



NCERT

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(English)

General Science



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NCERTs

Science

Year 2025-26

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Introduction

As we all know that we could see the object just because of the light. An object reflects light that falls on it. And this reflected light, when received by our eyes, enables us to see things. Light is the form of energy that provides sensation of vision. Some common phenomena associated with lights are image formation by mirrors, the twinkling of stars, the beautiful colour of a rainbow, bending of light by a medium and so on.

Properties of Light

1. Light is an electromagnetic wave.
2. Light travels in a straight line.
3. Light is a transverse wave, and does not need any medium to travel. Light can travel through vacuum. Its speed through vacuum is 3×10^8 m/s.
4. The velocity of light changes when it travels from one medium to another.
5. The wavelength (λ) of light changes when it goes from one medium to another.
6. The frequency (f) of the light wave remains the same in all media.
7. Light gets reflected back from polished surfaces, such as mirrors, polished metal surfaces, etc.
8. Light undergoes refraction (bending) when it travels from one transparent medium to another.
9. Light does not need a material medium to travel, that is, it can travel through a vacuum too. Scientists have assigned a value of 299,792,458 m/s to the speed of light in vacuum.
10. According to current scientific theories, no material particle can travel at a speed greater than that of light in vacuum.

When light falls on a surface, following may happen:

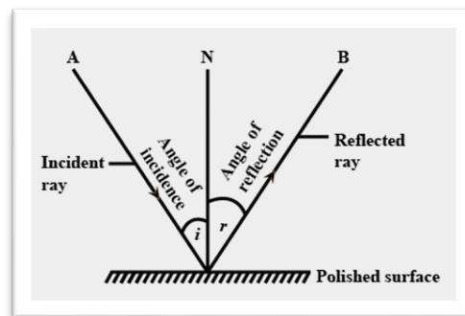
1. Reflection
2. Refraction
3. Absorption

What is Reflection?

Reflection is a phenomenon when light strikes on a polished surface and bounces back is called the Reflection of light.

Laws of Reflection of Light-

- a. The angle of incidence is equal to the angle of reflection, and
- b. The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.
- c. The Incident and reflected ray are on opposite sides of the normal.

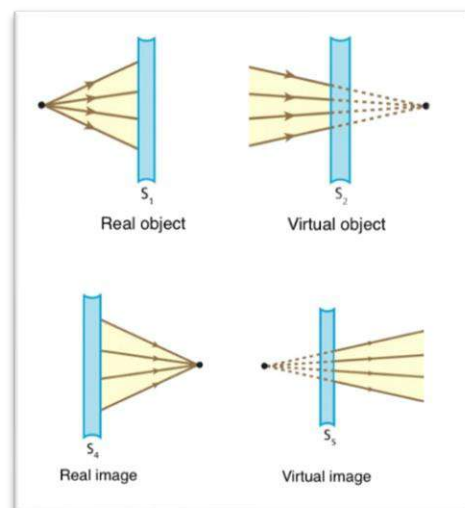


Note- These laws of reflection are applicable to all types of reflecting surfaces including spherical surfaces.

Virtual and Real Image

Image is a point where at least two light rays actually meet or appear to meet.

Real Image	Virtual Image
Light rays actually meet to form a real image	Light do not actually meet to form a virtual image
The image is generally inverted	The image is generally erect
Image can be obtained on the screens	Image cannot be obtained on the screen.
This image is in front of mirror and behind of the lens.	This image is behind the mirror and in front of the lens.
Real images can be formed on a screen	Virtual images cannot be formed on screen.



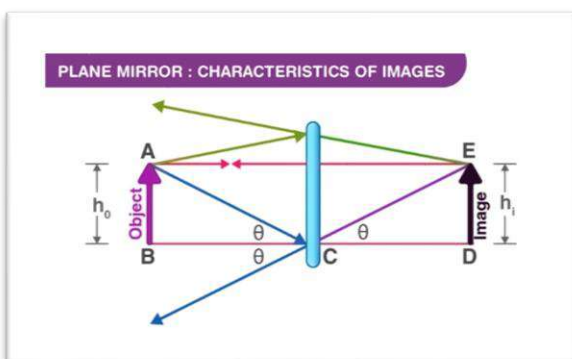
Types of reflection

Regular Reflection	Diffused Reflection
When parallel rays of light fall on a smooth surface, they are reflected back as parallel rays only. This is called regular reflection.	When parallel rays of light fall upon an irregular surface, they are reflected back into all the directions. This is called diffused reflection.
It is also called specular reflection.	It is also called irregular reflection.
It leads to the formation of an image.	It enables us to view different objects present in our environment.
For example, the image formed by a plane mirror.	For example, the reflection of rays of light through a wall

Image formed by Plane mirror

The most widely used mirrors are plane mirrors. The image formed by a plane mirror is a reflected image in its normal proportions but reversed from left to right.

Let us suppose an image is formed by a plane mirror as given below:



Characteristics of image formed by a plane mirror-

1. It is virtual, i.e., it is formed behind the mirror without the actual intersection of light rays.
2. It is erect, which means up straight.
3. The image is laterally inverted, i.e., it is reversed from left to right.
4. The size of the image is the same as the size of the object, $h_i = h_o$.
5. The distance of the object from the plane mirror is the same as the distance of the image from the plane mirror, i.e., $BC = CD$

What is Lateral Inversion?

Lateral inversion" means the apparent reversal of the mirror image's left and right when compared with the object. "Lateral" just means "sideways". ... In a plane mirror, each point on the image is as far behind the mirror plane as the corresponding point on the object is in front.

- **Illuminated objects-** Objects that do not produce light on their own but reflect the light that falls upon them are called illuminated objects. For example, the moon.
- **Luminous object-** Objects which can produce light on their own are called luminous objects. For example, tube light, bulb, the Sun and the Stars.

Application of lateral inversion

The word AMBULANCE is written in reverse direction so that it can be read correctly in rear view mirror of vehicles going in front of it.



Reflected light can be reflected again

Multiple reflections can be obtained by placing more than one mirrors at certain angles to each other which results in reflection of light for multiple times between the reflecting surfaces. This phenomenon is used in certain scenarios such as:

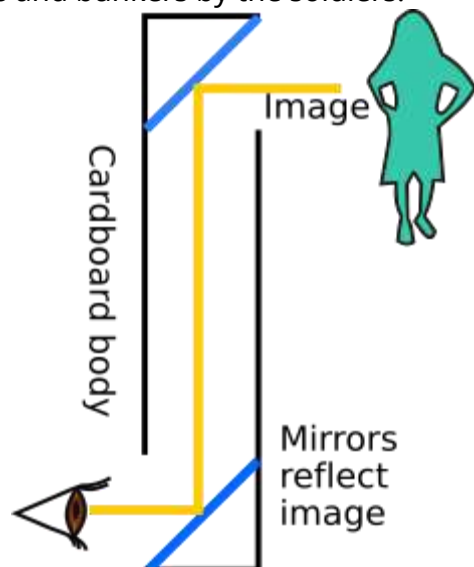
1. In a Periscope to see hidden objects
2. In a kaleidoscope to see beautiful patterns
3. In a barbershop to see the back of the head of a person getting a haircut

Let's explain each in short

Periscope

- A Periscope is an instrument that is used to look at objects that are not in the line of sight of the observer.
- In other words, it is used to see objects that are hidden.

- The Periscope works on the phenomena of multiple reflections of light.
- Inside the periscope, there are two mirrors that are inclined at an angle of 45°
- Periscopes are generally used in submarines, tanks and bunkers by the soldiers.



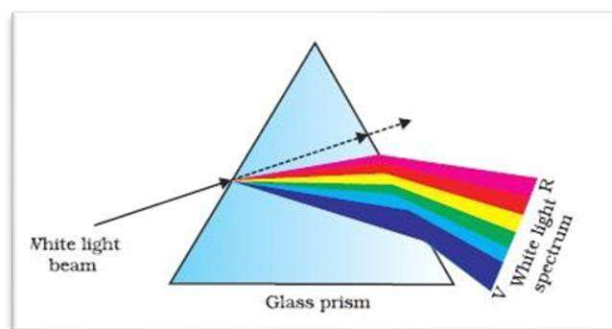
Kaleidoscope

- It is a device that works on the phenomena of multiple reflections with the help of multiple mirrors.
- It has a cylindrical structure with three plane mirrors inside it.
- It contains several pieces of beads, broken glass, colourful bangles, pebbles etc.
- The observer can look into the Kaleidoscope from one end and the light enters into the Kaleidoscope from the other end.
- When the light falls upon these objects in the Kaleidoscope, multiple reflections of these objects are created in the three Mirrors.
- This results in the formation of beautiful and colourful patterns.
- Since the reflection of light is not always the same the observer never sees a similar pattern in the kaleidoscope.

Sunlight- white or coloured

- The sun is the biggest source of light on the earth.
- The sunlight is white in colour however this white light often disperses into several colours which results in different colours of the sky at different times of the day.

- The white light consists of seven colours namely VIBGYOR (violet, indigo, blue, green, yellow, orange and red).
- This arrangement of seven colours of a white light is called as Spectrum.
- All these colours mixed together and form the white light. However, due to the reflection of light, the seven colours can split and be seen as separate colours rather than a single white light.
- This phenomenon of the splitting of light into its constituents is called **Dispersion of light**.

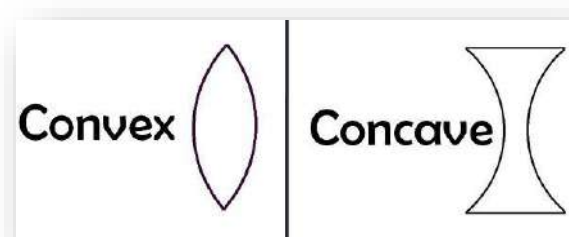


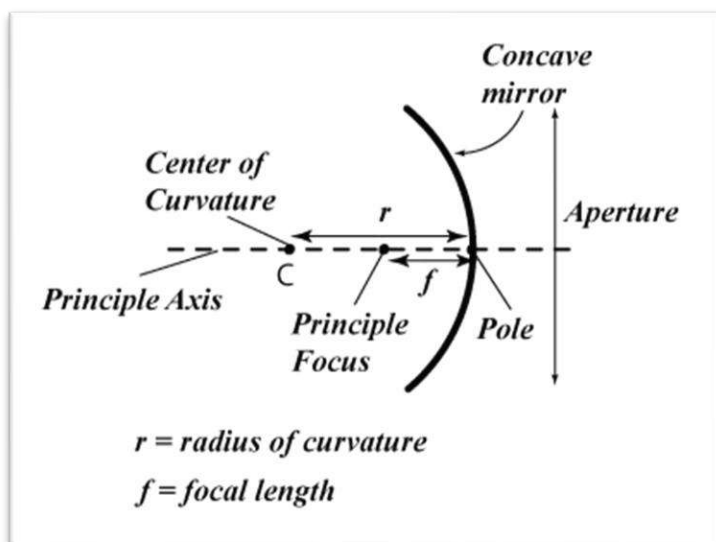
Some of the notable examples of Dispersion of light

- Formation of rainbow due to the dispersion of white light through the water droplets.
- Passing of Sunlight through a prism
- Dispersion of light through the soap Bubbles
- Dispersion of light on the CDs

Spherical mirrors

- Spherical mirrors are those type of mirrors whose reflecting surfaces are curved
- Reflecting surface of a mirror can be curved inwards or curved outwards.
- There are two types of spherical mirrors-
 - **Concave mirror**- the one which is curved inward is known as concave mirror.
 - **Convex mirror**- the one which is curved outward is known as a convex mirror
 - Some important terms used in spherical mirrors





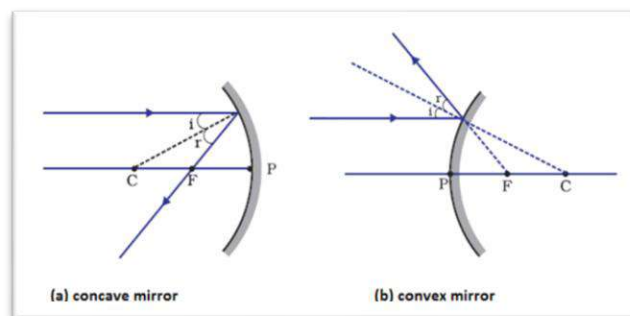
- **Pole-** The centre of the reflecting surface in a spherical mirror is a pole. It is represented by P.
- **Centre of curvature-** Reflecting surface in a spherical mirror has a centre, this is known as centre of curvature. Centre of curvature in convex mirror lies behind the mirror whereas in concave mirror, it lies in front of the mirror. For a concave mirror, it lies in front of the mirror (on the same side as the object). For a convex mirror, it lies behind the mirror (on the opposite side of the object).
- **Radius of curvature-** The radius of the reflecting surface of the spherical mirror is known as radius of curvature. It is represented by R.
- **Principal axis-** Straight line passing through the pole and centre of curvature in a spherical mirror is known as principal axis.
- **Principal focus-** The reflected rays appear to come from a point on the principal axis, this is known as principal focus.
- **Focal length-** The distance between the pole and the principal focus in a spherical mirror is known as focal length and it is represented by f. It is half of the radius of curvature:
- **Aperture-** The diameter of the reflecting surface is defined as aperture. It determines the amount of light the mirror can capture.

Note- Radius of Curvature is twice the focal length ($R=2F$)

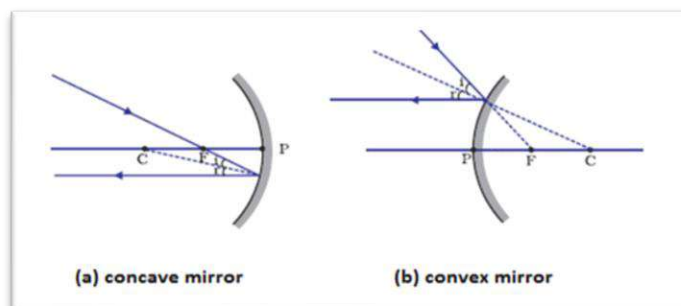
Representation of the images formed by Spherical Mirrors using Ray Diagrams

We draw the ray diagram to locate the image of an object formed. The intersection point of at least two reflected rays will give the position of image of the point object. The two rays that can be used to draw the ray diagram are-

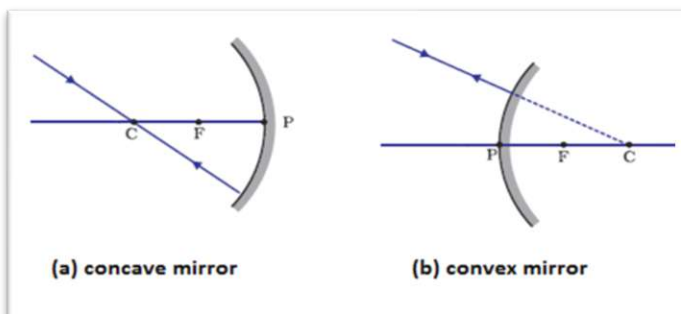
- A ray parallel to the principal axis** should pass through the focus after reflection in case of concave mirror, or appear to diverge in case of convex mirror.



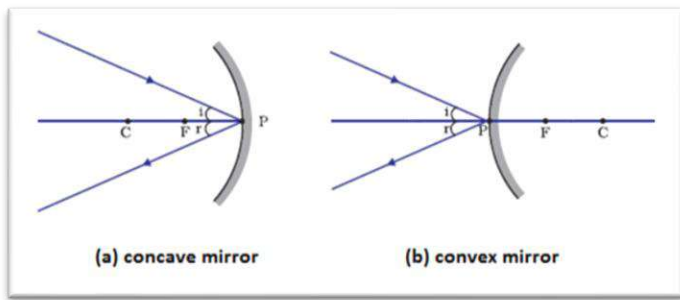
- A ray passing through the focus** of the concave mirror or directed towards the focus in case of convex mirror, should appear parallel to the principal axis after reflection.



- A ray which is passing through the centre of curvature** in a concave mirror or directed in case of convex mirror, should reflect along the same path.



- A ray when incident obliquely to principal axis** on a concave or convex mirror is also reflected obliquely.



- Flashlights
- Dental Mirror
- Microscopes
- Telescopes
- Makeup mirrors

Why we use concave mirrors?

These mirrors give a magnified reflection of the object that means the image in the mirror is larger, brighter, and, for the dentist, easier to see. Also, without these mirrors, we may miss out on various treatable problems, such as RCT (root-canal-therapy), as these mirrors give a magnified view of the mouth that helps the dentist perform various teeth operations easily.

So Recap Some Properties of Concave Mirrors The properties of concave mirrors are given below:

- They can produce both real and virtual images.
- They become upright when they produce a virtual image.
- The image is inverted if it produces a real image.
- The image of the object can be reduced, enlarged, or of the same size as the object based on the distance between the object and the mirror.

Image formation by Convex Mirrors

Two positions of the object are considered while understanding the image formed by convex mirror. Either the object should be at infinity or at finite distance from the mirror. Formation of the image by the convex mirror are as follows-

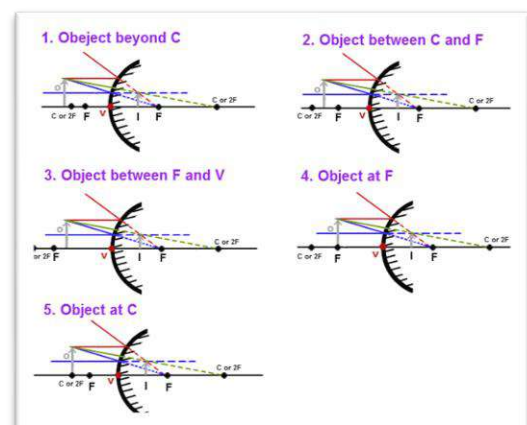
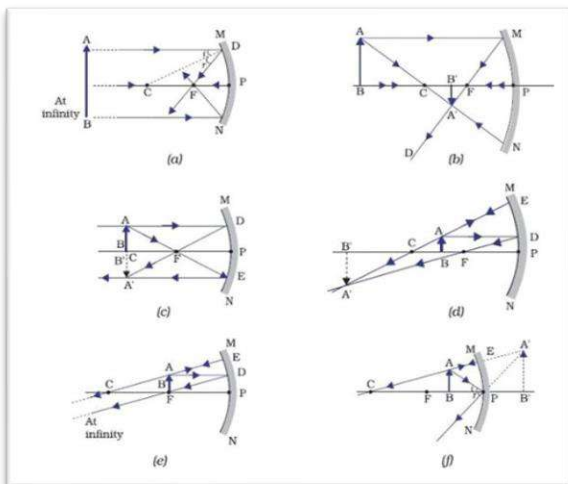


Image formation by Concave Mirror

Position on the objects	Position on the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly diminished	Real and inverted
Beyond c	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect



Position, nature, and the size of the image formed by a concave mirror is dependent on the position of the object in relation to P, C and F. Image formed can be real or virtual. The image can also be magnified, diminished or even of the same size.

Uses of Concave Mirror

- Used in Vehicle headlights
- Shaving mirrors
- Solar furnaces
- Searchlights
- Torches

Position of the Object	Position of the Image	Size of the Image	Nature of the Image
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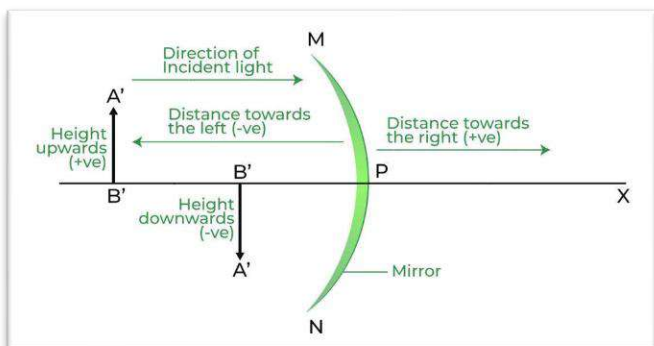
At infinity	At the focus f, behind the mirror	Highly diminished	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and Erect

Uses of Convex Mirrors

- Convex mirrors are used as a rear view mirrors in vehicle because
 - They always give an erect though diminished image.
 - They have a wider field of view as they are curved outwards.
- Convex mirrors are used at blind turns and on points of merging traffic to facilitate vision of both side traffic.
- Used in shops as security mirror.

Sign convention for Reflection by Spherical Mirror

- The object is placed to the left of the mirror.
- All distances parallel to the principal axis are measured from the pole of the mirror.
- All distances measured in the direction of incident ray (along + x-axis) are taken as positive and those measured against the direction of incident ray (along -X-Axis) are taken as negative.
- Distances measured perpendicular to and above the principal axis are taken as Positive
- Distances measured perpendicular to and below the principal axis are taken as negative.



- The distance of the object from its pole is known as object distance (u), whereas distance from the pole of the mirror is known as image distance (v). The mirror formula is given by-

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

- It is applicable for spherical mirrors in all positions of the object

Magnification of Spherical Mirrors

It is defined as relative extent to which an object is magnified in comparison to its object size.

$$m = \frac{h_i}{h_o} = -\frac{v}{u}$$

Simply it is the ration of the height of image to the height of object.

- m- height of image/ height of object
 - $m = h_i/h_o$, also $m = -v/u$
- if m is negative, image is real
- if m is positive, image is virtual
- If $h_i = h_o$ then $m = 1$, i.e., image is equal to object.
- If $h_i > h_o$ then $m > 1$ i.e., image is enlarged.
- If $h_i < h_o$ then $m < 1$ i.e., image is diminished.

Magnification of plane mirror is always + 1.

- '+' sign indicates virtual image.
- '1' indicates that image is equal to object's size.
- Produces real, inverted images $\rightarrow m < 0$
- Can produce virtual, erect, enlarged images if the object is very close (within focal length) $\rightarrow m > 1$

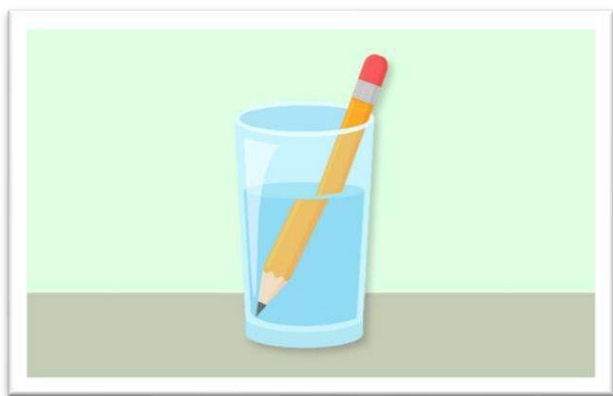
Refraction

What is Refraction?

Bending of the light rays as it passes from one medium to another medium is known as refraction of light. The main cause of refraction is change in speed of light. Speed of light is maximum in vacuum. It is 3×10^8 m/s.

Some of the Example of Refraction

- The bottom of swimming pool appears higher.
- A pencil partially immersed in water appears to be bent at the interface of water and air.



- Twinkling of stars in a clear sky.
- Rainbow formation in the sky
- Lemons placed in a glass tumbler appear bigger.
- Letters of a book appear to be raised when seen through a glass slab.

Laws of refraction?

- Incident ray, refracted ray and normal all lie in the same plane.
- The ratio of sine of angle of incidence to the sine of angle of refraction is constant. This law is also known as Snell's law of refraction.

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

What is refractive index?

- When light passes from one medium to another medium, it changes its direction. The extent to which the direction changes is expressed in terms of refractive index. The value of refractive index is dependent on the speed of light in two media. v_1 is the speed of light in medium 1 and v_2 is the speed of light in medium 2. **The refractive index of medium 2 with respect to medium 1 is represented as n_{21} .**

$$n_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$$

- If medium 1 is vacuum or air, then the refractive index of medium 2 with respect to vacuum is known as **absolute refractive index of the medium.**

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in the medium}} = \frac{c}{v}$$

- Where c is the speed of light in air, v is the speed of light in other medium and n_m is the refractive index of the medium.
- Refractive index of diamond is the highest. It is 2.42.
- Optically denser medium- Out of two given media, the medium with higher value of refractive index.
- Optically rarer medium: Out of two given media, the medium with lower value to refractive index

Physical significance of refractive Index-

The refractive index of a medium gives the following two information's:

- The value of refractive index gives information about the direction of bending of refracted ray. It tells whether the ray will bend towards or away from the normal.
- The refractive index of a medium is related to the speed of light. It is the ratio of the speed of light in vacuum to that in the given medium. For example, refractive index of glass is $3/2$. This indicates that the ratio of the speed of light in glass to that in vacuum is 2: 3 or the speed of light in glass is two-third of its speed in vacuum.

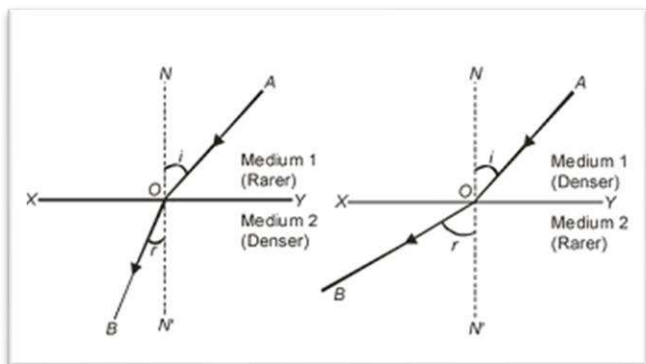
The absolute refractive index of some material media are as follows-

Material medium	Refractive Index	Material Medium	Refractive index
Air	1.0003	Canada Balsam	1.53
Ice	1.31	Rock salt	1.54
Water	1.33	Carbon disulphide	1.63
Alcohol	1.36	Dense Flint glass	1.65
Kerosene	1.44	Ruby	1.71
Fused quartz	1.46	Sapphire	1.77
Turpentine oil	1.47	Diamond	2.42
Benzene	1.50	Crown glass	1.52

The direction of bending of light

The two rules which give the direction of bending of a ray of light when it goes from one medium to another are as follows:

- When a ray of light goes from a rarer medium to a denser medium, it bends towards the normal at the interface of the two media.
- When a ray of light goes from a denser medium to a rarer medium, it bends away from the normal at the interface of the two media.

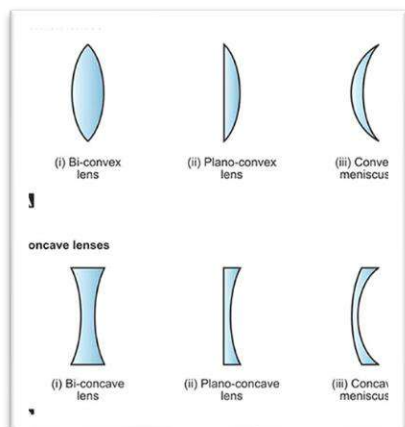


What are Spherical lens?

Lenses are defined as transparent materials which are bounded by two surfaces, out of which one or both can be spherical. When both the two spherical surfaces bulge outwards, it is known as **convex lens**. They converge the light rays. When the two spherical surfaces bulge inwards, they are known as **concave lens**. They are known as diverging lens. The centre of these spherical surfaces is known as centre of curvature, represented by C.

Any imaginary straight line passing through the centre of curvature of a lens is known as **principal axis**. The centre point is known as **optical centre**. The effective diameter of the spherical lens is known as **aperture**.

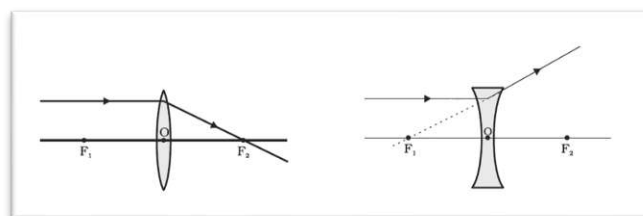
Convex lens	Concave lens
Thin from corners	Thick from corners
Thick at centre	Thin at centre
Converging	Diverging



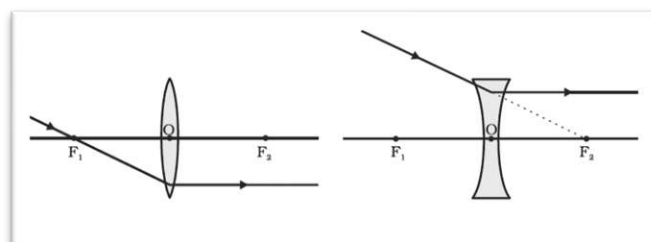
Rules for image formation by lenses using ray diagrams

Rules for drawing the ray diagrams are as follows-

1. **A ray of light which is parallel to the principal axis** will pass through the principal focus after refraction from the convex lens.



2. **A ray of light passing through principal focus**, will emerge parallel to principal axis after refraction from the convex lens.



3. **A light ray passing through optical centre** will emerge out without any deviation.

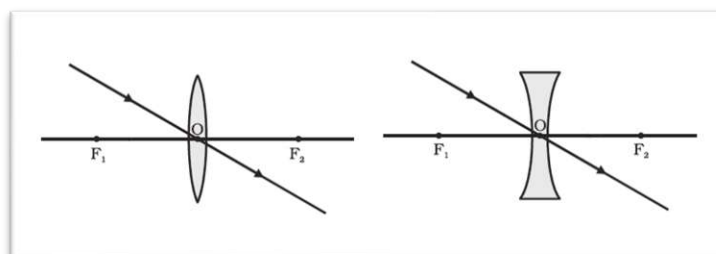


Image formation by lenses

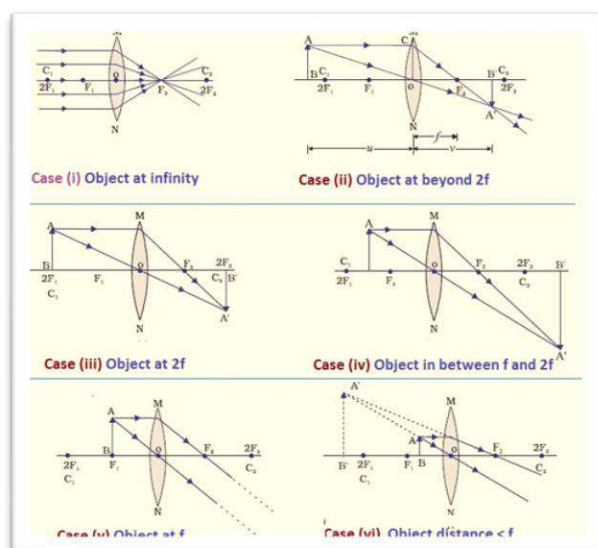
Nature, relative size, and position of the image formed by convex lens are given below in the form of table-

Position of the Object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F2	Highly diminished	Real and inverted
Beyond 2F1	Between F2 and 2F2	Diminished	Real and inverted
At 2F1	At 2F2	Same size	Real and inverted
Between F1 and 2F1	Beyond 2F2	Enlarged	Real and inverted
At focus F1	At infinity	Infinitely large	Real and inverted

Between focus F_1 and optical centre O .	On the same side of the lens as the object.	Enlarged	Virtual and erect
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$$m = \frac{h_i}{h_o} = \frac{v}{u}$$

Image formed by the Convex Lens for various positions of the object

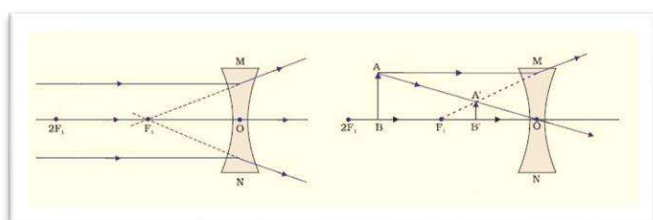


Power of a Lens

The degree of convergence or divergence of light rays is expressed in terms of power. So, the reciprocal of focal length is known as its power. It is represented by letter P . The power is given by-
 $P = 1/f$

The SI unit of power is dioptre. It is represented by D . Power of concave lens is negative and power of convex lens is positive.

Image formed by Concave lens



Sign convention for Spherical lenses

- Sign conventions are similar to the one used for spherical mirrors, except that measurements are taken from optical centre of the lens.

Lens formula and magnification

The lens formula is given as

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

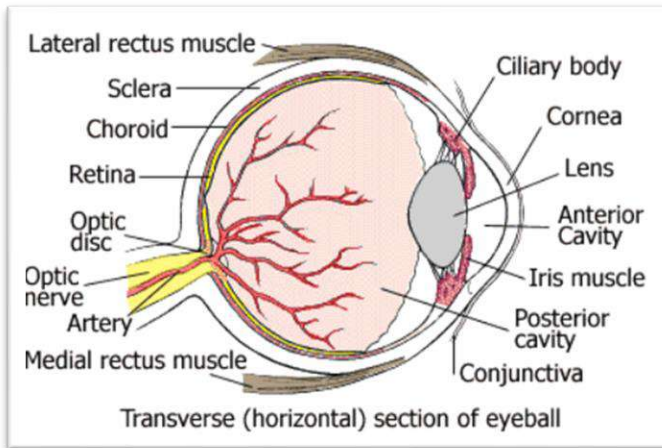
Where, u is object distance, v is image distance and f is focal length.

The ratio of the height of an image to the height of an object is defined as magnification.

Magnification is represented by m , h_o is the height of the object and h_i is the height of the image.

Introduction

The human eye is one of the most valuable and sensitive sense organs, which enable us to see the colourful world around us. It is just like a photographic camera. The lens system of the eye forms an image of the object on a light sensitive screen.



Structure and working of Human Eye-

The human eye has the following parts:

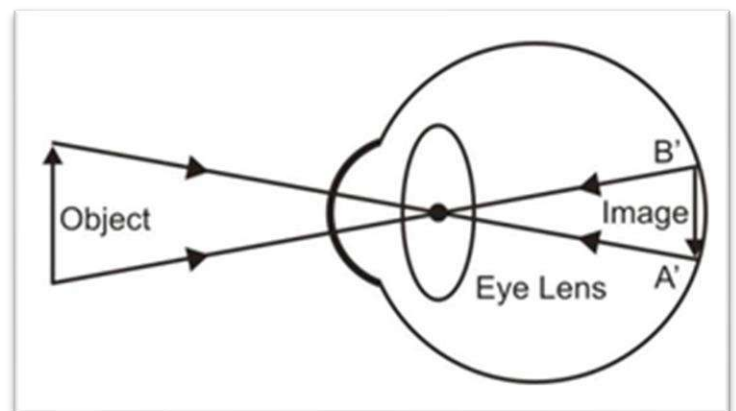
- **Cornea:** It is the transparent spherical membrane covering the front of the eye.
- **Iris:** It is the coloured diaphragm between the cornea and lens.
- **Pupil:** It is the small hole in the iris.
- **Eye lens:** it is a transparent lens made of jelly like material.
- **Ciliary muscles:** These muscles hold the lens in positions.
- **Retina:** It is the back surface of the eye.
- **Blind spot:** It is the point at which the optic nerve leaves the eye. An image formed at this point is not sent to the brain.
- **Aqueous humor:** It is clear liquid region between the cornea and the lens.
- **Vitreous humor:** The space between eye lens and retina is filled with another liquid called vitreous humor. In the eye, the image is formed on the retina by successive refractions at the cornea, the aqueous humor, the lens and the vitreous humor. Electrical signals then travel along the optic nerve to the brain to be interpreted. In good light, the yellow spot is (macula lutea) most sensitive to detail and the image is automatically formed there.

The following table lists the main parts of the human eye and their respective functions.

Human Eye Part	Functions
Pupil	Opens and closes in order to regulate and control the amount of light.
Iris	Controls light level similar to the aperture of a camera.
Sclera	Protects the outer coat.
Cornea	A thin membrane which provides 67% of the eye's focusing power.
Crystalline lens	Helps to focus light into the retina.
Conjunctive	Covers the outer surface (visible part) of the eye.
Aqueous humour	Provides the eye with its form and shape
Retina	Captures the light rays focussed by the lens and sends impulses to the brain via the optic nerve.
Optic nerve	Transmits electrical signals to the brain.
Ciliary muscles	Contracts and extends in order to change the lens shape for focusing.

Working of the Human Eye

Light rays coming from the object to be seen can enter the eye through pupil and fall on the eye lens. The eye lens being convex, forms a real and inverted image on the retina. The light sensitive cell of the retina gets activated upon illumination and generate electric signals. These signals are sent to the brain via the optic nerve. The brain interprets these signals and finally gives rise to the sensation of vision.



The Function of Iris and Pupil

The iris adjusts the size of the pupil according to the intensity of light received by the eye. The pupil regulates and controls the amount of light entering

the eye. When the intensity of outside light is high, the pupil contracts so that less light enters the eye. When the intensity of the outside light is low, the pupil expands so that more light enters the eye and we can see properly.

Vision decreases with the time/age

- Normally a person can see distant and nearby objects through the eyes.
- A person with normal eyes can read most comfortable at a distance of 25cm. However, this distance can decrease with age.
- Also sometimes people can see far objects clearly but not the objects that are nearby (**farsightedness or hyperopia**).
- Similarly, some people can see the nearby objects clearly but not the far objects (**near-sightedness or myopia**). Hence they use suitable lenses to correct such defects.
- Sometimes with old age, the lens of the eye can become cloudy or foggy. This condition is called **cataract** with results in loss of vision.
- However, this defect can be rectified by removing the old lens from the eye and inserting an artificial lens at that place.

Note- Blind spot - There is a point in the eye located at the junction of the retina and the optic nerve where no sensory cells are present. This spot is therefore called the blind spot as it does not support any vision.

How one should take care of eyes?

- One should go for a regular eye check-up.
- Wear spectacles if the eyesight is found weak.
- Always study or watch TV in a sufficient light. Excess or insufficient light both can lead to problems. Insufficient light can cause strain and leads to a headache.
- Do not look at the sharp source of light like the sun directly. Excess of light can damage the eyes.
- If dust enters into the eye one should not rub them and rather wash them straightway.
- Maintain a normal distance while reading or watching TV.
- Take a balanced diet to ensure that you get the right nutrients.

Night Blindness

- Night blindness also called **nyctalopia** is a defect in the vision in which people cannot view things properly in dim light or at night.
- It mainly occurs due to the lack of vitamin A in our body. Hence we should always take foods that are rich in vitamin A such as broccoli, green vegetables, carrot, milk, eggs, curd, papaya, mango etc.

How can visually impaired people read and write?

- Visual impairment is also known as vision loss.
- A person with vision loss cannot see at all.
- This loss of vision is up to a degree that cannot be corrected using usual means like using glasses or lenses.
- The people who have no eyesight at all develop the other senses of listening and touching sharply which allows them to do their day to day activities.

Some resources which helps to such people

Non- optical aids

1. **Visual aids-** They are used to magnify words ensuring appropriate intensity of light falls upon the eyes so that the person can recognize the word.
2. **Tactual aids (using sense of touch)** - They include Braille writer Slate and Stylus which allow a person to read and write.
3. **Auditory Aids (using sense of listening)** - They include devices like audio tapes, talking books etc.
4. **Electronic Aids-** They include talking calculators and computers, closed circuit televisions, audio CDs, that can help visually challenged people in listening and writing.

Optical aids

1. **Bifocal lenses-** they all are used to rectify the limitations of the eyes.
2. **Contact lenses-** they all are used to rectify the limitations of the eyes.
3. **Tinted lenses-** they all are used to rectify the limitations of the eyes.
4. **Magnifiers-** they all are used to rectify the limitations of the eyes.

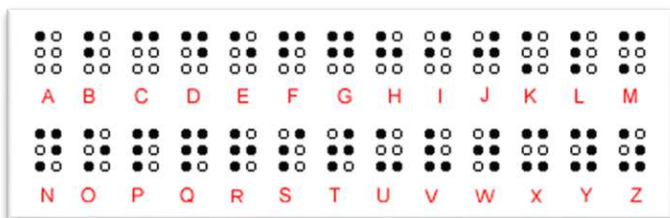
5. Telescopic Aids(they are used to view the chalkboard and class demonstrations)

Best innovation of time- Braille system

- Braille is a tactual aid for visually challenged people that allow them to read and write.
- It was developed by a visually challenged person called **Louis Braille**. This system was published by him in 1821 however the present Braille System was adopted in 1932.
- For many common languages including Hindi, Sanskrit, Tamil, Telugu, Mathematics and scientific notations a Braille code is present.
- In the Braille code, there are **63 Dots or 63 Characters**.
- These are arranged in a cell of two vertical rows having three dots each.
- The patterns are embossed on a Braille Sheet that allows a person to read by touching the pattern. Each

character in the Braille system can represent:

1. a letter
2. a combination of letters or a word
3. a grammatical sign



Note- eyes of some animals have different shape

- 1. Crab:** Crabs have small eyes but they can look all around with them even behind them.
- 2. Butterflies:** Butterflies have big eyes that consist of thousands of small eyes which allow them to see in the front and at the back.
- 3. Night owls (Night Birds):** Night owls are able to see things more clearly in the night rather than day time. This is so because the cornea of their eyes is large with a large pupil which allows light to enter into the eye at night time. However, their eyes have a large number of rod cells rather than cones that allow them to see the things at night easily.
- 4. Kites and Eagles (Day Birds):** These birds can see very well during daytime but have

decreased vision at night. This is because they have a large number of cone cells and a few rod cells.

What is Power of Accommodation?

The image of the objects at different distances from the eye are brought to focus on the retina by changing the focal length of the eye-lens, which is composed of fibrous jelly-like material, can be modified to some extent by the ciliary muscles.

Ciliary muscles can do two distinct actions -

Relaxed ciliary muscles	Contract Ciliary muscles
Eye lens become thin	Eye lens become thick
Increase the focal length	Decrease the focal length
Enable us to see distant object clearly	Enable us to see nearby object clearly

Near Point and Far Point

- The nearest point at which a small object can be seen distinctly by the eye is called the near point. For a normal eye, it is about **25 cm** and is denoted by the symbol D.
- With advancing age, the power of accommodation of the eye decreases at the eye lens gradually loses its flexibility. For most of the old persons aged nearly 60 years, the near point is about 200 cm and corrective glasses are needed to see the nearby objects clearly.
- The farthest point up to which our eye can see objects clearly, without any strain on the eye is called the far point. For a person with normal vision, the far point is at **infinity**.

Least Distance of distinct Vision

The minimum distance of an object from the eye at which it can be seen most clearly and distinctly without any strain on the eye, is called the least distance of distance of distinct vision. For a person with normal vision, it is about 25 cm and is represented by the symbol D, i.e.

Least distance of distinct vision = D = 25 cm

Persistence of Vision

- The image formed on the retina of the eye does not fade away. Instantaneously, when the object is removed from the sight. The impression (or

sensation) of the object remains on the retina for about $(1/16)^{\text{th}}$ of a second, even after the object is removed from the sight. This continuance of the sensation of eye is called the **persistence of vision**.

- Let a sequence of still pictures is taken by a movie camera. If the sequence of these still pictures is projected on a screen **at a rate of 24 images or more per second** then the successive impression of the images on the screen appear to blend or merge smoothly into one another. This is because an image (or a scene) on the screen appears just before the impression of previous image on the retina is lost. Hence, the sequence of images blend into one another giving the impression of a moving picture. This principle is used in motion picture projection or in cinematography.

Colour Blindness

- The retina of our eye has large number of **light sensitive cells** having shapes of rods and cones. The rod-shaped cells responds to the intensity of light with different of brightness and darkness were as the cone shaped cells respond to colour. In dim light rods are sensitive, but cones are sensitive only bright. The **cones** are sensitive to **red, green and blue** colour of light to different extents.
- Due to genetic disorder, some persons do not possess some cone-shaped cells that responds to certain specific colours only. Such persons cannot distinguish between certain colour but can see well otherwise. Such persons are said to have colour-blindness. Driving licenses are generally not issued to persons having colour-blindness. (most common type: red-green color blindness)

Colour Perception of Animals

- Different animals have different colour perception due to which different structure of rod shaped cells and cone shaped cells. For example, bees have some cone-shaped cells that are sensitive to ultraviolet. Therefore bees can see objects in ultraviolet light and can perceive colours which we cannot do.

- Human beings cannot see in ultraviolet light as their retina do not have cone-shaped cells that are sensitive to ultraviolet light.
- The retina of chicks have mostly cone shaped cells and only a few rod shaped cells. As rod shaped cells are sensitive to bright light only. Therefore, chicks wake up with sunrise and sleep in their resting place by the sunset.

Cataract

- Sometimes due to the formation of a membrane over the crystalline lens of some people in the old age, the eye lens becomes hazy or even opaque. This is called cataract. It results in decrease or loss in vision of the eye. Cataract can be corrected by surgery leading to normal vision.

Defects of Vision and their corrections

The ability to see is called vision. Sometimes the eye may gradually lose its power of accommodation. As a result, the eye of a person cannot focus the image of an object on the retina properly. In such cases, the vision of a person becomes blurred. As a result, he cannot see either the distant objects or nearby objects or both clearly and comfortably. The person is said to have defects of the eye. These defects of the eye are also known as the defects of vision or refractive defects of vision or the optical defects of the eye.

Following are the four common defects of vision

- Myopia or short-sightedness
- Hypermetropia or long-sightedness
- Presbyopia
- Astigmatism

Let's explain each in details

- **Myopia or short-sightedness**
- Myopia or short-sightedness is also known as near-sightedness.
- Myopia or near-sightedness is the defect of an eye due to which a person can see nearby objects clearly but he cannot see far away (distant) objects clearly and distinctly.
- A person with this defect has the far point nearer than infinity.

- In a myopic eye, the image of a distant object is formed in front of the retina and not at the retina as shown in the fig. (b)

Causes of Defect: The two possible causes of this defect are:-

- Excessive curvature of the eye lens or due to the high converging power of eye lens (short local length).
- Elongation of the eye ball.

Corrective Measures: This defect can be corrected by using **spectacles with concave lens** of suitable focal length or power as shown in the figure (c).

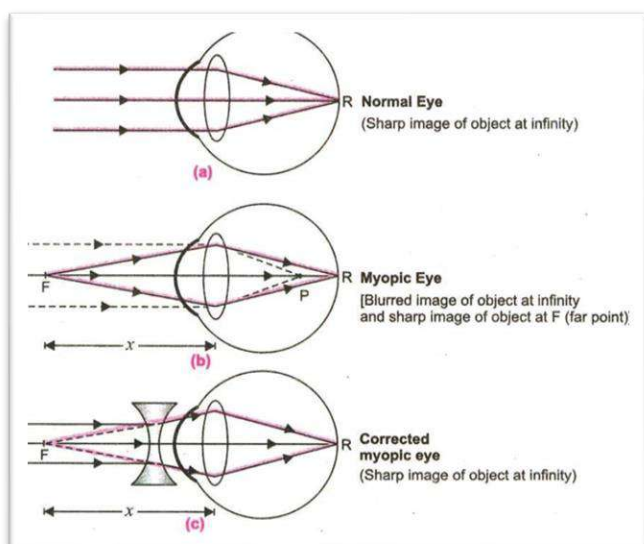
According to lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{f} = \frac{1}{-x} - \frac{1}{\mu} = \frac{1}{-x}$$

1. The formula for calculating the power of the concave lens for correcting myopia is:

1/image distance (v) - 1/object distance (u) = 1/focal length (f) i.e., (v-u)/f.



2. Hypermetropia or Long-sightedness

- **Hypermetropia or long-sightedness** also known as far-sightedness, is the defect of an eye due to which a person can see far away (distant) objects clearly but cannot see nearby objects clearly and distinctly.

- A person with this defect has the near point farther away from the normal point (25 cm).
- In a hypermetropic eye the image of nearby object is formed behind the retina and not on the retina as shown in the figure(b)
- **Causes of Defect-** The two possible causes of this defect are:-
 - Low converging power of eye lens because of large local length.
 - Eye-ball being too short (compressed).

Corrective Measures-

This defect can be corrected by using spectacles with convex lens of suitable focal length or power as shown in the figure (c).

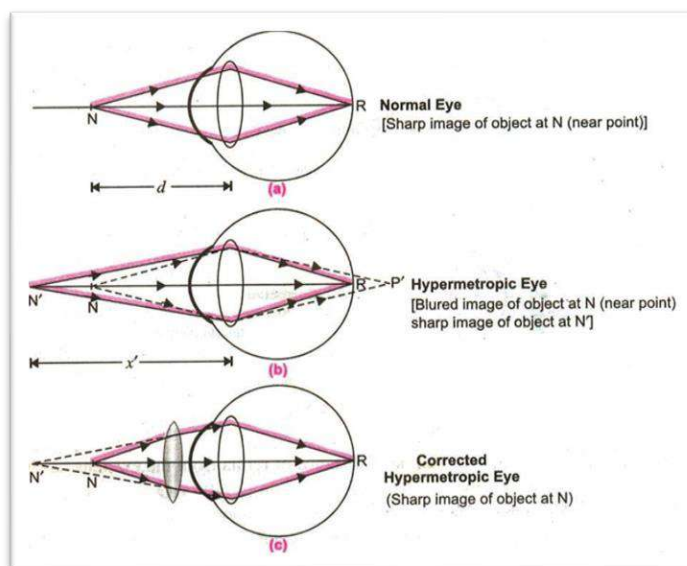
According to lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{f} = \frac{1}{-x} - \frac{1}{-d} = \frac{1}{-x} + \frac{1}{d}$$

$$f = \frac{xd}{x-d},$$

Where x is near point of hypermetropic eye and d is the near point of normal eye.



A. Presbyopia or old Sight

- Presbyopia or old sight is the defect of the eye due to which an old person cannot see the nearby objects clearly. The near point of the

old person having presbyopia gradually recedes and becomes much more than 25 cm.

Causes of defects-

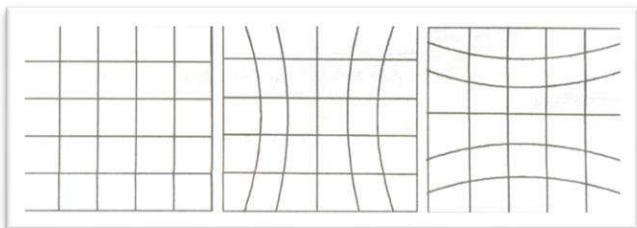
- Presbyopia arises due to the gradual weakening of the ciliary muscles and diminishing flexibility of the eye lens with age.
- Presbyopia is the hypermetropia caused by the loss of power of accommodation of the eye due to old age.

Corrective Measures-

- Presbyopia defect is corrected in the same way as hypermetropia i.e. by using spectacles having convex lenses.
- Sometimes, a person may suffer from both myopia and hypermetropia. Such persons often use spectacles having **bifocal lenses** in which upper part consists of a concave lens to correct myopia (used for distinct vision) and lower part consists of a convex lens to correct hypermetropia (used for reading).

B. Astigmatism-

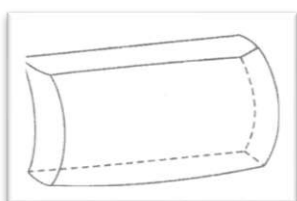
- The inability of the eye in focusing objects in both horizontal and vertical lines clearly is called astigmatism.



- Above are Normal Gauge, Wire gauge with distorted vertical lines, Wire Gauge with Distorted Horizontal lines.

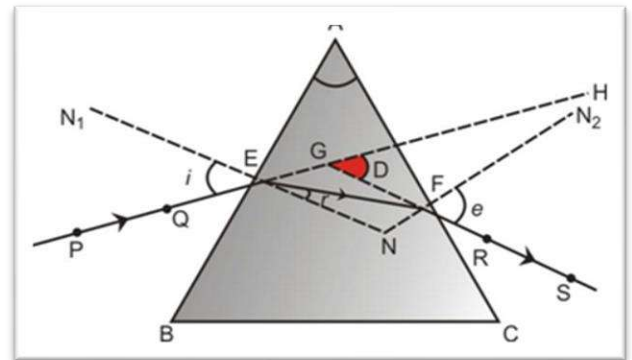
Causes of defects- This defect is caused due to varying curvature in the eye lens in horizontal and vertical lines.

Corrective measures- This defect is corrected by using cylindrical lenses.



Refraction through a Glass Prism

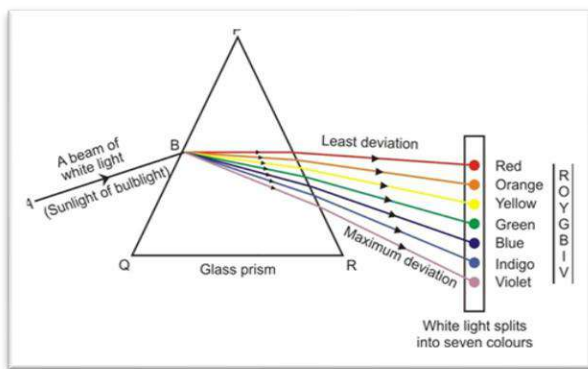
- A glass prism is a five-sided solid with a triangular cross-section. It has two parallel, triangular faces and three rectangular faces that are inclined to each other at some suitable angle, which is called the **angle of prism**.
- In the given figure $\triangle ABC$ is a glass prism of angle A . A ray of light PE is incident on the face AB of the prism at an angle $\angle PEN_1 = i$ (the angle of incidence). N_1N is normal to the face AB at E .



- The incident ray PE after refraction at E follows the path EF at an angle $\angle FEN = r$ (the angle of refraction). Since this ray is going from air (rarer medium) to prism (denser medium), so it bends towards normal N_1N .
- The refracted ray EF suffers second refraction at F and follows the path FS at an angle $\angle N_2FS = e$, known as the angle of emergence. Since, it is going from denser medium (glass prism) to rarer medium (air) so it bends away from normal N_2N .
- The incident ray PE undergoes two refractions, one at point E , while going from air to glass prism and other at point F , while going from glass prism to air. The path of the ray deviates through an angle $\angle HGS = D$, known as angle of deviation, on passing through the prism.
- The deviation of a ray on passing through a prism depends on angle of prism ' A ' and angle of incidence ' i ' of the ray on one face of the prism.

Dispersion of light by white Prism

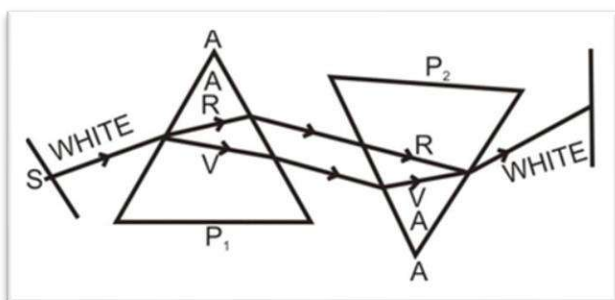
- The phenomenon of splitting up of white light into its constituent seven colours on passing through a prism is called dispersion of light.
- In the year 1665, Newton discovered that if a beam of white light is passed through a triangular glass prism, the white light splits to form a band of seven colours on a white screen held on the other side of the prism.



- This band of seven colours formed on the white screen, when a beam of light is passed through a glass prism, is called **spectrum of white light**.
- The colour sequence obtained on the screen is given by the famous acronym VIBGYOR where :
 - V stands for Violet
 - I stands for Indigo
 - B stands for Blue
 - G stands for Green
 - Y stands for Yellow
 - stands for Orange
 - R stands for Red
- Violet colour bends through maximum angle whereas the red colour bends the least on passing through the prism, that is why red colour is at the top and violet colour is at the bottom of the spectrum.

Recomposition of White Light.

- For this experiment, two prisms P_1 and P_2 of the same material and of the same refracting angle A are arranged as shown in figure. Sunlight from a narrow slit S falls on the first prism P_1 with its base downwards and gets dispersed into constituent colours (VIBGYOR) and the bending takes place downwards. Now this dispersed light falls on the second prism P_2 with its base upwards so that it deviates the light upwards.

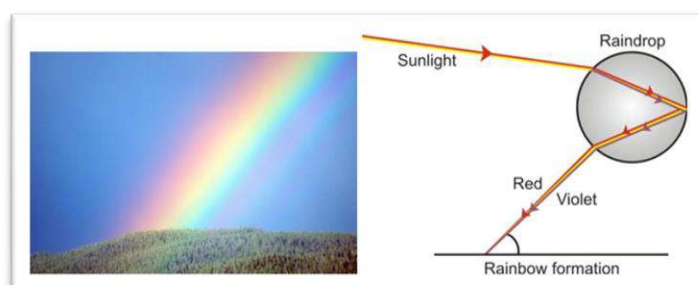


Recomposition of white light

- It is found that the light coming out of the second prism P_2 is almost white and is in direction parallel to the direction of light incident of the first prism P_1 . In fact, the two prisms P_1 and P_2 combined together effectively act like a parallel sided glass slab. This shows that the Prism P_1 simply disperses the white light into its constituent colours and the prism P_2 recombines these colours to form white light. The prism P_1 is called **dispersing-prism** and the prism P_2 is known as **recombination-prism**.

Formation of Rainbow

- A rainbow is a natural spectrum appearing in the sky in the form of an arch of seven colours which is produced by the dispersion of sunlight by tiny water droplets, present in the atmosphere.
- A rainbow is always formed in the opposite direction to that of the sun. The colours come from the dispersion of white light by raindrops suspended in air. The water droplets act like small prisms. Sunlight entering a drop gets refracted and is split into its component seven colours. These light rays of the component colours travel through the drop and fall on its other side.
- These light rays get reflected and again fall on the surface of the drop and get refracted on the way out. The two refractions bend the light through a large angle, keeping them separate.
- These lights of different colours emerging from the rain drops form a rainbow, such that the red colour is at the top and violet colour at the bottom.



Total internal reflection

- Total internal reflection, in physics, complete reflection of a ray of light within a medium such as water or glass from the surrounding surfaces back into the medium.

- The phenomenon occurs if the angle of incidence is greater than a certain limiting angle, called the **critical angle**. In general, total internal reflection takes place at the boundary between two transparent media when a ray of light in a medium of higher index of refraction approaches the other medium at an angle of incidence greater than the critical angle. For a water-air surface the critical angle is 48.5° . Because indices of refraction depend on wavelength, the critical angle (and hence the angle of total internal reflection) will vary slightly with wavelength and, therefore, with colour. At all angles less than the critical angle, both refraction and reflection occur in varying proportions.
- Glass prism can be shaped to produce total internal reflection and as such are employed in binoculars, periscopes, telescopes, and other optical instruments. Light rays may be conducted over long, twisting paths by multiple total internal reflection in glass or plastic rods or fibres.

Atmospheric Refraction

The refraction of light caused by the earth's atmosphere is called atmospheric refraction. The physical conditions of the refracting medium (air) are not stationary. Some of the air layers are cold and act like a denser medium whereas other layers of the atmosphere are comparatively warm and act like a rarer medium. In the atmosphere the air layers have different optical densities. So, when the light rays pass through the air layers of different optical densities, then refraction of light takes place.

Explanation with example-The air just above the fire becomes hotter than the air farther up. The hotter air is lighter (rarer medium) than the cooler air (denser medium) above it, and has a refractive index slightly less than that of cooler air. Since the physical conditions of the air are not stationary, therefore when we see the objects through hot and cold air layers then refraction of light takes place due to which the position of the objects fluctuates and the object appears shaking.

Some of the optical phenomena in nature which take place due to the atmospheric refraction of light are as follows:

TWINKLING OF STARS:

- The twinkling of stars is due to the atmospheric refraction of star's light. Since stars are very far off heavenly bodies and therefore are considered single point sources of light.
- When the light coming from a star enters the earth's atmosphere, it undergoes refraction due to the varying optical densities of layers of air. The continuous changing conditions of the atmosphere, refract the light coming from the stars by different amounts from one moment to another. When the atmosphere refracts more star light towards us, the stars appear to be bright and when the atmosphere refracts less star light towards us, the star appears to be dim. This phenomenon goes on thereby giving rise to twinkling of stars.

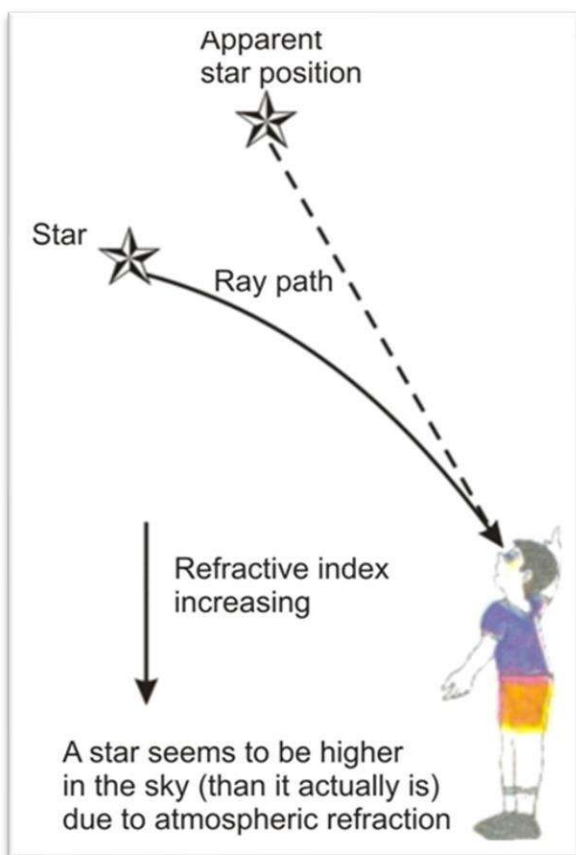
PLANETS DO NOT TWINKLE:

- The planets are much closer to the earth and are thus considered as the collection of infinite point sources of energy. Therefore the dimming effect produced by some of the point sources of light in one part of the planet is nullified by the brighter effect produced by the other point sources of light in the other part of the planet.
- As a result, the total variation in the amount of light entering our eye from all the point sources of light will average out to be zero. Thereby, nullifying the twinkling effect. Hence planets do not twinkle.

THE APPARENT POSITION OF THE STARS IS HIGHER THAN THEIR ACTUAL POSITION:

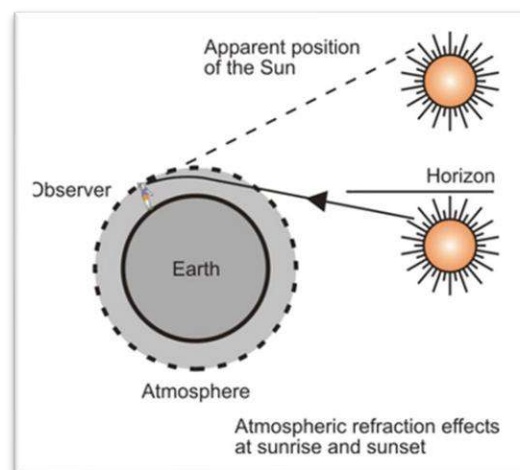
- The apparent position of the stars is higher than their actual position due to the atmospheric refraction. The upper layers of the atmosphere act like a rarer medium whereas the lower layers which are close to the earth acts like a denser medium. As the star light enters from rarer to denser medium it bends more towards the normal. Since the atmosphere bends starlight towards the normal, the apparent position of the star is slightly different from its actual position,

as a result, star appears slightly higher than its actual position, as shown in the figure.



ADVANCED SUNRISE AND DELAYED SUNSET:

- The sun is visible to us about 2 minutes before the actual sunrise and 2 minutes after the actual sunset because of atmospheric refraction. The actual sunrise takes place when the sun is just above the horizon.
- When the sun is slightly below the horizon, the sun's light coming from rarer medium (i.e. from less dense air) to denser medium (i.e. to more dense air) is refracted downwards as it passes through the atmosphere. Because of this atmospheric refraction, the sun appears to be raised above the horizon whereas it is actually slightly below the horizon (as shown in the figure).
- It is again due to the atmospheric refraction that we can see the sun for about two minutes even after the sun has set below the horizon. Because of this atmospheric phenomenon, the time from sunrise to sunset is lengthened by about $2 + 2 = 4$ minutes.



SCATTERING OF LIGHT:

- When light falls on tiny particles then diffused reflection takes place and light spreads in all possible direction. This phenomenon is known as scattering of light.
- Small particles scatter $\propto \frac{1}{\lambda^4}$ mainly **blue light**. When size of the particle increases then the light of longer wavelength also scatter. The path of a beam of light passing through a true solution is not visible. However, its path becomes visible through a colloidal solution where size of the particles is relatively larger. Rayleigh proved that the intensity of scattered light is inversely proportional to the fourth power of the wavelength, provide the **scatters is smaller in size than the wave length of light** :
- Scattering is proportional

TYNDALL EFFECT:

- The earth's atmosphere is a heterogeneous mixture of minute particles. These particles include smoke, tiny water droplets, suspended particles of dust and molecules of air. When a beam of light strikes such fine particles, the path of the beam become visible. The light reaches us after being reflected diffusely by these particles. **The phenomenon of scattering of light by the colloidal particle gives rise to tyndall effect.** This phenomenon is seen when a fine beam of sunlight enters a smoke filled room through a small hole. Thus, scattering of light makes the particles visible. Tyndall effect can also be observed when sunlight passes through a canopy of a dense forest. Here, tiny water droplets in the mist scatter light.]

PHENOMENA BASED UPON SCATTERING OF LIGHT:

a. Colour of the clear sky is blue:

The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelength at the blue end than light of longer wavelength at the red end. The red light has a wavelength about 1.8 times greater than blue light. Thus, when sunlight passes through the atmosphere, the fine particles in air scatter the blue colour more strongly than red. The scattered blue light enters our eyes. If the earth had no atmosphere, there would not have been any scattering. Then, the sky would have looked dark. The sky appears dark to a passenger flying at very high altitudes, as scattering is not prominent at such heights.

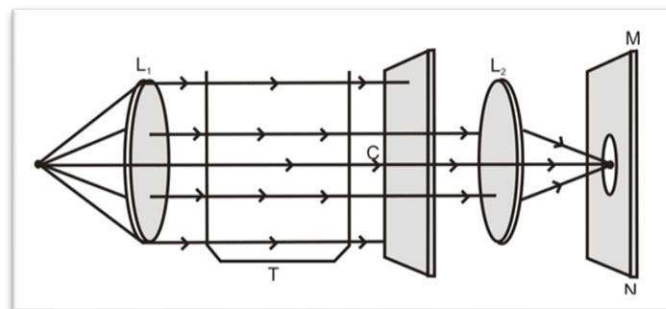
b. Colours of the sun at sunrise and sunset :

Let us do an activity to understand the colour of the sun at sunrise and sunset. Place a strong source (S) of white light at the focus of converging lens (L_1). This lens provides a parallel beam of light. Allow the light beam to pass through a transparent glass tank (T) containing clear water. Allow the beam of light to pass through a circular hole (c) made in a cardboard. Obtain a sharp image of the circular hole on a screen (MN) using a second converging lens (L_2). Dissolve 200 g of sodium thiosulphate in 2 L of clear water taken in the tank. Add 1 to 2 mL of concentrated sulphuric acid to the water.

We observe the microscopic sulphur particles precipitate in 2 to 3 minutes. As sulphur particles begin to form we can observe the blue light from the three sides of the glass tank.

It is due to scattering of short wavelengths by minute colloidal sulphur particles. We observe that the colour of the transmitted light from the fourth side of glass tank facing the circular tank at first is orange red colour and then bright crimson red colour of the screen. Light from the sun travels relatively short distance. At noon, the sun appears white as a little of blue and violet colours are scattered. Near the horizon, most of the blue light shorter wavelength are scattered away by the

particles. Therefore, the light that reaches our eye is of longer wavelength. This gives rise to the reddish appearance of the sun.



DANGER SIGNALS ARE RED

- Out of all the colours of visible light, red colour has the longest wavelength. Therefore red colour is least scattered. As a result, it can be seen from maximum distance. That is why danger signals are red.

Introduction

Electricity has an important place in modern society. It is a controllable and convenient form of energy for a variety of uses in homes, schools, hospitals, industries and so on.

What is Charge?

Protons and electrons possess some charge. Protons have a positive charge. Electrons have a negative charge. Neutron does not possess any charge. Like charges repel each other and unlike charges attract each other.

- S.I. unit of charge- **Coulomb (C)**.
- 1 Coulomb charge = Charge present on approx. 6×10^{18} electrons
- Charge on 1 electron = Negative charge of 1.6×10^{-19} C
i.e. $Q = ne$
Where, Q = Charge (total)
 n = No. of electrons
 e = Charge on 1 electron

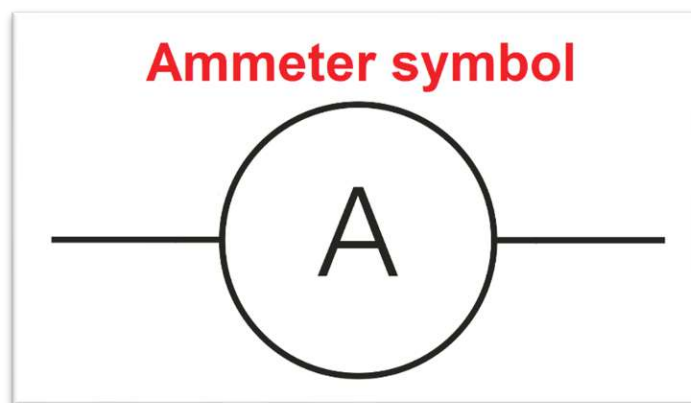
Conductors and Insulators

Conductors are those materials in which electrons can move freely. All metals are conductors. Insulators do not have any free electrons to move. For example, wood and plastic.

What is Electric Current?

- The flow of electric charge is known as Electric Current, Electric current is carried by moving electrons through a conductor. By convention, electric current flows in the opposite direction to the movement of electrons.
- Electricity is a form of energy and is a phenomenon that occurs due to the presence of electric charge. An atom's central part is called the nucleus which consists of positively charged particles called protons and uncharged particles called neutrons. When an outside force creates imbalance in the protons and electrons, an atom may lose or gain an electron. Electric current is created due to free movement of the electrons. Hence, the flow of the charges leads to production of electricity.
- The small area around electric charge where its effect can be felt is known as **electric field**

- The **electric circuit** is the path through which the electric current flows. For the flow of electricity, a close electric circuit is required
- By convention, the path of current is taken opposite to the path of the flow of electrons. It is the physical field that surrounds electrically charged particles and exerts force on the charged particles around it
- SI unit of electrical charge is **Coulomb (C)**
- The electric current is expressed by means of a unit referred to as **Ampere (A)**, named after the French scientist, Andre-Marie Ampere (1775–1836)
- Electric current is measured by means of a tool referred to as Ammeter.
- Current is measured by Ammeter. Its Symbol is-



- Ammeter has low resistance and always connected in series.
- Direction of current is taken opposite to flow of electrons were not known at the time when the phenomenon of electricity was discovered first and current was considered to be flow of positive charge.

Electric Potential and Potential difference

- Potential difference is the difference between two points that represents work involved or energy released in transfer of a unit of electricity from one point to another $V = W/Q$
- Electric current is the flow of charged particles like electrons or ions through an electrical conductor
- The electric potential is also known as the electric field potential and refers to the amount of work energy needed to move a unit of electric charge from one point to another in an electric field

- The SI unit of electrical potential difference is **volt (V)**, named after Alessandro Volta (1745–1827), an Italian physicist
- Potential difference is measured through a tool referred to as the **Voltmeter** that's continually linked in parallel.

Voltmeter- It is an instrument to measure the potential difference. It has high resistance and always connected in parallel.

- Symbol is-



- Cell is the simplest device to maintain potential difference.
- Current always flow from higher potential to lower potential.

Symbols of some commonly used components in circuit

S. No.	Component	Symbol
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	
8	A resistor of resistance R	
9	Variable resistance or rheostat	
10	Ammeter	
11	Voltmeter	

Ohm's Law

The potential difference between the two points is directly proportional to the current, provided the temperature is constant.

$$V \propto I$$

$$\Rightarrow V = IR$$

R is a constant known as **Resistance**. The SI unit of resistance is the **ohm (Ω)**

Factors on which resistance of a conductor depends-

- It is directly proportional to the length of the conductor.

- Inversely proportional to the area of cross-section.
- Directly proportional to the temperature.
- Depends on the nature of the material.

Rheostat- variable resistance is a component used to regulate current without changing the source of voltage.

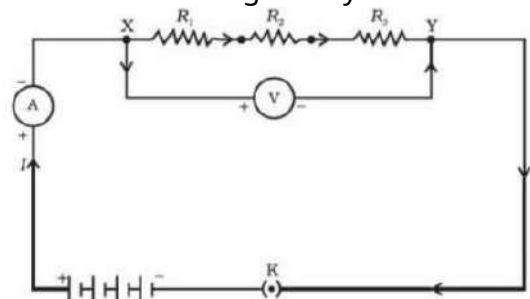
Resistivity

Resistivity is the property of the material. The SI unit of resistivity is **ohm-metre**.

- The resistivity of metals varies from 10^8 to 10^6 .
- The resistivity of insulators varies from 10^{12} to 10^{17}
- Resistivity of alloy is generally higher than that of its constituent metals.
- Alloys do not oxidize (burn) readily at high temperature, so they are commonly used in electrical heating devices.
- Copper and aluminium are used in electrical transmission due to their low resistivity.
 - Resistance = Resistivity * Length of Conductor/Cross-Sectional Area.

Resistor in series

When two or more resistors are joined in series, then their total resistance is given by the formula-



$$R_S = R_1 + R_2 + R_3$$

- The current will remain the same through all resistors.
- Equivalent resistance is larger than the largest individual resistance.

Total voltage is given by-

$$V = V_1 + V_2 + V_3$$

Voltage across each resistor is given as -

$$V_1 = IR_1$$

$$V_2 = IR_2$$

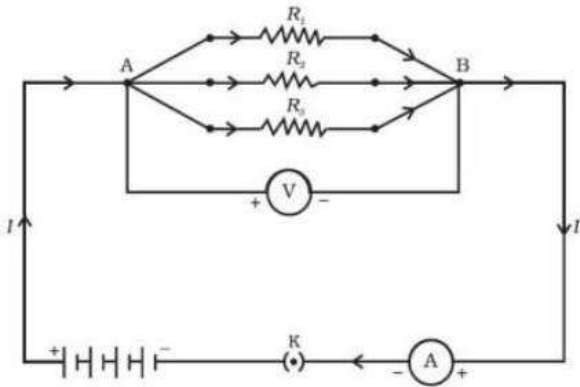
$$V_3 = IR_3 \Rightarrow V = IR_1 + IR_2 + IR_3$$

$$IR = I(R_1 + R_2 + R_3)$$

$$R = R_1 + R_2 + R_3$$

Resistors in parallel

In this case, voltage is the same across each resistor and is equal to the applied voltage. The total current is given as-



$$I = I_1 + I_2 + I_3$$

$$V/R = V/R_1 + V/R_2 + V/R_3$$

$$1/R_p = 1/R_1 + 1/R_2 + 1/R_3$$

- Equivalent resistance is less than the value of the smallest individual resistance in the combination.

Advantages of Parallel Combination over Series Combination

- Independent Operation: Each component gets full voltage and keeps working even if others fail.
- Flexibility & Scalability: Components can be added or removed without disrupting the circuit.
- Lower Resistance & Higher Current: More efficient power flow.
- Ideal for Household Appliances: Ensures stable voltage for each device.
- Better Fault Tolerance: One failure doesn't affect the entire circuit.

Heating effects of Electric Current

If an electric current is purely resistive, the source of energy continually gets dissipated entirely in form of heat. This is known as heating effect of electric current.

As $E = P \times T \propto VIt$ { $E = H$ }

Heat produced, $H = VIt$ { $V = IR$ }

Or, Heat produced, $H = I^2Rt$

When charge Q moves against the potential difference V in time t , the amount of work is given by-

$$W = Q \times V$$

$$W = V \times \frac{Q}{t} \times V$$

$$W = VIt$$

Joule's Law of Heating

- The heat produced in a resistor is directly proportional to the square root of the current.
- It is also directly proportional to resistance for a given current.

Also, directly proportional to the time for which current flows through the conductor,
 $H \propto t$.

So, $H = I^2Rt$

Practical Applications of the Heating Effect of Electric Current

- The electric laundry iron, electric toaster, electric oven, electric kettle and electric heater are some of the familiar devices based on Joule's heating.
- Electric heating is also used to produce light in a bulb. The filament of an electric bulb is made up of tungsten because it has a very high melting point and also does not oxidise readily at a high temperature. The bulbs are filled with chemically inactive gases like nitrogen and argon to prolong the life of filament.
- An electric fuse is a safety device to protect the electrical appliance from a short circuit. The fuse is placed in series with the device. It consists of a piece of wire made of a metal or an alloy of appropriate melting point, for example, aluminium, copper, iron, lead etc. If a current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. This melts the fuse wire and breaks the circuit.

Electric Power

The rate at which electric energy is dissipated or consumed in an electric current. The SI unit of power is **Watt**.

$$P = VI$$

$$\Rightarrow P = V^2/R = I^2R$$

The commercial unit of electric energy is a kilowatt-hour (KWh).

- 1 KWh = 3.6×10^6 J
- 1 KWh = 1 unit of electric energy

Recap by tables

QUANTITY	UNIT	SI Unit	SYMBOL
Capacitance	C	Farad	F
Charge	Q	Coulomb	C
Conductance	G	Siemens	S
Energy	W	Joule	J
Frequency	f	Hertz	Hz
Impedance	Z	Ohm	Ω
Inductance	L	Henry	H
Power	P	Watt	W
Reactance	X	Ohm	Ω
Resistance	R	Ohm	Ω
Voltage	V	Volt	V

Quantity	Symbol	Dimensions	Derived Units
Charge	q	Q	coulomb
Field Intensity	E	$MLT^{-2}Q^{-1}$	volt/meter
Elec. Displacement	D	$L^{-2}Q$	coulomb/meter ²
Charge Density	ρ	$L^{-3}Q$	coulomb/meter ³
Current Density	j	$L^{-2}T^{-1}Q$	amp/meter ²
Elec. Potential	V	$ML^2T^{-2}Q^{-1}$	volt
Total Current	I	$T^{-1}Q$	coulomb/sec
Mag. Field Strength	B	$MT^{-1}Q^{-1}$	weber/meter ²
Mag. Vector	H	$L^{-1}T^{-1}Q$	amp(turn)/meter
Permittivity	ϵ	$M^{-1}L^{-3}T^2Q^2$	farad/meter
Permeability	μ	MLQ^{-2}	henry/meter
Conductivity	σ	$M^{-1}L^{-2}TQ^2$	1/ohm-meter
Capacitance	C	$M^{-1}L^{-2}T^2Q^2$	farad
Inductance	L	ML^2Q^{-2}	henry
Resistance	R	$ML^2T^{-1}Q^{-2}$	ohm

As we all know that Compass needle is deflected on passing an electric current through a metallic conductor. It means that the electric current through the copper wire has produced a magnetic effects. Thus we can say that electricity and magnetism are linked to each other.

What is magnet?

Magnet is an object that attracts objects made of **iron, cobalt** and **nickel**. Magnet comes to rest in North – South direction, when suspended freely.

- Basically any substance that attracts iron and iron like objects is defined as magnet. When a wire carries an electric current, it behaves as a magnet.

Magnets are of two types

- Natural Magnet-** They are weak and mostly irregular in shape.
- Artificial Magnets-** When natural magnets are rubbed against iron or steel bars, the same property of attraction is communicated to these bars. They can be strong and have any desired shape and size.
 - **Types of artificial magnets**
 - **Bar Magnets:** They may be cylindrical or rectangular in shape.
 - **Magnetic Needle:** It is in the form of an elongated rhombus. The pole regions almost contract to the points at the ends of the needle while the remaining region is a neutral zone. The magnetic needle is either pivoted to a nail or suspended so that it can rotate freely.
 - **Magnetic compass:** It is a compact form of magnetic needle, which is pivoted at the center of a small box, made of brass having a glass top. The north pole of this needle is generally painted red.
 - **Use of Magnetic Compass-**
 - To check the polarity of a magnet.
 - To find the direction of magnetic field.
 - To find the magnetic north- south direction.

Uses of Magnets- Magnets are used

- In refrigerators.

- In radio and stereo speakers.
- In audio and video cassette players.
- in children's toys and;
- On hard discs and floppies of computers.

Properties of Magnet

- Every magnet has north and south poles.
- Same poles repel each other and unlike poles attract each other.
- A freely suspended magnet will align itself in north south direction, north facing north of the magnet and south facing south of the magnet.

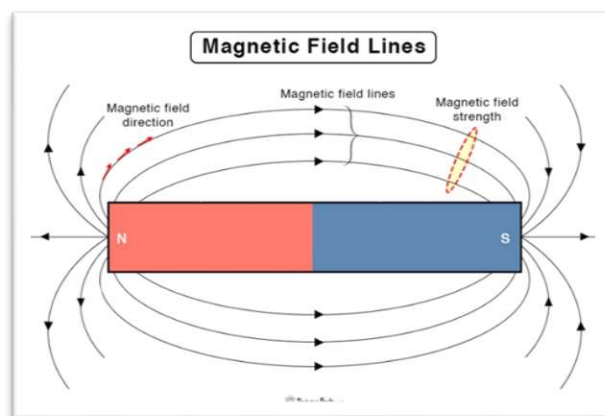
What is Magnetic Field?

The area around a magnet where a magnetic force is experienced is called the magnetic field. It is a quantity that has both direction and magnitude, (i.e., **Vector quantity**).

- **Magnetic Field Lines-** We can describe the magnetic field around a magnet by magnetic field lines. These are the curved paths along which magnetic force is acting on them in the magnetic field of the bar magnet. These lines are called magnetic lines of forces.

Characteristics of Magnetic field lines

- Field lines arise from North Pole and end into South Pole of the magnet.
- They are closed curves.
- Field lines never intersect each other.
- Direction of magnetic field lines inside the magnet is from south to north.
- The relative strength of magnetic field is shown by **degree of closeness of field lines**.



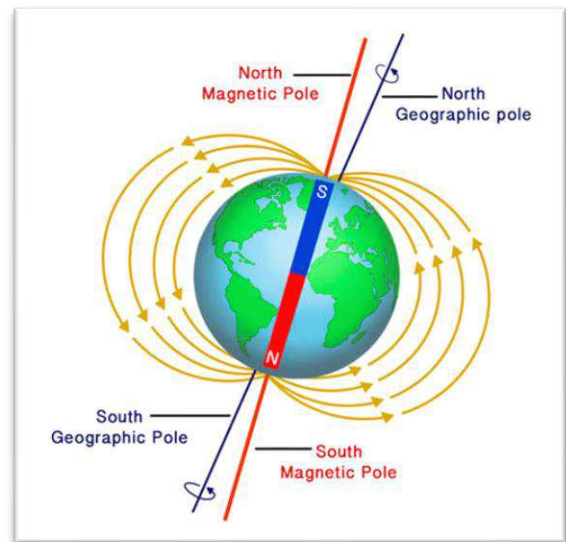
Magnetic field of a Bar Magnet

Magnetic Field of a Bar Magnet: Like all magnets, the field lines of a bar magnet will flow from the

North Pole into the south pole of the magnet. Field lines that originate near the edges of a pole will remain closer to the bar magnet than field lines that originate toward the middle of a pole. This is due to the fact that field lines can never intersect or cross over each other. If field lines could intersect, it would imply that particles traveling along the lines from the same starting position can wind up in different locations. When drawing the magnetic field lines of a single bar magnet, the field lines should always be symmetrical both horizontally and vertically. At the midpoint across the length of the magnet, the field lines will be parallel to the body of the magnet and curve symmetrically to both poles. At the midpoint of either pole, field lines leaving or entering the poles will be nearly perpendicular to the surface of the magnet and will curve toward the opposite pole over a much longer distance relative to the size of the magnet. When multiple magnets are near each other, the closest poles of each magnet will interact, while the farthest poles will be relatively unaffected. Like poles close together will have their field lines repelled away from each other without connecting and leaving a small void in between them. Opposite poles close together will resemble the field lines of a new bar magnet where the opposite poles are separated, but with more field lines connecting them where the physical magnet would be.

Magnetic Field of Earth

- A freely suspended magnet always come to rest in the north-south direction. it means, that the earth itself behaves like a magnet which causes a freely suspended magnet to rest always in north and south directions. The shape of the earth's magnetic field similar to an imaginary bar magnet.
- Earth's geographic North is its magnetic South, and geographic South is its magnetic North.
- It is now believed that the earth's magnetism is due to the magnetic effect of electric current which is flowing in the liquid core at the centre of the earth. Thus, earth is a huge electromagnet.



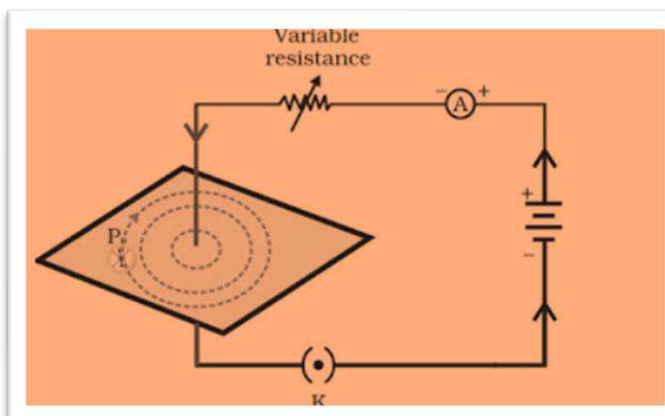
What is Electromagnetism?

- Electromagnetism, science of charge and of the forces and fields associated with charge. Electricity and magnetism are two aspects of electromagnetism.
- Electricity and magnetism were long thought to be separate forces. It was not until the 19th century that they were finally treated as interrelated phenomena. In 1905 Albert Einstein's special theory of relativity established beyond a doubt that both are aspects of one common phenomenon. At a practical level, however, electric and magnetic forces behave quite differently and are described by different equations. Electric forces are produced by electric charges either at rest or in motion. Magnetic forces, on the other hand, are produced only by moving charges and act solely on charges in motion.

Magnetic Field Produced by various Current Carrying Conductors

A. Magnetic Field lines due to Current Carrying straight conductors

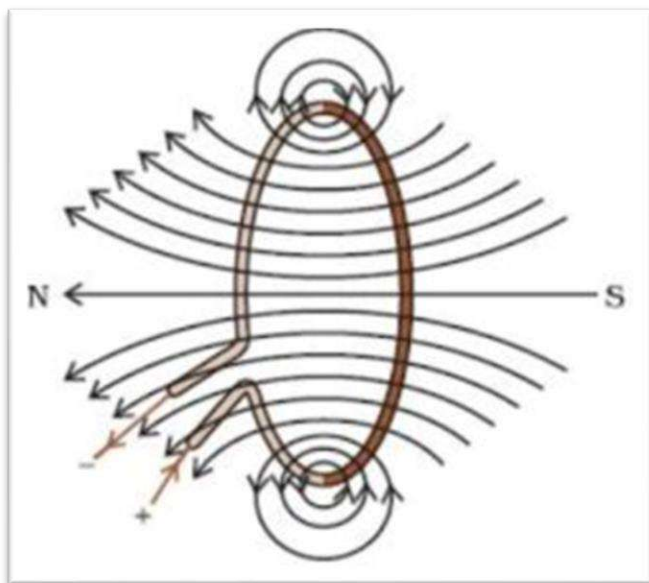
- A current carrying straight conductor has magnetic field in the form of concentric circles, around it. Magnetic field of current carrying straight conductor can be shown by magnetic field lines.
- The direction of magnetic field through a current carrying conductor depends upon the direction of flow electric current.



- Let a current carrying conductor be suspended vertically and the electric current is flowing from south to north. In this case, the direction of magnetic field will be anticlockwise. If the current is flowing from north to south, the direction of magnetic field will be clockwise.
- The direction of magnetic field, in relation to direction of electric current through a straight conductor can be depicted by using the **Right Hand Thumb Rule**. It is also known as **Maxwell's Corkscrew Rule**.

B. Magnetic field lines due to current through a circular loop

- In case of a circular current carrying conductor, the magnetic field is produced in the same manner as it is in case of a straight current carrying conductor.



- Magnetic field lines do form concentric circles around a circular current-carrying conductor.

- Since, magnetic field lines tend to remain closer when near to the conductor, so the magnetic field would be stronger near the periphery of the loop. On the other hand, the magnetic field lines would be distant from each other when we move towards the centre of the current carrying loop. Finally, at the centre, the arcs of big circles would appear as a straight line.
- The direction of the magnetic field can be identified using Right Hand Thumb's Rule. Let us assume that the current is moving in anti-clockwise direction in the loop. In that case, the magnetic field would be in clockwise direction, at the top of the loop. Moreover, it would be in an anti-clockwise direction at the bottom of the loop.

What is Clock Face Rule?

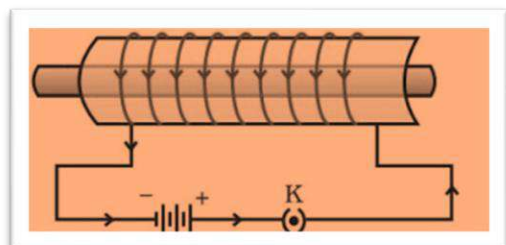
A current carrying loop works like a disc magnet. The polarity of this magnet can be easily understood with the help of Clock Face Rule. If the current is flowing in anti-clockwise direction, then the face of the loop shows North Pole. On the other hand, if the current is flowing in clockwise direction, then the face of the loop shows South Pole.

Magnetic Field and number of turns of coil-

- Magnitude of magnetic field gets summed up with increase in the number of turns of coil. If there are 'n' turns of coil, magnitude of magnetic field will be 'n' times of magnetic field in case of a single turn of coil.
- The Strength of the magnetic field at the centre of the loop (coil) depends on-
 - The radius of the coil:** The strength of the magnetic field is inversely proportional to the radius of the coil. If the radius increases, the magnetic strength at the centre decreases
 - The number of turns in the coil:** As the number of turns in the coil increase, the magnetic strength at the centre increases, because the current in each circular turn is having the same direction, thus, the field due to each turn adds up.
 - The strength of the current flowing in the coil:** As the strength of the current increases, the strength of three magnetic fields also increases.

C. Magnetic Field due to current in Solenoid-

- Solenoid is the coil with many circular turns of insulated copper wire wrapped closely in the shape of a cylinder. A current carrying solenoid produces similar pattern of magnetic field as a bar magnet. One end of solenoid behaves as the North Pole and another end behaves as the South Pole.

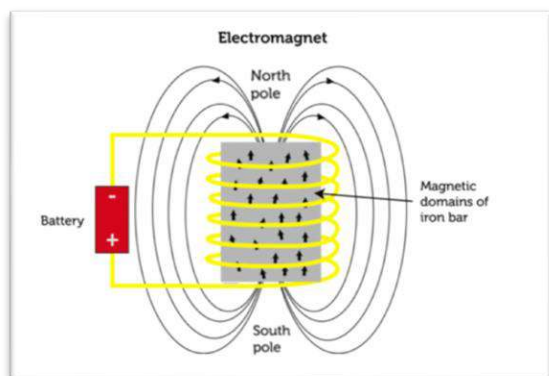


- Magnetic field lines are parallel inside the solenoid, similar to a bar magnet, which shows that magnetic field is same at all points inside the solenoid.
- Magnetic field produced by a solenoid is similar to a **bar magnet**. The strength of magnetic field is proportional to the number of turns and magnitude of current. By producing a strong magnetic field inside the solenoid, magnetic materials can be magnetized. Magnet formed by producing magnetic field inside a solenoid is called **electromagnet**.

Electromagnet

An electromagnet works on the magnetic effect of electric current. Electromagnet having temporary magnetism lasts till current flowing through it. An electromagnet is a magnet consisting of a long coil of insulated copper wire wrapped around a soft iron core that is magnetised only when electric current is passed through the coil.

The core of an electromagnet must be of soft iron because soft iron loses all its magnetism when current in the coil is switched off.



Factors affecting the strength of an electromagnet

- The number of turns in the coil.** - The more number of turns in the coil, the strength of electromagnet is more.
- The current flowing in the coil.** - If the current in the coil is more, the strength of electromagnet increases.
- The length of air gap between its poles.** - If we reduce the length of air gap between the poles of an electromagnet, then its strength increases.

What is Permanent magnet?

Permanent magnets are usually made of alloys like, Carbon steel, Chromium steel, Cobalt steel, Tungsten steel and Alnico. Permanent magnets are used in microphones, loudspeakers, electric clocks, ammeters, voltmeters, speedo- meters and many other devices.

Magnetism in Human Beings:

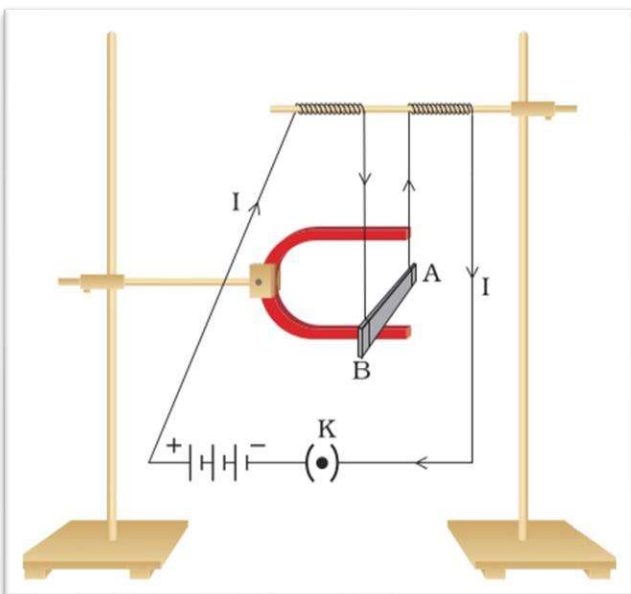
- Human body produces extremely weak electric current by the movement of charged particles called ions. So, this current is also called **ionic current**. Due to weak ionic currents flow along the nerve cells, it produces magnetic field in our body. The two main organs of the human body where the magnetic field produced is quite significant are the heart and the brain.
- It is obvious that magnetism produced in our body has an important use in medical diagnosis because, through MRI (**Magnetic Resonance Imaging**) scans, it enables the doctors to see inside the body. e.g., MRI can detect cancerous tissue inside the body.

Force on current carrying conductor placed in a magnetic field

- We know that, a current carrying conductor exerts a force on a compass needle and deflects it from its usual north- south position. We can also say that a current-carrying conductor exerts a mechanical force on a magnet, and if the magnet is free to move, this force can produce a motion in the magnet. Reverse of this, a magnet exerts a mechanical force on a current-carrying

conductor and if the conductor is free to move this force can produce a motion in conductor.

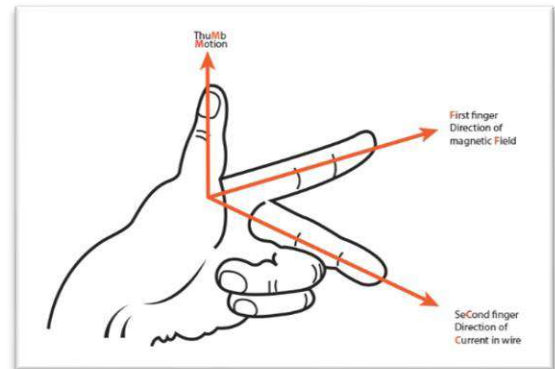
- In 1821, **Michael Faraday** discovered that, when a current-carrying conductor is placed in a magnetic field, a mechanical force is exerted on the conductor which can make the conductor move. This forms the basis of a various electrical devices like **electric motor and moving coil galvanometer**.
- The direction of force acting on a current-carrying conductor placed in a magnetic field is,
 - Perpendicular to the direction of current.
 - Perpendicular to the direction of magnetic field.
- It means that, the maximum force is exerted on a current-carrying conductor only when it is perpendicular to the direction of magnetic field. No force acts on a current-carrying conductor when it is parallel to the magnetic field. The direction of force on a current-carrying conductor placed in a magnetic field can be reversed by reversing the direction of current flowing through the conductor. Thus, the direction of force on a current-carrying conductor placed in a magnetic field can also be reversed by reversing the direction of magnetic field.
- If the direction of current in a conductor and the direction of magnetic field, are known, then the direction of force acting on the current carrying conductor can be found out by using **Fleming's left-hand rule**.



What is Fleming's Left Hand rule?

"According to Fleming's left-hand rule, Hold the forefinger, the middle finger and the thumb of your left hand

at right angles to each other, in such a way that the forefinger pointing towards the direction of magnetic field and the middle finger pointing towards the direction of current, then the direction in which thumb pointing, gives the direction of force acting on the conductor or motion of the conductor.



