

For BioResire students



Life sciences Material

Elite Batch

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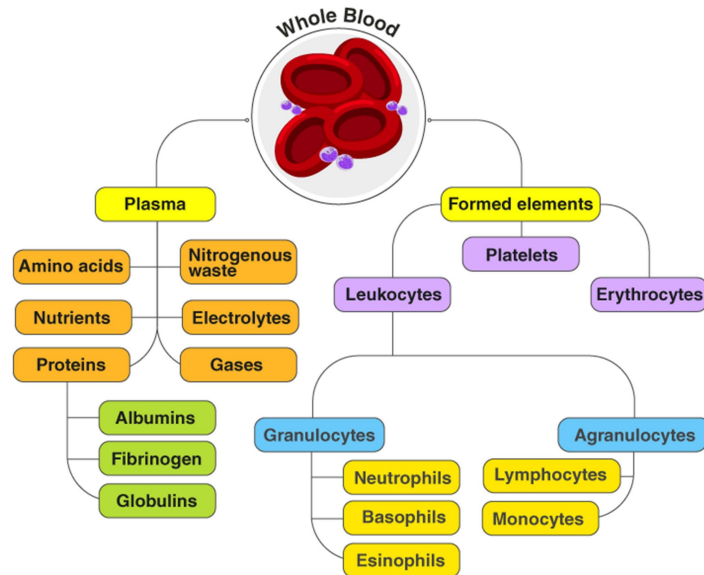
Physiology

Blood

A. Composition of Blood

Blood is a specialized bodily fluid that delivers necessary substances to cells and transports metabolic waste products away. It is composed of two main components:

- Plasma (55%): The liquid matrix. Contains water, electrolytes, nutrients, hormones, and waste products
- Key proteins:
 - ✓ Albumin: Maintains colloidal osmotic pressure.
 - ✓ Globulins: Alpha, Beta (transport), Gamma (immunoglobulins/antibodies).
 - ✓ Fibrinogen: Key protein for clotting.
- Formed Elements (45%):
 - Erythrocytes (RBCs): Biconcave, anucleate cells containing hemoglobin (Hb). Hb structure: 2 α & 2 β globin chains, each with a heme group (Fe^{2+} binds O_2).
 - Leukocytes (WBCs):
 - Granulocytes: Neutrophils (phagocytosis), Eosinophils (parasitic infections, allergies), Basophils (release histamine, heparin).
 - Agranulocytes: Lymphocytes (B-cells: antibody production; T-cells: cell-mediated immunity), Monocytes (mature into macrophages).
 - Thrombocytes (Platelets): Cell fragments derived from megakaryocytes; essential for clotting.



Blood Types (ABO and Rh System)

- **Principle:** Based on the presence or absence of inherited **antigens** on the surface of RBCs.
- **ABO System:** Determined by the presence of antigen A and/or antigen B.
- **Rh Factor:** Determined by the presence (+) or absence (-) of the Rh (D) antigen. Rh- individuals produce anti-Rh antibodies only after exposure to Rh+ blood (important in pregnancy).

YOUR VIRTUAL LABORATORY

ANTI-A	ANTI-B	ANTI-AB	Saline	Blood Group
+	O	+	O	A
O	+	+	O	B
+	+	+	O	AB
O	O	O	O	O

ANTI-D	Blood Group
+	D +ve
O	D -ve

+ = Agglutination. O = No agglutination.

Blood Coagulation (Clotting)

A complex cascade of events that prevents excessive blood loss from a damaged vessel.

