General Science

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Table of Content

PART A: LIFE SCIENCES

Table of Content

PART B: CHEMICAL SCIENCE

Table of Content

Table of Content

PART D: MISCELLANEOUS TOPICS OF GENERAL SCIENCE

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Introduction to Biology

Biology is the scientific study of life and living organisms. The word is derived from the Greek words *bios* (life) and *logos* (study). It examines the structure, function, growth, origin, evolution and distribution of living things. The vast field of biology is divided into many specialized branches based on the subject of study, the type of organism, or the level of organization.

Core Disciplines (Based on the Type of Organism)

This classification divides biology based on the group of organisms being studied.

- **Zoology**: The study of **animals**, including their classification, physiology, development, and behavior.
  - *Example: Studying the life cycle of a butterfly or the anatomy of a frog.*
- **Botany**: The study of **plants**, including their physiology, structure, genetics, and ecology.
  - *Example: Investigating photosynthesis in leaves or the medicinal properties of herbs.*
- **Microbiology**: The study of **microorganisms** (bacteria, viruses, fungi, algae, and protozoa).
  - *Example: Researching antibiotic resistance in bacteria or the role of yeast in baking.*

Branches Based on the Area of Focus / Scope of Study

These branches apply to all types of organisms and are defined by their specific focus.

- **Morphology**: The study of the **form and structure** of organisms.
- **Anatomy**: The study of the **internal structure** of organisms, typically involving dissection.
- **Physiology**: The study of the **functions and processes** of living organisms and their parts.
- **Histology**: The study of the **microscopic structure of tissues**.
- **Cell Biology (Cytology)**: The study of **cells**, their physiological properties, structure, and organelles.
- **Genetics**: The study of **genes, genetic variation, and heredity** in living organisms.
- **Ecology**: The study of the **interactions** between organisms and their physical environment.

One-Liner Key Points

1. The **Scientific Method** is a systematic process used to investigate natural phenomena.
2. The first step is making an **observation** about the world.
3. A **hypothesis** is a testable proposed explanation, often written as an "If... then..." statement.
4. The **independent variable** is the factor that is deliberately changed in an experiment.
5. The **dependent variable** is the factor that is measured as a result of the change.
6. The **control group** serves as a baseline and is not exposed to the independent variable.
7. **Constants (controlled variables)** are all the factors that are kept the same in an experiment.
8. A hypothesis is never "proven"; it is either **supported** or **rejected** by the experimental data.
9. **Peer review** is the process where other scientists evaluate a research study before it is published.
10. A scientific **theory** is a well-supported explanation, while a **law** is a descriptive statement of what happens.
11. **Biology** is the scientific study of life and living organisms.
12. **Zoology** is the branch of biology that deals with the study of animals.
13. **Botany** is the branch of biology that deals with the study of plants.
14. **Microbiology** is the study of microorganisms like bacteria and viruses.
15. **Morphology** deals with the form and structure of an organism.
16. **Anatomy** is the study of the internal structure of an organism.
17. **Physiology** deals with the functions and processes of living organisms.
18. **Genetics** is the study of genes, heredity, and genetic variation.

Cellular Organization

Introduction to Cells

The **cell** is the basic structural and functional unit of all living organisms. This concept is formalized in the **Cell Theory**, which states:

1. All living things are composed of one or more cells.
2. The cell is the fundamental unit of life.
3. All cells arise from pre-existing cells.

Living organisms exhibit a hierarchy of structural organization, from simple to complex:

Cells → Tissues → Organs → Organ Systems → Organism.

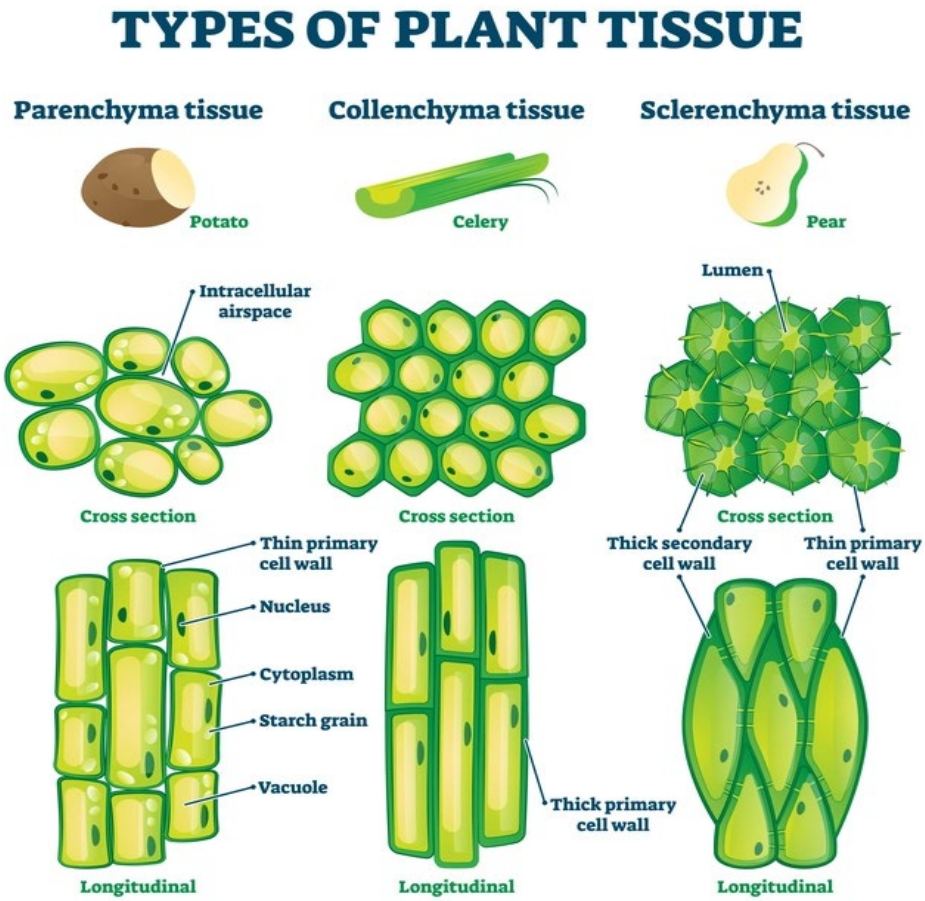
Unicellular vs. Multicellular Organisms

- **Unicellular Organisms**: A single cell performs all life processes (e.g., *Amoeba*, *Paramecium*, *Bacteria*).
- **Multicellular Organisms**: Composed of many cells that are specialized to perform specific functions (e.g., humans, plants, animals).

Cell Structure and Organelles

The internal components of a cell, known as organelles, perform specific life-sustaining functions.

Organelle	Structure	Function
Cell Membrane	Semi-permeable bilayer of **phospholipids and proteins**.	Regulates movement of substances in/out of cell (**selective barrier**).
Cell Wall (Plant only)	Rigid, fully permeable layer of **cellulose**.	Provides structural support and protection.
Nucleus	Double membrane (nuclear envelope)	Controls cell activities and stores genetic material; "Control Center."



Animal Tissues

- **Epithelial Tissue**: Covers body surfaces and lines organs. Functions: protection, secretion, absorption.
- **Muscle Tissue**: Responsible for movement.
    - **Skeletal Muscle**: Voluntary and striated; attached to bones.
    - **Cardiac Muscle**: Involuntary and striated; found only in the heart.
    - **Smooth Muscle**: Involuntary and non-striated; found in walls of internal organs.
- **Nervous Tissue**: Comprises **neurons** and supporting cells. Transmits electrical and chemical signals.
- **Connective Tissue**: Connects, supports, and separates other tissues. **Blood** and **bone** are examples.
    - **Blood**: A fluid connective tissue with **Plasma** (liquid matrix) and formed elements:
        - **Red Blood Cells (RBCs)**: Carry oxygen.

Variations, Heredity and Cell Division

Heredity

Heredity is the transmission of genetic characteristics from parents to offspring. This process explains why offspring share similarities with their parents. The scientific study of heredity is called **Genetics**.

Examples of **hereditary characteristics** include:

- Eye colour
- Skin colour
- Hair colour and type
- Blood group
- Earlobe attachment (free vs. attached)

These traits are controlled by **genes**, which are the basic physical and functional units of heredity. Genes are segments of DNA that carry the instructions for producing proteins, which in turn determine an organism's characteristics.

Difference between Adaptation and Variation

Variation

Variation refers to the differences in characteristics between individuals of the same species. It is the raw material for evolution and is crucial for the survival of a species in changing environments.

Sources of Variation:

Type of Variation	Cause	Examples	Heritable?
Genetic Variation	Changes in genes or chromosomes (e.g., mutation, recombination during meiosis).	Blood group, eye colour, genetic disorders.	**Yes**
Environmental Variation	Influence of the environment on an organism.	Language, accents, scars, acquired skills.	**No**

The **DNA** molecule is a double helix polymer made of repeating units called **nucleotides**. Each nucleotide consists of:

- A sugar (Deoxyribose)
- A phosphate group
- A nitrogenous base

The Four Nitrogenous Bases and Their Pairing:

Adenine (A) pairs with Thymine (T) via two hydrogen bonds.

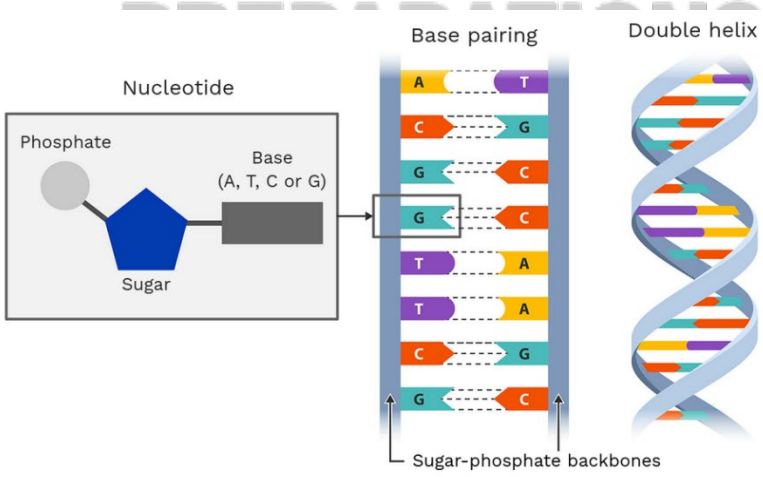
- **Cytosine (C) pairs with Guanine (G)** via three hydrogen bonds.

This specific **base-pairing rule (A-T, C-G)** is crucial for DNA replication and the accurate transmission of genetic information.

Transmission of Characters

Characters (traits) are transmitted from parents to offspring through sexual reproduction, which involves the formation and fusion of gametes.

1. **Meiosis** produces **haploid (n)** gametes in the reproductive organs, reducing the chromosome number by half.
2. During **fertilization**, a haploid sperm fuses with a haploid egg to form a **diploid (2n) zygote**.
3. The **zygote is the first cell of the new organism**. It contains a complete set of genetic instructions—half from the mother and half from the father—and undergoes mitotic divisions to develop into a full organism.



Biotechnology

Introduction

Biotechnology is the **application of biological systems, organisms, or derivatives** to develop or create different products and technologies. It is broadly defined as the **use of living cells and organisms** in processes that improve the **quality of human life**. This transformative discipline merges biology with technology to solve problems and create useful products. Its applications span **agriculture, health, food production, and environmental management**, with common examples in Pakistan including **bread, yogurt, cheese, vaccines, and insulin**.

Genetic Engineering

Genetic engineering is an advanced biotechnological technique that involves the **isolation, modification, and insertion of genes** from one organism into another. The organism that receives and expresses this foreign gene is called a **transgenic organism** or **Genetically Modified Organism (GMO)**.

Importance of Bacteria in Genetic Engineering

Bacteria, particularly *E. coli*, are the workhorses of genetic engineering due to:

- **Simple Structure:** They are **prokaryotes**, lacking a membrane-bound nucleus, with their single DNA chromosome floating in the cytoplasm.
- **Presence of Plasmids:** They contain small, circular, extra-chromosomal DNA molecules called **plasmids**. These act as perfect **vectors (carriers)** for foreign genes as they can be easily isolated, modified, and reintroduced.
- **Rapid Reproduction:** A bacterial cell can divide every 20 minutes under optimal conditions, enabling the quick production of a massive colony of genetically identical bacteria.

Process of Making a Transgenic Bacterium

The creation of a transgenic bacterium involves a series of precise steps, often referred to as the production of **recombinant DNA**.

1. **Isolation:** The desired gene is identified and cut out from the donor organism's DNA using **restriction enzymes** (molecular scissors).

Balanced Diet

Introduction to Balanced Diet

A **balanced diet** is a diet that contains the proper proportions and amounts of all essential nutrients—**carbohydrates, proteins, fats, vitamins, minerals, fibre, and water**—required by an individual to maintain health, support growth, and provide energy. **Nutrients** are the useful components in food that our bodies need for vital processes like growth, repair, reproduction, and protection from diseases. This chapter explores these nutrients, their functions, sources, and the consequences of their deficiency, emphasizing the critical link between diet and overall fitness.

Food Groups and Sources

The main sources of our food are **plants** (e.g., wheat, rice, vegetables, fruits) and **animals** (e.g., fish, meat, eggs, milk). Based on their primary nutritional value, foods are classified into the following groups.

Carbohydrates

Carbohydrates are the body's primary and quickest source of energy, functioning as its main fuel. They are composed of carbon, hydrogen, and oxygen.

- **Sources:** Glucose, sugar, starch, honey, fruits, milk, wheat, rice, barley, potatoes, and bread.
- **Digestion and Use:** In the digestive system, complex carbohydrates (like starch) are broken down into simple sugars, primarily **glucose**. Glucose is absorbed into the blood through the walls of the **small intestine** and transported to cells. Inside the **mitochondria**, glucose undergoes oxidation in the presence of oxygen to release energy, carbon dioxide, and water.
- **Energy Yield:** Provides approximately **4 kcal/gram**.

Proteins

Proteins are known as the building blocks of the body. They are essential for growth, the repair of tissues, reproduction, and the synthesis of vital substances like enzymes, hormones, and antibodies. They are composed of carbon, hydrogen, oxygen, and nitrogen (some also contain sulfur).

- **Sources:** Meat, eggs, fish, pulses, milk, chicken, nuts, beans, and peas.
- **Digestion and Use:** Complex protein molecules are broken down into simpler units called **amino acids** in the small intestine. These amino acids are absorbed into the blood

C	Citrus fruits, guava, broccoli, strawberry	Essential for healthy skin, gums, and healing; deficiency causes **scurvy** (swollen/bleeding gums).
D	Sunlight, milk, cod liver oil, fatty fish	Helps in calcium absorption for strong bones and teeth; deficiency causes **Rickets** in children and **Osteomalacia** in adults.
E	Eggs, nuts, seeds, vegetable oils	Acts as an antioxidant; keeps muscles and nerves healthy.
K	Leafy green vegetables, milk, eggs, fish	Essential for **blood clotting**; deficiency leads to excessive bleeding.