Electric Motor

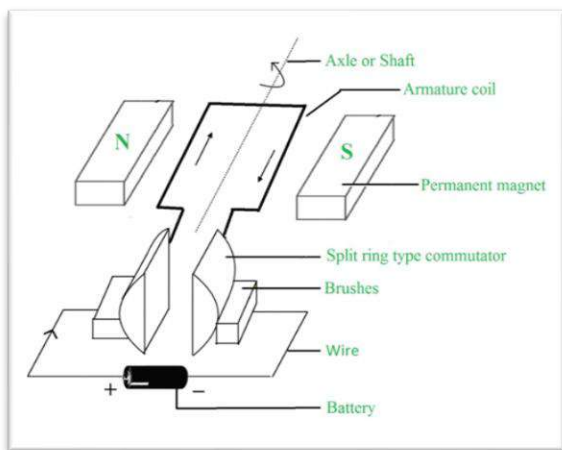
An electric motor is used to convert electrical energy into mechanical energy. Let's go through an instance: What does the mixer in your house do for you? The rotating blades mash and mix things for you. And if someone were to ask you how that works, what would you say? You would probably say that it works on electricity. Well, that's not incorrect. Motors convert electric energy to mechanical work. The opposite is done by generators that convert mechanical work to electrical energy.

- It is of two types: AC and DC Motor.
- Electrical energy is converted into mechanical energy by using an electric motor. Electric motor works on the basis of rule suggested by André-Marie Ampère. and Fleming's Left Hand Rule.

Different parts of an electric motor and their function

A simple motor has the following parts:

- A power supply – mostly DC for a simple motor
- Field Magnet – could be a permanent magnet or an electromagnet
- An Armature or rotor
- Commutator
- Brushes
- Axle



Let's discuss each part in short.

1. **Power Source:** A simple motor usually has a DC power source. It supplies power to the motor armature or field coils.
2. **Commutator:** It is the rotating interface of the armature coil with a stationary circuit.
3. **Field Magnet:** The magnetic field helps to produce a torque on the rotating armature coil by virtue of Fleming's left-hand rule.
4. **Armature Core:** Holds the armature coil in place and provides mechanical support.
5. **Armature Coil:** It helps the motor to run.
6. **Brushes:** It is a device that conducts current between stationary wires and moving parts, most commonly the rotating shaft.

Principle of Electric Motor

- When a rectangular coil is placed in a magnetic field and a current is passed through it, force acts on the coil, which rotates it continuously. With the rotation of the coil, the shaft attached to it also rotates.

Working of electric motor

- The working of an electric motor is based on the fact that a current-carrying conductor produces a magnetic field around it. To better understand, imagine the following situation.
- Take two bar magnets and keep the poles facing each other with a small space in between. Now, take a small length of a conducting wire and make a loop. Keep this loop in between the space between the magnets such that it is still within the sphere of influence of the magnets. Now for the last bit. Connect the ends of the loop to battery terminals.

- Once electricity flows through your simple circuit, you will notice that your loop "moves". So why does this happen? The magnetic field of the magnets interferes with that produced due to electric current flowing in the conductor. Since the loop has become a magnet, one side of it will be attracted to the north pole of the magnet and the other to the South Pole. This causes the loop to rotate continuously. This is the **principle of working of electric motor**.

Types of Electric Motors

The primary classification of electric motor is as follows-

- a. DC motors
 1. Brushless
 2. Brushed
- b. AC motors
 1. Synchronous
 2. Induction
 1. Single phase
 2. Double phase

Uses of electric motors

Electric motors are used in a variety of applications. Some of them are listed below.

- Drills
- Water Pumps
- Hard Disc Drives
- Washing Machines
- Industrial Equipment

You can expect the efficiency of a functioning motor to be around **70 – 85%** as the remaining energy is wasted in heat production and sounds emitted.

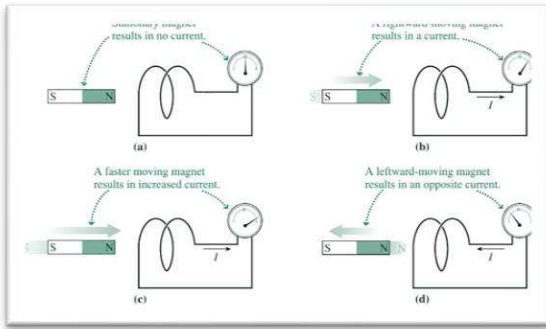
Some of commercial uses of the electric motors are as follows

- An electromagnet in place of permanent magnet
- Large number of turns of the conducting wire in the current-carrying coil
- A soft iron core on which the coil is wound.

Electromagnetic Induction

Electromagnetic induction is the creation of an electro-motive force (EMF) by way of a moving magnetic field around an electric conductor and,

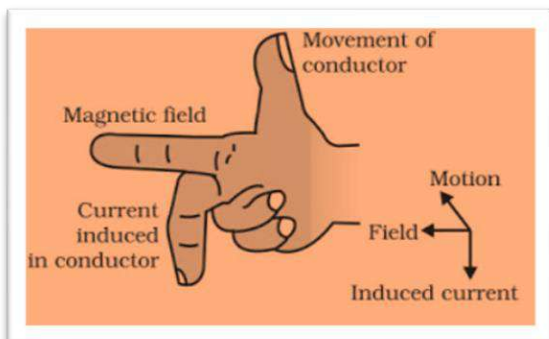
conversely, the creation of current by moving an electric conductor through a static magnetic field.



- When a conductor is set to move inside a magnetic field or a magnetic field is set to be changing around a conductor, electric current is induced in the conductor. This is just opposite to the exertion of force by a current carrying conductor inside a magnetic field. In other words, when a conductor is brought in relative motion $V_{is} - a - V_{is}$ a magnetic field, a potential difference is induced in it. This is known as **electromagnetic induction**.

What is Flemings Right hand Thumb rule?

Electromagnetic induction can be explained with the help of Fleming's Right Hand Rule. If the right hand is structured in a way that the index (fore) finger, middle finger and thumb are in mutually perpendicular directions, then the thumb shows direction of induced current in the conductor, in conductor. The directions of movement of conductor, magnetic field and induced current can be compared to three mutually perpendicular axes, i.e. x, y and z axes.



The mutually perpendicular direction also points to an important fact that when the magnetic field and movement are perpendicular, the magnitude of induced current would be maximum. Electromagnetic induction is used in the conversion of kinetic energy into electrical energy.

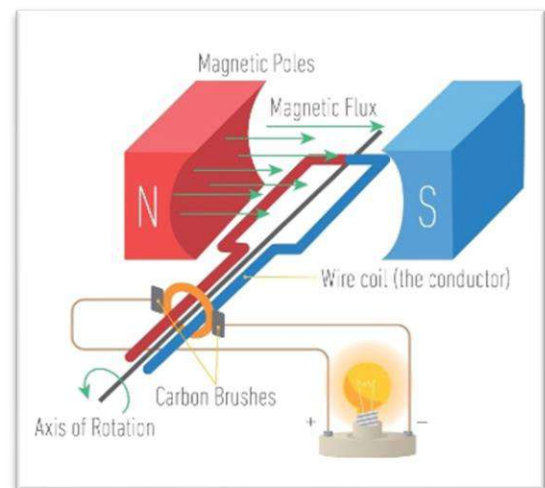
Electric Generator

- The electric generator converts mechanical energy into electrical energy, the small generator used on bicycles for lighting purpose is called a bicycle dynamo.

Principle of electric Generator

- Electric generators work on the principle of electromagnetic induction. A conductor coil (a copper coil tightly wound onto a metal core) is rotated rapidly between the poles of a horseshoe type magnet. The conductor coil along with its core is known as an armature.

Electric generator Diagram



Parts of Electric Generator

Electric Generator consists of various parts as mentioned under:

- 1. Armature:** It consists of an insulated copper coil wound over a rectangular frame and soft iron core, which is laminated.
- 2. Field Magnet:** The magnetic field is supplied by a permanent magnet (in a small dynamo) and by an electromagnet in the case of a big commercial dynamo which is nothing but the electric generator that we are currently studying.
- 3. Slip rings (in ACAC generator):** They are hollow metal rings held at different heights. One end of the armature is connected to one of the rings, and the other is connected to the other ring. These rings rotate with the rotation of the armature.
- 4. Split rings (in DCDC generator):** Two halves of the same ring. The ends of the armature are

connected to these halves of the same ring. These rings rotate with the armature.

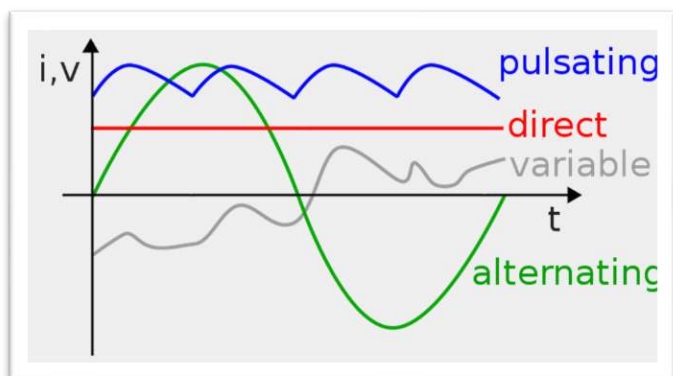
5. **Brushes or sliding contacts:** These are flexible metal plates or carbon rods. They are in constant touch with the rings. They help pass the induced current from the armature and the rings to the external circuit.

Working

- The structure of an electric generator is similar to that of an electric motor. In case of an electric generator, a rectangular armature is placed within the magnetic field of a permanent magnet. The armature is attached to wire and is positioned in a way that it can move around an axle. When the armature moves within the magnetic field, an electric current is induced. The direction of induced current changes, when the armature crosses the halfway mark of its rotation.
- Thus, the direction of current changes once in every rotation. Due to this, the **electric generator usually produces alternate current**, i.e. **A.C.** To convert an A.C generator into a D.C generator, a split ring commutator is used. This helps in producing direct current.
- Electrical generator is used to convert mechanical energy into electrical energy.

A.C and D.C Current

a. **A.C – Alternate Current:** Current in which direction is changed periodically is called Alternate Current. In India, most of the **power stations generate alternate current**. The direction of current changes after every $1/100$ second in India, i.e. the **frequency of A.C in India is 50 Hz**. A.C is transmitted upto a long distance without much loss of energy is advantage of A.C over D.C.



DC- Direct Current

Current that flows in one direction only is called Direct current. **Electrochemical cells** produce direct current.

Advantages of A.C over D.C

- Cost of generator of A.C is much less than that of D.C.
- A.C can be easily converted to D.C.
- A.C can be controlled by the use of choke which involves less loss of power whereas, D.C can be controlled using resistances which involves high energy loss.
- AC can be transmitted over long distances without much loss of energy.
- AC machines are stout and durable and do not need much maintenance.

Disadvantages of AC

- AC cannot be used for the electrolysis process or showing electromagnetism as it reverses its polarity.
- AC is more dangerous than DC.

Domestic Electric circuit

Electricity is generated at the power station. It brought to our house by two thick copper wires. In our houses, we receive AC electric power of **220 V** with a frequency of **50 Hz**.

The 3 wires are as follows

- **Live wire** – (Red insulated, Positive)
- **Neutral wire** – (Black insulated, Negative)
- **Earth wire** – (Green insulated) for safety measure to ensure that any leakage of current to a metallic body does not give any serious shock to a user.

Short Circuit: Short-circuiting is caused by the touching of live wires and neutral wire and sudden a large current flows.

It happens due to

- Damage of insulation in power lines.
- A fault in an electrical appliance.

Overloading of an Electric Circuit: The overheating of electrical wire in any circuit due to the flow of a

large current through it is called overloading of the electrical circuit.

A sudden large amount of current flows through the wire, which causes overheating of wire and may cause fire also.

Electric Fuse: It is a protective device used for protecting the circuit from short-circuiting and overloading. It is a piece of thin wire of material having a low melting point and high resistance.

- Fuse is always connected to live wire.
- Fuse is always connected in series to the electric circuit.
- Fuse is always connected to the beginning of an electric circuit.
- Fuse works on the heating effect

Conductors, Insulators and Semiconductors

- Conductor is any material or substance that allows electricity to flow through it.
- An insulator is any substance or material that prevents the flow of electricity through it.
- Any substance can be called as a conductor of electricity if it allows movement of charges through it.
- The electrons of the conductors can flow freely (they are delocalized) and hence can take electric current through them.
- Insulators do not allow the flow of charges through them because their electrons are tightly packed with their particles.

Good Conductors- Some materials can allow the complete flow of electricity through them and are called good conductors of electricity.

Bad Conductors- Some materials can allow a little flow of electricity through them and are called poor conductors of electricity.

Can Liquid Conducts electricity?

- Not all liquids can conduct electricity. However, some of them can be regarded as good conductors of electricity while others as poor conductors of electricity.
- Water containing salts and minerals dissolved in it always conduct electricity.
- Distilled water which does not contain any salts cannot conduct electricity.
- Any solution of acids or bases can also conduct electricity.

Good Conductors	Poor Conductors
Tap water	Distilled water
vinegar	Vegetable oil
Lemon Juice	Honey
Milk	Fuels

S.No	Conductors	Semiconductors	Insulators
1	Easily conducts the electrical current.	Conducts the electric current less than conductor and greater than insulator.	Does not conduct any current.
2	Has only one valence electron in its outermost orbit.	Has four valence electron in its outermost orbit.	Has eight valence electron in its outermost orbit.
3	Conductor formed using metallic bonding.	Semiconductors are formed due to covalent bonding.	Insulators are formed due to ionic bonding.
4	Valence and conduction bands are overlapped.	Valence and conduction bands are separated by forbidden energy gap of 1.1eV.	Valence and conduction bands are separated by forbidden energy gap of 6 to 10eV.
5	Resistance is very small	Resistance is high	Resistance is very high
6	It has positive temperature coefficient	It has negative temperature coefficient	It has negative temperature coefficient
7	Ex: copper, aluminium, etc	Ex: silicon, germanium, etc	Ex: Mica, Paper, etc

Mechanism behind how liquids conduct electricity?

- Different substances when mixed in water and electricity is passed through them can break apart and form positive and negative particles or ions in the water.
- These ions can pass the electric current through them.
- The more is the number of ions in a liquid the better conductor it is of electricity.
- That is why distilled water is a poor conductor of electricity but salt water is a good conductor of electricity.
- However, many compounds do not form any ions on mixing them with water and therefore they are poor conductors of electricity such as sugar water, oil and alcohol.

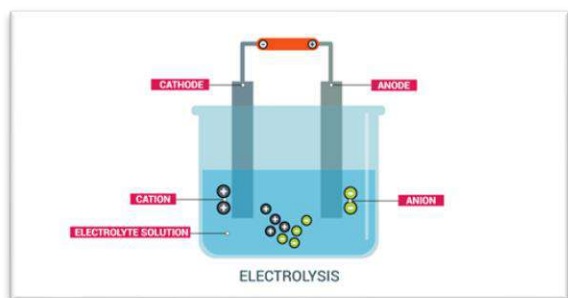
Note-

Suitability of LED bulbs for testing electrical conductivity of liquids

- The electric current often causes heating effect due to which the filament of the bulb gets heated up and glows.
- However, some liquids are capable of conducting electricity but they are weak conductors of electricity. Hence current passes through them but it is not that strong enough to heat up the filament. As a result, the filament would not light up in the case of such liquids.
- However, the LED bulbs can detect the flow of even a small amount of electric current as well. Hence, LED bulbs are suitable for testing the electrical conductivity of liquids.

Important terms

Electrolysis-The effect in which components of a compound get split due to passing an electric current through it is called electrolysis.



Electrode- An electrode is a conductor (usually metallic or carbon) through which electric current enters or leaves an electrolyte (a liquid or molten substance that conducts electricity by the movement of ions). They serve as the interface between the metallic conductor circuit (wires) and the ionic conductor circuit (electrolyte).

Electrolyte- An electrolyte is a substance (like an acid, base, or salt) that when dissolved in a polar solvent (like water) or melted will dissociate or ionize to produce mobile ions, making the resulting solution or melt capable of conducting electricity when electricity is passed through it.

Cathode and anode- The positively charged electrode is called anode and the negatively charged electrode is called cathode.

Anions- an anions are negatively charged ion.

Cation- A cation is a positively charged ion.

Effects of an electric current

- **Heating effect:** electric current causes heating of the electrical equipment. For example, the filament of a bulb gets heated up due to electric current and therefore glows.
- **Mechanical effect:** electric current can lead to generation of mechanical energy in appliances. For example, fans and motors work due to this effect.
- **Magnetic effect:** electric current can give rise to the magnetic field of a substance.
- **Chemical effect:** electric current can lead to the production of chemical energy or chemical reactions.

Chemical effects of electric current

We know that when an electric current passes through solution it ionizes and breaks down into ions. This is because of chemical reactions that take place when an electric current passes through a solution. Depending on the nature of the solution and the electrodes used, the following effects can be observed in the solution:

- Metallic deposits on the electrodes
- Change in the colour of the solution
- A release of gas or production of bubbles in the solution.

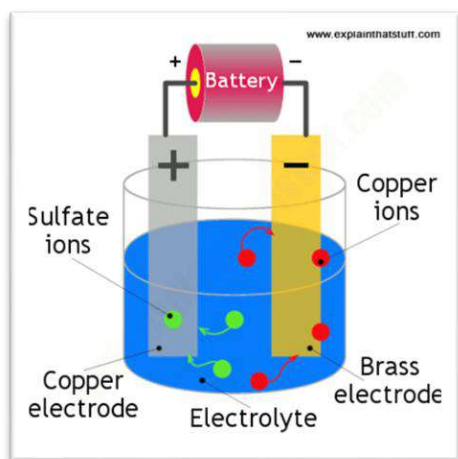
Application of Chemical effects of electric current

Electroplating

- Electroplating is a process in which layer of metal is deposited on another material with the help of electricity.
- Electroplating is used in many industries for depositing a layer of metal with desired characteristics on another metal.
- Different metals used for electroplating are Nickel, Copper, Gold Silver, Tin, Brass, Zinc, Chromium and Platinum.

Process of Electroplating

- In order to conduct electroplating right electrodes and electrolytes must be chosen so that metal can deposit over a material.
- For instance, if we want to deposit copper on a material we need an electrolyte that contains copper in it. Similarly, if we need gold on a material we need an electrolyte that contains gold in it.
- Also, we should make sure that the electrode that we are choosing is completely clean.
- The electrodes used are made up of different materials. One of the electrodes is of the same metal of which the electrolyte solution is. The second electrode needs to be the material on which we want to coat another metal.



- For instance, in case we want to plate copper upon brass, one electrode should be of Copper and the other electrode should be of Brass and the electrolyte solution should be any salt which contains copper in it, for example, copper sulphate solution. Consider the diagram given below that describes the process of electroplating of copper.
- Out of these two electrodes the copper electrode acts as the anode (positive electrode) and brass electrode acts as the cathode (negative electrode).
- When electricity is passed through the solution, the copper sulphate breaks down into its ions.
- The copper ions (they have a positive charge) get attracted by the brass electrode while the sulphur ions being negatively charged move towards the copper electrode.
- As a result, copper starts depositing on the brass electrode.
- The process of electroplating takes some time to complete.
- The amount of time that it will take depends upon the strength of the current that is being passed through the circuit and also upon the concentration of the electrolyte.
- As these two are increased the speed of the electroplating process also increases.

Applications of Electroplating

- Medical equipment is made up of nickel which is harmful to the human body hence to avoid it from coming in contact with our body a coating of platinum or gold is applied on the surface of nickel.

- Many kitchen equipment's, bath taps, parts of cars etc. are covered with chromium coating. Chromium is an expensive metal hence the objects are created with the cheaper metal and chromium coating is provided. Thus, to bring a shining over the objects and prevent them from corrosion chromium coating is used.
- Jewellery makers often make ornaments of less expensive metals and provide a coating of gold or silver upon them.
- The tin cans that are used to store food are actually made up of iron and have a coating of tin on them. Iron can easily react with food and spoil it, however, tin prevents the food from getting reacted with iron and therefore helps in preventing it from getting spoiled easily.
- Bridges and various parts of automobiles are made up of iron because it provides strength. However in order to prevent iron from getting rusted a coating of zinc is provided over it. This method is also called **galvanization of iron**.

Other applications of chemical effects of electric Current

a. Extracting metals from their ores

Electrolysis is indeed used for extracting highly reactive metals (like Aluminium, Sodium, Potassium, Calcium, Magnesium) from their molten ores or compounds (not solid ores, they need to be in molten or solution form to have mobile ions). These compounds are already in an ionic form (or form ions upon melting/dissolving). Passing electricity through the molten state or sometimes aqueous solution decomposes the compound, depositing the metal at the cathode.

b. Purification of metals

The method of electrolysis is also used to purify a metal by separating it from the impurities. The impure metal is used as an anode which first dissolves in the electrolyte solution and then deposits on the cathode in the pure form. The impurities of the metal remain in the electrolyte solution only. Metals like aluminium, zinc and copper are purified in this way.

c. Production of compounds

The electrolysis method is used for the production of some compounds. For example, sodium hydrochlorite

d. Decomposition of compounds

The electrolysis method is also used to decompose a compound into its constituents. For example, water can be decomposed using the process of electrolysis to obtain hydrogen and oxygen.

Introduction

We know that, a force is necessary to make a body move or a force is necessary to produce motion in a body. So, if we drop a ball from a specific height, the ball falls down towards the earth. As, the ball starts moving downwards, it is in motion, hence, a force must be acting on it. This force is due to the attraction between the earth and the ball and it is known as the gravitational force of so, a ball dropped from a height falls towards the earth because the earth exerts a force of attraction known as gravity on the ball.

- A famous English scientist Sir Isaac Newton was sitting in his garden under an apple tree when an apple from the tree fall on him. From this incidence Newton conclude that an apple falls down from the tree towards the earth because the earth exerts a force of attraction on the apple in the downward direction. This form of attraction exerted by the earth is called gravitational force or its gravity. The gravitational force of earth or gravity of earth is responsible for holding the atmosphere around the earth, for the rain falling to the earth and for the flow of water in the rivers. Because of the gravitational force of earth we can stand firmly on the ground.

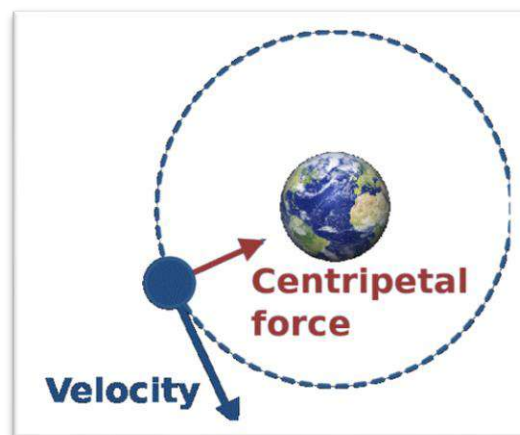
Every Object in the Universe Attracts Every Other Object:

- According to Newton, every object in this universe attracts every other object with a certain force, is called gravitational force for gravity. The gravitational force between two objects acts even if the two objects are not connected by any method.
- If the masses of the objects are small, then the gravitational force between them is also very small, whereas, one of the object is very large, then the gravitational force becomes very large.

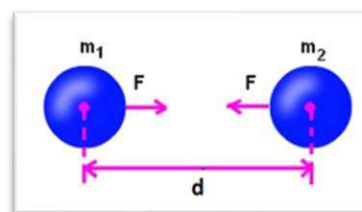
What is Centripetal force?

- We know that an object in circular motion keeps on changing its direction.
- Due to this, the velocity of the object also changes.
- A force called Centripetal Force acts upon the object that keeps it moving in a circular path.

- A force called Centripetal Force acts upon the object, directed towards the centre of the circular path, and keeps it moving in that path.
- Without the Centripetal Force objects cannot move in circular paths, they would always travel straight.
- For Example, The rotation of the Moon around the Earth is possible because of the centripetal force exerted by Earth.

**Universal laws of Gravitation by Newton**

- According to the universal law of gravitation, every object attracts every other object with a force.
- This force is directly proportional to the product of their masses.
- This force is inversely proportional to the square of distances between them.
- Consider the figure given below. It depicts the force of attraction between two objects with masses m_1 and m_2 respectively that are 'd' distance apart.
- The figure below describes how the universal law of gravitation is derived mathematically.



$$F \propto m_1 \text{ ----- (i)}$$

$$F \propto m_2 \text{ ----- (ii)}$$

$$F \propto \frac{1}{r^2} \text{ ----- (iii)}$$

From the above equations we can rewrite them as the following

$$F \propto \frac{m_1 m_2}{r^2} \text{----- (iv)}$$

If we remove the proportionality we get proportionality constant G as the Following

$$F = G \frac{m_1 m_2}{r^2}$$

The above equation is the mathematical representation of Newton's Universal Law of gravitation

Hence, $G = Fr^2 / m_1 m_2$

SI Unit: $\text{Nm}^2 \text{kg}^{-2}$

Value of **G = $6.673 \times 10^{-11} \text{ Nm}^2 \text{kg}^{-2}$** (was found out by Henry Cavendish (1731- 1810))

- The proportionality constant G is also known as the **Universal Gravitational Constant**

Why do we study the universal laws of gravitation?

It explains many important phenomena of the universe –

- Earth's gravitational force
- Why the moon always moves in a circular motion around the earth and the sun
- Why all planets revolve around the sun
- How the sun and moon can cause tides

Newton's third laws of motion and gravitation

- According to **Newton's third law of motion**, if one object exerts a force on another object, then the second object also exerts an equal and opposite force on the first object. This law of motion also applicable to the force of gravitation. It means that when earth exerts a force of attraction on an object, then the object also exert an equal force on the earth, in the opposite direction.
- When, an object falling on earth's surface from a specific height, it gets accelerated. So according to above stated law, if the earth exerts gravitational force on stone, then stone will also exerts an equal and opposite force on the earth, then we don't see the earth rising up towards the stone. Because, the mass of a stone is very small, due to which the gravitational force produces a large acceleration in it. Due to large acceleration of stone, we can see the stone falling towards the earth.

- Besides that, the mass of earth is, very huge and due to this large mass of the earth, the gravitational force produces very small acceleration in the earth. Also, the smaller acceleration produced in the earth is not visible to us.

Free fall study

- When an object falling from a height towards the earth without any external force acting on it under the gravitational force of earth is called free fall. So, whenever an object falls towards the earth on its own, we can say that it is a free fall.
- Earlier it was thought that the lighter object fall slowly and the heavier objects falls fastly when released from a same height. But this was proved wrong by Galileo.
- Galileo released two stones of different masses from the top of the leaning tower of Pisa. He found that both stones hit the ground at the same time. From this Galileo concluded that the acceleration of a freely falling object towards the earth does not depend on the mass of the object.
- In case of lighter objects like, feather, its acceleration during free fall, is less compared stone because the feather has large surface area so, it experiences much more resistance from air and its speed is slowed down.
- So, the acceleration produced in the freely falling bodies is the same for all the bodies and it does not depend on the mass of the body.

Acceleration due to gravity – Whenever an object falls towards the Earth there is an acceleration associated with the movement of the object. This acceleration is called acceleration due to gravity.

- Denoted by: g
- SI Unit: m s^{-2}
- We know that, $F = ma$
- Therefore, $F = mg$
- The following figure demonstrates the mathematical derivation of 'g'

The force (F) of gravitational attraction on a body of mass m due to earth of mass M and radius R is given by

$$F = G \frac{mM}{R^2} \quad \dots (1)$$

We know from Newton's second law of motion that the force is the product of mass and acceleration.

$$\therefore F = ma$$

But the acceleration due to gravity is represented by the symbol g . Therefore, we can write

$$F = mg \quad \dots (2)$$

From the equation (1) and (2), we get

$$mg = G \frac{mM}{R^2} \quad \text{or} \quad g = \frac{GM}{R^2} \quad \dots (3)$$

When the body is at a distance ' r ' from the centre of the earth then

$$g = \frac{GM}{r^2}$$

The value of g may vary at different parts of the earth

- From the equation $g = GM/r^2$ it is clear that the value of ' g ' depends upon the distance of the object from the earth's centre.
- This is because the shape of the earth is not a perfect sphere. It is rather flattened at poles and bulged out at the equator.
- Hence, the value of ' g ' is greater at the poles and lesser at the equator. However, for our convenience, we take a constant value of ' g ' throughout.

Finding the value of g

Calculation of g

- $F = GMm/r^2$
- $g = F/m = GM/r^2$
- Mass of Earth = $6 \times 10^{24} \text{ kg}$
- Radius of Earth = $6.4 \times 10^6 \text{ m}$
- Calculate g on Earth
- $g = GM/r^2$
- $= 6.67 \times 10^{-11} \times 6 \times 10^{24} / (6.4 \times 10^6)^2$
- $\approx 9.8 \text{ N kg}^{-1}$

What is Free fall?

When an object falls towards the earth due to the earth's gravity and no other force is acting upon it, the object is said to be in a free-fall state. Free-falling objects are not even resisted by the air.

$g = 9.8 \text{ m/s}^2$ is also called the Free-fall Acceleration. Value of ' g ' is the same on the earth, so the equations of motion for an object with uniform

motion are valid where acceleration ' a ' is replaced by ' g ', as given under:

- $v = u + gt$
- $s = ut + (1/2) gt^2$
- $2 g s = v^2 - u^2$

Equations of motion for free falling bodies under different scenario

- When an object at rest falls towards earth – its initial velocity is zero
 - $v = gt$
 - $s = (1/2) gt^2$
 - $2 g s = v^2$
- When an object with some initial velocity (u) falls towards earth –
 - $v = u + gt$
 - $s = ut + (1/2) gt^2$
 - $2 g s = v^2 - u^2$
- When an object is thrown upwards from the earth – the gravitational force acts in opposite direction, hence g is negative
 - $v = u - gt$
 - $s = ut - (1/2) gt^2$
 - $-2 g s = v^2 - u^2$

Kepler's laws of motion

Astronomer Johannes Kepler stated three laws of the motion of planets around the sun. These laws are known as Kepler's laws of planetary motion. These laws also describe the motion of satellites like moon around the earth.

1. Kepler's first law:

Kepler's first law stated that, the planets move in elliptical orbits around the sun, with the sun at one of the two foci of the elliptical (oval shape) orbit.

2. Kepler's second law:

Kepler's second law stated that, each planet revolves around the sun in such a way that the line joining the planet to the sun sweeps over equal areas in equal intervals of time. It means that a planet moves faster when it is closer to the sun, and moves slowly when it is away from the sun.

3. Kepler's third law:

Kepler's third law stated that, the cube of the mean distance of a planet from the sun is directly

proportional to the square of time it takes to move around the sun.

- r^3 directly proportional T^2 or $r^3 = \text{constant} \times T^2$
or
- **$r^3/T^2 = \text{constant}$**
- r = mean distance of planet from the sun
- T = time period of the planet around the sun

Although Kepler proposed the laws of planetary motion but he was unable to give a theory to explain the motion of planets. That was the Isaac Newton who proved that the cause of the motion of planets is the gravitational force which is exerted by the sun.

Mass and Weight

- The mass of an object is the quantity of matter present in it. Mass is a scalar quantity which has only magnitude. **The SI unit of mass is kilogram (kg)**. The mass of an object is always constant and does not change from place to place. Mass of an object is usually denoted by m . Mass of an object is a measure of **inertia of the object**.
- The weight of an object is the force with which it is attracted towards the centre of the earth. We know that, The acceleration produced by the force of attraction of the earth is known as acceleration due to gravity (g) so, the downward force acting on an object of mass m is given by, Force = mass $\times$ acceleration due to gravity **$F = mg$**
- As we know, the force of attraction of earth on an object is known as weight w of the body. **So, Weight $W = mg$**
- We know that the SI unit of force is newton (N). So, **SI unit of weight is also newton**. Weight is a vector quantity having magnitude as well as direction. Since, the value of the acceleration due to gravity changes from place to place, therefore the weight of an object will also changes from place to place. In space, where g is 0, the weight of an object becomes zero and we feel true weightlessness. Thus, the weight of an object can be zero but mass of an object will never zero.

Weight of object on the Moon

Just like the Earth, the Moon also exerts a force upon objects. Hence, objects on the moon also have some weight. The weight will not be the same as on the earth. So, weight on the Moon can be calculated as –

Now,

$$W_M = \frac{GM_M m}{R_M^2}$$

$$\Rightarrow \frac{W_M}{W_E} = \frac{M_M R_E^2}{M_E R_M^2}$$

Where,

$$M_E = 5.98 \times 10^{24} \text{ kg}$$

$$M_M = 7.36 \times 10^{22} \text{ kg}$$

$$R_E = 6.4 \times 10^6 \text{ m}$$

$$R_M = 1.74 \times 10^6 \text{ m}$$

$$\Rightarrow \frac{W_M}{W_E} = \frac{7.36 \times 10^{22} \times (6.4 \times 10^6)^2}{5.98 \times 10^{24} \times (1.74 \times 10^6)^2} = 0.165 \approx \frac{1}{6}$$

Therefore, weight of an object on the moon is $\frac{1}{6}$ of its weight on the Earth.

Introduction-

Actions like picking, opening, shutting, kicking, hitting, lifting, flicking, pushing, pulling are often used to describe certain tasks. Each of these actions usually results in some kind of change in the motion of an object.

What is Force?

- When a push or pull is applied to an object it is called force.
- A force can change the state of an object from rest to motion or vice versa.
- To let a force come into play, two or more objects must interact with each other.
- Force is an action that has tendency to change the position, shape, or size of objects.

Note- Magnets also exerts a force

We know that a magnet can attract a piece of iron. Hence, we can say that the magnet pulls the iron piece towards itself due to its magnetic force. Similarly, when opposite poles of a magnet repel each other we can say that they are pushing each other away.

Characteristics of forces-

- When two forces act in the same direction, the net resultant force on an object is the sum of these two forces.
- When two forces act in opposite directions the net resultant force is the difference of these two forces. The force has a magnitude which describes its strength.
- The force always has a direction in which it is applied and a measure of its strength or magnitude.
- The effects of a force may alter when the direction of the magnitude of the force is changed.
- The effect of more than one forces being applied on an object is calculated by evaluating the net force acting on that object.

- If two forces are acting upon each other having equal magnitudes (strength) and in opposite directions then the net force acting on the object will be zero.
- Force can bring different effects to an object's position, size and shape.

Formula for calculation of force

$$F = m \times a$$

$$\text{Force} = F$$

$$\text{Mass of Object} = m$$

$$\text{Acceleration} = a$$

- The SI unit of force is **Newton (N)**.

Force can change the state of motion of an object

- An object is said to be in motion if it is moving by a certain speed in a particular direction.
- If the object is at rest, it means that it is not changing its position with respect to an observing point. Hence it has zero speed.
- When the object starts moving it means that its position is being changed with respect to an observation point.
- In order to move an object from one place to another, a force is required to bring that object in motion.
- Not only this, a force applied on to an object can change its speed, bring it to rest or even change the direction of its motion.
- It may bring a combination of these effects as well such as a change in direction of motion and change in the speed of the motion altogether.
- Hence we can say that force can change the state of motion of an object.
- Any object cannot move by itself or change its state of motion on its own without the application of a force.
- However, applying a force does not always result in a visible change of state or shape, especially if the object is very rigid or the

applied force is balanced by other forces, like when pushing a wall.

Force can change the shape of object

- The shape of an object can be altered if some force is applied on to it. Depending upon the magnitude of the force that is being applied and the rigidity of the object, the effect on its shape and size can be observed.
- Examples are stretching of rubber band, pressing of sponge, squeezing of a spring can change in shape. But these object comes to original position when the force is reduced or removed.

What can force do?

- Force can move a stationary body or object. For example: - a football can be set to move by kicking it, i.e., by applying a force.
- Force can stop a moving body. For example: - by applying brakes, a running cycle or a running vehicle can be stopped.
- Force can change the direction of a moving object. For example, by applying force, i.e., by moving handle, the direction of a running bicycle can be changed.
- Similarly by moving steering, the direction of a running vehicle is changed.
- Force can change the speed of a moving body. By accelerating, the speed of a running vehicle can be increased or by applying brakes the speed of a running vehicle can be decreased.
- Force can change the shape and size of an object. For example, by hammering, a block of metal can be turned into a thin sheet. By hammering, a stone can be broken into pieces.

Types of Forces

a. Balanced force

b. Unbalanced force

Let's explain each in short

a. *Balanced force*

- If the resultant of applied forces is equal to zero, it is called balanced forces. An Example:
 - In the tug of war if both the team apply similar magnitude of forces in opposite directions, rope does not move in either side. This happens because of balanced forces in which resultant of applied forces become zero.
- Balanced forces do not cause any change of state of an object. **Balanced forces are equal in magnitude and opposite in direction.**
- Balanced forces can change the shape and size of an object. For example, when forces are applied from both sides over a balloon, the size and shape of balloon is changed.

b. *Unbalanced Force*

- If the resultant of applied forces are greater than zero, the forces are called unbalanced forces. An object in rest can be moved because of applying unbalanced forces.
- Unbalanced force can do following things
 - Move a stationary object
 - Increase the speed of a moving object
 - Decrease the speed of a moving object
 - Stop a moving object
 - Change the shape and size of an object

c. *Frictional forces*

- Frictional force refers to the force generated by two surfaces that contacts and slide against each other.
- The amount of frictional force depends on the nature of the surfaces in contact and the normal force pressing the surfaces together. The angle or position of an object can influence the normal force and thus affect friction.
- If an object is placed flat against an object, then the frictional force will be equal to the weight of the object.
- If an object is on a horizontal surface with no horizontal force, friction is zero. If a horizontal force is applied, static friction opposes it up to

a maximum value proportional to the normal force (equal to weight on a horizontal surface).

i. Types of Frictional Forces

- AA. Static friction
- BB. Sliding friction
- CC. Rolling Friction
- DD. Fluid Friction

d. Electromagnetic force

- The electromagnetic force is a type of physical interaction that occurs between electrically charged particle. It acts between charged particle and is the combination of all magnetic and electrical forces. The electromagnetic force is much stronger than the gravitational force. However, it is weaker than the strong nuclear force by a factor of about 100.

e. Nuclear Force

- The nuclear force is a force that acts between the protons and neutrons of atoms. The nuclear force is the force that binds the protons and neutrons in a nucleus together. This force can exist between protons and protons, neutrons and neutrons or protons and neutrons. This force is what holds the nucleus together. "This force is vastly stronger than the gravitational force (by a factor of roughly 10^{38} to 10^{41}).

f. Weak Force

- The Weak Force (or Weak Nuclear Force) is a fundamental force involved in certain types of radioactive decay, such as beta decay. It acts on fundamental particles called quarks and leptons.". This force is 10^{25} to 10^{26} times stronger than the gravitational force.

Types of Forces

On the basis of the nature of the interaction between two or more objects, force can be classified as

Contact forces	Non-contact forces
These kinds of forces are applied only when two or more objects come in contact with each other.	These kinds of forces are applied when the objects do not come in contact with each other and yet are exerting a force upon each other.
Example: Muscular Force, Frictional Force	Example: Magnetic Force, Gravitational Force, Electrostatic Force

Let's discuss each in details

Contact Forces

A. Muscular forces

The force that comes into play because of the action of muscles is called muscular force. For example:

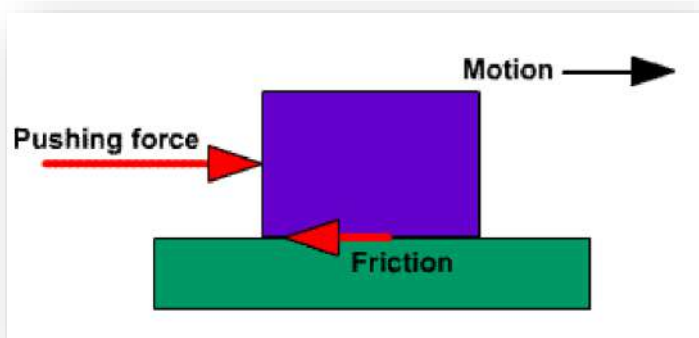
- Human beings use muscular force in order to walk.
- The expansion and contraction of lungs is because of muscular force
- Movement of food along the food pipe
- Animals can also exert muscular forces; that's why they can move from one place to another. Example is Bullock cart

B. Frictional Force

It is the force that is exerted by the surface over an object whenever the object moves on the surface. Force of friction has the following characteristics:

- The force of friction always acts in the opposite direction of the motion of the object.
- It leads to generation of heat as two surfaces come in contact with each other. For example, when we rub our hands together, heat is produced as a result of friction between our hands.
- Frictional force also leads to wear and tear of the surfaces of objects that come in contact with each other. For example, sole of shoes often gets worn-out due to

friction force that acts between them and the ground as we walk.



C. Air Resistance

Whenever an object moves or flies in the air, it experiences a force called air resistance.



Non-Contact Forces

- A. Magnetic Force
- B. Electrostatics force
- C. Gravitational Force

Let's explain each in details

A. Magnetic force

- The force exerted by any magnetic object is called magnetic force.
- We know that like magnetic poles always repel each other, that is, they push each other away.
- Also, opposite magnetic poles always attract each other, that is, they pull each other towards themselves.

B. Electrostatic force

- The force exerted by a charged particle is called electrostatic force.
- We know that like charges always repel or push each other away.

- Similarly, opposite charges always attract or pull each other towards themselves.

C. Gravitational Force

- It is an attractive force that is applied by the earth on all the objects.
- It is also called the force of gravity or gravity that acts upon all the objects that are present on or near the Earth's surface.
- Gravity is a property exhibited by every object present in the universe and not only the earth. Hence, all the planets, the moons and even the sun have a gravitational force of their own.

Newton's laws of Motion

Galileo's Observation

- He observed the motion of objects on an inclined plane.
- When marble is rolled down an inclined plane its velocity increases.

Galileo's Arguments

- When marble is rolled down from the left – It will go up on the opposite side up to the same height at which it is dropped down.
- If the inclination of planes is equal – The marble would travel equal distances while climbing up as travelled while rolling down.
- If we decrease the angle of inclination of the right plane – The marble would travel further until it reaches its original height.
- If the right side plane is made flat – Marble would travel forever to achieve the same height.

Galileo's Inference

- We need an unbalanced force to change the motion of the marble but no force is required when the marble is moving uniformly.
- In other words, objects move at a constant velocity if no force acts upon them.

First laws of Motion

Whether an object is moving uniformly on a straight path or is at rest, its state would not change until and unless an external force is applied to it.

- Hence, we can say that objects oppose a change in their state of motion or rest. This tendency of objects to remain in the state of rest or to keep moving uniformly is called **Inertia**.

Examples of Inertia

- We fall back when a vehicle starts moving in the forward direction because our body is in the rest state and it opposes the motion of the vehicle.
- We fall forward when brakes are applied in a car because our body is opposite the change of state of motion to rest.

Inertia and mass

- The inertia of an object is dependent upon its mass.
- Lighter objects have less inertia, that is, they can easily change their state of rest or motion.
- Heavier objects have large inertia and therefore they show more resistance.
- Hence '**Mass**' is called a **measure of the inertia of an object**.

What is Momentum?

In order to understand Newton's second law of motion we should first know the meaning of the term momentum of a moving body. We know that a cricket ball is much heavier than a tennis ball. If we throw a cricket ball and a tennis ball, both with the same speed, it will be found that more force is required to stop the cricket ball and less force is needed to stop the tennis ball. So, the force required to stop a moving body is directly proportional to its mass as well as its velocity. Thus, the quantity of motion in a body

depends on the mass and velocity of the body. And it is known as momentum. The momentum of a body is defined as the product of its mass and velocity. **Momentum = mass x velocity**
 $p = m \times v$

If a body is at rest, its velocity is zero and hence its momentum is also zero. Momentum is a vector quantity and takes place in the direction of velocity. The SI unit of momentum is kilogram metres per second (kg.m/s).

Every moving body possesses momentum. Since momentum depends on the mass and velocity of a body, so a body will have a large momentum:

- (i) it its mass is large, or
- (ii) If its velocity is more, or
- (iii) If both its mass and velocity are large.

Momentum is considered to be a measure of the quantity of motion of a moving object

The momentum of a stationary object –

Let the mass of a stationary object be 'm',

Let the velocity of a stationary object be 'v',

The stationary object has no velocity, so $v = 0$,

Therefore, $p = m \times v = m \times 0 = 0$

So, the momentum of a stationary object is zero.

- We know that the velocity of an object can be changed by applying an unbalanced force to it. Similarly, the momentum of an object can change by applying an unbalanced force.

Second Law of Motion

According to the second law of motion – The rate of change of momentum of an object is directly proportional to the applied unbalanced force on the object in the direction of the force.

Example- As the player pulls their hands back, they increase the time taken to decrease the velocity of the ball to zero. A larger time for the same change in momentum means the rate of change of momentum is smaller, and therefore the force exerted on the hands (and by the hands on the ball) is smaller, as per Newton's second law ($F \propto \Delta t / \Delta p$). If the ball is stopped suddenly (Δt is very small), the force (F) would be much larger.

Change in momentum $\propto p_2 - p_1$ $\propto mv - mu$ $\propto m(v - u)$	Initial velocity = u Final velocity = v Acceleration = $(v - u)/t$
Rate of change of momentum $\propto m(v - u)/t$	1 unit of force = $k \times (1 \text{ kg}) \times (1 \text{ m s}^{-2})$
Force $\propto m(v - u)/t$	$K = 1$
Force = $k m a$	
Force = ma	

Therefore, with help of the second law of motion, we can evaluate the amount of force that is being exerted on any object. From the formula stated above, we can see that the force is directly proportional to acceleration. So the acceleration of an object can change depending upon the change in force applied.

Newton's Third Law of Motion

Action and Reaction Forces

When two objects interact, they exert forces on each other. These forces are called action and reaction forces. Two forces acting from opposite directions are called Action and Reaction Forces.

For Example, when a ball hits the ground, the ball exerts a force on the ground (Action). Simultaneously, the ground exerts an equal and opposite force back on the ball (Reaction).

Whenever one body exerts a force on another body, the second body exerts an equal and opposite force on the first body. The force exerted by the first body on the second body is known as action and the force exerted by the second body on the first body is known as reaction. We can now write another definition of Newton's third law of motion to every action there is an equal and opposite reaction. Remember that action and reaction usually acts on two different bodies. e.g.

- Recoil of gun- when a bullet is fired from a gun, the gun only moves a little backwards (recoils) while the bullet can travel a large distance. This is because of the difference in the mass of the bullet and the gun.

Conservation of Momentum

The second law of motion stated that the moving bodies possess momentum which is equal to the product of mass and velocity. That is, Momentum = mass x velocity

- According to the law of conservation of momentum, when two or more bodies act upon one another, their total momentum remains constant or conserved provided no external forces are acting. It means that whenever one body gains momentum, then some other body must lose an equal amount of momentum. This law can also be stated as Momentum is never created or destroyed. The law of conservation of momentum is also known as the principle of conservation of momentum.
- It is obvious that the total momentum of the two bodies before and after the collision is the same. This means that the momentum of the two bodies remains constant or conserved.

Facts about conservation Laws

- They are considered the fundamental laws in physics.
- They are based on observations and experiments.
- They cannot be proved but can be verified or disproved with the help of experiments.
- A single experiment is enough to disprove a law, while a single experiment is not enough to prove the same.
- It requires a large number of experiments to confirm the law.
- The law of conservation of momentum was formulated 300 years ago.
- There is no single situation present until now that disproves this law.
- Other laws of conservation are – the law of conservation of energy, the law of conservation of angular momentum, the law of conservation of charge.

Applications of the Law of Conservation of Momentum: The rockets and jet aeroplanes work on the principle of conservation of momentum.

- **Rocket:** The chemicals inside the rocket burn and produce high velocity blast of hot gases. This gases passes out through nozzle at tail of the rocket in the downward direction with tremendous velocity and rocket moves up to balance the momentum of the gases. Although the mass of gases is very less but they have very high velocity and hence having very large momentum.
- **Jet Aeroplane:** In jet aeroplanes, large amount of gases produced by the combustion of fuel is allowed to escape through a jet in backward direction. Due to very high velocity the. Backward rushing gases have a large momentum due to which jet aeroplane moves with a great speed.

Pressure

- Not only the magnitude of the force but the area upon which it acts also affects the changes it may bring upon an object.
- The force acting upon a unit area is called pressure.
- Hence, the pressure exerted by an object depends upon its surface area.
- If the surface is small, the amount of pressure applied is large, and vice-versa.
- The SI unit of Pressure is **Pascal (Pa) or N/m^2**

Relation between Force, pressure and Area

- $\text{Pressure} = \text{Force} / \text{area}$
- $\text{Area} = \text{Force} / \text{Pressure}$
- $\text{Force} = \text{Area} \times \text{Pressure}$

Hence Smaller the area, larger the pressure for the same force.

Example of relationship between the area and Pressure

1. A needle has a pointed end that has a very small surface area. Hence when a large force is exerted

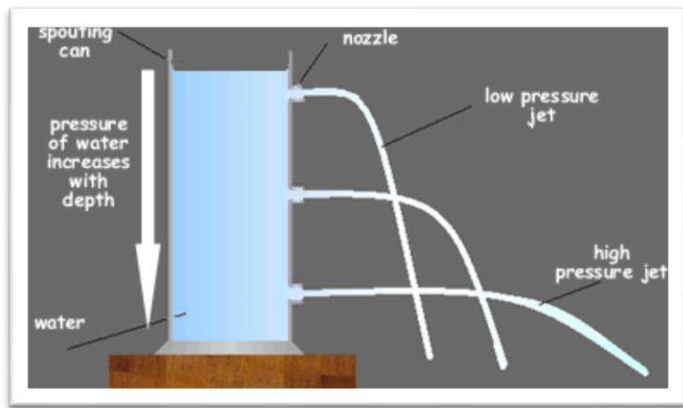
upon the needle with a hammer the pressure on the needle increases and it easily moves inside the wall.

2. Shoulder bags always have broad straps rather than thin straps in order to minimize the pressure that would be exerted on the shoulders of the weare due to the gravitational force acting upon the bag.
3. Tools that are used for cutting and piercing always have sharp edges because as a person would apply a force on the tool, its sharp edges would exert more pressure due to less surface area and the object would cut down easily.
4. The two tyres of a tractor are wider because it minimizes the pressure exerted by the tractor on the ground. As a result, it becomes easier to move the tractor on a muddy field.
5. Camel can walk easily over the sand because it has wide feet which allow them to walk on sand easily. Human beings, on the other hand, cannot as walk easily on sand as their feet have less surface area and therefore our feet sink in the sand.

Pressure Exerted by liquids and gases

- Liquids exert a pressure on the walls of the container in which they are put in.
- The pressure that a liquid exerts on the bottom of the container is dependent upon the height of the liquid in the container.
- The liquid exerts equal pressure on different points on the walls of the container having the same depth.

This pressure is known as the **Hydrostatic pressure**. The hydrostatic pressure is the pressure exerted by a fluid at equilibrium at any point of time due to the force of gravity. Hydrostatic pressure is proportional to the depth measured from the surface as the weight of the fluid increases when a downward force is exerted.

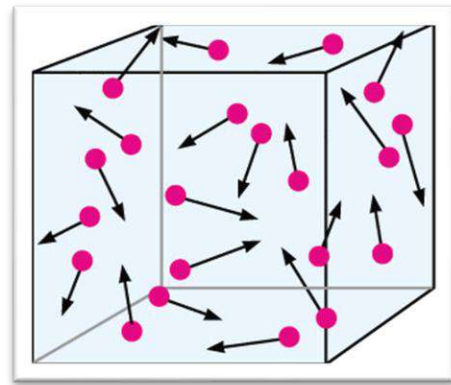


Fluids exert pressure in all directions equally. This rule leads to another interesting occurrence. If we consider the layer of water on the top of a bottle, the pressure exerted by the layer of water acts on the container at the sides, the surface of air on top and the layer of water at the bottom. As we move down from the top of the bottle to the bottom, the pressure exerted by the top layer on the bottom adds up.

- Due to this phenomenon, the fluid at the bottom of the container experiences more pressure than the fluid which is above it.

Fluid- Substance which can flow and has no fixed shape.

- Pressure due to liquid column of height h
 $(\rho) = \rho h g$
- Where, h = height of column
- ρ = density of fluid
- g = Acceleration due to gravity
- Similarly, gases also exert pressure on the walls of the container. The molecules of a gas of higher kinetic energy collide with walls applying large force, and as a result these molecules apply pressure on the walls of the container.



Atmospheric Pressure

- A layer of gases is present around the earth's surface. The air present in the atmosphere exerts a pressure on the earth which is called atmospheric pressure.
- The value of atmospheric pressure at the sea level is **101325 Pascal**.
- The atmospheric pressure keeps on increasing as we move towards the Earth's surface.
- The amount of atmospheric pressure upon us is quite large due to the large surface area of the atmosphere around the earth but we do not experience any of its effects.
 - This is so because the pressure of the air inside our body is equal to the atmospheric pressure. There are also fluids present in our body that exert a pressure inside our body. Hence, our bodies easily obtain a balance with the atmospheric pressure.
- However sometimes at higher altitudes where the atmospheric pressure is low as compared to that at the Earth's surface (low altitudes), nose bleeding occurs.
 - This is so because at that time the blood pressure in our body becomes higher than the atmospheric pressure outside us.

Note- at higher altitude pressure is low and at lower altitude pressure is high.

Pressure in Fluids: Those substances which can flow easily are called fluids. All the liquids and gases are fluids. Like solids, fluids can also exert pressure on the container in which they are placed. A fluid usually exerts pressure in all directions.

Buoyancy:

When an object is placed in a liquid, the liquid exerts an upward force on it. e.g.

1. When a plastic bottle is held below the surface of water by applying the pressure of our hand and then released, the bottle immediately rises to the surface. It means some upward force is exerted by water on it.
2. If we try to lift a brick from the bottom of a lake, it appears to be lighter as long as it is being lifted inside water. But as we lifted out the brick from water to air, the same brick feels much heavier. It means some upward force acting on the brick when it is immersed in water which makes it feel lighter.

What is buoyant force?

- The upward force acting on an object immersed in a liquid is called buoyant force.
- This upward force exerted by a liquid is also known as up thrust. Because of this upward force or buoyant force or up thrust exerted by water we are able to swim in water and ships can float in water. It is the buoyant force which makes the heavy objects appear lighter in water.
- It has been confirmed through experiments, that the maximum loss in weight of an object takes place when it is completely immersed in a liquid.
- As more and more volume of the object is immersed in a liquid, the buoyant force acting on it increases. Maximum upward buoyant force acts on an object when it is completely immersed in the liquid.

Factors affecting the Buoyant Force

The effect of buoyant force acting on an object immersed in a liquid depends on two factors,

- **Volume of object-** As the volume of solid object immersed inside the liquid increases, the upward buoyant force also increases.

- **Density of the liquid:** The liquid having higher density exerts more buoyant force on an object than other liquid having lower density. So, as the density of liquid increases, the buoyant force exerted by it also increases. E.g. it is easier to swim in sea-water because sea-water exerts a greater buoyant force due to its higher density. An iron block floats in mercury because mercury exerts a very high buoyant force on it due to its very high density.

Archimedes Principle

According to the Archimedes principle, whenever an object is immersed in a liquid (fully or partially), the liquid exerts an upward force upon the object. The amount of that force is equivalent to the weight of the liquid displaced by the object.

This means that if the weight of an object is greater than the amount of liquid it displaces, the object will sink into the liquid. However, if the weight of an object is less than the amount of liquid it displaces, the object will float.

- Submarines have a tank called **Buoyancy Tank**. Whenever the submarine needs to be taken inside water the tank is filled which thus increases the weight of the submarine. Similarly, when the submarine is to appear above water the tank is emptied and the weight of the submarine becomes lighter and it rises above the water.
- Ships are heavier than water but their unique shape gives them a large volume. Their volume is larger than their weight and hence the water displaced by a ship provides it with the right up thrust so that it can float on water.

Application of Archimedes Principle

1. Archimedes principle is used in measuring the relative density of a substance.
2. The hydrometer used for measuring the density of liquids is based on Archimedes principle.
3. The lactometers used for measuring the purity of milk is based on Archimedes principle.
4. Archimedes principle is used in designing ships and submarines.

What is the Density of Floating objects?

The Density of Floating Objects:

1. An object will float in a liquid if its density less than that of the liquid.
2. An object will float in a liquid if its density is equal to that of the liquid.
3. An object will sink in a liquid if its density is more than that of the liquid

Density: The density of a substance is defined as mass of the substance per unit volume.

- Density= Mass of the substance/ Volume of the substance
- Density= Mass/ Volume
- The SI unit of density is kilograms per cubic metre (kg/m^3).

Density of some common Substances in SI units.

Substance	Density, g/mL
Hydrogen (gas)	0.000089
Carbon dioxide (gas)	0.0019
Cork	0.21
Oak wood	0.71
Ethyl alcohol	0.79
Water	1.00
Magnesium	1.74
Table salt	2.16
Sand	2.32
Aluminum	2.70
Iron	7.86
Copper	8.92
Lead	11.34
Mercury	13.59
Gold	19.3

What is Relative Density?

The relative density of the substance is the ratio of its density to that of water.

- Relative density of substance = Density of the substance/ Density of the water.
- The relative density of the substance is the ratio of the mass of any volume of the substance to the mass of an equal volume of water. as the relative density is a ratio of two similar quantities, it has no units.

Why water is chosen as reference?

Water is present everywhere on earth so it becomes easier to evaluate the density of a substance in relation to water.

How relative density can be used as a measure to determine if an object will sink or float in water?

Relative Density of an object	Float / Sink
Greater than 1	Sink in water
Less than 1	Float in water

Relative density of some common Substances

Substance	Relative Density
Wood	0.2
Rubber	0.96
Paraffin wax	0.96
Aluminium	2.72
Iron	7.2
Gold	19.3

Work

The definition of work done may vary in real life and scientifically. For Example, We may consider studying, talking, singing, reading as work but it is not so in the case of science.

Examples of scientific work done are

- Moving a chair from one location to another
- Lifting a book from the shelf and placing it on a table
- Pushing a pebble lying on the ground.

In all these situations we are applying a force on an object which is then changing the state of rest or motion of the object.

So, we can conclude that work is done if and only if:

- A force is applied to an object.
- If the object is displaced from one point to another point.

These are also called '**Conditions of Work Done**'.

ILLUSTRATION OF FORCE

When you apply a certain force 'F Newton' on an object and the object moves a distance of 'd meters' in the direction where you applied the force then, the amount of work done can be calculated as:

- Work done = force * displacement
- $W = F * d$

Definition of Work

Work is defined as the product of the force applied on an object and displacement caused due to the applied force in the direction of the force. Work is a scalar quantity. It has no direction of its own but a magnitude.

- SI unit work = N-m or J (Joule) 1 Joule Work = A situation where 1 Newton force is applied on an object that can move the object by a distance of 1m in the direction of the applied force, then 1 joule of work is said to be done.
- Depending upon the direction of displacement and force applied the nature of work done may vary. Consider the table given below:

The Direction of Displacement	Work Done	Nature of Work Done	Angle between Force applied and Displacement occurred
Same as the direction of Force	$W = F * d$	Positive	0° (Force and Displacement are Parallel to each other)
Opposite direction of Force	$W = -F * d$	Negative	180°
No change in position	$W = F * 0 = 0$	Zero	90°

Work Done Against Gravity

The force of gravity of earth pulls everything towards the surface of earth. So, if we lift a book from a table, we do work against the force of gravity. Please note that when a body is lifted vertically upwards then the force required to lift the body is equal to its weight. So, whenever work is done against gravity the amount of work done is equal to the product of weight of the body and the vertical distance through which the body is lifted.

Suppose a body of mass m is lifted vertically upwards through a distance h. In this case, the force required to lift the body (at constant velocity) will be equal to its weight (mg). Now Work done in lifting a body = Weight of body x Vertical distance or Work done in lifting a body = $mg \times h = mgh$

Work done by a Force acting obliquely

- In many cases, the movement of the body is at an angle to the direction of the applied force. For example, when a child pulls a toy car with a string attached to it. The car moves horizontally on the ground but. force applied by the child is along the string held in his hand making some angle with the ground.
- In such cases we cannot use the formula $W = F \times s$ to calculate the work done because the distance moved, s, is not exactly in the direction of force applied. In this case, the whole of force F is not being used in pulling the toy car, only its horizontal component along the ground is the effective force pulling the toy car.

- Thus, the work done in pulling the body will be equal to the product of horizontal component of the force and distance moved by body. In this case the horizontal component of force F is $F \cos \theta$ and the distance moved is s . Thus, work done:
- $W = F \cos \theta \times s$ F = force applied
- θ = angle between the direction of force and direction of motion and s = distance moved

Energy

Any object that is capable of doing work possesses some energy. The object can gain or lose energy depending upon the work done. If an object does some work it loses its energy and if some work is done on an object it gains energy.

There are various types of energy

- Mechanical energy
- Thermal energy
- Nuclear energy
- Chemical energy
- Electromagnetic energy
- Sonic Energy
- Gravitational energy
- Kinetic Energy
- Potential energy
- Ionization Energy

Units of energy

- The unit of work and energy are the same. So, the **SI unit of energy is Joule**. The energy required to do 1 joule of work is called 1 Joule energy.
- Joule is a small unit of energy, so sometimes a bigger unit of energy called Kilojoule is used.
- 1 Kilojoule = 1000 joules or
- 1 KJ = 1000 J
- The unit of energy called Joules is named after a British physicist James Prescott Joule.

Different types of energy and short explanation

1. Kinetic energy

The kinetic energy of a moving body is measured by the amount of work it can do before coming to rest.

$$\text{Kinetic Energy} = \frac{1}{2} mv^2$$

Where, m = mass of the body

v = velocity of the body From this formula, it is clear that, The kinetic energy of a body is directly

proportional to the mass of the body and The kinetic of a body is directly proportional to the square of velocity of the body.

- Since the kinetic energy of a body is directly proportional to its mass, therefore if the mass of a body is doubled, its kinetic energy also gets doubled and if the mass of a body is halved, its kinetic energy also gets halved. Again, since the kinetic energy of body is directly proportional to the square of its velocity. Therefore, if the velocity of a body is doubled, its kinetic energy becomes four times, and the velocity of a body is halved, then its kinetic energy becomes one-fourth.

2. Potential energy

The energy of a body due to its position or change in shape is known as potential energy. Actually the energy of a body due to its position above the ground is called **gravitational potential energy** and the energy of a body due to a change in its shape and size is called elastic potential energy. **Elastic potential energy** is associated with the state of 'compression' or 'extension of an object for example, the energy possessed by a compressed spring or an extended spring is the elastic potential energy. The gravitational potential energy as well as elastic potential energy are commonly known as just potential energy. The sum of the potential and kinetic energies of a body is called its **mechanical energy**. E.g. A flying bird, a flying aeroplane.

Formula for Potential Energy:

The potential energy of a body is due to its higher position above the earth and it is equal to the work done on the body, against gravity, in moving the body to that position. **Potential energy = mgh**
Where, m = mass of the body, g = acceleration due to gravity, h = height of the body above a reference point

Power

The rate of doing work is known as power. Suppose an old man takes 20 minutes to do specific work whereas a young man takes 10 minutes to do same work. Thus, power of younger man is more than older man,

Power= work done/ time taken

$$P = w/t$$

p = power, W = Work done = time taken In other words power is the work per unit time or power is the work done per second. We know that when work is done, an equal amount of energy is consumed so, we can also define power by using the term energy in place of work. Power is also defined as the rate at which energy is consumed.

Power= energy consumed/ Time taken

$$P = E/t$$

P = power, E = energy consumed, t = time taken

- Power is a scalar quantity which has only magnitude but no direction.

Unit of Power

The unit of work done is joule and the unit of time is second. Thus, the unit of power will be joule/sec. The SI unit of power is watt. 1 watt is the power of an appliance which does work at the rate of 1 Joule/sec.

- 1 watt = 1 Joule 1 second
- **1W = (1J)/(1s)**
- so, 1 watt = 1 Joule/sec.

The unit of power called watt is named after a Scottish inventor James Watt, who became famous for steam engine. Watt is an important unit of power. Sometimes bigger unit of power called kilowatt and megawatt are also used.

- 1 kilowatt = 1000 watts
- 1 KW = 1000W
- 1 Megawatt = 10,00,000 watts or 1MW = 1000000W or 1MW = $10^6 \times W$

There is another unit of power called Horse power (HP) which is equal to 746 watts.

- **1 Horsepower = 746 watts or 1hp = 746W**
- This means that 1 Horsepower is equal to about 0.75 kilowatt (0.75 kW)
- The unit called Horsepower originated long back when the output of steam engines compared with the power of draft horses.

Other forms of energy

- **Mechanical Energy** – It is the sum of kinetic and potential energy of an object. Therefore, it is the energy obtained by an object due to

motion or by the virtue of its location. Example, a bicycle climbing a hill possesses kinetic energy as well as potential energy.

- **Heat Energy** – It is the energy obtained by an object due to its temperature. It is also called Thermal Energy. Example, energy possessed by a hot cup.
- **Chemical Energy** – It is the energy accumulated in the bonds of chemical compounds. Chemical energy is released at the time of chemical reactions. Example, energy possessed by natural gas and biomass.
- **Electrical Energy** – It is the energy associated with the movement of electric charges (current) through a conductor due to an electric potential difference (voltage), or energy stored in electric fields. Example, energy supplied by a battery, energy in lightning.
- **Light Energy** – It is the energy due to light or electromagnetic waves. It is also called as Radiant Energy or Electromagnetic Energy. Example, energy from the sun
- **Nuclear Energy** – It is the energy present in the nucleus of an atom. Nuclear energy releases when the nucleus combines or separate. Therefore, we can say that every atom in this universe comprises of nucleus energy. Example, uranium is a radioactive metal capable of producing nuclear energy in nuclear power plants
- **Sonic Energy** – It is the energy produced by a substance as it vibrates. This energy flows through the substance in the form of sound waves. Example, music instruments produce sound energy
- **Ionization Energy** – It is the energy required to remove an electron from an atom or ion. Specifically, it is the minimum energy needed to remove the most loosely bound electron from a neutral gaseous atom in its ground state (called First Ionization Energy). The energy required to remove subsequent electrons (Second Ionization Energy, etc.) increases.

Remind always- one form of energy can be transformed into other forms of energy.

Commercial unit of energy

- The commercial unit of energy is kilowatt-hour which is written in short form as kWh. The SI unit of electrical energy is joule and we know that, a joule is the amount of electrical energy consumed when an appliance of 1 watt power is used for one second.
- For commercial purposes we use a bigger unit of electrical energy called kilowatt-hour. One kilowatt-hour is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour.

Relation between Kilowatt-Hour and Joule:

- 1 kilowatt-hour = 1 kilowatt for 1 hour. Or 1 kilowatt-hour = 1000 watts for 1 hour but
- 1 Watt = $1\text{J}/1\text{s}$
- So, above equation can be written as,
 $1\text{ kw-hour} = 1000 \times \text{J/s for}$
 $1\text{ hour} = 60 \times 60\text{ seconds}$

So, $1\text{ kw-hour} = 1000 \times \text{J/s} \times 60 \times 60\text{ seconds}$ or **1 kilowatt hour = 36,00,000 J or $3.6 \times 10^6\text{ J}$ or $36 \times 10^5\text{ J}$**

Law of Conservation energy

According to the law of conservation of energy, the total amount of energy before and after transformation remains the same.

- Whenever energy changes from one form to another, the total amount of energy remains constant. Another definition of the law of conservation of energy is that: Energy can neither be created nor destroyed. During the conversion of energy from one form to another, some energy may be wasted. E.g. when electrical energy is converted into light energy in an electric bulb, then some electrical energy is wasted in the form of heat.

Conservation of Energy during the free fall of a body:

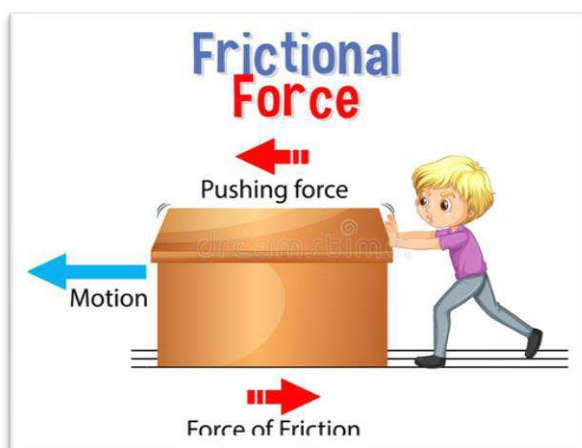
Suppose we have a ball of mass m and we raise it to a height h above the ground. The work done in raising the ball gives it a potential energy equal to

mgh . Let us allow the ball to fall downwards. As the ball falls, its height above the ground h decreases and thus the potential energy also decreases. But as the ball falls, its velocity v constantly increases and therefore, its kinetic energy also increases.

As the ball falls more and more its potential energy is gradually converted into an equal amount of kinetic energy. But the sum of potential energy and kinetic energy of the ball remains the same at every point during its fall. When the ball just reaches the ground, its potential energy becomes zero and its kinetic energy becomes the maximum. At this stage, all the potential energy has been converted into kinetic energy. From this we can conclude that the potential energy of ball has been changed into an equal amount of kinetic energy. There is no destruction of energy, and the total amount of energy remains constant.

What is Friction?

- Friction is a force that comes into play when two surfaces come in contact with each other.
- The frictional force or the force of friction acts in the opposite direction of the motion or the tendency of motion of the object relative to the surface it's in contact with.
- The force of Friction opposes the relative motion between the surfaces of two moving objects.



Factors that can affect the Friction?

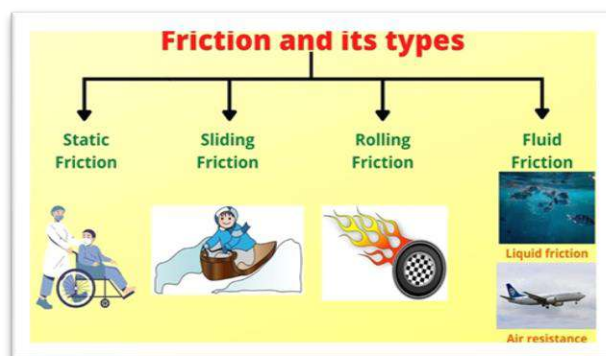
- 1. The irregularities of a surface:** If we move an object which has an irregular or rough surface on another surface which is also irregular, the force of Friction will be high in this case and the movement of the object would be restricted.
- 2. The regularity of a surface or its smoothness:** If the surfaces of either the objects or are smooth, the force of Friction would be less and the object would move easily over the surface. Even smooth surfaces have a certain irregularity.
- 3. If two surfaces are pressed hard:** the force of Friction increases between two surfaces if they are pressed hard and hence the movement of the object becomes restricted. However, if there is no pressure the object can easily move.

Types of Friction

- 1. Static Friction:** The Frictional force that comes into play until an object starts moving is called static Friction. An object has to overcome the

static Friction force in order to start its movement.

- 2. Sliding Friction:** Sliding Friction comes into play whenever an object moves along the surface of another object. Such a movement is called 'slide'. Hence, sliding Friction is the force that opposes the movement or slide of an object.
- 3. Rolling Friction:** When an object is rolling on a surface the force of Friction which acts upon it is called rolling Friction.
- 4. Fluid Friction:** When an object moves in a fluid, the fluid exerts a fluid Friction upon the object. It is also called **air Friction** (when the medium of travel is air) and **viscous Friction** (when the medium of travel is water). The frictional force exerted by fluids is also called drag.



Note- $\text{Rolling friction} < \text{Sliding Friction} < \text{Static Friction}$

Advantages of Frictional forces

Frictional force is necessary for various purposes in our daily lives such as:

- It allows us to walk on the earth surface.
- It allows us to write with a pen on a surface or a paper.
- It allows us to fix a nail in the wall.
- A moving object would never be able to come to the state of rest without the Frictional force.
- It would not be possible to drive any automobiles on the road without the Friction force.
- It would not be possible to construct any buildings without the Frictional force.

Disadvantages of Frictional Force

- Frictional force results in wear and tear of objects such as the moving parts of a machine, the tyres of a vehicle, sole of the shoes etc.

- It also results in the production of heat. In the case of machines, the production of heat leads to wastage of energy.
- The Frictional force also leads to a decrease in the speed of a moving object or some time stops it.
- It can lead to noise pollution in certain cases. For instance, aircrafts produce loud sound due to the resistance of the air.

How we can reduce or increase Friction

Increasing friction

Sometimes we need to increase the friction so as to avoid slipping of an object. Some of the example are as follows

1. The sole of the shoes is grooved so that the Friction between our feet and ground increases and we can walk safely
2. The tyres are treaded so that they can have a better grip over the ground and allow the smooth movement of the vehicles.
3. Brake pads are used in bikes to stop them suddenly from moving by increasing the amount of Friction.
4. Kabaddi players rub their hands with soil which helps in increasing the Friction between the hands and allows them to have an easy grip of the opponent.
5. Gymnasts also apply a coarse substance so that they can have a better grip due to increased Friction in their hands.

Reducing Friction

Sometimes in order to have a smooth movement of an object we need to reduce friction. For example,

- The powder is sprinkled over the carom board to decrease the Friction between the board's surface and the striker. In this way, the surface of the carom board becomes smooth.
- Grease is used in bicycles and other motors or different parts of a machine to reduce Friction and increase their efficiency.
- Oil is applied on the hinges of the door so that they can move easily.

Note- Applying substances like oil, grease or powder allows in smooth movement as they block the irregularities of a surface. The substances that can

reduce the amount of Friction between different objects are called lubricants. However, we can never reduce Friction to a level of zero. There are always some irregularities present on the surface.

How wheels can reduce the Friction?

- We know that when an object rolls over a surface rolling Friction is produced which resists its motion on the surface. However, its magnitude is lesser than the static and sliding Friction.
- Wheels are circulating objects that turn around a centre point.
- The wheels allow an object to roll over a surface rather than allowing them to slide over the surface.
- This results in less Friction and hence easy movement of the object.
- Rolling Friction is also used in the parts of machines that are moving continuously.
- In this way, the sliding Friction is removed with the help of rolling Friction and therefore the adverse effects of Friction such as the production of heat or wear and tear of the mechanical parts are also reduced.
- For instance, ball bearings are being used in fans and bicycles to reduce Friction.

What is Fluid Friction?

Air, water and other liquids collectively are called fluids. They also exert a Frictional force on the object that travels through them. Such a Friction is called fluid friction or drag. The amount of Frictional force by a fluid on an object depends upon the following:

1. The speed of the object with respect to the fluid.
2. The nature of the fluid, its viscosity or its tendency to resist the flow.
3. The shape of the object.

Fluid Friction comprises Internal and External Friction:

- Fluids comprise of internal Friction that occurs between the molecules of a liquid as they are also in motion. The viscosity of a liquid, therefore, depends upon the internal Friction.
- An external Friction in fluids is the force exerted by the fluid on the object that flows through it. As an object travels in a fluid it loses its energy in order to overcome the fluid Friction. Hence,

things that can easily flow in fluids have special shapes.

- For instance, ships and boats have a particular shape that allows them to resist fluid Friction.
- Birds and aeroplanes have a specific shape that allows them to fly in the air.
- Fishes also have a specific shape such as a tail and fins that allow them to swim continuously in water and even prevent the loss of energy due to fluid Friction.
- Not only this, all the vehicles are designed in a way that they can resist the fluid Friction because air is present everywhere.



What is Sound?

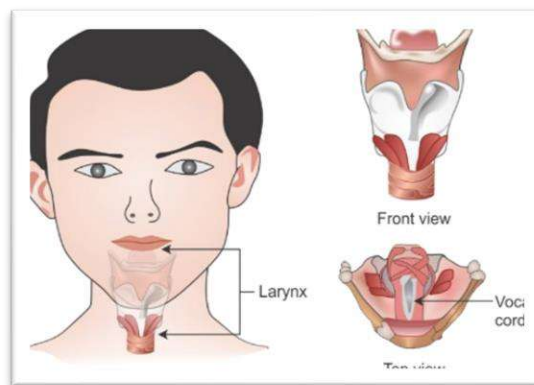
- Sound is a form of energy produced by vibrations. These vibrations cause the particles (molecules or atoms) of a medium (which can be air, liquid, or solid) to vibrate, and these vibrations propagate as waves through the medium..
- Vibration can be described as a back and forth motion of an object.
- Depending upon the vibrations, a sound is produced. Sound cannot be produced without any vibration.
- Sound helps to communicate with one another and plays an important role in our life.

Some of the examples

- When we hit the drum, membrane of drum vibrates producing sound.
- When we play a guitar, the string on it makes to and fro motion and produces sound.
- Sound produced by vibrating prong tuning fork.

How do Humans Produced sound?

1. Human beings have a voice box or larynx which is present in their throat on the upper side of the windpipe.
2. The larynx has two vocal cords which have a narrow slit between them so that air can pass through it.
3. As the lungs throw the air out of the windpipe, it passes through the slit and hence allows the production of sound as the vocal cords start vibrating.
4. The vocal cord muscles also play a role in the production of sound.
5. Their thickness and tightness describe the quality or type of the voice a person has.
6. The vocal cords in males are of length 20 mm and females have 15mm long vocal cords. Children, on the other hand, have very short length vocal cords. Hence, the voices, their quality and their type are always different in women, men and children.



Propagation of sound through medium

- Sound always requires a medium to travel from the source of its production to the receiver end. Different mediums of propagation of sound are air, liquid and solids.
- **Note-** Sound cannot travel through a vacuum as it lacks any medium of transmission.

How sound travels in a medium?

- Sound needs some vibration of molecules to travel.
- Solids, liquids and gases all have molecules present in them which allow the propagation of sound.
- These molecules or particles in solids, liquids and gases are packed in varied ways.
- Solids have tightly packed particles in them and hence they allow fast propagation of sound through them as the vibrations can be carried easily from one particle to another.
- Liquids have slightly loosely packed particles and hence it takes a little time for sound to travel in water or through a liquid.
- Gases have completely loosely packed particles and hence sound takes the most time in travelling through the air.

Note- Sound through water travels 4 times faster than through the air.

Sound through solids typically travels much faster than through air, often between 5 to 20 times faster or more, depending on the specific solid.

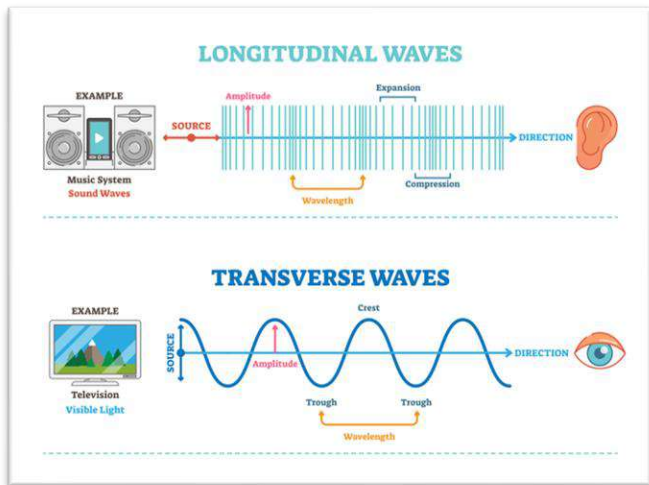
Sound travels in the form of waves

A wave is a vibratory disturbance in a medium which carries energy from one point to another

point without there being a direct contact between those points

There are two types of waves-

- **Longitudinal waves**
- **Transverse waves**



Let's discuss each with table format

Transverse waves	Longitudinal waves
The movement of the particle is perpendicular to the direction of wave	The movement of the particle is along the direction of the wave
Consists of troughs and crests	It contains rarefactions and compressions
Travel through solids, and on the surface of liquids. NOT in the bulk of ideal liquids or gases.	Can travel through all states of matter.
Light waves are transverse waves.	Sound waves are longitudinal waves.
The particles are displaced perpendicular to the direction of the travelling wave.	The movement of particles is usually parallel to the movement of energy.

Characteristics of Sound wave

Like any wave, a sound wave too has many characteristics. The five characteristics of sound are amplitude, wavelength, period, frequency, and speed or velocity. To understand sound well, it is imperative for everyone to learn about these characteristics.

Amplitude

- When a wave passes through a medium, there is a temporary displacement of the particles of the medium from their actual positions. The

maximum displacement of these particles of the medium from their actual positions when a wave passes through them can be defined as the amplitude of the wave. In other words, it is used to describe the **size of the wave**. It is measured in '**meter**' in the **S.I. unit**.

Wavelength

- Wavelength is the minimum distance in which the sound wave repeats itself. It is the **length of one complete wave**. In a sound wave, the combined length of an adjacent rarefaction and compression is known as the wavelength. It is also important to remember that the distance between the centres of two successive rarefactions and two successive compressions is equivalent to its wavelength. The **S.I. unit of wavelength is also metre**.

Period

- The time that is required to produce one complete wave or cycle is known as the period of the wave. One full vibration of the vibrating body produces one complete wave. So, the time taken for completing one vibration can be referred to as the period. The Period is denoted by the letter T and the **unit of measurement is second (S)**.

Frequency

- The total number of the cycles or waves that are produced in one second can be referred to as the frequency of the wave. Alternatively, frequency can also be defined as the number of vibrations per second. For instance, if 20 vibrations are produced in one second then the frequency of the waves will be 20 Hertz and 20 cycles. The frequency of a wave is fixed and it does not change when it passes through different medium. The **unit of frequency is Hertz or Hz**.

Velocity

- The distance that is covered or travelled by a wave in one second is regarded as the velocity (speed having a direction vector) of the wave. The unit of measurement of velocity is meters per second. The velocity of a wave can be found by dividing the distance travelled with the time taken. It can also be found by **multiplying the frequency of the wave with the wavelength**.

It is important to keep in mind that it applies to all forms of waves like transverse waves (for example water waves), electromagnetic waves (like light waves and radio waves), and most importantly, longitudinal waves like sound waves.

The idea that sound travels as wave dates back to about 240 B.C. Greek philosopher Chrysippus, Roman architect and engineer Vitruvius, and Roman philosopher Boethius each theorized that the movement of sound might take place in the form of waves.

Sound needs a material medium to travel

- The substance through which sound travels is called a **medium**. Sound needs a material medium like solid, liquid or gas to travel and be heard. In other words, sound can travel through solids, liquids and gases but it cannot travel through vacuum.
- Sound waves are called **mechanical waves** because they need a material medium for propagation. The sound waves involve the vibrations of the particles of the medium through which they travel. On the other hand, light waves and radio waves are called **electromagnetic waves** because they do not need a material medium for their propagation.
- They can travel even through vacuum. An electromagnetic wave involves the electric and magnetic fields of the empty space or vacuum. From this, we can conclude that though sound waves cannot travel through vacuum but light and radio waves can travel through vacuum.

Factors affecting the Speed of sound:

The speed of sound tells us the rate at which sound travels from the sound producing body to our ears. The speed of sound depends on a number of factors as given below,

1. **Material medium:** The speed of sound is different in different materials for different medium. E.g. the speed of sound in different materials like air, water and iron is different. At room temperature, the speed of sound in air is 344 m/s, the speed of sound in water is about 1500 m/s and the speed of sound in iron is 5130 m/s. In general, sound travels faster in solid and slower in gases.

2. **Temperature:** The speed of sound in air depends on the temperature. E.g. the speed of sound in air at a temperature of 0°C is 332 m/s but the speed of sound in air at a temperature of 20° C is 344 m/s. As the temperature of air rises, the speed of sound in it increases. Thus, the speed of sound in air will be more on a hot day than on a cold day.

3. **Humidity:** The speed of sound depends on the humidity of air. E.g. the speed of sound is less in dry air but more in humid air. Sound travels slower in dry air but faster in humid air. As the humidity of air increases the speed of sound through it also increases.

Sonic Boom

- Many objects such as some aircrafts, bullets and rockets, etc, travel at speeds which are greater than the speed of sound in air. They are said to have **supersonic speed**. Hence, the term supersonic refers to the speed of an object which is greater than the speed of sound. Due to its very high speed, a supersonic aircraft produces extremely loud Sound waves called shock waves in air. The tremendous air pressure variations caused by the shock waves produce a loud burst of sound called sonic boom.
- Sonic boom is an explosive noise caused by the shock waves from an aircraft or any other object which is travelling faster than the speed of sound. The first supersonic jet aircraft was made in 1948.

Compare speed between Sound and Light

- The speed of sound in air is about 344 m/s and the speed of light in air is 300,000,00 m/s. It is clear that the speed of light is very great as compared to the speed of sound. e.g.
 1. In rainy season, the flash of lightning is seen first and the sound of thunder is heard a little later.
 2. In the game of cricket, the ball is seen to hit the bat first and the sound of hitting is heard a little later.
 3. If a gun is fired from a distance, we see the flash of gun first and the sound of gunshot is heard a little later.

Reflection of Sound:

- Like light, sound can also be made to change its direction and turns back when it falls on a hard or solid surface. The turning back of sound when it strikes a hard surface is called reflection of sound.
- Sound is reflected in the same way as light. The laws of reflection of light are obeyed during the reflection of sound.

Applications of Reflection of Sound

1. **Megaphone and Bulb Horn:** The devices like megaphone and bulb horn all designed to send sound in a particular direction, without spreading all around. All these devices have a funnel-shaped tube which reflects sound waves repeatedly so that most of the sound waves produced go in the forward direction. Due to repeat reflections the amplitude of sound waves increases due to which the loudness of sound also increases.
2. **Stethoscope:** Stethoscope is a medical instrument used by the doctors for listening to the sounds produced within the human body, mainly in the heart and the lungs.
3. **Soundboard:** The soundboard is a concave board which is placed behind the speaker in large halls or auditoriums so that sound can be heard easily even by the persons sitting at a considerable distance. The soundboard works as follows: The speaker is made to stand at the focus of the concave soundboard. The concave surface of the soundboard reflects the sound waves of the speaker towards the audience. Due to this, sound is distributed uniformly throughout the hall and even the persons sitting at the back of the hall can hear the sound easily. The ceilings of concert halls, conference halls and cinema halls are made curved so that sound, after reflection from the ceiling, reaches all the parts of the hall.

Echo:

The repetition of sound caused by the reflection of sound waves is called an echo. An echo is heard when sound is reflected from a hard surface such as a tall brick wall or a cliff. It has been estimated by

scientists that if two sounds reach our ears within an **interval of $\frac{1}{10}$ th of a second**, then we cannot hear them as separate sounds, they appear to be just one sound. The human ear can hear two sounds separately only if there is a time interval of $\frac{1}{10}$ th of a second between the two sounds. This means that we can hear the original sound and the reflected sound (Echo) separately only if there is a time-interval of at least $\frac{1}{10}$ th of a second or 0.1 second between them.

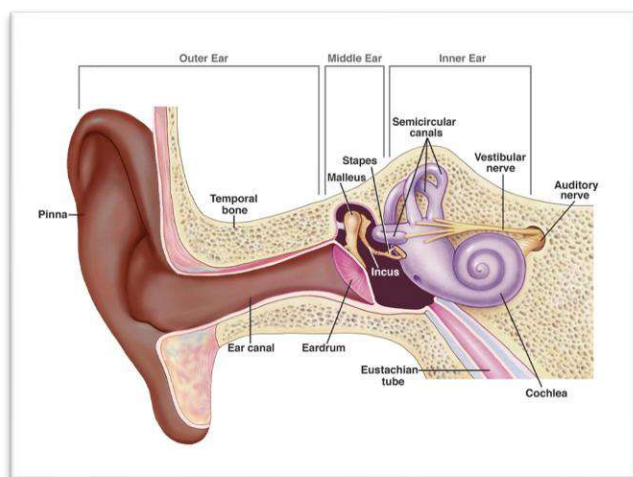
Reverberation:

If a sound is made in a big hall the sound waves are reflected repeatedly from the walls, ceiling and floor of the hall, and produce many echoes. The persistence of sound in a big hall due to repeated reflections from the walls, ceiling and floor of the hall is called reverberation. If the reverberation is too long then the sound becomes blurred, distorted and confusing due to overlapping of different sounds.

- Some of the methods used for reducing excessive reverberation in big halls and auditoriums are as follows:
 - Panels made of sound-absorbing materials are put on the walls and ceiling of big halls and auditorium.
 - Carpets are put on the floor to absorb sound.
 - Heavy curtains are put on doors and windows to absorb sound.
 - The material having sound absorbing properties is used for making the seats in a big hall or auditorium to reduce reverberations.

How do we hear?

- We know that sounds are produced as waves in the air or any other medium.
- As these sound waves travel to our ears they convert them into electrical signals or messages that our brain can understand.
- Our ears have a special structure that allows this function.
- There are three major parts of the human ear:



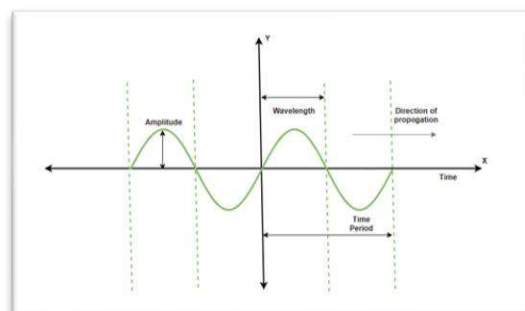
1. **The outer ear (Pinna):** It catches the sound waves and forwards them to the next part of the ear, that is, the middle ear.
2. **The middle ear:** It converts the sound waves into vibrations that then travel to the inner ear. It can do this with the help of the **eardrum**. The eardrum is a thin rubber-like sheet present in the Middle ear. As the sound waves reach the eardrum, it vibrates and these vibrations propagate to the inner ear.
3. **The inner ear (cochlea):** It receives the vibrations sent by the eardrum. It contains a liquid substance and the vibrations that enter the inner ear moves through this liquid. There are tiny hairs present inside the inner ear that turn these vibrations into signals for the brain and pass them to the brain through the hearing nerve. As the brain receives the signal it interprets the sound. However, this whole process is so quick that we cannot notice it.

Some important sound concepts

- a. **Oscillatory motion-** When an object travels in a 'to and fro' motion, that is, when an object vibrates it is said to have an oscillatory motion.
- b. **Oscillations-** An oscillation (or cycle) is one complete 'to and fro' movement of a vibrating object, returning to its starting point and moving in the same direction.
- c. **Frequency-** The number of oscillations an object takes per second is called its frequency.
 - The SI unit of frequency is **Hertz (Hz)**.
 - 1 Hz = 1 oscillation per second
 - 20 Hz = 20 oscillations per second

d. **Time period-** The time taken for one complete oscillation of a sound wave is called the time period of the sound wave.

e. **Amplitude-** The amplitude of a sound wave can be defined as the maximum displacement of the particles from their mean position due to the vibrations.



What is the Loudness of a sound?

- The loudness of a sound depends upon the amplitude of the sound.
- The higher the amplitude, the higher is the displacement of the particles and the higher is the loudness of the sound.
- The loudness of the sound is directly proportional to the square of its amplitude.
- The SI unit for measuring the loudness of a sound in decibels (dB).

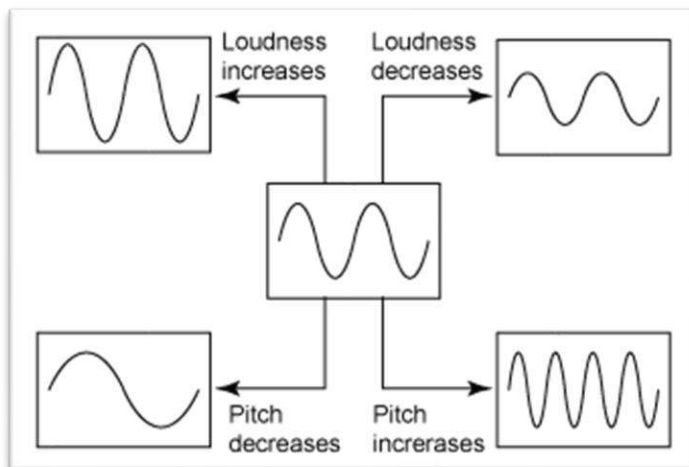
What is Pitch of the Sound?

- Every person has a different sound quality.
- Also, every musical instrument vibrates to produce a different kind of sound. The quality (or timbre) of a sound is what distinguishes different types of sound production, even if they have the same pitch and loudness. Timbre depends on the complexity of the sound wave, including the presence and relative intensity of harmonics or overtones.
- The pitch of a sound depends upon the frequency of the sound wave.
- The pitch would be higher if the frequency of the sound is high.

Different organisms and objects have different type of sound because of varied pitch:

Sound produced by	Pitch of the sound
Drum	Low
Bird	High
Lion	Low
Man	Low
Woman	low

Pitch and Loudness relation is described in below picture.



How Loudness and Pitch are different from each other?

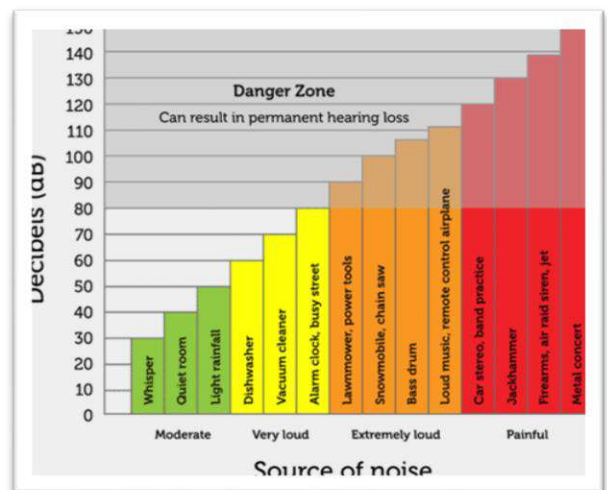
Pitch	Loudness
It depends upon the frequency of the sound.	The loudness of a sound depends upon the amplitude of the sound wave.
Pitch of a sound is how our ears react to the frequency of a sound.	The loudness of sound also depends upon the energy of the sound wave.
Pitch of the sound helps in recognizing whether the sound is shriller or flatter.	The loudness of a sound helps in recognizing whether a sound is loud or feeble.
High frequency - shriller sound shorter wavelength Low frequency - flatter sound longer wavelength	High amplitude - loud sound Low amplitude - feeble sound

What is audible Sound?

- Sounds that can be heard by human ears are called audible sounds. The range of **audible sounds** is from **20 Hz to 20 KHz**.

What is Inaudible Sound?

- Sounds that cannot be heard by human ears are called inaudible sound. Any sounds having a frequency less than 20 Hz or greater than 20 KHz are categorized as inaudible sounds.



- The Inaudible sound can be divided into two categories as Infrasound and Ultrasound

Infrasound	Ultrasound
The sounds having a frequency range below 20 hertz are called infrasound	The sound waves having a frequency range above 20 kilohertz are called ultrasounds
Infrasound cannot be heard by humans	Having too high frequency, they cannot be heard by human beings as well.
Animals like giraffe, rhinoceros and whales use infrasound to communicate	Bats, dogs and cats use ultrasounds to communicate.
It's used in fields like seismology, meteorology, and environmental monitoring to detect earthquakes, volcanic eruptions, and explosions.	Ultrasounds can be used for various purposes such as identifying abnormalities in the human body or calculating distances under the water through SONAR.

Applications of Ultrasound

- Ultrasound is used in industry for detecting flaws (cracks, etc.) In metal blocks without damaging them.
- Ultrasound is used in industry to clean "hard to reach parts of objects such as spiral tubes, shaped machines and electronic components, etc.
- Ultrasound is used to investigate the internal organs of the human body such as liver, gall bladder pancreas, kidneys, uterus and heart, etc.

The technique of obtaining pictures of internal organs of the body by using echoes of ultrasound pulses is called ultrasonography. And such pictures are called ultrasound scans. A machine which uses ultrasound for obtaining images of the internal organs of human body is called ultrasound scanner. The use of ultrasound waves to investigate the action of the heart is called '**echocardiography**'.

4. Ultrasound scans are used to monitor the development of foetus inside the mother's uterus.
5. Ultrasound is used to break kidney stones into fine grains.
6. Ultrasound is used in **SONAR apparatus** to measure the depth of sea or ocean and to locate under-sea objects like shoal of fish, shipwrecks, submarines, sea rocks and hidden ice bergs in the sea.
7. Bats use ultrasound to fly at night without colliding with other objects and to search their prey like flying insects.
8. The method used by some animals like bats, porpoises and dolphins to locate the objects by hearing the echoes of their ultrasonic squeaks is called **echolocation**. e.g.
 - a) Bats fly in the darkness of night without colliding with other objects or obstacles by the method of echolocation.
 - b) Bats search their prey (like flying insects) at night by the method of echolocation.

