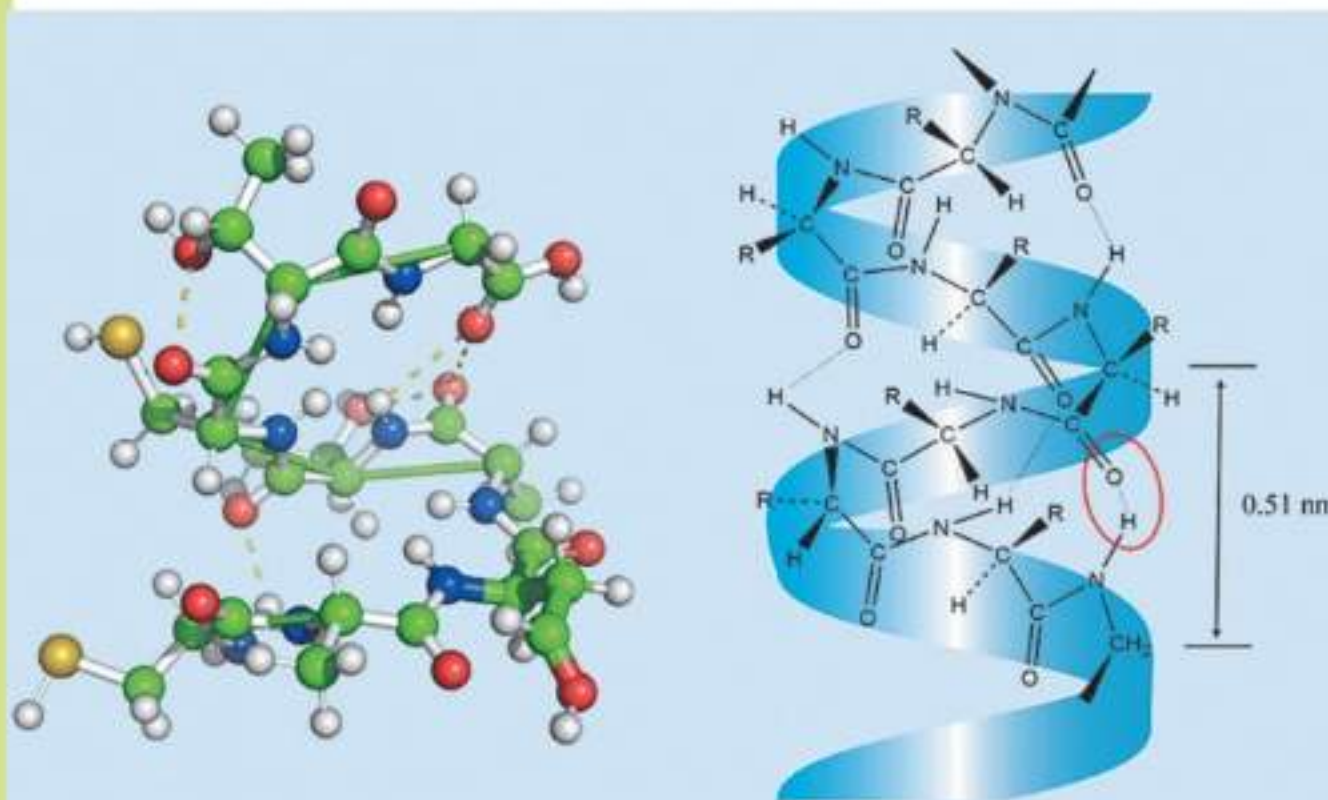


Student Learning Outcomes

After studying this chapter, students will be able to:

- Explain the importance and basics of nutrition and healthy eating
- Recognize the main biomolecules; carbohydrates, proteins, lipids and nucleic acids. their sources along-with the required daily intake for young adults
- Identify carbohydrates as a source of energy
- Describe proteins as natural polyamides and that they are formed from amino acid monomers with the general structure
- Draw the general structure of proteins
- Explain the sources, use and structure of proteins, lipids and carbohydrates
- Describe the importance of nucleic acids
- Explain vitamins, their sources and their importance to health
- Identify applications of biochemistry in testing (blood test, pregnancy test, cancer screening, parental genetic testing), genetic engineering, gene therapy and cloning





Biochemistry is the study of chemical substances which play a vital role in the processes taking place in living organisms.

