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CHEMISTRY

Chemical Reactions and Equations

Chemical Equation

Writing Chemical Equations

In a chemical reaction, the reactants are written on the left hand side and the products on the right hand side of the equation.

An arrow (→) pointing towards the products is inserted between the reactants and the products. It also represents the direction of the reaction.

A single arrow (→) indicates the direction in which the reaction proceeds.

$\leftrightharpoons$

A plus sign (+) is inserted between two or more reactants or products formed.

If reactions are carried out under specific conditions of temperature, pressure, catalyst etc., then these conditions are mentioned on the arrow.

The chemical equation can be made more informative by mentioning the physical states of the reactants and products.

If gas is liberated as a product then it is represented by an arrow pointing upwards (↑). If the product formed is in the form of a precipitate, it is represented by an arrow pointing downwards (↓).

Balancing the Chemical Equations

In a balanced chemical equation, the total number of atoms of each element of the reactants on the left hand side of the equation is equal to the number of atoms of the products formed on the right hand side of the equation.

The total mass of the reactants is equal to the total mass of the products or the number of atoms of each element before the reaction and after the reaction is equal.

Steps Involved in Balancing a Chemical Equation

Consider the chemical reaction between magnesium and oxygen to understand the steps involved in balancing a chemical equation.

Step 1

Let us first write the word equation for this reaction.

Magnesium + Oxygen → Magnesium oxide

Step 2

Write the chemical equation for the reaction between magnesium and oxygen.

$Mg + O_2 \rightarrow MgO$

Step 3

Count the number atoms of an element occurring on both L.H.S. and R.H.S. in this equation.

$Mg + O_2 \rightarrow MgO$

Component	Reactant	Product
Magnesium	1	1
Oxygen	2	1

This is an unbalanced equation.

Step 4

To balance a chemical equation, first draw boxes around each formula. Do not change anything inside the boxes while balancing the equation.

$$\boxed{Mg} + \boxed{O_2} \longrightarrow \boxed{MgO}$$

Choose a reactant or a product which has the maximum number of atoms in it. In that compound, select the element which has the maximum number of atoms. In this equation we shall select MgO i.e. magnesium oxide and the element oxygen in it.

To balance the oxygen atoms, let us multiply magnesium oxide molecule by 2 on the right hand side. The equation can now be expressed as,

$$\boxed{Mg} + \boxed{O_2} \longrightarrow 2\ \boxed{MgO}$$

Component	Reactant	Product
Magnesium	1	1 x2 = **2**
Oxygen	2	1 x 2 = **2**

Step 5

There are two oxygen atoms on either side of the equation but one magnesium atom on the reactant's side and two on the product's side. Therefore, multiply the magnesium atom by 2 on the left hand side.

Component	Reactant	Product
Magnesium	1 x 2 = **2**	2
Oxygen	2	2

Balanced equation is,

$$2\ \boxed{Mg} + \boxed{O_2} \longrightarrow 2\ \boxed{MgO}$$

The number of atoms of each element of reactants = The number of atoms of each element of products

Step 6

Writing Specific Conditions on the Arrow

The reaction is carried out in the presence of 'Heat'. On heating, magnesium combines with oxygen present in air to form magnesium oxide.

$$2\ Mg + O_2 \xrightarrow{Heat} 2\ MgO$$

Step 7

Writing Symbols of Physical States

$$2\ Mg_{(s)} + O_{2\,(g)} \xrightarrow{Heat} 2\ MgO_{(s)}$$

Using these steps, you can balance any chemical equation.

Types of Chemical Reactions

Combination Reaction

When two or more substances combine to form a single product, the reaction is known as a combination reaction.

For example:

In the laboratory, iron sulphide is prepared by mixing iron and sulphur.

$Fe_{(s)} + S_{(s)} \rightarrow FeS_{(s)}$

Endothermic Reaction: The reactions accompanied by the absorption of heat are called endothermic reactions.

Exothermic Reaction: The reactions accompanied by the evolution of heat are called endothermic reactions.

Decomposition Reaction

A chemical reaction in which a single compound splits into two or more simple substances is called a decomposition reaction.

For example:

When mercuric oxide is heated in a crucible, the orange-red powder begins to darken and a silver mirror begins to deposit on the cooler parts of the crucible.

$$\underset{\text{Mercuric oxide}}{2HgO_{(s)}} \xrightarrow{\text{Heat}} \underset{\text{Mercury}}{2Hg_{(s)}} + \underset{\text{Oxygen}}{O_2 \uparrow}$$

Thermal Decomposition Reaction: The decomposition reactions carried out by heating are known as thermal decomposition reactions.

Photochemical reaction: The chemical reactions which proceed with the absorption of light energy are called photochemical reactions.

Displacement Reaction

Reactions in which the more reactive element displaces the less reactive element from its compound are called displacement reactions.

For example:

Zinc displaces copper in copper sulphate to form zinc sulphate.

$$\underset{\text{Zinc}}{Zn_{(s)}} + \underset{\text{Copper sulphate}}{CuSO_{4\,(aq)}} \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_{4\,(aq)}} + \underset{\text{Copper}}{Cu_{(s)}}$$

Double Displacement Reaction

Reactions in which ions of the reactants exchange places to form two new compounds, are called double displacement reactions.

For example:

Sodium hydroxide reacts with hydrochloric acid to form sodium chloride and water.

$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

Oxidation Reactions

Reactions which involve the addition of oxygen or the removal of hydrogen are called oxidation reactions.

For example:

$C_{(s)} + 2H_{2\,(g)} \rightarrow CH_{4\,(g)}$

Reduction Reactions

Chemical reactions in which the reactants gain hydrogen are reduction reactions.
For example:

$$\underset{\text{Ferric oxide}}{Fe_2O_3} + \underset{\text{Carbon monoxide}}{3CO} \longrightarrow \underset{\text{Iron}}{2Fe} + \underset{\text{Carbon dioxide}}{3CO_2\uparrow}$$

Redox Reaction

The chemical reaction in which oxidation and reduction takes place simultaneously is known as a redox reaction.

Reduced

$$H_2S + Cl_2 \longrightarrow 2HCl + S$$

Oxidised

Corrosion

The slow process of decay and destruction of metals due to the action of air, moisture or acids is called corrosion.
For example:
Iron combines with oxygen present in the air, in the presence of water, to form a red-brown flaky substance called **rust**. This process is commonly called the **rusting of iron.**
The chemical formula of rust is $Fe_2O_3 . x H_2O$.

Prevention of Corrosion

Corrosion damages buildings, bridges, ships, automobiles and other articles made of iron. Hence, prevention of corrosion is necessary. This will not only save money but can also prevent the occurrence of accidents.
It can be prevented by processes like galvanising and electroplating with other metals.

Rancidity

Oils and fats react with oxygen and get oxidised or turn rancid. This process is called rancidity.
Rancidity can be prevented by keeping food in air tight containers or by using antioxidants.
Antioxidants are used to prevent oxidation of food containing fats and oils.
Storage of food in air tight containers also decelerates oxidation.

Acids, Bases & Salts

Acids and Bases in the Laboratory

Indicators

An indicator tells us whether a substance is acidic or basic in nature, by the change in colour.

Common Indicators

An acid turns blue litmus red and a base turns red litmus blue.
Methyl orange indicator gives a red colour in an acidic solution and gives a yellow colour in a basic solution.
Phenolphthalein is colourless in an acidic solution and gives a pink colour in a basic solution.

Olfactory Indicators

Those substances whose odour changes in acidic or basic media are called olfactory indicators. For example: onion, vanilla and clove oil.
On adding sodium hydroxide solution to a cloth strip treated with onion, the smell of the onion is not detected. An acidic solution does not eliminate the smell of the onion.

Reaction of Acids & Bases with Metals

Acids react with metals to produce salt by displacing hydrogen.

For Example:

When dilute sulphuric acid reacts with the metal zinc, zinc sulphate is formed with the evolution of hydrogen gas.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Zinc is the only metal which reacts with sodium hydroxide to form sodium zincate with the release of hydrogen gas.

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

Reaction of Metal Carbonates & Bicarbonates with Acids

Acids react with metal carbonates or bicarbonates to form salt and water with the evolution of carbon dioxide gas.

For Example:

Hydrochloric acid reacts with sodium carbonate to form sodium chloride and water with the release of carbon dioxide gas.

$Na_2CO_{3(s)} + 2\,HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

Similarly, sodium bicarbonate also reacts with hydrochloric acid to form sodium chloride and water with the release of carbon dioxide gas.

$NaHCO_{3(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

Neutralisation

The reaction between an acid and a base to form salt and water is called a neutralisation reaction.
For example:
Hydrochloric acid reacts with sodium hydroxide to form sodium chloride and water.
$HCl + NaOH \rightarrow NaCl + H_2O$

Reaction of Metallic Oxides with Acids

Acids react with metallic oxides to form salt and water.
For Example:
Copper oxide (II), a black metal oxide reacts with dilute hydrochloric acid to form a blue-green coloured copper chloride (II) solution.
$CuO + 2HCl \rightarrow CuCl_{2(aq)} + H_2O$

Reaction of Non-Metallic Oxides with Base

Bases react with non-metallic oxides to form salt and water.
For Example:
Calcium hydroxide reacts with non-metallic oxides like carbon dioxide to form calcium carbonate salt and water.
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

Acids and Bases in Water

Acids

An acid is a substance which dissociates (or ionises) when dissolved in water to release hydrogen ions.
For Example:
An aqueous solution of hydrochloric acid dissociates to form hydrogen ions. Since hydrogen ions do not exist as H^+ in solution, they combine with polar water molecules to form hydronium ions [H_3O^+].
$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
$H^+ + H_2O \rightarrow H_3O^+$
The presence of hydrogen ions [H^+] in hydrochloric acid solution makes it behave like an acid.

Bases

A base is a substance which dissolves in water to produce hydroxide ions [OH- ions].
Bases which are soluble in water are called alkalis.
For Example:
Sodium hydroxide dissolves in water to produce hydroxide and sodium ions.
$NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$
The presence of hydroxide ions [OH^-] in sodium hydroxide solution makes it behave like a base.

pH Scale

pH of a solution: pH of a solution is the negative logarithm to the base 10 of the hydrogen ion concentration expressed in mole per litre.

$pH = -\log_{10} (H^+)$

p H = 7 - Neutral	$[H^+] = [OH^-]$
pH less than 7 - Acidic	$[H^+]$ more than $[OH^-]$
pH more than 7 - Basic	$[OH^-]$ more than $[H^+]$

Universal Indicator

In case of a colourless liquid, the accurate pH can be obtained by adding a universal indicator.
It is a mixture of several indicators and shows different colours at different concentration of hydrogen ions in a solution.

For Example:

A universal indicator produces green colour in a neutral solution, pH = 7.
The colour changes from blue to violet as pH increases from 7 to 14.
The colour changes from yellow to pink and then to red as pH decreases from 7 to 1.

Importance of pH in everyday life

pH change and survival of animals

Our body works well within a narrow pH range of 7.0 to 7.8.
When the pH of rain water is less than 5.6, it is known as acid rain.
When this acid rain flows into rivers, it lowers the pH of the river water making the survival of aquatic life difficult.

pH in our digestive system

Our stomach produces hydrochloric acid which helps in the digestion of food without harming the stomach.
Sometimes excess acid is produced in the stomach which causes indigestion.
To get rid of this pain, bases called antacids are used.
Antacids are a group of mild bases which react with the excess acid and neutralise it.
Commonly used antacids are magnesium hydroxide $[Mg(OH)_2]$ & sodium bicarbonate$[NaHCO_3]$

pH change - Cause of tooth decay

Tooth decay starts when the pH in the mouth falls below 5.5.
Tooth enamel is made up of calcium phosphate which is the hardest substance in the body.
It is insoluble in water but gets corroded when the pH in the mouth falls below 5.5.
The bacteria present in the mouth produce acids due to the degradation of sugar and food particles after eating.
Hence, to prevent tooth decay, the mouth should be rinsed after eating food and toothpastes which are basic should be used cleaning teeth to neutralise the excess acid.

More about Salts

Salts having same positive ions (or same negative ions) are said to belong to a family of salts.

pH of Salts

Salts of strong acid and a strong base are neutral, with a pH value of 7. **For Example:** $NaCl$, Na_2SO_4

Salts of strong acid and weak base are acidic, with a pH value less than 7. **For Example:** Ammonium chloride solution has pH value of 6.

Salts of weak acid and strong base are basic, with a pH value more than 7. **For Example:** Sodium carbonate solution has a pH value of 9.

Common Salt

Common salt is a neutral salt and can be prepared in the laboratory by the reaction of sodium hydroxide and hydrochloric acid.

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(aq)}$$

It is an important raw material for products of daily use such as NaOH, baking soda, washing soda and bleaching powder.

Sodium Hydroxide

Sodium hydroxide is produced by the electrolysis of an aqueous solution of sodium chloride (called brine).

The process is called the chlor-alkali process because of the products formed, i.e. 'chlor' for chlorine and 'alkali' for sodium hydroxide.

K2

$$2NaCl_{(aq)} + 2H\ O_{(aq)} \rightarrow 2NaOH_{(aq)} + H_{2(g)} + Cl_{2(g)}$$

Bleaching Powder

- It is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$].

$$Ca(OH)_2 + Cl \rightarrow CaOCl_2 + H_2O$$

- It is represented as $CaOCl_2$

Uses

For bleaching cotton and linen in the textile industry and for bleaching wood pulp in the paper industry.

Used for disinfecting drinking water to make it free of germs.

Baking Soda

Chemical formula: $NaHCO_3$

It is produced on a large scale by treating cold and concentrated solution of sodium chloride (brine) with ammonia and carbon dioxide.

$$NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$$

On heating, it decomposes to give sodium carbonate with the evolution of carbon dioxide.

$$2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$$

Uses

Used as an antacid to treat acidity of the stomach.
Used to make baking powder, which is used in preparation of cakes, breads, etc.
Used in soda-acid fire extinguishers.

Washing Soda

Chemical formula: $Na_2CO_3.10H_2O$
Sodium hydrogen carbonate, on heating decomposes to give sodium carbonate with the release of hydrogen gas. Re-crystallisation of sodium carbonate produces washing soda.

$2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + H_2O + CO_2$

$Na_2CO_3 + 10H_2O \longrightarrow Na_2CO_3.\ 10H_2O$

Uses

Used in glass, soap and paper industries.
Employed in the manufacture of sodium compounds such as borax.

Water Of Crystallisation

Water molecules which form a part of the structure of a crystal are called water of crystallisation.
The salts which contain water of crystallisation are called hydrated salts.
Every hydrated salt has a fixed number of molecules of crystallisation in its one formula

unit. **For Example:** $CuSO_4.5H_2O$, $Na_2CO_3.10H_2O$, $CaSO_4.5H_2O$, and $FeSO_4.7H_2O$

Copper sulphate crystals ($CuSO_4.5H_2O$) are blue in colour, and on heating strongly they lose all the water of crystallisation and form anhydrous copper sulphate, which is white. On adding water to anhydrous copper sulphate, it gets hydrated and turns blue.

$CuSO_4.5H_2O \xrightarrow{Heat} CuSO_4 + 5H_2O$

$\longrightarrow$

Plaster of Paris

Plaster of Paris is prepared by heating gypsum at 373 K. On heating, it loses water molecules and becomes calcium sulphate hemihydrate ($CaSO_4.1/2\ H_2O$) which is called Plaster of Paris.

$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow{Heat} \underset{\text{Plaster of Paris}}{CaSO_4.\ ½\ H_2O} + 1\ ½\ H_2O$

Uses

Used in hospitals as plaster for supporting fractured bones in the right position.
Used as a fire-proofing material.

Metals & Non-Metals

Physical Properties of Metals

Difference in Physical Properties of Metals and Non-Metals:

Metals	Non-metals
1) Metals are good conductors of heat and electricity.	1) Non-metals are bad conductors of heat and electricity.
2) Metals are malleable that is they can be beaten into sheets.	2) Non-metals are not malleable.
3) Metals are ductile that is they can be drawn into wires.	3) Non-metals are not ductile.
4) Metals are sonorous.	4) Non-metals are not sonorous.
5) Metals have high tensile strength due to high attraction between molecules.	5) Non-metals have low tensile strength due to low attraction between molecules.
6) Metals have high density.	6) Non-metals have low density.

Chemical Properties of Metals

Reaction of Metals with Oxygen
Almost all metals react with oxygen to form metal oxides.

Sodium and potassium are the most reactive and react with oxygen present in the air at room temperature to form the oxides.
Magnesium does not react with oxygen at room temperature, but on heating, it burns in the air with intense light and heat to form magnesium oxide.

Reaction of Metals with Water
Metals react with water to produce metal oxides with the release of hydrogen gas. But all metals do not react with water.

Metals such as sodium and potassium react vigorously with cold water to lead to evolution of hydrogen, which immediately catches fire producing a large quantity of heat.
Metals such as aluminium, zinc and iron do not react with cold or hot water, but they react with steam to form metal oxides and hydrogen.

Reactions of Metals with Acids

Metals react with acids to form salt and hydrogen gas.

Metals react with dilute hydrochloric acid to give metal chloride and hydrogen gas.

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

Metals react with sulphuric acid to form metal sulphate and hydrogen gas.

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

Metals react with nitric acid, but hydrogen gas is not evolved since nitric acid is a strong oxidising agent. So, it oxidises the hydrogen to water and itself gets reduced to a nitrogen oxide.

But magnesium and manganese react with dilute nitric acid to evolve hydrogen gas.

$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$

$Mn + 6HNO_3 \rightarrow Mn(NO_3)_2 + H_2$

Reactivity Series

The arrangement of metals in the order of decreasing reactivities is called the reactivity series of metals.

Reactions of Metals with Solutions of Other Metal Salts

A more reactive metal displaces a less reactive metal from its salt solution.

For example:

When an iron nail is placed in a copper sulphate solution, the blue colour of $CuSO_4$ fades away slowly and a reddish brown copper metal is formed.

$CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu(s)$

Reaction of Metals with Chlorine

Metals react with chlorine to form metal chlorides.

For example:

Sodium readily reacts with chlorine to form ionic chloride called sodium chloride. $2Na_{(s)} + Cl_{2(g)} \rightarrow NaCl_{(s)}$

Calcium reacts vigorously with chlorine to form calcium chloride.

$Ca_{(s)} + Cl_{2(g)} \rightarrow 2CaCl_{2(s)}$

Properties of Ionic Compounds

Ionic compounds are hard solids, due to the strong force of attraction between the positive and negative ions.

They are generally brittle and break into pieces when pressure is applied.

Ionic compounds have high melting and boiling points, since a large amount of energy is required to break the strong intermolecular attractions.

They are soluble in water, but insoluble in solvents such as kerosene, petrol, etc.

They do not conduct electricity in a solid state, because electrostatic forces of attraction between ions in the solid state are very strong but conduct electricity in the fused (or in the aqueous state) because these forces weaken in the fused (or in solution) state so that their ions become mobile.

Metallurgy

Minerals : The naturally occurring compounds of metals, along with other impurities are known as minerals.

Ores: The minerals from which metals are extracted profitably and conveniently are called ores.

Gangue: Earthly impurities including silica, mud, etc. associated with the ore are called gangue.

Metallurgy: The process used for the extraction of metals in their pure form from their ores is referred to as metallurgy.

Extraction of Metals

The reactivity of elements differs for different metals.

Three major steps involved in the extraction of metals from their ores are:

Conversion of Concentrated Ore into Metal

The extraction of a metal from its concentrated ore is essentially a process of reduction of the metal compound present in the ore.

The method of reduction to be used depends on the reactivity of the metal to be extracted.

Extraction of Less Reactive Metals

Metals at the bottom of the reactivity series are not very reactive and the oxides of these metals can be reduced by heating the ore itself.

Extraction of Mercury

Cinnabar, an ore of mercury is first heated in the air and is converted into mercuric oxide.

$$2HgS_{(s)} + 3O_{2(g)} \xrightarrow{Heat} 2HgO_{(s)} + 2SO_{2(g)}$$

$$2HgO_{(s)} \xrightarrow{Heat} Hg_{(s)} + O_{(g)}$$

Extraction of Moderately Reactive Metals

- The moderately reactive metals in the middle of the reactivity series are extracted by the reduction of their oxides with carbon, aluminium, sodium or calcium.
- It is easier to obtain metals from their oxides (by reduction) than from carbonates or sulphides. So, before reduction can be done, the ore is converted into a metal oxide.
- The concentrated ores can be converted into metal oxides by the process of calcination or roasting.

  Calcination is the process in which a carbonate ore is heated strongly in the absence of air to convert it into a metal oxide.

  For example:

  $$ZnCO_{3(s)} \xrightarrow{Calcination} ZnO_{(s)} + CO_{2(g)}$$

  Roasting is the process in which a sulphide ore is strongly heated in the presence of air to convert it into a metal oxide.

  $$2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{Roasting} 2ZnO_{(s)} + 2SO_{2(g)}$$

  The metal oxides are converted to free metal by using reducing agents such as carbon, aluminium, sodium or calcium.

For example:

The metal zinc is extracted by the reduction of zinc oxide with carbon. Thus, when zinc oxide is heated with carbon, zinc is produced.

Aluminium reduces iron oxide to produce the metal iron with the evolution of heat. Due to this heat, the iron is produced in the molten state.

$Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow 2Fe_{(l)} + Al_2O_{3(s)} + Heat$

The reaction of iron (III) oxide with aluminium is used to join railway tracks or cracked machine parts. This reaction is known as the thermite reaction.

Extraction of Highly Reactive Metals

Metals high up in the reactivity series are very reactive.

These metals have a strong affinity for oxygen. So, oxides of sodium, magnesium, calcium and aluminium cannot be reduced by carbon.

These metals are obtained by electrolytic reduction.

Sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides.

For example:

Sodium metal is extracted by the electrolytic reduction of molten sodium chloride.

$2NaCl_{(l)} \xrightarrow{Electrolysis} 2Na_{(s)} + Cl_{2(g)}$

At Cathode: $Na^+ + e^- \rightarrow Na$

At Anode: $2Cl^- \rightarrow Cl_2 + 2e^-$

Refining of Metals

The most widely used method for refining impure metals is electrolytic refining.

Electrolytic refining means refining by electrolysis. Metals such as copper, zinc, tin, lead, chromium, nickel, silver and gold are refined electrolytically.

Corrosion

When the surface of a metal is attacked by air, moisture or any other substance around it, the metal is said to corrode and the phenomenon is known as corrosion.

Conditions necessary for rusting of iron

Presence of air (or oxygen)

Presence of water (or moisture)

Prevention of Corrosion

Galvanising: It is the process of giving coating a thin layer of zinc on iron or steel to protect them from corrosion. Example: shiny nails, pins. etc.

Tinning: It is a process of coating tin over other metals.

Electroplating: In this method, a metal is coated with another metal using electrolysis. Example: silver plated spoons, gold plated jewellery etc.

Alloying: An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal in a definite proportion. The resultant metals, called alloys do not corrode easily.

For example: Brass (copper and zinc), Bronze (copper and tin) and Stainless steel (iron, nickel, chromium and carbon)

Periodic Classification of Elements

Early Attempts of Classification of Elements

Dobereiner's Triads

Law of Triads: When elements are arranged in the order of their increasing atomic masses, the atomic mass of the middle element was approximately the mean of the atomic masses of the other two elements.
For example:
Consider the triad of lithium, sodium and potassium. The atomic mass of sodium is the mean of the atomic masses of lithium and potassium.

Element	Atomic Mass
Lithium	6.9
Sodium	Atomic mass of Na = $\frac{6.9 + 39}{2} = 23$
Potassium	39

Newlands' Law of Octaves

Law of Octaves: When elements are arranged in the increasing order of their atomic masses, the properties of every eighth element is similar to the first.

Limitations

Newland could arrange elements only up to calcium, out of the total 56 elements known.
After calcium, every eighth element did not possess properties similar to that of the first.
Only 56 elements were known at the time of Newland, but later several new elements were discovered.
In order to fit the existing element arrangement, Newland placed two elements in the same position which differed in their properties.
For example: Iron, an element which resembles cobalt and nickel in its properties is placed far away from these elements.
The periodic table did not include inert gases because they were not discovered then.

Mendeleev's Periodic Table

Mendeleev's Periodic Law: The physical and chemical properties of elements are a periodic function of their atomic masses.

Features of Mendeleev's Periodic Table

There are seven horizontal rows in the periodic table, numbered from 1 to 7. These seven rows are called periods.
There are eight vertical columns numbered from I to VIII. These eight columns are called groups. Groups I to VII are further divided into sub groups A and B.
The properties of elements in a particular period show regular gradation from left to right.

Merits of Mendeleev's Periodic Table

Mendeleev kept some blank spaces in the periodic table for the elements which were yet to be discovered.

Predicted element	Actual element discovered later
Eka-boron	Scandium
Eka-aluminium	Gallium
Eka-silicon	Germanium

He also predicted properties of some elements even before their discovery which were later found to be correct.

Property	Eka-aluminium	Gallium
Atomic mass	68	69.7
Formula of oxide	$_2O_3$	Ga_2O_3
Formula of chloride	ECl_3	$GaCl_3$

- Mendeleev's periodic table could accommodate noble gases when they were discovered.

Demerits of Mendeleev's Periodic Table

- Hydrogen resembles alkali metals as well as halogens. So, a correct position could not be assigned to hydrogen in the periodic table.
- The position of isotopes could not be explained. Isotopes are atoms of the same element having similar chemical properties but different atomic masses. If the elements are arranged according to atomic masses, the isotopes should be placed in different groups of the periodic table.
- At certain places, an element of higher atomic mass was placed before an element of lower atomic mass.
  For example: Cobalt (Co = 58.93) was placed before nickel (Ni = 58.71).
- Some elements placed in the same sub group had different properties.
  For example: Manganese is placed with the halogens which are totally different in their properties.

Modern Periodic Table

In 1913, Henry Moseley proved that the atomic number is the fundamental property rather than its atomic mass.

Modern Periodic Law: Properties of elements are a periodic function of their atomic numbers.

The periodic table, based on the Modern Periodic Law is called the Modern Periodic Table.

Position of Elements in the Periodic Table

Periods

The horizontal rows in the Modern Periodic Table are called periods.

The Modern Periodic Table consists of seven periods which are numbered from 1 to 7.

In each period, a new shell starts filling up. The period number is also the number of shell which starts filling up.

Groups

The vertical columns are called groups and consist of eighteen groups numbered from 1 to 18.
Elements having the same number of valence electrons are present in the same group.
Elements present in the same group show the same chemical properties.

Trends in the Modern Periodic Table

Valency

The valency of an element is determined by the number of valence electrons present in its outermost shell.
In a group, all the elements have the same number of valence electrons.
On moving from left to right in each short period, the valency increases from 1 to 4 and then decreases to zero.

Atomic Size

Atomic size refers to the radius of the atom.

- It is the distance between the centre of the nucleus and the outermost shell of an isolated atom.

In a period, the atomic radius decreases from left to right. his is because electrons are added to the same shell and so they experience a greater pull from the nucleus.
Moving in a group from top to bottom, the atomic radius increases as new shells are added, resulting in the outermost electrons being farther away from the nucleus.

