Biology

01 Chemical Basis of Life

The bodies of all organisms are composed of variety of chemical compounds. These chemical compounds are formed by the bonding of naturally existing elements in different ways.

There are only about 25 elements in the living body out of the 92 elements present in nature. They are present at different locations in the body in different forms.

The most common 4 elements in the living body are Carbon, Hydrogen, Oxygen and Nitrogen. Other than above Sulphur, Phosphorous, Sodium, Potassium, Calcium, Magnesium, Iron and Chlorine are essential for the survival of organisms.

Figure 1.1 shows the percentages of main elements in the human body.

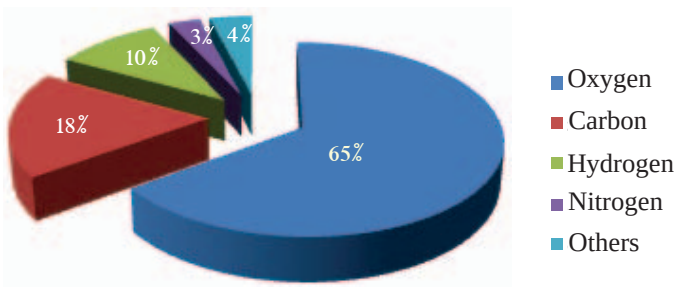


Figure 1.1- Percentages of 4 common elements in the human body (mass basis)

Chemical compounds that build up living matter can be divided into two categories as organic compounds and inorganic compounds. Compounds which contain Carbon are known as organic compounds and compounds which do not contain Carbon are known as inorganic compounds. (Carbon dioxide, Carbon monoxide,Carbonates and Bicarbonates are some of the inorganic compounds which contain Carbon) Those organic compounds that build up the living body or living matter are known as bio molecules. They are:

- Carbohydrates
- Proteins
- Lipids
- Nucleic acids

These are considered as the main types of bio molecules. Instead of these four

types, Vitamins are also one of the organic compounds found in living matter. Water, minerals and gases are some of the inorganic molecules that are essential for the maintenance of life.

For extra knowledge

Element	Percentage based on mass%	Locations present in human body
O	65	All fluids, tissues, bones, proteins
C	18	everywhere in the body
H	10	All fluids, tissues, bones, proteins
N	3	All fluids, tissues, proteins
Ca	1.5	Brain, lungs, kidneys, liver, heart, thyroid gland, muscles, bones
P	1.0	Urine, bones
K	0.35	Enzymes
S	0.25	Proteins
Na	0.15	All fluids, tissues
Mg	0.05	Brain, lungs, kidneys, liver, heart, thyroid gland, muscles
Cl	0.2	Skin cells
Fe	0.007	Haemoglobin in blood
I	0.0002	Hormones in thyroid gland

1.1 Carbohydrates

This is the most abundant organic compound on earth. They are produced during the photosynthesis of green plants. Potato, sweet potato, grains, sugar, flour are some of the examples for foods which contain carbohydrates.

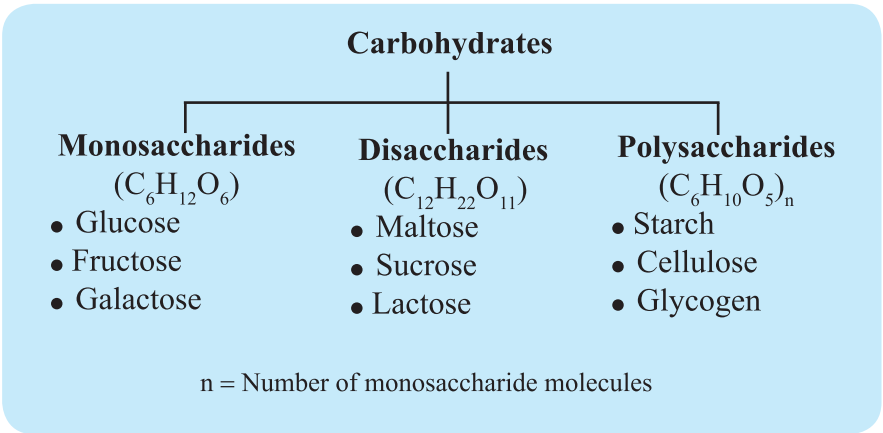
The main elemental composition of carbohydrates is Carbon (C), Hydrogen (H) and Oxygen (O).