Carbohydrates, lipids or fats and proteins are the three classes of foods which not only provide energy to human beings but are also responsible for their body structures. Lipids provide, on the average, twice as much energy as provided by carbohydrates or proteins.

Proteins are present in all living organisms. They form skin, hair, muscle, blood and almost all the organs of animals. They also play a very important role in all life processes.

Fats and oils come from a variety of natural sources like animals, plants and marine organisms. Animal fats are particularly located in tissues cells. Butter and ghee are a special type of animal fats which are made from milk.



25.1 Quick Check!

1. Which two functions are performed by proteins?
2. Is milk a fat, a protein or both?

25.1 The Importance of Nutrition

Nutrition is the study of the nutrients present in food and how they maintain a healthy body. Nutrients are the components of food that are needed on regular basis to maintain health and prevent diseases. A healthy human body needs the following nutrients.

1. Carbohydrates

They are the main source of energy for the human body. They also help body to use protein and fat efficiently.

A healthy adult needs 225 to 325 grams of carbohydrates per day for a standard 2000 calorie diet. However, individuals with higher activity levels may need more carbohydrates to meet their daily needs.

2. Lipids

They are also essential nutrients because they act as major energy reserves for our body. They also provide insulation and protection for vital organs of our body. A daily intake of fats for an adult is roughly between 44 to 78 grams.

3. Proteins

They also supply energy to our body. They are needed to build new cells and repair the injured ones. An adult should consume 60 grams of proteins per day.





4. Vitamins and Minerals

They help in growth, reproduction, the operation and maintenance of the body. A balanced diet rich in fruits, vegetables and grains can provide most of the vitamins and minerals needed daily.

25.1.1 Basics of Healthy Eating

The following are basics of healthy eating:

1. Consume a wide range of foods including fruits, vegetables, whole grains, lean proteins, and healthy fats.
2. They are full of nutrients which are required by our body.
3. Eat less and stay hydrated.
4. Reduce intake of saturated fats, sugar, and sodium.
5. Avoid eating processed and poor quality foods.

25.1.2 Healthy Eating

A healthy and balanced diet performs the following functions:

1. It prevents diseases like heart disease, diabetes, some cancers and osteoporosis.
2. Adequate nutrition provides fuel for healthy growth and development, leading to maintain a healthy weight.
3. A balanced diet can positively impact brain function and supports a strong immune system.



25.2 Quick Check!

1. What is a balanced diet?
2. Name any three nutrients.

25.2 Carbohydrates

Carbohydrates are the most abundant naturally occurring compounds on earth. They contain the elements carbon, hydrogen and oxygen. Because of the sweet taste of some carbohydrates, they are commonly called "sugars". Apart from a number of hydroxyl groups, they also contain aldehyde or ketonic functional groups.

Carbohydrates can be classified into three groups (monosaccharide, oligosaccharides and polysaccharides) based on the difference in their properties.

