Anatomy and Physiology: The Nervous System

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

I. Overview and Control Systems

A. Functions of the Nervous System

1. Control system for the body
2. Maintains homeostasis
3. Interacts with the endocrine system

B. Signal Types and Characteristics

1. **Endocrine System:** Chemical signals (hormones) – broadcast globally via bloodstream.
- **Nervous System:Electrochemical signals:** Action potentials (changes in voltage carried by ions).
- **Chemical signals:** Neurotransmitters – act locally at axon terminals.

1. **Excitable Tissues:** Only nervous tissue and muscle tissue can produce and transmit action potentials.
2. **Receptors:** Proteins that bind specific chemical signals (hormones or neurotransmitters) to elicit an effect.

C. Major Functions of the Nervous System

1. **Sensory Input (Afferent):** Information coming towards the Central Nervous System (CNS) via sensory neurons and action potentials.
- **Sense vs. Sensation:** Sensory input is any information received, not necessarily conscious. Sensation is high-level processing in the brain that leads to conscious awareness.

1. **Integration:** High-level processing of sensory input in the CNS to determine appropriate responses. Can be conscious (sensation) or unconscious (e.g., heart rate regulation).
2. **Motor Output (Efferent):** Information leaving the CNS to target tissues to produce a response (e.g., muscle contraction, gland secretion).

- Targets include skeletal muscle, cardiac muscle, smooth muscle, and glands.

II. Hierarchical Organization of the Nervous System

A. Major Divisions

1. **Central Nervous System (CNS):** Brain and spinal cord.
2. **Peripheral Nervous System (PNS):** All other nervous system components.

- Includes cranial nerves (bundles of neurons connecting to the brain) and spinal nerves (bundles of neurons connecting to the spinal cord).
- Nerves vs. Neurons: A nerve is a bundle of many neurons. A neuron is an individual cell.

B. Subdivisions of the Peripheral Nervous System (PNS)

1. **Sensory (Afferent) Division:** Carries incoming sensory information *towards* the CNS.
2. **Motor (Efferent) Division:** Carries outgoing motor information *away from* the CNS.

- **Somatic Motor Division:** Controls skeletal muscles; voluntary control.
- **Autonomic Division:** Controls involuntary functions (cardiac muscle, smooth muscle, glands); self-rule (autonomy).
- **Parasympathetic Division:** Antagonistic to sympathetic; generally promotes "rest and digest" functions.
- **Sympathetic Division:** Antagonistic to parasympathetic; generally promotes "fight or flight" functions.

III. Neuroglia (Glial Cells)

A. General Characteristics

1. Non-excitable cells that support neurons.
2. Do not produce action potentials or neurotransmitters.
3. Outnumber neurons.

B. Types of Neuroglia

- **CNS Neuroglia:Astrocytes:** Star-shaped cells with elaborate plasma membranes that wrap around capillaries, forming and maintaining the **blood-brain barrier**.
- **Microglial Cells:** Small phagocytes that survey the CNS, engulfing debris and pathogens.
- **Ependymal Cells:** Line the hollow interior surfaces of the CNS (ventricles in the brain and central canal of the spinal cord). Produce and secrete **cerebrospinal fluid (CSF)**, forming **choroid plexuses** in specific regions.

- **Oligodendrocytes:** Form **myelin sheaths** around axons of neurons in the CNS. Myelin appears white, hence **white matter**. One oligodendrocyte can myelinate parts of multiple axons (oligo = few).
- **PNS Neuroglia:Schwann Cells (Neurolemmocytes):** Form myelin sheaths around axons of neurons in the PNS. One Schwann cell myelinates only a portion of a single axon.
- **Satellite Cells:** Cover cell bodies of neurons in the PNS; function not fully understood.

C. Myelination and Action Potential Propagation

1. Myelin acts as insulation, dramatically increasing the speed of action potential propagation.
2. **Nodes of Ranvier:** Gaps between myelin sheaths, essential for faster "hopping" (saltatory conduction) of action potentials.

IV. Sensory Receptors in the Skin and Body

A. General Principles

1. Most sensory receptors are in the skin due to its proximity to the external environment.
2. Convert stimuli into action potentials.

