TARGET PRELIMS 2024
BOOKLET-8; S&T-8
BIOLOGY BASICS

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1. CELL: FUNDAMENTAL UNIT OF LIFE

1) WHY IS CELL THE FUNDAMENTAL UNIT OF LIFE?

- Cell is the fundamental structural and functional unit of living organisms i.e. it is the smallest living unit of an organism. Thus, it is also the basic fundamental unit of life.

- Every cell is capable of doing some basic things like respiration, obtaining nutrition, and clearing the waste material, or forming new proteins.

2) SHAPES OF CELLS

- With the discovery of electron microscope in 1940, it was possible to observe and understand the complex structure of the cell and its various organelles.
- The shapes and sizes of the cells are related to the specific function they perform. Some cells like Amoeba have changing shapes. Cells shape can be very peculiar. For example, nerve cells have a typical shape.

- **Some organism can have cells of different types**
  - For example, humans have different types of cells

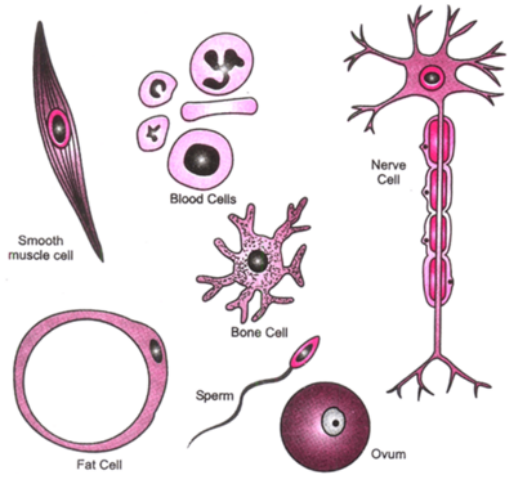


Figure : VARIOUS CELLS FROM THE HUMAN BODY

3) TWO BROAD CATEGORIES OF CELLS – EUKARYOTES AND PROKARYOTES

- The difference between the structures of Prokaryotes and Eukaryotes is so great that it is considered to be the **most important distinction** among group of organisms.

i. Eukaryotic

- They have membrane bound organelles such as nucleus.
- They are advanced cells found in plants and animals
- They are usually found in multi-cellular animals. But there are a lot of unicellular Eukaryotes too.

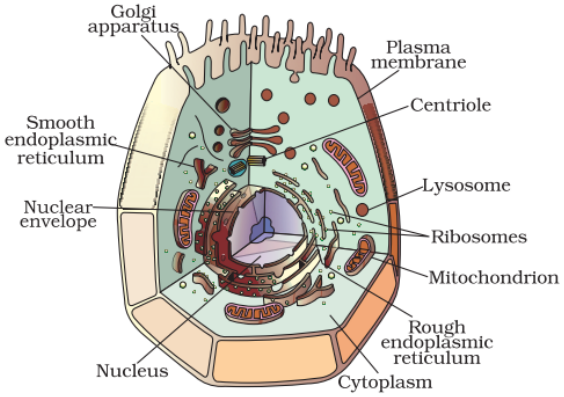
ii. Prokaryotic

- They don't have nucleus or other well-defined organelles. They do have genetic material, but it is not contained within a nucleus.
- They are found in primitive cells like that of bacteria and Archaea.
- Prokaryotic cells are **always unicellular** such as bacteria. But there is some evidence that some bacterial species can aggregate together and divide labor so that the "colony" is working more

efficiently. This is the characteristic of a multi-cellular organisms, but there is still a lot of resistance to the idea of calling these prokaryotes multi-cellular.
    - Prokaryotes are usually much smaller than Eukaryotes.

4) STRUCTURAL ORGANIZATIONS OF CELL

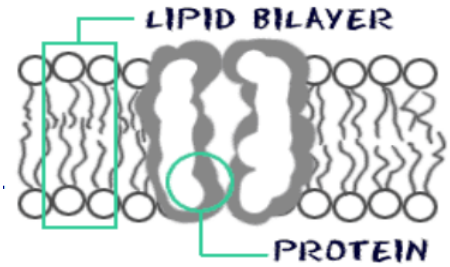
- Every living cell has the capacity to perform certain basic functions that are characteristics of all living forms. There is a division of labour seen within a single cell. The cell components called the cell organelles have specialized functions.
- These functions include making new material in the cell, clearing up the waste material from the cell and so on.
- These organelles together constitute the basic unit called the cell. It is **interesting to note that all cells are found to have the same organelles**, no matter what their function is or what organism they are found in.



- **Three Broad components of the cell**
    - **Plasma Membrane or Cell Membrane**
    - **Nucleus**
    - **Cytoplasm**

A) PLASMA MEMBRANE OR CELL MEMBRANE

- Cell membrane/Plasma membrane is the **outermost covering** of the cell that separates the contents of the cell from its external environment.
- It allows or permits the entry or exit of some materials in and out of the cells. It also prevents movement of some other materials. The cell membrane is therefore called **selectively permeable membrane**.



- Cell membrane is not a solid structure. Cell membranes are also described as lipid bilayers.
- There are two layers of phospholipids with protein embedded in the layers.
- **How does diffusion of substance take place into the cell?**
    - **Diffusion**
    - Continuous movement of a substance from a region of high concentration to a region where its concentration is low.
    - E.g.: O_2 enter the cell by the process of diffusion when the level of concentration of O_2 inside the cell decreases.
    - CO_2 moves out of the cell when the level of concentration of CO_2 inside the cell increases.

- Water also obeys the law of diffusion: **Osmosis** - the movement of water molecules through such selectively permeable membrane. It is basically movement of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration.

- **What happens when we put an animal cell or a plant cell into a solution of sugar or salt in water?**
  - **Hypotonic Solution:** If the medium has higher water concentration than the cell, meaning, outside cell is very dilute, the cell will gain water.
  - **Isotonic Solution:** Same concentration, no movement.
  - **Hypertonic Solution:** The medium has a lower concentration of water than the cell, meaning that it is a very concentrated solution, the cell will lose water by osmosis. Such solution is called a hypertonic solution.

- **Thus, osmosis is a special case of diffusion through a selectively permeable membrane**.
  - Unicellular freshwater organisms and most cells tend to gain water through osmosis. Absorption of water by plant roots is also an example of osmosis.
  - Only living cells, and not dead cells, are able to absorb water by osmosis.