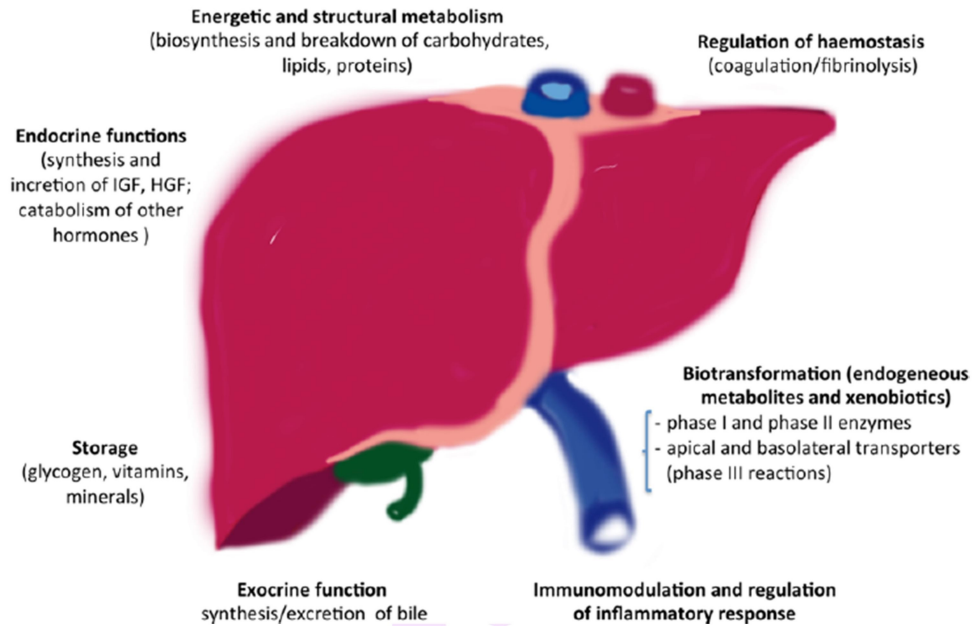
1. **Vascular Spasm:** Damaged blood vessels constrict immediately.

2. **Platelet Plug Formation:** Platelets adhere to the damaged site, become activated, and form a temporary plug.
3. **Coagulation (Clot Formation):** A cascade of clotting factors (proteins) leads to the conversion of **prothrombin** to **thrombin**. Thrombin then converts soluble **fibrinogen** into insoluble **fibrin** threads. These threads form a mesh that traps platelets and blood cells, forming a stable clot.
4. **Clot Retraction & Repair:** The clot pulls the wound edges together. Eventually, the clot is dissolved (fibrinolysis) after repair.

A. Major Organs: Structure & Function

i. The Liver

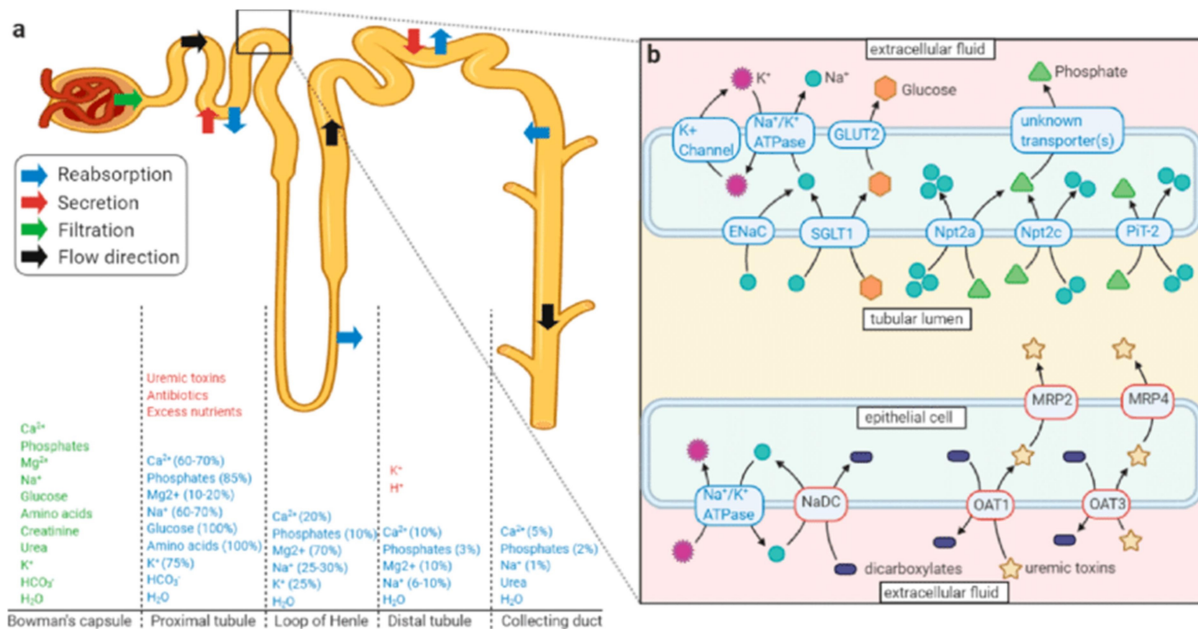
- **Structure:** Largest internal organ. Divided into two main lobes. Functional unit is the **lobule**, a hexagonal structure with a central vein and hepatocytes arranged in cords.
- **Key Functions:**
 - **Metabolism:** Regulates blood glucose (glycogenesis, glycogenolysis, gluconeogenesis).
 - **Detoxification:** Metabolizes drugs, alcohol, and harmful substances.
 - **Synthesis:** Produces **bile** (for fat digestion), plasma proteins (e.g., albumin, clotting factors).
 - **Storage:** Stores glycogen, vitamins (A, D, B12), and iron.



