CARBOHYDRATES, ENZYMES AND NUCLEIC ACID

The cell: Cell is the smallest fuctional and structural unit of all living matters. The cell is composed of C, H, N, O, P and S etc.

Structure of Cell

(*a*) Cell wall: It is the regid wall around the cell made up of carbohydrates such as cellulose, lignin etc.

(*b*) Cell membrane: It is the elastic membrane next to cell wall made up of phospholipids and proteins.

(*c*) Cytoplasm: It is the viscous translucent jelly like material having organelles embedded in it.

(*d*) Mitochondria: It is releases ATP by food oxidation during respiration.

(e) Lysosomes: It contains enzymes to digest food, foreign substances and worn out organelles.

(f) Nucleus: It is the control house of the cell having DNA packed with histone protein in it.

(g) Endoplasmic reticulum: It has ribosomes on its outer surface made up of r-RNA employed in protein synthesis.

(h) Golgi apparatus: It delivers biomolecules such as phospholipids, proteins etc. to other organelles.

Components of a bacterial cell

	Components	Percent of total cell weight
I.	Water	70
II.	Protein	15
III.	Nucleic acids: RNA	6
	DNA	1
IV.	Polysaccharides	2
V.	Phospholipids	2
VI.	Inorganic ions (Na^+, K^+, Mg^{2+} Ca^{2+})	1
VII.	Miscellaneous small molecules	3

Carbohydrates

Carbohydrates are the polyhydroxyaldehydes or polyhydroxyketones, and all those substances which yield these compounds on hydrolysis. They have the general formula $C_n(H_2O)_n$.

Classification of Carbohydrates

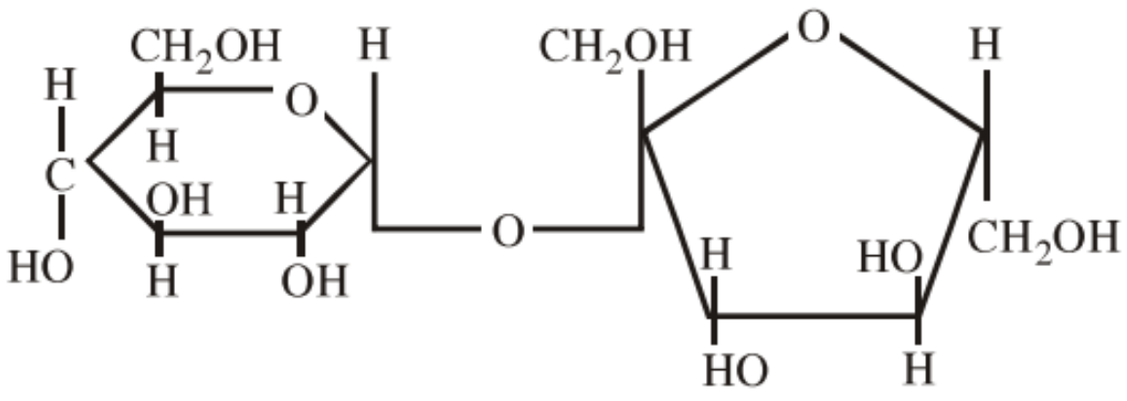
(a) Monosaccharides: These are the single unit of carbohydrates having general formula $C_nH_{2n}O_n$ (n = 3 to 8). These are sweet, water soluble, optically active and non-hydrolysable sugars. Sugars containing aldehyde group are known as **aldoses** and those containing keto group are known as **ketoses**. Some examples are as follows:

	Type of sugar	Formula	Aldose	Ketose
I.	Trioses	$C_3H_6O_3$	Aldotriose (Glycer-aldehyde)	Ketotriose (Di-hydrox-yacetone)
II.	Tetroses	$C_4H_8O_4$	Aldotetrose (Erythrose)	Ketotetrose (Eruthrulose)
III.	Pentoses	$C_5H_{10}O_5$	Aldopentose (Ribose)	Ketopentose (Xylulose)
IV.	Hexoses	$C_6H_{12}O_6$	Aldohexose (Glucose)	Ketohexose (Fructose)

(*b*) **Oligosaccharides:** Oligosaccharides are the sugars composed of 2-10 monosaccharides. Those containing two simple sugars are known as **disaccharides** and those having three simple sugar are known as **trisaccharides**. Sugars belonging to this class are sweet, water soluble and hydrolysable.