  - The flexibility of cell membrane also enables the cell to engulf in food and other material from its external environment. Such process is known as **Endocytosis**. Amoeba acquires its food through such processes.

- **Cell Wall**
  - Plant cells in addition to plasma membrane, have another rigid outer covering called the cell wall. The cell wall lies outside plasma membrane. The plant cell wall is mainly composed of cellulose. Cellulose is a complex substance and provides structural strength to plants.

  - **Plasmolysis:** When a living plant cell loses water through osmosis there is a shrinkage or contraction of the contents of the cell away from the cell wall. The phenomenon is known as plasmolysis.

  - **Plant cells can withstand much greater changes in the surrounding medium than animal cells. Why?**

  - **Animal cells never have a cell wall**.

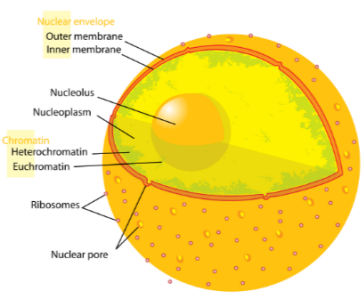
B) NUCLEUS

- Nucleus acts as **brain/control centre** of the cell. It stores DNA, the genetic information that tells a cell how to live its life. It controls basic activities like eating, movement, reproduction, basic characteristics etc.
- Sometimes there are more than one nucleus in certain cells. These are called **multi-nucleated cells**.
- Almost all human cells have **one nucleus** with identical DNA. Some human cells have no nuclei at all e.g. the Red Blood Cells. Some cells like liver cells and some muscle cells, are multinucleated, meaning they have multiple nuclei.

- **Multinucleated** cells are more efficient as they have two control centres. For instance – Liver cells – Hepatocytes do a lot of jobs. They make protein for digestion, help remove harmful stuff from your blood, produce enzymes to digest fats and carbohydrates and store carbohydrate energy for the body. Having two nuclei is like having two sets of blueprints, so the cells can build two proteins at the same time.

- **Nucleoid:** In some organisms like bacteria, the nuclear region of the cell may be poorly defined due to the **absence of nuclear membrane**. Such an undefined nuclear region containing only nucleic acids is called nucleoid.

- **Structure**
  - Nucleus has a double layered covering called the **nuclear membrane**.
  - The nuclear membrane has pores which allow the transfer of material (such as RNA and protein) from inside the nucleus to its outside, i.e. to the cytoplasm.



- **The nucleus contains**
  - **Chromosomes**
    - Chromosomes are composed of DNA and proteins.
    - It contains **information for inheritance** of features from parents to next generation in the form of DNA (Deoxyribonucleic Acid) molecules.
      - **DNA** molecules contain the information necessary for constructing and organizing cells.
      - Functional segments of DNA are called **genes**.
      - **Chromatin Material**
        i. When the cell is in a resting state (not dividing) there is something called chromatin in the nucleus. It is made up of DNA, RNA, and nuclear protein.
        ii. Chromatin material is visible as entangled mass of thread like structures.
        iii. Whenever the cell is about to divide the chromatin material gets organized into chromosome (the rod shape structure)

  - **Nucleolus**
    - It looks like nucleus inside a nucleus. It is made up of RNA and protein.
    - It is the structure where ribosomes are made.
    - After ribosomes leave the nucleus, they will have the important job of synthesizing proteins.

C) CYTOPLASM

- The cytoplasm is the fluid content inside the plasma membrane. It also contains many specialized cell organelles. Each of these cell organelles perform a specified function for the cell.

  A. **Cell organelles** are enclosed by membranes to keep its own content separate from external environment.

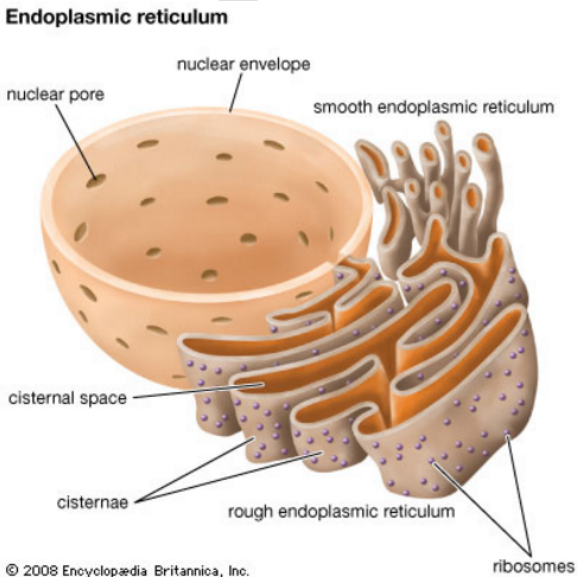
  B. **In Prokaryotes**, besides the absence of a defined nuclear region, the membrane-bound cell organelles are also absent. On the other hand, the **eukaryotic cells** have nuclear membrane as well as membrane-enclosed organelles.

  C. **Significance of membranes**
     i. Significance of membranes can be illustrated with the example of viruses.
     ii. Viruses lack any membranes and hence don't show characteristics of life until they enter a living body and use its machinery to multiply.

- **Important Cell Organelles**

  A. **Endoplasmic Reticulum (ER)**

  - ER functions both as a **passageway** for intercellular transport and as a **manufacturing surface**.
  - It is a large network of membrane bound tubes and sheets to transport material. It looks like long tubules or round and oblong bags (vesicles). The ER membrane is similar in structure to plasma membrane.
  - Some cells like Prokaryotes or RBCs **don't have** ER of any kind.
  - Cells that synthesize and release a lot of proteins would need a large amount of ER. Cells from Pancreas or liver will have large number of ER structures.



  - **Two types** of ER
    - **Rough Endoplasmic Reticulum (RER)**
      - RER looks rough under a microscope because it has particles called ribosomes attached to its surface. Ribosomes which are present in all active cells, are the sites of protein manufacture.
      - RER looks like sheets or disks of bumpy membranes while smooth ER looks more like tubes.
      - The manufactured proteins are then sent to various places in the cell depending on need, using the ER.
      - The RER are also attached to nuclear envelope that surrounds the nucleus. This attachment allows for movement of molecules through membranes.

