

Class: 12th

Subject: Biology

Chapter 4:

Molecular Biology

❖ Important Mcqs: Molecular Biology

1. Biochemistry is the study of:

- (a) Anatomy of living organisms
- (b) Chemical components and processes in living organisms
- (c) Physical structure of cells
- (d) Evolution of species

2. Which of the following processes can be described in biochemical terms?

- (a) Photosynthesis
- (b) Plate tectonics
- (c) Weathering of rocks
- (d) Erosion



3. What percentage of living organisms' mass is made up of water?

- (a) 50%
- (b) 60%
- (c) 80%
- (d) 95%

4. Molecules synthesized by cells and containing carbon are called:

- (a) Inorganic molecules
- (b) Organic molecules
- (c) Minerals
- (d) Salts

5. Which of the following is NOT an organic macromolecule?

- (a) Proteins
- (b) Carbohydrates
- (c) Lipids
- (d) Carbon dioxide



6. The molecules made up of many identical units are called:

- (a) Monomers
- (b) Polymers
- (c) Enzymes
- (d) Amino acids

7. Which of the following is a monomer of nucleic acids?

- (a) Amino acids

(b) Nucleotides

(c) Monosaccharides

(d) Fatty acids

8. Carbohydrates, proteins, lipids, and nucleic acids make up approximately what percentage of the dry mass of living organisms?

(a) 50%

(b) 70%

(c) 93%

(d) 100%

9. Small organic molecules like vitamins and inorganic molecules like salts make up what percentage of living organisms' dry mass?

(a) 3%

(b) 7%

(c) 10%

(d) 15%

10. Life on Earth evolved in which medium?

(a) Air

(b) Soil

(c) Water

(d) Rocks

11. Carbon is called tetravalent because it can form:

(a) 2 bonds

(b) 3 bonds

(c) 4 bonds

(d) 5 bonds

12. Which bond is a potential source of chemical energy for cellular activities?

(a) C-O bond

(b) C-H bond

(c) Peptide bond

(d) Glycosidic bond

13. Peptide bonds are formed between:

(a) Sugar molecules

(b) Amino acids

(c) Nucleotides

(d) Fatty acids

14. Covalent bonds are formed when:

- (a) One atom donates an electron
- (b) Two atoms share electrons
- (c) Hydrogen is attracted to oxygen
- (d) Nonpolar molecules cluster together

15. Ionic bonds are strongest in:

- (a) Aqueous solution
- (b) Solid state
- (c) Gaseous state
- (d) Lipid environment



16. Hydrogen bonds are important for maintaining the structure of:

- (a) Proteins and nucleic acids
- (b) Lipids and carbohydrates
- (c) Vitamins and minerals
- (d) Water only

17. Hydrophobic interactions occur between:

- (a) Polar molecules and water

(b) Nonpolar molecules in water

(c) Ions in solid state

(d) Hydrogen and oxygen atoms

18. Hydrophilic interactions occur between:

(a) Nonpolar molecules

(b) Polar molecules and water

(c) Hydrogen and carbon atoms

(d) Lipids in membranes

19. Which bond is mostly found in inorganic molecules like sodium chloride?

(a) Covalent

(b) Ionic

(c) Hydrogen

(d) Hydrophobic

20. Glycosidic linkages provide stability to which type of?

(a) Proteins

(b) Nucleic acids

(c) Carbohydrates

(d) Lipids

21. Condensation reactions are also known as:

(a) Hydrolysis

(b) Dehydration synthesis

(c) Oxidation

(d) Reduction

22. During a condensation reaction, what is removed from monomers?

(a) Only H atoms

(b) Only OH groups

(c) Both H and OH groups

(d) Neither H nor OH

23. The formation of maltose from two glucose molecules is an example of:

(a) Hydrolysis

(b) Condensation reaction

(c) Oxidation reaction

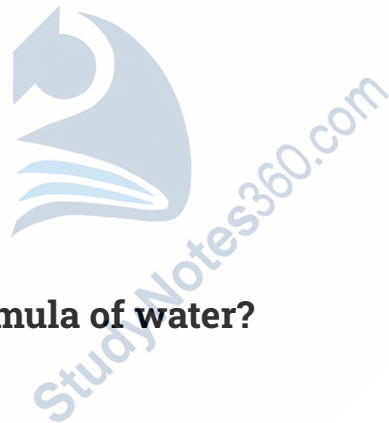
(d) Reduction reaction

24. Hydrolysis reactions involve:

-
- (a) Removal of water
 - (b) Addition of water
 - (c) Formation of peptide bonds
 - (d) Formation of glycosidic bonds

25. The breakdown of maltose into two glucose molecules is an example of:

- (a) Condensation
- (b) Hydrolysis
- (c) Dehydration synthesis
- (d) Polymerization



26. What is the chemical formula of water?

- (a) H_2O
- (b) CO_2
- (c) H_2
- (d) O_2

27. Approximately what fraction of the human body is composed of water?

- (a) One third

(b) Two thirds

(c) Half

(d) Three fourths

28. Which property of water allows it to dissolve a wide variety of substances?

(a) Non-polarity

(b) Polarity and hydrogen bonding

(c) Low boiling point

(d) High density

29. In a water molecule, which atom carries a partial negative charge?

(a) Hydrogen

(b) Oxygen

(c) Carbon

(d) Nitrogen

30. The weak attraction between a partially positive hydrogen of one water molecule and a partially negative oxygen of another water molecule is called:

(a) Ionic bond

-
- (b) Covalent bond
 - (c) Hydrogen bond
 - (d) Hydrophobic interaction

31. Polar or charged molecules are:

- (a) Insoluble in water
- (b) Soluble in water
- (c) Hydrophobic
- (d) Non-polar

32. When sodium chloride dissolves in water, water molecules:

- (a) Form covalent bonds with Na^+ and Cl^-
- (b) Form hydrogen bonds with Na^+ and Cl^-
- (c) Ignore the ions
- (d) React chemically to form HCl

33. Glucose dissolves in water because:

- (a) It is non-polar
- (b) Water forms hydrogen bonds with hydroxyl groups of glucose
- (c) Glucose reacts with water

(d) Glucose is hydrophobic

34. Water provides a medium for:

(a) Photosynthesis only

(b) Metabolism and other chemical reactions in cells

(c) Protein folding only

(d) Lipid synthesis only

35. Non-polar molecules are:

(a) Hydrophilic

(b) Hydrophobic

(c) Ionic

(d) Polar



36. Lipid molecules in water:

(a) Dissolve completely

(b) Form hydrophobic associations

(c) Form hydrogen bonds with water

(d) Ionize in water

37. The network of hydrogen bonds in water is responsible for:

-
- (a) Water's low boiling point
 - (b) Many unique properties of water ✓
 - (c) Insolubility of glucose
 - (d) Formation of covalent bonds

38. Which type of molecules are excluded from water?

- (a) Polar molecules
- (b) Charged molecules
- (c) Non-polar molecules ✓
- (d) Ionic molecules