Minerals

Minerals are inorganic nutrients needed for the formation of body tissues (bones, teeth, blood cells), fluid balance, and various metabolic functions.

Mineral	Sources	Functions & Deficiency Disorders
Calcium	Milk, cheese, green vegetables, eggs, fish	Makes **bones and teeth** strong; essential for muscle function, nerve signaling, and **blood clotting**. Deficiency can lead to osteoporosis.
Iron	Liver, red meat, eggs, dark green vegetables, legumes	Essential for making **haemoglobin** in red blood cells, which carries oxygen. Deficiency causes **Anemia** (fatigue, weakness).
Iodine	Iodized salt, seafood, dairy products	Essential for the production of thyroid hormones; deficiency causes **Goiter** (enlarged thyroid gland).
Potassium	Bananas, potatoes, citrus fruits, beans	Vital for nerve function, muscle control, and blood pressure regulation.
Sodium	Table salt, processed foods	Maintains fluid balance and nerve function. Excess can cause high blood pressure.

Fiber

Fiber, or **dietary roughage**, is a type of indigestible carbohydrate found in plant foods. It is not absorbed by the body but is crucial for digestive health.

- **Sources:** Fruits, vegetables, whole grains (brown rice, oats), and legumes.

DIGESTION

Digestion is the process by which large, complex, and insoluble food molecules are broken down into smaller, soluble, and diffusible molecules that can be absorbed across the intestinal wall into the bloodstream.

It involves two main processes:

Physical (Mechanical) Digestion

This is the mechanical breakdown of large food pieces into smaller ones, increasing the surface area for enzymatic action. It occurs through:

- **Chewing (Mastication):** In the oral cavity, using teeth and the tongue.
- **Churning:** In the stomach, by the muscular contractions of its walls.

Chemical Digestion

This involves the breakdown of complex, non-diffusible food molecules into simpler, diffusible ones using specific chemicals called **enzymes** and other secretions.

- **Enzymes:** These are biological catalysts, usually proteins, that speed up chemical reactions without being consumed in the process.

Human Digestive System: Components

The human digestive system consists of two primary components:

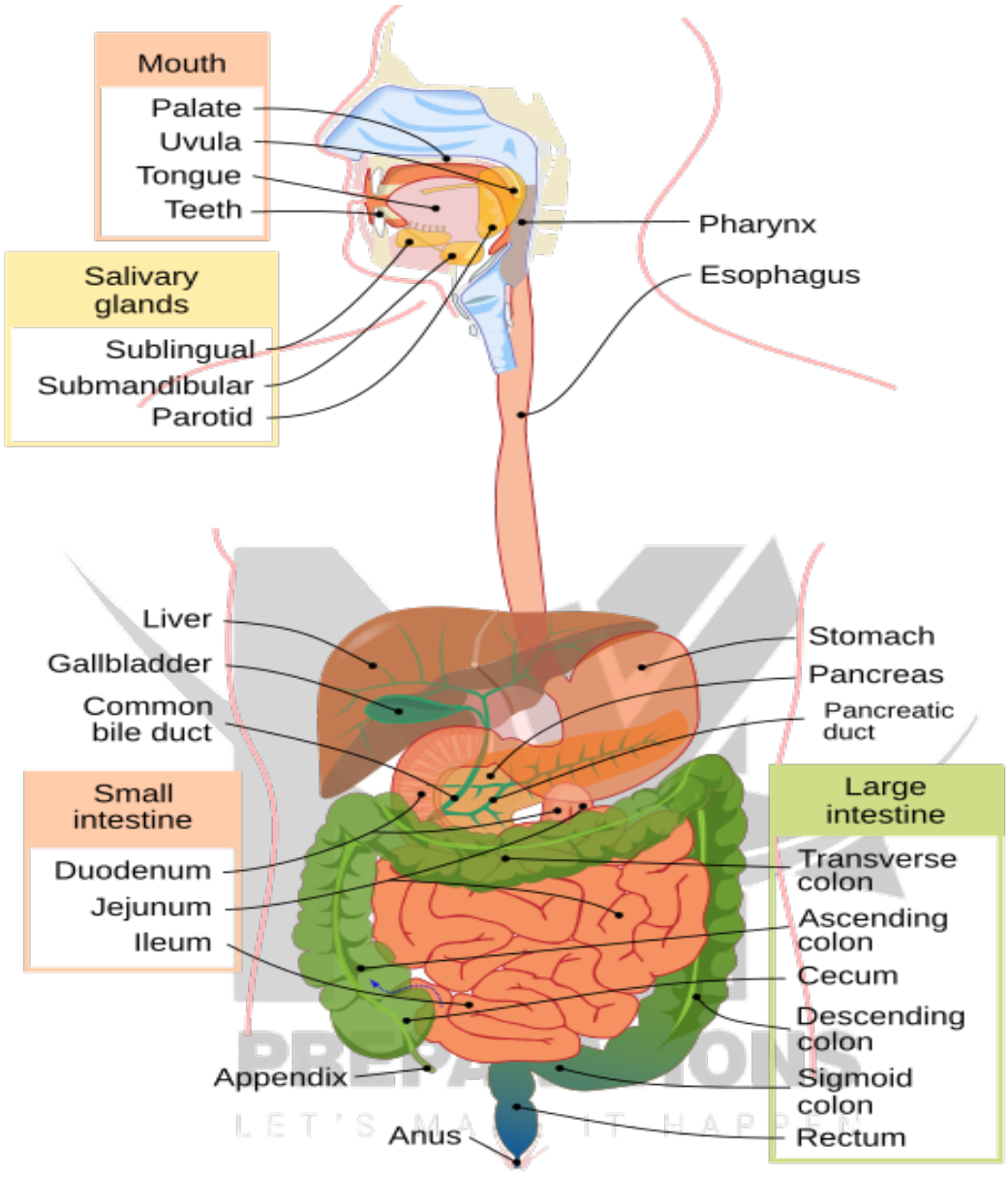
1. **Alimentary Canal (Gastrointestinal Tract):** A long, continuous, muscular tube running from the mouth to the anus.
2. **Digestive Glands:** Organs that secrete enzymes, acids, and other substances necessary for digestion.

Alimentary Canal

This is the pathway through which food passes. It is structured into specific organs, each with a unique function.

Oral Cavity (Mouth)

- **Function:** The site of **ingestion** and the beginning of both physical and chemical digestion.



DIGESTIVE GLANDS

These are specialized organs that secrete substances crucial for chemical digestion.

Gland	Secretion	Function
Salivary Glands	Saliva	Moistens food; contains **salivary amylase** to digest starch.

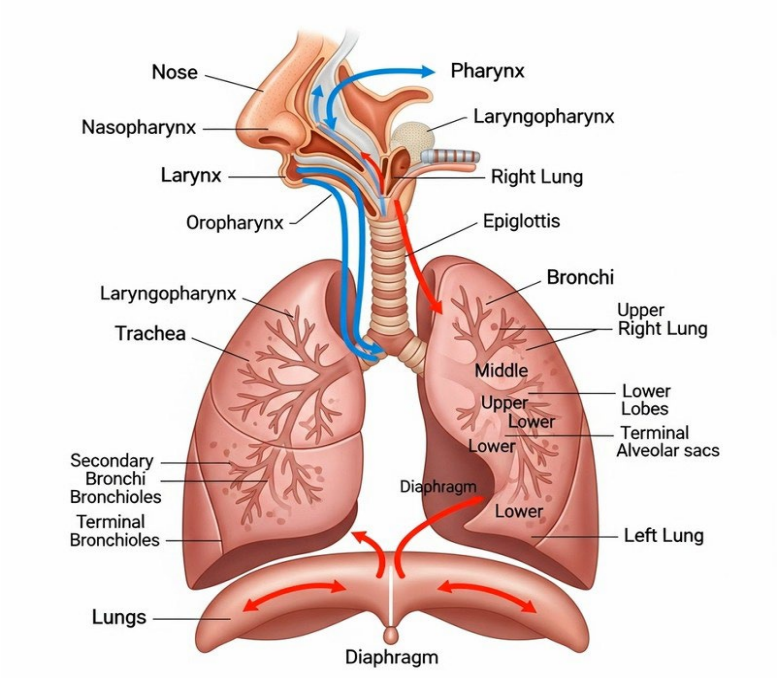
Human Respiratory and Circulatory Systems

Breathing

Definition: Breathing (or ventilation) is the mechanical process of inhaling and exhaling air, facilitating gas exchange.

Pathway of Air:

1. **Nostrils/Nasal Cavity:** Air enters. Hairs and mucus trap dust, pollen, and pathogens. The air is warmed and moistened.
2. **Pharynx:** A common passage for air and food.
3. **Larynx (Voice Box):** Contains vocal cords. The **epiglottis** acts as a flap to prevent food from entering the airway during swallowing.
4. **Trachea (Windpipe):** A tube lined with cilia and mucus-producing cells to trap and remove particles. It divides into two **bronchi**.
5. **Bronchi:** One bronchus leads to each lung, further branching into **bronchioles**.
6. **Bronchioles:** Fine tubes that end in clusters of **alveoli**.
7. **Alveoli:** Tiny, balloon-like air sacs surrounded by capillaries; the primary **site for gaseous exchange**.



Immunity and Diseases

Lines of Defense Against Pathogens

The human body employs multiple layers of defense to protect itself from disease-causing pathogens (microorganisms). These defenses are categorized into three main lines.

Physical Barriers

These form the **first line of defense**, preventing the entry of pathogens.

- **Skin:** The outer epidermis consists of dead, keratinized cells that are continuously shed, expelling pathogens. It contains **melanin**, a pigment that protects against harmful **Ultraviolet (UV) radiation**.
- **Mucous Membranes:** The moist linings of organs (e.g., respiratory tract, digestive tract, reproductive tract) produce **mucus**, which traps pathogens.
- **Nose Hairs & Cilia:** Filter dust, pollutants, and microbes from inhaled air. Cilia in the respiratory tract move mucus-trapped particles toward the throat to be swallowed or expelled.
- **Saliva & Stomach Acid: Saliva** has antiseptic properties and lysozyme enzymes. **Gastric juice** in the stomach contains hydrochloric acid, which kills most ingested pathogens.
- **Tears & Blinking:** Constantly flush and wipe away pathogens from the eyes; tears contain lysozyme.

Chemical Barriers

Body secretions create a hostile environment for microbes.

- **Skin Secretions: Sebum** (oil) and sweat create a slightly acidic film (pH 3-5) that inhibits bacterial growth.
- **Lysozyme:** An enzyme present in tears, saliva, sweat, and mucus that breaks down bacterial cell walls.
- **Stomach Acid: Hydrochloric acid** in the gastric juice effectively kills most pathogens entering through food and drink.

Nonspecific Defense (Innate Immunity)

This is a generalized **second line of defense** that acts against any foreign invader.

- **Phagocytosis:** A process where **phagocytes** (e.g., neutrophils, macrophages) ingest and destroy pathogens and cellular debris.

Human Nervous System

This chapter explains how the human body responds to environmental changes and how messages travel within the body. It covers the structure and function of the nervous system, types of neurons, parts of the brain, and how actions are controlled.

Nervous System

The nervous system is the body's master control, communication, and coordination network. It detects changes in the environment (stimuli), processes information, and coordinates voluntary and involuntary responses. It is primarily divided into two main parts:

- **Central Nervous System (CNS):** The command center.
- **Peripheral Nervous System (PNS):** The communication network.

Central Nervous System (CNS)
Composed of the **brain** and **spinal cord**. It integrates and processes information received from the PNS and sends out instructions.
Peripheral Nervous System (PNS)
A vast network of nerves that connects the CNS to the rest of the body. It is further subdivided:

- **Somatic Nervous System:** Controls voluntary movements (e.g., skeletal muscles).
- **Autonomic Nervous System:** Controls involuntary actions (e.g., heartbeat, digestion). It has two parts:
    - **Sympathetic:** Prepares the body for "fight or flight."
    - **Parasympathetic:** Promotes "rest and digest" activities.

The PNS includes:

- **Cranial Nerves:** 12 pairs of nerves emerging directly from the brain.
- **Spinal Nerves:** 31 pairs of nerves emerging from the spinal cord.

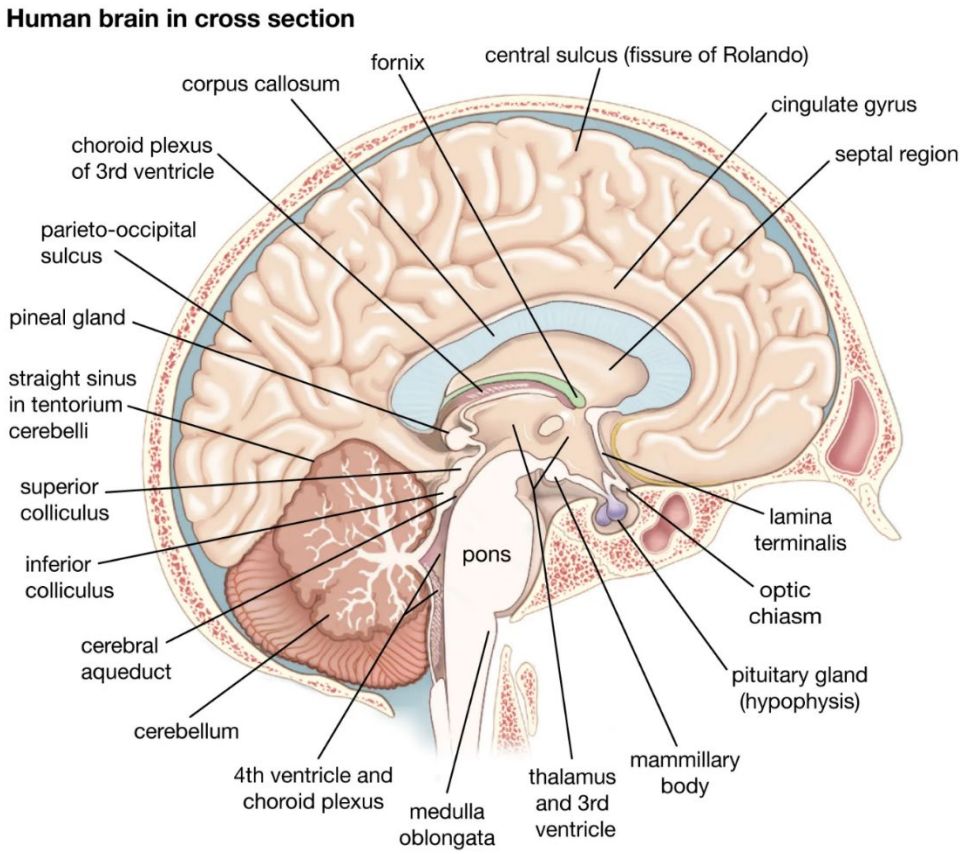
Neuron or Nerve Cell

The **neuron** is the basic structural and functional unit of the nervous system. It is specialized for the rapid transmission of messages in the form of **nerve impulses** (electrochemical signals).