Hydrogen and oxygen combine in 2:1 ratio in carbohydrates.

Common molecular formula

$C_x (H_2O)_y$

Carbohydrates can be classified into three groups as below according to the way they are formed.



• Monosaccharides

Monosaccharide is the structural unit of carbohydrates. They are commonly known as simple sugars. They are crystal shaped, generally sweet and water soluble molecules. Glucose, Fructose, and Galactose are examples for monosaccharides.

The characters of monosaccharides are discussed in the table below.

Table 1.1- Characters of different types of monosaccharides

Type of monosaccharide	Location it's present	Other facts
Glucose	Ripen fruits Bee honey	• The end product during hydrolysis of all starchy food is glucose. These glucose is absorbed into blood • Plants produce glucose during photosynthesis • Energy is released during breakdown of glucose in cellular respiration
Fructose	Ripen fruits Beehoney Pumpkin carrots	• Known as “fruit sugar” • Fructose is formed during ripening of fruits • This is the sweetest sugar
Galactose	Dairy products	• The end product during hydrolysis of lactose • No sweet taste

Disaccharides

Two Monosaccharides join to form a Disaccharide. During this process a water molecule is released. In the same way relevant Monosaccharides can be obtained by hydrolyzing Disaccharides. Disaccharides are sweet, water soluble crystals.

Monosaccharide + Monosaccharide $\rightleftharpoons$ Disaccharide + Water molecule

$$2\ C_6H_{12}O_6 \rightleftharpoons C_{12}H_{22}O_{11} + H_2O$$

Maltose, Sucrose and **Lactose** are examples for disaccharides.

The characters of disaccharides are discussed in the table below.

Table 1.2 - Characters of different types of disaccharides

Type of disaccharide	Location it's Present	Other Facts
Maltose	Germinating seeds	• Union of two glucose molecules forms a Maltose molecule . Glucose + Glucose ⟶ Maltose + Water • An intermediate product of starch hydrolysis
Sucrose	White and brown Sugar Sugar cane and Beet Some fruits Phloem sap in trees	• Union of a Glucose molecule with a Fructose molecule forms a Sucrose molecule Glucose + Fructose ⟶ Sucrose + Water
Lactose	In dairy products	• Union of a Glucose molecule with a Galactose molecule forms a Lactose molecule Galactose + Glucose ⟶ Lactose + Water • The only sugar that is absent in plants • Not sweet as Sucrose • The percentage of Lactose in cows milk according to the composition is 4% - 6% • The percentage of Lactose in human milk according to the composition is 6% - 7%

Polysaccharides

Polymerisation of a large number of monosaccharides form a polysaccharide molecule. Hydrolysis of Polysaccharide results relevant monosaccharides. Insoluble in normal water. They are not crystals. **Cellulose**, **Starch** and **Glycogen** are examples for polysaccharides. The structural unit of Cellulose, Starch and Glycogen is Glucose , but their properties are different according to the number of Glucose molecules and how they are bound with each other.

The characters of polysaccharides are discussed in the table below.

Table 1.3 - Characters of different types of polysaccharides

Type of polysaccharide	Location it's Present	Other Facts
Cellulose	Cell wall of plant cells In fibres	• It is not digested in the human digestive system, but it helps to avoid constipation.
Starch	Grains, Yams, Jak, Bread Fruit	• The type of carbohydrate that stores in plants is starch.
Glycogen	Animal liver and muscles	• The type of carbohydrate that stores in animal body is Glycogen

For extra knowledge

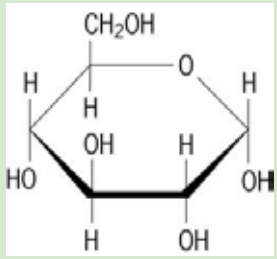


Figure 1.2 Structure of a glucose molecule

Significance of Carbohydrates

- **As an energy Source**

  The main source to obtain energy for the activities ofor ganisms ist he c arbohydrate.The Monosaccharides (Glucose) produced due to hydrolysis of those compounds release energy.
- **As a storage compound**
- **As a structural component in plant cell wall**
- **As a constituent of Nucleic acid**

Tests to identify Carbohydrates

The below mentioned tests can be conducted to test Starch, Monosaccharides and Disaccharides which are some of the identified Carbohydrates in foods.