39. The hydrophobic exclusion of lipids helps in:

- (a) Dissolving glucose
- (b) Maintaining cell membranes ✓
- (c) Breaking hydrogen bonds
- (d) Forming peptide bonds

40. Brain cells contain approximately what percentage of water?

- (a) 20%
- (b) 50%

(c) 85%

(d) 100%

41. Specific heat capacity is defined as the amount of heat required to raise the temperature of:

(a) 1 gram of a substance by 1°C

(b) 1 kg of a substance by 1°C

(c) 1 liter of water by 10°C

(d) 1 gram of water by 10°C

42. The specific heat capacity of water is approximately:

(a) $1 \text{ cal/g}^{\circ}\text{C}$

(b) $2 \text{ cal/g}^{\circ}\text{C}$

(c) $4.184 \text{ J/g}^{\circ}\text{C}$

(d) $10 \text{ J/g}^{\circ}\text{C}$

43. High specific heat capacity of water allows it to:

(a) Heat up very quickly

(b) Absorb and release heat with minimum temperature change

(c) Evaporate easily

(d) Freeze quickly

44. Heat of vaporization of water is:

- (a) 100 cal/g
- (b) 574 Kcal/kg
- (c) 50 cal/g
- (d) 1 Kcal/kg

45. The cooling effect of water in plants and animals during transpiration and perspiration is due to:

- (a) High density
- (b) Cohesion
- (c) High heat of vaporization
- (d) Maximum density at 4°C

46. Cohesion among water molecules is due to:

- (a) Ionic bonds
- (b) Hydrogen bonds
- (c) Covalent bonds
- (d) Hydrophobic interactions

47. Cohesion of water is important in plants because it helps in:

- (a) Photosynthesis

(b) Transport of water and nutrients from roots to leaves

(c) Carbon fixation

(d) Respiration

48. Hydrogen bonds give water a high:

(a) Density at 100°C

(b) Surface tension

(c) Ionization

(d) Heat capacity

49. Ionization of water produces:

(a) H₂ molecules

(b) O₂ molecules

(c) H⁺ and OH⁻ ions

(d) CO₂ and H₂O

50. At room temperature, the concentration of H⁺ ions in pure water is approximately:

(a) 10⁻³ moles/litre

(b) 10⁻⁵ moles/litre

(c) 10⁻⁷ moles/litre

(d) 10^{-9} moles/litre

51. pH of a medium affects:

(a) Density of water

(b) Biochemical reactions and enzyme activity

(c) Cohesion of water

(d) Evaporation rate

52. Water reaches its maximum density at:

(a) 0°C

(b) 4°C

(c) 25°C

(d) 100°C



53. Ice floats on water because:

(a) Ice is denser than water

(b) Ice is less dense than water

(c) Water has low heat capacity

(d) Hydrogen bonds break completely in ice

54. Ice floating on water acts as:

-
- (a) Solvent
 - (b) Insulator
 - (c) Cohesive layer
 - (d) Hydrogen bond breaker

55. High specific heat of water helps in:

- (a) Stabilizing temperature of organisms and environment
- (b) Breaking peptide bonds
- (c) Forming lipids
- (d) Dissolving salts only

56. Which property of water allows aquatic organisms to survive in winter?

- (a) Low surface tension
- (b) Ice floats, providing insulation
- (c) High ionization
- (d) High solubility of lipids

57. Heat absorbed by water during heating is mostly used to:

- (a) Increase kinetic energy only
- (b) Break hydrogen bonds between water molecules

-
- (c) Ionize water molecules
 - (d) Increase density

58. Water behaves as if it has an invisible film on its surface due to:

- (a) Cohesion
- (b) Hydrophilic interactions
- (c) Ionization
- (d) Heat of vaporization

59. Evaporation of water from leaves or skin removes:

- (a) 100 cal/g
- (b) 574 cal/g
- (c) 1 cal/g
- (d) 10 cal/g

60. The density of ice is lower than liquid water because:

- (a) Hydrogen bonds keep molecules further apart
- (b) Ice has more mass
- (c) Water has no hydrogen bonds
- (d) Ice contains salts

61. The term “carbohydrate” literally means:

- (a) Carbon compound
- (b) Hydrated carbon
- (c) Sugar molecule
- (d) Organic acid

62. Carbohydrates are synthesized as:

- (a) Secondary products of photosynthesis
- (b) Primary products of photosynthesis
- (c) By-products of respiration
- (d) Products of hydrolysis

63. The empirical formula of carbohydrates is:

- (a) CH_2O
- (b) $\text{C}_6\text{H}_{12}\text{O}_6$
- (c) $\text{C}_{12}\text{H}_{22}\text{O}_{11}$
- (d) $\text{C}_5\text{H}_{10}\text{O}_5$

64. Monosaccharides are classified based on:

- (a) Solubility

(b) Number of sugar molecules

(c) Number of carbon atoms ✓

(d) Type of glycosidic bond

65. Glucose, fructose, and galactose are:

(a) Structural isomers ✓

(b) Functional proteins

(c) Lipids

(d) Polysaccharides

66. Glucose and galactose differ in:

(a) Molecular formula

(b) Number of carbon atoms

(c) Orientation of one hydroxyl (OH) group ✓

(d) Type of glycosidic bond

67. Common pentose sugars include:

(a) Glucose and fructose

(b) Ribose and deoxyribose ✓

(c) Maltose and sucrose

(d) Lactose and glucose

68. The covalent bond between two monosaccharides in a disaccharide is called:

(a) Peptide bond

(b) Hydrogen bond

(c) Glycosidic bond

(d) Ionic bond

69. Maltose is composed of:

(a) Glucose + Galactose

(b) Glucose + Fructose

(c) Two glucose molecules

(d) Glucose only

70. Sucrose is also known as:

(a) Milk sugar

(b) Cane sugar

(c) Malt sugar

(d) Transport monosaccharide

71. Polysaccharides are made up of:



-
- (a) Two monosaccharides
 - (b) Many monosaccharides joined by glycosidic bonds ✓
 - (c) Amino acids
 - (d) Nucleotides

72. The plant storage polysaccharide is:

- (a) Glycogen
- (b) Cellulose
- (c) Starch ✓
- (d) Chitin



73. Amylose is:

- (a) Branched and soluble
- (b) Straight, unbranched, and forms a helix ✓
- (c) A protein
- (d) A lipid

74. Amylopectin differs from amylose because it:

- (a) Has no glycosidic bonds
- (b) Has branches with 1,6-glycosidic linkages ✓

- (c) Is made of beta-glucose
- (d) Is found in animals only

75. Glycogen is stored mainly in:

- (a) Plant roots
- (b) Muscles and liver
- (c) Cell walls
- (d) Nucleus

76. Cellulose is composed of:

- (a) Alpha-glucose
- (b) Beta-glucose
- (c) Fructose
- (d) Galactose

77. The structural difference between starch and cellulose is:

- (a) Number of carbon atoms
- (b) Type of glucose and arrangement of OH group
- (c) Presence of nitrogen
- (d) Type of glycosidic bond only

