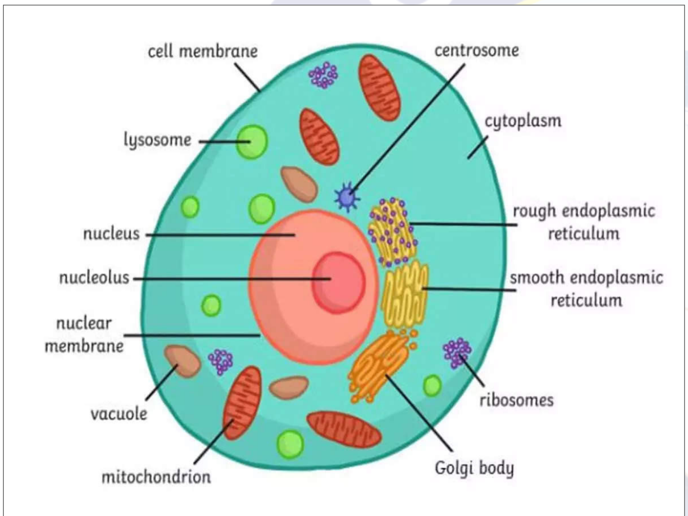
# GENERAL SCIENCE

## WHAT IS CELL?

- Components of Cell & their functions
- Classification of Cell
- Eukaryotic and Prokaryotic cell
- Plant Cell and Animal Cell
- Stem cell and Somatic Cell
- For the first time, Robert Hooke discovered and coined the term cell in 1665.
- After that Robert Brown discovered the Cell Nucleus in 1831. The cell theory, that all the plants and animals are composed of cells and that the cell is the basic unit of life was proposed by Scleiden & Schwann in 1839.




- Cells are the basic building blocks of all living things.
- The human body is composed of trillions of cells.
- They provide structure for the body, take in nutrients from food, convert those nutrients into energy, and carry out specialized functions.
- Cells also contain the body's hereditary material and can make copies of themselves.

### Cell Membrane

- Cell membrane is also called the plasma membrane.
- It can be observed only through an electron microscope. Plasma membrane is the outermost covering of the cell that separates the contents of the cell from its external environment.
- The plasma membrane is flexible and is made up of organic molecules called lipids and proteins.
- The flexibility of the cell membrane also enables the cell to engulf in food and other material from its external environment.

*Note: Viruses lack any membranes and hence do not show characteristics of life until they enter a living body and use its cell machinery to multiply.*

### Functions

i. The plasma membrane encloses the cell contents.
ii. It provides cell shape (in animal cells) e.g. the characteristic shape of red blood cells, nerve cells, and bone cells.
iii. It allows transport of certain substances into and out of the cell but not all substances so much it is termed 'selectively permeable'

- Cell wall: In bacteria and plant cells the outermost cell cover, present outside the plasma membrane is the cell wall.

### Structure

- Outermost non-living layer present in all plant cells.
- Secreted by the cell itself.
- In most plants, it is chiefly made up of cellulose but may also contain other chemical substances such as pectin and lignin

### Function

- The cell wall protects the delicate inner parts of the cell.
- Being rigid, it gives shape to the cell.
- As it is rigid, it does not allow distension of the cell, thus leading to turgidity of the cell that is useful in many ways
- It freely allows the passage of water and other chemicals into and out of the cells

### Cytoplasm

- It is the jelly-like substance present between the cell membrane and the nucleus. The cytoplasm is the fluid content inside the plasma membrane.
- It also contains other specialized cell organelles. Each of these organelles performs a specific function for the cell.

### Nucleus

- It is an important component of the living cell. Nucleus is the control center of the cell.
- Nucleus is separated from the cytoplasm by a double layered membrane called the nuclear membrane. This membrane is also porous and allows the movement of materials between the cytoplasm and the inside of the nucleus.

### Nucleus

- Nucleus contains nucleolus and thread-like structures called chromosomes.
- Chromosomes carry genes and help in inheritance or transfer of characters from the parents to the offspring. The chromosomes can be seen only when the cell divides.
- The entire content of a living cell is known as protoplasm which is (cytoplasm + nucleus).

### Vacuoles

- Empty structures in the cytoplasm is called vacuole. It could be single and big or multiple & small.
- Vacuoles are storage sacs for solid or liquid contents.
- Many substances of importance in the life of the plant cell

are stored in vacuoles. These include amino acids, sugars, various organic acids and some proteins.

- Large vacuoles are common in plant cells. Vacuoles in animal cells are much smaller. The central vacuole of some plant cells may occupy 50-90% of the cell volume.

## Lysosomes

- Lysosomes are a kind of waste disposal system of the cell.
- Lysosomes help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles.
- Lysosomes are able digest these because they contain powerful digestive enzymes capable of breaking down all organic material.
- During the disturbance in cellular metabolism, for example, when the cell gets damaged, lysosomes may burst and the enzymes digest their own cell. Therefore, lysosomes are also known as the 'suicide bags' of a cell.

## Golgi Apparatus or Golgi Complex

- Golgi apparatus is membrane-bound organelle of eukaryotic cells that is made up of a series of flattened, stacked pouches called cisternae.
- The Golgi apparatus is responsible for transporting, modifying, and packaging proteins and lipids into vesicles for delivery to targeted destinations.
- It is located in the cytoplasm next to the endoplasmic reticulum and near the cell nucleus. While many types of cells contain only one or several Golgi apparatus, plant cells can contain hundreds.
- The golgi apparatus is also involved in the formation of lysosomes.

## Ribosome

- Ribosomes are very important cell organelles composed of RNA and protein that converts genetic code into chains of amino acids.
- A ribosome is a complex molecular machine found inside the cells that produce proteins from amino acids during a process called protein synthesis or translation.
- The process of protein synthesis is a primary function, which is performed by all living cells.
- Ribosomes are known as the protein factory of the cell

## Endoplasmic Reticulum (ER)

- The endoplasmic reticulum (ER) is a large network of membrane-bound tubes and sheets. The ER membrane is similar in structure to the plasma membrane.
- There are two types of ER — rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER).
- RER looks rough under a microscope because it has particles called ribosomes attached to its surface.
- SER helps in the manufacture of fat molecules, or lipids, important for cell function.

## Endoplasmic Reticulum (ER)

- Endoplasmic Reticulum (ER) helps in production & utilization of proteins & lipids. Some of these proteins and lipids help in building the cell membrane. Some other proteins and lipids function as enzymes and hormones.
- ER also serves as channels for the transport of materials especially proteins between various regions of the cytoplasm or between the cytoplasm and the nucleus.

## Mitochondria

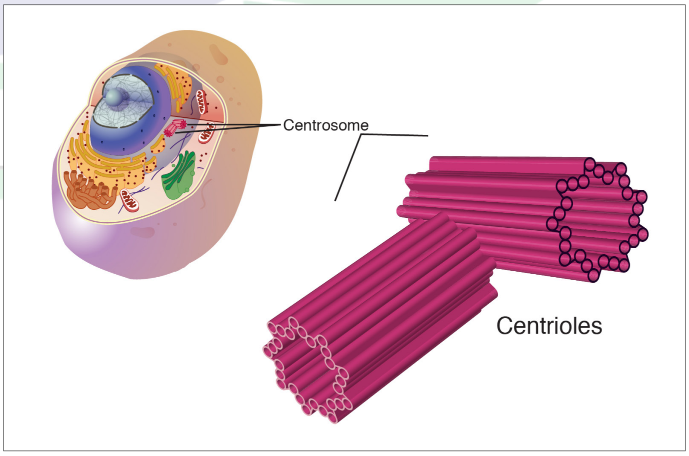
- Mitochondria is known as the powerhouse of the cell.
- The primary function of Mitochondria is to generate large quantities of energy in the form of adenosine triphosphate (ATP).
- Our body uses energy stored in ATP for making new chemical compounds and for mechanical work.
- Mitochondria have two membrane coverings instead of just one.
- Mitochondria are have their own DNA and ribosomes. Therefore, mitochondria are able to make some of their own proteins.

## Plastids

- Plastids are small colored bodies in the cytoplasm. Plastids are present only in plant cells.
- They are of different colours. Some of them contain green pigment called chlorophyll. Green coloured plastids are called chloroplasts. They provide green colour to the leaves.
- Some plastids are also colorless called Leucoplasts in which materials such as starch, oils and protein granules are stored.
- Plastids are similar to mitochondria in external structure. Like the mitochondria, plastids also have their own DNA and ribosomes.

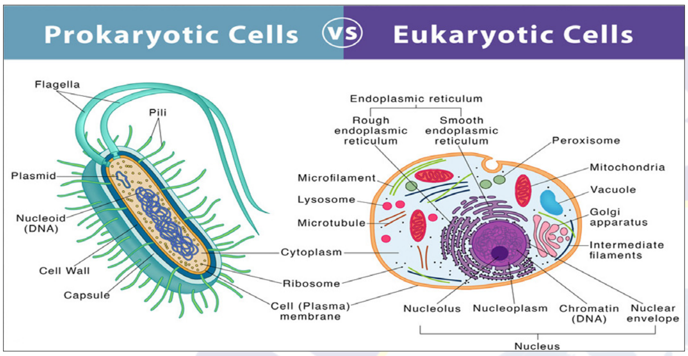
## Centrosome & Centriole

- Centrioles are paired barrel-shaped organelles located in the cytoplasm of animal cells near the nuclear envelope. Centrioles play a role in organizing microtubules that serve as the cell's skeletal system. They help determine the locations of the nucleus and other organelles within the cell.
- Centrioles play very important for cell division. When the cell is going to divide, those centrioles go to opposite ends of the nucleus.



## A. PROKARYOTIC AND EUKARYOTIC CELL

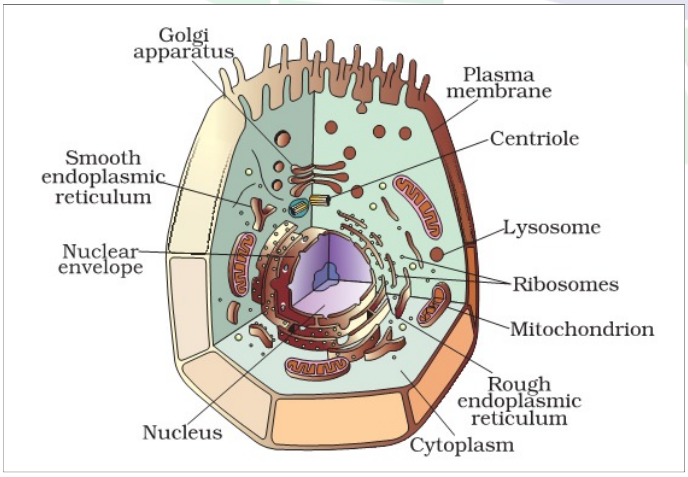
- Prokaryotic cell (Gk. Pro-before; karyon-nucleus):
- These cells do not have a well-organized nucleus.
- The genetic material is a single molecule of DNA lying in the cytoplasm.
- Not only is the nuclear membrane absent, cell organelles like mitochondria, lysosomes, endoplasmic reticulum, chloroplast, nucleolus, etc are also not present in prokaryotic cells.
- Examples: Bacteria and blue-green algae.

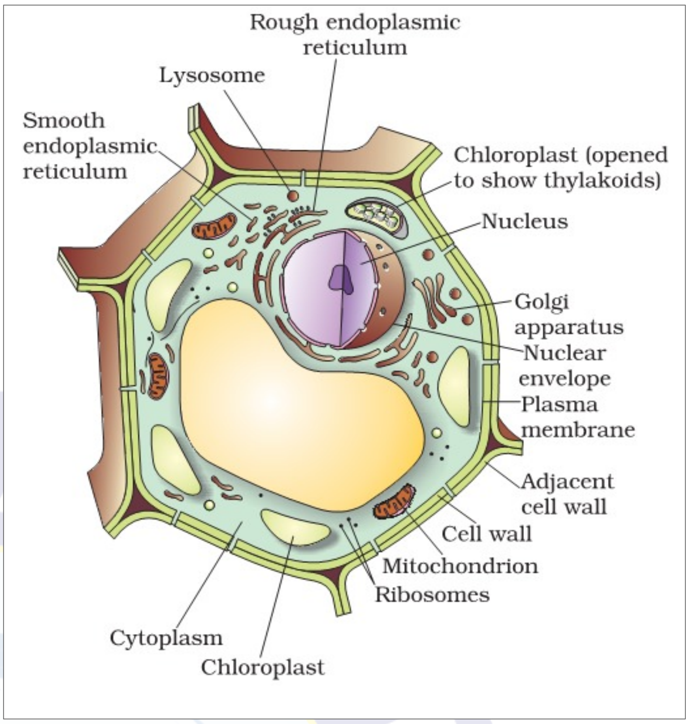



## A. PROKARYOTIC AND EUKARYOTIC CELL

- Eukaryotic cell (Gk. Eu-true; karyon-nucleus): DNA is enclosed in a nuclear membrane forming a nucleus.
- The genetic material is made of two or more DNA molecules, which are present as a network of chromatin fibres when the cell is not dividing.
- Membrane-bound organelles, such as mitochondria, endoplasmic reticulum, lysosome, chloroplast, nucleolus, etc. are present within the cytoplasm.
- Examples: Cells of plants, fungi, protozoa and animals.

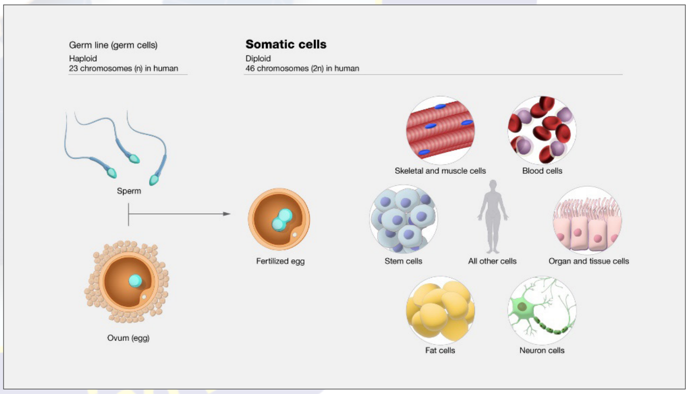
| Feature | Plant cell | Animal cell |
|---|---|---|
| Size and Shape | Larger in size and rectangular in shape. | Smaller in size and oval in shape. |
| Cell wall | Cell wall is made up of cellulose. | Cell wall absent. |
| Vacuoles | Vacuoles are large. In a mature plant cell, usually a single large central vacuole is present. | Vacuoles are mostly absent or if present are small in size and scattered. |
| Golgi bodies | Golgi bodies are diffused in the plant cells and are called dictyosomes. | Golgi bodies are well-developed and present near nucleus. |
| Centrosome | Centrosome and centrioles are absent. | Centrosome and centrioles are present. |
| Plastids | Present | Absent |
| Storage of reserve food | Reserve food is stored in the form of starch or oil. | Reserve food is stored in the form of glycogen. |




### Germ Cells vs Somtic Cell

- Difference Between Somatic Cells and Germ Cells
- Somatic Cells: Somatic cells are any cells in a multicellular organism that are not involved in the production of gametes.
- Germ Cells: Germ cells are the cells that create reproductive cells or gametes.




### Types

- Somatic Cells: Various types of somatic cells are arranged into different types of tissues in the body of multicellular organisms, performing specific functions.
- Germ Cells: Germ cells produce male and female gametes.
- Difference Between Somatic Cells and Germ Cells

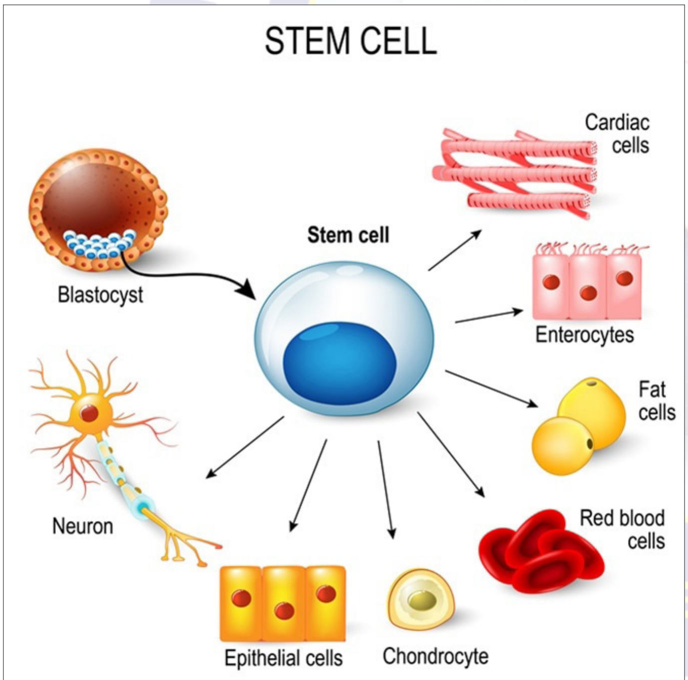
### Amount

- Somatic Cells: Majority of the body cells in multicellular organisms are somatic cells.
- Germ Cells: Germ cells are very few in number.

### Functions

- Somatic Cells: Somatic cells perform various functions in the body.

- Germ Cells: Germ cells produce gametes, which participate in sexual reproduction.
- Stem cells are unspecialized cells with self-renewal capacity. They can divide through mitosis limitlessly to replenish other cell types of multicellular organisms throughout their life.
- After stem cell division, each newly produced cell can either remain as a stem cell or differentiate to form any other cell type with more defined functions, such as muscle cell, blood cell, or neural cell.
- There are mainly two types of stem cells: embryonic stem cells, which are derived from embryos, and somatic or adult stem cells, which are undifferentiated cells residing in a tissue or organ along with other differentiated cells (somatic cells).
- The major difference between embryonic and somatic stem cells is that embryonic stem cells have the potential to differentiate into all cell types of the body, as they are pluripotent stem cells (cells that are able to differentiate into three primary germ cell layers of the early embryo and, thus, into any cell type of the body); whereas, it is believed that somatic stem cells can differentiate only into different cell types present in the tissue of their origin.