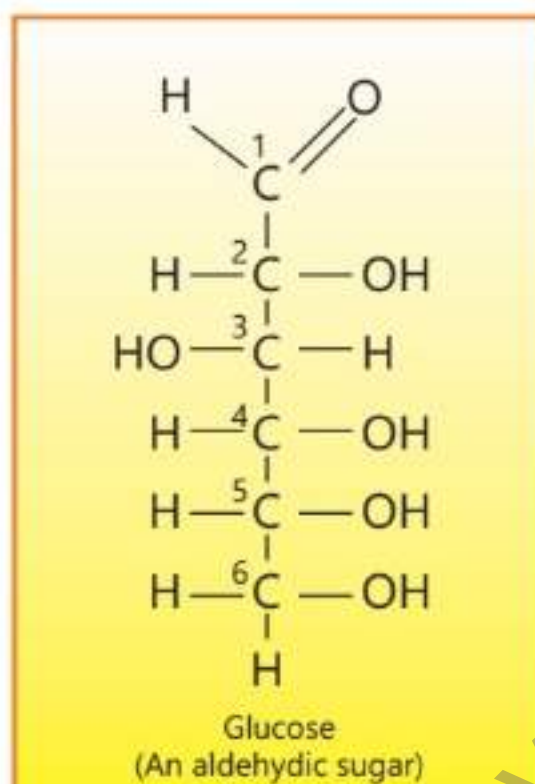
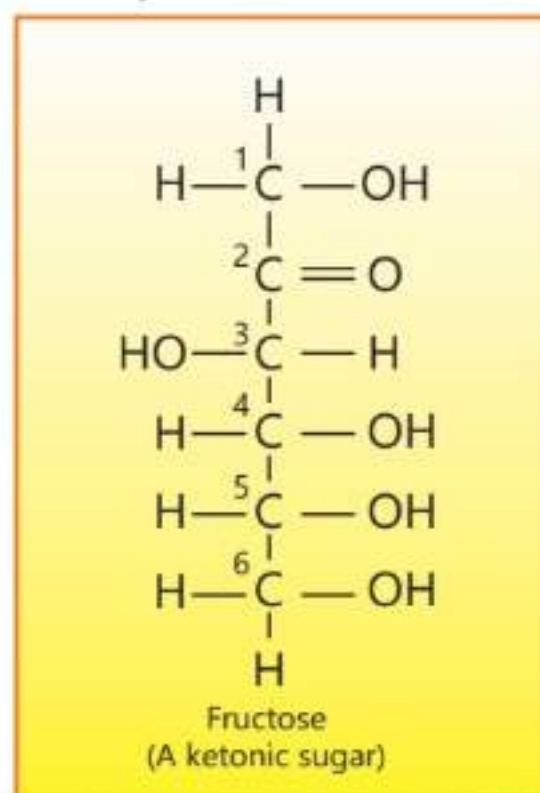
Glucose, the most abundant carbohydrate, is also called grape sugar or



dextrose. It is present in fruits such as grapes, in honey and also in the sap of plants. It is the main source of energy for all animals and is thus present in their blood and urine.

Fructose is another carbohydrate which is present in sweet fruit juices and honey.

Both glucose and fructose have the same molecular formula, $C_6H_{12}O_6$. Their open chain structures are shown here.



Interesting Information!

Acesulfame potassium is the most recently approved sweetener. It is used in soft drinks.



Sucrose, lactose and maltose are other important carbohydrates. All these carbohydrates have the same molecular formula $C_{12}H_{22}O_{11}$. Sucrose is present in sugar cane and sugar beets. Maltose is found in breads and other cereals while lactose is present in milk.

Interesting Information

Lactose is widely used in baking and in commercial milk used for infants. Unlike sucrose, it is a reducing sugar.

Starch and cellulose are the two examples of important polymeric carbohydrates, they have a common formula $(C_6H_{10}O_5)_n$. Starch is found in foods like potatoes, rice and grains whereas cellulose sources include plant materials like wood, cotton etc.



25.3 Quick Check!

1. Name any two sources of starch.
2. Are all carbohydrates equally beneficial for our health?

Interesting Information

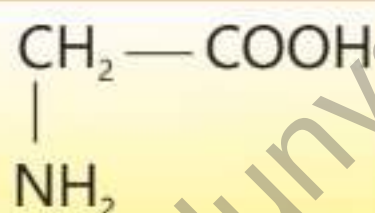
Glycogen is a carbohydrate that serves the same energy storage function in animals that starch serves in plants.