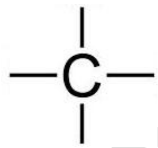
Metallic & Non-metallic Properties

Metals show a tendency to lose electrons and are said to be electropositive.
Non-metals show a tendency to accept or share electrons and are said to be electronegative.
Moving from left to right in a period, the metallic character decreases and the non-metallic character increases. The atomic size decreases and so electrons are not released easily.
In a group, the metallic character increases from top to bottom and the non-metallic character decreases. This is because, as the atomic size increases the valence electrons can be easily removed.
Elements on the left of the periodic table are all metals and on the right of the periodic table are all non-metals.
A zigzag line in the periodic table separates the metals from non-metals. The borderline elements show intermediate properties and are called metalloids.

Carbon and its Compounds

Bonding in Carbon

Carbon atom has four electrons in its outermost shell.
It requires four electrons to achieve the stable, 8 electron, inert gas configuration.
Carbon atoms can achieve the inert gas electron arrangement only by sharing their electrons. Hence, carbon always forms covalent bonds.
The valency of carbon is four since one carbon requires 4 electrons to achieve the nearest inert gas configuration. Thus, we can say that carbon is tetravalent.
The four valencies of carbon are usually represented by drawing four short lines around the symbol of carbon (C).



Allotropes of Carbon

Carbon has three allotropes:

- Diamond
- Graphite
- Buckminster fullerene

Diamond

In diamond, each carbon atom is bonded to four other carbon atoms, forming a three dimensional structure.
The rigid structure of diamond makes it a very hard substance.
It is a non-conductor of electricity since there are no free electrons in a diamond crystal.
It can be synthesised by subjecting pure carbon to a very high pressure and temperature.

Graphite

In graphite, each carbon atom is bonded to three other carbon atoms in the same plane, giving a hexagonal array.

- One of the bonds is a double bond and thus the valency of carbon is satisfied.

Graphite structure is formed by the hexagonal arrays being placed in layers, one above another.
Graphite is smooth and slippery.
It is a very good conductor of electricity due to the presence of free electrons.

Fullerene

It is an allotrope of carbon containing clusters of 60 carbon atoms joined together to form spherical molecules.
There are 60 carbon atoms in a molecule of buckminsterfullerene, so its formula is C_{60}.
The allotrope was named buckminsterfullerene after the American architect Buckminster Fuller.

Versatile Nature of Carbon

The two characteristic properties of the element carbon which leads to the formation of a very large number of organic compounds are:

Catenation: The property of the element carbon due to which its atoms can join one another to form long carbon chains is called catenation.

Types of Chains

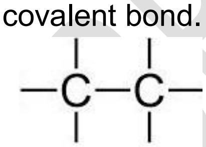
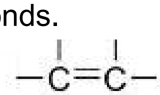
- Straight chain of carbon atoms
- Branched chain of carbon atoms
- Closed or ring chain of carbon atoms

Tetravalency: Carbon has a valency of four. So, it is capable of bonding with four other atoms of carbon or atoms of some other monovalent element.

Compounds of carbon are formed with oxygen, nitrogen, hydrogen, sulphur, chlorine and many other elements, giving rise to compounds with specific properties which depend on the elements other than the carbon present in the molecule.

Classification of Hydrocarbons

Comparison of Saturated and Unsaturated Hydrocarbons

Saturated hydrocarbons	Unsaturated hydrocarbons
1. All the four valencies of each carbon atom are satisfied by forming single covalent bonds with carbon and with hydrogen atoms.	1. The valencies of at least two carbon atoms are not fully satisfied by hydrogen atoms.
2. Carbon atoms are joined by a single covalent bond.  (Single bond)	2. Carbon atoms are joined by double covalent bonds.  (Double bond) or by triple covalent bonds.  (Triple bond)
3. They are less reactive due to the non-availability or electrons in the single covalent bond, and therefore, they undergo substitution reaction.	3. They are more reactive due to the presence of electrons in the double or triple bond and therefore undergo addition reaction.

Cyclic Hydrocarbons

Hydrocarbons in which the carbon atoms are arranged in the form of a ring are called cyclic hydrocarbons.

Cyclic hydrocarbons may be saturated or unsaturated.

Saturated cyclic hydrocarbon	Unsaturated cyclic hydrocarbon
○ Cyclohexane is an example of a saturated cyclic hydrocarbon. ○ Formula: C_6H_{12} ○ Cyclohexane contains 6 carbon atoms arranged in a hexagonal ring, with each carbon atom attached to 2 hydrogen atoms.	○ Benzene is an example of an unsaturated cyclic hydrocarbon. ○ Formula: C_6H_6 ○ Benzene is made up of 6 carbon atoms and 6 hydrogen atoms.

Functional Groups

Functional group: An atom or a group of atoms present in the molecules, which determines the characteristics property of the organic compounds, is called the functional group.

Functional group	General formulae	Organic compound	Suffix	Examples with common & IUPAC name
Halide-X (F,Cl,Br,I)	R-X	Haloalkanes	-ane	CH_3Cl Common name: Methyl chloride IUPAC name: Chloromethane
Hydroxyl-OH	R-OH	Alcohols	-ol	C_2H_5OH Common name : Ethyl alcohol IUPAC name: Ethanol
Aldehyde-CHO	$\begin{matrix} H \\ R \end{matrix}\!> C{=}O$	Aldehydes	-al	CH_3CHO Common name: Acetaldehyde IUPAC name: Ethanal
Carboxyl-COOH	$R-\overset{\overset{O}{\Vert}}{C}-O-H$	Carboxylic acids	-oic acid	CH_3CH_2COOH Common name: Propionic acid IUPAC name: Propanoic acid
Keto $-\overset{\overset{O}{\Vert}}{C}-$	$R-\overset{\overset{O}{\Vert}}{C}-R^{I}$	Ketones	-one	$CH_3COC_2H_5$ Common name: Diethyl ketone IUPAC name: Pentanone
Ethers $-\overset{\vert}{\underset{\vert}{C}}-O-\overset{\vert}{\underset{\vert}{C}}-$	R-O-R'	Ethers	-oxy	$CH_3 – O – C_2H_5$ Common name: Ethyl methyl ether IUPAC name: Methoxy ethane

Homologous Series

It is a group of organic compounds having a similar structure and chemical properties in which the successive compounds differ by a **-CH_2** group.

Characteristics of a Homologous Series

Each member of the series differs from the preceding one by the addition of a -CH_2 group and by 14 a.m.u.

All members of a homologous series have the same general formula.

The physical properties of the members show a gradation in properties as their molecular mass increases.

All members of a homologous series can be prepared by the same general method of preparation.

Chemical Properties of Carbon Compounds

Combustion

The process of burning a carbon compound in air to give carbon dioxide, water, heat and light is known as combustion.

For example:

$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O(g)$ + Heat and Light

Oxidation

Carbon compounds can be oxidised.

Alcohols on oxidation are converted to carboxylic acids.

Alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$ are used as oxidising agents.

Addition Reaction

This reaction occurs only in unsaturated compounds, where there are double or triple bonds.

The addition of hydrogen to an unsaturated hydrocarbon to obtain a saturated hydrocarbon is called hydrogenation.

The process of hydrogenation is used in industries to prepare vegetable ghee (or vanaspati ghee) from vegetable oils.

Substitution Reaction

The reaction in which one or more hydrogen atoms of a hydrocarbon are replaced by atoms of other elements is called a substitution reaction.

Substitution reactions are a characteristic property of saturated hydrocarbons.

Some Important Carbon Compounds – Ethanol & Ethanoic Acid

Properties of Alcohols

Reaction with Sodium: Sodium reacts steadily with ethanol to form sodium ethoxide along with the evolution of hydrogen gas.

$2C_2H_5OH$	+	$2Na \rightarrow$	$2C_2H_5ONa$ +	$H_2 \uparrow$
Ethanol		Sodium	Sodium ethoxide	Hydrogen

Dehydration: Ethanol, on heating with excess of conc. H_2SO_4 at 170°C gets dehydrated to form ethene.

$$C_2H_5OH \xrightarrow{Conc.H_2SO_4,\ 170^{o}C} CH_2=CH_2 + H_2O$$

Properties of Ethanoic acid

Esterification: Ethanoic acid reacts with alcohols in the presence of a little conc. sulphuric acid to form esters.

$$C_2H_5OH + CH_3COOH \xrightarrow{Conc.H_2SO_4} CH_3COOC_2H_5 + H_2O$$

The ester, on treating with a base such as NaOH is converted back to alcohol and sodium salt of carboxylic acid. This reaction is known as saponification because it is used in the manufacture of soap.

$$CH_3COOC_2H_5 + NaOH \rightarrow C_2H_5OH + CH_3COONa$$

Reaction with a base: Ethanoic acid reacts with a base such as sodium hydroxide to form a salt and water.

$$\underset{\text{Acetic acid}}{CH_3COOH} + NaOH \rightarrow \underset{\text{Sodium acetate}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

Reaction with Carbonates & bicarbonates: Acetic acid reacts with carbonates and bicarbonates to form salt, water and carbon dioxide.

$$\underset{\text{Acetic acid}}{2CH_3COOH} + Na_2CO_3 \rightarrow \underset{\text{Sodium acetate}}{2CH_3COONa} + H_2O + CO_2$$

$$\underset{\text{Acetic acid}}{CH_3COOH} + NaHCO_3 \rightarrow \underset{\text{Sodium acetate}}{CH_3COONa} + H_2O + CO_2$$

Soaps & Detergents

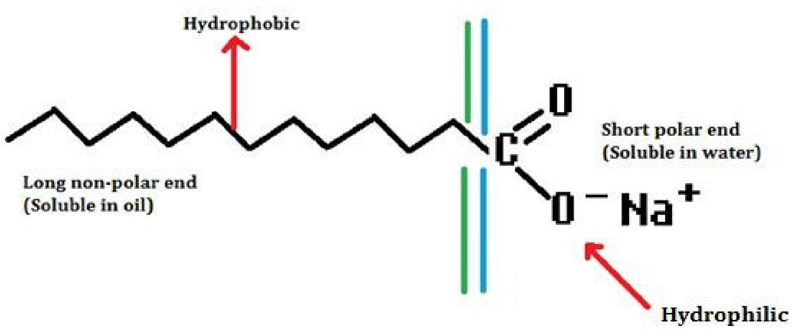
Soaps are cleansing agents capable of reacting with water and dislodging the unwanted particles from clothes or skin.

The molecules of soap are sodium or potassium salts of long chain carboxylic acids.

A soap molecule has a tadpole shaped structure.

At one end (long non-polar end) of the soap molecule is a hydrocarbon chain which is insoluble in water but soluble in oil.

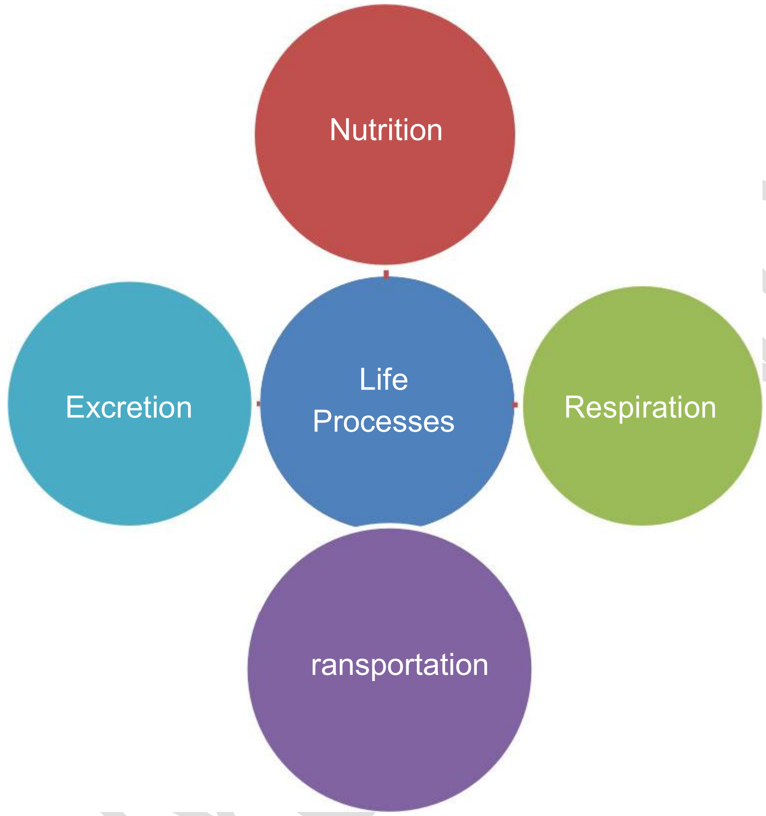
At the other end (short polar end) of the soap molecule, there is a carboxylate ion which is hydrophilic i.e. water soluble but insoluble in oil.



BIOLOGY

Life Processes

The basic functions performed by organisms to maintain their life on Earth are called **life processes**.



Nutrition

Autotrophic Nutrition

It is the mode of nutrition in which organisms synthesise their own food from simple inorganic substances such as water and carbon dioxide.

Green plants are autotrophs. They synthesise food by the process of photosynthesis.

Photosynthesis is a physiological process by which plant cells containing chlorophyll produce food in the form of carbohydrates using carbon dioxide, water and light energy. Oxygen is released as a by-product of this process.

Chlorophyll is the green pigment found in green plants.

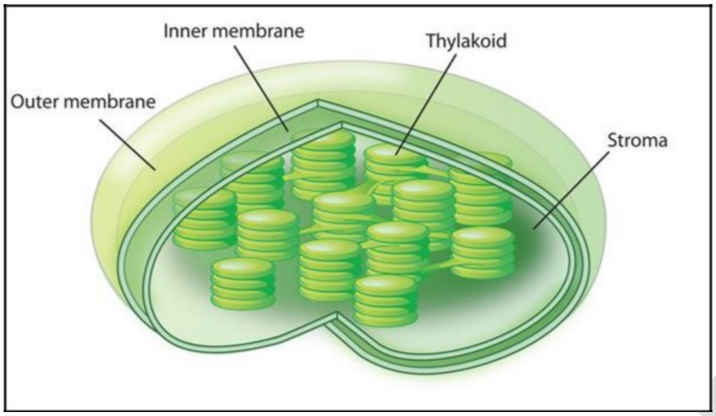
Chlorophyll is present in chloroplasts.

Chloroplast is a membrane-bound oval cell organelle.

It is enclosed by a double membrane. Its interior contains closely packed flattened sacs called **thylakoids**. Chlorophyll is present in the thylakoids.

Thylakoids are arranged in piles called **grana** lying in a colourless ground substance called **stroma**.

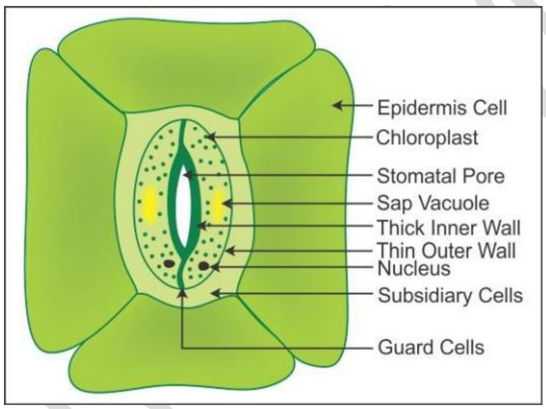
Cells present in the spongy mesophyll layer and the palisade layer contain chloroplasts; therefore, they are the site of photosynthesis.



Chloroplast

Stomata

Stomata are minute openings present in the epidermal layers of leaves.
They are responsible for gas exchange during photosynthesis.



Process of Photosynthesis

- The **palisade layer** is the centre for photosynthesis. Light energy is trapped in the chlorophyll of the mesophyll cells in the palisade layer of leaves.
- The chemical equation for photosynthesis is

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$$

Light is absorbed by chlorophyll.

Light energy absorbed is converted into chemical energy.

At the same time photolysis of water takes place i.e. a water molecule is split into hydrogen and oxygen.

Carbon dioxide is converted into glucose by using ATP and NADPH produced during the light reaction.

Chlorophyll, light, carbon dioxide and water are necessary for photosynthesis.

Heterotrophic Nutrition

It is the mode of nutrition of organisms which cannot synthesise their own food, but they are dependent on other organisms for food.
Organisms exhibiting heterotrophic nutrition are called **heterotrophs**.
Examples: yeasts, fungi, bacteria, human beings, tiger, monkey, birds, lion, cow etc.

Types of Heterotrophic Nutrition

Saprotrophic Nutrition: Organisms obtain their food from dead, decaying plants and animals.
Example: Mushrooms

Parasitic Nutrition: Organisms obtain their food from the bodies of other living organisms. Parasites usually harm the host while obtaining their food.
Example: Leech

Holozoic Nutrition: It is a mode of nutrition in which organisms feed on solid food. The food is complex organic material which when ingested is broken down into simple inorganic substances by the process of digestion.
Example: Humans

Nutrition in Amoeba

Amoeba engulfs its food by temporary finger-like projections of its body surface called pseudopodia.

↓

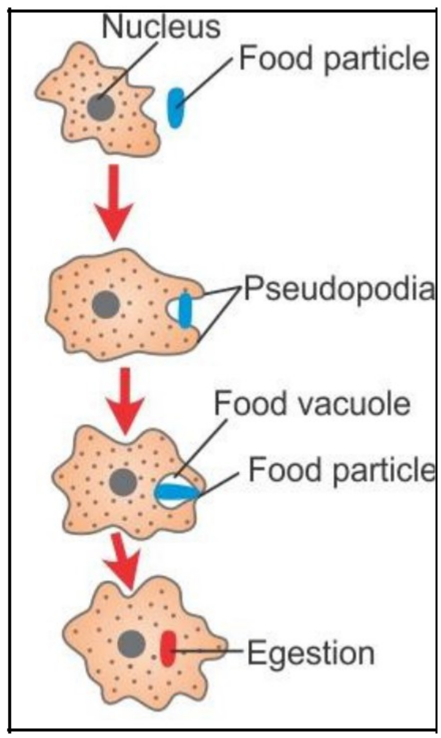
When a pseudopodium fuses with the food particle, it forms a food vacuole.

↓

Complex substances are broken down into simple substances inside the food vacuole. These simple substances are then diffused into the cytoplasm.

↓

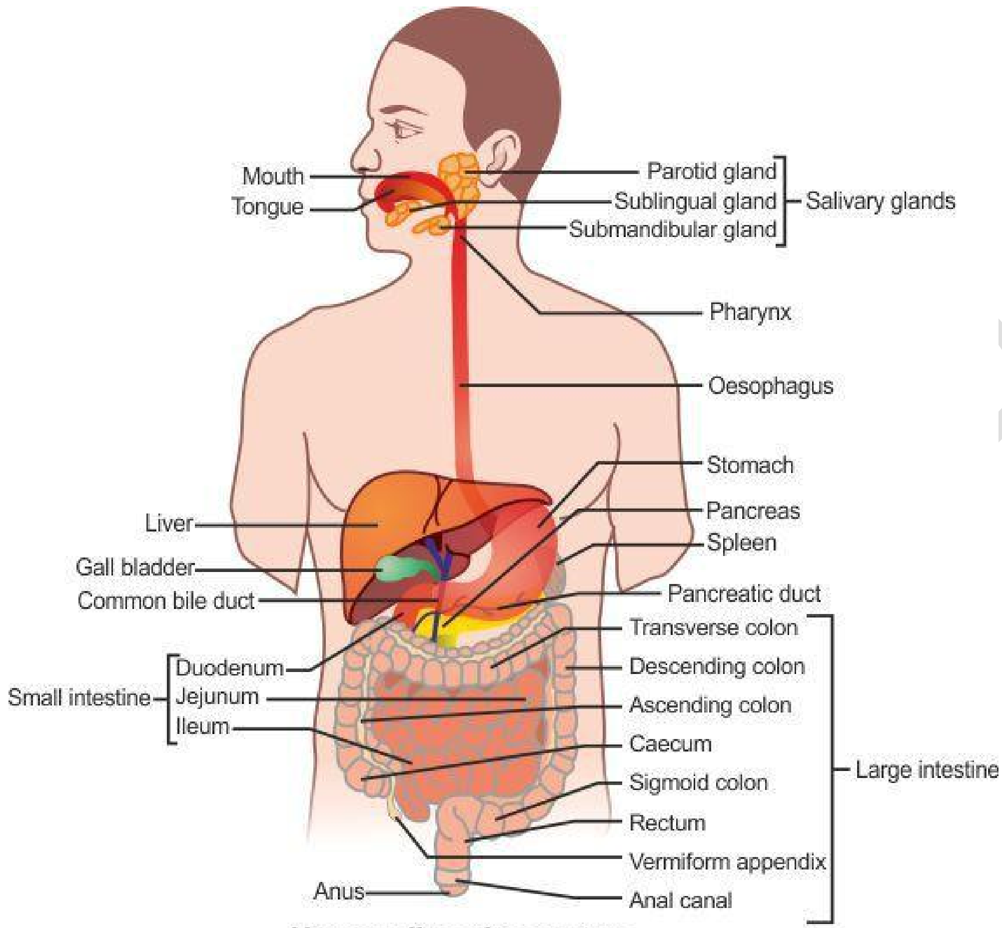
The remaining unwanted material is transported to the cell surface and is thrown out.



Nutrition in Paramecium

The food is taken in at a specific spot, i.e. the oral groove.
The food is brought close to the oral groove by the cilia present on the body surface of paramecium.

Nutrition in Human Beings



Human digestive system

The alimentary canal is the long tube extending from the mouth to the anus.

Food is chewed and mixed with saliva in the mouth with the help of tongue and teeth.

Saliva which contains salivary amylase acts on the starch present in food.

Saliva is secreted by 3 pairs of salivary glands.

The food is converted into smaller particles and made smooth by mixing it with mucus and saliva. It is now called bolus.

The bolus moves down through the oesophagus by peristaltic movements of the oesophageal wall.

Once the bolus reaches the stomach, it is acted upon by HCl, gastric juices and pepsin.

HCl creates an acidic medium for the action of pepsin.

Mucus prevents the lining of the stomach wall from the acidic environment.

Pepsin converts proteins into peptides.

The exit of food from the stomach is regulated by a sphincter muscle called the pyloric sphincter or pylorus which releases small amounts of partially digested food into the small intestine.

The small intestine is a very long tube found in the abdomen. It is about 6–7 metre in length and about 2.5–3 cm wide.

Bile and pancreatic juices are secreted into the small intestine.

Bile acts on the fat molecules and breaks them into small flat droplets. This eases the action of lipase on the fats. This process is called **emulsification**.

Pancreatic juices contain different enzymes such as trypsin, lipase, maltase, peptidases, sucrose, which act on the food to convert it into simpler units of carbohydrates, proteins and fats.
Intestinal glands also secrete intestinal juices which also contain enzymes, which act on the carbohydrates, proteins and fats.
The digested food is then absorbed by the walls of the small intestine.
Presence of brush-like borders called microvilli increase the surface area for absorption.
The unabsorbed food is sent to the large intestine where water is absorbed into the blood stream.
The left over material in the large intestine is sent to the rectum.
It is excreted out through the anus.
The opening of the anus is controlled by the anal sphincters.

Respiration

Respiration is a catabolic process of releasing energy from the simple sugar glucose for carrying out various life processes.

$$\underset{\text{GlucoseOxygen}}{C_6H_{12}O_6 + 6O_2} \rightarrow \underset{\text{Carbon dixoide}}{6CO_2} + \underset{\text{Water}}{6H_2O} + \underset{\text{Energy}}{A\ P}$$

The energy required for all cellular activities is obtained by the oxidation of glucose.
If glucose is not available, then the cells may break down proteins and fats to produce glucose.
This glucose is then oxidised further to fulfil the respiratory needs of the cell.
The first step towards obtaining energy is that the six-carbon glucose is broken down into two molecules of three-carbon pyruvate. This process takes place in the cytoplasm.

Aerobic Respiration

The breakdown of glucose in the presence of oxygen is called **aerobic respiration**.
The process of aerobic respiration releases carbon dioxide, water and energy.
The energy released in aerobic respiration is 686 kcal or 38 ATP of chemical energy and 420 kcal of heat energy.
Most of the animals, plants, human beings, several bacteria and fungi are aerobic.

Anaerobic Respiration

The breakdown of glucose in the absence of oxygen is called **anaerobic respiration**.
The process of anaerobic respiration results in the formation of ethanol (in plants) or lactic acid (in animals), along with the release of carbon dioxide and energy.
Water is not released in this process.
2 ATPs are released during anaerobic respiration.
During heavy physical exercise such as cycling, running or lifting heavy weights, the body is often deprived of oxygen. The demand for energy is high, while the supply of oxygen to the body is limited. Therefore, muscle cells perform anaerobic respiration to fulfil the increasing energy demands of the body. In this case, glucose gets converted to lactic acid.

$$\text{Glucose} \xrightarrow{\text{Lack of oxygen}} \text{Lactic acid} + \text{Energy}$$

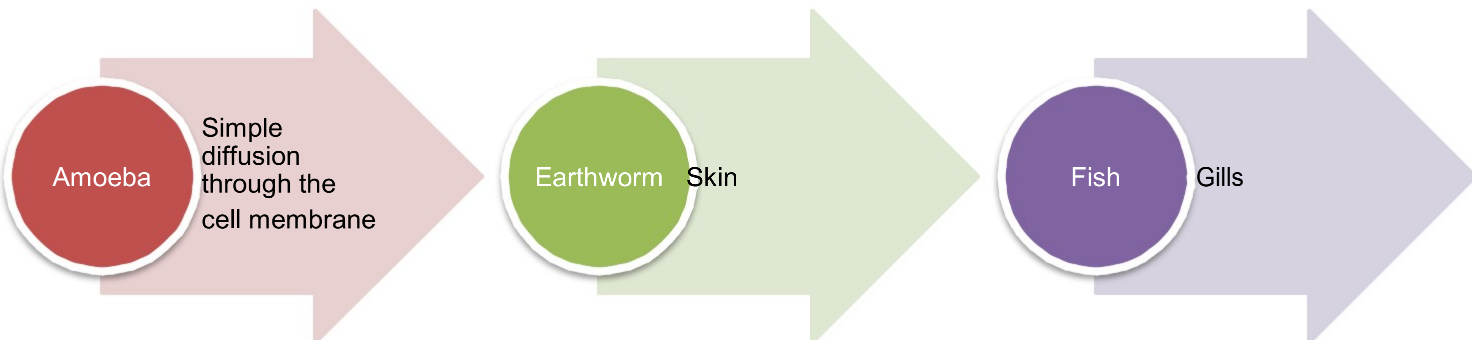
Sometimes, lactic acid formed during anaerobic respiration in muscle cells gets accumulated, causing muscular cramps. This condition is called oxygen debt. In the presence of sufficient oxygen, lactic acid gets oxidised to carbon dioxide and water.

Respiration in Plants

All parts of a plant perform respiration.
Plants exchange gases by diffusion through the stomata.
Oxygen from the air diffuses into a leaf and reaches all the cells for respiration.
Carbon dioxide produced during respiration is released into the air through the stomata.
In plants, respiration occurs during the day as well as during the night.
During the day, oxygen produced during photosynthesis is used for respiration and the extra amount of oxygen is given out through the stomata.
The roots of plants take up oxygen from the air present between the roots and soil particles.
In stems, the exchange of gases occurs through either the stomata or lenticels.

