OAS ଅର୍ଥାତ୍

Study OAS

For A Better Odisha

Pocket Notes

SCIENCE

For OPSC, OSSC &
Other State Level
Exams.
Last Minute Revise

BIOLOGY

What is Living?

The term "living" cannot be strictly defined, but living organisms share certain fundamental characteristics.

Characteristics of Living

1. Growth

- Increase in mass or number of cells.
- In multicellular organisms → growth occurs by cell division.
- In unicellular organisms → growth means increase in cell size.
- Non-living things (e.g., crystals) may show external growth by accumulation, but not internal cell division.

☞ Growth alone is not a defining property of living beings.

2. Reproduction

- Living organisms produce young ones of their own kind.
- Can be sexual or asexual.

Exceptions (Very Important for Prelims):

- Mule (sterile)
- Worker bees
- Some human individuals

☞ Hence, reproduction is not universal for all living beings.

3. Metabolism

- Sum total of all chemical reactions occurring inside the cell.
- Includes:
    - Anabolism (building up reactions)
    - Catabolism (breaking down reactions)
- Occurs only in living organisms.

☞ Metabolism is considered the most defining characteristic of life.

4. Response to Stimuli

- Ability to sense and respond to environmental changes.

- Plants respond slowly (e.g., phototropism).
- Animals respond quickly due to nervous system.

Classification of Organisms

A. Five Kingdom Classification (R.H. Whittaker, 1969)

Based on:

- Cell structure
- Body organization
- Mode of nutrition
- Reproduction
- Phylogenetic relationships

1. Monera

- Prokaryotic organisms.
- No true nucleus.
- Examples:
  - Bacteria
  - Cyanobacteria (Blue Green Algae)
  - Archaebacteria

Important:

- Archaebacteria survive in extreme conditions (thermophiles, halophiles).
- Cyanobacteria perform photosynthesis.

2. Protista

- Mostly unicellular eukaryotes.
- Mostly aquatic.
- Examples: Diatoms, Flagellates, Protozoa.

Special Case:

- Euglena → both autotrophic and heterotrophic (mixotrophic).

☞ Diatoms have silica cell wall.

3. Fungi

- Non-green organisms.
- Heterotrophic (saprophytic or parasitic).

- Cell wall made of chitin (not cellulose).
- Examples: Mushroom, Mucor, Albugo.

Important:

- Reserve food → Glycogen (like animals).

4. Plantae

- Multicellular eukaryotes.
- Autotrophic (photosynthesis).
- Cell wall made of cellulose.
- Includes algae, bryophytes, pteridophytes, gymnosperms and angiosperms.

5. Animalia

- Multicellular eukaryotes.
- No cell wall.
- Heterotrophic.
- Includes all animals except protozoans.

Additional Classification System

Three Domain System (Carl Woese)

- Bacteria
- Archaea
- Eukarya

Viruses

- Acellular.
- Obligate intracellular parasites.
- Contain either DNA or RNA (never both).
- Cannot reproduce outside host.

Related Terms:

- Viroids → Infect plants (RNA only).
- Prions → Infectious proteins (cause mad cow disease).

3. Cell

Cell Theory

- Proposed by Schleiden and Schwann.
- Modified by Rudolf Virchow.
- All living organisms are made up of cells.
- Cell is the structural and functional unit of life.
- New cells arise from pre-existing cells.

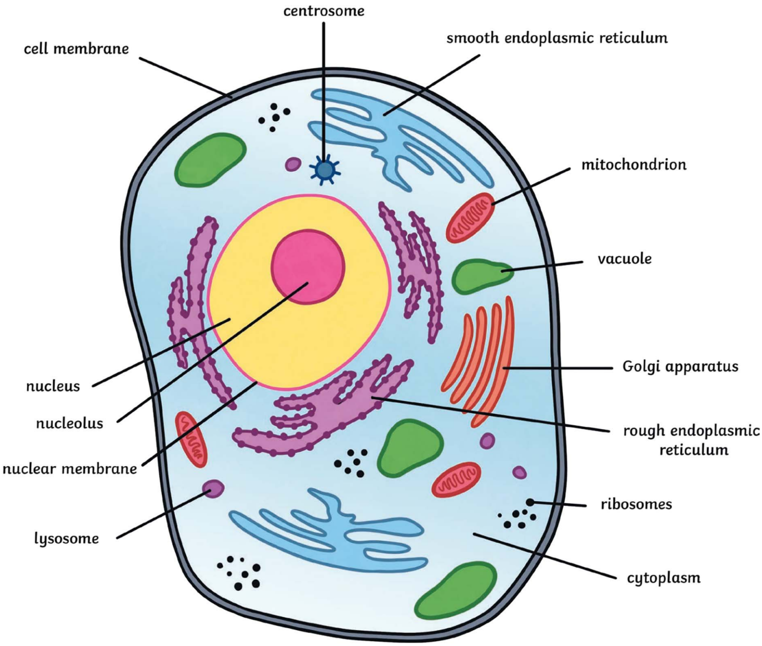
Important Cell Facts

- Smallest cell → Mycoplasma gallisepticum
- Longest cell → Neuron
- Largest cell → Egg of ostrich
- Largest organelle → Nucleus
- Powerhouse of cell → Mitochondria

Types of Cells

Feature	Prokaryotic	Eukaryotic
Size	Small	Large
Nucleus	Absent	Present
Chromosome	Single	Multiple
Membrane-bound organelles	Absent	Present
Cell division	Binary fission	Mitosis & Meiosis
Examples	Bacteria	Plants & Animals

Structure of Typical Cell



(Animal Cell)

Plant Cell Structure

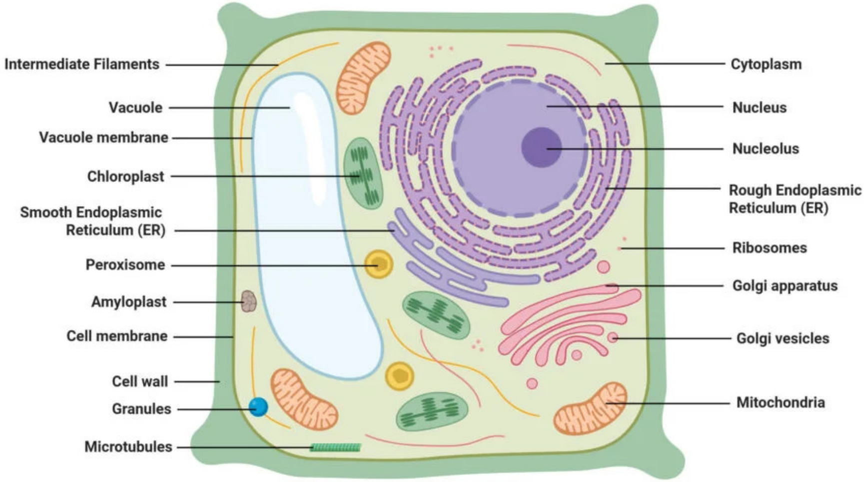


Figure: Plant Cell Structure

A typical eukaryotic cell consists of cell wall (in plants), plasma membrane, cytoplasm, nucleus and various cell organelles.

1. Cell Wall

- Present in plant cells, fungi and bacteria.
- Non-living and freely permeable.
- Made up of:
    - Cellulose (in plants)
    - Chitin (in fungi)
    - Peptidoglycan (in bacteria)
- Provides shape, rigidity and protection to the cell.
- Prevents osmotic bursting of cell.

Note:

- Animal cells do NOT have cell wall.
- Fungal cell wall is made of chitin.

2. Cell Membrane (Plasma Membrane)

- Present in all cells.
- Forms the outer covering of animal cell.
- In plant cell, found just inside the cell wall.
- Thin, elastic, living, selectively permeable membrane.
- Made up of phospholipid bilayer with embedded proteins (Fluid Mosaic Model – Singer & Nicolson).
- Regulates movement of substances inside and outside the cell.

Transport Mechanisms: Diffusion, Osmosis, Active transport

Notes:

- Cell membrane is selectively permeable, not freely permeable.

3. Protoplasm

- Entire living content inside plasma membrane is called protoplasm.
- Living part of the cell.
- Made up of water, ions, salts and organic molecules.
- Chemical composition:
  - Oxygen – 76%
  - Carbon – 10.5%
  - Hydrogen – 10%
  - Nitrogen – 2.5%

Divided into two parts:

(a) Cytoplasm

- Fluid found outside the nuclear membrane.
- Contains cell organelles.
- Site of many metabolic reactions.

(b) Nucleoplasm

- Fluid found inside the nuclear membrane.
- Contains chromatin and nucleolus.

4. Mitochondria

- Discovered by Altman (1886).
- Cylindrical, rod-shaped or spherical structure.
- Double membrane-bound organelle.

- Inner membrane forms folds called cristae.
- Site of cellular respiration.
- Synthesizes ATP (energy currency of cell).
- Known as "Power House" of the cell.

Important:

- Has its own DNA and ribosomes.
- Supports Endosymbiotic Theory (prokaryotic origin).
- Absent in prokaryotes and mature RBCs.

5. Golgi Bodies

- Discovered by Camilo Golgi.
- Made up of flattened sacs (cisternae), vesicles and vacuoles.
- In plants → called dictyosomes.
- Functions:
  - Storage
  - Processing
  - Packaging of proteins
  - Formation of lysosomes
  - Cell wall synthesis (in plants)
  - Formation of glycoproteins

Note:

- Golgi apparatus modifies and packages proteins synthesized by ribosomes.

6. Endoplasmic Reticulum (ER)

- Membranous network of tubules and sacs in cytoplasm.
- Connected to nuclear membrane.
- Helps in intracellular transport.
- Provides mechanical support to the cell.

Types:

- Rough ER (RER)
  - Ribosomes attached
  - Protein synthesis
- Smooth ER (SER)
  - No ribosomes
  - Lipid synthesis

- Detoxification (especially in liver cells)

7. Ribosome

- Discovered by George Palade.
- Small granular structures.
- Found attached to RER or freely in cytoplasm.
- Made up of RNA and protein.
- Site of protein synthesis.

Important:

- Present in both prokaryotes and eukaryotes.
- 70S type → Prokaryotes
- 80S type → Eukaryotes

Additional Organelles

Lysosome

- Known as "Suicidal bag" of cell.
- Contains digestive enzymes.
- Helps in intracellular digestion.

Plastids (Only in Plant Cells)

- Chloroplast → Photosynthesis
- Chromoplast → Pigments
- Leucoplast → Storage

Vacuole

- Large central vacuole in plant cell.
- Maintains turgor pressure.

Centrosome

- Present in animal cells.
- Helps in cell division.

Lysosome

- Discovered by Christian De Duve.
- Sac-like structures bounded by a single membrane.
- Contain hydrolytic (digestive) enzymes.

- Perform intracellular digestion.
- Can digest worn-out organelles (autophagy).
- If burst → may digest entire cell.
- Known as "Suicidal bag" of the cell.
- Not found in mammalian Red Blood Corpuscles (RBCs).

Note:

- Single membrane-bound organelle.
- More abundant in animal cells.

Centrosome

- Discovered by Theodor Boveri.
- Found only in animal cells.
- Not membrane-bound.
- Consists of two centrioles arranged perpendicular to each other.
- Helps in spindle fibre formation during cell division.

Trap:

- Centrosome absent in higher plant cells.

Plastids (Only in Plant Cells)

Plastids are double membrane-bound organelles.

Types of Plastids

(a) Chloroplast

- Green pigment-containing plastid.
- Known as "Kitchen of the cell".
- Site of photosynthesis.
- Bounded by double membrane.
- Contains:
  - Grana → Stacks of thylakoids containing chlorophyll.
  - Stroma → Matrix containing enzymes and starch grains.

Photosynthesis Stages:

- Light reaction → Occurs in grana.
- Dark reaction (Calvin cycle) → Occurs in stroma.

Note:

- Has its own DNA and ribosomes.

- Supports Endosymbiotic Theory.

(b) Chromoplast

- Provide colour to flowers and fruits.
- Contain pigments like carotenoids.

(c) Leucoplast

- Colourless plastids.
- Store food:
    - Starch (Amyloplast)
    - Fat (Elaioplast)
    - Protein (Aleuroplast)

Vacuole

- Fluid-filled sac.
- Single membrane-bound (Tonoplast).
- Larger in plant cells.
- Smaller in animal cells.
- Maintains turgor pressure in plants.
- Stores water, waste and nutrients.

Nucleus

- Discovered by Robert Brown.
- Spherical and centrally located in animal cells.
- In plant cells → pushed towards periphery due to large vacuole.
- Bounded by double-layered nuclear membrane with pores.

Contains Nucleoplasm, Nucleolus (rich in RNA and protein; ribosome formation) and Chromatin

Chromatin:

- Thread-like network.
- Made up of DNA and histone proteins.
- During cell division → condenses to form chromosomes.

Functions:

- Controls all activities of cell.
- Transmits hereditary characters.
- Known as "Control room of the cell".

Difference Between Plant and Animal Cells

Plant Cell	Animal Cell
Larger in size	Smaller in size
Cell wall present	Cell wall absent
Plastids present	Plastids absent
Centrosome absent	Centrosome present
Vacuole large	Vacuole small

Chromosomes

- Composed of DNA and protein.
- Thread-like structures found in nucleus.
- Visible during cell division.
- Consist of two chromatids joined at centromere.
- Gene → Bead-like functional unit present on chromosome.

Important Points:

- Prokaryotes → Single circular chromosome.
- Diploid (2n) → Paired chromosomes.
- Haploid (n) → Unpaired chromosomes.
- Humans → 23 pairs (46 total).

Prelims Focus:

- Virus does not have chromosome structure like eukaryotes.

Nucleic Acid

Complex organic compounds that store and transmit genetic information.

Types of Nucleic Acids

1. Deoxyribonucleic Acid (DNA)

- Hereditary material in almost all living organisms.
- Carries genetic instructions.
- Made up of nucleotides.

Each nucleotide consists of:

- Sugar (Deoxyribose)
- Phosphate group

- Nitrogen base

Four nitrogen bases:Adenine (A),Thymine (T), Guanine (G), Cytosine (C)

Base pairing rule:

- A pairs with T
- G pairs with C

Note:

- Same DNA in all cells of an individual (except RBCs).
- Replication is semi-conservative.
- Occurs during cell division.

DNA Fingerprinting

- Based on unique DNA sequence.
- Used in:
    - Forensic science
    - Paternity disputes
    - Criminal identification

Recombinant DNA (rDNA)

- Formed by combining DNA from multiple sources using genetic engineering.
- Achieved through molecular cloning.
- Basis of biotechnology.
- Example: Insulin production using bacteria.