## PLANT AND ANIMAL KINGDOM

- R.H. Whittaker (1969) proposed a Five Kingdom Classification.
- The kingdoms defined by him were named Monera, Protista, Fungi, Plantae and Animalia.
- The main criteria for classification used by him include cell structure, body organisation, mode of nutrition, reproduction and phylogenetic relationships

### KINGDOM MONERA

- Bacteria are the sole members of the Kingdom Monera.
- They are the most abundant micro-organisms.
- Bacteria occur almost everywhere. Hundreds of bacteria are present in a handful of soil.

**Table 2.1 Characteristics of the Five Kingdoms**

| Characters | Five Kingdoms | | | | |
|---|---|---|---|---|---|
| | Monera | Protista | Fungi | Plantae | Animalia |
| Cell type | Prokaryotic | Eukaryotic | Eukaryotic | Eukaryotic | Eukaryotic |
| Cell wall | Noncellulosic (Polysaccharide + amino acid) | Present in some | Present with chitin | Present (cellulose) | Absent |
| Nuclear membrane | Absent | Present | Present | Present | Present |
| Body organisation | Cellular | Cellular | Multiceullar/ loose tissue | Tissue/ organ | Tissue/organ/ organ system |
| Mode of nutrition | Autotrophic (chemosyn-thetic and photosynthetic) and Hetero-trophic (sapro-phytic/para-sitic) | Autotrophic (Photosyn-thetic) and Hetero-trophic | Heterotrophic (Saprophytic/ Parasitic) | Autotrophic (Photosyn-thetic) | Heterotrophic (Holozoic/ Saprophytic etc.) |

- They also live in extreme habitats such as hot springs, deserts, snow and deep oceans where very few other life forms can survive.
- Many of them live in or on other organisms as parasites.

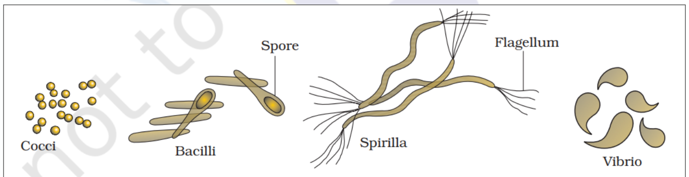
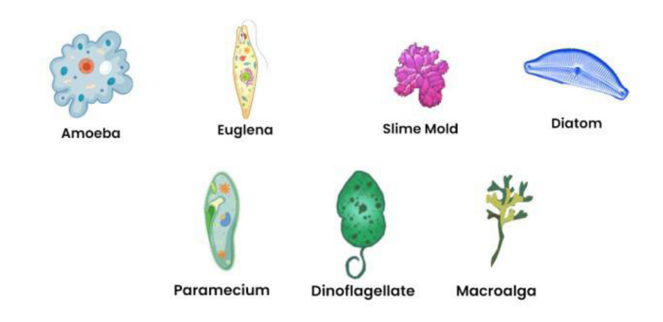



**Figure 2.1** Bacteria of different shapes

### Kingdom Protista

- All single-celled eukaryotes are placed under Protista, but the boundaries of this kingdom are not well defined.
- What may be 'a photosynthetic protistan' to one biologist may be 'a plant' to another.
- Members of Protista are primarily aquatic.
- This kingdom forms a link with the others dealing with plants, animals and fungi.
- Being eukaryotes, the protistan cell body contains a well defined nucleus and other membrane-bound organelles.
- Some have flagella or cilia. Protists reproduce asexually and sexually by a process involving cell fusion and zygote formation.



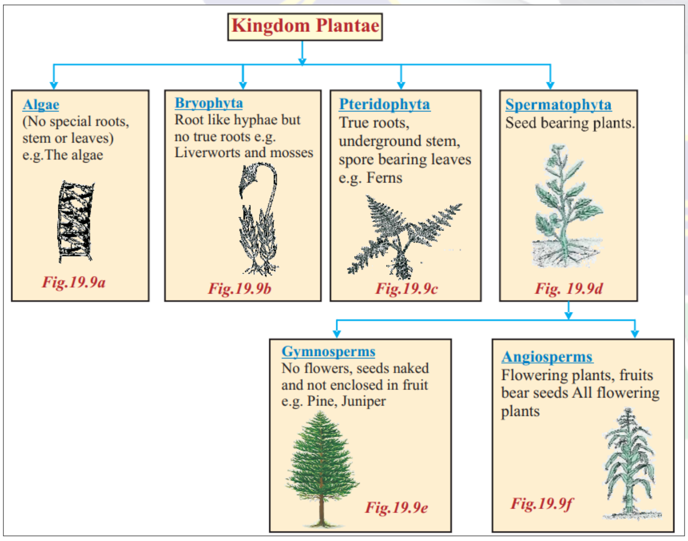

### Kingdom Fungi

- The fungi constitute a unique kingdom of heterotrophic organisms.
- They show a great diversity in morphology and habitat

- Fungi are cosmopolitan and occur in air, water, soil and on animals and plants.
- They prefer to grow in warm and humid places
- Most fungi are heterotrophic and absorb soluble organic matter from dead substrates and hence are called saprophytes.
- Those that depend on living plants and animals are called parasites.
- They can also live as symbionts – in association with algae as lichens and with roots of higher plants as mycorrhiza.

## KINGDOM PLANTAE

- Kingdom Plantae includes all eukaryotic chlorophyll-containing organisms commonly called plants.
- A few members are partially heterotrophic such as the insectivorous plants or parasites.
- Bladderwort and Venus fly trap are examples of insectivorous plants and Cuscuta is a parasite.
- The plant cells have an eukaryotic structure with prominent chloroplasts and cell wall mainly made of cellulose.




### Insectivorous Plants

- Insectivorous plants, also known as carnivorous plants,
- They are a group of plants that have developed unique adaptations to capture and digest insects and other small organisms as a source of nutrients.

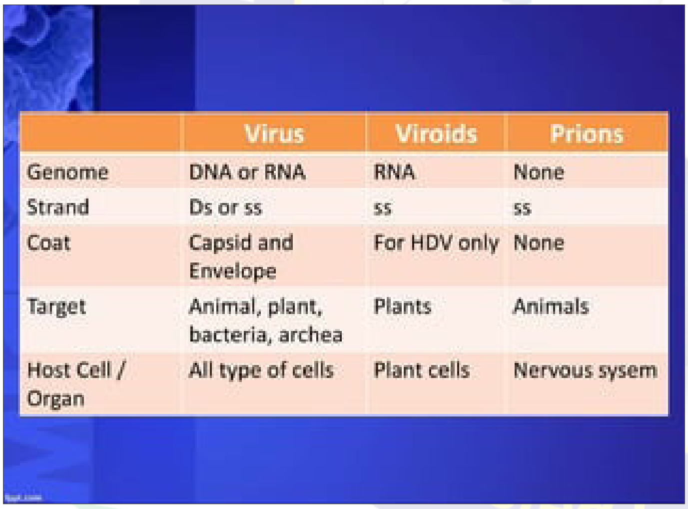
- These plants typically grow in environments where the soil is nutrient-poor
- They have evolved to supplement their nutritional needs by deriving nutrients from insects.
- They secrete enzymes, such as proteases and phosphatases, to break down the captured insects and release the essential nutrients, including nitrogen and phosphorus.
- Insectivorous plants are found in diverse habitats worldwide, including bogs, swamps, marshes, and other wetland areas.
- Some species also grow in nutrient-poor soils, such as sandy or rocky environments.
- Examples of insectivorous plants include pitcher plants, Venus flytrap, sundews, and bladderworts.
- Insectivorous plants have evolved to be carnivorous despite having normal roots and photosynthetic leaves
- because they typically inhabit nutrient-poor environments where they face limitations in
- obtaining essential nutrients, particularly nitrogen and phosphorus.
- Digestive Aid: Some insectivorous plants, such as sundews (Drosera species), have been traditionally used to support digestion.
- They are believed to have digestive-enhancing properties and have been used as herbal remedies for digestive disorders, such as indigestion, stomach ulcers, and gastritis
- Utricularia is beneficial for treating wounds, treating coughs, and curing urinary diseases.
- Medicinal tea is brewed using the dried leaves of Utricularia.
- Anti-cancer Potential: Some studies have explored the potential anti-cancer properties of compounds derived from insectivorous plants.
- For example, extracts from sundews and pitcher plants have shown cytotoxic effects on cancer cells in vitro.
- Antioxidant Activity: Insectivorous plants contain compounds with antioxidant properties, such as phenolic compounds and flavonoids.
- Antimicrobial and Antifungal Activity: Insectivorous plants produce a variety of secondary metabolites that may possess antimicrobial and antifungal properties.
- Such as pitcher plants (Nepenthes species) and sundews, exhibit inhibitory effects against certain bacteria and fungi.

## KINGDOM ANIMALIA

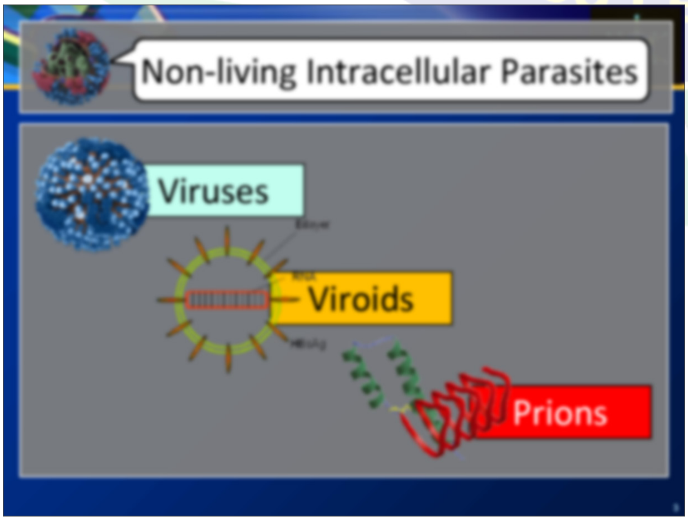
- This kingdom is characterised by heterotrophic eukaryotic organisms that are multicellular and their cells lack cell walls.
- They directly or indirectly depend on plants for food.
- They digest their food in an internal cavity and store food reserves as glycogen or fat.
- Their mode of nutrition is holozoic – by ingestion of food.
- They follow a definite growth pattern and grow into adults that have a definite shape and size.
- Higher forms show elaborate sensory and neuromotor mechanism. Most of them are capable of locomotion.
- The sexual reproduction is by copulation of male and female followed by embryological development.

## VIRUSES, VIROIDS, PRIONS AND LICHENS

- Viruses did not find a place in classification since they are not considered truly 'living', if we understand living as those organisms that have a cell structure.
- The viruses are non-cellular organisms that are characterised by having an inert crystalline structure outside the living cell
- Once they infect a cell they take over the machinery of the host cell to replicate themselves, killing the host.
- Virus means venom or poisonous fluid



| | Virus | Viroids | Prions |
|---|---|---|---|
| Genome | DNA or RNA | RNA | None |
| Strand | Ds or ss | ss | ss |
| Coat | Capsid and Envelope | For HDV only | None |
| Target | Animal, plant, bacteria, archea | Plants | Animals |
| Host Cell / Organ | All type of cells | Plant cells | Nervous sysem |




- In addition to proteins, viruses also contain genetic material, that could be either RNA or DNA.
- No virus contains both RNA and DNA. A virus is a nucleoprotein and the genetic material is infectious.
- In general, viruses that infect plants have single stranded RNA and viruses that infect animals have either single or double stranded RNA or double stranded DNA.
- Bacterial viruses or bacteriophages (viruses that infect the bacteria) are usually double stranded DNA viruses

### Viroids

- In 1971, T.O. Diener discovered a new infectious agent that was smaller than viruses and caused potato spindle tuber disease.
- It was found to be a free RNA; it lacked the protein coat that is found in viruses, hence the name viroid.
- The RNA of the viroid was of low molecular weight.

### Prions

- In modern medicine certain infectious neurological diseases were found to be transmitted by an agent consisting of abnormally folded protein.
- The agent was similar in size to viruses. These agents were called prions.
- The most notable diseases caused by prions are bovine spongiform encephalopathy (BSE) commonly called mad cow disease in cattle and its analogous variant Cr–Jacob disease (CJD) in humans.

### Lichens

- Lichens are symbiotic associations i.e. mutually useful associations, between algae and fungi.
- The algal component is known as phycobiont and fungal component as mycobiont, which are autotrophic and heterotrophic, respectively.
- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner.
- So close is their association that if one saw a lichen in nature one would never imagine that they had two different organisms within them.
- Lichens are very good pollution indicators – they do not grow in polluted areas.

## HUMAN BODY

- Circulatory System
- Respiratory System
- Digestive System
- Nervous System

### Some facts

- Blood is a fluid connective tissue that has a significant role in the transportation of nutrients, respiratory gases, hormones, in maintaining and regulation of body temperature, pH, and other thermo-regulation processes. It is 6 times thicker than water and each drop of blood contains about 250 million cells.
- Cornea that is the transparent front part of the eye is the only part in Human body with no blood supply and it gets oxygen directly from the air.
- Skin is the human body's largest organ
- A large amount of the dust in your home is actually dead skin. Humans shed about 600,000 particles of skin every hour.
- The smallest bone found in the human body is located in the middle ear. The staples (or stirrup) bone is only 2.8 millimetres long.
- The femur (thigh bone) is the longest bone in the human body.
- Goose bumps evolved to make our ancestors' hair stand up, making them appear more threatening to predators.
- Between birth and death, the human body goes from having 300 bones, to just 206.
- Our brain is programmed to erect the inverted image formed on our retina by the convex eye lens. A newborn baby sees the world upside down till its brain starts erecting it.
- In camera terms, the human eye is about 576 megapixels.

### Circulatory System

- Human circulatory system consists of
  - i. Centrally located muscular pump called heart, and
  - ii. Blood vessels, which are tube-like structures, connected to the heart.

### Blood vessels are of three kinds

- Arteries: Carry blood from heart to various parts of body.
- Veins: Bring blood from various parts of body to the heart.
- Capillaries: Thin vessels between the artery and the vein. The capillaries allow the exchange of materials between blood and tissues.

### (iii) Circulating fluid–blood, tissue fluid and lymph

- Blood is a specialized body fluid. It has four main components: plasma, red blood cells, white blood cells, and platelets. Blood has many different functions, including: transporting oxygen and nutrients to the lungs and tissues forming blood clots to prevent excess blood loss carrying cells and antibodies that fight infection, bringing waste products to the kidneys and liver, which filter and clean the blood regulating body temperature
- The blood that runs through the veins, arteries, and capillaries is known as whole blood, a mixture of about 55 percent plasma and 45 percent blood cells. About 7 to 8 percent of your total body weight is blood. An average-sized man has about 12 pints of blood in his body, and an average-sized woman has about nine pints.

### Plasma

- The liquid component of blood is called plasma, a mixture of water, sugar, fat, protein, and salts. The main job of the plasma is to transport blood cells throughout your body along with nutrients, waste products, antibodies, clotting proteins, chemical messengers such as hormones, and proteins that help maintain the body's fluid balance.

### Red Blood Cells (also called erythrocytes or RBCs)

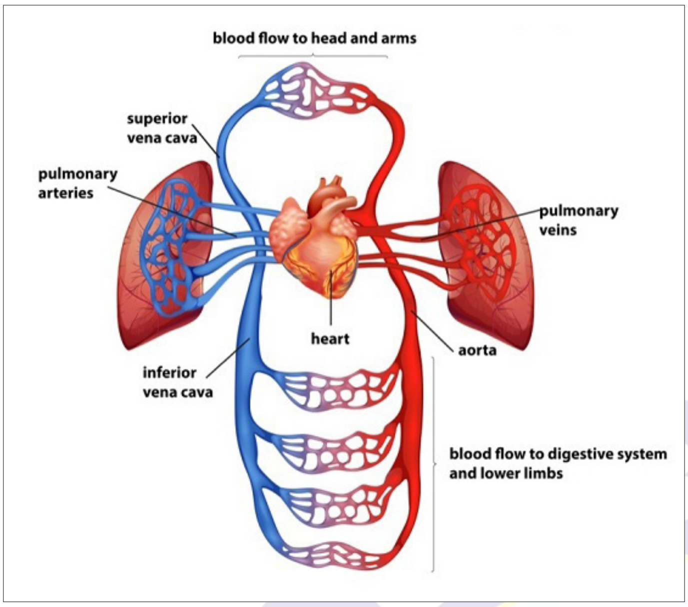
- Known for their bright red color, red cells are the most abundant cell in the blood, accounting for about 40 to 45 percent of its volume. Red cells contain a special protein called haemoglobin, which helps carry oxygen from the lungs to the rest of the body and then returns carbon dioxide from the body to the lungs so it can be exhaled. Blood appears red because of the large number of red blood cells, which get their color from the hemoglobin.
- The other major type of white blood cell is a lymphocyte. There are two main populations of these cells. T lymphocytes help regulate the function of other immune cells and directly attack various infected cells and tumors. B lymphocytes make antibodies, which are proteins that specifically target bacteria, viruses, and other foreign materials.

### Platelets (also called thrombocytes)

- Unlike red and white blood cells, platelets are not actually cells but rather small fragments of cells. Platelets help the blood clotting process (or coagulation) by gathering at the site of an injury, sticking to the lining of the injured blood vessel, and forming a platform on which blood coagulation can occur. This results in the formation of a fibrin clot, which covers the wound and prevents blood from leaking out. Fibrin also forms the initial scaffolding upon which new tissue forms, thus promoting healing.
- A higher than normal number of platelets can cause unnecessary clotting, which can lead to strokes and heart attacks

### Blood groups

- There are 4 main blood groups (types of blood) – A, B, AB and O. Your blood group is determined by the genes you inherit from your parents.
- The blood group is identified by antibodies and antigens in the blood.
- Antibodies are proteins found in plasma. They're part of your body's natural defences. They recognise foreign substances, such as germs, and alert your immune system, which destroys them.
- Antigens are protein molecules found on the surface of red blood cells.