B. The Kidneys

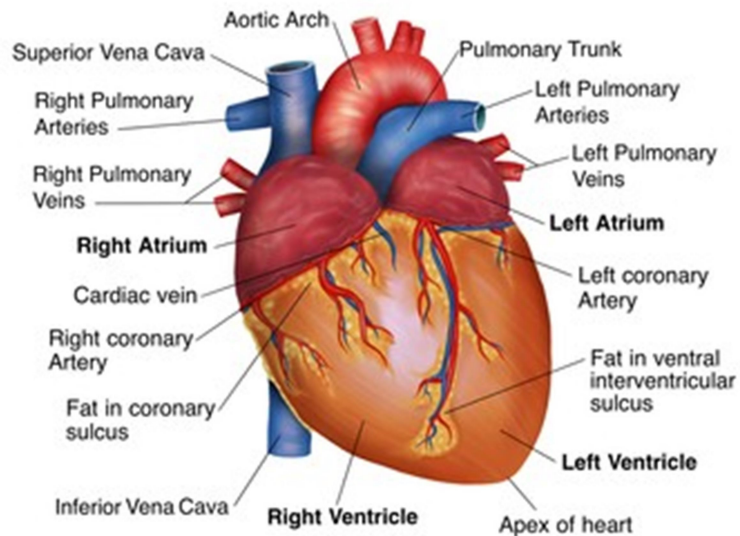
- **Structure:** Bean-shaped organs. Functional unit is the **nephron** (over 1 million per kidney). Each nephron consists of a **glomerulus** (ball of capillaries) and a **renal tubule**.
- **Key Functions (Process: Filtration -> Reabsorption -> Secretion -> Excretion):**
 - **Filtration:** Blood is filtered in the glomerulus to form **filtrate**.
 - **Reabsorption:** Essential substances (water, glucose, ions) are reabsorbed back into the blood from the tubule.
 - **Secretion:** Wastes (urea, drugs, excess H⁺ ions) are actively secreted from the blood into the tubule.
 - **Excretion:** The final product, **urine**, is excreted.
 - **Homeostasis:** Regulates blood volume, pressure, pH, and electrolyte balance (e.g., Na⁺, K⁺).
- **The Gut-Brain Axis:** The vagus nerve and gut hormones (e.g., ghrelin, GLP-1) create a bidirectional communication system between the gastrointestinal tract and the brain, influencing appetite, mood, and metabolism.

- **Renin-Angiotensin-Aldosterone System (RAAS):** A complex hormonal cascade that regulates blood pressure and fluid balance. Dysregulation is a major target for hypertension drugs (ACE inhibitors, ARBs).
- **Cardiac Electrophysiology:** The detailed ion channel dynamics (Na^+ , K^+ , Ca^{2+}) that generate the action potential in cardiomyocytes and the basis of arrhythmias.