SONAR:

The word SONAR means **Sound Navigation And Ranging**. It is a device which is used to find the depth of sea or to locate the underwater things like shoals of fish, shipwrecks and enemy submarines. A sonar device consists of two parts:

i. A transmitter

ii. A receiver

- Sonar works by sending short bursts of ultrasound with very high frequency of about 50,000 Hz. From a ship down into sea water and then picking up the echo produced by the reflection of ultrasound from under water objects.
- This echo is converted into an electrical signal by the receiver of the sonar device. The sonar

device measures the time taken by the ultrasound pulse to travel from the ship to the bottom of the sea and back to the ship. Half of this time gives the time taken by the ultrasound to travel from the ship to the bottom of the sea. From this, we can calculate the distance between the ship and the bottom of the sea. This will give us the depth of the sea.

Noise and Music

Noise	Noise can be regarded as an unpleasant sound. Noise consists of sound waves of varied frequencies which have no particular periodic pattern of repetition. Therefore, noise is regarded as a mixture of sound waves with irregular frequencies.
Music	Music, on the other hand, is a pleasant sound that has a clear pitch. Musical sound can be created by arranging and combining different sounds in a particular order. The frequencies of a musical sound are harmonious in nature.

What is Noise pollution?

- Noise pollution can be defined as the presence of undesirable and unpleasant sounds in the earth's environment.
- Noise is unwanted/harmful sound, measured in decibels for its intensity/loudness.
- Generally, any sound that has a frequency of more than 30 dB is considered noise.
- The unwanted noise causes an adverse effect on the health of the organisms present on the earth.
- According to the World Health Organization, the maximum sound limit that is ideal for cities is 45 dB only.
- However, it has been found that the sound range in many big cities of the world lies up to 90 dB.
- Hence noise pollution is common in many cities today and even rural areas to a great extent.

Causes

1. **Transport noise:** The sound of the traffic on roads, railways and aircraft leads to noise pollution. As the number of vehicles such as cars,

motorcycles, buses and trucks is increasing in the cities, especially the Metropolitans, noise pollution is extremely high there.

2. **Industrial noise:** Industries, factories and other commercial businesses produce high-intensity sounds that pollute the environment.
3. **Neighbourhood noise:** The noise from the radios, televisions, air conditioners, coolers, kitchen applications and other electrical appliances used in houses lead to noise. Not only this, commercialization around the residential areas often leads to unwanted sounds due to small-scale industries such as printing, car repairing etc.
4. **Construction noise:** Construction of houses, industries and various architectures also lead to sound pollution.
5. **Political activities:** Noise pollution is also created due to the rallies and demonstrations conducted by various political parties in cities and rural areas.
6. **Bursting of crackers and fireworks:** People burst crackers on several occasions such as festivals and ceremonies that lead to sound pollution in the neighbourhoods.

Effects of Noise Pollution

1. Excessive noise in the surroundings can lead to serious health problems such as hypertension, lack of sleep or insomnia, anxiety, lack of memory, stress, irritation and even nervous breakdown.
2. It can lead to temporary or permanent hearing loss in human beings as well as animals.
3. Excessive noise leads to increased blood pressure. It increases cholesterol levels in the blood and therefore increases the chances of cardiovascular diseases in a person.
4. If sound intensity is more than 180 dB it can lead to the death of a person.
5. Noise pollution also leads to a decrease in the production of digestive juices by our body.
6. It can affect animals as well and can lead to their death and loss of habitats. Excessive noise decreases a person's ability to concentrate especially on children and they are unable to concentrate well on their studies due to neighbourhood noises.

7. Unwanted sounds in the environment can hinder the animals from finding their prey or their direction of motion.

Prevention of Noise Pollution

1. Factories and other industries should be set up at a distance from residential areas.
2. Silencing devices should be incorporated into heavy vehicles such as aircraft, industrial equipment, machinery and other home appliances.
3. We should always play television, radio and other music systems at a low sound so that it does not harm the neighbourhood.
4. Use of horns should be minimized especially near public places such as hospitals, religious places and schools.
5. Soundproofing systems should be installed in industries, party halls and other buildings that produce a high amount of unwanted sounds.
6. Trees should be planted in huge numbers as they can absorb unwanted noise from the environment.
7. People who work in noisy conditions such as industries and mines should be provided earplugs to protect their ears.
8. People should be made aware of noise pollution its adverse effects so that they can take an active involvement in preventing it.

A common characteristic of all the moving bodies is that they change their position with time. A body is said to be in motion when its position changes continuously with respect to a stationary object taken as reference point. For example, when the position of a car changes continuously with respect to stationary objects like houses and trees, etc. we say that the car is moving or that the car is in motion.

If a body moves fairly fast, then its movement or motion can be observed easily. But if a body moves very slowly, then it becomes difficult to observe its movement immediately. E.g. a wrist watch has three hands a second hand, a minutes hand and an hours hand, which move round and round on the dial of the watch. In order to study the motion of bodies, we should first know the meanings of distance and displacement.

So

- A **Reference Point** is used to describe the location of an object. An object can be referred to through many reference points.
- **Origin** – The reference point that is used to describe the location of an object is called Origin.

What is Motion?

If the location of an object changes with time the object is said to be in motion.

Motion in Straight Line

Distance

- The distance travelled by a body is the actual length of the path covered by a moving body irrespective of the direction in which the body travels.
- When a body moves from one point to another, the distance travelled refers to the actual length of the indirect path whereas displacement refers to the straight line path between the initial and the final positions.
- Distance is a numerical quantity. We do not mention the direction in which an object is travelling while mentioning the distance covered by that object.

Displacement

- So, whatever be the actual length of the path followed by a moving body, displacement of the body is always represented by the shortest distance between the initial and final positions of the body.
- Thus, when a body moves from one position to another, the shortest distance between the initial position and final position of body, along with direction, is known as its displacement.
- It is clear that the distance travelled has only magnitude whereas displacement has magnitude as well as direction.

Distance is a scalar quantity because it has magnitude only.

Displacement is a vector quantity because it has magnitude as well as a direction.

e.g. if a car travels a distance of 50 km, then the expression "50 km" is the distance travelled and if the car is travelling in a straight line in the East direction or any other direction. Then the expression "50 km" towards east is the displacement of the car.

- Displacement is denoted by Δx .

$$\Delta x = x_f - x_0$$

Where,

- x_f = Final position of the object
- x_0 = Initial position of the object

Note- Note distance can never be zero but displacement can be zero. When the first and final position of an object are the same, the displacement is zero and such displacement is called as Zero displacement.

Negative and Positive Displacement can be possible.

Scalar Quantity	Vector Quantity
• A scalar quantity describes a magnitude or a numerical value.	• A vector quantity describes the magnitude as well as the direction.
• Example of Scalar quantity is Distance.	• Example of vector quantity is Displacement.

Recap distance and displacement by table

Distance	Displacement
Distance provides the complete details of the path taken by the object	Displacement does not provide the complete details of the path taken by the object
Distance is always Positive	Displacement can be positive and negative
It is Scalar Quantity	It is vector quantity
The distance between two points may not be unique	Displacement between two points is always unique.

Uniform and Non-Uniform Motion

- **Uniform Motion-** A body has a uniform motion if it travels along a straight line and covers equal distances in equal intervals of time. E.g. a car running at a constant speed of 10 m/s, will cover equal distances of 10 metres, every second. So, its motion will be uniform and the distance-time graph for uniform motion will be a straight line.
- **Non-Uniform Motion-** A body has a non-uniform motion if it travels unequal distances in equal intervals of time. e.g., if we drop a ball from the roof of a tall building we will find that it covers unequal distances in equal intervals of time. The motion of a freely falling body is an example of non-uniform motion. The distance-time graph for a body having non-uniform motion is a curved line.

The motion of the body can be described by three terms, Speed, Velocity and Acceleration

Speed

- The speed of an object is defined as the distance travelled by the object per unit of time.
- SI Unit- Metre (m) / Second
- Formula; Speed (S)= Distance (d)/ Time (t)
- Speed is a scalar quantity

From the above formula we can have formula for distance, time also

- $Distance = Time * Speed$
- $Time = distance / speed$
- $Speed = distance / time$

Average Speed

- The average speed of the body is the total distance travelled divided by the total time taken to cover the distance.

$$Average\ Speed = \frac{Total\ distance\ travelled}{Total\ time\ taken}$$

Uniform or Constant Speed

A body has uniform speed if it travels equal distance in equal intervals of time.

E.g. a car is said to have uniform speed of say, 60 km per hour, if it travels 30 km every half hour. 15 km every quarter of an hour, 1 km every minute, and 1/60 km every second.

Velocity:

- Velocity of a body is the distance travelled by it per unit time in a given direction.
- $Velocity = \frac{Distance\ travelled}{Time\ taken}$
- $V = s/t$

Where

V = velocity of the body

s = distance travelled (in the given direction)

t = time taken

- We know that the Distance travelled in a given direction is known as Displacement. So, Velocity of a body is the displacement produced per unit time.
- **Velocity=Displacement/Time taken**
- The SI unit of velocity is the same as that of speed, **meters per second (m/s)**.

The Difference between the Speed and the Velocity is that speed has only magnitude, it has no specific direction, but velocity has magnitude as well as direction. Speed is a scalar quantity and velocity is a vector quantity. The direction of velocity is always same as the direction of displacement of the body.

Uniform velocity

- A body has a uniform velocity if it travels in specified direction in a straight line and moves over equal distances in equal intervals of time.
- The velocity of body can be changed in two ways
 - By changing the speed of the body
 - By keeping the speed constant but by changing the direction.

- When body does not cover equal distances in equal interval of time, the velocity of the body will be non-uniform. In this case, even speed of the body is constant but direction is changing, the velocity will not be uniform.
- E.g. car is moving on a circular path.

Acceleration

- Acceleration of body is defined as the rate of change of its velocity with time.
- Acceleration= **change in velocity/ time taken**
- Change in velocity= final velocity- initial velocity
- So acceleration is

Acceleration= (Final velocity- Initial velocity)/ Time taken

$$A = (v - u)/t$$

A= acceleration, u= initial velocity, v= final velocity, t= time taken

- The SI unit of acceleration is **metres per second square (m/s²)**
- Acceleration is a vector quantity.
- When body is moving with uniform velocity, its acceleration will be zero, because then the change in velocity (v- u) is zero.
- Thus, (i) when the velocity of a body is uniform, acceleration is zero, and (ii) when the velocity of a body is non- uniform the motion is accelerated.

Uniform Acceleration:

If the velocity increases at a uniform rate, the acceleration is said to be uniform. A body has a uniform acceleration if it travels in a straight line and its velocity increases by equal amounts in equal intervals of time. The velocity-time graph of a body having uniform acceleration is a straight line. e.g.

- The motion of a freely falling body.
- The motion of a bicycle going down the slope of a road.
- The motion of a ball rolling down an inclined plane.

Non-Uniform Acceleration:

A body has a non-uniform acceleration if its velocity increases by unequal amounts in equal intervals of time. E.g. The velocity of a car running on a crowded city road changes

continuously. The velocity-time graph for a body having non-uniform acceleration is a curved line.

Retardation or Deceleration or Negative Acceleration:

- If the velocity of a body increases, the acceleration is positive and if the velocity of a body decreases, the acceleration is negative. A body is said to be retarded if its velocity is decreasing e.g., a train is retarded when it slow down on approaching a station because its velocity decreases.
- Retardation is measured in the same way as acceleration, that is, retardation is equal to change in velocity/time taken and has the same units of metres per second square (m/s²)
- Retardation is actually acceleration with the negative sign (when the positive direction is defined). A negative value of acceleration means the acceleration vector points in the negative direction. If the object is moving in the positive direction, this means its speed is decreasing. If the object is moving in the negative direction, this means its speed is increasing in the negative direction.

Equations of Uniformly Accelerated Motion:

- There are three equations for the motion (given by Newton) of those bodies which travel with a uniform acceleration. These equations give relationship between initial velocity, final velocity, time taken, acceleration and distance travelled by the bodies.

First Equation of Motion:

- The first equation of motion gives the relation between velocity acquired by a body in time t.
 $v = u + at$ (velocity - time relation)

Second Equation of Motion:

- The second equation of motion gives the distance travelled by a body in time t.
- $s = ut + \frac{1}{2} at^2$ (distance time relation)

Third Equation of Motion:

- The third equation of motion gives the velocity acquired by a body in traveling a distance s .
- $v^2 = u^2 + 2as$ (velocity distance relation)

Remember that:

- If a body starts from rest, its initial velocity, $u = 0$
- If a body comes to rest or stops, its final velocity, $v = 0$
- If a body moves with uniform velocity, its acceleration, $a = 0$

Uniform Circular Motion:

When a body moves in a circle, it is called circular motion. In other words, motion of an object in a circle is called circular motion. e.g., a merry-go-round, a CD player.

- Suppose a person is running along a square tracks, he has to change his direction of motion four times at the four corners of the square track.
- When a body moves along a circular path then its direction of motion, keeps changing continuously. Since the velocity changes due to continuous change in direction, the motion along a circular path is said to be accelerated. When a body moves in a circular path with uniform speed, its motion is called uniform circular motion.

Examples of Uniform Circular Motion:

1. Artificial satellites move in uniform circular motion around the earth. The motion of a satellites around the earth is accelerated. The moon is a natural satellite of the earth.
2. The moon moves in uniform circular motion around the earth so, the motion of moon around the earth is accelerated.
3. The earth moves around the sun in uniform circular motion. So, the motion of earth around the sun is accelerated.
4. An athlete moving on a circular track with a constant speed having uniform circular motion. This motion is accelerated because of a continuous change in direction of motion.

The tip of a second's hand of a watch having uniform circular motion on the circular dial of the watch. Thus, the motion of the tip of second's hand of a watch is accelerated

Introduction

- A Natural Phenomenon is anything that occurs on its own in nature without any kind of human intervention.
- For example, the weather of a place, fog, storms, winds, tides, volcanic eruptions and cyclones all can be categorized as natural phenomena.
- Some natural phenomena can be destructive such as cyclones, thunderstorms, lightning and earthquakes.
- However, there are some ways with which we can protect and prepare ourselves from these natural disasters.

What is lightning?

- Lightning is an electric discharge or an electric spark that occurs in nature on a major scale. It is caused by the accumulation of charges in the clouds.
- It can be deadly and cause the destruction of life and property.
- In ancient times people were unaware of the cause of lightning and hence they were scared of it. Nowadays, scientists have evolved some precautions that can help us prepare and protect ourselves from this natural phenomenon.

History- Sparks that Greek Knew about

- The Greeks were already aware of the electric charges from 600 BC. They knew that when Amber (a type of resin) and fur are rubbed together, then amber can attract light objects like hair.
- Similarly, woollen clothes or polyester clothes also attract hair and can produce a little spark or crackling sound when they are taken off from the body. This is because of electric charges.
- Benjamin Franklin was an American scientist who in 1752 discovered and proved that lightning and spark produced from these clothes are all same things.

What is electric charge?

- We know that every atom comprises of subatomic particles such as electrons, protons and neutrons.

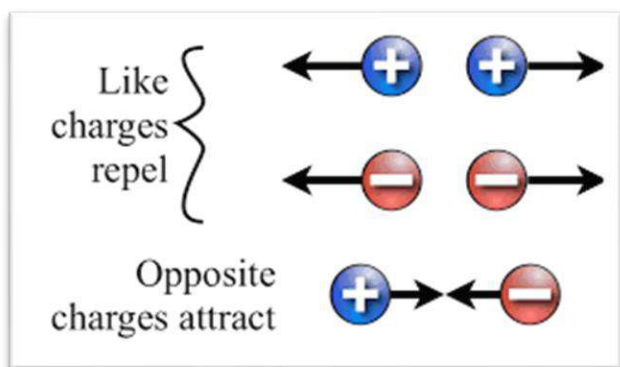
- Protons and electrons carry electric charges. Protons have a positive charge, and electrons have a negative charge. Neutrons are electrically neutral.
- It is basically amount of electricity contained in an object.
- There are two types of charges
 - Positive charge
 - Negative charge
- We know that atoms carry a balanced charge however these charges may sometimes become out of order.
- An object will be called electrically neutral if it is carrying a balanced proportion of positive and negative charges.
- An object is called a charged object if there is an imbalance of electrons and protons in it.

Charging by Rubbing

- When we rub two objects with each other they get charged due to a transfer of electrons between them.
- For example, if we rub a rubber balloon with animal fur, the balloon is made up of rubber attracts the electrons from the animal fur.
- This results in rubber having an excess of electrons while fur having a shortage of electrons.
- In the same way, if we rub a plastic comb with dry hair the comb acquires some charge.

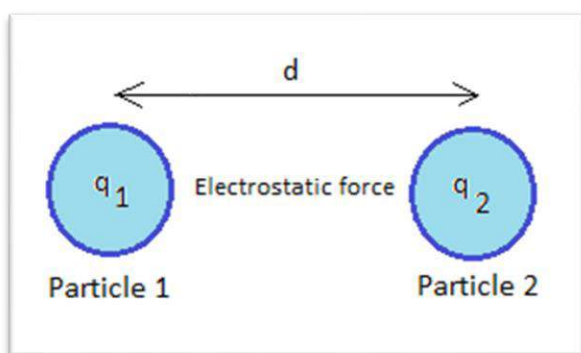
Types of charges and their interaction

- We know that charged objects may have a shortage or excess of electrons.
- Objects having an excess of electrons are called **negatively charged** while an object having a shortage of electrons are called **positively charged**.
- For instance, when a glass rod is rubbed with silk cloth it becomes positively charged while the silk cloth becomes negatively charged.
- These charged objects are now capable of attracting other charged and uncharged objects.
- Objects having the same kind of charges repel each other while objects with different kind of charges attract each other.



What is an electrostatic force?

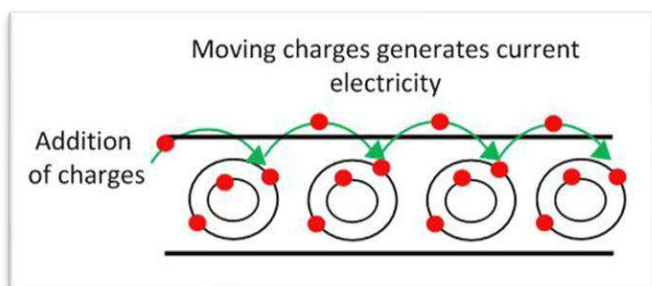
The force of attraction or repulsion experienced by charged objects is called electrostatic force.



What is a static electric charge?

Static charge or static electricity is an electric charge which does not move. Static charges are a result when two objects are rubbed with each other. When two surfaces come in contact with each other repeatedly it results in the transfer of electrons from one material to another. The strength of an electric charge depends upon different factors such as:

1. The temperature and humidity
2. Properties of the surface such as its material
 - In opposite to static charge, there is an electric current. The electric current results when the charges flow or move from one point to another. This electric current results in glowing of bulb or working of all the electrical appliances.



Transfer of charges

Charges can transfer from one object to another with the help of conduction and induction:

- **Conduction:** when a charged object comes in contact with a conductor it results in the transfer of charges through the conductor.
- **Induction:** When a charged object is brought near a neutral object, it causes a separation or redistribution of charges within the neutral object (polarization). This can lead to a net transfer of charge if the neutral object is temporarily connected to the ground.

How the transfer of electric charges leads to conservation of charge?

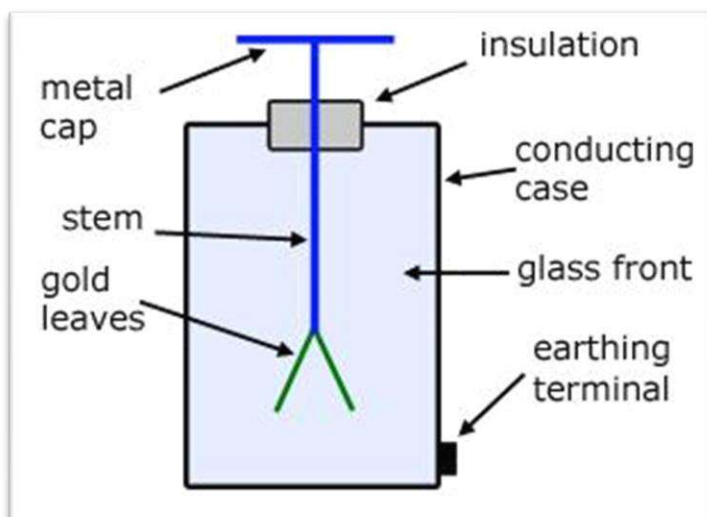
The net charge on a neutral object is zero. However, when an object receives some electrons from another object, the net negative charge on the first object is equal to the net positive charge of the second object. In this way, charges are conserved during transfer of charges.

What is an electroscope?

- It is a device which can test if an object is charged or not.
- Abraham Bennet developed a gold leaf electroscope in 1787.

Structure of an electroscope

- Generally, gold and silver are used to construct an electroscope because they are good conductors of electricity. Otherwise, copper and aluminium can also be used.
- It consists of a glass jar having a vertical brass rod.
- The rod is inserted into the jar through the cork.
- The brass rod has a brass disc or horizontal rod attached to it.
- From the other end, two leaves of gold are suspended.



Working of an electroscope

When a charged object touches the brass disc, electric charges get transferred from the brass rod to the gold leaves. As a result, the gold leaves move away from each other depicting the presence of charges.

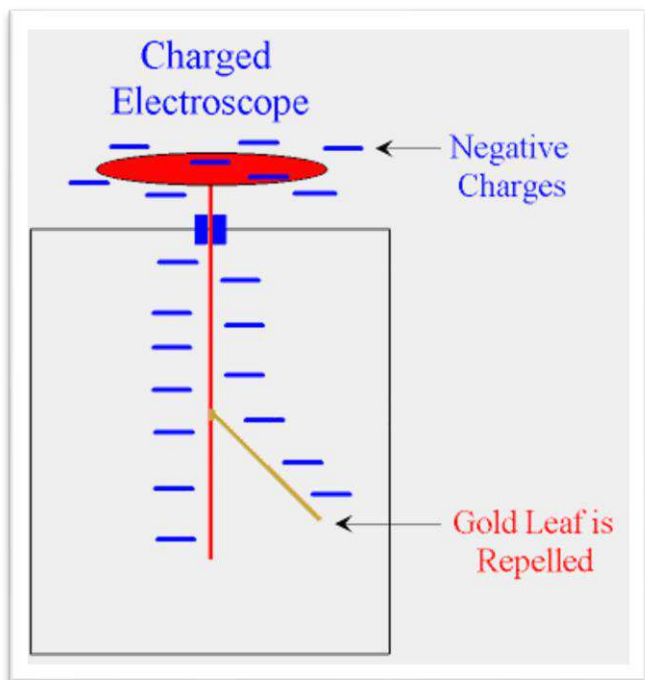
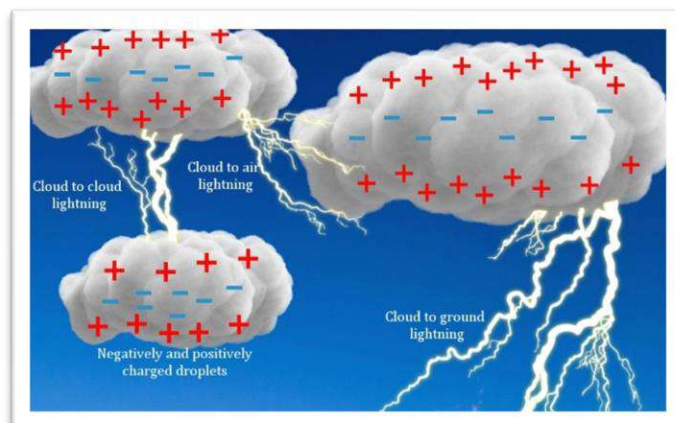


Figure 13 Working of an electroscope Discharging and Earthing

- When a charged object loses its charges it is said to be discharged.
- When a charged object transfers its charges to the earth it is called earthing. Generally, every building is provided with **earthing** to protect it from electrical shocks due to leakage of electric current.

Story of Lightning



1. During a thunderstorm, the hot air moves upwards while the raindrops fall downwards.
2. This leads to a separation of charges in the atmosphere.
3. As a result, negative charges get accumulated in the lower edges of the clouds while positive charges accumulate at the upper edges.
4. The ground is accumulated with a positive charge all over.
5. These charges begin to multiply due to the increase in winds and rainfall.
6. Although the air is a poor conductor of electricity due to strong electrical field it is unable to restrict the electric flow after some time.
7. The negative charges and positive charges meet which results in the production of electric sparks in the form of a streak of light accompanied by a sound.
8. The streak is called lightning and the whole phenomenon is called electric discharge. This electric discharge can occur between two or more clouds.

Why does lightning strikes tall buildings easily?

- We know that lightning occurs as a streak of charges that fall toward the ground. Tall buildings and tall trees can easily conduct the charge towards the ground. The air gap between these buildings and lightning is short hence they are more susceptible to lightning. That does not mean that short objects would not be affected by lightning.

Lightening Safety

- One should not stay at an open place during lightning and thunderstorm. Hence as soon as we hear any alert about lightning or thunderstorm, we should rush to a safe place such as a house or a building. If somebody is there in a car or bus, they should stay inside and keep all the doors and windows closed. One should read inside the safe place until the storm lasts.

Dos and don'ts for lightning safety

Outdoor Safety

1. One should not stay in an open place such as an open vehicle like a motorbike, tractor, or open fields, elevated places, or tall trees.
2. One should not carry an umbrella during the storm.
3. If a person is around a forest they should hide under short trees.
4. One should not get near to any poles or metal objects.
5. One should squat low on the ground instead of laying down.

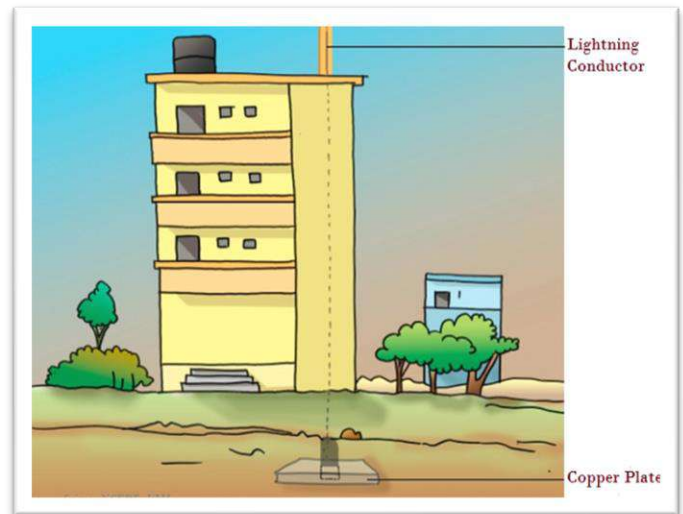
Indoor Safety

1. Lightning is an electric discharge hence one should stay away from electrical wires telephone, cables and metal pipes during a thunderstorm.
2. One may use a cordless phone or a mobile phone in an emergency.
3. One should not come in contact with the running water hence one should avoid bathing.
4. One should unplug all the electrical appliances in the house, for example TV, computers or music systems. Electrical lights do not cause any harm and hence can be kept on.

Using of lightning conductor

- In order to protect buildings from lightning, a lightning conductor device is used.
- When the building is being constructed a metallic rod having height more than the building is placed in the walls of the building.
- One end of the rod is in the air while the other end is buried inside the Earth.

- This rod is a conductor and hence during lightning it allows the flow of electric charges to the ground.



Working of Lightening conductor

- The lightning conductor rod consists of pointed ends which are made up of copper wire.
- These copper wires are brought down along the building and are attached to a metallic plate in the ground.
- If lightning hits the building the copper wires carry these charges quickly to the ground.

Earthquake

- Some natural phenomena such as thunderstorms and cyclones can be predicted by meteorologists. However, there are certain natural phenomena that are uncertain and cannot be predicted accurately. One of them is an earthquake.
- Earthquake is a natural phenomenon that occurs as shaking or trembling of the Earth's surface.
- It occurs or lasts for a very short span of time.
- The main cause of earthquake is disturbances inside the crust of the earth.
- Deep inside the earth, earthquakes occur all the time however they are not noticeable on the earth's surface. Sometimes major earthquakes occur on the earth surface which can be destructive.
- Earthquakes can lead to:
 - Loss of life

- Loss of property such as buildings, dams and bridges
- Floods
- Landslides
- Tsunamis

Causes of Earthquake

- Earth's surface is divided into several layers the crust, mantle, inner core and outer core.
- The outermost layer of the Earth is divided into several plates. These plates are always moving.
- As they move past each other or collide, disturbances are caused in the earth's crust. These disturbances are called earthquakes or tremors.

Other causes of an earthquake can be:

1. Volcanic eruptions
2. When a meteor hits the Earth surface
3. The nuclear explosion under the Earth surface
 - Although the causes of an earthquake are clear the scientists cannot predict when the earthquake would occur.

Seismic zones

- The movement of plates causes an earthquake. Hence the earthquakes are most likely to occur on their boundaries. The areas that lie on the boundaries of these plates are called weak zones, seismic zones or fault zones.

Richter scale

- A scale which is used to determine the magnitude or strength of an earthquake is called the Richter scale.
- Richter scale was developed in 1935 by Charles Richter and Beno Gutenberg of California Institute of Technology
- Destructive earthquakes have a Richter scale magnitude of more than 7.
- A Richter scale is not a linear scale, that is, a magnitude of Richter scale 6 does not imply that it is one and a half times more destructive than an earthquake with a magnitude of 4.

- It rather means that an earthquake of a magnitude of 6 is 100 times more powerful than an earthquake with a magnitude of 4.

Richter Scale of Earthquake Energy:

Each level is **10 time stronger** than the previous level

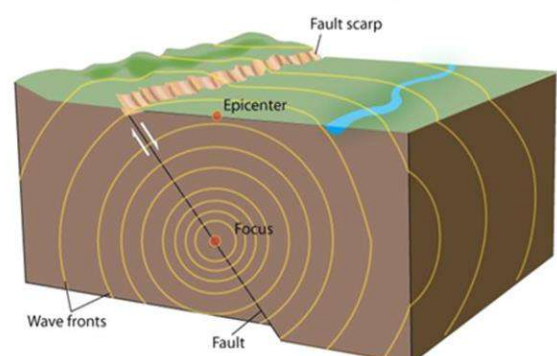
	Description	Occurrence	In Population	Movement
1	Small	Daily	Every minute	Small
2	Small	Daily	Every hour	Small
3	Small	Daily	Every day	Small
4	Small	Daily	Every week	Moderate sudden
5	Moderate	Monthly	Every 10 years	Strong Sudden
6	Moderate	Monthly	Every 30 years	Strong Sudden
7	Major	Monthly	Every 50 years	Severe Sudden
8	Great	Yearly	Every 100 years	Very Severe
9	Great	Yearly	Every 300 years	Very Severe
10	Super	Rarely	Every 1,000 years	Extreme

Richter scale and its interpretation

Key concepts of earthquake

- **Seismic Wave-** The earthquakes produce waves on the earth surface which are called seismic waves. These waves travel in all the directions on the Earth's surface.
- **Focus of earthquake-** The focus of an earthquake is a point inside the earth's surface where the earthquake originates. It is also called hypocentre.
- **Epicerentre of earthquake-** The epicentre is a region on the earth's surface that lies just above the focus of the earthquake is called epicentre. The earthquake does not originate from the epicentre.

Seismic Waves Radiate from the Focus of an Earthquake



Seismograph

- A seismograph is an instrument which can record the seismic waves.
- It contains a metal rod or a pendulum which can vibrate as the earthquake occurs.
- The metal rod is attached to a pen which records the waves on the paper.
- Scientists study these waves and then construct a map of the earthquake.
- This also helps them in determining the power of the earthquake.

Protection against an Earthquake

The buildings located in the seismic zones should be constructed in a way that they can handle major tremors. The following measures should be taken by people to make the houses of buildings quake-safe:

- People should always consult architects and engineers before constructing a new building.
- The roofs of the building should be kept light.
- Timber or mud should be used in the construction of buildings rather than heavy materials.
- The shelf and cupboard should be fixed to the walls so that they do not fall off easily.
- Things such as photo frames, geysers, clocks and other wall hangings should be placed in a place that does not harm anybody if they fall off.
- Buildings should have firefighting equipment as earthquakes may cause fires.

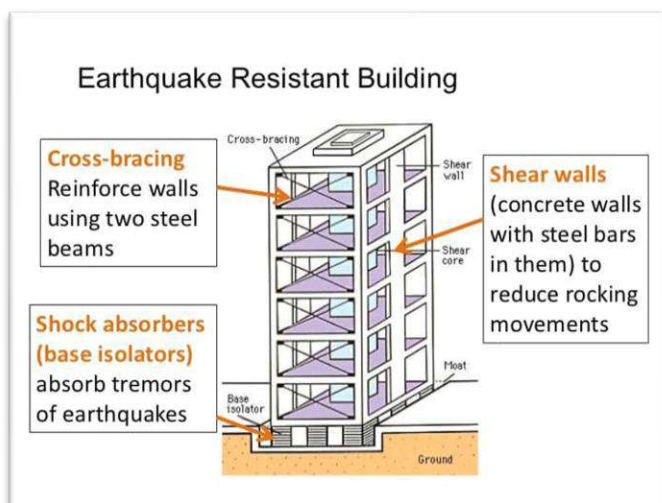
How can we protect us from Earthquake?

Indoor Safety Measures

1. One should hide under a table until the earthquake stops.
2. One should not stay close to heavy and tall objects.
3. If one is in bed they should cover their head with a pillow instead of getting up.

Outdoor safety measures

1. One should find a place which has no tall buildings around or even trees.
2. If a person is inside a car or a bus they should drive slowly to a clear place and be inside until the earthquake stops.



Introduction

- The Universe includes all the stars, planets and galaxies and its size is unknown.
- However, there is a spherical region of the universe that can be observed from the Earth which is called Observable Universe.
- This Observable Universe comprises of different physical objects that occur naturally on their own. These objects are called celestial objects.
- For example, the sun, the moon, the stars and the planets in our solar system all are called celestial objects.

Let's Know about Astronomy

- Astronomy is the study of the celestial objects and the phenomena associated with them. It is said to be one of the oldest Sciences in the world.
- It is associated with the study of the evolution of the universe, the motion of the celestial objects and their formation.
- In ancient times astronomers used to study the sky and observe the changes in it at the night time. With these methodological observations, they used to devise calendars.
- In ancient times, astronomers' observations of celestial cycles helped in understanding the changing seasons and developing calendars, which were important for agriculture.
- These interpretations used to help the farmers in choosing the right crops for a certain season and in finding the right time to sow the seeds.
- Their interpretations also help in deciding various festivals in India and the occurrence of seasons.
- Nowadays, there are computers that help in methodological observations of the sky.

The Moon

- We know that the moon is a natural satellite of the earth that revolves around the earth in a fixed orbit.
- Just like the earth other planets of the solar system also have their own moons or natural satellites.
- Also, the moon does not emit any light of its own but it reflects the light of the sun that falls on it.

- However, as the moon revolves around the earth the part of the Moon that faces the sun gets to light up while the other part remains in dark.
- This results in different shapes of the moon in the sky.
- These shapes of the lit part of the Moon are called the 'Phases of the Moon'.

Phases of the Moon

- The phases of the moon repeat themselves after every 29 days and there are eight major moon phases.
- The day when we can see the whole moon in the sky is called a '**Full Moon Day**'.
- Now as the Moon revolves and changes its position relative to Earth and the Sun, the portion of the illuminated half that is visible to us from Earth changes, and the Moon appears as if a smaller part is lit.
- On the 15th day after a Full Moon (approximately), the Moon becomes completely invisible (New Moon). This is because the Moon is positioned between the Earth and the Sun, and the side facing Earth is not illuminated by sunlight.
- The next day the moon that appears in the sky is called '**Crescent Moon**'.
- From this day, the moon starts growing larger until the 15th day when it reaches its full shape, that is, the Full Moon Day comes.

Note-

- Waning phase of the moon: it is the phase of the Moon in which it decreases in size.
- Waxing phase of the moon: it is the phase of the moon in which it increases in size.

Know it

Blue Moon- Generally there occurs one Full Moon every month. However, at times, there can be two Full Moons in a single month. The second Full Moon in a month is called the Blue Moon.

The phases of the Moon hold an importance in the Indian society and culture as different festivals in India are celebrated depending upon the Phases of the Moon.

Some of the important festivals and relation with the phases of the Moon

- Diwali- Celebrated on New Moon Day
- Guru Nanak birthday- Celebrated on Full Moon Day
- Maha Shivratri- Celebrated on the 13th night of Waning Moon
- Eid-ul-Fitr- Celebrated on the Day following the Crescent Moon

The Surface of the Moon

- The surface of the Moon is barren and all covered with dust.
- There are Craters or bowl-shaped cavities present on the surface of the Moon.
- There are steep and high mountains present in huge numbers on the Moon.
- Some of the mountains are as high as the highest mountains found on the earth.
- There is no presence of water and atmosphere on the moon.

Can we hear sound on the Moon?

There is no atmosphere on the Moon that is, no gases are present on the Moon that could act as a medium for the propagation of sound. Hence, the astronauts of the Moon cannot hear each other. They generally use signs or microphones to communicate with each other.

Fact-

Neil Armstrong was the first person to land on the moon followed by another Astronaut Edwin Aldrin. Neil Armstrong landed on the moon on July 21 1969.

Lunar Eclipse

- The lunar eclipse occurs when the moon, the Earth and the Sun are very closely aligned with each other and the earth is present exactly in the middle of the moon and the sun.
- Hence, the shadow of the earth falls upon the moon.
- Therefore, during the lunar eclipse, the Moon does not receive direct sunlight. It is instead dimly lit by sunlight that is filtered and refracted by the Earth's atmosphere onto the Moon's surface.

- As a result, the moon appears reddish in colour during a lunar eclipse.
- This is due to the scattering of blue light by Earth's atmosphere, allowing red light to reach the Moon.

The Stars

- The stars are celestial bodies comprising of hot gases (mainly helium and hydrogen).
- All the stars emit their own light.
- All the stars are not the same. They may vary in brightness, size, colours and temperature.
- They are massive in size however they appear as a point-sized object from the Earth's surface.
- This is so because they are at a huge distance from the earth.
- Stars have life cycles (birth, evolution, and death) that span millions to billions or even trillions of years, depending on the star's mass. More massive stars have shorter lifespans, while less massive stars live much longer..

Why Sun is a star?

- The sun is also a star because the sun can produce heat and light energy on its own.
- The sun has a life period just like every other star.
- The sun is estimated to be born around 5 billion years ago and would live for the next 5 billion years.

Twinkling of stars. Why?

Stars emit light that when enters the earth surface has to travel through the several layers of the earth's atmosphere. Hence, as the light travels through the Earth's atmosphere, it undergoes repeated refraction due to the continuous changes in the density (and refractive index) of the air. This causes the apparent position and brightness of the star to fluctuate rapidly.

Distance between sun and Earth

- The sun does not appear as a point-sized object like other stars because the sun is at a close distance to the earth as compared to other stars.
- The distance between the Earth and the Sun is estimated to be 150,000,000 km.
- The star that is closer to the Earth, after the sun, is called Alpha Centauri. The distance between

the Earth and the Alpha Centauri is estimated to be 40,000,000,000,000 km.

Light Year

- The distance between celestial objects is described in light years.
- A light year, as the name suggests, is the total distance light travels in 1 year's time.
- The speed of light = 300,000 km per second
- The distance between the sun and the earth = 8 light minutes
- The distance between Alpha Centauri and the earth = 4.3 light years

Some important facts

1. **Stars invisible during the daytime-** Stars are present in the sky during the day as well as night time. However, during the daytime, the sunlight is so bright that it becomes difficult to locate stars in the sky.
2. While stars appear to move across the sky over the course of a night, their positions relative to each other (forming constellations) remain fixed over human timescales. Their apparent motion is due to the Earth's movements. If we observe a star or a group of stars for some hours, their position appears to change across the sky. This apparent motion is caused by the Earth's rotation on its axis. The Earth's revolution around the Sun causes different constellations to be visible in the night sky at different times of the year.
3. **Stars appear moving from east to west-** The rotation of the Earth takes place in a direction from west to east. To us, it appears as if the earth is still and the sky is moving from east to west direction. However, it is not true. Also, this is the same reason why the sun appears to rise from the east and set in the west.

Pole Star

The Pole star is situated in the direction of the Earth's axis therefore it appears to be stationary. It is not visible from the Southern Hemisphere. All the stars appear to revolve around the Pole Star as they do not lie exactly on the extension of the Earth's axis. Therefore, when the Earth rotates from west to east,

the constellations appear to move in circles from east to west around the Pole Star.

Significance of Pole Star

The pole star also called as Polaris is situated close to the earth's axis of rotation. As a result, the position of the pole star appears to be fixed. This is unlike the other stars as their position keeps on changing with respect to the earth.

Constellations

- A constellation is described as a group of stars that form a recognizable shape or pattern.
- Ancient people used constellations as a way to recognise the stars.
- The shape of the constellations generally resembles with objects that ancient people used.
- There are not only 5 to 10 stars in a constellation. A constellation comprises of several stars but only some of them which are the brightest can be viewed.
- The stars that make up a constellation are found in the same line of sight; however the distance between these stars is not the same.

Some of the Major Constellations

1. Ursa Major or the Great Bear or Saptarishi or the Big Dipper

- This constellation comprises of seven major stars.
- These stars form the shape of a big question mark or a ladle.
- The handle of the ladle is made by joining the 3 stars in a row and the remaining four stars are in the shape of the bowl of the ladle.

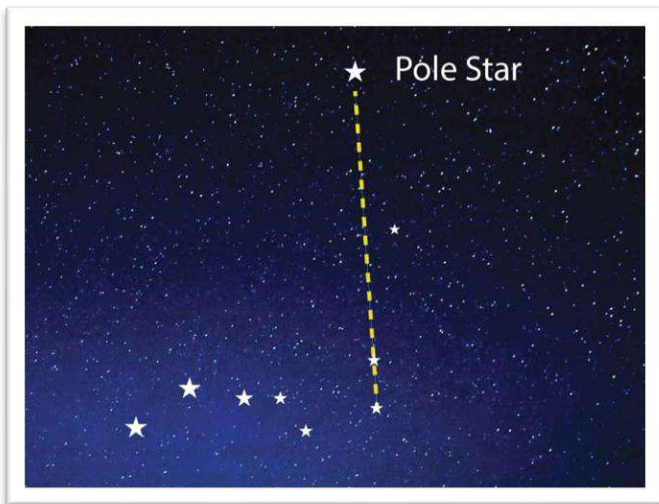
Significance- The seven stars in the Ursa Major constellation are believed to signify seven saints according to the Indian mythology. These seven Saints are believed to preserve the knowledge of the Vedas that they propagate to people in every new age.

How can we locate pole star using Ursa Major?

- The Ursa Major constellation includes two stars called Merak and Dubhe.
- If we draw an imaginary line from Merak to Dubhe and extended further in the same

direction the first bright star that we would come across is the pole star.

- The pole star is located above the northern hemisphere and hence it cannot be seen through the southern hemisphere.
- Similarly, many constellations of the northern hemisphere can't be located from different points of the southern hemisphere.



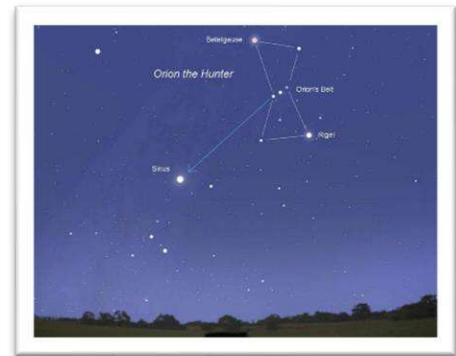
2. Orion or the Hunter

- It is one of the most magnificent constellations of the sky.
- It comprises of 7 or 8 bright stars.
- There are three stars in the middle that appear as the belt of a hunter.
- The remaining four stars are arranged in the form of a quadrilateral.



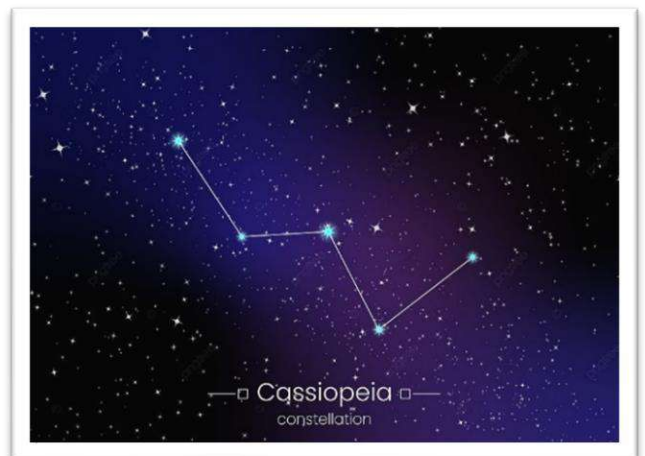
Sirius Star

- The Sirius Star is the brightest star of the sky.
- It can be located with the help of the Orion constellation.
- If we draw an imaginary line through the three stars in the middle of the Orion and extended further we will reach the brightest star, Sirius.



3. Cassiopeia

- It is a constellation found in the Northern hemisphere and can be located in the sky during the winter season at the beginning of the night.
- The shape of this constellation resembles with a W or a distorted M.
- The name of this constellation was given after queen Cassiopeia in Greek mythology.



4. Leo Major

- It consists of several bright stars and that is why it can be easily located in the sky.
- It can be viewed from the Northern hemisphere (January to June) as well as Southern hemispheres (summer and autumn).
- The Leo appears upside down from the southern hemisphere.
- It is one of the oldest constellations that were recognised almost 6000 years ago

The Solar System

- The Solar System comprises the sun, the planets, asteroids, meteors and other celestial bodies.

- There is a gravitational attraction between the sun and the celestial objects that keep them revolving around the sun.
- The sun acts as the main source of heat and light energy for all the planets in the solar system.

The Planets

- Our solar system comprises of 8 planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The planets do not have their own light. They can reflect the light of the sun that falls upon them.
- The planets revolve around the sun in a fixed path called 'Orbit'.
- The period of revolution of a planet is the time that it takes to complete one revolution around the sun. As the distance between the sun and the planets increases the period of revolution of that planet also increases.
- All the planets also revolve around their own axis. The time of rotation of a particular planet is defined as the time it takes to complete one rotation.
- The planets have satellites or celestial objects that revolve around them.
- For example, the moon is a natural satellite of the earth. However, there are different artificial satellites also that revolve around a planet.

Fact-

Planets do not fall into the sun. We know that the sun exerts a gravitational force on all the planets. But they do not fall into the sun because they are also revolving around the sun in a fixed path. This revolution prevents them from falling off into the sun.

1. Mercury

- It is the planet that lies closest to the sun.
- It is the smallest of all the planets.
- It is difficult to observe Mercury because it hides in the glare of the sun.
- Therefore it can only be observed or viewed in the sky just before the sunset or before the sunrise.
- It has no natural satellite of its own.

2. Venus

- It is the brightest planet.
- It can sometimes be viewed in the eastern sky before the time of the Sunrise or in the western sky before the sunset. Hence it is often called **morning or evening star**.
- It has no natural satellite of its own.
- Venus rotates from **east to west**, unlike the Earth which rotates from west to east.
- Venus also shows phases just like the moon.

3. Earth

- Life exists only on earth.
- The earth has favourable environmental conditions such as the presence of atmosphere and water that enable the existence of life on the earth.
- The temperature conditions of the Earth are also favourable for the existence of life because it is at a perfect distance from the sun.
- The earth possesses tilted axis which results in changing of seasons on the earth.
- The earth is covered with water naturally and therefore appears bluish-green when viewed from the space. The earth possesses its own natural satellite - the moon.

Orbital Plane of the Earth-The plane in which it revolves around the Sun is called its orbital plane. Earth revolve around the sun in an orbit.

Equatorial plane of the Earth- the Equator is an imaginary line drawn from the middle of the earth. The plane of the equator is called the equatorial plane.

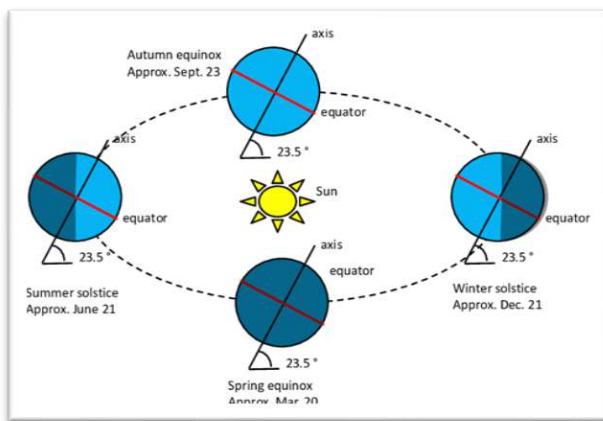
The equatorial plane and the orbital plane of the earth are inclined at an angle of 23.5° . Hence, the axis of the earth is tilted at an angle of 66.5° to the orbital plane.

4. Mars

- **"Red Planet" Basics:** Fourth planet from the Sun; about half Earth's diameter, 38%

of its gravity; known for its iron-oxide-rich, reddish surface.

- **Key Features:** Home to Olympus Mons (22 km high) and Valles Marineris (4 000 km long); seasonal water-ice and CO₂ polar caps.
- **Atmosphere & Climate:** Thin, CO₂-dominated air (<1% of Earth's pressure) causes extreme temperatures from -125 °C to +20 °C.
- **Exploration Highlights:** Over 50 missions launched, including Viking landers, orbiters like MRO, and rovers Spirit, Opportunity, Curiosity, and Perseverance; future sample-return and human missions planned.



5. Jupiter

- It is the largest planet in the solar system. It can comprise of 1300 Earth-like planets.
- It is extremely massive, with a mass almost 318 times that of the Earth. However, its density is much lower than the rocky planets.
- The rotation time of Jupiter is small around 9 hours 55 minutes.
- Jupiter has many moons out of which 4 large moons can be viewed from the earth with the help of a telescope. Jupiter has 95 moons that have been officially recognized by the International Astronomical Union.
- Jupiter has thin rings around it.

6. Saturn

- Saturn has thick rings around it that can be easily viewed with a telescope.

- Saturn has 274 confirmed moons in its orbit, far more than any other planet in our solar system. In March 2025, astronomers confirmed the discovery of 128 small moons around Saturn — adding to the already large moon count..
- The density of Saturn is less than that of water making it the least dense Planet of the solar system.

7. Uranus

- Just like Venus, Uranus rotates from east to west.
- Uranus has 28 known moons, including five major moons: Miranda, Ariel, Umbriel, Titania, and Oberon. The moons are sometimes called the "literary moons" because they are named for Shakespearean characters, along with a couple of the moons being named for characters from the works of Alexander Pope.
- The rotation axis of Uranus is highly tilted.
- The atmosphere of Uranus comprises hydrogen and methane gas mainly.

8. Neptune

- It is the farthest planet from the sun hence it takes the most time to revolve around the sun.
- Neptune has 16 known moons..

Inner planets- the first four planet of the solar system are called as inner planets. These planets have few moons and also smaller in size. These are mostly solid by composition.

Outer planets- the planet after Mars are called outer planets of the solar system. All these planets have a sing of system around them and possess a large number of moons.

Recap by table

Difference between the stars and planets

BASIS FOR COMPARISON	STARS	PLANETS
Meaning	Stars are the astronomical objects, that emit their own light, produced due to thermonuclear fusion, occurring at its core.	Planets refers to the celestial object that has a fixed path (orbit), in which it moves around the star.
Light	They have their own light.	They do not have their own light.
Position	Their position remain unchanged.	They change position.
Size	Big	Small
Shape	Dot shaped	Sphere-shaped
Temperature	High	Low
Number	There is only one star in the solar system.	There are eight planets in our solar system.
Twinkle	Stars twinkle.	Planets do not twinkle.
Matter	Hydrogen, Helium and other light elements	Solid, liquid or gases, or a combination thereof

Other members of the Solar system

1. Asteroids

- Besides planets, there are other celestial bodies orbiting the Sun. Asteroids are small rock-like objects that are found orbiting the sun.
- They are generally found between the orbits of Mars and Jupiter. This region is also called the Asteroid belt. However, asteroids can also be found in other places in the solar system.

2. Comet

- Comets are big pieces of ice and rock that also revolve around the sun in elliptical shaped orbits.
- Comets are the leftover pieces of rocks that were formed at the time when the solar system was beginning its formation.
- Comets are often observed to have a tail. This tail appears as a comet approaches the sun.
- At that time, dust and gas are discharged from the comet due to the heat of the sun. Since the comet is approaching the sun, the tail of the comet is always in the opposite direction of the sun.
- As the distance between the Sun and the comet decreases (as it approaches the Sun), the size of the tail of the comet increases. As the distance increases again

(moves away from the Sun), the tail shrinks or disappears.

- Since comets revolve around the sun they can be viewed at periodic times from the Earth.
- For example, **Halley's Comet** appears after every 76 years. It was last viewed in 1986.

Superstition about the comets

Some people think that comets are messengers of disasters, such as wars, epidemics and floods. But these are all myths and superstitions. Appearance of a comet is a natural phenomenon. We have no reason to be afraid of it.

3. Meteoroids and Meteors

- The asteroids in the space sometimes collide with each other and form meteoroids. Hence the small pieces of an asteroid can be called as meteoroids.
- From these meteoroids, meteors are formed.
- When a meteoroid enters the atmosphere of the Earth it appears as a streak of light in the sky or a meteor. The Meteors generally have high speed as they enter the atmosphere. Thus, they get heated up due to the friction of the atmosphere.
- Hence the meteors light up as a streak of light. However, they get evaporated in the sky before reaching the Earth's surface and this streak of light is therefore visible for a short time span only.
- Meteors are also called shooting stars because of their characteristic feature however they are not stars but just a piece of rock.

Fact- Meteor Shower

When the earth crosses a comet's tail a large number of flying meteors can be observed in the sky. This is called a Meteor shower. Certain meteor showers occur periodically in the sky.

4. Artificial Satellites

- These are the man-made satellites that are sent out into space to revolve around the

earth. They orbit nearer to the earth as compared to the moon. Functions of artificial satellites:

- Weather forecasting
- Transmission of signals of radio and television
- Remote-sensing - acquiring information about an object from a distance, for example, the artificial satellite can acquire information about the earth from a distance
- Telecommunication - transmission of information by means of radio signals and electromagnetic systems.
- Notable Artificial satellites
 - Aryabhata
 - INSAT
 - IRS
 - Kalpana-1
 - EDUSAT

Recap by table

Artificial satellite	Natural Satellite
They are formed and controlled by humans	They are formed naturally
They are not permanent	They are permanent
They can be used to send and receive signals from the earth	They cannot be used for the purpose of communication or sending signals from the earth.

Introduction

Energy is the capacity of a body for doing work. Energy stored in a body or a system is equivalent to total work done by the body till whole of its energy has been completely exhausted. Most of our energy requirement is fulfilled from the fuels & electricity. Solar energy is also available to us in the form of a variety of fuels that have been stored in the earth's crust. Energy can be converted from one form to another.

Need of energy

- For making food
- For lighting
- For transport
- For running machines
- For industrial activities and agricultural work.

Qualities of Good Source of Energy

- Which would do a large amount of work per unit mass.
- Safe and convenient to use, For example; nuclear energy can be used only by highly trained engineers with the help of nuclear power plants. It cannot be used for our household purpose.
- Easy to transport, For example; coal, petrol, diesel, LPG etc. have to be transported from the places of their production to the consumers.
- Easy to store, For example; huge storage tanks are required to store petrol, diesel, LPG etc.
- Does not cause environmental pollution.

Characteristics of Good Fuel

- High calorific value (give more heat per unit mass)
- Burn cleanly without giving out excessive smoke or harmful gases.
- Proper ignition temperature.
- Cheap and easily available
- Easy to handle, safe to transport
- Convenient to store
- Burn smoothly

Classification of sources of energy

Energy is the capacity to do work. Energy exists in several ways: heat, kinetic or mechanical energy, light, potential energy, electricity, or other forms.

Energy is the ability to do work. The sources of energy are classified as follows

- **Based on long term availability**
 1. Renewable energy
 2. Non-renewable energy
- **Based on traditional use**
 1. Conventional energy

2. Non- conventional energy

Let's explain each in details.

Based on Long term availability**i. Renewable sources of energy**

- The sources of energy which are in constant supply to us by nature and are inexhaustible are known as renewable sources of energy.
- **e.g.** The sun (solar energy), oceans, tidal energy, wind energy, running water energy, wood, geothermal energy etc.

ii. Non-renewable sources of energy

- The sources which can't be used again and again and are exhaustible are known as non-renewable sources of energy.
- **e.g.** Coal, natural gas, petroleum; fossil fuels etc.

Based on traditional use

They can be studied as follows-

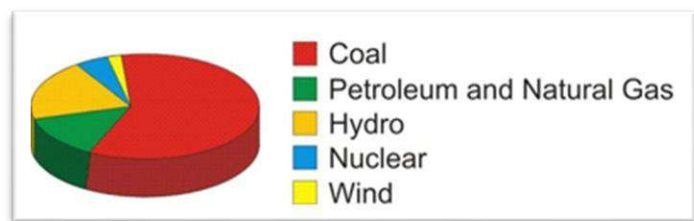
i. Conventional sources of energy

- These are sources of energy that have been widely used for a long time and meet a major portion of our energy requirement. These are used extensively and meet a major portion of our energy requirement since ancient times.
- Examples of conventional sources of energy are fossil fuels (coal, oil and natural gas), hydro energy, biomass (firewood, animal dung and biodegradable waste) energy, wind energy, etc.

ii. Non-conventional sources of Energy

- These are sources of energy that are relatively new or not as widely used compared to conventional ones. Many non-conventional sources are also renewable sources. These sources of energy are not used as extensively as the conventional ones and meet our energy requirement only on limited scale.

- Examples of non-conventional sources of energy are solar energy, ocean energy (tidal energy, wave energy, ocean thermal energy, etc), nuclear energy, etc.



Conventional Sources of energy

The various types of conventional sources of energy are as follows-

a. Fossil Fuels

- Fossil fuels are the remains of the prehistoric animals or plants, buried under the earth, millions of years ago
- E.g. Coal, petroleum and natural gas.
- Fossil fuels are formed in the absence of oxygen. The chemical effects of pressure, heat and bacteria convert the buried remains of plants & animals into fossil fuels like coal, petroleum and natural gas.
- It was the sunlight of long ago that made plants grow, which were then converted into fossil fuels. Fossil fuels are energy rich compounds of carbon, which were originally made by the plants with the help of sun's energy.

Types of Fossil Fuels-

The various types of Fossil fuels are-

iii. Coal

- It is the most abundant fossil fuel on the Earth which is essentially carbon. It is used as a combustion fuel.
- The exploitation of coal as a source of energy made the industrial revolution possible. Increasing industrialization has led to a better quality of life all over the world.
- Coal is the principal source of heat for electricity generation and is used as a reducing agent (coke) in heavy industries like iron and steel.
- India, endowed with the fifth-largest coal reserves globally, stands as the second-

largest consumer of coal, propelled by a fast-growing economy..

Note it- Lignite (lower carbon) and Bituminous coal burn with varying efficiency and release more pollutants than anthracite." Anthracite, with highest carbon content burns slowly, releases much less smoke, delivers more energy and is the best quality coal.

iv. Petroleum

- Petroleum (also called crude oil) is a thick black liquid and is not used as fuel in its natural form. It is refined by the process of fractional distillation to obtain a number of useful components like fuel oil, kerosene, diesel oil, petrol or gasoline and petroleum gas. On liquefaction, petroleum gas changes into a liquid which is called liquefied petroleum gas (LPG). It is used for cooking.
- Natural gas is also a fossil fuel usually found underground near an oil source. It is the cleanest burning fossil fuel as it gives off less carbon dioxide than coal and oil on burning. It is used as CNG (Compressed Natural Gas).

Efficiency and use of Fossil Fuels

The pollution caused by burning fossil fuels can be reduced by increasing the efficiency of the combustion process and using various techniques to reduce the escape of harmful gases and ashes into the surroundings. Besides being used directly for various combustion process, fossil fuels are the major fuels used for generating electricity, a form of energy which has become a necessity in today's scenario.

Pollution caused by Fossil Fuels

- Released oxides of carbon, nitrogen and sulphur (acidic in nature) which causes acid rain that damages trees, plants, reduces fertility of soil.
- Produces large amount of CO₂ in the atmosphere which causes greenhouse effect leading to excessive heating of the earth.

b. Thermal power plants

- A "thermal" power plant as the name suggests generates electric power from large amount of heat produced by burning fossil fuels, i.e.,

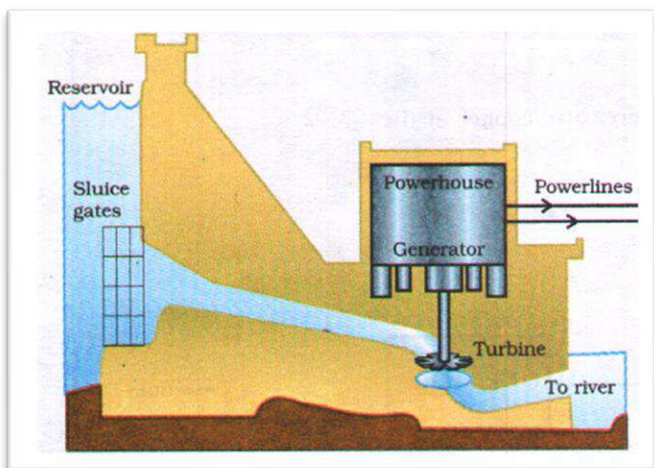
coal and petroleum. Fossil fuels are burnt in large amounts in power stations to heat up water to produce steam which further runs the turbine to generate electricity. Transmission of electricity is more efficient than transporting coal or petroleum over the same distance. Therefore, many thermal power plants are set up near coal or oil fields.

c. Hydro (Hydel) Energy

- Solar energy appears in the form of energy of water flowing in the rivers which is obvious from the water cycle in nature.

Hydroelectric power plant:

- Hydro electricity is the electricity produced from the kinetic energy of flowing water and a plant which generates hydroelectricity on a large scale is called hydroelectric power plant.
- Hydroelectric power plants meet a significant portion of India's electricity needs. Since there are very few waterfalls which could be used as a source of potential energy, hydro power plants are mostly associated with dams.



A schematic view of a hydroelectric power plant Steps for generation of hydro electricity

The various steps for generation of hydroelectricity are:

- Water is collected in storage dams (high rise structure) where kinetic energy of flowing water is transformed into its potential energy.
- Water from the dam is allowed to fall through pipelines over the blades of a turbine at the bottom of the dam. The potential energy of water

changes into its kinetic energy which is transferred to the turbine.

- Moving turbine converts its mechanical kinetic energy into electricity using a generator.

Advantages of Hydel Power

- The process of generating hydel power during operation does not cause air or water pollution.
- The moving water needed for the purpose is available free of cost.
- Water energy is a renewable source of electrical energy which will never get exhausted.
- The construction of dams on rivers helps in controlling floods and in irrigation.
 - Limitation of Hydel Power
- Moving or flowing water is not available at all places. It is available near the sites of flowing rivers.
- To generate a reasonable amount of electricity from water, fast moving water should be available in large quantities.
- The construction of dam on a river disturbs the ecological balance in downstream area of the river.
- The soil in the downstream area may become poor in quality because there were no annual floods to deposit nutrient rich silt on the bank of the river. Therefore there may be ecological problems.

Improvement in the technology for using Conventional Sources of Energy

Biomass and Bio Energy

If we can ensure that enough trees are planted, a continuous supply of fire-wood can be assured. Even the cow-dung cake serves as a fuel. These fuels called biomass are plant and animal products.

Biomass

The decomposition which takes place in the absence of oxygen is called **anaerobic** degradation. Anaerobic degradation is carried out by anaerobic bacteria. Biogas is a mixture of methane, carbon dioxide, hydrogen and hydrogen sulphide. The major constituents of biogas is methane. Biogas is produced by the anaerobic degradation of animal wastes like animal dung in the presence of water.

Biogas Plant:

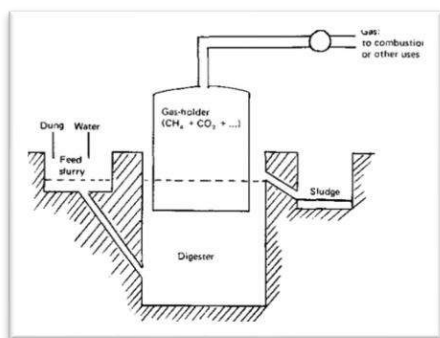
Biogas is prepared by anaerobic degradation of animal wastes like cow dung in biogas plant. The two types of biogas plant are:

- (i) Floating gas holder type biogas plant.
- (ii) Fixed-dome type bio-gas plant.

The raw material used for producing biogas in both the plants is the same, it is a mixture of cattle dung and water.

Floating gas holder type bio-gas plant:

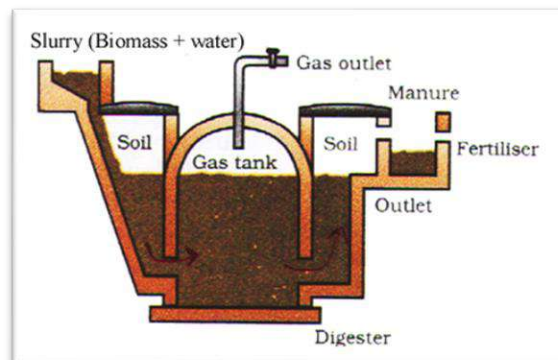
This biogas plant consists of a well-shaped underground tank called **digester**, which is made up of bricks. A drum-shaped gas holder made of steel floats in the inverted position over the dung slurry in the digester tank. Since the gas holder floats over the dung-slurry, so this biogas plant is called floating gas-holder type biogas plant. The gas holder can move up and down, and its movement is controlled by the control pipe. There is a gas outlet at the top of the gas holder tank having a valve. A partition wall divides the digester tank in two parts: on the left of the digester tank is an inlet pipe made of cement (the inlet is connected to a mixing tank, on the right side of the digester tank is an outlet pipe, also made of cement, which is connected to an over-flow tank. The inlet pipe is for feeding the fresh dung slurry into the digester tank whereas the outlet pipe is for removing the spent dung after the extraction of biogas. Cattle dung and water are mixed in equal proportions in the mixing tank to prepare the slurry. This slurry of dung and water is fed into the digester tank through the inlet pipe. The dung undergoes anaerobic degradation in the presence of water with the gradual evolution of biogas. As more and more bio-gas collects in the gas-holder, the pressure of gas in it increases. As the spent dung slurry goes out, more fresh dung slurry is added to the digester tank on daily basis.



Fixed dome type biogas plant:

This biogas plant is a dome-like structure built with bricks and consists of the following parts:

- **Mixing tank:** It is a tank where the slurry (semi fluid mixture) of animal dung and other waste materials is prepared by mixing it with an equal amount of water.



Schematic diagram of a bio-gas plant

Digester tank: The slurry so prepared is fed into the digester tank through an inlet chamber. The digester is a sealed chamber with no oxygen. The anaerobic microbes decompose complex compounds of the slurry within few days (50-60 days) and produce biogas.

- The biogas keeps collecting in the dome. It exerts pressure on the slurry in the digester tank which forces the spent slurry into the overflow tank through an outlet chamber.
- To get a continuous supply of biogas, fresh slurry is periodically added to replace the spent slurry.

Composition and advantages of biogas:

Biogas is mainly composed of methane (upto 75%), CO₂ (25%) and traces of other gases such as nitrogen, hydrogen sulphide and hydrogen. The advantages are as follows:

- Biogas is a clean fuel that burns without smoke and leaves no ash like in wood, charcoal and coal burning.
- The main constituent of biogas, i.e., methane has a higher calorific value than that of petrol.
- The spent slurry being rich in nitrogen and phosphorus is good manure.
- By using biogas, firewood is saved and deforestation is reduced.
- The large-scale utilization of bio-waste and sewage material provides a safe and efficient

method of waste-disposal besides supplying energy and manure.

Wood

it is a biomass and used as a fuel for a long time.

- Disadvantages of using wood as fuel
 - Produces a lot of smoke on burning.
 - Do not produce much heat.
 - Thus by improvement in technology we can improve the efficiency of traditional sources of energy.
 - **For example-** wood can be converted into much better fuel called Charcoal.
- **Charcoal-** when wood is burnt in limited supply of air, then water and other Volatile materials gets removed and charcoal is formed.
- Woods on limited supply of oxygen gas get converted into charcoal
- Charcoal is better fuel than wood because
 - It has higher calorific value than wood.
 - Does not produce smoke while burning.
 - It is a compact fuel, easy to handle and convenient to use.
- **Cowdung-** It is biomass but it is not good to burn cow dung directly as fuel because
 - Produces lot of smoke.
 - cowdung does not burn completely, produces lot of ash as residue.
 - Low calorific value.
 - By making bio gas (or gobar gas) from cow dung, we get a smokeless fuel.

Wind Energy

- Moving air is called wind. As the moving objects possess K.E. and as such they are capable of doing mechanical work by virtue of its motion. Wind also possess the ability of performing mechanical work because it is air in motion. So wind energy is the K.E. associated with large mass of air by virtue of its motion.
- Solar energy is responsible for the blowing of air.
- **This can be explained as follows:** The sunrays fall on the earth but the intensity of sun-rays is much stronger near the equator than in the Polar Regions. Due to more intense sun-light, the air near the surface of earth in equatorial regions becomes quite hot. This hot air, being lighter, rises upwards. The cooler air from the polar

regions of the earth start flowing towards the equatorial regions of the earth to fill the space vacant by the hot rising air. In this way air flows from the higher pressure regions to the lower pressure regions of the earth. This flow of air from one place to another constitutes wind.

Uses of Kinetic energy generated by wind energy

- To generate electricity by turning the rotor of the turbine
- To lift water from the well.
- To run the Flour mills.
- The output of a single wind mill is quite small so a number of windmills are erected over a large area called wind energy farm.
- The minimum wind speed for wind mill to serve as a source of energy is 15-20 KmPH.



Advantages of Wind energy

- Use of wind energy does not lead to pollution.
- Wind energy is available free of cost.
- The source of wind energy i.e. air is an inexhaustible and reversible source.

Disadvantages of Wind Energy

- One of the most important limitation of wind energy is that it may not be available at all times.
- The windmill and sail-boats remain un-operational and no useful work can be done unless there is a plenty of fast blowing wind.
- The speed of the wind at a place varies with time and season.
- The K.E. of the wind can be utilized only at the site.
- There is no guarantee that we will get wind energy when required, since there is no place in the world where wind blows all the time.
- The wind is not predictable.

Some Facts-

- Denmark is called the country of winds.
- India is ranked 4th in harnessing wind energy for the production of electricity
- India's largest wind energy farm is the Muppandal Wind Farm, located in Kanyakumari, Tamil Nadu, with a capacity of 1500 MW. It is also considered one of the world's largest onshore wind farms.

Some of the Practical Devices making use of Wind Energy

Wind Mill-

- A windmill is a machine, which works with the energy of blowing air or wind. It consists of large blades to catch the wind. When the wind strikes against these blades, they start rotating. The motion can then be passed on the other connected parts & is used to do useful work.
- A windmill consists of a system of big blades (or vanes) capable of rotating about a horizontal axis. The system of vanes is mounted on the top of a high tower. Its working is based on the transformation of K.E. of wind into the rotational energy of the blade. The system of blades is connected to one end of the rod called shaft. The other end of the shaft is connected to a pump rod in case of water pump. This end is bent in form of inverted V and is connected to the free end of the pump rod of the water pump. When the wind blows, it rotates the blades of the windmill. The shaft turning about its axis rotates the crank. The rotation of the crank moves the piston rod of the water pump up and down & draws water from the well.



Alternative or Non-Conventional Sources of Energy

Our energy demand is increasing day by day as our lifestyles are also changing. As our demand for energy increases, we need to look for more and more sources of energy. So technologies are developed to use the available or known sources of energy more efficiently and also look for new sources of energy.

A. Solar Energy

- The sun is the primary source of energy for all living beings on the earth. It provides all of us with heat and light. The energy generated by the sun is the result of a reaction called nuclear fusion, occurring continuously in the interior part of the sun. Hans Bethe, a physicist proposed that the enormous release of energy from the sun is due to the fusion (combination) of four hydrogen atoms to yield a single helium atom (${}^4_2\text{He}$).
- For this discovery, he was awarded the 1967 Noble Prize in Physics. The sun emits energy in all directions in space.
- Solar energy is trapped by plains, plateaus, mountains, rivers, lakes, oceans, and ponds. Plants use solar energy to manufacture food by photosynthesis and also solar energy is the source of wind storms, rain, and snowfall & ocean waves.
- It is the perennial (forever) source of energy.
- This perennial source of energy has some features:
 - It comes to earth surface in a very diffused form.
 - Upper atmosphere gets 1.3 KJ of energy per second per square meter of this only 47% i.e. approximately 0.64 KJ energy reaches per second per square meter on earth's surface.
 - Moreover this amount of energy is not available uniformly and keeps changing every day a place to place during the day.

Uses of Solar Energy:

1. Solar cooker absorb solar energy and cook food.
2. Solar water heaters are used for heating water.

3. Solar cells convert solar energy into electricity to run watches, calculators, and spaceships for various experiments.
4. Solar energy is absorbed by green plants to make their food by photosynthesis.
5. Solar energy is used for drying clothes and food grains.
6. Solar energy is used for making salt from sea water.

Advantages of Solar Energy:

1. It is inexhaustible and renewable as it is being produced continuously in the core of the sun by nuclear fusion of H-atoms.
2. Its quantity is unlimited and is available in all parts of the world in abundance.
3. It does not cause any pollution.
4. It can be put to practical applications.

Limitations of Solar Energy:

1. It is not available at night.
2. It is not available uniformly in all parts of world.
3. Solar energy received by the earth is quite diffused and in scattered form and hence only a part of it is utilized.
4. It is not available at constant rate due to clouds, fog, mist, haze, winds etc.

Solar Heating Devices

These are the devices that can collect and store heat obtained from solar energy. These are used for heating and cooking purposes. Solar heating devices are designed in such a way that they can make maximum utilization of solar heat radiations. It is done by adopting the following procedure:

1. **Concentration of solar energy by using reflectors:** For moderate heating sun rays are reflected by using plane mirrors, as in solar cookers and solar water heaters. For high temperatures, sun's energy is concentrated using concave mirrors as reflectors.
2. **Black paint:** Since black bodies are good absorbers as well as good radiators of heat, hence black paint is used to absorb and store heat radiations in large quantities by using a large surface area.
3. **Glass-sheet cover:** Glass sheet cover is used to protect the hot infrared rays of solar energy from

escaping the body of the black box. It allows incoming solar radiation (mostly visible light and near-infrared) to enter the box of the solar heating device and traps the outgoing thermal radiation (longer wavelength infrared) emitted by the hot absorber.. Hence, more heat is retained by solar heating devices for a long time.

Some Devices are

- i. Solar Cooker
- ii. Solar Water Heater

B. Geothermal Energy

- Geothermal energy is the heat energy of hot rocks present inside the earth. This heat can be used as the source of energy to produce electricity. Geothermal energy is one of the few sources of energy that do not come directly or indirectly from solar energy. The places where very hot rocks occur at same depth below the surface of earth are called 'hot spots' (geothermal reservoirs) and are sources of geothermal energy.
- The Geothermal energy is harnessed as follows
 - The extremely hot rocks present below the surface of earth, heat the underground water and turn it into steam. As more and more steam is formed between the rocks, it gets compressed to high pressures. A hole is drilled into the earth, and the hot steam or water comes up through the pipe at high pressure. This high-pressure steam run the turbine of a generator to produce electricity.
 - Large rocks are present in the underground rocks, which allow steam and hot water to go up. The steam & hot water gushing out of the ground are a kind of natural geyser. This steam is then used to turn turbines and generate electricity and the hot water is used to cook food.

Merits of Geothermal Energy

- It is the most versatile and less polluting renewable source of energy.
- Where available, geothermal power plants can have a high-capacity factor, providing reliable power.

Demerits of Geothermal Energy

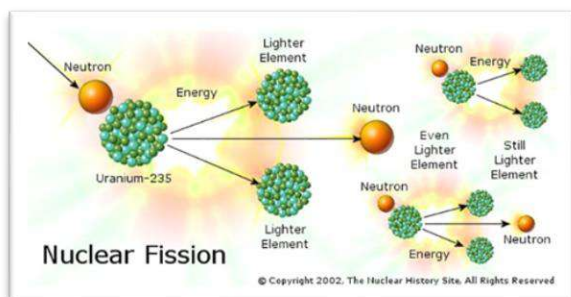
- Though geothermal energy is inexhaustible, a single bore has a limited life span of about 10 years.
- Geothermal hot spots are scattered.
- Deep Drilling in the earth to obtain geothermal energy is very difficult and expensive.

C. Nuclear Energy

- The energy obtainable from the nucleus of an atom is called nuclear energy or atomic energy.
- Nuclear energy is measured in terms of an electron volt (eV) where $1 \text{ eV} = 1.6 \times 10^{-19}$ There are two distinct ways of obtaining nuclear energy.
- It can be obtained by two types of nuclear reactions
 - Nuclear Fission
 - Nuclear Fusion

a. Nuclear Fission

- Nuclear fission is a nuclear reaction in which the nucleus of an atom is bombarded with low-energy neutrons which splits the nucleus into smaller nuclei. An abundant amount of energy is released in this process. Nuclear fission reactions are used in nuclear power reactors since it is easy to control and produces large amounts of energy.
- When **uranium-235** is bombarded with slow-moving neutrons, the heavy nucleus of the uranium splits and produces **krypton-89** and **barium-144** with the emission of three neutrons.



- Working- in a nuclear reactor self-sustaining chain reaction release energy at a controlled

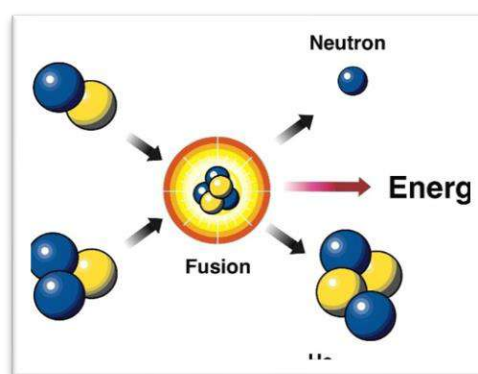
rate, which is used to produce steam and further generate electricity.

Major Nuclear Power Plants

- i. Tarapur (Maharashtra)
- ii. Rana Pratap sagar (Rajasthan)
- iii. Kalpakkam (Tamil Nadu)
- iv. Narora (U.P.)
- v. Kakrapar (Gujarat)
- vi. Kaiga (Karnataka)

b. Nuclear Fusion

- Nuclear fusion is a reaction that occurs when two or more atoms combine together to form to a single heavier nucleus. An enormous amount of energy is released in this process, much greater than the energy released during the nuclear fission reaction.
- Very- very high pressure is needed for fusion.
- Hydrogen Bomb is based on this phenomenon.
- Nuclear fusion is the source of energy in the sun and other stars.
- Fusion occurs in the Sun, where isotopes of hydrogen (like deuterium and tritium, among other reactions like the proton-proton chain) combine at extremely high temperatures and pressures to form a heavier nucleus (like helium) and release energy.



Advantages of Nuclear Fusion

- Production of large amount of useful energy from a very small amount of nuclear fuel.
- Does not produce greenhouse gases like CO₂.

Disadvantages of Nuclear Fusion

- Environmental contamination due to improper nuclear waste storage and its disposal.
- Risk of accidental leakage of harmful radiations.

- High cost of installation.
- The extreme technical challenge of maintaining the necessary conditions (confinement and temperature).

Let's compare this two for better understanding

Nuclear Fission	Nuclear Fusion
When the nucleus of an atom splits into lighter nuclei through a nuclear reaction, the process is termed nuclear fission.	Nuclear fusion is a reaction through which two or more light nuclei collide with each other to form a heavier nucleus.
When each atom splits, a tremendous amount of energy is released	The energy released during nuclear fusion is several times greater than the energy released during nuclear fission.
Fission reactions do not occur in nature naturally	Fusion reactions occur in stars and the sun
Comparatively less energy is needed to split an atom in a fission reaction	High energy is needed to fuse two or more atoms together in a fusion reaction.
Atomic bomb works on the principle of nuclear fission	Hydrogen bombs works on the principle of nuclear fusion.

- known reservoirs of petroleum for another 60 years and those of natural gas for about 40 years.
- We can get a continuous supply of biomass only if we plant trees in a planned manner. In case, it is not done so, we would fall short of biomass.
- Geothermal energy is an inexhaustible source of energy.
- Nuclear energy is also inexhaustible as only a small mass of uranium produces large amount of energy, e.g., one atom of uranium produces 10 million times the energy produced by the combustion of an atom of carbon from coal.
- Solar energy, Water energy, Wind energy and Ocean energy are inexhaustible sources of energy.

Environmental Consequences of exploiting Sources of energy-

Environment is disturbed whenever a source of energy is used to derive energy from it.

- Burning of fossil fuels cause air-pollution.
- Construction of dams destroys large ecosystems and creates problem of rehabilitation of displaced population.
- Continuous whirling and whistling of windmills cause noise-pollution and plays havoc with the lives of migratory birds.
- Heavy energy structures to exploit wave energy affect marine mammal and seabird population.
- Using wood as fuel results in deforestation which affects environment.

How long will an energy source last us?

- Fossil fuels (coal, petroleum and natural gas) will get depleted someday as these are exhaustible sources of energy. It has been estimated that coal will last for another 200 years whereas

What is Matter?

The matter is the material of which everything in this universe, (in and around us) is made up of. It is anything that occupies space and has mass and offers resistance to any applied force.

Constituent of Matter

According to the early Indian philosophers, every living and non-living thing is made of five basic elements called the Panchtatva – Air, Water, Earth, Sky, and Fire.

Therefore, matter is a composition of these five constituents.

- Since early times human beings have been trying to understand their nature. Early Indian philosopher classified matter into five basic elements. the “Panch Tatva” – air, earth, fire, sky and water. According to them, living as well as non-living things are made up of these elements.
- Now a days, scientists evolved two types of classification of matter – physical properties and chemical nature.

Physical Nature of Particles

- Matter is made up of particles. All matter constitute of very small particles. These small particles are called atoms.
- These particles of matter are too small so they cannot be seen by naked eyes or simple microscope.
- Particles of matter are continuously moving as they possess kinetic energy, with the increase of temperature kinetic energy of particles also increases so particle moves faster.

Characteristics of Particles

Particles of matter have three important characteristics

1. Particles of matter have spaces between them
2. Particles of matter are moving all the time
3. Particles of matter attract each other.

Let's explain this in short.

1. Particles of matter have spaces between them.

- Salt gets dissolved in water because its particles have spaces between them. The particles of the salt get in between the spaces between the particles of water and a mixture is formed.
- When we make tea, coffee or lemonade (nimbu pani), particles of one type of matter get into the space between particles of the other. This shows that there is enough space between particles of matter.
- We cannot see these particles through naked eye.

2. Particles of matter are continuously moving

- Particles of matter are in motion all the time. Hence, they possess kinetic energy.
- **Kinetic Energy** – Energy due to motion
- The particles of a matter intermix on their own with other particles of a matter. For Example, Salt in water, various gases in the air, Ink in water.
- **Diffusion** – The process of mixing two different types of particles together is called diffusion. Diffusion becomes faster on heating.
- The Kinetic energy of particles also increases on heating

Note- Brownian motion- The zig-zag or random path travelled by the particles of matter is called Brownian motion.

1. Particles of matter attract each other

- The particles of matter are always held together because of a force of attraction between them.
- The amount of this force between the particles varies in different forms of matter.
- Solids have the highest force of attraction. That is why we cannot move our hands through a solid object. The particles are so tightly bound.
- Similarly, particles of gases have the least force of attraction in them. We can move our hands easily in the air, can't we? This is because the particles of air are loosely bound.

- We can arrange the force of attraction between different types of matter (solids, liquids, and gases) in decreasing order as:
 - Solid > liquid > Gas.
 - We can also move our hands through water or liquid matter but not as freely as we can in the air. This means that they are also loosely bound to some extent.
2. The space between the particles and kinetic energy of particles is minimum in solids, intermediate in liquids and maximum in gases.
 3. The force of attraction between the particles is strongest in solids, intermediate in liquids and weakest in gases.
 4. Movement of particles is minimum in solids, more in liquids and maximum in gases.

States of Matter



Now we know that particles of matter have a force of attraction between them. Based on this criterion, we can say that matter is present in three different states: solid state, liquid state, and gaseous state.

The solid state

- Solids are the objects that have these three properties:
 - They have a specific shape.
 - They have distinct boundaries.
 - They have a volume.
- There is less kinetic energy among the particles in solids. They are generally arranged in order. Thus they possess a fixed shape. They cannot be compressed.
- The force of attraction is the maximum among the particles of solids. There is not much space between the particles. Therefore, they cannot be compressed.

- The molecules of the solid are closely packed because of the strong intermolecular forces. Intermolecular forces are strong when the distance between neighbouring particles is small.

The Liquid state

- Liquids have the following properties:
 - Liquids have a fixed volume
 - Liquids do not have a fixed shape.
- The force of attraction in liquid particles is less than in solids. Therefore, there is a space between the particles of liquids and they can flow easily. They have very low compressibility."
- The intermolecular forces of liquids are weaker than the solids but are stronger than the gaseous state.
- Particles of liquids arrange each other and Particles of liquids are not arranged in fixed positions. You might have seen that liquids take the shape of the container in which we put them. This is because the particles of liquids have high kinetic energy, they always keep on moving.

Know it!

Can other matter diffuse into liquids?

- Yes, other matter can diffuse into liquids whether it is solids, liquids, or gases. This is so because there is a space between the particles of liquid so particles of other matter can slip into those spaces.
- Diffusing solids into liquids: Mixing sugar in tea
- Diffusing liquids into liquids: Mixing ink in water
- Diffusing gases into liquids: The presence of oxygen and carbon dioxide in water

The Gaseous State

- Gases have the following properties:
 - They do not have a fixed volume.
 - They do not have a fixed shape.
- The particles of gases have the least or almost no force of attraction between them. Therefore, the particles have a large number of spaces between them and they can freely move in any direction.
- Also, they can be easily compressed and put into a small container, unlike solids and liquids.
- Since there is a lot of space between the particles, different gases can diffuse into each other easily.

- The kinetic energy between the particles is the maximum in the case of gases. Therefore, the particles move around freely at high speed and there is no fixed shape of gases.

The Plasma State

- Plasma, in physics, an electrically conducting medium in which there are roughly equal numbers of positively and negatively charged particles, produced when the atoms in a gas become ionized.
- It is sometimes referred to as the fourth state of matter, distinct from the solid, liquid, and gaseous states.
- The negative charge is usually carried by electrons, each of which has one unit of negative charge. The positive charge is typically carried by atoms or molecules that are missing those same electrons.
- The uniqueness of the plasma state is due to the importance of electric and magnetic forces that act on a plasma in addition to such forces as gravity that affect all forms of matter. Since these electromagnetic forces can act at large distances, a plasma will act collectively much like a fluid even when the particles seldom collide with one another.
- Nearly all the visible matter in the universe exists in the plasma state, occurring predominantly in this form in the Sun and stars and in interplanetary and interstellar space. Auroras, lightning, and welding arcs are also plasmas; plasmas exist in neon and fluorescent tubes and in many other phenomena and objects. The Earth itself is immersed in a tenuous plasma called the solar wind and is surrounded by a dense plasma called the ionosphere.

A plasma may be produced in the laboratory by heating a gas to an extremely high temperature, which causes such vigorous collisions between its atoms and molecules that electrons are ripped free, yielding the requisite electrons and ions. A similar process occurs inside stars. In space the dominant plasma formation process is photoionization, wherein photons from sunlight or starlight are

absorbed by an existing gas, causing electrons to be emitted. Since the Sun and stars shine continuously, virtually all the matter becomes ionized in such cases, and the plasma is said to be fully ionized. This need not be the case, however, for a plasma may be only partially ionized. A completely ionized hydrogen plasma, consisting solely of electrons and protons (hydrogen nuclei), is the most elementary plasma.

Bose-Einstein Condensate (BEC)

- This state was first predicted, in 1924-1925 by Satyendra Nath Bose, as a dilute gas of low densities called bosons cooled to temperatures very close to absolute zero (-273.15°C) will transform into new state of matter.
- Einstein extended this idea in 1925 and proposed that cooling bosonic atoms to a very low temperature i.e., absolute zero temperature, would cause them to condense into a new state of matter.
- On June 5, 1995, the first gaseous condensate was produced by Eric Cornell and Carl Wieman at the University of Colorado.
- A gas of rubidium atoms cooled to 170 nanokelvins (nK).
- Shortly thereafter, Wolfgang Ketterle realized a BEC in a gas of sodium atoms. For their achievements Cornell, Wieman, and Ketterle received the 2001 Nobel Prize in Physics.

Let's compare the solid, liquids and gaseous in table format

Properties	Solids	Liquids	Gas
1. Volume	Definite volume, as intermolecular forces between the constituent particles are very strong.	Definite volume, as intermolecular forces between the constituent particles are strong.	No definite volume, as intermolecular forces between the constituent particles are weak.
2. Diffusion	Can diffuse into liquids.	Diffusion is higher than solids.	Highly diffusible as particles move randomly at high speed.
3. Compressibility	Negligible	Negligible	High
4. Rigidity or Fluidity	Very rigid and cannot flow	Less rigid and can flow easily.	No rigidity and can flow most easily.
5. Density	High	Moderate	Low
6. Shape	They have a definite shape	They do not have a definite shape.	They do not have a definite shape.
7. Kinetic energy of particles at a given temperature	Least energy	Higher than solids	Maximum energy
8. Interparticle space	Least	Lesser	More than others
9. Interparticle force of attraction	Very strong	Less strong	Weak
10. Intermolecular forces	Strong enough to hold the constituent particles in fixed positions.	Strong enough to hold the constituent particles in aggregation within the bulk but not in fixed positions.	Extremely low, so that the constituent particles are free to move in a continuous random motion.
11. Arrangement of molecules	Packed in definite pattern so they possess a definite geometry.	Packed weak in comparison to solids, shape not fixed.	Packed very poorly so they fill the container, no definite shape.

Properties of Matter- Solid State

A. Rigidity: Solids are rigid as resist to the structural change in shape or volume. It's all

because of the relative larger intermolecular force of attraction between them as compared to liquids and gas. Rigidity, also known as stiffness.

- B. Hardness:** Hardness means resistance of a solids to deformation, indentation, or penetration by means such as abrasion, drilling, impact, scratching, or wear. Hardness is measured by hardness tests such as Brinell, Knoop, Rockwell, or Vickers. Since there is no standard hardness scale, each test expresses its results in its unique measure. Moh's scale is the scratch hardness scale of hardness. Talc is the softest substance, and diamond is the hardest.
- C. Elasticity:** The ability of few solids to temporarily change their shape on applying force or pressure, but return to the original shape when the force or pressure is removed. e.g., Rubber, spring, Sponge.
- D. Plasticity:** It is the ability of a solid material to undergo deformation, a non- reversible change of shape in response to applied forces. e.g., various objets or things of specific shapes are made of solids like soil, glass, wax, plastic, cement, metals, foam etc.

Properties of matter- Liquid State

- 1. Fluidity**-Liquids are fluid, which means they can flow or spread over the surface. Fluidity of few liquids is more while for few liquids, it is less. It depends on&iscosity of liquid.
- 2. Viscosity** - Viscosity means opposition or resistance to flow. The reciprocal of the viscosity is called the fluidity, means viscosity and fluidity are inversely proportional to each other. Viscosity is measured by determining the rate at which a liquid or gas flows through a small-diameter glass tube. Higher the viscosity, slow will be the liquid flow. Viscosity decreases with increase in temperature, with some exceptions. e.g., honey is more viscous than water, gum is more viscous than honey etc.
Viscosity of Blood - Whole blood has a much higher viscosity than water,
- 3. Surface Tension** - Cohesive forces (forces of attraction between molecules of the same substance) between molecules cause the surface of a liquid to contract to the smallest possible surface area. This general effect is called surface

tension. Molecules on the surface are pulled inward by cohesive forces, reducing the surface area. Molecules inside the liquid experience zero net force, since they have neighbours on all sides. The stronger the bonds between the molecules in the liquid, the larger the surface tension. The surface tension of water at 100°C is 0.059 N/m and mercury is 0.47 N/m. The cohesive forces between liquid molecules are responsible for the phenomenon known as surface tension.

Examples of Surface tension

- **Walking on water:** Small insects such as the water strider can walk on water because their weight is not enough to penetrate the surface.
- **Floating a needle:** A carefully placed small needle can be made to float on the surface of water even though it is several times as dense as water. If the surface is agitated to break up the surface tension, then needle will quickly sink.
- **Don't touch the tent!-** Common tent materials are somewhat rainproof in that the surface tension of water will bridge the pores in the finely woven material. But if you touch the tent material with your finger, you break the surface tension and the rain will drip through.
- **Clinical test for jaundice:** Normal urine has a surface tension of about 66 dynes/centimeter but if bile is present (a test for jaundice), it drops to about 55. In the Hay test, powdered sulfur is sprinkled on the urine surface. It will float on normal urine, but will sink if the surface tension is lowered by the bile.
- **Surface tension disinfectants:** Disinfectants are usually solutions of low surface tension. This allow them to spread out on the cell walls of bacteria and disrupt them.
- **Soaps and detergents:** These help the cleaning of clothes by lowering the surface tension of the water so that it more readily soaks into pores and soiled areas.
- **Washing with cold water:** The major reason for using hot water for washing is that its surface tension is lower and it is a better wetting agent. But if the detergent lowers the surface tension, the heating may be unnecessary.
- **Why bubbles are round:** The surface tension of water provides the necessary wall tension for the

formation of bubbles with water. The tendency to minimize that wall tension pulls the bubbles into spherical shapes.

- **Surface tension and droplets:** Surface tension is responsible for the shape of liquid droplets. Although easily deformed, droplets of water tend to be pulled into a spherical shape by the cohesive forces of the surface layer.

Properties of Matter – Gaseous State:

1. **Compressibility** – The property of a substance that allows its volume to be reduced by applying pressure. Gases are, highly compressible whereas most liquids have very low compressibility. e.g., LPG (Liquified Petroleum Gas) used as domestic fuel, CNG (compressed Natural gas) used as a fuel for vehicle, CO_2 gas is used in cold drinks and in fire extinguishers.
2. **Pressure** - The pressure of gas is the force exerted by the molecules of gas per unit area on the walls of container. Simple **Barometer** or **mercury manometers** are used to determine atmospheric pressure or pressure of gas.
3. **Diffusion** - The process of mixing of two or more gases to form homogenous mixture is known as diffusion. Usually, lighter gases i. diffuse faster than heavier gases. Rate of diffusion of gas is volume of gas diffused per unit time.

Gas Laws:

1. **Boyle's Law** - The pressure (P) of a given mass of a gas varies inversely as its volume (V) at a constant temperature.
2. **Charle's Law** - The volume of a given mass of a gas increases or decreases by $\frac{1}{273.15}$ of its volume at 0°C for every degree rise or fall of absolute temperature at constant pressure.
3. **Gay Lussac's Law** - At constant volume pressure of a given mass of a gas varies directly with the temperature. It is also called Pressure temperature law.

Can matter change its state?

Yes matter can change the state. For example water exist in three state

- Ice- solid
- Water- liquid
- Water vapour- Gas

- This is the indication that matter can change the state

Effects of change of temperature

What happens to matter when we heat it?

1. Solid-

- As we heat solids, the kinetic energy between the particles of solids increases which overcomes the force of attraction between them.
- They start vibrating and changing their positions. Slowly, due to heat the particles become free and a solid converts into liquid.
- In the melting process, once a solid reaches its melting point, its temperature does not increase further. So where does all the heat go? The heat present in the solid at the time of melting is used by the particles to diminish the force of attraction between each other. The heat energy is therefore considered hidden.

Melting Point- the temperature at which a solid melts to become a liquid at the atmospheric pressure is called its melting point. For example ice has a melting point of 273.16 K , this means that ice turns into liquids at the above temperature.

Some important concepts

- **Fusion-** The process of melting a solid into liquid is called Fusion.
- **Latent Heat-** The heat energy which is used to break the force of attraction between the particles of matter is known as latent heat. Since the heat is hidden therefore it is called Latent Heat.
- **Latent Heat of Fusion-** The amount of heat energy required to change 1 kg of a solid into liquid at atmospheric pressure at its melting point is known as the **Latent Heat of Fusion**.

