Cell - Cell Organelles: Plasma Membrane, Cell Wall, Cytoplasm, Nucleus, Mitochondria. Prokaryotic Cells vs. Eukaryotic Cells. Plant Cell vs. Animal Cell.

Cell

Robert Hooke	Discovered and coined the term cell in 1665
Robert Brown	Discovered Cell Nucleus in 1831
Schleiden and Schwann	Presented The cell theory, that all the plants and animals are composed of cells and that the cell is the basic unit of life. Schleiden (1838) and Schwann (1839).

- With the discovery of the electron microscope in 1940, it was possible to observe and understand the complex structure of the cell and its various organelles.

Cell Organelles

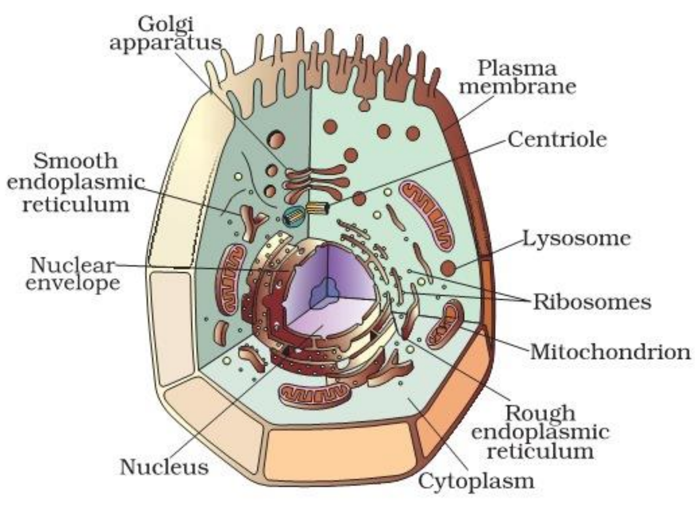


Fig. 5.5: *Animal cell*

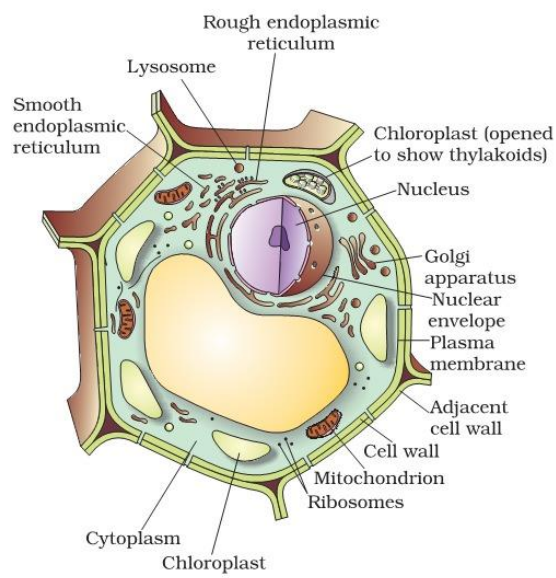


Fig. 5.6: *Plant cell*

Plasma Membrane or 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.

Endocytosis

- 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. Such processes are known as endocytosis (endo → internal; cyto → of a cell). **Amoeba** acquires its food through such processes.

Diffusion

- Plasma membrane is a selectively permeable membrane [The plasma membrane is porous and allows the movement of substances or materials both inward and outward].
- Some substances like carbon dioxide or oxygen can move across the cell membrane by a process called **diffusion** [spontaneous movement of a substance from a region of high concentration (hypertonic solution) to a region where its concentration is low (hypotonic solution)].
- Thus, diffusion plays an important role in gaseous exchange between the cells as well as the cell and its external environment.

Osmosis

- Water also obeys the law of diffusion. The movement of water molecules through a selectively permeable membrane is called osmosis.
- Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration. Thus, **osmosis is a special case of diffusion** through a selectively permeable membrane.
- Unicellular freshwater organisms and most plant cells tend to gain water through osmosis. **Absorption of water by plant roots** is also an example of osmosis.
- Thus, diffusion is important in exchange of gases and water in the life of a cell. In additions to this, the cell also obtains nutrition from its environment.
- Different molecules move in and out of the cell through a type of transport requiring use of energy in the form of **ATP.**

Reverse Osmosis (RO)

- Reverse osmosis (RO) is a **water purification technology** that uses a semipermeable membrane to remove larger particles from drinking water.
- In reverse osmosis, an **applied pressure** is used to overcome osmotic pressure.
- Reverse Osmosis is a phenomenon where pure water flows from a dilute solution [hypotonic] through a semi permeable membrane to a higher concentrated solution [hypertonic].
- **Semi permeable** means that the membrane will allow small molecules and ions to pass through it but acts as a barrier to larger molecules or dissolved substances.

Cell Wall

- Cell wall is **absent in animals**.
- Plant cells, in addition to the plasma membrane, have another **rigid** outer covering called the cell wall. The cell wall lies **outside** the 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 shrinkage or contraction of the contents of the cell away from the cell wall. This phenomenon is known as plasmolysis (plasma → fluid; lysis → disintegration, decomposition).
- **Only living cells**, and not dead cells, are able to absorb water by osmosis. Cell walls permit the cells of **plants, fungi** and **bacteria** to withstand very dilute [hypotonic] external media without shrinkage.
- In such media the cells tend to lose water by osmosis. The cell shrinks, building up pressure against the cell wall. The wall exerts an equal pressure against the shrunken cell.
- Cell wall also prevents the bursting of cells when the cells are surrounded by a hypertonic medium (medium of high concentration).
- In such media the cells tend to gain water by osmosis. The cell swells, building up pressure against the cell wall. The wall exerts an equal pressure against the swollen cell.
- Because of their walls, plant cells can withstand much greater changes in the surrounding medium than animal 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 many specialized **cell organelles [**mitochondria, golgi bodies, ribosomes, etc**]**.
- Each of these organelles performs a specific function for the cell.
- Cell organelles are enclosed by **membranes**.
- The significance of membranes can be illustrated with the example of viruses.
- **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.

Nucleus

- It is an important component of the living cell.
- It is generally spherical and located in the center of the cell.
- It can be stained and seen easily with the help of a microscope.
- 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 [diffusion].
- With a microscope of higher magnification, we can see a smaller spherical body in the nucleus. It is called the **nucleolus**.
- In addition, nucleus contains thread-like structures called **chromosomes**. These 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**.
- Gene is a **unit of inheritance** in living organisms. It controls the transfer of a hereditary characteristic from parents to offspring. This means that your parents pass some of their characteristics on to you.
- Nucleus, in addition to its role in inheritance, acts as **control center** of the activities of the cell.
- The entire content of a living cell is known as **protoplasm [cytoplasm + nucleus]**. It includes the cytoplasm and the nucleus. Protoplasm is called the **living substance** of the cell.
- The nucleus of the bacterial cell is not well organized like the cells of multicellular organisms. There is **no nuclear membrane**.
- Every cell has a membrane around it to keep its own contents separate from the external environment.
- Large and complex cells, including cells from multicellular organisms, need a lot of chemical activities to support their complicated structure and function.
- To keep these activities of different kinds separate from each other, these cells use membrane-bound little structures (or 'organelles') within themselves.

Chromosomes

- The nucleus contains chromosomes, which are visible as rod-shaped structures only when the cell is about to divide.
- Chromosomes contain **information for inheritance** of features from parents to next generation in the form of **DNA (deoxyribo nucleic acid)**
- Chromosomes are composed of **DNA and Protein**.
- DNA molecules contain the information necessary for constructing and organizing cells. Functional segments of dna are called **genes**.
- In a cell which is not dividing, this dna is present as part of **chromatin material**. Chromatin material is visible as entangled mass of thread like structures. Whenever the cell is about to divide, the chromatin material gets **organised into chromosomes**.
- The nucleus plays a central role in **cellular reproduction**, the process by which a single cell divides and forms two new cells.
- It also plays a crucial part, along with the environment, in determining the way the cell will develop and what form it will exhibit at maturity, by directing the chemical activities of the cell.