Important:

- All organisms share same basic DNA structure.
- Differ only in nucleotide sequence.

Hachimoji DNA

- Synthetic DNA with eight nitrogen bases.
- Contains four natural bases (A, T, G, C) + four artificial bases.
- Can store and transmit genetic information.
- Important in astrobiology and synthetic biology research.

Advanced Molecular Biology & Cell Cycle

DNA Metabarcoding

- Technique used to identify species composition from an environmental sample.
- Works by:
  - Amplifying target genomic regions
  - Sequencing DNA
  - Analysing sequences
- Uses high-throughput sequencing (HTS).
- Does not require prior specimen sorting.
- Can analyse bulk samples simultaneously.
- Useful even when DNA is degraded.

Difference from DNA Barcoding:

- DNA barcoding → Identifies one species at a time.
- DNA metabarcoding → Identifies multiple species from mixed sample.

Applications:

- Biodiversity assessment
- Environmental monitoring
- Food authentication
- Wildlife forensics

Photo 51

- X-ray diffraction image of DNA fibre.
- Taken by Raymond Gosling under supervision of Rosalind Franklin (1952).
- Provided critical evidence for the double helix structure of DNA.
- Helped Watson and Crick propose DNA model.

Note:

- Key evidence in discovery of DNA structure.

Genome Sequencing

- Determining the exact order of nucleotides (A, T, G, C) in a genome.
- Reveals complete genetic blueprint of an organism.

Applications:

- Disease research
- Personalized medicine
- Evolutionary studies
- Agriculture

CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats)

- Derived from bacterial immune system.
- Gene-editing tool.
- Works like "cut-copy-paste" or "find-replace".
- Uses Cas enzymes (e.g., Cas9).

Applications:

- Genetic disorder treatment
- Crop improvement
- Cancer research

Note:

- Nobel Prize 2020 awarded for CRISPR gene editing.

Next Generation Sequencing (NGS)

- High-throughput DNA sequencing technology.
- Allows parallel sequencing of millions of DNA fragments.
- Generates gigabases of data quickly.

Advantages:

- Faster, Cost-effective, High accuracy

Ribonucleic Acid (RNA)

- Synthesised from DNA.
- Single-stranded molecule.
- Contains ribose sugar.
- Nitrogen bases: A, U, G, C (Uracil replaces Thymine).
- Plays key role in protein synthesis.

Types of RNA

1. tRNA (Transfer RNA)

- Also called soluble RNA.
- Transfers amino acids to ribosome.
- Acts as adaptor between mRNA and amino acids.

2. rRNA (Ribosomal RNA)

- Found in ribosomes.
- Major structural component of ribosome.
- Most abundant RNA in cells.
- Site of protein synthesis.

3. mRNA (Messenger RNA)

- Carries genetic message from DNA to ribosome.
- Template for protein synthesis.
- Formed during transcription.

4. MicroRNA (miRNA)

- Small RNA (~21 nucleotides).
- Regulates gene expression.
- Destroys specific mRNA molecules.
- Process called gene silencing.

Gene Knockout

- Technique used to study gene function.
- Gene is silenced or inactivated.
- Often achieved using RNA interference or CRISPR.
- Helps in understanding disease mechanisms.

Differences Between DNA and RNA

DNA	RNA
Double-stranded	Single-stranded
Sugar: Deoxyribose	Sugar: Ribose
Bases: A, T, G, C	Bases: A, U, G, C

Stable	Less stable
Self-replicating	Formed from DNA
Genetic storage	Protein synthesis

Cell Cycle

- Sequence of events by which a cell grows and divides.
- It includes:
  - Interphase (G1, S, G2)
  - M phase (Mitosis + Cytokinesis)

Interphase:

- G1 → Growth
- S → DNA replication
- G2 → Preparation for division

Typical eukaryotic cell cycle → ~24 hours.

Cell Division

- Process by which cells increase in number.
- Required for growth, development and repair.

Two types:

1. Mitosis

- Occurs in somatic (body) cells.
- Responsible for growth and repair.
- In unicellular organisms → asexual reproduction.
- Produces two identical daughter cells.
- Chromosome number remains same (2n → 2n).
- Also called Equational Division.

Stages:

- Prophase
- Metaphase
- Anaphase
- Telophase
- Followed by Cytokinesis

2. Meiosis

- Occurs in reproductive cells.
- Produces gametes (sperm and ova).

- Two successive divisions: Meiosis I and Meiosis II.
- Produces four haploid daughter cells.
- Chromosome number reduced to half (2n → n).
- Also called Reduction Division.

Importance:

- Maintains chromosome number across generations.
- Introduces genetic variation (crossing over).

GENETICS

Basic Concepts

- Heredity → Transmission of characters from one generation to next.
- Genetics → Study of heredity and variation.
- Variation → Differences between offspring and parents.

Important Personalities:

- Term "Genetics" coined by William Bateson (1905).
- Term "Gene" given by Wilhelm Johannsen (1909).
- Father of Genetics → Gregor Johann Mendel.

Mendel's Laws of Inheritance

Based on experiments on pea plants (Pisum sativum).

1. Law of Dominance

- In a heterozygous condition, one allele expresses itself (dominant), other remains masked (recessive).

2. Law of Segregation

- Allele pairs separate during gamete formation.

Prelims Focus:

- Monohybrid cross → One trait.
- Dihybrid cross → Two traits.

Chromosomal Theory of Inheritance

- Proposed by Sutton and Boveri.
- Genes are located on chromosomes.
- Chromosome segregation during meiosis explains Mendelian

inheritance.

Sex Determination in Humans

- Humans follow XY type mechanism.
- 23 pairs of chromosomes:
    - 22 pairs autosomes
    - 1 pair sex chromosomes

Female → XX
Male → XY

During spermatogenesis:

- 50% sperms carry X
- 50% sperms carry Y

Female produces only X-bearing ova.

If fertilization by:

- X sperm → Female (XX)
- Y sperm → Male (XY)

Notes:

- Sex of child determined by father.

Genetic Disorders

1. Mendelian Disorders

- Caused by mutation in single gene.
- It can be Autosomal dominant, Autosomal recessive and Sex-linked

Examples:

- Hemophilia (Sex-linked)
- Cystic Fibrosis (Autosomal recessive)
- Sickle Cell Anaemia
- Albinism

Detected by pedigree analysis.

2. Chromosomal Disorders

- Caused by change in chromosome number or structure.
- Affect multiple genes.

Examples:

- Down's Syndrome → Trisomy 21
- Turner's Syndrome → XO

- Klinefelter's Syndrome → XXY

Prelims Focus:

- Trisomy = Addition of chromosome.

3. Multifactorial Inheritance

- Caused by multiple genes + environmental factors.

Examples:

- Heart disease
- Hypertension
- Cancer
- Alzheimer's

4. Mitochondrial Inheritance

- Due to mutation in mitochondrial DNA.
- Inherited only from mother.

Examples:

- Leber's Hereditary Optic Atrophy (LHON)
- Mitochondrial encephalopathy

Botany

- Study of plants.
- Father of Botany → Theophrastus.

Classification of Plantae

A. Cryptogams (Non-flowering plants)

1. Thallophyta

- No true root, stem, leaves.
- No vascular tissue.

(a) Algae

- Autotrophic.
- Can be unicellular or multicellular.

Economic Importance:

- Food → Porphyra, Ulva
- Iodine → Laminaria
- Manure → Nostoc, Anabaena
- Agar-Agar → Obtained from algae

Important Phenomena:

- Red Snow → Due to Chlamydomonas nivalis.
- Sea Snot → Marine mucilage due to nutrient pollution + warming.

(b) Fungi

- Study → Mycology.
- Non-vascular, heterotrophic.
- Lack chlorophyll.
- Cell wall contains chitin.
- Reproduce by spores.

Types:

- Saprophytic → Rhizopus
- Parasitic → Puccinia
- Symbiotic → Lichens, Mycorrhiza

Lichens → Symbiosis of algae + fungi.
Mycorrhiza → Symbiosis of fungi + plant roots.

2. Bryophyta

- Called "Amphibians of Plant Kingdom".
- No true roots (have rhizoids).
- Lack vascular tissue.
- Example: Moss.

3. Pteridophyta

- Vascular plants without seeds.
- Body differentiated into root, stem, leaves.
- Reproduce by spores.
- Example: Ferns.

B. Phanerogams (Seed-bearing plants)

1. Gymnosperms

- Naked seeds.
- Woody, perennial plants.
- Pollination by wind.

Important Examples:

- Sequoia gigantea → Tallest plant (~120 m).
- Cycas, Ginkgo biloba → Living fossils.
- Ginkgo biloba → Maiden hair tree.

2. Angiosperms

- Seeds enclosed within fruit.
- Have flowers.
- Most advanced plants.

Photosynthesis

Process by which green plants prepare food using sunlight.

Equation:

$CO_2 + H_2O \rightarrow$ Glucose + O_2 (in presence of light & chlorophyll)

Occurs in chloroplast.

Light reaction → Grana

Dark reaction → Stroma

Factors Affecting Photosynthesis

1. Light intensity → Directly proportional (up to limit).
2. CO_2 concentration → Increases rate.
3. Temperature → Optimum 25°–35°C.
4. Water → Essential raw material.
5. Pollution → Blocks stomata, reduces CO_2 intake.

Plant Hormones

Plant hormones are chemical messengers that regulate growth, development and responses to stimuli.

1. Auxins

- Found in growing apices of roots and stems.
- Promote cell elongation.
- Used in agriculture and horticulture.

Functions:

- Induce parthenocarpy (fruit without fertilisation) → e.g., Tomato.
- Prevent premature fall of leaves and fruits.
- Help in rooting during stem cutting and grafting.
- Promote flowering (e.g., Pineapple).
- Responsible for apical dominance.
- Synthetic auxins used as herbicides (e.g., 2,4-D).

2. Gibberellins

- Acidic hormones.
- Found in higher plants and fungi.

Functions:

- Promote bolting (rapid elongation of internodes before flowering).
- Elongate stem and reverse dwarfism.
- Delay senescence.
- Induce parthenocarpy.
- Promote maleness in some plants (e.g., Cannabis).
- Used to increase sugarcane yield by increasing internode length.

3. Cytokinins

- Promote cell division (cytokinesis).
- Promote lateral and adventitious shoot growth.
- Overcome apical dominance.
- Delay leaf senescence.
- Stimulate chloroplast formation.
- Promote nutrient mobilisation.

Used in tissue culture for shoot formation.

4. Abscisic Acid (ABA)

- Growth-inhibiting hormone.
- Known as "Stress hormone".

Functions:

- Induces abscission of leaves and fruits.
- Inhibits seed germination.
- Promotes seed dormancy.
- Induces leaf senescence.
- Stimulates closure of stomata during water stress.
- Helps plant survive drought conditions.

5. Ethylene

- Only gaseous plant hormone.
- Acts both as growth promoter and inhibitor.
- Produced in ripening fruits.

Functions:

- Hastens fruit ripening.
- Breaks seed and bud dormancy.
- Causes epinasty of leaves.
- Promotes senescence.

Notes:

- Artificial ripening sometimes done using ethylene.

Plant Diseases

A. Viral Diseases

1. Tobacco Mosaic Disease
- Caused by Tobacco Mosaic Virus (TMV).
- Leaves shrink and chlorophyll destroyed.

2. Bunchy Top of Banana
- Caused by Banana virus.
- Plants become dwarf, leaves cluster at top.

3. Fiji Virus (Southern Rice Black-Streaked Dwarf Virus – SRBSDV)
- Affects rice and maize.
- Spread by white-backed plant hopper (Sogatella furcifera).
- Not transmitted by seed.
- Causes serious yield loss.

B. Bacterial Diseases

➢ Wilt of Potato (Ring disease)
  - Caused by Pseudomonas solanacearum.
  - Brown ring in xylem.

➢ Black Arm of Cotton
  - Caused by Xanthomonas.

➢ Bacterial Blight of Rice
  - Caused by Xanthomonas oryzae.
  - Yellow-green spots on leaves.

➢ Citrus Canker
  - Caused by Xanthomonas citri.

➢ Tundu Disease of Wheat
  - Caused by Corinobacterium + nematode.

➢ Sandalwood Spike Disease
  - Caused by phytoplasma.
  - First reported in Kodagu (1899).
  - Infected trees must be removed.

➢ Xoo Infection
  - Caused by Xanthomonas oryzae pv. oryzae.
  - Gram-negative bacteria.
  - Prevention: Resistant rice varieties.

C. Fungal Diseases

- Yellow Rust of Wheat
  - Appears as yellow powder on leaves.
  - Favourable conditions: Cool weather, dew, fog.
- Athelia rolfsii
  - Causes fruit rot in jackfruit.
  - Soil-borne pathogen.
- Fusarium Wilt TR4
  - Affects banana (Grand Nain variety).
  - Causes yellowing and wilting of leaves.
- Damping Off
  - Caused by Pythium debaryanum.
- Red Root of Sugarcane
  - Caused by Colletotrichum falcatum.

Classification of Animal Kingdom

Phylum Chordata

1. Pisces (Fishes)

- Aquatic animals.
- Cold-blooded (poikilothermic).
- Two-chambered heart.
- Heart pumps only impure blood.
- Respiration through gills.

Examples:

- Scoliodon
- Torpedo

2. Amphibia

- Live both on land and in water.
- Cold-blooded.
- Respiration through gills (larval stage), lungs and skin (adult).
- Three-chambered heart (two auricles, one ventricle).

Examples:

- Frog
- Toad

3. Reptilia

- Crawling animals.
- Cold-blooded (poikilothermic).
- Mostly terrestrial, some aquatic.
- Usually two pairs of limbs (absent in snakes).
- Respiration through lungs.
- Eggs covered with calcareous shell (Calcium carbonate).
- Internal fertilization.

Important Points:

- Mesozoic Era → "Age of Reptiles".
- Cobra → Only snake known to make nest.
- Venom injected through fangs.
- Heloderma → Only poisonous lizard.
- Hydrophis (Sea snake) → Highly poisonous.

Examples:

- Lizard, Snake, Tortoise, Crocodile, Turtle,Sphenodon

4. Aves (Birds)

- Warm-blooded (homeothermic).
- Body covered with feathers.
- Forelimbs modified into wings.
- Boat-shaped body: head, neck, trunk, tail.
- Respiration through lungs (with air sacs).
- Four-chambered heart.
- No teeth; beak present (formed by jaws).
- Oviparous (egg-laying).

