

# 1. Introduction to Anatomy & Physiology

- **Anatomy:** Study of the *structure and shape* of the body and its parts, including how structures relate to each other *Ex:* Parts of a heart.
- **Physiology:** Study of *how the body and its parts work or function*.  
*Ex:* How the heart pumps blood.  
Physiology is explainable only in terms of underlying anatomy.
- **Physiology Defined:**
  - Study of biological function; how the body works.
  - Concerned with normal function.
  - Emphasizes mechanisms.
  - Explained by cause-and-effect sequences.
  - Based on scientific experiments.

## 2. Homeostasis

- **Definition:** Constancy of the internal environment.
- **Purpose:** The main goal of physiological mechanisms is to maintain homeostasis.
- **Deviation:** Indicates disease.
- **Mechanism:** Most often accomplished by *negative feedback loops*.

### 2.1. Negative Feedback Loops

- **Pathway:**
  1. **Sensors:** Detect change and send information to the integrating center.
  2. **Integrating Center** (Brain, CNS, endocrine glands): Assesses change around a set point (like a thermostat) and sends instructions to an effector.
  3. **Effector** (muscle or gland): Makes appropriate adjustments (increase/decrease) to counter the change from the set-point.
- **Example: Body Temperature Regulation**
  - Sensors in the brain detect deviation from **37°C**.
  - Integrating center assesses this, stimulating effectors (sweat glands) to cool the body.
  - Once cool, sensors alert the integrating center, and sweat glands are inhibited.
  - The end result regulates the entire process, **shutting off or down-regulating** the process (hence "negative").
- **Antagonistic Effectors:** Homeostasis often maintained by opposing effectors moving conditions in opposite directions.
  - Maintains conditions within a normal range (*dynamic constancy*).
  - *Ex:* Sweating when hot, shivering when cold.
  - Negative feedback loops are *continuous*.
  - *Ex:* Blood glucose levels.



## 2.2. Positive Feedback

- **Mechanism:** The end product in a process *stimulates* the process, amplifying changes.
- **Role:** Cannot work alone but contributes to many negative feedback loops.
  - *Ex:* Blood clot formation (initial clotting involves positive feedback, but the overall process ends when damage is fixed, showing negative feedback).
  - *Ex:* Uterine contractions during childbirth.

## 2.3. Intrinsic and Extrinsic Regulation

- **Intrinsic Regulation:** Cells within an organ sense a change and signal neighboring cells to respond.
- **Extrinsic Regulation:** The brain or other organs regulate an organ using the *endocrine system* (hormones via blood) or *nervous system* (nerve fibers/innervation).

# 3. Interaction between Cells and Extracellular Environment

## 3.1. Extracellular Environment

- Everything located outside the cells.
- **Extracellular Matrix:** Contains protein fibers (*collagen, elastin*) and a gel-like ground substance.
- **Function:**
  - Cells receive nourishment and release wastes here.
  - Cells communicate by secreting chemical regulators into it.

## 3.2. Body Fluids

- **Intracellular Compartment:** 67% of body water (within cells).
- **Extracellular Compartment:** 33% of body water.
  - 20% is *blood plasma*.
  - 80% is *tissue fluid (interstitial fluid)*, connecting intracellular compartment with blood plasma.

## 3.3. Plasma Membrane Transport

- **Plasma Membrane Permeability:**
  - **Selectively permeable:** Allows some molecules, not others.
  - Generally *not permeable* to proteins, nucleic acids, or large molecules.
  - Generally *permeable* to ions, nutrients, and wastes.

