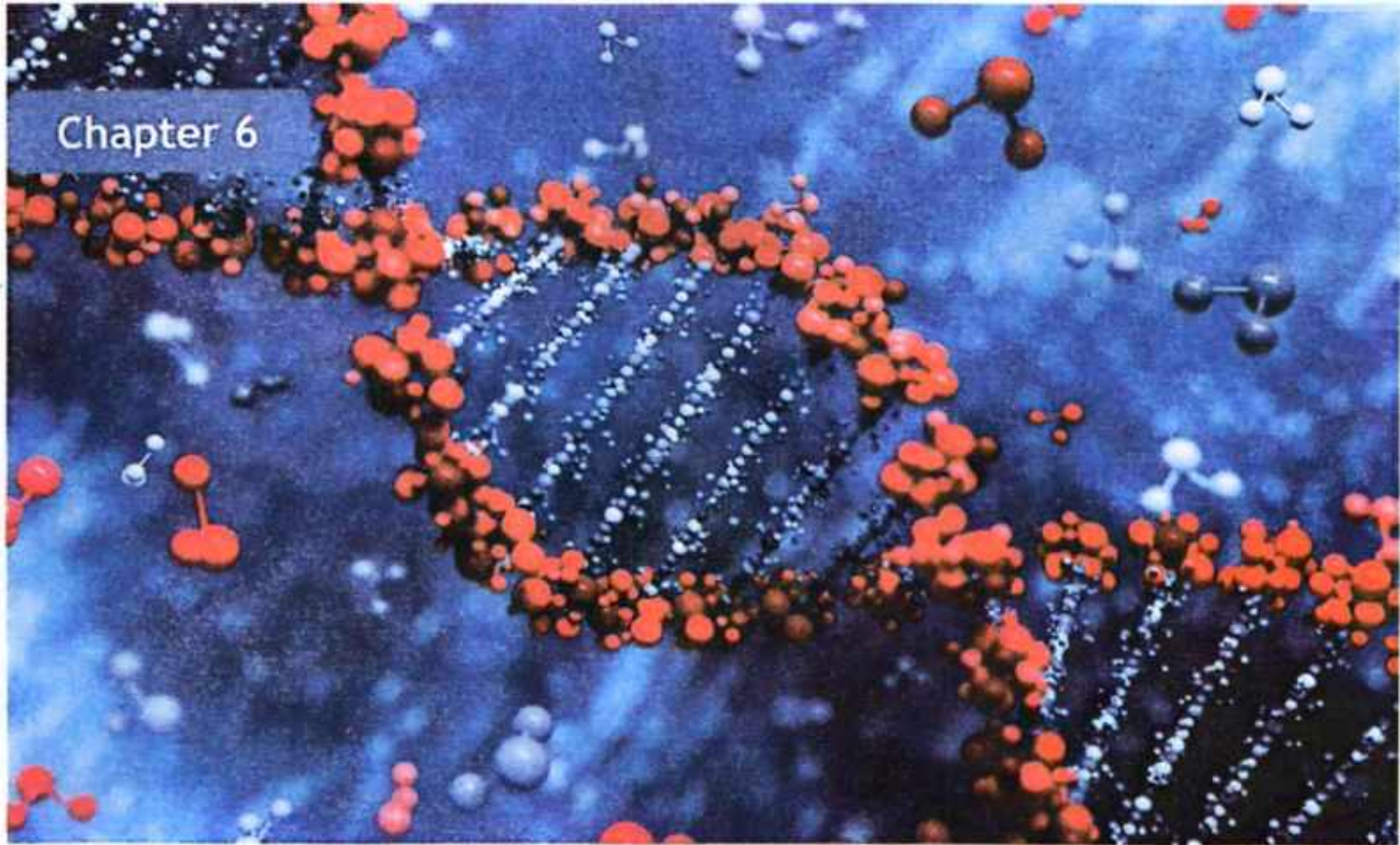


Chapter 6



MOLECULAR BIOLOGY

SLOs: After completing this lesson, the student will be able to:

1. Define Biochemistry/molecular biology
2. Outline the various types of common biomolecules (DNA, RNA, Proteins, Lipids, and Carbohydrates) including their locations inside the cell and main roles.
3. Outline the structure and function and sources of proteins with structure of amino acids
4. Outline the structure, function and sources of lipids
5. Define Carbohydrates and Outline the structure, function and sources of Carbohydrates.
6. Identify carbohydrates as monosaccharides, disaccharides and polysaccharides.
7. Describe briefly the structure of DNA as a double helix macromolecule made of nucleotides with base pairing in between the two helices through complementary base pairing.
8. Outline function of DNA as carrier of hereditary information
9. Describe briefly the structure of RNA as single stranded macromolecule made of nucleotides with nitrogenous base overhangs
10. Outline the function of RNA as aid in converting hereditary information into useful proteins.
11. Outline how information in the DNA is converted to information on RNA and then into proteins.

6.1 BIOCHEMISTRY/ MOLECULAR BIOLOGY

Biochemistry is the study of different chemical compounds and the chemical processes taking place within the living organisms. Biochemistry is related to both biology and chemistry. Therefore, biochemistry solves the problems faced by living organisms by using the knowledge and techniques of chemistry.

Sometimes biochemistry and molecular biology are taken as same but molecular biology is the specialized branch of biochemistry that is mainly concern with the interaction of bio-molecules with in the cells and biochemical processes like DNA replication, transcription and translation.

6.1.1 Importance of biochemistry

Study of biochemistry is greatly helpful to explore the cell biology and anatomy as all the structures of the living organisms (cells, tissues and organs etc.) have specific biochemical organization. Similarly, knowledge of biochemistry is essential to study the physiology of organisms because life processes such as photosynthesis, respiration, digestion, inheritance, are explained in biochemical terms.

6.1.2 Bioelements

Bodies of living organisms is composed of protoplasm, which is made of certain elements called **bioelements**. Out of 92 naturally occurring elements of earth, 16 of these bioelements. On the basis of their proportions in the living organisms, bioelements are further classified into **Major** and **Minor** bioelements. Six most common bioelements constitute 99% of protoplasm so called major bioelements. Remaining ten bioelements constitute only 1% of the biomolecules so called Minor bioelements. The proportions of these bioelements are given in the fig: 6.1.