B. Specific Receptors

1. **Free Nerve Endings:** Simplest receptors; detect pain, temperature, and pressure.
2. **Meissner's Corpuscles:** Located superficially in the dermis; respond to light touch and fine discrimination.
3. **Lamellar Corpuscles (Pacinian Corpuscles):** Located deeper in the dermis; respond to deep pressure and vibration.
4. **Golgi Tendon Organ:** Located in tendons; a **proprioceptor** (detects body position) that responds to excessive muscle tension, preventing injury.
5. **Muscle Spindle:** Embedded in muscles; a proprioceptor that responds to muscle stretch, triggering a reflexive contraction to resist further stretching (e.g., knee-jerk reflex).

V. Action Potentials and Synaptic Transmission

A. Resting Membrane Potential

1. All living cells have a voltage difference across their plasma membrane.
2. More positive outside, more negative inside.
3. Maintained by **sodium-potassium pumps** (expend significant energy).

4. This voltage difference is a **charge gradient** (difference in electrical charge).

B. Generation of an Action Potential

1. A drastic, rapid change in membrane voltage from resting potential.
2. Caused by the opening of **voltage-gated sodium ion channels**.
3. Sodium ions (Na+) rush into the cell, making the inside more positive.
4. **Propagation:** The change in voltage at one point opens adjacent channels, causing a chain reaction down the axon (like falling dominoes), maintaining signal strength.

C. Synaptic Transmission (Neuron to Neuron Synapse)

1. **Axon Terminal:** The end of the presynaptic neuron's axon where neurotransmitters are released.
2. **Synaptic Cleft:** The tiny extracellular fluid-filled space between the presynaptic and postsynaptic neurons.

- **Events at the Synapse:**Action potential arrives at the axon terminal.
- Opens **voltage-gated calcium ion channels**.
- Calcium ions (Ca2+) rush into the axon terminal (down their concentration gradient).
- Influx of Ca2+ triggers **exocytosis** of neurotransmitter-filled vesicles.
- Neurotransmitters diffuse across the synaptic cleft.
- Neurotransmitters bind to **chemically-gated ion channels (receptors)** on the postsynaptic membrane.
- Binding causes a conformational change in the receptor, opening the channel.
- Ions (e.g., Na+) flow into the postsynaptic neuron, causing a change in its membrane voltage.
- If the voltage change reaches threshold, a new action potential is generated in the postsynaptic neuron.
- **Neurotransmitter Degradation:** Enzymes in the synaptic cleft quickly break down neurotransmitters to prevent continuous stimulation, ensuring precise signal transmission.

VI. Brain Anatomy

A. Major Subdivisions

1. **Cerebrum:** Largest part of the brain; responsible for higher-level functions, conscious thought, and voluntary movement.

- **Cerebral Cortex:** Superficial layer of gray matter (unmyelinated) with peaks (gyri) and valleys (sulci).
- **Central Sulcus:** Major sulcus dividing the cerebrum into anterior (motor) and posterior (sensory) regions.

- **Precentral Gyrus:** Primary motor area (anterior to central sulcus); plans and executes voluntary movements.
- **Postcentral Gyrus:** Primary somatic sensory area (posterior to central sulcus); receives and processes general sensory information.
- **Lobes:** Named after cranial bones: Frontal, Parietal, Temporal, Occipital.
- **Homunculus:** Distorted representation of the body on the cerebral cortex, reflecting the amount of brain area devoted to sensory input or motor control for different body parts (e.g., large hands, face, tongue).
- **Longitudinal Fissure:** Deep crack separating the two cerebral hemispheres (left and right).

1. **Cerebellum:** "Little brain"; located posterior and inferior to the cerebrum; crucial for coordination of fine motor movements, balance, and motor learning ("muscle memory").
2. **Thalamus:** A "switchboard" for sensory information; almost all sensory input passes through the thalamus for processing before reaching the cerebral cortex.
3. **Hypothalamus:** Located inferior to the thalamus; crucial for maintaining homeostasis, regulating hormones (connects to pituitary gland), and acting as an anatomical overlap between nervous and endocrine systems.
4. **Brain Stem:** Inferior part of the brain, connects to the spinal cord.

- **Pons:** Part of the brainstem, superior to the medulla oblongata.
- **Medulla Oblongata:** Most inferior part of the brainstem; contains vital control centers for heart rate, breathing, and blood pressure.

B. White and Gray Matter

1. **White Matter:** Composed primarily of myelinated axons, appears white due to myelin.
2. **Gray Matter:** Composed of unmyelinated axons, neuron cell bodies, and dendrites; appears gray.
3. In the brain, the cerebral cortex is gray matter, and deeper regions (medulla) are white matter. In the spinal cord, this arrangement is reversed.