(*i*) **Sucrose ($C_{12}H_{22}O_{11}$, table sugar):** It is dextro-rotatory, disaccharide of glucose and fructose. The two monosaccharides are joined together by α-1, 2-glycoside bond. Under mild acidic conditon, on hydrolysis, it yields equimolar mixture of glucose and fructose which is called as invert sugar.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{or Invertase}]{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$



Structure of sucrose

(*ii*) Maltose ($C_{12}H_{22}O_{11}$, malt sugar): It is a disaccharide obtained by partial hydrolysis of starch by the enzyme diastase. On hydrolysis under acidic conditions it yields two molecules of D(+) glucose.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Glucose}}{C_6H_{12}O_6}$$

(*iii*) Lactose ($C_{12}H_{22}O_{11}$, milk sugar): It is a disaccharide of glucose and galactose.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

(c) Plysaccharides: Polysaccharides contain more than ten units of monosaccharides.

(*i*) Starch $[(C_6H_{10}O_5)_n]$: It occures in roots, tubers and seeds. Large amount (60 – 80%) of starch is present in wheat, rice, corn, legumes, potatoes and other vegetables. Starch is made of repeating units of α-glucose and mixture of amylose and amylopectin.

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow[\text{Hydrolysis}]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

(*ii*) **Cellulose:** It is most abundant of all carbohydrates and is the chief constituent of wood (50%), cotton and paper etc. It is a linear polymer of β-glucose.

(*iii*) **Glycogen:** It is the animal polysaccharide and is stored in liver and muscles. It contains 10-14 units of glucose.

Functions of Carbohydrates

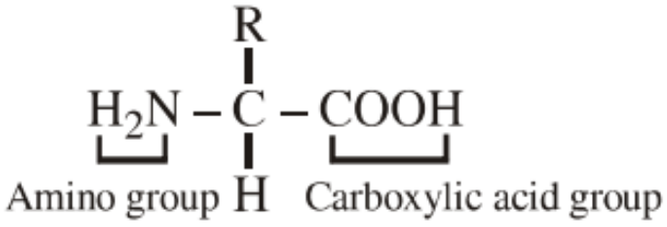
(*a*) They provide energy for the functioning of living system.

(*b*) They serve as the structural materials for cell walls.

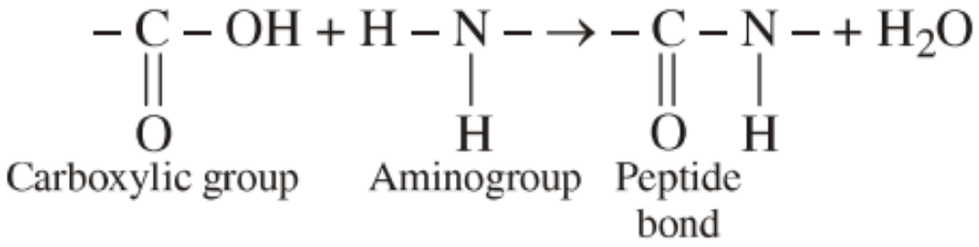
(*c*) Glycogen carbohydrate stored in liver acts as instant food on hydrolysis glucose.

2. Proteins: It may be defined as condensation polymers of α-amino acids.

Amino acids: These are the bifunctional compounds containing amino acid and a carboxylic acid group.



Peptide bond: Amino acids are joined through peptide bonds. peptide bonds are formed by condensation of carboxylic acid of an amino acid with amino group of the same or another molecule of amino acid.



Functions of Proteins

(*i*) They are essential for growth and maintenance of life.

(*ii*) They are structural material of animal tissues like skin, hair, nails etc.

(*iii*) They act as transport agents like haemoglobin.

3. Enzymes

(*i*) e.g. Amylase, invertase, lactase, maltase, urease etc.

