**8.1 FUNCTIONS OF THE NERVOUS SYSTEM**

Functions

- Receiving sensory input

- Integrating information

- Controlling muscles and glands

- Maintaining homeostasis

- Establishing and maintaining mental activity

**8.2 DIVISIONS OF THE NERVOUS SYSTEM**

- Central Nervous System (brain and spinal cord)

- Peripheral Nervous System (nerves and ganglia)

- PNS is subdivided into the sensory division and motor division

- Sensory division or afferent (toward) conducts action potential from sensory receptors to the CNS

- Motor division or efferent (away) conducts action potential from CNS to effector organs

- Motor neurons are neurons that transmit action potentials from the CNS toward the periphery.

- Motor division can be further subdivided into somatic and autonomic.

- Somatic nervous system transmits action potentials from the CNS to skeletal muscles. (Bodily)

- Autonomic nervous system transmits action potentials from the CNS to cardiac muscle, smooth muscle, and glands. (Self-governing)

- Enteric Nervous System (ENS) is a unique subdivision of the peripheral nervous system, consisting of sensory and motor neurons entirely within the digestive tract, capable of functioning independently from the CNS or other parts of the PNS.

**8.3 CELLS OF THE NERVOUS SYSTEM**

- Two types of cells that make up the nervous system are neurons and glial cells.

**Neurons**

- Neurons or nerve cells receive stimuli, conduct action potentials, and transmit signals to other neurons or effector organs.

- The three parts of a neuron are: cell body, and processes called dendrites and axons

- Each neuron contains a single nucleus. The nucleus of the neuron is the source of information for gene expression.

- Rough ER, Golgi apparatus, and mitochondria surround the nucleus.

- Dendrites are short, branching extensions that receive information from other neurons or sensory receptors and transmit it toward the neuron cell body.

- Each neuron contains an axon, a single long cell process extending from the neuron cell body.

- The area where the axon leaves the neuron cell body is called the axon hillock.

- Sensory neuron axons conduct action potentials toward the CNS, while motor neuron axons conduct them away, with axons potentially branching into collateral axons at the axon hillock.

*Types of Neurons*

- Multipolar neurons have many dendrites and a single axon. Most of the neurons within the CNS and nearly all motor neurons are multipolar

- Bipolar neurons, with one axon and one dendrite, are located in some sensory organs like the retina and nasal cavity.

- Pseudo-unipolar neurons have a single process that splits into two branches, one extending to the periphery and the other to the CNS.

**Glial Cells**

- also called neuroglia are supportive cells of the CNS and PNS, which do not conduct action potentials, instead enhance neuron functions and maintain normal conditions in nervous tissue.

- Far more numerous than neurons, retaining the ability to divide while neurons do not

- Glial cells are different in the CNS and PNS

- In the CNS, there are four types: astrocytes, ependymal cells, microglia, oligodendrocytes.

- The PNS has two glial cells: Schwann cells and satellite cells.

- Astrocytes serve as the major supporting cells in the CNS, they can stimulate or inhibit nearby neurons and help form the blood-brain barrier with blood vessel endothelium.

- Ependymal cells line the fluid-filled cavities of the CNS, with some producing cerebrospinal fluid and others using cilia to help move it through the CNS.

- Microglia are the immune cells of the CNS which protect the brain by removing bacteria and cell debris.

- Oligodendrocytes provide an insulating material that surrounds the axons.

- In the PNS, the glial cells known as Schwann cells provide insulating material around axons

- Satellite cells, found around the cell bodies of certain PNS neurons, provide support and nutrition while protecting neurons from heavy-metal poisons like lead and mercury.

**Myelin Sheaths**

- Specialized cell layers that wrap around the axons of some neurons

- Formed by the cell processes of oligodendrocytes in the CNS and Schwann

cells in the PNS

- Axons with these myelin sheaths are called myelinated atoms.

- Myelin is an excellent insulator that prevents almost all ion movement across the membranes.

- Nodes of Ranvier are gaps in the membrane which occur about every millimetre between the myelinated areas.