Examples:

- Crow, Peacock, Parrot

Notes:

- Only vertebrates with feathers.

5. Mammalia

- Warm-blooded.
- Skin has hair.
- Sweat glands and oil glands present.
- External ear (Pinna) present.

- Four-chambered heart.
- Mostly viviparous.
- Diphyodont → Two sets of teeth.
- RBCs lack nucleus (except camel and llama).

Subclasses of Mammals:

- Prototheria
  - Egg-laying mammals (Monotremes).
  - Example: Echidna, Duck-billed Platypus.
- Metatheria
  - Marsupials; immature young born.
  - Example: Kangaroo.
- Eutheria
  - Placental mammals; well-developed young.
  - Example: Human.

Important Facts:

- Goat has highest body temperature (~39°C).
- Allantois in mammalian embryo helps in respiration.

Human Blood

About Blood

- Fluid connective tissue.
- Transports oxygen, nutrients and wastes.
- Two components:
  1. Plasma (55%)
  2. Blood Corpuscles (45%)

1. Plasma

- Straw-coloured fluid.
- 90–92% water.
- 6–8% proteins.

Major Proteins:

- Fibrinogen → Blood clotting.
- Globulins → Immunity.
- Albumin → Osmotic balance.

Contains:

- Electrolytes (Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-)
- Glucose
- Amino acids
- Lipids

Plasma without clotting factors → Serum.

2. Blood Corpuscles

(A) Red Blood Cells (RBCs)

- Also called Erythrocytes.
- 5–5.5 million/mm^3 in adult males.
- Formed in red bone marrow.
- Biconcave shape.
- Contain haemoglobin (iron protein).
- Life span → 120 days.
- Destroyed in spleen ("Graveyard of RBCs").

(B) White Blood Cells (WBCs)

- Also called Leucocytes.
- 6000–8000/mm³.
- Nucleated.
- Function → Immunity.

Types of WBCs

1. Granulocytes

(a) Neutrophils

- 60–65% of WBCs.
- First line of defence.
- Found in pus.
- Destroy bacteria.

(b) Eosinophils

- 2–3% of WBCs.
- Fight parasitic infections.
- Involved in allergy and asthma.

(c) Basophils

- 0.5–1% of WBCs.
- Release histamine, serotonin, heparin.
- Involved in inflammation and allergic reactions.

2. Agranulocytes

(a) Monocytes

- Largest WBCs.
- 6–8% of WBCs.
- Phagocytic; clean dead cells.

(b) Lymphocytes

- B cells and T cells.
- Responsible for humoral and cell-mediated immunity.
- Produce antibodies.

(C) Platelets (Thrombocytes)

- Produced in bone marrow.
- Help in blood clotting.
- Essential during injury.

Blood Coagulation

- Prevents excessive blood loss.
- Fibrinogen → Converted to Fibrin by thrombin.
- Thrombin formed from prothrombin.
- Forms clot (coagulum).

Blood Groups

1. ABO System

- Based on antigens A and B on RBCs.
- Plasma contains antibodies.
- Controlled by gene I.

2. Rh System

- Based on Rh antigen.
- Rh+ → Antigen present.
- Rh− → Antigen absent.
- Rh incompatibility can cause haemolytic disease in newborn.

Human Digestive System

Components

1. Alimentary Canal
2. Accessory Organs

Alimentary Canal

Sequence:
Mouth → Pharynx → Esophagus → Stomach → Small intestine → Large intestine → Rectum → Anus

Mouth (Buccal Cavity)

- Teeth → Mechanical digestion.
- Saliva contains amylase (digests starch).

Stomach

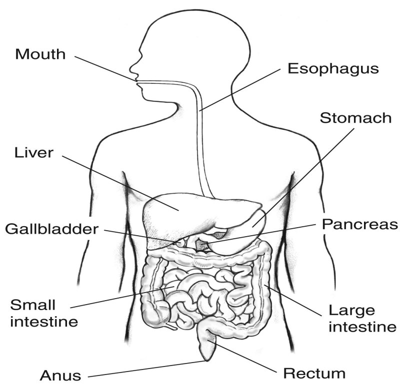
- Secretes HCl and pepsin.
- Protein digestion begins.

Small Intestine

- Main site of digestion and absorption.
- Divided into duodenum, jejunum, ileum.

Large Intestine

- Absorbs water.
- Forms faeces.



The digestive system of human beings consists of two major parts:

1. Alimentary Canal
2. Accessory Organs

The main function of this system is ingestion of food, digestion, absorption of nutrients and elimination of undigested waste.

Alimentary Canal

The alimentary canal is a long muscular tube that begins at the mouth and ends at the anus. It includes the mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum and anal canal.

Mouth (Buccal Cavity)

The process of digestion begins in the mouth.

- Teeth are specially designed for mechanical digestion. They grind food into small particles so that digestive enzymes can act efficiently.
- The food is mixed with saliva secreted by salivary glands.
- Saliva contains the enzyme salivary amylase (ptyalin) which begins the digestion of starch into maltose.
- Saliva also moistens and lubricates the food to form a bolus.
- The tongue helps in mixing food with saliva and pushes the bolus into the pharynx during swallowing.

Pharynx

The pharynx is a fibromuscular Y-shaped tube attached to the posterior end of the mouth.

- It acts as a common passage for food and air.
- Its main function in digestion is to conduct the chewed food from the mouth to the esophagus.
- Swallowing (deglutition) is a coordinated muscular action that pushes food downward.

Esophagus

The esophagus is a muscular tube connecting the pharynx to the stomach.

- It passes through the thoracic cavity and pierces the diaphragm.
- Food moves through the esophagus by rhythmic contractions called peristalsis.
- No digestion occurs here; it only transports food.

Stomach

The stomach is a J-shaped muscular bag located on the left side of the abdominal cavity, beneath the diaphragm.

Functions:

- Acts as a temporary storage organ for food.
- Performs mechanical churning of food.
- Secretes gastric juice.

Gastric juice contains:

- Mucus
  - Protects the inner lining of the stomach from acid.
  - Prevents self-digestion of stomach wall.
- Hydrochloric Acid (HCl)
  - Kills harmful microorganisms present in food.
  - Creates acidic medium for enzyme activity.
  - Activates pepsinogen into pepsin.
- Digestive Enzymes
  - Pepsin: Breaks proteins into peptones.
  - Renin (in infants): Coagulates milk protein.

The semi-digested food formed here is called chyme.

Small Intestine

The small intestine is about 10 feet long and occupies most of the abdominal cavity. It is the main site of digestion and absorption. It is divided into:

- Duodenum
- Jejunum
- Ileum

Intestinal Juice contains:

- Erepsin → Converts peptides into amino acids.
- Maltase → Converts maltose into glucose.
- Sucrase → Converts sucrose into glucose and fructose.
- Lactase → Converts lactose into glucose and galactose.
- Lipase → Converts emulsified fats into glycerol and fatty acids.

The inner lining contains villi which increase surface area for absorption. Most nutrients enter the bloodstream here.

Large Intestine

The large intestine is about 5 feet long.

Functions:

- Absorbs water and minerals.
- Contains symbiotic bacteria which help in breakdown of waste and synthesis of Vitamin K and B-complex vitamins.
- Forms feces.

Rectum

The rectum is the terminal portion of the large intestine.

- Stores semi-solid feces temporarily.
- Waste is expelled through the anal canal by defecation.

Accessory Organs

These organs help in digestion but food does not pass through them.

Pancreas

The pancreas is a large gland located behind the stomach.

It secretes pancreatic juice into the duodenum containing:

- Trypsin → Converts proteins into polypeptides and amino acids.
- Amylase → Converts starch into sugars.
- Lipase → Converts fats into glycerol and fatty acids.

It also has endocrine function (insulin and glucagon secretion).

Liver

The liver is the largest gland in the body, located on the right side of the abdomen.

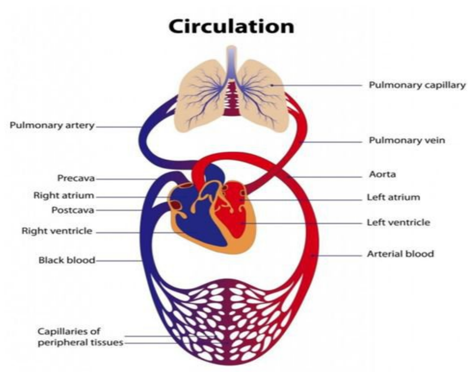
Functions:

- Produces bile.
- Bile helps in emulsification of fats.
- Detoxifies harmful substances.
- Converts excess glucose into glycogen.

Bile is stored in the gallbladder, a small pear-shaped organ.

Circulatory System

The circulatory system transports oxygen, nutrients, hormones and removes wastes.



Heart

- Located in thoracic cavity.
- Protected by pericardial membrane.
- Average weight: ~300 grams.
- Four chambers:
    - Right auricle
    - Left auricle
    - Right ventricle
    - Left ventricle

Valves:

- Tricuspid valve → Between right auricle and right ventricle.
- Bicuspid (Mitral) valve → Between left auricle and left ventricle.

Blood Vessels:

- Veins carry blood towards heart.
- Arteries carry blood away from heart.

Exceptions:

- Pulmonary vein carries oxygenated blood.

- Pulmonary artery carries deoxygenated blood.

Right side of heart → Deoxygenated blood.
Left side of heart → Oxygenated blood.

Coronary arteries supply blood to heart muscles. Blockage causes heart attack.

Double Circulation

Mammals show double circulation. Blood passes twice through the heart in one complete cycle.

Pathway:
Body → Right auricle → Right ventricle → Pulmonary artery → Lungs → Pulmonary vein → Left auricle → Left ventricle → Aorta → Body

Cardiac Cycle

One complete contraction and relaxation of heart chambers.

- Systole → Contraction
- Diastole → Relaxation

Heart Beat

The heartbeat originates from a specialized node called the SA node (pacemaker). It maintains rhythmic contraction throughout life.

Excretory System

Excretion is the removal of nitrogenous metabolic wastes from the body.

Kidneys

- Bean-shaped organs.
- Each weighs about 140 grams.
- Outer region → Cortex
- Inner region → Medulla

Each kidney contains millions of nephrons.

Nephron is the structural and functional unit of kidney.

Parts of Nephron:

- Bowman's capsule
- Glomerulus
- Tubules

Glomerulus is a network of capillaries inside Bowman's capsule.

- Afferent arteriole → Brings blood to glomerulus.
- Efferent arteriole → Takes blood away.

Ultrafiltration → Filtration of blood in glomerulus.

Daily filtration:

- 180 litres filtered.
- 1.5 litres urine formed.

Normal urine contains:

- 95% water
- 2% salts
- 2.7% urea
- 0.3% uric acid

Urine pH → Around 6 (slightly acidic).

Colour → Due to urochrome.

Kidney stones → Often calcium oxalate.

Other Excretory Organs

Skin

- Sweat glands excrete sweat.
- Oil glands secrete sebum.

Liver

- Converts ammonia into urea.

Lungs

- Excrete carbon dioxide and water vapour.
- Also excrete volatile substances like garlic smell.

Nervous System

The nervous system is a highly organized and complex network of specialized cells that coordinate and control all activities of the body. It helps in receiving stimuli from the environment, processing the information, and generating appropriate responses.

Neuron – Structural and Functional Unit

A neuron is the structural and functional unit of the nervous system. Unlike most body cells, neurons are irregular in shape and are specialized to conduct electrochemical impulses.

Structure of a Neuron

- Cell Body (Cyton)
  - Contains cytoplasm and nucleus.
  - It is the metabolic center of the neuron.
- Dendrites
  - Short, branched fibers extending from the cell body.
  - They receive impulses from other neurons or sensory receptors.
- Axon
  - The longest fiber of the neuron.
  - Conducts impulses away from the cell body.
  - Usually covered by a myelin sheath which acts as an insulating and protective covering.
  - Myelin sheath increases the speed of nerve impulse conduction.
- Synapse
  - A microscopic gap between two adjacent neurons.
  - Nerve impulses pass across synapse through chemical messengers called neurotransmitters.

Nerves

Nerves are thread-like bundles of nerve fibers that arise from the brain and spinal cord. They transmit messages throughout the body.

Types of Nerves:

- Sensory Nerves
  - Carry impulses from sense organs to the brain.
- Motor Nerves

- Carry impulses from brain to muscles and glands.

➢ Mixed Nerves
- Contain both sensory and motor fibers.

Divisions of Nervous System

The nervous system is divided into two major parts:

1. Central Nervous System (CNS)
2. Peripheral Nervous System (PNS)

Central Nervous System (CNS)

It consists of the brain and spinal cord. It acts as the command and control center of the body.

Brain

The brain is the central information processing organ. It controls vision, hearing, speech, memory, emotions, intelligence and voluntary movements.

Protection of Brain:

- Skull (cranium)
- Three layers of meninges:
  - Dura mater (outer layer)
  - Arachnoid mater (middle layer)
  - Pia mater (inner layer)

Major Parts of Brain

1. Forebrain
- Includes Cerebrum, Thalamus and Hypothalamus.
- Cerebrum controls intelligence, memory and voluntary actions.
- Hypothalamus regulates temperature, hunger and thirst.

1. Midbrain
- Connects forebrain and hindbrain.
- Controls visual and auditory reflexes.

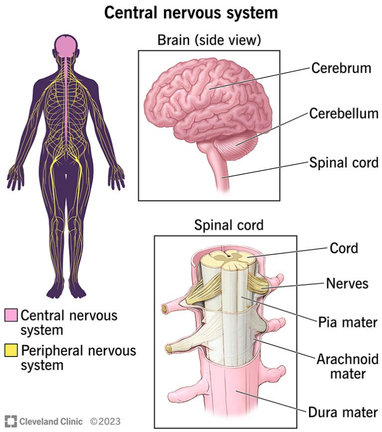
1. Hindbrain
- Includes Cerebellum, Pons and Medulla.
- Cerebellum controls balance and coordination.
- Medulla controls involuntary activities like breathing and heartbeat.

Spinal Cord

- A long cylindrical bundle of nerve fibers.

- Enclosed within vertebral column.
- Extends from medulla downward.
- Responsible for reflex actions and conduction of impulses to and from brain.

Reflex action is a quick automatic response to stimulus without conscious thought.



Peripheral Nervous System (PNS)

It includes all nerves outside CNS.

Nerve Fibers in PNS:

- Afferent fibers → Carry impulses from tissues to CNS.
- Efferent fibers → Carry impulses from CNS to tissues.