Enzymes are the powerful biological catalyst. They are all proteins, higly efficient (at pH = 7 and temperature = 37°C) and reaction specific. Some enzymes are associated with non-protein part known as **co-enzymes**.

Enzymes and the reactions they catalyse

	Enzyme	Reaction catalysed
I.	Amylase	Starch → Glucose
II.	Carbonic anhydrase	Carbonic acid → $H_2O + CO_2$.
III.	Invertase	Sucrose → Glucose + Fructose
IV.	Lactase	Lactose → Glucose + Galactose
V.	Maltase	Maltose → Glucose
VI.	Pepsin	Protein → Amino acids
VII.	Urease	Urea → $NH_3 + CO_2$

The dificiency of an enzyme can cause serious disease. The dificiency of an enzyme phenylalanine causes the disease phenyl ketone urea; dificiency of enzyme tyrosinase cause albinism.

4. Nucleic acids

e.g. Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Nucleic acids are the polynucleotide which are composed of sugar, phosphoric acid group and four bases, two purines and two pyremidines. The two type of nucleic acid are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

Nucleoside				Acid
Sugar		Base		
		Purines	Pyrimidines	
RNA	Ribose	Adenine (A)	Cytosine (C)	Phosphoric acid
		Guanine (G)	Uracil (U)	
DNA	Dexyribose	Adenine (A)	Cytosine (C)	Phosphoric acid
		Guanine (G)	Thymine (T)	

Nucleic acids transmit hereditary effects from one generation to next generation and also cotntrol biosynthesis of protein.

Double Helix

Nucleic acid DNA has two polynucleotide chains held together by hydrogen bonds and twisted about a common axis to form double helix. The two strands of double helix are complementary. A thymine base (T) is linked to adenine base (A) in the opposite chain and guanine base (G) is always linked to cytosine base (C) in the opposite chain.

5. **Viruses:** Chemically, viruses contain nucleic acid surrounded by simple proteins. They are ultramicroscopic infectious agents and are responsible for many diseases

known as **virus diseases**. e.g. AIDS (caused by HIV), common cold, rabies, yellow fever, poliomyelitis, measles etc.

6. **Lipids:** These are oily substances, insoluble in water and soluble in benzene, chloroform etc.

   (i) **Triglycerides:** These are the triesters of unbranched long chain saturated or unsaturated fatty acids with glycerol. Triglycerides containing higher proportion of saturated fatty acids are known as fats, while those with higher proportion of unsaturated fatty acids are known as **oils**.

Some Important Facts

I. Aldehydric and ketonic groups in carbohydrates exist in combination with one hydroxyl group of the molecule in the form of hemiacetals and hemiketals.

II. Glucose is also known as grape sugar, blood sugar and corn sugar.

III. In maltose, two D (+) glucose molecules are joined together by α–1, 4–glycoside bond.

IV. In lactose, D(+) glucose and D(+) galactose are joined together by β–1, 4–glycoside bond.

V. Humans cannot digest cellulose because of absence of enzymes to hydrolyse it.

VI. Glucose exists in two optically active forms, α–D–Glucose and β–D–glucose.

VII. Pentoses and hexoses are most common naturally occurring monosaccharides.

VIII. Sucrose is dextrorotatory but on hydrolysis it yields equimolar solution of glucose and fructose (invert sugar) that is levorotatory. This inversion of optical rotation is called as **inversion of sugar**.

IX. More the unsaturated acid, lower is the melting point of fat.

X. Fats differ from each other due to different acid radicals present in triglycerides.

XI. Proteins are nitrogenous organic compounds of high molecular masses.

XII. Protein is name given to a polypeptide containing more than 100 amino acid molecules.

XIII. DNA contains the genetic code and directs protein synthesis through RNA.

XIV. Mutation is any physical or chemical change that alters the sequence of bases in DNA molecule.

XV. Amylopectin is a branched chain polymer and has molecular mass in the range of 50,000 – 100,000 amu.

XVI. Insulin is a harmone which contains 51 amino acids in two polypeptide chains.

XVII. The enzymes are much larger than the molecules they catalyse.

XVIII. Anything that causes mutation is called a **mutagen**.