78. Chitin is a modified form of:

- (a) Starch
- (b) Cellulose
- (c) Glycogen
- (d) Agar

79. Agar is primarily found in:

- (a) Fungi cell walls
- (b) Red algae cell walls
- (c) Animal exoskeletons
- (d) Plant roots



80. Murein is:

- (a) A sugar-peptide polymer found in prokaryotic cell walls
- (b) A storage polysaccharide in plants
- (c) A structural polysaccharide in fungi
- (d) A component of animal muscle

81. Proteins are polymers of:

- (a) Fatty acids

(b) Monosaccharides

(c) Amino acids ✓

(d) Nucleotides

82. The term “protein” was coined by:

(a) Charles Darwin

(b) J. J. Berzelius ✓

(c) Robert Hooke

(d) Louis Pasteur

83. Proteins are regarded as:

(a) Secondary metabolites

(b) Storage sugars

(c) Principal compounds of cells ✓

(d) Inorganic molecules

84. The basic structural unit of proteins is:

(a) Glucose

(b) Amino acid ✓

(c) Fatty acid



(d) Nitrogen base

85. An amino acid contains how many groups attached to the alpha carbon?

(a) Two

(b) Three

(c) Four

(d) Five

86. The unique properties of each amino acid depend on its:

(a) Amino group

(b) Carboxyl group

(c) Side chain (R group)

(d) Hydrogen atom

87. Most proteins are made up of how many types of amino acids?

(a) 10

(b) 15

(c) 20

(d) 170

88. Amino acids that our body can synthesize are called:

-
- (a) Essential amino acids
 - (b) Non-essential amino acids
 - (c) Neutral amino acids
 - (d) Acidic amino acids

89. Methionine, valine, and lysine are examples of:

- (a) Non-essential amino acids
- (b) Essential amino acids
- (c) Peptides
- (d) Enzymes

90. The bond linking two amino acids is called:

- (a) Hydrogen bond
- (b) Ionic bond
- (c) Peptide bond
- (d) Glycosidic bond

91. Formation of a peptide bond occurs through:

- (a) Hydrolysis
- (b) Oxidation

(c) Dehydration synthesis

(d) Reduction

92. When two amino acids join together, the product formed is:

(a) Polysaccharide

(b) Dipeptide

(c) Lipid

(d) Monosaccharide

93. Insulin contains how many amino acids?

(a) 20

(b) 51

(c) 100

(d) 574

94. Haemoglobin contains how many polypeptide chains?

(a) One

(b) Two

(c) Three

(d) Four

95. A protein may consist of:

- (a) Only one polypeptide chain
- (b) Two or more polypeptide chains
- (c) One or more polypeptide chains ✓
- (d) Only dipeptides

96. The primary structure of a protein is:

- (a) Folding of polypeptide chain
- (b) Linear sequence of amino acids ✓
- (c) Globular shape
- (d) Two chains combined

97. The primary structure of insulin consists of:

- (a) One chain of 51 amino acids
- (b) Two polypeptide chains (21 & 30 amino acids) ✓
- (c) Four chains
- (d) Three chains

98. Haemoglobin is composed of:

- (a) One polypeptide chain

-
- (b) Two alpha chains only
 - (c) Two alpha and two beta chains
 - (d) Three chains

99. The sequence of amino acids in a protein is determined by:

- (a) Ribosomes
- (b) Enzymes
- (c) DNA nucleotide sequence
- (d) Cytoplasm

100. Sickle cell anaemia occurs due to:

- (a) Absence of haemoglobin
- (b) Replacement of glutamic acid by valine
- (c) Iron deficiency
- (d) Extra alpha chain

101. Secondary structure of protein includes:

- (a) Alpha helix and pleated sheet
- (b) Globular structure
- (c) Peptide bond

(d) Quaternary arrangement

102. Secondary structure is stabilized mainly by:

(a) Ionic bonds

(b) Hydrogen bonds

(c) Peptide bonds

(d) Disulphide bonds

103. The tertiary structure of protein is:

(a) Linear chain

(b) Helix only

(c) Complex globular shape

(d) DNA-controlled step

104. Tertiary structure is maintained by:

(a) Peptide bonds

(b) Hydrogen bonds only

(c) Ionic, hydrogen & disulphide bonds

(d) Glycosidic bonds

105. Hydrophobic amino acids in tertiary structure are:

-
- (a) Present on surface
 - (b) Buried inside the protein
 - (c) Bonded with water
 - (d) Negatively charged

106. Quaternary structure forms when:

- (a) Amino acids combine
- (b) One chain folds
- (c) Two or more polypeptide chains join
- (d) DNA mutates

107. Proteins are structurally classified into:

- (a) Simple and complex
- (b) Structural and functional
- (c) Fibrous and globular
- (d) Acidic and basic

108. Fibrous proteins are mainly:

- (a) Enzymes
- (b) Structural proteins

(c) Hormones

(d) Transport proteins

109. Globular proteins are generally:

(a) Structural only

(b) Functional proteins

(c) Insoluble

(d) Found only in plants

110. Channel proteins function in:

(a) DNA replication

(b) Movement of substances across membrane

(c) Protein digestion

(d) Energy storage

111. Sodium-potassium pump is present in:

(a) Mitochondria

(b) Nucleus

(c) Cell membrane of neurons

(d) Ribosomes

112. Collagen and keratin are examples of:

- (a) Hormones
- (b) Enzymes
- (c) Fibrous structural proteins
- (d) Antibodies

113. Enzymes are proteins that:

- (a) Store ions
- (b) Catalyse metabolic reactions
- (c) Form cell wall
- (d) Transport oxygen