## The ABO system

- There are 4 main blood groups defined by the ABO system:
- blood group A – has A antigens on the red blood cells with anti-B antibodies in the plasma
- blood group B – has B antigens with anti-A antibodies in the plasma
- blood group O – has no antigens, but both anti-A and anti-B antibodies in the plasma
- blood group AB – has both A and B antigens, but no antibodies
- Blood group O is the most common blood group.

## The Rh system

- Red blood cells sometimes have another antigen, a protein known as the RhD antigen. If this is present, then blood group is RhD positive. If it's absent, then blood group is RhD negative.

## This means there are 8 blood groups

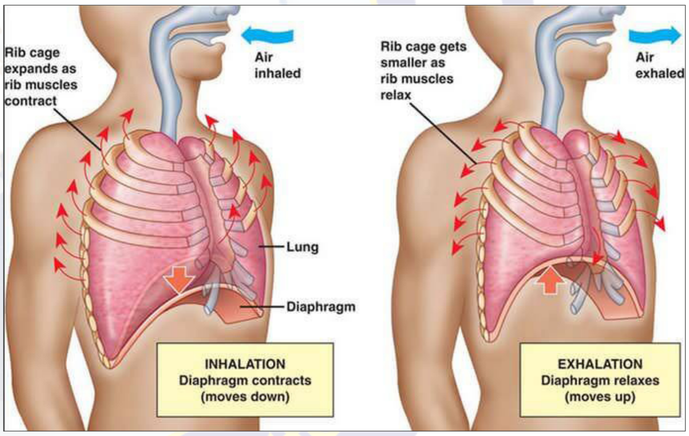
- A RhD positive (A+) A RhD negative (A-)
- B RhD positive (B+) B RhD negative (B-)
- O RhD positive (O+) O RhD negative (O-)
- AB RhD positive (AB+) AB RhD negative (AB-)
- In most cases, O RhD negative blood (O-) can safely be given to anyone. It's often used in medical emergencies when the blood type is not immediately known.
- It's safe for most recipients because it does not have any A, B or RhD antigens on the surface of the cells, and is compatible with every other ABO and RhD blood group

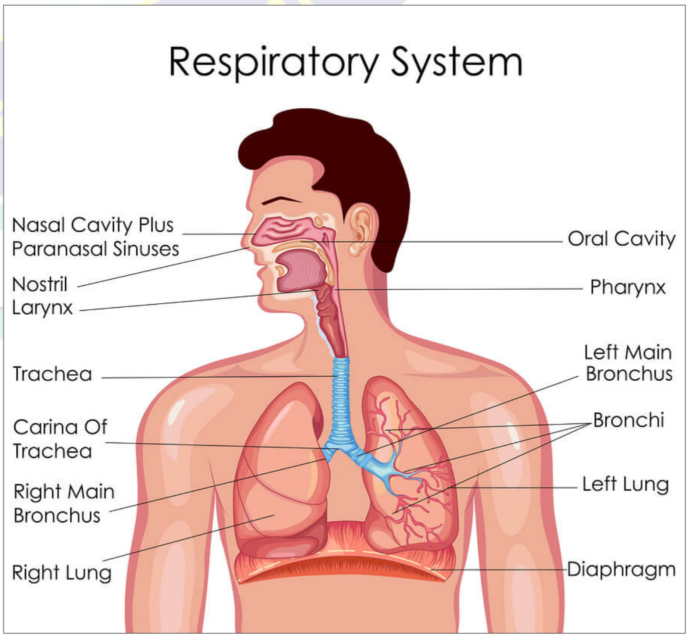
## White Blood Cells (also called leukocytes)

- White blood cells protect the body from infection. They are much fewer in number than red blood cells, accounting for about 1 percent of your blood.
- The most common type of white blood cell is the neutrophil, which is the "immediate response" cell and accounts for 55 to 70 percent of the total white blood cell count. Each neutrophil lives less than a day, so your bone marrow must constantly make new neutrophils to maintain protection against infection. Transfusion of neutrophils is generally not effective since they do not remain in the body for very long.

## Respiratory System

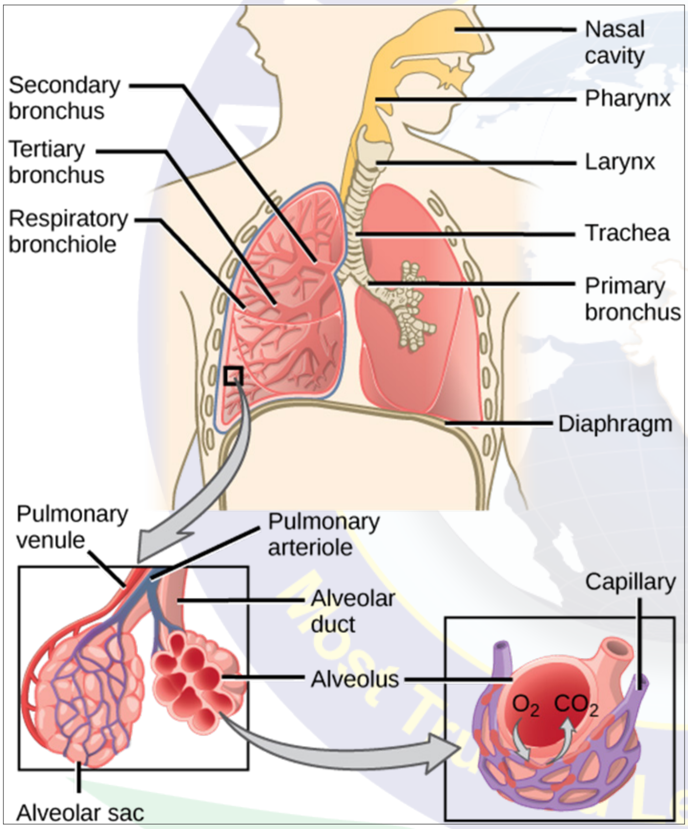
- The respiratory system is the network of organs and tissues that helps to breathe. It includes airways, lungs and blood vessels. The muscles that powers lungs are also part of the respiratory system. These parts work together to move oxygen throughout the body and clean out waste gases like carbon dioxide.
- What does the respiratory system do?
- The respiratory system has many functions. Besides helping you inhale (breathe in) and exhale (breathe out), it:
- Allows you to talk and to smell.
- Warms air to match your body temperature and moisturizes it to the humidity level your body needs.
- Delivers oxygen to the cells in your body.
- Removes waste gases, including carbon dioxide, from the body when you exhale.
- Protects your airways from harmful substances and irritants.



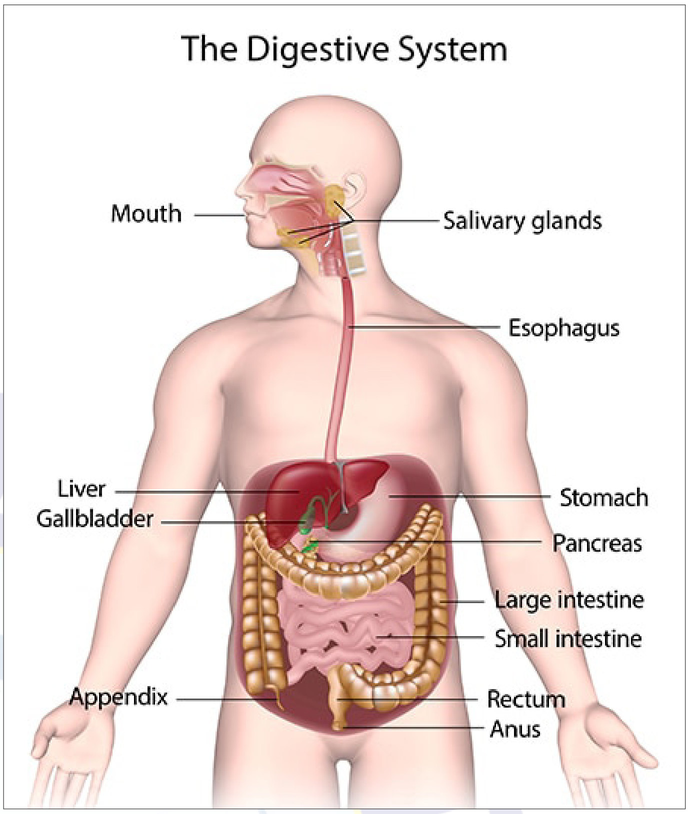
### Parts of Respiratory System

- Mouth and nose: Openings that pull air from outside your body into your respiratory system.
- Sinuses: Hollow areas between the bones in your head that help regulate the temperature and humidity of the air you inhale.
- Pharynx (throat): Tube that delivers air from your mouth and nose to the trachea (windpipe).
- Trachea: Passage connecting your throat and lungs.
- Bronchial tubes: Tubes at the bottom of your windpipe that connect into each lung.
- Lungs: Two organs that remove oxygen from the air and pass it into your blood.
- Alveoli are the primary sites of exchange of gases.
- Exchange of gases also occur between blood and tissues. $O_2$ and $CO_2$ are exchanged in alveoli by diffusion based on pressure & concentration gradient.




### Human Digestive System

- The human digestive system consists of the gastrointestinal tract plus the accessory organs of digestion.
- Digestion involves the breakdown of food into smaller and smaller components, until they can be absorbed and assimilated into the body.
- Ingestion happens through the mouth. The mouth leads to the buccal cavity or oral cavity where digestion starts.
- 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 and enzymes.




### Salivary Amylase

- The chemical process of digestion is initiated in the oral cavity by the hydrolytic action of the carbohydrate-splitting enzyme, salivary amylase.
- Lysozyme is also present in saliva and acts as an antibacterial agent that prevents infections.
- The oral cavity leads into a short pharynx which serves as a common passage for food and air.
- The Oesophagus and the trachea (wind pipe) open into the pharynx.
- Epiglottis prevents the entry of food into the glottis (opening of the wind pipe).
- The swallowed food passes into the foodpipe or oesophagus then enter stomach.
- The esophagus is a muscular tube that connects the pharynx (throat) to the stomach.
- The esophagus contracts as it moves food into the stomach.
- A "valve" called the lower oesophagal sphincter (LES) is located just before the opening to the stomach.
- This valve opens to let food pass into the stomach from the esophagus and it prevents food from moving back up into the esophagus from the stomach.
- The inner lining of the stomach secretes mucous, hydrochloric acid and digestive juices. The mucous protects the lining of the stomach.

### Why Stomach have an acidic pH?

- The acidic nature of the stomach kills many bacteria that enter along with the food.
- The digestive juices break down the proteins into simpler substances.
- Small intestine is distinguishable into three regions

1. Duodenum 2. Jejunum 3. Ileum

- The small intestine is highly coiled and is about 5-6 meters long.
- It also 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.
- Villi increase the surface area for absorption of the digested food.
- 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.
- The large intestine is wider and shorter than small intestine. It is about 1.5 metre in length.
- Large intestine's function is to absorb water and some salts from the undigested food material.
- **Rectum:** An 8-inch chamber that connects the colon to the anus. The rectum receives stool from the colon, sends signals to the brain if there is stool to be evacuated, and holds stool until evacuation can happen.

### Anus

- The last part of the digestive tract, the anus, consists of pelvic floor muscles and two anal sphincters (internal and external). Together their jobs are to detect rectal contents, whether they are liquid, gas or solid, and then control when stool should and shouldn't be excreted from your body.

### Liver

- The liver is the largest gland in the body, weighing about 1.5 kg (3.3 lb) in an adult.
- The liver has many roles in the digestive system.
- It produces a yellow-green fluid called bile, which breaks down fats and removes wastes and toxins from the body
- Bile is alkaline and contains salts which help to emulsify or break the fats or lipids present in the food.
- Bile also helps carry waste from the liver that cannot go through the kidneys.

### Pancreas

- The pancreas is located below the stomach.
- It produces a mix of enzymes that together are called pancreatic juice.
- The pancreas secretes pancreatic juice which contains digestive enzymes like pancreatic amylase, trypsin and lipase.
- This juice helps neutralize the very acidic chyme when it enters the small intestine.
- Pancreatic juice also helps us to digest proteins, fats and carbohydrates.
- Amylase breaks down the starch, trypsin digests the proteins and lipase breaks down the emulsified fats.

### Gall bladder

- The gall bladder is a pouch-shaped organ that stores the bile produced by the liver.
- The gall bladder shares a vessel, called the common bile duct, with the liver.
- When bile is needed, it moves through the common bile duct into the first part of the small intestine, the duodenum.
- It is here that the bile breaks down fat.

### Nervous System

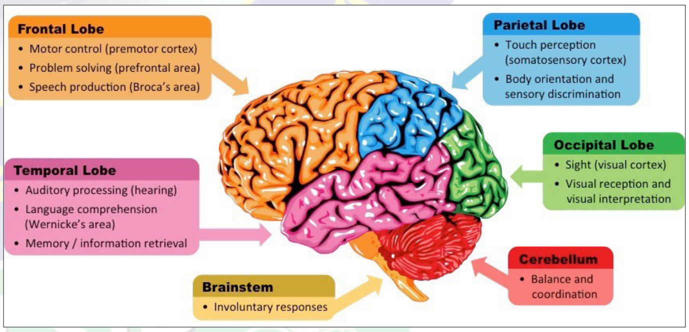
- We see people, identify them, listen to their thoughts and speak our thoughts etc. All these co-ordinating activities are done by our brain and nerves which is called nervous system

1. brain 2. Spinal cord 3. nerves
4. sensory organs

- brain - human brain is a soft and delicate part. It is around 3 to 5 kg kilograms in an adult. This part is safe in skull.
- Human brain is the biggest size in all living organisms. It has the only secret of how humans can do all other works that other organisms cannot do.

### Parts of brain:

- Fore brain: this is the biggest part of brain. Its main function is to think and remember. This part is related to will power, intelligence and consciousness. It also gives us other areas related to knowledge centre like speaking, seeing, taste and smell.
- Mid brain: this is a small part found below fore brain and back side of skull. Its function is to control various muscles.
- Medulla oblongata - this is also known as pillar of brain. Its function is to control involuntary activities like heart rate and exhale breathing



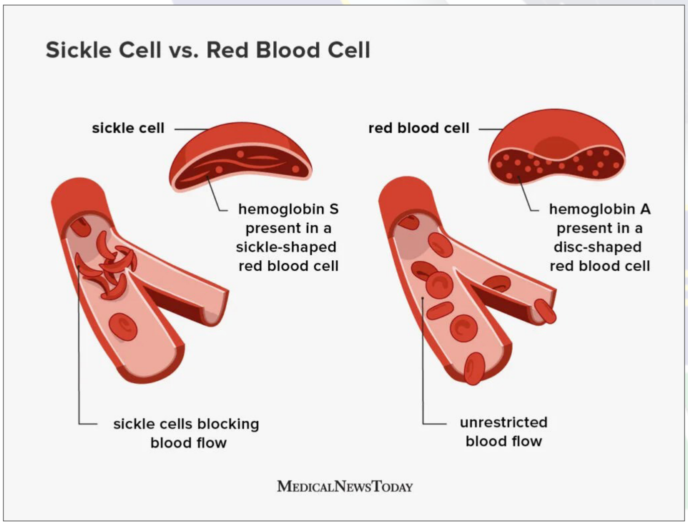

- Spinal cord - this is a pipe like structure starting from brain and going to backbone internally in body. All message sent from brain to body reach by this pipe. This also helps in giving fast reaction like if a thorn pricks than we take our hand back internally.
- Nerves- Nerves carry electrical signals from brain that help you feel sensations and move your muscles. Nerves also control body functions like digesting food and maintaining your heart rate. Nerves are one of the foundational parts of your nervous system.

## Cancer

- Cancer is a disease in which some of the body's cells grow uncontrollably and spread to other parts of the body.
- Cancer can start almost anywhere in the human body, which is made up of trillions of cells.
- Normally, human cells grow and multiply (through a process called cell division) to form new cells as the body needs them.
- When cells grow old or become damaged, they die, and new cells take their place.
- Sometimes this orderly process breaks down, and abnormal or damaged cells grow and multiply when they shouldn't.
- These cells may form tumors, which are lumps of tissue.
- Tumors can be cancerous or not cancerous (benign).
- Cancerous tumors spread into, or invade, nearby tissues and can travel to distant places in the body to form new tumors (a process called metastasis).
- Cancerous tumors may also be called malignant tumors.
- Many cancers form solid tumors, but cancers of the blood, such as leukemias, generally do not.
- Benign tumors do not spread into, or invade, nearby tissues.
- When removed, benign tumors usually don't grow back, whereas cancerous tumors sometimes do.
- Benign tumors can sometimes be quite large, however.
- Some can cause serious symptoms or be life threatening, such as benign tumors in the brain.

## Sickle cell Anaemia

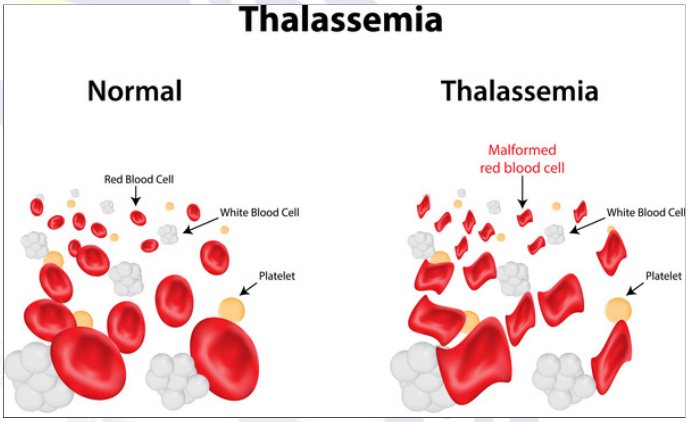
- India is the second-worst affected country in terms of predicted births with SCA — i.e. chances of being born with the condition.