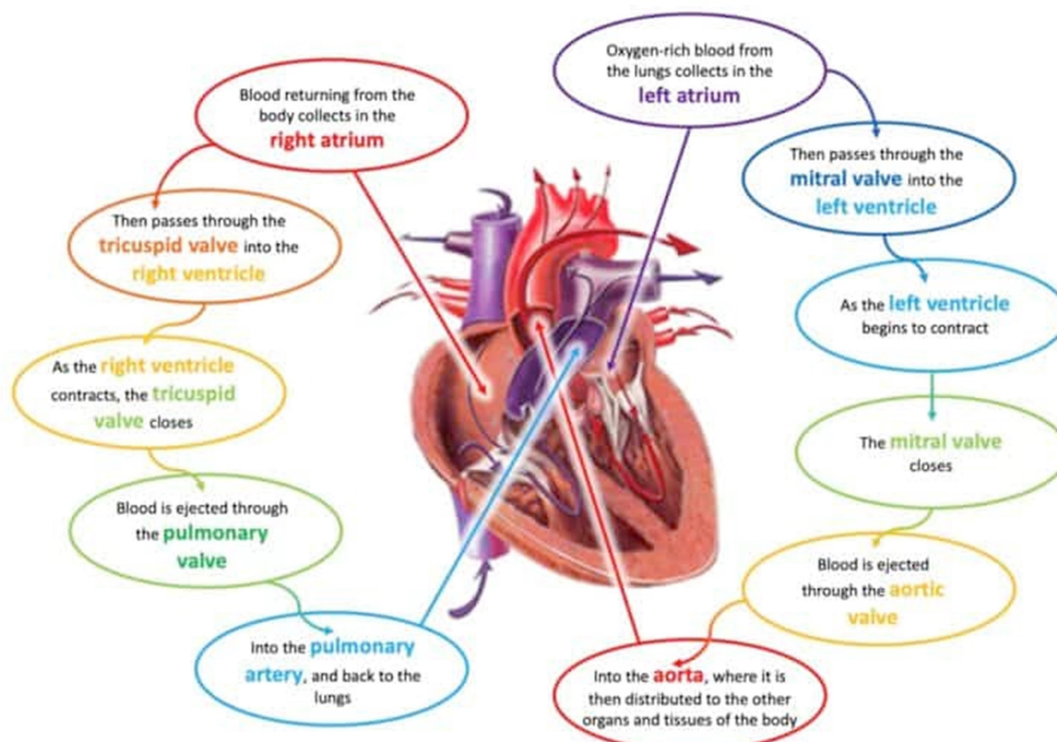
C. The Heart

- **Structure:** A muscular pump with four chambers.
 - **Atria (Left & Right):** Thin-walled upper chambers that *receive* blood.
 - **Ventricles (Left & Right):** Thick-walled lower chambers that *pump* blood out.
 - **Valves (AV and Semilunar):** Ensure one-way flow of blood.



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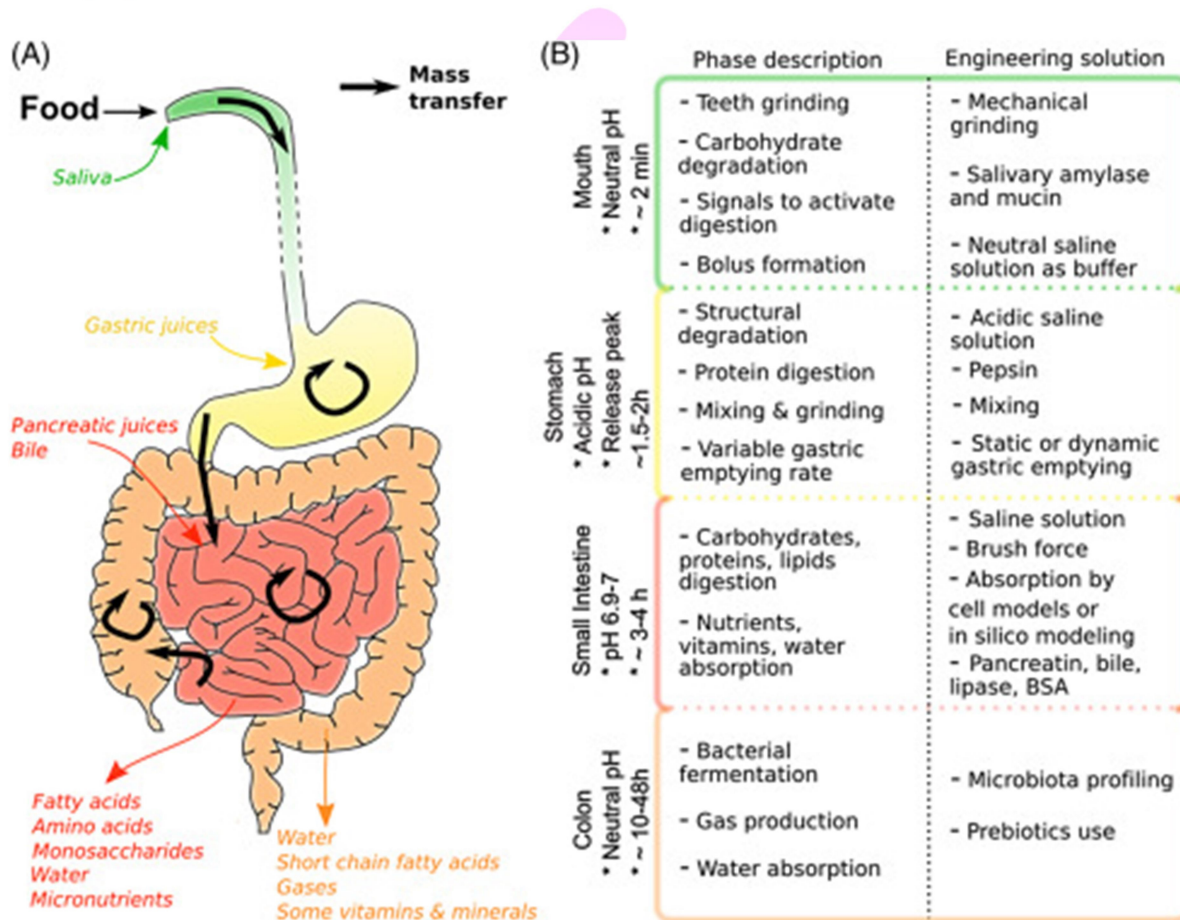
- **Key Function:** Powers the **circulatory system**.
 - **Right Side:** Pumps deoxygenated blood to the lungs (Pulmonary Circulation).
 - **Left Side:** Pumps oxygenated blood to the rest of the body (Systemic Circulation).