Starch test

- Small amount of food is obtained and grind well with water.
- A drop of Iodine solution is added to the above solution.

  Purplish blue colour appears

Test for Glucose

- A solution of Glucose is obtained into a test tube.
- Few drops of Benedict solution to the above solution is added.
- The above solution is immersed in a water bath and heated.
- Can observe colour changes as below.

Blue → Green → Green yellow → Orange → Brick red precipitate

Test for (Sucrose)

- A sucrose solution is obtained into a test tube.
- Few drops of Benedict solution is added to it.
- The test tube is immersed in a water bath and heated.

  No colour change.
- Few drops of diluted Sulphuric acid (H_2SO_4) is added to a freshly prepared sugar solution and heated.
- Next few drops of Benedict solution is added to it.
- Can observe colour changes as below.

Blue → Green → Green yellow → Orange → Brick red precipitate

1.2 Proteins

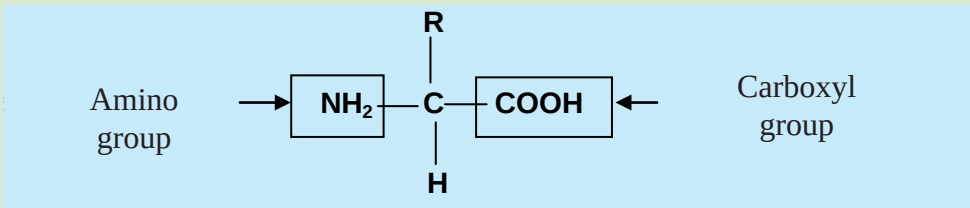
Protein is an essential constituent in all living cells. **Carbon(C) Hydrogen (H), Oxygen (O) and Nitrogen (N) are always present in proteins.** Sometimes Sulphur can also be present.

17% of the mature human body is composed of proteins. Protein is a complex molecule made up of polymerized amino acid molecules. Meat, fish, egg white cereals are some of the foods rich with proteins.

For extra knowledge

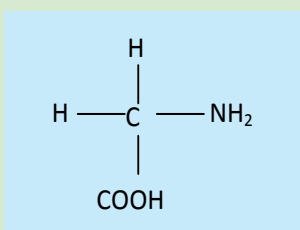
- ### Amino acids

Below is the structure of a typical amino acid molecule.



R-represents a group containing both Carbon (C) and Hydrogen (H). Due to the change in R group, 20 different amino acids are present. All proteins present in organisms from bacteria to human are made up of these 20 different amino acids combined in different sequences.

The simplest Amino acid is Glycine. Here Hydrogen (H) is present as the R group.



Some amino acids cannot be synthesized within the body. So they have to be taken from outside with food. Therefore they are known as essential amino acids.

For extra knowledge

Different proteins present in plants and animals

- Proteins present in muscles - Myosin, actin
- Proteins present in bones - Osein
- Proteins present in Red blood cells - Haemoglobin
- Proteins present in hairs - Keratin
- Proteins present in Leguminous food - Legumin
- Proteins present in wheat - Gluten
- Proteins present in egg white - Albumin

• Significance of Proteins

- **As an energy source**

  When energy supply from Lipids and Carbohydrates is not sufficient protein is used in energy generation.

- **To make structural components**

  Proteins are important components in making cell membrane. Hairs and feathers also contain keratin protein.

- **As enzymes**

  All the bio-chemical reactions take place in organisms are catalyzed by enzymes. The enzymes are proteins.

- **As hormones**

  Some hormones are proteins which involve in homeostasis and coordination of organisms.

- **As antibodies**

  The antibodies that are produced in the body to protect the body against microorganisms that enter into the body are proteins.

Test to identify proteins

Biurete test

- A solution made by grinding dhal or an egg white is obtained into a test tube.
- An extra amount of Sodium hydroxide (NaOH) and then few drops of Copper Sulphate is added into it.($CuSO_4$)

  Solution turn to purple colour

■ Enzymes

The special proteins (organic catalysts) that are produced within the organism to increase the rate of bio-chemical reactions are known as enzymes.