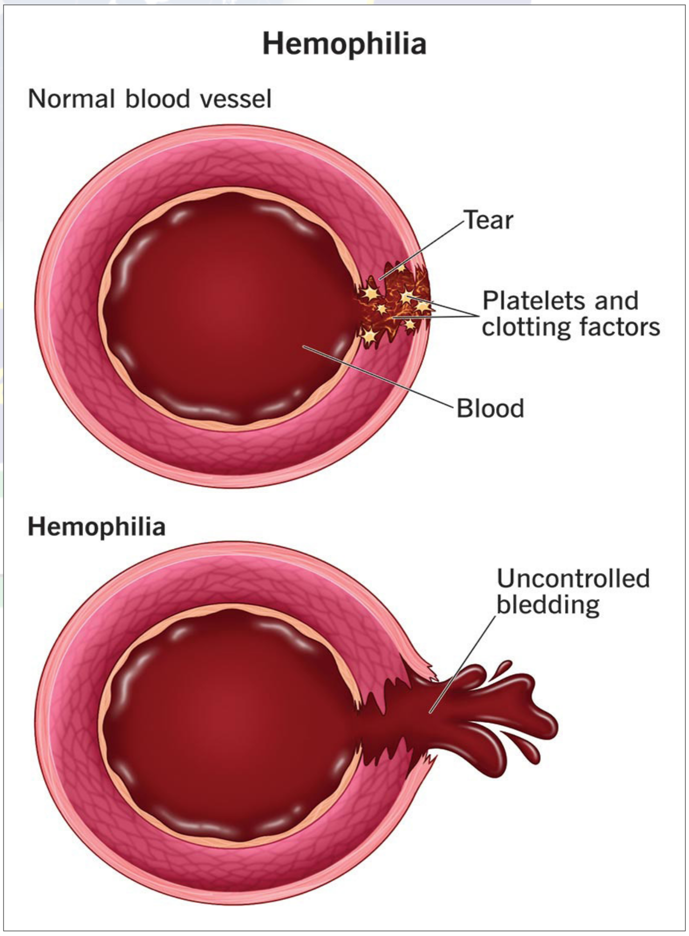

- It changes the shape of red blood cells, making them stiff and sticky, and shaped like sickles or crescent moons.
- These sickle cells can block blood flow, which can lead to serious complications.
- Sickle cell anaemia is caused by inheriting two genes, one from each parent, that code for haemoglobin "S".
- Haemoglobin S is an abnormal form of haemoglobin that causes the red cells to become rigid and sickle-shaped
- Sickle cell disease is a lifelong illness. It can lead to serious complications including pain, infections, organ damage and failure
- A bone marrow transplant is the only cure for some patients with sickle cell disease.

## Thalassemia

- Patients suffering from this disorder are unable to manufacture haemoglobin, the pigment present in red blood corpuscles that carries oxygen to tissues.
- This is because the pair of genes controlling haemoglobin production are defective.
- Thallasemics (persons suffering from thallasemia) require frequent blood transfusions in order to survive.
- The thalassemia gene is present in an autosome



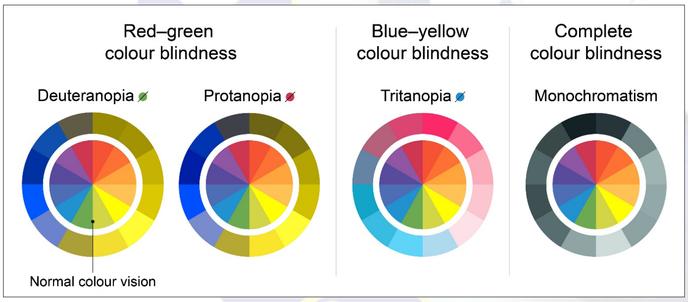

## Haemophilia



- Those persons suffering from haemophilia have either a defective gene or lack genes, which control the production of substances responsible for blood clotting.
- In the absence of such a substance, blood does not coagulate. Once bleeding starts, it does not clot easily.

### Colour-blindness

- Different kinds of colour blindness have been detected but in the most common form of the disorder, a person is unable to distinguish the blue colour from green.
- Again this is due to the presence of a defective gene or the absence of the gene, responsible for colour vision.
- The genes for both haemophilia and colour blindness are located on the X chromosome, and hence, the disorder is passed down from the mother to the son because a boy receives the X chromosome from the mother and the Y chromosome from the father.
- In the mother, with two X chromosomes, the defect does not show up.
- Also in the daughter, the effect of a defective gene on the X-chromosome inherited from the mother may be masked by a normal gene on the X-chromosome, inherited from her father.
- Since the X chromosome bears the defective gene, the son suffers from the genetic disorder, as the male has only one X chromosome and one Y chromosome and so the defective gene does not get masked




### Erythroblastosis foetalis

- A special case of Rh incompatibility (mismatching) has been observed between the Rh-ve blood of a pregnant mother with Rh+ve blood of the foetus.
- Rh antigens of the foetus do not get exposed to the Rh-ve blood of the mother in the first pregnancy as the two bloods are well separated by the placenta.
- However, during the delivery of the first child, there is a possibility of exposure of the maternal blood to small amounts of the Rh+ve blood from the foetus.
- In such cases, the mother starts preparing antibodies against Rh antigen in her blood.
- In case of her subsequent pregnancies, the Rh antibodies from the mother (Rh-ve) can leak into the blood of the foetus (Rh+ve) and destroy the foetal RBCs.
- This could be fatal to the foetus or could cause severe anaemia and jaundice to the baby. T
- his condition is called erythroblastosis foetalis.
- This can be avoided by administering anti-Rh antibodies to the mother immediately after the delivery of the first child.

### Down's Syndrome

- Incidence: Occurs in approx.1 per 800 live births.
- Chromosomal basis: Down syndrome is a genetic condition that arises due to presence of an extra chromosome 21.
- Here, chromosome 21 is repeated thrice (trisomy 21), instead of showing up twice in a normal individual
- Many people with Down syndrome have the common physical signs and have healthy lives.
- But some people with Down syndrome might have one or more birth defects or other health problems. Some of the more common ones include:
- Hearing loss, Sleep apnea (a disorder that causes you to repeatedly stop breathing during sleep), Ear infections, Eye diseases, Congenital heart defects (heart defects that are present at birth), Digestive problems, Problems with the upper part of the spine, Obesity


### Klinefelter's syndrome

- Incidence: Occurs in approximately 1 out of 1000 new born males.
- It Affects males.
- The extra chromosome is not transmitted genetically (i.e., a Klinefelter newborn cannot have a Klinefelter father) but arises from inability of X chromosome to detach itself from the pair during meiosis (at the time of gamete formation).
- Fertilisation of an XX ova with a Y sperm produces an XXY zygote.
- Klinefelter's syndrome children are unusually tall for their age, have reduced facial and body hair, smaller testes, enlarged breasts and coarse voice

### Turner's Syndrome

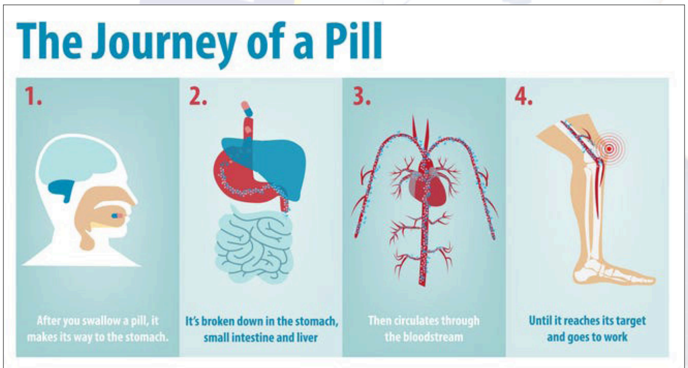
- Incidence: Occurs in 1 in 2,500 newborn girls, frequently observed in miscarriages and still births.
- Turner syndrome is a chromosomal condition that affects

development in people who are assigned female at birth.

- Females typically have two X chromosomes, but in individuals with Turner syndrome, one copy of the X chromosome is missing or altered.
- The most common feature of Turner syndrome is short stature, which becomes evident by about age 5.
- Reduced functioning of the ovaries, the female reproductive organs that produce egg cells (oocytes) and female sex hormones, is also very common.
- The ovaries develop normally at first, but egg cells usually die prematurely and most ovarian tissue breaks down before birth.
- Many affected individuals do not undergo puberty unless they receive hormone therapy, and most are unable to become pregnant naturally.

### What is a drug?

- A drug is a chemical substance that changes the way our body and mind work. A pharmaceutical preparation or a naturally occurring substance used primarily to alter the physical or mental functioning of an individual, is called a drug.
- Life of A drug inside living Body
- A Medicine usually goes through 4 stages inside our body, commonly referred to as ADME – Absorption, Distribution, Metabolization, Excretion.




### Antibiotics

- Antibiotics are medicines that help stop infections caused by bacteria. They do this by killing the bacteria or by keeping them from copying themselves or reproducing.
- The word antibiotic means "against life." Any drug that kills germs in your body is technically an antibiotic. But most people use the term when they're talking about medicine that is meant to kill bacteria
- Before scientists first discovered antibiotics in the 1920s, many people died from minor bacterial infections, like strep throat. Surgery was riskier, too. But after antibiotics became available in the 1940s, life expectancy increased, surgeries got safer, and people could survive what used to be deadly infections.
- Only bacterial infections can be killed with antibiotics. The common cold, flu, most coughs, some bronchitis infections, most sore throats, and the stomach flu are all caused by viruses. Antibiotics won't work to treat them.

## ANTI VIRALS

### What are antivirals?

- Antivirals are medications that help your body fight off certain viruses that can cause disease. Antiviral drugs are also preventive. They can protect you from getting viral infections or spreading a virus to others.
- How do antiviral medications work?
- Antiviral medicines work differently depending on the drug and virus type. Antivirals can:
- Block receptors so viruses can't bind to and enter healthy cells.
- Boost the immune system, helping it fight off a viral infection.
- Lower the viral load (amount of active virus) in the body.

### Can antivirals cure viral infections?

- Antiviral drugs can ease symptoms and shorten how long you are sick with viral infections like the flu and Ebola. They can rid your body of these viruses.
- Viral infections like HIV, hepatitis and herpes are chronic. Antivirals can't get rid of the virus, which stays in your body. However, antiviral medicines can make the virus latent (inactive) so that you have few, if any, symptoms. Symptoms that develop while you take antivirals may be less severe or go away faster.

### Can antivirals prevent the spread of viral infections?

- Yes, antiviral drugs can keep you from getting certain viral infections after a suspected or known exposure. For instance, taking specific antivirals:
- During pregnancy lowers the risk of a mother passing HIV to her newborn (babies also receive antiviral medicine after delivery).
- Daily lowers the risk of giving herpes or HIV to others or getting HIV from an infected partner.
- Within 72 hours of a potential HIV exposure can lower the chances of getting infected.
- Within 48 hours of exposure to the flu virus may keep you from getting sick.

### Generic Drug and Brand Drug

- When a new drug is discovered, the company that discovered it would apply for patency to prevent other companies from producing and selling the drug. This patency may take up to 20 years and during this period, the company will produce and sell the drug under a brand name to recover its investment and make a profit. With time, this name becomes synonymous with the drug. But after the patency expires, other companies are allowed to produce a similar drug. It is what gave rise to brand and generic name in drugs.
- The difference between brand name and generic drugs is in the circumstances of producing the drugs. While brand name drug refers to the name giving by the producing company, generic drug refers to a drug produced after the active ingredient of the brand name drug. Generic

drugs will, however, be sold under different brand names, but will contain the same active ingredients as the brand-name drug. But with regards to the effectiveness of the drugs, generic drugs have the same quality active ingredient as brand name drugs.

### Drug Abuse

- Drug abuse occurs when drugs are taken without medical reasons and without medical supervision, especially when they are taken in an amount, strength, frequency, or manner that damages the physical and mental functioning of the individual. Cough syrups, pain killers, and tranquillizers are some common medicines that are often abused.

### What is antimicrobial resistance?

- Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death. As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat.

### Recent Findings

- Based on estimates from 204 countries and territories, the Global Research on Antimicrobial Resistance (GRAM) report published in the Lancet provides the most comprehensive estimate of the global impact of AMR so far.

| Type of Vitamin | Function | Examples of Ingrendients |
|---|---|---|
| Vitamin A | Vision and cell development in the body | Sweet potato, mangoes, eggs |
| Vitamin B1 | Energy metabolism and nervous system function | Tuna, whole grains, pork |
| Vitamin B2 | Energy metabolism and normal vision | Mushrooms, whole grains, milk |
| Vitamin B3 | Energy metabolism | Whole grains, milk, eggs, meat |
| Vitamin B5 | Energy metabolism | Mushrooms, avocado, beef, poultry |
| Vitamin B6 | Synthesis in new cells | Green leafy vegetables, fruits, fish |
| Vitamin B7 | Energy metabolism | Nuts, egg yolk, liver, fish |
| Vitamin B9 | Synthesis in new cells | Green leafy vegetables, legumes, liver |
| Vitamin B12 | Synthesis in new cells | Lamb, oysters, sardines |
| Vitamin C | Immunity and formation of collagen in skin | Citrus fruits, strawberries, tomatoes, potatoes |
| Vitamin D | Maintains calcium and phosphorus in blood | Fatty fish, fish liver oils, eggs |
| Vitamin E | Antioxidant | Nuts, green leafy vegetables, fish |
| Vitamin K | Blood clotting | Spinach, green leafy vegetables |

- Its headline finding is that as many as 4.95 million deaths may be associated with bacterial AMR in 2019.
- Estimates included in the paper show that AMR is a leading cause of death globally, higher than HIV/AIDS or malaria.
- In South Asia, over 389,000 people died as a direct result of AMR in 2019.
- In 2019, one in five global deaths attributable to AMR occurred in children under the age of five – often from previously treatable infections.
- AMR is threatening the ability of hospitals to keep patients safe from infections and undermining the ability of doctors to carry out essential medical practice safely, including surgery, childbirth and cancer treatment since infection is a risk following these procedures.

## FORCES OF NATURE, FRICTION, LAWS OF MOTION

- Force: In science, a push or a pull on an object is called a force. It can also be stated as an external agent which can cause change in the state or shape of any object.
- Speed & velocity: Speed is the time rate at which an object is moving along a path, while velocity is the rate and direction of an object's movement. Put another way, speed is a scalar value, while velocity is a vector. For example, 50 km/hr (31 mph) describes the speed at which a car is traveling along a road, while 50 km/hr west describes the velocity at which it is traveling.
- Acceleration: It is the rate at which velocity changes with time, in terms of both speed and direction.
- A point or an object moving in a straight line is accelerated if it speeds up or slows down. Motion on a circle is accelerated even if the speed is constant, because the direction is continually changing. For all other kinds of motion, both effects contribute to the acceleration. Because acceleration has both a magnitude and a direction, it is a vector quantity.

## TYPES OF FORCES

### The Four Fundamental Forces of Nature are

- Gravitational force, Weak Nuclear force, Electromagnetic force and Strong Nuclear force.
- The Four Fundamental Forces and their features
- Gravitational Force – It is the weakest force in Nature but it has infinite range.
- Weak Nuclear Force – It is the next weakest force but it has short range.
- Electromagnetic Force – It is comparatively stronger force and at the same time it has infinite range.
- Strong Nuclear Force – It is considered as the strongest force in nature but it has short range.
- Gravitational force: Gravity, also called gravitation, in mechanics, the universal force of attraction acting between all matter. It is by far the weakest known force in nature and thus plays no role in determining the internal properties of everyday matter.
- On the other hand, through its long reach and universal action, it controls the trajectories of bodiesin the solar system and elsewhere in the universe and the structures and evolution of stars, galaxies, and the whole cosmos.
- On Earth all bodies have a weight, or downward force of gravity, proportional to their mass, which Earth's mass

exerts on them. Gravity is measured by the acceleration that it gives to freely falling objects.

- At Earth's surface the acceleration of gravity is about 9.8 metres (32 feet) per second per second. Thus, for every second an object is in free fall, its speed increases by about 9.8 metres per second.

### Examples of Gravitation

- The force that holds the gases in the sun.
- The force that causes a ball you throw in the air to come down again.
- The force that keeps the Earth and all of the planets in line in the proper position in their orbits around the sun. The force that causes the moon to revolve around the Earth. The force from the moon that causes the tides of the ocean. The force that keeps you walking on Earth instead of floating away into space.

### Gravity in Action

- Gravity has the same effect on every object. If you drop a huge elephant or if you drop a small, thin feather, they fall at the exact same speed. The feather will look like it falls more slowly and it does on Earth because there is air resistance that interferes with the force of gravity and can slow it down. However, if you dropped a feather and an elephant in a vacuum where there was no air resistance, they'd fall at the exact same speed because there is the exact same amount of force being exerted.

### Weak & Strong Nuclear Force

- The effects of the weak force were first discovered at the turn of the 20th century, in the place where it is most obviously at work: in radioactive beta decay.
- In the most common form of this decay, beta-minus decay, a neutron decays into a proton, also spitting out a negatively charged electron in order to conserve electric charge; beta-plus decay does the reverse and turns protons into neutrons.
- To understand what this, and the weak force, is all about, we first need to mention the strong nuclear force. The strong force binds the fundamental particles known as quarks together to form particles such as the protons and neutrons of the atomic nucleus.
- Protons and neutrons are both composites of three quarks of two types, or "flavours", up and down. Protons have the configuration up-up-down, and neutrons up-down-down.
- So if the strong force binds quarks together, it becomes apparent that the weak force allows them to change flavour: for example switching a down quark to an up quark or vice versa in beta decay
- It sounds quirky, but it is far from irrelevant: only the action of the weak force changing protons into neutrons within a star like the sun allows nuclear fusion to get off the ground within its core at all. The burning of stars – and so the existence of life – depends on the weak force.