- **Cardiac Cycle:** The sequence of events in one heartbeat, involving systole (contraction) and diastole (relaxation).

3. Digestion and Absorption

- **Digestion:** The mechanical and chemical breakdown of food into absorbable molecules.
- **Absorption:** The uptake of these molecules from the digestive tract into the blood or lymph.



1. Endocrinology

Principle: The study of hormones (chemical messengers) and the endocrine glands that secrete them directly into the bloodstream.

Function: Hormones regulate long-term processes like growth, development, metabolism, and reproduction.

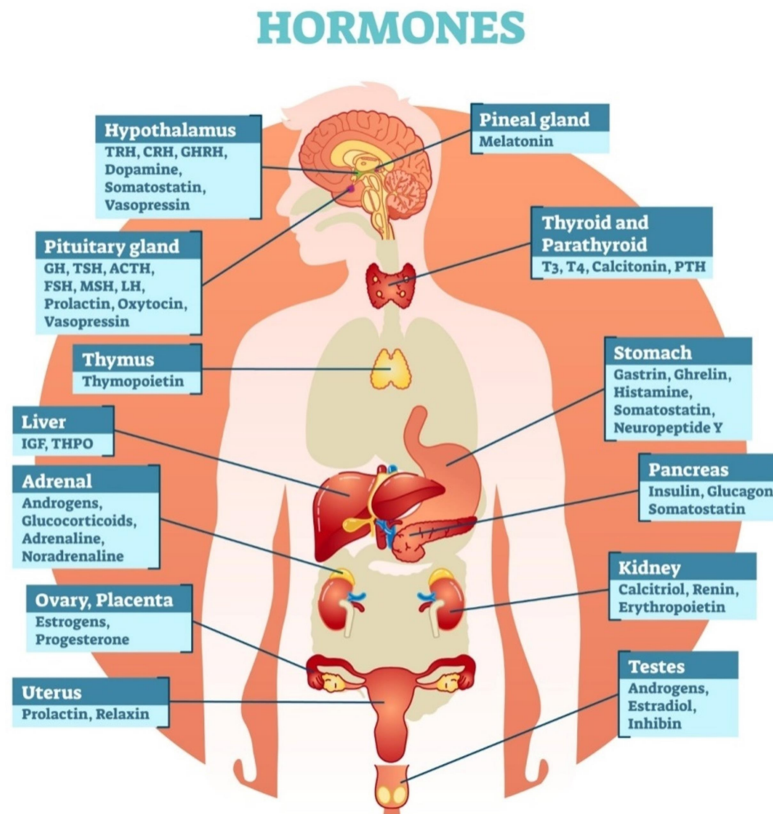








TABLE 10.2 Endocrine Glands, Hormones, and Their Target Tissues

Gland	Hormone	Target Tissue	Response	
Pituitary gland 	Anterior	Growth hormone	Most tissues	Increases gene expression, breakdown of lipids, and release of fatty acids from cells; increases blood glucose levels
		Thyroid-stimulating hormone (TSH)	Thyroid gland	Increases thyroid hormone secretion (thyroxine and triiodothyronine)
		Adrenocorticotropic hormone (ACTH)	Adrenal cortex	Increases secretion of glucocorticoid hormones, such as cortisol; increases skin pigmentation at high concentrations
		Melanocyte-stimulating hormone (MSH)	Melanocytes in skin	Increases melanin production in melanocytes to make skin darker in color
		Luteinizing hormone (LH) or interstitial cell-stimulating hormone (ICSH)	Ovary in females, testis in males	Promotes ovulation and progesterone production in ovary; promotes testosterone synthesis and support for sperm cell production in testis
		Follicle-stimulating hormone (FSH)	Follicles in ovary in females, seminiferous tubules in males	Promotes follicle maturation and estrogen secretion in ovary; promotes sperm cell production in testis
		Prolactin	Ovary and mammary gland in females, testis in males	Stimulates milk production and prolongs progesterone secretion following ovulation and during pregnancy in women; increases sensitivity to LH in males
	Posterior	Antidiuretic hormone (ADH)	Kidney	Conserves water; constricts blood vessels
		Oxytocin	Uterus	Increases uterine contractions
			Mammary gland	Increases milk letdown from mammary glands