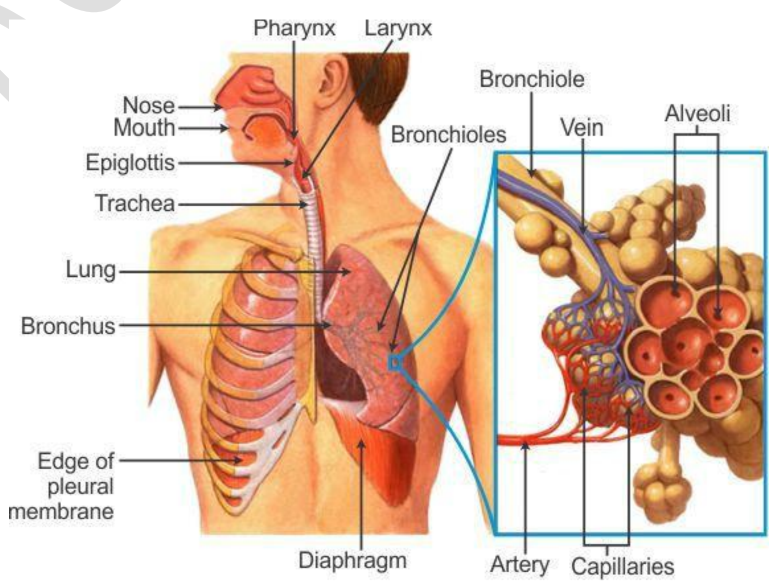
Respiration in Animals

Different animals have evolved different respiratory organs:



Human Respiratory System

The respiratory system in human beings consists of the nose, pharynx, larynx, trachea, bronchi and lungs.



Human respiratory system

Air is taken in through the nostrils.
Hairs present in the nostrils prevent the entry of dust particles inside the nose.
Nostrils further continue into the nasal cavity.
Nostrils humidify the air passing through it.
There is a bony plate called the palate, which separates the oral cavity from the nasal cavity.
Nasal cavity opens into the pharynx.
The pharynx is a muscular chamber acting as a common passage for the windpipe or trachea and the food pipe or oesophagus.
It is connected to the larynx through a slit-like opening called the glottis.
The larynx is also called the voice-box or Adam's apple.
The larynx connects the pharynx to the trachea.
The trachea shows the presence of cartilaginous rings.
The cartilaginous rings provide flexibility thus, facilitating continuous air flow.
The inner wall of the trachea is lined by a mucous membrane consisting of ciliated columnar epithelium.
The trachea divides into two branches or tubes called bronchi, one of which enters the right lung and the other enters the left lung.
The bronchi have cartilaginous rings for distention.
Each bronchus divides into fine secondary bronchi. hese bronchi further divide into finer tertiary bronchi.
In the lungs, each bronchus finally divides into finer and smaller branches called bronchioles.
The bronchioles further divide to form smaller terminal bronchioles.
The bronchioles divide repeatedly to form a cluster of tiny air chambers called air sacs or alveoli.
Alveoli have thin and moist walls which enable gaseous diffusion with blood capillaries.

- The lungs are a pair of spongy and elastic respiratory organs protected by a bony rib cage.

The base of the lungs rests on the diaphragm.
Each lung is covered by two membranes. The inner membrane is called the inner or visceral pleura and the outer membrane is called the outer or parietal pleura.
The diaphragm is a curved, musculo-fibrous sheath which separates the thoracic cavity from the abdominal cavity.
The diaphragm plays a major role during respiration.
The intercostal muscles found between the ribs and the radial muscles of the diaphragm bring about the breathing movements.
When we breathe in, the ribs are pulled upwards and the diaphragm becomes flat which results in an increase in the volume of lungs.
When we breathe out, the ribs come back to their normal position, the diaphragm is relaxed, lungs attain their normal size and air is expelled out of the body through the nostrils.

Transportation

Transportation in Human Beings

Blood

Blood is a liquid connective tissue.

Functions of Blood

Transportation

- Transports oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs.
- Transports cellular waste products from the tissues to the kidneys.
- Transports nutrients from the intestine to the tissues.
- Carries hormones from the place where they are produced to the target organ.

Defense Mechanism

- White blood cells destroy disease-causing microorganisms and thus help in preventing infections.
- Blood platelets prevent excessive blood loss by blood clotting.

Regulatory Functions

- Blood maintains the water balance in the tissues and organs of the body.
- It also regulates the body temperature by distributing the heat in different parts of the body.

Composition of Blood

Plasma

It is a light yellow-coloured or straw-coloured liquid.

It constitutes 55% of the total blood volume.

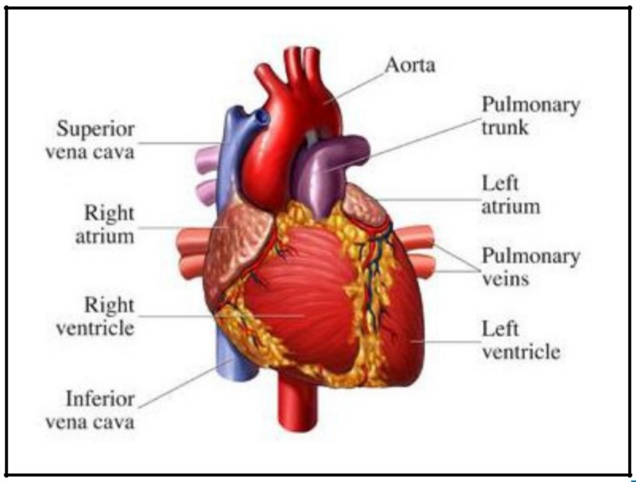
Blood Cells

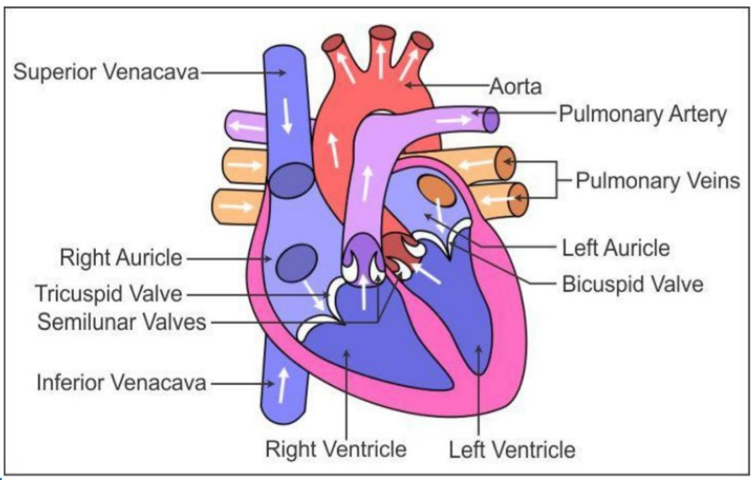
Blood cells constitute 45% of the total blood volume.

Three kinds of cells are found in the blood.

Red Blood Cells (RBCs/erythrocytes)	White Blood Cells (WBCs/leucocytes)	Blood Platelets (Thrombocytes)
• RBCs are circular, disc-shaped and biconcave. • They are produced in the bone marrow of long bones. • Mature RBCs do not have nuclei. • The lifespan of RBCs is 120 days. • RBCs are made up of a iron-containing respiratory pigment called haemoglobin. Haemoglobin transports oxygen from the lungs to tissues.	• Irregular, colourless, larger than RBCs. They have a large and lobed nucleus. • WBCs are produced in the bone marrow, lymph glands and spleen. • WBCs provide immunity.	• Blood platelets are minute, oval or round, non-nucleated cells. • Platelets are formed in the bone marrow. • Blood platelets play an important role in blood clotting.

Heart – The Pumping Organ



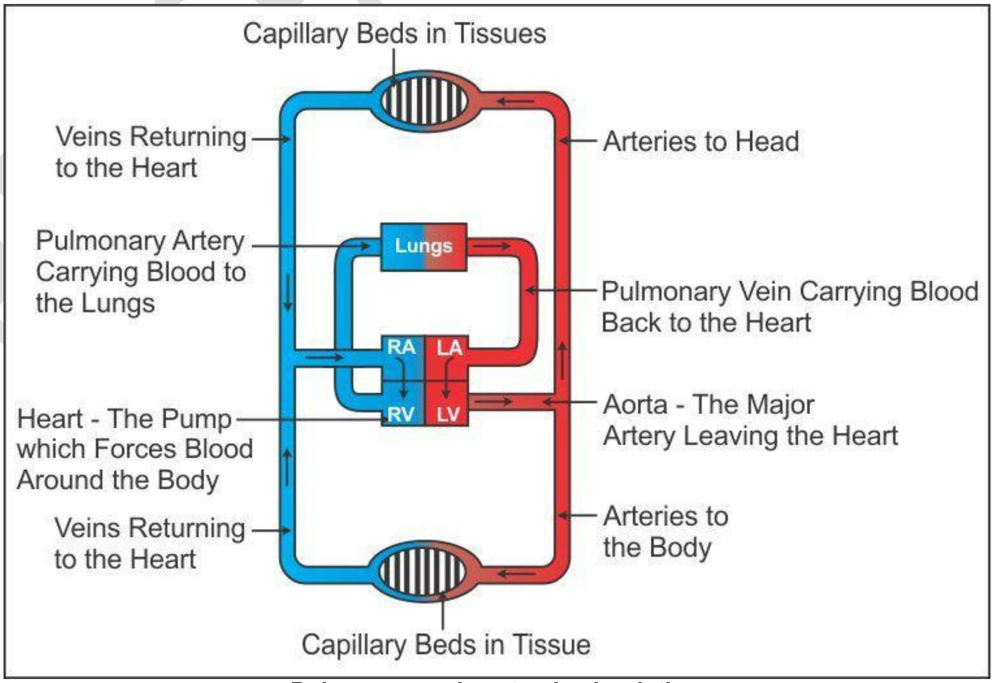


Location	• The heart is a muscular organ located in the chest cavity towards the left side.
Size	• In adult humans, it is about the size of one's fist.
Covering	• Covered by a double membrane called **pericardium**. It contains the lubricating **pericardial fluid**. • The pericardial fluid provides lubrication during the contraction and relaxation of the heart. • It also protects the heart from mechanical injuries.
Chambers of the heart	• Internally, the heart is divided into four chambers: ○ Two thin-walled upper chambers—left atrium and right atrium. ○ Two thick-walled lower chambers—left ventricle and right ventricle.

	• The superior vena cava brings deoxygenated blood from the anterior part of the body, i.e. head, chest and arms, to the right atrium.
	• The inferior vena cava brings blood from the posterior region of the body, including the abdomen and legs, to the right atrium.
	• The blood from the right atrium enters the right ventricle. • From the right ventricle, the blood is sent to the lungs through the pulmonary artery.
Blood vessels leaving the heart	• Four pulmonary veins carry oxygenated blood from the lungs to the left atrium. • From the left atrium, the blood enters the left ventricle.
	• From the left ventricle, oxygenated blood is sent to all parts of the body through the aorta.
Heart valves Heart valves prevent the backflow of blood or regulate the flow of blood in a single direction.	• The tricuspid valve which has three projections or cups is located between the right atrium and the right ventricle.
	• The bicuspid valve/mitral valve has two projections or cups and is located between the left atrium and the left ventricle.
	• The opening of the left ventricle into the aorta and the opening of the right ventricle into the pulmonary artery is guarded by semilunar valves.

Double Circulation

The heart receives deoxygenated blood from different parts of the body, and it pumps this blood to the lungs. The oxygenated blood from the lungs returns to the heart, which is pumped again into different parts of the body by the heart. Thus, the blood passes twice through the heart making one complete round through the body. This is called **double circulation**.



Pulmonary and systemic circulation

The pulmonary circulation pertains to lungs. The blood flows from the right ventricle to the lungs. Pulmonary veins collect oxygenated blood from the lungs and carry it back to the heart (left auricle).
The systemic circulation pertains to the major circulation of the body. The aorta receives the blood from the left ventricle and sends it to the various parts of the body. Veins collect the deoxygenated blood from the body parts and pour it back into the right auricle.

Blood Pressure

Blood pressure is the pressure which the blood exerts on the walls of the blood vessels.
The blood pressure in the arteries during ventricular systole is called **systolic pressure**, and the blood pressure in the arteries during the ventricular diastole is called **diastolic pressure**.
A person’s blood pressure is usually expressed in systolic pressure over diastolic pressure.
The normal blood pressure for an adult human is 120/80 mm Hg.
Blood pressure varies according to the age and health of a person.
A sphygmomanometer is an instrument used to measure blood pressure.
High blood pressure is also called hypertension, while low blood pressure is called hypotension.

Blood Vessels

The blood vessels are tubes from which blood from the heart is carried to all parts of the body and again brought back to the heart.
There are three types of blood vessels.

Artery	Vein	Capillaries
• An artery is a blood vessel which carries blood away from the heart towards any organ.	• A vein is a vessel which carries the blood away from an organ towards the heart.	• A capillary is a very narrow blood vessel which is located within the tissue.
• It has elastic and thick muscular walls.	• It has thin muscular walls.	• It has an extremely thin wall.
• Narrow cavity through which the blood flows.	• Broad cavity through which the blood flows.	-
-	• The veins have valves which prevent the backflow of blood.	• The arteries branch to form arterioles, and arterioles break up into capillaries.
• The largest artery is the aorta.	-	• The capillaries gradually reunite to form venules. Venules further combine to form veins.
-	-	• Capillaries allow the exchange of materials such as nutrients, metabolic wastes and respiratory gases between the blood and cells.

Lymph and Lymphatic System

As the blood flows through capillaries, the water, dissolved substances and a few white blood cells pass through the capillary walls into the spaces between the cells, i.e. intercellular spaces. This fluid is called **tissue fluid**.

White blood cells in the lymph protect the body against diseases.

The lymphatic system carries excessive tissue fluid back to the blood.

- Some tissue fluid enters tiny vessels called lymph capillaries.
- Lymph capillaries further join to form lymph vessels.
- Lymph vessels together with small sac-like structures called lymph nodes form the lymphatic system.
- Lymph vessels from different parts of the body join to form ducts or tubes.
- The colourless fluid which flows within the lymphatic system is called lymph.

Clotting of Blood (Coagulation)

When a blood vessel is cut, blood escapes from it. Soon a clot is formed on the wound, and the flow is stopped.

Blood clotting is a complex process:

The platelets release an enzyme at the site of injury.

↓

This enzyme converts fibrinogen present in the blood plasma into fibrin.

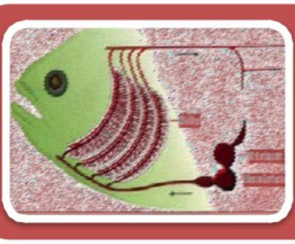
↓

Fibrin forms a fine mesh into which RBCs get trapped.

↓

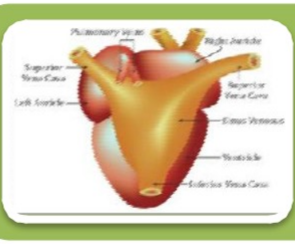
Fibrin along with the trapped RBCs contracts and forms a clot, thus stopping the bleeding.

Heart in Other Vertebrates



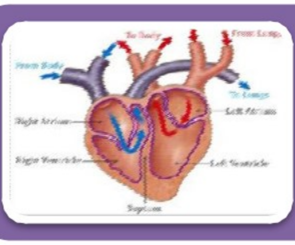
Fish

- Two-chambered heart.
- One atrium and one ventricle.
- The heart pumps deoxygenated blood to the gills for oxygenation.
- The oxygenated blood from the gills is supplied to all the body parts.



Amphibians and Reptiles

- Three chambered heart.
- Two atria and one ventricle.
- Due to incomplete division within the heart, oxygenated and deoxygenated blood mix to some extent.



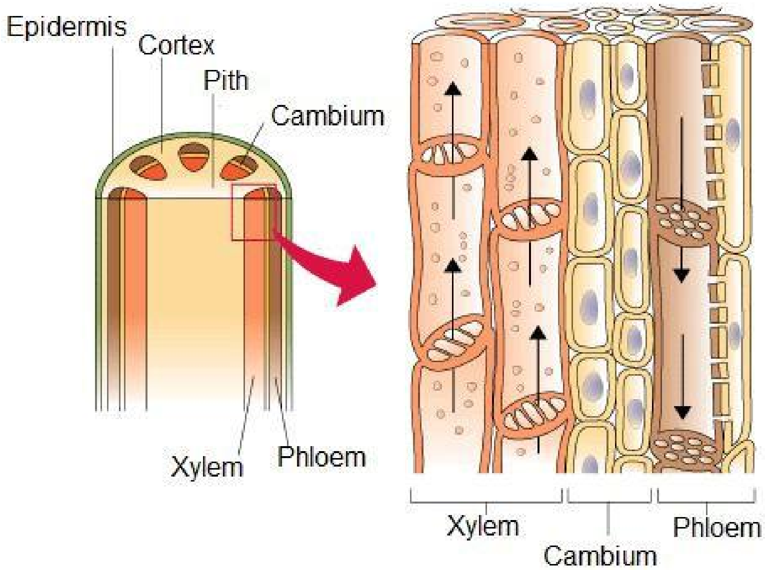
Birds

- Four-chambered heart.
- Two atria and two ventricles.
- The left side of the heart is completely separated from the right side of the heart to prevent mixing of oxygenated and deoxygenated blood.

Transportation in Plants

Transportation in plants is the process by which a substance, absorbed or synthesised in one part of the plant, is transported to the other parts of the plant.
Substances transported by the transport system are water, mineral and food prepared by plants.

Conducting Tissues in Plants
- Xylem
- Phloem



Xylem

It conducts water upwards in a plant.
Xylem also provides strength to the stem and helps the plant to stand upright.
It is located in the centre of the plant body.
Xylem mainly consists of tracheids and vessels.

Mechanism of Transport of Water and Minerals

A.

Water enters the root hair through osmosis, and mineral ions enter the root cells by active transport.
Both water and minerals move upward from cell to cell through the cortex of the root by osmosis.
From the cortex, water and minerals are brought to the xylem.
The sap which contains water and dissolved minerals move upwards from the root cells to xylem. The upward movement of sap is called the ascent of sap.
The xylem vessels of the roots are in continuation with the xylem vessels of the stem.

B.

Transpiration is the loss of water in the form of water vapour from the aerial parts of a plant.
It occurs through openings called stomata.
Water loss through evaporation lowers the concentration of water inside the mesophyll cells.
Due to this, water enters mesophyll cells from neighbouring xylem vessels through osmosis.
As water evaporates from the leaves, a suction force is created. This force helps to draw more water up through the stem which causes the roots to absorb more water from the soil.

- Higher the rate of transpiration, greater the rate of absorption of water and solutes from the soil.

Transpiration also helps in maintaining the temperature of the plant body.

Phloem

It conducts manufactured food from the leaves to different parts of the plant.
The food in the phloem can move in the upward and downward directions.
Phloem mainly consists of sieve tube cells and companion cells.
Sieve tubes are living cells of the phloem. They contain cytoplasm but no nucleus.
The end walls of the cells form sieve plates.
Sieve plates have small pores in them which allow food to pass through the phloem.
Each sieve tube cell has a companion cell next to it.

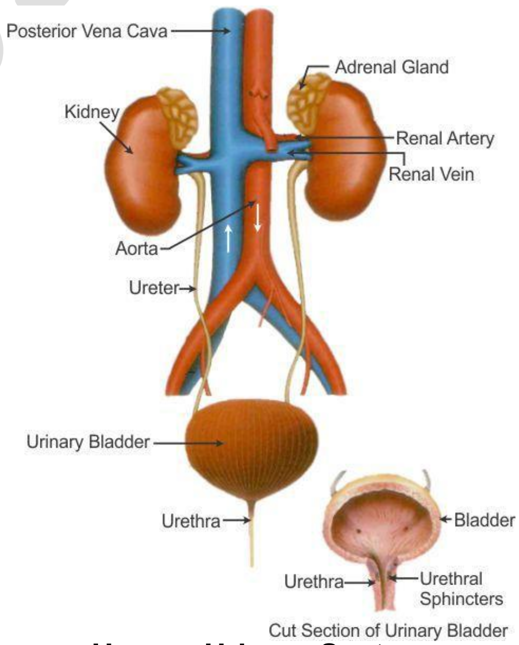
Mechanism of Transport of Water and Minerals

Food synthesised during photosynthesis is loaded into sieve tubes by utilising ATP.
The presence of food inside the phloem develops the concentration gradient for water. Thus, water enters the phloem by osmosis.
Osmosis develops high pressure inside the phloem which transports the food from the phloem to plant parts where the concentration of food is less.
This process is called **translocation**.
In spring, the sugar stored in the root or stem tissues is transported to the buds.

Xylem and phloem constitute the conducting tissues and are known as vascular tissues.

Excretion

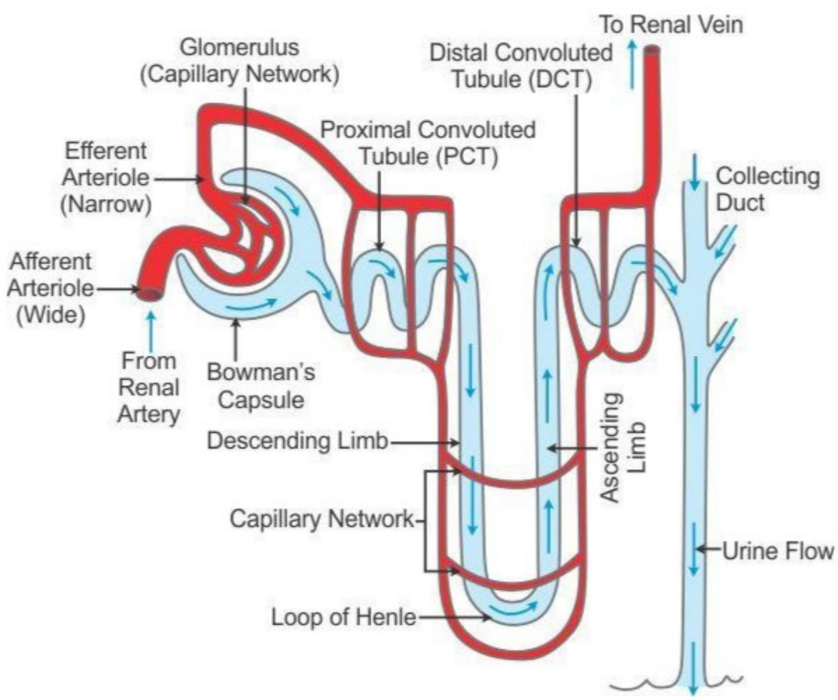
Excretion is the removal of harmful and unwanted substances, especially nitrogenous wastes, from the body.
The human urinary system consists of-
Pair of kidneys
Pair of ureters
Urinary bladder
Urethra



Human Urinary System

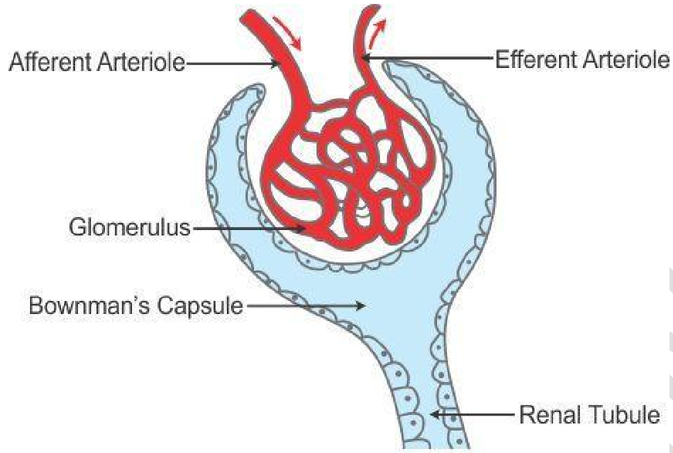
Pair of kidneys	• Dark red, bean-shaped, 10 cm long, 6 cm wide. • The right side of the kidney is slightly lower in position due to the presence of the liver.
Pair of ureters	• Ureters are tube-like structures which arise from the notch, i.e. the hilum of each kidney. The ureters connect behind with the urinary bladder. The ureters carry the urine produced to the urinary bladder.
Urinary bladder	• Muscular sac-like structure. It stores urine temporarily. Its opening is guarded by muscular sphincters. The sphincters open at the time of micturition (urination).
Urethra	• Short muscular tube which expels urine out of the body. • The urethra is long in males and is very short in females. • The opening is guarded by sphincters which open at the time of urination.

Uriniferous Tubule



Uriniferous Tubule

Each kidney is composed of an enormous number of uriniferous tubules.
They are also known as nephrons, renal tubules or kidney tubules.
Uriniferous tubules are the structural and functional units of the kidney.



Malpighian Tubule

Each nephron has a Malpighian body and body of tubules.
Malpighian body is nothing but a cup-shaped Bowman's capsule. In its cup-shaped depression, a tuft of blood capillaries called glomerulus is situated.
The body of tubules contains proximal convoluted tubule (PCT), loop of Henle and distal convoluted tubule (DCT).
DCT opens into the collecting duct.

Approximately 2 million uriniferous tubules are present in both the kidneys.
Each single uriniferous tubule is 4 to 5 cm long.
The great length of the uriniferous tubule provides a large surface area for the reabsorption of usable substances such as water.
Blood flow through the kidneys per minute = 1 litre
Glomerular filtrate produced in 24 hours = 160 litre
Urine produced from the glomerular filtrate after reabsorption per day = 1.2 litre

Formation of Urine

The process of urine formation occurs in two major steps.

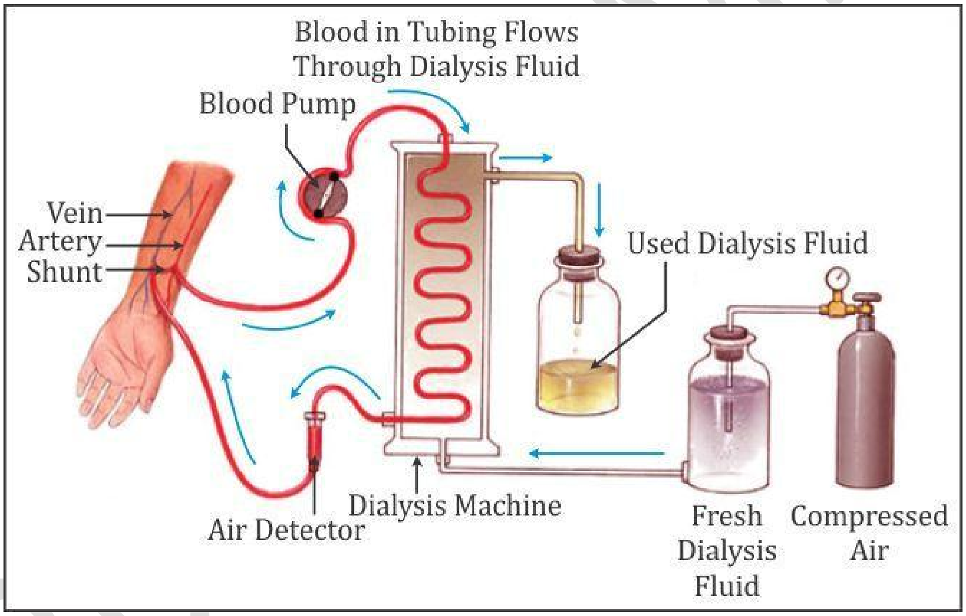
Ultrafiltration	Reabsorption
• The efferent arteriole is narrower than the afferent arteriole which develops a hydrostatic pressure on the blood. • Thus, the blood flows through the glomerulus with a great pressure. • Due to the pressure, the liquid part of the blood filters out from the glomerulus and passes into the Bowman's capsule. • The glomerular filtrate consists of water, urea, salts, glucose and other plasma solutes.	• The glomerular filtrate entering the renal tubule contains many useful substances. • Hence, as the filtrate passes down the tubule, water and other substances required by the body are reabsorbed. • Potassium ions and certain substances such as penicillin are passed into the forming urine through the distal convoluted tubule (DCT). • The cells of the walls of DCT are

• Blood corpuscles, proteins and other large molecules remain behind in the glomerulus. • Therefore, the blood carried away by the efferent arteriole is relatively thick.	involved in bringing potassium ions and other substances back into the renal tubule; hence, this process is known as tubular secretion.