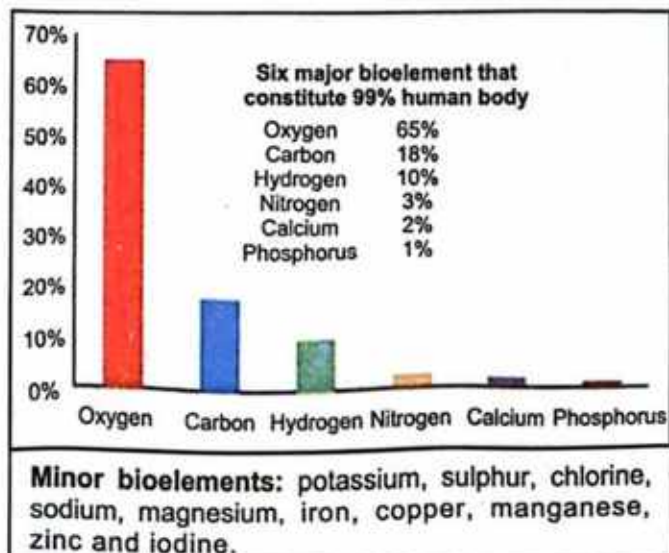


Fig. 6.1 Proportions of bio-elements in human body

6.2 BIOLOGICAL MOLECULES

Molecules produced and utilized in the metabolic processes within the living organisms are called biological molecules. Bio-molecules are the building blocks of life and perform important functions in living organisms like growth, development, energy production reproduction. Different bio-elements combine with each other to form biomolecules. Biomolecules may be **inorganic** (water and salts) and **organic** (carbohydrates, lipids, proteins and nucleic acids). Complex organic biomolecules are polymers of their building blocks called monomers. Major organic bio-molecules, their locations inside the cell and main roles are given in table 6.1.

Table 6.1: Biomolecules, their location in the cell and roles

Biomolecules	Location in cell	Main roles
Carbohydrates e.g. Glucose, lactose, sucrose, starch, cellulose, chitin	Cell wall, cell membrane, Smooth endoplasmic reticulum, Golgi bodies	Used as food, energy source, components of plant and fungi cell walls, cell surface markers, component of DNA and RNA as 5-carbon sugar
Proteins e.g. Hemoglobin, Actin, myosin, hormones, enzymes, antibodies	Cytoplasm, Rough Endoplasmic reticulum, Golgi bodies,	Energy source, components of cell membrane, gaseous transport, chemical messenger, Speed-up chemical reactions, immunity, Component of chromosomes
Lipids e.g. Fats, phospholipids, waxes, oils, vitamin D	Cell membrane, smooth endoplasmic reticulum,	Provide cells with long-term energy, component of cell membranes.
DNA	Nucleus (Chromosomes)	Component of chromosomes Store and pass on genetic information
RNA (mRNA, tRNA, rRNA)	Nucleolus, cytoplasm	Tools for translation, protein synthesis,

6.3 PROTEINS

Proteins are main structural and functional components of the cell, which make up around 55% of the dry weight of cell. They are present in all types of cells and contribute in the variety of cell functioning. Proteins are synthesized in the cells by ribosomes.

6.3.1 Chemical composition of Proteins

Proteins molecules mainly composed of C, H, O, N and sometimes P, S, Fe etc. Chemically proteins are **polypeptide chains** which are **polymers of amino acids**.

6.3.2 Amino acids

Amino acids are the building blocks or monomers of proteins. There are about 20-25 different types of amino acids commonly found in proteins. Each amino acid contains a central carbon atom called α (alpha) carbon. Four different groups are attached to α -carbon, including a hydrogen atom (-H), an amino group (-NH₂), a carboxyl group (-COOH) and an alkyl group labelled as -R. Each amino acid has a different -R group which determines its chemical properties.

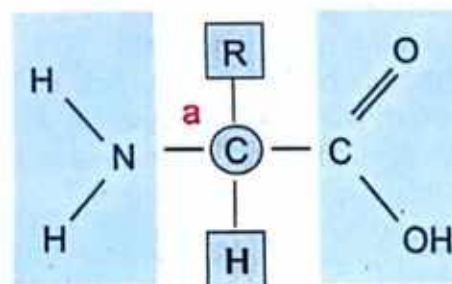


Fig: 6.2 General structure of an amino acid

6.3.3 Structure of proteins

Structure of protein may consist of a single polypeptide or more than one polypeptide. Number of amino acids and polypeptide chain varies in different proteins. Bond between two amino acids is called **peptide bond** as shown in figure given.

The structure of proteins is classified as primary, secondary, tertiary and in some cases quaternary. These structures are based on the level of complexity of the folding of a polypeptide chain. A linear polypeptide with a specific number, type and sequence of amino acids is called **primary structure**.

After synthesis a protein does not remain in its primary structure. Polypeptide folds upon itself due to additional bonds to form some higher structural level (secondary, tertiary or quaternary) to perform its specific role. Shape of the proteins (fibrous or globular) also depends upon the structural level in the protein.

6.3.4 Functions of Proteins

Proteins are very important molecules in our cells. Each protein within the body has a specific function. They are involved in the formation of many structures of body. They also play many important roles with in body. One gram of protein has 4 kcal of energy. A list of important proteins and their roles is given in table 6.2.