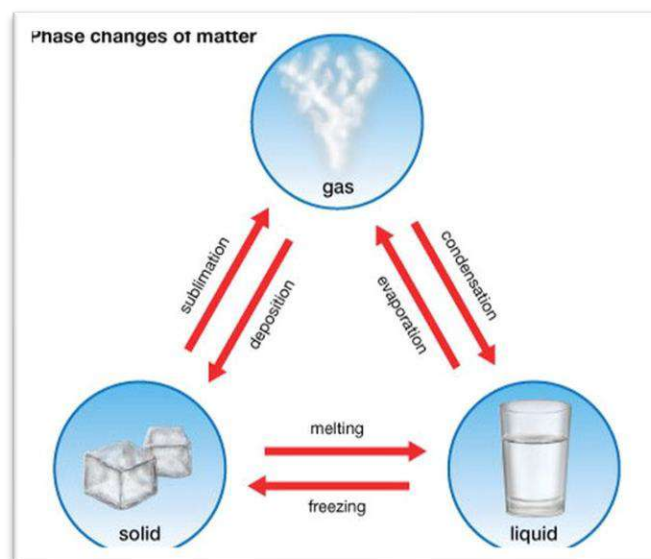
2. Liquid

- Just like in solids, the kinetic energy of particles of liquid increases, the force of attraction among them decreases and they start moving freely.

- As we keep on supplying the heat, a point comes when the particles overcome the forces of attraction completely.
- This is when a liquid starts changing into gas.

Some important concepts

- **Boiling point**- The temperature at which a liquid starts boiling at the atmospheric pressure is known as its Boiling Point. For Example, The boiling point of water is 373 Kelvin.
- **Latent Heat of Vaporisation**- the amount of heat energy required to change 1 kg of a liquid into a gas at atmospheric pressure at its boiling point is known as Latent Heat of Vaporisation.



Change when we decrease temperature

1. Gases

- The kinetic energy between the particles decreases and they turn into a liquid state.
- **Condensation / Liquefaction** – The process of converting gas into a liquid by cooling down its temperature. For Example, The formation of clouds is due to the condensation of water vapour from Earth.

2. Liquids

- The kinetic energy between the particles decreases and they turn into a solid-state. For Example, The formation of ice.
- **Sublimation** – change of state of gas directly into solid and vice-versa is known as sublimation. For Example, Camphor is a solid that directly evaporates into the air without changing to a liquid state. Therefore, by increasing or decreasing the temperature we can change the states of matter into one another. Here is a diagram that sums this up.

Effects of change of pressure

- By applying pressure, we can bring the particles of matter close to each other thereby, increasing the force of attraction among the particles.
- When we compress and decrease the temperature of a gas, the gas changes into a liquid.
- Solid CO_2 gets converted directly to gaseous state on decrease of pressure to 1 atmosphere without coming into liquid state. This is the reason that solid carbon dioxide is also known as **dry ice**.
- Dry Ice – Carbon dioxide in solid form is known as Dry Ice. It can directly turn into a gas by decreasing the pressure to 1 atmosphere.

Evaporation

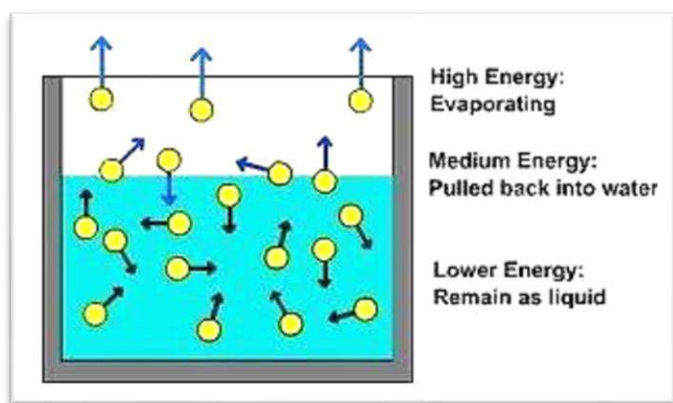
- We already know that –
 - Particles of matter are never at rest
 - Particles of matter possess different amounts of kinetic energy
- At the surface of a liquid, some particles have enough kinetic energy to overcome the forces of attraction holding them in the liquid state and escape into the vapour phase. This process can happen at any temperature.
- **Evaporation** – The phenomenon of change of a liquid into vapours at any given temperature below its boiling point is called Evaporation. Vaporization is the general term for the transition from liquid to gas, which includes both boiling and evaporation. Evaporation is basically a surface phenomenon.

Factors affecting the rate of evaporation

Conditions	Rate of Evaporation	Reason
Increase in Surface Area	Increase in rate of evaporation.	Particles have more space and thus can evaporate easily
Increase in temperature	Increase in rate of evaporation	Kinetic energy among the particles increases
Increase in humidity	Decrease in evaporation	Water content in air increases and so evaporation decreases
Increase in wind	increase	Water vapours are blown away by winds allowing more evaporation

How does evaporation cause cooling?

The process of evaporation uses the energy of the liquid particles. Therefore, the particles absorb energy from the surroundings in order to compensate for the energy that is being lost in the process of evaporation. This results in the cooling of the surrounding area.



Some of the notable examples

1. Our palm feels cool when we put some acetone (nail paint remover) on it. The particles gain energy from your palm or surroundings and evaporate causing the palm to feel cool.
2. After a hot sunny day, people sprinkle water on the roof or open ground because the large latent heat of vaporisation of water helps to cool the hot surface.

3. We are able to sip hot tea faster in a saucer than a cup.

Know it!

- **Why do people wear cotton clothes in summer?**

We sweat more in summer. As the sweat evaporates it takes energy from our body surface and keeps our body cool. Cotton can absorb the sweat easily and exposes it to the atmosphere causing evaporation to take place easily. This, in turn, keeps us cool on summer days.

- **Why do water droplets appear in the surrounding of glass with ice-cold water?**

There are water vapours present in the air. When they come in contact with the walls of the glass that has ice-cold water in it they condense. As a result, their state changes from the gaseous state to liquid state thus forming tiny water droplets on the walls of the glass.

Important Measurement Units

SI units of Mass	Kg (Kilogram)
SI unit of Volume	m ³ (cubic metres)
Common unit of Volume	L (Litres)
SI unit of temperature	Kelvin 0° C = 273.16 K or 273 K (approximately) Kelvin = Celsius + 273
SI unit of Pressure	Pa (Pascal)
For measuring the pressure exerted by Gas	Atmosphere (atm) 1 atm = 1.01 X 10 ⁵ Pa Normal Atmospheric Pressure = 1 atm (at sea level)

Matter Around us

- **Substance-** Anything that cannot be broken into further particles by applying any physical processes is called a Substance.
- **Matter-** Anything which occupies space and has mass is called matter. Matter can be divided in two types of substances.
 - **Pure Substances-** It consists of single types of particles which are same in their chemical nature. For example, Diamond, Salt, Sulphur, Tin etc.
 - **Impure substances (Mixture)-** it is a substance in which two or more substances (

elements or compounds) are simply mixed together in any proportion. Examples- the air is a mixture of oxygen, nitrogen, carbon dioxide and water vapour.

	we may see separate layers of the substances
Example- a mixture of water and milk	A mixture of oil in water

Mixture can be of two types

1. Homogenous mixture
2. Heterogeneous mixture

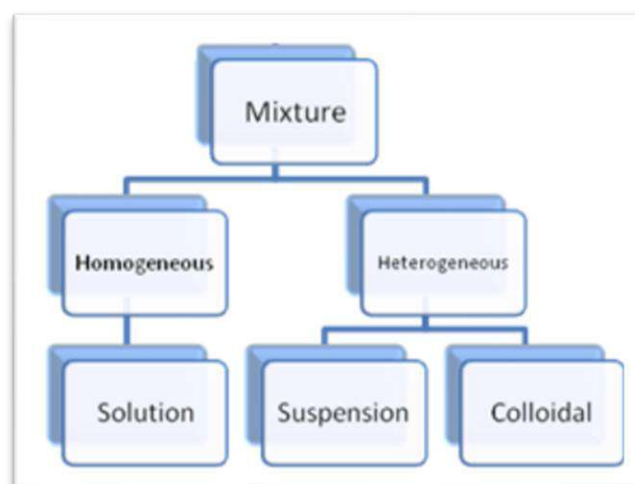
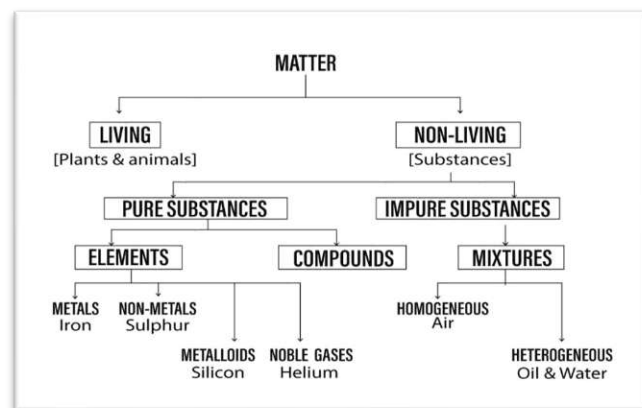
Let's explain each in details

1. Homogenous mixture

- When we add sugar, water and lemon juice together they all uniformly mix with each other. Now it is not possible to separate these substances from the mixture. Such mixtures in which the components mix with each other uniformly are called Homogeneous Mixtures.
- The ratio of compositions of homogeneous mixtures can be different. For Example, one may add two spoons of sugar in lemonade while someone else may add only one spoon of sugar in their lemonade. Still, lemonade is a homogeneous mixture.

2. Heterogeneous mixture

- The components in a heterogeneous mixture do not completely dissolve in each other and we can separate them by physical means. In other words, the composition of such mixtures is not uniform.
- For Example, if we mix sand in water the sand settles down in water after some time and we can separate it by filtration.



What is Solution?

A solution is nothing but a uniform mixture of two or more substances. Homogenous Mixtures are solutions.

Some of the notable example of Solution are

Solution of -

- Liquid into a liquid: Water and Ink
- Solid into solid: Alloys
- Gas into gas: Air
- Solid into a liquid: Sugar and Water
- Solid into gas: Iodine vapor in air
- Liquid into gas: Water vapor in air

What is alloy?

An alloy is a mixture of different metals or non-metals and metals that cannot be separated from each other using physical methods. For Example

Brass – Copper with up to 50% zinc

Let's see the difference between Homogenous and Heterogeneous mixture

Homogeneous mixture	Heterogeneous mixture
They have a uniform composition throughout	They have a non-uniform composition
We cannot separate the components of the mixture through physical processes	We can separate the components through physical processes
Components cannot be seen through naked eyes	Components can easily be seen through naked eyes
The mixture is in single-phase throughout	The substances can be of two different phases and

Bronze – Copper with up to 12% tin

Solution has two components

1. **Solvent**- The component of the solution that dissolves the other component in it (usually the component present in larger amount) is called the solvent.
2. **Solute**- the component of the solution that is dissolved in the solvent (usually present in lesser quantity) is called the solute.

Properties of Solution

- A solution is a homogeneous mixture.
- The particles of a solution are smaller than 1 nm (10^{-9}) in diameter which cannot be seen by naked eyes.
- They do not scatter a beam of light passing through the solution that is they don't show Tyndall effect. So, the path of light is not visible in a solution.
- The solute particles cannot be separated from the mixture by the process of filtration.
- The solution is stable and solute particles do not settle down when left undisturbed.

Stable Solution- A stable solution is a solution in which particles do not settle down if we leave the solution undisturbed for some time. This is because the particles of a stable solution are homogeneously spread.

Different types of solutions

- **Dilute Solution** – A solution in which the concentration of the solute is much less than that of the solvent.
 - For Example, if we mix 1gm of salt in 500 ml of water, the salt solution thus obtained will be diluted. If we keep on adding the solute in a solution there comes a point when no more solute dissolves in the solution. This is called the Saturation Point of a Solution.
- **Unsaturated Solution** – A solution, in which we can add more solute as it has not achieved its saturation level yet, is called an Unsaturated Solution. A dilute solution can be called an Unsaturated Solution.

- **Concentrated Solution** – A solution with a large amount of solute relative to the amount of solvent is called a Concentrated Solution.
- **Saturated Solution** – A solution in which no more solute can be added since it has already dissolved the maximum amount of solute it can is called a Saturated Solution.

Concentration

Concentration refers to the amount of a substance per defined space or can be defined as the ratio of solute in a solution to either solvent or total solution.

There are two methods to find the concentration of the solution-

1. Mass by percentage of a solution = $(\text{Mass of solute} / \text{mass of solution}) \times 100$
2. Mass by volume percentage of a solution = $(\text{Mass of solute} / \text{Volume of solution}) \times 100$

Note-

Some important formulae to calculate the concentration of solution

- **Molarity (M)** = number of moles of solute / Volume of Solution in litres Where, Moles of solute = given mass/molar mass
- **Molality (m)** = Moles of solute / weight of solvent in kg
- **Normality (N)** = Number of mole equivalents / volume of solution in litres = $\text{Mass of solute} / (\text{equivalent mass} \times \text{volume of solution in Litres})$
- **ppm (Parts Per Million)** = $(\text{Mass of Solute} / \text{Mass of Solvent}) \times 10^6$
- **Mole Fraction SOLUTE** = Moles of Solute / Total Moles of Solution
- **Mole Fraction SOLVENT** = Moles of Solvent / Total Moles of Solution
- **Mole Fraction SOLUTE + Mole Fraction SOLVENT = 1**

Suspension

A suspension is a heterogeneous mixture in which the solute particles do not dissolve but remain suspended throughout the bulk of the medium. Ex: Chalk in water, smoke in the air

Properties of Suspension

1. It is a heterogeneous mixture.

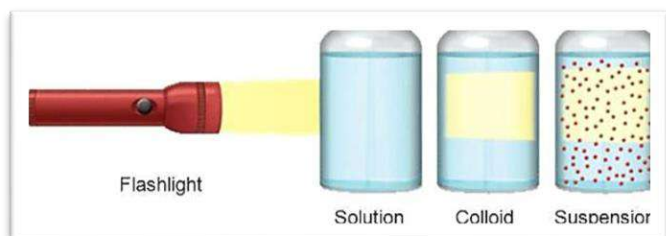
2. Particles of a suspension are visible to the naked eye.
3. Size of the particles is greater than 100 nm.
4. It is unstable mixture. Solute settles down at the bottom over period of time.
5. If the solution is passed through filter paper, solute and solvent gets separated.
6. It scatters light when light is passed through the solution i.e. it shows Tyndall effect.

Colloids or Colloidal solution

A colloidal solution or a colloid is a heterogeneous mixture of two or more substances. The particles are relatively very small and the solution appears as a homogeneous mixture but it is not. Hence colloid solution is heterogeneous mixture in which the size of particles lies between the true solutions and suspensions. Colloidal particles can easily scatter a beam of visible light. This phenomenon is called **Tyndall effect**.

Properties of Colloidal solution

1. The particles of colloid can't be seen by naked eyes individually.
2. It is a heterogeneous mixture and thus solute and solvent can't be separated by filter paper.
3. Size of particles is smaller than suspensions but greater than solutions (1 nm to 100 nm).
4. It is a stable mixture. Particles do not settle down at the bottom over a period of time.
5. They do not settle down when left undisturbed which means colloid is quite stable.
6. We cannot separate the particles of a colloid through filtration. We use a method called **Centrifugation** to separate the particles of a colloid.



What is Tyndall Effect?

When a beam of light is passed through a colloid the particles of the colloid scatter the beam of light and we can see the path of light in the solution. For Example, when a ray of light enters a dark room it is

scattered by the dust particles present in the air and we can see the path of light clearly.

Classification of Colloids

Dispersed Phase – The dispersed particles or the solute-like components in a colloid

Dispersing Medium – The substance in which these solute-like particles are added

Some common examples of Colloids

Example	Dispersing Medium	Dispersed Substance	Colloid Type
Fog, Aerosol sprays	Gas	Liquid	Aerosol
Smoke	Gas	Liquid	Aerosol
Whipped cream, Soapsuds	Liquid	Gas	Foam
Milk, Mayonnaise	Liquid	Liquid	Emulsion
Paints, Clays, Gelatin	Liquid	Solid	Sol
Marshmallow, Styrofoam	Solid	Gas	Solid foam
Butter, cheese	Solid	Liquid	Solid emulsion
Ruby glass	Solid	Solid	Solid sol

How to separate components of a mixture?

We can separate the heterogeneous mixtures into their constituents by means of physical methods like

- Filtration
- Hand-picking
- Sieving

The components of Mixture can be separated from each other using several other techniques like

- Evaporation
- Centrifugation
- Sublimation
- Chromatography
- Distillation

Let's see each in short.

1. Evaporation

- For separating a mixture of a non-volatile and a volatile substance.

- **Basic Principle-** out of two components of a mixture one can evaporate (I.e., has less boiling point) and other has higher boiling point.
- **Application-** Separating coloured component from the ink, Salt from water, Sugar from Water

2. Centrifugation

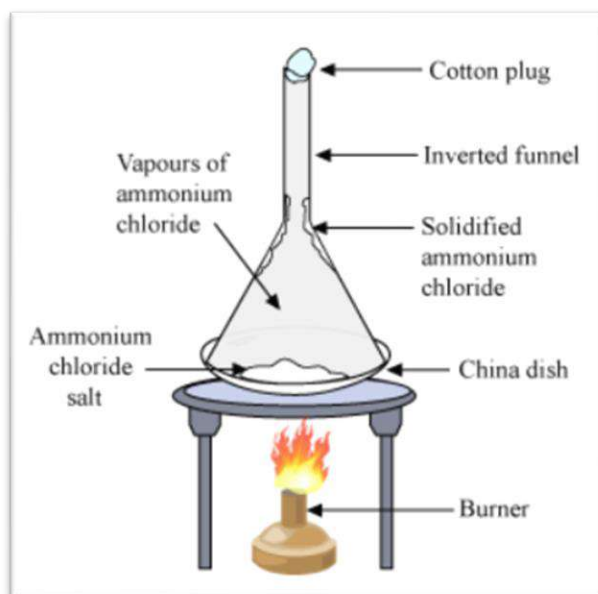
- Separating dense particle from lighter particle on the basis of density, when mixture is rotated very fast, the denser particles are forced at the bottom and lighter particles stay above.
- **Applications-**
 - Separating cream from milk
 - Squeezing out water from wet clothes
 - Used in diagnostic lab for blood and urine tests.

3. Separating funnel

- Two immiscible liquids (which do not dissolve in each other) can be easily separated by putting in a separating funnel.
- **Applications**
 - Separation of oil from water
 - Extraction of iron from its ore. Lighter slag is removed from above the molten iron.
- **Method-** The immiscible liquids are allowed to settle in the funnel. They soon form separate layers due to varying densities. The first liquid is allowed to flow out of the funnel and as soon as it is completely poured out, the stopcock is closed thereby separating the two liquids from each other.

4. Sublimation

- This process is used to separate mixtures that contain a sublimable volatile component from a non-sublimable impurity.
- Sublimation is process where a substance directly changes from solid to gaseous state on heating.
- **Applications-** Ammonium chloride/ camphor/ naphthalene and salt

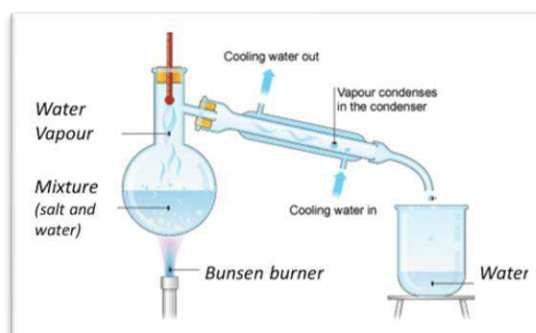


5. Chromatography

- Basic principle- Coloured components of a mixture can be separated by using an Adsorbent on which they are adsorbed at different rates.
- Used to separate those solutes which dissolve in the same solvent.
- Application
 - To separate colours of dye (the colours which are more soluble in water rise faster and get separated into layers)
 - To separate pigments from natural colours like chlorophyll.
 - To separate drugs from bloods.

6. Distillation

- **Basic Principles-** based on separating mixture of miscible liquids having different boiling points, followed by condensation. Out of the two components one has a lower boiling point and other has higher boiling point. This is used to separate two or more miscible liquids.



- **Application-** mixture of Acetone and water is separated by this method.
- **Method-**
 - The mixture is heated in a distillation apparatus. The one substance with a lower boiling point evaporates first, condenses and gets separated from the one with a higher boiling point.
 - **Simple Distillation** – when the miscible liquids have a satisfactory difference in their boiling points
 - **Fractional Distillation** – when the difference between the boiling points of the liquids is less than 25 K

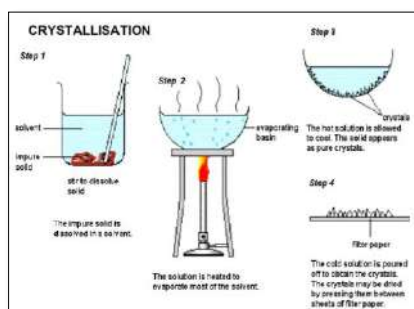
How can we separate different gases from the air?

Method – Fractional Distillation

- Compress and cool the air by increasing the pressure and decreasing the temperature. The air turns to liquid air.
- Liquid air is warmed up slowly in a fractional distillation apparatus
- The several components of air get separated and are collected at various heights on the basis of their boiling points

Methods for purifying Solids Crystallisation

Basic Principles- To remove the impurities from a mixture by first dissolving in a suitable solvent and then crystallising out one components.



Method-

- The impurities of a substance are filtered out.
- Water is evaporated to obtain a saturated solution.
- The solution is covered with filter paper and left as it is.

- After some time, the crystals of pure solid are formed.

Applications

- Salt from seawater
- Purification of copper sulphate
- Separation of crystals (e.g., alum (phitkari), copper sulphate) from their impure crystals.

Physical and chemical changes

Physical property of a substance- properties of a substance such as rigidity, colour, fluidity, boiling point, melting point, density and hardness which we can observe are called as physical properties.

Physical change

- When the physical properties of a substance change it is known as a Physical Change. When we convert a substance from one state to another, such as a solid into a liquid or vice-versa, it is also a physical change as only the physical nature of the substance changes without affecting its chemical nature.
- For example, change of ice into water, the chemical property of water remain the same.

Chemical property of a substance

The chemical nature of a substance is known as its Chemical Property such as its odour or its chemical composition.

Chemical change- When the chemical properties or chemical composition of a substance gets altered it is called a chemical change. It is also called a Chemical Reaction. For example- Burning paper

Physical change	Chemical change
It brings about change in physical properties such as physical state, shape, size etc.	It brings about changes in chemical properties.
No changes in chemical compositions are observed.	Changes in chemical properties are observed.
It is reversible	It is irreversible that means permanent
No new substance is formed.	New substance is formed.

Matter is of two types that is pure substance and mixture. We have seen the detailed study about the mixture. Now we will see the pure substance in short.

Pure substances

Pure substances includes elements and compounds. Let's look into each.

1. Elements

- Elements are the pure form of matter, composed of only one type of particles and cannot be broken down into simpler or new substances.
- Elements are the fundamental building blocks that constitute all ordinary (observable) matter in the universe. However, astronomical observations suggest that ordinary matter makes up only about 15% of the total matter and energy in the universe; the remaining is dark matter and dark energy.
- There are 94 elements that occur naturally on Earth (though some are found only in trace amounts). Scientists have created synthetic elements in laboratories. As of now, a total of 118 elements have been discovered and classified in the periodic table.

Discovery of Elements

- Copper, Lead, Gold, Silver, Iron, Carbon, Tin, Sulphur, Mercury are known as ancient elements, which are been in used since ancient periods.
- In modern period, Phosphorus was the first element to be discovered in 1669 by a scientist H. Brand. Phosphorus emits a faint glow when exposed to oxygen. Hence, the name Phosphorus is given (Phosphorescence glow after illumination).
- The last naturally occurring element to be discovered was francium (87) in 1939 by M. Perey. Since that discovery, Plutonium (94), Neptunium (93) and Astatine (85), which were initially prepared in lab in 1940, have since been found in nature.

Symbols of the Elements:

In chemistry, a symbol is an abbreviation for a chemical element. Symbols for chemical elements normally consist of one or two letters from the Latin

alphabet and are written with the first letter capitalised.

Elements are further characterised as Metals, Non-metals and metalloids

a. Metals

- Metals are lustrous (shiny)
- Metals conduct heat and electricity
- Metals have a silver-grey or gold-yellow colour
- We can hammer metals and form thin sheets (Malleability)
- We can convert metals into wires (Ductility)
- Metals always produce a ringing sound if they are hit (Sonorous)
- Example are silver, Mercury, Copper and Gold

b. Non-metals

- Non-Metals do not conduct heat and electricity
- Non-Metals are not sonorous, lustrous or ductile
- Non-Metals have varied colours
- Examples are Carbon, iodine, chlorine, oxygen and hydrogen.

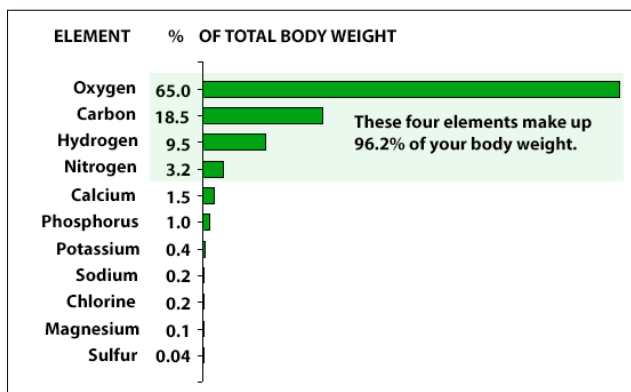
c. Metalloids

- They show some properties of metals and some of the non-metals.
- Examples are silicon, Germanium

Note-

Element	Abundance (%)	Element	Abundance (%)
Oxygen	46.6	Vanadium	0.014
Silicon	27.7	Chromium	0.010
Aluminium	8.1	Nickel	0.0075
Iron	5.0	Copper	0.0055
Calcium	3.6	Zinc	0.0070
Sodium	2.8	Cobalt	0.0025
Magnesium	2.1	Lead	0.0013
Potassium	2.6	Uranium	0.00027
Titanium	0.44	Tin	0.0002
Manganese	0.095	Tungsten	0.00015
Barium	0.043	Mercury	8×10^{-6}
Strontium	0.038	Silver	7×10^{-6}
Rare earths	0.023	Gold	$< 5 \times 10^{-6}$
Zirconium	0.017	Platinum Metals	$< 5 \times 10^{-6}$

Elements in Human Body



Facts about elements

- Elements found on Earth and Mars are exactly the same.
- Hydrogen is the lightest and most common element found in the universe.
- Helium is twice as heavy as hydrogen, but it is only one seventh the weight of air.
- The heaviest naturally-occurring element is Uranium, Osmium is the heaviest known element by density.
- Francium is the most reactive metal, followed by cesium, rubidium, potassium, and sodium. The most reactive nonmetal is fluorine.
- The only solid elements that assume liquid form at room temperature are bromine and mercury. However, you can melt gallium by holding a lump in the warmth of your hand.
- Although oxygen gas is colourless, the liquid and solid forms of oxygen are blue.
- The human body contains a large amount of carbon (about 16% of body mass), which is the same element that makes up graphite (used as 'lead' in pencils). The amount of carbon in an average adult body is roughly equivalent to the amount of graphite in several thousand pencils. "The rarest naturally occurring element in the Earth's crust may be astatine.
- Element with the lowest melting and boiling point is Helium.
- Element with the highest melting point is Carbon.
- Element with the highest boiling point is Tungsten.
- Element with highest density is Osmium.
- Element with lowest density is Hydrogen.
- Element with highest electronegativity is Fluorine.

- Element with lowest electronegativity (highest electropositivity) is Francium.
- The first element to be produced artificially is Technetium.

2. Compounds

- A compound is a substance composed of two or more elements, chemically combined with one another in a fixed proportion.
- Compounds are represented with the help of molecular formula.
- Example water- H_2O and Sodium Chloride- $NaCl$

Difference between mixture and compounds

Mixture	Compounds
Elements or compounds just mix together to form a mixture and no new compound is formed	Elements react to form new compounds
A mixture has a variable composition	The composition of each new substance is always fixed.
A mixture shows the properties of the constituent substances.	The new substance can be separated only by chemical or electrochemical reactions
The constituents can be separated fairly easily by physical methods	The constituents can be separated only by chemical or electrochemical reactions.

Historical background

The Idea of divisibility by Indian Philosophers

- **Maharishi Kanad** – He postulated that if we keep on dividing the matter (called 'padarth') we will get smaller and smaller particles. And soon we will achieve the smallest of particles (called as 'parmanu') which may not divide further.
- **Pakudha Katyayama** – He postulated that there are various forms of matter because the particles of matter exist together in combinations.

The Idea of Divisibility by Greek philosophers

- **Democritus and Leucippus** – They suggested that when we keep on dividing the matter there comes a time when no more division of particles can take place. Such particles are called atoms which means being invisible.

But all these ideas were not backed up by many experimental pieces of evidence until Antoine L. Lavoisier provided two laws of chemical combination.

Laws of Chemical Combination

- The chemical reaction between two or more substances give rise to products which is governed by certain laws called laws of chemical Combinations.
- There are five basic laws of chemical combinations that govern the chemical combinations of elements.
 - Law of Conservation of mass
 - Law of definite proportions
 - Law of multiple proportions
 - Gay Lussac's law of Gaseous Volumes
 - Law of Reciprocal Proportion (sometimes called the Law of Equivalent Proportions)

But we required only two to have little foundation of other topics.

The following two laws of chemical combination were established after much experimentations by Lavoisier and Joseph L. Proust.

Law 1

- **Law of Conservation of Mass**- mass can neither be created nor destroyed in a chemical reaction (During a chemical reaction, the total mass of

reactants will be equal to the total mass of the products.)

- **Example-** $A \text{ (reactant)} + B \text{ (reactant)} \rightarrow AB \text{ (product)}$

mass of A + mass of B = mass of AB

Law 2

- Law of Constant Proportions/ Law of definite proportions- The elements are always present in definite proportions by mass in a chemical substance.
- For example, Hydrogen and oxygen are present in water in a ratio of 1:8. So if we decompose 9g of water we will obtain 1g of hydrogen and 8g of oxygen.

Modern Atomic Theories

1. John Dalton (1808) – Solid Sphere model

John Dalton proposed an atomic theory that acted as an explanation of the above two laws. As per the theory, all matter whether it is an element, a compound or a mixture consists of tiny invisible particles called 'atoms'.

The postulates of the atomic theory by John Dalton

1. The matter is made up of tiny particles called atoms that cannot be divided.
2. Atoms are never formed or destroyed during a chemical reaction.
3. Atoms of an element exhibit the same nature. They have the same size, mass, and character.
4. Atoms of different elements exhibit variant nature. They do not have the same characteristics.
5. Atoms form compounds by combining them in a ratio of whole numbers.
6. A compound contains a constant number and kinds of atoms

Scientist	Proposed Atomic Mode
John Dalton (English Chemist, proposed atomic theory in 1808)	He proposed the atomic theory of matter based on his experimental observations.

What is Atom?

- Atom is the building block of the matter.
- According to modern atomic theory, an atom is the smallest particle of an element which takes part in chemical reaction.
- Atoms are very small and which can't be seen even through very powerful microscope.

Size of the Atom

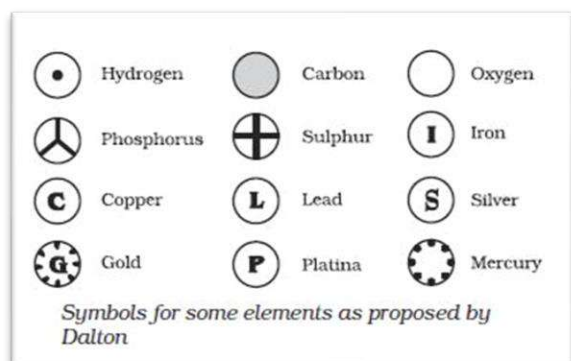
- Atoms are extremely small. Their size is measured in nanometres, where $1\text{nm} = 1/10^9\text{ m}$.
- Atomic radius of smallest atom in hydrogen is $0.37 \times 10^{-10}\text{ m}$ or 0.037 nm .

Relative Size of some entity

Radii (in m)	Example
10^{-10} m	Atoms of hydrogen
10^{-9} m	Molecule of water
10^{-8} m	Molecule of haemoglobin
10^{-4} m	Grain of sand
10^{-2} m	Ant
10^{-1} m	Watermelon

Modern day symbols of elements

- Dalton was the first scientist to use the symbols for elements in a very specific sense. When he used a symbol for an element he also meant a definite quantity of that element, that is, one atom of that element.
- Berzilius suggested that the symbols of elements be made from one or two letters of the name of the element.



- In the beginning, the names of elements were derived from the name of the place where they were found for the first time.

- For example, the name copper was taken from Cyprus. Some names were taken from specific colours.
- For example, gold was taken from the English word meaning yellow.
- Now-a-days, **IUPAC (International Union of Pure and Applied Chemistry)** is an international scientific organisation which approves names of elements, symbols and units. Many of the symbols are the first one or two letters of the element's name in English.
- The first letter of a symbol is always written as a capital letter (uppercase) and the second letter as a small letter (lowercase).
- Symbols of some elements are formed from the first letter of the name and a letter, appearing later in the name. Examples are: (i) chlorine, Cl, (ii) zinc, Zn etc.
- Other symbols have been taken from the names of elements in Latin, German or Greek. For example, the symbol of iron is Fe from its Latin name ferrum, sodium is Na from natrium, potassium is K from kalium. Therefore, each element has a name and a unique chemical symbol.

Element	Symbol	Element	Symbol	Element	Symbol
Aluminium	Al	Copper	Cu	Nitrogen	N
Argon	Ar	Fluorine	F	Oxygen	O
Barium	Ba	Gold	Au	Potassium	K
Boron	B	Hydrogen	H	Silicon	Si
Bromine	Br	Iodine	I	Silver	Ag
Calcium	Ca	Iron	Fe	Sodium	Na
Carbon	C	Lead	Pb	Sulphur	S
Chlorine	Cl	Magnesium	Mg	Uranium	U
Cobalt	Co	Neon	Ne	Zinc	Zn

The Atomic Mass

- Dalton's Atomic Theory suggested that each element has a distinguishing atomic mass. With this theory, the law of constant proportions could be explained easily.
- But it is indeed difficult to evaluate the mass of an atom since the size of an atom is relatively small.
- Therefore scientists started evaluating the mass of an atom by comparing it with the mass of a standard atom.
- Earlier $1/16$ of the mass of an oxygen atom was used as a standard for calculating the mass of other elements. Now, carbon - 12 is considered a standard atom for calculating the mass.
- Its atomic mass is 12u (12 atomic mass units). Thus we can say that one atomic mass unit is the

mass of 1/12 the mass of a carbon-12 atom. Here is a list of atomic masses of a few elements.

- 1 amu or u = $1/12 \times \text{Mass of an atom of } C^{12}$
 $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$

Some of the elements with atomic masses

Element	Atomic mass
Hydrogen	1 μ
Carbon	12 μ
Nitrogen	14 μ
Oxygen	16 μ
Sodium	23 μ
Magnesium	24 μ
sulphur	32 μ
Chlorine	35.5 μ
Calcium	40 μ

How Do Atoms Exist?

- Atoms of most elements are not able to exist independently.
- Only the atoms of noble gases (such as He, Ne, Ar, Kr, Rn) are chemically unreactive and can exist in the free state as single atom)
- Atoms form molecules and ions. These molecules or ions aggregate in large numbers to form the matter that we can see, feel or touch.
- Generally ions are electrically charged whereas molecules are electrically neutral

Molecules

- A molecule is in general a group of two or more atoms that are chemically bonded together that is, tightly held together by attractive forces.
- A molecule can be defined as the smallest particle of an element or a compound that is capable of an independent existence and shows all the properties of that substance.
- Atoms of the same element or of different elements can join together to form molecules.

Categorized of molecule

A molecule may have atoms of same or different elements, depending upon this, molecule can be categorized into two categories-

- **Homoatomic molecules-** containing of same elements e.g. O_2 , N_2 , O_3 etc.
- **Heteroatomic molecules or compounds-** Containing atoms of different elements, e.g. H_2O , NO_2 , SO_2 .

- **Diatomic** – when an molecule comprises two atoms.

Example – Some common gases like oxygen (O_2), nitrogen (N_2), and hydrogen (H_2).

- **Triatomic** – when an molecule comprises of three atoms
- **Tetra-atomic** – when an molecule comprises of four atoms
- **Poly-atomic** – when an molecule comprises of more than two atoms

Atomicity

The number of atoms present in one molecule of an element is called its atomicity

Below are the few examples of atomicity of elements

Atomicity of some elements

Element	Atomicity	Elements	Atomicity
H	2	F	2
He	1	Ne	1
Li	1	Na	1
N	2	P	4
O	2	S	8

Molecules of Compounds

Atoms of different elements join together in definite proportions to form molecules of compounds.

Compound	Combining Elements	Ratio by mass
Water	Hydrogen, oxygen	1:8
Ammonia	Nitrogen and hydrogen	14:3
Carbon dioxide	Carbon and oxygen	3:8

What is Ion?

- Compounds formed from metals and non-metals (ionic compounds) consist of charged species which are known as ions.
- Thus, an ion is a particle that has a positive or negative charge.
- **Anion** are negatively charged ion
- **Cation** are positively charged ion
- There can be a single charged atom (a simple ion) or a group of atoms that carries a net charge (a polyatomic ion).

- When a group of atoms carries a charge, it is called a polyatomic ion." (This ion can then be a part of an ionic compound).
- Some positively charged ions : Na^+ , K^+ , Ca^{2+} , Al^{3+}
- Some negatively charged ions : Cl^- (chloride ion), S^{2-} (sulphide ion), OH^- (hydroxide ion), SO_4^{2-} (sulphate ion)

We can classify ions into two types

1. Simple ions

- Mg^{2+} (Magnesium ion)
- Na^+ (Sodium ion)
- Cl^- (Chloride ion)
- Al^{3+} (Aluminium ion)

2. Compounds ions

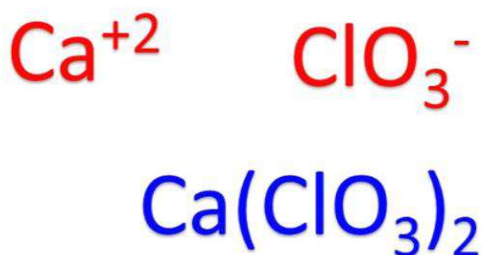
- NH_4^+ (Ammonium ion)
- CO_3^{2-} (Carbonate ion)
- SO_4^{2-} (Sulphate ion)
- OH^- (Hydroxide ion)

Some ionic compounds

Ionic compound	Constituting elements	Ratio by mass
Calcium oxide	Calcium and oxygen	5:2
Magnesium sulphide	Magnesium and sulphur	3:4
Sodium chloride	Sodium and chlorine	23:35.5

Chemical formula for ionic compounds

25. Calcium and chlorate



Chemical Formula

It is the symbolic representation of the composition of a compound.

The chemical formulae of different compounds can be written easily. To write a chemical formula we must know two things-

a. Symbols

b. Valency

What is valency?

- It is also known as the combining capacity of an element. In other words, valency explains how atoms of one element will mix with atoms of another element.
- The valency of the atom of an element can be thought of as hands or arms of that atom.
- For example, the hydrogen ion is represented as H^+ which means that its valency is 1. Similarly, the oxygen ion is represented as O^{2-} which means that its valency is 2. Here is a list of valencies of various elements.

name of the element	symbol	valency	Ion.
Hydrogen	H	1	H^+
Helium	He	0	-
Lithium	Li	1	Li^+
Beryllium	Be	2	Be^{2+}
Boron	B	3	B^{3+}
Carbon	C	4 (Shares electrons)	-
Nitrogen	N	3	N^{3-}
Oxygen	O	2	O^{2-}
Fluorine	F	1	F^-
Neon	Ne	0	-
Sodium	Na	1	Na^+
Magnesium	Mg	2	Mg^{2+}
Aluminium	Al	3	Al^{3+}

Characteristics of chemical formulae

- The valencies or charges on ion must balance.
- When a compound is formed of metal and non-metal, symbol of metal comes first. E.g., CaO , NaCl , CuO .
- When more than one polyatomic ion is needed to balance the charge, the ion's formula is enclosed in brackets, and the number required is written as a subscript outside the brackets. E.g., $\text{Ca}(\text{OH})_2$, $(\text{NH}_4)_2\text{SO}_4$

Rules for writing chemical formulae

- We first write symbols of elements which form compound.
- Below the symbol of each element, we should write their valency.
- Now cross over the valencies of combining atoms.
- With first atom, we write the valency of second atom (as a subscript).
- With second atom, we write the valency of first atom (subscript).

Formula of Sodium oxide

write symbol	Na	O
Remember charge	+1	-2
Cross the charge	Na_2O	

Formula of Sodium hydroxide

write symbol	Na	OH
Remember charge	+1	-1
Cross the charge	$NaOH$	

Formula of Sodium Chloride

write symbol	Na	Cl
Remember charge	+1	-1
Cross the charge	$NaCl$	

Formula of Calcium chloride

write symbol	Ca	Cl
Remember charge	+2	-1
Cross the charge	$CaCl_2$	

Molecular mass

- It is the sum of atomic masses of all the atoms in a molecule of that substance.
- Example: Molecular mass of $H_2O = 2 \times \text{Atomic mass of Hydrogen} + 1 \times \text{Atomic mass of Oxygen}$.
So, Molecular mass of $H_2O = 2 \times 1 + 1 \times 16 = 18 \text{ u}$.
- The molecular mass of HNO_3 can be calculated as:
Atomic mass of H = 1u
Atomic mass of N = 14u
Atomic mass of O = 16u
Molecular mass of $HNO_3 = 1 + 14 + (16 \times 3) = 63 \text{ u}$

Formula unit mass

The sum of atomic masses of all atoms in a formula unit of a compound is called its formula unit mass. The formula unit mass is used in the case of substances that constitute ions. For example, the formula unit mass of Sodium Chloride ($NaCl$) can be calculated as: $(1 \times 23) + (1 \times 35.5) = 58.5 \text{ u}$

Formula unit mass of ZnO

$$= 1 \times \text{atomic mass of Zn} + 1 \times \text{atomic mass of O} \\ = 1 \times 65 \text{ u} + 1 \times 16 \text{ u} = 81 \text{ u}$$

Formula unit mass of Na_2O

$$= 2 \times \text{atomic mass of Na} + 1 \times \text{atomic mass of O} \\ = 2 \times 23 \text{ u} + 1 \times 16 \text{ u} = 62 \text{ u}$$

Formula unit mass of K_2CO_3

$$= 2 \times \text{atomic mass of K} + 1 \times \text{atomic mass of C} + 3 \times \text{atomic mass of O} \\ = 2 \times 39 \text{ u} + 1 \times 12 \text{ u} + 3 \times 16 \text{ u} \\ = 78 \text{ u} + 12 \text{ u} + 48 \text{ u} = 138 \text{ u}$$

Mole Concept

How do we interpret chemical equation?

- Suppose a chemical equation is: $2C + 2O_2 = 2CO_2$

- We say that two molecules of carbon combine with two molecule of oxygen to form two molecules of carbon dioxide.
- We can also say that 24u of Carbon molecules combine with 64u of oxygen molecules to form 88u of carbon dioxide molecules.
- Therefore, we can characterise the quantity of a substance by its mass or by its number of molecules.
- A chemical equation directly indicates the number of molecules participating in the reaction. Thus, it is convenient for us to refer to the number of substances in a chemical reaction as numbers of molecules or

Mole

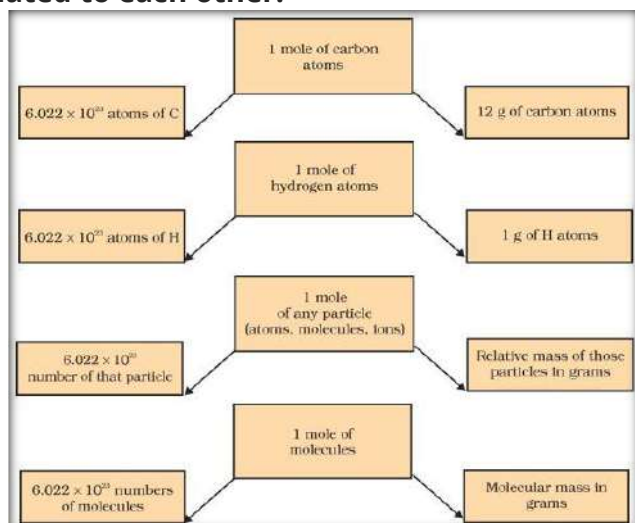
- Mole is a numerical quantity that has a mass equal to the atomic or molecular mass of species (atoms, molecules, ions or particles).
- 1 mole of any substance = 6.022×10^{23} number of particles (atoms, ions or molecules)
- This is called the **Avogadro number or Avogadro Constant** which is represented as N_0
- The mass of 1 mole of a substance is the same as that of its atomic mass or molecular mass expressed in grams.
- The **gram atomic mass of a substance** – the atomic mass of a substance when expressed in grams is known as its gram atomic mass.
- The **gram molecular mass of a substance** – the molecular mass of a substance when expressed in grams is known as its gram molecular mass.
- For example, the atomic mass of Sulphur is 32u. The gram atomic mass of Sulphur is 32g.
- Also, 32u of Sulphur has 1 atom of Sulphur. 32g of Sulphur has 1-mole atoms, that is, 6.022×10^{23} atoms of Sulphur.
- Similarly, we can say that the gram molecular mass of Carbon Dioxide is 44g.
- But we know that in the case of the chemical equation mole is the measuring unit.
- Therefore, **1 mole = 6.022×10^{23} number = Relative mass in grams**
- Wilhelm Ostwald introduced the word 'mole' which means a heap or a pile. Therefore, we consider a substance as a heap of atoms or molecules.

Remember two important formulae for calculating number of moles

1. Number of moles= Mass of substance/ molar mass

2. Number of moles= Number of particles/ Avogadro number

Recap how mole, Avogadro number and mass are related to each other.



Introduction

- As we all know that atom is the structural and basic building block of matter. Different kinds of matter exist because there are different kinds of atoms present in them.
- John Dalton considered atom to be an indivisible entity, but his concept had to be discarded at the end of nineteenth century, when scientists through experiments were able to find existence of charged (electrons and protons) and neutral particles (neutrons) in the atom. These particles were called the '**Sub-atomic Particles**'.

Charged particles in matter

- Whenever we rub two objects together, they become electrically charged. This is because atoms contain charged particles in them. Therefore, atoms can be divided further into particles i.e proton, electron and neutron.

Discovery of Electrons

- J.J Thomson** explained presence of electrons by cathode rays tube experiment.
- Important facts about electron-
 - Charge on electron = $-1.6 \times 10^{-19} \text{ C}$ (C = Coulomb) (As calculated by Robert E. Millikan)
 - Mass of electron = $9.1 \times 10^{-31} \text{ kg}$

Discovery of Protons

- Ernest Rutherford is credited with discovering the nucleus through the gold foil experiment and later identifying protons within the nucleus. However, the detection of positive particles (canal rays) earlier hinted at the existence of protons, which is attributed to E. Goldstein. Rutherford's work established them as fundamental particles of the nucleus.
- Facts about Protons
 - Charge on Proton = $+1.6 \times 10^{-19} \text{ C}$
 - Mass of proton = $1.673 \times 10^{-24} \text{ gm}$
i.e., Mass of proton $\cong 1840 \times$ Mass of electron

Discovery of Neutrons

- J. Chadwick** bombarded lighter elements (like lithium, boron etc.) with α -particles and observed

emission of new particles having zero charge but having mass equal to that of proton.

- These particles were called 'Neutron' i.e., neutral particle of the atom.
- Neutrons are absent in Protium isotope of hydrogen atom ($^1\text{H}^1$)
- Since, mass of electrons are negligible as compared to that of proton and neutrons hence, sum of masses of protons and neutrons in an atom will compose its atomic mass.
- Atoms consist of protons and electrons in a balanced proportion.
- Protons exist in the interiors of the atom and electrons exist in the exteriors of the atom. Therefore, electrons can be removed from an atom.

Comparison of Subatomic particles

Particle	Who Discovered	Location	Charge (C)	Mass (g)	Mass (amu)
Proton	Goldstein	Inside nucleus	$1.602 \times 10^{-19} \text{ C}$	1.67262×10^{-24}	1.00727
Neutron	James Chadwick	Inside Nucleus	0	1.67262×10^{-24}	1.00866
Electron	J.J. Thomson	Outside nucleus	$-1.602 \times 10^{-19} \text{ C}$	$9.1093837 \times 10^{-28}$	0.00055

Failure of Daltons Atomic Theory

The postulates of the atomic theory by **John Dalton**

- The matter is made up of tiny particles called Atoms that cannot be divided.
- Atoms are never formed or destroyed during a chemical reaction.
- Atoms of an element exhibit same nature. They have the same size, mass, and character.
- Atoms of different elements exhibit variant nature. They do not have same characteristics.
- Atoms form compounds by combining in a ratio of whole numbers.
- A compound contains a constant number and kinds of atoms

So Dalton suggested that the atom was indivisible and indestructible, but the discovery of two fundamental particles (electrons and protons) inside the atom, led to the failure of this aspect of Dalton's atomic theory. It was then considered necessary to know how electrons and protons are arranged within an atom. For explaining this, many scientists proposed various atomic models. **J.J. Thomson** was

the first one to propose a model for the structure of an atom.

Various Atomic models

From the knowledge of existence of subatomic particles like electron, proton and neutron in an atom, various atomic models were proposed by different scientists.

Some of the atomic models are

1. Thomson's Model of Atom
2. Rutherford's Model of Atom
3. Bohr's Model of Atom

Note- the most trusted and scientifically established model of atom which is adopted these days is '**Quantum Mechanical Model of Atom**'.

Let's explain each in short.

1. Thomson's Atomic Model

- Thomson proposed the model of an atom to be similar to that of a Christmas pudding. The electrons, in a sphere of positive charge, were like currants (dry fruits) in a spherical Christmas pudding.
- We can also think of a watermelon, the positive charge in the atom is spread all over like the red edible part of the watermelon, while the electrons are studded in the positively charged sphere, like the seeds in the watermelon.

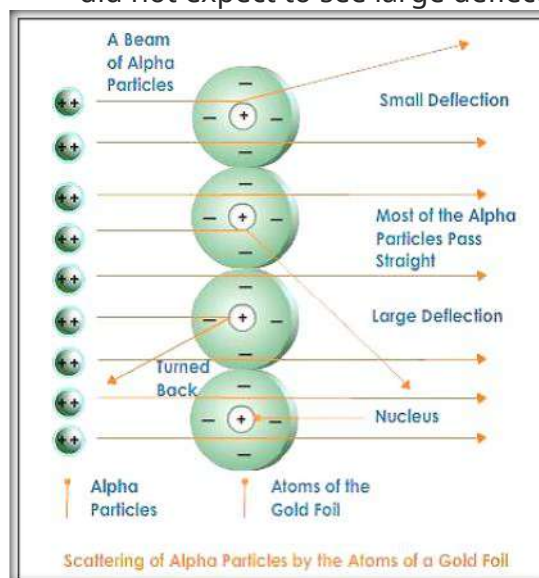
Thomson Proposed that-

- An atom consists of a positively charged sphere and the electrons are embedded in it.
- The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically neutral.

2. Rutherford's Model of an Atom

- Ernest Rutherford was interested in knowing how the electrons are arranged within an atom.
- Rutherford designed an experiment for this. In this experiment, fast moving alpha (α)-particles were made to fall on a thin gold foil.
 - He selected a gold foil because he wanted as thin a layer as possible. This gold foil was about 1000 atoms thick.

- α -particles are doubly-charged helium ions. Since they have a mass of 4 u, the fast-moving α -particles have a considerable amount of energy.
- It was expected that α -particles would be deflected by the sub-atomic particles in the gold atoms. Since the α -particles were much heavier than the protons, he did not expect to see large deflections.



Observations of Rutherford's experiment

- Most of the fast moving α -particles passed straight through the gold foil.
- Some of the α -particles were deflected by the foil by small angles.
- Surprisingly one out of every 12000 particles appeared to rebound.

Conclusions of Rutherford's α -particle scattering experiment

- Most of the space inside the atom is empty because most of the α -particles passed through the gold foil without getting deflected.
- Very few particles were deflected from their path, indicating that the positive charge of the atom occupies very little space.
- A very small fraction of α -particles were deflected by 180 degree, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

Note- From the data collected in above experiment Rutherford also calculated that the radius of the nucleus is about 10^5 times less than the radius of the atom.

On the basis of his experiment, Rutherford put forward the nuclear model of an atom, which had the following features:

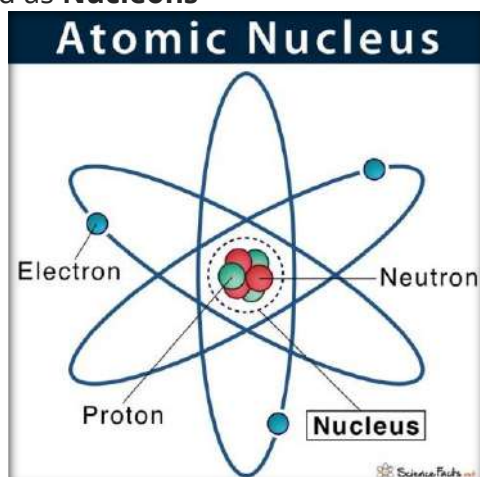
- There is a positively charged centre in an atom called the nucleus. Nearly all the mass of an atom resides in the nucleus.
- The electrons revolve around the nucleus in circular paths.
- The size of the nucleus is very small as compared to the size of the atom.

Drawbacks of Rutherford's Model of the Atom

- Rutherford's atomic model failed to explain the stability of electrons in a circular path. He stated that electrons revolve around the nucleus in a circular path, but particles in motion would undergo acceleration and cause energy radiation.
- Eventually, electrons should lose energy and fall into the nucleus. But it never happens.

The Nucleus of an Atom

- The nucleus is located at the center of the atom.
- All the mass of the atom is because of the nucleus.
- The electrons revolve around the nucleus in circular parts which are called Orbits
- If we compare the size of the atom and nucleus, the nucleus is much smaller than the atom.
- Nucleons- Protons and Neutrons are collectively called as **Nucleons**



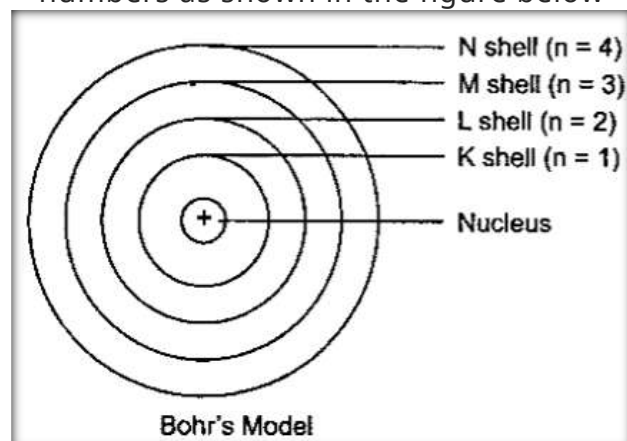
Drawbacks of the Nuclear Model of an Atom

- The Nuclear Model of the Atom failed to explain how an atom remains stable despite having positive and negative charges present in it.
- **Maxwell** has suggested a theory according to which if any charged particle moves in a circular motion it radiates energy. So, if electrons start moving in a circular motion around the nucleus they would also radiate some energy which would decrease at the speed of the electrons.
- As a result, they would fall into the nucleus because of its high positive charge.

3. Bohr's Model of an Atom

In order to overcome the objections raised against Rutherford's model of the atom, Neils Bohr put forward the following postulates about the model of an atom:

- Only certain special orbits known as discrete orbits of electrons, are allowed inside the atom.
- While revolving in discrete orbits the electrons do not radiate energy.
- These **orbits or shells** are called **energy levels**.
- They are represented using letters or numbers as shown in the figure below -



Neutrons

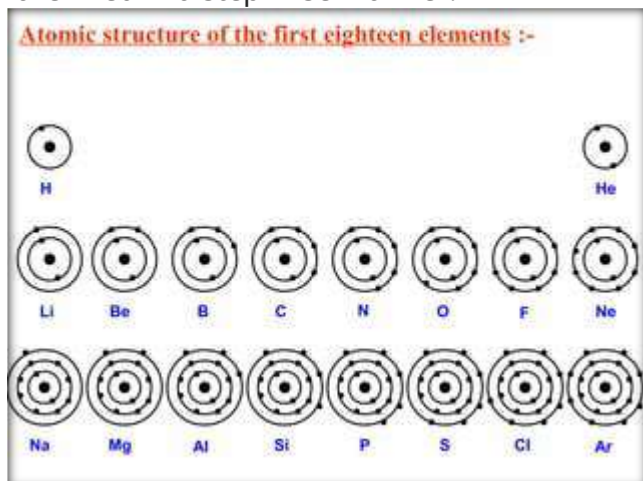
In 1932, **J. Chadwick** discovered another subatomic particle which had no charge and a mass nearly equal to that of a proton. It was eventually named as **neutron**. Neutrons are present in the nucleus of all atoms, except hydrogen. In general, a neutron is represented as 'n'. The mass of an atom is therefore given by the sum of the masses of protons and neutrons present in the nucleus

Distribution of electrons in various shells

The distribution of the electrons in various shells is done in accordance to Bohr- Bury Scheme.

Bohr-Bury Scheme

- The filling of electrons in an atom is done in accordance to ' $2n^2$ ', where ' n ' is the number of shell and ' $2n^2$ ' represents the total number of electrons that can be accommodated in that particular shell.
- Maximum number of electrons that can be filled in a particular shell is as follows-
 - If $n = 1$, i.e., K = shell, $2n^2 = 2 \times 1^2 = 2$ electrons
 - If $n = 2$, i.e., L = shell, $2n^2 = 2 \times 2^2 = 8$ electrons
 - If $n = 3$, i.e., M = shell, $2n^2 = 2 \times 3^2 = 18$ electrons
 - If $n = 4$, i.e., N = shell, $2n^2 = 2 \times 4^2 = 32$ electrons
- Here from the above calculations they concluded that the outermost shell have a limited vacancy for accumulation. Here first shell can hold only 2 electrons, second shell cannot hold more than 8 electrons and similarly thirds and fourth have a capacity of 18 and 32 respectively.
- The maximum number of electrons that can be accommodated in the outermost orbit is 8.
- Electrons are not accommodated in a given shell, unless the inner shells are filled. That is, the shells are filled in a step-wise manner.



Valence shell and Valence Electron

- From Bohr-Bury sequence, we know that maximum number of electrons which can be accommodated in outermost shell is 8.
- Every element has an urge to have 8 electrons in its outermost shell, in achieving 8 electrons an atom can either gain electrons or lose electrons.
- The electrons present in the outermost shell of an atom are called its valence electrons." The

number of electrons lost, gained, or shared is related to its valency.

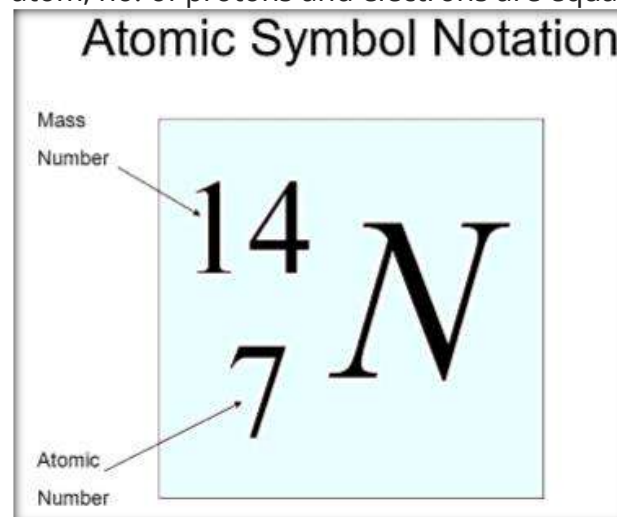
- For elements like H, Li, Be and B, these elements lose their outermost electron to achieve 2 electrons in their outermost shell. These elements will have valency in accordance to this act.
- The atoms which have completely filled the outermost shell are not very active chemically.
- The valency of an atom or the combining capacity of an atom is related to the number of valence electrons and the number of electrons an atom needs to lose, gain, or share to achieve a stable electron configuration.

What happens when the outermost shell contains a number of electrons that are close to its maximum capacity?

Valency in such cases is generated by subtracting the number of electrons present in the outermost orbit from octet (8). For example, oxygen contains 6 electrons in its outermost shell. Its valency is calculated as: $8 - 6 = 2$. This means oxygen needs two electrons to form a bond with another element.

What is atomic Number?

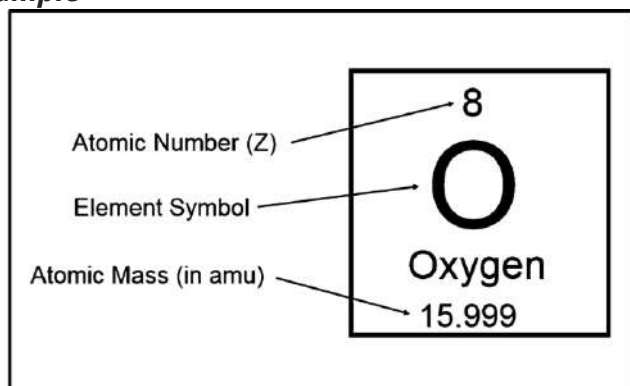
- The total number of proton lying in the nucleus of any atom is called the atomic number.
- An atomic number is the identity of an atom, changing atomic number means changing the atom.
- Atomic number is denoted by ' Z '.
- Atomic number = no. of protons or a neutral atom, no. of protons and electrons are equal.



What is Mass number of element?

- It is a sum of total number of protons and no. of neutrons lying in the nucleus of an atom.
- It is denoted by Letter A
- A = no. of protons + no. of neutrons

Example-



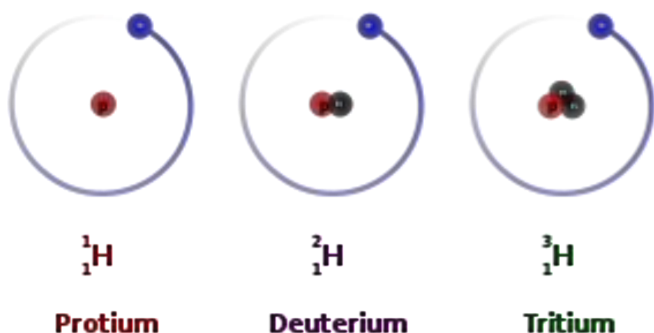
Representation of the Elements/atoms

- ${}_Z E^A$ or ${}^A_Z E$ (E = symbol of an element)
- Here the atomic number is represented by the letter Z, mass number by A and element by E.

What is Isotope?

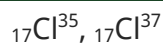
- In nature, a number of atoms of some elements have been identified, which have **the same atomic number but different mass numbers**. Such atoms of elements are known as Isotopes.
- Isotopes are pure substances.
- Isotopes have a similar chemical nature.
- Isotopes have distinct physical characteristics.

Examples of Isotopes



Here you will see the protium, deuterium and tritium are different due to mass number, but they have same atomic number as 1 and mass number are 1, 2, and 3 respectively.

- Chlorine has two isotopes of mass numbers 35 and 37 respectively.



Uses of Isotopes

- The isotope of Uranium is used in Nuclear reactor as fuel.
- Isotope of Cobalt is used in treatment of Cancer.
- Isotope of Iodine is used in treatment of Goiter.

Let's understand this concept by illustration

Example- Consider two atomic species namely U and V. Are they isotopes?

	U	V
Protons	5	5
Neutrons	5	6
Mass Number	5+5= 10	5+6=11
Atomic Number	5	5

From the above example, we can infer that U and V are isotopes because their atomic number is the same.

What are Isobars?

- Isobars are the atoms of those elements which have the **same mass number but different atomic numbers are called isobars**.
- ${}_{20}\text{Ca}^{40}$ and ${}_{18}\text{Ar}^{40}$ have same mass number and different atomic number.
- ${}_{11}\text{Na}^{24}$ and ${}_{12}\text{Mg}^{24}$ are another example of Isobar.

Isobars	Atomic Number (Z)	Mass Number (A)	Electrons (e)	Protons (P)	Neutrons (n)
${}_{18}\text{Ar}^{40}$	18	40	18	18	22 (40-18)
${}_{19}\text{K}^{40}$	19	40	19	19	21 (40-19)
${}_{20}\text{Ca}^{40}$	20	40	20	20	20 (40-20)

- Placing similar groups and species together is known as Classification. Classification is needed to easily understand the properties of different elements in a periodic table. Elements with similar properties are placed in one group to understand them easily.
- Matter around us is present in the form of elements, compounds and mixtures.
- Elements are the substances which contain atoms and these are of only one type.
- There are 118 elements known to us till now. All of these have different properties.

What is Periodic table?

The periodic table is a tabular method of displaying the elements in such a way, that the elements having similar properties occur in the same vertical column or group".

Earlier attempts of the classification of elements-

i. Dobereiner's Triads

ii. Newlands laws of Octaves

Let's explain this in details

i. Dobereiner's Triads

- This classification is based on the **atomic mass**.
- According to this, when elements are arranged in order of increasing atomic masses, groups of three elements, having similar properties are obtained.
- The atomic mass of middle element of the triad being nearly equal to the average of the atomic masses of the other two elements.
- For Example **Li (6.9), Na (23), K (39)**. The arithmetic mean of 7 and 39 gives 23. But disadvantage is the presence of only few triads.

Elements	Atomic mass	Average	Density	Average
Cl	35.5		1.56	
Br	79.9	81.2	3.12	3.25
I	126.9		4.95	
Ca	40.1		1.55	
Sr	87.6	88.7	2.6	2.53
Ba	137.3		3.5	

Limitation of Dobereiner Triads-

- It fails to arrange all the known elements in the form of triads, even having similar properties.
- Only three triads were recognized from the elements known at that time.

(i) **Li, Na, K** (ii) **Ca, Sr, Ba** (iii) **Cl, Br, I**

ii. Newlands Laws of Octaves

- According to this 'when elements are placed in order of **increasing atomic masses**, the physical and chemical properties of **every 8th element** are a repetition of the properties of the first element.'
- He compared this to the octaves found in music and called it the '**Law of Octaves**'. For example, the properties of lithium (Li) and sodium (Na) were found to be the same.

sa (do)	re (re)	ga (mi)	ma (fa)	pa (so)	da (la)	ni (ti)
H	Li	Be	B	C	N	O
F	Na	Mg	Al	Si	P	S
Cl	K	Ca	Cr	Ti	Mn	Fe
Co and Ni	Cu	Zn	Y	In	As	Se
Br	Rb	Sr	Ce and La	Zr	—	—

Limitations of the Newland's Law of Octave

- Law of octaves was applicable only upto calcium (only for lighter elements).
- For example, he placed cobalt (Co) and nickel (Ni) together in the same slot, and in a position in the table corresponding to elements like fluorine, chlorine, bromine, and iodine, despite having very different properties.
- According to Newland, only 56 elements existed in nature and no more elements would be discovered in future.

Present Attempts for the classification of elements

- Mendeleev's Periodic Table
- The Modern Periodic Table

Let's explain each in details

1. Mendeleev's Periodic Table

- Mendeleev's periodic table is based on the physical and chemical properties of elements and their atomic masses.
- According to this "The physical and chemical properties of the elements are the periodic

function of their atomic masses.”(**Mendeleev's Periodic Law**)

- When elements are arranged in the order of increasing atomic masses, the element with similar properties occur at regular intervals. It is also called as **Periodicity of Properties**.
- So Mendeleev's Periodic table is based on the physical and chemical properties of elements, arranged primarily by increasing atomic mass.
- It contains 6 Periods (Horizontal rows) and 8 groups (vertical columns)

Periodic Table of Elements
based on Mendeleev's Periodic Law

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Merits of the Periodic table

- Mendeleev's left vacant places in his table which provided an idea for the discovery of new elements. Example: Eka-boron, Eka-aluminium and Eka-silicon.
- Mendeleev's periodic table was predicted properties of several undiscovered elements on the basis of their position in Mendeleev's periodic table.
- It is useful in correcting the doubtful atomic masses of some elements.
- Noble gases could accommodate in the Mendeleev's periodic table without disturbing the periodic table after discovery.

Limitations of Mendeleev's Periodic Table

- No fixed position for hydrogen: No correct position of the hydrogen atom was in Mendeleev's periodic table. Example: Position of hydrogen with alkali metals and halogens.
- No place for isotopes: Position of isotopes were not decided.

Example: Cl-35 and Cl-37.

- Anomalous pairs of elements: In some cases, elements with higher atomic mass were placed before elements with lower atomic mass to maintain chemical periodicity..

Example: Cobalt (Co, 58.9) placed before Nickel (Ni, 58.7)

2. Modern Periodic Table

- In 1913, **Henry Moseley** showed that the atomic number of an element is a more fundamental property than its atomic mass.
- According to modern periodic law, "properties of an element are the periodic function of their increasing atomic number".
- In modern periodic table all the anomalies of Mendeleev's classification disappear.

Explanations of the Anomalies by Modern Periodic Table

- Isotopes are placed at one place in the same group.
- There is no element between hydrogen (atomic number 1) and helium (atomic number 2) because atomic numbers are consecutive whole numbers that increase by exactly one from element to element.
- Atomic number is represented by Z, and it is equal to the number of protons in the nucleus of the atom.
- It also consists of **18 vertical columns known as Groups** and **7 horizontal rows known as Periods**.
- Elements having same number of valence electrons are placed in the same group.
- As we go down in a group, number of shell increases.
- Elements having same number of occupied shells are placed in same period.

- Each period has a new electronic shell getting filled.
- Number of elements placed in a particular period depends on the point how electrons are filled into various shell.
- To find out the number of electrons in a shell, $2n^2$ formula can be used, where n is shell number.
K Shell $n = 1$ or $2n^2 = 2(1)^2 = 2$
L shell $n = 2$ or $2n^2 = 2(2)^2 = 8$
- Valence electron also determines the number of bonds which is formed by an element.

Modern Periodic Law

The physical and chemical properties of the elements are periodic functions of their atomic numbers. Modern Periodic Table:

- The modern periodic table has 18 vertical columns known as Groups and 7 horizontal rows known as Periods.
- According to Modern periodic law, the properties of the elements repeat after certain regular intervals when these elements are arranged in order of their increasing atomic numbers.
- Atoms of different elements with same number of occupied shells are placed in the same period. It means that 1st period contain elements having 1 shell only. In the same manner other periods also having that much number of elements having same number of shells.e.g.

Period	No. of Shell	Table no. elements	Type of period
1 st	1	2	Shortest
2 nd	2	8	Short
3 rd	3	8	Short
4 th	4	18	Long
5 th	5	18	Long
6 th	6	32	Longest
7 th	7	32	Longest and Incomplete.

- **Lanthanide series** - This series consists of the 14 elements, with atomic numbers 58 to 71 having similar properties.
- **Actinide series** - This series consists of the 14 elements, with atomic numbers 90 to 103 having similar properties.

- The columns of the table represent groups, or families of elements. The elements in a group often look and behave similarly, because they have the same number of electrons in their outermost shell as given below -
- On the basis of electron configurations, the periodic table can be divided into 4 blocks namely **s block**, **p block**, **d block** and **f block** that denoting which sublevel is in the process of being filled. Elements in each block also shows some similar properties as given below-

Group number	Group name	Property
Group 1 or 1A	Alkali metals	Forms strong alkalis with water
Group 2 or IIA	Alkaline earth metals	Forms weak alkalis with water
Group 13 or IIIA	Boron Family	Boron is the first member
Group 14 or IVA	Carbon Family	Carbon is the first member
Group 15 or VA	Nitrogen family	Pnictogens- Suffocating gases
Group 16 or VIA	Oxygen Family	Chalcogens- ore or mineral forming
Group 17 or VIIA	Halogen Family	Salt forming elements
Group 18	Zero group	Noble or inert gases with Zero valency.

Periodic table blocks of elements

Periodic table blocks are sets of elements grouped by their valence electron orbitals. The four block names are s-block, p-block, d-block, and f-block. Should a new element be discovered, it will be in g-

block. Each block indicates which electron sublevel is in the process of being filled.

Charles Janet introduced the concept of element blocks as an alternative to element groups (and also envisaged helix and left-step periodic tables).

Periodic Table of the Elements
Orbital Shell Blocks

Periodic table block names

The block names come from the electron azimuthal quantum number values, which represent characteristics of spectroscopic lines: **sharp (0), principal (1), diffuse (2), or fundamental (3)**. G-block gets its name because “g” is the next letter after “f”.

The four periodic table blocks are the basis for the **main group (s- and p-blocks), transition metal (d-block), and inner transition metal (f-block) elements**.

Properties of Periodic table blocks

S-Block

The s-block elements (except for helium) are on the left side of the periodic table.

- With the exception of helium (and possibly hydrogen), all of the s-block elements are metals. The s-block includes the alkali metals and alkaline earth metals.
- S-block elements tend to form soft solids with low melting points.
- With the exception of helium, all s-block elements are electropositive and reactive.

P-Block

The p-block elements are on the right side of the periodic table. They include the last six element groups of the table (except for helium). P-block elements include all of the **non-metals, all of the metalloids, and the post-transition metals**.

- P-block elements can gain, lose, or share their valence electrons.
- Most p-block elements form covalent compounds. The halogens form ionic compounds with s-block elements.

D-Block

D-block elements are the **transition metals (groups 3-12)**.

- D-block elements display properties between those of the highly reactive electropositive s-block elements and the more electronegative p-block elements. This is why they are called “transition” metals.
- These elements are all metals, usually with two or more oxidation states.
- D-block elements tend to have high melting points and boiling points.
- Many of these elements form colored complexes and salts.
- D-block elements tend to be good catalysts.

F-Block

The f-block elements or inner transition metals are the lanthanides and actinides. They are the two rows of elements found below the main body of the periodic table.

- F-block elements display variable oxidation states.
- Most f-block elements have high melting points.
- These elements form colored complexes and salts, but they tend to be paler than those formed by d-block elements.
- Many of the f-block elements (the actinides) are **radioactive**.

G-Block

- The g-block elements will be elements beyond oganesson (element 118). As these elements have not yet been synthesized, their properties have yet to be determined.

Blocks vs Groups and Periods

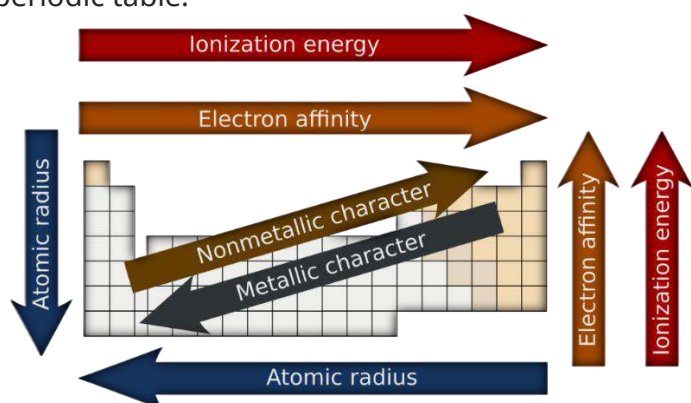
Blocks, groups, and periods are three broad ways of classifying elements based on their position on the periodic table and common properties.

- Blocks indicate which electron sublevel is being filled.

- Groups are the vertical columns on the periodic table. Moving down a group adds a new electron shell. For s-block elements, the group number is the number of valence electrons. For p-block elements, the group number is 10 plus the number of valence electrons. For d-block elements, the group number is generally the sum of the electrons in the outermost s subshell and the (n-1)d subshell.
- Periods are the horizontal rows of the periodic table. The length of a period is determined by the number of electrons needed to fill the electron sublevel.

Periodic trends in Modern periodic table

Periodic trends in modern periodic table: If properties of elements in a period or a group are compared, certain regularity is observed in their variations. It is known as periodic trends in modern periodic table.



1. **Valency:** In groups, there is no change in valency or all elements are having same valency. Across a period it gradually increases and then decreases.
2. **Atomic Radius:** The atomic radius usually increases while going down a group due to the addition of a new electron shell. The atomic radius tends to decrease across a period from left to right due to the shrinking of the atom because effective nuclear charge pulling the valence electrons closer in the same shell.
3. **Metallic and non-metallic properties:** Metallic properties increases in groups as decreasing attraction between the nucleus and the outermost electrons. Across the period, from left to right, increasing attraction between the nucleus and the outermost electrons causes the

metallic character to decrease. Non-metallic property increases across a period (due to increasing effective nuclear charge) and decreases down the group (due to decreasing effective nuclear charge on valence electrons).

4. **Electronegativity:** Electronegativity is the ability of an atom of any element to attract a shared pair of electrons in a chemical bond, towards itself. In groups, the electronegativity decreases, because number of shells increases as we go down in a group, so the pull of the nucleus to attract electrons decreases. In period as we move left to right, electronegativity goes on increasing.
5. **Electron affinity:** Electron affinity of an atom or molecule is defined as the amount of energy released or spent when an electron is added to a neutral atom or molecule in the gaseous state to form a negative ion. Electron affinity decreases down the groups and from right to left across the periods on the periodic table because the electrons are placed in a higher energy level far from the nucleus, thus a decrease from its pull. Electron affinity increases upward for the groups and from left to right across periods of a periodic table because the electrons added to energy levels become closer to the nucleus, thus a stronger attraction between the nucleus and its electrons.

Diagonal relationship: A diagonal relationship is said to exist between certain pairs of diagonally adjacent elements in the second and third periods of the periodic table. Diagonal relationships occur because of the directions in the trends of various properties as you move across or down the periodic table.

	main group				
	1	2	13	14	15
period 2	Li	Be	B	C	N
period 3	Na	Mg	Al	Si	P

Background- most of the changes around us undergoes various changes. Some of these changes are temporary with no new substance being formed. They are called physical changes. In certain other changes the new substance formed in which the reactant or the parent loses its identity to form new substance called product. These changes are permanent changes as we won't get the reactant back

Chemical Reaction

The process in which new substances with new properties are formed from one or more substances is called Chemical Reaction.

Examples- Digestion of food, Respiration, Rusting of iron, Burning of Magnesium ribbon, Formation of curd etc.

Characteristics of a Chemical Reaction

- The product that is formed as new compound with new chemical formula.
- These reactions required splitting and forming of chemical bonds.
- Properties of products formed during a chemical reaction are different from those of the reactants.
- Energy changes are always involved in chemical reactions, and various forms of energy (such as heat, light, or electricity) can be used to carry out chemical changes.

How to identify a chemical reaction?

These factors show that a chemical reaction has taken place-

- Change in state
- Change in colour
- Change in temperature
- Evolution of gas

Reactant- The substances which take part in chemical reaction are called Reactants.

Product- The substances which are formed in a chemical reaction are called Products.

What is chemical Equation?

All chemical reactions are shown by chemical equations. A chemical equation is a shorthand representation of a chemical reaction using the

symbols and formulae of substance involved in the chemical reaction.

Example- $A + B$ is reactant and $C + D$ is a product.

In this equation, A and B are called reactants and C and D are called the products. The arrow shows the direction of the chemical reaction. Condition, if any, is written generally above the arrow.

- A chemical reaction can be represented by chemical equation.
- It involves the use of symbols of elements or chemical formulas for reactants and products, with mention of their physical state.
- The necessary conditions such as temperature, pressure or any catalyst should be written on arrow between reactant and products.

Example- When magnesium ribbon is react with oxygen, it gets converted to magnesium oxide.

The word equation for the above equation would be
 Magnesium + Oxygen $\rightarrow$ Magnesium oxide
 (Reactant) (Product)

Types of Chemical equation

There are two types of chemical equation-

1. Word Equation- A word equation is that equation which links together the names of the reactants and products. For example, the word equation, when sodium metal react with water to give sodium hydroxide and hydrogen gas, it written as:

Sodium + Water $\rightarrow$ Sodium hydroxide + Hydrogen gas

- In a word equation There are certain rules for writing word equation :-
 - On the left hand side the reactants are written with a positive sign (+) is put between them.
 - On the right hand side the products are written with a plus sign (+) is put between them.
 - The direction of the arrow shows the product formation direction.
 - An arrow ($\rightarrow$) is put between the reactants and products.

2. Symbol equation- Symbol equation is short representation of a chemical reaction in terms of

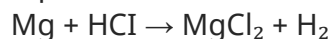
formulae and symbols of the element/substance that are involved in reaction.

- In a symbol equation, the symbols and formulae of the elements and compounds are written in place of their word names.
- For example: - Sodium metal react with Water to give sodium hydroxide and hydrogen gas.
 $\text{Na} + \text{H}_2\text{O} \rightarrow \text{NaOH} + \text{H}_2$

Unbalanced chemical equation/ skeletal equation

In an unbalanced equation, the number of atoms of different elements that are taking part in a chemical reaction on both side of the equation are not equal.

For example- in the equation given below, the number of CL atoms on both sides of the equation and the other number of hydrogen atoms are not equal, it is known as an unbalanced equation

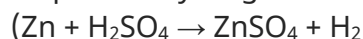


Balanced Chemical Equation

- In a balanced equation, the number of different atoms on both sides of the equation are always equal. The balanced equation when magnesium reacts with HCl is written as :-
 $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$

Significance of Balanced chemical equation- The balancing of a chemical equation is essential or necessary to fulfil the condition of “**Law of conservation of mass**”. (Matter can neither be created nor be destroyed in a chemical reaction.)

Another example is- zinc + Sulphuric acid → Zinc Sulphate+ Hydrogen



Balancing of chemical equation

- The balancing of a chemical equation is done with the help of Hit and Trial method. In this method, the coefficients before the symbols or formulae of the reactants and products are adjusted in such a way that the total no. of atoms of each element on both the side of the arrow are equal.
- "This balancing is also known as mass balancing because when the number of atoms of each element is equal on both sides, their total mass is

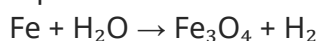
also equal, thus obeying the law of conservation of mass."

Some important steps that are involved in balancing of a chemical equation-

- The chemical equations are written in the form a word equations. Reactants are kept on the left hand side and the products are on the right side. The reactants and products are separated by an arrow.
- Word equation is then converted into the symbol equation with symbols and formulae used for all the reactants and product are written.
- Then the atoms of different elements on both side of the equation are made equal. This is how balancing of equation is done.
- The formulae of the substance while balancing the equation should not be changed.
- Try to make the equations more informative if possible.

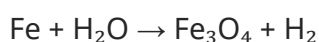
As the number of atoms of each elements is the same on both sides of the arrow and it is a balanced chemical equation-

Let us try to balance the following chemical equation-



Stepwise balancing (Hit and Trial)

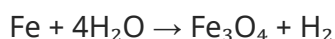
Step 01. Write chemical equation and draw boxes around each formula. Do not change anything inside the box.



Step 02. Count the number of atoms of each element on both the sides of chemical equation.

Elements	No. of atoms at reactant side	No. of atoms at product side
Fe	1	3
H	2	3
O	1	4

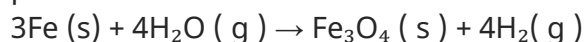
Step 03. Equalise the number of atoms of element which has maximum number by putting in front of it.



Step 04. -Try to equalize all the atoms of elements on reactant and product side by adding coefficient in front of it.

$3\text{Fe} + 4\text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + 4\text{H}_2$ (Now all the atoms of elements are equal on both sides)

Step 05. Write the physical states of reactants and products



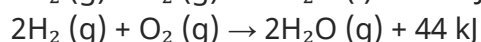
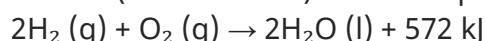
Step 06. Write necessary conditions of temperature, pressure or catalyst on arrow above or below.

Writing State Symbols

- The physical states of the reactant and product species involved in the reaction can be mentioned in the symbol equation to make it more informative, using specific symbols known as state symbols. These symbols are :-
 - (s) For solid state
 - (l) for liquid state
 - (g) for gaseous state
 - (aq) for aqueous solution i.e., solution that prepared in water.
- "A gas evolution is sometimes shown by the symbol ($\uparrow$) next to the substance, indicating a gas escaping. Similarly, the formation of a precipitate is sometimes shown by the symbol ($\downarrow$) next to the substance, indicating a solid settling."

Importance of State Symbols

The state symbols are most important part for those chemical reactions that are either accompanied by the release of heat (exothermic) or by the absorption of heat (endothermic). For example:-



- The above reactions are exothermic as heat is released in these reaction. Thus, actual amounts of heat are different when water is in the liquid state i.e. $\text{H}_2\text{O}(\text{l})$ and when it is in the gaseous state.

Importance of chemical equation

- The weight of reactant or products can be calculated by chemical equation.
- Total weight of reactants is equal to the total weight of products because matter is never destroyed.
- It gives information about the substance that are taking part and formed in the reaction.

- The information about the number of molecules of elements or compounds which are either taking part or formed in the chemical reaction.

Some of limitations of Chemical Equation-

- It does not give information about the physical state of reactants and products unless state symbols are included.
- We does not get information about the reactants and products concentration.
- It does not give information about the speed of reaction and sense of timing. It does not explicitly state the favorable conditions (temperature, catalyst, pressure, etc.) unless they are indicated on the arrow.
- The information whether heat is absorbed or released is not obtained unless the energy change is indicated in the equation..
- The information about the necessary precautions that has to be taken for the completion of reaction is not obtained.

Types of Chemical Reaction-

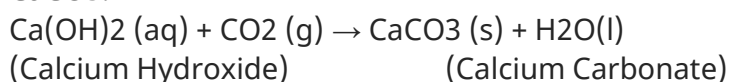
1. Combination Reaction

a reaction in which a single product is formed from two or more reactants is known as a combination reaction.

Examples are-

- Calcium oxide reacts vigorously with water to produce slaked lime (Calcium hydroxide) releasing a large amount of heat... (Quick lime)
 $\text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Ca}(\text{OH})_2(\text{aq})$ (Slaked lime)
- Burning of coal :- $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
- Formation of water :- $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$

Note- A solution of slaked lime is used for whitewashing walls. Calcium hydroxide reacts slowly with the carbon dioxide in air to form a thin layer of calcium carbonate on the walls. Calcium carbonate is formed after two to three days of whitewashing and gives a shiny finish to the walls. It is interesting to note that the chemical formula for marble is also CaCO_3 .



2. Exothermic reactions

- Reaction in which heat is released along with formation of products. Example :-

- Burning of natural gas :- $\text{CH}_4(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) + \text{Heat}$
- Respiration is also an exothermic reaction :- $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + \text{energy}$
- The decomposition of vegetable matter into compost is also an example of an exothermic reaction.

3. Decomposition Reaction

- The reaction in which a compound splits into two or more simple substances is called decomposition reaction. ($\text{A} \rightarrow \text{B} + \text{C}$)
- Example is- $2\text{FeSO}_4(\text{s}) \xrightarrow{\text{Heat}} \text{Fe}_2\text{O}_3(\text{s}) + \text{SO}_2(\text{g}) + \text{SO}_3(\text{g})$
- In above reaction the reactant is broken down into three product. Ferrous sulphate crystals ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) lose water when heated and the colour of the crystals changes. It then decomposes to ferric oxide (Fe_2O_3), sulphur dioxide (SO_2) and sulphur trioxide (SO_3). Ferric oxide is a solid, while SO_2 and SO_3 are gases.
- Another example is Decomposition of calcium carbonate to calcium oxide and carbon dioxide on heating is an important decomposition reaction used in various industries. Calcium oxide is called lime or quick lime. It has many uses – one is in the manufacture of cement. When a decomposition reaction is carried out by heating, it is called **thermal decomposition**.
 $\text{CaCO}_3(\text{s}) \xrightarrow{\text{Heat}} \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

• Types of Decomposition Reaction

- **Thermal decomposition-** When decomposition is carried out by heating.
- **Electrolytic Decomposition:** - When decomposition is carried out by passing electricity.
- **Photolytic decomposition-** When decomposition is carried out presence of sunlight.
- The decomposition reactions are mostly endothermic in nature. Energy in the form of heat, light or electricity is generally absorbed in these reactions.

4. Endothermic reaction

- The reactions **which require energy in the form of heat, light or electricity** to break reactants are called endothermic reactions.

5. Displacement reaction

- The chemical reaction in which more reactive element displaces less reactive element from its salt solution.
- $\text{Fe}(\text{s}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{FeSO}_4(\text{aq}) + \text{Cu}(\text{s})$
- The iron nail becomes brownish in colour by deposition of Cu and blue CuSO_4 changes to dirty green colour due to formation of FeSO_4 .
 $\text{Zn} + \text{CuSO}_4 \rightarrow \text{ZnSO}_4 + \text{Cu}$

6. Double Displacement reaction

- A reaction in which new compounds are formed by mutual exchange of ion between reactants are called double displacement reaction.
- Example- $\text{Na}_2\text{SO}_4(\text{aq})$ (Sodium sulphate) + $\text{BaCl}_2(\text{aq})$ (Barium chloride) $\rightarrow \text{BaSO}_4(\text{s})$ (Barium sulphate) + $2\text{NaCl}(\text{aq})$ (Sodium chloride)
- White precipitation of BaSO_4 is formed, so it is also called **precipitation reaction**. (All double displacement reaction are not precipitation reaction).

Oxidation

It is a chemical reaction in which a **substance gains oxygen or loses hydrogen**. As O is an electronegative element and H, is an electropositive element. Thus, oxidation is defined as a reaction in which a substance gains an electronegative ion or loses an electropositive ion.

Reduction

The chemical reaction in which there is a **gain of hydrogen or any electropositive ion or a loss of oxygen or electronegative ion**.

Redox Reaction

The oxidation and reduction occur simultaneously, i.e. there can be no oxidation without and equivalent reduction. In a reaction when one substance is oxidised the other is reduced and vice-versa. Those reactions in which oxidation and reduction take place simultaneously are known as redox reactions.

- **Reducing Agent-** A substance that brings about reduction is known as a reducing agent.
- **Oxidizing Agent-** A substance, which brings about oxidation, is known as an oxidizing agent.

Day today example of Oxidation

1. Corrosion- When a metal is exposed to moisture, air, acid etc. for some time, a layer of hydrated oxide is formed which weakens the metal and hence metal is said to be corroded.

Example- rusting of iron, black coating on silver and green coating on copper are examples of corrosion.

- Measures to prevent erosion- corrosion can be prevented by galvanization, electroplating or by putting paints.

2. Rancidity- the oxidation of fats and oils when exposed to air known as rancidity. It leads to bad smell and bad taste of food.

• **Methods to prevent Rancidity-**

- **By adding antioxidants:** - Manufacturer sometimes add certain food additives to the food materials. These are known as antioxidants and check/inhibit oxidation.
- **Keeping food in air tight containers:** - Food should be kept in air tight containers to prevent its oxidation.
- **Refrigeration:** - Refrigeration of food also retards rancidity as the temperature inside refrigerator is very low and direct contact with air or oxygen is avoided.
- **Replacing air by nitrogen:-** Chips manufacturers usually fill their bags with nitrogen gas (as it is an unreactive gas) before packing so that they may not be oxidised.

As we all know that the taste of the food is due to the presence of acids and bases in them.

Acids

- The term 'acid' has been derived from the Latin word, *acidus*, which means sour.
- Acids are those chemical substances which have a sour taste and turn blue litmus solution red.
- According to Arrhenius concept, substances that **furnish H^+ ions** in an aqueous solution are called acids. Example :- $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$

Some of the notable properties of acids

Physical Properties-

- Sour in taste.
- Change the colour of blue litmus to red.
- Acid solution conducts electricity.
- Give H^+ ions in aqueous solution.

Chemical properties-

- Reacts with metals to liberate hydrogen.
- Reacts with metal carbonates/metal hydrogen carbonate to liberate CO_2
- Reacts with certain metal oxides to form salt and water.

Natural Sources of Acid-

Substance that contain acids	acid present in them
Orange, lemon	Citric acid, ascorbic acid (vitamin C)
Apple	Malic acid
Tamarind (imli), Grape	Tartaric acid
Olive oil	Oleic acid
Vinegar	Acetic acid
Curd (Sour Milk)	Lactic acid
Urine	Uric acid
Tomato	Oxalic acid
Tea	Tannic acid
Red Ant	Formic acid
Green Leafy Vegetables	Folic acid
Gastric Juice	Hydrochloric acid
Amla	Ascorbic acid
Spinach	Oxalic acid
Bees and nettle sting	Formic acid
Rancid Butter	Butyric acid

Types of Acids

On the basis of their source/ occurrence acids are of two types

- Mineral acids-** these are obtained from rocks and minerals are known as mineral acids. E.g. HCl , HNO_3

Some of the commonly used mineral acid along their uses are given below as-

Name	Types of acids	Chemical formula	Uses
Hydrochloric acid	Mineral Acid	HCl	Purification of $NaCl$ to make aqua regia mixture of HCl and HNO_3 in ratio of 3 : 1, bleaching agent
Phosphoric acid	Mineral Acid	H_3PO_4	In fertilizers and in antirust paints.
Carbonic acid	Mineral Acid	H_2CO_3	Used in tanning industry, in soft drinks etc.
Sulphuric acid	Mineral Acid	H_2SO_4	Used in car batteries, in paints, plastics, drugs, in petroleum refining.
Nitric acid	Mineral Acid	HNO_3	Used in explosives manufacture like TNT and fertilizers, refining of gold and silver.

- Organic acids-** Acids that are present in animals and plants are called as organic acids. e.g., Lactic acid, Formic acid.

Some of the commonly used organic acids along their chemical formula with their uses are given as-

Name	Type of acid	Chemical Formula	Uses
Lactic acid	Organic Acid	$\text{CH}_3\text{CH}(\text{OH})\text{COOH}$	Flavouring agent and food preservative.
Benzoic acid	Organic Acid	$\text{C}_6\text{H}_5\text{COOH}$	Flavouring agent and food preservative (e.g., in pickles)
Acetic acid	Organic Acid	CH_3COOH	Used as a solvent in the manufacture of dyes and perfumes, in vinegar, production of plastics.
Formic acid	Organic Acid	HCOOH	In tanning leather, in medicines for treating disease like gout of joints.
Citric Acid	Organic Acid	$\text{C}_6\text{H}_8\text{O}_7$	Flavouring and preserving agent in soft drink and toffees.

What is strong and Weak Acids?

- **Strong Acids**-These acids ionise more or less completely when dissolved in water, e.g., sulphuric acid (H_2SO_4), nitric acid (HNO_3) and hydrochloric acid (HCl).
- **Weak Acids**- These acids ionise to a small extent when dissolved in water, e.g., acetic acid (CH_3COOH), formic acid (HCOOH) and carbonic acid (H_2CO_3).

Concentrated and Dilute Acids

- **Concentrated Acids**- More amount of acid is present and less amount of water is present.
- **Dilute acids**- More amount of water is present and less amount of acid is present.

Litmus test of Acids- Blue litmus paper turns into red.

What are Indicators?

Indicators are the substances that change their colour or odour when added into an acid or alkaline solution.

Classification of Indicators-

Indicators can be classified as natural, synthetic indicators, olfactory indicators and universal indicators.

1. Natural Indicators- These indicators are found in nature in the plants. E.g. Litmus solution is a purple colour dye extracted from the lichen plant.

- **Litmus**- It is a natural dye made from small plants called lichens (a plant belong to division Thallophyta). Litmus solution is a purple dye that is used as an indicator. Blue and red litmus solutions are prepared from two different varieties of lichens.
- **Litmus Paper**- Blue or red litmus paper is made by dipping a strip of filter paper in blue or red litmus solutions. The paper is then removed from the solution and then dried up. Blue litmus paper will turn red in an acidic solution and red litmus paper will turn blue in a basic solution.

2. Synthetic Indicators- The indicators which are synthesised in the laboratory or industry are known as synthetic indicators. e.g. Methyl orange, phenolphthalein.

- **Methyl orange**- Solid methyl orange in very little amount is dissolved in hot water and then filtered. The filtrate is used as methyl orange that will turn red in acidic solutions and yellow in basic solutions
- **Phenolphthalein**- An alcoholic solution of phenolphthalein is used as an indicator. It became colourless in an acidic solution, but it will become pink (red) in basic solution.