For example to convert Sucrose into Glucose, Sucrose has to be heated with a dilute acid. But the enzymes present in the digestive system do the same reaction at a low temperature.

Therefore the activity of enzyme is to catalyze the bio-chemical reactions.

Engage in the following activity on how enzymes function.

Activity 01

Activity of Amylase on Starch

Materials required

Flour, Amylase, Test tube, white porcelain tile, Iodine solution, Water, A stop watch

Method

- Put 2ml of Starch solution into a test tube.
- Add 2ml of Amylase (Filter a solution of ground germinating green gram (Mung) seedlings) into it and mix well.
- Get a drop from the solution after 2 minutes and place it on a white porcelain tile.
- Add a drop of Iodine onto the drop of mixture.
- Continue same procedure for about 20 minutes in 2 minute intervals.

The blue colour of the drop obtained from the mixture gradually reduces with time and finally obtains the colour of Iodine (yellow /brown colour)

Starch gives black blue colour with Iodine but it does not give colour change with Iodine after 20 minutes as there is no Starch there.That is because Starch is converted to Maltose by Amylase enzyme.

1.3 Lipids

Fats and oils belong to this group. Lipids which are solid at room temperature are called fats and liquids are called oils.

Similar to carbohydrates, fats also contain Carbon, Hydrogen and Oxygen as constituent elements. But a lipid contains much less oxygen than a carbohydrate. Lipids are insoluble in polar solvents including water. They are soluble in organic solvents.

Ground nut, coconut, gingelly, butter and margarine are examples for foods which contain lipids.

Fatty acids and glycerol react to form Lipids.

Fatty acids + Glycerol ⟶ Lipids + Water

• Significance of Lipids

- **As an energy source**

  Lipids act as an energy source as carbohydrates and proteins. More energy is produced during burning of lipids.

- **To form different structural components**

  Lipid is one of the most important compounds in cell membrane. (Specially phospho lipids and cholesterol)

- **For conservation of water**

  The wax known as cutin present on the surface of the plant body conserve water. Most animals' body covering also contains wax which helps to avoid desiccation as it is impermeable to water.

- **To maintain the body temperature**

  Warm blooded animals such as birds and mammals possess a hypodermal fat layer which acts as a thermal insulator. It helps to maintain their body temperature.

- **To protect internal body organs**

  The fat layer surrounds the organs and structures in the body and absorbs external shocks. Thereby provides protection.

- **To synthesize some hormones**

  Some Hormones of vertebrates (Oestrogen, Testosterone, Cortisone) are lipid compounds.

Test to identify lipids

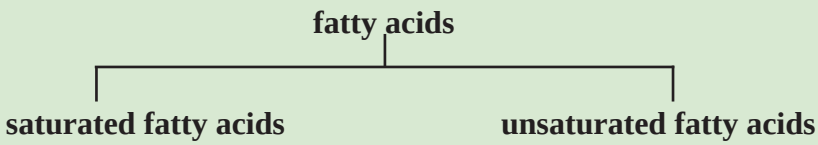
Sudan III test

- Some amount of gingelly oil or coconut oil is added into a test tube.
- Sudan III reagent is added into it.

Appearance of red fat globules

For extra knowledge

Fatty acids can be divided into two groups as follows.



Saturated fatty acids

fatty acids which contain only single bonds within Carbon atoms are called saturated fatty acids. Saturated fatty acids exist in room temperature as solids or semi-solids.

Unsaturated fatty acids

fatty acids which contain one or several double bonds within Carbon atoms are called unsaturated fatty acids.

Unsaturated fatty acids exist in room temperature as liquids.

1.4 Nucleic Acids

Nucleic acid is the most important molecule out of the main bio molecules in living matter in genetical aspect. It is a linear polymer made up of large number of nucleotides. **It contains Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N) and Phosphorous (P).**

For knowledge

Each nucleotide is made up of 3 components. They are ;

- **Nitrogenous base**
- **Pentose suger group**
- **Phosphate group**

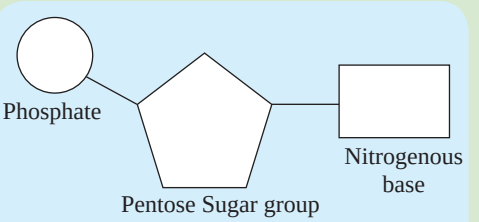


Figure 1.3 - A nucleotide

There are two types of Nucleic acids

- DNA - Deoxy ribo Nucleci Acid
- RNA - Ribo Nucleic Acid

- **DNA**

The structural unit of DNA is Deoxy ribo Nucleotide. DNA transfers genetic characteristics from generation to generation

- **RNA**

Except DNA, the other nucleic acid present in organisms is RNA.