PNS is further divided into:

- Somatic Nervous System
  - Controls voluntary muscles.
- Autonomic Nervous System
  - Controls involuntary organs and smooth muscles.
  - Regulates heart rate, digestion, respiration etc.

Skeletal System

The skeletal system forms the framework of the body and provides shape, support and protection.

It is divided into two parts:

1. Axial Skeleton
2. Appendicular Skeleton

Axial Skeleton

Forms the central axis of the body. It consists of 80 bones.

Skull

- Total 29 bones (including ear ossicles and hyoid).
- 8 cranial bones protect the brain.
- 14 facial bones form the face.
- Bones are joined by sutures.

Vertebral Column

- Made of vertebrae separated by intervertebral discs.
- Provides flexibility and shock absorption.
- Functions:
    - Protects spinal cord.
    - Supports head and body.
    - Enables bending and twisting movements.

Appendicular Skeleton

Includes bones of limbs and girdles.

Girdles

- Pectoral girdle → Attaches forelimbs to axial skeleton.
- Pelvic girdle → Attaches hindlimbs to axial skeleton.

Major Bones:

- Humerus → Upper arm bone.
- Femur → Thigh bone (longest bone in body).

Functions of Skeletal System

- Provides shape and support.
- Protects internal organs.

- Helps in movement with muscles.
- Produces red blood cells (bone marrow).

Endocrine System

The endocrine system consists of ductless glands that secrete hormones directly into bloodstream. Hormones regulate growth, metabolism, reproduction and many other body functions.

Major Endocrine Glands

Pituitary Gland

- Located at base of brain.
- Known as "Master gland".
- Controls other endocrine glands.
- Secretes growth hormone, prolactin, ACTH etc.
- Regulates metabolism and milk production.

Thyroid Gland

- Located in neck.
- Secretes T3 and T4 hormones.
- Regulates metabolism, growth and development.

Deficiency leads to goitre or hypothyroidism.

Parathyroid Glands

- Four small glands behind thyroid.
- Secrete Parathyroid Hormone (PTH).
- Regulate calcium levels.
- Excess may cause kidney stones and brittle bones.

Adrenal Glands

- Located above kidneys.
- Secrete adrenaline (fight or flight hormone).
- Increases heart rate, blood sugar, pupil dilation.

Pancreas

- Both exocrine and endocrine gland.
- Secretes insulin and glucagon.

Insulin → Lowers blood glucose.
Glucagon → Raises blood glucose.
Imbalance leads to diabetes or hypoglycemia.

Gonads

- Ovaries (female) → Produce estrogen.
- Testes (male) → Produce testosterone.
- Regulate secondary sexual characteristics.

Pineal Gland

- Located between two hemispheres of brain.
- Produces melatonin.
- Regulates sleep-wake cycle (circadian rhythm).

Respiratory System and its Organs

The respiratory system is responsible for the intake of oxygen and the removal of carbon dioxide from the body. Oxygen is essential for cellular respiration, while carbon dioxide is a waste product that must be eliminated. Respiration includes both breathing and cellular oxidation of food.

Main Organs of Respiratory System

Nasal Passage

The nasal passage is the first part of the respiratory tract.

- It is lined internally with a mucous membrane.
- Approximately half a litre of mucus is secreted daily.
- The mucus traps dust particles, bacteria and other harmful microorganisms.
- The nasal cavity also moistens and warms the incoming air.
- It helps in adjusting the temperature of air to match body temperature.
- It plays a role in sniffing and detecting smell.

Thus, the nasal passage acts as a filtering, warming and moistening chamber.

Pharynx

The pharynx is located behind the nasal cavity.

- It is a common passage for both respiratory and digestive systems.
- It conducts air to the larynx and food to the esophagus.

- It plays a dual role but ensures proper separation of air and food during swallowing.

Larynx

The larynx is situated at the upper end of the trachea.

- It is also known as the voice box.
- The opening of the larynx is called the glottis.
- A cartilaginous flap called epiglottis covers the glottis during swallowing.
- Epiglottis prevents food from entering the respiratory tract.
- Inside the larynx, a pair of vocal cords is present.
- Vibrations of vocal cords produce sound.

Thus, the larynx is important for both respiration and speech.

Trachea

The trachea is a long tube extending from the larynx to the thoracic cavity.

- It passes through the neck and enters the chest cavity.
- It is supported by C-shaped cartilaginous rings.
- These rings prevent collapse of the trachea.
- Internally lined with ciliated epithelium and mucus-secreting cells.
- The cilia help in removing trapped particles upward.

Bronchi and Bronchioles

Inside the thoracic cavity, the trachea divides into two branches called bronchi.

- Each bronchus enters its respective lung.
- Within the lungs, bronchi divide repeatedly into smaller tubes called bronchioles.
- Bronchioles finally end in tiny air sacs called alveoli.

Alveoli are the site of gaseous exchange.

Lungs

There is a pair of lungs in the thoracic cavity.

- They are pink and spongy in texture.
- The right lung is slightly larger than the left lung.
- Each lung is surrounded by a pleural membrane.

- Inside the lungs, alveoli are surrounded by a dense network of capillaries.
- Oxygen diffuses into blood and carbon dioxide diffuses out.

Process of Respiration

Respiration occurs in four main steps:

1. External Respiration

This occurs in the lungs.

Breathing

Breathing is the mechanical process of inhaling and exhaling air.

Inspiration:

- Thoracic cavity expands.
- Pressure inside lungs decreases.
- Air enters lungs from environment.

Expiration:

- Thoracic cavity contracts.
- Pressure increases.
- Air is expelled from lungs.

Exchange of gases occurs due to differences in partial pressures of oxygen and carbon dioxide.

2. Transportation of Gases

- Oxygen is transported by haemoglobin in RBCs.
- Carbon dioxide is transported partly by haemoglobin (10–20%) and mostly dissolved in plasma as bicarbonate ions.

3. Internal Respiration

This occurs between blood and tissues.

- Oxygen diffuses from blood into tissue cells.
- Carbon dioxide diffuses from tissues into blood.

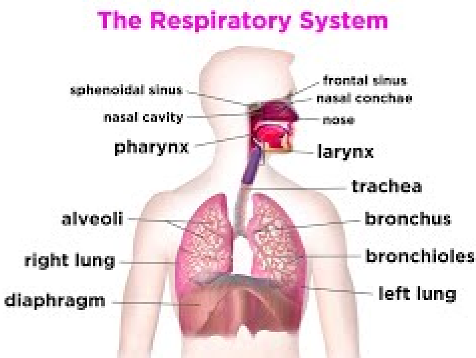
4. Cellular Respiration

Inside cells, glucose is oxidized using oxygen to produce energy (ATP).

Two types:

Aerobic Respiration → Occurs in presence of oxygen.

Anaerobic Respiration → Occurs in absence of oxygen.



Nutrients

Nutrients are substances that provide energy and are used for growth, repair and maintenance of the body.

Carbohydrates

Carbohydrates are organic compounds composed of carbon, hydrogen and oxygen in the ratio 1:2:1.

- Major source of energy.
- 50–75% of daily energy comes from carbohydrates.
- Include sugars and starch.

Types:

Monosaccharides

- Simplest form.
- Cannot be hydrolyzed further.
- Examples: Glucose, Fructose, Ribose, Galactose.

Oligosaccharides

- Yield 2–10 monosaccharides on hydrolysis.
- Example: Disaccharides like sucrose and lactose.

Polysaccharides

- Yield large number of monosaccharides.
- Examples: Starch, Glycogen, Cellulose.
- Not sweet in taste.

Proteins

- Complex organic compounds made of amino acids.
- About 15% of human body is protein.
- Contain nitrogen in addition to carbon, hydrogen and oxygen.

Twenty amino acids are required:

- 12 synthesized by body.
- 8 essential amino acids obtained from food.

Functions:

- Growth and repair.
- Enzyme formation.
- Hormone synthesis.

Fats

Fats are macronutrients and major energy sources.

- Provide more calories than carbohydrates and proteins.
- Help in absorption of fat-soluble vitamins (A, D, E, K).
- Chemically triglycerides (glycerol + three fatty acids).

Lipids

- Insoluble in water.
- Include triglycerides and cholesterol.
- Important structural components of cell membranes.

Types of Fats

Saturated Fats

- Only single bonds.
- Mostly from animal sources.
- Excess intake linked to heart disease.

Unsaturated Fats

- Contain one or more double bonds.
- Generally from plant oils and fish.
- Considered healthier.

Trans Fats

- Industrially produced by hydrogenation.

- Increase LDL (bad cholesterol).
- Decrease HDL (good cholesterol).
- Harmful to cardiovascular health.

Vitamins

- Organic compounds required in minute quantities.
- Do not provide calories.
- Essential for metabolic regulation.
- Term "Vitamin" coined by Funk.
- Important in enzyme function and immunity.

Minerals and Water

Minerals

Minerals are homogeneous inorganic substances that are essential for normal growth, development and maintenance of the human body. Unlike carbohydrates, proteins and fats, minerals do not provide energy, but they are vital for various physiological functions.

Minerals are broadly classified into two categories:

1. Major minerals (required in larger amounts)
   Examples: Calcium, Phosphorus, Sodium, Potassium, Magnesium, Chlorine
2. Trace minerals (required in very small amounts)
   Examples: Iron, Iodine, Zinc, Copper, Fluoride

Functions of Minerals:

- Calcium and Phosphorus help in the formation of bones and teeth.
- Iron is a component of haemoglobin and helps in oxygen transport.
- Iodine is required for the synthesis of thyroid hormones.
- Sodium and Potassium help in maintaining osmotic balance and nerve impulse conduction.
- Magnesium plays a role in enzyme activity.

Deficiency of minerals may lead to diseases such as:

- Iron deficiency → Anaemia
- Iodine deficiency → Goitre
- Calcium deficiency → Weak bones

Water

Water is one of the most important components of the human body.

- Around 65–75% of total body weight is water.
- It is obtained mainly by drinking water and consuming water-rich foods.

Functions of Water:

- Acts as a solvent for biochemical reactions.
- Helps in transportation of nutrients and waste.
- Maintains body temperature through sweating and evaporation.
- Aids in digestion and absorption.
- Maintains blood volume and pressure.

Without adequate water intake, dehydration occurs which can disturb electrolyte balance and body functions.

Human Diseases

Diseases are abnormal conditions that disturb the normal functioning of the body. They may be caused by protozoa, bacteria, viruses or other agents.

Diseases Caused by Protozoa

Malaria

Malaria is a mosquito-borne blood disease caused by Plasmodium parasites.

- Transmitted by the bite of infected female Anopheles mosquito.
- Parasite first multiplies in liver cells and later infects Red Blood Cells.
- Causes periodic fever and chills.
- Preventable and curable.
- Vaccine: RTS,S (Mosquirix).

Diarrhoea

Diarrhoea is the passage of three or more loose stools per day.

- Caused by bacterial, viral or parasitic infections.
- Spread through contaminated water and food.
- Major risk: Dehydration.
- Treated with Oral Rehydration Solution (ORS).

Diseases Caused by Bacteria

Tetanus

- Caused by Clostridium tetani.
- Also called lockjaw.
- Affects nervous system.
- Bacteria found in soil and animal faeces.
- Treated with wound cleaning, antibiotics and Tetanus Immune Globulin (TIG).

Cholera

- Caused by Vibrio cholerae.
- Acute diarrheal disease.
- Spread through contaminated water.
- Vaccines: Dukoral, Shanchol, Euvichol-Plus.

Typhoid

- Caused by Salmonella Typhi.
- Spread by contaminated food and water.
- Drug-resistant strain: XDR Typhoid.

Tuberculosis (TB)

- Caused by Mycobacterium tuberculosis.
- Affects lungs primarily.
- Vaccine: BCG.
- Drug-resistant forms: MDR-TB and XDR-TB.

Pneumonia

- Infection of alveoli.
- Spread through droplets.
- Preventable by Pneumococcal Conjugate Vaccine (PCV).
- Indian vaccine: Pneumosil.

Leprosy

- Caused by Mycobacterium leprae.
- Also called Hansen’s disease.

- Treated with Multi-Drug Therapy (MDT).

Diseases Caused by Viruses

HIV/AIDS

- HIV attacks CD4 T-cells.
- Weakens immune system.
- Spread through infected blood, sexual contact, mother to child.
- Managed with antiretroviral therapy (ART).

Dengue

- Caused by Dengue virus (Flavivirus).
- Transmitted by Aedes aegypti mosquito.
- No specific antiviral drug.
- Diagnosis by blood test.
- Vaccine under development in India.

Polio

- Viral disease affecting nervous system.
- India declared polio-free in 2014.

Vaccines:

- OPV (Oral Polio Vaccine)
- IPV (Injectable Polio Vaccine)

Influenza

- Caused by influenza viruses A, B and C.
- Spread through droplets.
- Type A and B cause epidemics.
- Type C causes mild illness.

Smallpox

- Caused by Variola virus.
- Spread through droplets.
- Eradicated through vaccination.
- Vaccine developed by Edward Jenner.

Hepatitis

Inflammation of liver.

Types:

- Hepatitis A
- Hepatitis B
- Hepatitis C
- Hepatitis D
- Hepatitis E

Caused mainly by hepatotropic viruses.
Affects bile production, metabolism and protein synthesis.

Types of Hepatitis

Hepatitis is an inflammatory condition of the liver. It affects important liver functions such as bile production, fat metabolism, protein synthesis, detoxification and enzyme activation. Hepatitis is mainly caused by hepatotropic viruses, though certain drugs, alcohol and other infections may also cause liver inflammation.

There are five major types of viral Hepatitis:

Hepatitis A (HAV)

- Caused by Hepatitis A Virus.
- Spread mainly through contaminated food and water (faeco-oral route).
- It is usually acute and self-limiting.
- Does not cause chronic infection.
- Vaccine is available and effective.

Hepatitis B (HBV)

- Caused by Hepatitis B Virus.
- Spread through infected blood, sexual contact and from mother to child.
- Can be acute or chronic.
- Chronic infection may lead to liver cirrhosis or liver cancer.
- Vaccine is available under Universal Immunisation Programme.

Hepatitis C (HCV)

- Caused by Hepatitis C Virus.
- Spread mainly through infected blood (e.g., unsafe injections).

- Often becomes chronic.
- No widely available vaccine yet.
- Treated with antiviral drugs.

Hepatitis D (HDV)

- Also called Delta Hepatitis.
- Occurs only in individuals already infected with Hepatitis B.
- Spread through blood and body fluids.
- Can worsen Hepatitis B infection.