### 3.4. Diffusion and Osmosis

- **Solution:** Solvent (water) + Solute (dissolved molecules).
- Molecules are in constant motion; concentration differences lead to equilibrium via diffusion.
- **Net Diffusion:** From high to low solute concentration.
- **Diffusion through Plasma Membrane:**
  - **Non-carrier-mediated (Passive Transport):**
    - *Simple diffusion:* Lipid-soluble molecules (O<sub>2</sub>, CO<sub>2</sub>, steroid hormones) through phospholipid bilayer.
    - *Simple diffusion:* Ions (Na<sup>+</sup>, Cl<sup>-</sup>) through membrane channel proteins.
    - *Osmosis:* Water through aquaporin channels.
  - **Carrier-mediated:**
    - *Facilitated diffusion:* Needs a carrier; no ATP; down concentration gradient.
    - *Active transport:* Needs ATP; against concentration gradient; via pumps.

### 3.5. Osmosis

- **Definition:** Net diffusion of water (solvent) across a membrane.
- Water can pass slowly through the plasma membrane; aided by *aquaporins* (in kidneys, eyes, lungs, salivary glands, brain).

- **Requirements:**

1. Solute concentration difference on either side of a water-permeable membrane.
2. Membrane must be *impermeable* to the solute.

*Osmotically active solutes* cannot freely pass and promote water movement.

### 3.6. Tonicity

- **Definition:** Effect of solute concentration on water osmosis.
- **Isosmotic/Isotonic:** Solutions with the same osmolality as plasma.
  - *Ex:* **0.3m glucose** or **0.15m NaCl** solution.
  - Normal saline: **0.9g NaCl/100mL water**.
  - **5% dextrose: 5g glucose/100 mL water**.
  - No net water movement between isosmotic/isotonic solutions.
- **Hypoosmotic/Hypotonic:** Lower solute concentration than the cell.
  - Water moves *into* the cell; cell swells and may *lyse*.
- **Hyperosmotic/Hypertonic:** Higher solute concentration than the cell.
  - Water moves *out of* the cell; cell shrivels and may *crenate*.
- **Regulation of Blood Osmolality:**
  - Constant osmolality vital to prevent neuron damage.
  - *Osmoreceptors* in the hypothalamus detect increased osmolality (dehydration).
  - Triggers thirst and decreased water excretion in urine (via *antidiuretic hormone - ADH*).
  - Decreased osmolality leads to less ADH and more water excretion.

### 3.7. Carrier-Mediated Transport

- For large or polar molecules (amino acids, glucose) that cannot diffuse.
- Involves *carrier proteins* in the plasma membrane.
- **Characteristics of Carriers & Enzymes:**
  - Specificity (to a given molecule).
  - Competition.
  - Saturation (limited number of carriers).

### 3.8. Facilitated Diffusion

- Powered by thermal energy of diffusing molecules.
- Net transport from high to low concentration.
- **No ATP required.**
- *Ex:* Glucose transport.
  - Carrier protein binds to glucose, causing a conformational change.
  - **GLUT** (Glucose Transporters) isoforms:
    - *GLUT1*: Central nervous system.
    - *GLUT2*: Pancreatic beta cells, liver hepatocytes.
    - *GLUT3*: Neurons.
    - *GLUT4*: In unstimulated muscles, found in cytoplasmic vesicles; exercise/insulin causes fusion with plasma membrane.
  - Glucose cannot use simple diffusion due to size and hydrophobic tails.

### 3.9. Active Transport

- Moves molecules *against* their concentration gradient (low to high).
- **Requires ATP expenditure.**
- Often performed by *pumps*.

#### 3.9.1. Primary Active Transport

- Hydrolysis of ATP *directly* powers carrier protein function.
- Transport protein is also an ATPase enzyme.
- Pump activated by phosphorylation (*P<sub>i</sub>* from ATP).

#### 3.9.2. The Ca<sup>2+</sup> Pump

- Located on all cell plasma membranes (PM) and endoplasmic reticulum (ER) of striated muscle cells.
- Removes Ca<sup>2+</sup> from cytoplasm (pumping to extracellular fluid or ER cisternae).
- Creates a strong concentration gradient for rapid Ca<sup>2+</sup> movement back into the cell (important for signals).
- Aids in neurotransmitter release and muscle contraction.