Structure of a Neuron:

A. Brain

The brain is the main control center, protected by the skull (cranium) and three membranes called **meninges**. It is cushioned by **cerebrospinal fluid (CSF)**.



Major Part	Subparts & Functions
Forebrain	**Cerebrum:** Largest part; divided into **left & right hemispheres** connected by the **corpus callosum**. Controls **voluntary actions, intelligence, learning, memory, reasoning, and emotions.** **Thalamus:** Major relay station for sensory impulses (except smell) to the cerebrum. **Hypothalamus:** Master regulator of **homeostasis**; controls body temperature, hunger, thirst, and pituitary gland.
Midbrain	Acts as a bridge between the forebrain and hindbrain. Controls **visual and auditory reflexes, and sleep-wake cycles.**

Excretory System of Human

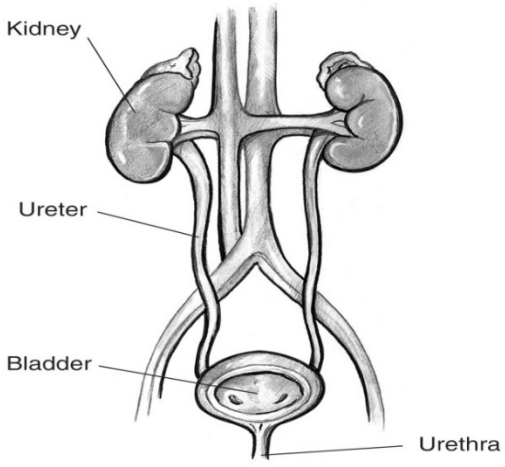
Introduction

The excretory system is a vital biological system responsible for **removing waste products of metabolism**, excess water, and salts from the body. Its primary function is to maintain **homeostasis**—the stable internal environment of the body—by regulating the chemical composition of blood. The main organs involved in this process are the **kidneys, ureters, urinary bladder, and urethra**. The system collectively produces, stores, and eliminates **urine**.

Main Organs and Their Functions

Kidneys

- **Location:** A pair of bean-shaped organs located on either side of the spine, just below the rib cage.
- **Function:**
  - **Filtration:** Filter nitrogenous wastes (like **urea** and **uric acid**), excess salts, and water from the blood to form urine.
  - **Osmoregulation:** Regulate the water and electrolyte balance in the body.
  - **Acid-Base Balance:** Maintain the pH of the blood.
  - **Blood Pressure Regulation:** Release the enzyme **renin** which helps control blood pressure.
  - **Erythropoiesis:** Secrete the hormone **erythropoietin**, which stimulates the production of red blood cells in the bone marrow.



Endocrine System of Human

Introduction

The endocrine system is a complex network of glands that produce and secrete **hormones** directly into the bloodstream. These hormones act as **chemical messengers**, regulating a wide range of physiological processes including growth, metabolism, reproduction, and mood. Unlike the nervous system, the effects of the endocrine system are slow but long-lasting. The major endocrine glands include the **pituitary, thyroid, parathyroid, adrenal, pancreas, pineal, and gonads (testes and ovaries)**.

Hormones: The Chemical Messengers

- **Definition:** Hormones are **chemical substances secreted by endocrine glands** into the blood, which carry them to target organs or tissues to exert a specific effect.
- **Classification:** They can be steroids (e.g., sex hormones), proteins (e.g., insulin), peptides, or derivatives of amino acids (e.g., thyroxine).
- **Function:** They regulate the body's activities by **stimulating or inhibiting** specific processes in target cells.

Major Endocrine Glands, Their Hormones, and Functions

Hypothalamus

- **Location:** In the brain, above the pituitary gland.
- **Function:** Acts as a link between the nervous and endocrine systems. It produces **releasing and inhibiting hormones** that control the pituitary gland.
- **Key Hormone: ADH (Antidiuretic Hormone)** and **Oxytocin** (these are stored and released by the posterior pituitary).

Pituitary Gland (The "Master Gland")

- **Location:** At the base of the brain, attached to the hypothalamus.
- **Function:** It controls the activities of many other endocrine glands. It is divided into the **Anterior** and **Posterior** lobes.

Thyroid Gland

- **Location:** In the neck, wrapped around the trachea.
- **Hormones: Thyroxine (T4)** and **Triiodothyronine (T3)**.

Reproductive System of Human

Introduction

The human reproductive system is a set of organs responsible for producing gametes (sperm in males, ova in females), facilitating fertilization, and, in females, supporting the development of a fetus. It is essential for the survival of the species. The systems are distinctly different in males and females but work together for reproduction.

Male Reproductive System

Parts and Functions

Testes

- **Location:** Housed in the **scrotum**, an external pouch that keeps the testes **2-3°C cooler** than the core body temperature, which is crucial for sperm production.
- **Function:**
  - **Spermatogenesis:** Production of male gametes, called **sperm**.
  - **Endocrine Function:** Secretion of the male sex hormone **testosterone**.

Epididymis

- **Location:** A highly coiled tube located on the back of each testis.
- **Function:** Stores sperm and allows them to mature and gain motility.

Vas Deferens

- **Description:** A long, muscular tube.
- **Function:** Transports mature sperm from the epididymis towards the urethra in preparation for ejaculation.

Accessory Glands

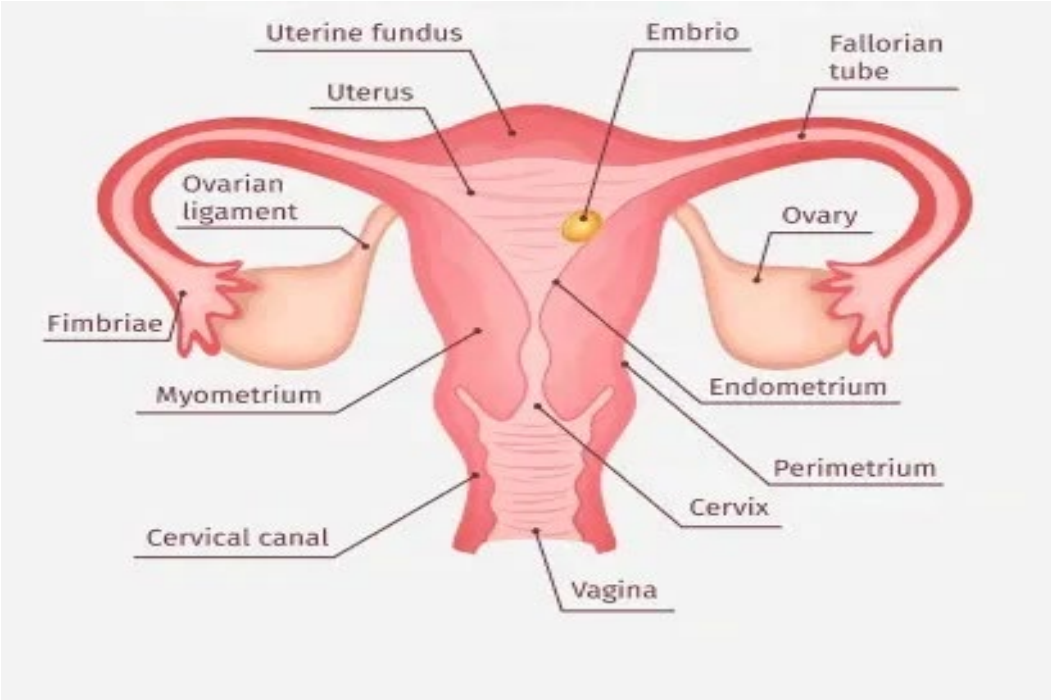
- **Seminal Vesicles:** Produce a fructose-rich fluid that provides energy for sperm motility.
- **Prostate Gland:** Produces a milky fluid that neutralizes the acidity of the vaginal tract.
- **Bulbourethral Glands (Cowper's Glands):** Produce a pre-ejaculate fluid that lubricates and cleanses the urethra.
- The combination of sperm and these fluids is called **semen**.

Cervix

- **Description:** The lower, narrow part of the uterus that opens into the vagina.
- **Function:** Produces mucus that helps sperm travel during ovulation and forms a protective plug during pregnancy.

Vagina

- **Description:** A muscular, elastic canal.
- **Function:** Receives the penis during intercourse and serves as the **birth canal**.



The Menstrual Cycle

A approximately **28-day** cycle that prepares the female body for pregnancy. It is regulated by hormones from the **pituitary gland (FSH, LH)** and the **ovary (Estrogen, Progesterone)**.

Key Phases:

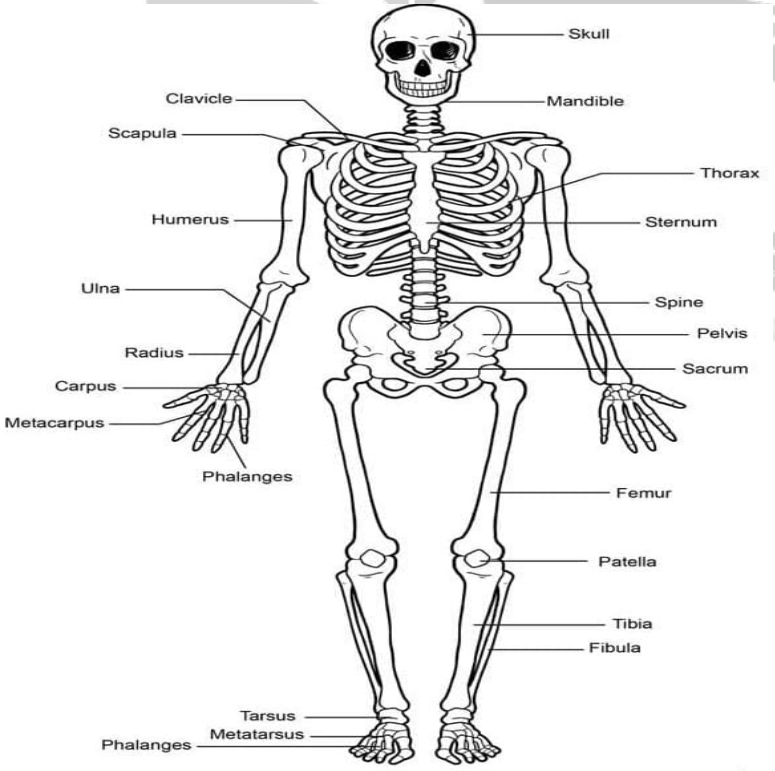
1. **Menstrual Phase (Days 1-5):** Breakdown and shedding of the endometrial lining, resulting in menstrual flow.
2. **Follicular Phase (Days 1-13): FSH** from the pituitary stimulates the development of an ovarian follicle, which produces **estrogen**. Estrogen rebuilds the endometrium.

Skeletal System of Human

The human skeletal system is the internal framework of the body. Composed of **bones, cartilage, ligaments, and tendons**, it provides structure, protection, and movement. An adult human body has **206 bones**. The skeletal system is dynamic and living, constantly undergoing remodeling throughout life.

Functions of the Skeletal System

- **Support:** Provides a rigid framework that supports the body and gives it shape.
- **Protection:** Protects delicate internal organs (e.g., the **skull** protects the brain, the **rib cage** protects the heart and lungs).
- **Movement:** Serves as points of attachment for skeletal muscles. Bones act as levers, converting muscular contractions into movement.
- **Mineral Storage:** Acts as a reservoir for minerals, chiefly **calcium** and **phosphorus**.
- **Blood Cell Production: Hematopoiesis** occurs in the **red bone marrow** found in certain bones.
- **Storage of Energy: Yellow bone marrow** stores fat, which is an energy reserve.



Muscular System of Human

Introduction

The muscular system is an organ system consisting of **skeletal, smooth, and cardiac muscle**. It permits movement of the body, maintains posture, and circulates blood throughout the body. Muscles function by contracting, which is the ability to shorten forcibly. They are responsible for all locomotion and manipulation.

Functions of the Muscular System

- **Movement:** Locomotion (walking, running), movement of body parts, and propulsion of contents through various organs (e.g., food through the digestive system).
- **Posture Maintenance:** Skeletal muscles constantly make tiny adjustments to maintain body posture.
- **Joint Stability:** Tendons of muscles reinforce and stabilize joints.
- **Heat Generation:** Muscle contractions produce heat as a by-product, which is essential for maintaining **homeostasis** and **body temperature (thermoregulation)**. This process is called **thermogenesis**.

Types of Muscles

There are three distinct types of muscle tissue, classified based on structure and function.

Skeletal Muscle

- **Appearance: Striated** (striped) and **multinucleated**.
- **Control: Voluntary** (under conscious control).
- **Location:** Attached to bones by tendons.
- **Function:** Responsible for body movement, posture, and breathing.
- **Cell Structure:** Long, cylindrical fibers.

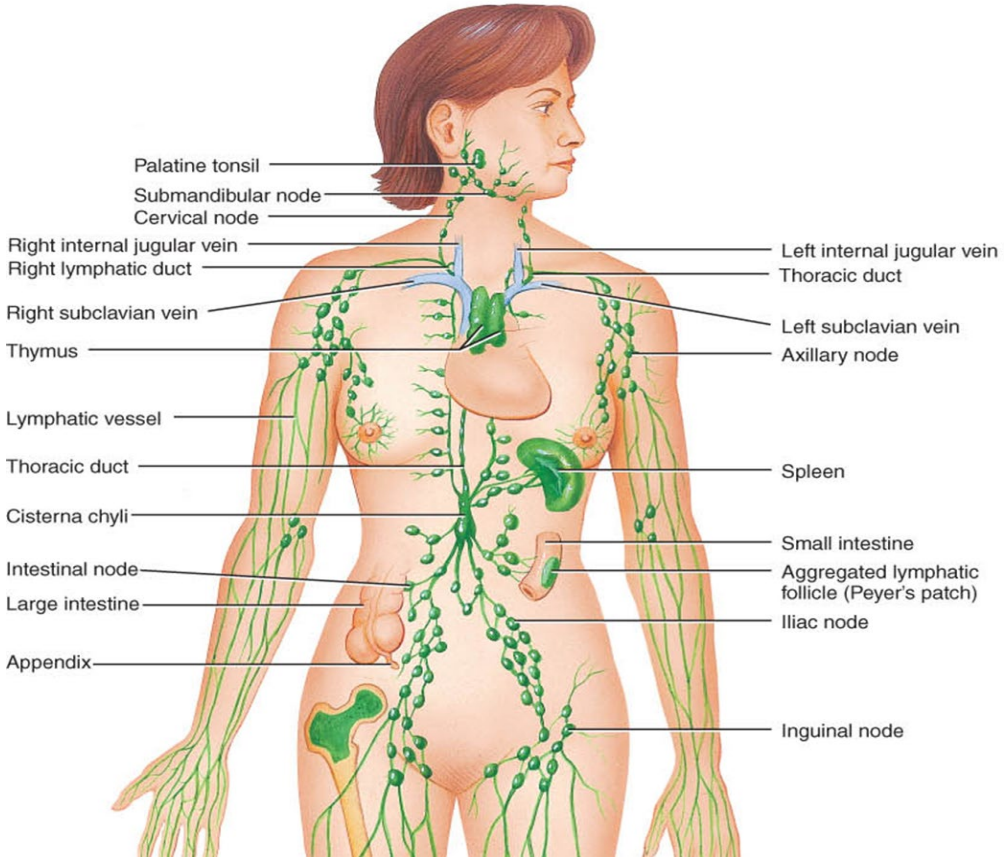
Smooth Muscle

- **Appearance: Non-striated** (smooth), spindle-shaped cells with a single nucleus.
- **Control: Involuntary** (not under conscious control).
- **Location:** Walls of hollow internal organs (e.g., stomach, intestines, blood vessels, uterus).
- **Function:** Moves substances through internal pathways (e.g., peristalsis in the gut, regulating blood pressure).