### Electromagnetic Force

- The term electromagnetism combines the electric and magnetic forces into a single word because both forces are due to the same underlying phenomenon. "Charged" particles generate electric fields, and positive and negative charges react to that field differently, which explains the force we observe. For electric interactions, positively charged particles (like protons) push away positively charged particles and attract negatively charged ones (like electrons), and vice versa. Electric field lines spread directly outward from positive electric charges, and this pushes particles in the direction of – or in the opposite direction to – the field lines.
- Magnetism comes from magnetic fields, which are generated by moving charges. Particles don't respond to magnetic fields in the same way as they do to electric fields. Magnetic field lines form circles, with no beginning or end. In response to them, particles move in a direction perpendicular to both their motion and the field line. As with electric forces, positively charged particles and negatively charged ones move in opposite directions.
- The electromagnetic force is the second strongest force in nature. The strong nuclear force is the strongest, electromagnetic forces are 137 times less powerful, the weak nuclear force is a million times smaller, and gravity is much, much smaller than the rest (about 6 × 10–39 Ɵmes weaker than the strong nuclear force).
- 1st Law of Motion An object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force.
- In other words, all objects resist a change in their state of motion. In a qualitative way, the tendency of undisturbed objects to stay at rest or to keep moving with the same velocity is called inertia. This is why, the first law of motion is also known as the law of inertia.
- Certain experiences that we come across while travelling in a motorcar can be explained on the basis of the law of inertia. We tend to remain at rest with respect to the seat until the driver applies a braking force to stop the motorcar. With the application of brakes, the car slows down but our body tends to continue in the same state of motion because of its inertia.
- When a motorcar makes a sharp turn at a high speed, we tend to get thrown to one side. This can again be explained on the basis of the law of inertia. We tend to continue in our straight-line motion. When an unbalanced force is applied by the engine to change the direction of motion of the motorcar, we slip to one side of the seat due to the inertia of our body.

### 2nd Law of Motion

- The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object. The acceleration of an object depends directly upon the net force acting upon the object, and inversely upon the mass of the object. As the force acting upon an object is increased, the acceleration of the object is increased. As the mass of an object is increased, the acceleration of the object is decreased.

## EXAMPLES

- While catching a fast moving cricket ball, a fielder in the ground gradually pulls his hands backwards with the moving ball? In doing so, the fielder increases the time during which the high velocity of the moving ball decreases to zero. Thus, the acceleration of the ball is decreased and therefore the impact of catching the fast moving ball is also reduced. If the ball is stopped suddenly then its high velocity decreases to zero in a very short interval of time. Thus, the rate of change of momentum of the ball will be large. Therefore, a large force would have to be applied for holding the catch that may hurt the palm of the fielder. In a high jump athletic event, the athletes are made to fall either on a cushioned bed or on a sand bed.
- This is to increase the time of the athlete's fall to stop after making the jump. This decreases the rate of change of momentum and hence the force.
- 3rd Law of Motion: The third law of motion states that when one object exerts a force on another object, the second object instantaneously exerts a force back on the first. These two forces are always equal in magnitude but opposite in direction. These forces act on different objects and never on the same object.
- In other words, to every action there is an equal and opposite reaction. However, it must be remembered that the action and reaction always act on two different objects, simultaneously.

*Example: When we are walking, we push the road below us in backward direction and the road exerts an equal amount of force on us in the forward direction thus helping us to move.*

- It is important to note that even though the action and reaction forces are always equal in magnitude, these forces may not produce accelerations of equal magnitudes. This is becauseeachforce acts on a different object that may have a different mass. When a gun is fired, it exerts a forward force on the bullet. The bullet exerts an equal and opposite force on the gun. This results in the recoil of the gun. Since the gun has a much greater mass than the bullet, the acceleration of the gun is much less than the acceleration of the bullet.
- Another example: Launching a rocket relies on Newton's Third Law of Motion. A rocket engine produces thrust through action and reaction. The engine produces hot exhaust gases which flow out of the back of the engine. In reaction, a thrusting force is produced in the opposite reaction.
- Frictional Force: The force of friction always acts on all the moving objects and its direction is always opposite to the direction of motion.
- Frictional force is the opposing force that is created between two surfaces that try to move in the same direction or that try to move in opposite directions. The main purpose of a frictional force is to create resistance to the motion of one surface over the other surface. The frictional force depends on the body surface textures.
- Friction is caused by the irregularities on the two surfaces in contact. Even those surfaces which appear very smooth have a large number of minute irregularities on them. Irregularities on the two surfaces lock into one another. When we attempt to move any surface, we have to apply a force to overcome interlocking. On rough surfaces, there are a larger number of irregularities. So the force of friction is greater if a rough surface is involved

### When friction is highest? In moving body or static body?

- The force required to overcome friction at the instant an object starts moving from rest is a measure of static friction. On the other hand, the force required to keep the object moving with the same speed is a measure of sliding friction. When the box starts sliding, the contact points on its surface, do not get enough time to lock into the contact points on the floor. So, the sliding friction is slightly smaller than the static friction.

## WHAT IS LIGHT?

- Light, or Visible Light, commonly refers to electromagnetic radiation that can be detected by the human eye. Light can also be described in terms of a stream of photons, massless packets of energy, each travelling with wavelike properties at the speed of light. A photon is the smallest quantity (quantum) of energy which can be transported, and it was the realization that light travelled in discrete quanta that was the origins of Quantum Theory.
- Visible light is not inherently different from the other parts of the electromagnetic spectrum, with the exception that the human eye can detect visible waves. This in fact corresponds to only a very narrow window of the electromagnetic spectrum, ranging from about 400nm for violet light through to 700nm for red light. Radiation lower than 400nm is referred to as Ultra-Violet (UV) and radiation longer than 700nm is referred to as Infra-Red (IR), neither of which can be detected by the human eye

## NATURE OF LIGHT

- Many scientists had some experimental evidence (diffraction and interference) that indicated light was a wave and other experimental evidence (black body radiation and the photoelectric effect) that indicated light was a particle. The solution to this problem was to develop a concept known as the wave-particle duality of light. The point of this concept is that light travels as a wave and interacts with matter like a particle. Thus when light is traveling through space, air, or other media, we speak of its wavelength and frequency, and when the light interacts with matter, we switch to the characteristics of a particle (quantum).

## REFRACTION OF LIGHT

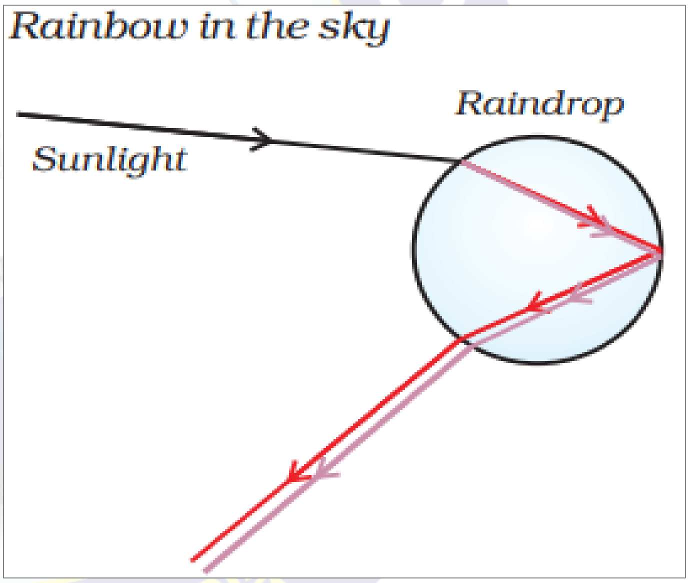
- When light passes from denser medium to rarer medium it bends away from the normal. When it passes from rarer medium to denser medium it bends towards the normal. This phenomenon of bending of light is called refraction of light.
- When light travels from one medium to another its speed changes. A ray of light from a rarer medium to a denser medium slows down and bends towards the normal. On the other hand the ray of light going from a denser medium to a rarer medium is speeded up and bends away from the normal. It shows that the speed of light in different medium varies. Different medium have different abilities to bend or refract light.
- **Twinkling of stars:** The twinkling of a star is due to atmospheric refraction of starlight. The starlight, on entering the earth's atmosphere, undergoes refraction continuously before it reaches the earth. The atmospheric refraction occurs in a medium of gradually changing refractive index. Since the atmosphere bends starlight towards the normal, the apparent position of the star is slightly different from its actual position. The star appears slightly higher (above) than its actual position when viewed near the horizon.
- Further, this apparent position of the star is not stationary, but keeps on changing slightly, since the physical conditions of the earth's atmosphere are not stationary, as was the case in the previous paragraph. Since the stars are very distant, they approximate point-sized sources of light. As the path of rays of light coming from the star goes on varying slightly, the apparent position of the star fluctuates and the amount of starlight entering the eye flickers – the star sometimes appears brighter, and at some other time, fainter, which is the twinkling effect.
- **Advance sunrise and delayed sunset**: The Sun is visible to us about 2 minutes before the actual sunrise, and about 2 minutes after the actual sunset because of atmospheric refraction. By actual sunrise, we mean the actual crossing of the horizon by the Sun. The following shows the actual and apparent positions of the Sun with respect to the horizon. The time difference between actual sunset and the apparent sunset is about 2 minutes. The apparent flattening of the Sun's disc at sunrise and sunset is also due to the same phenomenon.

## DISPERSION OF LIGHT

- When white light or sun light passes through a prism it splits up into constituent colours. This phenomenon is called dispersion and arises due to the fact that refractive index of prism is different for different colours of light.
- **Total Internal Reflection:** Total internal reflection happens at a time when a light ray that travels from a denser to a rarer medium. The ray is incident at an angle of incidence that is greater than the critical angle. After that, the light rays are reflected in another denser medium. It is the same medium before reflection. The entire process is known as Total internal reflection.
- When light travels between two surfaces made of transparent materials, then it gets refracted. This is also called as the bending of light. Light or rays that come towards or drive away from the normal have interfered. This happens due to a change of one medium to another medium. This gives the simple definition of total internal reflection.

## APPLICATION OF TOTAL INTERNAL REFLECTION:

- **Optical fibers:** Fiber optics uses total internal reflection, which has many advantages in telecommunications. Fiber optics are light-travelling glass or plastic threads the size of a hair. When light contacts the core-cladding boundary at an angle of incidence larger than the critical angle, it is refracted back into the core. As a result, light can travel many kilometers with little energy loss.
- **Endoscope:** An endoscope is a medical device used for diagnostic and surgical procedures. It has two fiber-optic tubes in a pipe. The light enters the patient's organ through one of the endoscope's fiber tubes and is then reflected by the physician's viewing lens through the outer fiber tube thus confirming total internal reflection.




- **Rainbow Formation:** A rainbow is a natural spectrum appearing in the sky after a rain shower. It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere. A rainbow is always formed in a direction opposite to that of the Sun. The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop. Due to the dispersion of light and internal reflection, different colours reach the observer's eye.

## SCATTERING OF LIGHT

- When light passes from one medium to another, say air, a glass of water, then a part of the light is absorbed by particles of the medium, preceded by its subsequent radiation in a particular direction. This phenomenon is termed a scattering of light

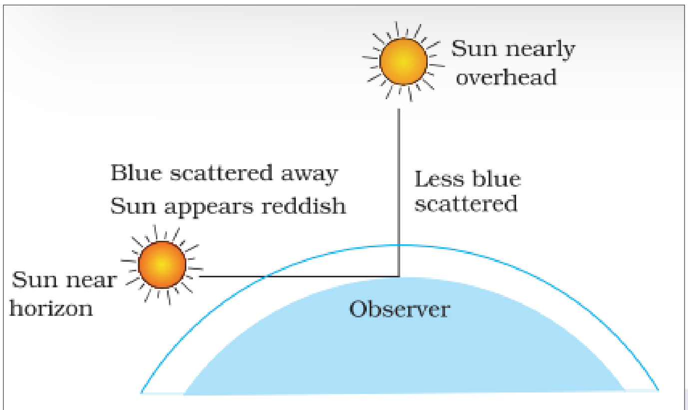
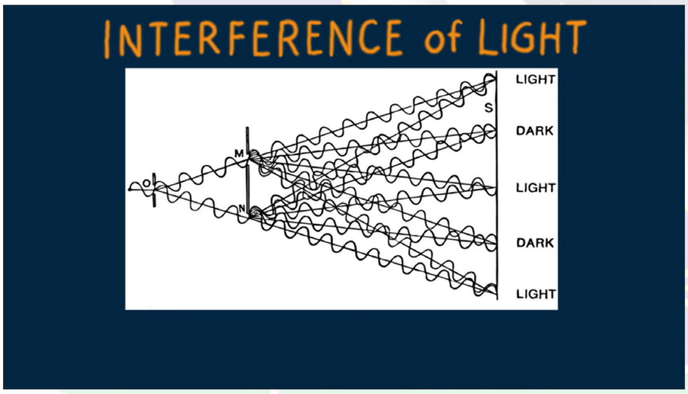
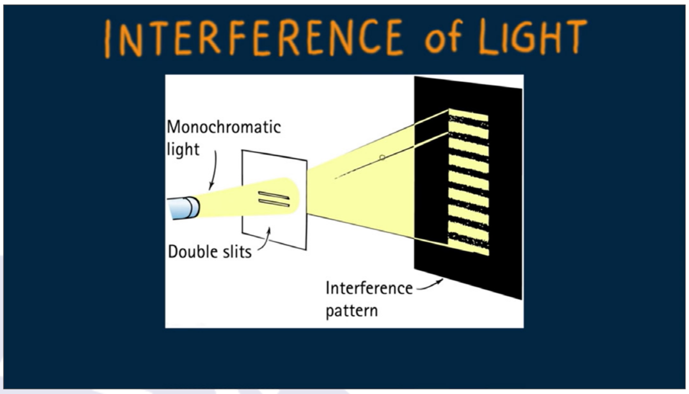



***Figure 11.12***
*Reddening of the Sun at sunrise and sunset*

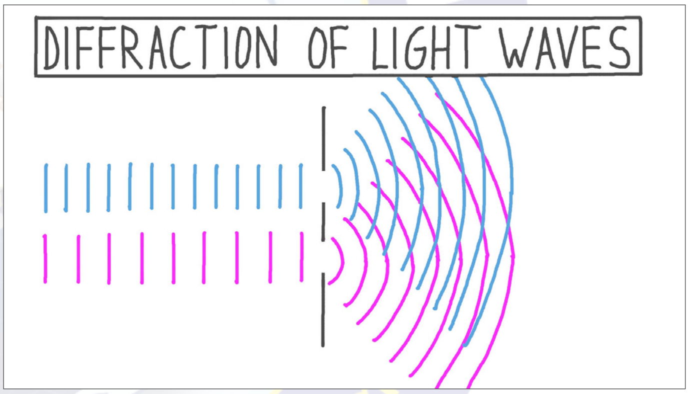
- **Why is the colour of the clear Sky Blue?** The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. The 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 (shorter wavelengths) 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 passengers flying at very high altitudes, as scattering is not prominent at such heights. You might have observed that 'danger' signal lights are red in colour. Do you know why? The red is least scattered by fog or smoke. Therefore, it can be seen in the same colour at a distance.




- The light from the Sun overhead would travel relatively shorter distance. At noon, the Sun appears white as only a little of the blue and violet colours are scattered. Near the horizon, most of the blue light and shorter wavelengths are scattered away by the particles. Therefore, the light that reaches our eyes is of longer wavelengths. This gives rise to the reddish appearance of the Sun
- Interference of Light: Interference of light is the phenomena of multiple light waves interfering with one another under certain circumstances, causing the combined amplitudes of the waves to either increase or decrease. The definition of interference in physics is the superposition of waves, causing an increase or decrease in the amplitude of the resulting wave.




- Diffraction of Light: Diffraction is the slight bending of light as it passes around the edge of an object. The amount of bending depends on the relative size of the wavelength of light to the size of the opening. If the opening is much larger than the light's wavelength, the bending will be almost unnoticeable. However, if the two are closer in size or equal, the amount of bending is considerable, and easily seen with the naked eye.




## ELECTRICITY

- Electron theory According to this theory, every object consists of extremely fine particles, which are called atoms. It was found by experiments that the atom itself is made up of two types of very fine electrical particles.
- Out of this, one type of particle is called a proton, which has a positive electric charge and another type of particle is called an electron, which has a negative electric charge.
- When we rub two objects together, the electrons of one object transfer to another. The object that loses the electron becomes positively charged. Conversely, the object on which electrons move becomes negatively charged. Thus we see that there are two types of charge - (1) positive charge and (2) negative charge

## WHAT ARE CONDUCTORS?

- The materials from which electric charge flows easily are called electric conductors. In contrast, these substances in which charge cannot flow are called insulators. All metals are electrical conductors. Our body is also an electrical conductor. Water and moisture are also electrical conductors. Rubber, plastic, dry wood, enamel paint are some examples of insulating materials. Dry air is insulated, while moist air is not insulated

## WHAT ARE SEMI-CONDUCTORS?

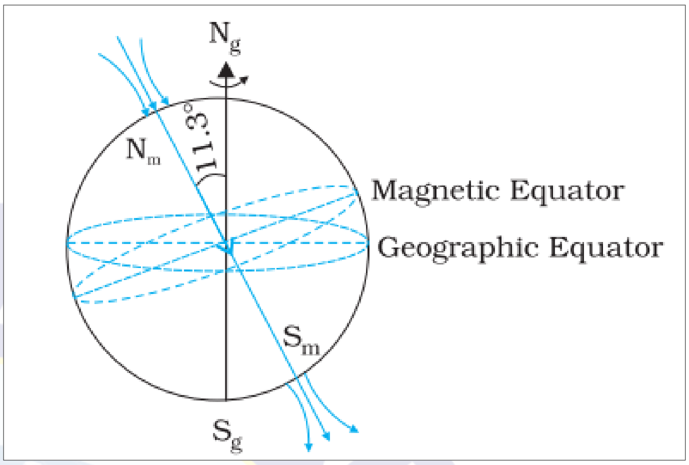
- Semiconductors are materials which have a conductivity between conductors (generally metals) and non-conductors or insulators (such as most ceramics). Semiconductors can be pure elements, such as silicon or germanium, or compounds such as gallium arsenide or cadmium selenide. In a process called doping, small amounts of impurities are added to pure semiconductors causing large changes in the conductivity of the material.