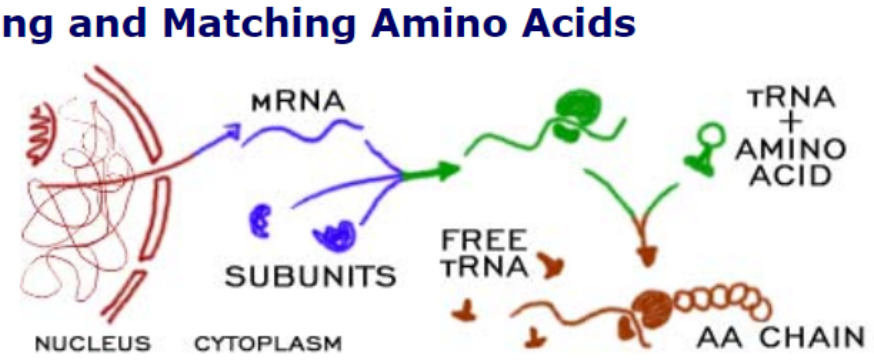
- **Smooth Endoplasmic Reticulum (SER)**
  - SER help in manufacturing of fat molecules, or lipids, important for cell function.
  - They are mostly shaped like tubes.
  - Some of these lipids help in building of cell membrane. This process of known as membrane **biogenesis**.
  - Some other proteins and lipids function as enzymes and hormones.

- Although the ER varies greatly in appearance in different cells, it always forms a **network system**. Thus, one function of ER is to serve as **channels for the transport of materials (**especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus.
- The ER also functions as a cytoplasmic framework providing a **surface for some of the bio-chemical activities of the cell**.
  - e.g.: In liver cells of vertebrates, SER plays a crucial role in detoxifying poisons and drugs

B. **Ribosomes (not organelles)**

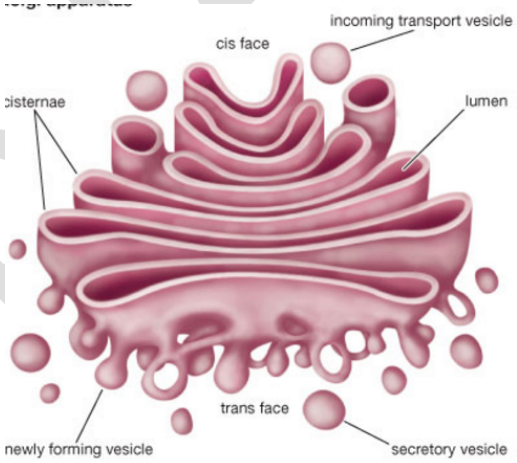
- **Note:** Ribosomes are not organelles. They are not membrane-enclosed, instead they are macro-molecules made of both RNA and proteins.
- They are the protein factories of the cell. Composed of two subunits, they can be found floating freely in cell's cytoplasm or embedded within the endoplasmic reticulum.
- **Every cell needs Ribosomes**, so they are found in both prokaryotes and Eukaryotes.
- Using the templates and instructions provided by two different types of RNA, ribosomes synthesize a variety of proteins that are essential to the survival of the cell.
- There are two sub-units to every ribosome.
- **The Process of protein synthesis**
  - Protein synthesis starts when mRNA moves from nucleus to a ribosome on the surface of RER.
  - The two sub-units of ribosomes come together and combine with mRNA. They lock onto the mRNA and start the protein synthesis.
  - Ribosome builds the amino acid chain. The process is simple. First, you need an amino acid. Another nucleic acid that lives in the cell is **transfer RNA**. It is bonded to amino acids floating around the cell. With mRNA offering instructions, the ribosome connects to a tRNA and pulls of one amino acid. The tRNA is then released back into the cell and attached to another amino acid.
  - When the protein is complete RER pinches off a vesicle. That vesicle, a small membrane bubble, can move to the cell membrane or the Golgi apparatus. Some of the protein will

be used in the cell and some will be sent out into intercellular-space.



C. Golgi Apparatus (pronounced 'GOL-JI)

- **Structure:** The Golgi apparatus, first described by Camillo Golgi, consists of system of membrane-bound vesicles arranged approximately parallel to each other in stacks called cisterns. These membranes often have connection to membrane of ER and therefore **constitute another portion of a complex cellular membrane system**.

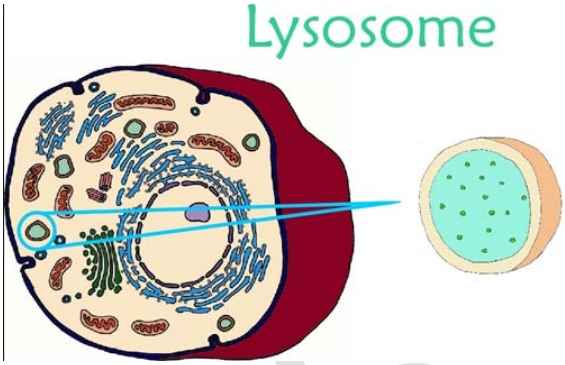


- **Functions** of GA include storage, modification and packaging of products in vesicles.
  - Complex sugar can be made out of simple sugar
  - Turning protein into usable form by folding them into different shapes or adding other materials to protein such as lipids or Carbohydrates.
  - It is also involved in formation of lysosomes.
- After making these big molecules, Golgi apparatus packages them into vesicles, and either stores them for later use or sends them out of the cell.

D. **Lysosomes**

- **Structure:** Lysosomes are membrane bound sacs filled with powerful **digestive enzymes** capable of breaking down organic material. These enzymes are made at RER. The membrane ensures that the internal enzymes don't digest the cell itself.

- **Functions**
  - It is a kind of waste disposal system of the cell. Lysosome help to keep the cell clean by digesting any foreign material as well as worn-out cell organelles.

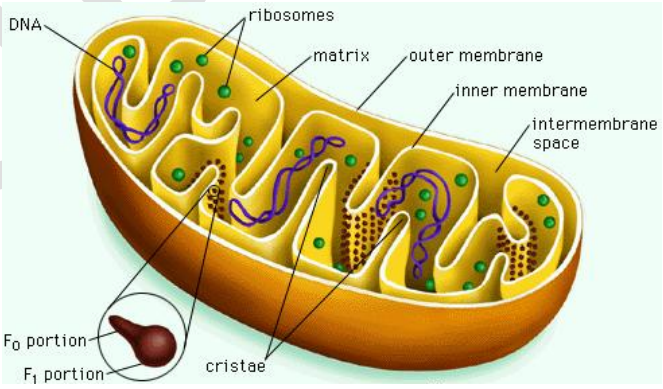


- **Suicide bags of cell**
  - During the disturbance in cellular metabolism, for example, when the cell gets damaged, lysosomes may burst, and enzymes digest their own cell. Therefore, lysosomes are also known as suicide bags of a cell.
- They are not commonly found in plant cells. The tough cell walls keep out the foreign substance.