#### 3.9.3. Na<sup>+</sup>/K<sup>+</sup> Pump

- Found in all body cells.
- ATPase enzyme pumps **3 Na<sup>+</sup> out** of the cell and **2 K<sup>+</sup> into** the cell.
- **Functions of the steep Na<sup>+</sup>/K<sup>+</sup> gradient:**
  - 1. Provides energy for coupled transport of other molecules.
  - 2. Produces electrochemical impulses in neuron and muscle cells (including heart).
  - 3. Maintains osmolality (prevents osmotic inflow of water and cell damage due to increased intracellular Na<sup>+</sup>).



NURSING TEAM

# 4. The Membrane Potential

## 4.1. Unequal Charge Distribution Across Plasma Membrane

- Due to:
  - Permeability properties of PM.
  - Action of Na<sup>+</sup>/K<sup>+</sup> pumps.
  - Negatively charged molecules inside the cell.
- **Potential Difference:** This charge difference, making the inside of the cell negative compared to the outside.
  - Cellular proteins, ATP phosphate groups, other organic molecules are negatively charged at cell pH.
- **Fixed Anions:** Negative ions (anions) are "fixed" inside the cell (cannot penetrate PM).
  - Attract positive inorganic ions (cations: K<sup>+</sup>, Na<sup>+</sup>, Ca<sup>++</sup>) from extracellular fluid through ion channels.
  - Influence cation distribution between compartments.

## 4.2. Membrane Potential: K<sup>+</sup>

- K<sup>+</sup> accumulates inside the cell due to:
  - Na<sup>+</sup>/K<sup>+</sup> pumps actively bringing K<sup>+</sup> in.
  - Membrane is very permeable to K<sup>+</sup>.
  - Negative anions inside attracting cations.
  - Limited by strong concentration gradient.
- Inside K<sup>+</sup> concentration: **150 mEq/L**; Outside: **5 mEq/L**.

## 4.3. Equilibrium Potentials

- Membrane is more permeable to K<sup>+</sup>, so K<sup>+</sup> concentration gradient largely determines membrane potential.
- Cell is more negative inside than outside.
- **K<sup>+</sup> Equilibrium Potential (E<sub>K<sup>+</sup></sub>):** Electrical attraction pulling K<sup>+</sup> in balances the concentration gradient pushing K<sup>+</sup> out.
  - More K<sup>+</sup> inside than outside at equilibrium.
  - Measured at **-90mV**.
  - This is the voltage needed to maintain 150 mM K<sup>+</sup> inside and 5 mM K<sup>+</sup> outside.

## 4.4. Na<sup>+</sup> Equilibrium

- Na<sup>+</sup> is also important for membrane potential.
- Na<sup>+</sup> concentration: **12mM inside, 145mM outside**.
- To keep Na<sup>+</sup> out, the inside would need to be positive to repel it.
- **Na<sup>+</sup> Equilibrium Potential (E<sub>Na<sup>+</sup></sub>): +66mV**.
- Membrane is less permeable to Na<sup>+</sup>, so actual membrane potential is closer to E<sub>K<sup>+</sup></sub>.

## 4.5. Resting Membrane Potential (RMP)

- **Definition:** Membrane potential of a cell not producing impulses.
- **Depends on:**
  - Ratio of ion concentrations ( $K^+$ ,  $Na^+$ ,  $Ca^{2+}$ ,  $Cl^-$ ) on either side of the membrane.
  - Specific permeability to each ion.
- If only permeable to  $Na^+$ , RMP = +66mV. If only permeable to  $K^+$ , RMP = -90mV.
- In most cells, RMP is between **-65mV** and **-85mV**.
  - Neuron RMP is usually **-70mV** (close to  $E_{K^+}$ ).
- Because the membrane is most permeable to  $K^+$ , it has the greatest influence.
- Changes in membrane permeability or ion concentrations alter RMP.
- Some  $Na^+$  leaks in, so RMP is not as negative as  $E_{K^+}$ .