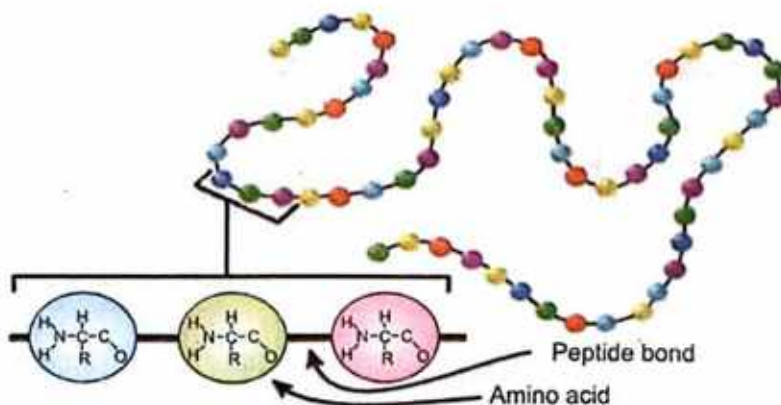


Fig: 6.3 Polypeptide chain and peptide bond

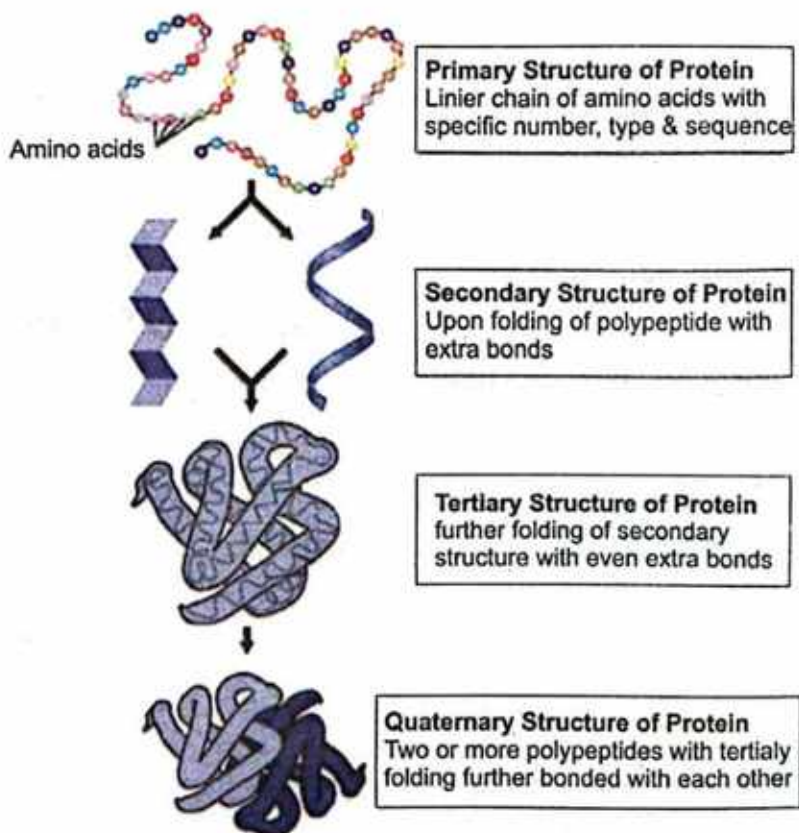


Fig: 6.4 Structure of Proteins

Table 6.2: Examples and Functions of Proteins

Examples	Functions
cell membrane protein	Many proteins in plasma membrane act as channel and carrier proteins. Some proteins at the surface of cell act as antigen.
Enzymes	Most of the enzymes are protein which control biochemical reactions.
Hormones	Protein hormones act as chemical messengers and regulate different functions in body e.g. growth, reproduction, digestion, glucose level etc.

Antibodies	Antibody proteins produced by WBCs provide immunity against germs.
Haemoglobin	RBCs have red pigment haemoglobin protein that is involved in the transport of oxygen and carbon dioxide in the body via blood.
Fibrinogen	Blood plasma contains a blood clotting protein to stop bleeding at injuries.
Actin and Myosin	These proteins are present in muscle cells. These are involved in contraction and relaxation of muscles during movement.
Collagen	It is major component in structure of skin, bones, cartilage, muscles, tendons and ligaments. It provides support and strength.
Keratin	It is the component of hair, nails, feathers, horns and beaks to make them hard and protective.
Histone	It is attached to DNA to form chromosome.

6.3.5 Sources of proteins

Proteins may be obtained from plants fungi and animals. Plant seeds are most common source of proteins like beans, lentils, peas, nuts. Animal products are sources high protein contents e.g. Milk, beef, mutton, poultry meat, egg, fish, sea food. Some proteins are obtained from mushrooms.

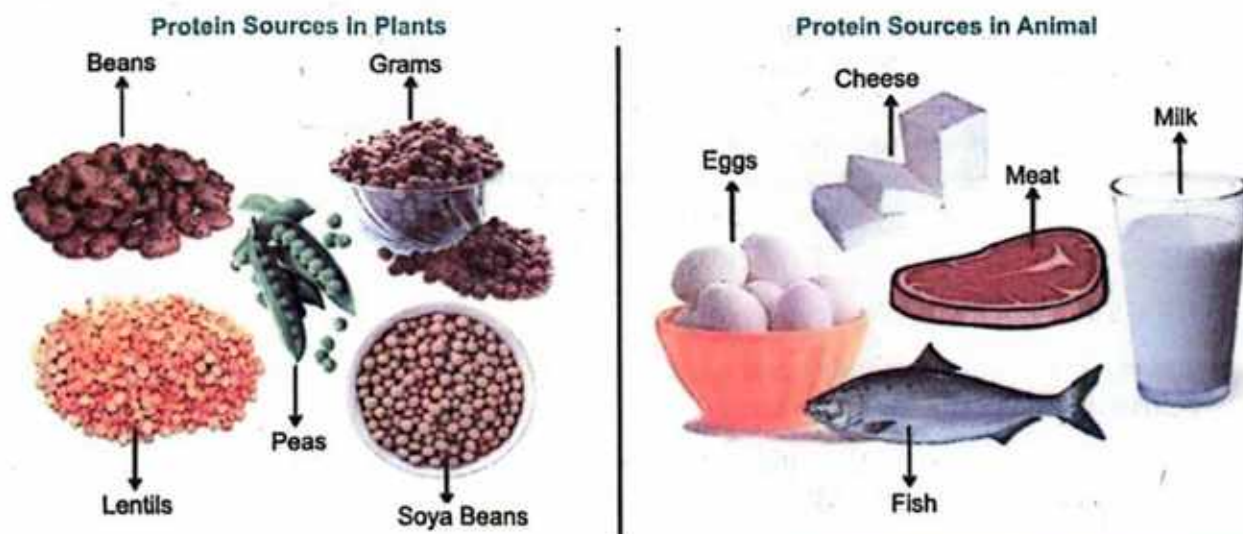


Fig: 6.5 Sources of proteins

STEAM ACTIVITY 6.1

The presence or absence of protein in a given sample can be confirmed by biochemical tests.

Experiment	Observations	Inference
Biuret Test: Take 2 ml of test solution (Protein solution) add 2 ml of concentrated solution of NaOH and two to three drops of 1% copper sulphate solution and then Shake well	Pink or Violet coloration is produced in test tube.	Protein is present in the solution

6.4 LIPIDS

A group of different types of organic compounds which are all hydrophobic in nature, collectively called lipids. Hence, lipids are a heterogeneous group of organic compounds which are insoluble in water but soluble in organic solvent such as alcohol, ether etc. Lipids found in living organisms include fats, oils, waxes and steroids.

Molecules of lipids are composed of C, H and O like carbohydrates. However one gram of lipids contain double amount of energy than carbohydrates because they have relatively more carbon-hydrogen ratio than carbohydrates.

6.4.1 Structure of Lipids

Lipids which are mainly made up of fatty acids and glycerol (an Alcohol) are called Acyl glycerides. Fatty acids may be saturated or unsaturated. **Saturated fatty acids** have all C-C single bonds and are solid at room temperature e.g. cheese, butter, ghee etc. **Unsaturated fatty acids** have double or triple C-C bonds and are liquid at room temperature e.g. soybean oil, mustard oil, olive oil etc. Most common types of acyl glycerides are tri-acyl glycerides which contains one glycerol and three fatty acids.