C. Fiber Types in the Cerebrum

1. **Association Fibers:** Connect different parts within the *same* cerebral hemisphere.
2. **Commissural Fibers:** Connect corresponding areas of the *two different* cerebral hemispheres; **decussate** (cross over).

- **Corpus Callosum:** Largest commissure, a prominent band of commissural fibers connecting the two hemispheres.

1. **Projection Fibers:** Connect the cerebrum to other parts of the brain (e.g., brainstem) or to the spinal cord.

D. Ventricles and Cerebrospinal Fluid (CSF)

1. **Ventricles:** Four interconnected hollow chambers within the brain filled with CSF.

- **Lateral Ventricles (2):** Symmetrical, located laterally in the cerebrum.

- **Third Ventricle (1):** Located on the midline, between the two halves of the thalamus.
- **Fourth Ventricle (1):** Located in the brainstem.

1. **Central Canal:** Hollow tube extending down the center of the spinal cord, continuous with the fourth ventricle.
2. **Cerebrospinal Fluid (CSF):** Produced by ependymal cells in the choroid plexuses.

- Circulates through the ventricles, central canal, and in a space surrounding the brain and spinal cord.
- Provides **shock absorption** and protection for the CNS.
- Continuously produced and drained into the bloodstream (via arachnoid granulations into sinuses).

VII. Nerves (PNS) Structure

A. Organizational Layers (Similar to Muscles)

1. **Epineurium:** Connective tissue sheath surrounding the entire nerve (bundle of fascicles).
2. **Perineurium:** Connective tissue sheath surrounding each **fascicle** (bundle of nerve fibers/neurons).
3. **Endoneurium:** Connective tissue sheath surrounding each individual **axon** (nerve fiber/neuron).

B. Cranial Nerves

1. 12 pairs of nerves connected directly to the brain.
2. Can be sensory only, motor only, or mixed (containing both sensory and motor neurons).
3. Sensory (afferent) neurons carry information toward the brain.
4. Motor (efferent) neurons carry information away from the brain.

C. Spinal Nerves

1. Nerves connected to the spinal cord.
2. Named according to the region of the vertebral column they exit (e.g., cervical, thoracic).
3. All spinal nerves are mixed nerves, containing both sensory and motor neurons.
4. **Nerve Plexuses:** Regions where several spinal nerves branch and rejoin, forming complex networks.

VIII. Wiring Diagram: Somatic vs. Autonomic Motor Systems

A. Somatic Motor Nervous System

1. **Single motor neuron** extends from the CNS directly to the skeletal muscle.
2. **Voluntary control.**
3. Target: Skeletal muscles.

B. Autonomic Nervous System

1. **Two neurons in series:** a presynaptic neuron and a postsynaptic neuron, with a synapse between them.
2. **Involuntary control.**
3. Targets: Cardiac muscle, smooth muscle, glands.
4. Sympathetic and parasympathetic divisions have antagonistic effects on target tissues.

Quiz: Nervous System Fundamentals

Instructions: Answer each question in 2-3 sentences.

1. Compare and contrast the types of signals used by the nervous system and the endocrine system, highlighting a fundamental difference in their action.
2. Explain the concept of "excitable tissues" and name the two types of tissues in the body that possess this property.
3. Describe the three major functions of the nervous system and the order in which they typically occur.
4. Distinguish between sensory input and sensation, providing an example of sensory input that is typically not a sensation.
5. What is the primary anatomical difference between the Central Nervous System (CNS) and the Peripheral Nervous System (PNS)?
6. Describe the role of Schwann cells in the Peripheral Nervous System, and name their counterparts in the Central Nervous System.
7. Explain the purpose of the blood-brain barrier and identify the specific neuroglial cells responsible for its maintenance.
8. Outline the sequence of events that occur at a synapse from the arrival of an action potential at the presynaptic terminal to the generation of a new action potential in the postsynaptic neuron.
9. Explain the functional significance of the distortions seen in the sensory and motor homunculi of the cerebral cortex.
10. Differentiate between somatic motor and autonomic nervous system pathways regarding the number of neurons involved and their target tissues.