## 4.6. Role of $Na^+/K^+$ Pump in RMP

- Counters  $K^+$  leaking out and  $Na^+$  leaking in at resting potential.
- Transports **2  $K^+$  in** for every **3  $Na^+$  out** to maintain voltage difference.
- Contributes to negative intracellular charge (*electrogenic effect*).
- Keeps RMP and concentration differences stable.



## 5. Introduction to the Nervous System

### 5.1. Divisions

- **Central Nervous System (CNS):** Brain and spinal cord.
  - Receives sensory input, directs motor output.
  - Association neurons integrate sensory stimuli with motor responses, maintain homeostasis.
  - Perceptions, learning, memory, emotions, self-awareness originate here.
- **Peripheral Nervous System (PNS):** Cranial nerves (from brain) and spinal nerves (from spinal cord).

### 5.2. Nervous Tissue Cells

- **Neurons:** Conduct impulses; generally cannot divide.
- **Glial Cells (Neuroglia):** Support neurons; cannot conduct impulses but *can divide*.

### 5.3. General Structure of Neurons

- Vary in size/shape, but all have:
  1. **Cell Body (Soma):** Contains nucleus, *Nissl bodies* (large stacks of rough ER for membrane protein synthesis).
  2. **Dendrites:** Receive impulses, conduct *graded impulses* (local events) toward the cell body.
  3. **Axon:** Conducts *action potentials* away from the cell body.
    - Vary in length (few mm to 1 meter).
    - Connected to cell body by *axon hillock*.
    - Covered in *myelin* (insulating sheath) with open spots called *nodes of Ranvier*.

## 5.4. Functional Classification of Neurons

- **Sensory (Afferent) Neurons:** Conduct impulses from sensory receptors to the CNS.
- **Motor (Efferent) Neurons:** Conduct impulses from CNS to target organs (muscles/glands).
  - **Somatic Motor Neurons:** Reflexes and voluntary control of skeletal muscles.
  - **Autonomic Motor Neurons:** Innervate involuntary targets (smooth muscle, cardiac muscle, glands).
    - *Sympathetic:* Emergency situations ("fight or flight").
    - *Parasympathetic:* Normal functions ("rest and digest").
- **Association/Interneurons:** Located entirely within the CNS; integrate nervous system functions.

## 5.5. Classification of Nerves

- **Nerve:** Bundle of axons located *outside* the CNS (in PNS).
- **Tract:** Bundle of axons in the CNS.
- Most nerves are *mixed nerves* (contain both sensory and motor neurons).
- Some cranial nerves are *sensory only* (sight, hearing, smell).

## 5.6. Electrical Activity in Axons: Resting Membrane Potential

- Neurons RMP: **-70mV**.
- Established by:
  - Large negative molecules inside the cell.
  - Na<sup>+</sup>/K<sup>+</sup> pumps.
  - Membrane permeability to positively charged inorganic ions.
- At rest: High K<sup>+</sup> inside, high Na<sup>+</sup> outside.

## 5.7. Altering Membrane Potential

- Neurons and muscle cells can change membrane potentials (excitability/irritability) in response to stimulation.
- Caused by changes in ion permeability.
- Ions follow their *electrochemical gradient* (concentration gradient + attraction to opposite charges).
- Flow of ions = *ion currents*, occurring in limited areas with ion channels.
- **Polarized:** Neuron at rest, inside more negative than outside.
- **Depolarization:** Membrane potential inside cell becomes *more positive* (e.g., Na<sup>+</sup> entry).
  - Excitatory.
- **Repolarization:** Return to resting potential.
- **Hyperpolarization:** Membrane potential inside cell becomes *more negative* (e.g., K<sup>+</sup> leaving or Cl<sup>-</sup> entering).
  - Inhibitory.