Hepatitis E (HEV)

- Spread through contaminated water.
- Common in areas with poor sanitation.
- Usually acute and self-limiting.
- Dangerous for pregnant women as it may cause severe complications.

Classification of Viral Variants

Viruses mutate over time. Based on the public health impact of mutations, variants are classified into different categories.

Variant Under Investigation

A variant becomes a Variant Under Investigation when mutations are detected and there is previous association with similar variants that are suspected to impact public health. These variants are monitored closely for their behaviour and impact.

Variant of Interest (VOI)

A Variant of Interest includes variants with specific genetic markers that have been associated with:

- Changes in receptor binding
- Decreased neutralisation by antibodies generated through vaccination or previous infection
- Reduced effectiveness of treatments
- Potential diagnostic impact
- Predicted increase in transmissibility or disease severity

Such variants require enhanced surveillance and laboratory assessment.

Variant of Concern (VOC)

When there is evidence of increased transmission through field and clinical investigations, a variant becomes a Variant of Concern.

Variants of Concern have one or more of the following characteristics:

- Higher transmissibility
- Change in virulence or disease presentation
- Evidence of increased disease severity
- Ability to evade diagnostics, drugs and vaccines

Variant of High Consequence

A Variant of High Consequence has clear evidence that prevention measures or medical countermeasures have drastically reduced effectiveness compared to earlier variants.

Possible attributes include:

- Demonstrated diagnostic failure
- Higher severity and increased hospitalisations
- Reduced susceptibility to treatment
- Decreased vaccine effectiveness
- Large number of vaccine breakthrough cases
- Very low protection against severe disease

CHEMISTRY

Matter

Matter is made up of particles. It is not continuous but particulate in nature. The particles of matter are extremely small.

Characteristics of Matter

- Matter is made up of particles.
- Matter has inter-particle space.
- Particles constituting matter are very small.
- Particles are always in motion.
- Motion of particles increases with increase in temperature.

Particles of Matter

Atoms

An atom is the smallest particle of an element that may or may not exist independently and retains all its chemical properties.

- Atoms of different elements have different masses and properties.
- Atoms take part in chemical reactions.

Molecules

A molecule is a group of two or more atoms chemically bonded together.

- It is the smallest particle of an element or compound capable of independent existence.
- It shows all properties of that substance.
- However, it does not take part directly in chemical reactions.

States of Matter

Solid

- Particles are tightly packed.
- Very small inter-particle space.
- Fixed shape and fixed volume.
- Particles vibrate about mean position.
- Strong force of attraction.
- Very low rate of diffusion.

Examples: Ice, sugar, rock, wood.

Liquid

- Particles less tightly packed than solids.
- Fixed volume but no fixed shape.
- Take shape of container.
- Moderate force of attraction.
- Higher diffusion rate than solids.

Examples: Water, milk, blood.

Gas

- Particles are far apart.
- Negligible force of attraction.
- No fixed shape and no fixed volume.
- Highest compressibility.
- Highest diffusion rate.

Examples: Oxygen, nitrogen, carbon dioxide.

Plasma

- Highly ionised state of matter.
- Very high kinetic energy particles.
- Found in stars.
- Used in neon signs.

Bose-Einstein Condensate (BEC)

- Discovered in 1995.
- Formed near absolute zero temperature.
- Atoms clump together to form a super-atom.
- Shows superfluid properties (flows without friction).

Classification of Matter

Matter is divided into:

1. Pure substances
2. Mixtures

Pure Substances

A pure substance cannot be separated into other kinds of matter by physical methods.

Elements

Simplest form of pure substance.

Metals

- Hard, lustrous.
- Good conductors of heat and electricity.
- High melting and boiling points.
- Conductivity decreases with increase in temperature.
  Examples: Iron, Copper, Gold.

Non-metals

- Opposite properties of metals.
- Poor conductors (except graphite).
- Not malleable or ductile.
  Examples: Hydrogen, Oxygen, Nitrogen.

Metalloids

- Show properties of both metals and non-metals.
  Examples: Arsenic, Antimony, Bismuth.

Compounds

Pure substances composed of two or more elements in fixed proportion.

- Properties differ from constituent elements.
  Examples: Water, Sugar, Salt.

Organic Compounds

- ➢ Derived from living sources.
  Examples: Carbohydrates, Proteins, Fats.

Inorganic Compounds

- ➢ Derived from non-living sources.
  Examples: Salt, Marble, Washing Soda.

<u>Mixtures</u>

Formed when substances mix without chemical reaction.

Heterogeneous Mixture

- Non-uniform composition.
  Examples: Sand and salt mixture.

Homogeneous Mixture

- Uniform composition throughout.
  Examples: Salt in water, alloys.

Separation of Mixtures

Evaporation: Used to separate volatile solvent from non-volatile solute.

Sublimation

Solid directly converts to gas.
Examples: Ammonium chloride, camphor.

Chromatography: Separates components based on differential solubility.

Distillation: Separates miscible liquids with significant boiling point difference.

Fractional Distillation: Used when boiling point difference is less than 25 K.

Crystallisation: Purifies solid by forming crystals.

Reverse Osmosis: Used for desalination of seawater.

Centrifugation: Uses centrifugal force to separate particles based on density.

Concept of Change in State

Melting Point

- Temperature at which solid changes to liquid.
- Impurities lower melting point.

Boiling Point

- Temperature at which liquid changes to vapour.
- Decreases with decrease in pressure.

Freezing Point

- Temperature at which liquid changes to solid.

Evaporation

- Conversion of liquid to vapour at room temperature.
- Causes cooling.

Vapour Pressure

- Pressure exerted by vapour in equilibrium with liquid.
- Increases with temperature.

Atomic Structure

Atomic structure refers to nucleus and arrangement of electrons.

- Nucleus contains protons and neutrons.
- Electrons revolve around nucleus.
- Atomic number = number of protons.

Subatomic Particles

Protons

- Positive charge
- Mass approx 1.672×10^{-24} g

Neutrons

- Neutral
- Similar mass as proton

Electrons

- Negative charge
- Very small mass

Atomic Models

Dalton's Atomic Theory

- Matter made of atoms.
- Atoms indivisible.
- Atoms rearrange in reactions.

Limitations: Could not explain isotopes and subatomic particles.

Thomson's Atomic Model

- Proposed plum pudding model.
- Atom as positively charged sphere with embedded electrons.
- Explained electrical neutrality of atom.

Rutherford Atomic Theory

Rutherford, a student of J. J. Thomson, modified the atomic structure with the discovery of another subatomic particle called the nucleus. His atomic model is based on the Alpha ray scattering experiment.

Main postulates:

- The nucleus is located at the center of the atom.
- Most of the mass and positive charge of the atom are concentrated in the nucleus.
- The atom is spherical in structure.
- Electrons revolve around the nucleus in circular orbits similar to planets revolving around the sun.
- Most of the space inside an atom is empty.

Limitations:

- If electrons revolve around the nucleus, they should continuously lose energy due to radiation.
- Due to loss of energy, electrons should spiral inward and fall into the nucleus.
- Therefore, stability of the atom could not be explained.
- If electrons revolve continuously, a continuous spectrum should be observed.
- However, experimentally, a line spectrum is observed.

Bohr's Atomic Theory

Niels Bohr proposed his atomic model in 1915. It is based on Planck's theory of quantization.

Main postulates:

- Electrons are placed in discrete circular orbits called stationary orbits.
- Each orbit has a fixed and quantized energy.
- Energy levels are represented by quantum numbers.
- Electrons revolve around the nucleus only in these stationary orbits.
- As long as an electron remains in a stationary orbit, it neither absorbs nor emits energy.
- An electron can jump to a higher energy level by absorbing energy.
- It can return to a lower energy level by emitting energy.

Limitations:

- Applicable only to single-electron species such as H, He+, Li2+, Be3+.

- Could not explain fine structure of hydrogen spectrum.
- Could not explain Stark effect (splitting of spectral lines in electric field).
- Could not explain Zeeman effect (splitting in magnetic field).

Periodic Classification of Elements

Features of Long Form Periodic Table:

- 18 vertical columns called groups.
- Groups numbered from 1 to 18.
- 7 horizontal rows called periods.
- Groups 1, 2 and 13 to 17 are called main group or representative elements.
- Groups 3 to 12 are called transition elements.
- Elements with atomic numbers 58 to 71 (Ce to Lu) are lanthanides.
- Elements with atomic numbers 90 to 103 (Th to Lr) are actinides.
- Lanthanides and actinides are called f-block or inner transition elements.

Chemical Bonding

Chemical bonds are forces that hold atoms together in a molecule due to intramolecular interactions.

Ionic Bond

- Formed by transfer of electrons.
- Formed between a metal and a non-metal.
- Attraction between oppositely charged ions.
  Example: Sodium and chlorine form NaCl.

Covalent Bond

- Formed by sharing of electrons.
- Common between non-metals.
- Atoms satisfy octet rule.
- Strong and common in living organisms.

Types:

- Nonpolar covalent bond → Equal sharing of electrons.
- Polar covalent bond → Unequal sharing of electrons.

Hydrogen Bond

- Attraction between hydrogen and an electronegative atom.
- Not purely ionic or covalent.
- A type of dipole-dipole interaction.
  Example: Bonding between water molecules.

Metallic Bond

- Present in metals.
- Valence electrons move freely.
- Electrons are not associated with specific atoms.
- Responsible for conductivity and malleability.

Oxidation and Reduction

Oxidation:

- Gain of oxygen
- Loss of hydrogen
- Loss of electrons

Reduction:

- Loss of oxygen
- Gain of hydrogen
- Gain of electrons

Types of Chemical Reactions

- Combination reaction → Two or more substances combine to form one.
- Decomposition reaction → One compound breaks into simpler substances.
- Precipitation reaction → Formation of insoluble solid from two solutions.
- Neutralization reaction → Acid + Base → Salt + Water.
- Combustion reaction → Substance reacts with oxygen producing heat.
- Displacement reaction → One element replaces another.
- Double displacement reaction → Exchange of ions between reactants.

Solution

A solution is a homogeneous mixture of two or more non-reacting substances whose composition can vary within limits.

Binary solution → Two components.

Ternary solution → Three components.

Components of a binary solution:

- Solute → Present in smaller amount.
- Solvent → Present in larger amount.

Types of Solutions:

- Saturated solution → Cannot dissolve more solute at given temperature.
- Unsaturated solution → Can dissolve more solute.
- Supersaturated solution → More solute than saturated solution at same temperature.
- Dilute solution → Small amount of solute.
- Concentrated solution → Large amount of solute.

Solubility

- Maximum amount of solute dissolved in 100 g solvent at given temperature.
- Gas solubility decreases with increase in temperature.
- Gas solubility increases with increase in pressure.
- Pressure has little effect on solubility of solids.

Henry's Law

At constant temperature, the amount of gas dissolved in a liquid is directly proportional to the pressure of the gas above the liquid.

True Solution

- Homogeneous.
- Particle size less than 10^{-9} m.
- Particles not visible even under microscope.

Suspension

- Heterogeneous.
- Particle size greater than 10^{-7} m.
- Particles visible.

Colloidal Solution

- Heterogeneous.
- Particle size between true solution and suspension.
- Pass through filter paper but not through animal membrane.

Examples: Milk, blood, ink.

Dispersion System

- Dispersed phase → Distributed substance.
- Dispersion medium → Medium in which dispersed.

Types:

- Sol → Solid in liquid.
- Aerosol → Solid or liquid in gas (smoke, fog).
- Foam → Gas in liquid.

Brownian Movement

Continuous zig-zag movement of colloidal particles due to unequal bombardment by dispersion medium particles.

Tyndall Effect

Scattering of light by colloidal particles when light passes through a colloidal solution.

Dialysis

Separation of colloidal particles from crystalloids using animal membrane.

Electrophoresis

Movement of colloidal particles under electric field.
Positive particles move to cathode.
Negative particles move to anode.

Coagulation

Aggregation of colloidal particles leading to precipitation.

Acids, Bases and Salts

Acid

- Sour in taste.
- Turns blue litmus red.
- Contains replaceable hydrogen.
- Gives H^+ ions in aqueous solution.
- Proton donor.
- Electron acceptor.

Uses of Acids

HCl → Digestion, cleaning, tanning.
HNO_3 → Fertilizers, explosives, dyes.
H_2SO_4 → Batteries, fertilizers, detergents.
Boric acid → Antiseptic.
Phosphoric acid → Fertilizers, bones.
Ascorbic acid → Vitamin C.
Citric acid → Food preservative.
Acetic acid → Vinegar.
Tartaric acid → Baking powder component.

Base

- Bitter in taste.
- Turns red litmus blue.
- Gives OH^- ions in aqueous solution.
- Proton acceptor.
- Electron donor.
- Water soluble bases are called alkalis.

Uses of Bases

NaOH → Soap, paper, rayon.
$Ca(OH)_2$ → Bleaching powder.
$Mg(OH)_2$ → Laxative.
NH_4OH → Laboratory reagent.

Buffer Solution

A solution whose pH does not change significantly upon addition of small amount of acid or base.

Salt

Formed by reaction of acid and base.

Important salts:

NaCl → Preservative, soap manufacture.
NaOH → Soap, paper.
Na2CO3 → Washing soda.
NaHCO3 → Baking soda, antacid, fire extinguisher.
Bleaching powder → Disinfection.
Plaster of Paris → Fracture treatment, toys.

pH

pH = Negative logarithm of H+ ion concentration.
Scale ranges from 0 to 14.
pH < 7 → Acidic
pH = 7 → Neutral
pH > 7 → Basic

Limitations:

- pH can be zero for strong acid.
- pH can be negative for very high concentration acids.
- Hammett acidity function used for very strong acids.

Electrolysis

Electrolysis is an important process in chemistry in which electrical energy is used to bring about a chemical change. It helps us understand how electricity and chemical reactions are related.

Electrolytes

Electrolytes are substances that allow electricity to pass through them in their molten state or when dissolved in water, and during this process they undergo chemical decomposition.

- When dissolved in water or melted, electrolytes break into charged particles called ions.
- These ions are responsible for conducting electricity.
- Examples: Acids (HCl), Bases (NaOH), Salts (NaCl, KCl).

Strong Electrolytes

Strong electrolytes are substances that almost completely dissociate into ions in aqueous solution.

- They produce a large number of ions.
- Hence, they conduct electricity strongly.
  Examples: NaCl, KCl, HCl, NaOH.

Weak Electrolytes

Weak electrolytes do not completely ionize in solution.

- Only a small number of ions are produced.
- Therefore, electrical conductivity is low.
  Examples: Acetic acid (CH_3COOH), Hydrocyanic acid (HCN).