Quiz Answer Key

1. **Compare and contrast the types of signals used by the nervous system and the endocrine system, highlighting a fundamental difference in their action.** Both systems use signals for control. The endocrine system exclusively uses chemical signals (hormones) that are broadcast globally via the bloodstream. The nervous system uses both chemical signals (neurotransmitters) and electrochemical signals (action potentials), with neurotransmitters acting locally and action potentials involving changes in voltage.
2. **Explain the concept of "excitable tissues" and name the two types of tissues in the body that possess this property.** Excitable tissues are those capable of producing and transmitting action potentials, which are rapid changes in membrane voltage used for communication. The two excitable tissues in the body are nervous tissue and muscle tissue.
3. **Describe the three major functions of the nervous system and the order in which they typically occur.** The three major functions are sensory input, integration, and motor output. Sensory input involves gathering information from the environment and body. Integration is the processing and interpretation of that information. Motor output is the resulting action or response carried out by effector organs.
4. **Distinguish between sensory input and sensation, providing an example of sensory input that is typically not a sensation.** Sensory input refers to any information flowing into the central nervous system, regardless of awareness. Sensation, however, is a higher-level processing event in the brain that results in conscious awareness of that information. An example of sensory input without sensation is the continuous monitoring of blood pressure or body temperature by the nervous system, of which we are usually unaware.
5. **What is the primary anatomical difference between the Central Nervous System (CNS) and the Peripheral Nervous System (PNS)?** The Central Nervous System (CNS) anatomically consists solely of the brain and the spinal cord. The Peripheral Nervous System (PNS) includes all other nervous tissue outside of the brain and spinal cord, such as cranial nerves and spinal nerves, connecting the CNS to the rest of the body.
6. **Describe the role of Schwann cells in the Peripheral Nervous System, and name their counterparts in the Central Nervous System.** Schwann cells are neuroglial cells in the Peripheral Nervous System that form myelin sheaths around the axons of neurons. Myelin acts as an insulation, significantly speeding up the propagation of action potentials. Their functional counterparts in the Central Nervous System that also produce myelin are oligodendrocytes.
7. **Explain the purpose of the blood-brain barrier and identify the specific neuroglial cells responsible for its maintenance.** The blood-brain barrier is a protective mechanism that strictly regulates what substances can pass from the bloodstream into the brain and spinal cord. Its purpose is to shield the delicate CNS tissue from harmful chemicals and pathogens. Astrocytes, a type of CNS neuroglia, are primarily responsible for forming and maintaining this barrier by wrapping around capillaries.
8. **Outline the sequence of events that occur at a synapse from the arrival of an action potential at the presynaptic terminal to the generation of a new action potential in the postsynaptic neuron.** An action potential arriving at the presynaptic

axon terminal opens voltage-gated calcium channels, causing calcium influx. This triggers exocytosis of neurotransmitters into the synaptic cleft. Neurotransmitters bind to chemically-gated ion channels on the postsynaptic membrane, opening them and allowing ions (e.g., sodium) to flow in, which can generate a new action potential if the threshold is reached.

9. **Explain the functional significance of the distortions seen in the sensory and motor homunculi of the cerebral cortex.** The distorted proportions in the sensory and motor homunculi (the "little person" mapped on the cortex) illustrate that the amount of cerebral cortex devoted to a body part is not proportional to its size, but rather to its functional importance. Areas with fine motor control (like hands and face) or high sensory sensitivity (like fingertips and tongue) receive disproportionately larger areas of cortical representation.
10. **Differentiate between somatic motor and autonomic nervous system pathways regarding the number of neurons involved and their target tissues.** The somatic motor nervous system uses a single motor neuron that extends directly from the CNS to its target, which is always skeletal muscle, enabling voluntary control. In contrast, the autonomic nervous system uses two neurons in series (presynaptic and postsynaptic) with a synapse between them, and it involuntarily controls cardiac muscle, smooth muscle, and glands.

Essay Format Questions

1. Discuss the critical importance of myelin sheaths and nodes of Ranvier for efficient nervous system function. Compare and contrast the cells responsible for myelination in the CNS and PNS, including specific names and key differences in their myelination patterns.
2. Trace the pathway of information flow through the nervous system, beginning with a sensory stimulus and ending with a motor response. Incorporate the roles of sensory input, integration, motor output, and specific anatomical divisions (CNS, PNS, sensory, motor) in your explanation.
3. Detail the process of synaptic transmission from the arrival of an action potential at the presynaptic terminal to the termination of the signal on the postsynaptic neuron. Be sure to include the roles of specific ions, channels, neurotransmitters, receptors, and enzymes.
4. Explain how the nervous system maintains homeostasis by controlling the body's variables. Discuss the general components of a homeostatic control mechanism (sensor, control center, effector) and illustrate how the nervous system fulfills these roles, providing examples of both conscious and unconscious homeostatic regulation.
5. Describe the hierarchical organization of the nervous system, starting from the broadest divisions and detailing subsequent subdivisions down to the sympathetic and parasympathetic divisions. For each major division and subdivision, provide its anatomical components and primary functions.