Prokaryotic Cells vs. Eukaryotic Cells

- Organisms whose cells **lack a nuclear membrane**, are called **prokaryotes** (pro = primitive or primary; karyote ≈karyon = nucleus).
- Organisms with cells **having a nuclear membrane** are called eukaryotes.
- Prokaryotic cells also **lack most of the other cytoplasmic organelles** present in eukaryotic cells.
- Many of the functions of such organelles are also performed by **poorly organised parts of the cytoplasm**.
- The chlorophyll in photosynthetic prokaryotic bacteria is associated with **membranous vesicles (bag like structures) but not with plastids** as in eukaryotic cells.

Prokaryotes → defined nuclear region, the membrane-bound cell organelles are absent.

Eukaryotic Cells → have nuclear membrane as well as membrane-enclosed organelles.

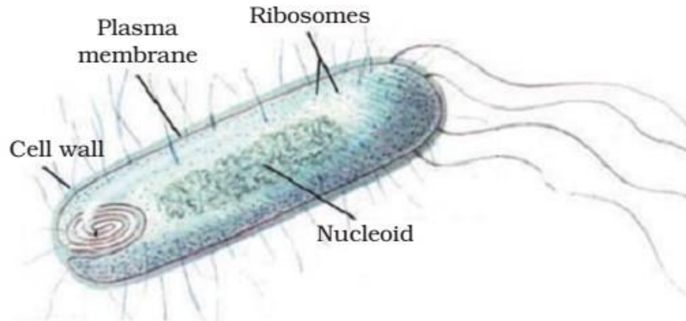


Fig. 5.4: *Prokaryotic cell*

	Prokaryotes	Eukaryotes
Organisms	Monera: Eubacteria and Archebacteria	Protists, Fungi, Plants and Animals
Meaning of name	Pro = before Karyon = nucleus	Eu = after Karyon = nucleus
Evolution	3.5 billion years ago (older type of cell)	1.5 billion years ago
Uni-/multicellular	Unicellular (less complex)	Multicellular (more complex)
Cell wall	almost all have cell walls (murein)	fungi and plants (cellulose and chitin): none in animals
Organelles	usually none	many different ones with specialized functions
Metabolism	anaerobic and aerobic: diverse	mostly aerobic

Genetic material	single circular double stranded DNA	complex chromosomes usually in pairs; each with a single double stranded DNA molecule and associated proteins contained in a nucleus
Location of genetic information	Nucleoid region	Nucleus
Mode of division	binary fission mostly; budding	mitosis and meiosis using a spindle: followed by cytokinesis

Nucleoid

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

Vacuoles

- Empty structure in the cytoplasm is called vacuole. It could be single and big as in an onion cell (plant cell). Cheek cells (animal cells) have smaller vacuoles.
- **Large vacuoles are common in plant cells. Vacuoles in animal cells are much smaller.**
- Vacuoles are **storage sacs** for solid or liquid contents.
- The central vacuole of some plant cells may occupy 50-90% of the cell volume.
- In plant cells vacuoles are full of cell sap and provide **turgidity** [swollen and distended or congested] and **rigidity** to the cell.
- 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.
- In single-celled organisms like amoeba, the food vacuole contains the food items that the amoeba has consumed.
- In some unicellular organisms, specialized vacuoles also play important roles in expelling excess water and some wastes from the cell

Endoplasmic Reticulum (ER)

- The endoplasmic reticulum (ER) is a large network of membrane-bound tubes and sheets. It looks like long tubules or round or long bags (vesicles).
- 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)**.

Rough Endoplasmic Reticulum RER – Ribosomes

- RER looks rough under a microscope because it has particles called **ribosomes** attached to its surface.
- The ribosomes, which are present in all active cells, are the **sites of protein manufacture.**
- The manufactured proteins are then sent to various places in the cell depending on need, using the ER.

Smooth Endoplasmic Reticulum SER

- The SER helps in the manufacture of **fat molecules, or lipids**, important for cell function.

Functions of Endoplasmic Reticulum (ER)

- Some of these proteins and lipids help in building the cell membrane. This process is known as **membrane biogenesis**.
- Some other proteins and lipids function as **enzymes and hormones**.
- Although the ER varies greatly in appearance in different cells, it always forms a network system.
- Thus, one function of the ER is to serve as **channels for the transport** of materials (especially proteins) between various regions of the cytoplasm or between the cytoplasm and the nucleus.
- The ER also functions as a cytoplasmic framework providing a **surface** for some of the **biochemical activities** of the cell.
- **In the liver cells of the group of animals called vertebrates, SER plays a crucial role in detoxifying many poisons and drugs**.

Golgi Apparatus or Golgi Complex

- The golgi apparatus consists of a system of membrane-bound vesicles arranged approximately parallel to each other in stacks called **cisterns**.
- These membranes often have connections with the membranes of ER and therefore constitute another portion of a complex cellular membrane system.
- The material synthesized near the ER is **packaged and dispatched** to various targets inside and outside the cell through the golgi apparatus.
- Its functions include the **storage, modification and packaging** of products in vesicles.
- In some cases, **complex sugars** may be made from simple sugars in the golgi apparatus.
- The golgi apparatus is also involved in the formation of **lysosomes**.

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.

- Foreign materials entering the cell, such as bacteria or food, as well as old organelles end up in the lysosomes, which break them up into small pieces. Lysosomes are able to do this 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.
- Structurally, lysosomes are membrane-bound sacs filled with digestive enzymes. These enzymes are made by **RER**.

Mitochondria

- Mitochondria are known as the **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.

[If Mitochondria is the Power Plant. ATP is the Electricity].

- ATP is known as the **energy currency** of the cell.
- The body uses energy stored in ATP for making new chemical compounds and for mechanical work.
- Mitochondria have **two membrane** coverings instead of just one.
- The outer membrane is very porous while the inner membrane is **deeply folded**. These folds create a large surface area for **ATP-generating chemical reactions**.
- Mitochondria are strange organelles in the sense **that they have their own DNA** and **ribosomes**. Therefore, mitochondria are able to make some of their **own proteins [ribosomes prepare proteins]**.

Plastids

- You might have noticed several small colored bodies in the cytoplasm of the cells of Tradescantia leaf. They are scattered in the cytoplasm of the leaf cells. These are called plastids.
- 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.
- Chloroplasts are important for **photosynthesis** in plants.
- Chloroplasts also contain various yellow or orange pigments in addition to chlorophyll.
- Plastids are present **only in plant cells**. There are two types of plastids – **chromoplasts (coloured plastids)** and **leucoplasts (white or colourless plastids)**.
- Leucoplasts are primarily organelles in which materials such as starch, oils and protein granules are stored.
- The internal organization of the plastids consists of numerous membrane layers embedded in a material called the stroma.

- Plastids are similar to mitochondria in external structure. Like the mitochondria, **plastids also have their own dna and ribosomes**.

Summary

- Each cell acquires its structure and ability to function because of the organization of its membrane and organelles in specific ways. The cell thus has a basic structural organization. This helps the cells to perform functions like respiration, obtaining nutrition, and clearing of waste material, or forming new proteins. Thus, the cell is the fundamental structural unit of living organisms. It is also the basic functional unit of life.
- Cells are enclosed by a plasma membrane composed of **lipids and proteins**.
- The presence of the cell wall enables the cells of plants, fungi and bacteria to exist in hypotonic media without bursting.
- The ER functions both as a passage way for intracellular transport and as a manufacturing surface.
- The golgi apparatus consists of stacks of membrane-bound vesicles that function in the storage, modification and packaging of substances manufactured in the cell.
- Most plant cells have large membranous organelles called plastids, which are of two types – chromoplasts and leucoplasts.
- Chromoplasts that contain chlorophyll are called chloroplasts and they perform photosynthesis. Leucoplasts help in the storage of oils, starch and protein granules.
- Most mature plant cells have a large central vacuole that helps to maintain the **turgidity** of the cell and stores important substances including wastes.
- Prokaryotic cells have **no membrane-bound organelles**, their chromosomes are composed of only nucleic acid, and they have **only very small ribosomes** as organelles.
- A white blood cell (**WBC**) in human blood is an example of a single cell which can change its shape.
- Bacterial cell also has a cell wall.
- In egg white material is albumin which solidifies on boiling. The yellow part is yolk. It is part of the single cell.
- **Valonia ventricosa**, a species of algae with a diameter that ranges typically from 1 to 4 centimetres is among the largest unicellular species.