Thyroid gland 	Thyroid hormones (thyroxine, triiodothyronine)	Most cells of the body	Increase metabolic rates, essential for normal process of growth and maturation	
	Calcitonin	Primarily bone	Decreases rate of bone breakdown; prevents large increase in blood Ca ²⁺ levels following a meal	
Parathyroid glands 	Parathyroid hormone	Bone, kidney	Increases rate of bone breakdown by osteoclasts; increases vitamin D synthesis, essential for maintenance of normal blood calcium levels	
Adrenal medulla 	Epinephrine mostly, some norepinephrine	Heart, blood vessels, liver, fat cells	Increases cardiac output; increases blood flow to skeletal muscles and heart; increases release of glucose and fatty acids into blood; in general, prepares body for physical activity	
Adrenal cortex 	Mineralocorticoids (aldosterone)	Kidneys; to lesser degree, intestine and sweat glands	Increase rate of sodium transport into body; increase rate of potassium excretion; secondarily favor water retention	
	Glucocorticoids (cortisol)	Most tissues (e.g., liver, fat, skeletal muscle, immune tissues)	Increase fat and protein breakdown; increase glucose synthesis from amino acids; increase blood nutrient levels; inhibit inflammation and immune response	
	Adrenal androgens	Most tissues	Insignificant in males; increase female sexual drive, growth of pubic and axillary hair	
Pancreas 	Insulin	Especially liver, skeletal muscle, adipose tissue	Increases uptake and use of glucose and amino acids	
	Glucagon	Primarily liver	Increases breakdown of glycogen and release of glucose into the circulatory system	


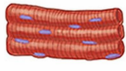
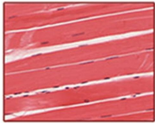

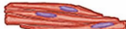


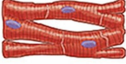
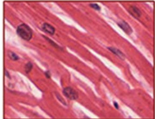
2. Muscle and Nervous System

A. Muscle Physiology

- **Function:** Movement, posture, heat production.

- **Types:**

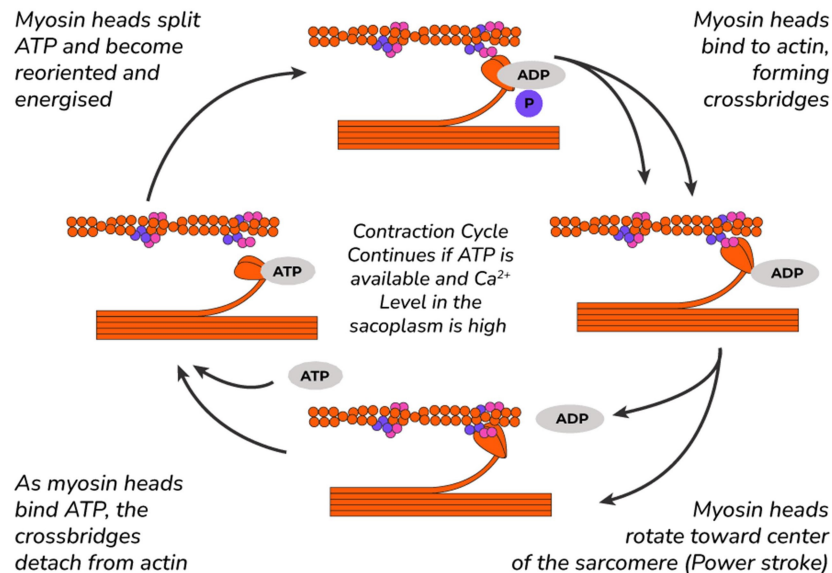
- **Skeletal Muscle:** Voluntary, striated, attached to bones.
- **Smooth Muscle:** Involuntary, non-striated, found in walls of hollow organs.
- **Cardiac Muscle:** Involuntary, striated, found only in the heart.