Urine Excretion

The filtrate left after reabsorption and tubular secretion is called urine.
The urine passes from the collecting duct into the pelvis of the kidney. From there it is sent to the urinary bladder through the ureters.
By relaxing the sphincters present at the opening of the urethra, the urine is expelled from the body. This process is known as micturition or urination.

Artificial Kidney



- If one kidney is damaged or removed, then the other kidney alone can fulfil excretory needs.
  However, the failure of both the kidneys allows urea and other wastes to accumulate in the blood.
  Such a patient undergoes dialysis.
  In dialysis, an artificial kidney is used.
  The artificial kidney contains tubes with a semi-permeable lining.
  These tubes are suspended in a tank filled with a dialysing solution.
  This fluid contains water and glucose in concentrations similar to those in blood.
  The patient's blood is led from the radial artery through the tubes of the artificial kidney where excess salts and urea are removed.
  The purified blood is returned through a vein in the same arm.
  The function of dialysis is similar to the function of the kidney, but the only difference is there is no reabsorption during dialysis.

Excretion in Plants

Plants also produce several waste products during their life processes.
The major waste products are water, carbon dioxide and oxygen produced during respiration and photosynthesis.
These wastes are excreted through the stomata and lenticels.
Plants store some waste products in leaves which fall off.
Wastes such as gums and resins are stored in the old xylem.

Control and Coordination

For survival, an organism's body must respond correctly to various stimuli it receives.

Some important terms:

Stimulus: An agent or sudden change in the external or internal environment which causes a change in an organism or any of its body parts.

Response: The change in organisms resulting from a stimulus.

Receptors: Nerve cells which initiate waves of impulses towards the central nervous system on receiving a stimulus.

Effectors: Muscles or glands which contract or secrete substances on receiving an impulse from the brain or spinal cord.

Functions of the Nervous System

Keeps us informed about the outside world through sensory organs.

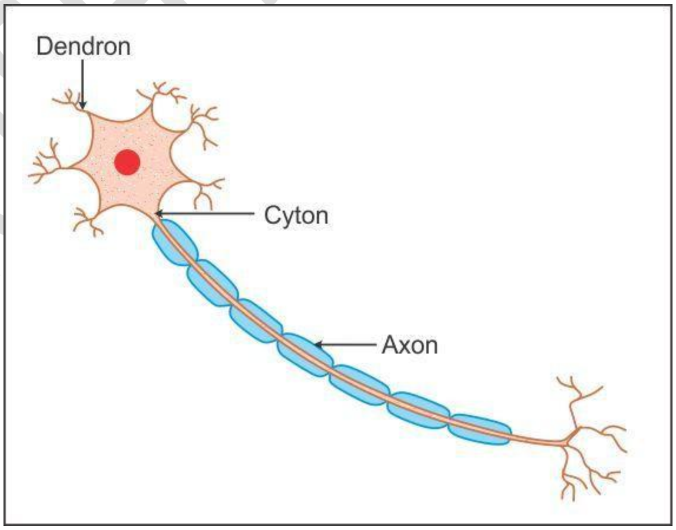
Controls and harmonises all voluntary muscular activities. Example- running and writing.

Enables us to remember, think and reason.

Regulates involuntary activities such as breathing and beating of the heart.

Neuron

A **neuron** is the structural and functional unit of the nervous system.



The three main parts of a neuron are:

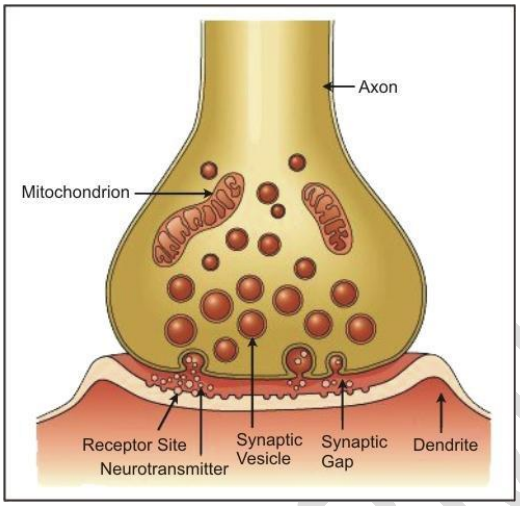
Cell Body- It has a well defined nucleus and granular cytoplasm.

Dendrites- Dendrites are branched cytoplasmic projections of the cell body.

Axon- It is a long process of the cell body. The end portions of the axons have swollen bulb-like structures which store neurotransmitters.

Synapse

The **synapse** is the point of contact between the terminal branches of the axons.



Axon terminals of a neuron and the dendrites of another neuron are separated by a fine gap, i.e. a **synaptic cleft**.
The nerve impulse is sent across the synaptic cleft with the help of the neurotransmitter acetylcholine.

Reflex Action

Involuntary actions in response to external or internal stimuli are termed as **reflex actions**.
The peripheral nervous system and spinal cord are involved in controlling reflex actions.
The path travelled by the impulse during a reflex action is called a reflex arc.
A reflex arc can be represented as follows:
Stimulus → Receptor in the sense organ → Afferent (sensory) nerve fibre → CNS (spinal cord) → Efferent (motor) nerve fibre → Muscle/Gland → Response

Examples of Reflex Arc

When you touch a hot object, you withdraw your hand from it immediately.
Shivering when it is too cold or sweating when it is too hot.
Dilation of the pupils of the eye to look in the dark and *vice versa*.
When you smell your favourite dish, your mouth waters.

Divisions of the Nervous System

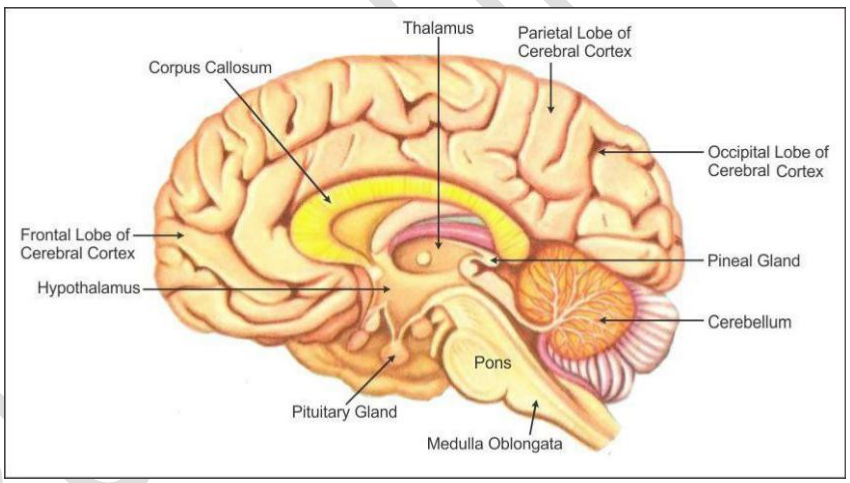
- Nervous System
  - Central Nervous System (CNS)
  - Peripheral Nervous System (PNS)

The Central Nervous System

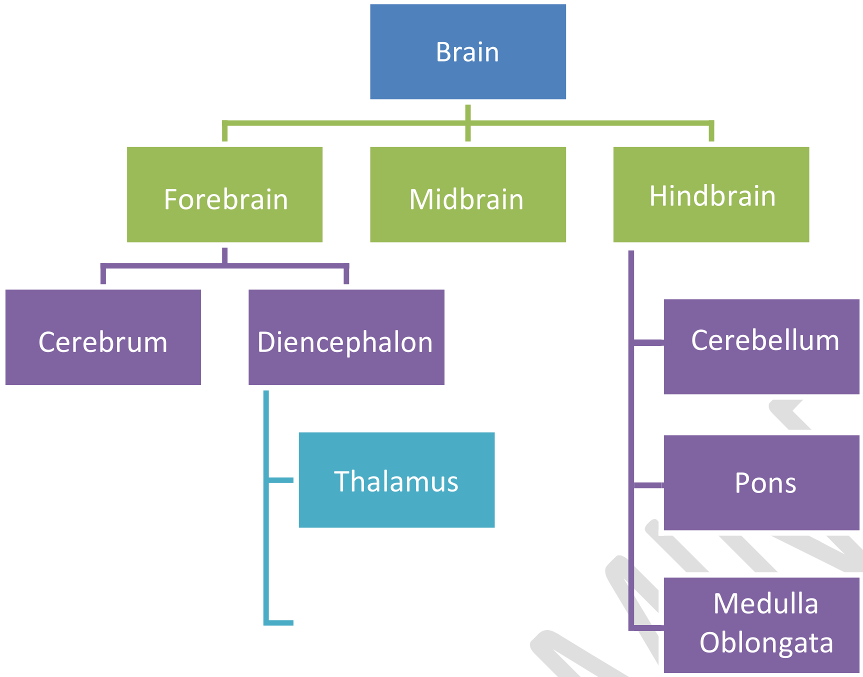
The central nervous system includes the brain and the spinal cord.

A. The Brain

The human brain is the largest among all animals.



It is well protected by the cranium or the skull.
Three membranous coverings called meninges cover the brain.
Inflammation of the meninges is called meningitis.
The space between the covering membranes, central spaces of the brain and the central canal of the spinal cord is filled with **cerebrospinal fluid**.
Three primary regions of the brain are forebrain, midbrain, and hindbrain.



Parts of the Brain

1. Cerebrum	• It is divided into two cerebral hemispheres connected to each other by the **corpus callosum**. • The walls have an outer cortex and inner medulla. • The cortex contains cell bodies of the neuron and is greyish in colour; hence, it is called **grey matter**. • The medulla consists of axons of the nerve fibres and is called **white matter.**
2. Cerebellum	• It is located at the base of the cerebrum. • It has numerous furrows.
3. Medulla Oblongata	• It is located at the base of the skull. • It is roughly triangular. • It continues behind the brain as the spinal cord. • Injury to the medulla oblongata results in death.

B. The Spinal Cord

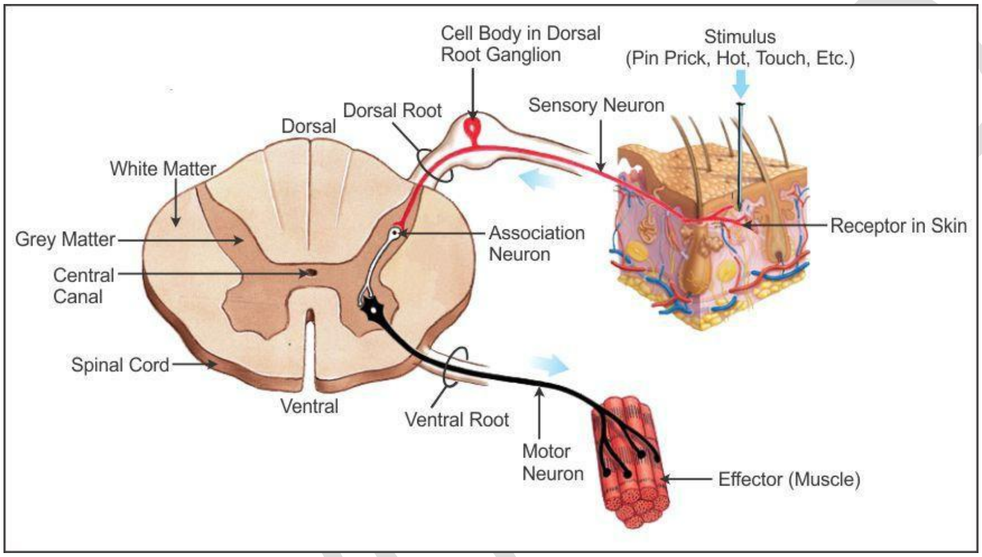
Extends from the medulla oblongata down to almost the whole length of the backbone and ends at the second lumbar vertebra.

The grey matter is on the inner side and white matter is on the outer side of the spinal cord.

The spinal cord is responsible for reflexes below the neck.

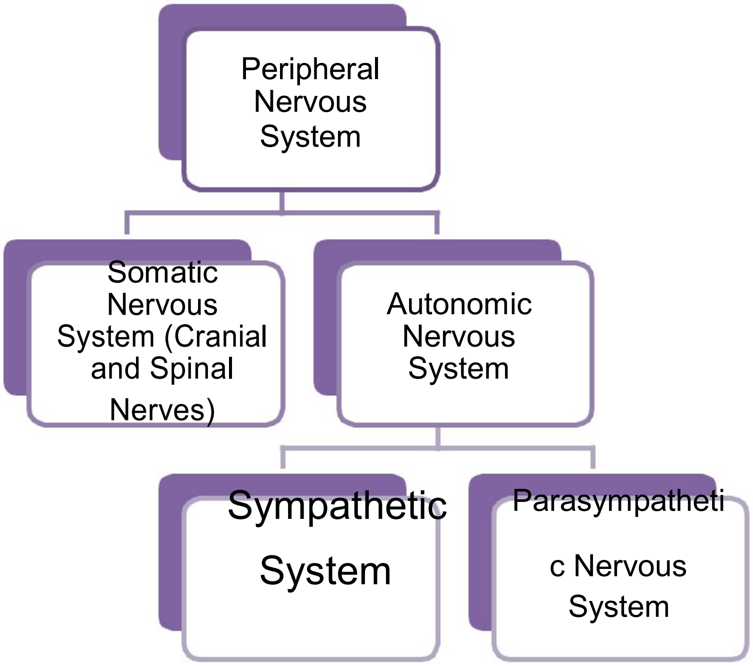
It conducts sensory impulses from the skin and muscles to the brain.

It conducts motor responses from the brain to muscles of the trunk and limbs.



Peripheral Nervous System

The Peripheral Nervous System consists of nerves which carry impulses to and from the central nervous system.



The Somatic Nervous System is made up of 12 pairs of cranial nerves and 31 pairs of spinal nerves. Cranial nerves emerge from the brain and spinal nerves originate from the dorsal and ventral roots of the spinal cord.

Coordination in Plants

Nastic Movements

The movement of a plant in response to an external stimulus, in which the direction of response is not determined by the direction of stimulus, is called **nastic movement**.

Nastic movements are shown by flat parts of the plants such as leaves and petals.

Example-

Daisy flowers close at dusk and open at daybreak; this may be referred to as sleep movements. This response however should not be confused with thigmotropism as the folding of leaves always occurs in the same direction irrespective of the direction of the stimulus.

Two types of nastic movements are:

Photonasty is a nastic movement to the light and dark phases of the day. Example- Flowers of primrose blossom during the evening but close during the day.

Nyctinasty is the movement in response to dark. Certain parts of a plant such as the leaves and flowers take up a different posture at night than that in the day.

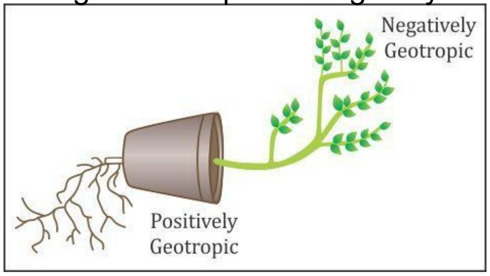
Example- Leaves of the rain tree fold by nightfall.

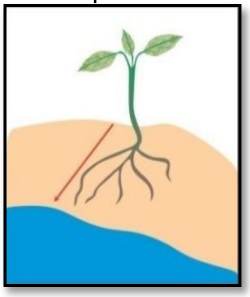
Movement Due to Growth

The movement of plant organs towards or away from a stimulus is known as **tropism**.

Since the tropic movements are slow, the stimulus needs to be continued for a longer time for the effects to be noticed.

The different types of tropic movements in plants are:

1. Phototropism	• The movement of plant parts towards or away from light is termed as phototropism.  • Because shoots of most plants grow towards the source of light, it is termed as positive phototropism. • Roots grow away from light and hence are negatively phototropic.
2. Geotropism	• The movement of plant organs in response to gravity is termed as geotropism.  Roots are positively geotropic because they grow in the direction of gravity. The shoot grows upwards, i.e. against gravity, and hence is negatively geotropic.

3. Thigmotropism	• The movement of plant organs in response to stimuli caused by physical contact with solid objects is termed thigmotropism. • Weak-stemmed plants use twining stems and tendrils to climb on other plants/objects which provide them support. Hence, twining stems and tendrils are positively thigmotropic.
4. Hydrotropism	• The movement of plant organs in response to water is termed hydrotropism.  • Roots grow towards the source of moisture and hence are positively hydrotropic.
5. Chemotropism	• The movement of plant organs in response to a chemical stimulus is called chemotropism.  When plant organs grow away from the chemical response it is called negative chemotropism. When plant parts grow towards the chemical response it is called positive chemotropism. For example, pollen tubes grow towards the sugary substance secreted by the stigma of the flower.

Plant Hormones (Phytohormones)

Plant hormones control some aspects of the growth of plants such as cell division, cell enlargement and cell differentiation.

Phytohormones	Description
1. Auxins	• Promote growth of plants. • They are secreted by the cells present in the tip of stems and roots. • Synthetic auxins are used in horticulture.
2. Gibberellins	• Promote cell differentiation in the presence of auxins. • They break seed dormancy. • Stimulate elongation of shoots.
3. Cytokinins	• Promote cell division in plants. • Delay ageing of leaves. • Promote opening of stomata. • Promote fruit growth.
4. Abscisic Acid	• Acts as a growth inhibitor. • It promotes dormancy in seeds and buds. • Promotes closing of stomata. • Promotes wilting and falling of leaves. • Detachment of flowers and fruits from the plants is due to abscisic acid.

Hormones in Animals

Hormones	Functions	Disorders
1. Adrenaline Produced by the adrenal glands.	• Adrenaline prepares the body for the fight and flight mechanism.	
2. Thyroxine Secreted by the thyroid gland.	• Regulates carbohydrate, protein and fat metabolism. • It increases the basal metabolic rate (BMR). • It regulates body growth such as ossification of bones and mental development.	• Simple goitre • Ophthalmic Goitre • Cretinism
3. Growth Hormone Secreted by the anterior lobe of the pituitary gland.	• It is essential for normal growth.	• Dwarfism • Gigantism

4. Insulin Secreted by pancreas	• Regulates the blood glucose (sugar) level.	• Diabetes Mellitus High concentration of sugar in blood (hyperglycemia).
5. Testosterone Secreted by the testes in males.	• Controls the development of sex organs in males. • Controls the development of secondary sexual characters during puberty.	
6. Oestrogen Secreted by the ovaries in females.	• Controls the development of female sex organs. • Controls the development of secondary sexual characters during puberty in females.	

Feedback Mechanism

The body has mechanisms to maintain its normal state.

Whenever there is a change in the normal state, messages are sent to increase secretions if there is a fall below the normal levels or to decrease secretions if there is a rise above the normal levels to restore the normal body state. Such a mechanism is called **Negative Feedback Mechanism**.

Example- Blood sugar level

The increase in blood sugar level stimulates the secretion of insulin so that the sugar level is maintained. If there is a fall in the blood sugar level below normal, it stimulates the secretion of glucagon. Glucagon stimulates the breakdown of glycogen to glucose, and thus the normal sugar level is maintained.

How Do Organisms Reproduce?

Reproduction

Reproduction is the ability of living organisms to produce living beings similar to themselves.
The two modes of reproduction, i.e. asexual reproduction and sexual reproduction can be seen in animals.

Importance of Variation

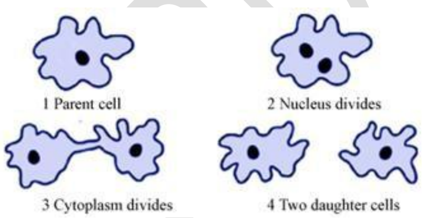
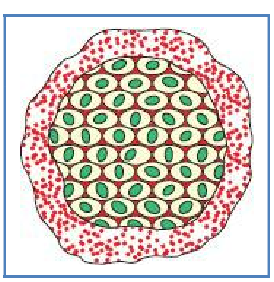
Sexual reproduction provides great scope forvariation.
Variation is important for the survival of aspecies.
Variation helps a species to adapt to different environmentalchanges.

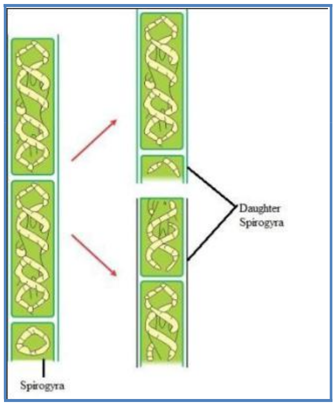
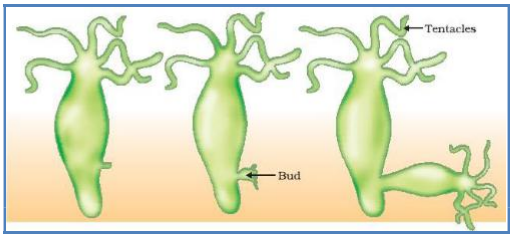
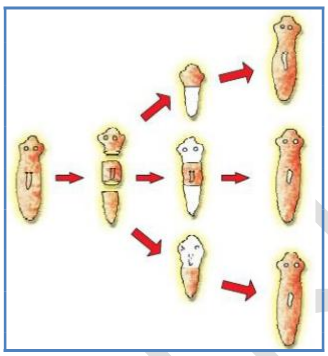
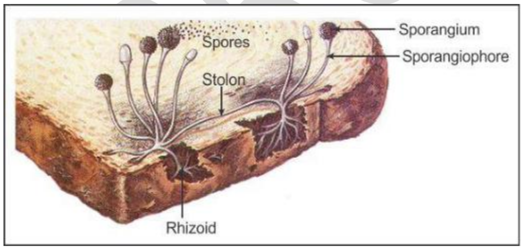
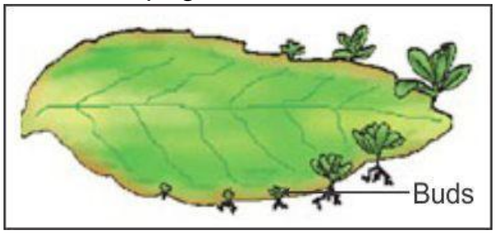
Reproduction and its kinds

Sexual Reproduction	Asexual Reproduction
• It involves the formation ofspecial reproductive cells calledgametes.	• It does not involve the formationof gametes.
• Male and female gametes fuse toform the zygote which develops into a new individual.	• New organisms are formed either bythe division of the parent body or by the differentiation of the parent body.

Modes of Asexual Reproduction

Plants and animals from lower classes reproduce by asexual methods.

Method	Description	Example
Binary Fission 	• Most common method inunicellular organisms. • It is division of the parent cell intotwo identical daughterorganisms.	Amoeba, Paramecium, bacterium
Multiple Fission 	• Parent cell divides to produce many identical newindividuals.	*Plasmodium vivax*, *Leishmania*

Fragmentation  	• Adult organisms, on maturation, break up into smaller fragments. Each fragment develops into a new individual.	Spirogyra
Budding  	• A small outgrowth called a bud arises on the parentbody. • The bud grows by repeatedcell divisions. • It then breaks off from the parent body and develops into a newindividual.	Hydra, sponges, corals, yeast
Regeneration 	• Regeneration is the ability oforganisms to generate lost or damaged body parts. • Regeneration is carried outby specialisedcells. • These form a mass of cellswhich undergo changes to form cells specialised in differentfunctions. • If planaria is cut into small pieces,then each piece develops into a new planaria.	Lizard, starfish, planaria,hydra
Spore Formation  	• Spores are special structures produced in sacs calledsporangia. • When spores mature, sporangia burst and spores are carried by air or water to differentplaces. • When spores fall on a suitable ground, they germinate and give rise tonew plants.	Moss, Fern, Fungi
Vegetative Propagation  **Vegetative propagation in *Bryophyllum***	• Several plants are capable ofproducing naturally through their roots, stems and leaves. Such type of reproduction is called vegetativepropagation.	Sweet potato (by roots) *Bryophyllum*(by leaves) Ginger (by stem)

Different methods used to develop plants which can bears fruits and flowers by vegetative propagation are asfollows:

Stem cutting: This involves cutting a part of the stem and planting it in the soil to allow the growth of roots and buds intoshoots.
Examples: sugarcane, pear, china rose

Grafting: In grafting, the stem or bud of two best quality plants is combined to form a new plant.
Examples: guava, apple,mango

Layering: Inthis,thelowerbranchofaplantisbentandcoveredwithsoil.Oncenewrootsstart developing on the branch, it is cut from the parent plant and allowed to grow as an individual plant.
Examples: rose, jasmine

Tissue Culture

Cells from the growing tip of a plant are separated and are grown on a nutrient medium containing all nutrients and hormones necessary for plantgrowth.
These cells form a mass calledcallus.
The callus developsplantlets.
These plantlets are transferred to the soil and grow as newindividuals.

Advantages of Vegetative Reproduction

- New plants show the exact characteristics as those of the parent plant.
- This method is faster and certain.
- Plants not capable of producing sexually can be produced by this method.
- Examples: Seedless bananas and grapes

Disadvantages of Vegetative Reproduction

- There is no possibility of variation.
- The new plant grows in the same area as the parent plant which leads to competition for resources.

Sexual Reproduction

In sexual reproduction, two gametes or germ cells, i.e. the male gamete called sperm and the female gamete called ovum, areinvolved.
Both the sperm and ovum fuse together to form a zygote which develops into a newindividual.

Sexual Reproduction in Flowering Plants
A **flower** is the reproductive organ in angiosperms.

Stalk/Pedicel

Point ofattachment.

Thalamus

It is an enlarged, flattened tip of thestalk.
Petals and other parts arise from thethalamus.

Calyx

Outermost whorl of the flower consisting of sepals.
The calyx protects the inner parts of the flower in their budstage.

Corolla

Second whorl of the flower which is made up ofpetals.
Helps flowers in attracting insects to carry outpollination.

Androcium

Third whorl and the male organ of theflower.
Consists ofstamens.
Each stamen is made of the filament andanther.
Anthers storepollegrains.

Gynoecium

Innermost whorl and the female reproductiveorgan.
Consists of pistils orcarpels.
Carpel is made of stigma, style andovary.

Pollination

Pollination is the transfer of pollens from the anther to the stigma of the same plant or a different plant of the samespecies.