Plant Cell vs. Animal Cell

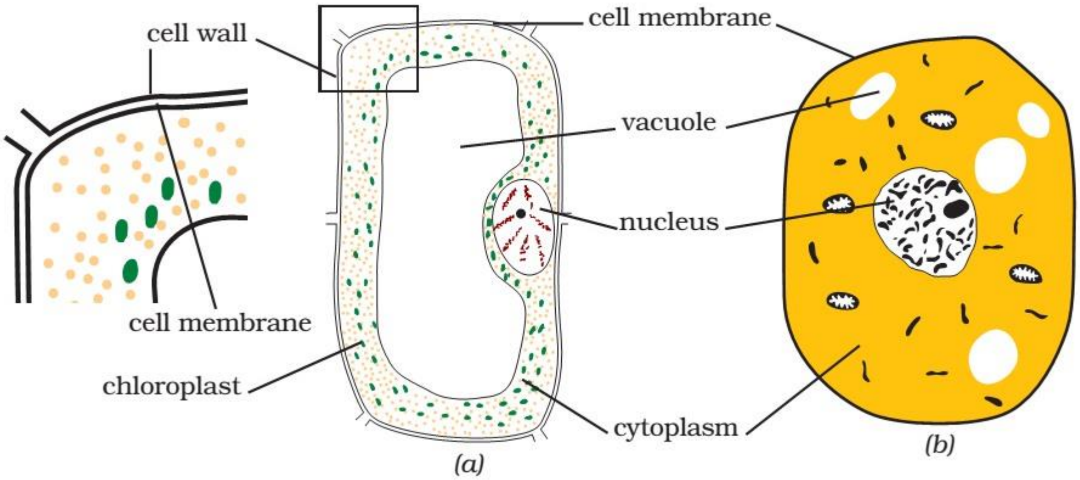


Fig. 8.7 : *(a) Plant cell (b) Animal cell*

Table 8.1 : Comparison of Plant Cell and Animal Cell

	Animal Cell	**Plant Cell**
Nucleus	Present	Present
Cilia	Present	It is very rare
Shape	Round (irregular shape)	Rectangular (fixed shape)
Chloroplast	Animal cells don't have chloroplasts	Plant cells have chloroplasts because they make their own food
Cytoplasm	Present	Present
Endoplasmic Reticulum (Smooth and Rough)	Present	Present
Ribosomes	Present	Present
Mitochondria	Present	Present
Vacuole	One or more small vacuoles (much smaller than plant cells).	One. large central vacuole taking up 90% of cell volume.

Questions

- Can you name the two organelles we have studied that contain their own genetic material?
- What would happen to the life of a cell if there was no golgi apparatus?
- Where do the lipids and proteins constituting the cell membrane get synthesised?
- What is osmosis?
- Why are lysosomes known as suicide bags?
- Where are proteins synthesized inside the cell?

Q1. Statements

1. Diffusion and osmosis are similar processes.
2. In osmosis, the particles flow from hypertonic solution to hypotonic solution.
3. In Reverse Osmosis, the particles flow from hypotonic solution to hypertonic solution.
4. Osmosis is used in water purification process.
5. Reverse osmosis is used by plant cells to avoid bursting due to plasmolysis.

Which of the above are true?

a. All
b. 3,4 and 5 only
c. 1,2 and 3 only
d. 1 and 2 only

Q2. Statements

1. Protoplasm = Cytoplasm + Nucleus + Plasma Membrane
2. Osmosis happens in dead cells as well.
3. Bacteria have cell walls.
4. Virus are non-living substances.
5. Animals have no cell walls and vacuoles.

Which of the above are true?

a. All
b. 3,4 only
c. 2, 3 and 5 only
d. 1, 3 and 4 only

Answers

Q1 → C

Q2 → B

Biomolecules – Carbohydrates – Monosaccharides: Glucose, Fructose; Disaccharides: Sucrose, Lactose; Oligosaccharides and Polysaccharides: Starch, Cellulose, Glycogen.

Biomolecule

- A biomolecule [biological molecule] is any molecule that is present in living organisms — microorganisms, plants and animals.
- They are mostly made up of **carbon, oxygen, hydrogen** and **nitrogen**.
- **Proteins, carbohydrates, lipids,** and **nucleic acids [DNA** and **RNA]** are Macromolecules or Macro-biomolecules.
- Other small molecules such as vitamins, primary metabolites, secondary metabolites, etc. are also biomolecules.
- Most biomolecules are organic compounds.

Metabolism == the chemical processes that occur within a living organism to maintain life.

Metabolite == a substance formed in or necessary for metabolism.

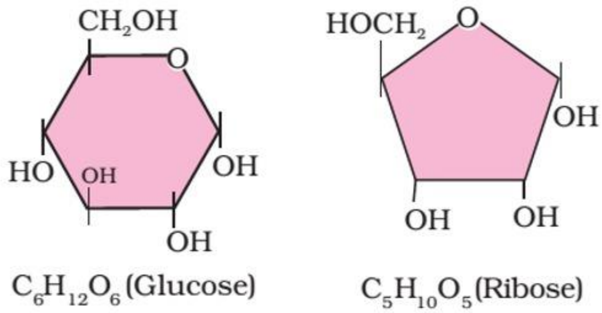
Primary metabolite == Metabolite that is directly involved in normal growth, development, and reproduction. Eg: **ethanol, lactic acid**, and **certain amino acids**.

Secondary metabolite == Metabolites that are not directly involved in the normal growth, development, or reproduction of an organism. Unlike primary metabolites, absence of secondary metabolites does not result in immediate death, but rather in long-term impairment. Eg: ergot alkaloids, antibiotics, etc.

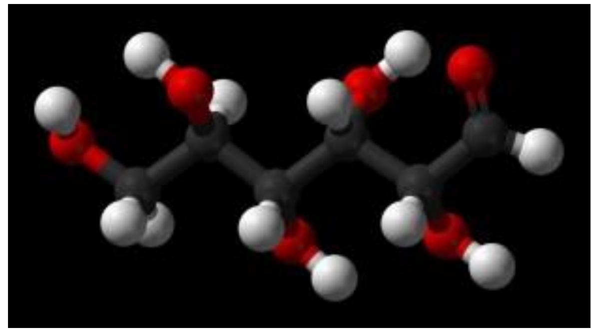
Alkaloid == any of a class of nitrogenous organic compounds of plant origin which have pronounced physiological actions on humans. Eg: **morphine** obtained from **opium poppy**.

Carbohydrates

- Carbohydrates are one of the most important biomolecules that forms a major part of the living things.
- Carbohydrates are primarily produced by **plants** and form a very large group of naturally occurring organic compounds.
- Some common examples of carbohydrates are cane **sugar, glucose, starch,**
- Most of them have a general formula, $C_x(H_2O)_y$, and were considered as **hydrates of carbon** from where the name carbohydrate was derived.



Sugars (Carbohydrates)



Hydrate == a compound in which water molecules are chemically bound to another compound or an element. Eg: α-d-Glucose hydrate ($C_6H_{14}O_7$).

- For example, the molecular formula of glucose ($C_6H_{12}O_6$) fits into this general formula, $C_6(H_2O)_6$. But all the compounds which fit into this formula may not be classified as carbohydrates.

Acetic acid (CH_3COOH) fits into this general formula **$C_x(H_2O)_y$** → $C_2(H_2O)_2$ but is **not a carbohydrate.**

Exception: **Rhamnose**, $C_6H_{12}O_5$ is a **carbohydrate** but does not fit in this definition of **$C_x(H_2O)_y$**.

- Chemically, the carbohydrates may be defined as optically active **polyhydroxy [multiple HO groups]** aldehydes or ketones or the compounds which produce such units on hydrolysis.