114. Haemoglobin transports:

- (a) Glucose
- (b) Oxygen and some CO₂
- (c) Hormones
- (d) Lipids

115. Albumin helps to:

- (a) Transport oxygen

(b) Maintain osmotic concentration of blood ✓

(c) Form muscle

(d) Break proteins

116. Fibrinogen is involved in:

(a) Muscle contraction

(b) Blood clotting ✓

(c) Oxygen transport

(d) Gene regulation

117. Actin and myosin are responsible for:

(a) Immunity

(b) Muscular contraction ✓

(c) Blood clotting

(d) Ion storage

118. Antibodies function to:

(a) Carry oxygen

(b) Store iron

(c) Recognize and neutralize antigens ✓

(d) Regulate DNA

119. Ferritin is a protein that:

(a) Transports oxygen

(b) Stores iron ions

(c) Forms clots

(d) Synthesizes RNA

120. Repressors regulate gene action by:

(a) Increasing protein synthesis

(b) Preventing RNA synthesis

(c) Breaking peptide bonds

(d) Forming spindle fibres

121. Lipids are best defined as compounds that are:

(a) Soluble in water

(b) Polar molecules

(c) Insoluble in water but soluble in organic solvents

(d) Carbohydrate polymers

122. The main components of acylglycerols are:

(a) Amino acids and glycerol

(b) Glycerol and fatty acids ✓

(c) Glucose and alcohol

(d) Nitrogen bases

123. Fats differ from oils because fats are:

(a) Liquid at room temperature

(b) Solid at room temperature ✓

(c) Unsaturated

(d) Found only in plants

124. Most plant acylglycerols occur in the form of:

(a) Fats

(b) Oils ✓

(c) Waxes

(d) Steroids

125. Triglycerides are also called:

(a) Neutral lipids ✓

(b) Compound lipids

(c) Steroids

(d) Glycolipids

126. Glycerol molecule contains:

(a) Two carbon atoms

(b) Three carbon atoms with three $-OH$ groups

(c) Four carbon atoms

(d) One carboxyl group

127. Saturated fatty acids:

(a) Have double bonds

(b) Have no double bonds and high melting point

(c) Have low melting point

(d) Are bent in shape

128. Unsaturated fatty acids have:

(a) Straight chains

(b) Maximum hydrogen atoms

(c) One or more double bonds and bent chains

(d) No carbon atoms

129. Lipids are good energy-storage molecules because they:

- (a) Are polar
- (b) Contain many C–H bonds
- (c) Contain nitrogen
- (d) Are soluble in water

130. Waxes act mainly as:

- (a) Hormones
- (b) Energy sources
- (c) Protective waterproof coverings
- (d) Enzymes

131. Phospholipids are mainly important in the formation of:

- (a) Cell wall
- (b) Plasma membrane
- (c) Ribosomes
- (d) Chromosomes

132. Phosphatidic acid is composed of:

- (a) One glycerol and one fatty acid

(b) One glycerol, two fatty acids and one phosphate group ✓

(c) Two glycerol molecules

(d) One fatty acid and one protein

133. The polar head of a phospholipid contains:

(a) Fatty acids

(b) Hydrocarbon chains

(c) Phosphate group and nitrogenous base ✓

(d) Steroid ring

134. The non-polar tail of a phospholipid consists of:

(a) Amino acids

(b) Two fatty acids ✓

(c) Phosphate group

(d) Nitrogen base

Terpenes

135. Terpenes are built from repeating units of:

(a) Glucose

(b) Amino acids

(c) Isoprene units

(d) Glycerol

136. Vitamin A and rubber are examples of:

(a) Steroids

(b) Terpenes

(c) Prostaglandins

(d) Phospholipids

Steroids

137. Steroids are characterized by:

(a) Long hydrocarbon chains

(b) Four fused carbon rings

(c) Peptide bonds

(d) Phosphate groups

138. Cholesterol is important because it:

(a) Forms enzymes

(b) Maintains membrane structure and forms steroid hormones

(c) Stores glucose

(d) Forms RNA

Prostaglandins

139. Prostaglandins mainly act as:

- (a) Structural lipids
- (b) Energy storage molecules
- (c) Local chemical messengers
- (d) Membrane phospholipids

Role of Lipids in Life

140. One gram of lipids provides approximately:

- (a) 4.1 kcal
- (b) 5.6 kcal
- (c) 9.5 kcal
- (d) 12 kcal

141. Nucleic acids are polymers of:

- (a) Amino acids
- (b) Monosaccharides
- (c) Nucleotides

(d) Fatty acids

142. The pentose sugar present in DNA is:

(a) Ribose

(b) Deoxyribose

(c) Glucose

(d) Fructose

143. Which nitrogenous base is present only in RNA?

(a) Thymine

(b) Cytosine

(c) Uracil

(d) Guanine



144. The linkage that joins two nucleotides together is called:

(a) Peptide bond

(b) Glycosidic bond

(c) Phosphodiester bond

(d) Hydrogen bond

145. DNA differs from RNA because DNA:

-
- (a) Is single stranded
 - (b) Contains uracil
 - (c) Is double helical and made of two polynucleotide chains
 - (d) Contains ribose sugar

146. Who studied the molecular architecture of DNA using X-ray diffraction?

- (a) James D. Watson and Francis Crick
- (b) Rosalind Franklin and Maurice Wilkins
- (c) Erwin Chargaff
- (d) Linus Pauling

147. Who proposed the double helix model of DNA in 1953?

- (a) Rosalind Franklin
- (b) Maurice Wilkins
- (c) James D. Watson and Francis Crick
- (d) Erwin Chargaff

148. The observation by Chargaff was important because it:

- (a) Suggested DNA is single-stranded
- (b) Helped in determining base pairing rules

-
- (c) Proved DNA is RNA
 - (d) Showed DNA is made of proteins

149. DNA is composed of:

- (a) Single polynucleotide chain
- (b) Two polynucleotide chains coiled around each other
- (c) Three RNA chains
- (d) Protein and RNA

150. The double helix of DNA resembles:

- (a) A twisted ladder
- (b) A straight rod
- (c) A circle
- (d) A branched chain

151. The poles of the DNA ladder are made of:

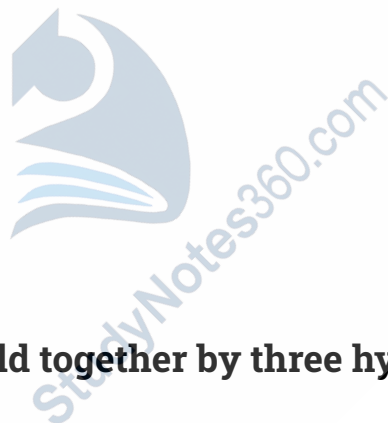
- (a) Nitrogenous bases
- (b) Sugars and phosphate groups
- (c) Amino acids
- (d) Lipids

152. The rungs of the DNA ladder are made of:

- (a) Sugar molecules
- (b) Phosphate groups
- (c) Nitrogenous base pairs
- (d) Proteins

153. Which base pairs are held together by two hydrogen bonds?

- (a) Adenine–Thymine
- (b) Guanine–Cytosine
- (c) Adenine–Cytosine
- (d) Thymine–Guanine



154. Which base pairs are held together by three hydrogen bonds?

- (a) Adenine–Thymine
- (b) Guanine–Cytosine
- (c) Adenine–Cytosine
- (d) Thymine–Guanine

155. DNA strands are:

- (a) Parallel

(b) Anti-parallel

(c) Circular

(d) Single-stranded

156. In eukaryotes, DNA is mainly located in:

(a) Cytoplasm

(b) Mitochondria

(c) Nucleus

(d) Ribosomes

157. DNA is the hereditary material for:

(a) Only animals

(b) All organisms except some viruses

(c) Only plants

(d) Only prokaryotes

158. A gene is:

(a) A protein molecule

(b) A sequence of nucleotides in DNA coding for a polypeptide

(c) A type of RNA

(d) A ribosome

159. RNA is synthesized by:

(a) Linking deoxyribonucleotides

(b) Joining ribonucleotides in front of deoxyribonucleotides of DNA

(c) Splitting DNA

(d) Breaking amino acids

160. mRNA:

(a) Is double-stranded

(b) Carries genetic message from DNA to ribosomes

(c) Transports amino acids

(d) Forms ribosomes

161. tRNA:

(a) Is single-stranded and forms ribosomes

(b) Is cloverleaf-shaped and transports amino acids to ribosomes

(c) Carries genetic message

(d) Stores DNA

162. rRNA:

-
- (a) Synthesized by ribosomes
 - (b) Synthesized by nucleoli and forms ribosomes ✓
 - (c) Is a messenger RNA
 - (d) Transports amino acids

163. What percentage of total RNA in a cell is rRNA?

- (a) 3–4%
- (b) 10–15%
- (c) 80% ✓
- (d) 50%

164. The function of rRNA is to:

- (a) Carry genetic information
- (b) Catalyze protein synthesis machinery in ribosomes ✓
- (c) Transport amino acids
- (d) Form DNA

165. Which RNA is the smallest and carries amino acids to mRNA?

- (a) mRNA
- (b) rRNA

(c) tRNA

(d) snRNA

EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. Which characteristic of water molecules is responsible for most of the unique properties of water?

