullness, results.
5. Neurotransmitters may play a role in influencing or causing psychological disorders. The following chart lists the key neurotransmitters that have generated multiple-choice questions on the AP Psychology exam:

| Neurotransmitter | Functions | Disease Associated With |
|---|---|---|
| Dopamine | Movement<br>Thought processes | Parkinson's disease<br>Schizophrenia |
| Serotonin | Emotional state<br>Sleep | Depression<br>Anxiety<br>OCD (obsessive compulsive disorder) |
| Norepinephrine | Physical arousal<br>Learning and memory | High blood pressure<br>Anxiety |
| Acetylcholine | Learning and memory<br>Muscle contraction | Alzheimer's Disease<br>Muscular disorders |
| GABA (gamma-aminobutyric acid) | Inhibition of brain activity | Anxiety |
| Endorphins (natural pain killers) | Pain Perception | Opiate addiction (pain-killing drugs) |




***The AP Psychology exam includes a number of multiple-choice questions that focus on the link between selected neurotransmitters and psychological disorders. Be sure you know that acetylcholine is linked to Alzheimer's disease, that excess dopamine is linked with schizophrenia, and that too little dopamine is linked to Parkinson's disease.***

## E. DRUG EFFECTS ON NERVOUS SYSTEM

1. Psychoactive drugs have inhibitory or excitatory effects on the nervous system.
2. Agonists are drugs that mimic the effect of the neurotransmitter.

3. Antagonists are drugs that inhibit the effect of the neurotransmitter.
4. Prozac is an antidepressant drug that works as an agonist of serotonin.
5. Many psychoactive drugs have side effects because the drug of choice may work on different neural pathways. For example, Prozac treats depression, but can alter sleep, eating patterns, and other thought processes.

## II. Nervous System

### A. THE CENTRAL NERVOUS SYSTEM (CNS)

1. Comprised of the brain and the spinal cord, the central nervous system is considered to be the command center of the body.
2. The spinal cord deals with reflex or involuntary actions. Spinal cord injuries can produce paralysis of limbs. The higher the site of the damage on the spinal cord, the more severe the injury.
3. A common reflex is known as the "knee-jerk" reflex. This reflex is tested by tapping just below the knee, causing the lower leg to suddenly jerk forward. Often used by doctors in performing a clinical neurologic exam.
4. The brain is required for voluntary movements.

### B. THE PERIPHERAL NERVOUS SYSTEM (PNS)

1. The peripheral nervous system connects the CNS with the rest of the body through nerves.
2. The peripheral nervous system carries incoming messages to your brain and outgoing signals to your body's muscles and glands.
3. For example, as you cross a traffic-filled street, your PNS will notice the auditory sounds of cars and the visual patterns of oncoming traffic. Your brain assesses the situation and tells your body that danger may be lingering, so you cross the street with caution.

### C. THE SOMATIC DIVISION OF THE PNS

1. The somatic division of the PNS allows communication with the outside world. It carries information to the CNS and sends voluntary signals to your muscles. For example, if you smell a food that gives you an arousal, your muscles are then induced to eat the food.

### D. THE AUTONOMIC DIVISION OF THE PNS

1. The autonomic division of the PNS carries information to the CNS and sends voluntary signals to your muscles.
2. The autonomic division regulates digestion, respiration, sleep, and other vital functions.
    - *Sympathetic nervous system—the part of the autonomic nervous system (ANS) responsible for arousing the body and mobilizing its energy during times of stress. Activation of the sympathetic nervous system results in an increase in respiratory and heart rates and dilation of pupils. The "fight-or-flight" response of the sympathetic nervous system allows you to either attack or flee from a situation.*
    - *Parasympathetic nervous system—the part of the autonomic nervous system that allows a person to return to a calm and collected state after arousal from the sympathetic division.*



## III. Endocrine System

### A. THE ENDOCRINE SYSTEM IS A SYSTEM OF HORMONES THAT CARRIES MESSAGES THROUGH DIFFERENT GLANDS.

### B. MAJOR GLANDS AND TISSUES

1. Hypothalamus—links the nervous and endocrine systems by receiving signals and propagating the endocrine response. Located in the lower half of the brain, it also allows humans to sense a need such as thirst or hunger.