## 5.8. Ion Gating in Axons

- Changes in membrane potential controlled by ion flow through channels.
- **K<sup>+</sup> Channels:**
  - *Not gated (leakage channels):* Always open.
  - *Voltage-gated K<sup>+</sup> channels:* Open when specific membrane potential reached; closed at rest.
- **Na<sup>+</sup> Channels:**
  - *Voltage-gated Na<sup>+</sup> channels:* Closed at rest; membrane less permeable to Na<sup>+</sup> at rest.

## 5.9. Voltage-Gated Na<sup>+</sup> Channels

- Closed at rest.
- Open if membrane depolarizes to **-55mV** (the *threshold*).
- Na<sup>+</sup> rushes in due to electrochemical gradient, membrane potential climbs toward E<sub>Na<sup>+</sup></sub>.
- Become inactivated at **+30mV**.

## 5.10. Voltage-Gated K<sup>+</sup> Channels

- Open around **+30mV**.
- K<sup>+</sup> rushes out of the cell, following electrochemical gradient.
- Causes cell to repolarize back toward E<sub>K<sup>+</sup></sub>.

## 5.11. Action Potentials (Nerve Impulse)

1. **Threshold (-55mV):** Voltage-gated Na<sup>+</sup> channels open, Na<sup>+</sup> rushes in.
    - Positive feedback loop: More depolarization opens more Na<sup>+</sup> channels.
    - Rapid depolarization to 0mV, then overshoot to **+30mV**.
  2. **Peak (+30mV):** Na<sup>+</sup> channels inactivate, voltage-gated K<sup>+</sup> channels open.
    - Negative feedback loop: K<sup>+</sup> efflux causes repolarization.
  3. **After-Hyperpolarization:** Repolarization overshoots resting potential, reaching **-85mV** due to continued K<sup>+</sup> outward movement.
    - Doesn't reach E<sub>K<sup>+</sup></sub> because K<sup>+</sup> channels inactivate as potential falls.
    - Na<sup>+</sup>/K<sup>+</sup> pumps quickly reestablish resting potential.
- Duration: **(-70mV → +30mV → -85mV) = 3 msec**.

## 5.12. All-or-None Law

- Once threshold is reached, an action potential *will* occur.
- Stimulus size does *not* affect action potential size (**always reaches +30mV**) or duration.

## 5.13. Coding for Stimulus Intensity

- Stronger stimulus = *more frequent* identical action potentials (frequency modulation).
- Stronger stimulus may also activate *more axons* in a nerve (recruitment).
- Stimulus strength coded by **frequency**, not amplitude.

## 5.14. Refractory Periods

- Limit action potential frequency.
- **Absolute Refractory Period:** During action potential; neuron cannot be excited again (Na<sup>+</sup> channels inactive).
- **Relative Refractory Period:** K<sup>+</sup> channels still open; only a very strong stimulus can overcome it.
- Each action potential is a separate, all-or-none event.

## 5.15. Cable Properties of Neurons

- Ability of neurons to conduct charges through cytoplasm is poor (high internal resistance, charge leakage).
- Neurons cannot rely solely on cable properties for impulse conduction over long distances.

## 5.16. Conduction of Nerve Impulses

- Action potential at one point opens voltage-gated Na<sup>+</sup> channels, depolarizing the next region.
- **Unmyelinated Neurons:**
  - Action potentials produced down entire length of axon at every membrane patch.
  - Conduction rate is *slow* due to many individual action potentials.
  - Amplitude is constant (conducted without decrement).
- **Action Potential Conduction Speed Increased by:**
  1. **Increased diameter** of neuron (reduces resistance).
  2. **Myelination** (due to *saltatory conduction*).

Ex: Thin, unmyelinated: **1.0 m/sec**; Thick, myelinated: **100 m/sec**.