(a) Small in size

(b) Held together by covalent bonds

(c) Can easily separate from one another

(d) Stick together

2. To which group of lipids do the human sex hormones belong?

(a) Steroid

(b) Waxes

(c) Prostaglandins

(d) Phospholipids

3. Which of the following is NOT a protein?

(a) Haemoglobin

(b) Cholesterol

(c) Pepsin

(d) Antibody

4. Which one is the largest carbohydrate?

(a) Cellulose

(b) Ribose

(c) Glyceraldehyde

(d) Glucose

5. What compound would be manufactured difficultly when soil has a shortage of phosphorus?

(a) DNA

(b) Fatty acids

(c) Proteins

(d) Cellulose

6. A compound whose chemical composition is most closely related to maltose is:

(a) Starch

(b) Protein

(c) ATP

(d) RNA

7. Which group is found in all fatty acids?

(a) PO₄

(b) SO

(c) C-N

(d) COOH

8. Haemoglobin has:

(a) Primary structure

(b) Secondary structure

(c) Tertiary structure

(d) Quaternary structure

9. Which process produces peptide bonds?

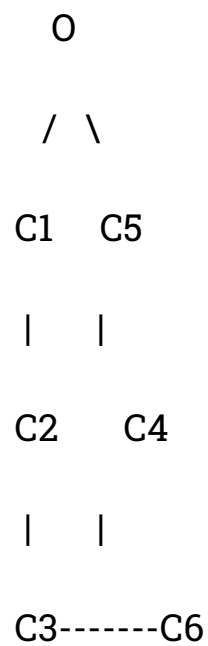
(a) Digestion

(b) Dehydration synthesis

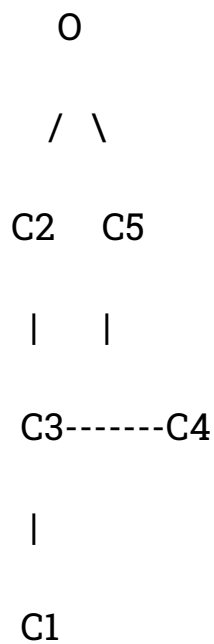
(c) Hydrolysis

(d) Enzyme deactivation

Glucose (α -D-glucose, 6-membered ring / pyranose form):



Fructose (β -D-fructose, 5-membered ring / furanose form):



Answer:

Monosaccharides like glucose and fructose form cyclic structures in solution. Glucose usually forms a six-membered ring (pyranose) while fructose forms a five-membered ring (furanose). Ring formation occurs when an oxygen atom from a hydroxyl group reacts with the carbonyl group, creating a stable ring. This cyclic form is essential for energy storage and metabolism in living cells.

3. Define isomers and stereoisomers.

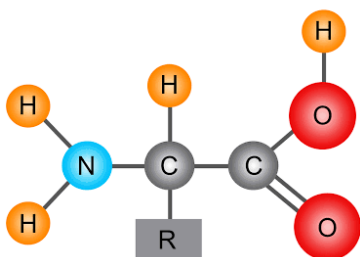
Answer:

Isomers are molecules that have the same molecular formula but differ in the arrangement of atoms. For example, glucose, fructose, and galactose all have the formula $C_6H_{12}O_6$ but different structures.

Stereoisomers are a type of isomer in which the atoms are connected in the same order but differ in spatial orientation. For instance, glucose and galactose differ in the orientation of the hydroxyl group on carbon 4, making them stereoisomers.

4. Draw the sketch of amino acid.

Sketch:

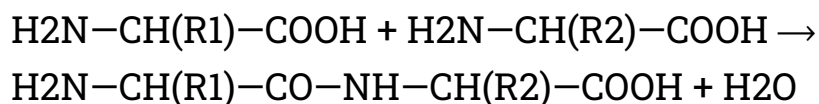


Answer:

An amino acid is the basic building block of proteins. It has four groups attached to a central carbon (α -carbon): an amino group ($-\text{NH}_2$), a carboxyl group ($-\text{COOH}$), a hydrogen atom, and a variable side chain (R group) that determines its properties. Amino acids link together through peptide bonds to form proteins, and the specific sequence of amino acids determines protein structure and function.

5. Outline the synthesis of peptide linkages.

Sketch (Peptide Bond Formation):

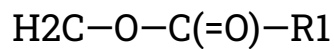
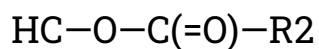
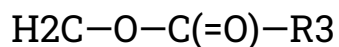
**Answer:**

Peptide linkage, also called a peptide bond, is formed by a dehydration synthesis reaction between the carboxyl group of one amino acid and the amino group of another. In the process, a water molecule is removed ($-\text{OH}$ from carboxyl and $-\text{H}$ from amino group). This covalent bond links amino acids into dipeptides, tripeptides, or polypeptides, which then fold to form functional proteins. Peptide bonds are critical for protein structure and biological activity.

6. Draw the sketch of acylglycerol, phospholipid, and terpene.

Acylglycerol (Triglyceride) Sketch:

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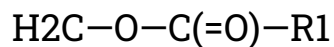
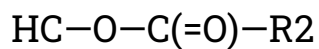

$$|$$

$$|$$
**Answer:**

Acylglycerols are fats and oils, composed of glycerol (3-carbon alcohol) esterified with three fatty acids. They are important energy storage molecules and are hydrophobic.

Phospholipid Sketch:

Id="b2l7mw"

Head (polar)

$$|$$

$$|$$

$$|$$


Answer:

Phospholipids are composed of glycerol, two fatty acids (tails), and a phosphate group with a nitrogenous base (head). The polar head is hydrophilic, while the fatty acid tails are hydrophobic. They form bilayers in membranes, providing structure and selective permeability.

Terpene Sketch (General Isoprene Units):

Id="c3m8hz"

$\text{CH}_2=\text{C}-\text{CH}=\text{CH}_2$ → multiple isoprene units joined

Answer:

Terpenes are hydrocarbons built from isoprene units (C_5H_8). They form biologically important compounds such as chlorophyll, vitamin A, and rubber. Terpenes are diverse in structure and function.