3. Olfactory Indicators- Those substances whose odour changes in acidic or basic medium are called olfactory indicators. e.g. Vanilla extract and onion.

4. Universal Indicators-To judge how strong a given acid or base is, a universal indicator is used which is a mixture of several indicators. It shows

different colours at different concentrations of hydrogen ion in a solution.

Chemical Properties of Acids-

- **Reaction with Metals:** - Dilute acids (e.g. HCl and H_2SO_4 not HNO_3) react with certain active metals like zinc (Zn), iron (Fe), etc., to evolve H_2 gas.
e.g. :- $\text{Zn(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{H}_2(\text{g})$
- **Reaction with Metal Oxides :-** Acids react with certain metal oxides (basic oxides) to form salt and water.
e.g :- $\text{CaO(s)} + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O(l)}$
- **Reaction with Metal Carbonate and Hydrogen Carbonate :-** Acids react with metal carbonates and hydrogen carbonates to produce carbon dioxide gas.
e.g :-
 $\text{CaCO}_3(\text{s}) + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O(l)} + \text{CO}_2(\text{g})$
 $\text{NaHCO}_3(\text{s}) + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)} + \text{CO}_2(\text{g})$

Bases –

Substances that furnish **hydroxide ions (OH^-)** in aqueous solution are called bases. e.g.

- Bases are chemical compounds which have bitter taste, are soapy and slippery to touch, and turn red litmus solution blue, e.g., sodium hydroxide, potassium hydroxide, aluminium hydroxide, etc.

Properties of bases

Physical properties-

- Bitter in taste
- Turn red litmus blue
- Give OH^- ions in aqueous solution
- Conduct electricity in aqueous solution

Chemical Properties of Bases-

- Alkali reacts with metal to liberate H_2
- Bases react with acidic oxides to form salt and water.

Types of Bases-

- **Strong Bases-** The substances/bases which ionise completely to furnish OH^- ions are called strong bases. E.g. KOH (caustic potash).

- **Weak bases-** The bases which ionise only partially are called weak bases. E.g. Calcium hydroxide [Ca(OH)_2].
- **Alkali water-** soluble base is called alkali. E.g. NaOH. All alkalis are base, but all base are not alkalis.

Chemical Properties of Bases-

- **Reaction with Metals:** - Strong bases react with active metals to produce hydrogen gas. e.g. :-
 $\text{Zn(s)} + 2\text{NaOH(aq)} \rightarrow \text{Na}_2\text{ZnO}_2(\text{aq}) + \text{H}_2(\text{g})$
- **Reaction with Non-metallic Oxide:** - Bases react with non-metallic oxides (acidic oxides) to produce salt and water. This reaction proves that non-metallic oxides are acidic in nature. e.g. :-
 $\text{CO}_2(\text{g}) + \text{Ca(OH)}_2(\text{aq}) \rightarrow \text{CaCO}_3(\text{s}) + \text{H}_2\text{O(l)}$
- **Reaction between Acids and Bases:** - Acids react with bases to produce salt and water. In this reaction, acid neutralises a base, i.e. reduce its effect or vice-versa, thus the reaction is known as neutralisation reaction.
 - In general, neutralisation reaction can be written as $\text{Base} + \text{Acid} \rightarrow \text{Salt} + \text{Water}$
 - e.g. :- $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$

Common between acid and Bases-

- All acids have H^+ ions in common.
- Acids produce H^+ ions in solution which are responsible for their acidic properties.
- All bases have OH^- (hydroxyl ions) in common.

Strength of Acid or Bases-

- Strength of an acid or base depends on the number of H^+ ions or OH^- ions produced by them respectively.
- Larger the number of H^+ ions produced by an acid, stronger is the acid. Similarly, larger the number of the OH^- ions produced by a base, stronger is the base.

PH Scale

- A scale that is used measuring the strength of acids and bases in a solution is known pH scale. It has been developed by S.P.L. Sorensen. The P in pH stands for '**potenz**' in German meaning power and 'H' stands for **hydrogen ions**.

- The acidity or basicity of a solution is usually expressed in terms of a function of the H^+ ion concentration. This function is called the pH of a solution.
 - PH should be thought of simply as a number that indicates the acidic or basic strength of solution.
 - On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline).
 - Higher the H^+ ion concentration, Lower will be value of the pH scale
 - The pH of an aqueous solution is the negative logarithm of its H ion concentration. That is,
 - $pH = -\log [H^+]$.
 - $pOH = -\log [OH^-]$

Characteristics of PH scale

- For acidic solution, $pH < 7$
- For alkaline solution, $pH > 7$
- neutral solution, $pH = 7$

Importance of PH in everyday

- **Plants and animals are pH sensitive:** -
 - Our body works within the pH range of 7-7.8.
 - When pH of rain water is less than 5.6, it is called acid rain.
- **PH of the soil:** - Plants require a specific pH range for their healthy growth.
- **pH in our digestive system :-**
 - Our stomach produces HCl acid which helps in digestion.
 - During indigestion, stomach produces more acid and cause pain and irritation.
 - To get rid of this pain, people uses antacid (mild base) like milk of magnesia $[Mg(OH)_2]$ to neutralize excess acid.
- **PH change as cause of tooth decay:** -
 - Tooth decay starts when pH of mouth is lower than 5.5.
 - **Tooth enamel** made up of calcium phosphate (**hardest substance in body**) does not dissolve in water but corrodes when pH is lower than 5.5 due to acids produced by degradation of food particles by bacteria.
 - Using toothpaste (generally basic) tooth decay can be prevented.
- **Self-defence by animals and plants through chemical warfare :-**

- Bee sting leaves an acid which cause pain and irritation. Use of a mild base like baking soda on stung area gives relief.
- Stinging hair of nettle leaves inject methanoic acid causing burning Sensation or pain. Rubbing with leaf of dock plant give relief.

Salt-

- A salt is a compound that is formed by the reaction of an acid with a base in which the hydrogen of the acid is replaced by the metal.
- $H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$
- This type of reaction is known as neutralisation reaction.

There are various types of Salts

- 1. Normal salt-** A salt which does not contain any replaceable H atoms or hydroxyl groups
Examples: - $CaSO_4$, K_3PO_4 , Na_2SO_4
- 2. Acidic salt:** - When a polybasic acid is not completely neutralized by a base, the salt formed will contain replaceable H atoms. A salt that contains replaceable hydrogen atoms is called an acidic salt.
 - $H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$
 - $NaHSO_4 + NaOH \rightarrow Na_2SO_4 + H_2O$
 - $NaHSO_4$, $KHCO_3$ and KH_2PO_4 , are examples of acidic salts.
- 3. Basic Salt-** When these salts are the product of incomplete neutralization of strong base and weak acid, the salt produced contain hydroxyl group(s) (OH) also. Such a salt is known a basic salt. Example :- $2PbCO_3.Pb(OH)_2$, $Br(OH)_2NO_3$
 - $Bi(OH)_3 + HNO_3 \rightarrow Bi(OH)_2NO_3 + H_2O$
- 4. Double Salt-** In a double salt, there are two different negative ions and/or positive ions are present. Example :- Potash alum, $K_2SO_4.Al_2(SO_4)_3.24H_2O$, is a double salt

Classification of Salts Based on PH Values

- 1. Neutral salt solutions:** - Salt solutions of strong acids and strong bases that are neutral in nature and they have pH value equal to 7. They do not change the colour of litmus solution. For **Example:** - $NaCl$, $NaNO_3$, Na_2SO_4 etc.
- 2. Acidic salt solutions:** - It is salt solutions of strong acids and weak bases that are of acidic nature and they have pH value less than 7. They

change the colour of blue litmus solution to red. For **Example :-** $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl etc.

- In both these salts, the base NH_4OH is weak while the acids H_2SO_4 and HCl are strong.

3. Basic salt solutions: - Salt solutions of strong bases and weak acids that are of basic nature and they have pH value more than 7. They change the colour of red litmus solution to blue. For **Example:-** K_3PO_4 , Na_2CO_3 etc.

Sodium Chloride (NaCl) - Common Salt

- Sodium chloride (NaCl) also known as common salt or table salt. It is the most important part of our diet.
- It is produced by the reaction between of sodium hydroxide (NaOH) and hydrochloric acid (HCl) solutions.
- It is separated by some suitable methods.
- Deposits of the salts that are found in different part of the world and is called as rock salt. When salt is pure, it is white in colour & crystalline solid. However, it is often brown in colour due to the presence of impurities in it.

Uses of NaCl

- **Raw material for chemical:** - Sodium chloride is also a very useful raw material for different chemicals. Like for hydrochloric acid (HCl), washing soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$), baking soda (NaHCO_3).
- **Essential for life:** - Sodium chloride is quite important for life. Biologically, NaCl has a number of functions to perform such as in muscle contraction, in conduction of nerve impulse in the nervous system and it is also converted in HCl that helps in the digestion of food in the stomach

Sodium Hydroxide (NaOH)-

- NaOH is chemically known as **Caustic Soda**. When electricity is passed through an aqueous solution of sodium chloride (called **brine**), it decomposes to form sodium hydroxide. The process is known as the **chlor-alkali** process because of the products formed-chlor for chlorine and alkali for sodium hydroxide.
 - $2\text{NaCl}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \xrightarrow{\text{Electric current}} 2\text{NaOH}(\text{aq}) + \text{Cl}_2(\text{g}) + \text{H}_2(\text{g})$

- Chlorine gas is released at the anode.
- Hydrogen gas is released at the cathode.
- Sodium hydroxide solution is formed near the cathode

Uses

- H_2 : Fuels, margarine
- Cl_2 : Water treatment, PVC, CFC's
- HCl : Cleaning steels, medicines
- NaOH : Degreasing metals, soaps and paper making
- $\text{Cl}_2 + \text{NaOH} \rightarrow \text{Bleach}$: Household bleaches, bleaching fabrics

Chemical from Common Salt-

- Sodium Hydroxide (NaOH)
- Bleaching Powder (CaOCl_2)
- Baking Soda (NaHCO_3)
- Washing Soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$)
- Plaster of Paris ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$)

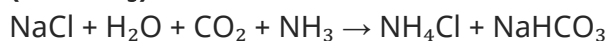
Bleaching Powder (CaOCl_2)-

- It is produced by the action of chlorine on dry slaked lime.
- $\text{Cl}_2 + \text{Ca}(\text{OH})_2 \rightarrow \text{CaOCl}_2 + \text{H}_2\text{O}$

Uses-

- Bleaching cotton and linen in textile industry.
- Bleaching wood pulp in paper factories.
- Oxidizing agent in chemical industries.
- Disinfecting drinking water.

Baking Soda (Sodium Hydrogen Carbonate) (NaHCO_3)-



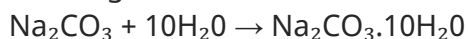
- It is mild non-corrosive base.
- When it is heated during cooking :- $2\text{NaHCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2$

Uses-

- For making baking powder (mixture of baking soda and tartaric acid). When baking powder is heated or mixed with water, CO_2 is produced which causes bread and cake to rise making them soft and spongy.
- An ingredient in antacid.
- Used in soda acids, fire extinguishers.

Washing Soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) :-

- Recrystallization of sodium carbonate gives washing soda. It is a basic salt.



Uses-

- In glass, soap and paper industry.
- Manufacture of borax.
- Cleaning agent for domestic purposes.
- For removing permanent hardness of water.

Plaster of Paris (Calcium sulphate hemihydrates) ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$) :-

- On heating gypsum ($\text{CaSO}_4 \cdot \text{H}_2\text{O}$) at 373K, it loses water molecules and becomes Plaster of Paris (POP). It is a white powder and on mixing with water it changes to **gypsum**. $(\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}) + 1\frac{1}{2}\text{H}_2\text{O} \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}$

Uses:-

- Doctors use POP for supporting fractured bones.
- For making toys, material for decoration.
- For making surfaces smooth.

Water of Crystallisation:

- Certain salts that contain fixed amount of some H_2O molecules loosely attached to their own molecules. They are known **hydrated salts** and they are of crystalline nature. The molecules of H_2O present are called as 'water of crystallisation'.
- Example :-**
 - $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ has 5 water molecules.
 - $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ has 10 water molecules.
 - $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ has 2 water molecules.

Metals and Non-metals are different types of materials present around us. Elements can be divided into metals and non-metals and it is important to know whether a particular element is a metal or non-metal. Metals (like copper and aluminium) are good conductors of heat and electricity, while non-metals (such as phosphorus and sulphur) are insulators. Materials are distinguished as above, based on their properties.

Physical Properties of metals and Non-metals

Elements are classified as metals and non-metals based on different properties. The properties of metals and non-metals are given in the form of the table below-

Physical Properties	Metals	Non-metals
Conductivity	Metals (such as iron or copper) are good conductors of heat and electricity.	Non-metals (such as coal or sulphur) are poor conductors of heat and electricity. Graphite is an exception as it is a good conductor of electricity.
Ductility	Metals (such as aluminium and copper) are ductile, which means that they can be drawn into wires.	Non-metals are brittle (break down when struck) and hence, they cannot be drawn into wires.
Hardness	All metals are hard though there are some exceptions. Sodium and potassium are soft and can be cut with a knife.	Most non-metals are soft. Diamonds are exceptions as they are the hardest material found on Earth. However, they are also very brittle and break when struck with a hammer.
Lustre	Metals (such as gold, silver and copper) are lustrous, which	Non-metals (such as coal) are generally dull and do not reflect

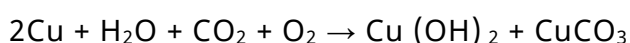
	means that they reflect light from their surface and can be polished.	light. Hence, they lack metallic lustre.
Malleability	Metals (such as silver and aluminium) are malleable, which means that they can be beaten into thin sheets.	Since non-metals break easily, they cannot be pounded into sheets.
Physical State	Most metals remain solid at room temperature, except mercury and gallium which remain liquid at room temperature.	Most non-metals exist in two of the three states of matter at room temperature: Gases (such as oxygen), and Solids (such as carbon).
Sonorous	Metals produce ringing sounds when they are struck and hence, they are sonorous, except Mercury which is liquid in nature.	Non-metals are non-sonorous and do not produce the typical metallic sound when they are struck.
Examples	Iron, copper, aluminium, calcium, magnesium, etc.	Sulphur, carbon, oxygen, phosphorus, etc.

Remember-

Copper Vessels also acquire a dull green coating (made up of copper hydroxide and copper carbonate) when they are exposed to moist air. It is called **Verdigris**. It is called patina.

Chemical equation for Green Coating on Copper

Copper (Cu) + Moist Air (Water (H₂O) + Oxygen (O₂) + Carbon Dioxide (CO₂)) → Copper Hydroxide (Cu (OH) ₂) + Copper Carbonate (CuCO₃)



Copper carbonate and copper hydroxide are basic in nature.

Note: This green coating can be copper chloride if the copper reacts with sea air, or copper acetate if the copper reacts with acetic acid.

Some key Observations

- All metals except mercury exist as solids at room temperature. Metals have high melting points but gallium and caesium have very low melting points. These two metals will melt if you keep them on your palm.
- Iodine is a non-metal but it is lustrous.
- Carbon is a non-metal that can exist in different forms. Each form is called an **allotrope**. Diamond, an allotrope of carbon, is the hardest natural substance known and has a very high melting and boiling point. Graphite, another allotrope of carbon, is a conductor of electricity.
- Alkali metals (lithium, sodium, potassium) are so soft that they can be cut with a knife. They have low densities and low melting points.

Chemical properties of Metals

Elements can be more clearly classified as metals and non-metals on the basis of their chemical properties.

1. Metals react with air or oxygen to form metal oxide.

For Example, Copper reacts with oxygen to form copper oxide.

$\text{Metal} + \text{O}_2 \rightarrow \text{Metal oxide}$

$2\text{Cu} + \text{O}_2 \rightarrow 2\text{CuO}$

$4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$

For Example:

1. Copper + Oxygen $\rightarrow$ Copper Oxide (black) $2\text{Cu} + \text{O}_2 \rightarrow 2\text{CuO}$
2. Aluminium + Oxygen $\rightarrow$ Aluminium Oxide $4\text{Al} + 3\text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3$
3. Magnesium + Oxygen $\rightarrow$ Magnesium Oxide $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO}$

The reactivity of metals with oxygen differs. For example-

- Sodium and Potassium react so vigorously with air that they catch fire when they are kept in open. Hence, they are immersed in kerosene to store them.
- The surfaces of Magnesium, Aluminium, Zinc and Lead are covered with a thin layer of oxide to

make sure that they do not get oxidised anymore.

- While iron does not burn when heated, iron filings burn vigorously.
- Copper surface is coated with a thin layer of black copper oxide to slow down the process of further oxidation from taking place.
- Gold and silver do not react with Oxygen.

2. Oxides of metals can react with both acids and bases to produce salt and water. Such oxides are known as Amphoteric Oxides.

- Aluminium Oxide + Hydrochloric Acid $\rightarrow$ Aluminium Chloride + Water
 $\text{Al}_2\text{O}_3 + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + \text{H}_2\text{O}$
- Aluminium Oxide + Sodium Hydroxide $\rightarrow$ Sodium Aluminate + Water
 $\text{Al}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$

3. Metals also react with water to form metal oxide.

Metal oxide in turn can react with water to form metal hydroxide. For Example

- Metal + (cold) Water $\rightarrow$ Metal hydroxide + Hydrogen
- Metal + Steam $\rightarrow$ Metal oxide + Hydrogen

Some of the Notable examples

- Sodium + Water $\rightarrow$ Sodium Hydroxide + Hydrogen + Heat
 $2\text{Na} + 2\text{H}_2\text{O} \rightarrow 2\text{NaOH} + \text{H}_2 + \text{Heat}$
- Calcium + Water $\rightarrow$ Calcium Hydroxide + Hydrogen
 $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$
- Magnesium + Water $\rightarrow$ Magnesium Hydroxide + Hydrogen
 $\text{Mg} + 2\text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2 + \text{H}_2$
- Aluminium + Water $\rightarrow$ Aluminium Oxide + Hydrogen
 $2\text{Al} + 3\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2$
- Iron + Water $\rightarrow$ Iron Oxide + Hydrogen
 $3\text{Fe} + 4\text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + \text{H}_2$

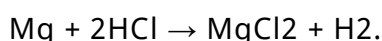
The reactivity of metals with water differs. For Example:

- Sodium, Potassium and Calcium react with cold water.
- Magnesium reacts slowly with hot water to form slightly soluble magnesium hydroxide.

- Aluminium, Zinc and Iron react with steam.
- Lead, Copper, Silver and Gold do not react with water.

Note: Calcium and magnesium float on water as bubbles of hydrogen stick to their surface.

4. Metals also react with dilute acids to form salt and hydrogen. For example, magnesium reacts with dilute hydrochloric acid to form magnesium chloride and hydrogen.



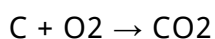
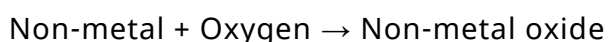
- When a metal is put in acid, it gets smaller and smaller as it gets used up in the chemical reaction. At the same time, bubbles of gas can be seen. The bubbles produced in the reaction are hydrogen gas.

5. Reaction of Metals with Solutions of Other Metal Salts

- Metal A + Salt Solution of Metal B $\rightarrow$ Salt Solution of Metal A + Metal B
- More reactive metals replaces less reactive metals.
- Less reactive metals cannot replace more reactive metals.
- Notable examples is-
 - Iron + Copper Sulphate $\rightarrow$ Iron Sulphate + Copper
$$\text{Fe} + \text{CuSO}_4 \rightarrow \text{FeSO}_4 + \text{Cu}$$

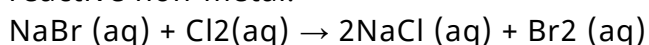
Chemical Properties of Non-Metals

1. Non-metals react with oxygen to form non-metal oxide.

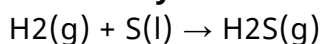


2. Non-metals do not react with water and acids to evolve hydrogen gas.

3. Non-metals can react with salt solution; the more reactive element will displace the less reactive non-metal.



4. Non-metals can also react with hydrogen to form hydrides.



Reactivity Series

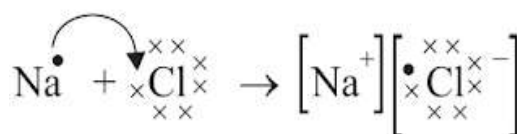
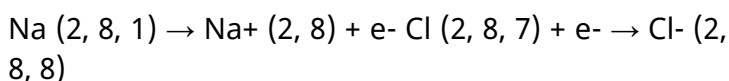
The series in which metals are arranged in the decreasing order of reactivity is known as the Reactivity Series.

potassium	most reactive	K
sodium		Na
calcium		Ca
magnesium		Mg
aluminium		Al
carbon		C
zinc		Zn
iron		Fe
tin		Sn
lead		Pb
hydrogen		H
copper		Cu
silver		Ag
gold		Au
platinum	least reactive	Pt

How do metals and Non- Metals React?

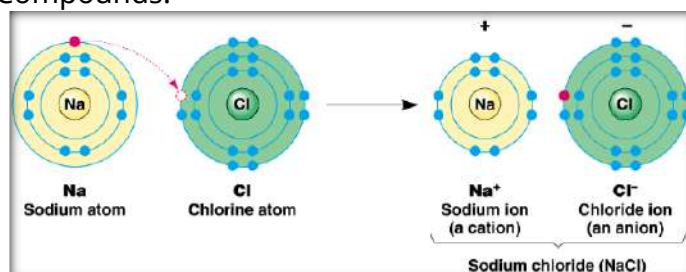
- Reactivity of elements is the tendency to attain a completely filled valence shell.
- Atoms of the metals lose electrons from their valence shell to form cation. Atom of the non-metals gain electrons in the valence shell to form anion.

Formation of NaCl



What is Ionic Compounds?

Compounds formed due to the transfer of electrons from a metal to a non-metal are known as Ionic Compounds.



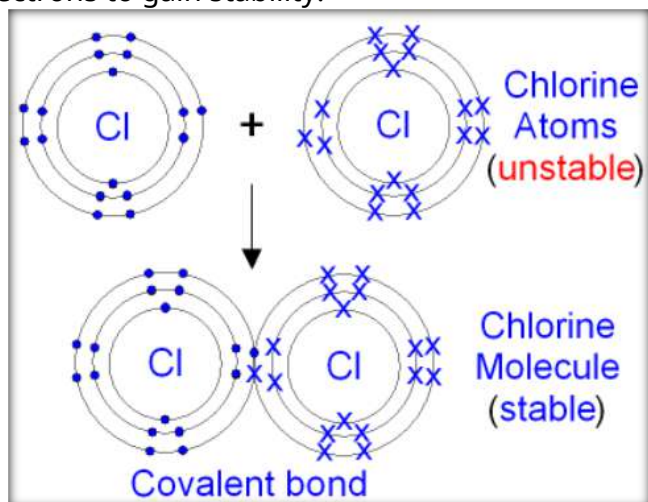
Properties of Ionic compounds

- They are generally hard and solid.
- They have a high melting and boiling point.
- They are soluble in water but insoluble in inorganic solvents such as ether etc.

- They are conductors of electricity in molten and solution states

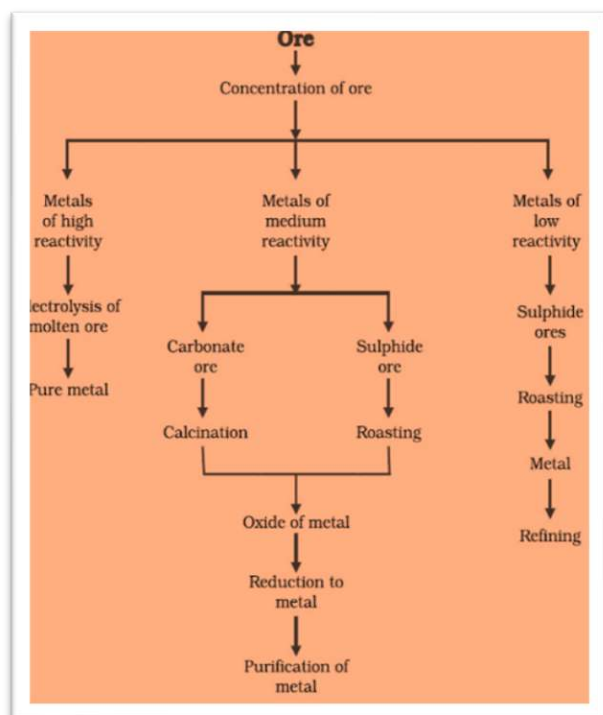
Covalent Bonds

A bond is formed by the sharing of electrons between the two atoms. They share their valence electrons to gain stability.



Occurrence of Metals

- Elements or compounds which occur naturally in earth crust are known as Minerals.
- Minerals from which pure metals can be extracted economically and conveniently are known as Mineral Ores.



Extraction of pure metals from its ores/ steps for extraction of metals from its ore

- The first step is the enrichment of the ore
- The second step includes extraction of metals

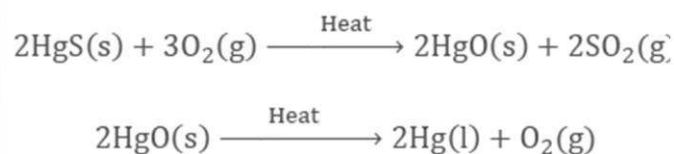
- Third steps involve refining of metal

What is gangue?

Ores contain different impurities in it such as sand, soil etc. These **impurities** are known as Gangue.

Extracting Metals which are low in activity series

- Metals which are low in the activity series are unreactive. The oxides of such metals can be reduced to metals by heating alone. For example, Silver oxide (Ag_2O) decomposes to silver metal and oxygen upon heating. "Some low-activity metals, like mercury from Cinnabar (HgS), can be obtained by roasting the sulphide ore in air



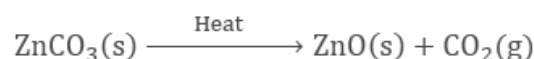
Extracting Metals in the middle of the Activity Series

- These metals are moderately reactive. They exist as sulphides or carbonates in nature. Before reduction, metal sulphides and carbonates must be converted into metal oxides. Sulphide ores are converted into oxides by heating strongly in the presence of excess air, this is known as Roasting. Carbonate ores are converted into oxides by heating in limited air. This is known as Calcination.

Roasting



Calcination



Reduction-metal oxides can be reduced to metals using a reducing agent such as Carbon.

Extracting metals towards the top of the activity series

- The metals are highly reactive. They cannot be obtained by heating. For Example, Sodium,

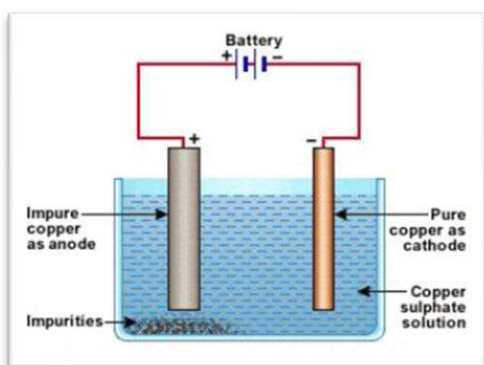
magnesium and calcium are obtained by the electrolysis of their molten chlorides.

At cathode $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$

At anode $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$

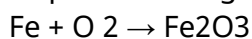
Refining of Metals

- Refining of impure metal is done using electrolytic refining. Impure copper is used as anode and a strip of pure copper is used as Cathode. Acidified copper sulphate is used as an electrolyte. When an electric current is passed through this, the impure metal from the anode dissolves into the electrolyte solution as ions. Ions of the pure metal from the solution are then deposited as pure metal at the cathode. Less reactive impurities in the anode settle as anode sludge, while more reactive impurities remain dissolved in the electrolyte.
- Deposition of insoluble residue formed from the dissolution of the anode during commercial electrolysis.



What is Corrosion?

When exposed to moist air for a long period of time, metals become corroded. This is known as Corrosion. For Example, Silver reacts with moist air and becomes black in colour due to silver sulphide coating.



Prevention of Corrosion

- Rusting of iron can be prevented by oiling, galvanising, painting, greasing etc.
- To protect steel and iron from rusting, a thin layer of zinc is coated on them, this is known as Galvanization.

Alloy

Mixture of two or more metals or metal and non-metal is known as **Alloy**. For Example,

- Brass is an alloy of copper and zinc.
- Bronze is an alloy of copper and tin.
- Solder is an alloy of lead and tin.

Uses of Metals

As discussed above, metals are hard, malleable, ductile, and sonorous and are hence, can be used for:

- Making machinery
- Making automobiles, trains, and aeroplanes
- Making cooking utensils and water boilers
- Making industrial gadgets and satellites etc.
- Non-metals also have several uses, such as:
- Essential for life (such as oxygen)
- Used as fertilizers (such as nitrogen and phosphorus)
- Used to purify water (such as chlorine)
- Applied on wounds as an antiseptic (such as purple-coloured iodine solution)
- Used in crackers (such as sulphur)

Carbon is one of the most important element and its percentage is very meagre. The amount of carbon present in the earth's crust and in the atmosphere is quite meagre. The earth's crust has only 0.02% carbon in the form of minerals (like carbonates, hydrogen carbonates, coal and petroleum) and the atmosphere has 0.03% of carbon dioxide. In spite of this small amount of carbon available in nature, the importance of carbon seems to be immense.

Two or more elements combine to form a compound. There are two types of compounds- Organic compounds and Inorganic compounds. **Organic compounds** are the ones that are made up of carbon and hydrogen.

What is Covalent Bond?

The bond formed by **sharing a pair of electrons** between two atoms is known as Covalent Bond. Carbon forms covalent bonds. Carbon exists in two forms- as a free state and as a combined state. **Freeform of carbon** is found in graphite, diamond and fullerene. In the **combined state**, carbon exists as Carbon-dioxide, Glucose, and Sugar etc.

• Physical Properties of Covalent Compounds

- Covalent compounds have low melting and boiling points as they have weak intermolecular force.
- They are generally poor conductor of electricity as electrons are shared between atoms and no charged particles are formed.

Two Important properties of Carbon.

- Catenation and tetravalency are the two important properties of carbon.
- **Catenation** is a property of carbon by which carbon atoms can link one another via the covalent bonds and can form long chains, closed rings or branched chains etc.
- Carbon atoms can be linked by single, double or triple bonds. Carbon has a valency of 4 due to which it is known to have tetravalency. Due to this one carbon atom can bond with other 4 carbon atoms, with other atoms also such as Oxygen, Nitrogen etc.

Noble gas Configuration of Carbon

- Carbon is tetravalent, it does not form ionic bond by either losing four electrons (C^{4+}) or by gaining four electrons (C^{4-}). It is difficult to hold four extra electron and would require large amount of energy to remove four electrons. So, carbon can form bond by sharing of its electrons with the electrons of other carbon atom or with other element and attain noble gas configuration.
- The atoms of other elements like hydrogen, oxygen and nitrogen, chlorine also form bonds by sharing of electrons.

Allotropes of Carbon

Different forms of an element that have the same chemical properties but different physical properties are known as Allotropes. There are three allotropes of carbon- diamond, graphite and fullerene.

1. Diamond

- Diamond exists as a three-dimensional network with strong carbon-carbon covalent bonds. Diamonds are hard in nature with high melting points. It shines in the presence of light and it is a bad conductor of electricity. The most common use of diamonds is in making jewellery. It is also used in cutting and drilling tools.

2. Graphite

- Graphite is made from layers of carbon atoms arranged in hexagonal rings. Strong covalent bonds exist within each layer, and weak Van der Waals forces exist between the layers, allowing them to slide easily. It serves as a good conductor of heat and electricity. It is used as a dry lubricant for machine parts as well as it is used in lead pencils.

3. Fullerene

- A fullerene is an allotrope of carbon whose molecules consist of carbon atoms connected by single and double bonds so as to form a closed or partially closed mesh, with fused rings of five to six atoms. The molecules may have hollow sphere- and ellipsoid-like forms, tubes, or other shapes.

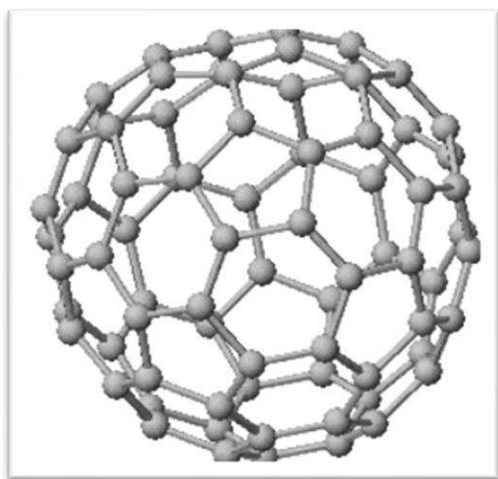


Fig.1 Structure of fullerene

Hydrocarbons

- Compounds made up of hydrogen and carbon are called hydrocarbons
- There are two types of hydrocarbons found **Saturated Hydrocarbons** and **Unsaturated Hydrocarbons**.

Classification of organic compounds or hydrocarbons:

- The compounds in solid, liquid or gaseous state which contain carbon and hydrogen in its molecule are known as organic compounds or hydrocarbons. There are about 27 million known organic compounds and therefore a proper systematic classification was required to study them in detail.
- Hydrocarbons are broadly classified in two groups - aliphatic or acyclic or open chain hydrocarbons and cyclic or closed chain or ring hydrocarbons.
- Hydrocarbons are the simplest organic compounds containing the elements carbon and hydrogen. Liquefied petroleum gas (LPG), compressed natural gas (CNG) and liquefied natural gas (LNG) contain the lower members of alkanes (C to C).
- The alkanes C₅ to C₁₂ are the constituents of gasoline and petrol, Diesel contains a mixture of alkanes C₁₂ to C₂₀. Waxes that occur in nature as coating on green leaves contain alkanes C₂₃ to C₃₀.
- Undecane** secreted by cockroaches, helps to attract opposite gender of its species. Cyclohexane, the cyclic alkane, is one of the

common components of mangoes. Alkenes, ethylene, propylene, styrene are used for the manufacture of polymers. LPG, kerosene are used as domestic fuels CNG, petrol, diesel are used as fuels for automobiles.

- Hydrocarbons are classified as **aliphatic**, **alicyclic** and **aromatic** hydrocarbons. Aliphatic hydrocarbons contain open chains of carbon atoms, which are further classified as saturated and unsaturated hydrocarbons.

Saturated hydrocarbons or Alkanes:

- Saturated hydrocarbons are compounds containing only carbon-carbon single covalent bonds. Acyclic saturated hydrocarbons are known as alkanes. General formula of alkanes is C_nH_{2n+2}
- e.g. Methane, ethane, propane, butane... etc. Alkanes are aliphatic saturated hydrocarbon Alkanes have open chain structure and carbon atoms are linked together by single covalent bonds. In alkanes, all the four valences of carbon are satisfied by four atoms or group of atoms.
- Alkanes are also called **paraffin's** because alkanes do not undergo chemical reactions easily.

Classification of alkanes:

- Straight chain alkanes:** The alkanes in which each carbon atom is bonded to not more than two other carbon atoms are known as straight chain alkanes or normal alkanes. In these alkanes all carbon atoms form a continuous carbon chain without branching. e.g. $CH_3-CH_2-CH_2-CH_2-CH_2-$
- Branched chain alkanes:** The alkanes in which at least one carbon atom is bonded to more than two other carbon atoms are known as branched chain alkanes. Some branched chain alkanes (up to six carbon atoms) may be classified as,
 - Isoalkanes:** Alkanes characterized by having a single methyl group branch on the second carbon atom of the longest continuous carbon chain (i.e., containing the $CH_3-CH(CH_3)-$ structural unit at one end of the chain).
 - Neoalkanes:** Alkanes characterized by having three methyl groups attached to a central carbon atom (i.e., containing the $-C(CH_3)_3$

structural unit, where the central carbon is the second carbon atom of the longest chain)."

Uses of Alkanes

- As alkanes have high heat of combustion, they are used as fuels. LPG, kerosene are used as domestic fuels. CNG, petrol, diesel are used as fuels for automobiles. ii) Liquid alkanes are used as solvents.
- Alkanes ranging from C^{18} to C_{20} are viscous liquids and used as lubricants.
- Incomplete combustion of alkanes in limited amount of air produces carbon black which is used for the manufacture of printing ink, black pigments, shoe polish, etc.
- Solid alkanes ranging from C^{20} to C_{30} are constituents of paraffin wax, which is used as base for many cosmetics as well as for the preparation of candles.
- Alkanes are used as a source of hydrogen

Unsaturated hydrocarbons:

Unsaturated hydrocarbons are compounds containing at least one carbon-carbon double or triple covalent bond. Unsaturated hydrocarbons are classified into two types. They are alkenes and alkynes.

Alkenes

- Hydrocarbons with double bond between carbon atoms are known as alkenes.

No. of C atoms	Name of alkene	Molecular formula
2	Ethene	C_2H_4
3	Propene	C_3H_6
4	Butene	C_4H_8
5	Pentene	C_5H_{10}
6	Hexene	C_6H_{12}
7	Heptene	C_7H_{14}
8	Octene	C_8H_{16}
9	Nonene	C_9H_{18}
10	Decene	$C_{10}H_{20}$

- Alkenes are aliphatic unsaturated hydrocarbon containing one or more double bonds Alkenes with one carbon-carbon double bond contain two-hydrogen atoms less than corresponding alkanes, have general formula C_nH_{2n} The aliphatic unsaturated hydrocarbons containing

two or three carbon-carbon double bonds are called **alkadienes** and **alkatrienes** respectively. Ethylene, the simplest alkene, reacts with chlorine to form oily substance and therefore alkenes are also known as **olefins** (oil forming).

- Alkenes play an important role in our everyday life, Ethene on polymerization gives **polyethene**, a well-known plastic. **Ethene** is also responsible for germination of seeds, flower maturation and ripening of fruits (eg, tomatoes).
- **Limonene**, containing two carbon-carbon double bonds, is responsible for the smell of lemons and oranges. B-phellandrene is present in Eucalyptus oil. Natural rubber is obtained from a basic unit, **isoprene**, which contains two carbon-carbon double bonds. Many edible oils consist of fatty acids that have one or more carbon-carbon double bonds (eg **oleic acid**). The orange pink colour of carrot is due to the presence of **B-carotene** that contains eleven carbon-carbon double bonds.
- The flavour of ginger is due to the presence of **zingiberene**, which contains three carbon double bonds
- The skin of apple contains a compound known as **a-farnesene**. Which contains four carbon-carbon double bonds. Chemistry of vision of all animals is closely related to the chemistry of alkenes B-carotene decomposes to form vitamin A, which undergoes a number of chemical reactions in presence of light which is responsible for the ocular activity.

Alkynes

- Hydrocarbons with triple bonds between carbon atoms are known as Alkynes. General formula for alkynes are C_nH_{2n-2} .
- Alkynes are aliphatic unsaturated hydrocarbons containing at least one triple bond. Alkynes contain four hydrogen atoms less than corresponding alkanes and two hydrogen atoms less than corresponding alkenes.
- aliphatic unsaturated The hydrocarbons containing two or three carbon-carbon triple bonds in their structure are called **alkadiynes** and **alkatriynes** respectively

Uses of Acetylene:

- Acetylene is used in oxy-acetylene flame which is used for cutting and welding of metals.
- As an illuminant in lamps
- For **artificial ripening of fruits**
- In the manufacture of westron and westrosol.
- In the manufacture of acetaldehyde, acetic acid, oxalic acid, etc.
- In the manufacture of plastic, synthetic rubber, synthetic fibers (orlon), etc.

Carbon Compounds based on the Structure

Carbon Compounds can be classified into three types as

1. **Straight (Unbranched) Chain Compounds**
2. **Branched Chain Compounds**
3. **Cyclic Compounds**

Let's explain each in details

1. Straight (Unbranched) Chain

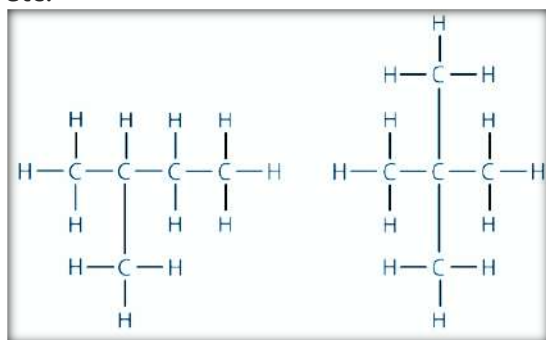
- A **straight-chain** compound consists of carbon atoms connected in a continuous straight line.

The carbon atoms are connected in a continuous, unbranched sequence.

Example is $-C-C-C-C-C-$

2. Branched chain Compounds

- A branched chain alkane or branched alkane is an alkane which has alkyl groups bonded to its central carbon chain. Branched alkanes contain only carbon and hydrogen (C and H) atoms, with carbons connected to other carbons by single bonds only, but the molecules contain branches (methyl, ethyl, etc).

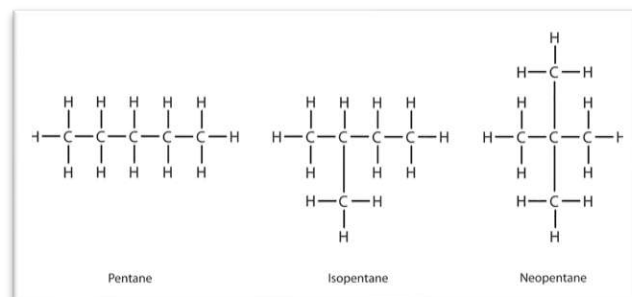


What is Isomer and isomerism?

Chemical compounds that have identical chemical formulae but differ in properties and the arrangement of atoms in the molecule are called

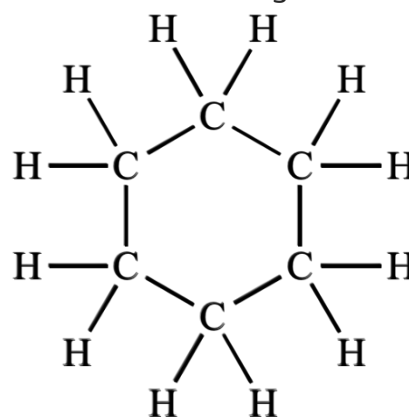
isomers. Therefore, the compounds that exhibit isomerism are known as isomers. The word "isomer" is derived from the Greek words "isos" and "meros", which mean "equal parts".

Example-



3. Cyclic Chain Compounds

- A cyclic organic compound containing all carbon atoms in ring formation is designated as a carbocyclic compound, while the cyclic compounds consisting of at least one hetero (i.e., noncarbon) atom in the ring are known as **heterocyclic compounds**.
- For example, Cyclohexane has the formula C₆H₁₂ and the following structure-



Functional Groups

- In organic chemistry, a functional group is a specific group of atoms or bonds within a compound that is responsible for the characteristic chemical reactions of that compound. The same functional group will behave in a similar way, by undergoing similar reactions, regardless of the compound of which it is a part. The atoms of a functional group are linked together and to the rest of the compound by covalent bonds.
- When heteroatoms (atoms other than carbon and hydrogen, such as oxygen, nitrogen, sulfur, or halogens) replace hydrogen atoms in a hydrocarbon chain, they introduce specific

properties. These heteroatoms or groups of atoms containing them, which are responsible for the characteristic chemical reactions of a compound, are called functional groups.

Functional Group	Structure	Nomenclature	Examples
alkanes	$R-CH_3$	-ane	methane, butane, hexane, heptane
alkenes	$R_1-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}=\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-R_2$	-ene	ethene, butene, hexene, heptene
alkynes	$R_1-C\equiv C-R_2$	-yno	ethyne, butyne, hexyne, heptyne
dienes	$CH_2=CH-CH=CH_2$	-diene	butadiene, hexadiene
alcohols	$R-OH$	-ol	methanol, butanol, hexanol, heptanol
ethers	R_1-O-R_2	-oxy-	ethoxyethane or diethyl ether
aldehydes	$R-\overset{\text{O}}{\underset{\text{H}}{\text{C}}}$	-al	methanal, butanal, hexanal, heptanal
ketones	$R-\overset{\text{O}}{\text{C}}-R$	-one	propanone, butanone
carboxylic acids	$R-\overset{\text{O}}{\text{C}}-OH$	-oic acid	ethanoic acid, butanoic acid
esters	$R_1-\overset{\text{O}}{\text{C}}-O-R_2$	-oate	ethyl ethanoate or ethyl acetate
amides	$R_1-\overset{\text{O}}{\text{C}}-N(R_2)-H$	-amide	N-methylethanamide
amines	$R-N(H)_2$	-amine	ethanamine
nitriles	$R-C\equiv N$	-nitrile	ethanenitrile
Thiols	$R-S-H$	-thiol	ethanethiol

Homologous Series

Series of compounds in which the same functional group substitute for the hydrogen atom in a chain of carbon.

Characteristics of Homologous series

1. It is represented by same general formula.
2. Chemical properties of all the members in a homologous series are similar.
3. The molecular formula of each member of a series is differ by one CH_2 group.
4. The molecular mass of each member of a series is differ by 14.

Homologous Series	General Formula	Functional Group	Example
Alkanes	C_nH_{2n+2}		Methane, CH_4 Ethane, C_2H_6 Propane, C_3H_8 Butane, C_4H_{10}
Alkenes	C_nH_{2n}	$C=C$	Ethene, C_2H_4 Propene, C_3H_6 Butene, C_4H_8
Alcohols	$C_nH_{(2n+1)}OH$	-OH	Methanol, CH_3OH Ethanol, C_2H_5OH Propanol, C_3H_7OH Butanol, C_4H_9OH
Carboxylic Acids	$C_nH_{(2n+1)}COOH$	-COOH	Methanoic Acid, $HCOOH$ Ethanoic Acid, CH_3COOH Propanoic Acid, C_2H_5COOH Butanoic Acid, C_3H_7COOH

Example- Alcohols- CH_3OH , C_2H_5OH , C_3H_7OH , C_4H_9OH

- They have same general formula
- Any two homologues differ by $-CH_2$ group and difference in molecular mass is 14u.

- They have similar chemical properties but show gradual change in physical properties.

Nomenclature of carbon Compounds

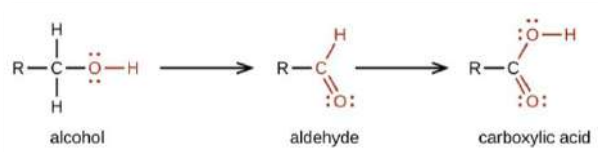
- The names of compounds in a homologous series are based on the name of the basic carbon chain modified by a "prefix" or "phrase before" and "suffix" or "phrase after" indicating the nature of the functional group.
- First of all, identify the number of carbon atoms in compounds. And in it identify the longest chain
- Then the functional group can be indicated by suffix or prefix.
- Cyclic hydrocarbon is designated by the prefix cyclo.
- If there are two or more different substituents they are listed in alphabetical order
- If the same substituent occurs more than once, the location of each point on which the substituent occurs is given.

Functional Group Name	Suffix Ending	Functional Group Structure
Alkane	-ane	C-H atoms
Alcohol	-ol	--OH
Alkene	-ene	$C=C$
Alkyne	-yne	$HC\equiv CH$
Aldehyde	-al	$\begin{array}{c} O \\ \\ -C-H \end{array}$
Amine	-amine	--N--
Ether	-ether	--O--
Ester	-oate	$\begin{array}{c} O \\ \\ -C-O- \end{array}$
Ketone	-one	$\begin{array}{c} O \\ \\ -C- \end{array}$
Nitrile	-ile	$-C\equiv N$

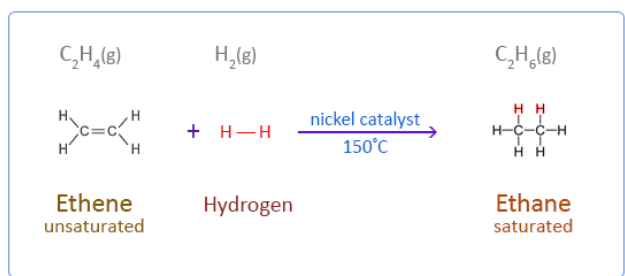
Chemical Properties of carbon Compounds

1. **Combustion**- Carbon along with its compound is used as a fuel as it burns in presence of oxygen to release energy. **Saturated hydrocarbons** produce blue and non-sooty flame whereas **unsaturated hydrocarbons** produce a yellow sooty flame because percentage of carbon is higher than saturated hydrocarbon which does not get completely oxidized in air.
 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
2. **Oxidation**- Alcohol can be oxidised to aldehydes whereas **aldehydes**, in turn, can be

oxidised to **carboxylic acid**. Oxidising agents such as potassium permanganate can be used for oxidation.



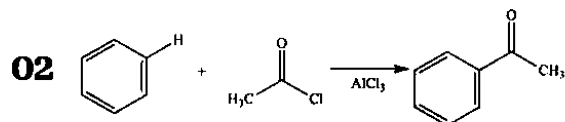
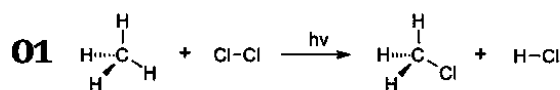
3. Addition Reaction- Addition of hydrogen in presence of catalyst such as nickel and palladium. This reaction is called as **Hydrogenation of vegetable oil**. This is best example of additional reaction. This reaction converts oil into ghee.



4. Substitution Reaction- Substitution reaction is also known as single displacement reaction or single replacement reaction is a chemical reaction during which one functional group is replaced by another functional group in a chemical compound. **Halogenation** is a good example of a replacement reaction.

Example

Substitution Reaction



Some Important carbon Compounds

Uses of Hydrocarbons:

a. Methane:

- Methane is a simplest saturated hydrocarbon with a chemical formula CH_4 .
- It is the simplest form of alkane.
- It is odourless or has a sweet oil type smell and has no colour.
- It is a flammable non-toxic gas.
- It is a tetrahedral molecule which has four equivalent C-H bonds.

Uses of Methane:

- It is used in automobiles, ovens and water heater as a fuel.
- It is used in the generation of electricity and used as rocket fuel in its refined liquid form.
- Used as a raw material in the production of fertilizers
- It is used in gas-fired power stations and in gas cookers. It is used for the production of carbon black, methyl alcohol, freon and acetylene.

b. Ethane (C_2H_6):

- Ethane is a saturated hydrocarbon found in gaseous state. Ethane is the second simplest alkane. It is prepared by laboratory method using sodium propionate.

Uses of Ethane:

- Used in the petrochemical industry as a fraction of that produced in the natural gas liquids plants alone.
- Used in the preparation of ethanol, acetaldehyde and acetic acid which find use in paints, varnishes, adhesive, plastic etc.
- Used as the most specific volatile marker for the investigation of lipid peroxidation.
- Used as a feedstock to produce ethylene, which is then used for everything from antifreeze to plastics to ripening fruit.

c. Methyl alcohol (CH_3OH):

- Methanol is a simplest alcohol. It consists of a methyl group linked with a hydroxy group. It is also known as Wood alcohol or Methanol..

Uses of methyl alcohol:

- It is widely used in the production of acetic acid and formaldehyde.
- It is used as a raw material for methyl ethers, methylamines and methyl halides.
- It is used as a fuel for internal combustion engines, in boating stoves and camping. Pure methyl alcohol is used in the manufacture of perfumes, resins, and pharmaceuticals.

d. Ethyl alcohol ($\text{C}_2\text{H}_5\text{OH}$):

- Ethanol, also called ethyl alcohol, grain alcohol, or alcohol. Pure ethanol is a

colourless flammable liquid (boiling point 78.5 °C (173.3 °F) with an agreeable ethereal odour and a burning taste. Ethanol is toxic, affecting the central nervous system. Moderate amounts relax the muscles and produce an apparent stimulating effect by depressing the inhibitory activities of the brain, but larger amounts impair coordination and judgment, finally producing coma and death. It is an addictive drug for some persons, leading to the disease alcoholism.

- **There are two main processes for the manufacture of ethanol:** the fermentation of carbohydrates and the hydration of ethylene. Fermentation involves the transformation of carbohydrates to ethanol by yeast. The raw materials fermented for the production of industrial alcohol are sugar crops such as beets and sugarcane and grain crops such as corn (maize).

Uses of ethyl Alcohol:

- Ethanol is an important industrial chemical; it is used as a solvent, in the synthesis of other organic chemicals, and as an additive to automotive gasoline.
- Ethanol is also the intoxicating ingredient of many alcoholic beverages such as beer, wine, and distilled spirits.
- Ethanol is a common ingredient in many cosmetics and beauty products. It acts as an astringent to help clean skin, as a preservative in lotions.
- Ethanol is effective in killing microorganisms like bacteria, fungi and viruses, it is a common ingredient in many hand sanitizers.
- Ethanol mixes easily with water and many organic compounds, and makes an effective solvent for use in paints, lacquers and varnish, as well as personal care and household cleaning products.

e. Ethylene (C₂H₄)

- It is unsaturated organic compounds. It is the simplest member of the alkene class of hydrocarbons

Uses

- It is used in the manufacturing of alcohol or polystyrene.
- Used in promoting senescence.
- Used to produce fabricated plastics and in welding materials

Soap and Detergent

Soaps and detergents are known as the chemical compounds of a mixture of compounds that are used as cleansing agents. A soap is either sodium or potassium salt of different combinations of fatty acids that possess cleansing action in the water. On the other hand, detergents are far better solutions when it comes to cleaning purposes since they are not affected by the hardness of the water.

- Soaps are sodium or potassium salts of several combinations of fatty acids and have cleansing action in combination with water. They are produced from fats and oils. Examples of soap include sodium oleate, sodium stearate, and sodium palmitate.
- Soap consists of 2 primary raw materials: (i) fat and (ii) alkali. Alkali is the most commonly used material and is also called sodium hydroxide. Potassium hydroxide is also used in manufacturing soaps. Potassium-based soap is also called soft soap because it creates a more water-soluble product than sodium-based soap. Softsoap is generally used in shaving products, alone or in combination with sodium-based soap

Cleansing action of Soap and detergents

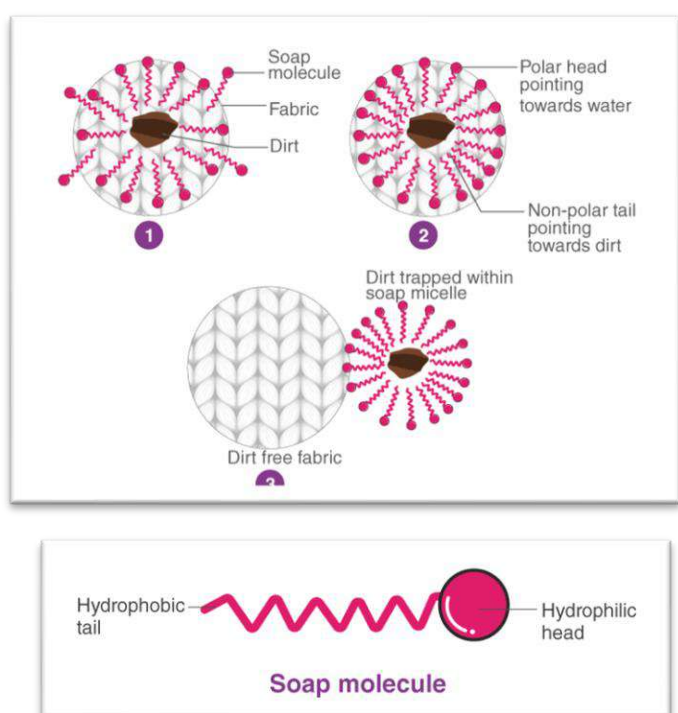
- Most of the dirt is oily in nature and oil does not dissolve in water.
- The molecule of soap constitutes sodium or potassium salts of long-chain carboxylic acids. In the case of soaps, the carbon chain dissolves in oil and the ionic end dissolves in water. Thus, the soap molecules form structures called **micelles**. In micelles, one end is towards the oil droplet and the other end which is the ionic faces outside. Therefore, it forms an emulsion in water and helps in dissolving the dirt when we wash our clothes.

Soap is a kind of molecule in which both the ends have different properties.

- *Hydrophilic end*
- *Hydrophobic end*

The first one is the **hydrophilic end** which dissolves water and is attracted to it whereas the second one is the **hydrophobic end** that is dissolved in hydrocarbons and is water repulsive in nature. If on the surface of the water, soap is present then the hydrophobic tail which is not soluble in water will align along the water surface.

Micelles



In water, the soap molecule is uniquely oriented which helps to keep the hydrocarbon part outside the water. When the clusters of molecules are formed then hydrophobic tail comes at the interior of the cluster and the ionic end comes at the surface of the cluster and this formation is called a micelle. When the soap is in the form of micelles then it has the ability to clean the oily dirt which gets accumulated at the centre. These micelles remain as colloidal solutions. Therefore, the dirt from the cloth is easily washed away. The soap solution appears cloudy as it forms a colloidal solution which scatters light.

Introduction

Fuels are used to get energy in the form of heat. Cow dung, wood, coal, charcoal, petrol, diesel, compressed natural gas (CNG), etc. are the examples of fuels. As we all know that when something burns it produces a flame. The chemistry of flames suggests the chemical and physical nature of reaction while burning. We use different types of fuels in home, in trade and industry, and to run automobiles. Some of these fuels burn with a flame and some without a flame.

Some of the notable examples are as follows

- Remember, when we burn magnesium ribbon in air, it produces heat and light and we get magnesium oxide.
- Chemical equation for burning of magnesium
 $\text{Magnesium} + \text{Oxygen} \rightarrow \text{Magnesium Oxide} + \text{Heat and Light}$
 $2\text{Mg} + \text{O}_2 \rightarrow 2\text{MgO} + \Delta$
- Similarly, when we burn charcoal in air, it produces carbon dioxide, heat and light.
- Chemical equations for burning of coal
 $\text{Carbon} + \text{Oxygen} \xrightarrow{\Delta} \text{Carbon Dioxide} + \text{Heat and Light}$
 $\text{C} + \text{O}_2 \rightarrow \text{CO}_2 + \Delta$

What is Combustion?

- Combustion** is a chemical process in which a substance **reacts with oxygen** and generates heat in the process.
- Oxygen (in air) is essential for combustion.
 - Combustible Substance** - Combustible substances are those substances that undergo combustion. It means that these substances give off heat and sometimes light (as a flame or glow) when they react with oxygen.
 - Non-combustible substances** - those that do not burn in combustion reaction are called as non-combustible substances.
 - Inflammable substances** - Inflammable substances are substances which have low ignition temperature and catch fire easily.

They burn with a flame. For example, petrol, LPG etc.

Ignition temperature

- Ignition temperature is the lowest temperature at which a substance catches fire or starts burning.
- Ignition temperature of different materials
 - White Phosphorous- 35°C
 - Petrol- 246°C
 - Kerosene- 220°C
 - Diesel- 210°C
 - Wood- 300°C
 - Coal- 454°C
 - Piece of paper- 233°C

Note- Food is fuel for our body

- When we eat food, it gets broken down in simpler substances which react with oxygen and generate energy (or heat). Hence, food is referred to as 'fuel' for our body.

Supporters of Combustion

- The gaseous environment that supports combustion of a combustible substance is called supporter of combustion.
- Smaller the size of combustible particles, faster is the rate of combustion.
- Nature of combustible substances: Inflammable substances burn faster as compared to substances such as wood.

Conditions necessary for the Combustion to take place are

- Combustion requires fuel-** Combustion only takes place when there is a fuel which produces heat and light when it catches fire. For example, petrol and diesel.
- Combustion requires air-** We can prove it with the help of the following experiment:
 - A candle keeps burning in open air. However, when we cover it with a glass or a jar, it only burns until the oxygen inside it is consumed. Once the oxygen is exhausted, the flame of the candle flickers off.

- Combustion requires heat- The substance must reach its ignition temperature to catch fire.

Types of combustion

There are three types of combustion

1. **Rapid Combustion-** Combustion in which a gas burns quickly producing heat and light in the process. E.g. LPG
2. **Spontaneous Combustion-** Combustion in which a material bursts into flames suddenly without applying heat. E.g. Phosphorus which burns at room temperature. Spontaneous combustion of coal dust often causes accidental fires in coal mines. Heat from the sun or lighting may also cause spontaneous forest fires.
3. **Explosion-** When a material bursts suddenly to produce heat, light and sound on the application of heat or pressure, it is called an explosion. E.g. Crackers and fireworks which release a large amount of gas too.

How do we control fire?

We can control the fire by one or more of the following:

- Removing the fuel
- Cutting off the air supply (or oxygen supply)
- Cutting off heat or lowering the temperature of the fuel

Case study

Fire extinguishers

Fire extinguishers are devices used to put out fires. They either cut off the air supply to fire or cool off the fuel (below the ignition temperature) or both.

The three main types of fire extinguishers are:

1. Dry Powder fire extinguisher
2. Soda Acid Fire extinguishers
3. Foam types fire extinguishers

Let's see each in details

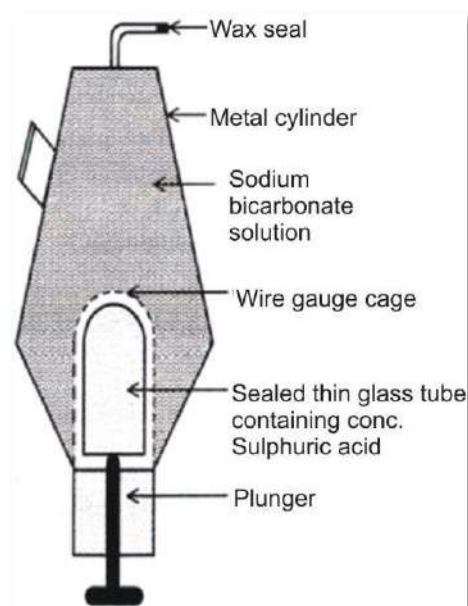
1. Dry powder fire extinguishers

This type of fire extinguishers contain a mixture of baking soda (sodium bicarbonate) and sand. When you throw it over the fire, the baking soda decomposes by its heat to produce carbon dioxide. Since CO_2 is heavier than air, it descends to envelop the burning flame and cuts off its contact with air (and the oxygen supply).



2. Soda Acid Fire extinguishers

This fire extinguisher is a metallic cylinder which contains the sodium bicarbonate (NaHCO_3) solution. At the bottom of the cylinder, the concentrated sulphuric acid (H_2SO_4) is placed in a thin sealed glass tube. A fixed wire gauze surrounds this tube



- Below the tube, a plunger is placed with its sharp end touching the thin glass tube.
- On the top of the cylinder, there is a nozzle which is sealed with wax.
- When the plunger hits against the floor, its sharp end breaks the thin glass tube and the acid inside it reacts with sodium bicarbonate to produce carbon dioxide.
- CO_2 forces the wax seal open and rushes out of the nozzle to put out the fire in the direction where the nozzle is pointed.

3. Foam type fire extinguishers

Like the soda-acid fire extinguisher, it uses sodium bicarbonate solution. However, in this case, a substance called Saporin or Turkey Red Oil is added to the solution to produce foam along with the gas from the nozzle. Since this foam is lighter than oil, it floats on the surface of the oil and cuts off its air supply. Hence, it is very effective in putting out oil fires.

Some important notes

1. When should we use water to extinguish the fire?

- When wood, paper and clothes are on fire, we can use water to extinguish them. Water lowers the temperature of burning material below ignition temperature and thus, the fire stops burning.
- We should not use water when electrical equipment is on fire as water may conduct electricity and give a shock to people dousing the fire. Also, it should not be used when oil or petrol catches fire as water is lighter than oil and petrol and sinks down. Oil and petrol keep floating on the top and keep burning.

2. What should we do when electrical or inflammable materials (like Petrol) catch fire?

- Carbon Dioxide is the best fire extinguisher in such cases. CO_2 is heavier than oxygen and hence, covers the burning material like a blanket and cuts off its oxygen supply. Also, it does not harm the electrical equipment.
- CO_2 can be stored as a liquid in cylinders at high pressure. When it is released, it immediately expands, cools down, and envelopes the fire - bringing down the temperature of the fuel. One can also pour dry chemicals like sodium bicarbonate (or baking soda) or potassium carbonate on the fire as they release CO_2 near a fire.

What is Flame?

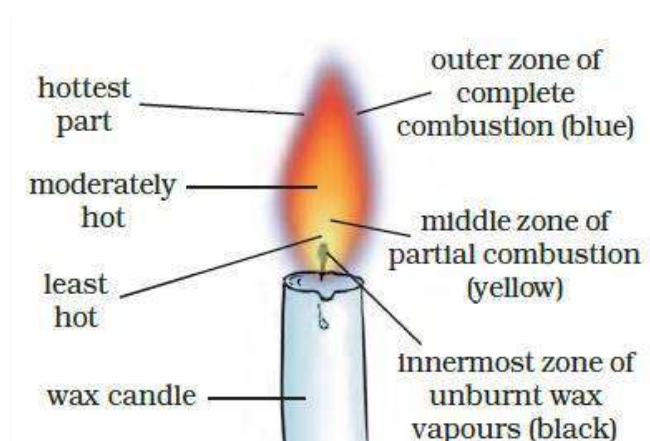
Flame is a hot glowing body of ignited gas which is produced when something is on fire.

Some materials burn with a flame and some do not.

Here is a table based on a general observation:

Material	Forms flame	Does not form a flame
candle	Forms flame	
Magnesium	Forms flame	
Camphor	Forms flame	
Kerosene stove	Forms flame	
Charcoal		Does not form flame

Structure of Flame



A flame has three zones

- Outermost zone-** Outermost zone is blue in colour and is the hottest part of the flame. This is also the zone where complete combustion takes place.
- Middle zone-** Middle zone is yellow in colour and is moderately hot. In this zone, partial combustion takes place.
- Innermost Zone-** Innermost zone is black in colour and least hot. Here, we can find the unburnt wax vapours of a candle.

Remember

- Kerosene oil and molten wax vapourise during burning but charcoal does not produce flame or vapourise when it burns.
- Goldsmiths blow at the outermost zone of a flame for melting of gold and silver because

the outermost zone of a flame is its hottest part. Gold and silver have high melting points and hence, goldsmiths blow at the outermost zone of the flame to melt gold and silver quickly.

What is Fuel?

Fuels are substances that give us heat which we use for domestic and industrial purposes, such as wood, kerosene, and petrol.

- **Ideal Fuel-** There is probably no fuel that could be considered as an ideal fuel. We should look for a fuel which fulfils most of the requirements for a particular use.

Characteristics of a good fuel

- It should be cheap and readily available.
- It should be easy to store.
- It should burn at a slow rate and its combustion should be controllable
- It should have low ignition temperature.
- It should produce very small amount of residues such as ash.
- It should have large calorific value.
- It should not produce gases which pollute the air.
- It should not produce any hazards during transportation.

Classification of fuels

On the basis of physical state, fuels are classified into three parts.

- **Solid fuels:** The fuels which occur in a solid state at room temperature are called solid fuels. Example: Wood, agricultural residues, charcoal, coal, coke, etc.
- **Liquids fuels:** The fuels which occur in a liquid state at room temperature are called liquid fuels. Example: Liquefied hydrogen, petrol, oil, kerosene, diesel, etc.
- **Gaseous fuels:** The fuels which occur in a gaseous state at room temperature are called gaseous fuels. Example: Water gas, producer

gas, coal gas, compressed natural gas (CNG) and gobar gas, etc.

Fuel efficiency

- The amount of heat energy produced on completely burning one Kilogram of fuel (in O₂) is called the **calorific value of a fuel**.
- The more is the calorific value of a fuel, more is the efficiency of the fuel. The calorific value of the fuels is expressed in Kilojoules per kilogram (kJ/kg) or Kilojoules per gram (kJ/g). The calorific value of common solids, liquids and gaseous fuels is given below.

Calorific value of solid fuels

Fuel	Calorific value in kJ/kg
1. Cow dung cake	6000 – 8000
2. Wood	17000 – 22000
3. Coal	25000 – 33000

Calorific value of liquid fuels

Fuel	Calorific value in kJ/kg
1. Petrol	48000
2. Kerosene	35000
3. Diesel	45000

Calorific value of gaseous fuels

Fuel	Calorific value in kJ/kg
1. Methane	50000
2. Butane (LPG)	50000
3. CNG	50000
4. Biogas	35000 – 40000
5. Hydrogen	150000

Harmful effects of burning fuels

The increasing fuel consumption has harmful effects on the environment. The main products formed during the fuel combustion which produce harmful effect are:

- Carbon fuels like wood, coal, petroleum release unburnt carbon particles. These fine particles are

dangerous pollutants causing respiratory disease, such as asthma.

- Incomplete combustion forms carbon monoxide gas. It is very poisonous gas. It is dangerous to burn coal in a closed room. The carbon monoxide gas produced can kill persons sleeping in that room.
- Combustion of most fuels releases carbon dioxide in the environment. Increased percentage of carbon dioxide in the air causes global warming. Global warming is the rise in temperature of the earth. This results in melting of polar glaciers. This leads to rise in sea level and floods in the sea coast.
- Burning of coal and diesel release sulphur dioxide gas. It is an extremely suffocating and corrosive gas. Sulphur dioxide and nitrogen oxide dissolve in rain water to form acid. Such rain is called acid rain. It is very harmful for crops, buildings and soil.
- Wood is also used as a fuel. Burning of wood gives a lot of smoke which causes air pollution and is also very harmful for humans. It may lead to many respiratory problems. Cutting of trees for obtaining wood leads to deforestation which is quite harmful to environment.
- Carbon particles of smoke or the ash get suspended in the air. Excessive amount of them in the air causes breathing problems.

Fabrics are made by weaving fibres (or threads) obtained from natural or artificial sources. They can be of **two types**:

1. Natural fibres

- Natural fibres are produced by plants and animals.
- Examples- Cotton, Wool, Silk, etc.

2. Synthetic fibres

- Synthetic fibres or man-made fibres are textile fibres made by human beings using natural materials or petrochemicals.
- Examples- rayon, Nylon, polyester, etc.

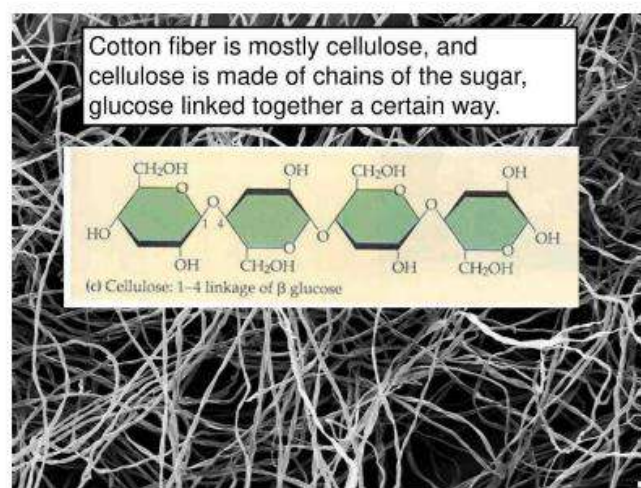
What are synthetic fibres?

A synthetic fibre, as well as plastic, is made up of a chain of small units (called Monomers) which combine to form polymers.

- **Monomers**- A monomer is a single molecule that can bond with other identical molecules to form polymers through a process called Polymerization.
- **Polymers**- Polymer is a Greek word in which 'poly' means 'many' and 'mer' means units. Hence, polymers are large molecules made up of several molecules (or monomers) linked together. Types of polymers are-
 - **Addition Polymers**- Monomers combine together to form a giant molecule known as the polymer. No molecule is eliminated during formation of addition polymers. Examples are Polythene, polyvinyl chloride etc.
 - **Condensation Polymers**- Several small units of monomers combine with each other, along with elimination of simple molecule like water to form polymer unit. Examples of condensation polymer are nylon-66, terylene etc.

Examples of Polymers

- All synthetic fibres, such as Rayon and Nylon, are polymers.
- Polymers are also found in Nature. '**Cotton**' is a polymer called '**Cellulose**'. 'Cellulose' is made up of a number of single units (or monomers) called '**Glucose**'



Note- Polymerization Reaction- The process of linking small monomers together to form polymers is called Polymerization.

Types of Synthetic fibres

There are four types of synthetic fibre

1. Rayon
2. Nylon
3. Polyester
4. Acrylic

Let's discuss each in shortly

1. Rayon-

- It is also known as **Artificial Silk**.
- It is made up of **Wood Pulp** (Naturally-occurring Cellulose)
- Absorbs moisture and comfortable to wear.
- Rayon is a versatile fibre and can imitate the feel and texture of silk, wool, cotton and linen with drape and slipperiness akin to nylon.

Why it is called artificial Silk?

- Rayon resembles silk in appearance, texture and shine. Hence, it is also known as Artificial Silk.
- Silk fibre was discovered in China and made from silkworms. It had a beautiful texture and was very costly. By the end of the 19th century, scientists managed to make an artificial silk-like fibre made by treating wood pulp chemically.

Uses of Rayon

- This man-made fibre uses natural material (wood pulp) and can be woven like silk fibre. It is cheaper than silk and can be dyed in a variety of colours. It can be:
 - Make apparels like suits, slacks, jackets etc.

- Make automobile tyre cords (because of its strength)
- Mixed with cotton to make bedsheets and bedspreads
- Mixed with wool to make carpets and blankets
- Used to make other home furnishings, such as curtains and tablecloths

2. Nylon

- Nylon is the first synthetic fibre to be prepared without using any natural raw materials (materials produced by plants and animals).
- It was prepared from **coal, water and air**. It was the first **fully synthetic fibre**.

Key properties make Nylon suitable for-

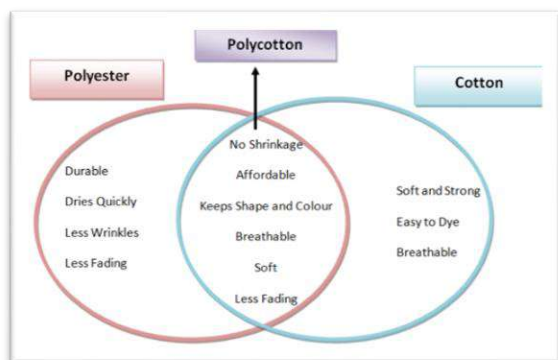
- Making Ropes used for Rock Climbing- Strong fibre, Lightweight, Weather Resistant.
- Making fishing Nets- Strong, Elastic, Water Resistant.
- Making Tents- Strong, Light, Does not absorb much water, Dries quickly.

Uses of Nylon

Developed in 1931, this **thermoplastic silky material** is strong, elastic, light, lustrous and easy to wash. A nylon thread is, in fact, stronger than a steel wire. Hence, it is used to:

- Make clothes (including socks)
- Make parachutes as well as ropes for rock climbing
- Make ropes, toothbrushes, and car seat belts etc.
- Make tents, curtains, and sleeping bags

3. Polyester



- Polyester fibre does not get wrinkled easily. Hence, a fabric made from this fibre is easy to

wash and does not need to be ironed - which makes it suitable for dress material.

- Polyester is made up of two words - 'poly' which means many, and 'ester' which is a chemical.
- **Esters** are chemicals which give fruits their smell.

Some notable types of Polyesters

Some popular polyester fibres are-

- **Terylene** (often known by brand name Dacron) which can be drawn into a very fine fibre and can be woven like any other yarn.
- **Polyethylene terephthalate** (P.E.T.) is used for making, films, bottles, utensils and other useful products.

Blended fibres

Blended fibres are formed by mixing natural and synthetic fibres. Polyester is often used in blended fibres. For Example,

- **Polywool** is made by mixing polyester and wool.
- **Polycot** is made by mixing polyester and cotton.
- **Terrycot** is made by mixing Terylene and cotton.

Uses of Polyester

Since polyester is strong, wrinkle-resistant and water-resistant, it has several uses. It can be used to:

- Make a variety of textiles (including sarees, curtains, dress materials etc.) and can be blended with natural fibres (like cotton and wool)
- Make films, magnetic recording tapes, etc. (as Mylar)
- Make sails of sailboats
- Make water hoses for firefighting purposes

4. Acrylic

- Acrylic is a strong, lightweight and warm synthetic fibre that resembles wool. It is available in a number of colours and is more durable and affordable than natural wool.
- The word 'acrylic' means 'containing acryl (or acrolein)'. Acrolein is a chemical known for its pungent, irritating smell, and its name has roots in two Latin words - 'acer'

which means 'sharp', and 'olere' which means 'to smell'.

Special property of acrylic clothes

Woollen clothes need naphthalene balls to protect them from attack by insects. Acrylic is synthetic wool and is hence, resistant to the action of moths and insects.

Uses of Acrylic Fibre

Acrylic can mimic wool as well as cotton at times and is **hypoallergenic** in nature. It means that people who have sensitive skin can wear it easily. Some acrylic fibres are very resilient – more than other natural or synthetic fibres. It can be used to:

- Make woollen clothes like hats, scarves, gloves, sweaters, blankets, and other home-furnishing fabrics.
- Make fake fur used for making toys and fur accessories.
- Make garments for babies (as the fabric is machine-washable).

Characteristics of Synthetic fibre

Made up of- all the synthetic fibres are manufactured by processing raw material of petroleum origin in a number of ways. The raw materials of petroleum origin are called Petrochemicals.

Advantages of using Synthetic fibres

- Colour resistant
- Do not bleed colour when washed
- Do not shrink when washed
- Easily available
- Easy to wash and dry
- Less expensive
- More elastic
- Resistant to moth attacks
- Stronger
- Tough and durable.

Disadvantages of Synthetic fibres

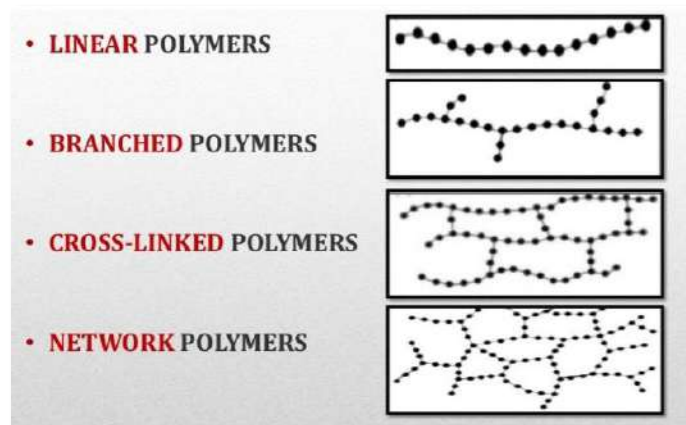
- Cannot absorb Moisture (hence, not good for summers when we sweat more)
- Catch fire easily (and hence, should not be worn when we are near fire).
- Difficult to iron (as they can melt because of heat).

Why should we not wear synthetic clothes in the kitchen?

Synthetic fibres melt on heating. If the clothes catch fire, the fabric made up of synthetic fibres will melt and stick to one's body. Hence, it is recommended that one should not wear synthetic clothes while working in the kitchen or laboratory.

Plastic

Plastic is a polymer (like the synthetic fibre) which can be moulded into different shapes. The word 'plastic' originates from the Greek word 'plastikos' which means 'that can be moulded or shaped'. Plastic polymers can have different types of arrangement of monomers:



Some popular types of plastics are:

1. Thermoplastics

- Plastics which can be deformed and bent easily on heating are known as thermoplastics.
- Thermoplastics are often used for manufacturing toys, combs and various types of containers
- Polythene and PVC are examples of thermoplastics
 - **Polythene**-It is commonly used for making plastic bags. The term is made up of poly (which means many) and ethene (the monomer for polythene).
 - **PVC- PVC (Polyvinyl Chloride)** is a strong but lightweight plastic. It can be rigid (which is used in construction) or flexible (which is used for making bottles, non-food packaging and bank cards)It can be made softer and more flexible by adding

plasticizers which can be used for plumbing, flooring, imitation leather, electrical cable insulation, inflatable products, as a rubber alternative etc.

2. Thermosetting Plastics

- Plastics that cannot be softened by heating (after being moulded once) are known as thermosetting plastics.
- Bakelite and Melamine are the examples
 - **Bakelite**- It is poor conductor of heat and electricity and hence, is used for making handles of utensils, electrical switches etc.
 - **Melamine**- it is a versatile material which is fire-resistant and can tolerate heat better than other types of plastics. Hence, it is used for making floor tiles, fabrics and resists fire, and kitchenware.

Plastics as material of Choice

Because it is

- Lightweight
- Has lower price
- Good strength
- Easy handling
- Not reactive (does not rust like iron when exposed to water and air, and doesn't corrode easily)
- Poor conductor of heat and electricity

Some key facts

- **Buckets** are made of plastic these days because plastic buckets are strong, lightweight, and do not rust.
- **Bakelite** plastic is used to make electrical switches because Bakelite is a poor conductor of heat and electricity. Hence, they would not give anyone an electric shock when someone touches the switch.
- **Melamine** is used to make crockery because Melamine is break resistant, fire resistant, and tolerate heat better than plastics. Hence, it can be used to make crockery that can hold hot liquids or dishes served in it.
- Plastics are used in cars, aircraft and spacecraft because plastics are strong, durable, lightweight, and corrosion-resistant.
- Chemicals are stored in plastic bottles because plastic bottles are lightweight, break resistant,

corrosion-resistant, and are resistant to the action of chemicals. Hence, they are suitable for storing chemicals.

Which plastic is used to make-

- Non-stick coating on Cookware: **Teflon**
- Insulation covering on Wires: **PVC**
- Polythene Bags: **Polythene**
- Flame-resistant Uniforms: **Melamine**

Notable uses of plastics

Besides being used in packaging for food and non-food items and several daily-used items (such as furniture, electrical switches, slippers etc.), plastic also has special uses such as:

- Used in the healthcare industry for packaging of tablets, syringes, doctor's gloves, a number of medical instruments, and threads for stitching wounds.
- Used to make cookware used in microwave ovens
- Used as a non-stick coating on cookware (made of a special plastic called Teflon is used on which oil and water do not stick)
- Used to make the fire-resistant uniform for firefighters (made of Melamine)



Plastics and Environment

Plastic is a threat to the environment as it is non-biodegradable. Its disposal is a big problem.

- **Biodegradable:** Material which gets decomposed through natural processes (such as bacterial action) is called Biodegradable.
- **Non-biodegradable:** Material which cannot be easily decomposed by natural processes is called Non-biodegradable.

Plastics contribute to the environmental pollution as

- Plastics are non-biodegradable, and
- Release toxic fumes when burnt (and hence, cause air pollution)

Strategy to minimize the Environmental pollution caused by plastic

- **Refuse:** Do not buy things we do not need.
- **Reduce:** Minimize the use of plastics in our daily lives.
- **Reuse:** Reuse the items we already instead of throwing them away.
- **Repurpose:** If we are not using something, alter or change to use it in a different way.
- **Recycle:** Some plastic waste can be sorted and made into other things in recycling factories. This helps us to reduce our carbon footprint.

Home strategy

We should use jute, cotton, or paper bags instead of plastics. We also need to minimize the use of plastic in our daily lives (such as using a steel lunch box instead of a plastic one). Also, we should not throw plastics on the road or in the water bodies.

What is Resources?

Resources is the source or supply from which we can benefit in some way.

Types of resources-

- **Natural Resources-** A natural resources is something we can obtain from nature, such as wind, soil, water, and air.
- **Man-made Resources-** A man-made resources is something made by humans for their consumption. They are not available naturally.

Natural resources can be of two types as-

1. Inexhaustible Natural Resource-

- The resources that occur naturally and are unlimited in nature are called inexhaustible natural resources.
- They do not get exhausted by human activities, such as air and sunlight.

2. Exhaustible Natural Resources-

- The resources that occur naturally but are called exhaustible natural resources.
- These resources can get exhausted by human activities and might disappear altogether or take hundreds or thousands of years to replenish. For example, forests, wildlife, minerals, coal, petroleum, natural gas etc.

Coal, Petroleum and natural gas are exhaustible natural resources. They are fossils fuels.

Fossil fuels are fuels that are formed by fossils (or dead remains) of living Americans.

What are fuels?

A fuel is any substance that releases large amounts of energy in the form of heat and light when it is burned. For example, coal and petroleum are fuels.

Classification of Fuels	definitions	examples
Solid Fuels	These fuels exist in a solid state at room temperature	For example, coal, firewood, animal dung cakes, charcoal, coke
Liquid fuels	These are volatile liquids that produce vapour which	For example, petrol, diesel, kerosene

	burns and produces energy	
Gaseous Fuels	These are the fuels that exist in the form of a gas or as a mixture of different gaseous fuels.	For example, natural gas, biogas, CNG, coal gas

Why do we need Fossil fuels?

Fuels are required for different purposes such as:

1. **Transportation:** fuels are used to run different vehicles such as cars, trucks, motorcycles, trains, airplanes etc.
2. **Cooking:** fuels are needed for cooking. For instance, LPG is used in urban areas while firewood, coal and cattle dung is used in rural areas.
Heating: fuel is also used to generate heat
3. **Electricity production:** different fuels such as coal, petrol, natural gas and diesel are used to generate electricity in power plants
4. **Industrial usage:** many industries use fuels for different purposes such as producing electricity, running their machinery and heating

Rockets and other space vehicles: fuels called propellants are used in rockets that help in launching the space vehicles.

Characteristics of good fuel-

1. It should be economical.
2. It should be available easily
3. It should not emit poisonous gases on burning
4. It should produce large amounts of heat with respect to its mass (it should have a high calorific value)
5. It should be easy to transport and handle
6. It should not produce a bad odour
7. It should be clean and should not produce many ashes
8. It should not ignite easily at room temperature

Coal

Coal is a fossil fuel formed from dead plant matter over millions of years due to heat and pressure.

Story of formation of coal

- About 300 million years ago the earth had dense forests in low lying wetland areas. Due to natural

processes, like flooding, these forests got buried under the soil.

- As more soil deposited over them, they were compressed. The temperature also rose as they sank deeper and deeper. Under high pressure and high temperature, dead plants got slowly converted to coal.
- As coal contains mainly carbon, the slow process of conversion of dead vegetation into coal is called carbonisation. Since it was formed from the remains of vegetation, coal is also called a fossil fuel.

Composition of the coal-

- Coal consists of hydrogen, carbon and oxygen and sulphur (small amount).

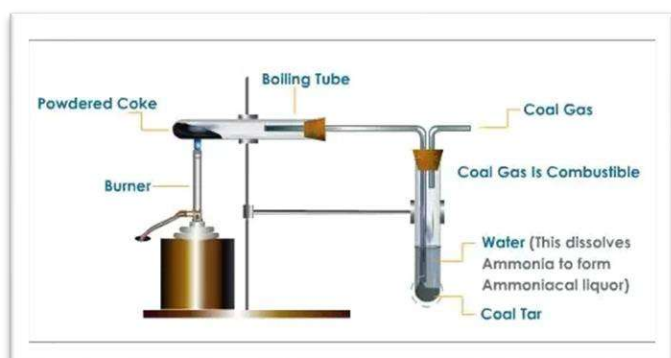
Coal mining- Coal is extracted from the ground with a process called mining. Coal Mining can be of two types:

1. **Open cast mining-** Mining in which coal is extracted from near the earth's surface.
2. **Underground Mining-** mining in which coal is extracted from deep inside the earth's surface.

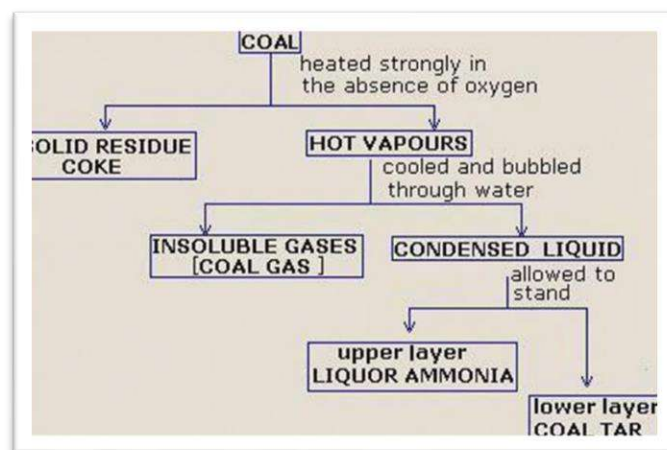
Different types of coal

- As coal gets older, the carbon content in it is higher. When coal is burnt, it mainly produces carbon dioxide gas.
- Peat
- Lignite
- Bituminous or sub bituminous coal
- Steam coal
- Anthracite
- Graphite

What is destructive distillation?



It is a process in which coal is heated at very high temperature in the absence of air to obtain various useful products from it. Consider the diagram below to understand the process of destructive distillation. Different products obtained through this process are coal gas, coal tar, and coke and liquor ammonia.



Major Coal Products

1. **Coke-** It is a tough, porous and black substance. It is an almost **pure form of carbon**. Coke is used in the manufacture of steel and in the extraction of many metals.
2. **Coal Tar-** it is Black, thick liquid with unpleasant smell. It is mixture of about 200 substances. Coal Tar yields many products that are used as raw materials to manufacture drugs, explosives, naphthalene balls, perfumes, synthetic dyes, paints, plastics, roofing materials, photographic materials etc. Earlier, coal tar was used for metalling the roads. Now, bitumen (a petroleum product) is used for the purpose.
3. **Coal Gas** – It is By-product of processing of coal to get coke. It is used in many industries as fuel. Mainly used as heat source (and not as a light source). Once used for street lighting. It was used for this purpose for the first time in London in 1810, and for the first time in New York in 1820.

If coal reserves get depleted?

- Coal is being used as a major source of energy in industries as well as rural areas.
- Not only this, it serves various other purposes like the synthesis of synthetic oil, natural gas, coke, coal tar and coal gas.
- If the amount of coal gets depleted it would become much difficult for us to produce energy

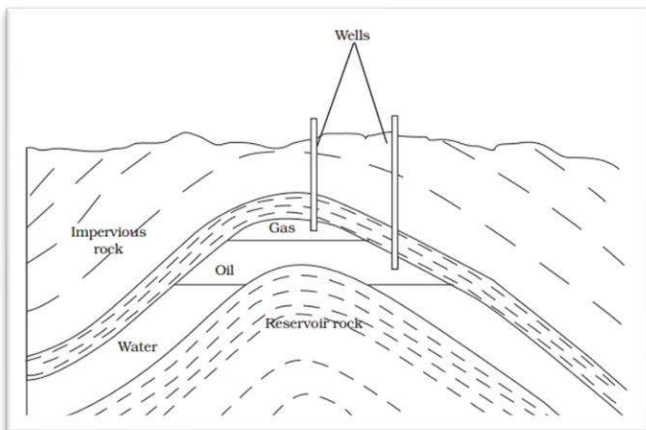
for various purposes. Hence, we must use coal in an efficient way.

Pollutants released when coal burns

1. Carbon dioxide
2. Carbon monoxide
3. Sulphur Dioxide
4. Nitrogen Oxides
5. Lead
6. Arsenic
7. Mercury

Petroleum

- It's also referred to as black gold because to a large extent Nation's economy depends on its petroleum wealth.
- Petroleum or crude oil is a sticky liquid with a foul smell because of the presence of compounds containing Sulphur
- It's formed from the dead remains of land and sea creatures, that got buried under the ocean or sea millions of years ago.
- As more and more sediments deposited on top of them, the heat and pressure gradually changed the layers at the bottom into petroleum and natural gas.
- Petroleum is taken out using an oil rig with the evolution of natural gas



Note some facts

- First Oil Well in the World was drilled in Pennsylvania, USA in 1859.
- Second Oil Well in the World was drilled in Makum, Assam, India in 1867 (after eight years).

In India, the oil is found in:

- Assam,
- Gujarat
- Mumbai high
- River basins of Godavari and Krishna



How refining of petroleum is done?

- Originally, petroleum is a mixture of many things, such as petrol, diesel, petroleum gas, paraffin wax, lubricating oil etc.
- It is a dark and oily liquid with an unpleasant odour.
- Refining of petroleum is the process by which different constituents of petroleum are separated.
- This process takes place in a petroleum refinery.

Constituent of Petroleum and its uses

Constituent	Uses
Liquid petroleum gas	Used as fuel at home and as industry.
Petrol	Used as a fuel in motor vehicle and aviation industry, and as solvent in dry cleaning
Kerosene	Used as fuel in stoves and lamps, and also in jet aircrafts
Diesel	Used as a fuel in electric generators as well as heavy moto vehicles
Lubricating oil	Used for lubrication in machinery

Paraffin wax	Used to manufacture ointments, candles, vaselines etc.
Bitumen	used to manufacture paints or for road surfacing.

Petroleum as Black Gold

Petroleum is called 'black gold' because it yields several substances that are commercially successful. The useful substances obtained from petroleum and natural gas are called 'petrochemicals'.

Petrochemicals are used in manufacturing:

- Synthetic fibres (such as Polyester, Nylon, Acrylic etc.),
- Detergents,
- Polythene, and
- Man-made plastics.

Natural Gas

Natural gas is a fossil fuel found naturally as a hydrocarbon gas mixture in the oil wells. Its main component is methane but it may also contain varying amounts of other higher alkanes (a group of elements). Gases like carbon dioxide, helium, nitrogen, and hydrogen sulphide are also found in natural gas in small percentages.

It is important source because,

- Natural gas is considered important as this fossil fuel can easily be transported through pipes.
- It is stored as CNG which is used for several purposes and is also used as a starting material for manufacturing many chemicals and fertilisers.
- Natural Gas does not cause pollution and has high calorific value.

Compressed natural Gas

- **Compressed natural gas (CNG)** is a fuel gas mainly composed of methane (CH_4), compressed to less than 1% of the volume it

occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 20–25 megapascals (2,900–3,600 psi), usually in cylindrical or spherical shapes.

- CNG is used in traditional petrol/internal combustion engine vehicles that have been modified, or in vehicles specifically manufactured for CNG use: either alone (dedicated), with a segregated liquid fuel system to extend range (dual fuel), or in conjunction with another fuel (bi-fuel). It can be used in place of petrol (gasoline), diesel fuel, and liquefied petroleum gas (LPG). CNG combustion produces fewer undesirable gases than the aforementioned fuels. In comparison to other fuels, natural gas poses less of a threat in the event of a spill, because it is lighter than air and disperses quickly when released. Biomethane refined biogas from anaerobic digestion or landfills – can be used.

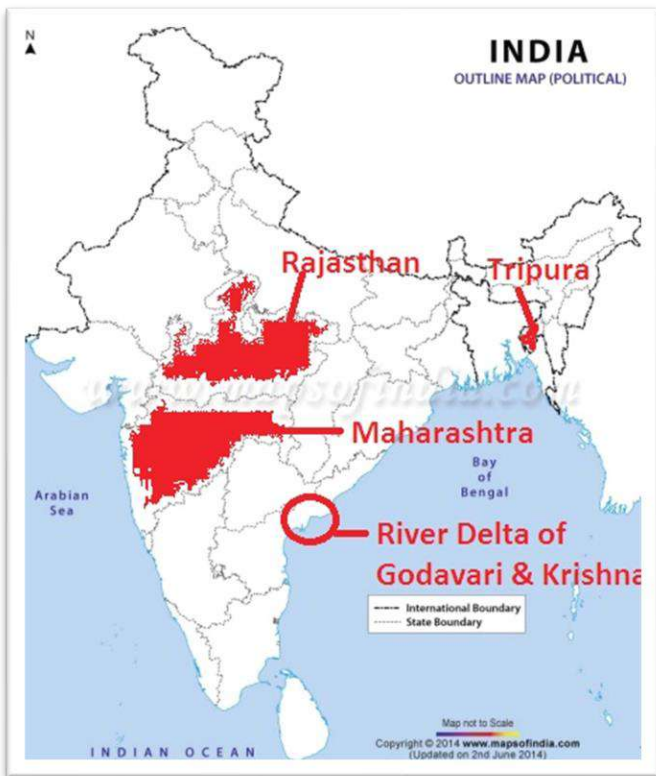
Uses of CNG?

- Fuel to generate power
- Cleaner fuel for transport vehicles (less polluting than petrol and diesel)
- Fuel in homes and industries which can be supplied through pipes.
- CNG pipeline network already exists in Vadodara in Gujarat, some parts of Delhi and some other places.

It is one of the cleaner fuel because

- Natural gas is considered a better fuel than coal and petroleum because it is cleaner.
- This means that it results in less amount of pollution than the other fossil fuels.
- Natural gas emits 50% less carbon dioxide, sulphur and nitrogen oxides in the air.
- However, it is not the best solution as there are better sources of energy present nowadays like solar energy.

India's vast reserves of Natural Gas



Its limited treasure- Fossil fuels, such as coal, petroleum, and natural gas cannot be created in the laboratory as it is not possible to create the natural conditions under which they are formed. Moreover, it takes thousands of years for them to be formed.