Glycerol + 3 fatty acids → Tri-acyl glyceride

Some lipids are even more complex and have phosphate, nitrogen base along with glycerol and fatty acids e.g. phospholipids and waxes.

Some lipids may not have fatty acids in their formula rather they have three ring structure called steroids e.g. cholesterol, vitamin D.

6.4.2 Functions of Lipids

Lipids are very useful biological molecules and have many important roles in cells and as a whole in bodies of living organisms.

1. Phospholipids and cholesterol are components of plasma membrane structure.
2. Lipids act as energy stores in fat cells, liver and in blood. One gram of lipids provides 9.1 kcal of energy which is double than carbohydrates or proteins.
3. Many lipids act as important steroid hormones e.g. testosterone, Aldosterone etc.
4. Some lipids act as insulators against atmospheric heat and cold.
5. Waxes are used by insects for constructing their hives.
6. Waxy cuticle of leaves act as protective and waterproof layer to avoid water loss.
7. Some vitamins are lipid in nature e.g. vitamin A, D, E and K. Vitamin D is derived from cholesterol.

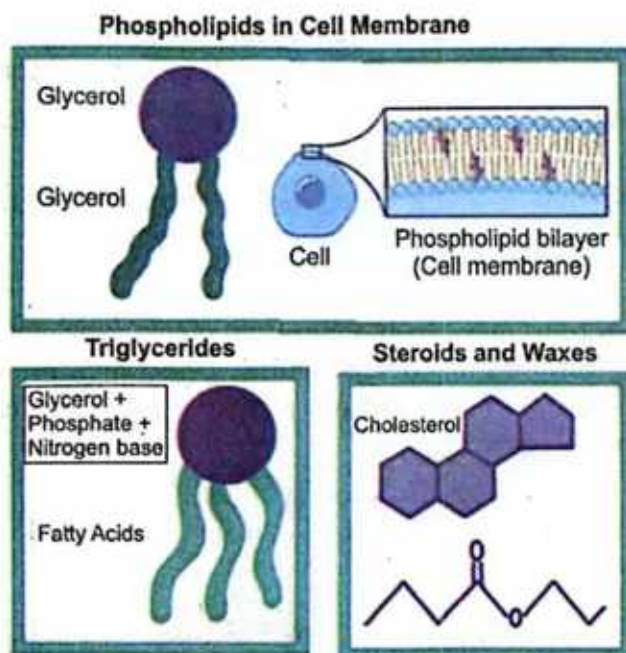


Fig: 6.6 Structure of different types of lipids

6.4.3 Sources of Lipids

Variety of food are rich sources of lipids. Foods containing large amounts of saturated fat include red meat, butter, cheese, ghee, fish liver oil etc.

Some oils are obtained from plant seeds like sunflower oil, soybean oil, peanut oil, coconut and palm oil are also rich in unsaturated fats. Wax is obtained from comb of many insects.

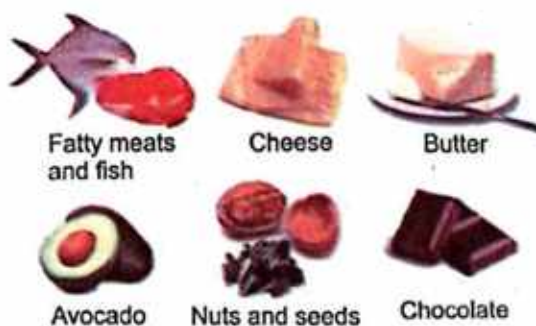


Fig: 6.7 Sources of lipids

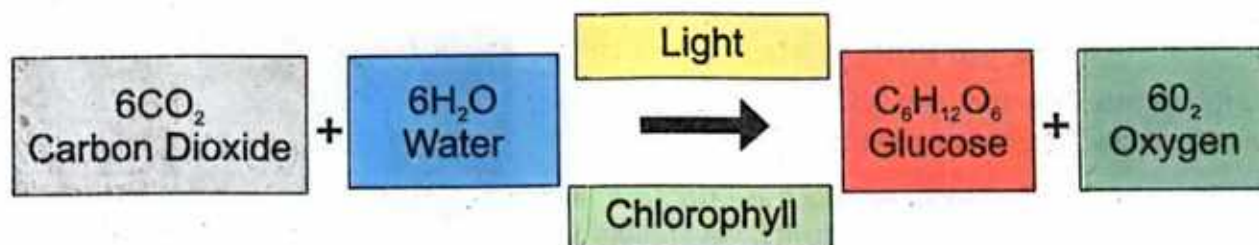
STEAM ACTIVITY 6.2

The presence or absence of lipids in a given sample can be confirmed by biochemical tests.

Experiment	Observations	Inference
A. Spot test: Put a drop of test solution (lipid solution) on a filter paper and allow it to dry	A clear or translucent greasy spot appears on paper	Lipid is present in the solution
B. Take a small amount of fat (butter or ghee) in a test tube and half fill the test tube with distilled water.	Fat and water remain separate	Fat is insoluble in water
C. Heat the water and fat in the test tube	Fat melts on heating but don't mix water and make clear upper layer over the lower water layer	Fat is insoluble in water and don't mix even in melted form
D. Emulsion Test: Take 2 ml of the test material (lipid) add 2 ml of absolute alcohol and shake well. Now add 4 ml of cold water and shake well again then allow to stand.	A cloudy white suspension (emulsion) is formed after shaking	Lipid is confirmed

6.5 CARBOHYDRATES

Carbohydrates are the important biological molecules present in all parts of cell. Carbohydrates are also called as sugars or saccharides due to their sweet taste. Word saccharide is derived from Greek word "Sakcharon" meaning sugar. Most common and simple carbohydrate, glucose is naturally produced in the green plants by the process of photosynthesis using CO_2 from air and H_2O from soil.



Plants use sunlight energy for food synthesis. This energy is stored as chemical energy in the bonds of glucose molecules and 4 kcal per gram of energy is released when glucose is broken

down in the cell. Plants use glucose molecules to form complex molecule like starch and cellulose.

6.5.1 Structure of Carbohydrates

Carbohydrates are the compounds of carbon, hydrogen and oxygen with a ratio of 1:2:1 respectively. Literal meaning of word carbohydrate is "hydrates of carbon". This name is given because number of carbon atoms are equal to the number of water molecules in the chemical formula of carbohydrates.