E. **Mitochondria**

- **Structure:**
  - Mitochondria has two membranes covering instead of one.
  - The outer membrane is very porous while the inner membrane is deeply folded. These folds create large surface areas for ATP generating chemical reactions.
  - Mitochondria are **strange organelles** in the sense that they have their own DNA and ribosomes. Therefore, mitochondria are able to make some of their proteins.

- **Functions**
  - Mitochondria are known as **powerhouse of the cell**.
  - The energy required for various chemical activities needed for life is released by mitochondria in the form of **ATP (Adenosine Triphosphate)** molecules during a process called cellular respiration.
  - ATP is known as the energy currency of the cell. It provides energy for all the cellular activities.

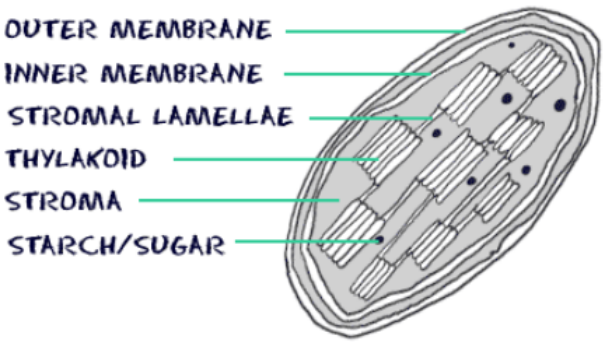


  - Cells which need more energy have more mitochondria. (For e.g. muscle cells)
  - The body uses energy stored in ATP for making new chemical compounds and for mechanical work.
  - Mitochondria are also involved in controlling the concentration of Calcium (Ca^{2+}) ions within cell.

F. **PLASTIDS** (not found in animal cells)

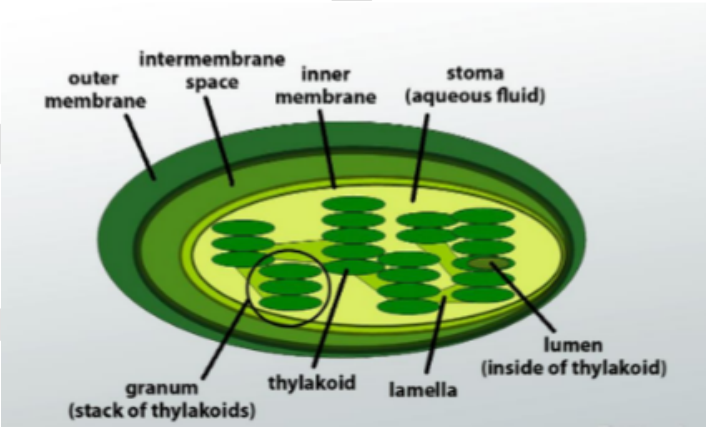
- **Structures:**
  - The internal structure of plastids consists of numerous membrane layers embedded in a material called the Stroma.
  - Plastids are similar to mitochondria in external structure.
  - Like mitochondria, plastids also have their own DNA and ribosomes.
- **Two types of plastids**
  - **Chromoplasts** (coloured plastids)

- **Leucoplasts** (white or colourless)-> these are organelles in which material such as starch, oil and protein granules are stored. Thus, primary purpose of leucoplast is **storage**.



- **Chloroplasts:** Plastids containing the green pigment chlorophyll are known as chloroplasts.
  - Chloroplasts are important for photosynthesis in plants and thus are food producers of the cell. They convert light energy of sun into sugars that can be used by cells. The entire process is called photosynthesis and it all depends on little green chlorophyll molecule in each chloroplast. In the process of photosynthesis, plants create sugar and release oxygen.

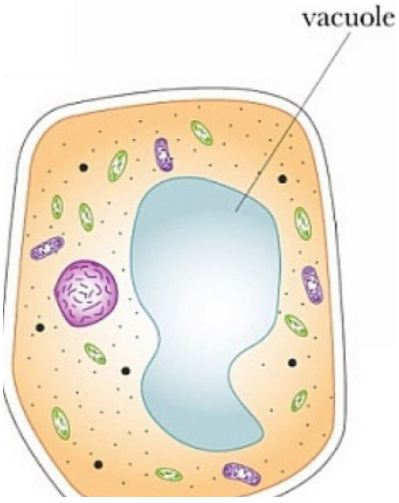
  - Two membranes (named outer and inner membrane) surrounds the stroma and the grana (stacks of thylakoid). One thylakoid stack is called granum. The stacks of thylakoid sacs are connected by **stroma lamella**. The lamella act like skeleton of the chloroplast, keeping all the sacs a safe distance from each other and maximizing the efficiency of the organelle.



  - **Chlorophyll molecules sit on surface of each thylakoid** and capture light energy from sun. As energy-rich molecules are created by the light-dependent reactions, they move to the stroma where carbon (C) can be fixed and sugars can by synthesized.They also contain various yellow and orange pigments in addition to chlorophyll.

G. **Vacuoles**

- **Structure:**
  - Vacuoles are of small size in animal cells while plant cells have very large vacuoles.
  - The central vacuole of some plant cells may occupy 50-90% of the cell volume.



-**Functions**

  - Vacuoles are storage sacs for solid and liquid contents. Many substances of importance in life of the plant cell are stored in vacuoles. These include amino acids,

sugars, various organic acids, some proteins and waste products.

- In plant cells vacuoles are full of cell sap and provide turgidity and rigidity to the cell.
- In single celled organisms like Amoeba, the food vacuole contains the food items that the amoeba has consumed.
- In some other unicellular organisms, specialized vacuoles also play important roles in expelling excess water and some wastes from the cell

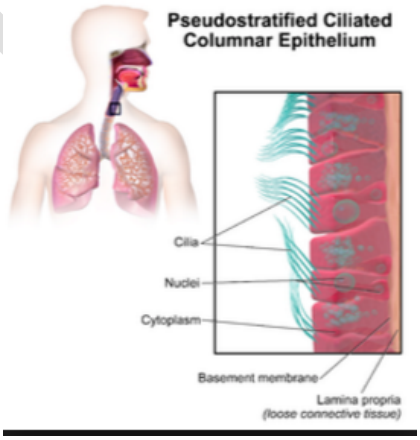
H. Cytoskeleton (Not organelles)

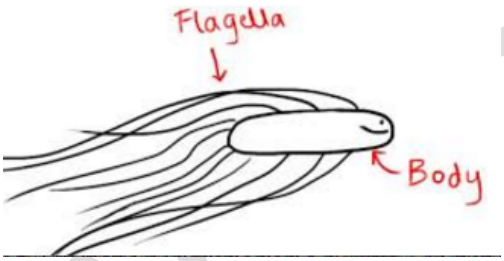
- It is the microscopic network of protein and tubules in the cytoplasm of many living cells, giving them **shape and coherence**.
- It is complex network of interlinking filament and tubules that extend throughout cytoplasm, from the nucleus to plasma membrane.