- Unmyelinated axons lack the myelin sheaths.

**Organization of Nervous Tissue**

- The nervous tissue varies in color due to the location and arrangement of the parts of neurons and glial cells. Nervous tissue exists as gray and white matter

- Gray matter consists of groups of neuron cell bodies and their dendrites where there is little myelin

- In the CNS, gray matter on the surface of the brain is called the cortex, clusters deeper within the brain are called nuclei

- In the PNS, a cluster of neuron cell bodies is called a ganglion

- White matter consists of bundles of parallel axons with their myelin sheaths

- CNS white matter forms nerve tracts or conduction pathways which propagate action potentials from one area of the CNS to another.

- White matter of the PNS consists of bundles of axons and associated connective tissue that forms nerves.

**8.4 ELECTRICAL SIGNALS AND NEURAL PATHWAYS**

**Resting Membrane Potential**

- is the electrical charge difference across the neuron's membrane when it is not actively transmitting a signal and is set by leak ion channels and the

sodium-potassium pump.

- Two basic types of ion channels: leak and gated

- Leak channels always open, allowing ions to leak across the membrane down their concentration gradient.

- Gated channels: Closed until opened by specific signals.

- Chemically gated channels: Opened by specific chemicals.

- Voltage-gated channels: Opened by a change in the electrical property of the cell membrane.

- The inside of most cell membranes is negatively charged compared to the outside of the cell membrane which is positively charged

- This uneven charge distribution across the cell membrane means that the membrane is polarized

**8.5 CENTRAL AND PERIPHERAL NERVOUS SYSTEM**

- The central nervous system (CNS) includes the brain, housed within the skull, and the spinal cord, located in the vertebral column. The peripheral nervous system (PNS) encompasses all nerves and ganglia outside the CNS, gathering information from the body and relaying it to the CNS via sensory neurons. The CNS then either ignores the information, triggers a reflex, or evaluates it further. Motor neurons in the PNS transmit signals from the CNS to muscles and glands, regulating their activity. The PNS comprises 12 pairs of cranial nerves and 31 pairs of spinal nerves.

**8.6 SPINAL CORD**

- The spinal cord extends from the foramen magnum at the base of the skull to the second lumbar vertebra, with spinal nerves facilitating communication between the spinal cord and the body, and its inferior end, known as the cauda equina, resembles a horse’s tail with the exiting spinal nerves.

- A cross section of the spinal cord shows a superficial white matter portion of myelinated axons and a deep gray matter portion of neuron cell bodies.

- The white matter in each half of the spinal cord is organized into three columns: dorsal (posterior), ventral (anterior), lateral.

- Each column of the spinal cord contains ascending and descending tracts, or pathways.

- Ascending tracts: axons conduct action potentials toward the brain.

- Descending tracts: axons conduct action potentials away from the brain.

- Gray matter of the spinal cord is shaped like an H with dorsal, ventral, and lateral horns.

- Central canal is a fluid-filled space in the spinal cord.

- Spinal nerves form from rootlets; ventral and dorsal roots unite to form a spinal nerve.

- Dorsal root has a ganglion containing sensory neuron cell bodies.

- Sensory axons travel from the periphery to the dorsal horn; they synapse or ascend/descend in white matter.

- Ventral and lateral horns contain motor neuron cell bodies; somatic motor neurons are in the ventral horn, autonomic neurons are in the lateral horn.

- Motor neuron axons form the ventral roots; spinal nerves have both sensory and motor axons.

**Reflex**

- is an involuntary reaction in response to a stimulus applied to the periphery and transmitted to the CNS

- allow a person to react to stimuli more quickly than is possible if conscious thought is involved

- Simplest reflex is the stretch reflex, occurring when muscles contract in response to a stretching force applied to them (ex; patellar reflex)

- Clinicians use the patellar reflex to determine if the higher CNS centers that normally influence this reflex are functional.

- The function of the withdrawal reflex, or flexor reflex, is to remove a part of the body away from a painful stimulus.l

- The sensory receptors are pain receptors, and stimulation of these receptors initiates the withdrawal reflex.