Thus, generalized formula of carbohydrates is $C_x(H_2O)_y$ Where X is number of carbon atoms and Y is number of water molecules. For example, formula of most common sugar glucose is $C_6(H_2O)_6$ or $C_6H_{12}O_6$.

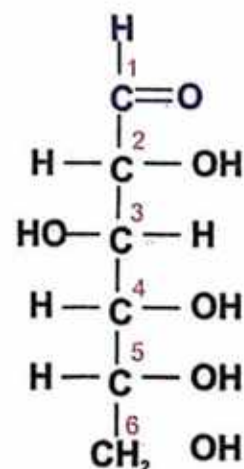


Fig: 6.8 Structure Of Glucose

6.5.2 Functions of carbohydrates

Carbohydrates play followings structural and functional role in living organisms

1. Carbohydrates are major source of useable and stored energy in the cells of living organisms.
2. Carbohydrates are structural material for cell wall of Plants (cellulose), Fungi (Chitin) and Bacteria (Peptidoglycan).
3. Cellulose present in the cell wall of plant fruit, vegetables, bran and whole grains is not digestible hence act as fiber or roughage in the human diet. It helps in the movement of food efficiently through the digestive tract and effective in avoiding constipation.
4. Cellulose fiber absorbs away toxic chemicals which might be present in food. It is used in paper industry. It also helps in lowering blood cholesterol and regulates blood pressure.
5. Sucrose is used as common table sugar and used as natural sweetener.
6. Extra glucose in plants is stored as starch in their root, stem, fruits or seeds used as animal and human food.
7. Extra blood glucose is stored in animal muscles and liver cells as glycogen which serves as energy bank. It can be converted back to glucose when needed for energy.
8. Chitin makes exoskeleton of arthropods

6.5.3 Sources Carbohydrates

Carbohydrates are the most abundant class of organic biomolecules. They have various sources.

1. Monosaccharides such as glucose, fructose and galactose are obtained from fruits, vegetables and cereals. They are also present in honey.
2. Disaccharide such as sucrose is obtained in sugarcane, sugar beet and fruits. Maltose is found



Fig: 6.9 Sources of carbohydrates

- in cereals. Lactose is milk sugar and found in dairy products.
- Cellulose is obtained from plants e.g. Cotton is pure cellulose.
 - Starch is present in cereals, wheat, barley, rice, maize, potato, sweet potato etc.

6.6 CLASSIFICATION OF CARBOHYDRATES

Carbohydrates are classified on the basis of number of monomers i.e. saccharide units in the molecule. Carbohydrates are generally classified into three groups.

6.6.1 Monosaccharides

Monosaccharides are the simplest form of carbohydrates which are primarily produced during photosynthesis. They are white crystalline solids and are soluble in water. They are sweet in taste. Number of carbon atoms in different monosaccharides may range from 3 to 7. Monosaccharides are named on the basis of number of carbon atoms in their structure e.g. trioses (3C), tetroses (4C), pentoses (5C), hexoses (6C) etc. Most common monosaccharides are pentoses and hexose. For example, ribose is a pentose ($C_5H_{10}O_5$), found in the nucleotides of nucleic acids. Glucose ($C_6H_{12}O_6$) is a familiar hexose. Monosaccharides are not further hydrolysed. If monosaccharides (mostly pentoses and hexoses) are in crystalline form they are found as open chain structure but when they are dissolved in water they are converted into ring structure.

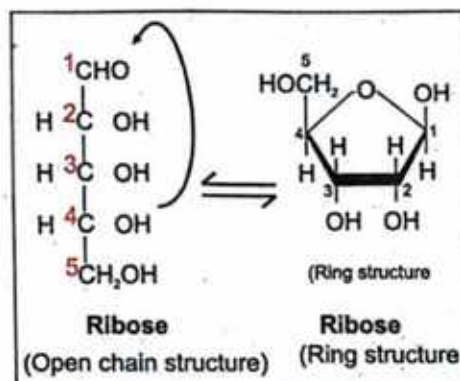
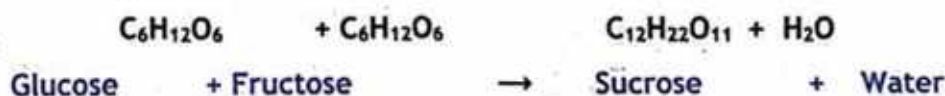


Fig: 6.10 Open chain and ring structure of pentose (ribose)

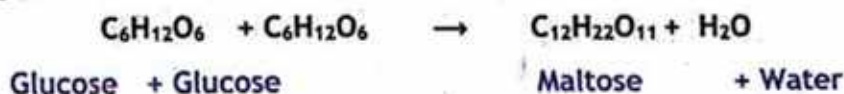
6.6.2 Disaccharides

Carbohydrates, which release two monosaccharides on their hydrolysis are called disaccharides because disaccharide are formed due to bonding of two monosaccharides. They are also white crystalline solids. They are comparatively less soluble in water and are less sweet in taste. The molecular formula of disaccharide is $C_{12}H_{22}O_{11}$. Examples of disaccharides are sucrose, maltose and lactose.

Sucrose is the most familiar disaccharide, commonly used sweetener and known as cane sugar. The sucrose is formed by the condensation of glucose and fructose releasing a water molecule.



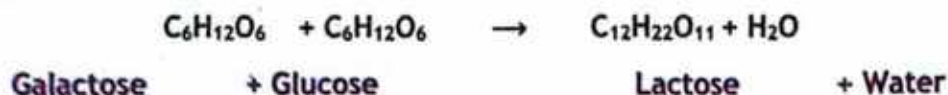
Maltose is also produced during hydrolysis of starch and glycogen, as an intermediate disaccharide. It is slightly sweet, very soluble in water. The maltose is formed by the condensation of two glucose molecules releasing a water molecule.



Science titbits:

Maltose is called malt sugar, because it is produced during the brewing the beer and related drinks by alcoholic fermentation of malted barley. Lactose is the only common sugar obtained from animals. Milk of all mammals is composed of 2-8% lactose. Lactose can be prepared from whey which is a by-product of the cheese-making process.

Lactose is a naturally found in milk and milk products. The lactose is formed by the condensation of galactose and glucose.



6.6.3 Polysaccharides

Polysaccharides is largest group of carbohydrates. They are complex carbohydrates and polymers of more than ten monosaccharides. They are produced in the cells of plants and animals to store extra carbohydrate food and energy e.g., starch, glycogen. They are storage molecule of carbohydrates. Polysaccharides are not sweet in taste rather usually tasteless. They yield many monosaccharide units upon complete hydrolysis for energy use. Polysaccharides are also structural components of cell walls in the cells of plant (cellulose), fungi (chitin) and bacteria (peptidoglycan).