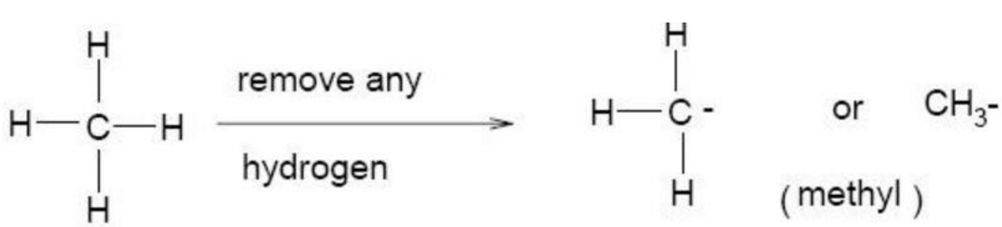
Carbohydrates produce **aldehydes** and **ketones** on **hydrolysis** [the chemical breakdown of a compound due to reaction with water].

Aldehyde == an organic compound containing the group — CHO, formed by the **oxidation of alcohols**. Typical aldehydes include methanal (formaldehyde) and ethanal (acetaldehyde).

Ketone == an organic compound containing a carbonyl group =C=O bonded to two alkyl groups, e.g. acetone].

Alkyl == denoting a hydrocarbon radical derived from an alkane by removal of a hydrogen atom].

Alkane == any of the series of saturated hydrocarbons including methane, ethane, propane, and higher members].



alkane-alkyl

- Some of the carbohydrates, which are sweet in taste, are also called **sugars**.
- The most common sugar, used in our homes is named as **sucrose** whereas the sugar present in milk is known as **lactose**.
- Carbohydrates are also called **saccharides** (Greek: sakcharon means sugar).
- Carbohydrates are classified on the basis of their behavior on hydrolysis. They have been broadly divided into following three groups.

Monosaccharides

- A carbohydrate that cannot be hydrolyzed further to give simpler unit of polyhydroxy aldehyde or ketone is called a monosaccharide.
- About 20 monosaccharides are known to occur in nature. Some common examples are **Glucose**, **Fructose**, **Ribose**, **Galactose**, etc.
- If a monosaccharide contains an aldehyde group [–CHO], it is known as an **aldose** and if it contains a keto group [=C=O], it is known as a **ketose**.

Glucose

- Glucose occurs freely in nature as well as in the combined form.
- It is present in **sweet fruits** and **honey**. **Ripe grapes** also contain glucose in large amounts.
- Glucose is an **aldohexose [**An aldohexose is a hexose with an aldehyde group on one end**]** and is also known as **dextrose**. It is the **monomer** of many of the larger carbohydrates, namely **starch, cellulose**.

Aldohexose == An aldohexose is a hexose with an aldehyde group on one end.

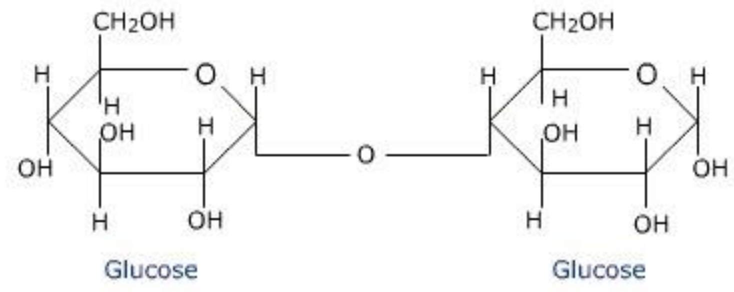
Aldehyde group [–CHO]

Hexose == any of the class of simple sugars whose molecules contain six carbon atoms (e.g. glucose)

- It is probably the most abundant organic compound on earth.
- Glucose is found to exist in two different crystalline forms which are named as α and β.
- Such isomers, i.e., α-form and β-form, are called **anomers**.

Fructose

- Fructose is an important **ketohexose**. It is obtained along with glucose by the hydrolysis of disaccharide, **sucrose**.
- The two monosaccharides are joined together by an oxide linkage formed by the loss of a water molecule.
- Such a linkage between two monosaccharide units through **oxygen atom** is called **Glycosidic Linkage**.



Glycosidic Linkage

Ribose

- The ribose β-D-ribofuranose forms part of the backbone of RNA. It is related to deoxyribose, which is found in DNA.

Galactose

- Galactose is a monosaccharide. When combined with glucose (monosaccharide), through a condensation reaction, the result is the disaccharide **lactose**.
- The hydrolysis of lactose to glucose and galactose is catalyzed by the enzymes **lactase** and β-**galactosidase**.

Oligosaccharides

- Carbohydrates that yield **two to ten** monosaccharide units, on hydrolysis, are called oligosaccharides.
- They are further classified as **disaccharides**, **trisaccharides**, **tetrasaccharides**, etc., depending upon the number of monosaccharides, they provide on hydrolysis.
- Amongst these the most common are **disaccharides**.
- The two monosaccharide units obtained on hydrolysis of a disaccharide may be **same or different.**
- For example, sucrose on hydrolysis gives one molecule each of glucose and fructose whereas maltose gives two molecules of glucose only.

Sucrose == Glucose + Fructose

Maltose == Glucose + Glucose

Lactose == Glucose + Galactose

Sucrose

- One of the common disaccharides is sucrose which on hydrolysis gives equimolar mixture of glucose and fructose.

Maltose

- Another disaccharide, maltose is composed of two α-D-glucose units

Lactose

- It is more commonly known as **milk sugar** since this **disaccharide is found in milk**. It is composed of β-D-galactose and β-D-glucose.

Polysaccharides

- Carbohydrates which yield a large number of monosaccharide units on hydrolysis are called polysaccharides.
- Some common examples are **Starch, Cellulose, Glycogen, Gums,**
- Polysaccharides are **long chains of sugars**. Polysaccharides are **not sweet** in taste, hence they are also called **non-sugars**.
- They are threads (literally a cotton thread) containing different **monosaccharides** as building blocks.
- For example, **Cellulose** is a polymeric polysaccharide consisting of only one type of monosaccharide i.e., **Glucose**. Cellulose is a homopolymer. **Starch** is a variant of this but present as a store house of energy in plant tissues.
- Animals have another variant called **Glycogen**.
- **Inulin** is a polymer of **fructose**.
- Plant cell walls are made of cellulose. Paper made from plant pulp and cotton fibre is **cellulosic**. There are more **complex polysaccharides** in nature.
- Exoskeletons of arthropods, for example, have a complex polysaccharide called These complex polysaccharides are mostly homopolymers.

Starch

- Polysaccharides contain a large number of monosaccharide units joined together by **glycosidic linkages**.
- These are the **most commonly** encountered carbohydrates in nature.
- They mainly act as the food storage or structural materials.
- Starch is the main storage polysaccharide of plants.
- It is the most **important dietary source** for human beings.
- High content of starch is found in cereals, roots, tubers and some vegetables.
- It is a polymer of α-glucose and consists of two components — **Amylose** and **Amylopectin**.
- **Amylose is water soluble** polysaccharide which constitutes about 15-20% of starch.

- **Amylopectin is water insoluble** polysaccharide which constitutes about 80- 85% of starch.

Cellulose

- Cellulose occurs **exclusively in plants** and it is the most abundant organic substance in plant kingdom.
- It is a predominant constituent of **cell wall** of plant cells.
- Cellulose is a straight chain polysaccharide **composed only of β-D-glucose units**.

Glycogen

- The carbohydrates are stored in animal body as
- It is also known as **animal starch** because its structure is similar to amylopectin and is rather more highly branched.
- It is present in **liver, muscles** and **brain**.
- Glycogen is also found in yeast and fungi.
- When the body needs glucose, enzymes break the glycogen down to glucose.

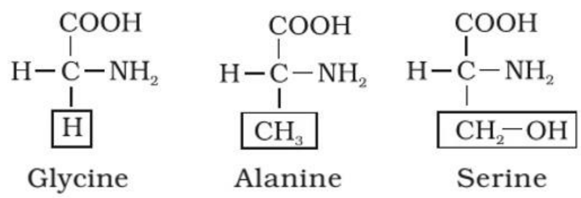
Importance of Carbohydrates

- Carbohydrates are essential for life in both plants and animals.
- They form a major portion of our food. Honey has been used for a long time as an instant source of energy in ayurvedic system of medicine.
- Carbohydrates are used as storage molecules as **starch in plants** and **glycogen in animals.**
- Cell wall of bacteria and plants is made up of cellulose which is a carbohydrate.
- We build furniture, etc. from cellulose in the form of wood and clothe ourselves with cellulose in the form of **cotton fibre**.
- They provide raw materials for many important industries like textiles, paper, lacquers and breweries.