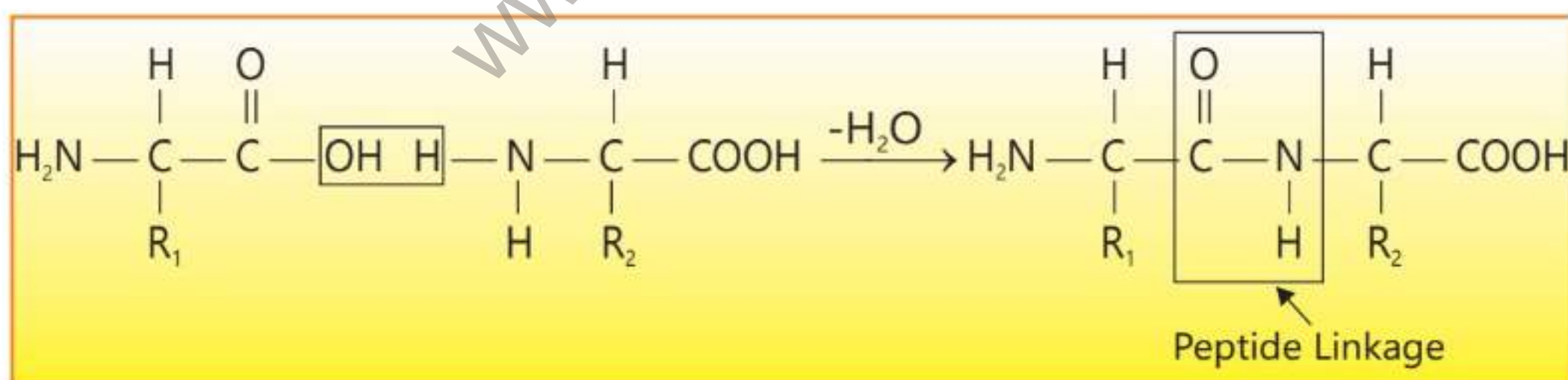
25.3 Proteins

Proteins are very large molecules containing C, H, O, N and sulphur atoms. The human body contains thousands of different type of proteins where they perform a large number of functions. There are fibrous proteins that are found in muscles, hair, nails, skin and connective tissues. Besides these, hormones and enzymes are also protein in nature. For example, the hormone insulin controls the level of sugar in the blood stream. Enzymes are the catalysts which speed up the biochemical reactions taking place in our body. Hemoglobin which carries oxygen in the blood stream and delivers to different parts of the body is also a protein.

Despite their wide range of functions, all proteins are formed by linking together molecules called amino acids. An amino acid has two functional groups, a carboxyl group - COOH and an amino group -NH₂. The simplest amino acid is called glycine and its structural formula is:



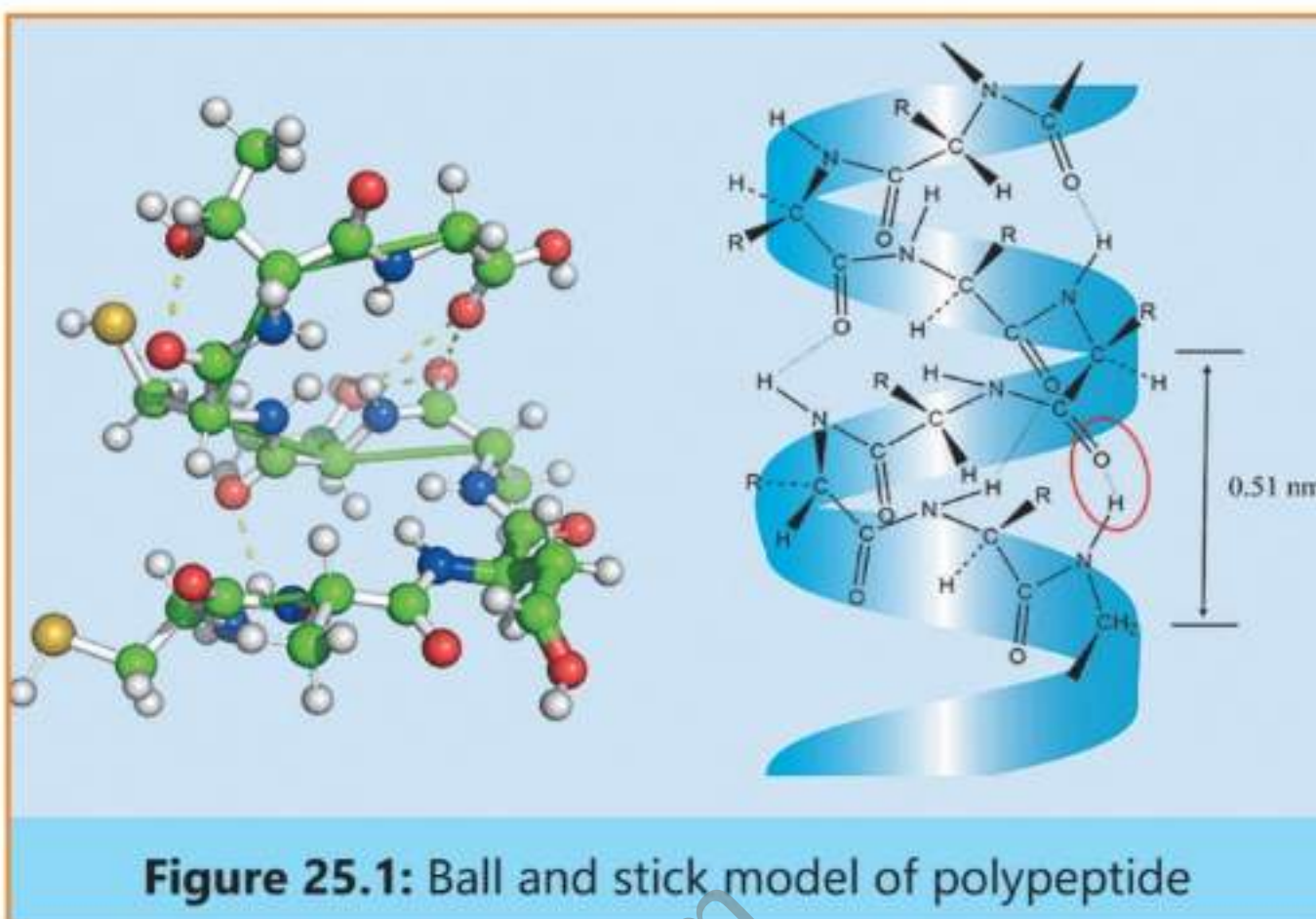
Although the number of proteins present in the human body runs into thousands, they are all formed by linking together only twenty amino acids. The basic reaction which leads to the formation of long chains of proteins involves the elimination of water from two molecules of same or different amino acids.