Glossary of Key Terms

- **Action Potential:** An electrochemical signal; a rapid, drastic, and transient change in the membrane potential of an excitable cell, propagated along the cell membrane.
- **Afferent (Sensory):** Direction of information flow *towards* the central nervous system.
- **Association Fibers:** Neurons in the cerebrum that connect different parts within the *same* cerebral hemisphere.
- **Astrocytes:** Star-shaped neuroglial cells in the CNS that contribute to the blood-brain barrier and provide support to neurons.
- **Autonomic Nervous System:** A subdivision of the motor division of the PNS that controls involuntary functions of cardiac muscle, smooth muscle, and glands.
- **Axon Terminal:** The bulbous end of an axon where neurotransmitters are released into the synaptic cleft.
- **Blood-Brain Barrier:** A protective mechanism that selectively regulates the passage of substances from the bloodstream into the brain and spinal cord, maintained by astrocytes.
- **Central Canal:** The hollow, fluid-filled channel running down the center of the spinal cord, continuous with the brain's ventricles.
- **Central Nervous System (CNS):** Consists of the brain and spinal cord, the primary control center of the nervous system.
- **Central Sulcus:** A prominent groove on the lateral surface of the cerebrum, separating the frontal and parietal lobes and marking the division between primary motor and primary somatic sensory areas.
- **Cerebellum:** Part of the brain located inferior and posterior to the cerebrum, important for coordination, balance, and motor learning.
- **Cerebral Cortex:** The superficial layer of gray matter covering the cerebrum, responsible for higher cognitive functions.
- **Cerebrospinal Fluid (CSF):** A clear, colorless fluid that circulates within the ventricles of the brain, the central canal of the spinal cord, and around the CNS, providing cushioning and nutrient transport.
- **Chemically-gated Channels:** Ion channels that open or close in response to the binding of a specific chemical signal (ligand), such as a neurotransmitter.
- **Choroid Plexus:** A specialized capillary network in the ventricles of the brain, lined by ependymal cells, that produces cerebrospinal fluid.
- **Commissural Fibers:** Neurons in the cerebrum that connect corresponding areas of the *two different* cerebral hemispheres, often decussating.
- **Corpus Callosum:** The largest commissure in the brain, a thick band of commissural fibers connecting the left and right cerebral hemispheres.
- **Decussation:** The anatomical crossing over of nerve tracts from one side of the body to the other.
- **Efferent (Motor):** Direction of information flow *away from* the central nervous system.
- **Ependymal Cells:** Neuroglial cells that line the ventricles of the brain and the central canal of the spinal cord, involved in CSF production and circulation.

- **Excitable Tissues:** Tissues (nervous and muscle) capable of generating and propagating action potentials.
- **Exocytosis:** A type of vesicular transport that moves substances from inside the cell to the outside by fusing vesicles with the plasma membrane.
- **Free Nerve Endings:** Simple sensory receptors in the skin that detect pain, temperature, and crude touch.
- **Golgi Tendon Organ:** A proprioceptor located in tendons that detects tension in the muscle-tendon unit, helping to prevent excessive force.
- **Gray Matter:** Regions of the CNS composed primarily of unmyelinated axons, neuron cell bodies, and dendrites, appearing grayish.
- **Gyrus (plural: Gyri):** A ridge or fold on the convoluted surface of the cerebral cortex.
- **Homunculus (Sensory/Motor):** A distorted representation of the human body on the cerebral cortex, reflecting the relative amount of brain tissue devoted to sensory or motor function for different body parts.
- **Hormones:** Chemical signals produced by endocrine glands and transported via the bloodstream to target cells, acting globally.
- **Hypothalamus:** A region of the brain inferior to the thalamus, crucial for regulating homeostasis, hormones, and serving as a link between the nervous and endocrine systems.
- **Integration:** The processing and interpretation of sensory information within the CNS to determine an appropriate response.
- **Lamellar Corpuscles (Pacinian Corpuscles):** Deeply located sensory receptors in the dermis that respond to deep pressure and vibration.
- **Ligand:** A molecule that binds specifically to another molecule, typically a protein, to form a complex and often trigger a conformational change or biological response.
- **Longitudinal Fissure:** The deep groove that separates the two cerebral hemispheres.
- **Meissner's Corpuscles:** Superficial sensory receptors in the dermis that detect light touch and discriminate textures.
- **Microglial Cells:** Small, phagocytic neuroglial cells in the CNS that remove cellular debris and pathogens.
- **Motor Output:** The command signals sent from the CNS to effector organs (muscles or glands) to produce a response.
- **Muscle Spindle:** A proprioceptor embedded within muscles that detects changes in muscle length and stretch, triggering a reflexive contraction.
- **Myelin Sheath:** A fatty insulating layer around some axons, formed by oligodendrocytes (CNS) or Schwann cells (PNS), that increases the speed of action potential propagation.
- **Nerve:** A bundle of many nerve fibers (axons of neurons) in the peripheral nervous system.
- **Neuroglia (Glial Cells):** Non-excitable supporting cells of the nervous system that provide metabolic, structural, and protective support to neurons.
- **Neuron:** The fundamental structural and functional unit of the nervous system, an excitable cell specialized for transmitting electrical and chemical signals.
- **Neurotransmitter:** A chemical signal released by neurons at synapses to transmit information to another neuron or effector cell, acting locally.