**Reflex Arc:**

- Sensory receptor

- Sensory neuron

- Interneurons

- Motor neuron

- Effector organ (muscles or glands)

**8.7 SPINAL NERVES**

- Spinal nerves arise from the union of dorsal and ventral roots

- Spinal nerves contain both sensory and somatic motor neurons (mixed nerves)

- Some spinal nerves also contain parasympathetic or sympathetic axons

- Most spinal nerves exit between adjacent vertebrae

- Spinal nerves categorized by region: cervical (C), thoracic (T), lumbar (L), sacral (S), coccygeal (Co)

- 31 pairs of spinal nerves: C1-C8, T1-T12, L1-L5, S1-S5, Co

- Dermatomes are skin areas supplied by specific spinal nerves

- All spinal nerves except C1 have cutaneous sensory distribution

- Three major plexuses: cervical, brachial, lumbosacral

- Plexuses reorganize neurons from different spinal segments

- T2-T11 spinal nerves do not join plexuses; extend between ribs

- Motor fibers from plexuses innervate muscles, sensory fibers supply skin

- Coccygeal plexus innervates pelvic floor muscles and skin over the coccyx.

- Cervical plexus originates from spinal nerves C1 to C4

- Innervates muscles attached to the hyoid bone

- Supplies sensory innervation to the neck and posterior head

- Phrenic nerve (branch of cervical plexus) innervates the diaphragm which enables breathing.

- Brachial plexus originates from spinal nerves C5 to T1

- Five major nerves emerge to supply the upper limb and shoulder

- Axillary nerve: innervates shoulder muscles and skin over part of the shoulder

- Radial nerve: innervates posterior arm and forearm muscles; skin over posterior arm, forearm, and hand

- Radial nerve near the humerus is prone to damage; improper crutch use can cause "crutch paralysis"

- Musculocutaneous nerve: innervates anterior arm muscles and skin over the radial forearm

- Ulnar nerve: innervates two anterior forearm muscles, most intrinsic hand muscles, and skin over the ulnar side of the hand; damaged at the "funny bone"

- Median nerve: innervates most anterior forearm muscles, some intrinsic hand muscles, and skin over the radial side of the hand.

- Lumbosacral plexus originates from spinal nerves L1 to S4

- Four major nerves supply the lower limb

- Obturator nerve: innervates medial thigh muscles and skin over the same region

- Femoral nerve: innervates anterior thigh muscles and skin over the anterior thigh and medial leg

- Tibial nerve: innervates posterior thigh, anterior and posterior leg muscles, intrinsic foot muscles; skin over the sole of the foot

- Common fibular nerve: innervates lateral thigh and leg muscles, some intrinsic foot muscles; skin over the anterior and lateral leg and dorsal surface of the foot

- Tibial and common fibular nerves are bundled as the sciatic nerve.

**8.8 BRAIN**

- The major regions of the brain are the brainstem, cerebellum, diencephalon, cerebrum.

- Brainstem connects spinal cord to the brain

- Consists of three parts: medulla oblongata, pons, midbrain

- Contains nuclei for vital functions: heart rate, blood pressure, breathing

- Damage to brainstem can be fatal; damage to cerebrum or cerebellum less critical

- Nuclei for all cranial nerves except the first two are in the brainstem

- Medulla oblongata is the most inferior part of the brainstem; continuous with the spinal cord

- Extends from the foramen magnum to the pons

- Contains ascending and descending nerve tracts for signal conveyance

- Regulates heart rate, blood vessel diameter, breathing, swallowing, vomiting, coughing, sneezing, balance, and coordination

- Features pyramids on the anterior surface, involved in conscious control of skeletal muscles

- Pons is superior to the medulla oblongata; functions as a bridge

- Contains ascending and descending nerve tracts and several nuclei

- Relays information between the cerebrum and cerebellum

- Appears as an arched footbridge on the anterior surface

- Extends nuclei from the medulla oblongata; controls breathing, swallowing, balance

- Additional nuclei control chewing and salivation.