The molecule which is formed as a result of this reaction is called a peptide and it contains a peptide linkage as shown above. This peptide molecule has a carboxyl group and an amino group at its two ends. It is capable of reacting further with two molecules of amino acids to give ultimately a long chain composed of many acid molecules called a polypeptide. This polypeptide chain then undergoes twists and turns and assumes a three dimensional structure

shown in the following Figure 25.1.

Complex changes in proteins occur when they are subjected to heat, a change in pH or an attack by oxidizing and reducing agents. The phenomenon is called denaturation of proteins. A familiar example is the frying or boiling of an egg which involves the denaturation of egg albumin (protein), the principal component of egg white.



Interesting Information!

Everyone, from infants to adult, needs protein. Children need large amounts of proteins for proper growth, and adults need protein to replace what is lost each day by the body's normal biochemical reactions.



25.4 Quick Check!

1. What are hormones made of?
2. What is denaturation of protein?

25.4 Lipids

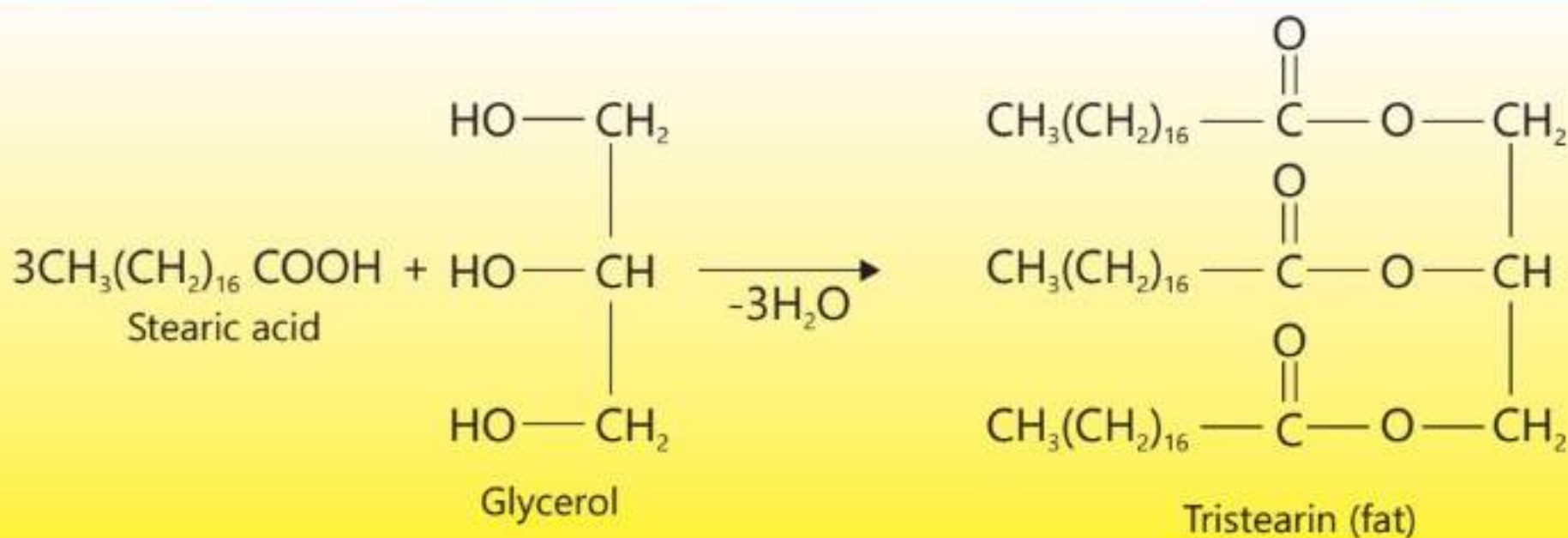
Most lipids are composed of simpler substances called fatty acids which serve as their building blocks. Fatty acids are long chain carboxylic acids containing from 12 to 28 carbon atoms. Examples of simple fatty acids along with their sources are as given in Table 25.1.