Lymphatic System of Human

Introduction

The lymphatic system is a vital part of the circulatory and immune systems. It is a network of **lymphatic vessels, lymph nodes, lymph, and lymphoid organs** (spleen, thymus, tonsils). Its primary functions are to maintain **fluid balance** in the body, absorb dietary fats, and provide the structural basis for the **immune system**.



Components of the Lymphatic System

Lymph

- **Definition:** A clear-to-white fluid that circulates through the lymphatic vessels.
- **Composition:** It is essentially **tissue fluid (interstitial fluid)** that has entered the lymphatic capillaries. It contains **white blood cells (especially lymphocytes)**, proteins, and sometimes bacteria or cell debris.

Plant Systems

Root and Shoot System in Plants

Root System

The root system is the underground part of a plant, primarily responsible for **anchoring** the plant and **absorbing water and minerals** from the soil. It originates from the **radicle** of the embryo.

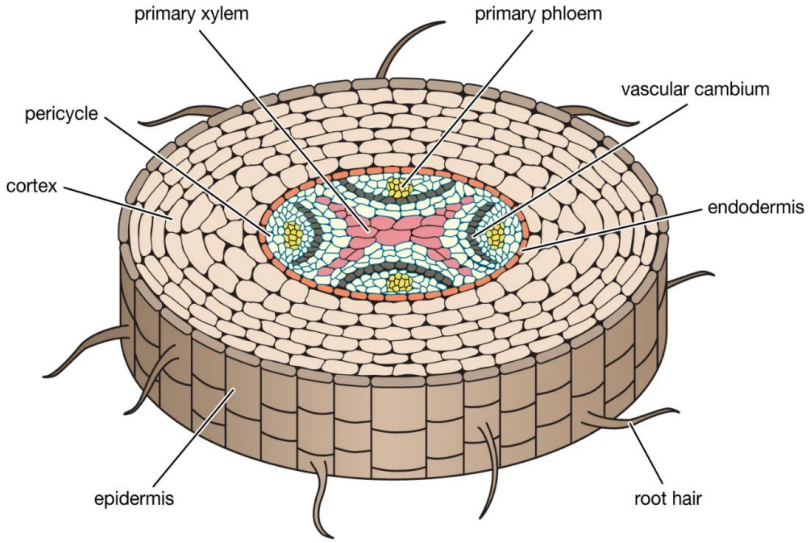
- **Types of Root Systems:**
    - **Taproot System:** Characterized by a single, dominant **primary root (taproot)** that grows vertically downward, giving rise to **secondary** and **tertiary roots**. Found in dicots like mustard and mango.
    - **Fibrous Root System:** Features numerous thin, thread-like roots that originate from the base of the stem and spread horizontally. Found in monocots like grasses and wheat.

- **Regions of a Root:**
    - **Root Cap:** A protective cap covering the tip, shielding the meristem.
    - **Region of Meristematic Activity:** Contains cells that are constantly dividing.
    - **Region of Elongation:** Where cells elongate, leading to root growth.
    - **Region of Maturation:** Contains **root hairs**, which are unicellular, thread-like extensions of epidermal cells that vastly increase the surface area for absorption.

Internal Structure of Root

- **Epidermis:** The outermost, protective layer with **root hairs** for water and mineral absorption.
- **Cortex:** Composed of loosely packed, thin-walled parenchyma cells that store food and facilitate the transport of water and minerals.
- **Endodermis:** The innermost layer of the cortex, featuring a **Casparian strip** (a waxy, suberin band) that regulates the movement of water and solutes into the vascular cylinder.

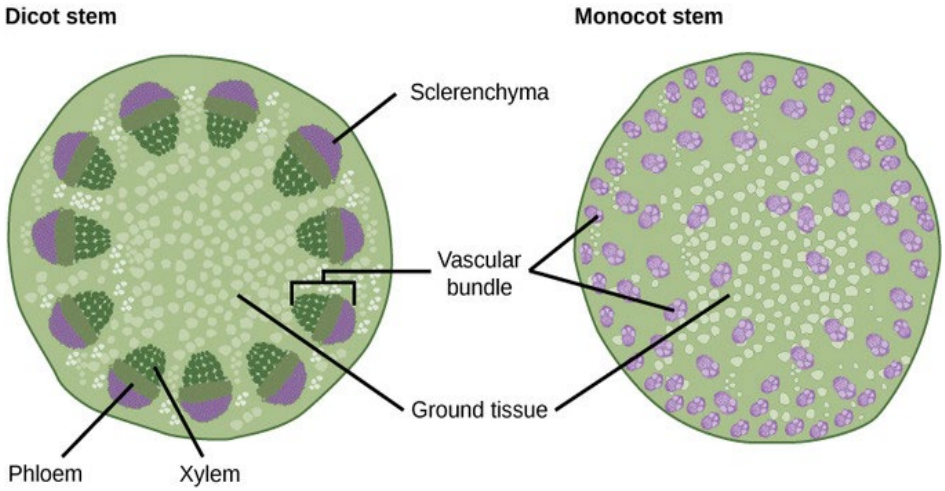
- **Vascular System:** Located in the center (stele), it contains:
    - **Xylem:** Conducts water and minerals **upwards** from roots to shoots.
    - **Phloem:** Transports food (**translocation**) in **all directions**.



Shoot System

The shoot system comprises the aerial parts of the plant: stem, branches, leaves, flowers, and fruits.

- **Stem:** Provides **support**, bears leaves and flowers, and contains **vascular bundles (xylem and phloem)** for transport.
- **Leaf:** The primary site for **photosynthesis** and **transpiration**.
  - **Petiole:** The stalk that attaches the leaf to the stem.
  - **Lamina:** The flat, green, expanded part (blade) which contains veins.
  - **Midrib:** The central, thick vein.



Internal Structure of Leaf

Reproduction in Plants

Reproduction

Reproduction is a fundamental biological process by which living organisms produce new individuals of their own kind, ensuring the **continuity of species** and the propagation of genetic information across generations. There are two main types:

1. **Asexual Reproduction**
2. **Sexual Reproduction**

Sexual Reproduction in Plants

Sexual reproduction involves the formation of specialized reproductive cells called **gametes**, followed by the fusion of male and female gametes (fertilization) to form a **zygote**. This zygote undergoes cell division and differentiation to develop into a new organism. This process introduces **genetic variation**, which is crucial for evolution and adaptation.

The Flower: A Detailed Look at Reproductive Structures

The flower is the reproductive organ of flowering plants (angiosperms). It is designed to carry out pollination and fertilization.

- **Essential Whorls:**
  - **Calyx**: The outermost whorl, composed of **sepals**. It protects the flower in the bud stage.
  - **Corolla**: The next whorl, composed of **petals**. Often brightly colored and scented to attract pollinators.
- **Reproductive Whorls:**
  - **Androecium (Male Reproductive Part)**: Consists of **stamens**.
    - **Anther**: A bilobed structure that produces **pollen grains**. Each pollen grain contains the **male gamete (sperm cell)**.
    - **Filament**: A long, slender stalk that holds the anther in a position suitable for pollen transfer.
  - **Gynoecium (Female Reproductive Part)**: Consists of **carpels** (also called a pistil). A flower can have one or multiple carpels.

Flowers and Seeds

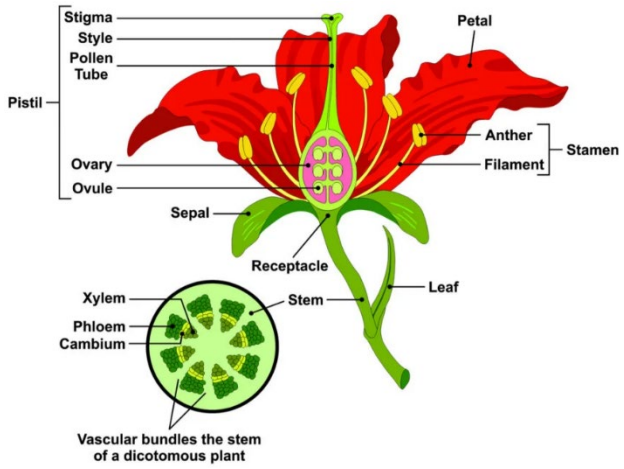
Structure of a Flower

A flower is the reproductive unit of a flowering plant (*angiosperm*). It is typically composed of four main whorls arranged on a stalk called the **pedicel**. The swollen upper end of the pedicel is the **thalamus** or **receptacle**.

- **Sepals (Calyx)**: The outermost, usually green, leaf-like structures. They protect the flower in the bud stage.
- **Petals (Corolla)**: Often brightly colored and scented to attract pollinators like insects and birds.
- **Stamen (Androecium)**: The male reproductive part. Each stamen consists of:
    - **Anther**: A bilobed structure that produces **pollen grains** containing male gametes.
    - **Filament**: A slender stalk that supports the anther.
- **Carpel (Gynoecium)**: The female reproductive part. A carpel consists of:
    - **Stigma**: The sticky, receptive tip for pollen grains.
    - **Style**: A long, slender tube that connects the stigma to the ovary.
    - **Ovary**: The enlarged basal part containing **ovules**. Each ovule contains a female gamete.

Flowers can be:

- **Bisexual**: Contain both stamen and carpel (e.g., Hibiscus/China rose).
- **Unisexual**: Contain either stamen (*staminate*) or carpel (*pistillate*) (e.g., Papaya, Maize).



Kingdom Plantae & Plant Divisions

Introduction

Kingdom Plantae comprises multicellular, eukaryotic, autotrophic organisms. They possess **chloroplasts** containing chlorophyll *a* and *b* and have cell walls primarily made of **cellulose**. They are fundamental to life on Earth as they are the primary producers, converting solar energy into chemical energy via **photosynthesis**.

General Characteristics of Kingdom Plantae

- **Mode of Nutrition:** Primarily **autotrophic** (photosynthetic).
- **Cell Type:** Eukaryotic.
- **Cellular Organization:** Multicellular with complex tissue organization.
- **Cell Wall:** Present, made of **cellulose**.
- **Reproduction:** Both asexual (vegetative propagation, fragmentation) and sexual reproduction.
- **Life Cycle:** Exhibit **alternation of generations**, where a diploid sporophyte generation alternates with a haploid gametophyte generation.

Major Divisions of Kingdom Plantae

The classification is primarily based on:

- Presence or absence of **vascular tissues** (Xylem and Phloem).
- Presence or absence of **seeds**.
- Whether the seeds are **enclosed** within a fruit or not.

Division 1: Bryophytes (The Amphibians of the Plant Kingdom)

Introduction

Bryophytes are the simplest and most primitive land plants. They are called the "amphibians of the plant kingdom" because they require water for sexual reproduction.

Key Features

- **Vascular Tissue: Absent**. They do not have true xylem and phloem.
- **Roots:** True roots are absent. They have **rhizoids** for anchorage.
- **Body:** The plant body is a **thallus** (not differentiated into true root, stem, and leaves).

Kingdom Animalia

Introduction

Kingdom Animalia includes all multicellular, eukaryotic, heterotrophic organisms. They lack cell walls and chlorophyll, and most are capable of locomotion at some stage in their life. They have a definite shape and size and follow a specific growth pattern.

General Characteristics of Kingdom Animalia

- **Mode of Nutrition: Heterotrophic** (they ingest or absorb their food).
- **Cell Type:** Eukaryotic.
- **Cell Wall: Absent**.
- **Cellular Organization:** Multicellular with complex tissue organization (except sponges).
- **Locomotion:** Most are **motile** (can move voluntarily).
- **Nervous System:** Present in most phyla for coordination.
- **Reproduction:** Mostly sexual reproduction, with embryonic development stages.
- **Storage:** Food is stored as **glycogen** or **fat**.

Basis for Classification

Animalia is a vast kingdom divided into various phyla based on fundamental body design and complexity.

1. **Symmetry:**
    - **Asymmetrical:** No plane of symmetry (e.g., Sponges).
    - **Radial Symmetry:** Body parts arranged around a central axis (e.g., Starfish).
    - **Bilateral Symmetry:** Body can be divided into two identical halves only along one plane (e.g., Humans, Birds).
2. **Germ Layers:** Tissues that form in the embryo.
    - **Diploblastic:** Two layers (Ectoderm and Endoderm). e.g., Cnidarians.
    - **Triploblastic:** Three layers (Ectoderm, Mesoderm, and Endoderm). e.g., Platyhelminthes to Chordates.
3. **Coelom (Body Cavity):** A fluid-filled cavity between the body wall and gut.
    - **Acoelomate:** No coelom (e.g., Platyhelminthes).

Past Paper MCQs Related to Biology

Human Anatomy & Physiology

1. The total number of **bones** in an adult human body is **206**.
2. The number of **bones in a newborn baby** is **300**.
3. The **longest bone** in the human body is the **Femur**.
4. **Nitrogenous waste** excreted through urine in humans is primarily **Urea**.
5. **Hemodialysis** is a process that cleans the **blood**.
6. Blood group is identified by the presence of **antigens** on the surface of red blood cells.
7. The **communication system** of the body is primarily handled by **neurons** and **nerves**.
8. The **central nervous system** is composed of the **brain, spinal cord, and nerves**.
9. The **largest part of the human brain** is the **Cerebrum**.
10. **EEG (Electroencephalogram)** is a test that detects abnormalities in the **Brain**.
11. **ECG (Electrocardiogram)** is associated with the **Heart**.
12. **Willem Einthoven** is known as the father of the **electrocardiogram (ECG)**.
13. **Goiter** is caused by the deficiency of **Iodine**.
14. The **Thyroid gland**, located in the neck, produces **Thyroxine**.
15. The **Liver** is the largest gland in the human body and produces **bile**.
16. The **Pancreas** secretes the hormone **Insulin**.
17. A severe deficiency of **Vitamin D** results in **Rickets** in children and **Osteomalacia** in adults.
18. A severe deficiency of **Vitamin A** results in **Night Blindness**.
19. **Vitamin E** is stored in **Adipose tissues**.