## THE PRESENCE OF ELECTRICITY IN CLOUDS?

- Thunderstorms are caused by small electrically-charged particles.
- As water molecules in the cloud are heated and cooled and they move up and down against each other, there is a separation of charge. Forming 2 poles within the cloud. One part becomes negatively charged, and the other part becomes positively charged.
- Objects on the ground then become oppositely charged to the lower part of the cloud.
- This imbalance tries to resolve itself, by passing current between the differently charged poles.
- Charged particles always flow in the direction where there are less particles of the same charge. This results in a lightning bolt.
- The electrical arc of the lightning bolt heats the surrounding air to extreme temperatures. In fact, the air around it can be heated to 5 times hotter than the sun!
- This heat causes the surrounding air to rapidly expand and vibrate. Which is the rumbling thunder that we hear.
- Each bolt carries about 10 billion Watts. That's enough power for 32 million people a year!
- 10 billion watts per bolt, and given that 50 bolts strike the earth's surface every single second means the power of lightning is extraordinary.

## EARTH'S MAGNETIC FIELD

- Earth's magnetic field is now thought to arise due to electrical currents produced by convective motion of metallic fluids (consisting mostly of molten iron and nickel) in the outer core of the earth. This is known as the dynamo effect.
- The magnetic field lines of the earth resemble that of a (hypothetical) magnetic dipole located at the centre of the earth. The axis of the dipole does not coincide with the axis of rotation of the earth but is presently titled by approximately 11.3° with respect to the later.
- In this way of looking at it, the magnetic poles are located where the magnetic field lines due to the dipole enter or leave the earth. The location of the north magnetic pole is at a latitude of 79.74° N and a longitude of 71.8° W, a place somewhere in north Canada. The magnetic south pole is at 79.74° S, 108.22° E in the Antarctica.
- The pole near the geographic north pole of the earth is called the north magnetic pole. Likewise, the pole near the geographic south pole is called the south magnetic pole.




- There is some confusion in the nomenclature of the poles. If one looks at the magnetic field lines of the earth, one sees that unlike in the case of a bar magnet, the field lines go into the earth at the north magnetic pole (Nm) and come out from the south magnetic pole (Sm).
- The convention arose because the magnetic north was the direction to which the north pole of a magnetic needle pointed; the north pole of a magnet was so named as it was the north seeking pole. Thus, in reality, the north magnetic pole behaves like the south pole of a bar magnet inside the earth and vice versa.

## VARIATION IN MAGNETIC FIELD OF EARTH

- The variation of earth's magnetic field with time is no less fascinating. There are short term variations taking place over centuries and long term variations taking place over a period of a million years.
- In a span of 240 years from 1580 to 1820 AD, over which records are available, the magnetic declination at London has been found to change by 3.5°, suggesting that the magnetic poles inside the earth change position with time. On the scale of a million years, the earth's magnetic fields has been found to reverse its direction.

## SOUND AND OTHER WAVES

### Sound Waves

- Sound is produced by vibrating objects. The matter or substance through which sound is transmitted is called a medium. It can be solid, liquid or gas. Sound moves through a medium from the point of generation to the listener. When an object vibrates, it sets the particles of the medium around it vibrating. The particles do not travel all the way from the vibrating object to the ear. A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position. It then exerts a force on the adjacent particle. As a result of which the adjacent particle gets displaced from its position of rest. After displacing the adjacent particle the first particle comes back to its original position.

- 
- This process continues in the medium till the sound reaches your ear. The disturbance created by a source of sound in the medium travels through the medium and not the particles of the medium.
- A wave is a disturbance that moves through a medium when the particles of the medium set neighbouring particles into motion. They in turn produce similar motion in others. The particles of the medium do not move forward themselves, but the disturbance is carried forward.
- This is what happens during propagation of sound in a medium, hence sound can be visualised as a wave. Sound waves are characterised by the motion of particles in the medium and are called mechanical waves.

## ECHO

- If we shout or clap near a suitable reflecting object such as a tall building or a mountain, we will hear the same sound again a little later. This sound which we hear is called an echo. The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo the time interval between the original sound and the reflected one must be at least 0.1s. If we take the speed of sound to be 344 m/s at a given temperature, say at 22 ºC in air, the sound must go to the obstacle and reach back the ear of the listener on reflection after 0.1s. Hence, the total distance covered by the sound from the point of generation to the reflecting surface and back should be at least (344 m/s) × 0.1 s = 34.4 m. Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, 17.2 m. This distance will change with the temperature of air. Echoes may be heard more than once due to successive or multiple reflections. The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds and the land.

## REVERBERATION

- A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. In an auditorium or big hall excessive reverberation is highly undesirable. To reduce reverberation, the roof and walls of the auditorium are generally covered with sound-absorbent materials like compressed fibreboard, rough plaster or draperies. The seat materials are also selected on the basis of their sound absorbing properties.

## Reflection of Sound Waves & its applications

1. Megaphones or loudhailers, horns, musical instruments such as trumpets and shehanais, are all designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.

**Note:** *Actually, a megaphone is based on the principle of superposition of waves too. When two or more waves superimpose, a new wave is formed. The amplitude of the resultant wave may be greater than the initial waves. This is how the sound is amplified with a megaphone.*

2. Stethoscope is a medical instrument used for listening to sounds produced within the body, mainly in the heart or lungs. In stethoscopes the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound.
3. Generally the ceilings of concert halls, conference halls and cinema halls are curved so that sound after reflection reaches all corners of the hall. Sometimes a curved soundboard may be placed behind the stage so that the sound, after reflecting from the sound board, spreads evenly across the width of the hall.

## Ultrasounds

- Ultrasounds are high frequency waves. Ultrasounds are able to travel along well-defined paths even in the presence of obstacles. Ultrasounds are used extensively in industries and for medical purposes.
- Ultrasound is generally used to clean parts located in hard-to-reach places, for example, spiral tube, odd shaped parts, electronic components etc. Objects to be cleaned are placed in a cleaning solution and ultrasonic waves are sent into the solution. Due to the high frequency, the particles of dust, grease and dirt get detached and drop out. The objects thus get thoroughly cleaned.
- Ultrasounds can be used to detect cracks and flaws in metal blocks. Metallic components are generally used in construction of big structures like buildings, bridges, machines and also scientific equipment. The cracks or holes inside the metal blocks, which are invisible from outside reduces the strength of the structure.
- Ultrasonic waves are allowed to pass through the metal block and detectors are used to detect the transmitted waves. If there is even a small defect, the ultrasound gets reflected back indicating the presence of the flaw or defect.
- Ordinary sound of longer wavelengths cannot be used for such purpose as it will bend around the corners of the defective location and enter the detector.
- Ultrasonic waves are made to reflect from various parts of the heart and form the image of the heart. This technique is called 'echocardiography'.
- Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body. A doctor may image the patient's organs such as the liver, gall bladder, uterus, kidney, etc. It helps the doctor to detect abnormalities, such as stones in the gall bladder and kidney or tumours in different organs.

In this technique the ultrasonic waves travel through the tissues of the body and get reflected from a region where there is a change of tissue density. These waves are then converted into electrical signals that are used to generate images of the organ. These images are then displayed on a monitor or printed on a film. This technique is called 'ultrasonography'. Ultrasonography is also used for examination of the foetus during pregnancy to detect congenial defects and growth abnormalities.

- Ultrasound may be employed to break small 'stones' formed in the kidneys into fine grains. These grains later get flushed out with urine.

## SONAR

- The acronym SONAR stands for SOund Navigation And Ranging. Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects.

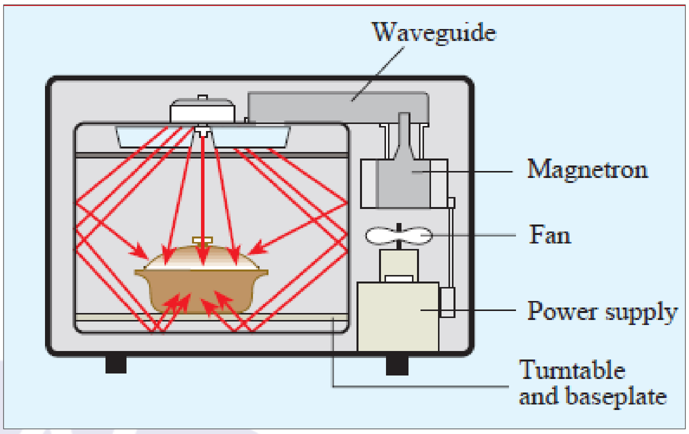
### How does the sonar work?

- Sonar consists of a transmitter and a detector and is installed in a boat or a ship The transmitter produces and transmits ultrasonic waves. These waves travel through water and after striking the object on the seabed, get reflected back and are sensed by the detector. The detector converts the ultrasonic waves into electrical signals which are appropriately interpreted. The distance of the object that reflected the sound wave can be calculated by knowing the speed of sound in water and the time interval between transmission and reception of the ultrasound.
- The above method is called echo-ranging. The sonar technique is used to determine the depth of the sea and to locate underwater hills, valleys, submarine, icebergs, sunken ship etc.

## WORKING OF MICROWAVE OVEN

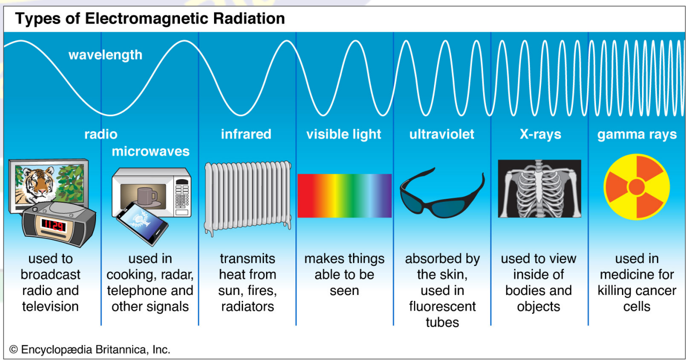
### How does a microwave turn electricity into heat?

- Inside the strong metal box, there is a microwave generator called a magnetron. When you start cooking, the magnetron takes electricity from the power outlet and converts it into high-powered, 12cm (4.7 inch) radio waves.
- The magnetron blasts these waves into the food compartment through a channel called a wave guide.
- The food sits on a turntable, spinning slowly round so the microwaves cook it evenly.
- The microwaves bounce back and forth off the reflective metal walls of the food compartment, just like light bounces off a mirror. When the microwaves reach the food itself, they don't simply bounce off. Just as radio waves can pass straight through the walls of your house, so microwaves penetrate inside the food. As they travel through it, they make the molecules inside it vibrate more quickly.
- Vibrating molecules have heat so, the faster the molecules vibrate, the hotter the food becomes. Thus the microwaves pass their energy onto the molecules in the food, rapidly heating it up.




## Electromagnetic waves

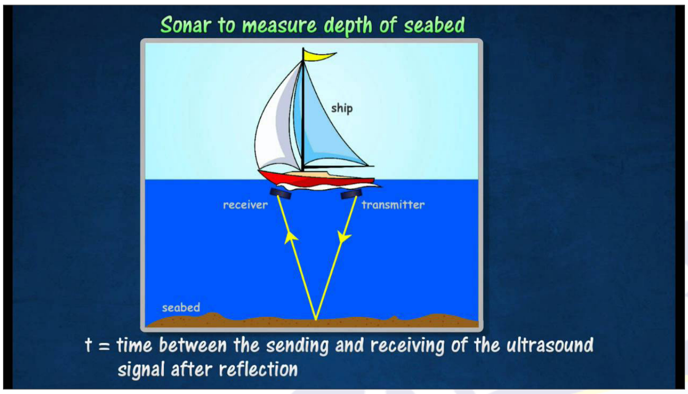
- **Definition:** Electromagnetic waves or EM waves are waves that are created as a result of vibrations between an electric field and a magnetic field. In other words, EM waves are composed of oscillating magnetic and electric fields.
- EM waves travel with a constant velocity of 3.00 x 108 ms-1 in vacuum. They are deflected neither by the electric field, nor by the magnetic field. However, they are capable of showing interference or diffraction. An electromagnetic wave can travel through anything - be it air, a solid material or vacuum.
- It does not need a medium to propagate or travel from one place to another. Mechanical waves (like sound waves or water waves), on the other hand, need a medium to travel.
- EM waves are 'transverse' waves. This means that they are measured by their amplitude (height) and wavelength (distance between the highest/lowest points of two consecutive waves).
- Electromagnetic waves can be split into a range of frequencies. This is known as the electromagnetic spectrum. Examples of EM waves are radio waves, microwaves, infrared waves, X-rays, gamma rays, etc.

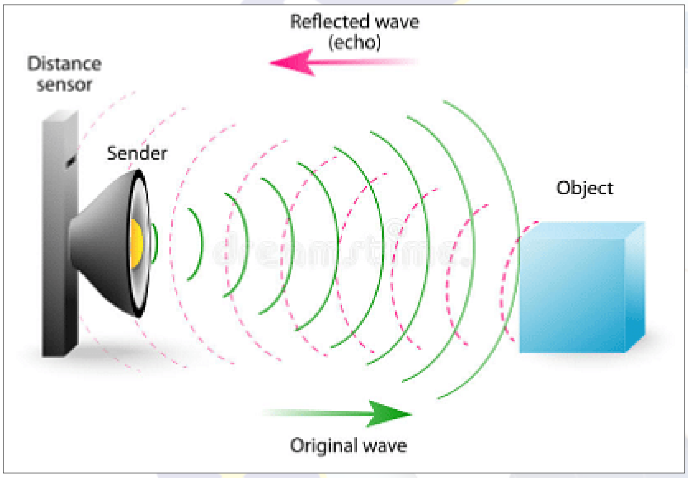


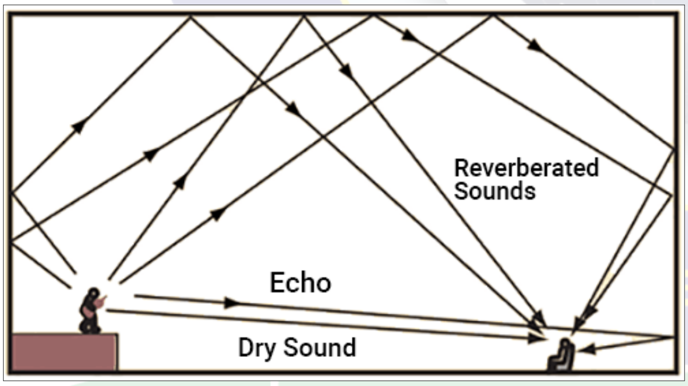

### Different parts of the EM spectrum have different uses

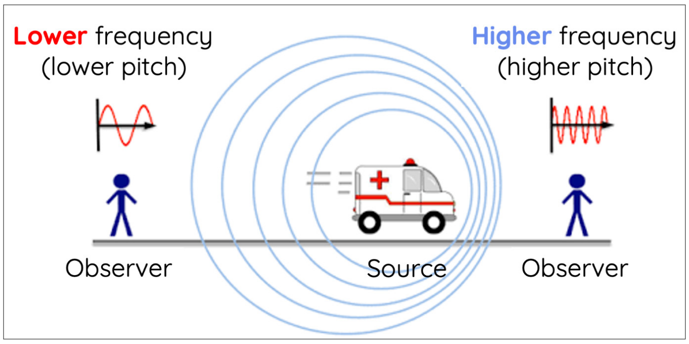
1. Radio waves - radio and television
2. Microwaves - satellite communications and cooking food
3. Infrared - Electrical heaters, cooking food and infrared cameras

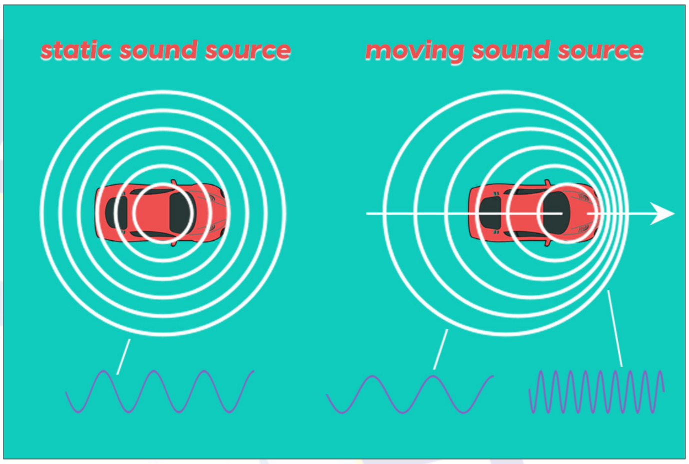
4. Visible light - Fibre optic communications
5. Ultraviolet - Energy efficient lamps, sun tanning
6. X-rays - Medical imaging and treatments
7. Gamma rays - Medical imaging and treatments

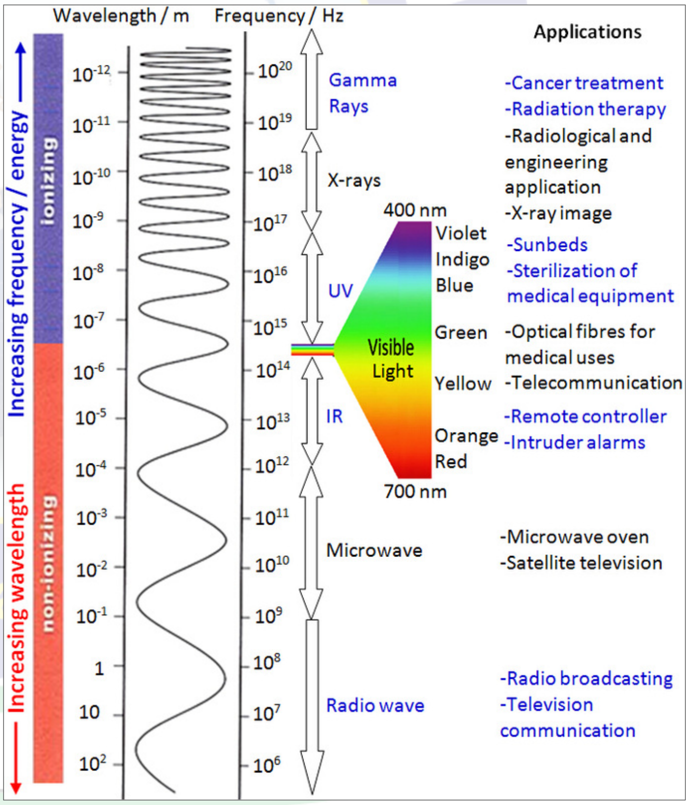


# UNIVERSE

### What is Universe?

- The universe is everything.
- It includes all of space and all the matter and energy that space contains.
- It even includes dark matter and Dark Energy
- It even includes time itself and, of course, it includes us.
- The size of the entire universe is still unknown.
- The Universe is expanding.
- What are the different components in it?
- Difficult to say, it is still unknown
- However, we have planets, moons, asteroids, meteors, exoplanets, galaxies, stars, and so on.
- Everything which we can see and feel around us and many more things which we are not even aware of.
- How & when did the universe originate and its expansion?
- Many of the experts believe that it involved a gigantic explosion of matter and Energy.