- **Nodes of Ranvier:** Gaps in the myelin sheath along an axon, where action potentials are regenerated, allowing for faster, saltatory conduction.
- **Oligodendrocytes:** Neuroglial cells in the CNS that form myelin sheaths around the axons of multiple neurons.
- **Parasympathetic Division:** A subdivision of the autonomic nervous system that generally promotes "rest and digest" functions and has antagonistic effects to the sympathetic division.
- **Peripheral Nervous System (PNS):** All parts of the nervous system outside of the brain and spinal cord, including nerves and ganglia.
- **Postcentral Gyrus:** The gyrus located posterior to the central sulcus, containing the primary somatic sensory area of the cerebral cortex.
- **Precentral Gyrus:** The gyrus located anterior to the central sulcus, containing the primary motor area of the cerebral cortex.
- **Presynaptic Cell:** The neuron or cell that sends a signal across a synapse, releasing neurotransmitters.
- **Projection Fibers:** Neurons that connect the cerebral cortex to other parts of the brain or to the spinal cord.
- **Proprioception:** Sensory input that provides information about the position and movement of the body and its parts in space.
- **Receptor (Protein):** A protein molecule, typically on the surface of a cell, that binds specifically to a chemical signal (ligand) and mediates its effect on the cell.
- **Resting Membrane Potential:** The steady voltage difference across the plasma membrane of a cell when it is not actively signaling, typically negative inside relative to outside.
- **Satellite Cells:** Neuroglial cells in the PNS that surround and support neuron cell bodies within ganglia.
- **Schwann Cells (Neurolemmocytes):** Neuroglial cells in the PNS that form myelin sheaths around individual axons.
- **Sensation:** The conscious perception of a stimulus, resulting from high-level processing of sensory input in the brain.
- **Sensory Input:** Information gathered by sensory receptors and transmitted to the central nervous system.
- **Somatic Motor Nervous System:** A subdivision of the motor division of the PNS that controls voluntary movements of skeletal muscles.
- **Spinal Nerves:** Nerves that connect to the spinal cord, carrying both sensory and motor information.
- **Sulcus (plural: Sulci):** A groove or furrow on the surface of the brain, especially the cerebrum.
- **Sympathetic Division:** A subdivision of the autonomic nervous system that generally prepares the body for "fight or flight" responses and has antagonistic effects to the parasympathetic division.
- **Synapse:** The specialized junction between two neurons or between a neuron and an effector cell, where information is transmitted.

- **Synaptic Cleft:** The small, fluid-filled gap between the presynaptic and postsynaptic membranes at a synapse.
- **Thalamus:** A large ovoid mass of gray matter in the diencephalon, serving as a major relay station for most sensory information entering the cerebral cortex.
- **Ventricles (Brain):** Interconnected hollow chambers within the brain that produce and circulate cerebrospinal fluid.
- **Voltage-gated Channels:** Ion channels that open or close in response to changes in the electrical potential (voltage) across the cell membrane.
- **White Matter:** Regions of the CNS composed primarily of myelinated axons, appearing white due to the myelin.