The structural unit of RNA is Ribonucleotide.

Protein synthesis is the function of RNA.

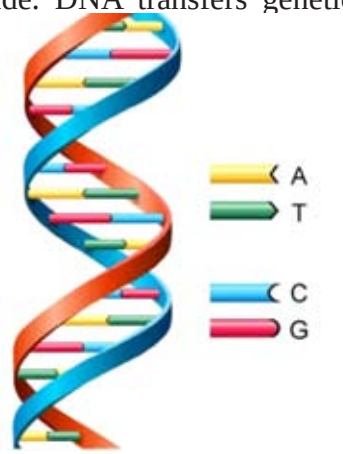


Figure 1.4- The structure of a DNA molecule

- **Significance of Nucleic acid**

- Important in storage of genetic information of organisms.
- Important in transferring genetic information from generation to generation.
- Important in protein synthesis process.
- Important in controlling all cellular activities in a cell. The information to control cellular activities is present in DNA.
- RNA is important in storing genetic information of some viruses.
- The variations occur in DNA due to mutations are important in evolution.

The above bio molecules contain mainly Carbon (C), Hydrogen (H),Oxygen (O) and Nitrogen (N). We will conduct below mentioned activities to confirm the presence of those elements.

Activity 02

Identification of water as a constituent in food

Materials required

Meat, Egg shell, Plant leaves, Crucibles

Method

- Grind /crush meat, egg shell, and leaves in their dried form separately.
- Put them separately into the crucibles and heat them.
- During heating, hold a glass sheet above the crucible.
- Use Anhydrous Cobalt Chloride / Copper Sulphate to identify whether the liquid drops on the glass is water.

Blue coloured Anhydrous Cobalt Chloride turn to pink and white coloured Anhydrous Copper Sulphate turn to blue. Then it is confirmed that water is formed on the glass sheet. Therefore the food that is used for the experiment contains water as a constituent.

Activity 03

Identification of presence of Carbon(C) in bio-molecules

Materials required

Several crucibles, Spinach stems, Piece of fish, Chick pea

Method

- Make pulps by crushing all above materials separately.
- Put them separately into crucibles and heat well.
- The final residue obtained should be rubbed against a white paper.

Lines drawn due to coal is observed.

Can confirm the food that is used for the experiment contains Carbon (C).

Activity 04

Identification of presence of Nitrogen(N) in bio-molecules

Materials Required

Two test tubes, solution of Sodium hydroxide, solution of Copper sulphate, egg white, piece of fish.

Method

- Crush fish thoroughly, add water and mix well. Filter the solution.
- Put 2ml of the fish extraction and egg white into separate test tubes.
- Add equal volume of sodium hydroxide.
- Add few drops of copper sulphate to it.

Purple colour appears in the solution and this confirms the presence of Protein in food. As Nitrogen is a constituent of Proteins, it is confirmed that the above tissues contain Nitrogen.

1.5 Water

The highest proportion of the body mass of living organisms is composed of water which is an inorganic compound. Two third ($2/3^{rd}$) of the body weight of most of organisms is by water. Water is an essential medium for the maintenance of living matter. Life originated in water. Composition of water is simple. As water is the most abundant inorganic compound found in livings beings, it is important in many biological functions. The table below, shows the specific properties of water and contribution of them to the maintenance of life.

Assignment - 1.1

As a group, collect information about specific features of water and functions to maintain life. Use internet, news papers and other journals. Present those information in a creative way to the class.