2. Pituitary gland—known as the "master gland" because it regulates the activity of several other glands. The pituitary gland is under the control of the hypothalamus.
3. Thyroid gland—located near the trachea.
4. Parathyroid gland—located on the surface of the thyroid gland.
5. Pancreas—located near the kidneys; contains specialized cells called Islets of Langerhans that secrete hormones.
6. Adrenal glands—located on top of the kidneys. In an emergency, the adrenal glands secrete hormones that cause an increase in heart rate, blood pressure, and sugar levels, while simultaneously reducing blood flow to the digestive system.
7. Gonads—testes and ovaries.
8. Pineal gland—small peanut-shaped gland near the center of the brain.
9. Thymus—located in the upper portion of the chest cavity.


*The nervous system and the endocrine system typically generate one or two multiple-choice questions on each exam. Be sure you understand the difference between the sympathetic and parasympathetic nervous systems. In addition, be sure you understand the functions of the pituitary gland and the adrenal glands.*

## C. TABLE OF MAJOR GLANDS, HORMONES SECRETED AND THE ACTIONS THAT ARE CONTROLLED

| Gland | Hormone | Action |
|---|---|---|
| Pituitary | Oxytocin | Contraction of uterus; breast milk let-down |
| Pituitary | Antidiuretic hormone | Water retention in kidneys |
| Pituitary | Growth hormone | Stimulates growth |
| Pituitary | Prolactin | Stimulates milk production from mammary gland |

| Gland | Hormone | Action |
|---|---|---|
| Pituitary | Follicle stimulating hormone | Stimulates production of ova and sperm |
| Pituitary | Luteinizing hormone | Stimulates ovaries |
| Pituitary | Thyroid Stimulating hormone | Stimulates the thyroid |
| Thyroid | Triiodothyronine ($T_3$) and thyroxine ($T_4$) | Stimulates metabolism |
| Thyroid | Calcitonin | Lowers calcium level in bloodstream; stimulates bone construction |
| Parathyroid | Parathyroid hormone | Raises blood calcium |
| Pancreas | Insulin | Lowers blood glucose |
| Pancreas | Glucagon | Raises blood glucose |
| Adrenal Gland | Norepinephrine and Epinephrine | Causes fight-or-flight response to emergency situations; stimulates metabolism |
| Testes | Androgens | Promotes sperm formation and secondary male characteristics |
| Ovaries | Estrogens | Stimulate uterine lining and secondary female characteristics |
| Ovaries | Progesterone | Stimulate uterine lining growth; maintains pregnancy |
| Pineal | Melatonin | Maintains sleep-wake cycle and other circadian rhythms |