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Basics of Chemistry

Introduction to Chemistry

Chemistry is the branch of science that deals with the composition, structure, properties, and changes of matter. It is often called the "central science" because it connects physics with other natural sciences like biology and geology.

Main Branches of Chemistry

The field of chemistry is divided into several main branches, each focusing on a specific area.

Physical Chemistry: The branch that deals with the principles and theories underlying chemical reactions and changes. It involves the study of kinetics, thermodynamics, and quantum mechanics.

- **Example:** Studying the rate of a chemical reaction or the energy changes involved.

Organic Chemistry: The study of compounds containing carbon, typically in chains or rings, and their properties, structure, and reactions.

- **Example:** Chemistry of fuels, plastics, pharmaceuticals, and DNA.

Inorganic Chemistry: The study of compounds that do not primarily contain carbon-hydrogen bonds, including metals, minerals, and organometallic compounds.

- **Example:** Study of salts, acids, bases, and coordination compounds.

Analytical Chemistry: The branch concerned with the identification (qualitative analysis) and measurement (quantitative analysis) of the chemical components of substances.

- **Example:** Determining the amount of lead in a water sample.

Biochemistry: The study of chemical substances and vital processes occurring in living organisms.

- **Example:** Understanding metabolism, enzyme action, and cellular respiration.

Other Important Branches:

- **Nuclear Chemistry:** Deals with radioactivity, nuclear processes, and properties.

Atoms, Molecules, Elements, And Compounds

Introduction: The Building Blocks of Matter

This chapter expands on the Particle Theory of Matter. Recall that the states of matter (solid, liquid, gas) are determined by the **arrangement, movement, and forces of attraction** between their particles. Now, we explore the nature of the particles themselves.

Fundamental Concepts of Matter

- **Mass:** The quantity of matter in an object.
- **Volume:** The space occupied by an object.
- **Density:** The mass per unit volume of a substance (Density = Mass/Volume).
- **Classification:** Matter is classified into **Pure Substances** (Elements and Compounds) and **Mixtures** (Impure Matter).

Elements

- **Definition:** An **element** is a pure substance that consists of only **one kind of atom**. It is the simplest form of matter and cannot be broken down into simpler substances by ordinary chemical means.
- **Occurrence:** There are **92 naturally occurring** elements. Others have been prepared artificially.
- **Periodic Table:** All known elements are systematically organized in the **Periodic Table**, which displays their names and symbols.

Atoms

- **Definition:** An **atom** is the smallest particle of an element that can take part in a chemical reaction. Atoms of a given element are identical in their chemical properties but differ from atoms of other elements.
- **Structure of an Atom:**
    - **Nucleus:** The small, dense, central core of the atom.
    - **Fundamental Particles:**

Physical and Chemical Changes of Matter

Fundamental Concepts Of Change

Physical Change

- **Definition:** Alteration in physical properties without changing chemical composition
- **Characteristics:**
  - No new substance formed
  - Reversible by physical methods
  - Chemical identity remains unchanged
  - Involves changes in state, shape, size, or appearance
- **Examples:**
  - Melting ice → water (state change)
  - Dissolving salt in water (mixture formation)
  - Crushing a can (shape change)
  - Cutting paper (size change)

Chemical Change

- **Definition:** Transformation into new substances with different chemical properties
- **Characteristics:**
  - New substances formed
  - Irreversible by physical methods
  - Chemical bonds broken and formed
  - Permanent change in composition
- **Examples:**
  - Burning wood → ash + smoke + gases
  - Rusting of iron → iron oxide
  - Digestion of food → nutrients
  - Cooking an egg → protein denaturation

Difference Between Physical and Chemical Changes

Mixtures of Substances

Introduction to Matter Classification

Matter is classified into two fundamental categories:

- **Pure Substances:** Have a fixed composition and distinct properties. Examples include **Elements** (e.g., Iron, Oxygen) and **Compounds** (e.g., Water, Salt).
- **Impure Substances (Mixtures):** Consist of two or more pure substances mixed together physically, not chemically.

Mixtures: Basic Concept

A **mixture** is a physical combination of two or more substances (elements or compounds) where:

- No new chemical substance is formed.
- The constituents retain their individual properties.
- They can be mixed in any proportion.
- They can be separated by physical methods.

Types of Mixtures

Mixtures are classified based on the uniformity of their composition:

Type	Definition	Key Characteristics	Examples
Heterogeneous Mixture	Composition is **not uniform** throughout.	Different components are visible and can be easily distinguished.	Salad, sand and iron filings, concrete, pizza.
Homogeneous Mixture	Composition is **uniform** throughout.	Components are indistinguishable; it has a single phase.	Air, sugar dissolved in water, vinegar, steel.

Solutions (A Type of Homogeneous Mixture)

A **solution** is a homogeneous mixture of two or more substances. A solution with two components is a **binary solution**.

Chemical Bonds

Introduction to Chemical Bonding

Chemical bonding is the process by which atoms combine to form molecules and compounds. Atoms bond to achieve stability by attaining a complete outer electron shell, typically with 8 electrons (octet rule) or 2 electrons for hydrogen and helium.

Ions and Ion Formation

Stable vs. Unstable Electronic Configuration

- **Stable Configuration:** Atoms with completely filled outermost shells (e.g., Noble Gases: He, Ne, Ar)
- **Unstable Configuration:** Atoms with incomplete outermost shells that tend to gain, lose, or share electrons

Ion Formation Process

- **Cation Formation:** Atom loses electron(s) → becomes positively charged
  - *Example:* $Na \rightarrow Na^+ + e^-$
  - Metals typically form cations
- **Anion Formation:** Atom gains electron(s) → becomes negatively charged
  - *Example:* $Cl + e^- \rightarrow Cl^-$
  - Non-metals typically form anions

Special Ions

- **Hydrogen Ion (H^+):** Essentially a proton
- **Ammonium Ion (NH_4^+):** Formed when ammonia (NH_3) gains a proton
- **Oxonium Ion (H_3O^+):** Formed when water (H_2O) gains a proton

Common Ions Table

Positive Ions (Cations)	Negative Ions (Anions)
Hydrogen (H^+)	Fluoride (F^-)
Sodium (Na^+)	Chloride (Cl^-)

Solutions and Solubility

Introduction to Solutions

A **solution** is a homogeneous mixture of two or more substances where the components are uniformly distributed at the molecular level. The mixture has uniform composition and properties throughout.

Components of a Solution

- **Binary Solution:** A solution prepared by mixing only two substances
- **Solute:** The substance that dissolves and is present in smaller quantity
  - *Examples:* Sugar in sugar solution, salt in salt water
- **Solvent:** The substance in which the solute dissolves, present in larger quantity
  - *Examples:* Water in sugar solution, water in salt water
- **Aqueous Solution:** A solution where water is the solvent

Naming Convention

- Solutions are typically named after their solute
- *Examples:* Sugar solution, salt solution, bromine solution

Types of Solutions Based on Physical States

Solutions can exist in various combinations of physical states of solute and solvent:

Solute State	Solvent State	Examples	Key Characteristics
Solid	Liquid	Salt water, Sugar water	Most common type, clear liquid
Solid	Solid	Brass (zinc in copper), Bronze (tin in copper)	Metal alloys, homogeneous solid mixtures
Liquid	Liquid	Alcoholic drinks, Vinegar	Miscible liquids, uniform appearance

Chemical Reactions

Introduction to Chemical Reactions

A **chemical reaction** is a process where the chemical bonds between atoms in one or more substances (reactants) are broken and reformed to create entirely new substances (products) with different chemical compositions and properties. This contrasts with a **physical change** (e.g., water turning to ice or steam), where the chemical identity of the substance remains the same. Chemical reactions involve the **rearrangement of atoms** to form new molecules, in accordance with the **Law of Conservation of Mass**.

Chemical Reactions

A chemical reaction involves the breaking and forming of chemical bonds, leading to the transformation of reactants into products. The initial substances are called **reactants**, and the newly formed substances are called **products**.

Applications of Chemical Reactions

Chemical reactions are fundamental to numerous natural and industrial processes:

- **Combustion:** Burning of fuels (e.g., natural gas, petrol, coal) to produce energy for vehicles, electricity, and heating.
- **Respiration:** In living cells, glucose reacts with oxygen to produce carbon dioxide, water, and energy (ATP).
  - **Equation:** $C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l) + Energy$
- **Photosynthesis:** In plants, carbon dioxide and water react in the presence of sunlight and chlorophyll to produce glucose and oxygen.
  - **Equation:** $6CO_2(g) + 6H_2O(\ell) \rightarrow (Sunlight/Chlorophyll)\ C_6H_{12}O_6(aq) + 6O_2(g)$
- **Fermentation:** Chemical changes brought about by microorganisms, such as the conversion of sugar into ethanol or milk into yogurt.
- **Corrosion:** The gradual destruction of materials (usually metals) by chemical reactions with their environment (e.g., rusting of iron).

Chemical Equations

A **chemical equation** is a symbolic representation of a chemical reaction using symbols, formulae, and signs.

- Reactants are written on the **left-hand side (LHS)**.
- Products are written on the **right-hand side (RHS)**.

Acids, Bases and Salts

Acids

An **acid** is a substance that donates hydrogen ions (H^+) and has a sour taste. Acids turn blue litmus paper red. They are primarily classified based on their origin.

Sources of Common Acids

- **Organic Acids:** These are naturally obtained from plants and animals.
  - *Examples:* Formic acid (ant's sting), Acetic acid (vinegar), Citric acid (citrus fruits), Lactic acid (curd/yogurt), Oxalic acid (tomatoes), Tartaric acid (tamarind, grapes).
- **Mineral Acids (Inorganic Acids):** These are derived from minerals and are typically prepared in laboratories.
  - *Examples:* Hydrochloric acid (HCl), Nitric acid (HNO_3), Sulphuric acid (H_2SO_4), Phosphoric acid (H_3PO_4).

Properties of Acids

1. **Sour Taste:** All acids have a sour taste (e.g., lemon, vinegar). **Warning:** Never taste or touch chemicals to identify them.
2. **Effect on Indicators:**
   - Turn blue litmus paper red.
   - Turn methyl orange solution red.
   - Keep phenolphthalein colorless.
3. **Corrosive Nature:** Strong acids are corrosive and can burn skin and destroy fabrics.
4. **Electrical Conductivity:** Their aqueous solutions conduct electricity due to the presence of H^+ ions.
5. **Reaction with Metals:** Acids react with reactive metals (e.g., Mg, Zn, Fe) to produce a salt and hydrogen gas (H_2).
   - $Mg + 2HCl \rightarrow MgCl_2 + H_2 \uparrow$
   - $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2 \uparrow$

Past Paper MCQs

1. The **most abundant metal** in the Earth's crust is **Aluminium**.
2. The **most abundant element** in the Earth's crust is **Oxygen**.
3. The **most abundant element** in the universe is **Hydrogen**.
4. **Isotopes** of an element have the same number of **Protons** but different neutrons.
5. The **uncharged particle** in an atom is the **Neutron**.
6. **Hydrogen** has **0 neutrons**.
7. The **Electron** was discovered by **J.J. Thomson**.
8. **Atoms** are formed by **three** basic particles.
9. **Saturated hydrocarbons** are known as **Alkanes**.
10. **Diamond** is an **allotropic form of Carbon**.
11. The **existence of an element in more than one form** in the same physical state is called **Allotropy**.
12. **Fructose** is a **Monosaccharide** sugar.
13. **Lactose** is **not a Monosaccharide**; it is a disaccharide.
14. The **sugar present in milk** is **Lactose**.
15. **Formic acid** is obtained from **Ants**.
16. **Cooking oil** can be converted into vegetable ghee by the process of **Hydrogenation**.
17. The reaction between an **acid and a base** forms **Salt and Water**.
18. **Water and salt** are produced by the reaction of an acid with a **Base**.
19. **Brass gets discolored** in air due to the presence of **Hydrogen Sulphide**.
20. **Bleaching powder** contains **Chlorine**.

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Energy

Energy is defined as the **ability to do work**. It is a **scalar physical quantity** that can be measured, and its SI unit is the **joule (J)**. Energy exists in various forms and can be transformed from one form to another.

Potential Energy (P.E.)

Potential Energy is the **stored energy** in an object due to its **position, condition, or chemical composition**.

Type of Potential Energy	Description	Examples
Gravitational P.E.	Energy stored in an object when it is **raised to a height** against gravity.	A book on a shelf, water in a dam.
Elastic P.E. (Strain Energy)	Energy stored in an object when it is **stretched, compressed, or bent**.	A stretched rubber band, a compressed spring, a bent archery bow.
Chemical Energy	Energy stored in the bonds of atoms and molecules.	**Food, batteries, fossil fuels** (coal, petrol, natural gas).
Nuclear Energy	Energy stored in the nucleus of an atom, released in nuclear reactions.	**Nuclear power plants, the Sun**.

Kinetic Energy (K.E.)

Kinetic Energy is the energy possessed by an object due to its **motion**. It depends on the **mass** and **velocity** of the object.

Other Forms of Kinetic Energy:

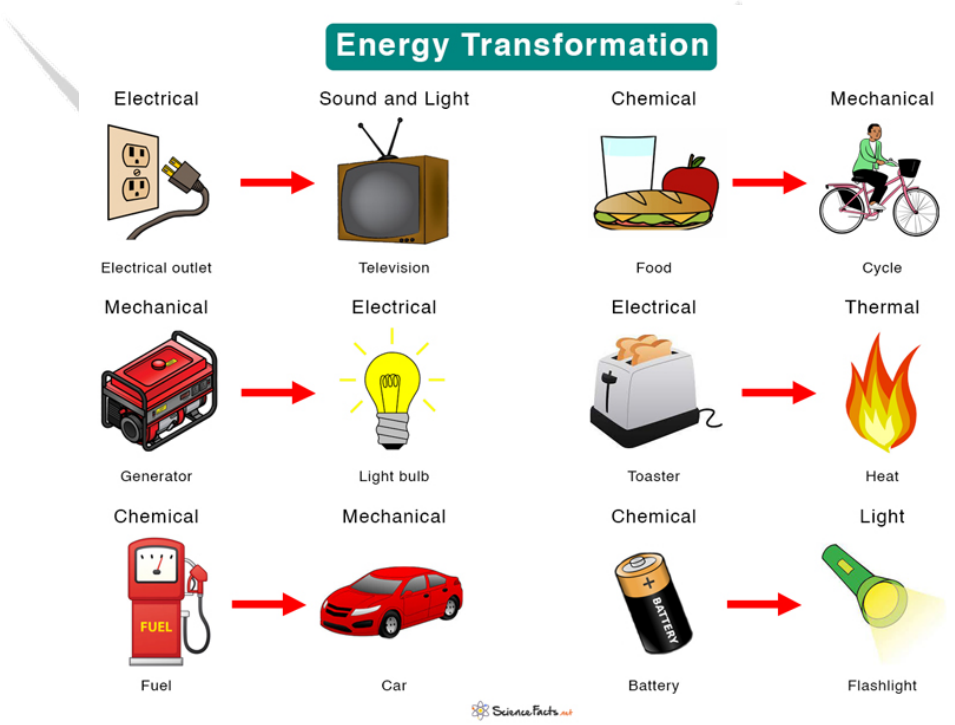
Form of Energy	Description	Examples
Heat (Thermal) Energy	Energy due to the **vibrational and translational motion of particles**.	Boiling water, a hot stove.