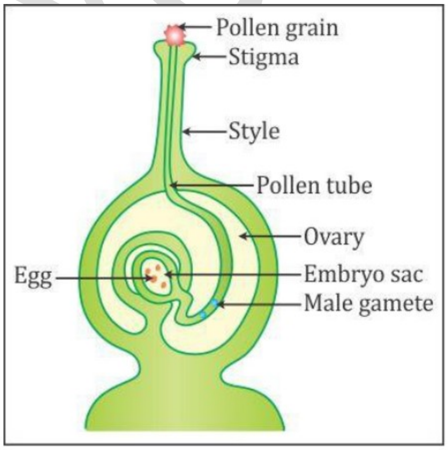
Types of Pollination

Self-pollination	Cross-pollination
The transfer of pollen grains from the anther to the stigma of the same flower.	The transfer of pollen grains from the anther of one flower to the stigma of another flower of the same species.

Different agents help to bring about cross pollination. They are insects, wind, water,etc.

Fertilisation

The process of fusion of the male gamete with the female gamete to form a zygote is called **fertilisation**.



Whenpollen grains setttle on the stigma, they form a tube called the pollen tube.

↓

The pollen tube grows through the style of the flower and enters the ovary.

↓

The tip of the pollen tube dissolves to release the pollen grain into the ovary.

↓

In the ovary, a female gamete fuses with the pollen grain to form a zygote.

Fruit and Seed Formation

After fertilization, the ovary enlarges and forms afruit.
Scientifically, the fruit is the ripenedovary.
Ovules become the seeds of thefruit.
All parts other than the ovary dry up and falloff.
Tomato, lady’s finger and brinjal are allfruits.

Reproduction in Human Beings

Growth and Development

Growth and development are gradual and irreversibleprocesses.
Size and complexity of the body increasegradually.
Growth in humans is divided into the followingstages:

Infant	Children between 1 month and 1 year of age are calledinfants.
Toddler	Children between 1 to 4 years ofage. Growth isfast. Children learn to balance thebody.
Adolescent	Children between the ages of 11 to 19years. The period of transition from childhood to adulthood iscalled adolescence.
Adulthood	It is from the age of 18 yearsonwards. An individual attains full growth and emotionalstability. Career and shouldering responsibilities arepriorities.

Puberty

Puberty is the period during which the reproductive system matures in boys and girls.
In girls, puberty begins at the age of 11years.
In boys, it begins at the age of 12–14years.
Puberty continues till the age of 18years.

Changes Which Occur At the Time of Puberty

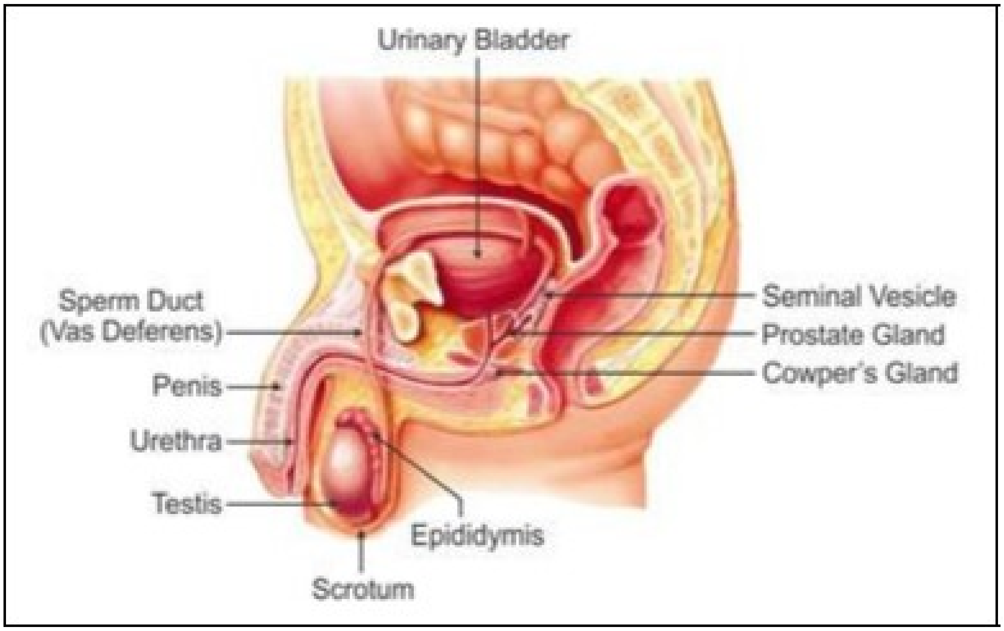
Changes in Boys	Changes in Girls
1. Testes mature and start producing sperms.	1. Ovaries mature and start producing ovum. The menstrual cycle begins.
2. Pectoral girdle (shoulder girdle) grows.	2. Pelvic girdle (hip girdle) becomes broad.
3. Hair growth in the pubic region.	3. Hair growth in the pubic region.
4. The skin in the pubic region becomes darker.	4. The skin in the pubic region becomes darker.
5. Development of moustache and beard.	5. Enlargement of breasts.
6. Development of a deep voice.	6. The voice becomes shrill.

Problems Related to Adolescence

Adolescence is a period of physical, mental and emotional changes.

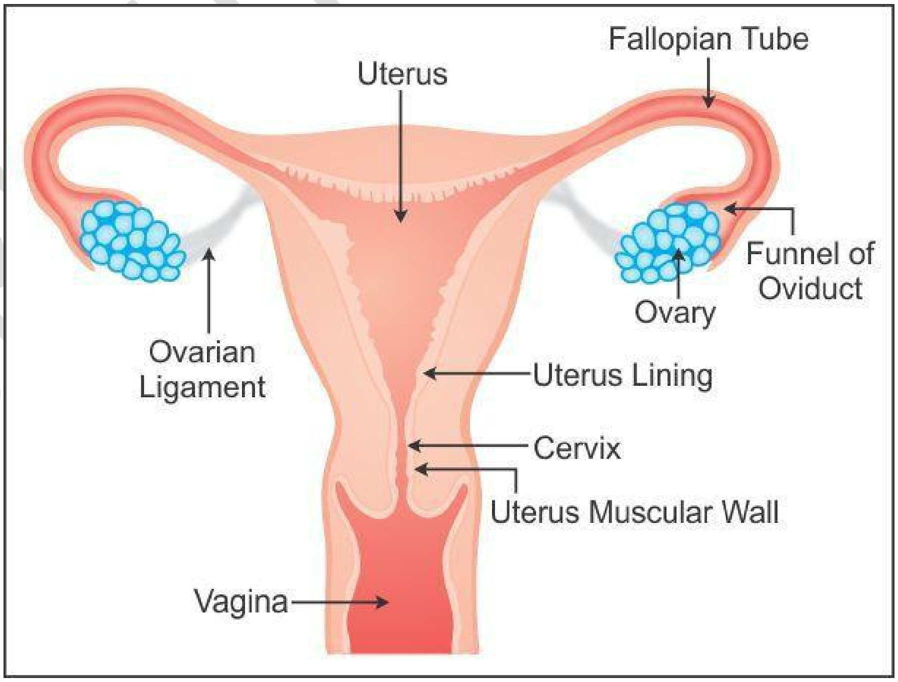
The spurt of growth in certain body parts creates confusion in teenagers. They start worrying about it.
They start feeling lonely and do not feel comfortable to share their problems with others.
Teenagers become highly sensitive about someone's opinion.
They tend to become angry or upset very easily.
They prefer the company of persons their age.
Due to hormonal changes, they experience depression.
They feel the urge to become independent but are unsure about themselves.
They have many questions about sex.
This makes it important to counsel them in the right manner.

Male Reproductive System



1. Testes (Testicles)	• A pair of testes is located below the abdomen in the scrotalsac orscrotum. • The testes produce male gametes or sperms (germcells). • To maintain the temperature 2–3°C below the body temperature, the scrotum is located outside the bodycavity.
2. Epididymis	• Tubes present in the testes join to form theepididymis. • The epididymis stores spermstemporarily.
3. Vas deferens (sperm duct)	• Each epididymis continues further as the sperm duct or vas deferens. • Each vas deferens unites with a tube coming from the urinary bladder on eitherside. • Thus, the urethra is the common passage for sperms andurine.
4. Seminal vesicles	• The seminal vesicles produce a secretion which isresponsible for the transport of sperms.
5. Prostate gland	• It is a bilobed structure which surrounds theurethra. • It pours an alkaline secretion into thesemen.
6. Cowper's gland	• These are two small ovoidglands. • They open into theurethra. • Their secretion serves as alubricant.
7. Penis	• The urethra passes through thepenis. • It carries either urine or semen at atime.

Female Reproductive System



1. OVARIES	• Two ovaries are present in the pelvic cavity, one on each side of the uterus. • Ovaries produce ova which are femalegametes. • One ovum is released by one ovary everymonth.
2. OVIDUCTS (Fallopian tube)	• Two oviducts or fallopian tubes are present, each close to one ovary of its side. • When the egg is released by the ovary, it passes down to theuterus through the oviduct.
3. UTERUS (Womb)	• The uterus is a hollow pear-shaped, muscularorgan. • The inner lining of the uterus called endothelium protects and nourishes the developingembryo.
4. VAGINA (Birth canal)	• The uterus opens into thevagina. • The vagina is a muscular, narrowtube.
5. VULVA	• The vagina and urethra both open into thevulva.

Fertilisation

The process of fusion of the male gamete with the female gamete is called **fertilisation.**

If Fertilisation Takes Place

Fertilisation occurs in the oviduct.

At the time of intercourse, semen is deposited into the female's vagina.

↓

Sperms swim through the uterus and reach the oviduct.

↓

A single sperm fuses with the ovum and forms the zygote. This completes the process of fertilisation.

Implantation

As soon as the zygote is formed, it startsdeveloping.
By the time it reaches the uterus, it is a mass of cells known as anembryo.
It remains attached to the wall of the uterus throughout itsdevelopment.
The period of development of the embryo inside the uterus is called the **gestationperiod**.
In humans, the gestation period is of 9 months, i.e. about 280days.
The embryo after completing three months of development is called thefoetus.
The placenta is a special tissue which provides food and oxygen to thefoetus.

If There Is No Fertilisation

If the ovum is not fertilised, then it lives for one day. The lining of the uterus breaks down and disintegrates.

↓

The ovum, lining of the uterus and some blood are discharged out of thebody. This is called menstruation.

↓

The menstrual discharge lasts for four days.

↓

After menstruation, the ovum is released, and the uterus again prepares itself for the receival of the fertilised egg cell.

↓

If there is no fertilisation, then menstruation is repeated.

Reproductive Health

Sexually Transmitted Diseases

1. Gonorrhoea **2. Syphilis**	• Caused bybacteria. • Bacteria spread through sexualcontact. • Burning sensation duringurination. • Urethral discharge containingpus. • Sores ingenitals. • Both diseases arecurable.
3. AIDS (Acquired Immuno Deficiency Syndrome)	• AIDS is caused by the infection of HIV (Human ImmunodeficiencyVirus). • This virus attacks the immune systemitself. • HIV penetrates theT-lymphocytes. • Reduction in the number of T-cells reduces the immunity ofa person. • HIV is transmittedby Sexualintercourse Sharing contaminatedneedles Blood transfusion of contaminatedblood From the infected mother to the unbornfoetus To create awareness about the severity of AIDS and protection from HIV, the **1st of December** is **World AIDSDay**.

Different methods are available in order to prevent pregnancy:

HormonalMethod:

Various hormonal preparations come in the form of tablets or pills, commonly called contraceptive pills.

BarrierMethods:

Condoms, diaphragms and spermicidals are used.

Condoms are used by males while diaphragms and spermicidals are used by females.

Intra-uterine Devices(IUDs):

IUDs such as Lippe's loop and copper – T are fitted in the uterus. They prevent fertilisation.

SurgicalMethods:

In females, the fallopian tubes are ligated. This is called tubectomy.

In males, the vas deferntia are ligated. This is called vasectomy.

Induced Abortion:

It is also known as Medical Termination of Pregnancy (MTP).

If a woman becomes pregnant and the couple is not willing to have a baby, then the option of induced abortion is chosen.

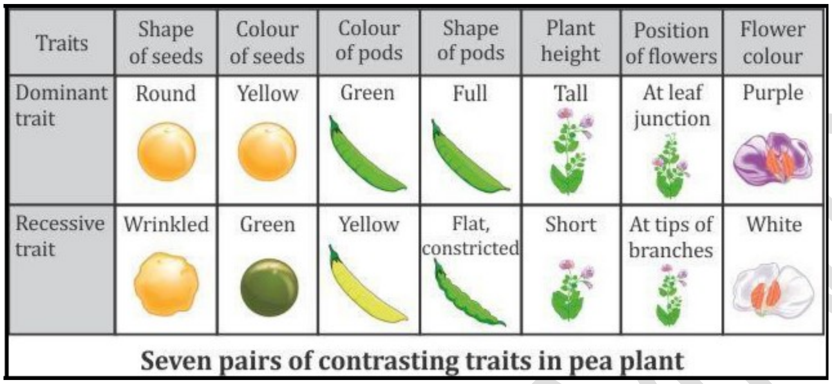
Heredity and Evolution

Heredity and Variation

Living organisms have certain recognisable heritable features such as height, complexion, colour of hair and eyes, shape of nose and chin etc. These are called **characters**.
The alternative forms of a character are called **traits**. The inheritable characteristics or traits may be morphological, anatomical, physiological or reproductive.
The transmission or passing of genetically based characters or traits from the parents to their offspring is called **heredity**.
The occurrence of small differences or changes among the individuals of a species is called **variation**.
Hereditary variations are of great importance in the process of **evolution** of a new species.
Asexual reproduction results in a small amount of variation as compared to sexual reproduction.
Genes are the specific parts of chromosomes or deoxyribonucleic acid (DNA) segments which determine hereditary characteristics.
Every gene has two alternative forms for a character, each of which produces different effects in an organism. These alternative forms are called **alleles**. Example: In case of pea plants, the stem height is controlled by two alleles—one for tallness and the other for dwarfness.
Of the two alleles of a gene, one is dominant, i.e. super ruling and the other is recessive, i.e. subordinate or submissive. A **dominant** allele is the allele which hides or masks the expression of its corresponding allele, which in turn becomes **recessive**.
A contrasting pair of alleles constitutes an **allelomorph**.
The genetic constitution of an organism is called its **genotype**. It is the description of genes present in an organism. The genotype of a tall plant could be TT or Tt, while that of a dwarf plant is tt.
Phenotype refers to the observable characteristics or the expressed shown character of an organism.
Example: Tall and dwarf are the phenotypes of a plant because these traits are visible to us.
When two parents are crossed to produce progeny, their progeny is called the **first filial generation** or **F_1 generation**.
When the first generation progeny or F_1 progeny is crossed amongst themselves to produce a second generation progeny, this progeny is called the **second filial generation** or **F_2 generation**.
A new form of plant resulting from a cross of different varieties of a plant is known as a **hybrid**.

Rules for Inheritance of Traits

Mendel conducted experiments on pea plants (***Pisum sativum***) and studied the inheritance of certain traits.



Traits	Shape of seeds	Colour of seeds	Colour of pods	Shape of pods	Plant height	Position of flowers	Flower colour
Dominant trait	Round	Yellow	Green	Full	Tall	At leaf junction	Purple
Recessive trait	Wrinkled	Green	Yellow	Flat, constricted	Short	At tips of branches	White

Seven pairs of contrasting traits in pea plant

A cross which involves only a single pair of contrasting characters is called a **monohybrid cross**. Example: A cross between a tall pea plant (TT) and a dwarf pea plant (tt).

Phenotypic ratio: 3 : 1

Genotypic ratio: 1 : 2 : 1

The results of the monohybrid cross enabled Mendel to formulate his first law of inheritance, which is called the **law of segregation**. It states that- ‘The characteristics or traits of an organism are determined by internal factors, which occur in pairs. Only one of a pair of such factors can be present in a single gamete’.

A cross which involves plants with two pairs of contrasting characters is called a **dihybrid cross**. Example: A cross of pea plants having round and yellow seeds (RRYY) and plants with wrinkled and green seeds (rryy).

Phenotypic ratio: 9 : 3 : 3 : 1

Genotypic ratio: 1 : 4 : 1 : 1 : 1 :2 : 2 : 2 : 2

The results of the dihybrid cross enabled Mendel to formulate his second law of inheritance, which is called the **law of independent assortment**. It states that- ‘In the inheritance of more than one pair of traits in a cross simultaneously, the factors responsible for each pair of traits are distributed independently to the gametes’.

DNA (Deoxyribonucleic acid) is a highly complex molecule with a spirally coiled, double helical structure which appears like a ladder.

Differences between Inherited and Acquired Traits

INHERITED TRAITS	ACQUIRED TRAITS
1. Characteristics inherited from the previous generation.	1. Characteristics which develop in response to the environment and cannot be inherited.
2. Occur due to a change in genes or DNA.	2. No change in genes or DNA is involved.
3. Pass on from one generation to another.	3. Cannot pass on from one generation to another.
4. Examples: Red curly hair, brown eyes	4. Examples: Cycling, swimming

Sex Determination

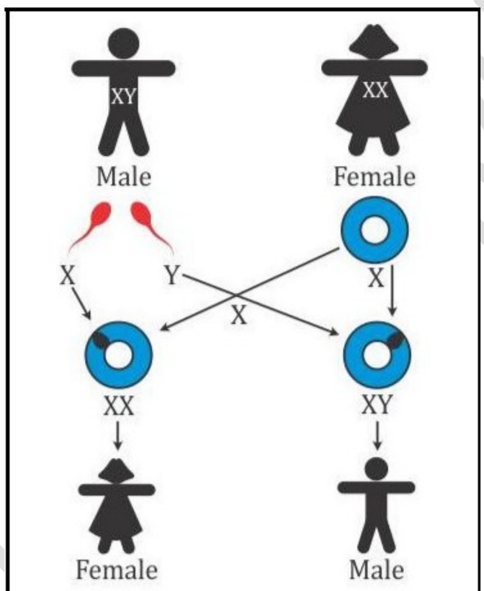
The phenomenon or process which determines whether a developing embryo will be a male or a female is known as **sex determination**.

In most organisms, **environmental** and **genetic** or **chromosomal** mechanisms are mainly responsible for the determination of sex of an individual.

Humans have 22 pairs of **autosomes** and 1 pair of **sex chromosome**.

Females have similar sex chromosomes **XX**, whereas **males** have a dissimilar pair, i.e. **XY**. All eggs carry the X chromosome, while sperms may either carry an X or a Y chromosome.

The sex of a child depends on whether the egg fuses with the sperm carrying an X chromosome (resulting in a **female**) or with the sperm carrying a Y chromosome (resulting in a **male**).



Sex determination in human beings

Evolution

Evolution can be defined as the formation of more complex organisms from pre-existing simpler organisms over a certain period. It is a slow, but progressive, natural, sequential development or transformation of animals and plants from ancestors of different forms and functions.

Variation and **heredity** are the two basic factors of evolution. The selection of variants by environmental factors forms the basis of evolutionary processes.

Evidences for Evolution

A large amount of information has been collected over the last 200 years to support the theory of organic evolution. Such supporting information which helps us in accepting the theory is called **evidence**.

Morphological Evidence	• Morphological evidence of evolution reflects in the form of external features or the appearance of an organism.
Anatomical Evidence	• Anatomical evidence of evolution is usually reflected in the form of structures, which appear quite similar in their organisation. • The similarities found in different groups of organisms indicate that these organisms must have had a common ancestor. • Different organisms have organs which perform a similar function. These organs which have a similar function but are different in structure and origin are called analogous organs. For example- tail fin of a lobster and flukes of a whale, wings of a fly and wings of a bird, eyes of arthropods and eyes of vertebrates, are all analogous organs. • There are some organs which are fundamentally similar in structure and origin but are modified to perform different functions in different organisms. They are called homologous organs. For example- forelimbs of man are adapted for handling, while forelimbs of bats and birds are adapted for flying, while those of whales and seals are adapted for swimming.
Vestigial Organs	• Organs which are found in a reduced or rudimentary condition and do not perform any function in the possessor are called vestigial organs or non-functional organs. For example- ear muscles, wisdom tooth, coccyx or reduced tail and plica semilunaris in man.
Study of Fossils	• Fossils are the preserved remains or traces of animals, plants and other organisms from the remote past. • The study of fossils is called palaeontology, which provides direct evidences in favour of organic evolution. • t helps us to compare the past with the present so as to establish the changes which have occurred in the course of evolution.
Embryological Evidence	• The study of development of an organism from the embryonic stage is called embryology. • The comparison of embryos states that in the course of development from the embryo to their adult form, animals go through stages which resemble or represent successive stages in the evolution of their remote ancestors.

Darwin's Theory of Evolution

According to **Darwin's Theory of Natural Selection**, organisms produce more offspring than they need for their existence. They compete among themselves and fight with the environmental factors for their various needs in life. In the struggle for existence, those with favourable variations continue to exist and those with unfavourable variations die out. Thus, a new species is formed by natural selection.

A **species** is a population of organisms consisting of similar individuals which can breed together and produce fertile offspring.

The process by which a new species develops from the existing species is known as **speciation**.

Important Factors which Contribute to Speciation

Geographical isolation	Leads to reproductive isolation due to which there is no flow of genes between separated groups of population.
Genetic drift	Genetic drift with changes in the gene flow imposed by the isolation mechanism acts as an agent of speciation.
Natural selection	Genetic variation within a population of organisms may cause some individuals to survive and reproduce more successfully than others.

Evolution by Stages

The great variety of organisms existing on the Earth is due to changes which have occurred gradually in stages and have resulted in the evolution of a new species.
The occurrence of different stages of evolution in a species is not because of a single DNA change.

Evolution of Eyes	• Primitive organisms which existed on the Earth were slow moving and small in size. hey did not require a specialised organ for observing any object. • As evolution progressed, comparatively larger and mobile organisms evolved. Most of them were predators and required better vision for predation. • Hence, from the basic design of eyes, more complex forms evolved.
Evolution of Feathers	• Birds make use of their feathers for flying. • However, feathers did not evolve for flight. They evolved as a means of providing insulation to the body in cold weather.
Evolution by Artificial Selection	• Artificial selection is the process in which human preferences have a significant effect on the evolution of a particular species. • Humans cultivate wild cabbage as a source of food and have produced different varieties of it by artificial selection. Common vegetables such as cabbage, kale, broccoli, cauliflower and kohlrabi are descendents of wild cabbage. • Artificial selection has helped in creating diversity in plants and animals.

Evolution and Classification

The principles of classification help us trace the evolutionary relationships of the species around us. In 1859, **Charles Darwin** first described this concept of evolution in his book ***The Origin of Species***.

Certain groups of organisms have ancient body designs and are referred to as **primitive** or lower organisms. Some organisms have acquired their body designs relatively recently and are called **advanced** or higher organisms.

There is a strong possibility that complexity within organisms increases with an increase in evolutionary time. Hence, we can say that older organisms are relatively simpler, while younger organisms are more complex.

Evolution Should Not Be Equated With Progress

Evolution has resulted in the generation of new varieties of species. It results in the production of diverse life forms subjected to environmental selection. he only progress which has occurred due to evolution is the emergence of more complex body designs of organisms.

When we consider the evolutionary history of man, we often say that human beings evolved from chimpanzees. However, this is not the case. In fact, both **chimpanzees** and **human beings** had a common ancestor a long time ago. The two offspring of that common ancestor evolved differently to form the modern day chimpanzees and human beings.

Human Evolution

Human evolution has been studied using various tools of tracing evolutionary relationships such as excavating, carbon-dating, studying fossils and determining DNA sequences.

Research reveals that the early members of *Homo sapiens* came from Africa. About hundred years ago, some of our ancestors left Africa, while others stayed back. So irrespective of where we live, all human species are natives of Africa. The earliest fossils of human beings include the genus ***Australopithecus***, followed by ***Homo habilis***, ***Homo erectus***, ***Homo heidelbergensis*** and finally modern day man ***Homo sapiens***.

Our Environment

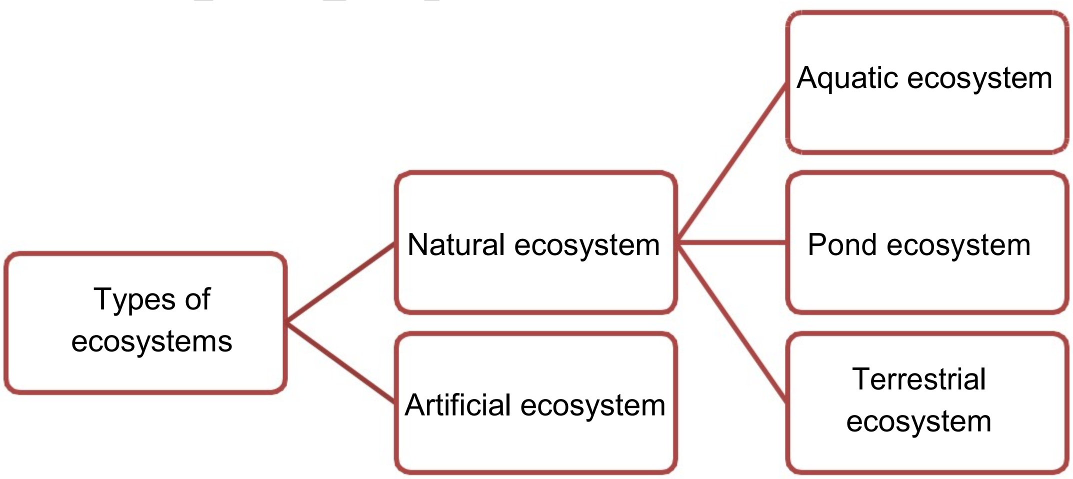
Biodegradable and Non-Biodegradable Wastes

BIODEGRADABLE WASTES	NON-BIODEGRADABLE WASTES
They can be broken down into non-poisonous substances by the action of microorganisms. They change their form and structure over time and become harmless. They do not pollute the environment. Examples: Spoilt food, vegetable peels, paper, leather etc.	They cannot be broken down into harmless substances by any biological processes. They remain unchanged over a long period of time. They continue to pollute the environment. Examples: Glass bottles, metal cans, polythene bags, synthetic fibres etc.

Ecosystem

An **ecosystem** is a self-contained area composed of different kinds of organisms which interact with each other as well as with the physical conditions such as sunlight, air, water, soil and climatic factors prevailing in the area.

Types of Ecosystem



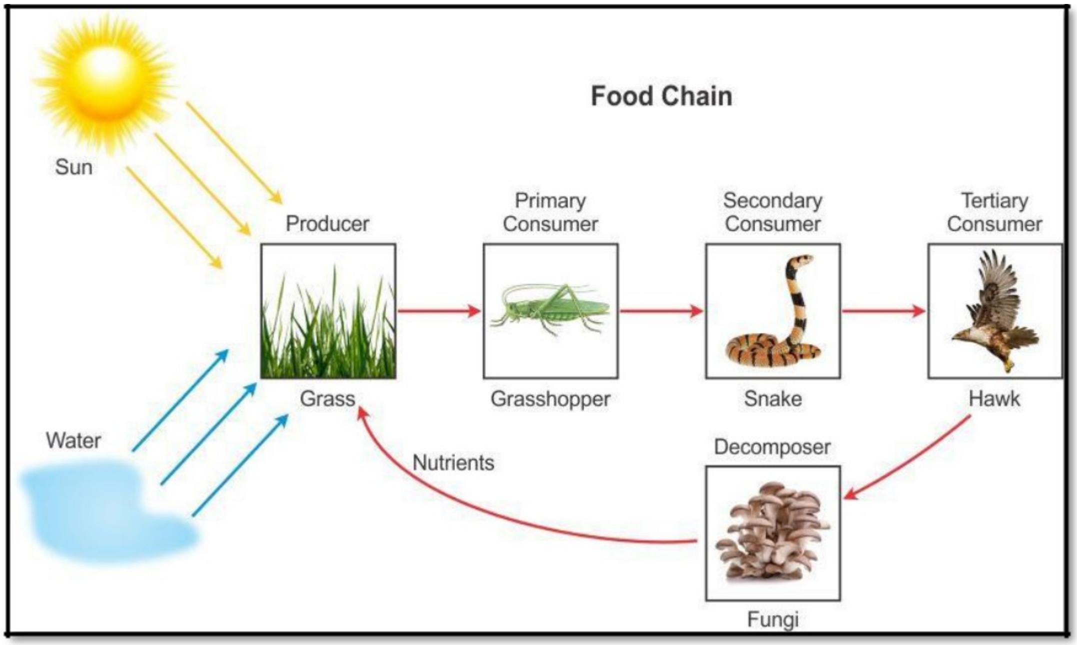
Components of an Ecosystem

An ecosystem consists of two main components: biotic components and abiotic components.