I. **Some unique structures which only some cells have**

i. **Cilia:** In humans, the respiratory tract is lined with cells that have cilia. These are microscopic hair like projections that can move in waves. This feature help in trapping inhaled particles in the air and expels when you cough.

ii. **Flagella:** Some bacteria have flagella. A Flagellum is like a little tail that can help a cell move or propel itself. The only human cell that have a flagellum is sperm cell.





5) SOME THINGS TO NOTE:

- Even every multi-cellular organism come from a single cell
- While observing a cell under micro-scope, we use iodine solution, safranin solution or methylene blue solution to stain the cells, so that different organelles are clearly visible.
- All cells have a cell membrane, cytoplasm, and genetic material.

6) IMPORTANT SCIENTISTS

- **Discovery of Cell (1665)**

- **Robert Hooke** (father of cytology - the branch of science which studies cell) while examining a thin slice of cork saw that the cork resembled the structure of a honey comb (hexagonal compartments). He in 1665 made the chance observation through a self-designed microscope. He called these boxes **cells**.
- This was the very first time that someone had observed that living things appear to consist of separate units.

- **Discovery of a living cell (1674)**
  - Anton Von Leeuwenhock (father of bacteriology). He studied bacterial, protozoan cells etc.
- **Discovery of nucleus (1831)**
  - Robert Brown
- Term **Protoplasm** was coined by Purkinje in 1839 for the fluid substance of the cell.

2. TISSUES

1) INTRODUCTION

- In a unicellular organism, a cell performs all basic functions. For example, in Amoeba, a single cell carries out movement, intake of food and respiratory gases, respiration and excretion.
- But in multicellular organism there are millions of cells. Most of these cells are specialized to carry out a few functions. Each specialized function is taken up by a different group of cells. A group of cells that are similar in structure and/or work together to achieve a particular function forms a **tissue**.
- Tissues are the fabric of your body. (Infact, the term tissue literally means woven)
- When two or more tissues combine, they form **organs**. Kidneys, lungs, liver etc are all organs which are made of different kind of tissues.
    - Function of an organ depend on the kinds of tissues it is made of.

- **Histology**: The study of tissues.

2) FOUR PRIMARY TYPES OF ANIMAL TISSUES

A) NERVOUS TISSUES

- All cells possess the ability to respond to a stimulus. However, cells of a nervous tissue are **highly specialized for being stimulated** and then transmitting stimulus very rapidly from one place to another within the body.
- **Two big functions of nervous tissues**
    - **Sensing stimuli**
    - **Sending electrical impulse through the body** often in response to stimuli.

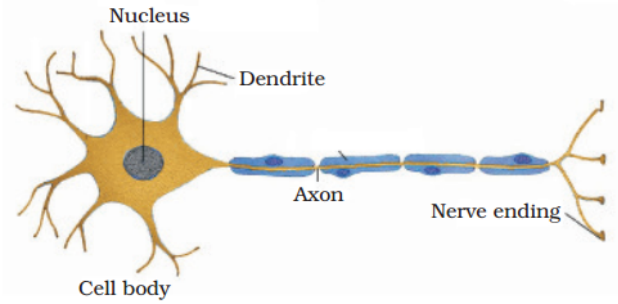
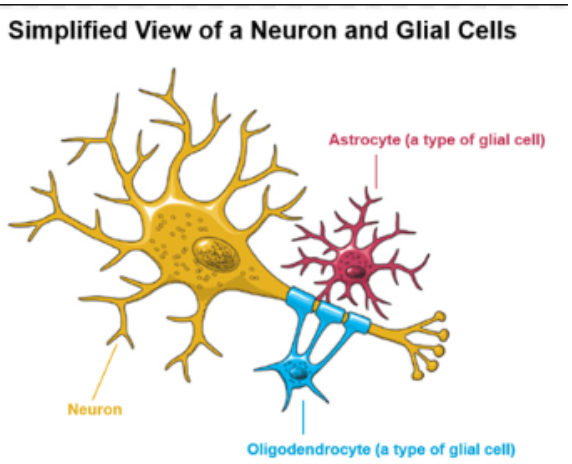


Figure 2.1: A neuron unit of nervous tissue

- The brain, spinal cord and nerves are all composed of the nervous tissue.
- **Nervous tissue is made of two different types of cells**
    - **Neurons**
    - **Glial cells**
- **A neuron** consists of a **cell body** with a cytoplasm and nucleus, from which long thin hair-like parts arise.

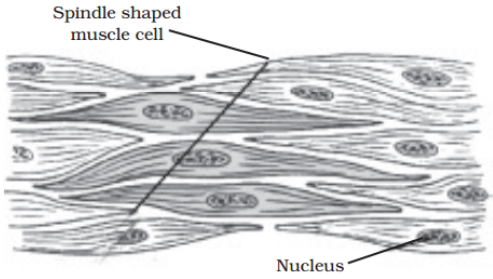
- Usually each neuron has a single long part, called the **axon** and many short, branched parts called **dendrites**.
- An individual nerve cell may be upto a meter long.



- **Cell body (soma)** is the neurons life support. It contains all the necessary things like nucleus, mitochondria etc.
- **Dendrites:** They collect signals from other cells to send back to soma. Thus, they are the listening end.
- **Axon** works like a transmission cable and carries messages to another neurons, muscles and glands.
- Neurons are present all over the body.
- **Glial Cells:** These are other types of nervous cells which provide support insulation, and protection and tethering them to blood vessels.

B) MUSCLE TISSUES/ MUSCULAR TISSUES

- Muscular tissues consist of elongated cells, also called muscle fibres. This tissue is responsible for movement in our body.
- Muscles contain special protein called **contractile protein,** which can contract and relax to cause movement.