Energy Transfer is the process of energy changing from one form to another.
Example: A Bouncing Ball

1. **GPE → KE:** When dropped, stored energy becomes energy of motion.
2. **KE → Elastic PE:** On impact, the ball deforms, storing energy.
3. **Elastic PE → KE:** The ball regains shape and pushes off.
4. **KE → GPE:** The ball rises to a new height.

Energy Converters are devices that change one form of energy into another.

- **Solar Cell:** Converts **light energy** into **electrical energy**.
- **Electric Motor:** Converts **electrical energy** into **kinetic (mechanical) energy**.
- **Car Engine:** Converts **chemical energy** (fuel) into **heat, sound, and kinetic energy**.
- **Human Body:** Converts **chemical energy** (food) into **heat and mechanical energy**.



Energy Dissipation:

During any energy conversion, some energy is always transformed into forms that are **not useful** (e.g., heat from friction, sound from a machine). This spread of non-useful energy is called **dissipation** or **wasted energy**.

Sources of Energy

Energy sources are classified based on their rate of replenishment.

Light and Sound

Sources of Light

Light is a form of **energy** that enables vision. Sources of light are classified as:

- **Natural sources**: Emit light naturally, e.g., **Sun, stars, fireflies**.
- **Artificial sources**: Man-made sources, e.g., **electric bulbs, LEDs, candles, lamps**.

The **Moon is not a luminous object**; it reflects sunlight, making it appear bright.

Luminous and Non-Luminous Objects

- **Luminous objects**: Emit their own light (e.g., **Sun, fireflies, a lighted candle**).
- **Non-luminous objects**: Do not emit light; they are visible only when **light reflects off them** (e.g., **chair, book, Moon**).

Transparent, Opaque, and Translucent Objects

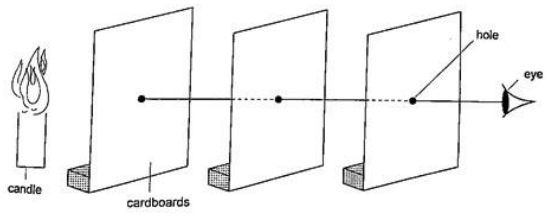
Based on light transmission:

Type	Light Transmission	Vision	Examples
Transparent	Complete	Clear	Glass, clean water, air
Translucent	Partial	Blurred	Frosted glass, butter paper, net curtain
Opaque	No light passes	Not possible	Wooden door, brick wall, metal

Light Travels in a Straight Line

Light always travels in a **straight line**, known as rectilinear propagation.

- This is demonstrated by the **candle-and-cardboard experiment**: when holes in multiple cardboards align, the candle flame is visible.
- Displacing any cardboard breaks the **line of sight**.



Force and Motion

Force

A **force** is a push or a pull that can cause several changes in an object:

Effect of Force	Description	Example
Start Motion	Make a stationary object move.	Pushing a stationary car.
Stop Motion	Bring a moving object to rest.	Applying brakes to a bicycle.
Change Speed	Increase or decrease the speed of a moving object.	Accelerating a car (increase); friction slowing a sliding box (decrease).
Change Direction	Alter the path of a moving object.	A batsman hitting a cricket ball.
Change Shape	Deform an object.	Stretching a rubber band or squeezing a sponge.

Unit of Force

- The SI unit of force is the **newton (N)**, named after Sir Isaac Newton.
- **Weight** is the force of gravity acting on an object's mass.
- The formula for weight is:
  w = m × g
  where:
  - *w* = weight (in newtons, N)
  - *m* = mass (in kilograms, kg)
  - *g* = acceleration due to gravity (on Earth, approximately **10 N/kg** or **9.8 m/s²**)

Examples:

- A mass of 1 kg has a weight of about 10 N on Earth.
- An apple with a mass of about 100 g (0.1 kg) has a weight of about 1 N.

Measuring Force:

Waves

Introduction to Waves

A **wave** is a disturbance that transfers **energy** from one point to another without transferring **matter**. Waves are produced by vibrating sources and propagate through a medium or space.

- **Example:** Ripples created by a pebble dropped in water carry energy outward.

Types of Waves

Waves are classified based on their requirement of a medium:

Type	Requirement for a Medium	Examples
Mechanical Waves	Require a material medium (solid, liquid, gas) to travel.	**Sound waves**, water waves, seismic waves.
Electromagnetic Waves	Do **not** require a medium; can travel through a vacuum.	**Light**, radio waves, X-rays.

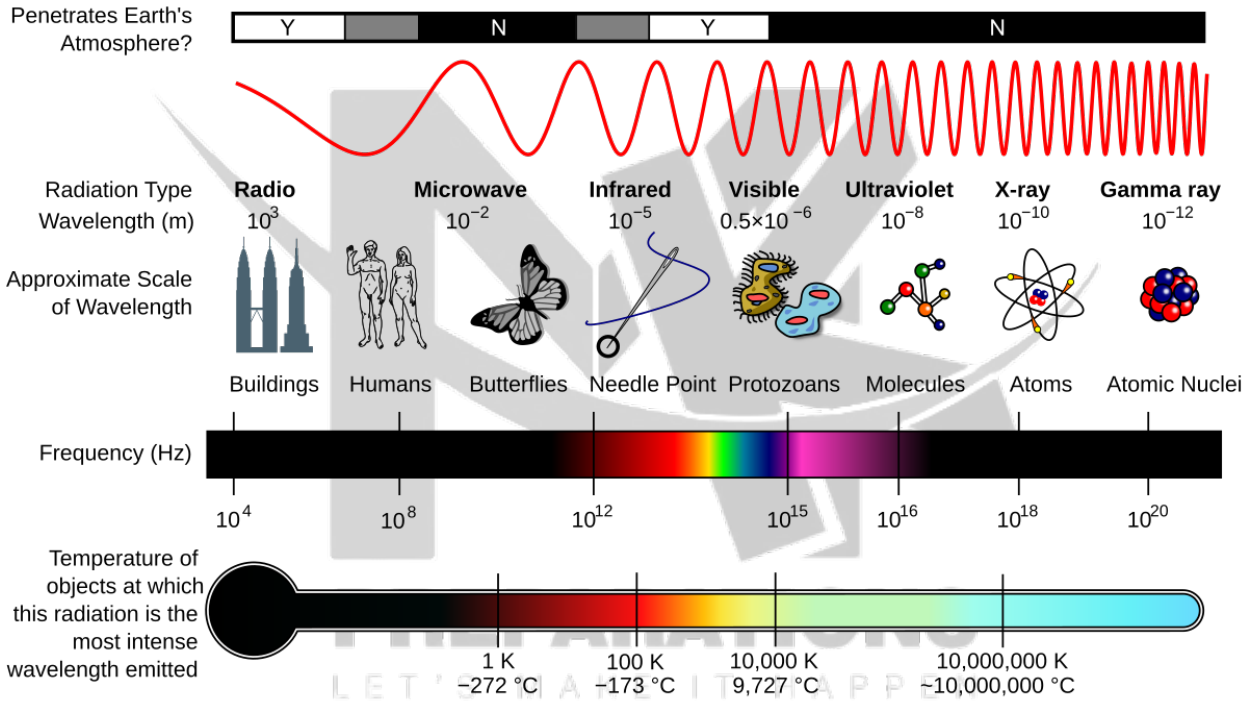
Mechanical waves are further classified based on the direction of particle vibration:

Type	Direction of Vibration	Wave Pattern	Can Travel Through
Transverse Waves	Perpendicular to the wave's direction.	**Crests** (high points) and **Troughs** (low points).	Solids, Liquid surfaces.
Longitudinal Waves	Parallel to the wave's direction.	**Compressions** (high-density) and **Rarefactions** (low-density).	Solids, Liquids, Gases.

- **Key Example: Sound is a longitudinal mechanical wave.** Light is a transverse electromagnetic wave.

Visible Light	The light we can see. Ranges from **Red (700 nm)** to **Violet (400 nm)**. A prism splits white light into VIBGYOR.
Ultraviolet (UV)	Sterilizing medical equipment, causing sunburn, vitamin D production.
X-Rays	Medical imaging (viewing bones), security scanning.
Gamma Rays	Radiotherapy for cancer treatment, sterilizing food.

Key Fact: Higher frequency EM waves (UV, X-rays, Gamma rays) carry more energy and can be dangerous to living tissues.



Heat and Temperature

Heat and Temperature

Concept	Definition	Depends On	SI Unit
Heat	A form of energy that flows from a hotter to a colder body.	Total kinetic energy of all particles in a substance.	**Joule (J)**
Temperature	The measure of hotness or coldness of a body.	Average kinetic energy of the particles.	**Kelvin (K)**

- **Heat Transfer:** Heat always flows from a region of **higher temperature** to a region of **lower temperature**.
- **Kinetic Molecular Theory:** All matter is made of particles (atoms, molecules) that are in constant, random motion. The energy of this motion is kinetic energy.

Thermometer and Temperature Scales

A **thermometer** is a device used to measure temperature. It works on the principle of **thermal expansion**—the liquid inside (mercury or alcohol) expands when heated and contracts when cooled.

Common Temperature Scales:

Scale	Fixed Points		Conversion Formulas
	Ice Point	Steam Point	Conversion Formulas
Celsius (°C)	0°C	100°C	
Fahrenheit (°F)	32°F	212°F	**°F = (9/5 × °C) + 32**
Kelvin (K)	273 K	373 K	**K = °C + 273**

*Kelvin is the SI unit and is also known as the absolute scale. 0 K (-273°C) is absolute zero, the temperature at which all molecular motion ceases.

- A ship is designed with a hollow shape, displacing a very **large volume** of water.
- The **weight of the water displaced** creates an upward force called **buoyancy**.
- The ship floats when the **buoyant force equals the ship's weight**. Its **average density** (total mass / total volume) becomes less than that of water.

Pressure, Force and Area

Pressure is defined as the force acting perpendicularly on a unit area.
Formula: Pressure (P) = Force (F) / Area (A)

- **SI Unit: Pascal (Pa)**, where 1 Pa = 1 N/m².
- A larger unit is the **kilopascal (kPa)**, where 1 kPa = 1000 Pa.

Key Relationships:

- For the **same force**, pressure **increases** when the area **decreases**.
  - *Example:* A sharp knife cuts easily because the force is concentrated on a very small area, creating high pressure.
- For the **same area**, pressure **increases** when the force **increases**.

Calculation Example:
A woman weighing 600 N stands on the floor. If the area of one high heel is 2 cm² (0.0002 m²), the pressure exerted by one heel is:
P = F/A = 600 N / 0.0002 m² = 3,000,000 Pa or 3000 kPa.

Pressure in Liquids (Water Pressure)

Liquids exert pressure on the bottom and sides of their container. This is called **hydrostatic pressure**.

Key Properties:

1. Pressure **increases with depth**. The deeper you go, the greater the weight of the liquid above you.
2. Pressure acts **equally in all directions** at a given depth.
3. Pressure **depends on the density** of the liquid.

Applications:

- **Dams** are built with thicker walls at the bottom to withstand the increasing pressure with depth.

Reflection and Refraction of Light

Introduction to Light

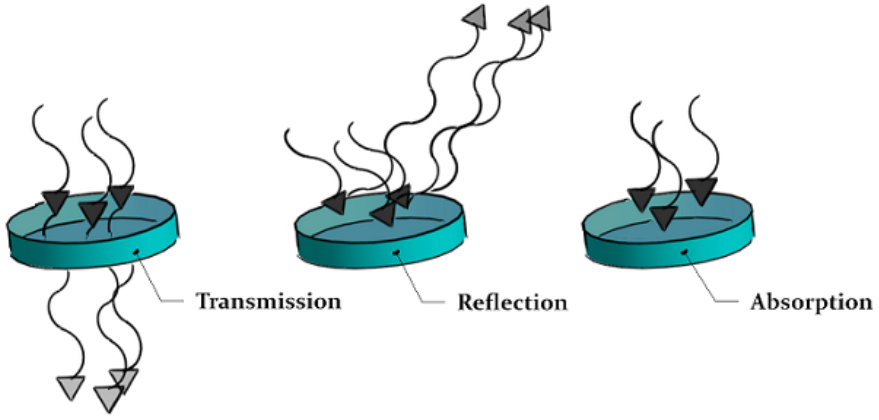
Light is a form of **electromagnetic energy** that enables vision. We see non-luminous objects when light from a source falls on them, reflects, and enters our eyes. Light travels in straight lines as rays.

Speed of Light

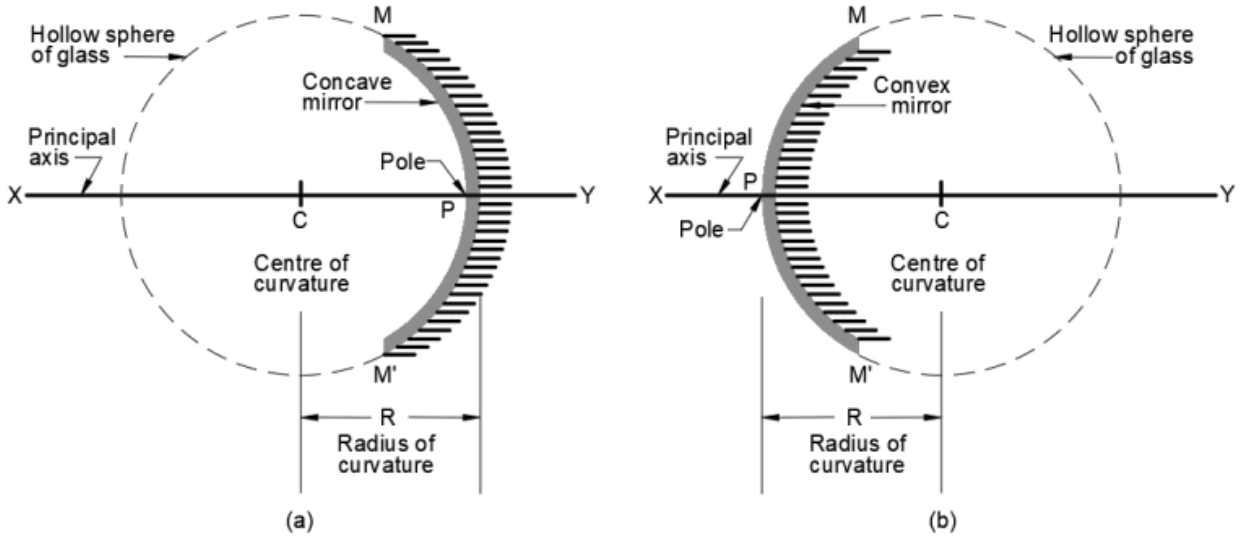
- The **speed of light (c)** in a vacuum is approximately **300,000 km/s** or **3×10^8 m/s**, which is the ultimate speed limit in the universe.
- Light slows down when passing through different transparent media due to interactions with atoms.
  - In air: ~300,000 km/s (slightly less than in a vacuum)
  - In water: ~225,000 km/s
  - In glass: ~200,000 km/s

Transmission, Absorption, and Reflection

- **Transmission:** Light passes through a medium. **Transparent** objects (e.g., clear glass) allow clear vision, while **translucent** objects (e.g., frosted glass) scatter light, blurring images.
- **Absorption:** Light energy is taken in by a material and converted, often into heat. **Opaque** objects (e.g., wood, metal) absorb and reflect light, preventing transmission.
- **Reflection:** The bouncing back of light from a surface. Surfaces that reflect all colours appear **white**; those that absorb all colours appear **black**.