Amino Acids – Proteins – Structure of Proteins, Fibrous proteins, Globular proteins, Role of Proteins. Enzymes, Factors Affecting Enzyme Activity.

Amino Acids

- Amino acids are organic compounds containing an **amino group [NH_2]** and an **acidic group [COOH]** as substituents on the same carbon i.e., the a-carbon. Hence, they are called a-amino acids. They are **substituted methanes**.



Amino acids

- All proteins are **polymers of α-amino acids**.
- Amino acids contain **amino (–NH2)** and **carboxyl (–COOH)** functional groups.
- Depending upon the relative position of amino group with respect to carboxyl group, the amino acids can be classified as α, β, γ, δ and so on.
- Only **α-amino acids** are obtained on hydrolysis of proteins.
- All α-amino acids have trivial names, which usually reflect the property of that compound or its source.
- **Glycine** is so named since it has **sweet taste** (in Greek glykos means sweet) and **tyrosine** was first obtained from cheese (in Greek, tyros means cheese.)
- Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule.

1. **Equal number of amino and carboxyl groups makes it neutral;**
2. **more number of amino than carboxyl groups makes it basic and**
3. **more carboxyl groups as compared to amino groups makes it acidic.**

- The amino acids, which can be synthesized in the body, are known as **nonessential amino acids**.
- On the other hand, those which cannot be synthesized in the body and must be obtained through diet, are known as **essential amino acids.**
- Amino acids are usually colorless, crystalline solids. These are **water-soluble**, high melting solids and behave like **salts** rather than simple amines or carboxylic acids.
- This behavior is due to the presence of both **acidic (carboxyl group)** and **basic (amino group) groups** in the same molecule.
- In aqueous solution, the carboxyl group can lose a proton and amino group can accept a proton, giving rise to a dipolar ion known as **zwitter ion**. This is neutral but contains both positive and negative charges.

- In zwitter ionic form, amino acids show **amphoteric** behavior as they react both with acids and bases.
- Except **glycine**, all other naturally occurring α-amino acids are **optically active**, since the α-carbon atom is asymmetric.

Proteins

- Proteins are the **most abundant** biomolecules of the living system.

Table 9.4 Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

- Chief sources of proteins are milk, cheese, pulses, peanuts, fish, meat, etc.
- They occur in every part of the body and form the fundamental basis of structure and functions of life.
- They are also required for **growth and maintenance** of body.
- The word protein is derived from Greek word, "proteios" which means primary or of prime importance.
- Proteins are **polypeptides**.

[**Peptide** == a compound consisting of two or more **amino acids** linked in a chain].

- Proteins are linear chains of amino acids linked by **peptide bonds**.
- Each protein is a **polymer of amino acids**.

[**Monomer** == a molecule that can be bonded to other identical molecules to form a polymer].

- Dietary proteins are the source of essential **amino acids**.
- Therefore, amino acids can be essential or non-essential.

[**Non-Essential Amino Acids** == Amino Acids that our body can make].

[**Essential Amino Acids** == We get them through our diet/food].

- **Collagen** is the most abundant protein in animal world.
- **Ribulose bisphosphate Carboxylase-Oxygenase (RuBisCO)** is the most abundant protein in the whole of the biosphere.

Structure of Proteins

- You have already read that proteins are the polymers of α-amino acids and they are connected to each other by **peptide bond** or **peptide linkage**.
- Chemically, peptide linkage is an amide [an organic compound containing the group -C(O)NH2] formed between –COOH group and $–NH_2$
- The reaction between two molecules of similar or different amino acids, proceeds through the combination of the **amino group of one molecule** with the **carboxyl group of the other**.
- This results in the elimination of a water molecule and formation of a **peptide bond –CO–NH–**. The product of the reaction is called a **dipeptide** because it is made up of **two amino acids**.
- If a third amino acid combines to a dipeptide, the product is called a **tripeptide**.
- **A tripeptide contains three amino acids linked by two peptide linkages**.
- Similarly when four, five or six amino acids are linked, the respective products are known as tetrapeptide, pentapeptide or hexapeptide, respectively.
- When the number of such amino acids is more than ten, then the products are called **polypeptides**.
- A polypeptide with more than hundred amino acid residues, having molecular mass higher than 10,000u is called a **protein**.
- However, the distinction between a polypeptide and a protein is not very sharp.
- Polypeptides with fewer amino acids are likely to be called proteins if they ordinarily have a well-defined conformation of a protein such as **insulin** which contains **51 amino acids**.
- Proteins can be classified into two types on the basis of their molecular shape: **Fibrous Proteins** and **Globular proteins**.

Fibrous proteins

- When the polypeptide chains run parallel and are held together by **hydrogen** and **disulphide** bonds, then fibre– like structure is formed.
- Such proteins are generally **insoluble in water**. Some common examples are **keratin** (present in hair, wool, silk) and **myosin** (present in muscles), etc.

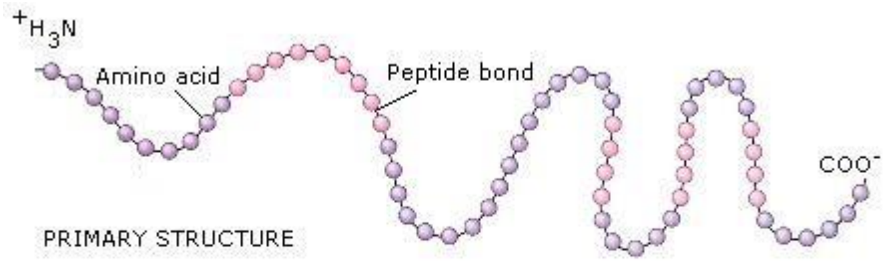
Globular proteins

- This structure results when the chains of polypeptides coil around to give a **spherical shape**.
- These are usually **soluble in water**. **Insulin** and **albumin**s are the common examples of globular proteins.

Primary structure of proteins

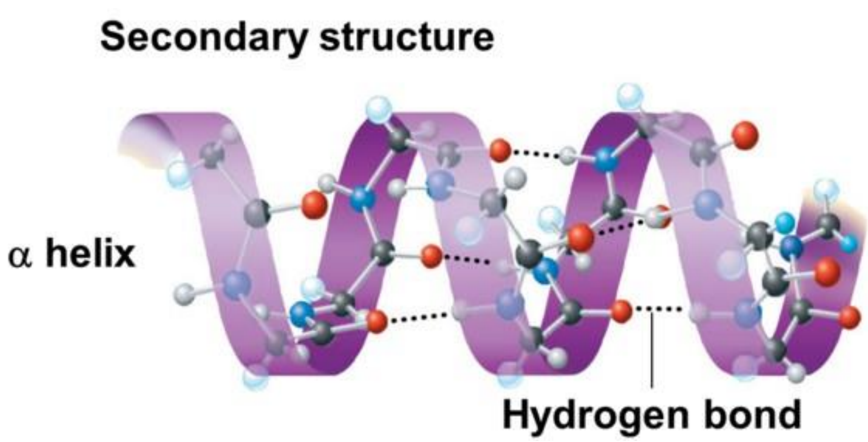
- Proteins may have one or more polypeptide chains. Each polypeptide in a protein has amino acids linked with each other in a specific sequence and it is this sequence of amino acids that is said to be the primary structure of that protein.

- Any change in this primary structure i.e., the sequence of amino acids creates a different protein.



Secondary structure of proteins

- The secondary structure of protein refers to the shape in which a long polypeptide chain can exist.
- Protein found in a biological system with a unique three-dimensional structure and biological activity is called a **native protein**.
- When a protein in its native form, is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and **protein loses its biological activity**. This is called **denaturation of protein**.
- During denaturation 2° and 3° structures are destroyed but 1° structure remains intact. The **coagulation of egg white** on boiling is a common example of denaturation. Another example is **curdling of milk** which is caused due to the formation of lactic acid by the bacteria present in milk.



Role of Proteins

1. Some transport nutrients across cell membrane,
2. some fight infectious organisms,
3. some are hormones,
4. some are enzymes, etc.