Biotic Components The biotic components are the living components of an ecosystem. They constitute the food-obtaining steps or trophic levels of the ecosystem.	
Trophic level I (Green plants/Autotrophs)	• They produce food through the process of photosynthesis. • These include trees, bushes and grasses.
Trophic level II (Herbivores/ Primary consumers)	• They directly eat plants or their products such as leaves, grains, etc. for food or suck plant sap from their leaves or stems. • These include animals such as deer, rabbits, rats, pigeons, parrots, grasshoppers, bees etc.
Trophic level III (Carnivores/ Secondary consumers)	• They capture their prey and eat it. • These include tigers, wolves, snakes, lizards, certain birds etc.
Trophic level IV (Large carnivores/ Tertiary consumers)	• They capture smaller carnivores and eat them. • These include peacock, eagle etc.
Parasites	• They live inside or on the body surface of another organism, called the host, and obtain their food or nourishment from the host. • Worms which live in the guts of animals and fleas which live on the skin of animals such as dogs are examples of parasites.
Decomposers/ Microconsumers/ Detritivores	• They breakdown the complex organic compounds present in these dead organisms into simpler substances. • These include certain bacteria and fungi, vultures, kites, crows, some insects etc.
Abiotic Components The abiotic components are the non-living components of an ecosystem.	
Sunlight	• The energy obtained from sunlight is essential for the production of food by photosynthesis.
Air	• Oxygen from the air is essential to animals for respiration. • Carbon dioxide is useful to plants for photosynthesis.
Water	• Water is the chief constituent of protoplasm in cells. • It is required for various biochemical reactions which occur in organisms.
Temperature	• Temperature affects the distribution of living organisms in the environment. • It affects the enzymatic activities in organisms.
Soil	• Soil provides the substratum for the growth of plants. • It contains water and mineral nutrients such as sodium and potassium required by plants.

Food Chain

The sequential process of eating and being eaten is called a **food chain**.
A food chain represents the unidirectional transfer of energy.



Energy Flow in a Food Chain

In a food chain, along with food, transfer of energy also occurs from one trophic level to the other. The flow of energy which occurs along a food chain is called **energy flow**.

All the energy used by a living organism is obtained from the Sun. Solar energy enters the living components through the autotrophs or green plants. However, only 1% of the total energy is actually captured by green plants.

The amount of energy gradually declines as one moves up to the next higher trophic level, because at each level, energy is lost in the form of heat.

The loss of energy in food chains and the transfer of energy from one trophic level to the other can be explained by the **Ten Percent Law** which states that, 'Only 10% of the energy entering a particular trophic level of organisms is available for transfer to the next higher trophic level'.

Significance of Food Chain

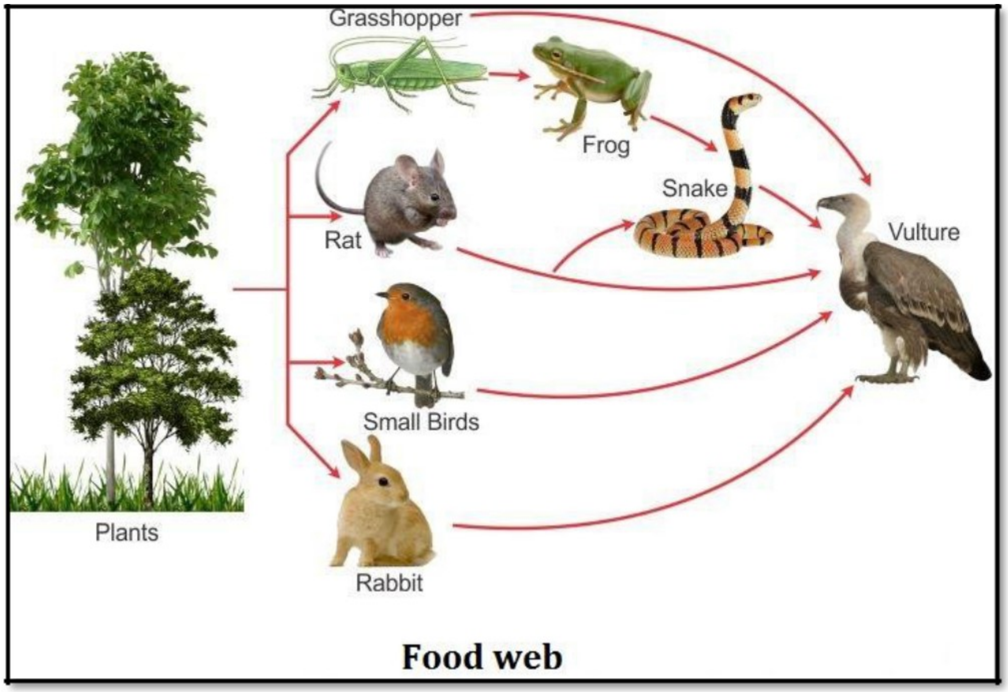
Food chain maintains a check on the population and a balance in the ecosystem.

Energy in the form of food is continuously transferred between different food chains. This helps to maintain the equilibrium in an ecosystem.

Food chains help us to understand the interaction and the interdependence of different organisms in an area.

Food Web

A network of interconnecting food chains in a natural community of different organisms is called a **food web**.



Significance of Food Web

Food webs permit alternative foods.
They ensure a better chance of survival for an organism if any of its food sources is scarce.

Food Pyramid

A graphical representation of various trophic levels of a food chain in an ecosystem is called an ecological pyramid or a **food pyramid**.
Ecological pyramids are of three types:

- Pyramid of numbers
- Pyramid of biomass
- Pyramid of energy

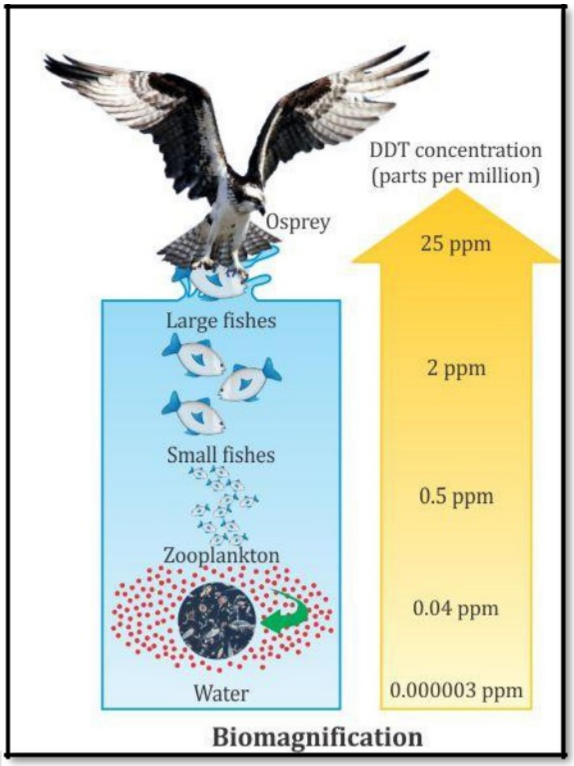
Significance of Food Pyramid

The trophic levels in a food chain can be explained by a food pyramid.
The ecological pyramids help us to understand the structure, functional diversity and energy conversion efficiency of ecosystems.

Biomagnification

Biomagnification or food chain magnification is the phenomenon of increase in the concentration of toxic substances in the bodies of living organisms at each trophic level of a food chain.

Dichlorodiphenyltrichloroethane (DDT), an organochlorine pesticide, cannot be removed by washing or by other means and tends to accumulate in the environment causing biomagnification.



Environmental Problems

Depletion of the Ozone Layer

About the Ozone Layer

Ozone is a product of ultraviolet radiations acting on the oxygen molecule and splitting it into free oxygen atoms. These atoms combine with molecular oxygen to form ozone.

The ozone layer extends to about 16–50 km above the Earth's surface.

Reasons for Ozone Depletion

The drop in ozone levels is due to certain synthetic chemicals such as chlorofluorocarbons (CFCs), which are used as refrigerants and in air conditioners and fire extinguishers.

Effects of Ozone Depletion

In the absence of the ozone layer, the ultraviolet rays reach the Earth's surface. They are highly harmful to organisms and can even cause skin cancer and other diseases in human beings.

Control Measures for Ozone Depletion

As per the agreement, The United Nations decided to freeze the production of CFCs at levels which existed in 1986.

Disposal of Wastes

Disposal of waste means to get rid of waste.

Recycling
Solid wastes such as paper, plastic and metals can be sent to paper mills, plastic processing factories and metal industries respectively. They can be recycled and used again.
Composting
Household garbage such as fruit and vegetable peels, egg shells, waste food, tea leaves as well as farmland wastes such as dried leaves, husk and parts of crop plants from fields after harvesting can all be converted into useful compost by rotting. The use of compost improves the fertility of soil as it provides nutrients to the soil.
Incineration
Hazardous bio-medical wastes such as discarded medicines, toxic drugs, human anatomical wastes, blood and pus, microbiological and biotechnological wastes are usually disposed of by incineration by burning at very high temperatures. Electricity can be generated from the heat released during burning.
Landfills
Large-scale disposal of solid waste can be done by putting it in low areas of the ground and then covering it with Earth.
Sewage Treatment
Waste water or sewage from houses, offices and hospitals enters a channel of pipelines which finally reach the wastewater treatment plant. Physical, biological and chemical processes are carried out for the treatment of sewage.

Role of an Individual in Management of Wastes

In order to save our environment and maintain ecological balance in nature, the **3R approach** should be implemented while using resources. The 3R's imply reduce, reuse and recycle.

Reduce

- We have to reduce the excess use of resources, when not required, in order to avoid their wastage.

Reuse

- We have to use the same resources again and again so that the demand for new resources is reduced and it will also conserve the resources.

Recycle

- We have to recycle the used resources rather than throwing them away.

Management of Natural Resources

Any matter or energy, derived from the environment, which can be used by all living organisms, including man, for their welfare constitute our **natural resources**.

Forests and wildlife, water, coal and petroleum are some of our important natural resources.

A system of controlling the use of natural resources in such a way so as to avoid their wastage and allow their use in the most judicial way is called **management of natural resources**.

We need to manage our resources to ensure that they are used judiciously, to prevent their exploitation for short-term gains, and to make equitable distribution of natural resources and deal with environmental problems.

Sustainable development is development which meets the needs of the present generation as well as preserves the resources for future generations.

Forests and Wildlife

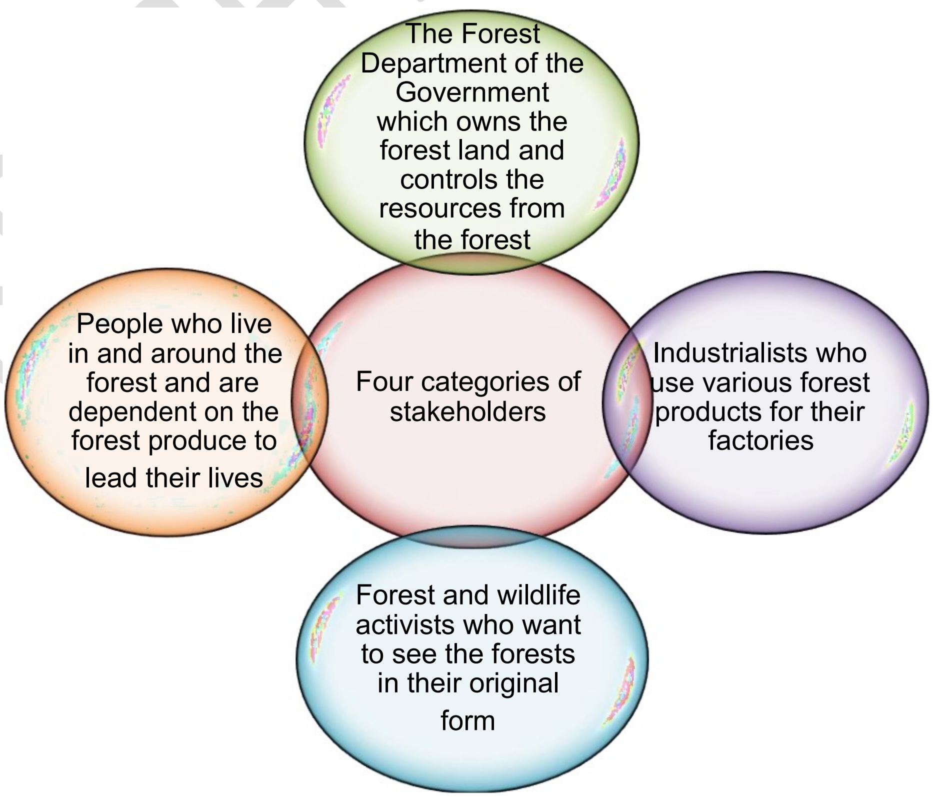
Forests refer to a large piece of land covered with trees, shrubs and herbs growing naturally and sustaining a variety of life forms.

Uncultivated plants and non-domesticated animals which live in their natural habitat collectively constitute the **wildlife** of an area.

Naturally occurring plants and animals constitute the **flora** and **fauna** of the forest.

The main aim of management of forests and wildlife is to conserve the vast inherited biodiversity, because loss of biodiversity leads to loss of ecological stability of the forest ecosystem.

Stakeholders in the Management of Forests



Sustainable Management of Forests

People's participation in the management of forests can help in increasing the forest produce as well as in their conservation.

INSTANCES OF PEOPLE'S PARTICIPATION IN THE MANAGEMENT OF FORESTS The Case of Khejri trees
In 1731, Amrita Devi Bishnoi led a group of 363 people who sacrificed their lives for the protection of Khejri trees in Khejrali village near Jodhpur in Rajasthan.
The Chipko Andolan
The Chipko Andolan also called the 'Hug the trees movement' was organised under the leadership of Sunderlal Bahuguna to stop the destruction of forests. The movement began in 1970s in a remote village called Reni in Garhwal in the Himalayas.
Revival of Sal forests
A forest officer, A. K. Banerjee got the villagers involved in protecting 1.272 hectares of badly degraded Sal forests of West Bengal. In return, the villagers were given employment in silviculture and harvesting operations. They were also given 25% if the final harvest and were allowed to collect fuel wood and fodder on the payment of a nominal fee.

Conservation of Wildlife

Large-scale poaching of wild animals disturbs the food chains in which these animals occur. This results in undesirable consequences for the entire ecosystem.

Measures to be Taken for the Conservation of Wildlife

- Breeding of wild animals in captivity and then releasing them into their original natural habitat.
- Enacting and enforcing strict laws, action plans and projects started by non-government organisations.
- Ban on hunting and killing of endangered animals.
- Establishment of national parks, wildlife sanctuaries and biosphere reserves.
- Educating the public about the importance of wildlife conservation by observing 'Wildlife Week'.

Water

Water is an important constituent of the body. Nearly 75% of our body weight is due to the presence of water.

Rains, rivers, lakes, ponds, wells, tube wells, dams, oceans and glaciers are the important sources of water.

Dams

What are dams?	• The large reservoir of a dam stores a huge amount of water which is allowed to flow downstream at the desired rate. • The Dharoi dam on the river Sabarmati, the Ukai dam on the River Tapi and the Machhu dam on the river Machhu are some famous dams.
Uses of dams	• They regulate the flow of water. • They also ensure the storage of water for irrigation and for generating electricity.
Problems faced in the construction of dams	• Social problems arise because construction of dams causes the displacement of a large number of tribals and peasants who are then rendered homeless. • Construction of dams leads to several environmental problems such as deforestation and loss of biodiversity leading to ecological imbalance. • Economic problems arise because the construction of dams involves spending of large amounts of public money without generating proportionate funds.

Rainwater Harvesting

What is rainwater harvesting?
Rainwater which falls on roofs and terraces of buildings can be collected through pipes and stored in underground tanks or can be allowed to percolate into the soil and used to recharge the groundwater table. This is called water harvesting or rainwater harvesting.
Advantages of rainwater harvesting
The main aim of rainwater harvesting is to check the runoff water. It also prevents flooding of living areas and streets in cities. It can also reduce topsoil loss or soil erosion and improve plant growth.
Method of rainwater harvesting
In rainwater harvesting, tanks are fitted with motors for lifting water for use. Water from the open space around buildings can also be recharged into the ground by simple, effective methods.

Traditional methods of rainwater harvesting

In traditional methods of rainwater harvesting, water is not only stored but also used to recharge the groundwater.

Region	Traditional water harvesting structures
Rajasthan	Tanks, Khadins, Nadis
Maharashtra	Tals, Bandharas
Bihar	Ahars, Pynes
Uttar Pradesh and Madhya Pradesh	Bundhis
Himachal Pradesh	Kuhls
Kerala	Surangams
Kandi belt of Jammu region	Ponds
Karnataka	Kattas

Bawris

Bawris or step-wells are wells or ponds constructed in the ground. The water in bawris can be reached by descending a set of steps.

With acute shortage of water, people began to revive these traditional bawris. As a result, despite scanty rains, these places are managing their water needs well.

Khadin

Khadin consists of a 100–300-m long embankment called bund made of Earth.

Rainwater from the catchment area flows down the slope and collects in front of the bund forming a reservoir.

Sluiceways or pathways through the bund allow excess water to flow through and collect in shallow wells dug behind the bund.

The water which collects in both the reservoir and the wells seeps into the land and recharges the groundwater. Later, crops can be grown on the water-saturated soil.

Water harvesting structures on the level terrain

The water harvesting structures on the level terrain are mostly crescent-shaped, earthen embankments or straight, low concrete and rubble check dams.

The main purpose of these water harvesting structures is to recharge the groundwater beneath the surface so as to provide moisture for vegetation.

The water does not evaporate, does not form breeding grounds for mosquitoes and is also protected from human and animal waste.

Coal and Petroleum

Fossil fuels such as coal and petroleum are **non-renewable resources** of energy and exist on the Earth in a limited amount.

On burning in air, coal produces mainly **carbon dioxide** as well as **oxides of nitrogen and sulphur** as products. Increased quantities of carbon dioxide in the atmosphere can cause climatic changes and lead to global warming.

Burning of coal in the absence of air produces **carbon monoxide** gas. High concentrations of carbon monoxide and oxides of nitrogen and sulphur are poisonous and pollute the environment.

Acid rain is caused because of sulphur particles present in coal.

Burning of coal also generates waste products which contain **arsenic** , **mercury**, **uranium**, **thorium** and other heavy metals which are harmful to human health and the environment.

Burning of coal produces dust nuisance and contaminates land and water.

Alternatives to Reduce the Consumption of Coal and Petroleum

- Switch off electrical appliances when not required.
- Use energy-efficient electrical appliances like CFL.
- Use pressure cookers or solar cookers for cooking food.
- Use of biogas as a domestic fuel should be encouraged.
- Bicycles should be used instead of cars and scooters to travel short distances.

Three R's to Save the Environment

In order to save our environment and maintain ecological balance in nature, the **3R approach** should be implemented while using resources. The 3R's imply reduce, reuse and recycle.

Reduce	• We have to reduce the excessive use of resources when not required in order to avoid their wastage.
Reuse	• We have to use the same resources again and again so that the demand for new resources is reduced and it will also conserve the resources.
Recycle	• We have to recycle the used resources rather than throwing them away.

PHYSICS

Light – Reflection and Refraction

Reflection of Light

Reflection is the phenomenon of bouncing back of light into the same medium on striking the surface of anyobject.

Laws ofReflection

- First law: The incident ray, the normal to the surface at the point of incidence and the reflected ray, all lie in the sameplane.
- Second∠∠ law: The angle of reflection (r) is always equal to the angle of incidence(i). i= r

The image formed by a **plane mirror** isalways

virtual anderect

of the same size as theobject

as far behind the mirror as the object is in front

ofit ○ laterallyinverted

Spherical mirrors are of twotypes:

Convex mirrors or diverging mirrors in which the reflecting surface is curvedoutwards.

Concave mirrors or converging mirrors in which the reflecting surface is curvedinwards. Some terms related to sphericalmirrors:

The **centre of curvature (C)** of a spherical mirror is the centre of the hollow sphere of glass, of which the spherical mirror is apart.

The **radius of curvature (R)** of a spherical mirror is the radius of the hollow sphere of glass, of which the spherical mirror is apart.

The **pole (P)** of a spherical mirror is the centre of themirror.

The **principal axis** of a spherical mirror is a straight line passing through the centre of curvature C and pole P of the sphericalmirror.

The **principal focus (F) of a concave mirror** is a point on the principal axis at which the rays of light incident on the mirror, in a direction parallel to the principal axis, actually meet after reflection from themirror.

The **principal focus (F) of a convex mirror** is a point on the principal axis from which the rays of light incident on the mirror, in a direction parallel to the principal axis, appear to diverge after reflection from themirror.

The **focal length (f)** of a mirror is the distance between its pole (P) and principal focus(F).

For spherical mirrors of small aperture, **R =2f**.

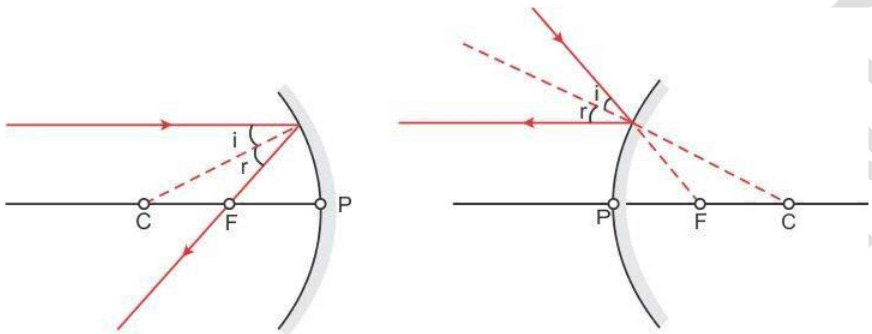
Sign Conventions for SphericalMirrors

According to **New Cartesian Sign Conventions**,

- All distances are measured from the pole of themirror.
- The distances measured in the direction of incidence of light are taken as positive and *viceversa*.
- The heights above the principal axis are taken as positive and *viceversa*.

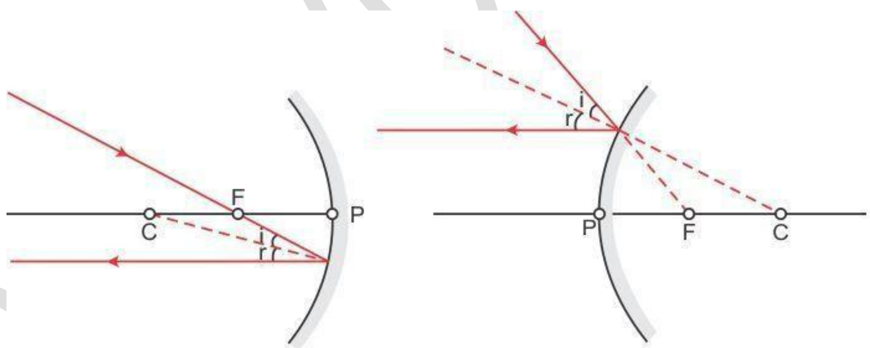
Rules for tracing images formed by sphericalmirrors

Rule 1: A ray which is parallel to the principal axis after reflection passes through the principal focus in case of a concave mirror or appears to diverge from the principal focus in case of a convex mirror.



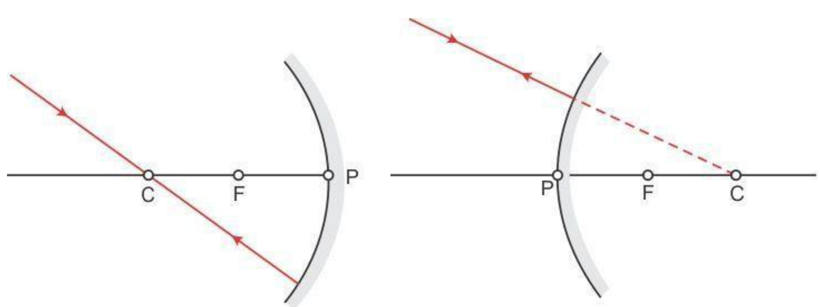
Concave Mirror   Convex Mirror

Rule 2: A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror emerges parallel to the principal axis afterreflection.



Concave Mirror   Convex Mirror

Rule 3: A ray passing through the centre of curvature of a concave mirror or directed towards the centre of curvature of a convex mirror is reflected back along the same path.



Concave Mirror   Convex Mirror

Rule 4: A ray incident obliquely towards the pole of a concave mirror or a convex mirror is reflected obliquely as per the laws of reflection.