- Midbrain is superior to the pons; smallest brainstem region

- Dorsal part has four colliculi:

- Superior colliculi: involved in visual reflexes, touch, and auditory input

- Inferior colliculi: major relay centers for auditory pathways

- Superior colliculi control reflexes like turning the head toward stimuli

- Contains nuclei for coordinating eye movements, controlling pupil diameter, and lens shape

- Substantia nigra (black substance) regulates general body movements

- Composed of ascending tracts from the spinal cord and descending tracts to/from the cerebrum or cerebellum.

- Reticular formation is a group of nuclei scattered throughout the brainstem

- Regulates cyclical motor functions like respiration, walking, and chewing

- Major component of the reticular activating system

- Involved in arousing and maintaining consciousness and regulating the sleep-wake cycle

- Stimuli like alarms, bright lights, or cold water can arouse consciousness

- Removal of stimuli may lead to drowsiness or sleep

- General anesthetics suppress the reticular activating system

- Damage to reticular formation cells can cause coma.

- Cerebellum is attached to the brainstem by cerebellar peduncles

- Provides communication routes between the cerebellum and CNS

- Structure and function discussed in "Motor Functions"

- Diencephalon is located between the brainstem and cerebrum

- Main components: thalamus, epithalamus, hypothalamus

- Thalamus is the largest part of the diencephalon

- Shaped like a yo-yo with two large parts connected by interthalamic adhesion

- Receives most sensory input and relays it to the cerebral cortex

- Influences mood and registers unlocalized, uncomfortable pain

- Epithalamus is superior and posterior to the thalamus

- Contains small nuclei involved in emotional and visceral responses to odors

- Houses the pineal gland, an endocrine gland

- Pineal gland may influence puberty and long-term cycles related to light-dark cycles

- In animals, affects annual behaviors, migration, and fur changes.

- Hypothalamus is the most inferior part of the diencephalon

- Contains small nuclei crucial for maintaining homeostasis

- Controls body temperature, hunger, and thirst

- Related to sensations like sexual pleasure, rage, fear, and post-meal relaxation

- Involved in inappropriate emotional responses like "nervous perspiration" and "emotional eating"

- Infundibulum extends from the hypothalamus to the pituitary gland, regulating hormone secretion

- Mammillary bodies on the posterior hypothalamus are involved in emotional responses to odors and memory

- Cerebrum is the largest part of the brain

- Divided into left and right hemispheres by a longitudinal fissure

- Surface features: gyri (folds) and sulci (grooves)

- Gyri increase the surface area of the cerebral cortex.

- Frontal Lobe: Controls voluntary motor functions, motivation, aggression, mood, and olfactory reception

- Parietal Lobe: Receives and perceives sensory information (touch, pain, temperature, balance); separated from the frontal lobe by the central sulcus

- Occipital Lobe: Receives and perceives visual input; not distinctly separate from other lobes

- Temporal Lobe: Involved in olfactory and auditory sensations, memory; anterior and inferior portions (psychic cortex) are linked to abstract thought and judgment; separated by the lateral fissure

- Insula: Often considered the fifth lobe; involved in taste perception; located deep within the lateral fissure.

**8.9 SENSORY FUNCTIONS.**

- CNS receives various stimuli from inside and outside the body

- Much sensory input is unnoticed but crucial for survival and normal functions

- Brainstem and diencephalon use sensory input to maintain homeostasis

- Cerebrum and cerebellum use input to monitor the environment and control motor functions

- Only a small portion of sensory input leads to perception, the conscious awareness of stimuli.