Electrolysis

Electrolysis is the process of chemical decomposition of an electrolyte by passing electric current through its molten state or aqueous solution.

- Electrical energy is converted into chemical energy.
- It is used in electroplating, extraction of metals and purification of metals.

Electrodes

To pass electric current through an electrolyte, two metal rods or plates are connected to the battery. These are called electrodes.

There are two types:

Anode

- Connected to the positive terminal of the battery.
- Oxidation occurs at the anode.
- Oxidation means loss of electrons.

Cathode

- Connected to the negative terminal of the battery.
- Reduction occurs at the cathode.
- Reduction means gain of electrons.

Thus, in electrolysis:
Oxidation → Anode
Reduction → Cathode

Carbon and Its Compounds

Carbon is one of the most important elements in chemistry because it forms the basis of all organic compounds.

Carbon

- Carbon is a non-metal.
- Atomic number = 6.
- Mass number = 12.
- Placed in Group 14 (Group IV A) of the periodic table.
- Tetravalent element (valency = 4).

Because of its tetravalency and ability to form long chains, carbon forms millions of compounds.

Allotropy

Allotropy is the property by which an element exists in two or more different physical forms having the same chemical properties but different physical properties.

Allotropes of carbon:

- Diamond
- Graphite
- Charcoal
- Buckminsterfullerene

Diamond

- Hardest natural substance known.
- Does not conduct electricity.
- Formed under extreme pressure and temperature.
- Used in cutting tools such as glass cutters and drilling equipment.
- Used in jewellery.

Reason for hardness: Strong covalent bonds in a three-dimensional network structure.

Graphite

- Greyish-black, soft and smooth.
- Conducts electricity.
- Used in dry cells and as electrodes.
- Used in pencil leads.

- Used in making black paints.

Reason for conductivity: Presence of free electrons between layers.

Buckminsterfullerene

- Allotrope of carbon containing 60 carbon atoms.
- Formula: C_{60}.
- Spherical structure resembling a football.
- Black solid at room temperature.

Hydrocarbons

Hydrocarbons are organic compounds made only of carbon and hydrogen. They are generally colourless gases or liquids with weak odour.

Types of Hydrocarbons

Saturated Hydrocarbons

- Only single bonds between carbon atoms.
- Also called alkanes.
- Simplest hydrocarbons.
  Example: Methane, Ethane.

Unsaturated Hydrocarbons

- Contain double or triple bonds.
- Alkenes → Double bond.
- Alkynes → Triple bond.

Cycloalkanes

- Hydrocarbons containing one or more carbon rings.

Aromatic Hydrocarbons

- Contain at least one aromatic ring (like benzene ring).
- Also called arenes.

Aliphatic Hydrocarbons

- Straight chain hydrocarbons without rings.

Alicyclic Hydrocarbons

- Hydrocarbons with ring structure but not aromatic.

Plastics

Plastics are materials made from polymers (long chains of carbon compounds).

- Discovered accidentally by Christian Schonbein in 1846.
- Organic substances of high molecular weight.

Properties of Plastics

- Strong and durable.
- Poor conductors of heat and electricity.
- Easily moulded into different shapes.
- Resistant to corrosion and chemicals.

Types of Plastics

Thermoplastics

- Soften on heating.
- Can be reshaped multiple times.
  Examples: PVC, Polythene, Nylon.

Thermosetting Plastics

- Once moulded, cannot be softened again.
- Highly cross-linked structure.
  Examples: Bakelite, Melamine.

Uses:
Bakelite → Electrical switches
Melamine → Floor tiles

Rubber

- Made from polymer of isoprene.
- Contains elastomers (elastic polymers).
- Can stretch and return to original shape.
- Thailand and Indonesia are leading producers.
- India is second-largest consumer of natural rubber.

Fibres

Fibres are polymers having strong intermolecular forces such as hydrogen bonding.

Examples: Nylon, Polyester.

Rayon

- Synthetic fibre obtained from cellulose.
- Also called artificial silk.

Fuels

A fuel is a substance that produces energy either alone or by reacting with another substance (usually oxygen).

- Heat produced is measured in calories.

Characteristics of an Ideal Fuel

- High calorific value.
- Cheap and easily available.
- Easy to store and transport.
- Controlled burning.
- Low ignition temperature.
- Produces less pollution.

Calorific Value

Calorific value is the total amount of heat released by complete combustion of one unit mass of fuel.

Higher calorific value → More energy produced.

Octane Rating

- Measures quality of petrol.
- Indicates resistance to knocking.
- Higher octane number → Better performance.
- Used in high-performance vehicles.

Knock Resistance

Knocking occurs when fuel burns in an uncontrolled manner inside engine cylinder.

Knock resistance is the ability of fuel not to self-ignite under compression.

- Higher octane fuel → Higher knock resistance.
- Ensures smooth engine operation.

Metallurgy

Basics of Metallurgy

Metallurgy is the branch of science and technology that deals with the extraction of metals from their ores and their purification.

- Metals in nature are mostly found in combined form as compounds.
- These compounds of metals mixed with soil, sand, limestone and rocks are called **minerals**.
- Not all minerals are suitable for extraction of metals.

Ore

An ore is a mineral from which a metal can be extracted economically and with minimum effort.

Example:

- Bauxite → Ore of Aluminium
- Hematite → Ore of Iron

Gangue

The unwanted impurities such as sand, clay, limestone etc. present in the ore are called gangue.

Flux

A substance added during smelting to remove gangue is called flux.
Flux reacts with gangue to form slag, which can be easily removed.

Metallurgy also includes:

- Purification of metals
- Formation of alloys

Principles of Metallurgy

The extraction of metal generally involves the following steps:

1. Crushing and Grinding (Pulverization)

- The ore is first crushed into small pieces.
- Then it is ground into fine powder using crushers or ball mills.
- This increases surface area and makes further processing easier.

2. Concentration of Ore (Ore Dressing)

This step removes gangue from the crushed ore.
Methods of concentration:

(a) Hydraulic Washing (Gravity Separation)

- The powdered ore is placed on a sloping vibrating table with grooves.
- A stream of water flows over it.
- Heavier ore particles settle in grooves.
- Lighter impurities are washed away.

Used when ore is heavier than gangue.

(b) Magnetic Separation

- Crushed ore is placed on a conveyor belt.
- One wheel of the belt is magnetic.
- Magnetic particles stick to the magnetic wheel.
- Non-magnetic impurities fall away.

Used for iron ores.

(c) Froth Floatation

Used mainly for sulphide ores.

- Crushed ore is mixed with water and oil.
- Compressed air is passed through the mixture.
- Sulphide ore particles stick to oil and rise as froth.
- Impurities remain in water.

3. Roasting and Calcination

After concentration, the ore is heated.

Roasting

- Heating concentrated sulphide ore in presence of oxygen.
- Converts sulphides into oxides.

Example:
$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$

Calcination

- Heating carbonate or hydrated ores in absence of air.

- Removes moisture and converts carbonate into oxide.

Example:
$CaCO_3 \rightarrow CaO + CO_2$

Importance and Properties of Metals

Physical Properties of Metals

Metals generally have the following properties:

- Good conductors of heat and electricity.
- Malleable → Can be beaten into thin sheets.
- Ductile → Can be drawn into wires.
- Lustrous → Shiny appearance.
- Sonorous → Produce sound when struck.
- Generally hard and strong.
- High melting and boiling points (except sodium, potassium).
- Usually solid at room temperature (except mercury).
- High density (except sodium and potassium).
- Usually grey or silver coloured (except copper and gold).

Important Uses of Metals

- Iron, copper, aluminium → Household utensils and machinery.
- Chromium → Electroplating of iron and steel.
- Lead → Car batteries.
- Zinc → Galvanization to prevent rusting.
- Iron → Catalyst in Haber's process for ammonia production.
- Lithium → Lightest and highly reactive metal.
- Silver chloride → Photochromatic glasses.
- Mercury → Thermometers.
- Gallium → Liquid at near room temperature.
- Cobalt-60 → Cancer treatment.
- Barium sulphate → X-ray imaging of abdomen.
- Fuse wire → Made of lead and tin.
- Pure gold → 24 carat (copper added to increase hardness).

Important fact:
Silver spoon should not be used with egg because it reacts with sulphur in

egg forming black silver sulphide.

Non-Metals

Physical Properties of Non-Metals

Non-metals show properties opposite to metals.

- Found in all three states (solid, liquid, gas).
- Bromine is liquid non-metal at room temperature.
- Generally low melting and boiling points.
- Brittle in solid state.
- Not malleable and not ductile.
- Poor conductors of heat and electricity.
- Not sonorous.

Exception:

- Graphite conducts electricity.
- Carbon fibres show ductility in special form.

Chemical Properties of Non-Metals

1. Reaction with Water

- Most non-metals do not react with water.
- Some are highly reactive in air.

Example:
Phosphorus is stored in water because it catches fire in air.

2. Reaction with Acids

- Non-metals generally do not react with acids.

3. Reaction with Bases

- Some non-metals react with bases.

Example:
Chlorine reacts with sodium hydroxide to form sodium hypochlorite and sodium chloride.

4. Reaction with Oxygen

- Non-metals form oxides when reacting with oxygen.
- These oxides are usually acidic or neutral.

Example:
CO_2 is acidic oxide.

5. Reaction with Metals

- Non-metals react with metals to form ionic compounds.

Example:
$Na + Cl \rightarrow NaCl$

PHYSICS

Unit System

Unit

A unit is a standard quantity chosen to measure a physical quantity.

For example:

- Meter → Unit of length
- Kilogram → Unit of mass

A good unit should be:

- Well defined
- Easy to reproduce
- Easy to compare
- Internationally accepted
- Independent of physical conditions

System of Units

A system of units is a complete set of units used to measure physical quantities.

Different systems existed earlier such as:

- CGS system
- MKS system

To remove confusion, a universal system was adopted.

SI Units

SI (Système International) is the internationally accepted system of measurement used in science and technology.

It avoids confusion and ensures uniformity worldwide.

Types of SI Units

1. Fundamental Units

These are basic units which cannot be derived from other units.

Examples:

- Meter (m) → Length
- Kilogram (kg) → Mass

- Second (s) → Time
- Ampere (A) → Electric current
- Kelvin (K) → Temperature
- Mole (mol) → Amount of substance
- Candela (cd) → Luminous intensity

2. Derived Units

These are obtained from fundamental units.
Examples:

- Speed → m/s
- Force → Newton (kg m/s²)
- Energy → Joule

Motion

Motion is one of the most common phenomena in the physical world.
An object is said to be in motion if its position changes with respect to time and surroundings.

Mechanics

Mechanics is the branch of Physics that studies motion.
It is divided into:

Kinematics

Study of motion without considering its cause.

Dynamics

Study of motion along with its cause (force).

Motion and Rest

An object is in motion if its position changes with time relative to a reference point.
An object is at rest if its position does not change with time relative to surroundings.

Frame of Reference

It is the object or background with respect to which motion is measured.

Example:
A passenger sitting in a moving train is at rest relative to the train but in motion relative to the ground.

Scalar and Vector Quantities

Scalar Quantities

Have only magnitude, no direction.

Examples:
Mass, Distance, Speed, Time, Volume

Vector Quantities

Have both magnitude and direction.

Examples:
Velocity, Acceleration, Displacement, Momentum, Force

Distance and Displacement

Distance

- Total path covered by an object.
- Scalar quantity.

Displacement

- Shortest distance from initial to final position.
- Vector quantity.

Example:
A bus travels 150 km from A to B and returns to A.

Distance = 150 + 150 = 300 km
Displacement = 0 (because starting and ending point same)

Speed and Velocity

Speed

Distance travelled per unit time.

Speed = Distance / Time

- Scalar quantity
- SI unit: m/s

Velocity

Velocity is speed in a specific direction.

Velocity = Displacement / Time

- Vector quantity

Acceleration

Acceleration is the rate of change of velocity.

Acceleration = Change in velocity / Time

SI unit: m/s^2

Vector quantity

Acceleration can:

- Increase speed
- Decrease speed
- Change direction

Circular Motion

Motion of an object along a circular path.

Types:

Uniform Circular Motion

Speed constant, direction changes.

Non-uniform Circular Motion

Speed and direction both change.

Examples:

Satellite orbiting Earth
Rotating fan
Car wheel

Angular Velocity

Angular velocity is the rate of change of angular displacement.

Symbol: ω (omega)

SI unit: radian per second

Newton's Laws of Motion

First Law (Law of Inertia)

An object remains at rest or in uniform motion unless acted upon by an external force.

Second Law

Force = Mass × Acceleration
F = ma

Acceleration depends on:

- Force applied
- Mass of object

Third Law

For every action, there is an equal and opposite reaction.

Centripetal and Centrifugal Force

Centripetal Force

Force acting towards the center of circular motion.

Examples:
Tension in string
Gravitational force

Centrifugal Force

Apparent outward force experienced in rotating frame.

Moment of Force (Torque)

Moment of force is the turning effect of force.

Torque = Force × Perpendicular distance

It causes rotation.

Centre of Gravity

The point at which the whole weight of a body is considered to act.

Important in stability analysis.

Equilibrium

A body is in equilibrium when:

- Net force = 0
- Net torque = 0

Types:

Stable Equilibrium: Returns to original position.

Unstable Equilibrium: Moves away from original position.

Neutral Equilibrium: Remains in new position.

Work

Work is done when force causes displacement.
Work = Force × Distance
SI unit: Joule
If no displacement → No work done.

Energy

Energy is the capacity to do work.
Unit: Joule

Types of Mechanical Energy

Kinetic Energy=Energy due to motion.

Potential Energy=Energy due to position.

Gravitational Potential Energy=Due to height above Earth.

Elastic Potential Energy=Due to deformation of elastic body.

Energy Conversion

Energy can change from one form to another.
Examples:

- Hydroelectric dam → Potential to Electrical
- Generator → Mechanical to Electrical
- Battery → Chemical to Electrical
- Electric heater → Electrical to Heat
- Photosynthesis → Solar to Chemical

Law of Conservation of Energy

Energy can neither be created nor destroyed.
It can only be converted from one form to another.
Total energy of isolated system remains constant.

Collision

A collision is an interaction between two bodies for a short time.

Elastic Collision

- Momentum conserved
- Kinetic energy conserved

Example: Billiard balls

Inelastic Collision

- Momentum conserved
- Kinetic energy not conserved

Example: Clay ball hitting floor

Power

Power is rate of doing work.
Power = Work / Time
Unit: Watt

Gravitation

Gravitation is the force of attraction between two masses.
It is always attractive.