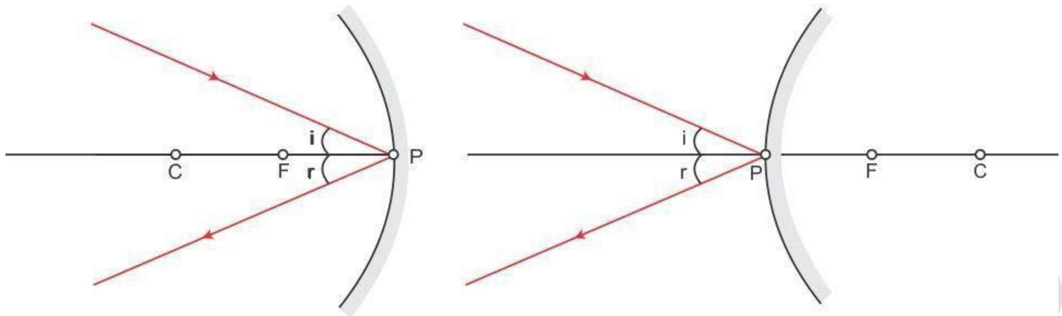
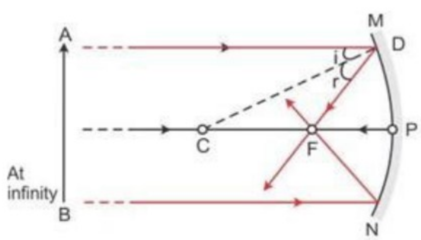
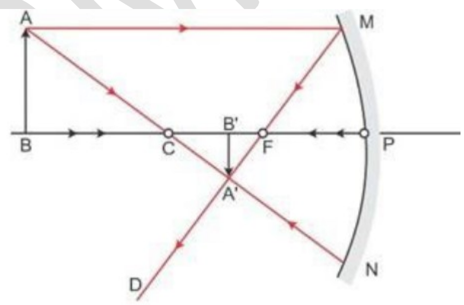


Image formation by a concavemirror

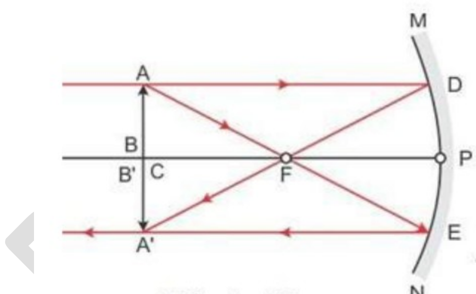
○ **RayDiagrams**



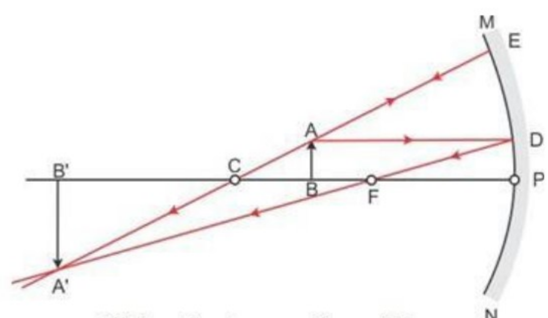
Object at infinity



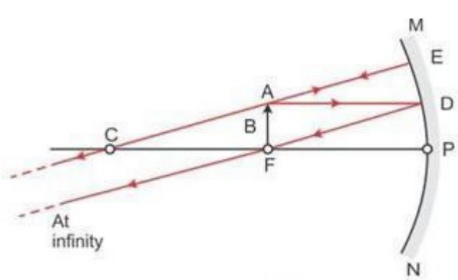
Object beyond C



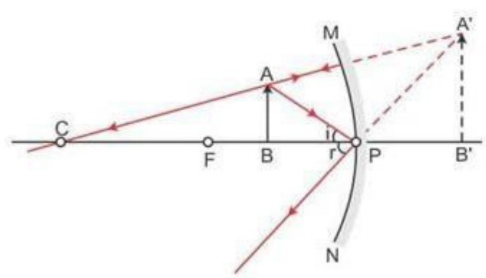
Object at C



Object between C and F



Object at F



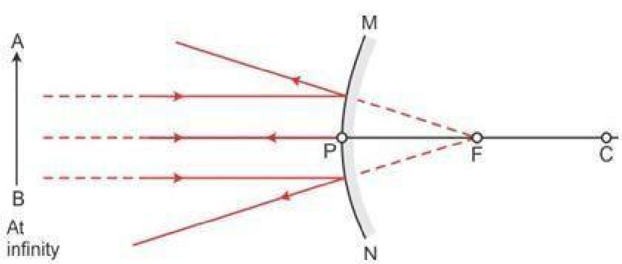
Object between F and P

Characteristics of imagesformed

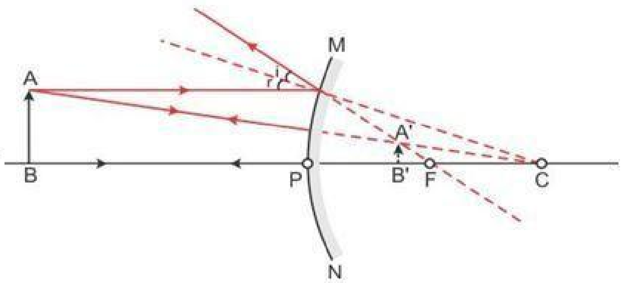
Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Highly diminished	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Equal to size of object	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between F and P	Behind the mirror	Enlarged	Virtual and erect

Image formation by a convexmirror

○ **RayDiagrams**



Object at infinity



Object anywhere between infinity and P

Characteristics of imagesformed

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F behind the mirror	Highly diminished, point sized	Virtual and erect
Anywhere between infinity and the pole of the mirror	Between P and F behind the mirror	Diminished	Virtual and erect

MirrorFormula

The object distance (u), image distance (v) and focal length (f) of a spherical mirror are related as

Linear Magnification (m) produced by a spherical mirroris

=size of image (h_2)= −image distance (v)
size ofobject(h_1)object distance(u)

m is **negative** for real images and **positive** for virtual images.

Refraction of Light

The phenomenon of change in the path of a beam of light as it passes from one medium to another is called refraction oflight.

The **cause of refraction** is the change in the speed of light as it goes from one medium toanother.

Laws ofRefraction

- FirstLaw:Theincidentray,therefractedrayandthenormaltotheinterfaceoftwomediaat the point of incidence, all lie in the sameplane.

Second Law: The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for a given pair ofmedia.

$$\frac{\sin i}{\sin r} = \text{constant} = {}_1n_2$$

This law is also known as **Snell's law**.

The constant, writtenas ${}_1n_2$ is called the **refractive index** of the secondmedium (in which the refracted ray lies) with respect to the first medium (in which the incident ray lies).

Absolute refractive index (n) of a medium is givenas

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in the medium}} = \frac{c}{v}$$

When a beam of light passes from medium 1 to medium 2, the refractive index of medium 2 with respect to medium 1 is called the **relative refractive index**, represented by ${}_1n_2$,where

$${}_1n_2 = \frac{n_2}{n_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$$

Similarly, the refractive index of medium 1 with respect to medium 2 is

$${}_2n_1 = \frac{n_1}{n_2} = \frac{c/v_1}{c/v_2} = \frac{v_2}{v_1}$$

$$\Rightarrow \quad {}_1n_2 \times {}_2n_1 = 1 \qquad \text{or,} \qquad {}_1n_2 = \frac{1}{{}_2n_1}$$

While going from **a rarer to a denser medium**, the ray of **light bends towards the normal**.

While going from **a denser to a rarer medium**, the ray of **light bends away from thenormal.**

Conditions for norefraction

- When light is incident normally on aboundary.
- When the refractive indices of the two media areequal.

In the case of a **rectangular glass slab**, a ray of light suffers **two refractions**, one at the air–glass interface and the other at the glass–air interface. The emergent ray is **parallel** to the direction of the incidentray.

Convex lens or converging lens which is thick at the centre and thin at theedges.
Concave lens or diverging lens which is thin at the centre and thick at theedges.

Some terms related to sphericallenses:

The central point of the lens is known as its **optical centre(O)**.

Each of the two spherical surfaces of a lens forms a part of a sphere. The centres of these spheres are called **centres of curvature** of the lens. These are represented as **C_1**and**C_2**.

The **principal axis** of a lens is a straight line passing through its two centres ofcurvature.

The **principal focus of a convex lens** is a point on its principal axis to which light rays parallel to the principal axis converge after passing through thelens.

The **principal focus of a concave lens** is a point on its principal axis from which light rays, originally parallel to the principal axis appear to diverge after passing through thelens.

The **focal length (f)** of a lens is the distance of the principal focus from the opticalcentre.

Sign Conventions for SphericalLenses

According to **New Cartesian Sign Conventions**,

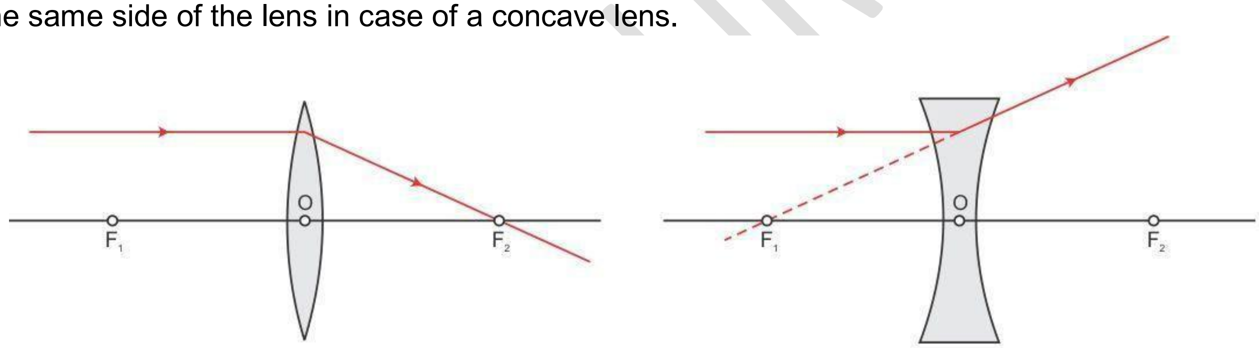
All distances are measured from the optical centre of thelens.

○ The distances measured in the direction of incidence of light are taken as positive and *viceversa*.

○ The heights above the principal axis are taken as positive and *viceversa*.

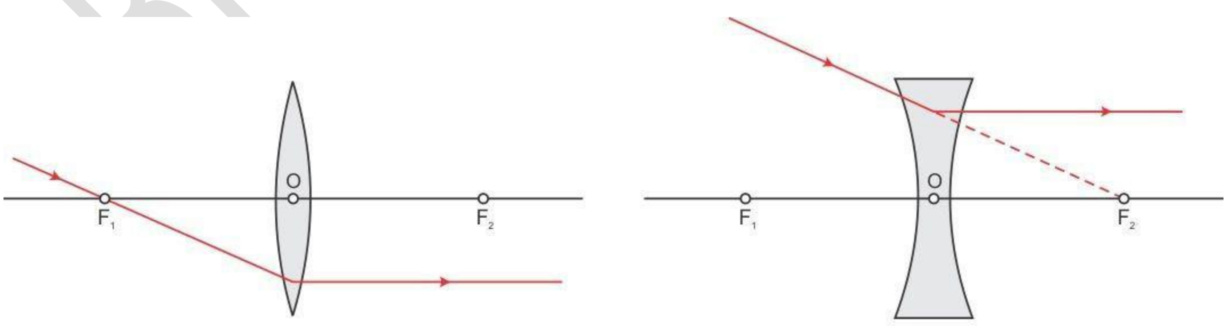
Rules for tracing images formed by sphericallens

Rule 1: A ray which is parallel to the principal axis, after refraction passes through the principal focus on the other side of the lens in case of a convex lens or appears to diverge from the principal focus on the same side of the lens in case of a concave lens.



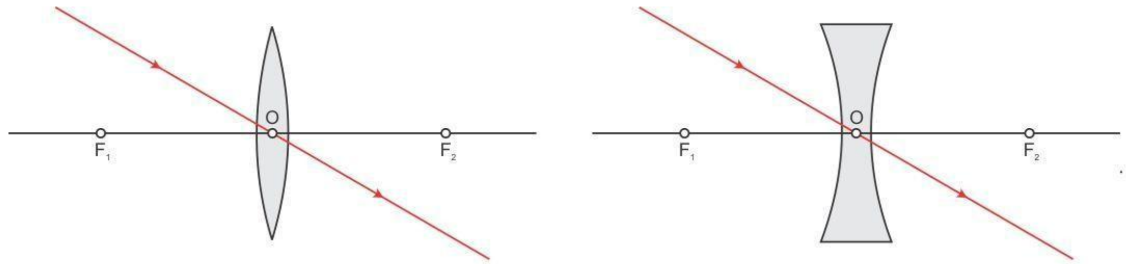
Convex Lens   Concave Lens

Rule 2: A ray passing through the principal focus of a convex lens or appearing to meet at the principal focus of a concave lens after refraction emerges parallel to the principalaxis.



Convex Lens   Concave Lens

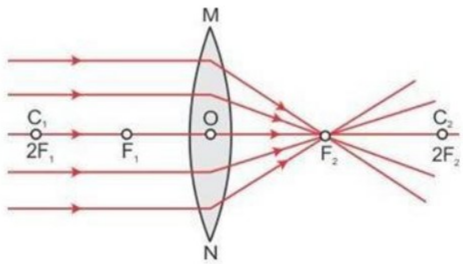
Rule 3: A ray passing through the optical centreof a convex lens or a concave lens emerges without any deviation.



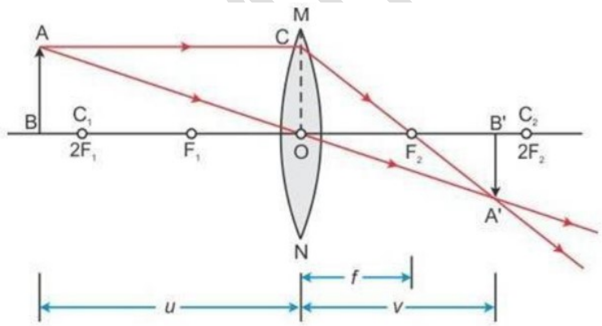
Convex Lens Concave Lens

Image formation by a convexlens

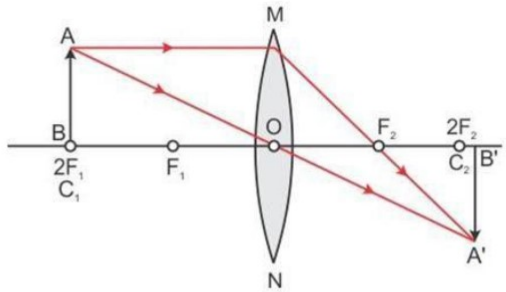
○ **RayDiagrams**



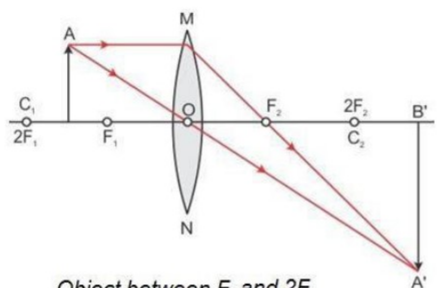
Object at infinity



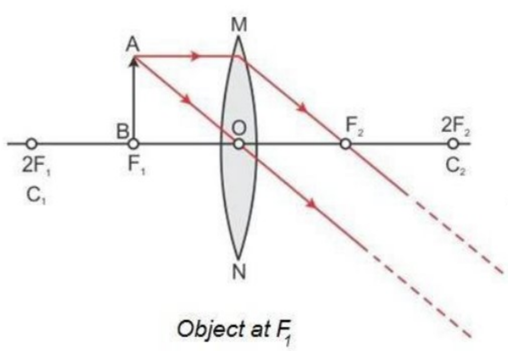
Object beyond $2F_1$



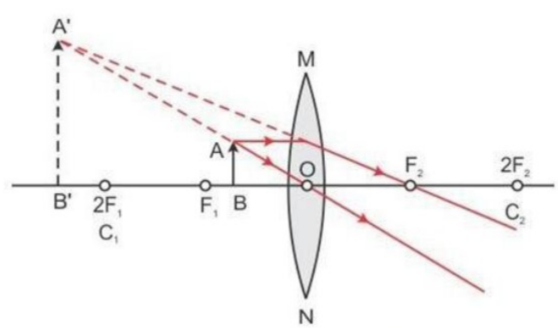
Object at $2F_1$



Object between F_1 and $2F_1$



Object at F_1

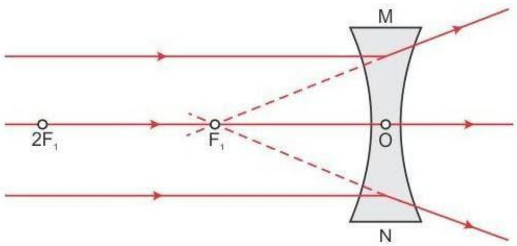


Object between F_1 and C

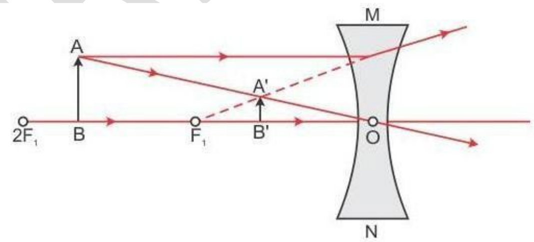
Characteristics of imagesformed

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_2	Highly diminished	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Equal to size of object	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Highly enlarged	Real and inverted
Between F_1 and O	Beyond F_1 on the same side as the object	Enlarged	Virtual and erect

Image formation by a concavelens ○ **RayDiagrams**



Object at infinity



Object between infinity and optical centre

○ **Characteristics of imagesformed**

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_1	Highly diminished	Virtual and erect
Between infinity and O	Between focus F_1 and O	Diminished	Virtual and erect

LensFormula

Object distance (u), image distance (v) and focal length (f) of a spherical lens are related as

$u1 - 1u = 1f$

Linear Magnification (m) produced by a spherical lensis

m=sizeofimage(h_2)=imagedistance(v) size
of object(h_1) object distance(u)

m is **negative** for real images and **positive** for virtual images.

Power of alens

- Power of a lens is the reciprocal of the focal length of the lens. Its S.I. unit is **dioptre(D)**.

$$\mathbf{P\ (dioptre)} = \frac{\mathbf{1}}{\mathbf{f\ (metre)}}$$

Power of a **convex lens** is **positive** and that of a **concave lens** is**negative**.

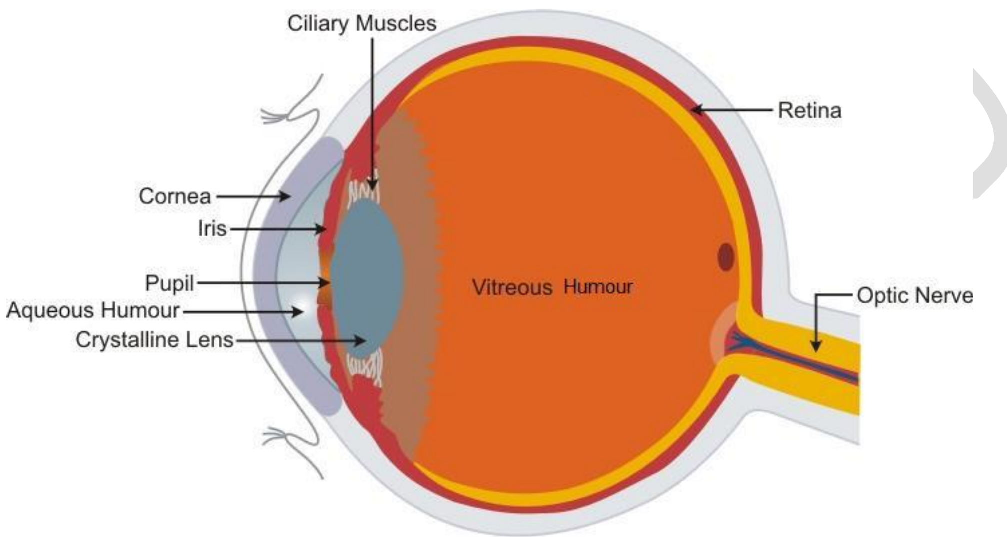
When several thin lenses are placed in contact with one another, the **power of the combination of lenses** is equal to the algebraic sum of the powers of the individuallenses.

$$\mathbf{P = P_1 + P_2 + P_3 + P_4 + \ldots}$$

Human Eye and the Colourful World

Human Eye

The human eye is an important and valuable sense organ which uses light and enables us to see the colourful world around us.



The various parts of the human eye and their respective functions include

Part	Function
Cornea	Protective layer of the eye Refraction of light rays entering the eye
Eye lens	Adjust the focal length and form an inverted image of the object on the retina
Pupil	Regulates the amount of light entering the eye
Iris	Controls the size of the pupil
Retina	Acts as a screen for forming the image
Ciliary muscles	Adjust the thickness of the lens
Optic nerves	Send signals to the brain

The image of any object seen persists on the retina for $\frac{1}{16}^{th}$ of a second, even after the removal of the object. This continuance of sensation on the eye for some time is called **persistence of vision**. The numerous light-sensitive cells contained in the retina of the eye are of two types:
- **Rod-shaped cells** which respond to the **brightness or intensity** of light.
- **Cone-shaped cells** which respond to the **colour** of light.

.

Power of Accommodation of the Human Eye

Power of accommodation of the eye is the ability of the eye to observe distinctly the objects, situated at widely different distances from the eye, on account of change in the focal length of the eye lens by the action of the ciliary muscles holding the lens.

The farthest point up to which the eye can see objects clearly is called the **far point (F)** of the eye. It is ideally **infinity** for a normal eye.

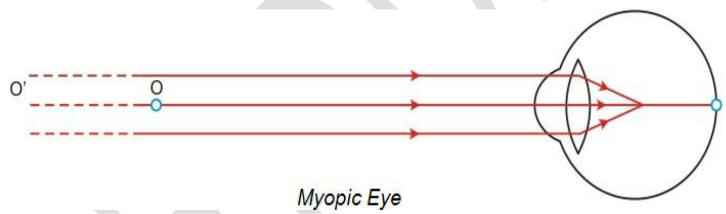
The point of closest distance at which an object can be seen clearly by the eye is called the **near point (N)** of the eye. For a normal eye, the near point is 25 cm, which is called the **least distance of distinct vision (d)** of a normal eye.

The distance between the far point (F) and near point (N) is called the **range of vision** of the eye.

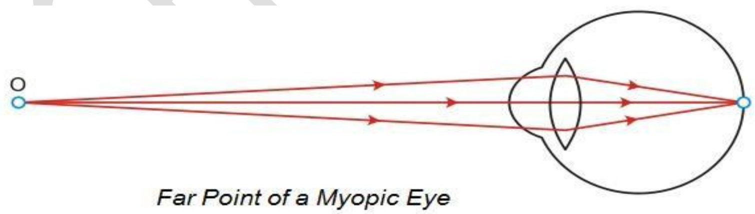
Defects of Vision

Myopia or Short-Sightedness

A person with myopia can see nearby objects clearly but cannot see distant objects distinctly, as if the far point of the eye has shifted from infinity to some particular distance from the eye.

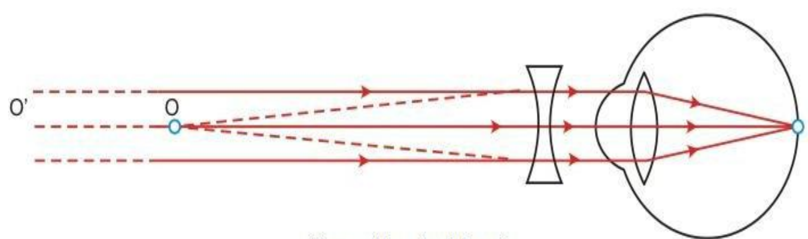


Myopic Eye



Far Point of a Myopic Eye

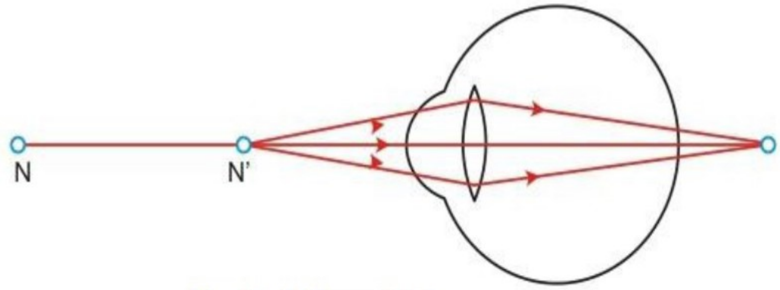
This defect may arise due to (i) excessive curvature of the eye lens or (ii) elongation of the eyeball. To correct myopia, the person has to wear spectacles with a **concave lens** of focal length equal to the distance of far point of the myopic eye.



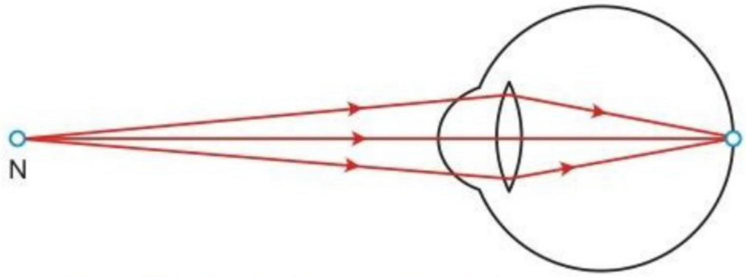
Correction for Myopia

Hypermetropia or Long-Sightedness

A person with hypermetropia can see objects lying at large distances clearly but cannot see nearby objects clearly, as if the near point of the eye has shifted away from the eye.



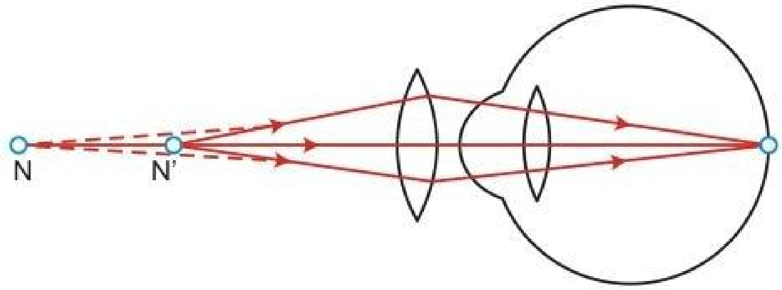
Hypermetropic Eye



Near Point of a Hypermetropic Eye

This defect may arise because (i) focal length of the eye lens is too long or (ii) the eyeball has become too small.

To correct hypermetropia, the person has to wear spectacles with a **convex lens** of focal length f, given by $f = \frac{x'd}{x'-d}$, where d is the least distance of distinct vision and x′ is the distance of near point N of the hypermetropic eye.



Correction for Hypermetropia

Presbyopia

Presbyopia is a human eye defect because of which an old person cannot read and write comfortably.

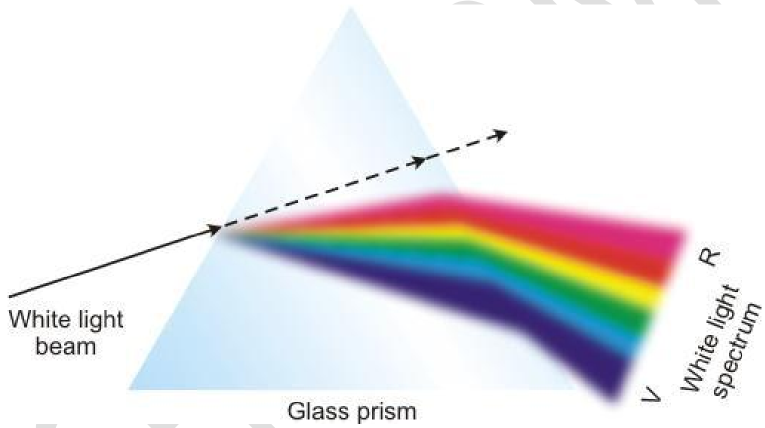
It occurs in old age when the ciliary muscles holding the eye lens weaken and the eye lens loses some of its flexibility.

To correct presbyopia, an old person has to wear spectacles with a **convex lens** of suitable focal length (as in hypermetropia).

Sometimes, a person may suffer from both myopia and hypermetropia. Such a person requires bi -focal lenses. The upper part of a bi-focal lens consists of concave lens facilitating distant vision, and the lower part consists of convex lens facilitating nearby vision.

Dispersion of Light

Dispersion of light is the phenomenon of splitting of a beam of white light into its seven constituent colours on passing through a glass prism.



The band of coloured components of a light beam is called its **spectrum**.

The sequence of colours given by the prism is Violet, Indigo, Blue, Green, Yellow, Orange and Red. **VIBGYOR** is the acronym for this sequence.

The **cause of dispersion** is that different colours of white light with different wavelengths undergo different deviations on passing through a glass prism.