- Has a **virtual principal focus (F)**, from which reflected rays appear to diverge.



Uses of Spherical Mirrors

- **Concave Mirrors:**
  - Shaving and makeup mirrors (magnification).
  - Dentist's mirrors.
  - Reflectors in torches and headlights (to produce parallel beam).
  - Solar cookers (to concentrate sunlight).
- **Convex Mirrors:**
  - Rear-view mirrors in vehicles (wider field of view).
  - Security mirrors in shops.
  - Blind corner mirrors on roads.

Past Papers Questions

1. The **SI unit of Temperature** is **Kelvin (K)**.
2. The **SI unit of Energy** is **Joule (J)**.
3. The **SI unit of Pressure** is **Pascal (Pa)**.
4. The **SI unit of Magnetic Induction (Magnetic Flux Density)** is **Tesla (T)**.
5. The **SI unit of Electric Current** is **Ampere (A)**.
6. The **SI unit of Force** is the **Newton**.
7. The **SI unit of Charge** is **Coulomb**.
8. The **SI unit of Work** is the **Joule**.
9. The **SI unit of speed** is **meter per second (m/s)**.
10. The **cubic meter (m^3)** is the **SI unit for volume**.
11. **Joule** is the unit of **Energy** and **Work**.
12. **Mass** is the same physical quantity as **Inertia**.
13. The resistance in any object which causes a change in its state of motion is **Inertia**.
14. **Coulomb** discovered the force of electrostatic attraction and repulsion.
15. The **speed of sound** is minimum in **Air** (compared to solids and liquids).
16. **Sound travels faster** in **Solids** than in liquids or gases.
17. The approximate speed of **sound in human tissue** is **1540 m/s**.
18. When **sound waves** pass through a medium and turn back, this phenomenon is known as **Reflection**.
19. The phenomenon of sound bouncing back after hitting a surface is called **Reflection**.
20. The **transfer of thermal energy** that requires no physical medium is **Radiation**.

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Space and Satellites

Introduction to Space and Heavenly Bodies

When we observe the night sky, the countless tiny lights we see are not all stars. Scientifically, they include a variety of **heavenly bodies** such as **galaxies, stars, planets, moons, asteroids, and comets**. All these objects are part of the vast, unlimited expanse known as the **universe**. Countries send **artificial satellites** and other spacecraft into this space for research, communication, and surveillance.

Space Exploration

Human curiosity about Earth and space led to the invention of the **rocket**, enabling travel beyond our atmosphere. The **space age** officially began on **October 4, 1957**, when the **Soviet Union launched Sputnik-1**, the first artificial satellite, into Earth's orbit. This was followed by the United States and other countries, which launched numerous spacecraft for monitoring weather, enabling long-range communication, precise navigation, and exploring Earth's resources.

The Role of NASA

The **National Aeronautics and Space Administration (NASA)** is the American agency responsible for space exploration and aviation. A key milestone achieved by NASA was the first human landing on the **Moon on July 20, 1969**, via the **Apollo 11** mission. NASA has also sent robotic spacecraft to other planets in the solar system, from which instruments send back valuable environmental data. To conduct experiments in a **microgravity environment**, NASA launched the **Skylab** space station on **May 14, 1973**.

Space Stations

- **Skylab:** NASA's first space station, used for microgravity research.
- **Mir:** A Russian (Soviet) space station that orbited Earth for 15 years, hosting numerous experiments.
- **International Space Station (ISS):** A massive, collaborative laboratory involving space agencies from the USA (NASA), Russia (Roscosmos), Japan (JAXA), Canada (CSA), and Europe (ESA). Larger than a football ground, it has been orbiting at **approximately 400 km** for over 20 years, completing one revolution every **90 minutes**. Scientists (astronauts and cosmonauts) live and conduct research there for months.

Solar System

Stars and Planets

A **star** is a massive, luminous sphere of plasma held together by gravity that emits its own heat and light through nuclear fusion. The **Sun** is a medium-sized star. In contrast, **planets** are celestial bodies that orbit a star, are spherical due to their own gravity, and have cleared their orbital path of other debris. They do not produce their own light but reflect the light of their star.

Solar System (The Sun and Planets)

The **solar system** consists of the Sun and all the objects gravitationally bound to it, including eight planets, dwarf planets, moons, asteroids, comets, and meteoroids.

The Sun

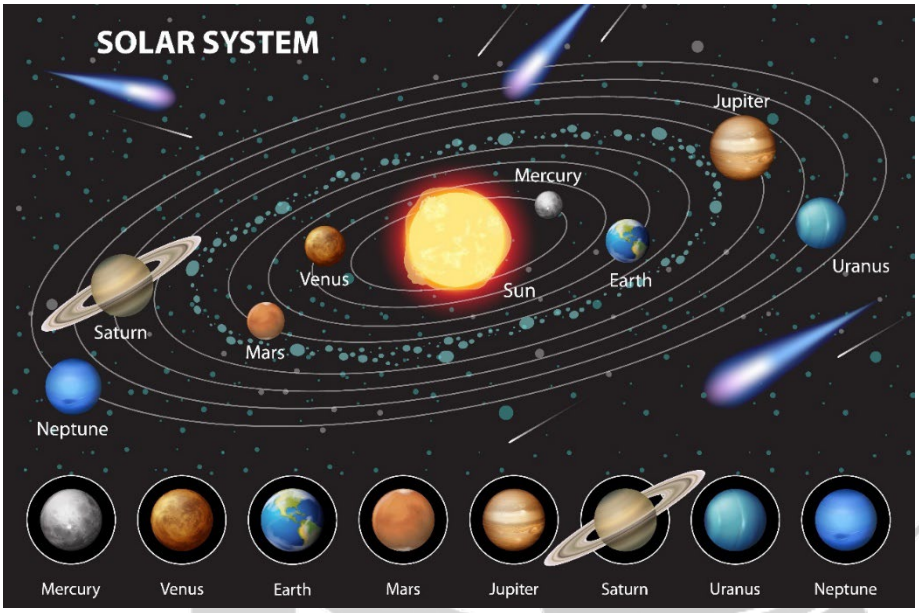
- A medium-sized star with a mass **330,000 times** that of Earth.
- Its diameter is **1,392,000 km**, about **110 times** Earth's diameter.
- The **photosphere** (visible surface) temperature is ~5,500°C, while the core temperature reaches ~**15 million degrees Celsius**.
- Composed of about **71% hydrogen** and **27% helium** by mass.
- Energy is produced in the core via **nuclear fusion**, where hydrogen nuclei fuse to form helium.

The Planets

The eight planets are categorized into **Terrestrial (Inner/Rocky) Planets** (Mercury, Venus, Earth, Mars) and **Jovian (Outer/Gas Giant) Planets** (Jupiter, Saturn, Uranus, Neptune).

1. **Mercury:** The closest, smallest, and fastest-orbiting planet. It has no substantial atmosphere and a surface covered with craters.
2. **Venus:** Similar in size and mass to Earth. Its thick atmosphere of **carbon dioxide** creates a runaway **greenhouse effect**, making it the hottest planet.
3. **Earth:** The only planet known to support life. It has liquid water, a protective atmosphere rich in nitrogen and oxygen, and a magnetic field generated by its molten iron core.
4. **Mars:** The "Red Planet" due to iron oxide (rust) on its surface. It has polar ice caps and signs of past water activity.
5. **Jupiter:** The largest planet, a **gas giant** composed mainly of hydrogen and helium. It is known for the **Great Red Spot**, a giant storm.

6. **Saturn:** The second-largest planet, famous for its spectacular **ring system** made of ice and rock particles. It is also a gas giant.
7. **Uranus:** An **ice giant** with a bluish-green hue due to **methane** in its atmosphere. It rotates on its side, nearly perpendicular to its orbit.
8. **Neptune:** The windiest planet, also an ice giant with a blue color from methane. It was the first planet discovered mathematically.



Key Planetary Data

Planet	Diameter (km)	Revolution Period (One Year)	Rotation Period (One Day)
Mercury	4,900	88 Earth days	59 Earth days
Venus	12,100	225 Earth days	243 Earth days (Retrograde)
Earth	12,800	365.25 days	24 hours
Mars	6,780	687 Earth days	24.6 hours
Jupiter	142,900	11.86 Earth years	10 hours
Saturn	120,800	29.5 Earth years	10.7 hours
Uranus	51,200	84 Earth years	17.3 hours (Retrograde)
Neptune	49,500	165 Earth years	16 hours

Gravity, Earth, and Space

Gravitational Force

Gravitational force is the universal force of attraction between any two objects that have mass. While imperceptible between everyday objects, its effects are dominant on a cosmic scale. The Sun's gravity holds the entire solar system together, keeping planets in orbit, just as Earth's gravity keeps the Moon in orbit. The region around a massive object where its gravitational influence is exerted is called its **gravitational field**.

Mass and Weight

- **Mass** is the quantity of matter in an object. It is a scalar quantity, constant everywhere in the universe. Its SI unit is the **kilogram (kg)**.
- **Weight** is the force of gravity acting on an object's mass. It is a vector quantity and varies with location (e.g., on Earth, the Moon, or in space). Its SI unit is the **newton (N)**.

The relationship is given by the formula: **W = m × g**
Where *W* is weight, *m* is mass, and *g* is the acceleration due to gravity (on Earth, *g* ≈ 9.8 m/s²).

Feature	Mass	Weight
Definition	Quantity of matter in a body.	Force of gravity on a body.
Nature	Scalar (has magnitude only).	Vector (has magnitude and direction).
SI Unit	Kilogram (kg).	Newton (N).
Variation	Constant regardless of location.	Changes with the strength of gravity.
Zero Value	Never zero.	Can be zero (e.g., in deep space or during free fall).

Weightlessness

Weightlessness is the sensation experienced when an object's apparent weight is zero, even though its mass remains unchanged. This occurs when an object is in a state of **free fall**, such as:

Our Universe

Introduction to the Universe

The universe is the vast, expanding expanse that contains all of space, time, matter, and energy, including billions of **galaxies, stars, planets, comets, and asteroids**. A **star** is a massive, luminous sphere of plasma held together by gravity, emitting immense heat and light through nuclear fusion. Most stars are incredibly distant; their distances are measured in **light-years**. One **light-year** is the distance light travels in one year, approximately **9.5 trillion kilometers**. Our **Sun** is the closest star to Earth, located about **150 million kilometers** away.

Composition of the Universe

The universe is not just made of the stars and planets we can see. Its total composition is a mystery, understood through theoretical physics and cosmology.

Component	Percentage	Details
Ordinary Matter	~5%	The matter that makes up stars, planets, gas, and everything we can see and detect.
Dark Matter	~27%	An invisible form of matter that does not emit light but exerts gravitational pull on galaxies.
Dark Energy	~68%	A mysterious force causing the accelerated expansion of the universe. It has a repulsive, anti-gravitational effect.

Theories on the Origin of the Universe

Scientists have proposed several theories to explain the universe's origin and evolution.

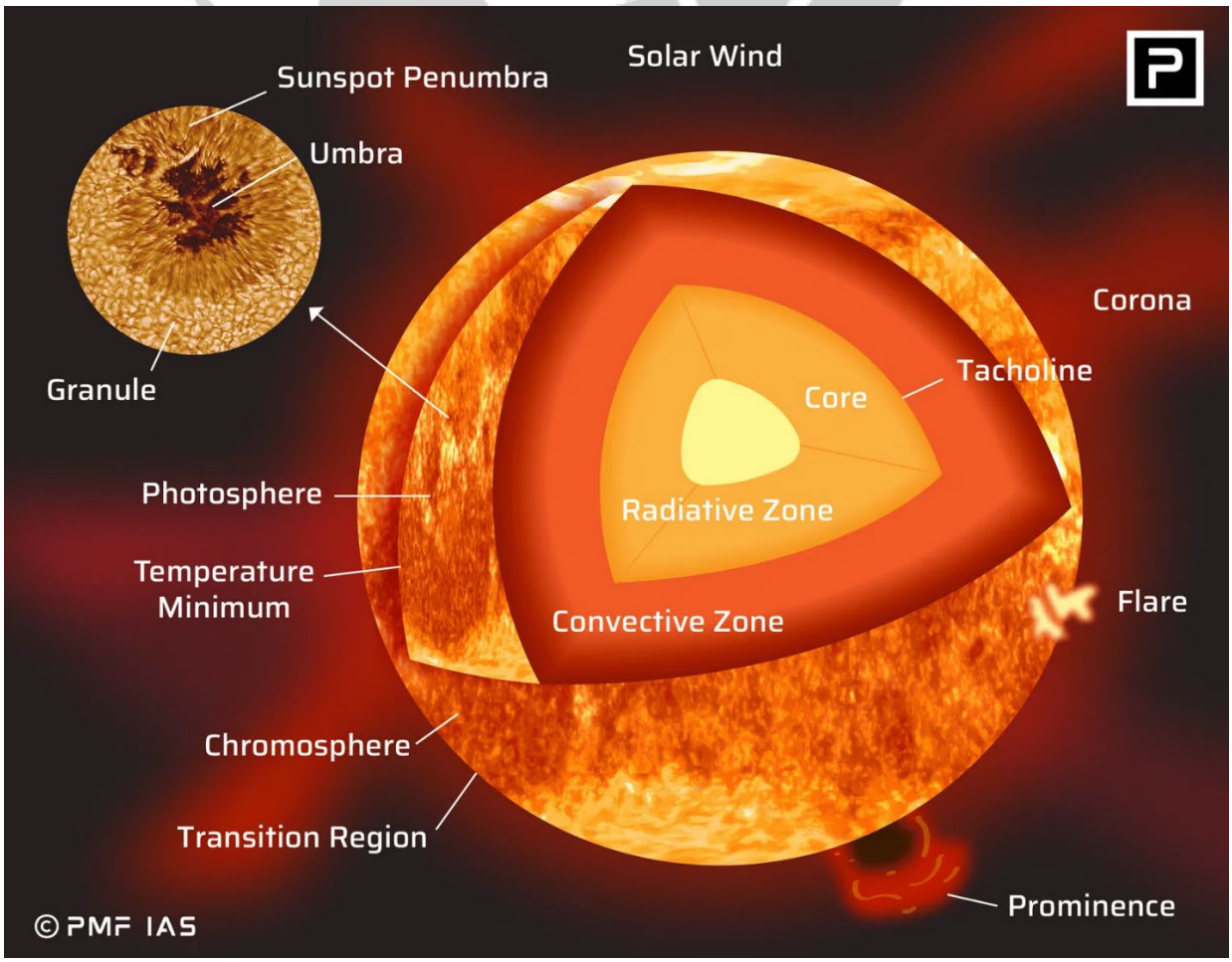
- **Big Bang Theory:** The most widely accepted theory. It states the universe began from an infinitely hot and dense singularity around **13.8 billion years ago** and has been expanding ever since. Key evidence includes the **Cosmic Microwave Background (CMB)** radiation, the leftover "echo" of the explosion.
- **Steady State Theory:** Proposed by **Sir Fred Hoyle**, this theory suggests the universe has always existed and has no beginning or end. New matter is continuously created as the universe expands to maintain a constant density.