Newton's Law of Gravitation

Every particle attracts every other particle with force:

- Directly proportional to product of masses
- Inversely proportional to square of distance

Kepler's Laws of Planetary Motion

First Law (Law of Orbits)

Planets move in elliptical orbits with Sun at one focus.

Second Law (Law of Areas)

Planet sweeps equal areas in equal times.
This means planets move faster when closer to Sun.

Satellite

A satellite is a natural or artificial body that revolves around a planet due to gravitational attraction.

Examples:

- Natural satellite → Moon (revolves around Earth)
- Artificial satellite → Communication and weather satellites

Orbital Speed of a Satellite

Orbital speed is the speed required by a satellite to remain in a stable circular orbit.

Important points:

- Orbital speed is independent of the mass of the satellite.
- Satellites of different masses at the same orbital radius have the same orbital speed.
- Orbital speed depends on the radius of orbit (height from Earth).
- Greater the radius → lesser the orbital speed.
- Orbital speed near Earth's surface ≈ 7.9 km/s.

Period of Revolution

The time taken by a satellite to complete one full revolution around Earth is called its period of revolution.

Higher orbit → Larger time period.

Escape Velocity

Escape velocity is the minimum speed required for an object to escape from the gravitational field of a planet without further propulsion.

For Earth:

- Escape velocity ≈ 11.2 km/s
- ≈ 11,186 m/s
- ≈ 40,270 km/h

If velocity is less than escape velocity, the object will fall back to Earth.

Escape velocity varies slightly:

- It is slightly less at equator (larger radius).
- Slightly more at poles.

Pressure

Pressure is defined as force acting per unit area.

Pressure = Force / Area

SI Unit: Pascal (Pa)

1 Pascal = 1 Newton per square meter

Atmospheric Pressure

The Earth is surrounded by a layer of gases (atmosphere), which exerts pressure on the surface.

- Atmospheric pressure decreases with height.
- It decreases approximately 3.5 millibars per 30 meters rise in height.

Reason: As altitude increases, density of air decreases.

Pressure in Liquids

Liquid exerts pressure due to weight of liquid above a point.

Pressure at depth h:

$P = h \times d \times g$

Where:

h = depth

d = density

g = acceleration due to gravity

Important Properties:

- Pressure increases with depth.
- Pressure increases with density of liquid.
- At same horizontal level → pressure is same.
- Pressure at a point acts in all directions.

Pascal's Law

If pressure is applied to a confined liquid, it is transmitted equally and undiminished in all directions.

Applications:

- Hydraulic lift
- Hydraulic press
- Hydraulic brake

Effect of Pressure on Melting and Boiling Point

Melting Point (MP)

- If substance expands on melting (like wax) → MP increases with pressure.
- If substance contracts on melting (like ice) → MP decreases with pressure.

Boiling Point (BP)

- Boiling point increases with increase in pressure.
  Example: Pressure cooker cooks food faster.

Floatation

Floatation is the tendency of a body to float in a fluid.

It depends on:

- Density of object
- Density of fluid

If object density < fluid density → Object floats

If object density > fluid density → Object sinks

Law of Floatation

A floating body displaces a weight of fluid equal to its own weight.

Example:

If wood weighing 300 kg floats in water → It displaces 300 kg of water.

Conditions for Floatation

1. Density of fluid > average density of object.
2. Weight of object = Upthrust force.
3. Sufficient volume must be submerged.

Ships float because of hollow shape → Average density becomes less than water.

Surface Tension

Surface tension is the tendency of liquid surface to contract and occupy minimum surface area.

Formula:

$T = F / L$

Where:

F = Force

L = Length

Examples:

- Insects walking on water
- Needle floating on water
- Soap helps in cleaning (reduces surface tension)

Viscosity

Viscosity is the measure of resistance offered by a fluid to flow.

Low viscosity → Water

High viscosity → Honey

Viscosity increases with:

- Increase in pressure
- Decrease in temperature (for liquids)

Newtonian and Non-Newtonian Fluids

Newtonian Fluids

Viscosity remains constant with change in stress.

Example: Water

Non-Newtonian Fluids

Viscosity changes with stress.

Example: Toothpaste

Elasticity

Elasticity is the property by which a body regains its original shape after deformation.

More elastic → More accurate recovery.

Example: Steel wire is more elastic than rubber band.

Hooke's Law

Within elastic limit: Extension ∝ Applied force

This is Hooke's Law.

Stress and Strain

Stress

Stress = Force / Area

It is restoring force per unit area.

Strain

Strain = Change in dimension / Original dimension

- It is dimensionless (no unit).

Simple Harmonic Motion (SHM)

SHM is a motion in which restoring force is directly proportional to displacement and directed towards mean position.

Characteristics:

- Motion is periodic.
- Mean position is stable equilibrium.
- Example: Simple pendulum, spring-mass system.

Periodic Motion

Motion which repeats itself after equal intervals of time.

Example: Uniform circular motion.

Oscillatory Motion

To-and-fro motion about a mean position.

- Restoring force present.
- Bounded between two extreme points.
- Example: Pendulum.

Waves

A wave is a disturbance that transfers energy without transferring matter.
Important Points:

- Energy is transferred.
- Particles vibrate but do not permanently move.

Types of Waves

Mechanical Waves

- Require medium.
- Examples: Sound waves, water waves.

Transverse Waves

- Particles vibrate perpendicular to direction of wave.
- Example: Water waves.

Longitudinal Waves

- Particles vibrate parallel to direction of wave.
- Example: Sound waves.

Electromagnetic Waves

- Do not require medium.
- Examples: Light, radio waves.

Matter Waves

Associated with moving particles like electrons.

Wave Parameters

Wavelength (λ)

Distance between two successive crests or compressions.

Frequency (ν)

- Number of vibrations per second.
- Unit: Hertz (Hz)

- $\nu = 1 / T$

Time Period (T)

- Time for one vibration.
- $T = 1 / \nu$

Wave Velocity

- Velocity = Frequency × Wavelength
- $v = \nu\lambda$

Sound Waves

Sound waves are longitudinal mechanical waves.
Frequency Range:

Audible (20 Hz – 20,000 Hz) -> Heard by humans.

Infrasonic (<20 Hz)-> Produced by earthquakes, elephants.

Ultrasonic (>20,000 Hz)

- Not heard by humans.
- Used in medical imaging.
- Bats use ultrasonic waves.

Speed of Sound

Speed of sound is the distance travelled per unit time by a sound wave.
Important Points:

- Same for all frequencies in same medium.
- Depends on medium and temperature.

Factors Affecting Speed of Sound

Density: Greater density → Faster sound (in solids).

Temperature: Higher temperature → Faster sound.

Speed of Sound in Different Media

In Solids

- Fastest (particles closely packed).
- Sound travels 35 times faster in diamond than air.

In Liquids

- Intermediate speed.
- Speed in water ≈ 1480 m/s.

In Gases

- Slowest among three states.
- Speed in air at 20°C ≈ 343 m/s.

In Vacuum

- Zero.
- Sound cannot travel in vacuum because there are no particles.

Diffraction of Sound

Diffraction is the bending of waves around obstacles or through openings.

The wavelength of sound is approximately 1 meter (for normal audible sound). When an obstacle of comparable size appears in its path, sound bends around the edges and continues to propagate.

This bending of sound waves around an obstacle is called diffraction of sound.

Example:

- We can hear a person speaking from behind a wall.
- Sound bends around doorways and corners.

Reason: Sound has relatively large wavelength compared to light, so diffraction is easily noticeable.

Doppler Effect

The Doppler Effect is the apparent change in frequency (or pitch) of a wave due to relative motion between source and observer.

If source and observer move towards each other → Frequency increases (higher pitch).

If they move away → Frequency decreases (lower pitch).

Example:

- Sound of ambulance siren appears high-pitched when approaching and low-pitched when moving away.

It applies to sound, light and all types of waves.

Mach Number

Mach number is the ratio of speed of an object to the speed of sound in the same medium.

Mach Number = Speed of object / Speed of sound

If Mach number:

- Less than 1 → Subsonic
- Equal to 1 → Sonic
- Greater than 1 → Supersonic

Shock Waves

When an object moves faster than the speed of sound (supersonic speed), it produces shock waves.

These are high-energy disturbance waves that form a cone-shaped region behind the object.

Effects:

- Sonic boom
- Cracks in window panes
- Structural damage

Bow Waves

When a motorboat moves faster than water waves, it creates wave patterns similar to shock waves. These are called bow waves.

They are seen on water surface.

Heat

Heat is a form of energy that produces the sensation of warmth.

SI Unit: Joule

Other unit: Calorie

1 calorie = 4.2 joules

Important Principle:

Heat always flows from a hotter body to a colder body.

Temperature Scales

- Celsius (°C)
- Fahrenheit (°F)

Absolute Zero:

Lowest possible temperature

-273.16°C

At absolute zero → Molecular motion nearly stops.

Modes of Heat Transfer

1. Conduction

- Heat transfer through direct contact (mainly in solids).
- Example: Metal spoon becomes hot when kept in tea.

2. Convection

- Heat transfer through movement of fluid particles (liquids and gases).
- Example: Boiling water circulation.

3. Radiation

- Heat transfer without any medium.
- Example: Heat from Sun reaches Earth.

Temperature

Temperature is the measure of hotness or coldness of a body.
Heat flows due to temperature difference.
Higher temperature → Higher average molecular kinetic energy.

Total Radiation Pyrometer

Used to measure very high temperatures without contact.

- Principle:
  A hot body emits radiation proportional to fourth power of its absolute temperature.
- Limitation:Cannot measure temperature below 800°C (radiation too weak).
- Used in:
  - Steel industries
  - Furnaces

Specific Heat Capacity

Specific heat capacity is the amount of heat required to raise temperature of 1 kg (or 1 gram) of a substance by 1°C.
Water has very high specific heat:
1 cal/g°C = 4.186 J/g°C
Importance:

- Oceans regulate climate.
- Water cools car engines.
- Human body temperature regulation.

Note: During phase change, temperature remains constant despite heat supply.

Thermal Expansion

Thermal expansion is increase in size or volume due to rise in temperature.

- Reason:
  Increase in molecular kinetic energy → Molecules move farther apart.
- Coefficient of thermal expansion:
  Measure of expansion per degree temperature change.
- Unusual Case:
  Some substances contract on heating within certain temperature ranges.

Newton's Law of Cooling

The rate of cooling of a body is directly proportional to the temperature difference between body and surroundings.

Greater difference → Faster cooling.

Used in:

- Estimating time of death (forensic science)
- Engineering cooling systems

Kirchhoff's Law of Radiation

At a given temperature:

Emissive power / Absorptive power = constant

Good absorbers are good emitters.

Example:
Black surfaces absorb more heat and emit more radiation.

Stefan's Law

Energy radiated per unit area is proportional to fourth power of absolute temperature.

Energy $\propto T^4$

Hotter bodies radiate much more energy.

Change of State

Matter exists in three states: Solid, Liquid, Gas

Change from one state to another occurs by heating or cooling.

Important Phase Changes

Fusion (Melting)

- Solid → Liquid
- Occurs at fixed melting point.

Freezing

- Liquid → Solid
- Melting point = Freezing point.

Vaporization

- Liquid → Gas

Evaporation

- Slow vaporization below boiling point.

Boiling

Occurs at fixed boiling point.

Temperature remains constant during boiling.

Boiling point increases with:

- Increase in pressure
- Addition of impurity

Condensation

- Gas → Liquid

Sublimation

- Solid → Gas directly
- Example: Camphor, naphthalene.

Latent Heat

Heat absorbed or released during phase change without temperature change.

Types:

- Heat of fusion

- Heat of vaporization

Thermodynamics

Branch of physics dealing with heat, work and energy transformations.

Laws of Thermodynamics

Zeroth Law: If A and B are in thermal equilibrium with C, then A and B are in equilibrium with each other.

First Law: Energy can neither be created nor destroyed.

Second Law: Entropy of isolated system always increases.

Third Law: Entropy approaches zero as temperature approaches absolute zero.

Light

Light is electromagnetic energy.
It does not require a medium.

Rectilinear Propagation

Light travels in straight lines in homogeneous medium.

Reflection of Light

Reflection is bouncing back of light when it strikes a surface.

- Law: Angle of incidence = Angle of reflection.

Refraction

Refraction is bending of light when it passes from one medium to another due to change in speed.

Example:

- Twinkling of stars
- Apparent depth of water

Reason for twinkling: Atmospheric refraction.

Laws of Refraction (Snell's Law)

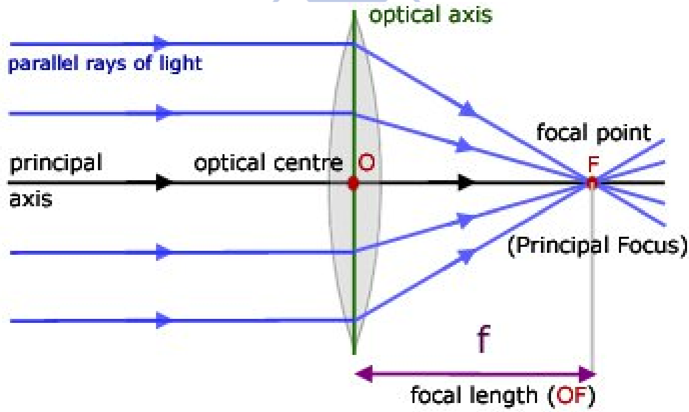
1. Incident ray, refracted ray and normal lie in same plane.
2. Sin i / Sin r = constant (for two media).

Lens

A lens is a transparent object that refracts light.

Important Terms

Pole → Centre of surface
Optical Centre → Centre of lens
Principal Axis → Imaginary central line
Focal Point → Point where parallel rays meet
Focal Length → Distance between optical centre and focus
Power = 1 / Focal length
Unit: Dioptre



Types of Lenses

Concave Lens

- Diverging lens
- Thinner at centre
- Used in spectacles for myopia

Convex Lens

- Converging lens
- Thicker at centre
- Used in magnifying glass

Dispersion of Light

Splitting of white light into VIBGYOR is called dispersion.

Cause: Different wavelengths bend differently.

Rainbow Formation

Due to:

- Refraction
- Internal reflection
- Dispersion

Scattering of Light

Deviation of light due to particles in medium.

Example:

- Blue sky (Rayleigh scattering)

Interference

Superposition of two waves producing bright and dark regions.

Polarization

Phenomenon due to transverse nature of light.