### When?

- About 13.8 billion years ago.
- Big Bang Theory: Big denotes large matters and Bang means strike violently.
- So Big Bang is that striking of big matters. It says the universe as we know it started with an infinitely hot and dense single point that inflated and stretched — first at unimaginable speeds, and then at a more measurable rate — over the next 13.7 billion years to the still-expanding cosmos that we know today.

### What is Matter?

- Anything that has weight and takes up space, as a solid, liquid, or gas.

### What is Anti-matter?

- Antimatter is the same as ordinary matter except that it has the opposite electric charge.
- For instance, an electron, which has a negative charge, has an antimatter partner known as a positron.
- A positron is a particle with the same mass as an electron but a positive charge.
- Antimatter was created along with matter after the Big Bang.
- But antimatter is rare in today's universe, and scientists aren't sure why.

### What is Dark Energy?

- Dark energy is the mysterious form of energy that makes up about 68% of the universe.
- Dark energy is a mysterious force that is accelerating the expansion of the universe.
- While dark matter attracts and holds galaxies together, dark energy repels and causes the expansion of our universe.
- Both components are invisible.
- It turns out that roughly 68% of the universe is dark energy.
- Dark matter makes up about 27%.
- The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the universe.

### WHAT IS DARK MATTER?

- **Roughly 80% of the mass of the universe is made up of material that scientists cannot directly observe.**
- **Known as dark matter, this bizarre ingredient does not emit light or energy.**
- **There is a certain amount of Dark Matter in each galaxy. This could be some exotic particles or just lots of stars too small to have ignited.**

### WHAT IS GALAXY?

- The galaxy is a gravitationally bound system of stars, dust, interstellar gas, and dark matter.
- Millions of stars in the universe together form a galaxy
- One galaxy may contain 100 million stars
- There are millions of galaxies in the world.
- We belong to the Milky Way galaxy
- It has 1,00,000 million stars.

### HOW DO STARS ORIGINATE?

- Stars are constantly being born from clouds of dust and gas.
- It happens over millions of years.
- Stars are balls of gas mainly hydrogen & helium.
- What are Planets?
- It has been derived from the Greek word Planetai.
- Planetai means wanderer.
- Planets are so named as they revolve around the sun.
- These celestial bodies don't have their light.
- They shine due to the reflection of light from stars such as the Sun.

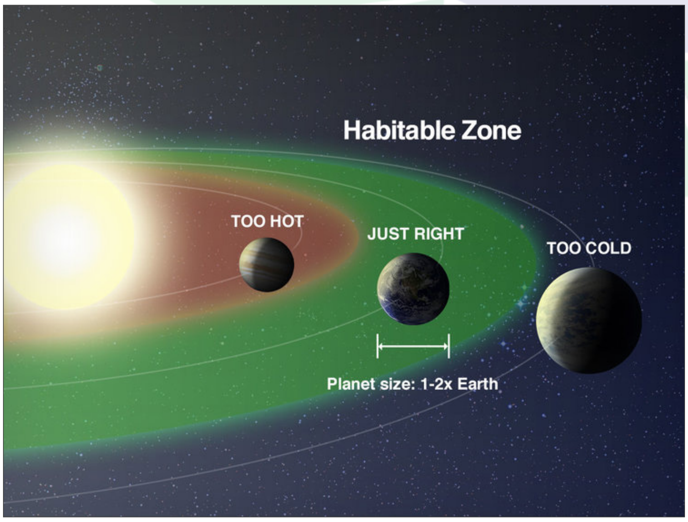
- Planets are made up of solid material and gases
- Process of Formation of Planets, Sun & Asteroids
- Our solar system began about 4.6 billion years ago when a big cloud of gas and dust collapsed.
- When this happened, most of the material fell to the center of the cloud and formed the sun.
- Some of the condensing dust in the cloud became planets.
- The objects in the asteroid belt never had the chance to be incorporated into planets.

### Planets of Solar System

- There are 8 planets in our solar system
- Yes, Pluto is now considered a dwarf planet.
- There are four inner planets often called terrestrial planets.
- Mercury, Venus, Earth & Mars
- They are called terrestrial as they have rocky surfaces.
- Four other outer planets are called Jovian Planets.
- Jupiter, Saturn, Uranus, and Neptune
- They're also mostly made of gases
- Like hydrogen, helium, and ammonia rather than of rocky surfaces
- What is the definition of a Planet?
- The IAU defines a true planet as a body
- that circles the sun without being some other object's satellite;
- is large enough to be rounded by its own gravity
- (but not so big that it begins to undergo nuclear fusion, like a star); and
- has "cleared its neighborhood" of most other orbiting bodies.
- The problem with Pluto
- its small size and offbeat orbit,
- it doesn't clear its neighborhood of debris
- it shares its space with lots of other objects in the Kuiper Belt.

### Exoplanets?

- An exoplanet is any planet beyond our solar system.
- Exoplanets are made up of elements similar to those of the planets in our solar system.



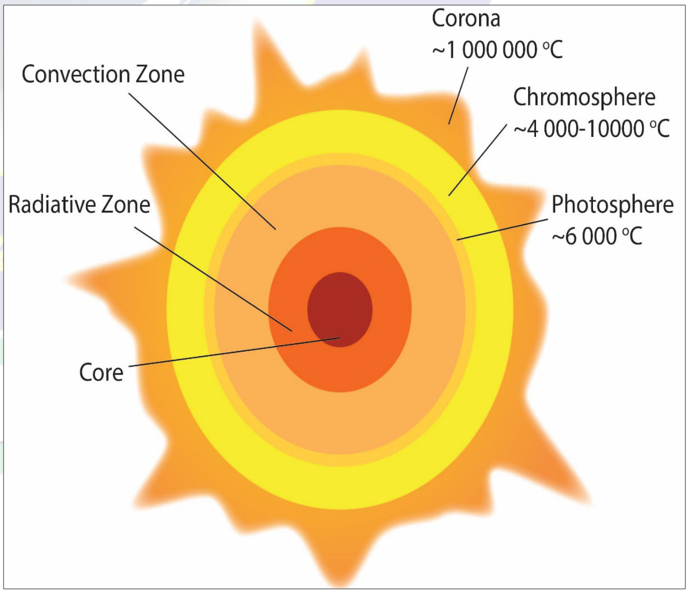

- However, their mixes of those elements may differ.
- Most orbit other stars, but free-floating exoplanets, called rogue planets, orbit the galactic center and are untethered to any star.
- What is Goldilocks Zone?
- It is a region of space in which a planet is at just the right distance from its home star so that its surface is neither too hot nor too cold.
- According to various reports, there are about 40 billion Earth-Sized planets orbiting in the habitable zone

### Our star- Sun

- The closest star to our planet.
- It is a ball of hydrogen gas that radiates heat and light.
- It generates power by nuclear fusion (smaller nuclei combined to form larger nuclei and produce energy).
- Sun was born under five billion years (approximately) ago.
- It is composed of about 74 percent hydrogen and 25 percent helium, with traces of iron, carbon, calcium, and sodium.
- Like other planets in the solar system, the Sun spins on its axis.
- The Sun takes up to 250 million years to complete one revolution around the Milky Way

### LAYERS OF SUN

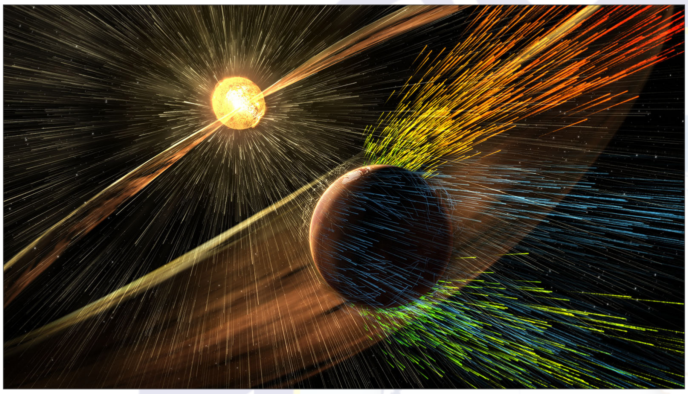
- It has three layers - photosphere, chromospheres and corona
- The photosphere is the visible surface of the Sun, from which the emitted sunlight reaches Earth.
- The chromosphere is the layer above the photosphere and below the corona.
- Corona is the outermost region of the Sun's atmosphere (consisting of plasma or hot ionized gas), which is visible as a white halo during a solar eclipse.




### What is Solar Wind?

- The solar wind is created by the outward expansion of plasma (a collection of charged particles) from the Sun's corona (outermost atmosphere).

- This plasma is continually heated to the point that the Sun's gravity can't hold it down.
- It then travels along the Sun's magnetic field lines that extend radially outward.
- When the solar wind encounters Earth, it is deflected by our planet's magnetic shield, causing most of the solar wind's energetic particles to flow around and beyond us.
- This region that meets and blocks the solar wind is called the magnetosphere.
- The space around our atmosphere is alive and dynamic because Earth's magnetosphere reacts to the Sun's activity.
- They can severely damage our communications, navigation, and electrical power systems; oil drilling processes and pipelines; and spacecraft and orbiting satellites.

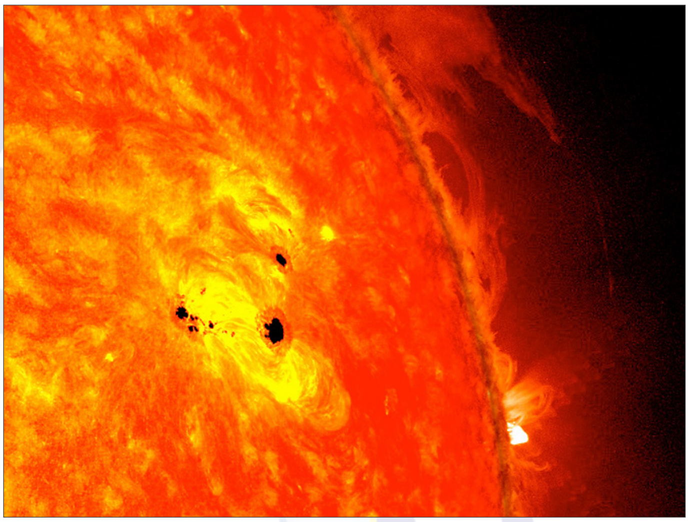


### Solar Tsunami?

- A solar tsunami is a powerful shockwave on the Sun's surface.
- It is triggered by explosions in the Sun's atmosphere
- This explosion results in large amounts of superhot plasma, containing electrically charged particles, being expelled into space.
- They can have a significantly disastrous impact on our communications, navigation, and electrical power systems; oil drilling processes and pipelines; and spacecraft and orbiting satellites.

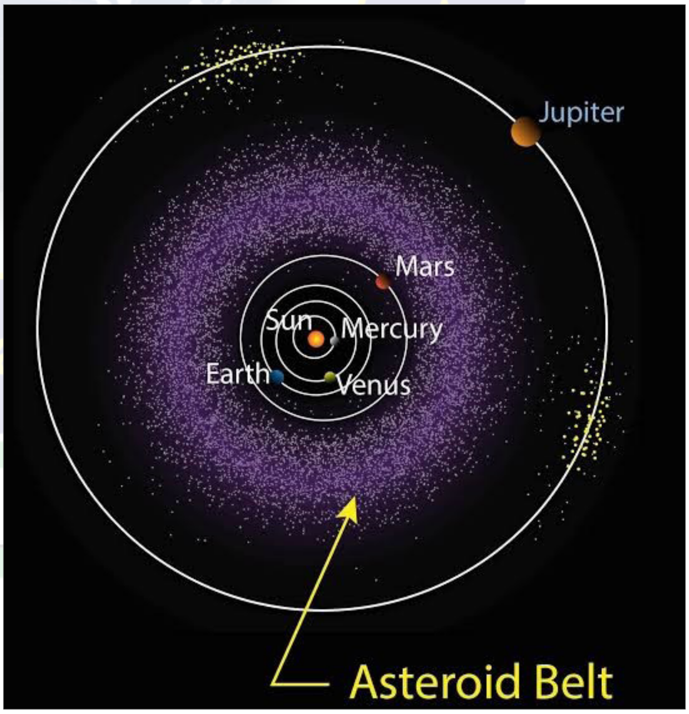
### Sun Spot?

- Sunspots are darker, cooler areas on the surface of the sun in photosphere
- They look dark only in comparison with the brighter and hotter regions of the photosphere around them.
- Sunspots can be very large, up to 50,000 kilometers in diameter.
- They are caused by interactions with the Sun's magnetic field.
- Sunspots occur over regions of intense magnetic activity, and when that energy is released, solar flares and big storms called coronal mass ejections erupt from sunspots.



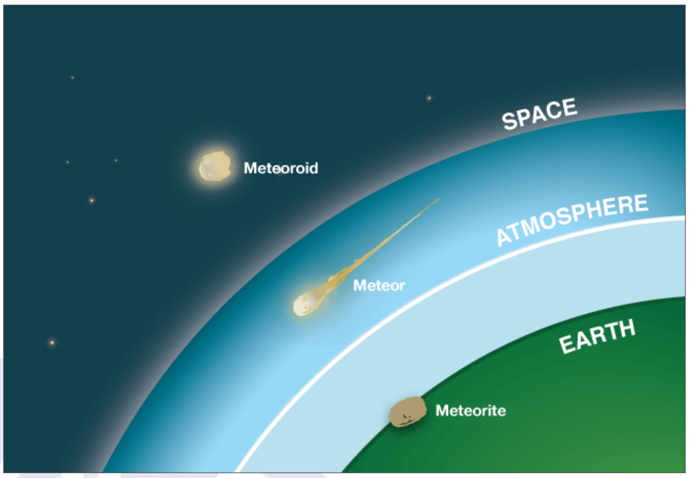
### What are asteroids?

- Asteroids are small, rocky objects that orbit the Sun
- Although asteroids orbit the Sun-like planets, they are much smaller than planets.




- There are lots of asteroids in our solar system.
- Most of them live in the main asteroid belt—a region between the orbits of Mars and Jupiter.
- Some asteroids are found in the orbital path of planets.

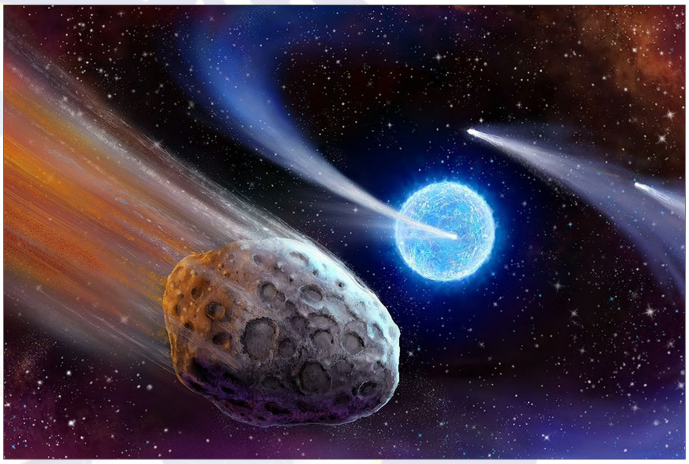
- This means that the asteroid and the planet follow the same path around the sun.
- Asteroids are leftover from the formation of our solar system.




## WHAT ARE METEORS, METEOROIDS, METEORITES?

- Meteoroids are objects in space that range in size from dust grains to small asteroids. Think of them as "space rocks."
- When meteoroids enter Earth's atmosphere (or that of another planet, like Mars) at high speed and burn up, the fireballs or "shooting stars" are called meteors.
- When a meteoroid survives a trip through the atmosphere and hits the ground, it's called a meteorite

### What are comets?



- Comets are cosmic snowballs of frozen gases, rock, and dust that orbit the Sun.
- When frozen, they are the size of a small town.
- When a comet's orbit brings it close to the Sun, it heats up and spews dust and gases into a giant glowing head larger than most planets.
- The dust and gases form a tail that stretches away from the Sun for millions of miles.

# CHEMISTRY

## What is matter?

- Matter is anything that has mass and takes up space. At a minimum, matter requires at least one subatomic particle, although most matter consists of atoms.

## Examples That Are Not Matter

- Not everything we can perceive consists of matter. If it does not have mass or volume, it's not matter. Examples of things that aren't matter include:
- Photons (light)
- Heat
- Thoughts
- Microwaves (the radiation, not the appliance)

## States of Matter

- The matter around us exists in three different states– solid, liquid and gas. These states of matter arise due to the variation in the characteristics of the particles of matter.