TABLE 9.5 Some Proteins and their Functions

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4	Enables glucose transport into cells

Enzymes

- Life is possible due to the coordination of various chemical reactions in living organisms. An example is the digestion of food, absorption of appropriate molecules and ultimately production of energy. This process involves a sequence of reactions and all these reactions occur in the body under very mild conditions. This occurs with the help of certain **biocatalysts** called **enzymes**.

Catalyst == a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change.

- Almost all the enzymes are **globular proteins**.
- Enzymes are very specific for a particular reaction and for a particular substrate.
- They are generally named after the compound or class of compounds upon which they work. For example, the enzyme that catalyses hydrolysis of maltose into glucose is named as **maltase**.
- Sometimes enzymes are also named after the reaction, where they are used. For example, the enzymes which catalyse the oxidation of one substrate with simultaneous reduction of another substrate are named as **oxidoreductase** The ending of the name of an enzyme is **-ase**.
- **Almost all enzymes are proteins**.
- There are some **nucleic acids** that behave like enzymes. These are called **ribozymes**.
- An enzyme like any protein has a primary structure, i.e., amino acid sequence of the protein.

- Enzyme catalysts differ from inorganic catalysts in many ways. Inorganic catalysts work efficiently at high temperatures and high pressures, while enzymes get damaged at high temperatures (say above 40°C).
- However, enzymes isolated from organisms who normally live under extremely high temperatures (e.g., hot vents and sulphur springs), are stable and retain their catalytic power even at high temperatures (up to 80°-90°C). Thermal stability is thus an important quality of such enzymes isolated from thermophilic organisms.

Thermophile == a bacterium or other microorganism that grows best at high temperatures (above 45°C).

Factors Affecting Enzyme Activity

- The activity of an enzyme can be affected by a change in the conditions which can alter the structure of the protein. These include temperature, pH, change in substrate concentration or binding of specific chemicals that regulate its activity.

Temperature and pH

- Enzymes generally function in a narrow range of temperature and pH.
- Each enzyme shows its highest activity at a particular temperature and pH called the **optimum temperature and optimum pH**.
- Activity declines both below and above the optimum value.
- Low temperature preserves the enzyme in a **temporarily inactive state** whereas high temperature **destroys enzymatic activity** because proteins are **denatured by heat**.

Concentration of Substrate

- With the increase in substrate concentration, the velocity of the enzymatic reaction rises at first. The reaction ultimately reaches a maximum velocity (Vmax) which is not exceeded by any further rise in concentration of the substrate. This is because the enzyme molecules are fewer than the substrate molecules and after saturation of these molecules, there are no free enzyme molecules to bind with the additional substrate molecules.
- The activity of an enzyme is also sensitive to the presence of specific chemicals that bind to the enzyme. When the binding of the chemical shuts off enzyme activity, the process is called **inhibition** and the chemical is called an **inhibitor**.
- When the inhibitor closely resembles the substrate in its molecular structure and inhibits the activity of the enzyme, it is known as **competitive inhibitor**.

Summary

- Proteins are the polymers of about twenty different α-amino acids which are linked by **peptide bonds**.
- Ten amino acids are called essential amino acids because they cannot be synthesised by our body, hence must be provided through diet.
- Proteins perform various structural and dynamic functions in the organisms.
- Proteins which contain only α-amino acids are called **simple proteins**.
- The secondary or tertiary structure of proteins get disturbed on change of pH or temperature and they are not able to perform their functions. This is called **denaturation of proteins**.
- Enzymes are biocatalysts which speed up the reactions in biosystems. They are very specific and selective in their action and chemically all enzymes are proteins.

Primary and Secondary Metabolites, Vitamins, Deficiency Diseases, Micronutrients – Vitamins and Minerals, Food Sources of Vitamins and Minerals.

Primary and Secondary Metabolites

- In animal tissues, one notices the presence of all categories of compounds shown in Figure 9.1. These are called primary metabolites.
- However, when one analyses plant, fungal and microbial cells, one would see thousands of compounds other than these called primary metabolites, e.g. alkaloids, flavonoids, rubber, essential oils, antibiotics, colored pigments, scents, gums, spices. These are called secondary metabolites.

TABLE 9.4 Average Composition of Cells

Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

TABLE 9.1 A Comparison of Elements Present in Non-living and Living Matter*

Element	% Weight of Earth's crust	% Weight of Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65.0
Nitrogen (N)	very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	negligible

TABLE 9.3 Some Secondary Metabolites

Pigments	Carotenoids, Anthocyanins, etc.
Alkaloids	Morphine, Codeine, etc.
Terpenoides	Monoterpenes, Diterpenes etc.
Essential oils	Lemon grass oil, etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin, etc.
Polymeric substances	Rubber, gums, cellulose

TABLE 9.2 A List of Representative Inorganic Constituents of Living Tissues

Component	Formula
Sodium	Na^+
Potassium	K^+
Calcium	Ca^{++}
Magnesium	Mg^{++}
Water	H_2O
Compounds	$NaCl$, $CaCO_3$, PO_4^{3-}, SO_4^{2-}

Vitamins

- Vitamins are organic compounds that are required in small amounts in our diet but their deficiency causes specific diseases.
- Most of the vitamins cannot be synthesized in our body but plants can synthesize almost all of them, so they are considered as **essential food factors**.
- However, the **bacteria of the gut** can produce some of the vitamins required by us.
- All the vitamins are generally available in our diet. Different vitamins belong to various chemical classes and it is difficult to define them on the basis of structure.
- They are generally regarded as **organic compounds** required in the diet in **small amounts** to perform **specific biological functions** for normal maintenance of optimum growth and health of the organism.
- Vitamins are designated by alphabets A, B, C, D, etc. Some of them are further named as sub-groups e.g. B1, B2, B6, B12, etc.
- Vitamin A keeps our skin and eyes healthy.
- Vitamin C helps body to fight against many diseases. Vitamin C gets easily destroyed by heat during cooking.
- Vitamin D helps our body to use calcium for bones and teeth.
- Excess of vitamins is also harmful and vitamin pills should not be taken without the advice of doctor.
- The term “Vitamine” was coined from the word vital + amine since the earlier identified compounds had amino groups.
- Later work showed that most of them did not contain amino groups, so the letter ‘e’ was dropped and the term vitamin is used these days.
- Vitamins are classified into two groups depending upon their **solubility** in water or fat.

Fat soluble vitamins

- Vitamins which are soluble in fat and oils but insoluble in water are kept in this group. These are vitamins **A, D, E and K**. They are stored in **liver** and **adipose (fat storing) tissues**.

Water soluble vitamins

- **B** group vitamins and vitamin **C** are soluble in water so they are grouped together.
- Water soluble vitamins **must be supplied regularly** in diet because they are readily **excreted in urine and cannot be stored** (except vitamin B12) in our body.

Deficiency Diseases

- A person may be getting enough food to eat, but sometimes the food may not contain a particular nutrient. If this continues over a long period of time, the person may suffer from its deficiency.
- Deficiency of one or more nutrients can cause diseases or disorders in our body. Diseases that occur due to lack of nutrients over a long period are called deficiency diseases.

1. **Vitamin A--------- Night blindness**
2. **Vitamin B1---------Beriberi**
3. Vitamin B2-------- Ariboflavinosis
4. Vitamin B3 --------Pellagra
5. Vitamin B5 --------Paresthesia
6. **Vitamin B6 --------Anemia**
7. Vitamin B7 ------ Dermatitis, enteritis
8. Vitamin B9 & Vitamin B12 ----- Megaloblastic anemia
9. **Vitamin C ------ Scurvy, Swelling of Gums**
10. **Vitamin D ------ Rickets & Osteomalacia**
11. Vitamin E ------ Less Fertility
12. **Vitamin K ------ Non-Clotting of Blood.**

Vitamin/ Mineral	Deficiency disease/disorder	Symptoms
Vitamin A	Loss of vision	Poor vision, loss of vision in darkness (night), sometimes complete loss of vision
Vitamin B1	Beriberi	Weak muscles and very little energy to work
Vitamin C	Scurvy	Bleeding gums, wounds take longer time to heal
Vitamin D	Rickets	Bones become soft and bent
Calcium	Bone and tooth decay	Weak bones, tooth decay
Iodine	Goiter	Glands in the neck appear swollen, mental disability in children
Iron	Anaemia	Weakness

Micronutrients – Vitamins and Minerals

https://www.dsm.com/content/dam/dsm/cworld/en_US/documents/what-are-micronutrients.pdf

- Micronutrients, as opposed to macronutrients (protein, carbohydrates and fat), are comprised of **vitamins and minerals** which are required in small quantities to ensure normal metabolism, growth and physical well-

Vitamins

- These are essential organic nutrients, most of which are not made in the body, or only in insufficient amounts, and are mainly obtained through food.
- When their intake is inadequate, vitamin deficiency disorders are the consequence.
- Although vitamins are only present and required in minute quantities, compared to the macronutrients, they are as vital to health and need to be considered when determining nutrition security.
- Each of the 13 vitamins known today have specific functions in the body: **vitamin A, provitamin A (Beta-carotene), vitamin B1, vitamin B2, vitamin B6, vitamin B12, biotin, vitamin C, vitamin D, vitamin E, folic acid, vitamin K, niacin and pantothenic acid.**

Minerals

- These are inorganic nutrients that also play a key role in ensuring health and well-
- They include the trace elements **copper, iodine, iron, manganese, selenium and zinc** together with the macro elements **calcium, magnesium, potassium and sodium**.