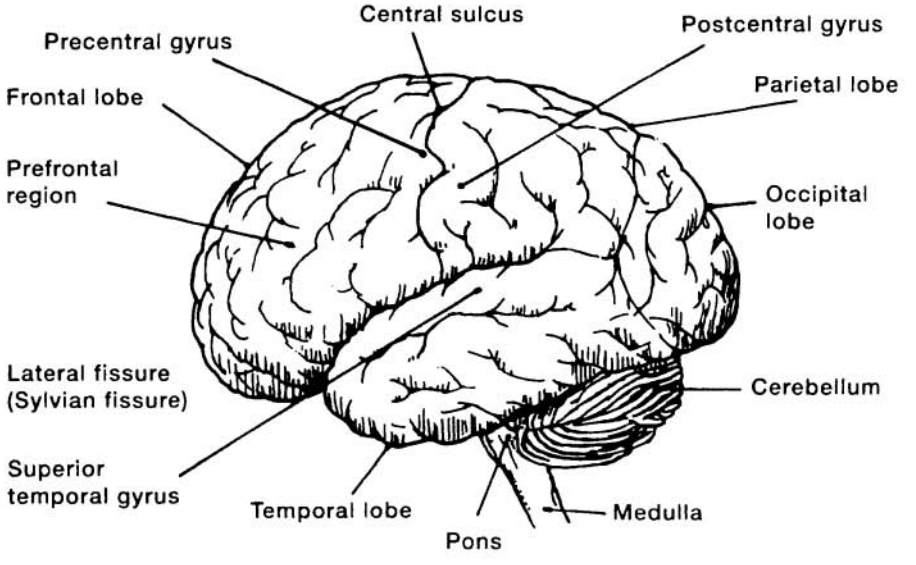
# IV. The Brain

## A. TOOLS FOR BRAIN RESEARCH

1. The electroencephalogram (EEG)
   - *Electrical activity throughout the brain sweeps in regular waves across its surface.*
   - *The EEG records the patterns of these waves.*
   - *The EEG reveals areas of the brain that are most active during a particular task or changes in mental states.*
   - *The EEG can trace abnormal brain waves caused by brain malfunctions such as epilepsy.*
2. Positron Emission Tomography (PET) scan
   - *Researchers inject a harmless, radioactive form of glucose into a person's bloodstream.*
   - *The PET scan produces computer-generated, color-coded images of the brain that provide information about glucose metabolism.*
   - *Originally designed to detect abnormalities, PET scans are now also used to identify brain areas active during ordinary activities.*
3. Computerized Tomography (CT) scan
   - *Uses X-rays to create a static picture of the brain.*
   - *Widely used in research because it is the least expensive type of imaging.*
   - *CT scans reveal the effects of strokes, tumors, and other brain disorders.*
4. Magnetic Resonance Imaging (MRI)
   - *Uses a high-frequency magnetic field to produce detailed, high-resolution pictures of the brain.*
   - *MRI images are used to map brain structures and identify abnormalities.*

## B. THE HINDBRAIN

1. The hindbrain is a region at the base of the brain that includes the medulla, the pons, and the cerebellum. The hindbrain is the oldest part of the brain to develop in evolutionary terms and controls such automatic behaviors as respiration and heartbeat.




2. Medulla
    - *Controls vital life functions such as breathing, circulation, and swallowing.*
3. Pons
    - *Pons is Latin for "bridge."*
    - *Located above the medulla, the pons contains axons that cross from one side of the brain to the other.*
    - *The pons is responsible for sleeping, walking, and dreaming.*
4. Cerebellum
    - *A large, two-sided hindbrain structure that is located at the back of the brain.*
    - *Responsible for coordinating fine muscle movement and maintaining posture and equilibrium.*

## C. THE MIDBRAIN

1. The midbrain is a small area in the brain located just above the spinal cord and below the forebrain. The midbrain integrates auditory and visual sensory information and muscle movements.

2. The reticular formation is a network of nerve fibers that run through the center of the midbrain. The reticular formation helps regulate attention, arousal, and sleep. Without the reticular formation, you would not be alert or even conscious.

## D. THE FOREBRAIN

1. The forebrain is the largest and most complex brain region. It contains centers for complex behaviors and mental processes.
2. Thalamus
   - *The thalamus is located at the top of the brainstem.*
   - *The thalamus receives input from all of the senses, except smell, and directs this information to the appropriate cortical areas.*
   - *Injury to the thalamus can cause blindness and deafness.*
3. Hypothalamus
   - *The hypothalamus is located under the thalamus. (The Latin word* hypo *means "under" or "beneath".)*
   - *Although only about the size of a peanut, the hypothalamus is often called the brain's "master control center" because it regulates key body functions such as hunger and thirst. Since the hypothalamus regulates both eating and satiety, damage to the hypothalamus can increase eating or produce a feeling of fullness.*
4. Hippocampus
   - *The hippocampus plays a key role in forming new memories of events and information.*
5. Amygdala
   - *The amygdala is linked to the production and regulation of emotions such as aggression, fear, and disgust.*
6. The Limbic System
   - *The hippocampus, the amygdala, and the hypothalamus are all part of the limbic system and play a key role in the experience of emotions.*

## E. THE CEREBRAL CORTEX

1. The word "cortex" means "bark." Like the bark of a tree, the cerebral cortex is the thin (about one quarter of an inch) outer covering of the forebrain.