7. Differentiate between nucleoside and nucleotide.**Answer:****Definition of Nucleoside**

A nucleoside is a nitrogenous base attached to a pentose sugar (ribose or deoxyribose). It does not contain a phosphate group.

It is formed when a base (purine or pyrimidine) combines with the C1' carbon of a sugar through a glycosidic bond.

Examples:

- Adenosine (Adenine + Ribose)
- Deoxyadenosine (Adenine + Deoxyribose)

Definition of Nucleotide

A nucleotide is composed of three components:

- Nitrogenous base
- Pentose sugar
- One or more phosphate groups

It is formed when a phosphate group is attached to a nucleoside at the C5' carbon of the sugar.

Examples:

- ATP (Adenosine Triphosphate)
- dATP (Deoxyadenosine Triphosphate)

Main Differences

- A **nucleoside** contains only a sugar and a base.
- A **nucleotide** contains sugar, base, and phosphate group.
- **Nucleotides** are the building blocks of DNA and RNA, while nucleosides are intermediate structures.
- **Nucleotides** can form phosphodiester bonds, but nucleosides cannot.

8. Illustrate the formation of phosphodiester bond.

Sketch:

Id="d4n9kf"

5' – Sugar – PO₄ – Sugar – 3'

Answer:

Phosphodiester bonds join nucleotides to form polynucleotide chains in DNA and RNA. A phosphate group of one nucleotide attaches to the 3' hydroxyl (–OH) of the sugar of another nucleotide, forming a strong covalent bond. This creates the sugar-phosphate backbone of nucleic acids, with free 5' phosphate and 3' hydroxyl ends.

9. State the central dogma of gene expression.

Answer:

The central dogma of molecular biology explains how genetic information flows in a cell. DNA is first transcribed into RNA, and RNA is then translated into proteins. Proteins carry out cellular functions and determine the phenotype of an organism. In short, the flow of information is:

DNA → RNA → Protein

SECTION 3: LONG QUESTIONS

★ **Q1. Distinguish Carbohydrates, Proteins, Lipids and Nucleic Acids as the Four Fundamental Biological Molecules**

❖ **Answer:**

Living organisms are composed of four major biological molecules: carbohydrates, proteins, lipids, and nucleic acids. These biomolecules differ in structure, chemical composition, and biological function, but together they are essential for life.

1. Carbohydrates

Carbohydrates are organic compounds made up of carbon, hydrogen, and oxygen, usually in the ratio 1:2:1. Their basic units are monosaccharides such as glucose. Carbohydrates serve as the primary source of energy in living cells. They are broken down during cellular respiration to produce ATP. Some carbohydrates like starch (in plants) and glycogen (in animals) store energy, while cellulose provides structural support in plant cell walls.

2. Proteins

Proteins are complex molecules made up of amino acids joined by peptide bonds. They contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Proteins perform a wide range of functions such as acting as enzymes, hormones, antibodies, and structural components. Enzymes speed up biochemical reactions in the body. The specific sequence of amino acids determines the three-dimensional structure and function of each protein.

3. Lipids

Lipids are organic molecules mainly composed of carbon and hydrogen with a small amount of oxygen. They are non-polar and insoluble in water. Lipids include fats, oils, phospholipids, and steroids. Their main function is long-term energy storage. Lipids also provide insulation and protection to organs. Phospholipids are important components of cell membranes, forming a bilayer structure.

4. Nucleic Acids

Nucleic acids are polymers made up of nucleotide units. Each nucleotide consists of a sugar, a nitrogenous base, and a phosphate group. The two main types are DNA and RNA. DNA stores genetic information and controls heredity, while RNA plays a key role in protein synthesis. Nucleic acids contain carbon, hydrogen, oxygen, nitrogen, and phosphorus. They regulate cell activities by directing protein formation.

◆ Summary:

In summary, carbohydrates mainly provide quick energy and structural support, proteins perform structural, enzymatic, and regulatory functions, lipids store energy and form cell membranes, and nucleic acids store and transmit genetic information. All four biomolecules work together to maintain the structure, growth, and proper functioning of living organisms.

★ Q2. Describe and draw sketches of dehydration synthesis reactions.

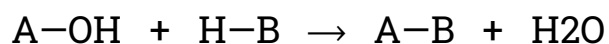
❖ Introduction:

Dehydration synthesis is a chemical reaction in which two small molecules combine to form a larger molecule with the removal of a water molecule (H₂O). It is also called a condensation reaction. This reaction is essential in the formation of biological macromolecules such as carbohydrates, proteins, and lipids.

General Mechanism of Dehydration Synthesis

In this reaction, a hydroxyl group (–OH) from one molecule and a hydrogen atom (–H) from another molecule combine to form water. After the removal of water, a new covalent bond is formed between the two molecules.

General Sketch:



1. Dehydration Synthesis in Carbohydrates

When two monosaccharides such as glucose combine, a glycosidic bond is formed and one molecule of water is removed.

Sketch:

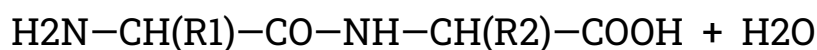


This reaction forms disaccharides like maltose and leads to the formation of polysaccharides such as starch.

2. Dehydration Synthesis in Proteins

Two amino acids combine through a peptide bond. The $-OH$ from the carboxyl group of one amino acid and $-H$ from the amino group of another amino acid form water.

Sketch:

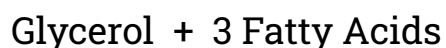


The bond formed ($-CO-NH-$) is called a peptide bond.

3. Dehydration Synthesis in Lipids

Glycerol reacts with fatty acids to form triglycerides. During this process, ester bonds are formed and water molecules are removed.

Sketch:



◆ **Summary:**

In summary, dehydration synthesis is a condensation reaction in which two small molecules join together with the removal of water. It is responsible for forming large biological molecules such as carbohydrates, proteins, and lipids. This process is essential for building macromolecules required for growth, repair, and proper functioning of living cells.

🌟 **Q3. Explain how the properties of water make it the medium of life.**

❖ **Introduction:**

Water is the most abundant substance in living organisms. About 60–90% of the body weight of living cells consists of water. It acts as the medium of life because most biochemical reactions occur in water. The unique chemical and physical properties of water make it essential for life.

1. Polarity and Universal Solvent Property

Water is a polar molecule because oxygen has a partial negative charge and hydrogen has a partial positive charge. Due to its polarity, water dissolves many ionic and polar substances such as salts, sugars, and gases.

This property makes water an excellent solvent and allows nutrients, minerals, and waste products to dissolve and move easily inside cells and body fluids.

2. High Specific Heat Capacity

Water has a high specific heat, meaning it can absorb a large amount of heat without a significant rise in temperature.

This property helps maintain stable internal body temperature in organisms and also stabilizes the temperature of aquatic environments.

3. High Heat of Vaporization

Water requires a large amount of heat energy to change from liquid to vapor.