Five Important Micronutrients

- As with vitamins, minerals they are found in small quantities within the body and they are obtained from a wide variety of foods.
- No single food contains all of the vitamins and minerals we need and, therefore, a balanced and varied diet is necessary for an adequate intake.
- Of course, we already know a huge amount about how these work, and the importance they have in normal human growth and development.
- Based on this, an Expert Panel of nutritionist, NGOs and development agencies indentified five micronutrients such as those below in their priority group:

Vitamin A

- This vital micronutrient is found in a range of different foods including carrots, spinach, broccoli, milk, egg, liver and fish.
- It plays an essential role in **vision** (lack of Vitamin A is a common cause of blindness), reproduction and growth, and the functioning of a healthy immune system (it plays a key role in the development of white blood cells).
- Worldwide about 5 million children under the age of five are affected by **xerophthalmia**, a serious eye disorder caused by vitamin A deficiency.
- These children are at **risk of becoming blind** and are more likely to die of common childhood diseases.

Folate (folic acid)

- This is a generic term for a **group of B vitamins** including **folic acid** and naturally occurring
- Folic acid is a synthetic folate compound used in vitamin supplements and fortified food because of its increased stability.
- Folates are found in egg, dairy products, asparagus, orange juice, dark green leafy vegetables, beans and brown bread.
- They play a key role in the **metabolism of amino acids** and the **production of proteins**, the **synthesis of nucleic acid** (the molecules that carry genetic information in the cells), and the **formation of blood cells**.

Iodine

- **Seaweed and fish** are rich sources but in many countries the addition of iodine (known as iodization) to salt is an important source.
- Iodine is one of the most important elements required by the **developing foetus** due to its effect on **brain development**.
- Iodine also serves a number of other important functions especially in the **production of hormones.**
- **Goitre** is a visible sign of severe iodine deficiency.

Iron

- Iron has a number of key functions within the body. It acts as a **carrier for oxygen** from the lungs to the body's tissues – it does so in the form of **hemoglobin** – and it also integral to the working of various tissues through the role that it plays in enzymatic reactions.
- Iron deficiency ultimately leads to **iron deficiency anemia**, the most common cause of anemia, a condition in which the blood lacks healthy red bloods cells required to carry oxygen, and which results in morbidity and death.
- Iron deficiency is the most widespread health problem in the world, impairing normal mental development in 40-60% of infants in the developing world.
- Iron-rich foods include lentils, red meat, poultry, fish, lentils, leaf vegetables and chick-

Zinc

- Found in a range of foodstuffs including liver, eggs, nuts, cereals and seafood.
- The absence of zinc is associated with a number of conditions including, **short stature, anemia, impaired healing of wounds, poor gonadal function, and impaired cognitive and motor function.**
- It can also lead to appetite disorders, as well as contributing to the increased severity and incidence of **diarrhea and pneumonia**.
- The most important effect of zinc deficiency is its impact on children's resistance to infectious diseases including the **risk of infection**, the recurrence of infections and the severity of

infection. This is well document in the case of diarrhoea. Zinc nutrition is therefore an important determinant of mortality in children.

Food Sources of Vitamins and Minerals

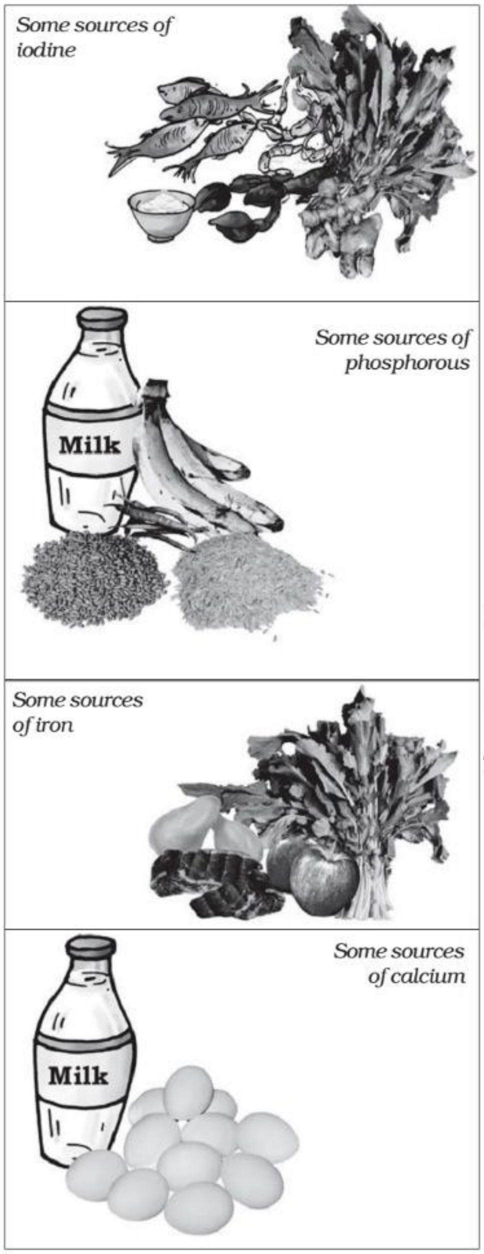


Fig. 2.10 *Sources of some minerals*

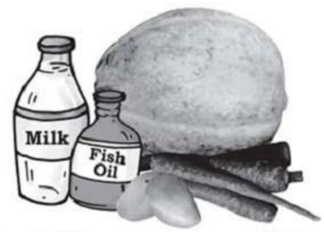


Fig. 2.6 *Some sources of Vitamin A*

Fig. 2.7 *Some sources of Vitamin B*

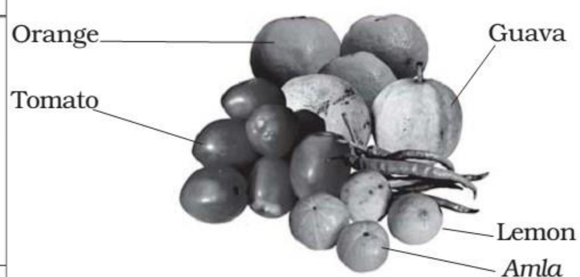


Fig. 2.8 *Some sources of Vitamin C*

Fig. 2.9 *Some sources of Vitamin D*

Dietry Fibers

- Dietary fibres are also known as roughage. Roughage is mainly provided by plant products in our foods.
- Whole grains and pulses, potatoes, fresh fruits and vegetables are main sources of roughage.
- Roughage does not provide any nutrient to our body, but is an essential component of our food and adds to its bulk. This helps our body get rid of undigested food.

Questions

Q1. Besides proteins and carbohydrates, other elements of nutritional value found in milk, include [1996]

a. Calcium, potassium and iron
b. **Calcium and potassium**
c. Potassium and iron
d. Calcium and iron

Q2. What is average fat content of Buffalo Milk?

a. **2%**
b. 5%
c. 0%
d. 0%

Buffalo Milk → 7.2%

Cow Milk → 4.4%

Buffalo's milk contain all nutrients in higher proportion than the cow's milk.