## 5.17. The Synapse

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- **Definition:** Functional connection between a neuron and its target cell.
- **CNS:** Neuron to another neuron.
- **PNS:** Neuron to muscle or gland (*myoneural* or *neuromuscular junctions*).
- **Presynaptic Neuron:** Signals the postsynaptic neuron.
- **Postsynaptic Neuron:** Receives signal.
- **Synaptic Types:**
  - *Axodendritic:* Axon to dendrite (most common).
  - *Axosomatic:* Axon to cell body (soma).
  - *Axoaxonic:* Axon to another axon's synapse.
- Most synapses are *one-directional*.
- Can be electrical or chemical.

### 5.17.1. Electrical Synapses

- Occur in smooth/cardiac muscle, some brain neurons, glial cells.
- Cells joined by *gap junctions* (membranes **2 nanometers** apart).
- Ions and molecules pass directly between cells.
- Stimulation causes phosphorylation/dephosphorylation of *connexin proteins* to open/close channels.

## 5.17.2. Chemical Synapses

- Release of *neurotransmitter* from axon terminal boutons into a *synaptic cleft*.
- Presynaptic and postsynaptic cells held close by *cell adhesion molecules (CAMs)*.

## 5.17.3. Release of Neurotransmitter (Ca<sup>2+</sup> and Synaptic Vesicles)

1. Action potential reaches axon terminal.
2. Voltage-gated Ca<sup>2+</sup> channels open.
3. Ca<sup>2+</sup> stimulates fusion of *synaptic vesicles* (containing NT) with plasma membrane.
4. NT released via *exocytosis*.
5. Greater action potential frequency = more NT release.
6. Ca<sup>2+</sup> binds to *synaptotagmin* (Ca<sup>2+</sup> sensor).
7. Vesicles docked by three *SNARE proteins*.
8. Ca<sup>2+</sup>-synaptotagmin complex stimulates vesicle fusion, forming a pore to release NT.

## 5.17.4. Action of a Neurotransmitter

1. NT diffuses across synapse.
2. Binds to specific *receptor protein* on postsynaptic cell (NT is the *ligand*).
3. Binding opens/closes *chemically regulated ion channels* or activates *second messenger systems*.

## 5.17.5. Graded Potential

- Changes in membrane potential of chemically regulated ion channels.
- Opening Na<sup>+</sup> or Ca<sup>2+</sup> channels → *Excitatory Postsynaptic Potential (EPSP)* (graded depolarization, moves toward threshold).
- Opening K<sup>+</sup> or Cl<sup>-</sup> channels → *Inhibitory Postsynaptic Potential (IPSP)* (graded hyperpolarization, moves away from threshold).
- **EPSPs & IPSPs:**
  - EPSPs move membrane potential closer to threshold; multiple EPSPs may be needed (*summation*).
  - IPSPs move membrane potential farther from threshold; can counter EPSPs.
  - Summation of EPSPs and IPSPs at the *initial segment of the axon (axon hillock)* determines if action potential occurs.

## 5.18. Acetylcholine (ACh)

- Neurotransmitter that directly opens ion channels upon binding.
- Can be excitatory or inhibitory depending on the organ.
  - Excitatory: Some CNS areas, some autonomic motor neurons, *all somatic motor neurons*.
  - Inhibitory: Some autonomic motor neurons.
- **ACh Receptors:**
  - **Nicotinic ACh receptors:** Stimulated by nicotine. Found on *motor end plate of skeletal muscle cells*, autonomic ganglia, some CNS parts.
  - **Muscarinic ACh receptors:** Stimulated by muscarine. Found in CNS, plasma membrane of smooth/cardiac muscles, glands innervated by autonomic motor neurons.

## 5.19. Chemically Regulated Channels

- Most synapses are one-way, via NT release from *terminal boutons*.
- NTs open channels by binding to:
  - **Ligand-gated ion channels receptors.**
  - **G-protein coupled receptors.**

### 5.19.1. Ligand-Gated Channels

- Receptor protein *is* the ion channel; NT binding directly opens it.
- *Nicotinic ACh receptors* are ligand-gated, with two sites for ACh.
- Binding of **2 ACh molecules** opens a channel permeable to Na<sup>+</sup> and K<sup>+</sup>.
  - More Na<sup>+</sup> flows in than K<sup>+</sup> flows out (due to electrochemical gradient).
  - Inward Na<sup>+</sup> flow depolarizes the cell, creating an **EPSP**.
  - EPSPs occur in dendrites/cell bodies, are graded, and can summate to reach threshold at axon hillock.