Human Eye

The eye is a natural optical instrument.

Functions:

- Light perception
- Colour vision
- Depth perception

Cone cells detect colours.

Colour blindness occurs due to defect in cone cells.

Structure of Human Eye

The human eye is one of the most important sense organs. It helps us to see objects, recognize colours, judge distance and perceive depth.

The human eye is roughly spherical in shape and about 2.3 cm in diameter. It is filled with transparent fluids that help in maintaining its shape and focusing light.

Let us understand its main parts and their functions clearly:

1. Sclera

- The sclera is the outermost tough, white protective layer of the eye.

- It protects the delicate inner parts of the eye from injury.
- The visible white portion of our eye is the sclera.

Function: Protection and maintaining shape of the eye.

2. Cornea

- The cornea is the transparent front portion of the sclera.
- Light first enters the eye through the cornea.
- It is slightly curved outward.

Function:

- It bends (refracts) the incoming light.
- It provides most of the focusing power of the eye.

3. Iris

- The iris is a dark, circular muscular structure located behind the cornea.
- The colour of the iris (brown, black, blue, etc.) determines the colour of the eye.

Function:

- It controls the amount of light entering the eye.
- It adjusts automatically according to brightness.

Example:

- In bright light → Iris contracts → Pupil becomes small.
- In dim light → Iris expands → Pupil becomes large.

4. Pupil

- The pupil is a small opening in the centre of the iris.
- It appears black because light entering it is absorbed inside the eye.

Function:

- Regulates the amount of light entering the eye.
- Works like the aperture of a camera.

5. Lens

- The lens is a transparent, flexible structure located behind the pupil.
- It is biconvex in shape.

Function:

- Focuses light rays onto the retina.
- Its shape changes with the help of ciliary muscles.

Accommodation of eye:

- For distant objects → Lens becomes thin.
- For nearby objects → Lens becomes thick.

This adjustment is called accommodation.

6. Retina

- The retina is a light-sensitive inner layer at the back of the eye.
- It contains special cells called rods and cones.

Function:

- It converts light energy into electrical impulses.
- These impulses are sent to the brain through the optic nerve.
- The brain interprets these signals and forms the image.

The image formed on retina is:

- Real
- Inverted
- Diminished

The brain corrects the orientation.

7. Rods and Cones

These are photoreceptor cells present in the retina.

Rods

- Sensitive to dim light.
- Help in night vision.
- Responsible for black and white vision.
- Help in peripheral vision.

Cones

- Sensitive to bright light.
- Responsible for colour vision.
- Help in detailed central vision.

8. Optic Nerve

- It connects retina to the brain.
- Carries electrical impulses from retina to brain.

Without optic nerve, vision is not possible.

Refractive Defects of Vision

Refractive defects occur when light rays are not focused properly on the retina.

1. Myopia (Near-Sightedness)

In this condition:

- Person can see nearby objects clearly.
- Distant objects appear blurred.

Cause:

- Image of distant object forms in front of retina instead of on retina.
- Eye ball may be elongated.

Correction:

- Concave (diverging) lens is used.

2. Hypermetropia (Far-Sightedness)

In this condition:

- Person can see distant objects clearly.
- Nearby objects appear blurred.

Cause:

- Image of nearby object forms behind retina.
- Eye ball may be shorter than normal.

Correction:

- Convex (converging) lens is used.

3. Presbyopia

- Occurs generally after 40 years of age.
- Person has difficulty seeing nearby objects.

Cause:

- Weakening of ciliary muscles.
- Decrease in elasticity of lens.

Correction:

- Reading glasses or bifocal lenses.

Magnetism

The word "magnet" comes from Magnesia (an island in Greece), where natural magnetic ore was found.

Magnetite (lodestone) is a natural magnet.

Basic Properties of Magnet

1. A freely suspended magnet always points in North–South direction.
2. The end pointing toward geographic North is called North pole.
3. The opposite end is called South pole.
4. Like poles repel each other.
5. Unlike poles attract each other.
6. Magnetic poles always exist in pairs (no isolated pole found).
7. Magnetic strength is maximum at the poles.

Magnetic Induction

Magnetic induction is the phenomenon in which an unmagnetized magnetic substance becomes magnetized due to the presence of a nearby magnet.

Important points:

- Depends on nature of magnetic material.
- Decreases with increase in distance.
- Stronger magnet produces stronger induction.

Magnetic Field

The region around a magnet where its magnetic force can be felt is called magnetic field.

Magnetic Lines of Force

- Imaginary lines representing direction of magnetic field.
- Outside magnet → From North to South.
- Inside magnet → From South to North.
- They never intersect each other.

Direction is defined as the direction in which a free North pole would move.

Static Electricity

Static electricity is the accumulation of electric charges on the surface of an object.

It is called "static" because charges remain at one place and do not flow.

Example:

- Rubbing balloon on hair
- Sparks when touching metal after walking on carpet

Electric Charge

Electric charge is a fundamental property of matter.

There are two types:

- Positive (protons)
- Negative (electrons)

Important properties:

- Like charges repel.
- Unlike charges attract.
- Charge is conserved (cannot be created or destroyed).

SI Unit: Coulomb

Conductors

Conductors are materials that allow electric charge to move freely through them.

- In conductors, outer electrons are loosely bound.
- These free electrons move easily when voltage is applied.
- Hence, electric current flows easily.

Examples:

- Metals like copper, aluminium, silver.

Reason metals are good conductors:
They have free electrons in their outer shell.

Insulators

Insulators are materials in which electric charges cannot move freely.

- Electrons are tightly bound to atoms.
- Very little or no current flows through them.

Examples:

- Glass
- Rubber
- Plastic
- Wood

Use:

Insulators are used to cover electric wires to prevent shock.

Electric Field of a Hollow Conductor

When a conductor is charged:

- All the charge resides on its outer surface.
- Electric field inside a hollow conductor is zero.

This phenomenon is called electrostatic shielding.

- Why?
  Because free charges rearrange themselves on the surface in such a way that internal electric field cancels out.

Application:

- It is safer to sit inside a car during lightning.
- The metal body of car acts as a protective shield.

Electric Potential

Electric potential at a point is defined as:

The work done in bringing a unit positive charge from infinity to that point.

- It represents potential energy per unit charge.
- SI Unit: Volt
- It is a scalar quantity.

Potential Difference

Potential difference between two points is:

The work done in moving a unit positive charge from one point to another.

It is commonly called voltage.

- SI Unit: Volt

- Scalar quantity.
- Important:Current flows due to potential difference.

Electric Capacity (Capacitance)

Electric capacity of a conductor is:

The amount of charge required to raise its potential by one volt.

Formula:

$C = Q / V$

Where:

C = capacitance

Q = charge

V = potential

- SI Unit: Farad
- Higher capacitance → Stores more charge at lower voltage.

Electrochemical Cell

An electrochemical cell is a device that converts chemical energy into electrical energy.

Examples:

- Voltaic cell
- Daniell cell
- Dry cell
- Leclanche cell

Cells are of two types:

Primary Cell

In primary cells:

- Chemical reaction is irreversible.
- Once discharged, cannot be recharged.

Example:

- Dry cell

After full discharge → Cell becomes useless.

Secondary Cell (Rechargeable Battery)

In secondary cells:

- Chemical reaction is reversible.
- Can be recharged by passing current in opposite direction.

Examples:

- Lead-acid battery
- Lithium-ion battery

Used in:

- Cars
- Mobile phones
- Inverters

Electric Current

Electric current is the continuous flow of electric charge in a closed circuit.
It is similar to flow of water in a pipe.
SI Unit: Ampere
Current flows only when:

- Circuit is complete
- Potential difference exists

Voltage

Voltage is the driving force that pushes electric charges through a circuit.
It is the measure of electrical potential energy between two points.
Without voltage → No current flows.

Resistance

Resistance is the opposition offered to the flow of electric current.
Every conductor offers some resistance.
Higher resistance → Less current
Lower resistance → More current

- SI Unit: Ohm (Ω)

Ohm's Law

Ohm's Law states:

At constant temperature, current flowing through a conductor is directly proportional to the applied voltage.

Mathematically:$V = IR$

Where:

V = voltage
I = current
R = resistance

This law forms the foundation of circuit analysis.

Fuse

A fuse is a safety device used to protect electrical circuits from excess current.

It contains a thin metal wire that:

- Melts when current exceeds safe limit.
- Breaks the circuit.

Thus prevents:Fire, Damage to appliances

Atomic Physics

Atomic physics studies:

- Structure of atom
- Subatomic particles
- Energy levels
- Interaction of atoms

It is based on quantum mechanics.

It explains:

- Atomic spectra
- Electron transitions
- Energy quantization

Radioactivity

Radioactivity is the spontaneous disintegration of unstable atomic nuclei.

Cause:

Imbalance between:

- Electrostatic repulsion (between protons)
- Nuclear strong force (holding nucleus together)

Heavier nuclei are more unstable.

During radioactivity, nucleus emits:

- Alpha particles
- Beta particles
- Gamma rays

Laws of Radioactivity

Important principles:

1. Radioactive decay is spontaneous.
2. It is independent of temperature and pressure.
3. It follows law of conservation of charge.
4. Daughter nucleus has different physical and chemical properties.
5. Decay rate depends on number of radioactive atoms present.

Radioactive decay follows exponential law.

Nuclear Energy

Nuclear energy is released during nuclear reactions involving atomic nuclei.

In nuclear reactions:

- One element may transform into another.
- Enormous energy is released.

This energy comes from mass-energy conversion ($E = mc^2$).

Types of Nuclear Reactions

1. Elastic Scattering

- Total kinetic energy conserved.
- Used to slow down neutrons.

2. Inelastic Scattering

- Energy is transferred to nucleus.
- Nucleus moves to excited state.

3. Transfer Reactions

- One or two particles are transferred between nuclei.

4. Capture Reactions

- Nucleus captures a particle.
- Gamma rays are emitted.
- Used to produce radioactive isotopes.

Important Note

Nuclear reactions are different from nuclear scattering:

- If nucleus changes → Nuclear reaction
- If nucleus does not change → Nuclear scattering

Nuclear Fission vs Nuclear Fusion

	Nuclear Fission	Nuclear Fusion
Definition	Splitting of a heavy nucleus into two lighter nuclei	Combination of two light nuclei to form a heavier nucleus
Type of elements involved	Heavy elements (Uranium, Plutonium)	Light elements (Hydrogen isotopes)
Energy Release	Large amount of energy	Even larger amount of energy than fission
Temperature Requirement	Relatively lower	Extremely high temperature and pressure
Chain Reaction	Possible and controllable	Difficult to control
Radioactive Waste	Produces significant radioactive waste	Produces very little radioactive waste
Occurrence	Nuclear reactors, atomic bomb	Sun, stars, hydrogen bomb
Safety	Risk of meltdown and radiation	Safer if controlled, but technologically difficult

AC vs DC

	AC (Alternating Current)	DC (Direct Current)
Direction of flow	Changes direction periodically	Flows in one direction only
Frequency	50 Hz in India	Zero
Source	Power stations	Battery, cell
Transmission	Suitable for long distance	Not suitable for long distance
Voltage conversion	Easily stepped up/down	Difficult to convert
Use	Household supply, industries	Electronics, mobile phones

Speed vs Velocity

	Speed	Velocity
Definition	Distance travelled per unit time	Displacement per unit time
Type	Scalar quantity	Vector quantity
Direction	No direction	Has direction
Can be zero?	No (if moving)	Can be zero
Formula	Distance / Time	Displacement / Time

Fundamental Units vs Derived Units

	Fundamental Units	Derived Units
Definition	Basic independent units	Formed from fundamental units
Dependence	Independent	Dependent
Examples	Meter, Kilogram, Second, Kelvin, Ampere	Newton, Joule, Pascal, Watt
Number in SI	7 fundamental units	Unlimited

pH Scale

pH Value	Nature	Example
0–6	Acidic	Lemon juice (2), Vinegar
7	Neutral	Pure water
8–14	Basic (Alkaline)	Soap solution, Ammonia
Blood pH	Slightly Basic	~7.4
Importance	Measures acidity/basicity	Used in soil, medicine, chemistry

Periodic Table

Feature	Description
Basis of arrangement	Increasing atomic number
Rows	Periods (7)
Columns	Groups (18)
Group 1	Alkali metals
Group 17	Halogens
Group 18	Noble gases
Left side	Metals
Right side	Non-metals
Trend	Similar properties in same group

Vitamin	Source	Deficiency Disease
Vitamin A	Carrot, Milk, Eggs	Night Blindness
Vitamin B1 (Thiamine)	Cereals, Pulses	Beriberi
Vitamin B2	Milk, Green vegetables	Cheilosis
Vitamin B12	Meat, Eggs	Anemia
Vitamin C	Citrus fruits	Scurvy
Vitamin D	Sunlight, Fish	Rickets
Vitamin E	Nuts, Vegetable oils	Muscle weakness
Vitamin K	Green leafy vegetables	Poor blood clotting

Antigen vs Antibody

	Antigen	Antibody
Definition	Foreign substance	Protein produced by immune system
Function	Triggers immune response	Neutralizes antigen
Origin	External (virus, bacteria)	Produced by B-lymphocytes
Specificity	Specific antigen	Specific antibody matches antigen

Blood Groups

Blood Group	Antigen Present	Antibody Present	Can Donate To	Can Receive From
A	A	Anti-B	A, AB	A, O
B	B	Anti-A	B, AB	B, O
AB	A and B	None	AB	All
O	None	Anti-A & Anti-B	All	O
Universal Donor	O Negative			
Universal Recipient	AB Positive			

DNA vs RNA

	DNA	RNA
Full Form	Deoxyribonucleic Acid	Ribonucleic Acid
Structure	Double stranded	Single stranded
Sugar	Deoxyribose	Ribose
Function	Stores genetic information	Protein synthesis
Location	Mainly nucleus	Nucleus & cytoplasm
Stability	More stable	Less stable

Plant Cell vs Animal Cell

	Plant Cell	Animal Cell
Cell Wall	Present	Absent
Chloroplast	Present	Absent
Vacuole	Large central vacuole	Small or absent
Shape	Fixed, rectangular	Irregular
Centrioles	Absent	Present
Energy Storage	Starch	Glycogen

Prokaryotic vs Eukaryotic Cell

	Prokaryotic Cell	Eukaryotic Cell
Nucleus	Absent	Present
Membrane-bound organelles	Absent	Present
Size	Smaller	Larger
Complexity	Simple	Complex
Genetic Material	Circular DNA	Linear DNA
Examples	Bacteria	Plants, Animals