Consequences of the burning of fossils fuels

- The Intergovernmental Panel on Climate Change (IPCC) has found that emissions from fossil fuels are the dominant cause of global warming. In 2018, 89% of global CO₂ emissions came from fossil fuels and industry.
- Coal is a fossil fuel, and is the dirtiest of them all, responsible for over 0.3C of the 1C increase in global average temperatures. This makes it the single largest source of global temperature rise.
- Oil releases a huge amount of carbon when burned - approximately a third of the world's total carbon emissions. There have also been a number of oil spills in recent years that have a devastating impact on our ocean's ecosystem.
- Natural gas is often promoted as a cleaner energy source than coal and oil. However, natural gas is still a fossil fuel and accounts for a fifth of the world's total carbon emissions.

Can we keep burning fossil fuels?

- The IPCC warns that fossil fuel emissions must be halved till 2030 if global warming is to be limited to 1.5°C above pre-industrial levels.
- In 2015, the world's governments signed up to the Paris Agreement committing to reduce carbon emissions. However, a recent report by the UN Environment Programme shows that globally, we are on track to produce more than double the amount of coal, oil and gas by 2030 than we can burn if we are to limit global warming by 1.5C. So more needs to be done.

What's the role of fossil fuel companies in the future of our planet?

- Fossil fuel companies remain huge polluters, producing and selling fossil fuel products while scientists say we need a mass switch to renewable energy and efficiency. In 2019, BP spent millions on an advertising campaign about its low-carbon energy and cleaner natural gas. While its advertising focused on clean energy, in reality, more than 96% of BP's annual expenditure is still on oil and gas. And it is definitely not just BP - it's an industry-wide problem.
- That's why, in December of 2019, we lodged a complaint with the UK National Contact Point about BP's adverts. We also launched a campaign calling for a ban on fossil fuel advertising unless it comes with a tobacco-style health warning. Because the public should know the whole truth about fossil fuels.
- In February 2020, BP withdrew its advertisements and its CEO Bernard Looney said they would not be replaced under the company's new policy promising an end to 'corporate reputation advertising'. He also committed BP to redirecting its advertising resources towards advocating for progressive climate policies.

Can we save petrol and diesel while driving?

According to the Petroleum Conservation Research Association (PCRA) in India, we can save petrol or diesel while driving by:

1. Drive at a constant and moderate speed.
2. Maintain tyre pressure at correct levels.

3. Switch off the engine when you are waiting (such as traffic light).
4. Do regular maintenance of your vehicle.

Why fossil fuels can last for 100 years only?

- Fossil fuels are exhaustible resources which mean that they are not present in abundant quantities on the earth.
- They take hundreds and thousands of years to replenish.
- The rate at which they are being consumed today is increasing at a rapid pace.
- It means that more amounts of fossil fuels are being used than it is being replenished.

Introduction**What is cell?**

A Cell (from Latin cella, meaning "Small Room") is the basic Structural, Functional, and Biological unit of all known Living Organisms. A cell is the **Smallest Unit of life** that can replicate independently, and cells are often called the "**Building Blocks of Life**".

- Organisms differ from one another but all are made up of cells. Cells in the living organism are complex living structures unlike non-living bricks.

Note- the egg of a hen is a single cell which can be seen by the naked eye.

- Cell is the structural and functional unit of life. It is the basic unit of life.
- It is discovered by Robert Hook in 1665 in cork slice with the help of primitive microscope.
- Leeuwenhoek (1674), discovered the free living cells in pond water with the improved microscope.
- Robert Brown discovered the nucleus in the cell in 1831.
- Purkinje coined the term 'protoplasm' for the fluid substance of the cell in 1839.

Discoveries about cells- the fundamental unit of life

Discovered by	Period of time	What did they discover
Robert Hooke	1665	He noticed the presence of cells in a cork slice.
Leeuwenhoek	1674	He found the presence of living cells in the pond water
Robert Brown	1831	Recognized the existence of nucleus in the cell
Purkinje	1839	Invented the term Protoplasm which is liquid present in a cell.
Schleiden and Schwann	1838,39	Presented the cell theory that all organism are actually made up of cells.
Virchow	1855	Suggested that all cells come from cells that already exist in nature

Organism show Variety in cell number, shape and size.

To study cells, scientists use microscopes to magnify them. They often use stains (dyes) to colour parts of the cell and study them in detail.

- Number of cells-** There are billions and trillions of cells in a tall tree or a large animal. A human body also has trillions of cells which have different shapes, sizes and functions.
 - Organisms can be of two types:
 - Multicellular Organisms** are made up of more than one cell. For Example, Mango Tree and Frog.
 - Unicellular Organisms** are made up of a single cell. For Example, Amoeba and Paramecium.

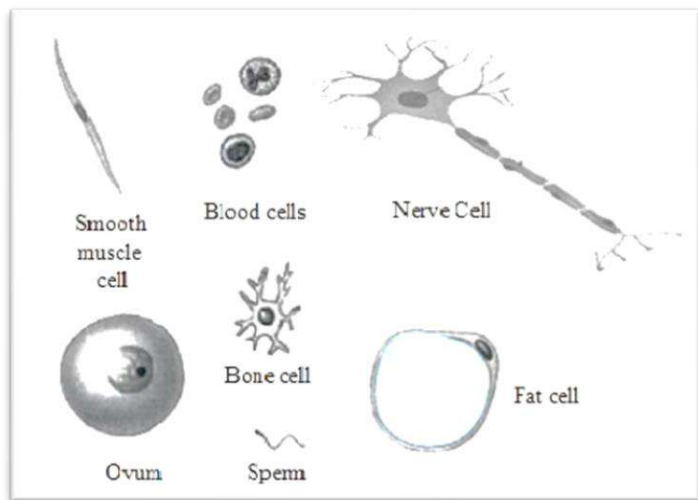
Do you know-?

- Multicellular organisms with billions of cells also start their life as a single cell. The fertilised egg (which is a single cell) multiplies to form more cells as the organism develops.
- Single-celled organisms also perform all the necessary life functions like multicellular organisms, including: ingestion, respiration, excretion, reproduction, and growth.
- The only difference is that while a single cell performs all the functions in the unicellular organisms, multicellular organisms have a specialised group of cells to perform different functions. The specialised cells form **tissues**, which in turn form organs.

Shape of cells

- Amoeba**, which is a single-celled organism, does not have a definite shape. Its shape keeps changing as it moves or feeds, protruding parts of its body to form 'pseudo' (meaning 'false') 'podia' (meaning 'feet'). These projects are known as **pseudopodia**.
- Humans have millions of cells, such as white blood cells (found in blood), cells that make up muscles, and cells that form nerves. Their shapes vary according to the functions they perform.
- Most cells are round, spherical or elongated. Some are spindle-shaped which are long and pointed at both ends. Nerve cells or neurons are

quite long and are branched out to receive and transfer messages.



- Shapes of the cells are maintained by a covering called **Cell Membrane or Plasma Membrane**.
- Bacterial cells and plant cells have an additional rigid covering called a **Cell Wall**.

Size of cells

The size of the cells may vary from a millionth of a metre (known as a micron) to a few centimetres but most of them cannot be seen with the naked eye. We need microscopes to see these microscopic cells.

It is not necessary that the size of cells of a large animal (such as an elephant) will be larger than cells of a small animal (such as a rat). The size of the cell depends on the function it performs. For example, nerve cells of a rat and nerve cells of an elephant perform the same functions and hence, are of the same size.

- **Smallest cell** is found in bacteria and is just 0.1 to 0.5 micrometre long.
- **Largest cell** is an ostrich's egg which has an area of about 17 cm × 13 cm

Facts about human cell

- **Ovum** in females is the largest whereas **sperm cell** is the smallest cell inside the human body.
- Brain contains nerve cells which are said to be **neurons**.
- Liver cells are said as **Hepatocytes**.
- Kidney cells are known to be **nephrons**.

The Cell Theory

- The theory that all the plants and animals are composed of cells and the cell is the basic unit of life, was presented by two biologists, **Schleiden and Schwann**.
- The cell theory was further expanded by Virchow by suggesting that all cells arise from pre-existing cells.

Types of Organism

On the basis of no. of cells, organisms are of two types:

- (I) **Unicellular Organism**- These organisms are single celled which perform all the functions. Example: Amoeba, paramecium, bacteria.
- (II) **Multicellular Organism**- Many cells grouped together to perform different function in the body and also form various body parts. Example: fungi, plants, animals. Every multicellular organism has come from a single cells of their own kind.

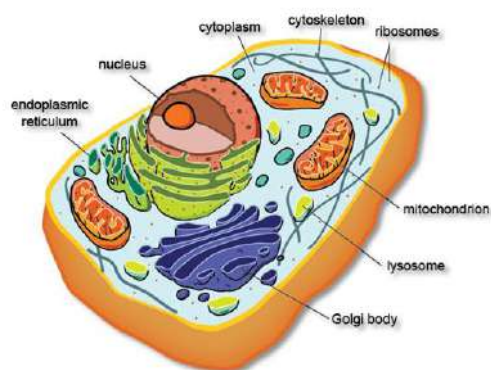
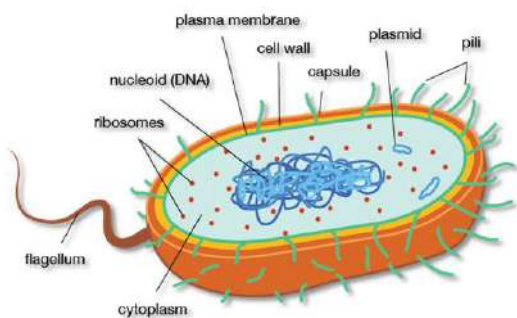
Types of Cells

There are two types of cells

a. Prokaryotes

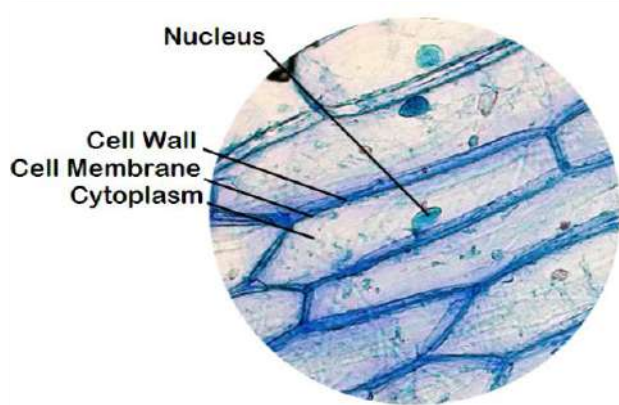
b. Eukaryotes

Prokaryotes	Eukaryotes
Cells of organism lacks nuclear membrane	Cells of organism have nuclear membrane
Nucleolus is absent	Nucleolus is present
Single Chromosomes	Single or multi-chromosomes
Reproduction is always asexual	Reproduction is both sexual and asexual
Always unicellular	Often multicellular
Membrane bound cell organelles are absent	Membrane bound organelles are present like mitochondria
Centriole is absent	Centriole is present only in animal cells
Cell divisions is by binary fission	Cell division is by mitosis or meiosis
Example: bacteria, blue green algae, etc.	Example: Fungi, plant cells, animals cells



Experiment to observe the basic components of a plant cell

- Peel an onion.
- Place a small piece of the dry and thin onion peel in a drop of water on a glass slide.
- Put a drop of methylene blue solution on this thin layer and place a coverslip on it (while ensuring that no air bubbles get trapped in the coverslip).
- Place the slide under the microscope.



Key Observations

- The boundary of the onion cell is a cell membrane, which is covered by another thick covering called the cell wall.
- The dense round body in the centre of the cell is called the nucleus.

- The jelly-like substance between the cell membrane and the nucleus is called the cytoplasm.

To observe the basic components of an animal cell

- Scrape the inside of your cheek lightly with a clean toothpick.
- Place it in a drop of water on a glass slide.
- Add a drop of iodine solution or methylene blue solution and place a coverslip on it.
- Place the slide under the microscope.

Key observations-

- Cell membrane (Cell wall is absent in animal cells),
- Nucleus, and
- Cytoplasm.

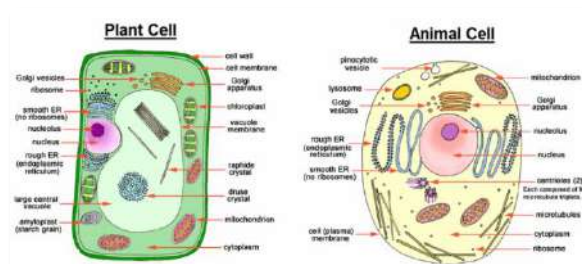
Comparison of plant and animal cells

Now, we know that both plant animal's cells have-

- Cell membrane
- Cytoplasm
- Nucleus
- Nuclear membrane

We also know that only plant cells, bacterial and fungal cells have cell walls.

Let's compare plant and animal cells

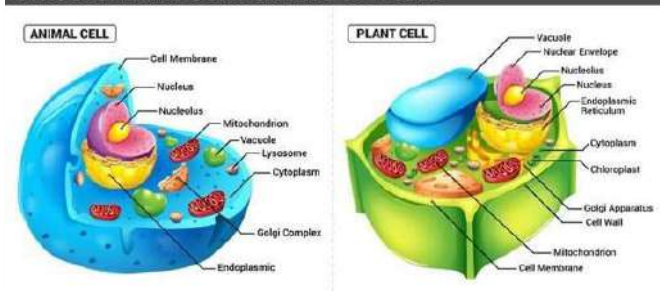


Cell part	Animal cell	Plant cell
Cell wall	Absent	Present (Formed of cellulose)
Shape	Round (Irregular shape)	Rectangular (Mixed shaped)
Vacuole	One or more small vacuoles (much smaller than plant cells)	One large central vacuole taking up 90 % of cell volume.

Centrioles	Present in most animal cells.	Only present in lower plant forms absent in higher plants.
Chloroplasts	Animal cells don't have chloroplasts	Plant cells have chloroplast. They make their own food
Plastids	absent	Present
Plasma membrane	Only cell membrane present	Cell wall and a cell membrane
Lysosomes	Lysosomes occur in cytoplasm	Lysosomes are less common or absent in most plant cells (functions often performed by vacuoles)

What is cell made up of? What is the structural Organisations of a cell?

STRUCTURE AND COMPONENTS OF A CELL



A cell contains three important components-

- The plasma membrane
- Nucleus
- Cytoplasm

Let's see the details of it.

a. The plasma Membrane

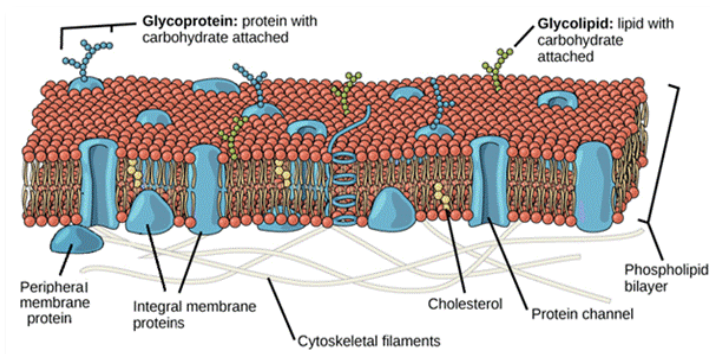
- It is just like an envelope that covers the whole cell. Therefore, a cell gets separated from the external environment because it has a plasma membrane.
- The plasma membrane can decide which materials should enter or leave the cell and which should not. That is why it is also called a 'Selectively Permeable Membrane'.

The Fluid Mosaic Model of Plasma Membranes

- The Fluid Mosaic model explains the structure of the plasma membrane. According to it, the plasma membrane comprises 3 components -

Lipids, Proteins and Carbohydrates. These components can flow freely and fluidly inside the plasma membrane.

- There are two types of lipids (fats) in the plasma membrane -
 - Phospholipid** - It is a lipid made up of glycerol, two fatty acids, and phosphate. It creates a semi-permeable membrane that allows the flow of only certain materials inside/ outside the cell
 - Cholesterol** - It is a lipid that provides fluidity to the surface of the plasma membrane.
- The **proteins** act as receptors of the cell and help in transportation across the cell membrane. The **carbohydrates** attach themselves with the lipids and proteins and are found on the extracellular side of the membrane.



Movement of substances, In and Out of a cell
Gaseous Exchange between the Cell and its External Environment -

- Movement of Oxygen and Carbon dioxide to and from the cell is carried out through **diffusion**. (spontaneous movement of a substance from a region of high concentration to a region where its concentration is low)
- Gaseous substances tend to move to areas where their concentration is less from the areas where there is higher. This movement is defined as the process of diffusion. Diffusion can take the place of solids, liquids, and gases.

Movement of water between the cell and its external Environment

It is carried out by the means of **osmosis**. Osmosis is a process in which water moves from the region of high concentration to one where its concentration is low through a semipermeable membrane. Therefore

we can say that Osmosis is just a special case of the process of diffusion.

Name of Solution	Conditions	Result
Hypotonic Solution	Medium surrounding the cell has higher water concentration than the cell	Cell will gain water by the process of osmosis and likely to swell up.
Isotonic solutions	Medium has exactly same water concentration as the cell.	Water crosses the cell membrane in both directions. Cell will stay the same size.
Hypertonic Solutions	Medium has lower concentrations of water than the cell.	Water crosses the cell in both directions, but more water leaves the cell and result it shrinkage of cell

What is Endocytosis?

It is a process by which the plasma membrane engulfs food and other materials inside the cell.

b. Cell Wall

- Cell wall is another rigid outer covering in addition to the plasma membrane found in plant cell. The cell wall lies outside the plasma membrane.
- The plant cell wall is mainly composed of **cellulose**. Cellulose is a complex substance which provides structural strength to plants.

Function of cell wall

- Cell walls permit the cells of plants, fungi and bacteria to withstand very dilute (hypotonic) external media without bursting.
- In such media the cells tend to take up water by osmosis. The cell swells, building up pressure against the cell wall. The wall exerts an equal pressure against the swollen cell.
- Because of cell wall, cells can withstand much greater changes in the surrounding medium than animal cells.

What is Plasmolysis?

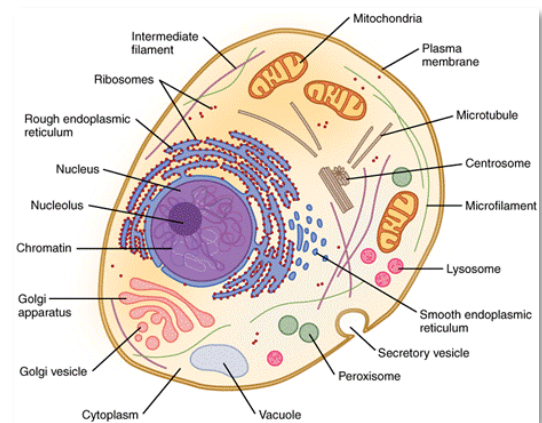
Plasmolysis is a process in which the contents of the

cell that are away from the cell wall shrink or contract when a cell loses water due to Osmosis when it is kept in hypertonic solution.

Note- Dead cell cannot absorb water through osmosis. Plants, fungi and bacteria exist in such situations because of their rigid cell wall. Even if the cells swell up the cell wall is able to prevent them from bursting out.

c. Nucleus

- Nucleus is a prominent organelle present in the cell which is the controlling centre of all activities of the cell.
- It is called the **brain of the cell**.



Structure of the Nucleus

- A nucleus has a nuclear membrane that covers it all around.
- There are pores present on the nuclear membrane that allow the movement of substances in and out of the nucleus.
- There are **chromosomes**, rod-shaped structures present in the nucleus which contain genetic information. These are visible only when the cell is about to divide.

Functions of Chromosomes

- Chromosomes contain information for inheritance of features from parents to next generation in the form of **DNA (Deoxyribonucleic Acid)** molecules. Chromosomes are composed of DNA and protein.
- DNA molecules contain the information necessary for constructing and organising cells.
- Functional segments of DNA are called **genes**.
- In non-dividing cell, this DNA is present as part of **chromatin material**.

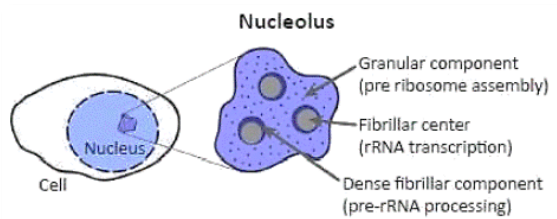
- Chromatin material is visible as entangled mass of thread like structures. Whenever the cell is about to divide, the chromatin material gets organised into chromosomes and perform cell division.

The chromosomes contain two types of things

- DNA-** This is responsible for organising and constructing new cells.
- Proteins-** These help in the packaging and condensation of DNA.

Nucleolus

It is called the ribosome factory. It consists of proteins and ribonucleic acids (RNA). It helps in the formation of ribosomes which help in the formation of proteins inside the cell.



Nucleoid- Sometimes cells do not have a well-defined nucleus because they lack a nuclear membrane. Such a nucleus with no definite nuclear boundaries is called a Nucleoid. Such an undefined nuclear region containing only nucleic acids is called a nucleoid.

Functions of Nucleus

- The nucleus plays a central role in cellular reproduction. It is the process by which a single cell divides and forms two new cells.
- It also plays a crucial part, along with the environment, in determining the way the cell will develop and what form it will exhibit at maturity, by directing the chemical activities of the cell.

What is Gene?

Gene is a unit of inheritance in living organisms. It controls the **transfer of a hereditary** characteristic from parents to offspring. This means that your parents pass some of their characteristics on to you. If your father has brown eyes, you may also have brown eyes. If your mother has curly hair, you might also end up having curly hair. However, the different

combination of genes from parents result in different characteristics.

d. Cytoplasm

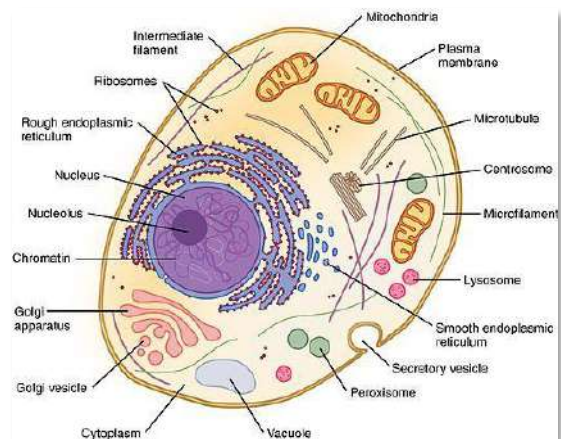
- The plasma membrane has a fluid-like substance in it which is called the cytoplasm.
- The cytoplasm contains several organelles that can perform distinct functions of the cell

Functions of Cytoplasm

- It supports and suspends the cell organelles and molecules.
- The cellular processes occur in the cytoplasm such as the formation of proteins.
- It allows the movement of substances in the cell such as hormones.
- Cellular wastes are present, dissolved in the cytoplasm (specifically the cytosol)..

The Cell Organelles

- In the case of Eukaryotic organisms, the cells contain organelles that have their own membranes apart from the overall cell membrane of the cell.



Significance of membrane-bound organelles in a cell?

The cells perform several functions. The organelles are useful because they allow the separation of different functions that are being performed by the cell.

Organelles which carry out important activities in a cell-

- Endoplasmic Reticulum
- Golgi Apparatus
- Lysosomes

4. Mitochondria
5. Plastids
6. Vacuoles
7. Centrioles
8. Ribosomes
9. Peroxisomes

Let's discuss each in details

1. Endoplasmic reticulum

- The endoplasmic reticulum (ER) is a large network of membrane-bound tubes and sheets.
- It looks like long tubules or round or oblong bags (vesicles).
- The ER membrane is similar in structure to the plasma membrane. It is also made up of lipid and proteins.

Types of Endoplasmic Reticulum

- **Rough Endoplasmic reticulum-** Rough ER contains **ribosomes** that are responsible for the manufacturing of proteins in the cells. They give a rough texture to the cell.
- **Smooth Endoplasmic reticulum-** The smooth ER manufactures fats or lipids in the cell which allow the functioning of the cell.

Functions of Proteins and Lipids

- Proteins and lipids synthesised on ER are used for making cell membranes. The process is known as **Membrane Biogenesis**.
- Proteins can act as an **enzyme**
- Both protein and lipids can act as **hormones**

Functions of Endoplasmic Reticulum

- RER looks rough under a microscope because it has particles called ribosomes attached to its surface. The ribosomes, which are present in all active cells, are the sites of protein manufacture. The manufactured proteins are then sent to various places in the cell depending on need, using the ER.
- The SER helps in the manufacture of fat molecules, or lipids, important for cell function.
- Some of these proteins and lipids help in building the cell membrane. This process is known as membrane biogenesis.

- Some other proteins and lipids function as enzymes and hormones.
- Although the ER varies greatly in appearance in different cells, it always forms a network system.
- One function of the ER is to serve as channels for the transport of materials (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus.
- The ER also functions as a cytoplasmic framework providing a surface for some of the biochemical activities of the cell.
- In the liver cells of the group of animals called vertebrates, SER plays a crucial role in detoxifying many poisons and drugs.

1.0 Golgi Apparatus

- Camillo Golgi discovered the Golgi apparatus.
 - It contains vesicles that are arranged parallel in stacks. These stacks are called **Cisterns**. These vesicles have their own membranes. These membranes are sometimes connected to those of the ER.
- Functions of Golgi Apparatus
 - Golgi apparatus carries materials synthesised by the ER to different parts of the cell. The material is stored and packaged in vesicles.
 - Formation of complex sugar
 - Formation of lysosomes.

2. Lysosomes

- They are single-membrane vesicles that are responsible for cleaning the cell. They can digest any foreign material such as food or bacteria and even the worn-out cell organelles.
- Lysosomes have membrane-bound structure whose sacs are filled with digestive enzymes.
- Mechanism of digestion of any foreign material that enters the cell Lysosomes are capable of doing so because they have digestive enzymes in them. These enzymes break the materials and digest them. These enzymes are synthesised by RER and packaged into lysosomes by golgi bodies

Why Lysosomes are called suicide bags?

Because if the cells of own cells gets damaged or dead, there are chances that lysosomes burst out, thus digesting own cells.

Functions of Lysosomes

- Lysosomes break foreign materials entering the cell, such as bacteria or food as well as old organelles into small pieces.
- They contain powerful digestive enzymes which are made in RER which is capable of breaking down all organic material made in RER.

3. Mitochondria

- Mitochondria are known as the powerhouses of the cell.

Structure of Mitochondria

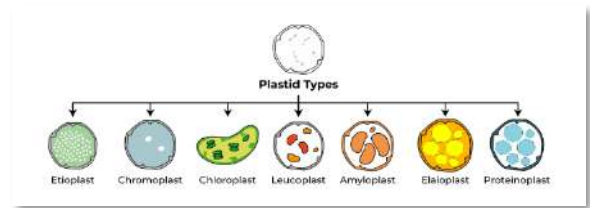
- Mitochondria have two membrane coverings.
- The outer membrane is very porous while the inner membrane is deeply folded.
- These folds create a large surface area for ATP-generating chemical reactions.
- The inner membranes of mitochondria called as cristae Facilitates Generations of ATP molecules as it has a larger surface area.

Functions of Mitochondria

- The energy required for various chemical activities needed for life is released by mitochondria in the form of ATP (**Adenosine triphosphate**) molecules.
- ATP is known as the energy currency of the cell. The body uses energy stored in ATP for making new chemical compounds and for mechanical work.
- Mitochondria have their **own DNA and ribosomes**. Therefore, mitochondria are able to make some of their own proteins.

4. Plastids

- Just like mitochondria, Plastids are also double membraned organelles that have their own DNA and ribosome.
- Plastids exist in plant cells and some algae. Depending upon the type of function they play in the cell they can be classified as –
- There are various types of plastids-



Some important one

Among plastids, chloroplasts are the most familiar: their internal thylakoid membranes house chlorophyll and the molecular machinery for the light - dependent reactions of photosynthesis, ultimately producing the sugars that fuel plant growth. In contrast, chromoplasts accumulate colorful carotenoid pigments (reds, oranges and yellows) that give ripe fruits and petals their vivid hues, aiding in pollinator and seed-disperser attraction. Leucoplasts, which lack pigments, specialize in storage and biosynthesis—amyloplasts store starch grains in roots and tubers, elaioplasts store lipids in seeds, and proteinoplasts concentrate or modify proteins in specific tissues.

Classification of Plastids

1. Amyloplast

- They are found in tubers, cotyledons and endosperm in plants.
- They are used to store starch.

2. Elaioplast

- They are found in epidermal cells of the plants
- They store oil.

3. Proteinoplast

- They are found in seeds and nuts.
- They store proteins.

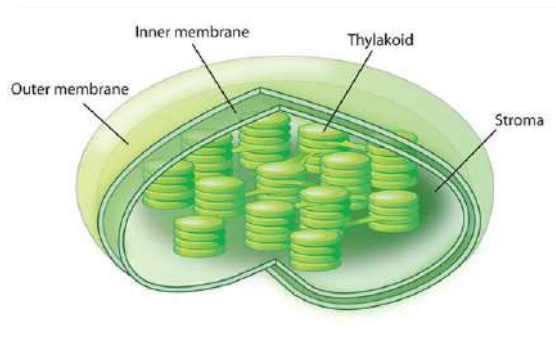
Chloroplasts

- Chloroplasts are cell organelles that conduct photosynthesis in plants.
- Chloroplast is derived from two Greek words Chloro and Plasts which means green and plants respectively.
- Chloroplasts contain photosynthetic pigments called 'Chlorophyll' along with lipids, carbohydrates, minerals, DNA, RNA, grana, thylakoids and stroma.
- The main functions of chloroplasts are:
 - Conducting photosynthesis in plants.
 - Protein synthesis

- Releases oxygen
- Storage of Starch

Structure of Chloroplasts

Light-dependent Reactions in Photosynthesis – During photosynthesis chlorophyll absorbs the light energy which is then used for two molecules ATP and NADPH.



Parts-

- **Thylakoids** – They are pillow-shaped compartments in the chloroplast. The light-dependent reactions in photosynthesis take place in the thylakoids.
- **Stroma** – It is a fluid-filled matrix in the chloroplasts. It is a colourless fluid that contains all the enzymes that are needed for the light-dependent reactions in Photosynthesis.
- **Grana** – Stacks of thylakoids are called Grana. They are found in the stroma. They provide a large surface area so that the reactions of photosynthesis can take place.

5. Vacuoles

- Vacuoles are the places where cells can store liquids and solids. They are present in both plants and animals but the plant vacuoles are bigger in size than the animal vacuoles.

Functions of vacuoles

- The central vacuole of some plant cells may occupy 50-90% of the cell volume.
- In plant cells vacuoles are full of cell sap and provide turgidity and rigidity to the cell.
- Many important substance in the life of the plant cell are stored in vacuoles which include amino acids, sugars, various organic acids and some proteins.

- In single-celled organisms like Amoeba, the food vacuole contains the food items that the Amoeba has consumed.
- In some unicellular organisms, specialised vacuoles also play important roles in expelling excess water and some wastes from the cell.

Difference between the Plant and animal cell vacuoles

Plant Cell Vacuole	Animal Cell Vacuoles
Plant cell vacuoles store all the material that is required for the plant to stay alive such as water	Animal cell vacuoles contain food items in unicellular organisms
Plant vacuoles maintain the turgidity of the plant cell	Animal vacuoles can also expel water and waste out of the cell
Plant cells generally contain a single large vacuole	Animal cell contain several small vacuoles
Plant vacuoles are present in the centre of the cell	Animal vacuoles are scattered throughout the cell

6. Centrioles

- **Verification:** Listed as an organelle. Numbering issue. Missing description.
- **Feedback:** Notes missing description and numbering error.

7. Ribosomes

- **Verification:** Listed as an organelle. Numbering issue. Missing description.
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8. Peroxisomes

- **Verification:** Listed as an organelle. Numbering issue. Missing description.
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Introduction

- A group of cells that are similar in structure and/or work together to achieve a particular function forms a tissue.
- For example, Muscles and Blood
- Cells within a simple tissue have the same structure and perform the same function. In complex tissues, different types of cells work together to perform a common function..

Tissues in plants and animals

Plant tissue	Animal tissue
Plants do not move so their tissues are predominantly the ones that provide support to them so that they can stand erect.	Animals need more energy as compared to plants because they are not stationary. Their tissues are the ones that can support the movement.
Some plant tissues, like sclerenchyma and cork, are made up of dead cells, which provide mechanical strength and require little maintenance.	The tissues in the case of animals are made up of living cells so that they can move and perform several functions.
Only certain parts of the plant can grow. The tissues present in such regions divide themselves and form new tissues.	Cells in animals grow uniform early and not only in certain regions of the body.
The structure of plant tissues is less specialised as compared to animals	The organs and organ systems in animals are highly developed.

Plant Tissue

Plant tissue are of two types

- Meristematic tissue**
- Permanent tissue**

Let's explain each in details

a. Meristematic tissue-

These are simple **living tissues** having thin walled compactly arranged immature cells which are capable of division and formation of new cells.

Features-

- Thin primary cell wall (**cellulosic**).
- Intercellular spaces are absent (compact tissue).

- Generally vacuoles are absent, dense cytoplasm & prominent nuclei are present.
- Large numbers of cell organelles are present.
- Active metabolic state, stored food is absent.
- Actively dividing cells are present in growing regions of plants, example: root & shoot tips.

Meristematic tissue classified on the basis of origin

- Primary (Promeristem) meristematic tissue**
- Secondary meristematic tissue**

Let's explain each in details

a. Primary Meristematic tissue

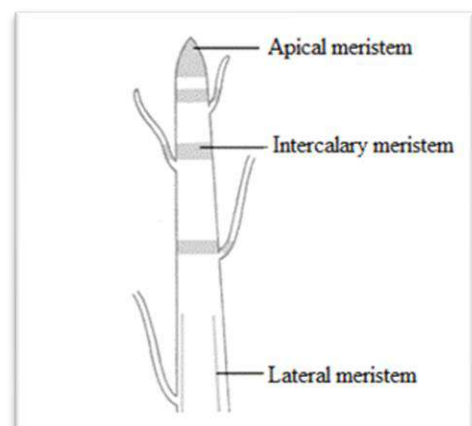
- Derived directly from the meristems of embryo.
- They add to primary growth of plants

b. Secondary Meristematic tissue

- Formed from permanent tissues through dedifferentiation.
- They consist of cells of permanent tissue that have regained the ability to divide.
- They usually add to the diameter of plants.

Meristematic tissue can be further classified differently based on the areas of the plants where they are **located**-

- Apical meristem
- Lateral meristem
- Intercalary meristem



Tissue	Characteristics
Apical Meristem	They are responsible for the growth of stems and roots in the plants They are found on the tips of the roots and stems.

Lateral Meristem	They are responsible for increasing the circumference of the middle part of the stem and hence are found there.
Intercalary meristem	These tissues are present at internodes of stem regions between the places at which leaves attach.

Note- Vacuoles are generally small or absent.

Because-

- The reason for small/absent large vacuoles in meristematic cells is related to providing space for the large nucleus and dense cytoplasm needed for rapid metabolic activity and division.

b. Permanent Tissue

- The cells that are formed by the meristematic tissues often have to take a certain role in the plant and thus, they lose their ability to divide and form more cells. They then become the permanent tissues of the plants.
- Differentiation** - The process by which cells of the meristematic tissues convert themselves into permanent tissue by taking a fixed shape, size and function is called differentiation.
- In cell differentiation, developing tissue and organs change from simple to more complex forms to become specialized for specific functions.
- The cells of permanent tissue lose the capacity to divide and attain a permanent shape, size and function.

Permanent tissue are classified into two types on the basis of structure and composition

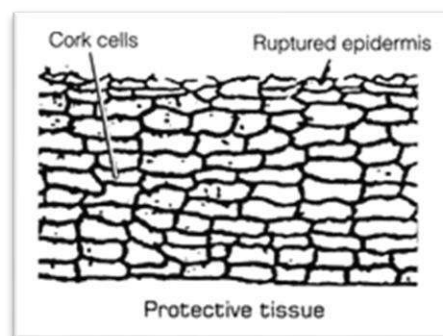
- Simple Permanent tissue
- Complex Permanent tissue

Let's explain each in details

1. Simple Permanent tissue

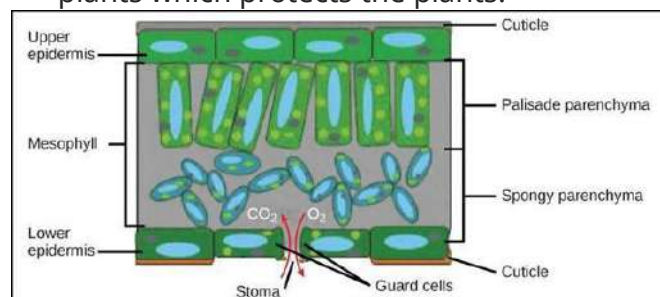
- These are made up of same type of cells which are similar structurally and functionally.
- Parenchyma, Collenchyma, and Sclerenchyma are the main types of Simple permanent tissue based on cell structure/wall properties, and they perform both supporting and protective (Epidermis, Cork) and other functions

(storage, photosynthesis). Epidermis and Cork are sometimes grouped as Protective Tissues, while Parenchyma, Collenchyma, and Sclerenchyma can be supporting (Collenchyma, Sclerenchyma) or fundamental (Parenchyma).



a) Epidermis-

- The outermost layer of the tissue is known as the Epidermis.
- It covers the entire plant.
- It is a thin layer of single cells but in places with less water, the epidermis of the plants can become thick in order to avoid frequent water loss.
- The cells are flat and they have no intercellular spaces between them.
- The outer walls of the epidermal cells are thick and the inner walls are thin.
- The epidermal cells often have long hair-like structures in roots which facilitate the absorption of water.
- The main function of the epidermis is to protect the plants from fungi, water loss and any injuries by secreting a wax-like water-resistant substance called a Cuticle on the surface of the plants which protects the plants.



Note- Stomata

- Stomata are pore-like structures that are present in the epidermis of the leaves.
- These pores are enclosed by two cells that have a similar shape as a kidney. These are

called **Guard Cells of Stomata**. Guard cells are modified epidermal cells.

- Guard cells are responsible for the exchange of gases and transpiration.

What is Transpiration?

The plant cells sometimes have extra they lose it in the form of water that evaporates through stomata. This process is called Transpiration.

Question: **Which gas is necessary for the process of photosynthesis?**

Carbon dioxide gas is necessary for the process of photosynthesis. Plants use carbon dioxide along with water and sunlight to produce glucose in the process of photosynthesis. Plants take in carbon dioxide and release oxygen as a by-product of the photosynthesis process.

Question: **Why do plants in desert areas have a waxy coating of cutting over them?**

The epidermis cells of plants that are found in deserts have a waxy coating of cutting over them because it prevents water loss from the surface of plants since water is already scarce in such areas.

- As a plant grows older and undergoes secondary growth, a lateral meristem called the cork cambium forms, which produces new protective layers called cork (phellem) to replace the epidermis.
- These are primarily dead cells that provide protection, rigidity, and contribute to the thickness of the branches.
- This is often called the Bark or the thick cork of the tree.
- The bark of the trees contains a substance called Suberin which makes it waterproof and does not allow gaseous exchanges.

Role of transpiration in plants

- **Exchange of Gases** – Stomata facilitate the exchange of gases (absorbing carbon dioxide and releasing oxygen).
- **Prevent the Plants from Overheating** - The leaves absorb sunlight during the process of photosynthesis. Some of it is used in the

photosynthesis process while the rest is radiated as Heat Energy. We know that absorption of water causes cooling of the surrounding area. Therefore transpiration keeps the leaves cool.

- **Transportation of Food and Water in Plants** – Transpiration creates a pull (transpirational pull) that draws water and minerals absorbed by the roots upwards through the xylem. They are then distributed throughout the plant through the transpiration stream.
- **Movement of Water in Plants** – As plants lose water in the form of water vapours, the density of water in leaves becomes low. So the water from the higher density areas such as the roots move up to lower density areas through a force called Transpirational Pull.

b) Cork/ Phellem

- In older roots and stems, tissues at the periphery become cork cells or phellem cells.
- Cork is made up to dead cells with thick walls and do not have any intercellular spaces.
- The cell walls in cork deposit waxy substance called as suberin.
- The cells of cork become impermeable to water and gases due to the deposition of suberin.
- After losing protoplasm upon death, cork cells are filled with air

Function of Cork

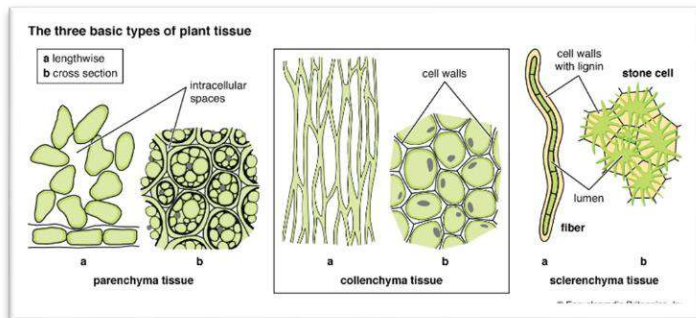
- Cork is protective in function. Cork cells prevent desiccation, infection and mechanical injury.
- Imperviousness, lightness, toughness, compressibility and elasticity make the cork commercially valuable.
- Cork is used for insulation, as shock absorber in linoleum.
- Cork is used in the making of a variety of sport goods such as cricket balls, table tennis, shuttle cocks, wooden paddles etc.

Supporting simple tissue

- The major function of these tissues are support to plant organs.
- There are three main types of simple tissues:
 - o Parenchyma
 - o Collenchyma
 - o Sclerenchyma.

(Chlorenchyma and Aerenchyma are types of Parenchyma).

Let's discuss each in details



Chlorenchyma	- These tissues are similar to that of parenchyma but they also contain chlorophyll in them. - Due to the presence of chlorophyll, they are capable of performing the process of photosynthesis in plants.
Aerenchyma	- They are found in aquatic plants. - They are also similar in structure to that of the parenchyma but they have large air cavities in them. - These cavities allow the aquatic plants to float in water.

Cells of Sclerenchyma are of two types

- Schereids-** these are also called **grit cells** or **stone cells**. These are small cells, where lumen due to higher thickening of cell wall, as present in drup fruit (mango, coconut, walnut) in legume seeds (macrosclereid)
- Fibres-** They are very long, narrow, thick, lignified cells. Lumen is large as compared to sclereids. They are generally 1-3 mm long. In the thick walls of both the fibres and sclereids are present thin areas called as pits. Sclerenchyma Fibres are used in the manufacture of ropes, mats & certain textile fibres. Jute and coir are obtained from the thick bundle of fibres.

Let's recap this by chart format

Simple Tissue	Characteristics
Parenchyma	- It is the fundamental tissue. - Tissue first time evolved in bryophyte. - Thin walled cells, oval or spherical in structure. - Cell wall mainly composed of cellulose & pectin. - Large central vacuole for food & water storage. - Primary function is food storage. - Some parenchyma involved in excretory substance storage are so called as idioblast, storing such as resin, tannin, gums & oils. - In typical parenchyma chlorophyll is absent. - Parenchyma provides turgidity to cells.
Collenchyma	- These tissues are responsible for providing flexibility to the plants so that they can bend easily. - They are a group of living cells with a cell wall made of cellulose and pectin. - The cells present in these tissues are broad and irregularly thick at corners. - They are present in the leaves and stems of a plant.
Sclerenchyma	- These tissues are responsible for making plants hard and rigid. - They are made up of dead cells having a cell wall made of lignin. - The cells do not have any intercellular spaces. - The cells have a long structure with thick walls. - The cells have a long structure with thick walls.

Features	parenchyma	Collenchyma	Sclerenchyma
Cell shape	Isodiametric cells which are oval, spherical or polygonal in shape	Circular, oval or polyhedral	Variable in shape. Fibres and sclereids are types
Cell wall	Thin cellulosic cell wall	Uneven thickening on their cell wall	Lignified secondary cell wall present
Cytoplasm	Abundant	Present	Absent
Nucleus	Present (Living tissue)	Present (Living Tissue)	Absent (Dead tissue)
Vacuoles	Large vacuole	vacuolated	Absent
Intercellular spaces	present	absent	Absent
occurrence	Basically packing tissue, all soft part of plant-pith, cortex, medullary rays.	Dicot stems, petiole and beneath the epidermis. Absent in monocot and roots.	Dicot hypodermis, bundle sheath, pericycl, seed, pulp of fruits.
Function	Food storage, photosynthesis.	Provide tensile strength, mechanical support, photosynthesis.	Protection from stress and strain, mechanical strength.

Note- Lignin- The cell walls of dead cells have a substance called lignin in them which provides rigidity to the cells. Lignin acts as the cement for the cells.

2. Complex Permanent Tissue

- Complex Permanent Tissues comprise different kinds of cells. These different types of cells coordinate with each other and perform a common function in these tissues.
- It helps in transportation of organic material, water and minerals.
- It also known as conducting or vascular tissue.
- Two Complex Permanent Tissues are - Xylem and Phloem.
- Xylem and phloem together form vascular bundles.

Similarity between xylem and Phloem

- Their main function is transport within the plant.
- Xylem and phloem are the components of vascular bundles, which are the conductive tissues in plants.

a. Xylem

- Xylem is made up of mostly dead cells having thick cell linings (except for xylem parenchyma).
- It is also known as wood and is a vascular and mechanical tissue.
- It consists of four types of cells called as elements tracheid's, Vessels, xylem parenchyma and xylem sclerenchyma
- It consists of the following four elements-
 - **Tracheids-** They are elongated angular dead cells (primitive elements) mainly involved in conduction of water and minerals in gymnosperms.
 - **Vessels-** They are advance element (generally found in angiosperms). Vessels are cylindrical tube like structures placed one above the other end to end which form a continuous channel for efficient conduction of water.
 - **Xylem Parenchyma-** they are small and thin walled parenchymatous cells subjected for storage of starch (food)
 - **Xylem Sclerenchyma-** Thy are non-living fibres with thick walls and narrow cavities

provide mechanical support. Except xylem parenchyma all other xylem elements are dead. The annual rings present in the trunk of a tree are xylem rings. By counting the number of annual rings, we can determine the age of a tree.

b. Phloem

- Phloem is made up of mostly living cells and it allows the movement of food (sugars) from leaves to other parts of the plant.
- They also consist of both parenchymatous and schlerenchymatous cells.
- Phloem consists of four types of element which are Sieve tubes, Companion cells, Phloem fibre and Phloem parenchyma.
- **Sieve tubes-**Sieve tubes are slender tube like structures made up of elongated, thin walled cells placed end to end. The end walls of sieve tube cells are perforated by numerous pores, called as sieve plates. Nucleus of sieve cell degenerates at maturity. However, cytoplasm persists, because of protoplasmic continuation of sieve tube with companion cell through plasmodesmata. Sieve cells possess slime protein or protein which is concerned with growth and repair of sieve cells.
- **Companion cells:** Companion cells have dense cytoplasm and prominent nuclei. Sieve cells & companion cells are so called sister cells because they originate from single mother cell.
- **Phloem fibre:** They give mechanical support to sieve tubes.
- **Phloem Parenchyma:** They store food and help in radial conduction of food.
- **Leptome:** Main part of the phloem involved in conduction of food, which is sieve tube.

features	xylem	Phloem
Cells: Living/dead	Dead	Living
Cells walls: Thickness	thick	Thin
material	Lignin	Cellulose
Permeability	Impermeable	Permeable
Cross walls	None	Sieve plates
Cytoplasm	None	Yes
Function	Carries water and salts	Carries sugars

Direction of flow	Unidirectional (Upwards)	Two directional (down and up)
Special features	Fibres	Companion cells

Animal tissue

Cells in body constitute a tissue and the contraction and relaxation of these cells result in movement. Blood flows and carries various substances from one part of the body to the other. Blood and muscles are both examples of tissues found in our body.

- There are different types of animal tissue present in human body are as follows
 - Epithelial tissue
 - Connective tissue
 - Muscular tissue
 - Nervous tissue

Let's explain each in details

a. Epithelial tissue

- They are the protective tissues of the human body. They cover many organs and cavities that are present inside the body.
- Where are the epithelial tissues found in the human body?
 - The lining of the blood vessels
 - The lining of the mouth
 - Kidney tubules
 - Skin
 - Lung alveoli

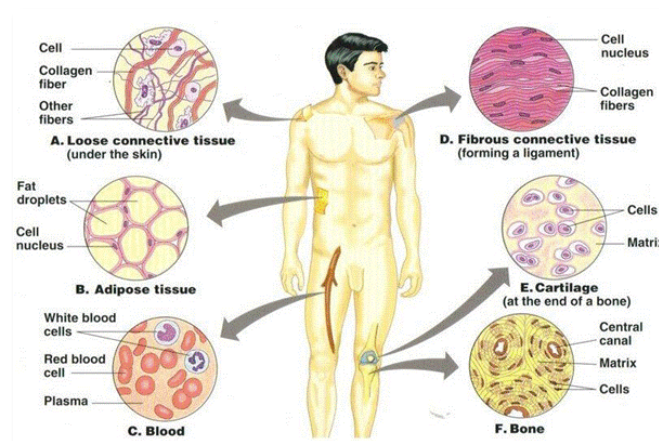
Structure and functions of the epithelial tissues-

- The main function of the epithelial tissues is to act as a barrier and separate different organs and systems from each other.
- There is no space between the cells of epithelial tissues
- The cells are selectively permeable. This makes it possible for them to exchange materials between different parts of the body and also between the body and the external environment.
- The epithelial tissues remain separated from the tissues beneath them because of a thin membrane over them.

Different types of epithelium tissues	Simple Squamous	Stratified squamous	columnar	Ciliated columnar	Cuboidal	Glandular
structure	They have delicate cell lining and possess a flat thin structure	The epithelium Squamous cells are arranged in several layers	They are the column-like shape tissues	Columnar epithelial tissues which have Cilia present on them		These are special gland cells that can secrete substances
Found in	Alveoli and Bowman's capsule-nephron in the kidney	skin	intestine	Respiratory system	Kidney tubules	Sweat glands in the skin

b. Connective tissue

The cells of the connective tissue are widely spaced and embedded in an intercellular matrix. The nature of matrix decides the function of tissue. White and yellow fibres are present in the matrix. Their basic function is to provide support to different organs & keeping them in place.



The below are the fluid or vascular tissue

a. Blood

- The main function of blood is to transport gases, food, waste materials and hormones in the body.
- Therefore, blood has a fluid Matrix present in it which is called **Plasma**.
- The plasma contains **red blood cells, white blood cells** and **blood platelets**.
- The RBC has haemoglobin pigment which carries oxygen to tissues.
- White blood cells fight diseases and platelets are involved in the clotting of blood when injured.
- The plasma also contains proteins and hormones in it.

b. Lymph

Lymph is a colourless fluid that carries white blood cells throughout the human body in lymphatic vessels. There are lymphoid organs

(such as lymph nodes and tonsils) in the body that are part of the lymphatic system and are involved in filtering lymph and housing immune cells. Lymph is formed from interstitial fluid.

Lymph is similar to blood except for a few differences:

- It contains white blood cells and lymph plasma, but lacks red blood cells and platelets.
- It contains less amount of blood proteins, calcium and phosphorus but more glucose.
- It flows in one direction only.
- Lymph moves in the body through its normal function, unlike blood which is pumped by the heart.

Constituents of Lymph:

Lymph Plasma – Lymph Plasma carries infection-fighting proteins along with other substances such as water, calcium and phosphorus.

Lymph Corpuscles – Lymph Corpuscles comprises white blood cells. Red blood cells and platelets are not present in lymph.

Functions of Lymph:

- It helps to maintain the fluid balance around body cells by draining excess interstitial fluid.
- It maintains the volume of the blood.
- It helps in eliminating harmful bacteria and viruses from the body and hence is responsible for the immunity of human beings.
- It absorbs fats from the intestine and transports them throughout the body.

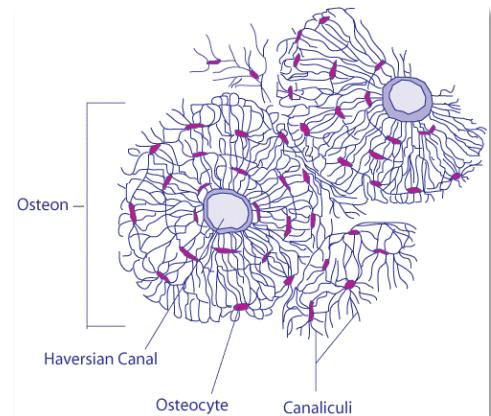
c. Bones

- Bones form a framework of the body over which the muscles are wrapped together.
- The bone tissue is strong and inflexible.
- Therefore, the bone cells are present in a rigid matrix that is formed from calcium and phosphorus.

What is Haversian Canals?

- The bones comprise microscopic tubes called Haversian Canals.

- They are contained in osteons, rough cylindrical structures present along the axis of the bone.
- They allow the blood vessels, lymphatic vessels, and nerve fibres to travel through them.
- These canals have concentric layers of bone matrix called Lamellae around them.
- The Haversian canals communicate with bone cells through connections called Canaliculi.



d. Cartilage

- Cartilage is present over the joints of the bones and provides them with a smooth structure.
- For Example in the nose tip and ear pinna, trachea, larynx.
- They contain a solid matrix made of protein and sugar. They have a homogenous matrix.
- It provides support and flexibility to various parts of our body.

e. Ligaments

- A ligament connects two bones together.
- It has an elasticity that facilitates the connection.
- Ligaments have cells (fibroblasts) embedded in a strong, fibrous matrix, which contains densely packed collagen fibers and some elastic fibers.

f. Tendons

- The tendon tissues are responsible for connecting bones and muscles together.
- They have limited flexibility but very great strength.

g. Areolar

- This tissue acts as a filter in between the spaces present inside the organs of the body.

- It helps in repairing other tissues as well.
- It is found in the skin and bone marrow.

h. Adipose

- Fats are stored in our body in the adipose tissues.
- They are found below the skin and between the organs of the body.
- Provides cushioning to the organs.

Components of the Areolar Connective Tissue

a. Cells

- **Fat Cells (Adipocytes)** – They are responsible for the storage of lipids (fats).
- **Fibroblasts** – They are present in the highest amount in areolar tissues. They are responsible for the secretion of fibres.
- **Mast Cells** – They release histamine that plays a role in allergic reactions
- **Macrophages** – They eat any germs or infectious cells in the body
- **Plasma Cells** – They produce antibodies.

b. Fibres

- **Collagen Fibres** – They provide tensile strength to the tissue
- **Elastin Fibres** – They provide elasticity to the tissue
- **Ground Substance** – It is a fluid matrix that holds cells and fibres of the tissue

Muscular Tissue

- It is made up of muscle fibres which are long cells.
- It allows movements in our bodies.
- How can muscles cause movement?

They contain special proteins called **Contractile Proteins**. These proteins cause contraction and relaxation of the muscles.

- **There are two kinds of muscles found in our body - Voluntary Muscles and Involuntary Muscles.**

Striated/Skeletal/Voluntary muscles	Smooth/Unstriated/Involuntary muscles
We can move them according to our own will	We cannot start or stop the movement

	of involuntary muscles.
They are also called Skeletal Muscles as they are attached to the bones.	They are also called Smooth Muscles.
They are also called Striated Muscles because of the presence of dark and light bands over them	They are also called Unstriated Muscles because they do not have any light or dark bands on them.
The cells of voluntary muscles have more than one nucleus, do not have any branches, and have a long cylindrical structure.	The cells of the involuntary muscles are long and have pointed ends.
For Example, Muscles of our hands and legs.	For Example, The muscles in the alimentary canal and the Iris of our eyes.

Cardiac Muscles

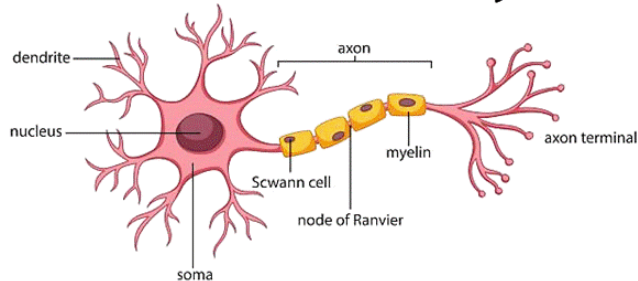
- These are special kinds of involuntary muscles.
- The muscles of the heart are called Cardiac Muscles. They perform rhythmic contraction and relaxation throughout our life.
- They are cylindrical in shape, they have branches and there is a single nucleus.
- Cardiac muscle consists of individual heart muscle cells connected by intercalated discs to work as a single functional organ..

Nervous Tissue

- **How do we react to stimuli?**
 - This is because of the nervous tissues present in our body. They are capable of transmitting information quickly from the brain to different parts of the body and vice-versa.
 - Therefore nervous tissues are found in nerves, brain, and spinal cord.
 - Nervous tissue is made up of cells called the Nerve Cells or **Neurons**.
 - These neurons connect together to form the nerves of our body.
- **Structure of a Neuron**
 - It is an elongated cell with a Cell Body that consists of some branch-like structure called **Dendrites**.

- There is a Nucleus present in the centre of the cell body.
- The Axon extends from the cell body to the Nerve Endings..
- A nerve cell can be up to 1 m long.

Neuron Anatomy



- It is covered with a special insulating substance called **myelin**. It helps in the rapid transmission of signals.

4. Schwann Cells

- The Myelin sheath that covers the axon is produced by Schwann cells, in the Peripheral Nervous System
- The Myelin sheath keeps the signal intact.

1. Dendrites

- They are tree-like extensions (highly-branched) at the beginning of a neuron.
- They increase the surface area of the neuron.
- They receive chemical signals from different neurons of the body.
- They then convert these chemical signals into electrical signals and pass them to the neuron cell body.
- A neuron can have a single dendrite or multiple dendrites

2. Cell Body

- Also called Soma.
- The main function of the cell body and nucleus of the neuron is to maintain the functionality of the cell.
- It plays a key role in integrating signals received by dendrites and maintaining cell function.
- It produces proteins that are required by different parts of the neuron to work properly.
- It contains different cell organelles such as mitochondria, Golgi apparatus etc that perform various functions of the cell.

3. Axon

- Neurons have one axon in general.
- It is a long structure that connects the cell body to the terminals and it also connects with other neurons, cells and organs of the body through nerve terminals.
- It allows for the fast transmission of signals. The larger the diameter of the axon the faster it will transmit signals.

Introduction

- We all know that there are abundant of living organisms present on the earth. Many organisms are not identical to each other.
- This variety of living beings present on the earth is called as a Biodiversity.
- Biologist have identified and classified more than 1.7 million species of organisms on this earth. Most of these species are found in the tropical regions of the world.
- There is a separate branch of Biology called **Taxonomy** which identifies, names and classifies different organisms present on the earth.
- **Carolus Linnaeus** is known as the Father of the Modern Taxonomy.

Importance of classification

- It makes the study of wide variety of organisms easy and in systematic manner.
- It helps to understand how the different organisms have evolved with time.
- It helps to understand the inter-relationships among different groups of organisms.
- It forms a base for the study of other biological sciences, like biogeography.

Basis of Classification

- There are certain features or properties used for the classification of living organisms which are known as characteristics.
- Organisms with same characteristics are placed in same groups.

Classification of Living things

- Classification presented by Aristotle – He classified animals on the basis of their habitats – land, water and air.
- But it can be easily observed that the animals that live at a particular habitat say land are still so different from each other.
- Therefore it was decided to classify the living organisms on the basis of a hierarchy.
- This hierarchical classification was based on the similarities and dissimilarities in the characteristics of the living organisms.

- Organisms having similar characteristics were placed in a similar category

What is Evolution?

Over a course of time the living organisms accumulate changes. These changes could be in their body type or size or their features. These changes allow them to survive better with the change in environment. This is called Evolution. This concept was introduced by Charles Darwin.

Primitive and advanced organisms

- Primitive Organisms are the ones that have an ancient body design. Their bodies haven't undergone many changes with time. They are called 'Lower' organisms as well.
- The Advanced Organisms are those who have recently acquired body changes. They are also called as 'Higher' organisms.

Hierarchy Classification- formation of Kingdom

Biologists categorized different organisms into several kingdoms.

1. Two kingdom classification

- Proposed by Carolus Linnaeus in 1758
- Types of organism are plants and animals

2. Five Kingdom classification

- Proposed by Robert Whittaker in 1959
- Types of organism were Monera, Protista, Fungi, Plantae and Animalia.

3. Five Kingdom system classification

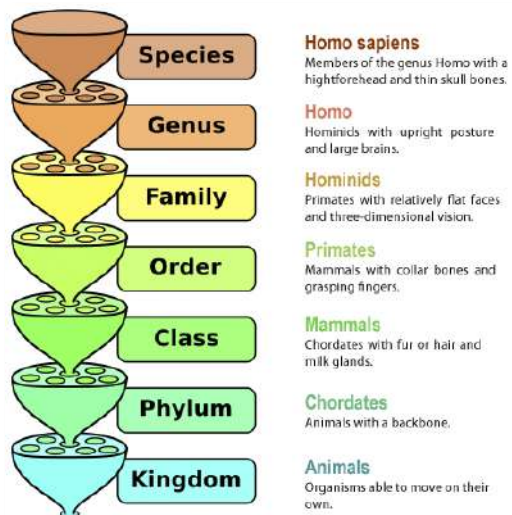
- Based on analysis of ribosomal RNA, Carl Woese and colleagues proposed in 1977 that the Kingdom Monera was actually composed of two very distinct groups. This work led to the development of the Three-Domain System of Classification: Bacteria, Archaea, and Eukarya. The Domain Eukarya includes the eukaryotic kingdoms: Protista, Fungi, Plantae, and Animalia." (Or similar wording that clarifies Woese's contribution was splitting prokaryotes, leading to domains).

The order of Classification

1. Kingdom
2. Phylum / Division
3. Class
4. Order

5. Family
6. Genus
7. Species

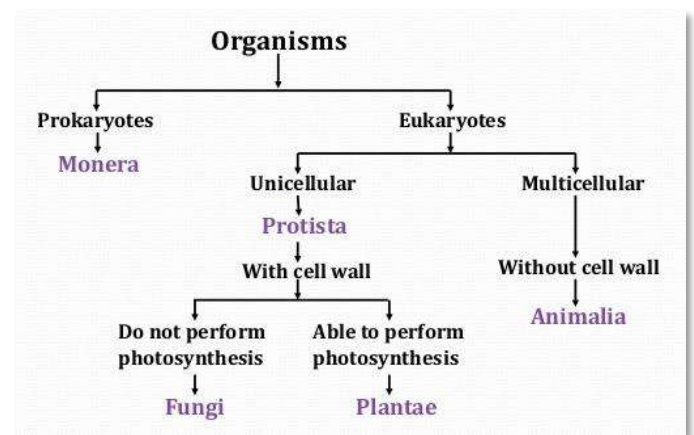
Species is called as the Basic Unit of Classification. Species is a group of organism which can interbreed with each other. The picture below explains how humans are classified in a hierarchical order.



Groups or levels from top to bottom

The major characteristics considered for classifying all organisms into five major kingdoms.

- **Types of cellular organisation**
 - **Prokaryotic cells**- These cells are primitive and incomplete cells without well-defined nucleus.
 - **Eukaryotic cells**- These are advanced and complete cells with well-defined nucleus.
- **Body Organization**
 - **Unicellular organisms**: These are organisms made up of single cell with all activities performed by the single cell.
 - **Multicellular organisms**: These are organisms made up of large number of cells with different functions performed by different cells.
- **Mode of obtaining food**
 - **Autotrophs**: These are the organisms that make their own food by photosynthesis.
 - **Heterotrophs**: These are the organisms which depend on other organisms for food.



Five kingdom Classification

	Monera	Protista	Fungi	Plantae	Animalia
Organizations inside the cells	Consists of Prokaryotes.	Eukaryotes – some of them use appendages to move around such as flagella (whip-like structure) and Cilia (hair-like structure)	Eukaryotes	Eukaryotes	Eukaryotes
Organizations of cells in the body	Unicellular	Unicellular	Initially unicellular. Can become multicellular in later stages of life	Multicellular	Multicellular
Organism obtain their food	Some of them are autotrophs like blue green algae while others are heterotrophs	Both autotrophs and heterotrophs	Heterotrophs. Most of them are decomposed or may be parasitic	Autotrophs	heterotrophs
Presence of cell wall	Some lack a cell wall while others have a cell wall	Only some have cell wall.	Have cell walls. They are made up of complex sugar called chitin .	Have cell walls made of cellulose	No cell walls
Example	Blue-green algae, Bacteria, Mycoplasma	Protozoan, Diatoms and	Yeast and Mushroom	Flowering plants, moss	Insects, reptiles

		Golden algae	(Agaricus), rhizopus (Bread mould). Penicillium		
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Archaea Kingdom

Archaea are a Domain of life, distinct from Bacteria (Eubacteria). In older classification systems, both Archaea and Bacteria were grouped under the Kingdom Monera. These are microbes that can live in harsh conditions. Since they can live in extreme temperatures they are also called Extremophiles. Most have a cell wall, but it is not made of peptidoglycan. Their cell membrane is made up of lipids. They are further classified into three categories, based on their habitat-

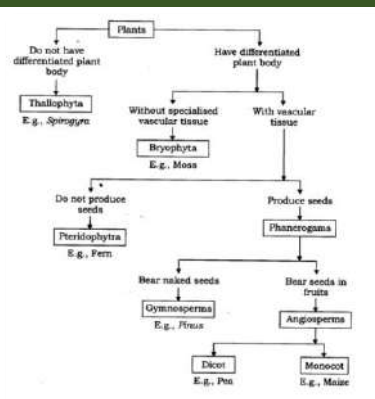
- **Halophiles-** These are salt loving bacteria. They live in extremely salty water.
- **Thermophiles-** They live in high temperature such as hot springs and volcanoes.
- **Methanogens-** They are found in the guts of animals like cow and sheep. They produce methane gas from their dung.

Who are saprophytes?

Fungi also called as Saprophytes because they grow over the organic material and survive on them.

Symbiotic relationship- Some species of fungi live in permanent mutually dependent relations with blue-green algae. They are said to have a symbiotic relationship. For Example, Lichens are often found on the bark of the trees. The fungal component of lichen is made of chitin.

Kingdom Plantae



- Plantae are eukaryotic, multicellular, autotrophic and cell wall is present.

Basis of division of kingdom plantae

- **Differentiated body parts:** Body is differentiated into leaves, stems, roots, flowers, etc.
- **Presence of vascular tissue:** There are two types of vascular tissues present in the plants.
 - **Xylem:** Helps in transport of water.
 - **Phloem:** Helps in transport of food.
- **Reproduction through seeds or spores:**
 - **Phanerogamae :** Plants with seeds are called phanerogamae. They contain embryo with stored food and are multicellular.
 - **Cryptogamae:** Plants that reproduce by spores are called cryptogams. They do not produce seeds and include organisms that range from unicellular forms (like some algae) to multicellular forms (like mosses and ferns).
- **Seeds are inside the fruit or naked:**
 - **Angiospermae:** These are plants with seeds inside the fruit and bear flowers.
 - **Gymnospermae:** These are plants with naked seeds and do not bear flowers

criteria	Thallophyta	Bryophyta	Pteridophyta
Components of plants	No distinct components. Undifferentiated Body	Little differentiated body. Distinct components are present as leaves and stem	Distinct components are present as roots, leaves and stem
Presence of special tissues- Vascular tissue	No	No	Yes
Presence of seeds	No	NO	No
Found In	Aquatic environment, snow	First terrestrial plants but need water for sexual reproduction. So called as Amphibian of plant kingdom.	Terrestrial or dry areas
Example	Spirogyra, Ulothrix, Volvox, Ulva, Chara	Hornwort, Moss and liverworts	Ferns, Marsilea, horsetails

Difference between Gymnosperms and Angiosperms

	Gymnosperms	Angiosperms
The ability to produce seeds	Naked seeds	Seeds develop in an organ which then turns into the fruit
Existence	Exist for long time periods, Evergreen	Grow for varied time periods
types	Woody, no flowers	Flowering plants
Meaning	Gymno-naked, Sperm- seeds	Angio- covered, Sperma- seeds
Example	Pines, Deodar	Mustard, Maize

Angiosperms are further divided on the basis of number of cotyledons into two parts i.e. Monocots and Dicots.

features	monocots	Dicot
seed	One cotyledon	Two cotyledon
Root	Fibrous root	Prominent primary root
stem	scattered vascular bundles and lack secondary growth	vascular bundles arranged in a ring and exhibit secondary growth
leaf	Parallel venation	Reticulate venation
Flower (petals)	Five or multiple of five	Three or multiple of three
example	Wheat, Maize, Rice, Grasses, Lilies, Onions, Bananas	Potato, Sunflower, Peanuts, Beans, Mango, Banyan, Roses, Peas, Tomatoes.

Kingdom- Animalia

Basic Characteristics of the Animalia Kingdom

1. Animals are eukaryotic, multicellular organisms that lack a cell wall.
2. They are heterotrophs therefore they rely on others for food.
3. They have a growth pattern. The adult animals have a specific shape and size.
4. Most of the organisms have well-defined organ systems such as **Respiratory System, Digestion System** and so on.
5. Most of the animals can move. They aren't stationary as **Plants**.
6. Animals have a nervous system which is why they are able to respond to an external stimulus.

Animals are classified on the basis of difference in their body type and design. The body cavity or coelom in animals contains the organs. Based on the presence of body cavity animals can be categorized as:

Symmetry

- **Bilateral symmetry:** It is when an organism can be divided into right and left halves, identical but mirror images, by a single vertical plane.
- **Radial symmetry:** It is when an organism is equally spaced around a central point, like spokes on a bicycle wheel.

Germ layers

In embryonic stages there are different layers of cells called germ cells.

The three different types of germ cells are:

- **Ectoderm:** It is the outermost layer which forms nail, hair, epidermis, etc.
- **Endoderm:** It is the innermost layer which forms stomach, colon, urinary, bladder, etc.
- **Mesoderm:** It is the middle layer between ectoderm and endoderm which forms bones, cartilage, etc.

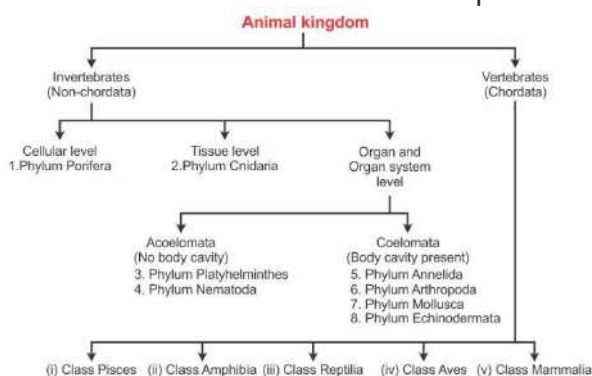
According to the number of germ layers present in embryonic stage, animals could be

1. **Diploblastic-** Organisms which are derived from two embryonic germ layers (ecto and endo).
2. **Triploblastic:** Organisms which are derived from all the three embryonic germ layers Coelom
3. **Coelomate-** They have true body cavity called **Coelom**
4. **Pseudocoelomate** – It means false cavity. They have a body cavity which is filled with fluid
5. **Acoelomate** – They have no body cavity at all.

Notochord

- It is a long rod like structure, which runs along the body between nervous tissues and gut and provides place muscle to attach for ease of movement.
- **Organisms could be:**
 - Without notochord
 - With notochord

- With notochord in initial embryonic stages and vertebral column in adult phase.



A. Phylum- Porifera

- Level of Organization – Cells are present
- Symmetry – Asymmetrical
- Segmentation – No segments
- Body Cavity/ Coelom – No
- Presence of Organs – No
- Examples – Sycon, Spongilla, Euspongia
- **Other Characteristics-**
 - They cannot move and are attached to a support.
 - They have pores in their body
 - These pores form a Canal system through which water and food circulate in the body and waste is removed.
 - They have a skeleton made of **spongin protein** and **calcium carbonate** – hard covering on them.

B. Phylum-Coelenterata (Cnidaria)

- Level of Organization – Tissues, Cells have two layers – so called as **Diploblastic Organism**
- Symmetry – **Radial**
- Segmentation – No segments
- Body Cavity/ Coelom – No
- Presence of Organs – No
- Examples – Aurelia (**Jelly fish**) and Adamsia (**Sea Anemone**)
- **Other Characteristics –**
 - Some of them live in colonies - They are physically attached to each other such as **Corals**
 - Some of them live solitary such as **Hydra**

C. Phylum Platyhelminthes

- Level of Organization – Organs, The cells have three layers – so are called **Triploblastic**
- Symmetry – **Bilaterally Symmetrical** - Left half of the body is identical to the right half
- Segmentation – No segments
- Body Cavity/ Coelom – No so called as **Acoelomates**
- Presence of Organs – Yes
- Examples – Taenia solium (**Tapeworm**), Fasciola hepatica (**Liver Fluke**)
- **Other Characteristics -**
 - They have a flat body and thus are called **Flatworms**
 - They can be **Free-living** like Planaria or **parasitic**.

D. Phylum Nematoda

- Level of Organization – Organ System so are called Triploblastic
- Symmetry – **Bilaterally Symmetrical** - Left half of the body is identical to the right half
- Segmentation – No segments
- Body Cavity/ Coelom - False body cavity so called as **Pseudocoelomates**
- Presence of Organs – Organ System Level Organisation
- Examples – **Parasitic worms** and worms in the intestine
- **Other Characteristics-**
 - They are called as Round Worms.
 - **Sexual dimorphism visible** - Female and male worms are distinct.

E. Phylum Annelida

- Level of Organization – Organ System so are called Triploblastic
- Symmetry – **Bilaterally Symmetrical** - Left half of the body is identical to the right half
- Segmentation – Body is segmented
- Body Cavity/ Coelom - True body cavity so called as Coelomates
- Presence of Organs – Organ System Level Organisation
- Examples – "Earthworms, Leeches, Marine worms
- **Other Characteristics-**

- Body is segmented externally and internally, Presence of setae (bristles).
- The name "Annelida" means "little rings".

F. Phylum Arthropoda

- Level of Organization – Organ systems
- Symmetry – Bilaterally symmetrical
- Segmentation – Present (organs can be identified separately)
- Body Cavity/ Coelom – True body cavity
- Presence of Organs – Definite organs
- Examples – Prawns and butterflies Crustacean and Insect, both Arthropods
- **Other Characteristics**
 - They have jointed legs
 - They have an open circulatory system – There are no well-defined blood vessels
 - They have chitinous exoskeleton

G. Phylum Mollusca

- Level of Organization – Organ systems, The cells have three layers– called Triploblastic
- Symmetry – Bilaterally symmetrical
- Segmentation – Little segmentation
- Body Cavity/ Coelom – Reduced
- Presence of Organs – Definite organs
- Examples – **Snails, Octopus, Clams, Mussels**
- **Other Characteristics**
 - Body is divided into head, Visceral Mass and Muscular Foot.
 - Some of the molluscs have hard external shell like that of Snails and some have internal reduced shell like that in Octopus.
 - They have an open circulatory system
 - There is a kidney-like organ for excretion

H. Phylum Echinodermata

- Level of Organization – Organ systems, the cells have three layers -- called Triploblastic
- Symmetry – Bilaterally symmetrical in larval stage and Radially symmetrical in Adults.
- Segmentation – No
- Body Cavity/ Coelom – True body cavity

- Presence of Organs – Definite organs
- Examples – **Starfish, Sea cucumber**
- **Other Characteristics-**
 - They have Spiny dermis made of **calcium carbonate**
 - They have a water vascular system which helps in feeding and locomotion.

I. Phylum Chordata

Characteristics of Chordates

- They have a **notochord**. It is a rod-shaped structure that provides skeletal support to the body. It is found in the embryonic stage of all chordates and in adult stages for some chordates.
- A nerve cord that connects brain.
- Most aquatic animals have a **Pharyngeal slit** that allows the exit of water
- They have a post-anal Tail made up of muscles and skeletal elements that helps in balancing.

Subphylum Protochordate

- Level of Organization – Organ systems, the cells have three layers– called Triploblastic
- Notochord present in some stage of life.
- Symmetry – Bilaterally symmetrical
- Segmentation – No
- Body Cavity/ Coelom – Present
- Presence of Organs – Definite organs
- Examples – **Ascidia, Herdmania**

Subphylum Vertebrata

- Level of Organization – Organ System Level Organisation. Triploblastic (derived from three germ layers).
- Symmetry – Bilaterally symmetrical
- Segmentation – Yes
- Body Cavity/ Coelom – Present, well-defined
- Presence of Organs – Definite organs
- Examples – **Mammals, Birds, Fishes**
- **Other Characteristics -**
 - They have **vertebral column** developed from notochord.
 - The internal skeleton muscles can attach at various points of the body
 - There is a dorsal hollow nerve cord in the upper side of the back

Differences between cold blooded and warm blooded animals

Cold-blooded animals	Warm-blooded animals
They cannot maintain a constant body temperature	They can maintain a constant body temperature
They obtain heat from the environment surrounding them	They obtain heat from the food they eat
Their body temperature can vary as per the surrounding temperature	They maintain a temperature of around 35 – 40 degree Celsius irrespective of the surrounding temperature
They regulate heat in their bodies by changing colors or by being in sunlight	They regulate their body heat by metabolic processes and adaptive mechanisms such as hibernation and sweating.
Examples – Fishes, Reptiles, Insects, Amphibians	Examples – Mammals and Birds

Reptilian	Have dry scales	3 chambers except crocodile which has 4 heart chambers	Cold blooded	lungs	eggs	Land, water	Turtle, king Cobra.
Aves/birds	They have waterproof skin which is covered with feathers, They have a beak or bill rather than teeth, Their forelimbs are developed into wings, They have hollow bones or pneumatic bones	4 chambers	Warm blooded	Lungs	eggs	Land, air	Crow, pigeon
Mammalia	Have skin with hair and sweat glands	4 chambers	blooded	Lungs	give birth to young ones except Duck billed Platypus and Echinoderm	Land, water, air	Humans, Cats

Body type		Heart chambers	Cold-Blooded/Warm-blooded	respiration	reproduction	Food	examples
Pisces / Fish	They have scales or plates on their body, a muscular tail, some have skeleton made up of cartilage, some have skeleton made up of bones and cartilage	2 chambers	Cold blooded	gills	eggs	water	Synchiropterus splendens (Mandarin fish), Scoliodon (Dog fish)
Amphibians	Have smooth and slimy skin	3 chambers	Cold blooded	Gills in larval stage and lungs in adult stage	eggs	Land and water	Toad, Hyla (tree frog)

Nomenclature of Living organisms

Why is nomenclature required?

It will help people identify an organism with a standard name anywhere in the world. The whole hierarchy of an organism is not mentioned in the name. Only genus and species of the organisms are mentioned. Concept of Binomial nomenclature was given by Carolus Linnaeus.

Conventions for Binomial Nomenclature -

- Genus name starts with a capital letter
- Species name starts with a small letter
- The scientific name of an organism is written in Italics while printing
- The genus name and species name should be underlined separately while writing
- Some examples of scientific name
 - Leo: *Panthera leo*
 - Tiger: *Panthera Tigris*
 - Human: *Homo sapiens*
 - Mango: *Mangifera indica*

Microbes

Microbes or microorganisms are tiny organisms which are so small that we cannot see them with an unaided eye. Some microorganisms can be seen with the help of a magnifying glass (such as fungus that grows on bread) while some can only be seen when you use a microscope (such as bacteria and protozoa). Microorganism were first observed by **Anton Van Leeuwenhoek**.

What are microorganism?

Microorganism are microscopic organism that cannot be seen with the naked eye. These organism are usually unicellular in nature.

There are four major types of microorganism-



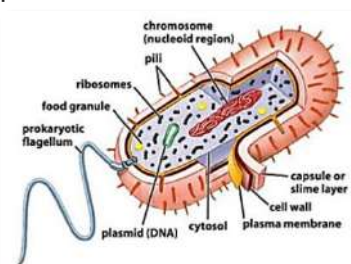
1. Bacteria
2. Fungi
3. Protozoa
4. Algae

Typhoid and Tuberculosis (TB) etc. is caused by the **Bacteria**.

Dysentery and Malaria etc. is caused by **Protozoans**.

Let's discuss each in detail

1. **Bacteria**- These are single-celled organisms with a rigid cell wall. They can only be seen under a microscope which enlarges images from 100 to 1000 times. They found in wide range of habitats from glaciers to deserts and hot springs. For example- **Curd Bacteria (Lactobacillus)**.



Types of Bacteria (based on their Shapes) and their Examples

Shape of Bacteria	Example	Image
Comma-shaped Bacteria	Vibrio Cholerae	
Spherical-shaped Bacteria (Cocci)	Staphylococcus and Streptococcus	
Rod-shaped Bacteria (Bacilli)	E. coli and Salmonella	
Spiral-shaped Bacteria (Spirilla)	Treponema and Borrelia.	

2. **Fungi**- They are multicellular and heterotrophic organisms. Fungi lacks chlorophyll and are generally found in colonies. Below is the example of **Puccinia trititica**. *Puccinia* which causes wheat leaf rust) or grow on the organic matter (such as bread mould).

Other example are- **Penicillium, Aspergillus**.



Fungi, like mushrooms, moulds, mildews, and yeasts, are **eukaryotic**. It means that they have a true nucleus.

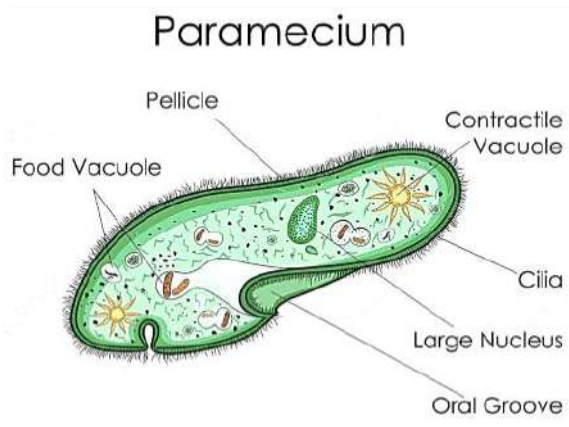
The main components of fungi are:

1. **Hyphae**: They are thread-like filaments which penetrate into substrates, secrete enzymes to break down nutrients into smaller molecules, and absorb them.
2. **Spores** are a unit of sexual or asexual reproduction. They can adapt for dispersal and

survival for extended periods of time in unfavourable conditions.

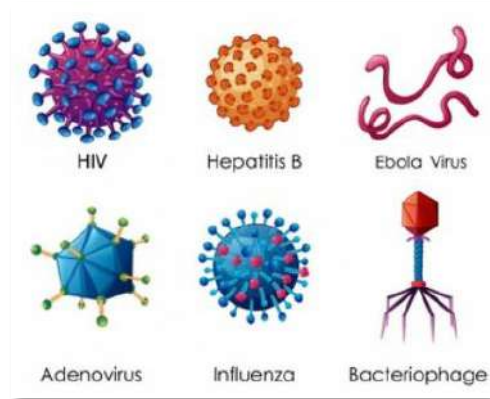
3. Algae-These are simple plant-like organisms which are usually aquatic in nature. They contain a cell wall and chlorophyll and can make their own food by photosynthesis. Algae can be unicellular or multicellular. Some of the common examples are **diatoms, Chlamydomonas**, and **seaweed**.

4. Protozoan- Protozoa are unicellular organisms. Some of them live independently while others live as parasites. Many of the parasitic protozoans cause diseases in plants, domestic animals, and human beings. Example of some protozoans are Amoeba, Plasmodium and Paramecium



Virus is different from other microorganism

- Viruses are also microscopic but are different from other microorganisms. They, however, reproduce only inside the cells of the host organism, which may be a bacterium, plant or animal. Common ailments like **cold, influenza (flu)** and most **coughs** are caused by viruses. Serious diseases like **polio** and **chicken pox** are also caused by viruses.
- Viruses are much smaller than bacteria and come in a wide variety of shapes and sizes. A complete virus particle is known as **Virion**.
- **Virion** consists of a nucleic acid surrounded by '**capsid**'. Capsid is a protective coat made of protein. The subunits of this protein called '**Capsomeres**'. Viruses can be seen only by an electron microscope as they are ultramicroscopic in size.



Where do Microorganism live?

They live in all types of environment, ranging from ice cold climate to hot springs; and desert to marshy lands. They are also found inside the bodies of animals including humans. Some microorganisms grow on other organism while others exists freely.

Microorganisms and Us

Some of the microorganisms are beneficial in many ways whereas some others are harmful and cause diseases.

Some of the uses of Microorganisms

- Preparation of curd, bread, and cake.**
- Production of alcohol, wine and acetic acid**
- Preparation of medicines and vaccines**
- Cleaning up the environment**
- Increasing soil fertility**

Some notable harms by microorganism

- Cause disease in plants, animals, and human beings**
- Spoil food and cause food poisoning**

How are bacteria useful to us?

Bacteria are helpful because

- It decomposes organic wastes (such as vegetable peels, animal remains, and faeces etc.).
- It is used in the preparation of medicines.
- It increases soil fertility by fixing nitrogen.
- It is used in the setting of curd and making cheese, pickles, and other food items.

Note- Curd is formed due to a bacterium called **Lactobacillus**, as this bacterium multiplies in milk and converts it into curd.

How is yeast useful to us?

- Yeast is used in the baking industry (to make bread, pastries, and cakes) because it helps in fermentation. It reproduces rapidly and produces carbon dioxide during respiration. Bubbles of the carbon-dioxide gas it produces fill the spaces in the dough and increases its volume.
- It is also used in the commercial production of alcohol and wine which is done by growing yeast on natural sugars present in fruit juices and grains like rice, wheat, and barley

Note about **Fermentation**- Fermentation is a process by which the yeast converts sugar into alcohol. It was discovered by Louis Pasteur in 1857.

Antibiotics and its uses

As we all know that the source of medicines are microorganism. These medicines kill or stop the growth of the disease-causing microorganisms. Such medicines are called **antibiotics**. Example is Penicillin

Note- **penicillin** is discovered by **Alexander Fleming** in 1929.

Antibiotics are used to-

- Cure a variety of diseases (such as streptomycin, erythromycin, and tetracycline that are made from bacteria and fungi),
- Cure microbial infection in animals (by mixing antibiotics with the feed of livestock and poultry), and
- Control several plant diseases.

Precautions should be followed while taking antibiotics

- Antibiotics should be taken only on the advice of the doctor, and one must complete the course the doctor prescribes.
- Antibiotics taken in wrong doses may make the body resistant to the drug and it may not be effective in the future. Moreover, antibiotics may also kill the beneficial bacteria in the body.
- **Please Note:** Antibiotics cannot cure cold and flu caused by viruses.

Important definitions

Pathogens: Disease-causing microbes are called Pathogens.

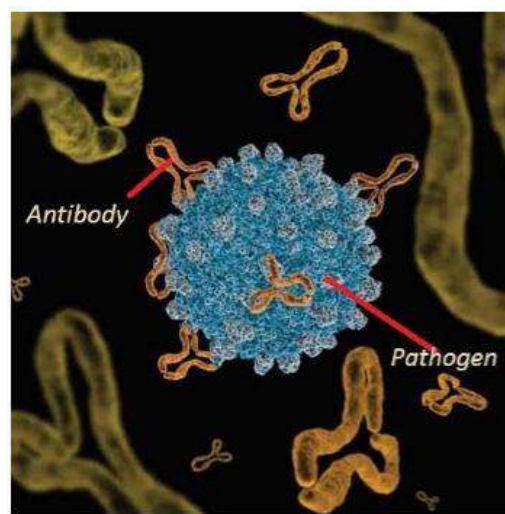
Antibodies: Antibodies are substances our body produces to fight disease-causing microbes.

Vaccines: Vaccines are weakened or dead disease-causing microbes that are injected in our body to trigger the production of antibodies. These antibodies remain in the body for a long time to protect it against any attack of disease-causing microbes.

Vaccination: The process of protecting the body from pathogens with the help of vaccines is called Vaccination.

Vaccine

- When a disease-carrying microbe enters our body, the body produces antibodies to fight the invader. The body also remembers how to fight the microbe if it enters again.
- If dead or weakened microbes are introduced into a healthy body, the body fights and kills the invading bacteria by producing suitable antibodies.
- The antibodies remain in the body and we are protected from the disease-causing microbes for long time.
- Several diseases, including cholera, tuberculosis, smallpox and hepatitis can be prevented by vaccination.



Note-

- **Edward Jenner** discovered the vaccine for smallpox in 1798.

- Pulse Polio Programme is run by the Government of India to eradicate polio. Children below 5 years of age are given oral polio drops under this programme.

Microorganism and soil fertility

- Some bacteria are able to fix nitrogen from the atmosphere to enrich soil with nitrogen and increase its fertility. These microbes are commonly called biological nitrogen fixers.
- **Blue green algae** and **Rhizobium** bacteria are biological nitrogen fixers.

Microorganisms in cleaning environment

Microbes or microorganisms decompose organic waste and dead remains of plants and animals and convert them into simpler substances (which can again be used by other plants and animals) by the process of **biodegradation**. Thus, they help us in getting rid of harmful and smelly substances and clean up the environment.

Glimpse of Nitrogen cycle

- It involves circulation of nitrogen through living and non-living components of nature.
- Nitrogen gas comprises 78 % of the atmosphere.
- First process of nitrogen cycle is fixation of nitrogen gas into nitrogenous compounds caused by bacterium *Rhizobium* and lightning.
- Nitrogen compounds in soil are taken up by the plants through roots used up in synthesis of plant proteins. Animals obtain nitrogen by feeding on plants.
- Waste of plants and animals are converted to nitrogenous compounds by the action of bacteria and fungi in the soil.
- Some bacteria convert nitrogenous compounds back to nitrogen to maintain atmospheric levels of nitrogen.

Harmful Microorganisms

Microorganism are harmful in many ways. Some of the microorganism cause disease in human beings, plants and animals. Such disease- causing

microorganism are called pathogens. Some microorganism spoil food, clothing and leather.

Disease causing Microorganisms in Humans

Important definitions

- **Communicable Diseases-** These are microbial diseases (diseases caused by microbes) that spread from one infected person to a healthy person through air, water, food or physical contact, such as cholera, chicken pox, common cold and tuberculosis.
- **Carriers-** Insects and animals that carry disease-causing microbes and transfer them from one place to other are called carriers or vectors, such as house flies and mosquitoes.

How do Houseflies transfer pathogens?

A housefly may sit on the garbage and animal excreta and the pathogens stick to their body. When they sit on uncovered food, these pathogens get transferred to the food. When someone eats this contaminated food, he or she may fall sick. So to avoid this, we must keep the food covered.



Some notable examples of carriers

- i. Housefly spreads diseases such as cholera, dysentery, and typhoid.
- ii. **Malaria- Female Anopheles mosquito** (Carries the parasite of malaria called **Plasmodium**).
- iii. **Dengue-** female *Aedes* mosquito (Carries the dengue virus called **Flavivirus**).

Some common Human Diseases caused by Microorganisms

Human Disease	Causative Microorganisms	Mode of Transmission	Preventive measures (Generalised)
Tuberculosis	Bacteria - Mycobacterium tuberculosis	Air	Keep the patient in complete isolation. Keep the personal belongings of the patient away from those of the others. Vaccination to be given at suitable age.
Measles	Virus - Measles virus (genus Morbillivirus)	Air	Keep the patient in complete isolation. Keep the personal belongings of the patient away from those of the others. Vaccination to be given at suitable age.
Chicken Pox	Virus - varicella-zoster virus	Air/ Contact	Keep the patient in complete isolation. Keep the personal belongings of the patient away from those of the others. Vaccination to be given at suitable age.
Polio	Virus - Poliovirus	Air/ Water	Keep the patient in complete isolation. Keep the personal belongings of the patient away from those of the others. Vaccination to be given at suitable age.
cholera	Bacteria - Vibrio cholerae	Water/ Food	Maintain personal hygiene and good sanitary habits. Consume properly cooked food and boiled drinking water. Vaccination.
Typhoid	Bacteria - Salmonella Typhi	Water	Maintain personal hygiene and good sanitary habits. Consume properly cooked food and boiled drinking water. Vaccination.
Hepatitis A	Virus - Hepatitis A virus (HAV)	Water	Drink boiled drinking water. Vaccination.
Malaria	Protozoa - Plasmodium	Mosquito	Use mosquito net and repellents. Spray insecticides and control breeding of mosquitoes by not allowing water to collect in the surroundings.

Disease caused by Microorganisms in Animals

- **Anthrax**- A dangerous disease that affects human and cattle is caused by a bacterium called **Bacillus Anthracis**.

- **Foot and mouth disease in Cattle**- It is caused by a virus called **Foot-and-mouth-disease Virus (FMDV)** or Picornavirus.

Note- Bacillus anthracis was discovered by **Robert Koch** in 1876.

Disease Caused by Microorganisms in Plants

Microorganisms can cause diseases in plants and reduce crop yield. Some of the plants in which they cause diseases are:



Common disease in plants caused by Microbes

- **Citrus Canker** is caused by Bacteria and spreads through Air.
- **Rust of Wheat** is caused by Fungi and spreads through Air or Seeds.
- **Yellow Vein Mosaic of Okra (Bhindi)** is caused by Virus and spreads through Insects.

Food Preservation

Why- We need to preserve food because microorganisms that grow on food can sometimes produce toxic substances which are poisonous to us. If we consume this spoilt food, we can become seriously ill or die. Hence, we need to preserve food from being spoilt.

Common methods of preserving food are-

1. Use of Preservatives

- Preservatives are used in pickles, jams and squashes to protect them from spoilage.
- Preservatives are common chemicals (such as salt and edible oils) that check the growth of microorganisms
- In pickles, we add salt or acid preservatives.
- Two commonly used preservatives are sodium benzoate and sodium metabisulphite

2. Use of common salt

- Meat and fish are covered with dry salt to check the growth of bacteria.
- Salt is also used to preserve tamarind, amla, raw mangoes etc.

3. Use of sugar

- In jams, jellies and squashes, sugar is used as preservatives.
- Sugar reduces the moisture content and hence, inhibits the bacteria from growing and spoiling food.

4. Use of oil and Vinegar

- Oil and vinegar are added to pickles, fruits, vegetables, fish and meats as preservatives.
- Bacteria cannot survive in an environment with oil and vinegar.

5. Use of Hot and Cold Treatments

- Boiling milk lasts longer as boiling kills many microorganisms.
- Refrigerating food preserves as low temperature inhibits the growth of microbes.
- Pasteurisation is the process by which milk is heated about 70 degree Celsius for 15 to 30 seconds and then, chilled suddenly before storing it, it prevents the growth of microbes, we can use pasteurised milk without boiling as it is free from harmful microbes.
- Pasteurisation was discovered by Louis Pasteur.

6. Use of Sealed- Air-tight packets.

- Dry fruits and vegetables are sold in air-tight packets as microbes cannot survive without air. Hence, the food does not get spoilt in air tight packets.

What are Life Processes?

All the processes such as respiration, nutrition, circulation, excretion etc. that are necessary for the survival of the living organisms are known as life processes.

- All living things perform certain life processes like growth, excretion, respiration, circulation etc.

Nutrition in Living things

Different life processes of an organism, like growth and maintenance, require energy which is obtained from food by a process called **nutrition**.

Different organisms have varied nutritional processes depending on their environment and specific food requirement. Nutrition provides nutrients to the body so that it can obtain energy to carry out the activities to stay alive.

Modes of Nutrition

Depending upon the source of energy, nutrition is categorized as

1. Autotrophic Nutrition
2. Heterotrophic Nutrition

Let's explain each in details.

1. Autotrophic Nutrition

- It is a kind of nutrition in which inorganic materials like CO_2 , water etc. are utilized to prepare organic food by the process of **photosynthesis**.
- The organisms which carry out autotrophic nutrition are called **autotrophs** (green plants).
- Autotrophs use simple inorganic material and convert it into complex high energy molecules (Carbohydrates).
- Autotrophic nutrition is fulfilled by the process by which autotrophs take in CO_2 and H_2O and convert these into carbohydrates in the presence of chlorophyll, sunlight is called **Photosynthesis**.
- The carbohydrates which are not used immediately are stored in the form of starch, which serves as the internal energy reserve to be used as and when required by the plant. A somewhat similar situation is seen in us where some of the energy derived from the food we

eat is stored in our body in the form of glycogen.