Table 25.1 Some Simple fatty acids.

Fatty acid	Source	Structure
Lauric acid	Coconut oil	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$
Stearic acid	Animal fats	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$
Palmitic acid	Palm oil	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$
Oleic acid	Olive oil	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$

Fatty acids react with an alcohol called glycerol to give triester which are called fats. For example, stearic acid reacts with glycerol to form tristearin which is a fat. A triester of glycerol is also called triglyceride.





Animal fats are located particularly in adipose tissue cells whereas vegetable oils are present in seeds and roots of plants. Lipids mainly serve as energy rich source in animals.

Interesting Information!

Soap has been known since at least 600BC when it was prepared by boiling goat fat with extracts of wood ash. The cleansing properties of soap did not become widespread until the 18th century. Chemically, soap is a mixture of sodium salts of the long chain fatty acids produced by hydrolysis of animal fat with alkali.



25.5 Quick Check!

1. What is the role of lipids in our body?
2. Which is an unsaturated fatty acid?

25.5 Vitamins

These are organic substances which do not directly serve the purpose of providing energy and building cells of our body like carbohydrates, lipids and proteins. They are, however, necessary to maintain normal health and growth of our body. These compounds are known to function as catalysts for the biological processes going on in our body. Since the first such compound discovered was an amine, so they were named vital amines or vitamins. Over the years, scientists have prepared 13 vitamins needed by the human body.

Importance of Vitamins

Vitamin A is present in milk, egg, fish and liver and its deficiency causes night blindness and dry skin.

Vitamin D may be obtained from butter and fish liver oils. Our skin can also prepare vitamin D directly in the presence of sunlight. This vitamin is related to normal teeth and bone development and its deficiency causes a disease called





rickets.

Vitamin C, also called ascorbic acid, is found in citrus fruits, green pepper and tomatoes. Its deficiency in our body causes scurvy.

Vitamins B₁ and B₂ are distributed widely in nature. They are present in red meat, nuts and leafy vegetables. Deficiency of vitamin B₁ leads to fatigue and depression whereas lack of vitamin B₂ causes inflammation of the lips and dryness and burning of eyes.



25.6 Quick Check!

1. Which vitamin is present in lemon?
2. Compare the roles played by vitamins and carbohydrates in our body?

25.6 Nucleic Acids

Carbohydrates, proteins and fats together with water constitute about 99% of the most living organisms. The remaining 1% represents some compounds of vital importance which include two nucleic acids deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). These compounds are responsible for the existence, development and reproduction of all forms of life.

Both DNA and RNA are chemically similar compounds which play different roles within the cell. Molecules of DNA are very large as compared to those of RNA. A DNA molecule may have molecular mass of up to 660 Da and lengths of up to 12 cm when stretched out. They are mostly found in the nucleus of the cells. RNA molecules, on the other hand, are much smaller, (molecular mass 340 Da) and are mostly found outside the cell nucleus.

The function of DNA is to store information and pass it on to RNA, at the proper time. The function of RNA, in turn, is to read, decode and use the information to make proteins.