This property allows cooling of organisms through sweating and transpiration. When water evaporates, it removes excess heat from the body.

4. Cohesion and Adhesion

Water molecules stick to each other due to hydrogen bonding (cohesion). They also stick to other surfaces (adhesion).

These properties help in the upward movement of water in plants through xylem and maintain surface tension.

5. Density of Ice

Ice is less dense than liquid water, so it floats on water.

This forms an insulating layer on water bodies during winter, protecting aquatic life underneath.

6. Role in Chemical Reactions

Water participates directly in many biochemical reactions such as hydrolysis and dehydration synthesis.

It is essential for digestion, metabolism, and cellular activities.

◆ **Summary:**

In summary, water is called the medium of life because of its polarity, solvent ability, high specific heat, high heat of vaporization, cohesion, and role in biochemical reactions. These properties help maintain stable conditions, transport substances, and support all life processes in living organisms.

★ **Q4. Distinguish the properties and roles of monosaccharides and classify them.**

❖ **Introduction:**

Monosaccharides are the simplest form of carbohydrates. They are single sugar units that cannot be hydrolyzed into smaller carbohydrate molecules. They are the basic building blocks of disaccharides and polysaccharides. Their general formula is $(\text{CH}_2\text{O})_n$.

Properties of Monosaccharides

Monosaccharides are usually colorless, crystalline solids and are sweet in taste. They are highly soluble in water due to the presence of multiple hydroxyl ($-\text{OH}$) groups. Most monosaccharides are reducing sugars because they possess a free aldehyde ($-\text{CHO}$) or ketone ($\text{C}=\text{O}$) group.

They can exist in both open-chain and ring forms in aqueous solution. They also show isomerism, including structural and optical isomers, due to the arrangement of atoms.

Roles (Functions) of Monosaccharides

Monosaccharides are the primary source of energy for living organisms. For example, glucose is used in cellular respiration to produce ATP.

They serve as building blocks for larger carbohydrates such as starch, glycogen, and cellulose.

Certain monosaccharides like ribose and deoxyribose are essential components of nucleic acids (RNA and DNA).

They also participate in the formation of glycoproteins and glycolipids, which are important for cell recognition and membrane structure.

◆ Classification of Monosaccharides

Monosaccharides are classified based on two main criteria:

1. Classification Based on Number of Carbon Atoms

Monosaccharides are divided into:

- Trioses – contain 3 carbon atoms (e.g., glyceraldehyde).
- Tetroses – contain 4 carbon atoms.
- Pentoses – contain 5 carbon atoms (e.g., ribose, deoxyribose).
- Hexoses – contain 6 carbon atoms (e.g., glucose, fructose, galactose).

Hexoses are the most common monosaccharides in living organisms.

2. Classification Based on Functional Group

Monosaccharides are also classified according to the type of carbonyl group present:

- Aldoses – contain an aldehyde group ($-\text{CHO}$), such as glucose.
- Ketoses – contain a ketone group ($\text{C}=\text{O}$), such as fructose.

◆ **Summary:**

In summary, monosaccharides are simple, water-soluble sugars that act as energy sources and building blocks of complex carbohydrates. They are classified based on the number of carbon atoms and the type of functional group present (aldose or ketose). Their properties and roles make them fundamental biological molecules.

✨ **Q5. Compare the structural isomers and stereoisomers of glucose.**

❖ **Introduction:**

Isomers are compounds that have the same molecular formula but different arrangements of atoms. Glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) shows both structural isomerism and stereoisomerism. These differences in arrangement result in different chemical and biological properties.

Structural Isomers of Glucose

Structural isomers have the same molecular formula but differ in the arrangement of atoms or in the position of functional groups.

For example, glucose and fructose both have the molecular formula $\text{C}_6\text{H}_{12}\text{O}_6$, but glucose is an aldose (contains an aldehyde group $-\text{CHO}$), while fructose is a ketose (contains a ketone group $\text{C}=\text{O}$).

This difference in functional group position makes them structural isomers. Although they contain the same number of carbon, hydrogen, and oxygen atoms, their chemical behavior differs.

Sketch:

Glucose (Aldose)



Fructose (Ketose)

**Stereoisomers of Glucose**

Stereoisomers have the same molecular formula and the same structural formula, but differ in the spatial arrangement of atoms.

Glucose has several asymmetric (chiral) carbon atoms, which allow it to form different stereoisomers. The most common example is D-glucose and L-glucose. These are mirror images of each other and cannot be superimposed.

In living organisms, D-glucose is the biologically active form used in metabolism.

Another type of stereoisomerism in glucose includes alpha (α) and beta (β) forms. These differ in the position of the $-\text{OH}$ group on the first carbon atom in the ring structure.

Sketch:

D-Glucose → OH on right side

L-Glucose → OH on left side

α -Glucose → OH below the ring

β -Glucose → OH above the ring

Main Differences

Structural isomers differ in the position of functional groups, while stereoisomers differ only in the spatial arrangement of atoms. Structural isomers may have different chemical properties, while stereoisomers usually have similar chemical properties but may differ biologically.

◆ Summary:

In summary, structural isomers of glucose differ in the arrangement of atoms and functional groups, whereas stereoisomers have the same structure but differ in three-dimensional orientation. Both types of isomerism are important in understanding the chemistry and biological role of glucose.

★ Q6. Distinguish the properties and roles of disaccharides

❖ Introduction:

Disaccharides are carbohydrates composed of two monosaccharide units joined together by a glycosidic bond. They are important energy sources and serve as transport forms of sugars in many organisms. Common examples include sucrose, lactose, and maltose.

Properties of Disaccharides

1. Solubility:

Disaccharides are soluble in water due to their polar hydroxyl (-OH) groups, but they are less soluble than monosaccharides.

2. Sweetness:

They have a sweet taste; sucrose is the standard sugar commonly used in foods.

3. Reducing or Non-Reducing:

Some disaccharides can act as reducing sugars (e.g., maltose, lactose) because they have a free aldehyde or ketone group. Others like sucrose are non-reducing because both anomeric carbons are involved in the glycosidic bond.

4. Hydrolysis:

Disaccharides can be hydrolyzed by specific enzymes to yield their monosaccharide units. For example:

- Sucrose → Glucose + Fructose (enzyme: sucrase)
- Lactose → Glucose + Galactose (enzyme: lactase)
- Maltose → Glucose + Glucose (enzyme: maltase)

Roles of Disaccharides

1. Energy Source:

They provide a quick source of energy when broken down into monosaccharides during digestion.

2. Transport of Sugars:

In plants, sucrose is the main sugar transported through phloem from leaves to other parts of the plant.

3. Osmotic Regulation:

Disaccharides help in maintaining osmotic balance within cells and tissues, preventing excessive water loss or gain.

4. Dietary Function:

Some disaccharides, such as lactose, contribute to the nutrition of young mammals by providing essential sugars in milk.