2. Gray and wrinkled, the cerebral cortex is composed of approximately 30 billion densely-packed neurons and nine times as many supporting glial cells. The grayish color explains why the cerebral cortex is often described as being composed of gray matter!
3. The wrinkles (also known as convolutions) significantly increase the brain's available surface area. If the cerebral cortex were not wrinkled, it would cover an area the size of a standard newspaper page.
4. The cerebral cortex is divided into left and right hemispheres. Each hemisphere controls the opposite side of the body. Thus, the left hemisphere controls the right side of the body, while the right hemisphere controls the left side of the body.
5. The two hemispheres have specialized functions. The left hemisphere specializes in verbal and analytical functions. The right hemisphere focuses on nonverbal abilities, such as visual recognition tasks and music. The following chart summarizes the functions of the left and right hemispheres:

| Left Hemisphere | Right Hemisphere |
|---|---|
| Positive emotions | Negative emotions |
| Controls muscles for speech | Response to commands |
| Controls movements | Memory for shapes |
| Spontaneity | Memory for music |
| Memory for words and numbers | Understanding spatial relationships |
| Understanding speech and writing | Understanding images |

6. Corpus callosum
   - *The corpus callosum is a bundle of nerve fibers that connect the brain's left and right hemispheres.*
   - *In rare cases, neurosurgeons prevent the spread of severe epileptic seizures by cutting the corpus callosum. Known as split-brain surgery, this procedure disrupts the communication between the left and right hemispheres.*

- *Split-brain patients provide a valuable source of information on how the two hemispheres function.*

## F. AREAS OF THE CEREBRAL CORTEX

1. The two cerebral hemispheres are divided into eight distinct areas, or lobes—four in each hemisphere. Although their functions overlap, each lobe performs specialized tasks.
2. Frontal lobes
   - *The two frontal lobes are located directly behind your forehead. The frontal lobes are responsible for abstract thought and emotional control. For example, the frontal lobes are invaluable in the mental process of weighing the consequences of an important decision. People who suffer damage to the frontal lobes may lose the ability to make and carry out plans.*
   - *The left frontal lobe contains an area, known as Broca's area, that plays a crucial role in speech production. An individual with damage to Broca's area would have difficulty making the muscle movements needed for speech.*
3. Parietal lobes
   - *The two parietal lobes are located at the top of the brain, just behind the frontal lobes.*
   - *The parietal lobes receive and interpret bodily sensations, such as pressure, temperature, touch, pain, and the location of body parts.*
4. Temporal lobes
   - *The two temporal lobes are located on each side of the brain above the ears. (The word "temporal" is Latin for "pertaining to the temples.")*
   - *The temporal lobes process incoming sensory information from the ears.*
   - *The left temporal lobe contains an area, known as Wernicke's area, that plays a crucial role in language development. An individual with damage to Wernicke's area would have difficulty comprehending a spoken request for directions.*

5. Occipital lobes
   - *The two occipital lobes are located at the back of the brain.*
   - *The occipital lobes are responsible for vision and visual perception.*
   - *Damage to the occipital lobes can produce blindness, even if the eyes are undamaged.*


***AP Psychology test writers know that you are not studying to be a brain surgeon. Relax, you will not be asked to label a diagram of the brain or write a free-response essay listing all of the lobes or parts of the forebrain. However, you are expected to know the functions of the hypothalamus, the hippocampus, the amygdala, the corpus callosum, and the occipital and temporal lobes. Taken together, these six parts of the brain have generated almost half of the multiple-choice questions asked about the brain.***