- Ascending tracts in spinal cord and brainstem transmit sensory information to the brain

- Each tract is specific to a type of sensory input (e.g., pain, temperature, touch)

- Tracts are named based on their origin and termination (e.g., spinothalamic tract)

- Most tracts involve 2-3 neurons from periphery to brain; terminate in thalamus, then to cerebral cortex

- Examples: spinothalamic tract (pain, temperature) and dorsal column tract (touch, pressure, proprioception)

- Sensory tracts cross to the opposite side of the body

- Some tracts terminate in the brainstem or cerebellum (e.g., spinocerebellar tracts for proprioception)

- Sensory areas of the cerebral cortex process sensory information received from ascending tracts

- Primary sensory areas include:

- Primary somatosensory cortex (parietal lobe, posterior to central sulcus): Processes general sensory input (pain, pressure, temperature) with a topographic map of the body

- Visual cortex (occipital lobe): Processes visual input

- Primary auditory cortex (temporal lobe): Processes auditory input

- Taste area (insula): Processes taste information

- Association areas are adjacent to primary sensory areas and involved in recognition and interpretation

- Example: Visual association area compares current visual input with past experiences

- Other examples: Auditory association area (for sound recognition), somatosensory association area (for touch recognition)

**8.10 SOMATIC MOTOR FUNCTIONS**

- Somatic motor system controls posture, balance, and movement of the trunk, head, limbs, tongue, and eyes

- Enables communication through facial expressions and speech

- Involuntary movements: Reflexes mediated by the spinal cord and brainstem, occurring without conscious thought

- Voluntary movements: Consciously activated for specific goals (e.g., walking, typing), often performed automatically once learned

- Voluntary movements involve two types of motor neurons:

- Upper motor neurons: Located in the cerebral cortex; their axons form descending tracts that connect to lower motor neurons

- Lower motor neurons: Located in the spinal cord’s ventral horn or cranial nerve nuclei; their axons extend to skeletal muscles

- Lower motor neurons form motor units, which control muscle contraction.

**Motor Areas of the Cerebral Cortex**

- Primary motor cortex: Controls voluntary muscle movements; has a body map similar to the sensory cortex.

- Premotor area: Plans and organizes movements before they start; sends signals to the primary motor cortex.

- Prefrontal area: Handles motivation, planning, and emotional regulation; well-developed in humans for complex thinking.

- Descending tracts: Named for their origin in the brain and termination in the spinal cord or brainstem.

- Corticospinal tracts: Direct pathways from the cerebral cortex to spinal cord lower motor neurons, controlling voluntary movements.

- Indirect tracts: Originating in the brainstem and controlled indirectly by the cortex, basal nuclei, and cerebellum, regulate posture and balance.

- Lateral corticospinal tract: Controls skilled limb movements; axons cross to the opposite side of the body in the medulla oblongata.

- Typical crossover: Left brain controls right body muscles and vice versa.

- Basal nuclei: Functionally related group of nuclei, including the corpus striatum and substantia nigra.

- Functions: Plan, organize, and coordinate motor movements and posture.

- Connections: Form feedback loops with the thalamus and cerebral cortex, including both stimulatory and inhibitory circuits.

- Stimulatory circuits: Facilitate muscle activity, especially for initiating movements.

- Inhibitory circuits: Suppress random movements and reduce muscle tone at rest.

- Disorders: Affect movement initiation and muscle tone; include Parkinson's, Huntington's, and cerebral palsy.

- Cerebellum: Attached to the brainstem by cerebellar peduncles.

- Structure: Composed of gray matter (cortex) with smaller gyri and sulci than the cerebrum, and internal gray nuclei and white tracts.

- Functions: Maintains balance, muscle tone, and coordinates fine motor movements. Acts as a comparator, comparing intended movements (from the motor cortex) with actual movements (from proprioceptive feedback).

- Damage Effects: Decreased muscle tone and clumsy fine motor movements.

- Comparator Role: Compares intended movements with sensory information and corrects discrepancies to ensure smooth movements.

1. Action Potentials: Descend from the motor cortex to the spinal cord to initiate voluntary movements.

2. Collateral Branches: Send information about intended movements to the cerebellum.

3. Proprioceptive Neurons: Provide sensory feedback about body position to the cerebellum.

4. Comparison: The cerebellum compares intended movements with sensory feedback.

5. Correction: If discrepancies are found, the cerebellum sends signals to adjust movements.

- Motor Learning: Helps in learning and automating motor skills, such as playing the piano.