STEAM ACTIVITY 6.3

The presence or absence of starch, glycogen, cellulose and glucose in a given sample can be confirmed by biochemical tests.

Experiment	Observations	Inference
Iodine test for Starch in solution or food material		
A. Take 5 ml water in a test tube. Add a small amount of starch in water in test tube and then boil to prepare starch solution. Add a few drops of iodine solution into the clear starch solution in the test tube.	Dark blue black coloration is produced in test tube.	Starch is confirmed in solution
B. Take food material like potato, then cut a small slice of potato and add a few drops of iodine solution on the potato slice.	Dark blue black coloration is produced on potato slice.	Starch is confirmed in food
C. Take glycogen solution in test tube and add few drops of iodine solution	Red coloration is produced in test tube.	Glycogen is present in solution
D. Take cellulose solution in test tube and add few drops of iodine solution	No change in colour of iodine solution in test tube.	Starch and glycogen absent and Cellulose may be present
Test for Glucose		
A. Benedict's test for glucose: Take 5 ml of Benedict's solution in a test tube, add a few drops of the test solution (glucose solution) and boil for 2-3 minutes.	A dirty green, yellow or red precipitates are formed	Glucose is present
B. Fehling's solution test: Take 3 ml of Fehling's solution in a test tube, add 3 ml of test solution (glucose solution) and heat.	Red precipitates are formed	Glucose is present

6.7 NUCLEIC ACIDS

Nucleic acids are the most important organic biomolecules which store and transfer hereditary information from one generation to next. There are two main types of nucleic acid.

- i. Deoxyribonucleic Acid (DNA)
- ii. Ribonucleic Acid (RNA)

Both types of nucleic acids (DNA and RNA) are made up of many units called nucleotides.

Science titbits

Swiss physician Friedrich Miescher isolated a whitish material from nucleus of human pus cells. He named this material as nuclein as it was isolated from nucleus. Later on, on the basis of its acidic properties, nuclein was called nucleic acid.

6.7.1 Structure of Nucleotide

Each nucleotide is made up of three components.

- i. Pentose (5C Sugar)
- ii. Nitrogen containing ring structure called **nitrogen base**, which is attached at the first carbon of pentose sugar
- iii. **Phosphate group** Acid attached with fifth carbon of pentose sugar

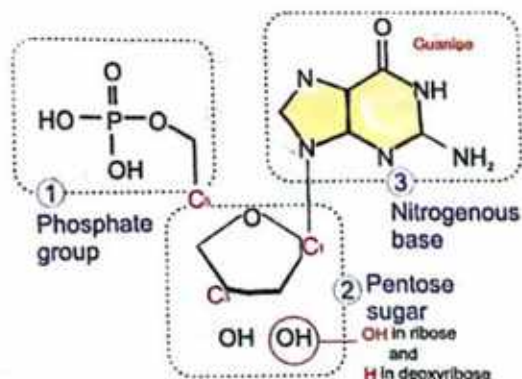


Fig: 6.11 Structure of a nucleotide

Pentose sugar in nucleic acid is of further two types:

- a) Deoxyribose in DNA
- b) Ribose in RNA.

The nitrogen bases in nucleic acid are also of two main types.

- a) **Purines**, which are nitrogen containing double ring structures i.e. Adenine and Guanine
- b) **Pyrimidines** which are nitrogen containing single ring structures i.e. Cytosine, Thymine and Uracil

Names of the nucleotides are given on the basis of the type of pentose sugar and nitrogen base they have. The DNA molecules consists of four different types of nucleotides called **deoxyribonucleotides**.

Each deoxyribonucleotides can have any one of the nitrogen base from Adenine, Cytosine, Guanine and Thymine. The RNA molecules also consists of four types of nucleotides called **ribonucleotide**. Each ribonucleotide can have any one of the nitrogen base from Adenine, Cytosine, Guanine and Uracil. So DNA nucleotides can have Thymine while RNA nucleotides can have Uracil as nitrogen base.