## Other states of Matter

- Plasma: The state consists of super energetic and super excited particles. These particles are in the form of ionised gases. The fluorescent tube and neon sign bulbs consist of plasma. Inside a neon sign bulb there is neon gas and inside a fluorescent tube there is helium gas or some other gas. The gas gets ionised, that is, gets charged when electrical energy flows through it. This charging up creates a plasma glowing inside the tube or bulb. The plasma glows with a special colour depending on the nature of gas. The Sun and the stars glow because of the presence of plasma in them. The plasma is created in stars because of very high temperature.

## Properties of Plasma

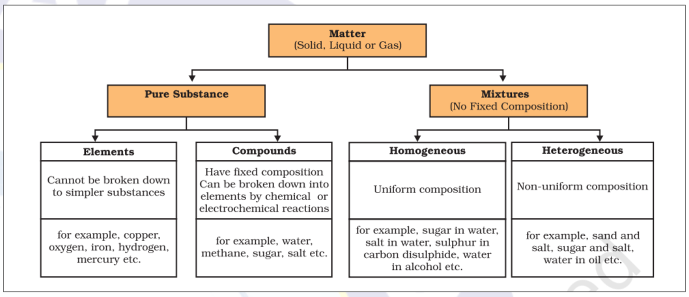
- Because plasma consists of charged particles, plasma reacts to electromagnetic fields and conducts electricity. In contrast, most gases are electrical insulators.
- Like a gas, plasma has neither a defined shape nor volume.
- When plasma is exposed to a magnetic field, it may assume structures, including layers, filaments, and beams. A good example of some of these structures can be observed in a plasma ball.

## Uses of Plasma

- Plasma is used in television, neon signs and fluorescent lights. Stars, lightning, the Aurora, and some flames consist of plasma.
- Bose-Einstein Condensate: In 1920, Indian physicist Satyendra Nath Bose had done some calculations for a fifth state of matter. Building on his calculations, Albert Einstein predicted a new state of matter – the Bose-Einstein Condensate (BEC). In 2001, Eric A. Cornell, Wolfgang Ketterle and Carl E. Wieman of USA received the Nobel prize in physics for achieving "Bose-Einstein condensation". The BEC is formed by cooling a gas of extremely low density, about one-hundred-thousandth the density of normal air, to super low temperatures.

## Uses

- BECs have also been used to create atom lasers, atomic clocks and gravitational, rotational or magnetic sensors with excellent sensitivity.




- The number of elements known at present are more than 100.
- Ninety-two elements are naturally occurring and the rest are manmade.
- Majority of the elements are solid.
- Eleven elements are in gaseous state at room temperature.
- Two elements are liquid at room temperature–mercury and bromine.
- Elements, gallium and cesium become liquid at a temperature slightly above room temperature (303 K).
- Alloys: Alloys are mixtures of two or more metals or a metal andanon-metal and cannot be separated into their components by physical methods. But still, an alloy is considered as a mixture because it shows the properties of its constituents and can have variable composition. For example, brass is a mixture of approximately 30% zinc and 70% copper.
- In alloys the chemical properties of the component elements are retained but certain physical properties are improved.
- Metal alloys are stronger than pure metals
- Metal alloys are more versatile than pure metals
- Metal alloys are more resistant to corrosion than pure metals most common metal alloys?

1. Brass
2. Carbon Steel
3. Stainless Steel
4. Bronze
5. Aluminum Alloy

## Physical & Chemical Change

- The interconversion of states is a physical change because these changes occur without a change in composition and no change in the chemical nature of the substance. Although ice, water and water vapour all look different and display different physical properties, they are chemically the same.

- Chemical change brings change in the chemical properties of matter and we get new substances. A chemical change is also called a chemical reaction. Burning is a chemical change. During this process one substance reacts with another to undergo a change in chemical composition.

### Evaporation

- We know that particles of matter are always moving and are never at rest. At a given temperature in any gas, liquid or solid, there are particles with different amounts of kinetic energy. In the case of liquids, a small fraction of particles at the surface, having higher kinetic energy, is able to break away from the forces of attraction of other particles and gets converted into vapour. This phenomenon of change of a liquid into vapours at any temperature below its boiling point is called evaporation.

## FACTORS AFFECTING EVAPORATION

### The rate of evaporation increases with

- • An increase of surface area: We know that evaporation is a surface phenomenon. If the surface area is increased, the rate of evaporation increases. For example, while putting clothes for drying up we spread them out.
- • An increase of temperature: With the increase of temperature, more number of particles get enough kinetic energy to go into the vapour state.
- • A decrease in humidity: Humidity is the amount of water vapour present in air. The air around us cannot hold more than a definite amount of water vapour at a given temperature. If the amount of water in air is already high, the rate of evaporation decreases.
- • An increase in wind speed: It is a common observation that clothes dry faster on a windy day. With the increase in wind speed, the particles of water vapour move away with the wind, decreasing the amount of water vapour in the surrounding.

## HOW DOES EVAPORATION CAUSE COOLING?

- In an open vessel, the liquid keeps on evaporating. The particles of liquid absorb energy from the surrounding to regain the energy lost during evaporation. This absorption of energy from the surroundings make the surroundings cold.
- 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.

### Chemical Change Examples

1. **Rusting**

- Rusting is the process of oxidation, which is the result of a reaction that takes place because of oxygen. It gives a flaky brown layer that gathers over iron surfaces, this layer is formed due to the oxidization of the topmost layer, leading to the formation of metal oxide. It is just not with iron but these layers forms on other metals as well, like copper, silver, and gold.
- $Fe + 3O_2 + xH_2O \rightarrow Fe_3O_4 . xH_2O$

2. **Digestion**

- Did you know? Every time we eat something, a chemical reaction is simultaneously taking place to digest it. Digestion is also a complex process, in which thousands of chemical reactions take place. For example, when you eat something, the water and enzyme named amylase breaks down carbohydrates and sugar into simple molecules.

3. **Photosynthesis**

- Just like humans, several chemical reactions take place in plants as well, a chemical reaction called photosynthesis converts carbon dioxide and water into plant food – glucose, and oxygen. It is one of the major chemical reactions as it leads to the generation of oxygen and provides food for both plants and animals.
- $6 CO2 + 6 H2O + light \rightarrow C6H12O6 + 6 O2$

4. **Combustion**

- Every time you strike a match, burn a candle, build a fire, or light a grill, you see the combustion reaction. Combustion combines energetic molecules with oxygen to produce carbon dioxide and water.
- A chemical process in which a substance reacts with oxygen to give off heat is called combustion. The substance that undergoes combustion is said to be combustible. It is also called a fuel. The fuel may be solid, liquid or gas. Sometimes, light is also given off during combustion, either as a flame or as a glow.

### Extinguishing Fire

- The most common fire extinguisher is water. But water works only when things like wood and paper are on fire. If electrical equipment is on fire, water may conduct electricity and harm those trying to douse the fire. Water is also not suitable for fires involving oil and petrol.
- Do you recall that water is heavier than oil? So, it sinks below the oil, and oil keeps burning on the top.
- For fires involving electrical equipment and inflammable materials like petrol, carbon dioxide (CO2) is the best extinguisher. CO2, being heavier than oxygen, covers the fire like a blanket.
- Since the contact between the fuel and oxygen is cut off, the fire is controlled. The added advantage of CO2 is that in most cases it does not harm the electrical equipment.

5. **When a candle burns, both physical and chemical changes occur.**

- **Physical Changes:** On heating, candle wax gets melted. Since it again turns into solid wax on cooling. So, the melting of wax and vapourisation of melted wax are physical changes.
- **Chemical Changes:** The wax near flame burns and gives new substances like carbon dioxide, carbon soot, water vapour, heat and light.

6. LPG is another example of a familiar process in which both the chemical and physical changes take place. LPG is present in liquid form in the cylinder. When it comes out of the cylinder, it converts into gaseous form which is a physical change. It undergoes chemical change when gas burns in air.

## Rare earth elements

- The Rare earth elements are a group of 17 metallic elements having similar chemical properties found in the periodic table.
- These comprise 15 lanthanides elements plus two other elements namely scandium and yttrium.
- Scandium and yttrium are considered rare-earth elements because they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties, but have different electronic and magnetic properties

| Rare earth name | Discovery tear | Atomic name &number | Light/heavy REE | Critical/ Uncritical |
|---|---|---|---|---|
| Yttrium | 1788 | Y-39 | Heavy | Critical |
| Cerium | 1803 | Ce-58 | Light | Excessive |
| Lanthanum | 1839 | La-57 | Light | Uncritical |
| Erbium | 1842 | Er-68 | Heavy | Critical |
| Terbium | 1843 | Tb-65 | Heavy | Critical |
| Ytterbium | 1878 | Yb-70 | Heavy | Excessive |
| Holmium | 1878 | Ho67 | Heavy | Excessive |
| Scandium | 1879 | Sc-21 | Heavy | Critical |
| Samarium | 1879 | Sm-62 | Light | Uncritical |
| Thulium | 1879 | Tm-69 | Heavy | Excessive |
| Praseodymium | 1885 | Pr-59 | Light | Uncritical |
| Neodymium | 1885 | Nd-60 | Light | Critical |
| Dysprosium | 1886 | Dy-66 | Heavy | Critical |
| Europium | 1886 | Eu-63 | Heavy | Critical |
| Gadolinium | 1886 | Gd-64 | Heavy | Uncritical |
| Lutetium | 1907 | Lu-71 | Heavy | Excessive |
| Promethium | 1947 | Pm-61 | | |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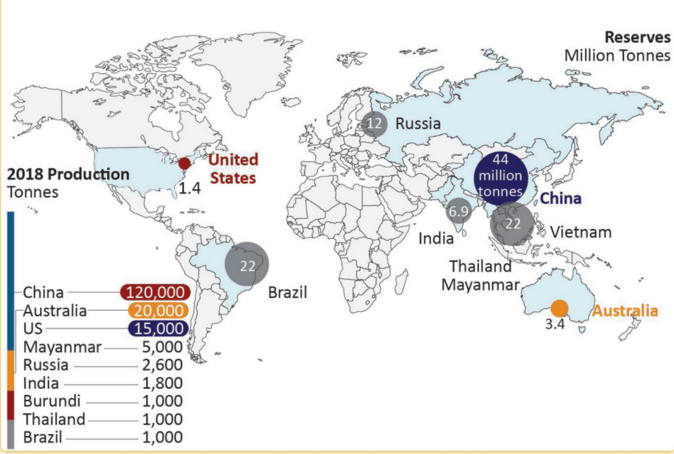
- The term ‘rare-earth’ is a misleading term because they are not actually scarce.
- Though rare-earth elements are technically relatively plentiful in the entire Earth’s crust (cerium being the 25th-most-abundant element and more abundant than copper),
- In practice, this is spread thin across trace impurities, so to obtain rare earths at usable purity requires processing enormous amounts of raw ore at great expense, thus the name “rare” earths.

**Rare earth metals production and reserves**



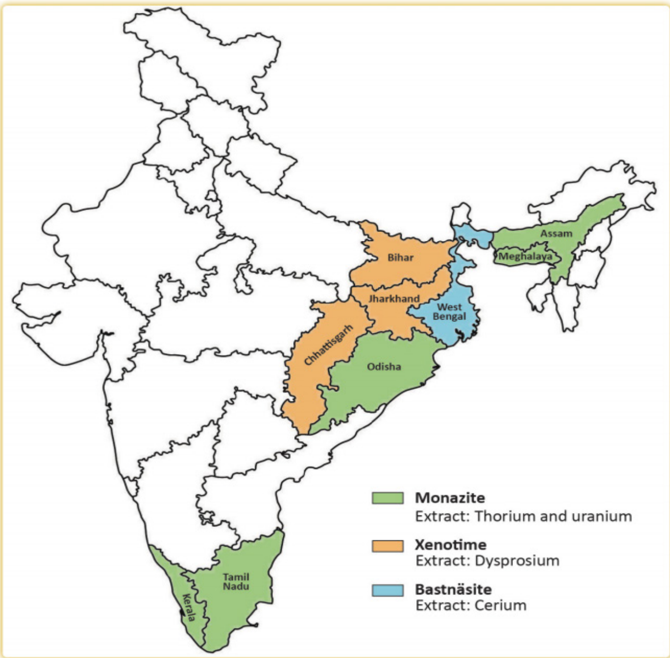

## Rare Earth Metal

- Supply Chain problems: Rare earths have a highly concentrated global supply scenario—much more so than oil and hydrocarbons—which presents a strategic challenge.
- Until a couple of years prior, China controlled 90% of the stockpile of intriguing earths.
- China’s share is now 60%, despite the aggressive production of the US, Australia, and Canada. Following a dispute with Japan over the East China Sea’s Senkaku Islands in 2010;
- China shut down products of Interesting Earth Components to Japan. China might use similar strategies in the future given the border dispute with India.
- To exploit domestic resources: India has more noteworthy stores than the US and Australia, just behind China, Vietnam, Russia, and Brazil.
- India must become a supplier for both domestic and international consumption given Russia’s involvement in the conflict
- Diverse uses especially in new technologies: Rare earth elements are utilized in numerous high-tech processes and applications, including EVs, medical devices, LEDs, and others. Hence, such elements must eventually be manufactured domestically
- Increasing demand: The numerous applications of rare earth elements in modern technologies indicate that their demand will rise in the future.
- For example, the ongoing interest in neodymium in India is little, at around 900 tons for each annum, since homegrown assembling of EVs and wind turbines is as yet restricted.

- However, it is anticipated that the demand for neodymium will sharply increase by 6-7 times by 2025 (6,000 tonnes) and by 18-20 times by 2030 (20,000 tonnes) as the production of electric vehicles and wind turbines picks up.
- Increases import dependency and bill: The majority of rare earths in India are almost entirely imported, placing enormous pressure on foreign exchange.
- Additionally, as demand for rare elements rises, so do their prices. For instance, the global cost of neodymium has skyrocketed from less than US$ 100 per kilogram in 2018 to more than US$ 200 per kilogram today.

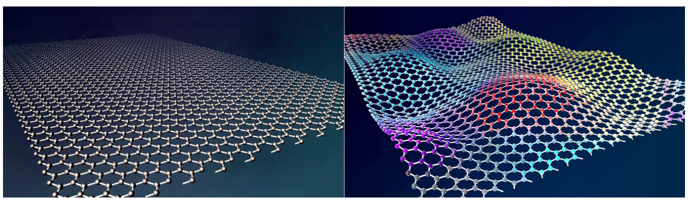
### Rare Earth Elements in India

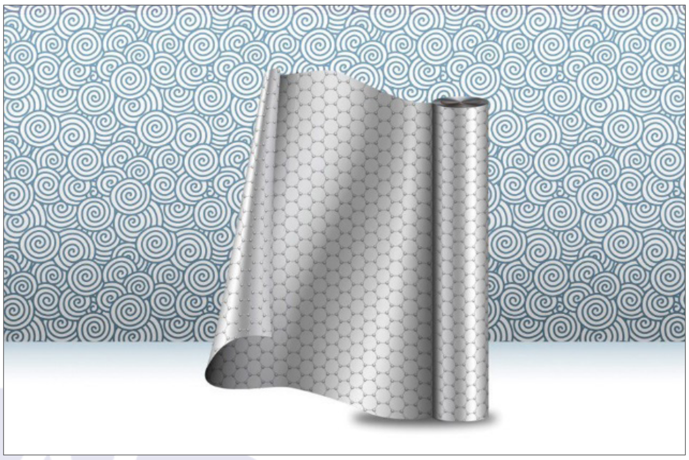
- The Rare Earth (RE) resources in India are reported to be the fifth largest in the world.
- Indian resource is significantly lean w.r.t. grade and it is tied with radioactivity making the extraction long, complex and expensive.
- Further, Indian resources contain Light Rare Earth Elements (LREE) while Heavy Rare Earth Elements (HREE) are not available in extractable quantities.

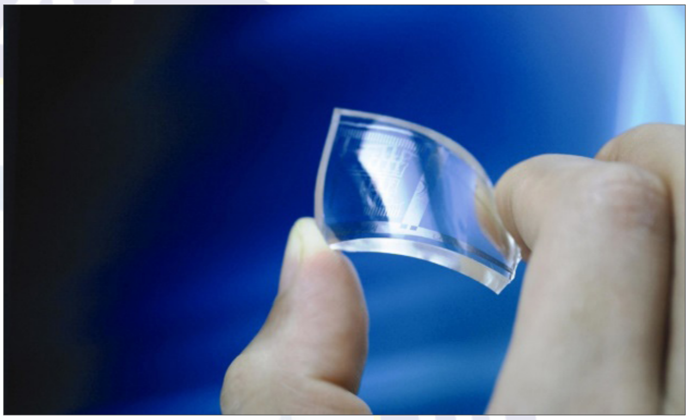



### Graphene: Why is Graphene the wonder Material?

- It is the world's thinnest, strongest, and most conductive material of both electricity and heat.
- It conducts electricity better than copper.
- It is 200 times stronger than steel but six times lighter.
- It is almost perfectly transparent as it absorbs only 2% of light.
- It is impermeable to gases, even those as light as hydrogen and helium.







### Use of Graphene

- Graphene composites are used in aerospace, automotive, sports equipment and construction.
- It is used for high-performance batteries and super-capacitors, touchscreens, and conductive inks.
- Graphene-based sensors are used for environmental monitoring, healthcare and wearable devices.
- Graphene oxide membranes are used for water purification and desalination.
- Graphene-based masks were made during COVID.
- Other applications of Graphene:
- Its exceptional strength makes it promising material for armour and ballistic protection.
- Graphene has the potential to absorb and dissipate electromagnetic waves, making it valuable for developing stealth coatings and materials that reduce radar signatures and electromagnetic interference.
- Graphene is highly sensitive to environmental changes, which makes it an excellent candidate for sensing chemical and biological agents, explosives, radiation, and other hazardous substances.
- Besides, graphene-based materials can also protect us against chemical and biological attacks.
- Better energy storage and electronics properties make graphene attractive in defence and aerospace as well as in civil and commercial applications.