- Alcohol Effect: Inhibits cerebellum function, affecting motor control.

**8.11 OTHER BRAIN FUNCTIONS**

- Hemispheric Control: The right hemisphere controls the left side of the body and vice versa.

- Communication: Information is exchanged between hemispheres via commissures, with the corpus callosum being the largest.

- Functional Differences: The left hemisphere is more analytical (e.g., math, speech), while the right hemisphere is more involved in spatial and artistic skills.

- Speech Areas: In most people, the left cerebral cortex has two main areas for speech:

1. Wernicke Area: Understands and formulates coherent speech.

2. Broca Area: Controls the movements necessary for speech.

- Aphasia: Damage to these areas can cause aphasia, affecting speech or comprehension, often due to stroke.

- Speech Pathways:

- Repeating Spoken Words:

1. Auditory cortex perceives the word.

2. Auditory association area recognizes it.

3. Sensory speech area comprehends it.

4. Motor speech area plans the muscle activity.

5. Premotor area programs movements.

6. Primary motor cortex triggers specific movements.

- Reading Aloud:

1. Visual cortex recognizes the word.

2. Visual association area processes it.

3. Sensory speech area formulates it.

4. Follows the same route as repeating heard words.

**Brain Waves and Consciousness**

- Electrodes on the scalp record the brain's electrical activity, producing an Electroencephalogram (EEG).

- EEG detects simultaneous action potentials in large numbers of neurons.

- Most EEG patterns are irregular due to asynchronous brain activity.

- Brain waves are wavelike patterns of brain activity, differing in intensity and frequency.

- Different brain waves correspond to different levels of consciousness.

- Alpha waves: observed in a quiet, resting person with eyes closed.

- Beta waves: higher frequency, occur during intense mental activity.

- Transition from beta to alpha waves marks the beginning of sleep.

- Delta waves: occur during deep sleep, in infants, and in patients with severe brain disorders.

- Theta waves: observed in children, and adults experiencing frustration or certain brain disorders.

- Neurologists use brain wave patterns for diagnosing and treating disorders.

- Memory storage has three stages: working, short-term, and long-term.

- Long-term memory can be subdivided into declarative (facts) and procedural (skills).

- Working memory: brief storage for immediate task performance; lasts seconds to minutes; located mostly in the frontal cortex; limited to about seven bits of information.

- Short-term memory: lasts minutes to days; involves increased synaptic transmission; affected by brain trauma and certain drugs.

- Short-term memory transfers to long-term memory through consolidation; involves forming new synaptic connections.

- Declarative memory: retains facts and emotional undertones; influenced by emotion and mood.

- Procedural memory: develops motor skills; retains skills with minimal loss over time.

- Long-term memory: involves structural and functional changes in neurons; memory engrams likely involved.

- Repeating and associating information with existing memories helps transfer from short-term to long-term memory.

- The limbic system includes the olfactory cortex, deep cortical regions, and nuclei of the cerebrum and diencephalon.

- It influences long-term declarative memory, emotions, visceral responses to emotions, motivation, and mood.

- Major sensory input comes from the olfactory nerves.

- The limbic system initiates survival responses like hunger and thirst.

- It is connected and functionally associated with the hypothalamus.

- Lesions in the limbic system can cause excessive appetite, increased or abnormal sexual activity, and docility, including loss of normal fear and anger responses.

**8.12 MENINGES, VENTRICLES, AND CEREBROSPINAL FLUID.**

- Meninges: three connective tissue membranes surrounding and protecting the brain and spinal cord.

- Three layers:

- Dura mater: most superficial and thickest; has two layers with dural folds and venous sinuses; helps hold the brain in place; collects blood and empties into internal jugular veins; damage can cause subdural hematoma and pressure-related brain function issues.

- Arachnoid mater: thin, wispy; located between dura mater and pia mater; subdural space is a potential space with minimal fluid.

- Pia mater: tightly bound to the brain and spinal cord surface; subarachnoid space between pia mater and arachnoid mater is filled with cerebrospinal fluid and contains blood vessels.