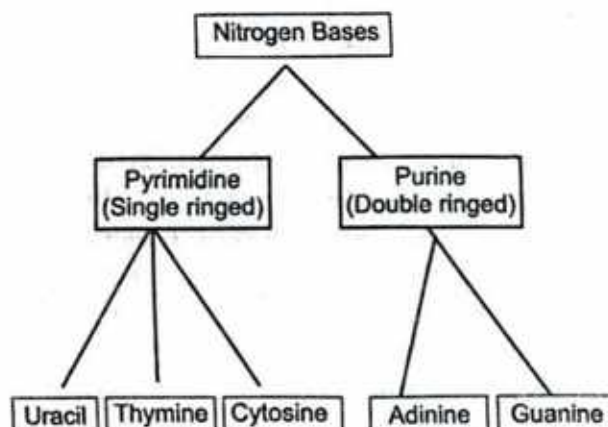


Fig: 6.12 Types of Nitrogen basis

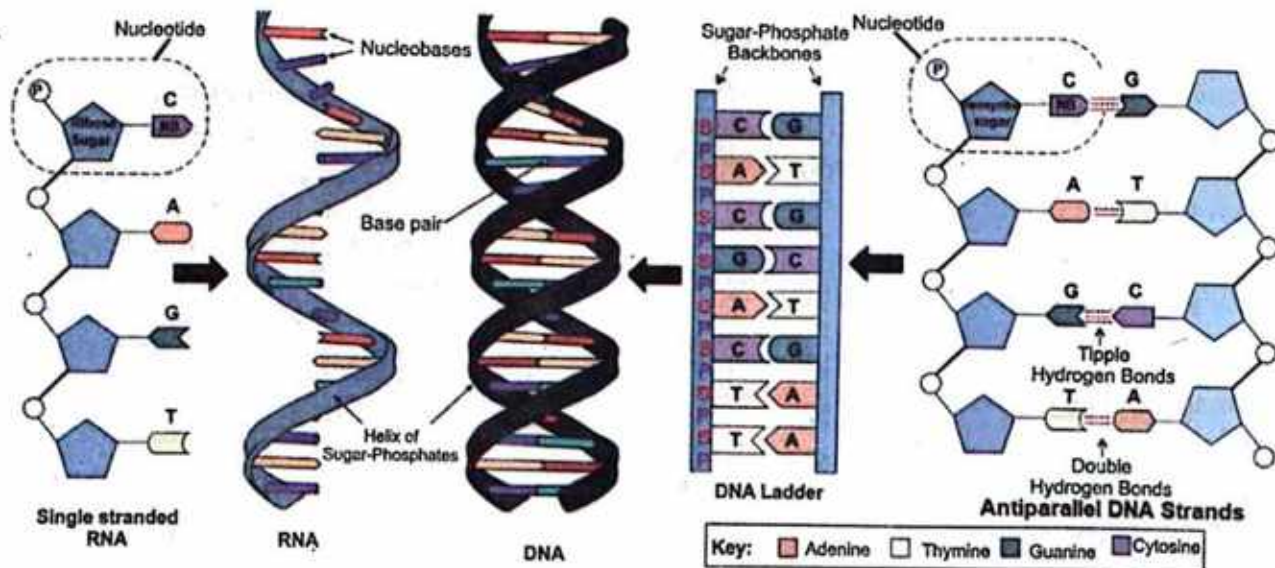


Fig. 6.13 Structure of RNA and Watson and Crick model for structure of DNA

6.7.2 Structure of DNA

DNA molecule is a polynucleotide as it is made up of many deoxyribonucleotides (Fig. 6.13). Each next nucleotide binds through its phosphate at the 3rd carbon of pentose sugar of previous nucleotide. Structure of DNA was explained by two scientists, James Watson and Francis Crick. The main points of Watson and Crick Model of DNA are:

1. The DNA molecule is a double stranded like a ladder and both strands are coiled around each other like a helix.
2. Both strands of DNA molecule are antiparallel (oppositely oriented to each other).
3. The back bone (uprights) of molecule are composed of sugar and phosphate part of nucleotide while bases form the rungs.
4. The amount of adenine and thymine is always equal and amount of cytosine and guanine is always equal in DNA molecule.
5. Base pairing between the both strands is highly specific. Adenine of one strand always pairs with thymine of other strand while cytosine of one strand always pairs with guanine of other strand. Due to this base pairing principle, the sequence of nucleotides in one strand is complimentary to the sequence of nucleotides in the other strand.
6. Both strands of DNA are held by weak hydrogen bonds. There are two hydrogen bonds between adenine and thymine and three hydrogen bonds between cytosine and guanine.
7. The diameter of double helix of DNA is thoroughly uniform and is about 2 nm.

6.8 FUNCTION OF DNA (GENES) AS CARRIER OF HEREDITARY INFORMATION

Heredity is the transmission of characters from one generation to the next and it is important for the continuity of all life forms. Although offsprings and parents may have different appearance but, they have a basic resemblance in many characters that runs from generation to generation. For the continuity of life forms, each generation transfer the hereditary instructions to the next generation.

These hereditary instructions are in the form of huge DNA molecules and are transferred from one generation to next. In a non-dividing cell, hereditary material (DNA) is found in nucleus in the form of thin fibres called **chromatin**. Chromatin is composed of DNA and a proteins called **histones**. Coiling of DNA around histones form bead like structures called **nucleosomes** (Fig. 6.14).

6.8.1 Chromosomes contain units of heredity: The Genes

During cell division chromatin fibres condense and further fold to form thread-like structures called **chromosomes**. Small piece of huge DNA molecule in the chromosome is called **Gene**. Genes actually store and control the hereditary information. Each chromosome is made up of large number of genes. The total number of genes found in the complete set of chromosomes of an organism is called **genome** of that organism.

6.8.2 Gametes act as vehicle for transfer of hereditary information (genes) to next generation

During sexual reproduction, gametes or spores are produced by meiosis. Male and female gamete (sperm and egg) contain chromosomes (set of genes) of parent generation. At fertilization, male and female gametes fuse to form zygote, thus genes of both parents are transferred to zygote. Zygote develops into the offsprings which are the next generation. Thus, genes are transferred from one generation to next though gametes or spores. So therefore, DNA (genes) in the chromosomes carry the hereditary information from one generation to next.

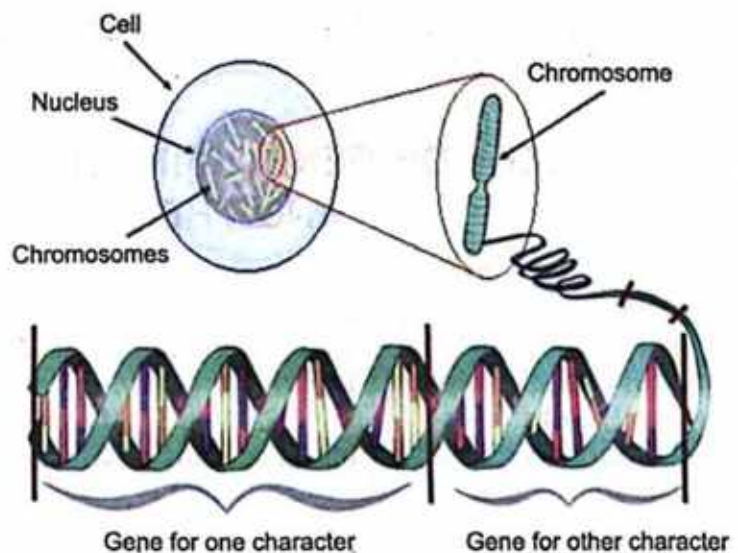


Fig. 6.14 DNA, Chromatin and condensed chromosome structure

6.9 STRUCTURE OF RIBONUCLEIC ACID (RNA)

The RNA is a polynucleotide helical chain like DNA but it is single stranded nucleic acid. (Fig.6.13) In RNA **pentose sugar ribose** is present instead of deoxyribose. RNA molecule also differs from DNA in having **uracil nucleotide** instead of thymine nucleotide. Nitrogen bases of RNA molecule are overhung because they are not bonded to nitrogen bases of other (complementary) strand like DNA. Sequence of nucleotides in RNA is synthesized by using the sequence of nucleotides in DNA by the process of transcription.

6.10 FUNCTION OF RNA IN CONVERTING HEREDITARY INFORMATION INTO USEFUL PROTEINS

After synthesis in the nucleus, RNA is transported to cytoplasm. RNA is an intermediate molecule for controlling the heredity. The primary function of RNA is to synthesize proteins by the process of translation. All three types of RNA are involved in translation of genetic information into various proteins necessary for cellular processes.

6.10:1 Types and functions of RNA

There are three types of RNA.

- Messenger RNA (mRNA):** It carries message of DNA from nucleus to cytoplasm for protein synthesis so called mRNA.
- Transfer RNA (tRNA):** It transfer amino acids to ribosomes during protein synthesis hence called tRNA.
- Ribosomal RNA (rRNA):** It is the component of ribosome therefore, called rRNA. It combines with ribosomal protein to form units of ribosomes, which are factory of proteins.