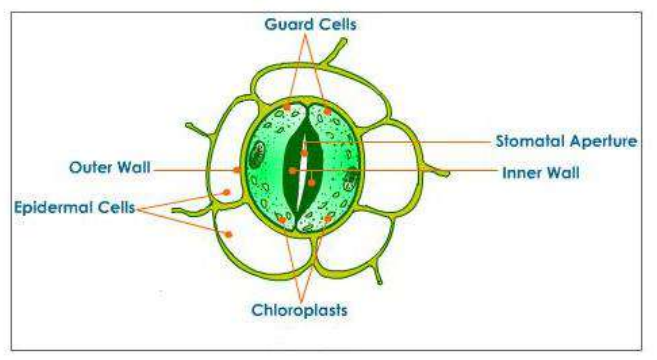
- On the basis of energy used by an organisms to synthesize their own food, there are two types of autotrophic mode of nutrition
 1. Photoautotrophic
 2. Chemoautotrophic

What actually happens during the Photosynthesis?

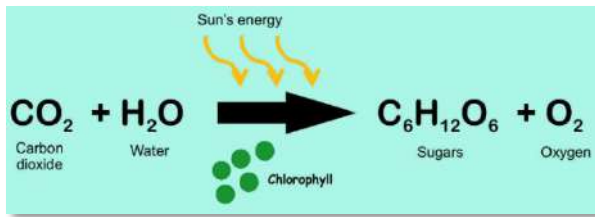
- For photosynthesis to occur, carbon dioxide, water, sunlight and chlorophyll are the required raw materials. Sunlight provides energy, chlorophyll is used to absorb the sunlight, carbon dioxide is reduced to carbohydrates and water is oxidised to release the oxygen. Water is taken up from the soil through the roots.
- The site where photosynthesis occurs is known as **chloroplast**. They contain a green colour pigment known as chlorophyll that traps sunlight for photosynthesis.
- **The Steps of photosynthesis are as follows-**
 1. Absorption of light by chlorophyll.
 2. Conversion of light energy into chemical energy.
 3. Splitting of water into hydrogen and oxygen.
 4. Finally, reduction of carbon dioxide into carbohydrates.

Site of Photosynthesis-

Leaves contain small openings known as **stomata** which helps in the exchange of gases. The stomata/stoma is surrounded by a **guard cell** which guards the opening and closing of stomata. Guard cells also contain chloroplast. So basically some cells contain green pigments which are cell organelles called chloroplasts which contain chlorophyll.



The Overall equation of Photosynthesis is-



Heterotopic Nutrition

- Kind of nutrition in which organisms do not possess the ability to synthesize their own food. They depend on autotrophs for their food supply directly or indirectly.
Example: Animals, fungi.
- There are various types of heterotrophic nutrition

1. Parasitic mode of nutrition

- Organisms that live in or on the bodies of other organism (host) and acquire their food are called parasites and mode is called parasitic.
- Most parasites are harmful to the host's health; sometimes, they even kill the host. Both animals and plants may serve as a host.
- Examples are Cuscuta (Plant parasites), ticks etc.

2. Holozoic mode of Nutrition

- Holozoic nutrition is a method of nutrition that involves the ingestion of liquid or solid organic food. It involves digestion, absorption and assimilation of the food and its utilization.
- In this process complex substance and converted into simpler forms. Most of the free living animals including humans exhibit this types of nutrition.
- Example- Amoeba, animals.

3. Saprophytic mode Nutrition

- Organism which follow saprophytic nutrition feeds on dead and decaying organisms for energy.
- They are an important part of the ecosystem as they help to keep our environment clean and recycle the nutrients back into the ecosystem.

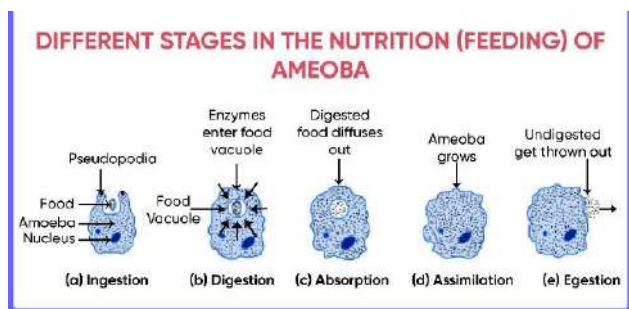
- Saprotrophs are also known as natural decomposers. Saprotrophs release certain enzymes which acts on the complex organic matter and breaking it into its constituents, which can be easily consumed by them.
- Examples- Fungi, termites, rhizopus (bread Mould), Mucor, yeast, aspergillus, agaricus-mushroom.

There are several stage of holozoic nutrition, which often occurs within an organism body (in the stomach and in the intestine's)

- 1. Ingestion-** it involves taking the food through mouth in the body. In protozoa, this most commonly occurs through phagocytosis.
- 2. Digestion-** it involved the breakdown of complex organic food particles with the help of teeth and tongue and the enzymatic breakdown of complex organic compounds into simple molecules in the stomach and intestines respectively.
- 3. Absorption-** the digested food get absorbed in the blood vessels through the walls of intestine and blood transports it to the cells.
- 4. Assimilation-** utilization of the absorbed molecules to release energy within cells and for various metabolic processes.
- 5. Egestion-** the removal of undigested material from the digestive system.

How organism obtain their food?

- In case of unicellular/ single celled organism food is taken up through entire surface.
- For example- For example, Amoeba takes in food using temporary finger-like extensions of the cell surface which fuse over the food particle forming a food-vacuole. Inside the food-vacuole, complex substances are broken down into simpler ones which then diffuse into the cytoplasm. The remaining undigested material is moved to the surface of the cell and thrown out.
- In **Paramoecium**, which is also a unicellular organism, the cell has a definite shape and food is taken in at a specific spot. Food is moved to this spot by the movement of cilia which cover the entire surface of the cell.



Nutrition in Human beings

The alimentary canal is basically a long tube extending from the mouth to the anus. Various regions are specialised to perform different functions. And the glands associated with digestion constitute the human digestive system.

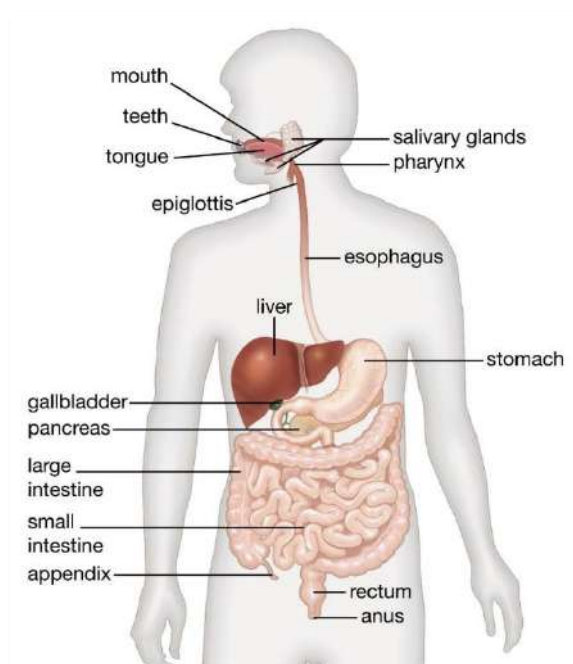
Human Digestive system

A. Alimentary canal- the alimentary canal in human beings measures about 8-10 meters in length. The canal can be divided into various compartments: **(1) the buccal cavity, (2) food pipe or oesophagus, (3) stomach, (4) small intestine, (5) large intestine** ending in the **rectum** and **(6) the anus**.

- The activities of the gastro-intestinal tract [alimentary canal] are under neural and hormonal control for proper coordination of different parts.
- The sight, smell and/or the presence of food in the oral cavity can stimulate the secretion of saliva.
- Gastric and intestinal secretions are also, similarly, stimulated by neural signals.
- The muscular activities of different parts of the alimentary canal can also be moderated by neural mechanisms.

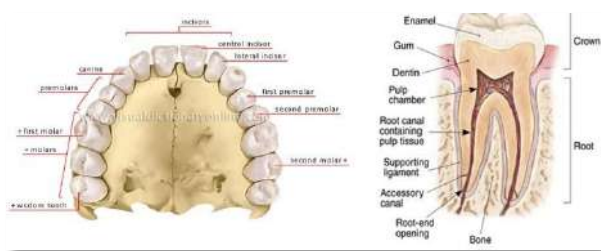
It includes following parts-

1. Mouth
2. Pharynx
3. Oesophagus/food pipe
4. Stomach
5. Small intestine
6. Large intestine
7. Rectum
8. Anus

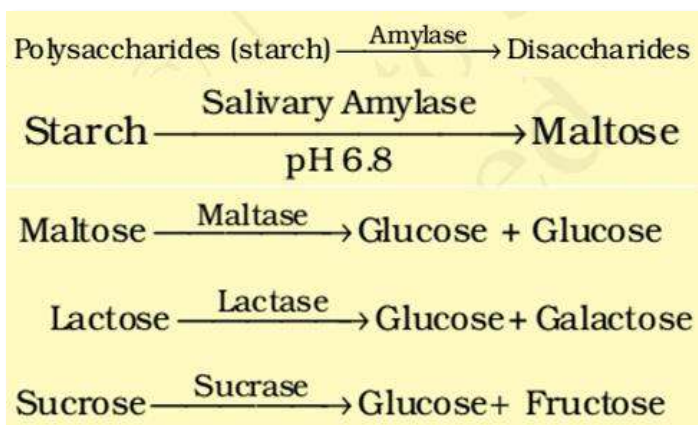


1. Buccal cavity or Oral Cavity- Teeth, Tongue, Saliva

- The process of taking food into the body is called ingestion. **Ingestion** happens through mouth. The mouth leads to the buccal cavity or oral cavity.
- The oral cavity has a number of teeth and a muscular tongue. Each tooth is embedded in a socket of jaw bone.
- Majority of mammals including human being forms two sets of teeth during their life, a set of temporary milk or deciduous teeth [milk teeth] replaced by a set of permanent or adult teeth [permanent teeth].
- An adult human has 32 permanent teeth which are of four different types, namely, **incisors (I), canine (C), premolars (PM) & molars (M)**.
- Arrangement of teeth in each half of the upper and lower jaw in the order I, C, PM, M is represented by a dental formula which in human is 2123/2123 [2-I,1-C,2-PM,3-M]
- The hard chewing surface of the teeth, made up of enamel (**Enamel** is the hardest substance in the human body and contains the highest percentage of minerals), helps in the mastication (chewing) of food.



- Our mouth has the salivary glands which secrete **saliva**. The saliva breaks down the starch into sugars.
- The saliva secreted into the oral cavity contains electrolytes (Na^+ , K^+ , Cl^- , HCO_3^-) and enzymes, **SALIVARY AMYLASE** and **LYSOZYME**.
- The chemical process of digestion is initiated in the oral cavity by the hydrolytic action of the carbohydrate splitting enzyme, the salivary amylase.
- About 30 per cent of starch is hydrolysed here by this enzyme (**optimum pH 6.8**) into a **disaccharide – maltose**.



- Lysozyme present in saliva acts as an **antibacterial agent** that prevents infections.
- The tongue is a fleshy muscular organ attached at the back to the floor of the buccal cavity. It mixes saliva with the food during chewing and helps in swallowing food.
- The tongue is attached to the floor of the oral cavity by the **frenulum** (a fold of skin beneath the tongue).
- The upper surface of the tongue has small projections called papillae, some of which bear taste buds.

What is dental caries?

Dental caries or tooth decay causes gradual softening of enamel and dentine. It begins when bacteria acting on sugars produce acids that softens

or demineralises the enamel. Masses of bacterial cells together with food particles stick to the teeth to form **dental plaque**. Saliva cannot reach the tooth surface to neutralise the acid as plaque covers the teeth. Brushing the teeth after eating removes the plaque before the bacteria produce acids. If untreated, microorganisms may invade the pulp, causing inflammation and infection.

2. Foodpipe/Oesophagus

- The oral cavity leads into a short pharynx which serves as a common passage for food and air. The esophagus and the trachea (wind pipe) open into the pharynx.
- A **cartilaginous flap** called **epiglottis** prevents the entry of food into the glottis during swallowing.
[Glottis == opening of the wind pipe].
- The swallowed food passes into the **foodpipe or oesophagus**. The oesophagus is a thin, long tube which extends posteriorly [further back in position] passing through the neck, **thorax** [the part of the body of a mammal between the neck and the abdomen] and **diaphragm** [separates the thorax from the abdomen in mammals] and leads to a 'J' shaped bag like structure called **stomach**.
- **Mucus** in saliva helps in lubricating and adhering the masticated food particles into a **bolus**. The bolus is then conveyed into the pharynx and then into the oesophagus by swallowing or **deglutition**.
- The bolus further passes down through the oesophagus by successive waves of muscular contractions called **peristalsis**. The gastro-oesophageal sphincter controls the passage of food into the stomach.

3. Stomach

- The inner lining of the stomach secretes **mucous, hydrochloric acid** and **digestive juices**.
 1. The mucous protects the lining of the stomach.
 2. The acid kills many bacteria that enter along with the food and makes the medium in the stomach acidic.
 3. The digestive juices break down the proteins into simpler substances.

- A **muscular sphincter (gastro-oesophageal)** [a ring of muscle surrounding and serving to guard or close an opening] regulates the opening of oesophagus into the stomach.
- The stomach, located in the upper left portion of the abdominal cavity, has three major parts – a cardiac portion into which the oesophagus opens, a fundic region and a pyloric portion which opens into the first part of small intestine.

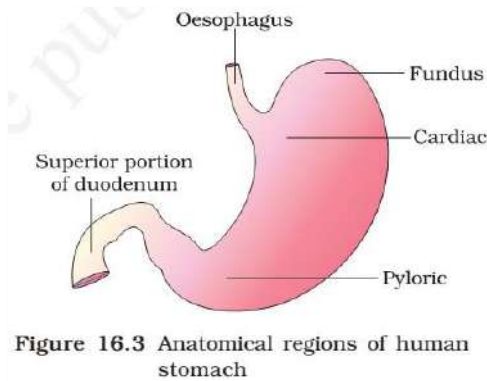


Figure 16.3 Anatomical regions of human stomach

4. Small Intestine

- Small intestine is distinguishable into three regions, a '**C**' shaped **duodenum**, a long coiled middle portion **jejunum** and a highly coiled **ileum**.
- The opening of the stomach into the duodenum is guarded by the **pyloric sphincter**. Ileum opens into the large intestine.
- The small intestine is highly coiled and is about 5 meters long. It receives secretions from the liver and the pancreas. Besides, its wall also secretes juices.
- The digested food passes into the blood vessels in the wall of the intestine. This process is called **absorption**.
- The inner walls of the small intestine have thousands of finger-like outgrowths. These are called **villi** (singular villus). The villi increase the surface area for absorption of the digested food.
- Villi are supplied with a network of capillaries and a large **lymph** (a colourless fluid containing white blood cells) vessel called the **lacteal**.
- The absorbed substances are transported via the blood vessels to different organs of the body where they are used to build complex

substances such as the proteins required by the body. This is called **assimilation**.

- In the cells, glucose breaks down with the help of oxygen into carbon dioxide and water, and energy is released.
- The food that remains undigested and unabsorbed then enters into the large intestine.

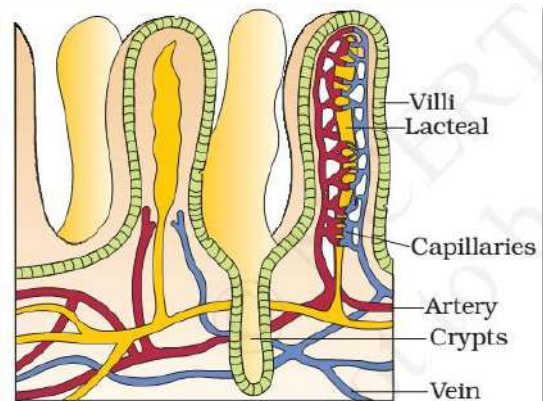


Figure 16.5 A section of small intestinal mucosa showing villi

5. Large intestine

- The large intestine is wider and shorter than small intestine. It is about 1.5 metre in length. Its function is to **absorb water** and **some salts** from the undigested food material.
 - The remaining waste passes into the rectum and remains there as semi-solid faeces. The faecal matter is removed through the anus from time-to-time. This is called **egestion**.
- Ingestion → Digestion → Absorption → Assimilation → Egestion**
- It consists of caecum, colon and rectum. **Caecum** is a small blind sac which hosts some symbiotic micro-organisms.
 - A narrow finger-like tubular projection, the vermiform appendix which is a vestigial organ [small remnant of something that was once more noticeable], arises from the caecum.

Appendix was helpful in digesting roughage (fibrous indigestible material in vegetable foodstuffs which aids the passage of food and waste products through the gut). Thousands of years ago, when man used to eat roots, leaves, etc., it was essential. But now it has lost its significance.

- The caecum opens into the colon. The **colon** is divided into three parts – an ascending, a transverse and a descending part. The

descending part opens into the rectum which opens out through the anus.

- No significant digestive activity occurs in the large intestine. The functions of large intestine are: absorption of some water, minerals and certain drugs; secretion of mucus which helps in adhering the waste (undigested) particles together and lubricating it for an easy passage.
- The undigested, unabsorbed substances called faeces enters into the caecum of the large intestine through **ileo-caecal valve**, which prevents the back flow of the faecal matter. It is temporarily stored in the rectum till defaecation.

Layers of Alimentary canal

- The wall of alimentary canal from oesophagus to rectum possesses four layers namely serosa, muscularis, sub-mucosa and mucosa.
 1. **Serosa** is the outermost layer and is made up of a thin mesothelium (**epithelium of visceral organs**) with some connective tissues.
 2. **Muscularis** is formed by smooth muscles.
 3. The **submucosal layer** is formed of loose connective tissues containing nerves, blood and lymph vessels. In **duodenum**, glands are also present in sub-mucosa.
- The innermost layer lining the lumen of the alimentary canal is the **mucosa**. This layer forms irregular folds (rugae) in the stomach and small finger-like foldings called villi in the small intestine. Mucosal epithelium has **goblet cells** which secrete mucus that help in lubrication. Mucosa also forms glands in the stomach (gastric glands).

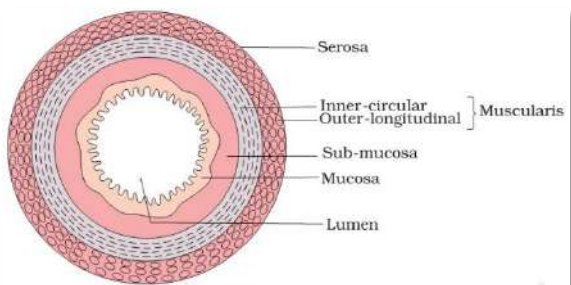


Figure 16.4 Diagrammatic representation of transverse section of gut

Digestive glands

Digestive Glands- it includes salivary glands, stomach or gastric glands, liver and pancreas, which

secrete enzymes and digestive juices which helps in digestion.

1. Salivary Glands

- Saliva is mainly produced by three pairs of salivary glands, the **parotids (cheek)**, the **sub-maxillary (lower jaw)** and the **sub-linguals (below the tongue)**.
- These glands situated just outside the buccal cavity secrete salivary juice into the buccal cavity.
- The saliva breaks down the **starch** into **sugars**.

2. Liver

- The liver is a reddish brown gland situated in the upper part of the abdomen on the right side.
- It is the **largest gland in the body**.
- It secretes **bile juice** that is stored in a sac called the **gall bladder**.
- The bile plays an important role in the digestion of **fats**.
- It has two lobes. The **hepatic lobules** are the structural and functional units of liver containing hepatic cells.
- The bile secreted by the hepatic cells passes through the hepatic ducts and is stored and concentrated in a thin muscular sac called the **gall bladder**.
- The duct of gall bladder (cystic duct) along with the hepatic duct from the liver, forms the **common bile duct**.
- The bile duct and the pancreatic duct open together into the **duodenum** as the common hepato-pancreatic duct which is guarded by a sphincter called the **sphincter of Oddi**.

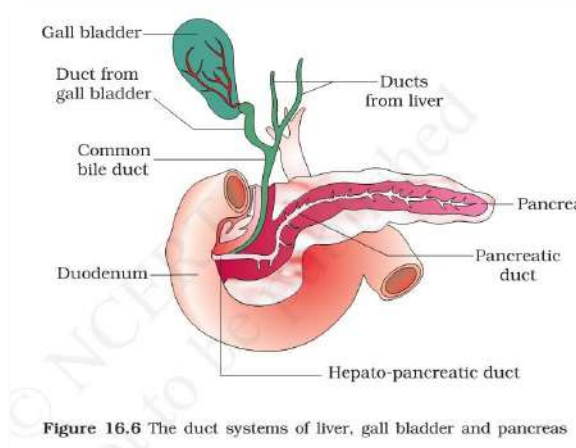


Figure 16.6 The duct systems of liver, gall bladder and pancreas

3. Pancreas

- The pancreas is a large cream coloured gland located just below the stomach.
- The pancreatic juice acts on **carbohydrates** and **proteins** and changes them into simpler forms.
- The partly digested food now reaches the lower part of the small intestine where the intestinal juice [**succus entericus**] completes the digestion of all components of the food.
- The pancreas is a compound (both exocrine and endocrine) elongated organ situated between the limbs of the 'U' shaped duodenum.
- The **exocrine portion** secretes an alkaline **pancreatic juice** containing enzymes and the **endocrine portion** secretes **hormones, insulin** and **glucagon**.

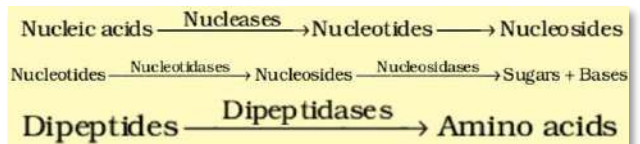
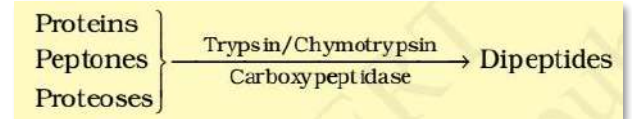
Digestion- Enzyme Action in stomach

- The stomach stores the food for 4-5 hours. The food mixes thoroughly with the acidic gastric juice of the stomach by the churning movements of its muscular wall and is called the **chyme**.
- The **proenzyme** [inactive precursor of an enzyme] **pepsinogen**, on exposure to hydrochloric acid gets converted into the active enzyme **PEPSIN**, the **proteolytic** (breakdown of **proteins** or **peptides** into **amino acids**) enzyme of the stomach.
- Pepsin converts proteins into proteoses and peptones (peptides).
- The mucus and bicarbonates present in the gastric juice play an important role in lubrication and protection of the mucosal epithelium from excoriation by the highly concentrated hydrochloric acid. HCl provides the acidic pH (pH 1.8) optimal for pepsins.
- Rennin is a proteolytic enzyme found in gastric juice of infants which helps in the digestion of milk proteins.

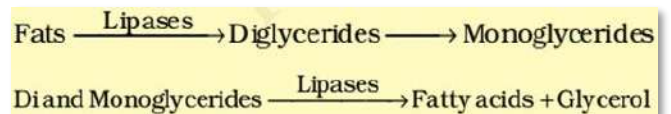
Digestion- Enzyme Action in Small intestine

- The pancreatic juice contains inactive enzymes – trypsinogen, chymotrypsinogen, procarboxypeptidases, amylases, lipases and nucleases.

- **Trypsinogen** is activated by an enzyme, enterokinase, secreted by the intestinal mucosa into active TRYPSIN, which in turn activates the other enzymes in the pancreatic juice.



- The bile released into the duodenum contains bile pigments (bilirubin and biliverdin), bile salts, cholesterol and phospholipids but no enzymes.
- **Bile helps** in emulsification of fats, i.e., breaking down of the fats into very small micelles. Bile also activates **LIPASES**. Small amounts of lipases are secreted by gastric glands.



- The intestinal mucosal epithelium has goblet cells which secrete mucus. The secretions of the mucosa along with the secretions of the **goblet cells** constitute the intestinal juice.
- This juice contains a variety of enzymes like **disaccharidases** (e.g., **maltase**), **dipeptidases**, **lipases**, **nucleosidases**, etc. Hormonal control of the secretion of digestive juices is carried out by local hormones produced by the gastric and intestinal mucosa.
- The mucus along with the bicarbonates from the pancreas protects the intestinal mucosa from acid as well as provide an alkaline medium (pH 7.8) for enzymatic activities.
- The breakdown of biomacromolecules mentioned above occurs in the duodenum region of the small intestine.
- The simple substances thus formed are absorbed in the jejunum and ileum regions of the small intestine.
- The undigested and unabsorbed substances are passed on to the large intestine.

Absorption of Digested product

- Absorption is the process by which the end products of digestion pass through the intestinal mucosa into the blood or lymph.
- Small amounts of monosaccharides like glucose, amino acids and some electrolytes like chloride ions are generally absorbed by simple diffusion. The passage of these substances into the blood depends upon the concentration gradients.
- However, sometimes substances like glucose and amino acids are absorbed with the help of carrier proteins. This mechanism is called the **facilitated transport**.
- Transport of water depends upon the osmotic gradient. Active transport occurs against the concentration gradient and hence requires energy. Various nutrients like amino acids, monosaccharides like glucose, and electrolytes like Na⁺ are absorbed into the blood by this mechanism.
- **Fatty acids** and **glycerol** being insoluble, cannot be absorbed into the blood. They are first incorporated into small droplets called **micelles** which move into the intestinal mucosa. They are re-formed into very small protein coated fat globules called the chylomicrons which are transported into the lymph vessels (lacteals) in the villi. These lymph vessels ultimately release the absorbed substances into the blood stream.
- Absorption of substances takes place in different parts of the alimentary canal, like mouth, stomach, small intestine and large intestine. However, maximum absorption occurs in the small intestine.

Summary of Absorption in Different parts of Digestive System

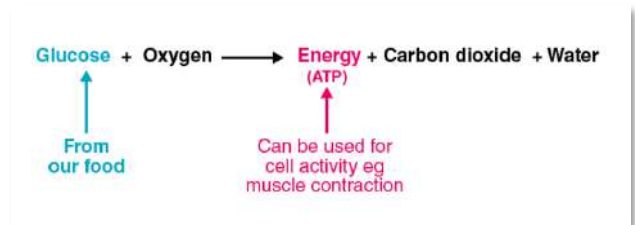
Mouth	Stomach	Small Intestine	Large Intestine
Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed	Absorption of water, simple sugars, and alcohol etc. takes place.	Principal organ for absorption of nutrients. The digestion is completed here and the final products of digestion	Absorption of water, some minerals and drugs takes place.

into the blood capillaries lining them.		such as glucose, fructose, fatty acids, glycerol and amino acids are absorbed through the mucosa into the blood stream and lymph.	
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- The absorbed substances finally reach the tissues which utilise them for their activities. This process is called assimilation.
- The digestive wastes, solidified into coherent faeces in the rectum initiate a neural reflex causing an urge or desire for its removal. The egestion of faeces to the outside through the anal opening (defaecation) is a voluntary process and is carried out by a **mass peristaltic movement**.

Respiration

- Respiration broadly means the exchange of gases. Gaseous exchange in case of living beings is intake of oxygen from atmosphere and release of carbon dioxide.
- Animals and plants have different means of exchange of gases.
- At a cellular level, respiration means the burning of the food for generating the energy needed for other life processes.
- Cellular respiration may take place in the **presence or absence of oxygen**.



Respiration in living beings

- The process of release of energy from assimilated food is called **respiration**. The term respiration was first used to describe the breathing that is exchange of gases between organism and the environment. Subsequently the term respiration was used in a wider sense including breathing, transport of gases as well as

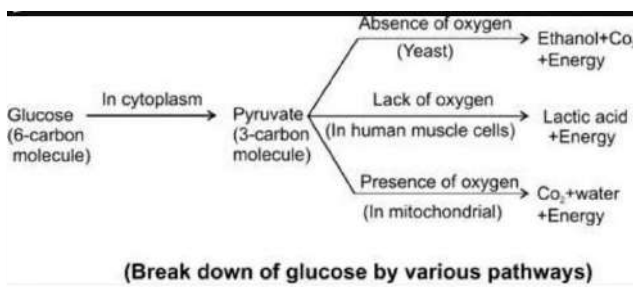
the oxidation of food leading to release of CO_2 and energy.

- It is now agreed that respiration has two fundamental processes-**external respiration and internal respiration.**

Breakdown of Glucose by Various Pathways

- The first step is the break-down of glucose (a six-carbon molecule) into a three-carbon molecule called pyruvate which takes place in the cytoplasm.
- The pyruvate may be converted into ethanol and carbon dioxide which takes place in yeast during fermentation. Since this process takes place in the absence of air (oxygen), it is called anaerobic respiration.
- In the presence of oxygen, the pyruvate is further broken down to give carbon dioxide and water. This process takes place in mitochondria. Since this process takes place in the presence of air (oxygen), it is called aerobic respiration.
- The pyruvate is converted into lactic acid when there is a lack of oxygen in our muscle cells, which is also a three-carbon molecule. This build-up of lactic acid in our muscles during sudden activity causes cramps.

The whole process of breakdown of glucose is shown below



- The energy released during cellular respiration is immediately used to synthesise a molecule called ATP which is used to fuel all other activities in the cell. In these processes, **ATP** is broken down giving rise to a fixed amount of energy which can drive the endothermic reactions taking place in the cell.
- The rate of breathing in aquatic organisms is much faster than that seen in terrestrial organisms because the amount of dissolved

oxygen is fairly low compared to the amount of oxygen in the air.

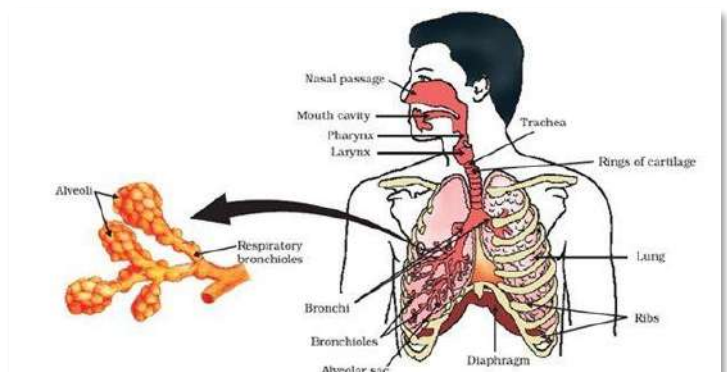
Types of Respiration

Depending on the availability of oxygen, Sachs (1890) classified respiration into two major types

- Aerobic respiration**
- Anaerobic respiration**

S.NO	Features	Aerobic Respiration	Anaerobic Respiration
1	O ₂ requirement	O ₂ required	Not required
2	Occurs in	Cytoplasm and mitochondria	Cytoplasm only
3	Breakdown	Complete breakdown of glucose takes place	Incomplete breakdown of glucose takes place
4	End products	CO ₂ and H ₂ O	CO ₂ and ethyl alcohol or lactic acid
5	Energy produced from one glucose molecule	38 ATP	2 ATP

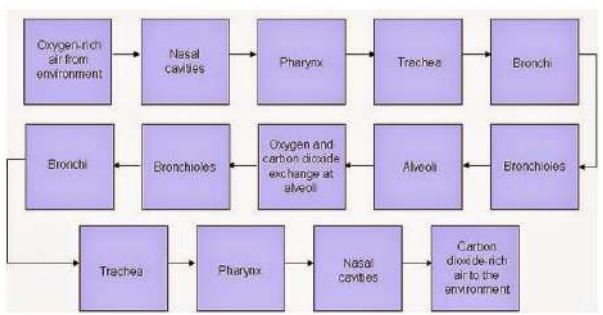
Human Respiratory system



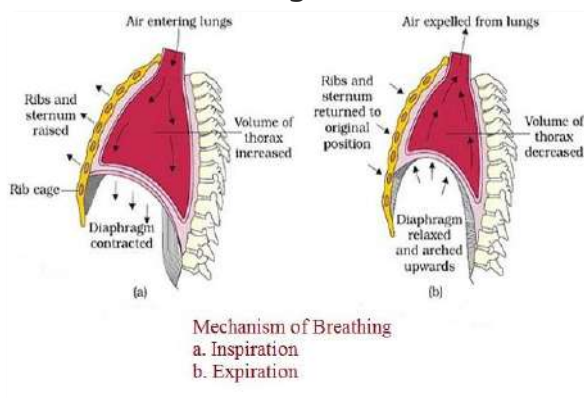
Human respiratory system consists of

- Nostril-** Air is taken into the body.
- Nasal passage-** It is a channel for airflow through the nose.
- Nasal cavity-** It is lined with hairs and mucus membrane. It warms, moisturize, and filter air before it reaches the lungs.
- Pharynx-** A muscular tube that serves as a common passageway for air and food.
- Larynx-** It houses the vocal cords and manipulates pitch and volume, which is essential for phonation. It is also known as voice box.
- Trachea-** Also called the windpipe. It extends from the larynx and connects to the bronchi of the lungs. It connects the larynx (or voice box) to the bronchi of the lungs. It provides air flow to and from the lungs for respiration.

7. **Bronchi-** They are the main passageway into the lungs. They are the extensions of the windpipe that shuttle air to and from the lungs. The oxygen goes to the lungs and carbon dioxide leave the lungs through them.
8. **Bronchioles-** Bronchi get smaller when they reach closer to lung tissues and are called Bronchioles. They are the passageways by which air passes through the nose or mouth to the alveoli of the lungs
9. **Alveoli-** Tiny balloon-like structures which finally terminate the bronchioles. They allow oxygen and carbon dioxide to move between the lungs and bloodstream.
10. **Blood capillaries-** They are the sites of the transfer of oxygen and other nutrients from the bloodstream to other tissues in the body. They also collect carbon dioxide and waste materials and return it to the veins.



Mechanism of Breathing



Inhalation	Exhalation
During inhalation the thoracic cavity (chest cavity) expands	Thoracic cavity contracts.
Ribs lift up	Ribs move downwards.
Diaphragm become flat in shape	Diaphragm becomes dome shaped.
Volume of lungs increases and air enters the lungs	Volume of lungs decreases and air exits from the lungs

Exchange of gases between alveoli, blood and tissue.

- Oxygen moves from the alveoli into the blood, where it binds to hemoglobin in RBCs. It is then transported by the blood to the body tissues, where Oxygen is released from hemoglobin and diffuses into the tissues.
- CO₂ is released in blood and dissolved into it and carried by blood vessels.
- The carbon dioxide is released in alveolar sac which is sent out through nostrils.

Note- Terrestrial organisms- Use atmospheric oxygen for respiration.

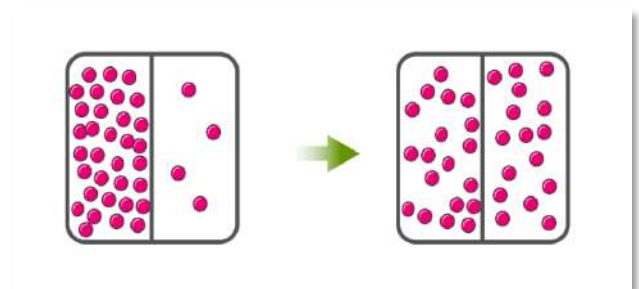
Aquatic organisms: Use dissolved oxygen for respiration.

Remember- Smoking is injurious to health.

Lung cancer is one of common causes of deaths in the world. The upper part of respiratory tract is provided with small hair-like structures called cilia. These cilia help to remove germs, dust and other harmful particles from inhaled air. Smoking destroys these hair due to which germs, dust, smoke and other harmful chemicals enter lungs and cause infection, cough and even lung cancer.

What is Diffusion?

Diffusion is the movement of molecules from high concentration area to the low concentration area without spending any energy.

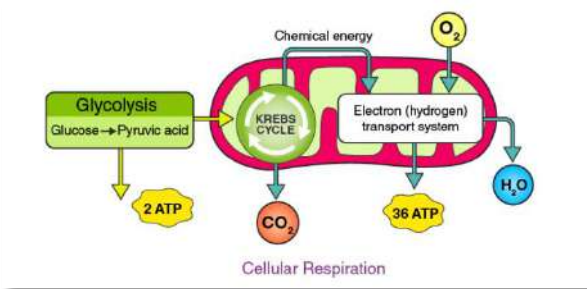


What is Cellular Respiration?

Cellular respiration is a set of metabolic reactions occurring inside the cells to convert biochemical energy obtained from the food into a chemical compound called **adenosine triphosphate (ATP)**.

- **Metabolism** refers to a set of chemical reactions carried out for maintaining the living state of the cells in an organism. These can be divided into two categories:

- **Catabolism** – the process of breaking molecules to obtain energy.
- **Anabolism** – the process of synthesizing all compounds required by the cells.
- Therefore, respiration is a catabolic process, which breaks large molecules into smaller ones, releasing energy to fuel cellular activities.
- **Glycolysis, Krebs cycle and electron transport chain** are the important processes of the cellular respiration.



Respiration in Plants

Respiration in plants is simpler than the respiration in animals. Gaseous exchange occurs through:

- Stomata** in leaves
- Lenticels** in stems
- General surface of the root

Transportation in Human Beings

Human beings like other multicellular organisms need a regular supply of food, oxygen etc. This function is performed by the circulatory system.

The circulatory system in human beings consists of-

- Heart**- PUMPING ORGAN
- Arteries and Veins**- Blood vessels
- Blood and Lymph**- Circulatory medium

Blood is a fluid connective tissue that transports food, oxygen, carbon dioxide, nitrogenous waste etc. Blood contains plasma and blood cells. Red blood cells carry oxygen throughout the body. The heart is the pumping organ in the body.

- The human heart is 4-chambered, with two atria and two ventricles.
- The left atrium receives the oxygen-rich blood from the lungs. While receiving the blood it relaxes.
- The left ventricle pumps oxygen-rich blood throughout the body.
- Deoxygenated blood comes from the body to the upper right atrium. It contracts to pump the blood to the right ventricle.

- The right ventricle pumps the blood to the lungs for oxygenation.

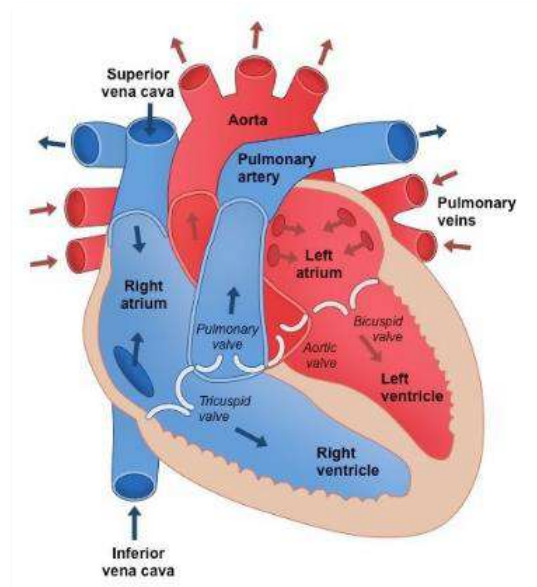


Fig.7. Structure of Human Heart

Note: Fishes have a two-chambered heart, amphibians and reptiles have a three-chambered heart except crocodiles which possess a 4-chambered heart. Birds and mammals also have 4-chambered hearts.

Blood circulation in human body- Double Circulation

The right side and left side of the heart are separated to prevent the mixing of oxygenated and deoxygenated blood. In vertebrates, blood goes through the heart twice during each cycle. This is defined as **double circulation**.

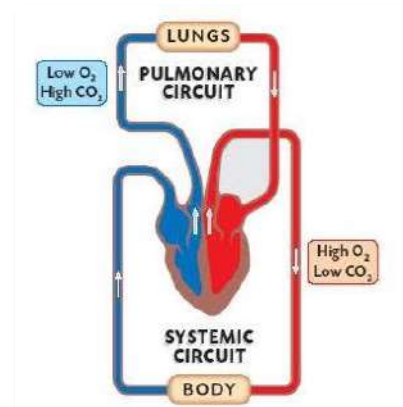


Fig.8. Double Circulation

Note: The force that the blood exerts against the wall of the vessel is known as **blood pressure**. The pressure of blood inside the artery during ventricular contraction is known as **systolic pressure** whereas the pressure in the artery during

ventricular relaxation is known as **diastolic pressure**. The normal blood pressure is **120/80 mm of Hg**.

Artery	Capillary	Vein
They carry blood away from the heart	One cell thick smallest vessels	They carry blood towards the heart
They carry oxygenated blood except for the pulmonary artery.	Help in the exchange of the material between the blood and surrounding cells.	They carry deoxygenated blood except for the pulmonary vein.
They have thick walls and do not have valves.	They do not have valves	They have thin walls and also possess valves.

- **Platelets** are blood cells that help in **blood clotting**.
- Lymph is a fluid that is formed from interstitial fluid that leaks out from the pores of the capillaries and enters the lymphatic vessels.

Transport in Plants

- Plants have the **xylem** tissue for the transportation of water. Xylem transports water from the roots to different parts of the plants. Xylem tissue consists of vessels and tracheids.
- Loss of water in the form of water vapour from the aerial parts of the plants is known as **transpiration**. The transpiration creates a suction that pulls the water up to the higher plants.
- Similarly, the transport of food in plants occurs via the **phloem**. It transports food from the leaves to different parts of the plants.

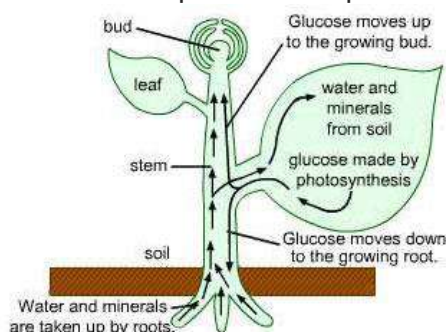


Fig.9. Transport in Plants

Excretion

- Excretion is elimination of metabolic waste, which is an essential process in all organisms. In vertebrates, this is primarily carried out by the lungs, kidneys, and skin.

- The excretory system of humans consists of a pair of kidneys, a pair of ureters, urinary bladder and urethra.
- The basic filtration unit of the kidneys is known as **nephrons**.
- The nephron is the structural and functional unit of the kidneys.
- They consist of a **bowman's capsule** and a renal tubule.
- For the formation of urine, some substances such as glucose and amino acids are selectively reabsorbed.
- The amount of water reabsorbed depends on how much water is there in the body.
- The urinary bladder is a muscular structure and it is under nervous control

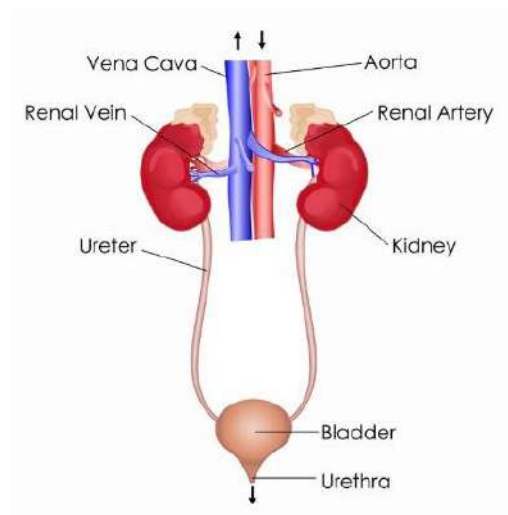


Fig.10. Human Excretory System

Note: Plants excrete their waste through transpiration. Plants also produce other excretory waste in the form of gums, resins etc.

All the living organisms respond and react to changes in the environment around them. The changes in the environment to which the organisms respond and react are called stimuli such as light, heat, cold, sound, smell, touch etc. Both plants and animals respond to stimuli but in a different manner.

Systems for control and coordination in Animals

Control and Coordination in animals is done with the help of two main systems:

- Nervous system
- Endocrine system

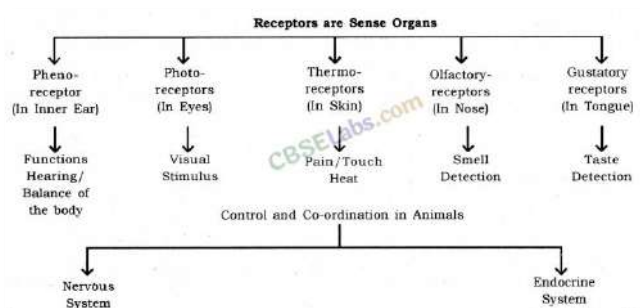
Nervous system

- Control and coordination are provided by nervous and muscular tissues.
- Nervous tissue is made up of an organized network of nerve cells or neurons which is specialized for conducting information via electrical impulses from one part of the body to another.

Receptors

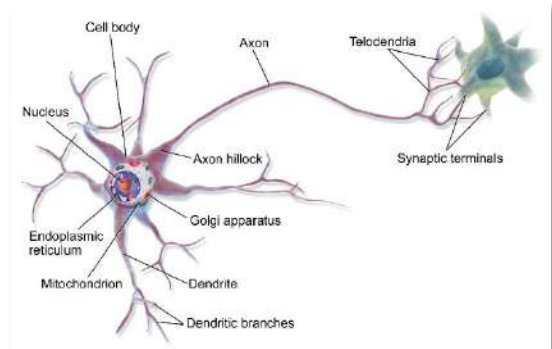
These are specialized tips of some nerve cells that detect the information from the environment. These are located in our sense organs.

- 1. Ear:** It acts as phonoreceptors (receiving sound). It helps in hearing and maintaining the balance of body.
- 2. Eyes-** It acts as photoreceptors (receiving light). It helps in seeing
- 3. Skin:** It contains various receptors, including thermoreceptors (feels temperature) and mechanoreceptors (feels touch and pressure). It helps in feeling heat, cold, touch, pressure, and pain.
- 4. Nose:** It acts as olfactory receptors (sense of smell). It helps in the detection of the smell.
- 5. Tongue:** It acts as gustatory receptors (sense of taste). It helps in the detection of taste.



Neuron

- It is the structural and functional unit of nervous system.
- Neuron is a highly specialized cell which is responsible for the transmission of nerve impulses.



Parts of Neuron

- a. Dendrite-** It acquires information.
- b. Cell body:** The information acquired by it travels as an electrical impulse.
- c. Axon:** It is a long extension from the cell body. It transmits electrical impulse cell body to dendrite of next neuron.

Synapse- It is the gap between the nerve ending of one neuron and dendrite of the other neuron. Here, electrical signal is converted into chemical signal for onward transmission.

Functioning of Neuron

- The information from receptors is acquired at the end of the dendritic tip of a nerve cell as chemical reaction that creates an electrical impulse.
- This impulse travels from the dendrite to the cell body and then at the end of the axon.
- Chemicals are released at the end of the axon by the effect of electrical impulse.
- These chemicals cross the gap (synapse) and start a similar electrical impulse in a dendrite of the next neuron.
- The similar synapse finally allows delivery of such impulses from neurons to other cells, such as muscles cells or gland.

Neuromuscular Junction (NMJ)

NMJ is the point where a muscle fibre comes in contact with a motor neuron carrying nerve impulse from the control nervous system.

from the CNS to the involuntary organs and smooth muscles of the body.

1. **Somatic Neural System** → Brain to Voluntary muscles.
2. **Autonomic Neural System** → Brain to Involuntary muscles.
 - The autonomic neural system is further classified into sympathetic neural system and parasympathetic neural system.

Central Neural System (CNS)

- The brain is the central information processing organ of our body, and acts as the 'command and control system'.
- It controls the voluntary movements, balance of the body, functioning of vital involuntary organs (e.g., lungs, heart, kidneys, etc.), thermoregulation, hunger and thirst, circadian (24-hour) rhythms of our body, activities of several endocrine glands and human behaviour.
- It is also the site for processing of vision, hearing, speech, memory, intelligence, emotions and thoughts.
- The human brain is well protected by the skull. Inside the skull, the brain is covered by cranial meninges consisting of an outer layer called **dura mater**, a very thin middle layer called arachnoid and an inner layer (which is in contact with the brain tissue) called **pia mater**.

Human Brain

- The brain can be divided into three major parts- (i) forebrain, (ii) midbrain, and (iii) hindbrain.

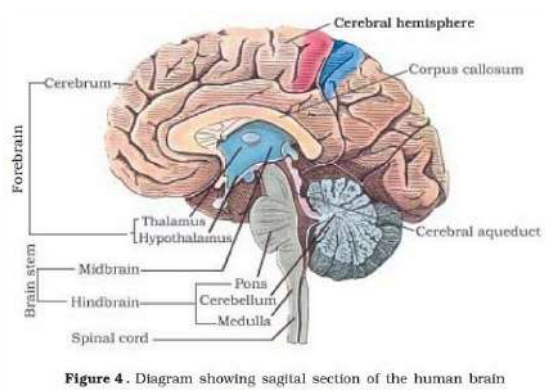


Figure 4. Diagram showing sagittal section of the human brain

Forebrain

- The forebrain consists of **cerebrum**, **thalamus** and **hypothalamus**.

- Cerebrum forms the major part of the human brain. A deep cleft divides the cerebrum longitudinally into two halves, which are termed as the **left and right cerebral hemispheres**.
- The hemispheres are connected by a tract of nerve fibres called **corpus callosum**.
- The layer of cells which covers the cerebral hemisphere is called **cerebral cortex**. The cerebral cortex is referred to as the **grey matter** due to its greyish appearance. The neuron cell bodies are concentrated here giving the colour.
- The cerebral cortex contains motor areas, sensory areas and large regions that are neither clearly sensory nor motor in function. These regions called as the **association areas** are responsible for complex functions like intersensory associations, memory and communication.
- Fibres of the tracts are covered with the myelin sheath, which constitute the inner part of cerebral hemisphere. They give an opaque white appearance to the layer and, hence, is called the **white matter**.
- The cerebrum wraps around a structure called **thalamus**, which is a major coordinating centre for sensory and motor signalling.
- Another very important part of the brain called **hypothalamus** lies at the base of the thalamus. The hypothalamus contains a number of centres which control body temperature, urge for eating and drinking. It also contains several groups of neurosecretory cells, which secrete hormones called **hypothalamic hormones**.
- The inner parts of cerebral hemispheres and a group of associated deep structures like **amygdala**, **hippocampus**, etc., form a complex structure called the **limbic lobe** or **limbic system**. Along with the hypothalamus, it is involved in the regulation of sexual behaviour, expression of emotional reactions (e.g., excitement, pleasure, rage and fear), and motivation.

Midbrain-

- The midbrain is located between the thalamus/hypothalamus of the forebrain and

pons of the hindbrain. A canal called the **cerebral aqueduct** passes through the midbrain.

- The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called **corpora quadrigemina**. Midbrain and hindbrain form the brain stem.

Hindbrain

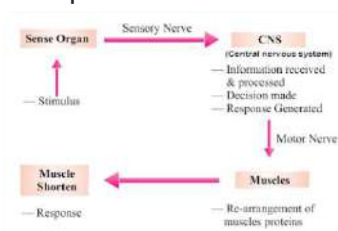
- The hindbrain comprises pons, cerebellum and medulla (also called the medulla oblongata).
- **Pons** consists of fibre tracts that interconnect different regions of the brain.
- **Cerebellum** has very convoluted surface in order to provide the additional space for many more neurons.
- **The medulla of the brain** is connected to the spinal cord. The medulla contains centres which control respiration, cardiovascular reflexes and gastric secretions.

Protection of Brain and Spinal Cord

- **Protection of Brain:** Brain is protected by a fluid filled balloon which acts as shock absorber and is enclosed in **cranium** (skull or brain box).
- **Protection of Spinal Cord-** Spinal cord is enclosed in vertebral column.

Coordination between Nervous and Muscular Tissue

- For taking place the voluntary actions, the brain has to send messages to muscles.
- The communication between the central nervous system and the other parts of the body is facilitated by the peripheral nervous system consisting of cranial nerves arising from the brain and spinal nerves arising from the spinal cord.
- The brain thus allows us to think and take actions based on that thinking. This is accomplished through a complex design, with different parts of the brain responsible for integrating different inputs and outputs.



How nervous tissue causes action?

Information from receptors is received by sensory neurons and transmitted to the central nervous system (brain or spinal cord). The CNS processes the information. For voluntary action, the brain sends signals via motor neurons to the muscles (effector tissues), which then carry out the action. The junction between the two neurons is known as synapse. Information are passed from one neuron to another neuron via electrical or chemical transmission.

Electrical transmission	Chemical transmission
No need of neurotransmitter is needed	Neurotransmitter is needed
Fast mode of nerve impulse transmission	Slow mode of nerve impulse transmission
Impulse are directly transmitted from one neuron to another neuron	Impulse are not directly transmitted from one neuron to another neuron

Coordination in Plants

Plants though do not have nervous system or muscles but they also respond towards the stimulus. For example, when we touch *Mimosa pudica* (touch-me-not plant), its leaves fold up and droop. There are two types of movements in plants-

1. Independent of growth

- Independent growth has immediate response to the stimulus.
- Plants use electrical-chemical means to convey information from cell to cell.
- For movement to happen, cells change their shape by changing the amount of water in the resulting in swelling or shrinking of cells.
- Example: Drooping of leaves of 'Touch-me-not' plant on touching it.

2. Dependent on growth

- These movements are tropic movement's i.e. directional movements in response to stimulus.
- Some plants like the pea plant climb up other plants or fences by means of **tendrils**. These tendrils are sensitive to touch. When they come in contact with any support, the part of the tendril in contact with the object does not grow as rapidly as the part of the tendril away

from the object. This causes the tendril to circle around the object and thus cling to it. More commonly, plants respond to stimuli slowly by growing in a particular direction. Because this growth is directional, it appears as if the plant is moving.

- **Phototropism-** It is a movement of plants towards light.
- **Geotropism-** It is a movement of plant towards or away from gravity.
- **Chemotropism-** Growth of pollen tube towards ovule.
- **Hydrotropism-** Movement towards water.

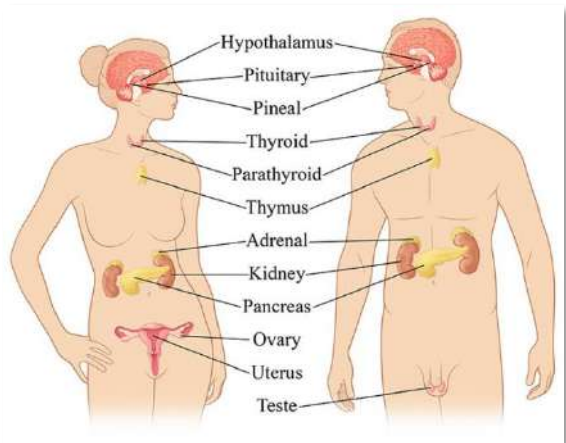
Hormones produced by the plants (NTSE LEVEL)

Hormones	Function
Auxins	Promote shoot elongation and cell division
Cytokinin	Promote shoot growth and cell division
Gibberellin	Promote stem elongation and seed germination; influence flowering (in some plants)
Absciscic acid	Stress hormone, Retards growth
Ethylene	It helps in fruit ripening.

Hormones in Animals

Hormones are the chemical substances which coordinate the activities of living organism also their growth.

Endocrine glands- These are ductless glands that produce and secrete hormones into the bloodstream. There are two types of glands- endocrine glands and exocrine glands. Endocrine glands do not have ducts to carry the secretion and they produce the hormones.



Exocrine glands do have ducts to carry their secretion. List of different hormones secreted and their function are given below-

Endocrine Glands	Function
Thyroid gland	Produces thyroxine that regulates carbohydrate, protein and fat metabolism
Adrenal gland	Produces adrenaline and it is secreted at the time of fear, fight or flight
Pancreas	Produces insulin and glucagon which regulate glucose metabolism in our body.
Testis	Produces male hormone known as testosterone required male secondary sexual characteristics such as beard and moustaches.
Pituitary gland	Secretes growth hormone that regulates the growth and development of an organism
Ovaries	Produces oestrogen needed for female sexual development

Introduction

Reproduction is the process by which living organisms produce new individuals similar to themselves. It ensures continuity of life on earth. Nucleus of the cell contains DNA (Deoxyribose Nucleic Acid) which is the heredity material. "DNA replicates before cell division. While DNA copying is generally accurate, errors (mutations) can occur during replication, which are a source of variation. New cells are formed containing these DNA copies. So, these new cells will be similar but may not be identical to original cell. Variations are useful for the survival of the individual and species over time as well as basis for evolution.

- Reproduction ensures continuity of life on earth.

Do organism create exact copies of themselves?

- Reproduction at its most basic level involves making copies of the blueprints of body design.
- The chromosomes in the nucleus of a cell contain information for the inheritance of features from parents to the next generation in the form of DNA (Deoxyribo Nucleic Acid) molecules.
- The DNA in the cell nucleus is the information source for making proteins. If the information is changed, different proteins will be made. Different proteins will eventually lead to altered body designs.
- The cells use chemical reactions to build copies of their DNA. This creates two copies of the DNA in a reproducing cell, and they will need to be separated from each other.
- To ensure that, a cell divides itself into two cells, each cell containing its own DNA and cellular apparatus.
- Now, both these cells will be identical, but we cannot say that copying of the DNA will be 100% identical.
- There might be some variations in the chemical reaction which means organisms cannot create exact copies of themselves.

Similarities between Reproduction in plants and animals

- Plants and animals can both undergo the sexual and asexual process of reproduction.
- Just like plants, in animals, the males and females have different reproductive organs.
- In both the plants and animals, the zygote is formed when the male and female gametes fuse together and hence the zygote develops into a new individual.

There are two types of reproduction

1. Asexual reproduction
2. Sexual reproduction

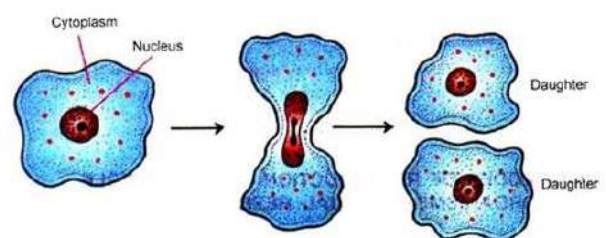
Let's explain each in short.**1. Asexual reproduction**

It is a mode of reproduction involving a single parent.

- A single individual give rise to new individual.
- Gametes are not formed.
- New individual is identical to parent.
- It is extremely useful as a means of rapid multiplication.
- Adopted by lower organisms.

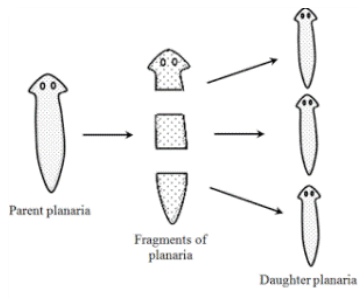
There are different modes of asexual reproduction-

1. **Fission-** Fission is defined as the splitting of the organisms into two halves and each half gives rise to a new organism. For example, **Amoeba, bacteria**. The most common type of fission is binary fission. It is a division of organisms such as bacteria into two parts. Binary fission can be irregular (division can take place in any plane), longitudinal (division occurs longitudinally), transverse (division occurs transversely) and can also be oblique (division occurs obliquely).

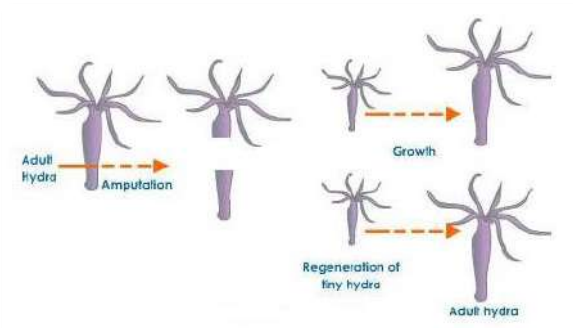


2. **Fragmentation-** Fragmentation is another mode of asexual reproduction in which organism

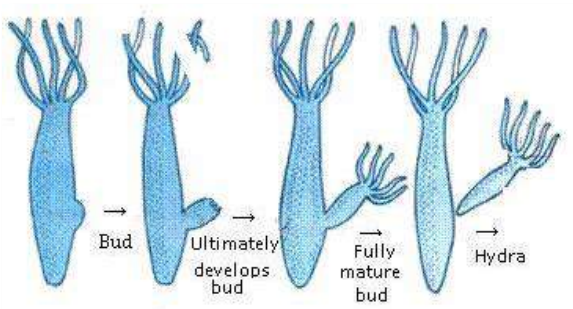
breaks into pieces and each piece give rise to a new organism. For example, **Spirogyra**, **Planaria**.



3. Regeneration- Regeneration is the ability to form new organisms from body parts. Cut or broken part generates a new organism. For example, **Hydra**, **Planarians**



4. Budding- Budding is defined as an outgrowth from the body of the organism. This outgrowth then detaches from the body and forms a new independent organism. For example, **Hydra** and **Yeast**.



5. Vegetative reproduction- Vegetative reproduction is another method of asexual reproduction. In this form of reproduction, stem, root and leaves are used to form plants when provided with suitable conditions. Layering and cutting are the two common methods used for vegetative propagation. For example, banana, rose, jasmine etc. The plant produced through vegetative propagation is genetically identical to the parent plant.

- **By roots-** Example- **Dahlias**, **Sweet potato**.
- **By stem-** Example- **Potato**, **ginger**.
- **By leaves-** Example- **Bryophyllum** (leaf notches bear buds which develop into plants).

Artificial methods in Vegetative Propagation-

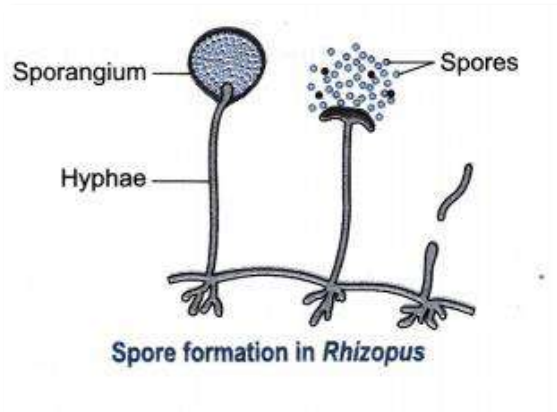
- **Grafting-** Example is Mango
 - A scion (young shoot) from the desired mango variety is joined onto a compatible rootstock. The cambial layers of both parts are carefully aligned and bound together. Once healed, the scion grows using the rootstock's established root system, ensuring true-to-type fruit and often improved vigor or disease resistance.
- **Cutting-** Example is Rose.
 - A healthy stem segment (about 10–15 cm long) of the rose variety is cut just below a node and its lower leaves removed. The cut end may be dipped in rooting hormone and then inserted into a moist growing medium. Roots form from the node region, producing a new, genetically identical rose plant.
- **Layering-** Example is Jasmine.
 - A low-growing jasmine branch is bent down and a small wound or slit is made on its underside. That wounded section is buried in contact with soil (often pegged down) while the tip remains attached to the parent plant. After roots develop at the buried site, the new plant can be severed and transplanted—clonal and well-established.

6. Tissue Culture- New plants are grown by using growing tip of a plant. These growing cells are kept in a culture medium leads to the formation of callus. Callus is then transferred to hormone medium which causes growth and differentiation. Example: ornamental plants, orchid.

Benefits of tissue culture- It allows rapid mass propagation of plants, including those that produce few or no seeds (like banana, rose, jasmine), and can produce disease-free plants.

New plants are genetically similar to parents. Helps in growing seedless fruits.

- 7. Spore Formation-** Spores are small bulb like structures which are covered by thick walls. Under favourable conditions, they germinate and produce new organism. Example: **Rhizopus**



Difference between Sexual and Asexual reproduction

Sexual Reproduction	Asexual Reproduction
1. It involves the fusion of the male and female gamete.	1. It does not involve the fusion of the male and the female gamete.
2. It requires two (usually) different individuals.	2. It requires only one individual.
3. The individuals produced are not identical to their parents and show variations from each other and also, from their parents.	3. The individuals produced are identical to the parent and are hence, called clones.
4. Most animals reproduce sexually. Both sexual and asexual modes of reproduction are found in plants.	4. Asexual modes of reproduction are common in organisms having simple organizations such as algae and fungi.
5. It is a slow process.	5. It is a fast process.
6. It has evolutionary importance.	6. It does not have evolutionary importance.

Sexual reproduction

Sexual reproduction is a natural way of reproduction that takes place in most multicellular organisms and some unicellular organisms. This process involves two individuals to produce offspring. In this, the male and the female gametes fuse together and give rise to a new cell.

Why the Sexual Mode of Reproduction?

- The creation of two new cells from one involves copying of the DNA as well as of the cellular apparatus. The DNA copying mechanism, as we have noted, cannot be absolutely accurate, and the resultant errors are a source of variations in populations of organisms.
- Every individual organism cannot be protected by variations, but in a population, variations are useful for ensuring the survival of the species. It

would therefore make sense if organisms came up with reproductive modes that allowed more and more variation to be generated.

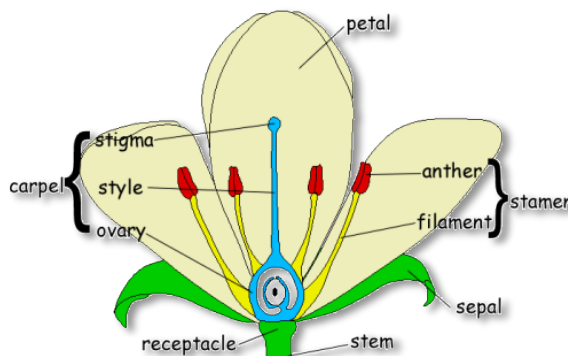
- While DNA-copying mechanisms are not absolutely accurate, they are precise enough to make the generation of variation a fairly slow process.
- If the DNA copying mechanisms were to be less accurate, many of the resultant DNA copies would not be able to work with the cellular apparatus, and would die.
- Combining variations from two or more individuals would thus create new combinations of variants. Each combination would be novel, since it would involve two different individuals. The sexual mode of reproduction incorporates such a process of combining DNA from two different individuals during reproduction.

Significance of Sexual Reproduction

- Sexual reproduction is the source of variation. The mixing of two organisms gives rise to new recombinants or variants.
- Sexual reproduction involves the mating of germ cells also known as **gametes**. These gametes are **haploid**, that is, they have a half set of chromosomes. These gametes are formed through the process of **meiosis**. When male gametes and female gametes each with a haploid set of chromosomes combine they will form a **diploid zygote**. Zygotes undergo repeated divisions to form a new organism.
- In humans, the male gamete is small and motile whereas the female gamete is large and non-motile.

Sexual Reproduction in Flowering Plants

The flower is the reproductive structure found in **angiosperms**. The flower consists of sepals, petals, stamens and pistils.



- A flower is said to be **unisexual** if it contains either **stamens** or **pistils** whereas if both stamens and pistils are present, it is known as **bisexual**. Papaya and watermelon are unisexual whereas Hibiscus and mustard are bisexual.
- **Pistil/carpel** is the female reproductive structure that consists of a swollen basal ovary, middle elongated style and terminal stigma. The ovary contains ovules, and each ovule contains an embryo sac, which bears the egg cell. **Stamen** is the male reproductive part and it consists of the **anther** and the filament. The anther contains pollen grains that fuse with a female gamete, that is, egg cells. Fusion leads to zygote formation which forms a new plant.
- Transfer of pollen grains from the anther to the stigma of the flower is known as pollination. When the pollen and the stigma are of the same flower, it is known as self-pollination. When pollen from one flower lands on the stigma of another flower it is known as cross-pollination.

What is Gametogenesis?

- The formation of gametes is known as gametogenesis. The male gamete is pollen grains whereas the female gamete is present inside the ovary.
- The ovary contains an ovule. Ovule contains the female gametophyte. **Ovule** also consists of outer layers known as integuments, nucellus and female gametophyte. Male and female gametes are produced and they are haploid in nature.
- There are two types of gametes- **homogametes** and **heterogametes**. When male and female gametes cannot be differentiated morphologically. They are known as homogametes. For example, gametes in Cladophora, Algae. When male and female gametes can be differentiated morphologically, they are known as heterogametes.

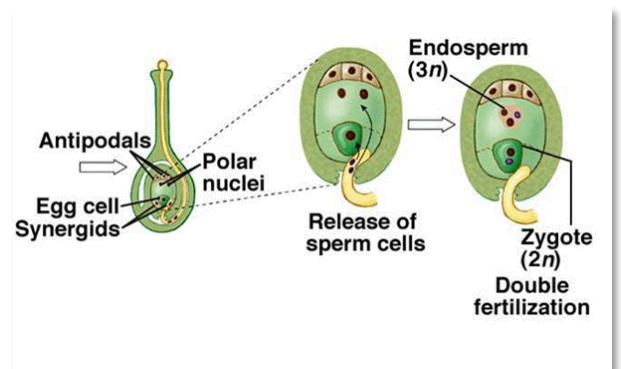
Post Fertilisation Events

The most important post-fertilization structure is the embryo and seeds. Zygote forms the embryo. Zygote

first forms a pro-embryo which later converts into a mature embryo. Seeds are the result of sexual reproduction. Ovules mature into seeds whereas the ovary develops into fruits.

What is Double fertilisation?

In flowering plants, one sperm fertilises the egg cell, whereas the other sperm fuses with the two polar nuclei forming the endosperm. This is known as double fertilisation as two fertilisation events are taking place.



Reproduction in Human Beings

All human beings undergo a sexual mode of reproduction. In this process, two parents are involved in producing a new individual. Offspring are produced by the fusion of gametes (sex cells) from each parent. Hence, the newly formed individual will be different from parents, both genetically and physically. Human reproduction is an example of sexual reproduction.

In human beings, both males and females have different reproductive systems; hence, they are known to exhibit **sexual dimorphism**. Males have testes- also called **testicles**, while the females have a **pair of ovaries**.

Changes at Puberty-

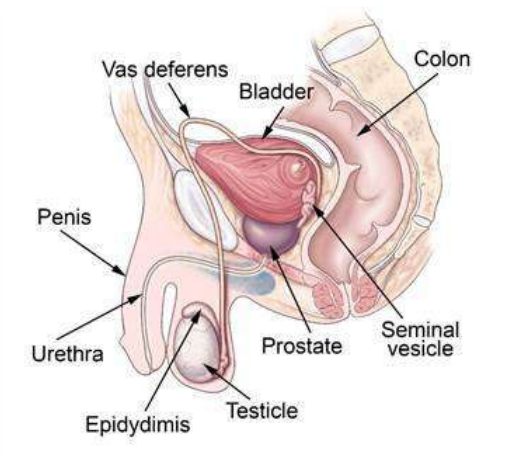
Changes in male and female are common.

- Thick hair growth in armpits and genital area.
- Skin becomes oily, may result in pimples.
- Breast size begin to increase, in females.
- Girls begin to menstruate.
- Thick hair growth on face.
- Voice begin to crack.

These changes signals that sexual maturity is taking place.

Male Reproductive System

- The male reproductive system comprises a pair of the testis, glands, accessory ducts, and male genitalia.
- The **testis** is the site where male gametes or germ cells are produced. They are located outside the abdominal cavity in a sac-like structure known as the **scrotum**. This is to maintain the lower temperature required for the formation of sperm. Testis produces the male hormone **testosterone** needed for the development of secondary sexual characteristics in males such as the formation of beard and moustaches and also in the development of sperm.
- **Vas deferens** is a duct that transports sperm to the urethra, which is a common passage for both urine and sperm ejaculation.
- **Prostate glands** and **seminal vesicles** are also found in males to nourish and for easy transport of sperm in the female genital tract. Cowper's glands (Bulbourethral glands) produce a fluid that lubricates the urethra and neutralizes acidic urine residue. Secretions from these and other glands contribute to semen, which is alkaline and helps neutralise the acidity of the female vagina.. All these secretions along with sperm form the semen.

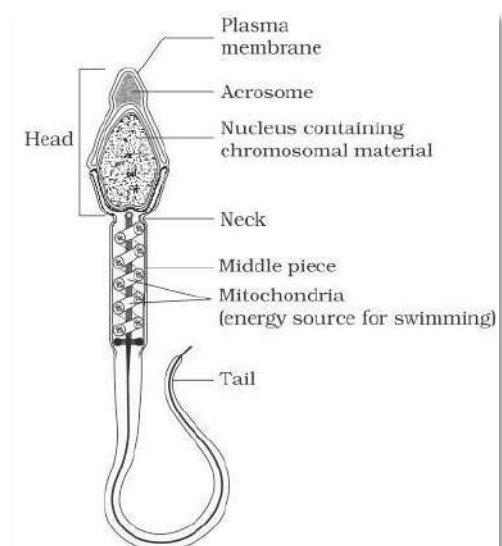
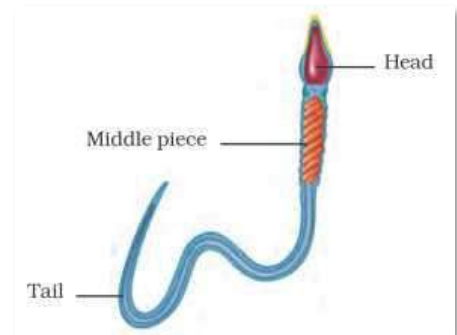


- The formation of male gametes or sperm in testes is known as **spermatogenesis**. Sperms are haploid in nature. Seminiferous tubules are the site for spermatogenesis.
- Testis produces a male hormone known as testosterone needed for the male secondary sexual characteristics as well as for spermatogenesis.

- Male sex hormones or testosterone
- The testis produce testosterone and the pituitary gland controls how much testosterone will be produced. This hormone is responsible for the development of male sex organs and development of secondary sexual characters in males during puberty such as deepening of voice and growth of facial and body hair.

The Sperm Cells

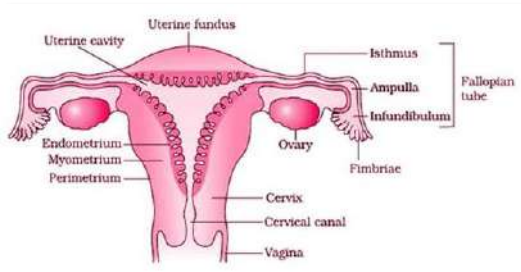
- The testes produce sperm. The sperm is very small in size. Each sperm has a head, middle piece and a tail. Sperm is a single cell with all the usual cell components. The structure of Sperm is as follows-



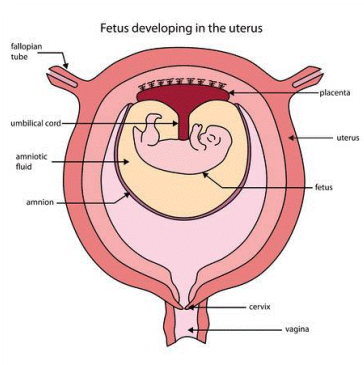
- **Head:** It consists of the nucleus which contains the DNA information of the cell.
- **Middle Part:** It is packed with cell organelles called **Mitochondria**. The mitochondria are responsible for producing energy in the cell. Hence, sperm uses this energy to move.
- **Tail:** It allows the sperm cell to travel at a fast pace.

Female Reproductive Tract

- The female reproductive system consists of a pair of ovaries, uterus, cervix, vagina, and external genitalia.
- Female eggs or ova are produced in the **ovaries**. The formation of ova in the ovaries is known as **oogenesis**. The ovary produces female hormones such as **oestrogen**, **progesterone**. These hormones are needed for female sexual development and well as for pregnancy. The fallopian tube carries ova from the ovary to the womb. The two oviducts (Fallopian tubes) connect to the upper corners of the uterus. Uterus then opens into Vagina via the cervix.



- Sperm enter into the female vagina at the time of sexual intercourse. Then the sperm reaches the **fallopian tube** where it fuses the ova to form a zygote. This is known as **fertilisation**. Then the **zygote** divides to form an **embryo**. The embryo gets implanted into the uterus. The embryo development occurs in the uterus to form the foetus.
- Mother supplies nutrition to the growing foetus via the **placenta**. The placenta helps in the exchange of nutrients, gases and the removal of excretory products. The development of a child inside the womb of the mother takes place for about 9 months. Then the rhythmic uterine contraction leads to the delivery of the baby outside the female body.



Female Reproductive hormones

There are several hormones in females which are naturally produced and secreted by the glands of the endocrine system. The hormones estrogen, and progesterone are secreted to influence on a woman's reproductive health and are termed female hormones. The testosterone hormone is a male reproductive hormone, but it is also present in females in smaller quantities. Other hormones that are involved in the functioning female reproductive systems are LH, FSH, prolactin, hCG, oxytocin and vasopressin.

Type of female Hormones

- **Estrogen-** Estrogen is the most well-known female sex hormone. According to the National Women's Health Resources Center, this sex hormone is produced in the **adrenal glands**, **ovaries** and **fatty tissue**. Its foremost function is to assist breast growth in puberty, help in the growth of uterus lining during the menstrual cycle and maintaining the bones strength by collaborating with vitamin D, calcium, and minerals. A little amount of estrogen is present in man's body also.
- **Progesterone-** Similar to estrogen, progesterone is also produced in the adrenal tissue and ovaries. The progesterone hormone performs its function in the second half of the cycle. It forms the uterus lining for the eggs to be implanted after ovulation. Experts noted that the production of progesterone initiates to wane after menopause in women. Low levels of progesterone could be behind symptoms like mood swings, irritability, depression, weight gain, osteoporosis, and other joint pains. Estrogen rises to be the primary sex hormone when progesterone is low and leads to estrogen dominance.

Menstrual Cycle

When females hit puberty, they start releasing mature eggs (ova) every month, indicating the ability to reproduce. (Females are born with the primary eggs cells). This process is called menstrual cycle. In this cycle, one of the ovaries typically releases a

mature egg (ovulates) every month. If the egg is fertilized, the resulting embryo travels to the uterus and implants/attaches to its lining. If the egg is not fertilized, the uterine lining is shed. If the egg is not fertilized, the uterus sheds its lining and the egg which result in bleeding in the females. On an average the duration of the menstrual cycle is 28 days. The cycle starts at puberty, around the age of 10 or 11 years and lasts until the age of 45 to 55 years.

Gametogenesis

It is the process of production of gametes by the male and female primary reproductive organs. It occurs in three phase in both males and females:

- Multiplication Phase
- Growth or maturation phase
- Meiotic Phase

Gametogenesis in males is called Spermatogenesis. It occurs in the testes and results in formation of sperm cells.

Gametogenesis in females is called Oogenesis. It occurs in the ovaries and results in production of female eggs or ova.

Fertilisation of Egg

When egg is fertilised

- The fertilized egg called **zygote** is planted in uterus and develops into an embryo.
- The embryo gets nutrition from the mother's blood with the help of a special tissue called **placenta**. It provides a large surface area for the exchange of glucose, oxygen and waste material.
- The time period from fertilization up to the birth of the baby is called **gestation period**. It is about 9 months.

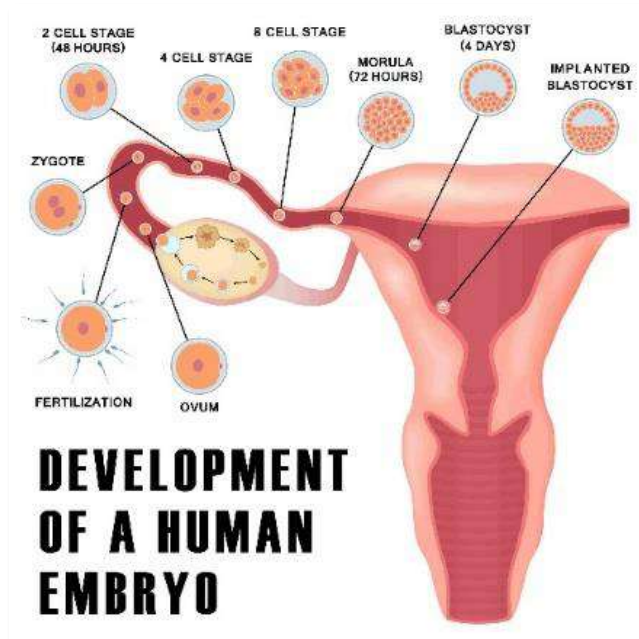
When egg is not fertilised

- The uterus prepares itself every month to receive fertilized egg.
- The lining of the uterus becomes thick and spongy, required to support the embryo.
- When fertilisation had not taken place, this lining is not needed any longer.
 - This lining breaks and comes out through vagina as blood and mucus.

- This cycle takes around 28 days every month and called menstruation.

Development of Embryo

As a result of fertilisation, **fertilised egg or zygote** is formed. The zygote divides repeatedly to give rise to an embryo. The embryo gets embedded in the wall of the uterus for further development. The stage of the embryo in which all the body parts are identifiable is called **foetus**.



Difference between Zygote and Embryo

Zygote	Embryo
A zygote consists of a single cell.	An embryo consists of more than one cell.
It is formed as the fertilization process occurs.	It is formed after the fertilization process.
It has no well-defined organs or tissues.	Body parts and tissues are developing in an embryo, but not yet fully formed or identifiable

External Fertilisation in Frogs and Toads

- The frogs and toads reproduce by laying eggs in a slow stream or ponds.
- The female frogs first lay hundreds of eggs together in the water.
- These eggs are not covered with any hard shell instead there is a jelly-like substance that guards them all and holds them together.
- As the female frogs lay their eggs, the male frogs deposit the sperms over them.

- This results in **external fertilization** when the sperms come in contact with the eggs in the water.
- Though the eggs are large in numbers only a few of them manage to survive.
- There are several factors which may hinder the fertilization process such as exposing to water movement, rainfall, winds and other animals.

Internal Fertilization in Hens

- Hens reproduce by laying eggs.
- After the formation of the zygote, it keeps on dividing itself and then travels through the oviduct.
- In this process, different layers are formed over the egg that then turns into a hard shell or covering of the egg.
- When this hard shell is formed the hen lays the egg.
- Then it takes almost 3 weeks for the embryo to develop into a chick.
- In this time period, the hen often sits over the egg to provide it with warmth.

What are test tube babies?

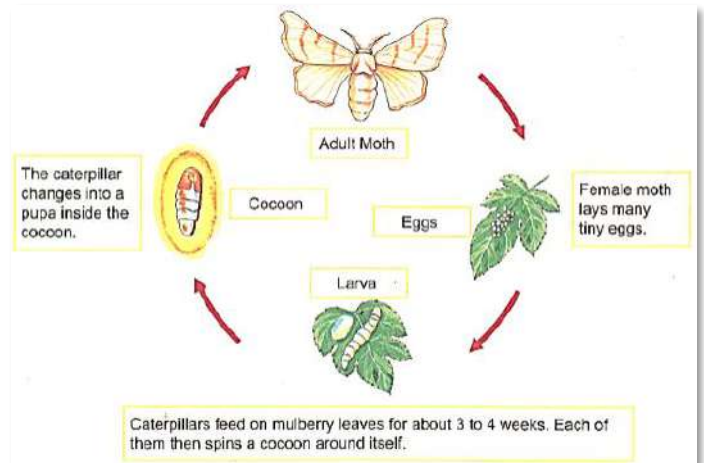
- In some women, the oviducts are blocked and hence they are unable to hold the eggs. This means that these women are not able to bear babies because of blocked oviducts. However, due to the process of In Vitro Fertilization or **IVF**, the freshly released eggs of females and the male sperms can be fertilized externally.
- The zygote thus formed is allowed to develop for a week outside the female body in safe conditions and is then placed in the woman's uterus.
- In this way, these women can bear babies.
- The babies that are born with the IVF process are called **Test Tube Babies**.

Based on the way how the organism give birth to their offspring's, they are classified into two categories

Viviparous	Oviparous
These are the organism that give birth to their young ones directly.	These are the organisms that reproduce by laying eggs.
For example, human beings, dogs, cattle, cats	For example, fishes, reptiles, amphibians.

What is Metamorphosis?

- The process in which the young ones undergo drastic changes as they develop into an adult is called Metamorphosis.
- Human beings do not undergo metamorphosis. This is because their body parts remain the same from the childhood to adulthood.



Reproductive Health

Reproductive health means a total well-being in all aspects of reproduction i.e. physical, emotional, social and behavioural.

Sexually transmitted Disease (STDs) - many diseases can be sexually transmitted such as-

- **Bacterial-** Gonorrhoea and Syphilis
- **Viral-** Warts and HIV- AIDS.

Use of Condoms prevent these infections to some extent. So Contraception is the avoidance of Pregnancy and this can be achieved by the preventing the fertilisation of ova.

Methods of Contraception

- **Physical Barrier-** To prevent union of egg and sperm. Use of condoms, cervical caps and diaphragm.
- **Chemical Methods-** Chemical methods includes use of oral pills. These change hormonal balance of body so that eggs are not released. Also it has many side effects.
- **Intrauterine contraceptive device (IUCD)** - Copper-T or loop is placed in uterus to prevent pregnancy.
- **Surgical Methods-** In males the vas deferens is blocked to prevent sperm transfer called vasectomy. In females, the fallopian tube is

blocked to prevent egg transfer called tubectomy.

What is female Foeticide?

- The practice of killing a female child inside the womb is called female foeticide. For a healthy society, a balanced sex ratio is needed that can be achieved by educating people to avoid malpractices like female foeticide and prenatal sex determination. Prenatal sex determination is a legal offence in our country so as to maintain a balanced sex ratio.

Introduction

Animals, as well as human beings, can reproduce only after a certain age or time period in their lives after growing up into an adult. This is because of changes in hormones in their bodies that make them capable of reproduction.

What is adolescence?

The time period when the body undergoes changes to reach reproductive maturity is known as adolescence.

- This period may vary in different individuals.
- The adolescence period includes the teenage and therefore adolescence are often called teenagers as well.

Adolescent period in	Begins at age around	Ends at age around
Boys	11 years	18 to 19 years
Girls	10 to 11 years	18 to 19 years

What is Puberty?

Puberty can be defined as the process of physical changes by which a child becomes an adult and is capable of reproduction.

- When the human body undergoes several changes during the adolescence, it marks the onset of puberty.
- The capability of reproduction is the most important change which marks the puberty.

Changes at Puberty

Changes	Explanation
The height increases suddenly	• The bones of the legs in the arms of a person start to grow longer and hence a person becomes taller in the puberty age. • This increase in height occurs until the age of 18 in both boys and girls. • However, it is observed that girls grow faster than boys initially.
Change in the shape of the body	• As boys and girls enter into the time period of puberty their body shapes start to change. • The boys generally experience a change in chest and shoulders as they become wider. • In girls, the area below the waist becomes wider.

	• However, the changes in boys and girls are different because the muscle growth in boys is higher than that in girls.
Change in voice	• A change in voice is accomplished as the body hits puberty, especially in boys. • The voice box or the larynx develops in boys. • It can also be seen as an enlarged part of the throat in boys and is named as Adam's Apple. • Boys also experience a coarse voice for some time due to the changes in the larynx. • The larynx in girls, on the other hand, is not visible because of its smaller size.
Increased sweat and oil production in the skin	• There are sweat glands and oil glands (called sebaceous glands) present in our bodies which start secreting more oil and sweat during the puberty age. • Many times girls and boys get acne and pimples on the face during the excess secretion of these glands.
Development of sex organs	• By the time girls and boys hit puberty the reproductive organs are developed completely. • In males, the sperm production begins. • In females, the size of the ovaries increases and it starts releasing the eggs.
Mental, emotional and intellectual maturity	• During the adolescent age, the brain has the maximum learning power. • The way of thinking of individuals starts to change. • It is also observed that girls and boys start feeling self-conscious. • They may also feel a little uncomfortable and insecure due to sudden changes in the body. However, all these changes are completely normal.

Know it.

a. What happens due to sudden increase in height of adolescents?

- It may not happen that all the parts of the body would grow at the same rate in this age.

- Hence, sometimes the legs and arms of teenagers appear oversized or not in proportion with respect to their bodies.
- But with time everything comes in proportion.

b. Why height of family members is generally similar?

- The height of a person is a characteristic that they receive from their parents.
- Hence, in general, the height of a person is similar to the height of a family member.
- But it is also recommended that adolescents should eat a proper diet which is rich in vitamins, minerals and other nutrients that can help in their growth

Secondary sexual character

At puberty, some changes occur in both males and females that distinguish them from each other. The features that develop in them are called **Secondary Sexual Characters**.

In Boys

- Appearance of moustaches and beard
- Appearance of hair on chest
- Growth of hair in genital area and other parts.

In Girls

- Increase in breast size
- Growth of hair in the pubic region and under the arms.

What are the Hormones?

There are endocrine glands present in humans which secrete chemical substances in the body called **Hormones**. These chemical substances are responsible for changes in the human body at the time of puberty.

The hormones act as messengers and are responsible for transporting signals from one cell to another. Hence they evoke responses from various organs of the body and tissues. Hormones have certain properties or characteristics such as:

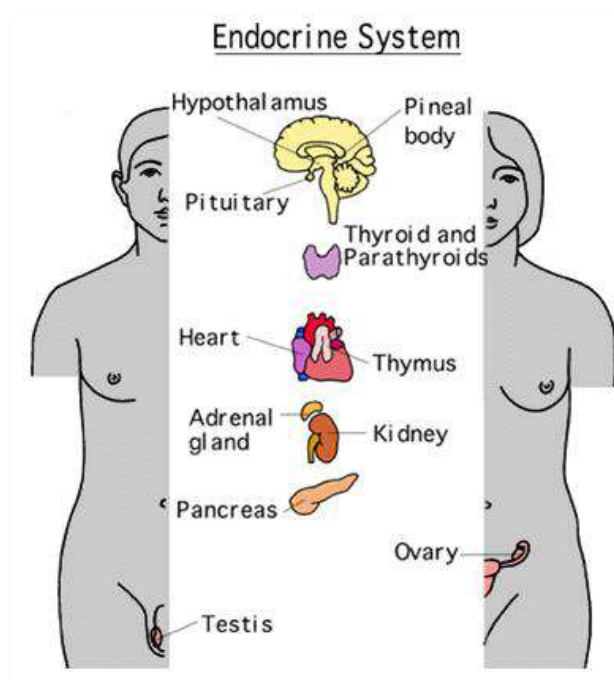
- They are secreted by the endocrine glands.
- They circulate in the body fluids.
- They are responsible for regulating the behaviour of the target cells.

- They cause **long term effects** in the body like change in behaviour, change in growth, development of organs, puberty, menopause etc.
- Hormones are secreted in limited quantities from time to time whenever they are required by the body.
- Different glands present in the body are responsible for secretion of different hormones.
- The nervous system can influence the secretion of many hormones..

The endocrine glands are also called **Ductless Glands** because they secrete the hormones directly into the blood. In males, the testes secrete the male hormones or the testosterone. In females, the ovaries secrete the female hormones or the estrogen.

Hormones

Endocrine glands	Hormones
Testes	Testosterone
ovary	Oestrogen
Pituitary gland	Growth hormone, FSH, LH, TSH, ACTH, Prolactin, ADH, Oxytocin
Adrenal Gland	Adrenaline, Cortisol, Aldosterone
pancreas	Insulin, Glucagon
Thyroid	Thyroxine



Pituitary glands

- It is a pea sized gland situated at the base of the brain. It secretes a growth hormone (GH).
- It is required for proper body growth.
- The hypo secretion of growth hormone causes a condition called **dwarfism**.
- The hypersecretion causes **gigantism** in children and acromegaly in adults.

Thyroid glands

- It is located close to trachea in the neck. It produces a hormone called **thyroxine**.
- It is required for regulating metabolism in the body.
- The hypo secretion of thyroxine causes **hypothyroidism**.
- This condition causes abnormalities like simple goitre, myxoedema and cretinism.
- Lack of **iodine** leads to deficiency of thyroxine, which results in a disease called goitre.
- The excess secretion of thyroxine causes **hyperthyroidism**. It results in high metabolism, protrusion of the eye balls, high BP, nervous tension, etc.

Parathyroid gland

- There are four parathyroid glands present on back side of thyroid glands that secrete **parathyroid hormone** or **parathormone (PTH)**.
- This hormone regulates the level of calcium ions in the bloodstream.
- Excess of parathyroid hormone removes calcium from bones and makes them soft.

Pancreas

- It produces two hormones- Insulin and Glucagon.
- These hormones maintain blood sugar level.
- Deficiency of insulin results in diabetes.

Adrenal Gland

- There are two adrenal glands located one on upper part of each kidney
- It has two parts- **cortex** and **medulla**.
- Cortex secretes the hormones like cortisol that regulates the rate of metabolism.
- The medulla secretes a hormone like adrenaline that prepares the body to face various stressful situations.

Gonads

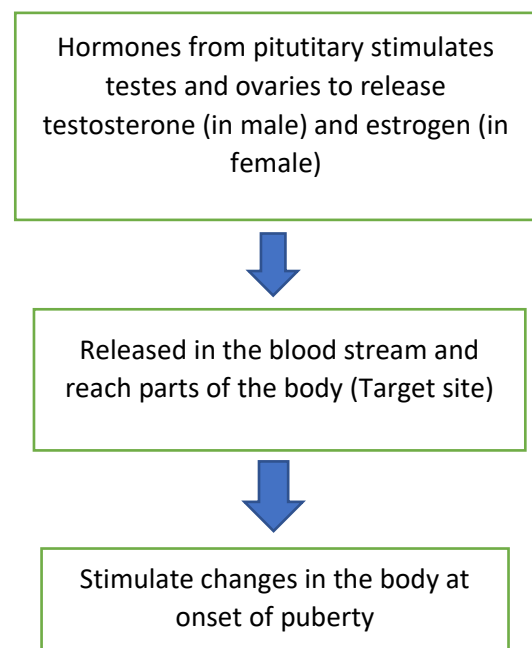
- It includes testes in males and ovaries in females.
- Male sex hormone is testosterone. It is produced by the testes on the onset of puberty.
- Female sex hormones produced by ovaries are estrogen and progesterone. Deficiency of estrogen causes infertility.

Pineal Gland

It is also known as **the Third Eye**, and is located between the two halves of the brain. The **Melatonin** is responsible for the working of the internal clock of the body. This means it influences the cardiac rhythm or the sleep-wake cycle of the body.

Role of hormones in initiating the Reproduction Function

The part of the body for which a particular hormone is meant is called the **Target Site**. The endocrine glands secrete the hormones in the blood and it reaches the target site. Then the target site response accordingly.



Reproductive phase of life in humans

Adolescents become capable of reproduction when their testes and ovaries begin to produce gametes. The capacity for maturation and production of gametes lasts for a much longer time in males than in females.

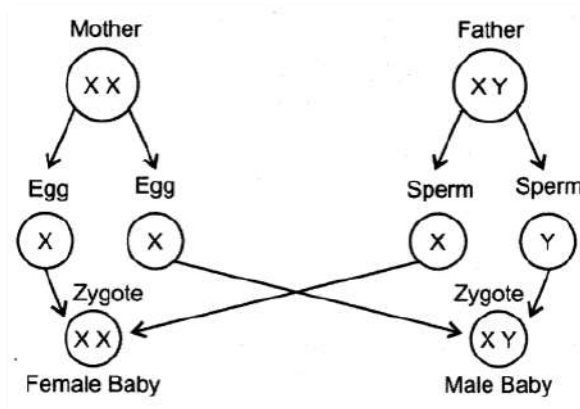
Reproductive Phase in females

- It begins from the age of 10 to 12 years and lasts until the age of 45 to 50 years.
- When females hit puberty, the eggs or ova start getting mature.
- One of the ovaries then releases the mature ovum around 28 to 30 days.
- The wall of the uterus at this time, when the egg is released, becomes thick to hold the egg in case if fertilization occurs and the egg develops.
- When the fertilization does not take place, the lining of the uterus sheds along with the egg and the blood vessels.
- This results in menstruation or bleeding in females.
- The first menstrual flow occurs at puberty and is called the **Menarche**.
- When the menstrual flow stops, it is termed as **Menopause**.
- The whole menstrual cycle occurs because of female hormones.

Determination of sex of the baby

- We know that there are 23 pairs of chromosomes present inside the nucleus of every human cell.
- These chromosomes have a thread-like structure and they always occur in pairs.
- The chromosomes help in determining the sex of the child.
- Out of the 23 pairs of chromosomes, 2 of them are sex chromosomes called X and Y.
- Females have two X chromosomes and males have one X and one Y chromosome.
- The gametes contain only one set of chromosomes that is either an X or a Y.
- The egg of the female contains an X chromosome always.
- However, the sperm can contain only one of the X or Y chromosomes.
- So if the sperm that contains a Y chromosome fertilizes with the egg which contains the X chromosome, the zygote develops into a male.
- On the other hand, if the sperm contains an X chromosome and fertilizes with the egg which contains X chromosome, the zygote develops into a female.

- Hence the **sex of the child** depends upon the **chromosomes of the father** and not the mother.