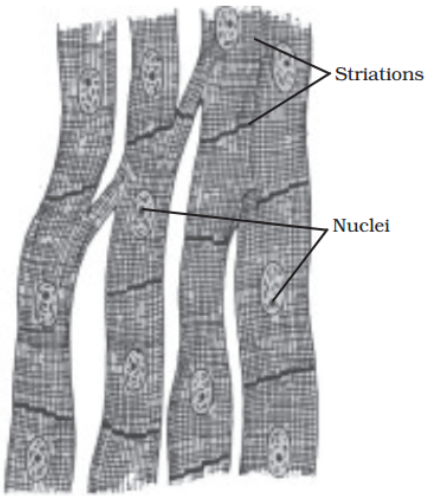


(b)

- Unlike your nervous tissues, your muscle tissues can contract and move.

- It is well vascularized meaning it has a lot of blood coming and going.

- **Two types of Muscle tissues**
  1. **Voluntary Muscles/Skeletal Muscles**
     - Can be moved by conscious will.
       - e.g. Muscle in our limbs
     - Also called skeletal muscles as they are mostly attached to bones and help in body movement.
     - Under microscope, these muscles show alternate light and dark bands or striations when stained appropriately. As a result, they are also **called striated muscles**.
     - The cells of this tissue are long, cylindrical, unbranched and **multinucleate** (having many nuclei).



(c)

Figure 2.3: Stri

2. **Involuntary Muscles**
    - It is not in our control. Movement is involuntary. We cannot really start them and stop them simply by wanting to do so.
    - The movement of food in the alimentary canal or the contraction and relaxation of blood vessels are the examples of involuntary movement.
    - **Smooth muscles** (a type of involuntary muscles) control such movements.
    - They are also found in iris of the eye and in the bronchi of the lungs.
    - The cells are long with pointed ends (spindle shaped) and uninucleate (having a single nucleus). They are also called unstriated muscles.
    - The **muscles of heart** show rhythmic contraction and relaxation throughout life. These muscles are called cardiac muscles (another type of involuntary muscles). Heart muscles cells are cylindrical, branched, striated and uninucleate.
        - Cardiac muscle is only found in heart.

C) EPITHELIAL TISSUES

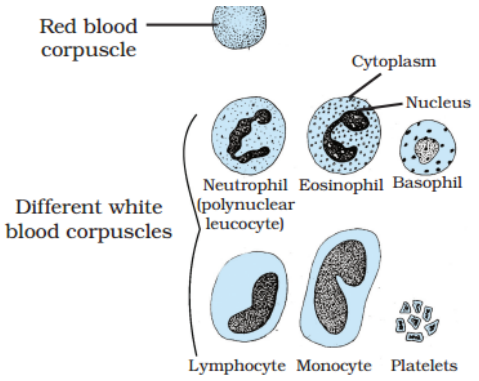
- The covering or protective tissues in animal body are epithelial tissues.
    - It covers most organs or cavities within the body.
        - **This protects** our deeper layers of tissues from injury or infection
        - E.g.: Lining of stomach with epithelial cells that produce mucus -> we don't digest our stomach along with our food.
    - It also **forms barrier** to keep different body systems separate.
    - Permeability of cells of epithelia play an important role **in regulating the exchange of materials** between the body and the external environment and also between different body parts.
        - Tissues lining small intestine allows you to absorb nutrients through diffusion and active transport.
        - Urinary waste gets filtered through different epithelia lining the kidneys

- E.g.
    - **The skin**, the lining of mouth, the lining of blood vessels, lung alveoli and kidney tubules are all made of epithelial tissues.

- They are tightly packed and form a continuous sheet. They have a very small amount of cementing material between them and almost no intercellular spaces.
- All epithelium is usually separated from the underlying tissues by an extracellular fibrous basement membrane.
- **Avascular:** All of our epithelial tissues are avascular - meaning they don't have blood supply.
    - Instead, they rely on the blood supply in the supporting connective tissues around them for the material they need.
- **Polar:** All of our epithelial tissues are polar - meaning that they have distinct sides.
    - **Apical Side** or the upper side is exposed to outside of the body of whatever internal cavity it is lining.
    - **Basal Side** or inner side is tightly attached to the basement membrane.

- **Epithelium can also be divided into following groups**

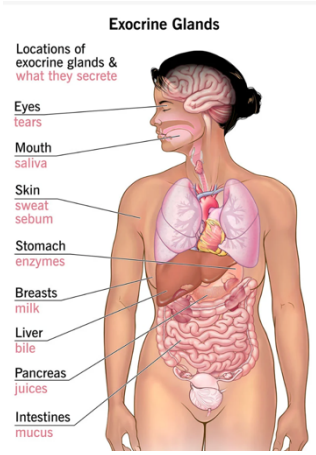
1. **Proper Epithelium**
   - **Discussed above**
   - **Covers most organs and cavities and separates various organs**



2. **Glandular Epithelium**
   - Epithelial cells often acquire additional specialization as **gland cells**, which can secrete substances at the epithelial surface. Sometimes a portion of the epithelial tissues folds inward, and a multicellular gland is formed. This is **glandular epithelium**.

   - **Glandular epithelium forms two different kinds of glands**
     - **Endocrine Glands**
       - Secrete hormones right into your blood stream or to nearby cells
       - e.g.1: Hormone thyroxine is secreted by endocrine gland: **Thyroid**
         - It needs to be distributed throughout the body so that it can stimulate the metabolism in all of our cells
       - E.g.2: Pancreas is an endocrine gland which releases **Glucagon** (raised blood sugar) and **Insulin** (lowers blood sugar; stimulates metabolism of glucose, protein, fat).
       - E.g3: **Testes** is an endocrine gland which releases testosterone (it develops and maintains male sexual characteristics and maturation)

     - **Exocrine Glands**
       - Secrete their juices into tubes or ducts that lead to the outside of the body or inside of the tube, rather than right into the blood.
       - E.g.
         - Sweat, Saliva, Mucus, stomach acids, milk (if you are lactating)
       - **Note**: The Pancreas is a unique dual gland that has both exocrine and endocrine function. It consist of 95% of exocrine and less than 5% of endocrine functions.



D) CONNECTIVE TISSUES

- Connective tissue is almost everywhere in the body. How much of it is there depends on organ to organ.
  - e.g. Skin is mostly connective tissue while the brain has very little of this since it is almost all nervous tissues
- Cells of connective tissues are loosely spaced and embedded in an **intercellular matrix**.