Q3. Prelims GS 2014: Consider the following pairs:

Vitamin Deficiency Disease

1. Vitamin C Scurvy
2. Vitamin D Rickets
3. Vitamin E Night blindness

Which of the pairs given above is/ are correctly matched?

a. **1 and 2 only**
b. 3 only
c. 1, 2 and 3
d. None

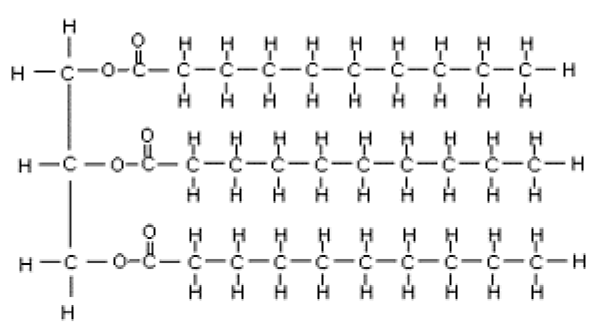
Fats - Lipids, Fatty Acids | Healthy Fats – Omega-3 and Omega-6, Monounsaturated and Polyunsaturated. Unhealthy Fats – Saturated Fat and Trans Fat.

Fats

- Fat is one of the three main macronutrients: fat, carbohydrate, and protein.
- Fat is a major source of energy and helps your body absorb vitamins.
- Fat has the most calories compared to any other nutrient. Controlling fat intake is one of the most important steps in losing or maintaining weight and preventing or delaying type 2 diabetes.
- Fats, also known as **triglycerides**, are esters of three **fatty acid chains** and the **alcohol glycerol**.
- Fats are solids at room temperature. Oil refers to a fat with unsaturated fatty acid chains that is liquid at room temperature.
- Fats, like other lipids, are generally **insoluble in water**.

Lipid

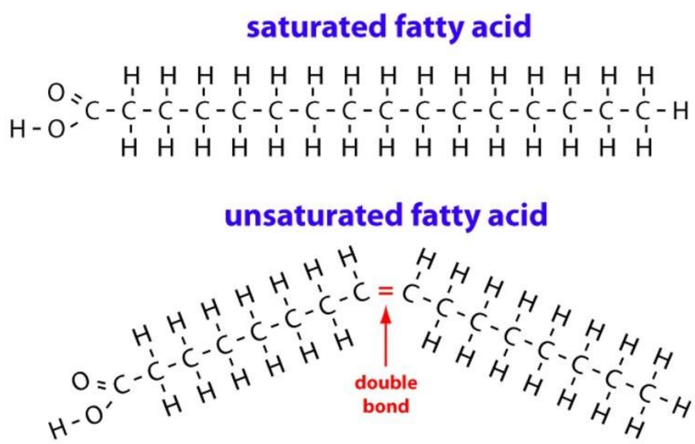
- A lipid is chemically defined as a substance that is **insoluble in water** and soluble in alcohol and chloroform.
- Lipids are an important component of living cells. Together with carbohydrates and proteins, lipids are the main constituents of plant and animal cells.
- **Cholesterol** and **triglycerides** are lipids. Lipid is not necessarily a triglyceride.
- Glycerol is a simple sugar alcohol compound. A triglyceride is an ester derived from glycerol and three fatty acids (tri + glyceride)
- **Triglycerides** are the main constituent of body fat in humans and animals, as well as vegetable fat.



Triglycéride

Fatty Acid

- A fatty acid is a carboxylic acid with a long aliphatic chain [organic compounds in which carbon atoms form open chains], which is either saturated or unsaturated.
- Some fatty acids are called essential because they cannot be synthesized in the body from simpler constituents.
- There are two essential fatty acids (EFAs) in human nutrition: **alpha-linolenic acid (an omega-3 fatty acid)** and **linoleic acid (an omega-6 fatty acid).**
- Fats and other lipids are broken down in the body by enzymes called **LIPASES** produced in the
- Fats are made of long chains of carbon (C) atoms. Some carbon atoms are linked by single bonds (-C-C-) and others are linked by double bonds (-C=C-).



Saturated fat

- A saturated fat is a fat in which the fatty acids all have **single bonds**.
- A saturated fat has the maximum number of hydrogens bonded to the carbons, and therefore is 'saturated' with hydrogen atoms.
- **Most animal fats are saturated** whereas the **fats of plants and fish are generally unsaturated**.
- Many experts recommend a **diet low in saturated fat**.
- Saturated fats are popular with manufacturers of processed foods because they are **less vulnerable to rancidity** and are, in general, **more solid at room temperature** than unsaturated fats.

Unsaturated fat

- An unsaturated fat is a fat or fatty acid in which there is at least one **double bond** within the fatty acid chain.
- Where double bonds are formed, hydrogen atoms are eliminated.
- In cellular metabolism, unsaturated fat molecules contain somewhat less energy (i.e., fewer calories) than an equivalent amount of saturated fat.

- The greater the degree of unsaturation in a fatty acid (i.e., the more double bonds in the fatty acid) the more vulnerable it is to **rancidity** [lipid oxidation][rusting of fats].
- **Antioxidants** can protect unsaturated fat from lipid oxidation.

Healthy Fats – Omega-3 and Omega-6, Monounsaturated and Polyunsaturated

- The main types of "healthy" fats are **monounsaturated**, **polyunsaturated, alpha-linolenic acid (an omega-3 fatty acid)** and **linoleic acid (an omega-6 fatty acid)**.
- The fat is termed "monounsaturated" if there is one double bond, and "polyunsaturated" if there are two or more double bonds.
- Omega-3 and Omega-6 fatty acids are heart healthy fats and can help in lowering high triglyceride values in blood. They are found in fish, soybean products, Walnuts etc.
- Both of these fatty acids are needed for growth and repair, but can also be used to make other fatty acids.
- The omega-3 and omega-6 are fatty acids are both polyunsaturated. The difference is in where the first of the double bonds occurs.
- Both omega-3 (ω-3) and omega-6 (ω-6) fatty acids are important components of cell membranes.
- There is increasing support for omega-3 fatty acids in protecting against fatal heart disease and it is known that they have **anti-inflammatory effects**.
- There is also growing interest in the role of omega-3 fatty acids in the prevention of diabetes and certain types of cancer.
- Monounsaturated and polyunsaturated fat are considered "heart healthy" and can help with improving cholesterol when used in place of unhealthy fats.
- Some sources of these fats include almonds, cashews, pecans, peanuts, pine nuts, pumpkin, sesame seeds, sunflower seeds, Olive oil and olives, vegetable oils (such as sunflower, safflower, corn, soybean, and cottonseed).

Unhealthy Fats – Saturated Fat and Trans Fat

- The main types of "unhealthy" fats are **saturated** and **trans-fat**.
- Saturated fats are primarily found in foods that come from animals, such as meat and dairy.
- Saturated fats are unhealthy because they increase LDL ("bad" cholesterol) levels in your body and increase your risk for heart disease.
- Many saturated fats are "solid" fats that you can see, such as the fat in meat. Other sources of saturated fats include high-fat cheeses, high-fat cuts of meat, butter, Ice cream, palm and coconut oils, etc..
- Trans fats, or trans-unsaturated fatty acids, trans fatty acids, are a type of unsaturated fats that are uncommon in nature.
- Trans fat is simply **liquid oils turned into solid fats** during food processing. There is also a small amount of trans fat that occurs naturally in some meat and dairy products, but those found in processed foods tend to be the most harmful to your health.
- Trans fats are worse than saturated fats. They increase LDL ("bad" cholesterol) and decreasing HDL ("healthy" cholesterol).
- Trans fatty acids are used as preservative in packaged food items. Foods containing trans-fat are usually labeled as "**partially hydrogenated**".
- Partially hydrogenated oil is less likely to spoil, so foods made with it have a longer shelf life.
- Trans fats are easy to use, inexpensive to produce and last a long time. Trans fats give foods a desirable taste and texture.

Q1. Statements:

- Trans fats are considered beneficial for the human body
- Double bond chemistry of the fat molecules in Trans fats causes a Plaque formation
- Omega-3 fatty acids are considered healthier than the saturated fatty acids

Codes:

a. 1 & 3
b. 2 & 3
c. 1 & 2
d. 1, 2, 3

Ans. B