	Main features	Location	Type of cells	Histology
Skeletal muscle	- Fibers : striated, tubular and multi nucleated - Voluntary - Usually attached to skeleton			
Smooth muscle	- Fibers : non-striated, spindle-shaped, and uninucleated. - Involuntary - Usually covering wall of internal organs.			
Cardiac muscle	- Fibers : striated, branched and uninucleated. - Involuntary - Only covering walls of the heart.			

- **Mechanism of Contraction (Sliding Filament Theory):**

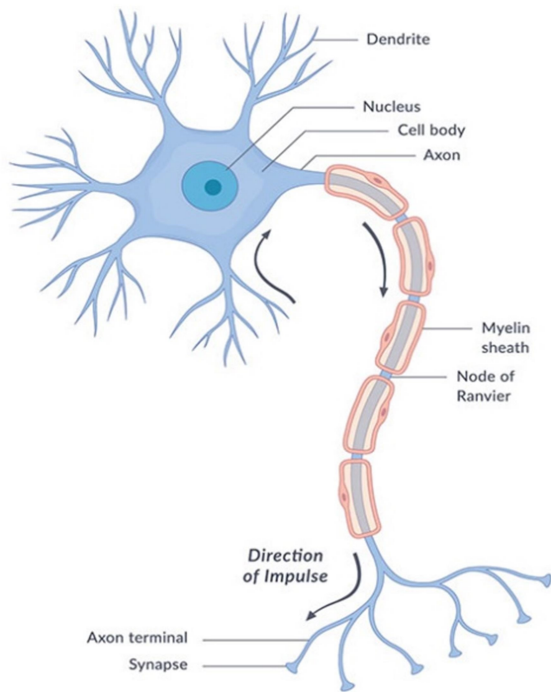
1. A nerve signal triggers the release of calcium.
2. Calcium binds to regulatory proteins, exposing myosin-binding sites on actin.
3. **Myosin heads** form cross-bridges with **actin** filaments and pull them, causing the sarcomere to shorten.
4. ATP provides the energy for this process.