6.11 FLOW OF GENETIC INFORMATION FROM DNA TO RNA AND THEN TO PROTEINS

DNA (genes) contain information needed for the synthesis of proteins. The flow of biological information, from DNA to RNA and from RNA to protein is known as the "central dogma of molecular biology" or "central dogma of life". Proteins are the main structural and functional molecules of living organisms. Correct Primary structure of any protein is primarily determined by DNA. Protein synthesis takes place in two sequential steps i.e. transcription and translation. Together transcription and translation are known as gene expression (Fig. 6.16).

6.11.1 Transcription

Transcription is the first step of gene expression that involves the formation of RNA molecule from DNA. Both DNA strands of a gene unwind from each other. Only one strand of DNA is copied. Nucleotide sequence of one DNA strand (coding strand) is copied in the form of mRNA. After the gene is copied to mRNA, both strands of DNA are again coiled together into its normal double stranded shape.

6.11.2 Translation

The mRNA synthesized in the nucleus of the cell moves into the cytoplasm where it binds to the ribosome. The mRNA message (codes) is translated by ribosomes which link amino acids to form polypeptide chain with specific sequence of amino acids. Different types of tRNAs, transfer amino acids to ribosome as per sequence of codes in mRNA.

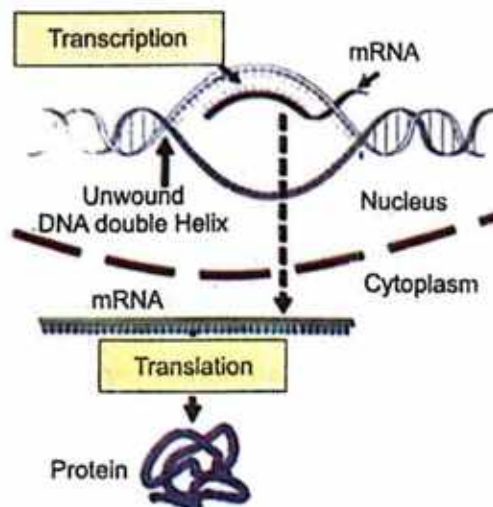


Fig. 6.15 Transcription and translation

SUMMARY

- Biochemistry is the study of different chemical compounds and the chemical processes taking place within the living organisms.
- Living organisms are composed of 16 out of 92 naturally occurring elements called bioelements out of which six are Major and ten are Minor bioelements.
- Different bio-elements combine to form inorganic and organic biomolecules including water, carbohydrates, lipids, proteins and nucleic acids.

- Proteins are made up of a single or more polypeptide chains which are polymers of amino acids. Amino acids are composed of C, H, O, N and sometimes P, S, Fe etc. Number, type and sequence of amino acids in each polypeptide chain is specific. Proteins play multiple structural and functional roles.
- A group of heterogeneous hydrophobic organic compounds including fats, oils, waxes and steroids found in the living organisms, is called lipids. One gram of lipids contain double amount of energy than carbohydrates due to higher carbon-hydrogen ratio.
- Most common types of lipids are tri-acyl glycerides which contains one glycerol and three fatty acids. Saturated fatty acids are solid at room temperature whereas unsaturated fatty acids are liquid at room temperature.
- Carbohydrates are the compounds of carbon, hydrogen and oxygen with a ratio of 1:2:1 respectively and literally called "hydrates of carbon".
- Carbohydrates are the important biological molecules commonly called sugars or saccharides. Glucose is a monosaccharide, naturally produced in the green plants by the process of photosynthesis using CO_2 from air and H_2O from soil.
- Polysaccharides are complex carbohydrates of plants and animals to store extra carbohydrate e.g., starch, glycogen and are usually tasteless. Cellulose, chitin and peptidoglycan are polysaccharides which are structural components of cell walls in the plant fungi and bacteria.
- Nucleic acids are of two types; Deoxyribonucleic Acid (DNA) and Ribonucleic Acid (RNA) which store and transfer hereditary information from one generation to next.
- DNA contain information for the synthesis of proteins. The flow of information, from DNA to RNA and from RNA to protein is known as the "central dogma of molecular biology" or "central dogma of life". Together transcription and translation are known as gene expression.

EXERCISE

Section I: Multiple Choice Questions

Select the correct answer:

- Which of the following is major bio-element?
A) sodium B) magnesium C) Phosphorous D) iron
- Peptide bond is formed between two:
A) Monosaccharides B) Amino acids C) Nucleotides D) Fatty acids
- During translation, sequence of amino acids in the protein is decides on the basis of sequence of nucleotides in:
A) tRNA B) rRNA C) tRNA D) DNA
- Different amino acids differ from each other on the basis of their ----- group:
A) Alkyl B) Carboxylic C) Amino D) Phosphate

5. Both strands of DNA are held together by hydrogen bonding, double hydrogen bonds are present between:
A) Adenine and thymine B) Cytosine and guanine
C) Cytosine and thymine D) Adenine and guanine
6. Transcription takes place in the
A) Cytoplasm B) Nucleus
C) Ribosomes D) Rough Endoplasmic reticulum
7. All the nucleotides of RNA differ from the nucleotides of DNA in having different:
A) Nitrogen base B) Pentose sugar C) Phosphate group D) carboxylic group
8. Diameter of DNA is thoroughly uniform and is about:
A) 34 nm B) 3.4 nm C) 2nm D) 1.1nm
9. Which of the disaccharide is also called transport sugar?
A) Sucrose B) Maltose C) Fructose D) Lactose
10. Vitamin D belongs to:
A) Carbohydrates B) Lipids C) Protein D) RNA

Section II: Short Answer Questions

1. Compare ratios of bio-elements.
2. Compare the energy level of carbohydrates, proteins and lipids.
3. How biochemistry is important for study of physiology, cell biology and anatomy?
4. Define gene (a localized region of DNA that codes for a protein).
5. Name structural and energy producing nature of carbohydrates.
6. What are different plant sources of proteins?
7. How primary structure of protein is important?

Section III: Extensive Answer Questions

1. How lipids are important for living organisms?
2. Explain the composition of chromatin material?
3. What are different types of disaccharides? How are they produced? Mentions their sources.
4. Give an account of genes on chromosomes.
5. Describe the role of gene in protein synthesis.
6. Explain how genes control inheritance of characters.
7. Describe the composition of chromatin material.
8. Explain that gene is a unit of inheritance and that it can be copied and passed on to the next generation.
9. Describe the central dogma stating the role of gene in protein synthesis.
10. Describe structure, sources and functions of lipids.