Table 1.4 - Specific properties of water and its contribution for the maintenance of life

Specific Property	The contribution for the maintenance of life
• A good solvent	• Provides a medium for bio-chemical reactions in the cells of organisms. • The main constituent in the extra-cellular fluids of organisms. • Facilitates removal of excretory material and faecal matter of animals. • Important in respiration of aquatic organisms as Oxygen (O_2) is soluble in water.
• A coolant	• Due to high specific heat capacity (Amount of heat needed to increare temperature by 1^0C in 1kg of mass) the body temperature does not fluctuate quickly with changes in the environment.
• High cohesive and adhesive force	• Being the main constituent of blood,it helps to transport nutrients, vitamins and hormones to relevant locations. • Transports water to the upper parts of the plant due to high cohesive (water-water attractions) and adhesive (water-another molecule attractions) force of water molecules
• Differential expansion in freezing	• Density of water is higher than density of ice. When ice is formed they come to top layers of water keeping water as it is in the bottom. This provides living environment for aquatic organisms.

1.6 Minerals

Minerals are important as a nutrient constituent to maintain the life processes of organisms. They are absorbed as trace or macro elements into the body. The elements needed in higher amounts are known as macro elements and the elements needed in small amounts are known as trace elements.

7% of the body weight is by minerals. ¾ th of the above amount is by Calcium and Phosphorous. Other than that Potassium, Iron, Magnesium, Copper and Iodine are also included. when the elements are not present in correct amounts, plants and animals show deficiency symptoms.

Table 1.5 Functions of minerals in human body and deficiency symptoms of them

Element	Functions	Deficiency Symptoms
Potassium	• Controls the ionic balance of the fluid in the cell • For the activity of heart and muscles • Transmission of nerve impulses	• Weakening of muscles • Psychological disorders
Sodium	• Activates enzymes • Constituent of digestive juice • To maintain constant osmotic pressure in cells • Transmission of nerve impulses	• Respiratory disorders • Cramps • Nausea • Diarrhoea
Magnesium	• Constituent of bones and teeth • To control nerve activity in skeletal muscles • Help in metabolic activities	• High heart beat • Nerve irritability
Calcium	• Growth of bones and teeth • Blood clotting • Proper function of nerves • Milk production • Absorption of Vitamin B	• Weakening of bones and teeth • Growth disorders • Osteoporosis

Phosphorous	• Growth of bones and teeth • As a constituent of nucleic acid • For carbohydrate and fat metabolism • Instant release of energy in muscles and nerves	• Weakening of bones and become fragile
Iron	• Synthesis of haemoglobin • Storage of oxygen in muscles • As a constituent of enzymes	• Anaemia • Sleepiness • Hypoactive nature • Weakness in psychological development
Iodine	• Synthesis of Thyroxin hormone	• Affects development of intelligence • Lethargic attitude towards studies • Limits body height

Functions of minerals in plants and deficiency symptoms of them are mentioned in the following table.

Table 1.6 **Functions of minerals in plants and deficiency symptoms of them**

Element	Functions	Deficiency Symptoms
Nitrogen	• As a constituent of amino acid, proteins, nucleic acid and chlorophyll	• Retardation in growth • Chlorosis in mature leaves
Phosphorous	• As a constituent of nucleic acid and ATP (Adenosine Tri Phosphate)	• Retarded growth of roots • Red and purple patches on leaves
Potassium	• Protein synthesis • Opening and closing of stomata	• Chlorosis in leaves • Yellow or brown patches in leaves

Iron	• Synthesis of chlorophyll • Synthesis of respiratory enzymes	• Chlorosis in tender leaves
Calcium	• Component of cell wall To maintain the structure and functions of plasma membrane For the Activity of enzymes	• Dying of tissues at the tips of the leaves
Zinc	• For the activity of most enzymes Synthesis of chlorophyll	• Dead cells and tissues throughout the plant. Extra thickness in leaves
Sulphur	• As a constituent of amino acids and proteins	• Chlorosis in veins and areas between veins.

Nitrogen deficiency symptoms
(Chlorosis in mature leaves)

Zinc deficiency symptoms
(Extra thickness in leaves)

Phosphrous deficiency symptoms
(Red and purple patches on leaves)

Potassium deficiency symptoms
(Yellow or brown patches in leaves)

Calcium deficiency symptoms
(Dying of tissues at tips of the leaves)

Figure 1.5- Deficiency symptoms in plants

Assignment 1.2

Observe a field or a farm and collect different parts of plants with different deficiency symptoms. Identify the deficient element for the relevent disease condition. (Make sure not to harm the cultivation)

1.7 Vitamins

They are organic compounds important in bio chemical reaction. Vitamins can be classified into 2 groups according to the solubility in water. Vitamin B and C are water soluble and A, D, E, and K are insoluble in water. But these are fat soluble.