Sliding Filament Theory

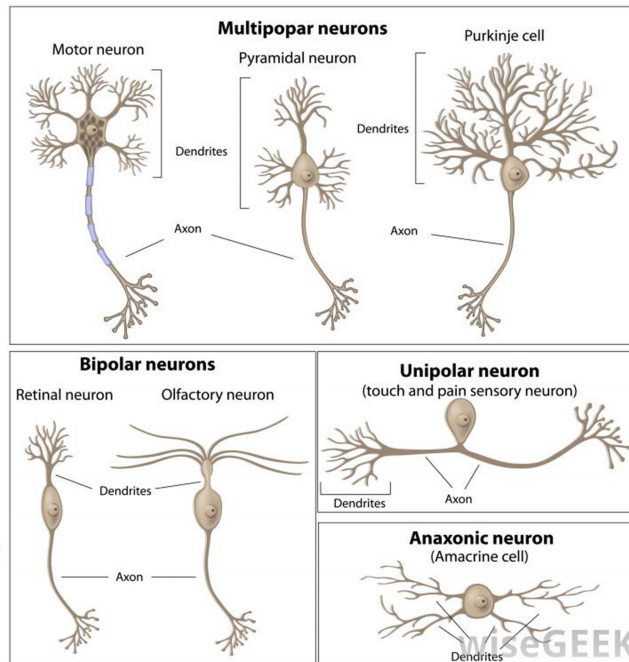


B. Nervous System

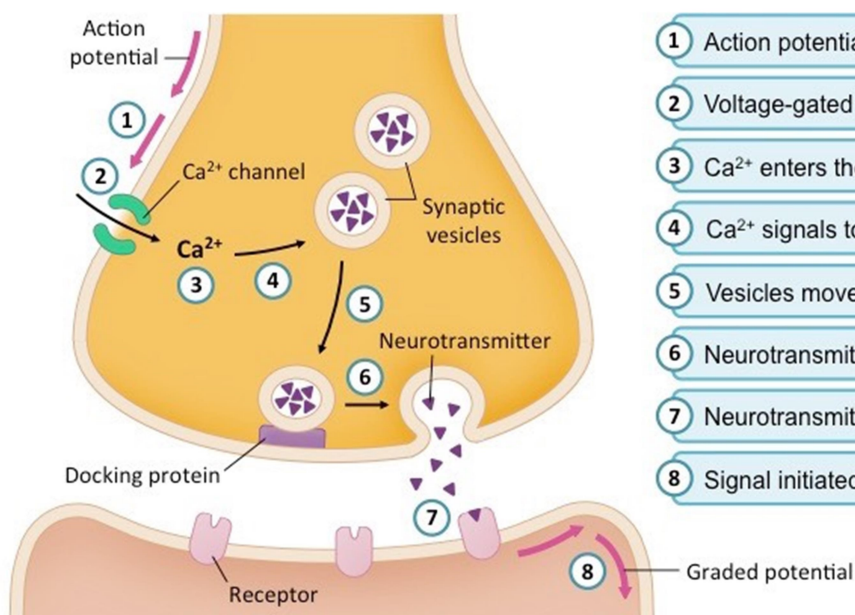
- **Function:** Rapid communication and control system using electrical and chemical signals.
- **Divisions:**
 - **Central Nervous System (CNS):** Brain and Spinal Cord (integration and command center).
 - **Peripheral Nervous System (PNS):** Nerves connecting CNS to the body.
- **Neuron (Nerve Cell) Structure:**
 - **Cell Body:** Contains the nucleus.
 - **Dendrites:** Receive signals from other neurons.
 - **Axon:** Transmits signals away from the cell body.



Types of Neurons



- **Nerve Impulse (Action Potential):** A self-propagating wave of electrical depolarization that travels along the axon.
- **Synapse:** The junction between two neurons. The electrical signal triggers the release of **neurotransmitters** (e.g., acetylcholine, dopamine) which cross the synaptic cleft to transmit the signal to the next neuron.



- 1 Action potential arrives at axon terminal
- 2 Voltage-gated Ca^{2+} channels open
- 3 Ca^{2+} enters the presynaptic neuron
- 4 Ca^{2+} signals to neurotransmitter vesicles
- 5 Vesicles move to the membrane and dock
- 6 Neurotransmitters released via exocytosis
- 7 Neurotransmitters bind to receptors
- 8 Signal initiated in postsynaptic cell

Action Potential: The Electrical Impulse of the Neuron

An **action potential** is a rapid, temporary reversal of the electrical voltage across the membrane of a neuron (or muscle cell). It is the fundamental unit of communication in the nervous system, propagating a signal along the axon from the cell body to the synaptic terminals.

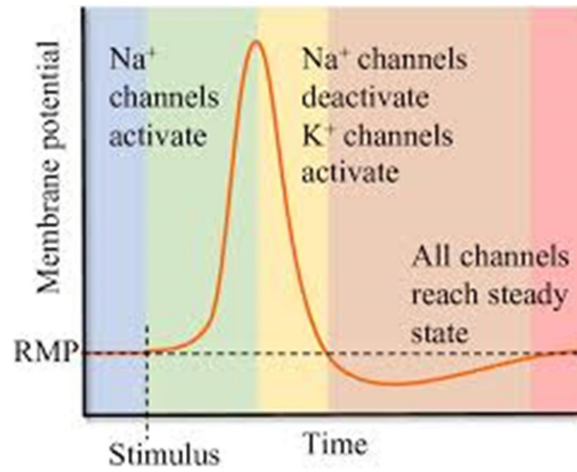
1. The Resting Membrane Potential (-70 mV)

Before an action potential occurs, the neuron is at rest.

- **Voltage:** The inside of the cell is about **-70 millivolts (mV)** relative to the outside. This negative charge is due to an unequal distribution of ions across the cell membrane.
- **Ionic Basis:**
 - There are more **Potassium ions (K⁺)** and large **negatively charged proteins (A⁻)** *inside* the cell.
 - There are more **Sodium ions (Na⁺)** and **Chloride ions (Cl⁻)** *outside* the cell.
- **The Sodium-Potassium Pump (Na⁺/K⁺ ATPase)** actively maintains this gradient by pumping 3 Na⁺ out for every 2 K⁺ it pumps in, using ATP.

2. The Phases of an Action Potential

The following graph illustrates the sequential phases of an action potential and the corresponding state of the ion channels: 



About us

BioResire (NEET | CSIR NET | Biotech Internships) is a life sciences research and training organization dedicated to bridging the gap between academic learning and industry skills. We provide internships, projects, and programs in Bioinformatics, Biotechnology, Molecular Biology, Cancer Research, Neuroscience, and related fields, helping students build job-oriented scientific careers.

"The future belongs to those who explore the unseen — where biology meets innovation and discovery begins."