### 5.19.2. G-Protein Coupled Channels

- NT receptor is *separate* from ion channel.
- Binding at receptor *indirectly* opens ion channels using a *G-protein*.
- *Muscarinic ACh receptors*, dopamine, norepinephrine receptors.
- **G-protein mechanism:**
  - 1. G-protein has three subunits (alpha, beta, gamma).
  - 2. NT binding causes dissociation of alpha subunit.
  - 3. Alpha or beta-gamma subunit diffuses to ion channel.
  - 4. Opens channel for a short period.
  - 5. Subunits dissociate, channel closes.
- ACh can open K<sup>+</sup> channels (IPSP) or close K<sup>+</sup> channels (EPSP).
  - *Heart*: Beta-gamma opens K<sup>+</sup> channels (IPSPs, slows heart rate).
  - *Stomach smooth muscle*: Alpha subunit closes K<sup>+</sup> channels (EPSPs, causes contraction).



## 5.20. Action of Acetylcholinesterase (AChE)

- Enzyme that inactivates ACh activity shortly after binding to receptor.
- Hydrolyzes ACh into acetate and choline.
- Choline is taken back into presynaptic cell for reuse (reuptake).

## 6. Central Nervous System (CNS) - Brain Regions

### 6.1. Regions of the Brain

1. Cerebrum (cerebral hemispheres)
2. Diencephalon
3. Brain Stem
4. Cerebellum

## 6.2. The Cerebrum (Cerebral Hemispheres)

- Derived from *telencephalon*.
- Largest portion (**80%** of brain mass).
- Responsible for *higher mental functions*.
- Right and left hemispheres connected by *corpus callosum* (large fiber tract).
- **Cerebral Cortex:** Outer region, **2-4 mm** gray matter with underlying white matter.
  - *Gyri*: Raised folds.
  - *Sulci*: Depressed grooves (together called *convolutions*).

### 6.2.1. Lobes of the Cerebrum

- Divided by deep sulci/fissures into 5 lobes:
  - **Frontal Lobe:** Front of brain.
    - Separated from parietal by *central sulcus*.
    - *Precentral gyrus*: Responsible for motor control (*primary motor cortex*).
  - **Parietal Lobe:** Middle section of brain.
    - *Postcentral gyrus*: Responsible for somesthetic sensation (skin, muscles, tendons, joints) (*somatosensory cortex*).
  - **Temporal Lobe:** Bottom section of brain.
    - Auditory centers (receives sensory fibers from cochlea).
  - **Occipital Lobe:** Back portion of brain.
    - Responsible for vision and eye movement coordination.
  - **Insula:** Hidden lobe.
    - Memory encoding, integration of sensory information with visceral responses.
    - Receives olfactory, taste, auditory, pain information.
    - Important in assessing bodily states accompanying emotions.

## 6.3. Diencephalon

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- Surrounded by cerebral hemispheres.
- Includes:
  - Epithalamus
  - Thalamus
  - Hypothalamus
  - Part of pituitary gland (posterior pituitary)
  - Third ventricle

### 6.3.1. Thalamus

- Forms most walls of third ventricle.
- **Geniculate nuclei:**
  - *Lateral geniculate nuclei*: Relays visual information to occipital lobe.
  - *Medial geniculate nuclei*: Relays auditory information to temporal lobes.
- **Intralaminar nuclei:** Promote arousal from sleep and alertness.

### 6.3.2. Epithalamus

- Dorsal segment of diencephalon.
- Contains *choroid plexus* (produces cerebrospinal fluid over third ventricle).
- Contains *pineal gland* (secretes melatonin for circadian rhythms).