The vitamins are needed for activities of human body, Their uses and deficiency symptoms are given in table 1.7.

Table 1.7 - Uses of vitamins and their deficiency symptoms

Type of Vitamin	Use	Deficiency Symptoms
Vitamin A	• Formation of visual pigments important in eye vision • To keep skin healthy and fair	• Night blindness • Bitot's patches in the eye • Dryness in the skin • Blisters on knees and elbow • Diseases associated with respiratory tract
Vitamin B	• Maintenance of nerves • To maintain a healthy skin • Formation of bone marrow • Maturation of Red Blood Cells • Antibody production	• Beriberi • Anaemia • Dryness in skin • Change in complexion • Reduction in antibody production
Vitamin C	• To keep skin healthy • To form enamel. • To synthesize collagen fibers.	• Weakening of gum • Internal bleeding • Delays recovery from diseases • Scurvy

Vitamin D	• Controls absorption of calcium and phosphorous	• Rickets (Deforming of bones)
Vitamin E	• Growth of tissues and cells	• Premature births • Increase rate of breaking down of red blood cells • Weaknesses in cell division • Weaknesses in reproduction
Vitamin K	• To produce components needed for blood clotting	• Delays blood clotting

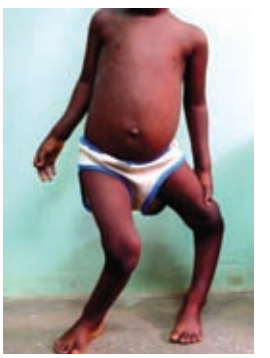
For knowledge

Vitamin B is a complex vitamin. There are vitamins as B_1, B_2, B_6, B_{12} in that complex. These are obtained through food and some vitamins are synthesized by bacteria living in human intestine.

Vitamin A deficiency symptoms
(Bito patches in the eye)

Vitamin B deficiency symptoms
(Change in complexion)

Vitamin C deficiency symptoms
(Weakening and bleeding of gum)



Vitamin D deficiency symptoms
(Deforming of bones)

Figure 1.6- Deficiency symptoms in Vitamins

Summary

- The main substances that form the living body are carbohydrates, proteins, lipids and nucleic acids. They are known as bio molecules belong to living matter.
- Beside organic compounds, inorganic compounds such as water, mineral salts also play an important role in living systems.
- Main elements found in bio molecules are C,H,O,N.
- The proteins that catalyze biochemical reactions are enzymes.
- Although Minerals and vitamins are needed in small amounts, when they are deficient in supply, organisms show deficiency symptoms.
- The specific properties of water are highly important in maintenance of life.

Exercises

01. Select the most appropriate answer.

(1) The food that contains highest amount of starch is,

1. Potato 2. Peanut 3. Cucumber 4. Gotukola

(2) Which belongs to monosaccharide?

1. Fructose 2. Sucrose 3. Maltose 4. Lactose

(3) A carbohydrate specially found in plants is,

1. Glycogen 2. Lactose 3. Cutin 4. Cellulose

(4) A Vitamin that helps in blood clotting is

1. Vitamin A 2. Vitamin D 3. Vitamin C 4. Vitamin K

(5) Not an organic compound present in living body,

1. Proteins 2. Water 3. Carbohydrates 4. Lipids

(6) An advantage of containing fibres in food is,

1. Low risk in cancers in large intestine 2. Prevent constipation
3. Helps, control blood sugar level 4. All the above

02. Below mentioned deficiency symptoms were identified at a health clinic conducted for grade 6 students in a particular school. Identify the relevant vitamin for the deficiency symptoms.

- Weaknesses in eye sight and bitot's patches in eyes.……..
- Weaknesses in growth of teeth and tooth decay.……..
- Bleeding gum ……..
- Wounds at ends of mouth ……..
- Anaemia ……..

(03) State 3 specific features of water. Explain one briefly mentioning how it helps in continuation of life.

Technical terms

Bio molecules	ජෛව අණු	உயிரியல் மூலக்கூறு
Enzymes	එන්සයිම	நொதியம்
Catalysts	උත්ප්‍රේරක	ஊக்கி