- The matrix can be jelly like, fluid, dense or rigid.
- The nature of matrix differs in accordance with the function of the particular connective tissues.

- **Blood** has a fluid (liquid) matrix called plasma, in which RBCs, WBCs and platelets are suspended.
  - The plasma contains proteins, hormones and salts.
  - Blood flows and transport gases, digested food, hormones and waste materials to different parts of the body.

- **Bones**
  - Another example of connective tissue. It forms the framework that supports the body. It also anchors muscles and support the main organs of the body.
  - It is also strong and inflexible tissue.
  - Bone cells are embedded in a hard matrix that is composed of calcium and phosphorus compounds.

- **Ligament**
  - Two bones can be connected to each other by another type of connective tissue called ligament. The tissue is very elastic.
  - Ligament contains very little matrix.

- **Tendons**
  - They connect muscles to bones and are another type of connective tissue.
  - Tendons are fibrous tissues with great strength but limited flexibility.

- **Cartilage**
  - Another type of connective tissue cartilage, has widely space cells. The solid matrix is composed of proteins and sugars.
  - Cartilage smoothens bone surface at joints and is also present in the nose, ear, trachea and larynx.

- **Areolar Connective tissue** is found between the skin and muscles, around blood vessels and nerves and in the bone marrow.
  - It fills the space inside the organs, supports internal organs and helps repair of tissues.

- **Adipose tissue**
  - Fat storing adipose tissues is found below the skin and between internal organs.
  - The cells of this tissue are filled with fat globules. Storage of fat also lets it act as an insulator.

- **Four Major Classes of Connective Tissues**
  - Proper Connective Tissues
  - Cartilage Connective Tissues
  - Bone Connective tissues
  - Blood Connective tissues
- **How connective tissues contribute**

- Binding and supporting
- Protecting
- Insulating
- Storing reserve fluid and energy
- Transporting substances within the body
- Movement

- **E.g.**
  - **Fat** which is a type of proper connective tissue provides insulation and fuel storage. It also serves structural purposes like holding your kidney in place etc.
  - **Bones, Tendons, and Cartilage** bind, support, and protect your organs and give you a skeleton so you can move with purpose.
  - **Blood** transports hormones, nutrients and other materials all over the body. It is a type of connective tissue.

- **All connective tissues have three factors in common** that sets them apart from other tissue types
  - **Common Origin**
    - They all develop from **MESENCHYME** a loose and fluid kind of embryonic tissue**.**
  - **Degree of vascularity**
    - Connective tissues have a different degree of vascularity or blood flow
    - E.g. most cartilages are avascular meaning no blood vessels, while other types of connective tissues like dense irregular tissue in our skin is brimming with blood vessels**.**
  - **Mostly composed of non-living material**
    - All connective tissues are mostly composed on non-living material called the extracellular matrix.
    - While other tissue types are mainly made of living cells.
    - Extracellular matrix is mostly made of two components
      - **i. Ground Substance**
        - Watery, rubbery, unstructured material that fills in spaces between the cells and protects the cells from their surroundings
        - It is made of starch and protein molecules mixed with water.
      - ii. **Fibers**
        - It provides support and structure to otherwise shapeless ground substances
          - E.g. Collagen fibre

3) **PLANT TISSUES**

- Plants and animals are not made of same kind of tissues.
  - i) Different structure
    - Most tissues are supportive, which provide them with structural strength
    - Most of these tissues are dead
      - Since dead cells can provide mechanical strength as easily as live ones, and need less maintenance.

ii) Different functions
- Plants are stationary, whereas animals are mobile
- The growth of plant is limited to certain regions, while this is not so with animals
- There are some tissues in plants that divide throughout their life. These tissues are localized in certain regions
  - Meristematic tissues -> always growing
  - Permanent tissues
- Animal tissues - > no such demarcation in dividing and non-dividing tissues
- Structural organization of organs simple in plants and far more complex in animals

iii) **Because of above differences it is clear that plant tissues must be very different than animal tissues**

- **Types of Plant Tissues**

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1) **MERISTEMATIC TISSUES**

- Growth of plants occur only in certain specific regions. This is because the dividing tissue, also known as meristematic tissues, is located in this point.
- Depending on the region where they are present, meristematic tissues can be classified as
  - **Apical**
    - Present at the growing tips of stems and roots and increase the length of the stem and the root.
  - **Lateral**
    - The girth of the stem of root increases due to lateral meristem (cambium).
  - **Intercalary meristem**
    - It is the meristem at the base of the leaves or internodes (on either side of the nodes) on twigs.

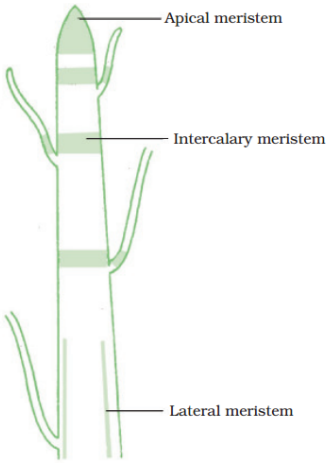

Fig. 6.2: *Location of meristematic tissue in plant body*

- As the cells of the tissue are very active, they have dense cytoplasm, thin cellulose walls and prominent nuclei. They lack vacuoles.
- New cells produced by meristem are initially like those of meristem itself, but as they grow and mature, their characteristics slowly change and they become differentiated as components of other tissues.

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2) **PERMANENT TISSUES**

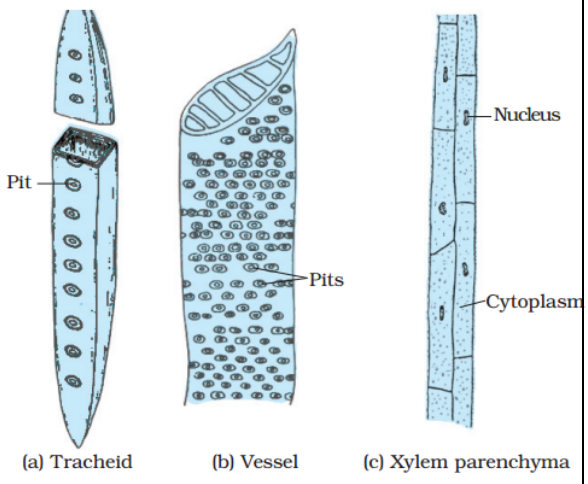
- After cells are formed by meristematic tissue, they take up a specific role and lose the ability to divide. As a result, they form permanent tissues.
- This process of taking up a permanent shape, size, and a function is called the **differentiation** to form different types of permanent tissues.
- **Types of Permanent Tissues**

(i) Simple Permanent Tissues

- They are made of one type of cells. A few layers of cells form the basic packaging tissue.