- Epidural space in the vertebral canal is used for epidural anesthesia.

- Spinal cord ends around the second lumbar vertebra; spinal block or spinal tap performed in the subarachnoid space without damaging the spinal cord.

- Ventricles: fluid-filled cavities in the CNS; vary in size.

- Lateral ventricles: large cavities in each cerebral hemisphere.

- Third ventricle: smaller, midline cavity in the diencephalon; connected to lateral ventricles by foramina.

- Fourth ventricle: located at the base of the cerebellum; connected to the third ventricle by the cerebral aqueduct; continuous with the spinal cord's central canal; opens into the subarachnoid space through foramina.

Cerebrospinal Fluid (CSF):

- CSF bathes and protects the brain and spinal cord.

- Produced by choroid plexuses in the ventricles, composed of ependymal cells.

- CSF flow:

- From lateral ventricles to third ventricle.

- Through the cerebral aqueduct to the fourth ventricle.

- Exits the fourth ventricle through openings into the subarachnoid space and a small amount enters the central canal of the spinal cord.

- Arachnoid granulations: masses of arachnoid tissue that allow CSF to pass from the subarachnoid space into the blood via the superior sagittal sinus.

- Hydrocephalus: condition from blocked CSF flow, leading to fluid accumulation, increased pressure, and brain compression; treated by placing a shunt to drain excess fluid.

**8.13 CRANIAL NERVE**

- Cranial Nerves: There are 12 pairs, numbered I to XII, with functions categorized into sensory, motor, and parasympathetic.

- Categories:

- Sensory: Includes special senses (e.g., vision) and general senses (e.g., touch, pain).

- Motor: Includes somatic motor (innervates skeletal muscles) and parasympathetic (innervates glands, smooth muscle, and cardiac muscle).

- Types of Cranial Nerves:

- Sensory Only: Olfactory (I), Optic (II), Vestibulocochlear (VIII).

- Somatic Motor Only: Trochlear (IV), Abducens (VI), Accessory (XI), Hypoglossal (XII).

- Mixed Functions: Trigeminal (V) has sensory and somatic motor functions; Oculomotor (III) has somatic motor and parasympathetic functions; Facial (VII), Glossopharyngeal (IX), and Vagus (X) have all three functions.

- Examples:

- Trigeminal Nerve: Major sensory nerve of the face, used for dental anesthesia.

- Vagus Nerve: Key parasympathetic nerve regulating heart rate, respiration, and digestion.

- Function Crossovers: Sensory and motor functions often cross to the opposite side of the brain. For example, sensory from the right face projects to the left cortex, and motor output from the left cortex controls the right face.

- The olfactory nerve is responsible for smell.

- The optic nerve transmits visual information from the retina to the brain, enabling sight.

- The oculomotor nerve controls most of the eye's movements, including constriction of the pupil and maintaining an open eyelid.

- The trochlear nerve allows the eye to move up and down.

- The trigeminal nerve controls the muscles for chewing and provides sensory input to the face and teeth.

- The abducens nerve allows the eye to move outward.

- The facial nerve controls the muscles of facial expression, conveys taste sensations from the front of the tongue, and stimulates the salivary and tear glands.

- The vestibulocochlear nerve provides control for hearing and balance.

- The glossopharyngeal nerve is involved in taste from the back of the tongue, swallowing, and the production of saliva.

- The vagus nerve regulates heart rate, controls muscles used in voice production and swallowing, and oversees functions of the digestive system.

- The accessory nerve controls the muscles of the neck and shoulders, aiding in head rotation and shoulder movement.

- The hypoglossal nerve controls the muscles of the tongue, which are essential for speech, swallowing, and food manipulation within the mouth.

“Oh, Oh, Oh, To Touch And Feel Very Good Velvet , AH!”

“Some Say Marry Money But My Brother Says Big Brains Matter More.”

S - Sensory

M - Motor

B - Both

**8.14 AUTONOMIC NERVOUS SYSTEM**

- The autonomic nervous system (ANS) consists of motor neurons that carry action potentials from the CNS to the periphery.