### 6.3.3. Hypothalamus

- Most inferior portion of diencephalon, below thalamus.
- Forms floor and part of lateral walls of third ventricle.
- **Crucial for homeostasis and autonomic system regulation.**
- Contains centers for:
  - Hunger/satiety and thirst.
  - Body temperature regulation.
  - Sleep and wakefulness regulation.
  - Sexual arousal and performance.
  - Emotions (fear, anger, pain, pleasure).
  - Control of endocrine system.
  - Controls hormone secretion from pituitary gland.

### 6.4. Brain Stem

- Connects cerebrum to spinal cord.

#### 6.4.1. Midbrain

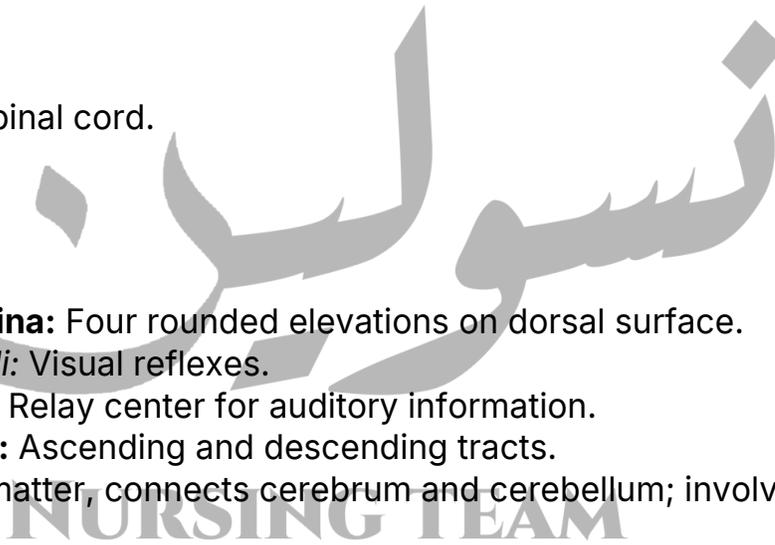
- Includes:
  - **Corpora quadrigemina:** Four rounded elevations on dorsal surface.
    - *Superior colliculi:* Visual reflexes.
    - *Inferior colliculi:* Relay center for auditory information.
  - **Cerebral peduncles:** Ascending and descending tracts.
  - **Red nucleus:** Gray matter, connects cerebrum and cerebellum; involved in motor coordination.

#### 6.4.2. Pons

- Houses sensory and motor tracts to/from spinal cord.
- Nuclei for cranial nerves V (trigeminal), VI (abducens), VII (facial), VIII (vestibulocochlear).
- Two respiratory control centers (cooperate with medulla oblongata to regulate breathing).
- Ventral pons damage can lead to *locked-in syndrome*.

#### 6.4.3. Medulla Oblongata

- All ascending and descending tracts pass through.
- Tracts cross sides (*decussation*) in the pyramids.
- Nuclei for Cranial nerves VIII, IX, X, XI, XII.
- Contains *vital centers* (for breathing and cardiovascular response):
  - **Vasomotor center:** Controls blood vessel diameter (autonomic innervation).
  - **Cardiac control center:** Controls heart rate (autonomic nerve control).
  - **Respiratory center:** Works with pons to control breathing.
- Also contains *reticular formation*.



## 6.5. Cerebellum

- Second largest brain structure.
- Gray matter outside, white matter inside.
- Receives input from *proprioceptors* (joints, tendons, muscles).
- Works with basal nuclei and motor cortex to coordinate movement.
- Needed for motor learning, proper timing and force of limb movements.
- Influences motor coordination via inhibition on motor cortex from *Purkinje cells*.
- May also have roles in sensory data acquisition, memory, emotion, and other higher functions.

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**NURSING TEAM**