Role of hormones in completing the life history of insects and frogs

- Insects like silk moths and some animals like frogs undergo the process of metamorphosis which results in drastic changes in their bodies.
- The insect hormones control the process of metamorphosis in the insects.
- In frogs, thyroid releases thyroxine which controls the process of metamorphosis in them.
- The thyroxine only produces with the help of iodine that is present in the water.
- If there is a lack of iodine in water the tadpoles would never turn into adult frogs.

Reproductive health

The physical and mental well-being of an individual is regarded as an individual's health. To keep the body healthy, every human being, at any age, needs to have a balanced diet. The person must also observe personal hygiene and undertake adequate physical exercise.

1. Nutritional health of Adolescents

- The adolescent age requires a balanced diet which is rich in nutrients such as proteins and carbohydrates along with vitamins and essential minerals.
- This is needed because the bodies of adolescents are changing and developing at a rapid rate at this time.
- Healthy and nutrition-rich diets are essential for their right growth.
- Also, they should avoid foods such as chips, soft drinks and soda as they have low nutritional value.

Food item	Major nutrient	Function
Pulses and nuts	proteins	Growth, repair of body cells
Oranges and amla	Vitamin-c	Keep the body healthy by providing resistance
Sugar and roti	carbohydrates	Provide energy
oils	fats	Provide energy
vegetables	Vitamins and minerals	Keep the body healthy and disease free

2. Personal Hygiene

Personal hygiene also plays a role in maintaining the mental and physical well-being of adolescents. Here are a few ways they can maintain their personal hygiene:

- Having bath daily as the sweat glands and the oil glands secrete high amounts of sweat and oil in the skin which can lead to bad odour.
- Maintaining cleanliness of the body as there can be chances of getting a bacterial infection otherwise.
- Females should take note of the menstrual cycle and prepare themselves accordingly.

3. Physical exercise.

- Exercising not only keep the body fit but also helps in relieving stress and maintaining mental well-being.
- Therefore, adolescents should indulge in sports, exercises, walking, cycling and other physical activities.

4. Say 'No' to Drugs

- Adolescent age incorporates different changes in the mind and body of the individual.
- As a result, the adolescents may feel a little uneasy sometimes.
- However, they should understand that this is natural and they should not be worried about it.
- But many times the adolescents are fooled by others by saying that taking drugs would bring relief to them.

- They should always say NO to that as taking drugs can be dangerous for their health.
- Drugs should be taken only if a doctor prescribed them otherwise not.
- This is because the drugs are addictive and once a person takes them they feel like taking them again and again.
- As a result, the mental and physical health of the person starts getting affected due to drugs.
- Also, taking drugs through syringes can cause AIDS (Acquired Immunodeficiency Disease).
- This disease is caused by a hazardous virus that can get transmitted from an infected person to another through the use of same syringes.
- Along with this, it can transmit through sexual contact or from the infected mother's milk.

Introduction

An elephant resembles other elephants, a rose plant looks like other rose plants, and children resemble their parents, even grandparents or great-grandparents. This resemblance among the individuals of a species has given rise to a general truth 'like begets like' which implies continuity of life. Origin of first life on earth still remain unclear because evidences are hidden in very distant past which can't be revealed easily. The problem of creation comes under two headings, the origin of life itself and origin of the forms of life. The variety of life is tremendous; more than one million species have already been discovered. In this vast arena of life, there are widest varieties. There has been lots of presumption made since long that how life in its varied form originated.

What is a Theory of Organic Evolution?

- Many theories have been put forward to account for the existence of the various kind of animals and plants found in this universe today Primitive life was produced in the water bodies in reducing conditions from non-living materials by chemical evolution.
- Term evolution has coined by **Herbert Spencer** and has been derived from Latin word evolve-re which means unfold or unroll and literally means the "process of continuous change". Therefore, evolution is defined as a naturally occurring slow continuous and irreversible process of change.
- The term organic evolution, promoted by Charles Darwin, signifies 'Descent with modification' which states that present complex plants and animals have evolved from earlier simpler forms of life by gradual changes.
- Organic evolution means the progressive development of simple organisms to the complex organisms means origin of species and other groups from the old ones.
- According to the evolution theory there is no break in the chain of life and everything has originated from something of the past. In simple words, it means that the present is the child of past and the father of the future in all things.
 - Genetics deals with the study of Heredity and variation

- The transmission of character/ traits from one generation to the next generation is called heredity
- The differences in the character/traits between the parent and offspring is called **Variation**

Types of Variation**1. Somatic Variation**

- It takes place in the body cell.
- It is neither inherited nor transmitted.
- It is also known as **acquired traits**.
- Examples- cutting of tails in dogs, boring of pinna etc.

2. Gametic Variation

- It takes place in the gametes/reproductive cells.
- Inherited as well transmitted in the next generation.
- Also known as **inherited traits**.
- Example- Human heights, skin colour etc.

Importance of Variation-

- It is the basis of evolution.
- It is the basis of evolution also. Example, Bacteria that can withstand heat will survive better in a heat wave.
- It increases the chances of the survival of the organism according to the changing environment.

Causes of Variation

The most common causes of variations are mutation, recombination and random mating. Recombination or crossing over is one of the important reasons for variation. It is an exchange of chromosome segments at the time of gamete formation.

What is Heredity?

Heredity is the passing of traits to offspring (from its parent or ancestors). This is the process by which an offspring cell or organism acquires or becomes predisposed to the characteristics of its parent cell or organism. Through heredity, variations exhibited by individuals can accumulate and cause some species

to evolve. The study of heredity in biology is called **genetics**, which includes the field of **epigenetics**.

What is Genetics?

Study of Heredity and variations is said to be known as genetics. The term genetics was first of all used by **William Bateson** in 1905. An Austrian monk namely **Gregor Johann Mendel** was the first person to study genetics. He was therefore regarded as the 'Father of Genetics'. Modern genetics is concerned with study of genes. Genes are the units of heredity that control the characteristics of organisms. Geneticists investigate how these genes are transferred from generation to the next, what their structure is and how they function to determine the characteristics of living organisms.

Heredity and Variation in Asexual Reproduction

- **Heredity** (L. hereditas = heirship or inheritance; Spencer, 1863) is the transmission of characters from parents to offspring. There are organisms in which reproduction occurs by asexual means. These include Bacteria, Amoeba, Euglenas, fungi etc., many plants such as rose and sugarcane, lower animals namely Hydra, planaria etc.
- This asexual reproduction is monoparental and the organism produced by it inherits all the traits of its single parent. It is almost a carbon copy of the parent and is known as its clone. It is also called as clonal reproduction.

The Clone may develop variation

- **By environmental factors**
- **By mutation**

The variations caused due to environmental factors are not transferable but those variations which are caused by mutation are stable and inheritable.

Offspring or siblings (offspring of the same parents but at different births, e.g., brothers and sisters) are the product of sexual reproduction. The monozygotic twins are exactly similar in their genetic makeup whereas dizygotic twins are not exactly similar, they possess genetic variations. But, the Progeny of asexually reproducing organisms are exactly similar because they are formed by mitosis. The individuals which are carbon copies of one another and/or the parents are called **clones**, while

the group of such individuals is known as **clone**. Identical twins are also clones of each other.

Basis for Heredity

Mendel (1866) proposed that inheritance is controlled by paired germinal units or factors, now called **genes**. They are present in all cells of the body and are transferred to the next generation through gametes. Factors or genes are thus physical basis of heredity. Genes or factors are passed from one generation to the next or from one cell to its daughter cells in the form of chromosomes - chromosomal basis of heredity. The genetic material present in chromosomes is DNA. Genes are segments of DNA called **cistrons**. Therefore, DNA is the chemical basis of heredity

HEREDITY AND VARIATIONS IN SEXUAL REPRODUCTION:

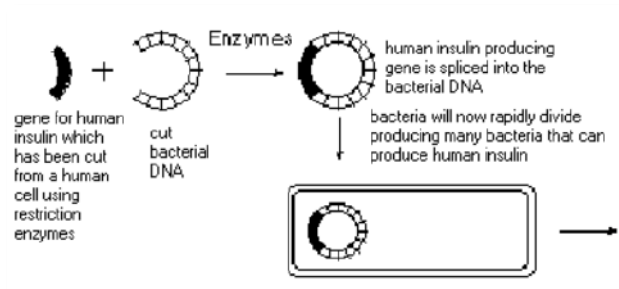
In sexually reproducing organisms, the new individual receives half of the genetic information from its mother through the egg and half from its father from his sperm. Sexually produced offspring resemble, but are not identical to, either of their parents. Some reasons for these variations between sexually reproduced offspring and their parents include crossing over when gametes are formed in each parent and genetic recombination, which is the combining of the genetic instructions of both parents into a new combination in the offspring when fertilization occurs.

The science of genetics explains how the characteristics are inherited by the offspring's from the parents. The pioneering work in this regard was carried out by an Austrian priest, Gregor Johann Mendel (1822-1884). He worked on **garden pea plant (Pisum sativum)** and studied the inheritance of a number of contrasting pairs of characters (like tall and dwarf seeds) for a number of generations. From his studies, he concluded that the contrasting characters in pea plant are controlled by certain units, which he called "**factors**". And that each pair of contrasting characters is controlled by one factor. Thus, the character plant height (tall or dwarf) is controlled by one factor. The factors are the carriers of hereditary information from one generation to the next.

Mendel, thus, explained the principles of inheritance for the first time.

Mendel's "factors" were identified as 'genes' by later scientists. The genes are present on the chromosomes. The term gene was given by the Danish botanist **Johansen in 1909**.

Genetic Recombination:



Note: Two of the four offspring in the punnett square at the right have a completely different genetic makeup than that of either parent.

- The processes of crossing over and genetic recombination will result in offspring exhibiting variation from the original parents. The variations shown between different sexually produced offspring provide the driving force for the process of natural selection.

Earlier Views of Heredity:

Different theories have been put forward to explain in what physical form the traits pass from the parents to the offsprings.

A. Preformation theory: This theory was proposed by Antan Von Leeuwenhoek who was the first to observe human sperm. He called them "animalcules". He stated that each sperm has a potential to develop into a new individual when introduced into the woman's womb where it could get nourishment. This theory was rejected because it failed to explain the inheritance of maternal characters by offspring.

B. Particulate theory: A French biologist Mauperkius proposed that each animal produces minute particles for reproduction and a new individual is formed by the union of the particles of the two parents. Then a famous English naturalist **Charles Darwin** forwarded the **theory of pangensis** for the inheritance of characters. He assumed that tiny particles called pan genes or gemmules by him were formed in the various

parts of the body and migrate to the reproductive cells and hence to the offsprings to guide the formation of the respective parts. Thus, the young one has a blend (mixture) of the pangenes hence, there is a presence of the characters of both the parents.

Mendel was the first to give the particulate theory of heredity. He had experimented on pea plants to study how traits are transferred or inherited. He unfortunately failed to explain the cause of inheritance. He also proposed various principles to explain the inheritance. Later on other scientists lead to the discovery of genes and chromosomes.

Mendel's Experiment and Laws of Inheritance

Development of Mendel's experiments

- Gregor Johann Mendel (1822-1884) was a monk (religious man) in Austria in 1843. In 1847, he became the head of Augustinian monastery at Brunn.
- In 1851, he went to the University of Vienna where he studied natural history and mathematics for two years.
- Mendel returned to Monastery in 1858. He also worked as a teacher of physics and natural history in a school from 1856 to 1865.
- Mendel conducted breeding experiments on garden pea in the garden of his monastery. Luckily he formulated the laws of heredity by his experiments and published his finding in a journal in 1866.
- His laws from the basis of the science of genetics and, therefore, he is remembered as the father of genetics.
- At the time of publication of Mendel's research paper, Darwin's theory of evolution was also in the air. So nobody concentrated on Mendel's work. Mendel died in 1884 without getting any appreciation.
- In 1900, the Mendel's work was rediscovered by three biologists de Vries of Netherland, Carl Correns of Germany and Erichron T shermak of Austria. A few years later, W. Batesonet al. confirmed Mendel's work and found that same laws can be applied to animals also.

In human beings, the rules for the inheritance of traits are related to the fact that both the father and the mother contribute practically equal amounts of genetic material to the child. Each trait in the child is influenced by both paternal and maternal DNA (deoxyribo nucleic acid). In other words, for each trait, there will be two versions in each child, one from father and another from mother. Gregor Johann Mendel was the first scientist to work out the basic rules of such inheritance of traits more than a century ago. This involved the transfer of characteristics from parents to offspring. He did this by using different varieties of **pea plants (Pisumsativum)** which he grew in his garden.

Contrasting character studied by Mendel

- The characters which always appear in two opposing conditions are called contrasting characters.

Seed		Flower	Pod		Stem	
Form	Cotyledons	Color	Form	Color	Place	Size
						
Grey & Round	Yellow	White	Full	Yellow	Axial pods, Flowers along	Long (6-7ft)
						
White & Wrinkled	Green	Violet	Constricted	Green	Terminal pods, Flowers top	Short (1-1.5ft)
1	2	3	4	5	6	7

Some General terms used by him are

- Genotype-** The internal genetic constitution of an organism is termed genotype. Environment has no effect on it.
- Filial generation-** The generation of offspring is termed filial generation.
- First filial generation (F1)** - The first generation of offspring produced from parent generation.
- Second filial generation (F2)** - The second generation of the offspring.
- Monohybrid cross-** A cross between parents differing in one trait or in which only one trait is studied.
- Dihybrid cross-** It is a cross between two organisms of the same species which is made to study inheritance of two pairs of factors or genes."
- Phenotype-** It refers to externally visible characters of an organism. It is the net result of interactions between genotype and environment.

- Genome-** A complete set (n) of chromosomes inherited as a unit from one parent is termed genome.
- Gene-** A hereditary determiner specifying a biological function; a unit of inheritance (DNA) located in a fixed place on the chromosome is called gene. Gene represents factor used by Mendel.
- Factor-** Discrete heredity information called as factor by Mendel.
- Dominant gene-** A gene which expresses itself in the presence of its contrasting gene in a hybrid is termed dominant gene.
- Recessive Gene-** It is that gene whose expression is suppressed in the presence of dominant gene e.g., in a hybrid (Tt) tall plant, t gene for dwarfness is recessive and T gene for tallness is dominant.
- Alleles-** Two alternative genes at the same locus in homologous chromosomes are termed alleles. It is an abbreviated form of **allelomorph**.
- Heterozygous-** An individual having two different alleles for a particular character is called heterozygous or hybrid (Tt).
- Homozygous-** An individual having two identical alleles is called homozygous (TT or tt).

Mendel's Experimental Plant

Mendel selected garden **pea plant (Pisumsativum)** for series of hybridization experiments because it had the following **special features**:

- It had a short life cycle and, therefore, it was possible to study a number of generations quickly.
- Garden pea plant had distinct, easily detectable contrasting variants of features. For instance, some plants were tall and some dwarf; some had violet flowers and some had white flowers; some plants had round seeds and some had wrinkled seeds and so on. Mendel, in fact, noted seven pairs of such contrasting characters in garden pea plant.
- All the contrasting traits existed in every generation because plants had **bisexual flowers** and normally resorted to **self-pollination**.
- In these bisexual plants, artificial cross-fertilization could easily be achieved. It was done by removing the stamens (male part) before

maturity of the female part of flower and later dusting the pistil (female part) of this flower with the matured pollens from a desired plant.

- Each pea plant produced many seeds in one generation.
- The garden pea plants could easily be raised, maintained and handled.

Crossing technique employed by Mendel

Since garden pea is self – fertilizing, the anthers have to be removed before maturity. This operation is called as emasculation. The stigma is protected against any foreign pollen with the help of a bag. The pollens then at the dehiscence stage, is brought from the plant to be used as male parent and is dusted on the feathery stigma of the emasculated flower. At the time of pollination, the pollens should be mature and the stigma should be receptive.

Emasculation → Bagging (for protection) → Artificial Pollination (Dusting collected pollen) → Re-bagging

Mendel Performed experiments in three stages

- He made sure that, the plant which he had chosen must be a true breeding plant, by letting the plant to undergo **self - fertilization**.
- He performed the **process of cross pollination** of alternate forms of traits. The resultant generation obtained was termed as hybrid and these hybrids formed are called F₁ generation i.e., first filial generation.
- He allowed the hybrids to self-pollinate up to five generations and these generations are subsequently termed as F₂, F₃, F₄ and so on.

How to carry out monohybrid cross-

The ratios of the **phenotype** and the **genotype** that are estimated are only probabilities. Listed below are steps that can be used to calculate a monohybrid cross:

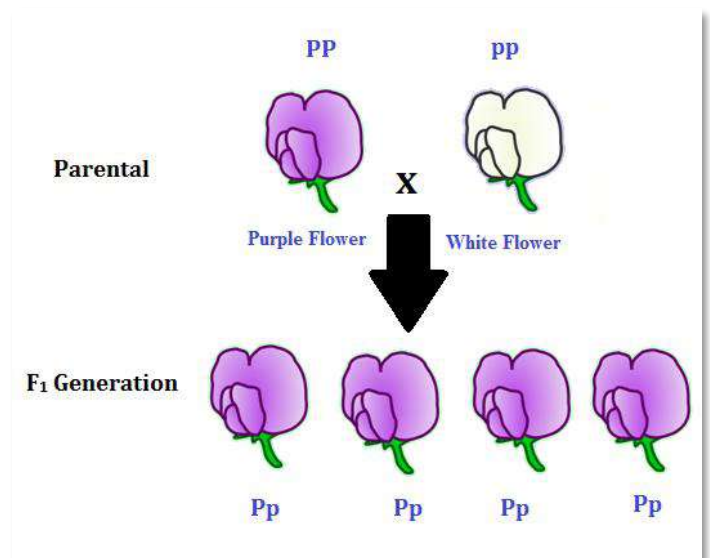
1. Indicate the alleles using characters – recessive alleles can be indicated by lower case letters while dominant alleles can be indicated by upper case letters
2. Note down both the phenotype and the genotype of the parents or the parental generation that are being crossed

3. Jot down the genotype of the gametes from the parental generation – As a result of meiotic division, the gametes will be haploid
4. Tabulate a Punnett square to chalk out the probable combinations of the gametes – Any combination is possible as the process of fertilization is random
5. The phenotype and the genotype ratios of the prospective offspring can be written. The outcome hence obtained is known as the F₁ generation. The F₂, F₃ etc generations form the subsequent generations.

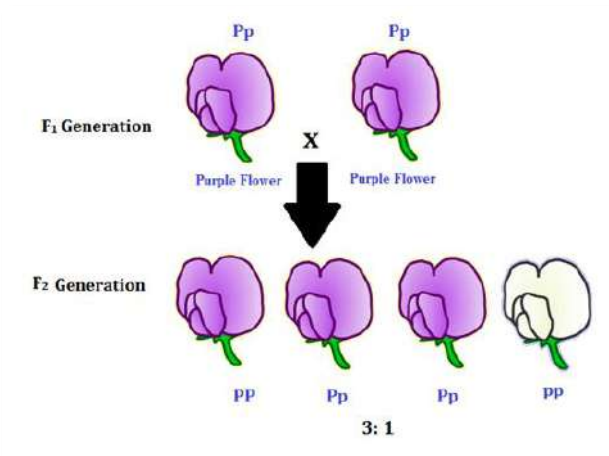
Let's discuss his experiment in details.

A. Monohybrid cross- Cross between two pea plants one pair of contrasting characters is called a **monohybrid cross**.

- Example- Cross between a Purple and a white flower plants.



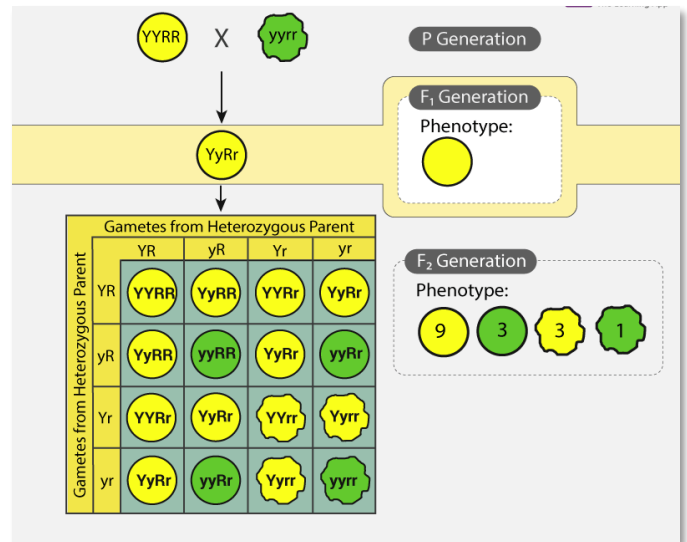
- He continued his experiment with self-pollination of F₁ progeny plants. Surprisingly, he observed that one out of four plants were dwarf while the other three were tall. The tall and the short plants were in the ratio of 3:1.
- He also noted that no progeny was in intermediate height, i.e., no blending was observed. The result was the same for other traits of plants too, and he called them second hybrid generation and the offspring were called Filial₂ or F₂ progeny.



- Mendel observed that traits which were absent in F₁ generation had reappeared in the F₂ generation. He called such suppressed traits as **recessive traits** and expressed traits as **dominant traits**. He also concluded that some 'factors' are inherited by offspring from their parent over successive generations.
- Later, these 'factors' were called genes. Genes are responsible for the inheritance of traits from one generation to another. Genes are units of inheritance. In diploid organisms, each gene is represented by a pair of alleles which code for different forms of a trait. If a pair of alleles is the same, i.e., TT or tt, such alleles are called **homozygous pair** while those that are different or non-identical (e.g. Tt) are called **heterozygous pair**.

B. Dihybrid cross- A cross between two plants having two pairs of contrasting characters is called dihybrid cross.

- A dihybrid cross is a breeding experiment between two organisms which are identical hybrids for two traits. In other words, a dihybrid cross is a cross between two organisms, with both being heterozygous for two different traits. These traits are determined by DNA segments called genes.
- In a dihybrid cross, the parents carry different pair of alleles for each trait. One parent carries homozygous dominant allele, while the other one carries homozygous recessive allele. The offsprings produced after the crosses in the F₁ generation are all heterozygous for specific traits.



Another examples of dihybrid cross

- Mendel took a pair of contradicting traits together for crossing, for example colour and the shape of seeds at a time. He picked the wrinkled-green seed and round-yellow seed and crossed them. He obtained only round-yellow seeds in the F₁ generation. This indicated that round shape and yellow colour of seeds are dominant in nature.
- Meanwhile, the wrinkled shape and green colour of seeds are recessive traits. Then, F₁ progeny was self-pollinated. This resulted in four different combinations of seeds in the F₂ generation. They were wrinkled-yellow, round-yellow, wrinkled-green seeds and round-green in the phenotypic ratio of 9:3:3:1.
- During monohybrid cross of these traits, he observed the same pattern of dominance and inheritance. The phenotypic ratio 3:1 of yellow and green colour and of round and wrinkled seed shape during monohybrid cross was retained in dihybrid cross as well.
- Consider "Y" for yellow seed colour and "y" for green seed colour, "R" for round shaped seeds and "r" for wrinkled seed shape. Thus, the parental genotype will be "YYRR" (yellow-round seeds) and "yyrr" (green-wrinkled seeds).

- c. **Trihybrid cross-** the offspring shows 27:9:9:9:3:3:3:1 ratio is found in trihybrid cross. This suggests that a di, tri, or polyhybrid cross is actually a combination of respectively two, three or more monohybrid crosses operating together

How do these traits get expressed?

- Cellular DNA is the information source for making proteins in the cell.
- A section of DNA that provides information for one protein is called the gene for that protein.
- Plant height can thus depend on the amount of a particular plant hormone. The amount of the plant hormone made will depend on the efficiency of the process for making it.
- Cellular DNA (Information source) → for synthesis of Proteins (Enzyme) → Works efficiently → More Hormone → produced Tallness of plant. Therefore, genes control characteristics/traits.

Reasons for Mendel's success

- He selected true breeding (pure) pea plant for his experiment.
- He studied single trait at a time.
- He kept an accurate mathematical record of his breeding experiments and noted down the number of each type of offspring produced in each cross.
- He was lucky enough to select the seven traits, as the gene for these traits are located on four different chromosomes.

Mendel's laws of inheritance

On the basis of the experiments performed and the results obtained Mendel formulated four laws. They are:

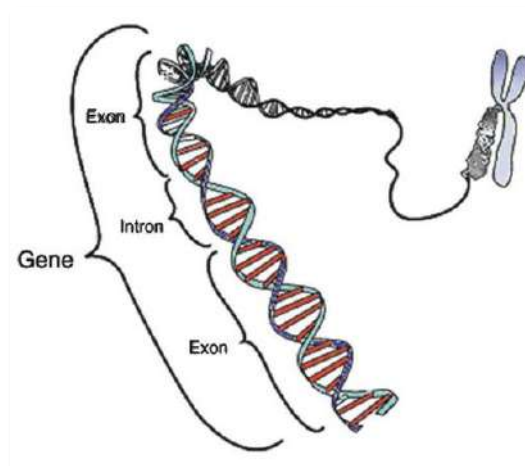
- The Principle of Paired Factors:** Each character in an individual is governed by two factors called as gene. The alternative form of gene is called as alleles or allelomorphs. If an individual consists of similar types of alleles, they are called as homozygous e.g. TT, tt while those having different types of alleles are called as heterozygous e.g. Tt etc.
- The Principle of Dominance or Law of Dominance:** When two homozygous individuals with one or more sets of contrasting characters are crossed the characters that appear in the F₁ hybrids are dominant characters and those which do not appear in F₁ are recessive characters.
- The Principle of Segregation or Law of Segregation : (Law of purity of gametes)** The

law of segregation states that when a pair of contrasting factors or genes or alleles are brought together in a heterozygous condition, the two remains together without being contaminated but when gametes are formed from them the two separate out from each other. This is also known as Mendel's first law of heredity.

- The Principle of Independent Assortment or Law of Independent Assortment:** If the inheritance of more than one pair of characters is studied simultaneously, the factors or genes for each pair of characters as sort out independently. It is called as Mendel's second law of heredity.

Genes-

Genes are specific stretches of DNA located at fixed positions called loci on chromosomes, each carrying the instructions to build a particular protein or functional RNA. Different versions of the same gene, called alleles, can exist (for example, A versus a), and the combination of alleles an organism inherits (its genotype) interacts with the environment to produce its observable traits (phenotype). Dominant alleles mask the effects of recessive ones when both are present, and through guiding protein synthesis, genes ultimately govern an organism's structure, function, and development.



In general, gene is the basic unit of inheritance. According to the recent information a gene is a segment of DNA which contains the information for one enzyme or one polypeptide chain coded in the language of nitrogenous bases or the nucleotides. The sequence of nucleotides in a DNA molecule representing one gene determines the sequence of amino acids in the polypeptide chain

(the genetic code). The sequence of three nucleotides reads for one amino acid (codon).

1. Gene action: Gene act by producing enzymes. Each gene in an organism produces a specific enzyme, which controls a specific metabolic activity. It means each gene synthesizes a particular protein which acts as enzyme and brings about an appropriate change.

- **One gene one enzyme:** This theory was given by Beadle and Tatum, while they were working on red mould or Neurospora (ascomycete's fungus). Which is also called Drosophila of plant kingdom. Wild type Neurospora grows in a minimal medium (containing sucrose, some mineral salts and biotin). The asexual spores i.e. conidia were irradiated with x-rays or UV-rays (mutagenic agent) and these were crossed with wild type. After crossing sexual fruiting body is produced having asci and ascospores. The ascospores produced are of 2 types -

- a. The ascospores, which are able to grow on minimal medium called '**prototrophs**'.
- b. Which do not grow on minimal medium but grow on supplemented medium called '**auxotrophs**'.

2. Molecular structure of gene: Gene is chemically DNA but the length of DNA which constitutes a gene, is controversial 3 term i.e. cistron, muton and recon were given by Seymour Benzer to explain the relation between DNA length and gene.

- **Cistron or functional gene or gene in real sense: Cistron** is that particular length of DNA which is capable of producing a protein molecule or polypeptide chain or enzyme molecule.
- **Muton or unit of mutation: Muton** is that length of DNA which is capable of undergoing mutation. Muton is having one or part of nucleotide.
- **Recon: Recon** is that length of DNA which is capable of undergoing crossing over or capable of recombination. Recon is having one or two pairs of nucleotides.
- **Complon: It** is the unit of complementation. It has been used to replace cistron. Certain

enzymes are formed of two or more polypeptide chains.

- **Operon: Operon** is the combination of operator gene and sequence of structure genes which act together as a unit. Therefore it is composed of several genes. The operator is a DNA sequence that controls the transcription of the structural genes, often by binding regulatory proteins that activate or repress transcription..
- **Replicon: It** is the unit of replication. Several replicons constitute a chromosome.

Sex Determination

The mechanism, by which the sex of an individual is determined as it begins life, is called sex determination.

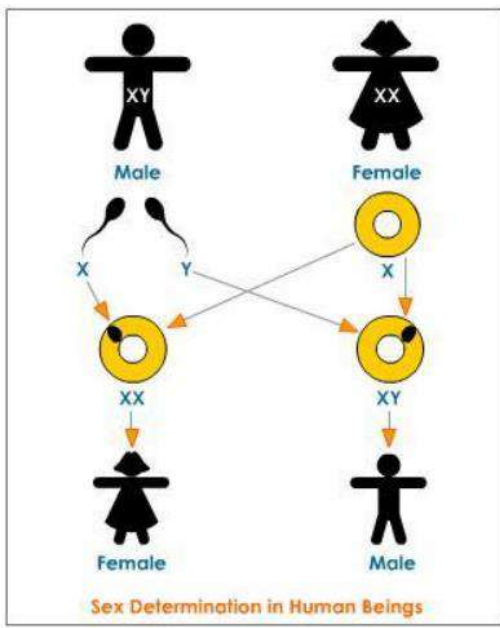
In diploid organisms having separate sexes, a specific pair of chromosomes in each diploid cell, determines the sex of the individual. They are called sex chromosomes. All other chromosomes are termed **autosomes** as these have genes, which control the somatic (body) characters. The two members of each pair of homologous autosomes are similar in size and shape, but this may not be true with sex chromosomes. For instance, In human beings, there are 46 chromosomes. Of these, 44 (22 pairs) are autosomes and 2 (one pair) are **sex chromosomes**. The sex chromosomes in human beings and also in **fruit-fly (Drosophila)**, are of two types - X chromosome and Y chromosome.

- i. A male individual contains one X chromosome and one Y chromosome i.e. XY (heteromorphic sex chromosomes having different size and shape). Therefore male produces two different kinds of gametes (sperms); half of the gametes having X chromosome and other half having Y chromosomes. Therefore, male is called heterogametic.
- ii. A female individual contains two similar X chromosomes i.e., XX (homomorphic sex chromosomes of same size and shape). Female, therefore, produces same type of all gametes (ova or eggs). So, female is called homogametic.

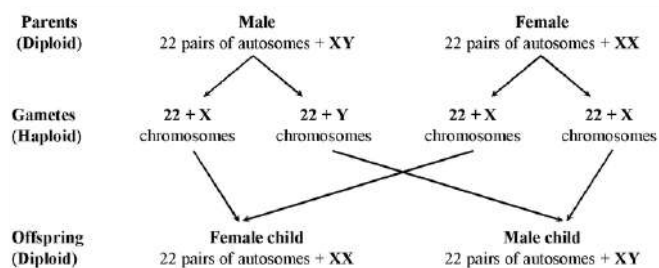
The sex of the child is determined at the time of fertilization when male and female gametes fuse to form zygote.

If a sperm (male gamete) carrying X chromosome fertilizes an egg or ovum (female gamete) carrying X chromosome, then the offspring will be a girl (female). This is because the offspring will have XX combination of sex chromosomes.

If a sperm (male gamete) carrying Y chromosome fertilize an egg or ovum (female gamete) which has X chromosome, then the offspring will be a boy (male). This is because the offspring will have XY combination of sex chromosomes.



So, we can conclude that the sex of the child (offspring) is determined by the type of sperm that fuses with ovum at the time of fertilization. Therefore, there is 50% chance of a male child being born and a 50% chance of a female child being born.



This mechanism of sex determination in human beings and also in fruit-fly (*Drosophila*) is called XX - XY mechanism. In grasshoppers and some other insects, the male has only one sex chromosome (XO) whereas the female has two homomorphic (of same size and shape) sex chromosomes (XX). This type of sex determination mechanism is called XX - XO mechanism.

Evolution

The sequence of gradual changes that take place in an organism over a million years and leads to the formation of new species is known as evolution. J.B. Lamarck was the first scientist who gave the theory of evolution. He gave the theory of inheritance of acquired characters. Later on, Charles Darwin came and gave the theory of natural selection or Darwinism. According to his theory, evolution occurs through natural selection.

1. Theory of Lamarckism

This theory is also known as the **"Theory of inheritance of acquired characters"**. Lamarckism is based on the following postulates-

1. Living organisms tend to increase in size.
2. New needs lead to the formation of new organs.
3. Continued use of a particular organ makes it more developed and disuse of an organ leads to its degeneration.
4. New characters are acquired by individuals during their lifetime

2. Theory of Darwin

Darwin's theory was also known as the **"Theory of Natural selection"**.

Postulates of Darwin's theory

1. Variation among individuals

Darwin pointed to the striking diversity of domestic pigeon breeds—barbs, pouters, fantails, tumblers, etc.—as proof that significant differences can and do arise within a single species under selective influences.

2. Inheritance of variation

By crossing different pigeon varieties and noting that offspring reliably resembled their parents, Darwin showed that many of these traits are heritable—that is, passed from one generation to the next.

3. Overproduction and struggle for existence

He observed that most wild plants and animals produce far more offspring than can possibly survive (for instance, oyster larvae numbering in the millions, most of which never reach adulthood). Limited food, space and other resources therefore force a perpetual

“struggle” in which only some individuals survive.

4. Differential survival and reproduction (natural selection)

In the Galápagos, Darwin noted that finch species with beak shapes best suited to their island's food sources—whether cracking seeds or probing cactus flowers—tended to flourish there, while less well-equipped forms remained rare or died out. Over many generations, this “natural” winnowing leads populations to become better adapted to their local environments.

Speciation

The origin of new species from already existing species is known as speciation. Speciation can take place through-

1. Reduced or absent Gene flow (Isolation) can lead to speciation. It is a transfer of genetic variation from one population to another
2. Random change in allele frequency known as **genetic drift** can also lead to speciation.
3. **Natural selection** is another reason through which speciation can take place
4. Geographical barriers such as mountains, rivers can also lead to speciation. This is known as **geographical isolation**.

Evolution and Classification

Evolution and classification are linked to each other. There is different evidence of evolution given-

- **Homologous organs** are the organs evolved from the same ancestors but they have different functions. For example, the forelimb of a horse and the wings of a bat. The Flippers of the whale, the human hand are other examples of homologous organs.

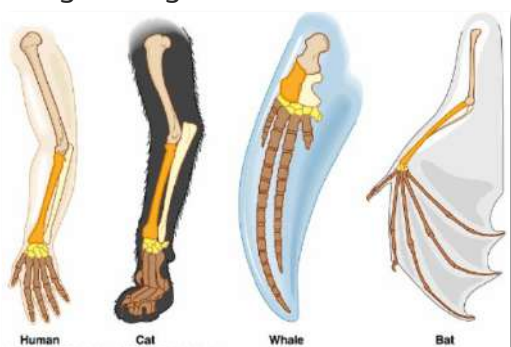


Fig.4. Examples of homologous organs

- **Analogous organs** are the organs that arise from different ancestors but have the same function. For example, wings of bats, wings of birds, wings of insects etc.

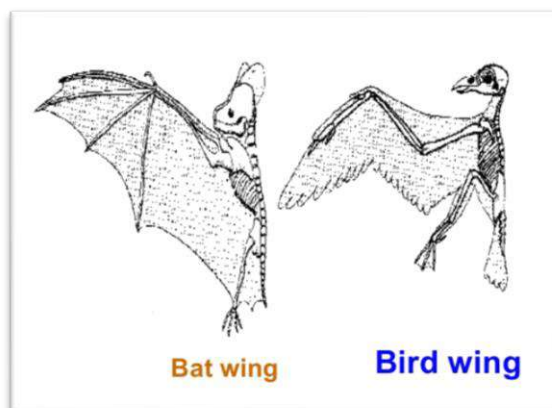


Fig.5. Examples of analogous organs

- **Paleontological (fossil)** evidence was also given for evolution. The dead remains of the organisms are known as fossils. For example, Archaeopteryx possesses features of both reptiles and birds. This concludes that birds evolved from reptiles. There are methods for finding the age of fossils, including radiometric dating (like carbon dating, for absolute age) and relative dating (based on their position in rock layers; deeper fossils are generally older).
- **Vestigial organs** are rudimentary in nature. They have lost their function through evolution. For example, appendix in humans, muscles of ears, wisdom tooth etc.

Evolution by Stages

- Evolution can take place in stages. For example, the evolution of eyes shows different levels of complexity in different organisms, ranging from rudimentary eyes in flatworms to compound eyes in insects and complex camera-type eyes in vertebrates like humans, providing binocular vision.
- The evolution of feathers is also an example of evolution by stages. For example, dinosaurs have feathers but are unable to fly. But later on, birds used feathers for flying.

Molecular Phylogeny

Changes in DNA (mutations) are the source of new genetic variation. Analyzing differences in DNA or protein sequences among organisms provides evidence for evolutionary relationships and the timing of divergences.

Evolution by artificial selection

Artificial selection selects special phenotypic characters to produce organisms with enhanced characteristics. For example, plants that are disease or insect resistant. Artificial selection can be used to produce different cabbage varieties such as broccoli, cauliflower, red cabbage etc.

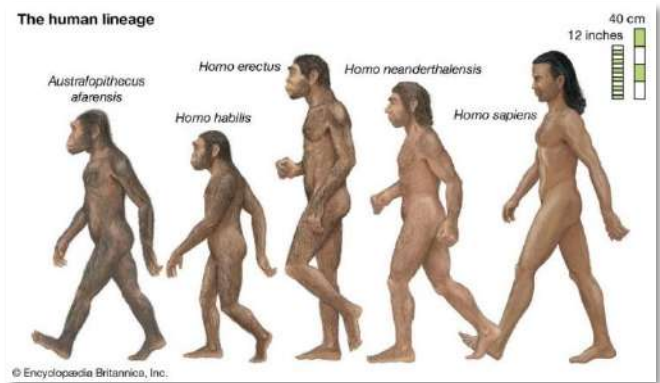
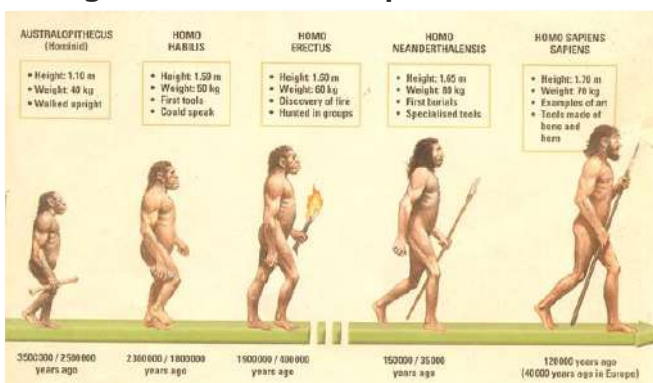
Acquired and Inherited traits

Acquired traits	Inherited traits
These are the traits which are developed in an individual due to special conditions.	These are the traits which are passed from one generation to the next.
They cannot be transferred to the progeny	They get transferred to the progeny.
They cannot direct evolution. Examples- Low weight of starving beetles	They are helpful in evolution n. Example- colour of eyes and hair.

Human Evolution

Excavating fossils, time dating and determination of DNA sequences are used to study human evolutionary relationships. The study of human evolution indicates that all of us belong to a single species that evolved in Africa and then spread across the world in stages.

The stages of human development are as follows-



What are Genetic Engineering?

Genetic engineering, also called genetic modification, is the direct manipulation of an organism's genome using modern DNA technology. It involves the introduction of foreign DNA or synthetic genes into the organism of interest. The introduction of new DNA does not require the use of classical genetic methods, however traditional breeding methods are typically used for the propagation of recombinant organisms.

Application of genetic Engineering

- It is applied for modification of plant colours.
- It helps in cloning of transgenic plants.
- It is used in research aimed at improving plants, e.g., attempts to transfer nitrogen-fixing ('nif') genes from bacteria to non-leguminous plants are ongoing research projects
- It is used in the development of gene therapy, which aims to treat or manage certain genetic disorders by correcting the underlying genetic defect.
- It can be proved beneficial for synthesis of insulin, growth hormone etc.
- It can be used to delay ripening of fruits.

Introduction

Human requires food for their survival as the energy obtained from the food is used for various metabolic activities as Respiration, Excretion etc. We get our food from plants by Agricultural practices and animals too by the process of Animal husbandry (the branch of agriculture which deals with the rearing of animals-livestock). In order to provide food for a population, regular production, proper management and distribution of food is necessary.

What is Crop?

When plants of the same kind are grown and cultivated at one place on a large scale, it is a crop. For example- wheat, rice, cereals, vegetables, fruits. These are classified on the basis season in which they grow. India is a vast country. The climatic conditions like temperature, humidity and rainfall vary from one region to another. Accordingly, there is a rich variety of crops grown in different parts of the country.

Types of Crops

Major crop production in India is from the Kharif and Rabi crops.

- **Kharif Crops**-The crops which are sown in the rainy season are called kharif crop. The rain season in India is from June to September. For Example- Paddy, maize, soybean, groundnut, cotton etc.
- **Rabi Crops**- The crops grown in the winter season are Rabi crops. Their time Period is generally from October to March. For Example- Wheat, gram, pea, mustard and linseed.

Note- Besides these, pulses and vegetables are grown during summer at many places.

Basic practices of Crop Production. Paddy cannot be grown in winter season because Paddy requires a lot of water. Therefore, it is grown only in the rainy season.

Agricultural practices

There are multiple activities or task, which we referred to as agricultural practices are listed below

1. Preparation of soil
2. Sowing

3. Adding manure and fertilisers
4. Irrigation
5. Protecting from weeds
6. Harvesting
7. Storage

Let's discuss each in shortly**1. Preparation of Soil**

- The first and most important task in agricultural practices is to turn the soil and loosen it.
- This allows the roots to penetrate deep into the soil. The loose soil allows the roots to breathe easily even when the deep into the soil.
- The loosened soil helps in the growth of earthworm and microbes present the soil. These organisms are friends of the farmer since they further turn and loose the soil and add humus to it.
- Dead plants and animals get decomposed by soil organisms. In this way, various nutrients in the dead organisms are released back into the soil. These nutrients are again absorbed by plants
- Only a few centimetres of the top layer of soil supports plant growth, turning loosening of soil brings the nutrient-rich soil to the top so that plants can use these nutrient. Thus, turning and loosening of soil is very important for cultivation of crops.

What is tilling or ploughing?

The process of loosening and turning of the soil is called **tilling or ploughing**. This is done using a plough. Ploughs are made of wood or iron. The ploughed field may have big pieces of soil called **crumbs**. Field is levelled for **Sowing**.

Levelling the field is beneficial for sowing as well as for irrigation. Levelling of soil is done with the help of a leveller. Sometimes, manure is added to the soil before tilling. This helps in proper mixing of manure with soil. The soil is moistened before sowing.

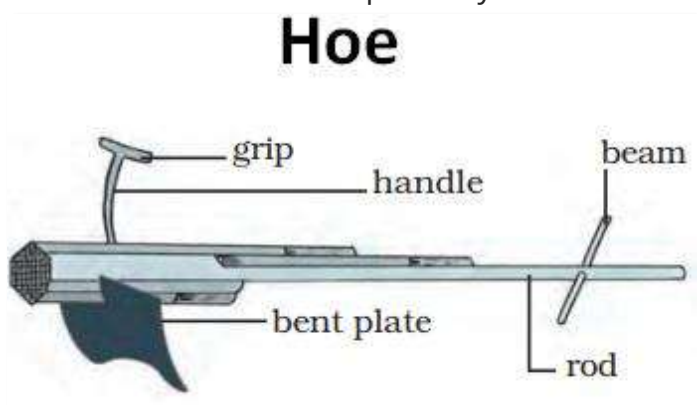
Agricultural implements

Before sowing the seeds, it is necessary to break soil clumps to get better yield. This is done with the help of various tools. The main tools used for this purpose are the plough, hoe and cultivator.

- **Plough**-This is being used since ancient times for tilling the soil, adding fertilisers to the crop, removing the weeds and turning the soil. This is made of wood and is drawn by a pair of bulls or other animals (horses and camels). It contains a strong triangular iron strip called ploughshare. The main part of the plough is a long log of wood which is called a plough shaft. There is a handle at one end of the shaft. The other end is attached to a beam which is placed on the bulls' necks. One pair of bulls and a man can easily operate the plough



- **Hoe**- It is a simple tool which is used for removing weeds and for loosening the soil. It has a long rod of wood or iron. A strong, broad and bent plate of iron is fixed to one of its ends and works like a blade. It is pulled by animals.



- **Cultivator**
 - Nowadays ploughing is done by tractor-driven cultivator. The use of cultivator saves labour and time.

2. Sowing

- Sowing is the most important part of crop production. Before sowing, good quality of seeds are selected. Farmers prefer to use seeds which give a high yield.
- Selection of Seed-seeds should be of high quality and Yield higher percentage of growth.
- **Traditional Tools:-** The tool used traditionally for sowing seeds is shaped like a funnel. The seeds are filled into the funnel, passed down through two or three pipes having sharp ends. These ends pierce into the soil and place seeds there.
- **Seed drill**- The seed drill is used for sowing with the help of tractors. This tool sows the seed uniformly at proper distances and depths. It ensures that seeds get covered by the soil after sowing. This prevents damage caused by birds. Sowing by using a seed drill saves time and it is important to maintain the distance to avoid overcrowding of plants to ensure proper nutrients, sufficient sunlight and water.

3. Adding manure and Fertilisers

- The substances which are added to the soil in the form of nutrients for the healthy growth of plants are called manure and fertilisers.
- Continuous grow of crops makes the soil poorer in certain nutrients. Therefore, farmers have to add manure to fields to replenish the soil with nutrients. This process is called **Manuring**. Improper or insufficient Manuring results in weak plants.
- **Manure**- Manure is an organic substance obtained from the decomposition of plant or animal wastes. Farmers dump plant and animal waste in pits at open places and allow it to decompose. The decomposition is caused by some microorganisms. The decomposed matter is used as **organic manure**.
- **Fertilisers**- Fertilisers are chemicals which are rich in a particular nutrients. Some examples of fertilisers are- urea, ammonium sulphate, super phosphate, potash, NPK (Nitrogen, Phosphorus, and Potassium).

Difference between the Manure and Fertilisers

Manure	Fertilisers
Manure is obtained by decaying plant and animal waste which is added to increase soil productivity.	Fertilizers are human-made chemical substances added to the soil to increase its fertility.
It is completely organic.	They are inorganic salts.
It provides humus to the soil.	It does not provide humus.
It is absorbed slowly by the plants.	The plants quickly absorb it.
It is not very rich in plant nutrients.	Extremely rich in plants nutrients (Nitrogen, Phosphorus).
It does not cause water pollution and has no side effects.	It causes water pollution if used in an excess amount.

Advantages of Manure-

- The use of manure improves soil texture as well as its water retaining capacity. It replenishes the soil with nutrients.
- The organic manure is considered better than fertilisers. This is because
 - It enhances the water holding capacity of the soil.
 - It makes the soil porous due to which exchange of gases becomes easy.
 - It increases the number of friendly microbes.
 - It improves the texture of the soil.

Note- Another method of replenishing the soil with nutrients is through **crop rotation**. This can be done by growing different crops alternately. Earlier, farmers in northern India used to grow legumes as fodder in one season and wheat in the next season. This helped in the replenishment of the soil with nitrogen. Farmers are being encouraged to adopt this practice. **Rhizobium bacteria** present in the nodules of roots of leguminous plants. They fix atmospheric nitrogen.

4. Irrigation

- The supply of water to crops at regular intervals is called irrigation. The time and frequency of irrigation varies from crop to crop, soil to soil and season to season. In

summer, the frequency of watering is higher. In summer water losses due to the evaporation.

• Sources of Irrigation-

- The sources of irrigation are wells, tube wells, lakes, ponds, rivers, dams and canals.
- Two methods of irrigation are most prominent-

1. Traditional system- These methods are cheaper, but less efficient. The various traditional ways are: Moat (pulley-system), Chain pump, Dhekli and Rahat (Lever system). Pumps are commonly used for lifting water. Diesel, biogas, electricity and solar energy is used to run these pumps.

2. Modern method of Irrigation- Modern methods of irrigation help us to use water economically. The main methods used are as follows

- a. Sprinkler System
- b. Drip system

5. Protection from weed

- In a field many other undesirable plants may grow naturally along with the crop. These undesirable plants are called **weeds**.
- The removal of weeds is called **weeding**. Weeding is necessary since weeds compete with crop plants for water, nutrients, space and light. The best time for the removal of weeds is by they produce flowers and seeds.
- Weeds are also controlled by using certain chemicals, called **weedicides**, like 2,4-D. These are sprayed in the fields to kill the weeds. They do not damage crops.
- The weedicides are diluted with water to the extent required and sprayed in the field a sprayer.
- Here we must note that weedicides are sprayed on weeds but there is high risk of entering these chemicals inside the farmer's body. So farmers should use these chemicals very carefully.

6. Harvesting

- Harvesting of a crop is an important task. The cutting of crop after it is mature is called harvesting. In harvesting crops are pulled out or cut close to the ground.

- It usually takes 3 to 4 months for a cereal crop to mature.
- Harvesting our country is either done manually by **sickle** or by a machine called **harvester**.
- In the harvested crop, the grain seeds need to be separated from the chaff. This process is called **threshing**. This is carried out with the help of a machine called '**combine**' which is in fact a combined **harvester** and **thresher**. Farmers with small holdings of land do the separation of and chaff by winnowing.

Harvest Festival

After three or four months of hard work there comes the day of the harvest. The sight of golden fields of standing crop, laden with grain, fills the hearts of farmers with joy and a sense of well-being. The efforts of the past season have borne fruit and it is time to relax and enjoy a little. The period of harvest is, thus, of great joy and happiness in all parts of India. Men and women celebrate it with great enthusiasm. Special festivals associated with the harvest season are **Pongal, Baisakhi, Holi, Diwali, Nabanya** and **Bihu**.

7. Storage

- If the harvested grains are to be kept for longer time, they should be safe from moisture, insects, rats and microorganisms.
- Harvested grains have more moisture. If freshly harvested grains (seeds) are stored without **drying**, they may get spoilt or attacked by organisms, making them unfit for use or for germination.
- Hence, before storing them, the grains are properly dried in the sun to reduce the moisture in them. This prevents the attack by insect pests, bacteria and fungi.
- Farmers store grains in jute bags or metallic bins. However, large scale storage of grains is done in silos and granaries to protect them from pests like rats and insects.
- Dried neem leaves are used for storing food grains at home. For storing large quantities of grains in big godowns, specific chemical treatments are required to protect them from pests and microorganisms.

Animal husbandry

Animal are reared at home or in farms, have to be provided with proper food, shelter and care. When this is done on a large scale, it is called animal husbandry.

- Animal husbandry refers to livestock raising and selective breeding. It is the management and care of animals in which the genetic qualities and behavior of animals are further developed for profit.
- A large number of farmers depend upon animal husbandry for their livelihood. It supports the livelihood of almost 55% of the rural population.
 - As per the Economic Survey-2021, the contribution of Livestock in total agriculture and allied sector Gross Value Added (at Constant Prices) has increased from 24.32% (2014-15) to 28.63% (2018-19).
 - India is the highest livestock owner of the world.
 - As per the 20th Livestock Census, the total Livestock population is 535.78 million in the country showing an increase of 4.6% over Livestock Census-2012.
 - Animal rearing has multidimensional potential.
 - For instance, Operation Flood, launched in 1970, helped dairy farmers direct their own development, increased milk production ("a flood of milk"), augmented rural incomes and ensured reasonable prices for consumers.

Importance:

- It has contributed significantly to the empowerment of women and has increased their income and role in society.
- It is a major risk mitigation approach for small and marginal farmers, particularly across the rain-fed regions of India.
- It is at the centre of poverty alleviation programs from equity and livelihood standpoints.
- Livestock productivity has been identified as one of the seven sources of income growth by the Inter-Ministerial Committee under the government's target of doubling farmers' income by the year 2022.

Man has always inhabited two worlds. One is the natural world of plants, animals soil, air and water, of which we are also a component while, the other is the world of society that we have created ourselves using science, technology and political organization. Both of these are essential for our survival but integrating them sometimes causes alterations in the environment. Thus, to ensure a sustainable future for ourselves and future generations. We need to know about our environment, its working and our role in its working, protection and management.

What is Environment?

- Environment is defined as the surroundings in which the organism lives.
- **Environmental science** is the systematic, scientific study of our environment as well as our place in it. This study gives us the scientific foundations to understand certain important areas of economic importance that are essential for the existence, such as agriculture, forestry and fisheries.
- This study also gives us a basis for predicting, preventing and finding remedial measures to minimize pollution. It helps us to understand the consequences of the human intervention in the natural processes, such as construction of dams on rivers, diversion of rivers, cutting of forests, etc.

The environment may be the physical environment, the chemical environment or the biological environment. Thus, the environment has two components

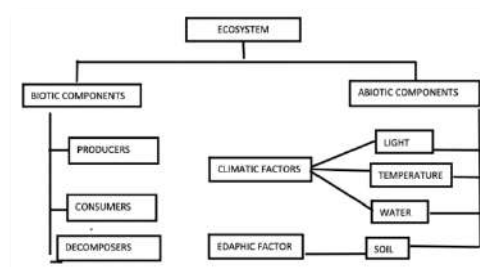
What is Ecosystem?

- Everything that surrounds us is environment. It includes both **living and non-living components**. Interaction between these biotic and abiotic components form an ecosystem.
- In an ecosystem living components depends on each other for their food which give rise to food chains and food webs in nature.
- Human activities lead to environmental problems such as depletion of ozone layer and production of huge amount of garbage.

Types of Ecosystem

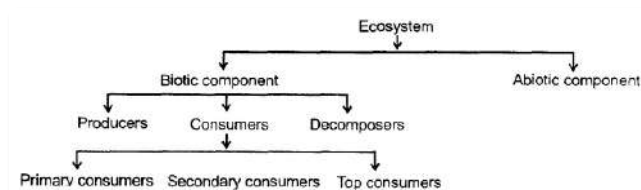
There are two types of ecosystem- natural ecosystem and artificial ecosystem.

- The ecosystem present naturally is known as **Natural Ecosystem**. Example of **Natural Ecosystem** are forests, grasslands, deserts, ponds, lakes, rivers, estuaries, sea.
- The ecosystem which is man-made is known as **Artificial Ecosystem**. For Example Gardens, Aquariums and Agro ecosystem which is the largest manmade ecosystem.



Biotic component: It is the living component of the environment. All the living organisms are included in it.

- On the basis nutrition biotic components are further divided into various types. Different biotic components are connected, through food chain or other relation. That is why it is said that all the living organisms comes under biotic components. Food available for biotic components can be of three types.



Let's explain these in short.

1. **Producers-** All the autotrophs of ecosystem are called as producers. The green plants are the main producers. Green plants absorb solar energy and convert it into chemical energy. It means energy enters into the ecosystem through the producers. The **solar energy** is the only ultimate source of energy in ecosystem. This energy is available to the remaining living organisms through the medium of food.
2. **Consumers-** Those organisms which consume food (eat food) prepared by producers are called consumers. The consumers depend on

producers for food, directly or indirectly. The consumers get their food by eating other organisms or their products. All the animals are consumers. They are known as **heterotrophs**. Consumers can be further divided into three groups: herbivores, carnivores and omnivores.

a. Herbivores- Some animals eat only plants (or their products). Those animals which eat only plants are called herbivores. The herbivores may eat grasses, leaves, grains, fruits or the bark of trees. Some of the examples of herbivores are: Cow, Buffalo, Goat, Sheep, Horse, Deer, Camel, Ass, Ox, Elephant, Monkey, Squirrel, Rabbit and Hippopotamus. Since herbivores obtain their food directly from plants (or producers), therefore, herbivores (like Cattle, Deer, Goat, etc.) are Primary Consumers.

b. Carnivores- Some animals eat only other animals. They do not eat plant food at all. Those animals which eat only other animals as food are called carnivores. Some of the examples of the carnivores are: Lion, Tiger, Frog, Vulture, Kingfisher, Lizard, Wolf, Snake and Hawk. The carnivores are usually of two types (a) small carnivores and (b) large carnivores. The small carnivores which feed on herbivores (primary consumers) are called secondary consumers. "For example, a fox (feeding on rabbits), a snake (feeding on mice), or a spider (feeding on insects) are Secondary Consumers. The large carnivores (or top carnivores) which feed upon the small carnivores (secondary consumers) are called tertiary consumers. For example, lion, tiger, birds of prey (such as hawk) and humans (man) are some of the Tertiary Consumers.

c. Omnivores- Some animals eat both, plants as well as other animals. Those animals which eat both, plants and animals are called omnivores. Some of the examples of omnivores are: Man (Human Beings), Dog, Crow, Sparrow, Bear, Mynah and Ant.

3. Decomposers or Micro consumers- Those living organisms which decompose the dead bodies of producers and consumers and release mineral substances again into the soil which are present

in the dead bodies. So that decomposers help in mineral cycle. Decomposers help in mineral cycling, returning essential nutrients to the soil for producers to use. The main decomposers in ecosystem are - bacteria and fungi which decompose continuously dead animals and dead plants.

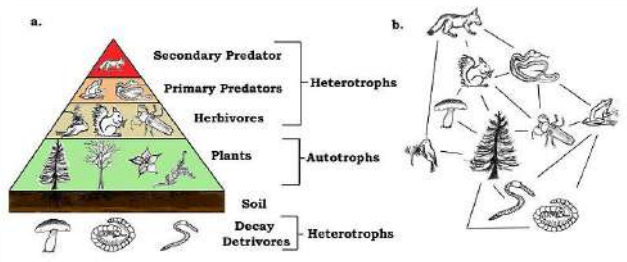
4. Detritivores - Detritivores are heterotrophic animals that consume dead organic fragments (detritus), digesting it internally and excreting finer particles. By breaking down leaf litter, carcasses and other debris, organisms like earthworms, woodlice and dung beetles accelerate decomposition and recycle nutrients back into the ecosystem.

Abiotic component: It is the non-living component of the environment. The abiotic components are the physical factors such as:

- Climatic factors (light, wind, humidity, temperature, precipitation) and Edaphic factors (soil texture, pH, topography). Chemical factors include minerals (nutrients), water, air, etc

Structure of Ecosystem

- The characteristic structure of an ecosystem is obtained by the systematic physical organisation of the abiotic and biotic components of that particular ecosystem.
- The two main structural features of any ecosystem are its 'species composition' and 'stratification'.
- An ecosystem can be represented by depicting the producers - consumer's relationship in the given ecosystem.
- This is also called the '**Trophic structure**' of an ecosystem, wherein each animal population forms the various trophic levels.
- The producers (green plants) always form the first trophic level. Herbivores, which feed on producers, are at the second trophic level followed by secondary consumers, tertiary consumers and so on.
- The amount of nutrients in the soil at any given time is referred as 'standing state' whereas the amount of living material is referred as 'standing crop'. Structure



What is the function of Ecosystem?

The main function of ecosystem are energy flow. This can be from sun to producers, producers to consumers, Consumers to decomposers.

- **Energy flow** in an ecosystem is a key function of an ecosystem. It determines the following two laws of Thermodynamics:
 - First Law-** It states, that energy can neither be created nor destroyed, but can be transferred from one form to other.
 - Second law-** It states, that every energy change involves the degradation or dissipation of energy, from concentrated to the dispersed form due to metabolic functions, so that only a small part of energy is stored in the biomass.

Important Terms

- Productivity:** The rate of organic matter or biomass production is called as productivity. The study of biomass production in the ecosystem is called as production ecology.
- Nutrient cycles:** All living organisms get matter from the biosphere component i.e. lithosphere, hydrosphere and atmosphere. Essential elements or inorganic substances are provided by earth and are required by organisms for their body building and metabolism, they are known as biogeochemical or biogenetic nutrients.
- Development and stabilization:** This function is necessary for the development and giving stability to various life forms, by undergoing certain modifications.
- Mineral cycling (Biogeochemical cycles) :** The chemical elements composing the abiotic components are circulated in an ecosystem starting from nutrient pool (soil) to producers, producers to consumers, consumers to decomposers and then back to the nutrient pool.

What is Biome?

Various ecosystems combine together in a larger region to constitute a biome.

- The total annual rainfall, temperature range, nature of soil, barriers, latitude and altitude determine the nature and extent of a biome. Basically a biome is the largest terrestrial community. Tundra, northern coniferous forests (taiga), deciduous forests, tropical rain forests, Mediterranean scrub forests (chapparral), tropical savanah, grass land and deserts are the principal biomes of the world.

What is Biosphere?

- A zone having land, water and air where life exists is referred to as biosphere.

Or

- The life supporting zone of earth, where atmosphere, lithosphere and hydrosphere meet, interact and make life possible is known as biosphere.
- The term biosphere was proposed by **Eduard Suess**.

What is Biological Systems?

- The biosphere is called a biological system because just like any other system, a biosphere has different components which receive certain inputs, undergo interaction and give some output. There is a constant interaction between living and non-living components resulting in the transfer of food and energy, which makes it a dynamic but stable system.
- Biosphere is considered to be the largest biological system because it is made up of all the non-living and living components on the earth where each component performs a certain function.

Food Chain

Definition

- The chain of organisms which involves the transfer of energy from one trophic level to the next trophic level is called a food chain.
- The flow of food or energy in an ecosystem is called a food chain. The different steps or positions in the food chain are called trophic levels.

- Usually, there are four trophic levels present in the ecosystem because the level of energy decreases during the flow of energy from one trophic level to another trophic level.
 1. First trophic level [T1] - Producers
 2. Second trophic level [T2] - Primary consumers
 3. Third trophic level [T3] - Secondary consumers
 4. Fourth trophic level [T4] - Top consumers
- The flow of energy occurs in an ecosystem from the first trophic level to subsequent trophic levels in the food chain. Food chains typically have 3 to 4 trophic levels, but in some ecosystems, there can be five or even more levels: Producers (T1) → Primary Consumers (T2) → Secondary Consumers (T3) → Tertiary Consumers (T4) → Quaternary Consumers (T5), etc. The top consumer is at the highest trophic level in that chain."

Types of Food chains

There are three types of food chains which are found in nature-

- Predator food chain
- Parasitic food chain
- Saprophytic food chain

Characteristics of food chain

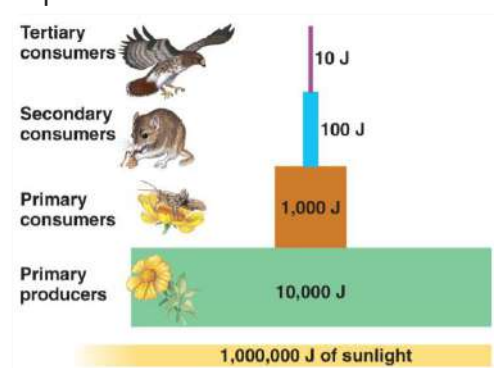
- There is a unidirectional flow of energy from producers to consumers.
- There are generally 3 to 4 trophic levels.
- It is always straight
- Organism can occupy different trophic levels in different food chain.

Flow open energy

Energy is used and conveyed from one trophic level to another in a food chain. This is called flow of energy. Green plants capture about 1% of the solar energy incident on the Earth through the biochemical process of photosynthesis. A part of this trapped energy is used by plants in performing their metabolic activities and some energy is released as heat into the atmosphere. The remaining energy is chemical energy stored in the plants as 'carbohydrates'. When plants are eaten up by herbivores, the chemical energy stored in the plants is transferred to these animals. These animals

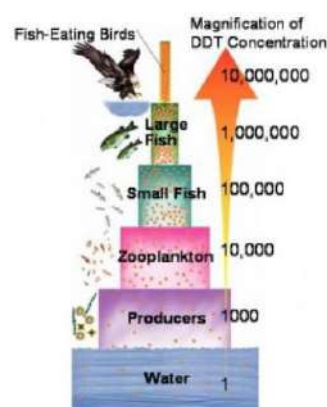
(herbivores) utilize some of this energy for metabolic activities, some energy is "released as heat and the remaining energy is stored. The process of energy transferred is similarly repeated with carnivores and so on.

- 10 percent law-** A 10 percent law is followed in energy transfer which was given by Raymond Lindeman. This law states that "only 10 percent of energy is transferred from one trophic level to another trophic level". The remaining 90 percent will be used by the present trophic level in different processes. Therefore there are usually 3-4 trophic levels in a food chain.



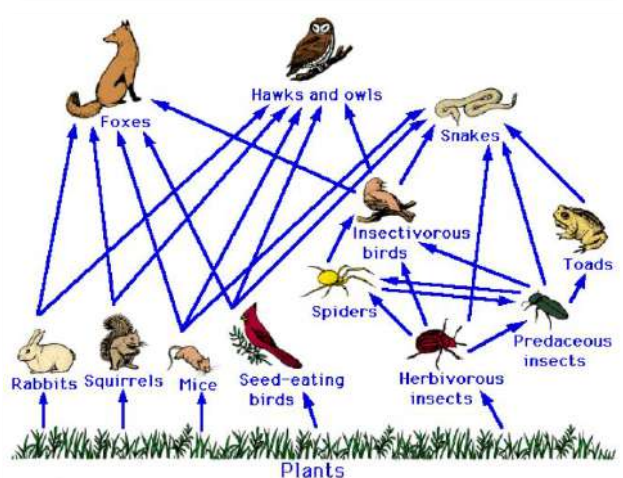
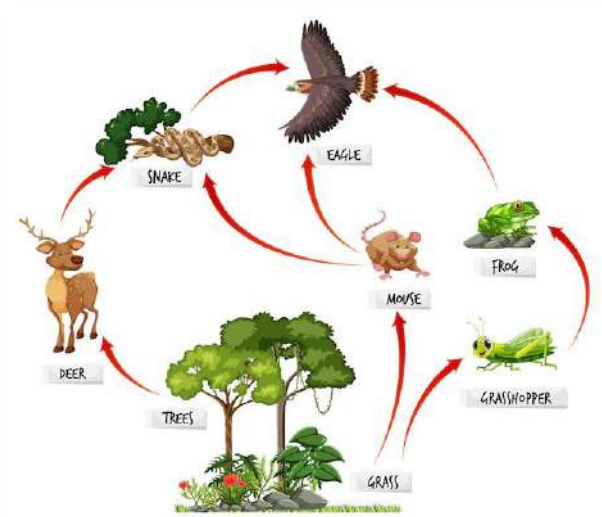
What is Biological magnification?

The concentration of harmful chemicals increases with every next trophic level in a food chain. This is called biological magnification. Maximum concentration of such chemicals get accumulated in human bodies as human occupy the top level in any food chain.



Food Web

- A food web (or food cycle) depicts feeding connections (what eats what) in an ecological community and hence is also referred to as a consumer-resource system.
- In simple language food web are consist of large number of interconnected food chains.



Characteristics of Food Web

- Food webs are never straight as they are formed by interlinking of food chains.
- Food web provides alternative pathways of food availability. If a particular species is destroyed, the predator can feed on an alternative species.
- Food webs increase ecosystem stability.

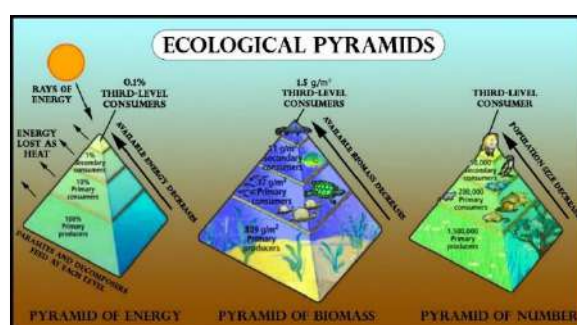
Recap by Differences

Food Chain	Food Web
Food chains is the straight single path of transfer of food energy in the ecosystem.	It consists of a number of inter-connected food chains through which food energy is passed in the ecosystem.
Members of higher tropic level feed upon a single type of organism of lower tropic level.	Members of higher tropic level can feed as a number of alternative organism of the lower tropic level
	Presence of food web increases the stability of the ecosystem.

What is Ecological Pyramids?

Ecological Pyramid is a graphical representation to show biomass or bio productivity. There are different ecological pyramids such as pyramid of biomass, pyramid of number and pyramid of energy. Pyramid of number indicates number of individuals at different trophic levels. Pyramid of biomass indicates biomass of the members of the food chain present at different trophic levels. Pyramid of energy indicates energy at different trophic levels.

- Pyramid of number and pyramid of biomass can be inverted also. In aquatic ecosystem pyramid of biomass is inverted.



Biogeochemical Cycles

- The plants need some elements for their growth. These elements are referred to as nutrients.
- There are some ten elements required by the plant in large amount, they are called macro-nutrients.
- Some nutrients are required in very small amount called as micro-nutrients or trace elements.
- In addition to ten macro and six micro nutrients, the plants also require a few other elements too, all of which participate in its organisation and metabolism. They are sometimes designated as biogenetic elements by some workers.
- Except for carbon, which is obtained from the aerial environment in gaseous form, all other elements are obtained by the plant from the soil. The elements flow from the environment (soil and aerial) into and out of the plant in a cyclic manner. This flow of nutrients from abiotic to biotic components of the ecosystem and vice-versa constitute the biogeochemical cycles.

Environmental problems

Changes in the environment affect us and our activities change the environment around us. This

led to the slow degradation of the environment that arose many environmental problems. For Example; depletion of the Ozone Layer and waste disposal.

Ozone Layer- High UV radiation break down oxygen into oxygen atoms. These oxygen atoms when combine with oxygen, they form ozone.

- Ozone layer, commonly called ozone blanket, comprises of high concentration of ozone about 18-26 km above in the stratosphere. As per estimates, 90% of the total atmospheric ozone is present in this region.

Formation of Ozone molecules

- The high energy UV radiations break down the O_2 molecules into free oxygen (O) atoms.
 $\rightarrow (UV) \quad O + O \text{ (atoms)}$
- These oxygen atoms then combine with oxygen (O_2) molecule to form the ozone molecule.
 $O_2 + O \rightarrow O_3 \text{ (ozone)}$

Depletion of Ozone Layer

- Between 20 and 26 km above the sea level ozone layer is present and the part of atmosphere containing it is called ozonosphere (Stratosphere). This layer is established due to an equilibrium between photo dissociation of ozone by UV - radiations and regeneration of ozone.
- The thickness of this ozonosphere averages 5 km. The ozone layer acts as an ozone shield and absorbs the harmful UV-radiations of the sunlight so protects the earth's biota from the harmful effects of strong UV-radiations. So this layer is very important for the survival and existence of life on earth.
- The thickness of the ozone layer over Antarctica was found to be decreased in the year 1985. This is defined as ozone depletion. This is due to excessive use of chlorofluorocarbons in refrigerators, ACs, aerosols, etc. Thinning of ozone would allow penetration of Ultraviolet rays into earth's atmosphere causing blindness, skin cancers and mutations.
- In 1987 **United Nations Environment Programme** (UNEP) signed an agreement to limit the usage of CFCs. This is known as **Montreal Protocol**.

Causes of Ozone Depletion

Ozone layer depletion is a major concern and is associated with a number. The main causes responsible for the depletion of the ozone layer are listed below-

a. Chlorofluorocarbons

Chlorofluorocarbons or CFCs are the main cause of ozone layer depletion. These are released by solvents, spray aerosols, refrigerators, air-conditioners, etc.

The molecules of chlorofluorocarbons in the stratosphere are broken down by ultraviolet radiations and release chlorine atoms. These atoms react with ozone and destroy it.

b. Unregulated Rocket Launches

Researchers say that the unregulated launching of rockets results in much more depletion of the ozone layer than the CFCs do. If not controlled, this might result in a huge loss of the ozone layer by the year 2050.

c. Nitrogenous Compounds

The nitrogenous compounds such as NO_2 , NO, N_2O are highly responsible for the depletion of the ozone layer.

d. Natural Causes

The ozone layer has been found to be depleted by certain natural processes such as Sun-spots and stratospheric winds. But it does not cause more than 1-2% of the ozone layer depletion. The volcanic eruptions are also responsible for the depletion of the ozone layer.

Ozone depleting Substances (ODS)

- Ozone-depleting substances are the substances such as chlorofluorocarbons, halons, carbon tetrachloride, hydrofluorocarbons, etc. that are responsible for the depletion of the ozone layer."

Following is the list of some main ozone-depleting substances and the sources from where they are released-

Ozone depleting Substances	Sources
Chlorofluorocarbons (CFC)	Refrigerators, air-conditioners, Solvents, dry-cleaning agents, etc.
Halons	Fire-extinguishers
Carbon tetrachloride	Fire extinguishers, solvents
Methyl chloroform	Adhesives, aerosols
Hydrofluorocarbons	Fire extinguishers, air-conditioners, solvents

Four Practices which help in the protection of our environment

- Disposal of wastes after separating them into biodegradable and non-biodegradable waste material.
- Use of unleaded petrol and alternate sources of energy, and keeping the engine properly tuned and serviced and the tyres inflated to the right pressure so that the vehicle runs efficiently.
- The use of gunny bags and paper bags in place of polythene/plastic bags.
- Activities such as gardening, rain-water harvesting and use of compost in place of fertilizers will help protect our environment from further damage.

Harmful effects of agricultural practices on the environment

- Excessive use of fertilisers changes the chemistry of soil and kills useful microbes.
- Excessive use of non-biodegradable chemical pesticides leads to biological magnification.
- Extensive cropping causes loss of soil fertility.
- Excess use of groundwater for agriculture lowers the water table.
- Agricultural practices lead to some amount of damage to the natural ecosystem/habitat.

Consequences of ozone Depletion

Exposure of UV rays causes skin cancer. UV-rays damage the eyes also. It affects humans, plants as well as animals.

Garbage Disposal

Waste materials are known as **garbage**. There are two types garbage - Biodegradable Garbage and Non-biodegradable Garbage.

- Biodegradation is the degradation of materials via biological means. It can be via microorganisms such as bacteria, fungi, etc. This biodegradation can be either aerobic or anaerobic, depending on the amount of oxygen present in the surrounding. The term biodegradable is used to name any material that can undergo biodegradation and the term non-biodegradable refers to the opposite of it. Non-biodegradable materials do not undergo biodegradation.
- The main difference between biodegradable and non-biodegradable materials is that biodegradable materials are easily decomposed or dissolved by biological means whereas non-biodegradable materials **cannot be decomposed or dissolved by biological means**.

Biodegradable	Non-biodegradable
The term biodegradable is used to name any material that is capable of undergoing biodegradation	The term non-biodegradable is used to name any material that cannot be degraded by biological means
Biodegradable material easily and quickly undergo biodegradation	Non-biodegradable material do not undergo biodegradation or will take a very long time for the biodegradation.
Rate of biodegradation is very high	Rate of biodegradation is very low.
Examples includes paper, clothes, fruit, etc.	Example includes plastics, polyethylene, and many other synthetic polymer materials.

Methods of waste Disposal

- **Biogas plant:** Biodegradable waste can be used in biogas plant to produce biogas and manure.
- **Sewage treatment plant:** The drain water can be cleaned in sewage treatment plant before adding it to rivers.

- **Land fillings:** The wastes are buried in low lying areas and are compacted by rolling with bulldozers.
- **Composting:** Organic wastes are filled in a compost pit and covered with a layer of soil, after about three months garbage changes to manure.
- **Recycling:** Non-biodegradable wastes are recycled to make new items.
- **Reuse:** It is a conventional technique to use an item again. Example: newspaper for making envelopes.

Introduction

Anything in the environment which can be used is called a natural resource. Natural Resources includes total natural environment that support human life and contribute to the production of necessities and comforts to mankind. So natural resources are the components of atmosphere, hydrosphere and lithosphere.

The word 'resource' means a source of supply or support that is generally held in reserve.

These resources occur in their natural form. Few examples are as follows:

- Air, wind, and atmosphere
- Plants (Flora)
- Animals (Fauna)
- Agronomy (the science of using plants for food, fuel, feed, and fiber)
- Wildlife
- Forestry and Agroforestry
- Coal and fossil fuels
- Range and pasture
- Soils
- Water, oceans, lakes, and rivers

Types of natural resources

- a) Inexhaustible natural resource-** These are in plenty and cannot be exhausted by man's consumption. For example; air, sand, clay etc. It gets affected by the over-population of mankind.
- b) Exhaustible natural resources-** These are limited and can get exhausted over a period of time, i.e., coal, petroleum etc.

Natural resources are also classified as biotic and abiotic resources

- **Biotic Resources-** can be obtained from forests, animals etc. For Example, include plants, animals, fungi, microorganisms.
- **Abiotic Resources-** are those that come from non-living and non-organic material.

There are three important terminologies used which are as follows-

- **Refuse:** Say no to things that are offered to an individual. For Example, an individual say no to buy plastic products.
- **Reduce:** Minimize the use of anything. For Example, minimize the use of fans, tube lights etc.
- **Reuse:** To use the things again and again is defined as reuse.
- **Repurpose:** When a particular thing cannot be used for a purpose, it can be used for another purpose.
- **Recycle:** When the material can be used to make the needed things.

Management of natural Resources

A system of controlling the use of natural resources in such a way, as to avoid their wastage and to use them in the most effective way is called management of natural resources.

Why do we need to manage our natural resources- we need to manage our natural resources because of the following reasons-

- The resources of the earth are limited. Because of the rapid increase in human population, the demand for resources is increasing day-by-day. The proper management can ensure that the natural resources are used judiciously, so that they fulfil the needs of present generation and also last for the generations to come.
- The proper management of natural resources takes into consideration long-term perspective (or view) and prevents their exploitation to hilt for short-term gains.
- The proper management can ensure equitable distribution of natural resources so that all the people can benefit from the development of these resources.
- The proper management will take into consideration the damage caused to the environment during the 'extraction' or 'use' of the natural resources and find ways and means to minimise this damage.

Conservation of wildlife

Wildlife- It means all those naturally occurring animals, plants and their species which are not cultivated, domesticated and tamed.

Conservation of wildlife- It is the sensible use of the earth's natural resources in order to avoid excessive degradation and betterment of the environment. It includes - the search for alternative food and fuel supplies these are endangered, an awareness of the dangers of pollution and the maintenance conservation of habitats and its biodiversity.

Steps for conservation of wildlife-

- Laws should be imposed to ban poaching or capturing of any animal or bird belonging to an endangered species.
- The natural habitats of wild animals and birds should be preserved by National Parks, Sanctuaries and Biosphere reserves throughout the country.
- The Government Department should conduct periodic surveys of National Parks sanctuaries and Biosphere Reserves to have knowledge of all the species of wild animals and birds
- More attention should be given to conserve the endangered species of wild animals and birds to prevent their extinction.
- Unauthorized cutting of forest trees should be stopped.

STAKEHOLDERS OF FORESTS:

The conservation of forests depends on its forest resources or its various stakeholders, who are as follows:

a. People Who Live in or Around Forests:

- They depend on forest produce, for various aspects of their life.
- The local people need large quantities of firewood, small timber.
- Bamboo is used to make slats for huts and baskets for collecting and storing food.
- Implements for agriculture, fishing and hunting are largely made of wood.
- People collect fruits, nuts and medicines from forests, their cattle also graze in forest.

b. Forest Department of the Government:

- Which owns the land and controls the forest resources?

- People develop practices to ensure that forest resources are used in a sustainable manner.
- The forest resources were overexploited after the British took control of the forest.
- Forest department of independent India then owned the land and control the resources of the forest but local needs such as herbs, fruits and fodder were ignored.
- Monoculture of pine, teak or eucalyptus have been started which can destroy the biodiversity of the area.

c. Industrialist:

- Industries consider the forest as a source of raw material for its factories.
- These industries are not interested for the sustainability of the forest in one area as they go to a different area after cutting down all trees in one area.

d. Wildlife and Nature Enthusiasts:

- They are not dependent on the forest but conserve nature and take part in its management.
- Conservationists started with conserving large animals but are now preserving biodiversity as a whole.
- The local people, for instance the Bishnoi community in Rajasthan worked for conservation of forest and wildlife as a religious act. Thus management of forest resources has to take the interests of various stakeholders into account.

TRADITIONAL USE OF FOREST:

- Alpine grasslands in Himalayas were grazed by sheep in summer.
- Nomadic shepherds drove their flock every summer in this area.
- But when the great Himalayan National Park was formed this practice was put to an end. This resulted in tall grasses, preventing fresh growth.

Causes of Damages to Forests:

- i. Local people damage forests to fulfil their daily needs.
- ii. Deforestation caused by industrial needs.
- iii. Deforestation caused for development projects like building roads or dams.

- iv. By tourists or in making arrangements for tourists.

Conservation of Forests:

A comprehensive World Conservation Strategy for the judicious use of natural resources has been formulated by the scientists from 100 countries of the world.

- **Afforestation:** It is growing of forests on unprotected barren lands. **Van Mahotsava** is a tree plantation movement carried out twice a year (February and July) by both government and voluntary agencies.
- **Reforestation:** It is developing forest cover in the area which has been damaged or cleared during exploitation.
- **Separation of Commercial Forestry:** Useful plants required by industry should be planted separately preferably on waste land. Growing industry required plants is called production plantation.
- **Grazing:** Grazing should be regulated according to the availability of pasturage.
- **Deforestation:** Removal, decreases or deterioration of forest cover of an area is called deforestation.

Effect of Deforestation

- **Soil Erosion:** Removal of plant cover exposes the fertile soil to wind and water. The latter remove the top soil and make the area infertile.
- **Desertification:** Removal of forest cover in the plains makes the area dry. In hot season, the soil becomes loose. Air currents take away the fine soil particles leaving behind sand.
- **Floods:** In rainy season many temporary rivulets are formed due to loss of absorption capacity by unprotected soil. The rivulets produce floods in low land causing loss to agriculture, property and life.
- **Destruction of wildlife:** Deforestation leads to destruction of natural habitats of wild animals and plants. Wildlife is, therefore, destroyed.
- **Climatic Changes:** In the absence of forest cover, the summer becomes hotter while the winters become extra cool. The frequency of rainfall decreases.

Some of the proposed steps to protect the wild life are:

- Protection of useful animals and plants, and their wild relatives both in their natural habitat (in situ) and in zoological and botanical gardens (ex situ).
- Preservation of critical habitats (the feeding, breeding, nursery and resting areas) of the plant and animal species to promote their growth and multiplication. Protection of wild life should be done by legislation also.
- Priority should be given in wild life conservation programme to an endangered species over a vulnerable species, and to a vulnerable species, over a rare species.
- The management of life-supporting systems (air, water, land) of the wild life.
- Hunting should be regulated.
- Introduction of successful captivity of breeding programmes.
- Public awareness programme to realise value of forest and wild life.

ROLE OF LOCAL PEOPLE IN MANAGEMENT OF FOREST:

- Management of protected areas by keeping local people away cannot possibly be successful in the long run.
- Studies have shown that the prejudice against the traditional use of forest areas has no basis. Here is an example – The Great Himalayan National park contains, within its reserved area, alpine meadows which were grazed by sheep in summer. Nomadic shepherds drove their flock up from the valleys every summer. When this national park was formed, this practice was put to an end. Now it is seen that, without the regular grazing by sheep the grass first grows very tall, and then falls over, preventing fresh growth.

Let us study some instances where ordinary people have played a great role in the conservation of forests.

The case of Khejri tree:

There is a **Bishnoi community** in Rajasthan for whom conservation of forest and wildlife has been a religious belief. In 1731, **Amrita Devi Bishnoi** led a group of 363 persons who sacrificed their lives for the protection of Khejri trees in Khejrli village near

Jodhpur. The government has recently instituted an 'Amrita Devi Bishnoi National Award for wildlife conservation' in the memory of Amrita Devi Bishnoi.

The Chipko Andolan:

The Chipko movement (Chipko Andolan) is a movement that practised the Gandhian methods of satyagraha and non-violent resistance, through the act of hugging trees to protect them from being felled. The modern Chipko movement started in the early 1970s in the Garhwal Himalayas of Uttarakhand. Then in Uttar Pradesh with growing awareness towards rapid deforestation. The landmark event in this struggle took place on March 26, 1974, when a group of peasant women in Reni village, Hemwalghati, in Chamoli district, Uttarakhand, India, acted to prevent the cutting of trees and reclaim their traditional forest rights that were threatened by the contractor system of the state Forest Department. Their actions inspired hundreds of such actions at the grassroots level throughout the region. By the 1980s the movement had spread throughout India and led to formulation of people-sensitive forest policies, which put a stop to the open felling of trees in regions as far reaching as Vindhyas and the Western Ghats.



The Chipko movement

Arabari forest:

In 1972, The West Bengal forest department formulated a novel scheme to revive the degraded sal forests by involving the local people. It was started in the Arabari forest range of Midnapore district. A.K. Banerjee, the reserve forest officer involved the villagers of the area around the forest in the protection of 1272 hectares of badly degraded

sal forest. In return, the villagers were given employment in both silviculture (a programme to replenish the forest by growing more trees and plants) and harvesting operations of the forest. 25% of the final harvest produce were given and they were allowed to collect firewood and fodder from the forest on a nominal payment. With this participation of the local people, the degraded sal forest of Arabari became green within ten years.

Economic growth and Ecological conservation:

- Forest resources should be used in an environmentally and developmentally sound manner.
- The benefits of controlled exploitation of resources goes to the people and the environment is also preserved.
- If the exploitation is too high, economic and social development will be faster but the environment will further deteriorate.
- We should use natural resources cautiously so that economic growth and ecological conservation go hand in hand.

Water as Resources

- Water is a basic necessity for all terrestrial forms of life. Regions of water scarcity are closely related to the regions of acute poverty.
- Failure to sustain water availability has resulted in loss of vegetation cover, diversion for high water demanding crops and pollution from industries and, urban wastes and less rain.
- Irrigation methods like dams, tanks should be used in various parts of India.

TYPES OF WATER RESOURCES

Water resources can be classified into two types i.e.

1. Fresh water resources
2. Salt water resources

Let's discuss each in short

1. Fresh water Resources-

Fresh water resources range from ponds to lakes and large rivers. It has following characteristics:

- Fresh water is exhaustible, however it is being made available again by oceans through hydrological cycle.

- 77.2 percent of fresh water is stored in glaciers and ice caps and 22.4 percent is ground water and soil moisture. Remaining 0.36 percent is found in lakes, rivers, streams and swamps etc. Out of total water evaporated from oceans 90 per cent falls to the oceans and remaining 10 per cent falls on the land. This water is utilised by various terrestrial ecosystems.
- Fresh water is essential for life on earth as well as for survival of human race.
- The total water in hydrosphere is 1.4 billion cubic kilometres (km)³. Total 97% is ocean water. The ocean water cannot be consumed by human beings. Remaining three percent (fresh water) is available for human consumption.
- The water resources in India have an average run off in river system of 1,869 km³ and 432 km³ ground water.

Sources of Freshwater

- Rainwater
- Surface water
- Ground water

2. Salt water resources

India has a very long coast line hence, it has a large source of salt water of seas and oceans.

Oceans can be used in following aspects:

- Mineral concentrates in the form of mineral nodules can be used for the source of various minerals.
- To build offshore terminals for ships etc.
- As a source of food and other edible animals mainly fishes.
- Shells of molluscs are source of calcium and quicklime's.
- For the production of many useful products such as algin, agar, carrageenan, diatomitic etc.
- It is used for commercial navigation and shipping.
- For generating power from sea tides
- Pearls produced by pearl oysters form valuable jewellery.
- As a source of edible sea weeds as many brown algae (keips) etc.
- For the extraction of common salt.

- Planning floating cities on the ocean surface is under way.

What are Dams?

Dams are the large water storing bodies usually built by the government agencies. This stored water is then allowed to flow downstream at the desired rate.

Advantages of Dams

- Water from a dam is used for irrigation in fields through a network of canals. Dams ensure round the year water supply to the crop fields and help raise agricultural production.
- Water from a dam is supplied to the people in towns and cities through pipelines after suitable treatment. In this way, construction of dams ensures continuous water supply in the region.
- The falling water (or flowing water) from the dam is used for generating electricity. The water rushing down the dam turns turbines which run electric generators.

Disadvantages of Dams

Irrespective of their array of benefits, dams have a significant share of disadvantages. The following offers a brief idea about it.

- Displacement of people during construction.
- Reservoirs often emit a high percentage of greenhouse gases.
- Often disrupts local ecosystems.
- It disrupts the groundwater table.
- Blocks progression of water to other countries, states or regions.

What is watershed management?

It means scientific conservation of soil and water to increase the biomass production.

- Watershed management not only increases the production and income of the watershed community but also overcomes drought and flood.
- It increases the life of downstream dams and reservoirs.

What is water harvesting?

Water harvesting is the collection and storage of rainwater or runoff from rooftops, land surfaces, or streams.

Various ancient methods of water harvesting

Methods	State
Khadin, tanks, nadis	Rajasthan
Banderas, tals	Maharashtra
Bundhis	Madhya Pradesh and U.P
Pyhes and pynes	Bihar
Kulhs	Himachal Pradesh
Ponds	Jammu Region
Eris (tanks)	Tamil Nadu

What are Baolis (Stepwells)?

Baolis (Stepwells) are old methods of water harvesting and access, particularly in arid and semi-arid regions, found in Delhi and nearby regions.

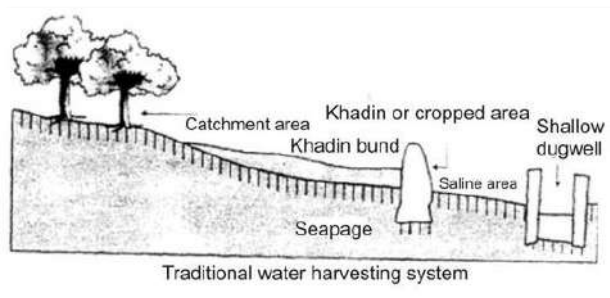
These techniques are specific to local conditions and are designed to prevent the mismanagement and over-exploitation of water resources.

Some of the water harvesting technique are

- Capturing of runoff water roof tops.
- Capturing of runoff water from local catchments.
- Capturing seasonal flood water from local streams.
- **Advantages of Water Harvesting**
 - Provide drinking water.
 - Provide irrigation water.
 - Increase in ground water resources.
 - Reduces storm water discharge, urban flood and overloading of sewage treatment plants.

Traditional water harvesting system

- The water harvesting structures are mainly crescent shaped.
- Monsoon rains fill ponds behind the structures.
- The large structure hold water throughout the year while most dry up after monsoon.
- The main purpose of this system is to recharge the ground water and not to hold surface water.



Advantages of water harvesting system

The various advantages of water harvesting system are-

- The water stored in ground does not evaporate.
- The water stored in ground spreads out to recharge wells and provides moisture for crops.
- The water stored in ground does not promote breeding of mosquitoes.
- The water stored in ground is protected from contamination by human and animal wastes.
- The water stored in ground is utilized for the benefit of the local population.

Pollution of water

The Pollution of water is caused by the dumping of untreated sewage and industrial wastes into it.

The Contamination of river water can be usually found from two factors-

- the presence of coliform bacteria in river water, and
- Measurement of pH of river water.

Ganga Action Plan (GAP)

ACTION PLAN	
Eight ministries to work on specific issues for three years to carry forward these 21 action points under the 'Namami Gange' programme: ➤ Taking up comprehensive measures to determine and maintain environmental flow of Ganga round the year ➤ Rehabilitation and upgradation of existing sewage treatment facilities and taking up new projects of sewage infrastructure ➤ Treatment of sewage and other effluents flowing directly into the river through various drains by adoption of suitable technology and financial models ➤ Tackling industrial pollution ➤ Promoting sanitation in rural areas on the banks of the river Ganga and development	and at Ganga Sagar ➤ Engagement of Ganga Task Force ➤ Providing support to states for preparation of Detailed Project Reports ➤ Coordination between various ministries of the central government and concerned state governments; capacity building of state governments, urban local bodies and panchayati raj institutions ➤ GIS and spatial mapping of Ganga Basin ➤ Research projects including Ganga River Basin Management Plan ➤ Establishment of National Ganga Monitoring Centre ➤ Establishment of Ganga Institute of River Sciences at a suitable location along Ganga ➤ Afforestation drive for medicinal plants and native tree species ➤ Conserving diversity of Gangetic aquatic life ➤ Creation of Ganga Vahini ➤ Communication and public outreach activities

- In 1985 a multicore project came in 1985 to improve the quality of Ganga. **Ganga Action Plan (GAP)** was formulated to reduce the pollution load of river Ganga by more than 75%. The water quality has been tested from time-to-time by checking coliform (a group of harmless bacteria in human intestine) number/100 ml.
- Accordingly, a survey was conducted and data was collected for total coliform (a group of

bacteria found in human intestine) between 1993-1994 which was as below:

- 1993-94 Total Coliform (MPN/100ml) (MPN= Most Probable Number)
 - Minimum found in Rishikesh (600-650 MPN/100ml)
 - Minimum desired level (450 MPN/100ml)
 - Maximum found in Kannauj (1400MPN/100ml)

Ground water.

Water which percolates into the ground through air spaces of soil.

Zone of Saturation: When porous soil is saturated with water at certain level below soil surface, it is called as zone of saturation.

Water table: The upper level of zone of saturation is called water table.

Water level: Water table is exhibited with reference to the mean sea level. Vertical distance from a place on the surface to the water table is called water level.

Uses Ground water

- It provides soil moisture for plant growth.
- It is commonly used for human consumption.
- It supplements water in streams.
- This water is used by human beings for drinking, cooking, bathing, cleaning etc.
- Fresh water is also required for various types of industries.
- It is required for irrigation purpose (agriculture).
- It is required for construction of buildings.

Air as a resource

Air is an important form of inexhaustible natural resource which is essential for our survival. In a world without air, there would be no plant or animal life; no fire as burning needs oxygen; no protection from harmful solar radiation; and great temperature variation (from about 110° C at day time to about -184°C at night). So, atmosphere (air) is a transport protective envelope of gases that surrounds the earth.

Composition of Atmosphere

Nitrogen (N₂): 78%

Oxygen (O₂): 21%

Carbon dioxide (CO₂): 0.03%

Argon: 0.93% 1%

Helium, Neon, Ozone, ammonia: 0.04%

Role of Atmosphere (Air)

It provides

- Oxygen for respiration in plants and animals
- CO₂ for photosynthesis
- Medium for locomotion of flying animals
- Medium for communication
- Medium for combustion (oxygen is required for combustion)

Coal and Petroleum Conservation

Coal and petroleum are fossil fuels found in earth's crust.

They are non-renewable and exhaustible resources.

1. **Coal:** Coal is combustible fossilized rock derived from a large accumulation of plant remains that is gradually compressed. Coal is used for cooking, heating, in industry and thermal power plants.
2. **Petroleum:** Petroleum is another fossil fuel that occurs in the form of liquid oil. It has been formed in the past (about 10 to 20 crore years old) from plant and animal remains and occur in the form of mineral oil in sedimentary rocks. Petroleum is mainly used as fuel for transport, agricultural operations, generators and some industries.

Pollution caused by Burning Coal and Petroleum based Fuels

- Coal and petroleum have been formed from biomass. In addition to carbon, these contain hydrogen, nitrogen and sulphur.
- When these are burnt, the products are carbon dioxide, water, oxides of nitrogen and sulphur. When combustion takes place in insufficient air (oxygen), then carbon monoxide is formed instead of carbon dioxide.
- These products are harmful and hence pollute the environment.

Some of the methods of Conservation of Fossil Fuels

- Burning of coal causes air pollution. Thus direct use of coal for the purpose or burning should be avoided. Coal may be converted into liquid fuel and compressed natural gas (CNG) through coal gasification.
- Techniques should be developed to recover maximum fossil fuel that lies in deep mines and wells. Wastage during extraction and transportation should be avoided.
- Both oil wells and coal mines are prone to catch fire. Therefore, these should be well protected from fire to avoid wastage pollution and loss of life and property.
- Over-consumption of oil in automobiles should be checked. We must save oil for future use because only a few years are left for its depletion.
- Alternative sources of energy, such as hydroelectric, nuclear, solar, wind power and biogas plants should be encouraged.





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