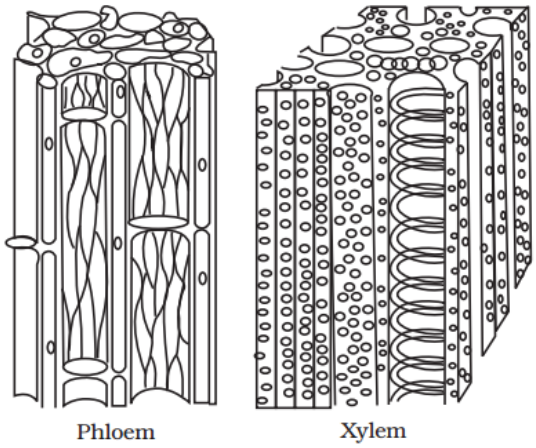
(ii) Complex Permanent Tissues

- Complex permanent tissues are made of more than one type of the cells. All these cells coordinate to perform a common function.
- **Xylem and Phloem** are examples of such complex tissues.
  - They are both conducting tissues and constitute a vascular bundle.
  - Vascular or conductive tissues are distinctive feature of complex plants, one that has made possible their survival in the terrestrial environment.
- **Xylem**
  - It consists of tracheid's, vessels, xylem parenchyma and xylem fibres.
  - Tracheid and vessels are tubular structures. This allows them to **transport water and minerals vertically**.
  - The **parenchyma stores food** and helps in the sideways conduction of water.
  - Fibres are mainly supportive in function



- **Phloem** is made up of four types of elements:
  - Sieve tubes
    - Tubular cells with perforated walls.
  - Companion cells
  - Phloem fibres
  - Phloem parenchyma

- **Phloem is unlike xylem** in that material **can move in both directions** in it.
  - Phloem transfers food in leaves to other parts of the plant.
  - Except for phloem fibres, phloem cells are living cells.



3. BLOOD TYPE AND RELATED ISSUES

- **Introduction**
  - Blood consists of red blood cells (and other cells not relevant here) floating in fluid called Plasma. The RBCs carry on their surface a set of markers with which plasma interacts. The compatibility and cross talk between the RBC and the plasma is what makes each blood type special.

  - The markers on the cell are determined by a master type called H, out of which are generated types A, B, AB and O.
  - In addition to A and B antigen, there is a third antigen called **Rh factor**, which can either be (+) or (-)
    - Rh- patient can only be given Rh- blood
    - Rh+ patient can get either Rh- or Rh+ blood

  - **A blood type** (also called a blood group) is defined as the classification of blood based on **the presence or absence of inherited antigenic substances** on the surface of red blood cells (RBCs).

  - A series of related blood types constitutes a **blood group system**, such as the Rh or ABO system. The frequencies of the ABO and Rh blood types vary from population to population

- **ABO System**

Blood Group	Antigen
A	Has only A antigen on red cells (and B antibody in the plasma)
B	Has only B antigen on red cells (and A antibody in the plasma)
AB	Has both A and B antigens on red cells (but neither A nor B antibody in the plasma)
O	Has neither A nor B antigens on red cells (but both A and B antibody are in the plasma)

  - The universal red cell donor has Type O negative blood type
  - The universal plasma cell donor has Type AB positive blood type.

- **Donating blood by compatibility type**
  - In a blood transfusion, a patient must receive a blood type compatible with his or her own blood type. If the blood types are not compatible, red blood cells will clump together, making clots that can block blood vessels and cause death.

Blood Type	Donate Blood To	Receive Blood From
A+	A+ AB+	A+ A- O+ O-
O+	O+ A+ B+ AB+	O+ O-
B+	B+ AB+	B+ B- O+ O-
AB+	AB+	Everyone
A-	A+ A- AB+ AB-	A- O-
O-	Everyone	O-
B-	B+ B- AB+ AB-	B- O-
AB-	AB+ AB-	AB- A- B- O-

- **Blood types are inherited just like the eye colour.** The chart below shows possible blood type of a child according to their parents blood group

Parent 1	AB	AB	AB	AB	B	A	A	O	O	O
Parent 2	AB	B	A	O	B	B	A	B	A	O
O					🩸	🩸	🩸	🩸	🩸	🩸
A	🩸	🩸	🩸	🩸		🩸	🩸		🩸	
B	🩸	🩸	🩸	🩸	🩸	🩸		🩸		
AB	🩸	🩸	🩸			🩸				

  - **RH Factor Inheritance**
    - We inherit one Rh factor from each parent, either Rh+ or Rh-. Everyone has 2 Rh "factors" in their blood cells. They can be either positive (+) or negative (-). The only way to be Rh negative is for both parents to have at least 1 negative (-) factor and for you to receive it from both of them.
    - If you receive one Rh+ factor you are Rh+. **Only those people with two Rh negative "factors" are considered Rh- blood type**.
    - **Possible Rh Factor combinations are**
      a. ++ = Rh positive
      b. +- = Rh positive
      c. -- = Rh Negative
    - **Examples**
      a. If both parents are ++, then the child must be ++
      b. If both parents are --, then child must be --
      c. If one parent is ++ and the other parent is +-, there is 50/50 chance of the child being either ++ or +-.

      A child who is (--) cannot come from a parent who is (++) , because the child must inherit at least one of those (+'s). Both parents must have at least 1 Negative (-) "setting" to have a Rh-Negative Child.

- **Bombay Blood**
  - It is a blood type called (hh)- , a rare one (1 in 10,000 Indians) first discovered in 1952).

- **Biology behind Blood types**
  - The markers on the cell are determined by a master type called H, out of which are generated types A, B, AB and O.
  - The Bombay doctors found that the **hh type (Bombay type people)** can accept only from other hh type, and also can receive only from the hh types. This makes the Bombay Blood types a very special and rare category of people.
  - **How did this happen and why are these people so rare**? It is largely because of **extensive inbreeding within the same lineage or close-community marriages**, often consanguineous, such that the **'blood type' or the gene pool is greatly restricted**. Such intra-community marriages have happened in small isolated communities such as the gypsies, Russian Jewish or Parsi communities. **It is thus likely that the Bombay Blood types have common ancestral origins.**