If a second identical prism is placed in an inverted position with respect to the first prism, all the seven colours **recombine to form white light**.

The **rainbow** is a beautiful example of dispersion of light in nature. Sunlight gets dispersed on passing through tiny droplets of water suspended in air during or after a shower.

Atmospheric Refraction

Atmospheric refraction is the phenomenon of bending of light on passing through the Earth's atmosphere. This reason for this occurrence is that the upper layers of the Earth's atmosphere are rarer compared to the lower layers.

On account of atmospheric refraction of light,

- The stars seem higher than they actually are.
- The Sun appears to rise 2 minutes before and set 2 minutes later, increasing the apparent length of the day by 4 minutes.
- The Sun appears oval at sunrise and sunset, but appears circular at noon.
- The stars twinkle and planets do not.

Scattering of Light

The phenomenon in which a part of the light incident on a particle is redirected in different directions is called scattering of light.

When the size of the scatterer (x) is very much less than the wavelength (λ) of light, Rayleigh scattering is valid. The intensity of scattered light (I_s) varies inversely as the fourth power of wavelength (λ) of incident light.

$$I_s = \frac{1}{\lambda^4}$$

The phenomenon of scattering of light by colloidal particles is called the **Tyndall effect**.

On the basis of scattering, we can account for the:

- Blue colour of clear sky
- White colour of clouds
- Reddish colour of Sun at sunrise and sunset
- Red colour of danger signals

Electricity

Electric Current

Electric current is expressed as the amount of charge flowing through a particular area in unit time. Quantitatively, **electric current** is defined as the rate of flow of electric charge.

Current, I = $\dfrac{\text{Charge flowing (Q)}}{\text{Time taken (t)}}$

The S.I. unit of current is **ampere (A)**, where 1 ampere = 1 coulomb/second.

- 1 mA = 10^{-3} A,   1 μ A = 10^{-6} A

The conventional direction of electric current is the one in which positive charges move orderly.

Electric Potential Different

Electric potential difference (pd) between two points in an electric circuit, carrying some current, is the amount of work done to move a unit charge from one point to another.

Potential difference, pd = $\dfrac{\textbf{Work done (W)}}{\textbf{Quanity of charge moved (Q)}}$

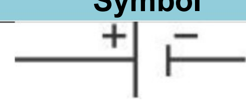
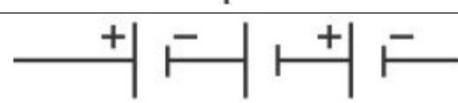
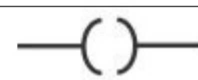
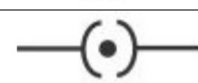
The S.I. unit of pd is **volt (V)**, where 1 volt = 1 joule/coulomb.

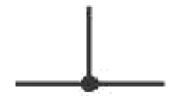
Electric Circuit

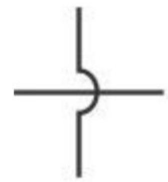
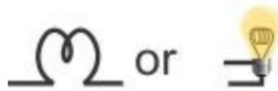
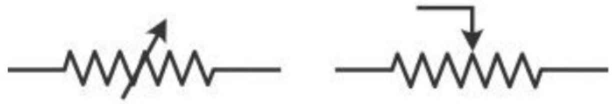
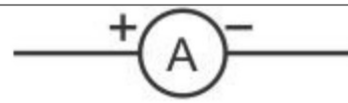
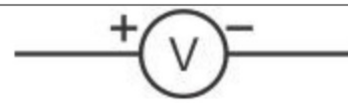
A continuous conducting path between the terminals of a source of electricity is called an **electric circuit.**

A drawing showing the way various electric devices are connected in a circuit is called a **circuit diagram.**

Some commonly used circuit elements are given below:

Sr. No.	Element	Symbol
1	An electric cell	
2	A battery	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	

5	A wire joint	

	Wires crossing without joining	
	Bulb	
	Resistor	
	Variable resistor or Rheostat	
10	Ammeter	
11	Voltmeter	

Ohm's law

According to Ohm's law, the current (I) flowing through a conductor is directly proportional to the potential difference (V) across its ends, provided its physical conditions remain the same.

$V \propto I$

V/ I = Constant

V/I=R

V=IR

where R is a constant of proportionality called **resistance** of the conductor.

Resistance is the property of a conductor to resist the flow of charges through it.

The S.I. unit of resistance is **ohm (Ω).**

From $R = \frac{V}{I}$, 1 ohm = 1 volt/ampere

Resistivity

The resistance of a conductor is directly proportional to its length (l) and inversely proportional to its area of cross section (A).

$R \propto l/A$

$R = \rho\, l/A$

where ρ is a constant of proportionality called **specific resistance** or **resistivity** of the material of the conductor.

The S.I. unit of resistivity is **ohm metre (Ω m).**

Combination of Resistances

Resistances in Series

The current flowing through each resistance is the same.

The potential difference across the ends of the series combination is distributed across the resistances.

The equivalent resistance (R_s) of a series combination containing resistances R_1, R_2, R_3... is

$$R_s = R_1 + R_2 + R_3 + \dots$$

The equivalent resistance is greater than the greatest resistance in the combination.

Resistances in Parallel

$$= \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

- The potential difference across INSTITUTE each resistance is the same and is equal to the potential difference across the combination.
- The main current divides itself, and a different current flows through each resistance.
- The equivalent resistance (R_p) of a parallel combination containing resistances R_1, R_2, R_3... is given by

  $$\frac{1}{R_p}$$

- The equivalent resistance is lesser than the least of all the resistances in the combination

Heating Effect of Electric Current

- The effect of electric current due to which heat is produced in a conductor, when current passes through it, is called the heating effect of electric current.
- The total work (W) done by the current in an electric circuit is called **electric energy** and is given as

  $$W = VIt = I^2Rt$$

  $$W = V^2 t / R$$

  This energy is exhibited as heat. Thus, we have $H = VIt = {}_2Rt$.

  This is called **Joule's Law of Heating**, which states that the heat produced in a resistor is directly proportional to the

  - Square of the current in the resistor
  - Resistance of the resistor
  - Time for which the current flows through the resistance

Practical Applications of the Heating Effects of Electric Current

Electrical appliances like laundry iron, toaster, oven, kettle and heater are some devices based on Joule's Law of Heating.

The concept of electric heating is also used to produce light, as in an electric bulb.

Another application of Joule's Law of Heating is the fuse used in electric circuits.

Electric Power

Electric power is the rate at which electrical energy is produced or consumed in an electric circuit

$P=VI=I^2R$ P

$= V^2/R$

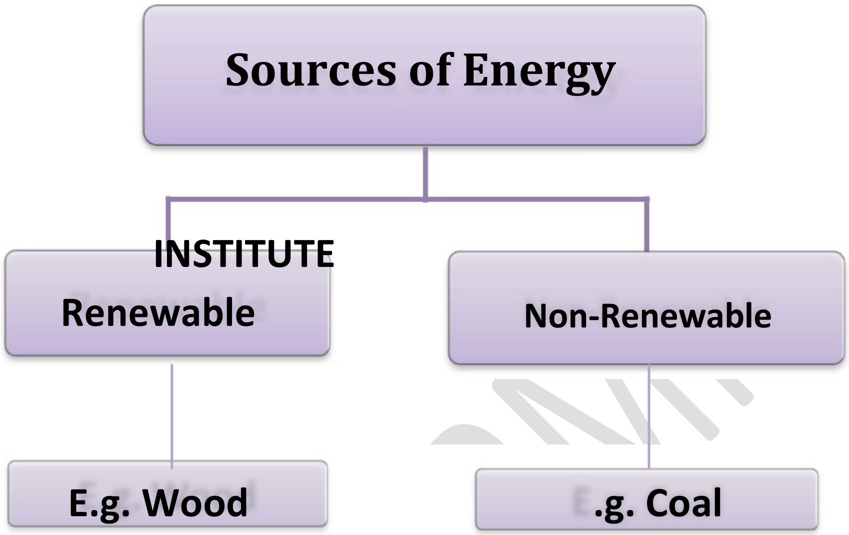
The **S.I. unit** of power is **watt (W).**

One watt of power is consumed when 1 A of current flows at a potential difference of 1 V. The commercial unit of electric energy is **kilowatt hour (kWh)**, commonly known as a **unit**.

1 kWh = 3.6 MJ

Sources of Energy

A **source of energy** provides adequate amount of energy over a long period of time.



Renewable Sources of Energy

Renewable soure of energy	• They are inexhaustible. • They are being produced continuously in nature.

Non-Renewable Source of Energy

Non-Renewable soure of energy	They are exhaustible. They are not produced continuously in nature.

A good source of energy would be one which would:

- Do a large amount of work per unit volume or mass
- Be easy to transport from one place to aanother
- Be easily accessible
- Be economical

The materials which can be burnt to produce heat energy are known as **fuels**. Wood, coal, petrol, kerosene etc. are fuels.

Sources of energy can also be categorised as conventional sources of energy and non-conventional sources of energy.

Conventional Sources of Energy

The traditional sources of energy which are familiar to most people are known as conventional sources of energy.

The types of conventional sources of energy are

Fossil Fuel

Natural fuel formed deep under the Earth from the remains of living organisms is called **fossil fuel**. Coal, petroleum and natural gas are fossil fuels.

Thermal Power Plant

A thermal power plant generates electric power from heat produced by burning fossil fuels, i.e. coal and petroleum.

Hydro Power Plants

Hydropower plants utilise the kinetic energy of flowing water to generate electricity.

Bio-Mass

Biomass is the fuel obtained from dead parts of plants and waste material of animals.

This fuel does not produce much heat on burning and a large quantity of smoke is given out when it is burnt.

Biogas is obtained when cow dung, sewage and various plant materials (such as vegetable waste and residue of crops after harvesting) are decomposed in the absence of oxygen. It is popularly known as **gobar gas**.

Biogas contains 75% methane and hence is an excellent fuel.

Wind Energy

Air in motion is called **wind**.

It possesses kinetic energy. Thus, it can be used to produce electricity.

Windmills are used to generate electricity from wind energy.

A windmill is a simple machine with a structure similar to a large fan erected at some height. The rotatory motion of the windmill is utilized to run the turbine of the electric generator, thus producing electricity.

Non-Conventional Sources of Energy

Sources of energy which are not familiar to most people are known as non-conventional sources of energy.

The types of non-conventional sources of energy are

Solar Energy

The Sun is the most powerful source of radiation energy. It has been radiating energy for the past 5 billion years and will continue to do so for the next 5 billion years.

India receives approximately **5000 trillion kWh** of solar energy per year.

The **solar constant** is the solar energy reaching unit area at the outer edge of the Earth's atmosphere exposed perpendicularly to the rays of the Sun at an average distance between the Earth and the sun. Its value is approximately equal to **1.4 kJ per second per m^2** or **1.4 kW/m^2**.

A device which either uses solar energy directly as heat or converts it into electricity is called a **solar energy device.** For example, solar cooker, solar cell, solar water heater etc.

Energy from the Sea

Tidal Energy

Tidal energy is the energy derived from the rising and falling tides in the ocean. It is a renewable source of energy.

Wave Energy

Sea waves have both kinetic and potential energy as they rise and fall. The energy possessed by these waves is called **wave energy** and it is a renewable source of energy.

Ocean Thermal Energy

The energy available due to the difference in the temperature of water at the surface of the ocean and at deeper levels is called ocean thermal energy.

The Ocean Thermal Energy Conversion (OTEC) is the process of utilising OTE. The devices used for this purpose are called **OTEC power plants**.

Geothermal Energy

Geothermal energy is the heat energy from hot rocks present inside the Earth.
It is a source of energy which does not come directly or indirectly from solar energy.

Nuclear Energy

The energy obtained from the nucleus of an atom is called nuclear energy.
Nuclear fission is the phenomenon of splitting of an unstable nucleus of a heavy atom into two medium weight nuclei with the liberation of an enormous amount of energy
A nuclear reaction in which the particle which initiates the reaction is also produced during the reaction and it carries the reaction further is called a **nuclear chain reaction**.
An uncontrolled nuclear chain reaction is the basis of the **atom bomb** and a controlled nuclear chain reaction is the basis of a **nuclear power plant**.
Nuclear fusion is the phenomenon of combining two or more lighter nuclei to form a more stable heavy nucleus with the liberation of a large amount of energy.
Uncontrolled nuclear fusion is the basis of the **hydrogen bomb.**
The sum of the masses of products of a nuclear reaction is somewhat less than the sum of the masses of the reactants. The difference in mass appears as **mass defect (Δ m).** It is this mass defect which appears in the form of energy according to **Einstein's mass–energy relation, $E = (\Delta m)c^2$**.

Environmental Consequences

Factors to be kept in mind while choosing a source of energy are:

The economics of extracting energy from the source
The efficiency of the technology available
The damage to environment which will be caused by using that source

Some environmental consequences of the increasing energy demands are:

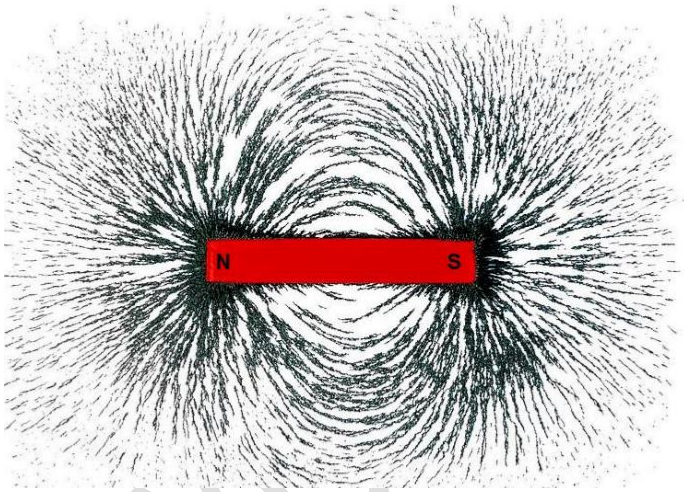
Burning fossils causes air pollution
Assembly of solar cell causes some environmental damage
The cutting down of trees from the forests causing soil erosion and destroys wild life

Magnetic Effects of Electric Current

Magnetic Field and Field Lines

The space around a magnet in which the force of attraction and repulsion caused by the magnet can be detected is called the **magnetic field**.

The curved paths along which iron filings arrange themselves due to the force acting on them in the magnetic field of a bar magnet are called **magnetic field lines**.



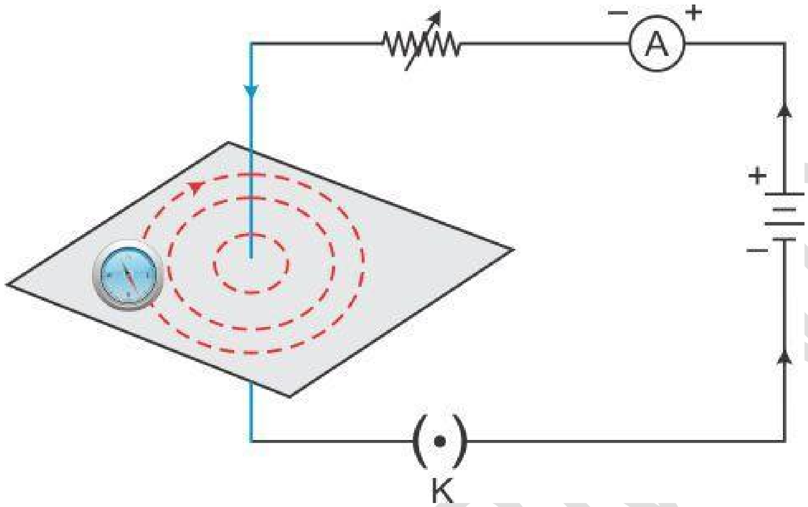
The direction of the magnetic field at any point is obtained by drawing a tangent to the field line at that point.

Properties of Magnetic Field Lines

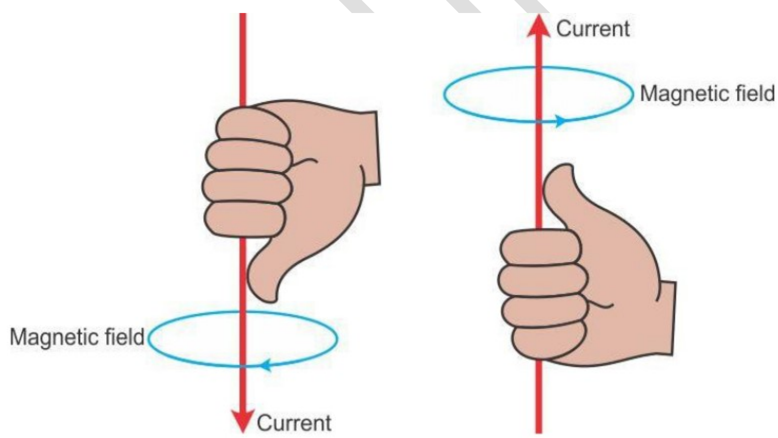
- A magnetic field line is directed from the North Pole to the South Pole outside the magnet.
- A magnetic field line is a closed and continuous curve.
- The magnetic field lines are closer where the magnetic field is strong and farther apart where the magnetic field is weak.
- The magnetic field lines never intersect each other.
- Parallel and equidistant field lines represent a uniform magnetic field.

Magnetic Field due to a Straight Current-carrying Conductor

The magnetic field lines around a straight conductor carrying a current are concentric circles.



The direction of a magnetic field is given by the **Right-Hand Thumb Rule.**



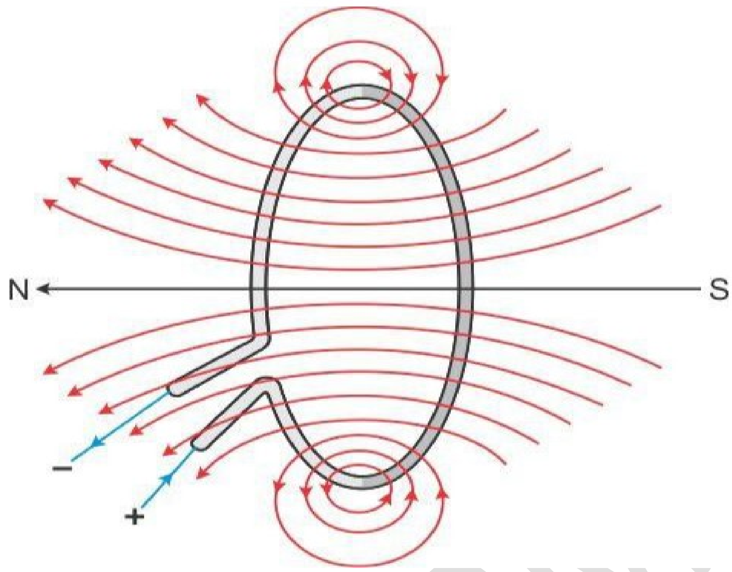
Right-Hand Thumb Rule:

Imagine that you are holding a straight current-carrying conductor in your right hand such that the thumb points towards the direction of the current. Then, your curved fingers wrapped around the conductor point in the direction of the field lines of the magnetic field.

The **magnitude of the magnetic field** due to a straight current-carrying conductor at a given point is ○ Directly proportional to the current flowing through the conductor

○ Inversely proportional to the distance of that point from the conductor

Magnetic Field due to a Current-carrying Circular Coil

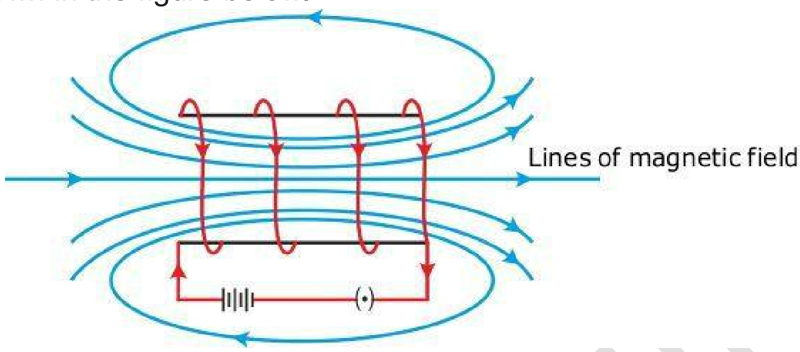


The magnetic field lines near the coil are nearly circular or concentric.
The magnetic field at the centre of the coil is maximum and almost uniform.
Looking at the face of a coil, if the current around it is in the clockwise direction, then it faces the South Pole. If the current around it is in the anticlockwise direction, then it faces the North Pole. This is called the **Clock rule.**

The **magnitude of a magnetic field** at the centre of the coil is
- Directly proportional to the current flowing through it
- Inversely proportional to the radius of the coil
- Directly proportional to the number of turns of the coil

Magnetic Field due to a Current-carrying Solenoid

The pattern of the magnetic field lines around a current-carrying solenoid is similar to that produced by a bar magnet as shown in the figure below.

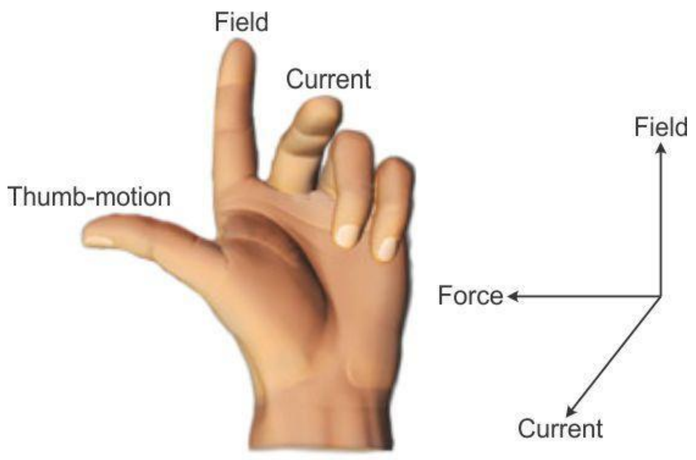


The magnetic field inside a solenoid is uniform.

The **magnitude of the magnetic field** inside the solenoid is directly proportional to the
- Current flowing through it
- Number of turns per unit length of the solenoid

Force on a Current-carrying Conductor in a Magnetic Field

A current-carrying conductor when placed in a magnetic field experiences a force.
The direction of the force gets reversed when the direction of the current is reversed or when the direction of the magnetic field is reversed.
The force acting on a conductor is found to be maximum when the current and magnetic field are at right angles to each other.
When the conductor is placed parallel to the magnetic field, no force acts on it.
Fleming's Left-Hand Rule gives the direction of the magnetic force acting on the conductor.



Fleming's Left-Hand Rule:

Stretch the thumb, forefinger and middle finger of the left hand such that they are mutually perpendicular to each other. If the forefinger points in the direction of the field, and the middle finger in the direction of the current, then the thumb gives the direction of motion or the force acting on the conductor.

The force experienced by a current-carrying conductor in a magnetic field is the underlying principle of an **electric motor** where electric energy is converted into mechanical energy. Such motors are used to run many electrical appliances, including fans, toys etc.

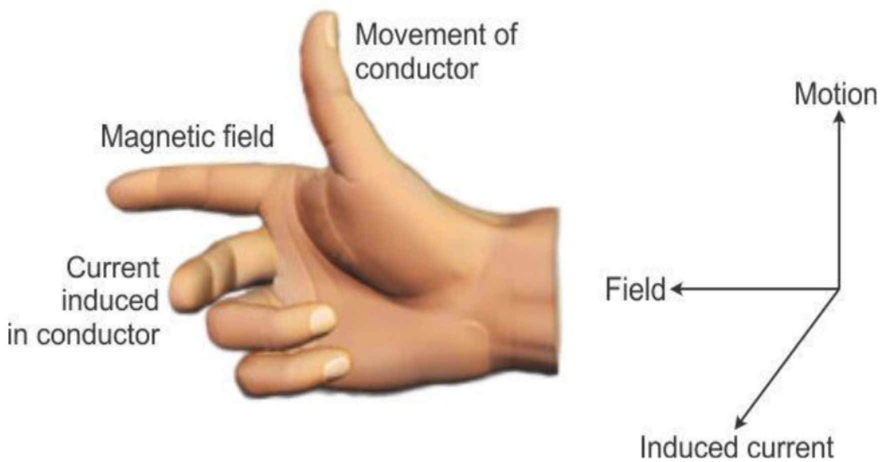
Electromagnetic Induction

The phenomenon of generating an electric current in a circuit (coil) by changing the magnetic flux linked with it is called **electromagnetic induction**.

The change in magnetic flux in a coil may be due to the

- Relative motion between the coil and the magnet placed near it.
- Relative motion between the coil and a current-carrying conductor placed near it
- Change of current in the conductor placed near the coil

Fleming's Right-Hand Rule is used to find the direction of induced current.



Fleming's Right-Hand Rule:

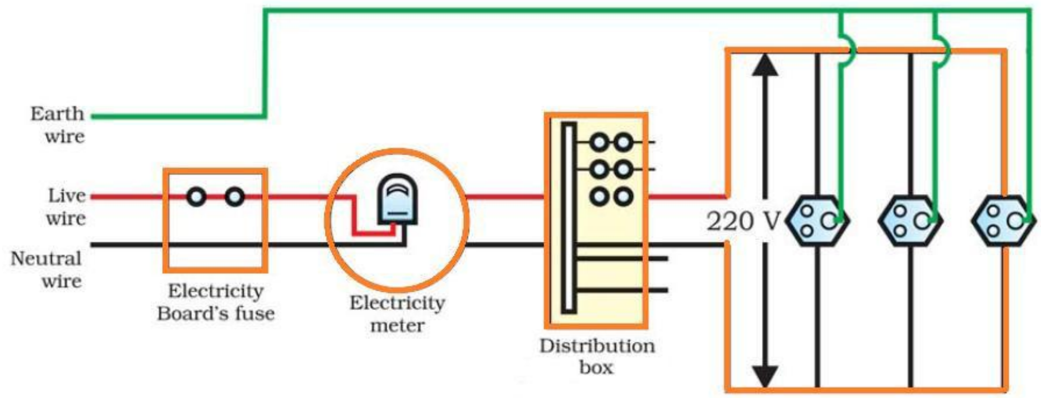
Stretch the thumb, forefinger and middle finger of the right hand such that they are mutually perpendicular to each other. If the forefinger points in the direction of the field and the thumb in the direction of the motion of the conductor, then the middle finger gives the direction of the induced current in the conductor

Electric Generator

The electric generator is based on the principle of **electromagnetic induction** and converts mechanical energy into electrical energy.
There are two types of generators:
○ AC generator producing a current which periodically changes its direction ○
DC generator producing a current which always flows in the same direction
An **AC generator** can be changed into a **DC generator** by replacing the slip-ring arrangement with the split-ring (commutator) arrangement

Domestic Electric Circuits

In our homes, we receive electric power through a main supply called the **mains**. We receive an AC electric power of 220 V with a frequency of 50 Hz.
One of the wires in the electricity wiring of houses has a red insulation and is called the **live wire**. The other, of black insulation is called the **neutral wire**. The third is the **earth wire** which has green insulation and is connected to a metallic plate deep inside the Earth.



The earth wire in wiring is used as a safety measure to ensure that any leakage of current in the metallic body does not give the user a severe shock.
A **fuse** is an important safety device used to protect circuits and appliances from **short-circuiting** (which occurs when a live wire and a neutral wire come in contact) or **overloading** (which occurs when an electric circuit draws more current than the permitted value).