- Autonomic neurons innervate smooth muscle, cardiac muscle, and glands, with functions controlled unconsciously.

- Unlike somatic motor pathways, the ANS uses two neurons in series to reach effector organs: preganglionic and postganglionic neurons.

- Preganglionic neurons synapse with postganglionic neurons in autonomic ganglia in the PNS.

- An exception exists for the adrenal gland, where preganglionic neurons directly stimulate hormone-secreting cells in the adrenal medulla.

- The ANS has two divisions: sympathetic and parasympathetic.

- Sympathetic activity prepares the body for physical activity.

- Parasympathetic stimulation supports involuntary functions, like digestion, during rest.

- Sympathetic preganglionic neuron cell bodies are located in the lateral horn of the spinal cord from T1 to L2.

- Preganglionic neurons exit via ventral roots and connect to either sympathetic chain ganglia or collateral ganglia.

- Sympathetic chain ganglia form chains along both sides of the spinal cord.

- Postganglionic neurons in the sympathetic chain ganglia form sympathetic nerves that innervate the thoracic cavity.

- Preganglionic fibers that don't synapse in the sympathetic chain form splanchnic nerves, which connect to collateral ganglia.

- Collateral ganglia (celiac, superior mesenteric, inferior mesenteric) are near target organs, and postganglionic neurons project to abdominal and pelvic regions.

- Parasympathetic preganglionic neuron cell bodies are in the brainstem or spinal cord regions that give rise to S2-S4 spinal nerves.

- Preganglionic neurons extend through cranial or spinal nerves to terminal ganglia near or within effector organs.

- Postganglionic neurons travel short distances from terminal ganglia to target organs.

- The vagus nerve provides most parasympathetic innervation to thoracic and abdominal organs like the heart, lungs, liver, and digestive organs.

- Autonomic neurotransmitters differ based on the synapse.

- All preganglionic neurons and parasympathetic postganglionic neurons secrete acetylcholine.

- Most sympathetic postganglionic neurons secrete norepinephrine.

- Drugs can either mimic or block neurotransmitters to stimulate or inhibit body functions.

Functions of the Autonomic Nervous System

- Sympathetic division (fight-or-flight) prepares the body for physical activity:

- Increases heart rate, blood pressure, and glucose release from the liver.

- Dilates respiratory passages and redirects blood to active muscles.

- Inhibits digestion and cools the body via vasodilation and sweating.

- Parasympathetic division (rest-and-digest) supports resting functions:

- Stimulates digestion, urination, and defecation.

- Releases digestive enzymes and coordinates digestive organ activity.

- Lowers heart rate, blood pressure, and decreases airflow.

- Sympathetic and parasympathetic divisions can be both stimulatory and inhibitory:

- Sympathetic: Stimulates smooth muscle contraction in blood vessels, inhibits smooth muscle in lung airways.

- Parasympathetic: Stimulates bladder contraction, inhibits heart contraction.

- Dual innervation: Most organs receive both parasympathetic and sympathetic input, affecting the organs in opposite ways (e.g., heart rate).

- Sympathetic division is dominant during stress, parasympathetic during rest.

- Some organs, like sweat glands and blood vessels, are innervated mainly by sympathetic neurons.

**8.15 ENTERIC NERVOUS SYSTEM**

- The enteric nervous system (ENS) consists of plexuses in the digestive tract wall.

- ENS includes:

- Sensory neurons connecting the digestive tract to the CNS.

- Sympathetic and parasympathetic neurons connecting the CNS to the digestive tract.

- Enteric neurons located entirely within the enteric plexuses.

- Enteric neurons can monitor and control the digestive tract independently of the CNS via local reflexes.

- Example: Digestive tract stretching stimulates sensory neurons, which activate interneurons and motor neurons to trigger gland secretion.

- Although the ENS can function independently, the CNS (via parasympathetic and sympathetic nerves) can override ENS actions.

- ENS is an independent part of the PNS but is integrated with the ANS.