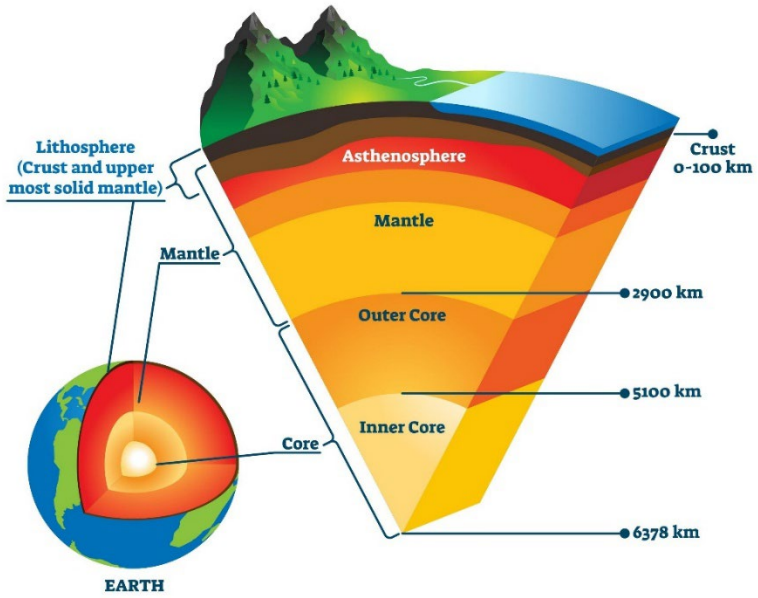
- **Oscillating Universe Theory:** This theory proposes the universe goes through endless cycles of a **Big Bang** followed by a **Big Crunch**, expanding and contracting repeatedly.

The Sun's Structure

The Sun is a complex sphere of hot plasma with distinct layers:

1. **Core:** The innermost layer where **nuclear fusion** occurs, converting hydrogen into helium. Temperature: ~**15 million °C**.
2. **Photosphere:** The visible "surface" of the Sun from which light is emitted. Temperature: ~**5,500 °C**.
3. **Chromosphere:** A reddish layer of gas just above the photosphere. Temperature: ~**6,000°C to 50,000°C**.
4. **Corona:** The outermost, super-heated atmosphere of the Sun, visible during a total solar eclipse. Temperature: ~**1-2 million °C**.



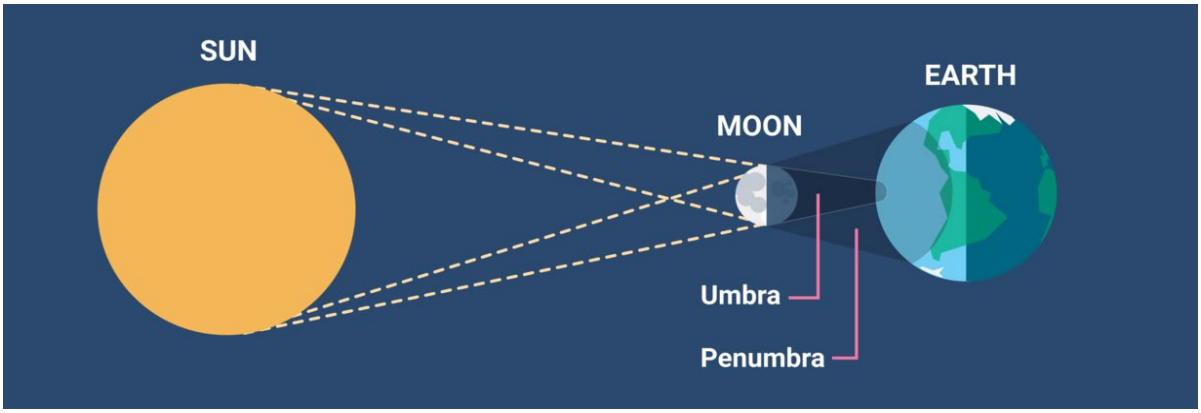


Earth's Orbital Points

- **Perihelion:** The point in Earth's orbit where it is **closest** to the Sun (around **January 3**).
- **Aphelion:** The point in Earth's orbit where it is **farthest** from the Sun (around **July 4**).

Eclipses

- **Solar Eclipse:** Occurs when the **Moon** passes directly between the **Sun** and the **Earth**, casting a shadow on Earth.
    - **Total Solar Eclipse:** The Moon completely blocks the Sun's photosphere.
    - **Partial Solar Eclipse:** The Moon only partially covers the Sun.
    - **Annular Solar Eclipse:** The Moon is too far from Earth to completely cover the Sun, leaving a "ring of fire" visible.



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Important Abbreviations Used In General Science

Physics and Units

- **SI:** International System of Units (Système International)
- **m:** Meter (unit of length)
- **kg:** Kilogram (unit of mass)
- **s:** Second (unit of time)
- **K:** Kelvin (unit of thermodynamic temperature)
- **A:** Ampere (unit of electric current)
- **cd:** Candela (unit of luminous intensity)
- **mol:** Mole (unit of amount of substance)
- **Hz:** Hertz (unit of frequency)
- **N:** Newton (unit of force)
- **J:** Joule (unit of work or energy)
- **W:** Watt (unit of power)
- **Pa:** Pascal (unit of pressure)
- **V:** Volt (unit of electric potential)
- **Ω:** Ohm (unit of electrical resistance)
- **C:** Coulomb (unit of electric charge)
- **Hz:** Hertz (unit of frequency)
- **LED:** Light Emitting Diode
- **LASER:** Light Amplification by Stimulated Emission of Radiation
- **SONAR:** Sound Navigation and Ranging
- **RADAR:** Radio Detection and Ranging
- **AC:** Alternating Current
- **DC:** Direct Current
- **CRO:** Cathode Ray Oscilloscope
- **LDR:** Light Dependent Resistor
- **UV:** Ultraviolet
- **IR:** Infrared
- **MRI:** Magnetic Resonance Imaging
- **CT Scan:** Computed Tomography Scan
- **GPS:** Global Positioning System

Important Scientific Instruments And Their Uses

Instruments Used in Physics

Instrument	Main Function / Use
Ammeter	Measures the strength of an electric current (in Amperes).
Voltmeter	Measures the electric potential difference between two points (in Volts).
Ohmmeter	Measures electrical resistance (in Ohms).
Galvanometer	Detects the presence and direction of a small electric current.
Barometer	Measures atmospheric pressure.
Hygrometer	Measures the relative humidity of the air.
Anemometer	Measures wind speed.
Rain Gauge	Measures the amount of rainfall.
Thermometer	Measures temperature.
Calorimeter	Measures the heat involved in a chemical or physical change.
Spectroscope	Splits light into its spectrum to study its composition.
Telescope	Views distant objects in space (Astronomical) or on Earth (Terrestrial).
Microscope	Views magnified images of very small objects.
Manometer	Measures the pressure of a gas.
Lactometer	Measures the purity (density) of milk.
Hydrometer	Measures the relative density (specific gravity) of liquids.
Viscometer	Measures the viscosity (resistance to flow) of a fluid.
Geiger Counter	Detects and measures radioactivity.

Important Discoveries And Inventors

Physics & Astronomy

- **Law of Gravitation & Laws of Motion**: Sir Isaac Newton (1687)
- **Planetary Motion Laws**: Johannes Kepler (1609-1619)
- **Heliocentric Model (Sun-centered Solar System)**: Nicolaus Copernicus (1543)
- **Telescopic Discoveries (Moons of Jupiter, etc.)**: Galileo Galilei (1610)
- **Atmospheric Pressure & Barometer**: Evangelista Torricelli (1643)
- **Principles of Hydrostatics (Pascal's Principle)**: Blaise Pascal (1650s)
- **Speed of Light Calculation**: Ole Rømer (1676)
- **Nature of Electricity (Lightning)**: Benjamin Franklin (1752)
- **Law of Electrostatic Force (Coulomb's Law)**: Charles-Augustin de Coulomb (1785)
- **Battery (Voltaic Pile)**: Alessandro Volta (1800)
- **Electromagnetism**: Hans Christian Ørsted (1820)
- **Electromagnetic Induction**: Michael Faraday (1831)
- **Laws of Thermodynamics**: Various, including Sadi Carnot and Lord Kelvin (1824-1850)
- **Radio Waves**: Heinrich Hertz (1887)
- **X-Rays**: Wilhelm Conrad Röntgen (1895)
- **Radioactivity**: Henri Becquerel (1896)
- **Electron**: J.J. Thomson (1897)
- **Quantum Theory**: Max Planck (1900)
- **Photoelectric Effect**: Albert Einstein (1905)

Muslim Scientists And Their Contributions To Science

During the Golden Age of Islam (8th to 14th centuries), Muslim scientists were at the forefront of scientific discovery. They preserved ancient Greek knowledge, added their own groundbreaking observations and experiments, and laid the foundation for the European Renaissance.

Astronomy

Muslim astronomers made highly accurate observations, built sophisticated observatories, and developed instruments that were used for centuries.

- **Al-Battani (Albatenius) (c. 858 – 929 CE):**
    - **Contributions:** Accurately calculated the solar year as 365 days, 5 hours, 46 minutes, and 24 seconds. He improved Ptolemy's astronomical models and determined the precise direction of Mecca (Qibla) from various locations.
- **Abd al-Rahman al-Sufi (Azophi) (903 – 986 CE):**
    - **Contributions:** Wrote the **"Book of Fixed Stars,"** a detailed catalog of stars, their positions, magnitudes, and color. He was the first to describe the **Andromeda Galaxy,** referring to it as a "little cloud."
- **Ibn al-Shatir (1304 – 1375 CE):**
    - **Contributions:** Developed a planetary model that eliminated the problematic Ptolemaic equant. His models were mathematically identical to those later proposed by **Copernicus**, suggesting a possible influence.
- **Ulugh Beg (1394 – 1449 CE):**
    - **Contributions:** Built a giant observatory in Samarkand and produced the **"Zij-i-Sultani,"** a star catalog considered one of the most accurate of the pre-telescopic era, detailing 1,019 stars.

Medicine

Muslim physicians transformed medicine from a theoretical field into a practical science based on observation and experimentation.

- **Al-Razi (Rhazes) (c. 854 – 925 CE):**

	(Spinach, Broccoli), Vegetable oils, Cereals	- Important for **bone metabolism**	

Water-Soluble Vitamins

These vitamins are not stored in the body and must be replenished regularly through diet.

Vitamin	Key Sources	Primary Functions / Roles	Deficiency Diseases
Vitamin B1 (Thiamine)	Whole grains, Pork, Legumes, Nuts, Seeds	- Helps convert food into **energy** - Crucial for **nerve function**	**Beri Beri**, Wernicke-Korsakoff syndrome
Vitamin B2 (Riboflavin)	Milk, Eggs, Yogurt, Lean meats, Green vegetables	- Energy production - **Skin and eye health** - Antioxidant activity	Ariboflavinosis (sore throat, skin disorders)
Vitamin B3 (Niacin)	Meat, Poultry, Fish, Whole grains, Peanuts	- **Energy metabolism** - **Nervous system** health - Digestive system health	**Pellagra** (Diarrhea, Dermatitis, Dementia)
Vitamin B9 (Folate/Folic Acid)	Leafy greens, Legumes, Citrus fruits, Fortified grains	- Crucial for **DNA synthesis** and **cell growth** - Prevents **neural tube defects** in fetuses	Megaloblastic anemia, Birth defects
Vitamin B12 (Cobalamin)	Animal products (Meat, Fish, Poultry, Eggs, Dairy)	- Vital for **nerve function** - **Red blood cell formation** - DNA synthesis	**Pernicious Anemia**, Nerve damage

Important Chemical Compounds - Common And Scientific Names

Many chemicals are known by common names in everyday language, while their scientific names describe their chemical composition.

Common Chemical Compounds

Common Name	Scientific (IUPAC) Name	Chemical Formula	Primary Use / Significance
Table Salt	Sodium Chloride	NaCl	Food seasoning, preservative
Water	Dihydrogen Monoxide	H_2O	Universal solvent, essential for life
Sugar (Table)	Sucrose	$C_{12}H_{22}O_{11}$	Sweetener, food ingredient
Baking Soda	Sodium Hydrogen Carbonate	$NaHCO_3$	Baking, antacid, fire extinguisher
Washing Soda	Sodium Carbonate	Na_2CO_3	Water softener, cleaning agent
Vinegar	Acetic Acid	CH_3COOH	Food preservative, cooking ingredient
Marble / Chalk	Calcium Carbonate	$CaCO_3$	Construction, antacid, writing material
Bleaching Powder	Calcium Oxychloride	Ca(OCl)Cl	Disinfectant, bleaching agent
Plaster of Paris	Calcium Sulphate Hemihydrate	$CaSO_4 \cdot \frac{1}{2}H_2O$	Casts, molds, building material
Gypsum	Calcium Sulphate Dihydrate	$CaSO_4 \cdot 2H_2O$	Cement, plaster, fertilizer

Wheat Rust	*Puccinia* species	Fungus	Leaves, Stems
Red Rot of Sugarcane	*Colletotrichum falcatum*	Fungus	Stem (Cane)

Common Phobias

A phobia is an irrational and extreme fear of a specific object, situation, or activity that poses little to no actual danger.

List of Common Phobias

Phobia	Fear Of
Arachnophobia	Spiders
Ophidiophobia	Snakes
Acrophobia	Heights
Agoraphobia	Open or crowded spaces, being in situations where escape is difficult
Aerophobia	Flying
Claustrophobia	Confined or enclosed spaces
Mysophobia	Germs, dirt, and contamination
Astraphobia	Thunder and lightning
Cynophobia	Dogs
Trypophobia	Clusters of small holes or bumps
Glossophobia	Public speaking
Nyctophobia	Darkness or night
Hemophobia	Blood

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