25.7 Quick Check!

1. What is the function of RNA?
2. What are the basic differences between DNA and RNA?

Interesting Information!

Molecular mass of polymers are often expressed in millions or billions of Daltons (Da).

25.7 Applications of Biochemistry

Blood Tests

Doctors use the blood tests to identify various health conditions including infections, diabetes, anemia, organ failure and much more. Basic blood





chemistry tests check the amount of electrolytes, fats, proteins, glucose and enzymes. These tests give important information about how well a person's kidneys, liver, and other organs are working.

Pregnancy Test

A pregnancy test checks the urine or blood to see if a woman is pregnant or not. HCG is a hormone produced in the body when a woman gets pregnant. Doctors usually perform two tests to check pregnancy. Quantitative blood tests can measure the exact amount of HCG present in the blood. It can also give information about how far along the pregnancy has progressed.

Blood Test for Cancer Screening

A specific type of blood test called the Galleri test is performed to detect cancer in early stages. It uses DNA sequencing to find the characteristic patterns which may tell whether a person is suffering from cancer or not.

Parental Genetic Testing

Genetic tests are often performed by taking a sample of blood or saliva. Persons get genetic testing to know if they have genetic changes themselves or if they can pass on genetic changes to their children.

Genetic Engineering

Genetic engineering is a method for changing an organism's genome. This can involve changing one single DNA base or can involve deleting or inserting a whole region of DNA. It is done to modify the genes to enhance the capabilities of the organism beyond what is normal. Plants can be made to fight diseases or pollution by changing them through genetic engineering.

Gene Therapy

In gene therapy a doctor fixes a faulty gene or replaces it with a healthy gene in order to cure a disease or enable the body to fight the disease in a better way. This technique may be helpful in future to fight with a wide range of diseases like diabetes, AIDs, cancer and haemophilia.





Cloning

Cloning describes the methods used to create an exact genetic replica of a cell, a tissue or the whole organism. The copied material is called a clone and it will have the same genetic characteristics as the original one.

EXERCISE

A Multiple Choice Questions

Choose and tick the correct answer from the given choices.

- Functional groups present in fructose are:
(a) Hydroxyl and aldehyde (b) Hydroxyl and Ketone
(c) Hydroxyl and ester (d) Hydroxyl and amide
- Which functional group is present in a fat?
(a) Carboxyl group (b) Ester group
(c) Carbonyl group (d) Hydroxyl group
- Which function is not performed by proteins in our body?
(a) They serve as chemical messengers.
(b) They serve as storage of energy-rich fuel.
(c) They store genetic information.
(d) They serve as catalysts for biochemical reactions.
- Which functional groups react to produce a peptide linkage in proteins?
(a) Carboxyl group and hydroxyl group
(b) Carboxyl group and amino group
(c) Hydroxyl group and amino group
(d) Ester group and amino group
- The test performed to detect cancer in early stages is:
(a) Genetic test (b) Urine test
(c) Galleri test (d) Electrolyte test
- Fatigue and depression are caused by deficiency of:
(a) Vitamin A (b) Vitamin C
(c) Vitamin D (d) Vitamin B1





B Short Answer Questions

- 25.1 What is the difference between glucose and fructose?
- 25.2 Give two examples of denaturation of proteins.
- 25.3 What are the sources of vitamin D?
- 25.4 What is the role of enzymes in our body?
- 25.5 Which commercial products are obtained from oils and fats?
- 25.6 Which vitamin helps in blood clotting?

C Constructed Response Questions

- 25.1 What is the function of DNA?
- 25.2 Write down three important functions played by of proteins in our body.
- 25.3 Fatty acids serve as building blocks of lipids just like amino acids are for proteins. Comment on this statement.
- 25.4 Write down about the sources of vitamin C. Which diseases are caused by its deficiency?
- 25.5 Write down the names of two polymeric carbohydrates.

D Descriptive Questions

- 25.1 What are the sources of fructose, maltose and lactose?
- 25.2 Draw open chain structures of glucose and fructose.
- 25.3 Construct peptide linkage and explain the structure of a polypeptide.
- 25.4 What are DNA and RNA? Describe the role played by them in our body.
- 25.5 Compare the roles played by carbohydrates, proteins and lipids in our body.