◆ Summary:

Disaccharides are formed from two monosaccharides linked by a glycosidic bond. They can be reducing or non-reducing, soluble in water, and hydrolyzed to release energy. Their biological roles include energy supply, sugar transport, osmotic regulation, and nutrition.

☀ Q7. Define Proteins and Amino Acids and Outline the Synthesis and Breakage of Peptide Linkages

❖ Introduction:

Proteins are the most abundant organic molecules in cells and are essential for the structure and functioning of all living organisms. They are polymers of amino acids linked together through peptide bonds. Proteins participate in almost all cellular processes, acting as enzymes, structural components, transporters, hormones, and antibodies.

Amino acids are the basic building blocks (monomers) of proteins. Each amino acid has a central carbon (alpha carbon) attached to an amino group (-NH₂), a carboxyl group (-COOH), a hydrogen atom (H), and a variable side chain (R group) that determines its properties.

Synthesis of Peptide Linkages

Peptide linkages are covalent bonds that join amino acids to form proteins. The formation occurs via dehydration synthesis (condensation reaction):

1. The amino group (-NH₂) of one amino acid reacts with the carboxyl group (-COOH) of another amino acid.
2. A molecule of water (H₂O) is released in the process.
3. A covalent bond, known as a peptide bond, is formed between the carbon (C) of the carboxyl group and the nitrogen (N) of the amino group.

This reaction produces a dipeptide. Addition of more amino acids leads to polypeptide chains, which fold to form functional proteins.

Equation:

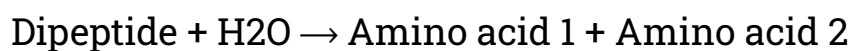


Breakage of Peptide Linkages

Peptide bonds can be broken by hydrolysis reactions, which involve the addition of water:

1. Hydrolysis is catalyzed by enzymes such as proteases or occurs under acidic or basic conditions.
2. The peptide bond is cleaved, releasing the individual amino acids.

Equation:



This reaction is essential for digestion and recycling of proteins in living organisms.

◆ Summary:

Proteins are polymers of amino acids linked by peptide bonds. Amino acids have a central carbon, an amino group, a carboxyl group, and a side chain (R). Peptide bonds are formed by dehydration synthesis and broken by hydrolysis. Proteins perform structural, enzymatic, transport, and regulatory roles in the cell.

🌟 Q8. Justify the Significance of the Sequence of Amino Acids through the Example of Sickle Cell Haemoglobin

❖ Introduction:

The sequence of amino acids in a protein determines its primary structure, which ultimately dictates the protein's shape and function. Even a single change in the sequence can significantly alter the protein's properties and biological activity. Proteins rely on precise amino acid sequences to fold correctly into secondary, tertiary, and quaternary structures.

Sickle Cell Haemoglobin as an Example

Haemoglobin is a protein in red blood cells that carries oxygen. Normal haemoglobin has four polypeptide chains: two alpha chains and two beta chains. Each chain has a specific sequence of amino acids essential for its function.

- In sickle cell haemoglobin (HbS), a single amino acid substitution occurs in the beta chain: valine replaces glutamic acid at position 6.
- This small change causes the haemoglobin molecules to stick together, forming long fibers that distort red blood cells into a sickle shape.

Consequences of the Amino Acid Sequence Change

1. Structural Impact: The abnormal folding of the beta chains changes the shape of the haemoglobin and the red blood cells.

2. Functional Impact: Sickle-shaped cells are rigid and less efficient at transporting oxygen.

3. Clinical Impact: These cells get trapped in capillaries, causing pain, anemia, and organ damage—a condition known as sickle cell anemia.

This example demonstrates that the sequence of amino acids is crucial, as even a single change can impair the protein's structure and biological function.

◆ **Summary:**

Proteins' functions depend on their amino acid sequences. A single substitution, as in sickle cell haemoglobin, can change the protein's shape, reduce its function, and cause disease. This illustrates the critical role of amino acid sequences in maintaining protein structure and biological activity.

★ **Q9. Describe the Properties and Roles of Acylglycerols, Phospholipids, Terpenes, and Waxes**

1. Acylglycerols (Fats and Oils)

Properties:

Acylglycerols are composed of glycerol and fatty acids. They can be solid at room temperature (fats) or liquid (oils). Fatty acids can be saturated (no double bonds, straight chains, high melting point) or unsaturated (one or more double bonds, bent chains, low melting point). They are non-polar, insoluble in water, and store high amounts of energy.

Roles:

- Act as energy storage molecules, providing more energy than carbohydrates due to more C–H bonds.
- Serve as insulation under the skin and cushioning for vital organs.

-
- In plants, oils serve as long-term energy reserves (e.g., seeds).

2. Phospholipids

Properties:

Phospholipids have a glycerol backbone, two fatty acids, and a phosphate group attached to a nitrogenous base (like choline). They are amphipathic: polar head (hydrophilic) and non-polar tail (hydrophobic).

Roles:

- Major components of cell membranes, forming the lipid bilayer.
- Provide structural integrity and control movement of substances in and out of cells.
- Play roles in cell signaling.

3. Terpenes

Properties:

Terpenes are made of isoprene units (C₅H₈) and are diverse in structure. They are usually non-polar, hydrophobic, and can form linear or cyclic structures.

Roles:

- Serve as pigments (e.g., chlorophyll in plants, retinal pigments in eyes).
- Function as vitamins (e.g., Vitamin A) and precursors for hormones.
- Natural products like rubber are also terpenes.

4. Waxes

Properties:

Waxes are long-chain hydrocarbons, alcohols, and fatty acids. They are chemically inert, solid at room temperature, hydrophobic, and have high melting points.

Roles:

- Act as protective coverings for plants (leaves, fruits) and animals (skin, feathers).
- Provide waterproofing and reduce water loss.
- Used by humans in candles, polishes, and cosmetics.

◆ Summary:

- **Acylglycerols:** Energy storage, insulation, cushioning.
- **Phospholipids:** Membrane structure, selective permeability, signaling.
- **Terpenes:** Pigments, vitamins, natural products.
- **Waxes:** Protection, waterproofing, high melting point.

★ Q10. Describe the Molecular-Level Structure of a Nucleotide

❖ Definition:

A nucleotide is the basic structural and functional unit of nucleic acids (DNA and RNA). It is a building block of genes and is essential for storing and transferring genetic information.

Molecular Components of a Nucleotide

A nucleotide consists of three main components:

1. Pentose Sugar

- A five-carbon sugar, either ribose (in RNA) or deoxyribose (in DNA).
- The sugar provides the backbone to which the other components attach.

2. Nitrogenous Base

A nitrogen-containing molecule attached to the C1 carbon of the sugar.

There are two types:

1. **Purines:** Adenine (A) and Guanine (G) – double-ringed bases.
2. **Pyrimidines:** Cytosine (C), Thymine (T in DNA), Uracil (U in RNA) – single-ringed bases.

3. Phosphate Group

- Attached to the C5 carbon of the sugar.
- Provides negative charge, contributes to the phosphodiester linkage, and gives the nucleotide its acidic property.

Phosphodiester Linkage

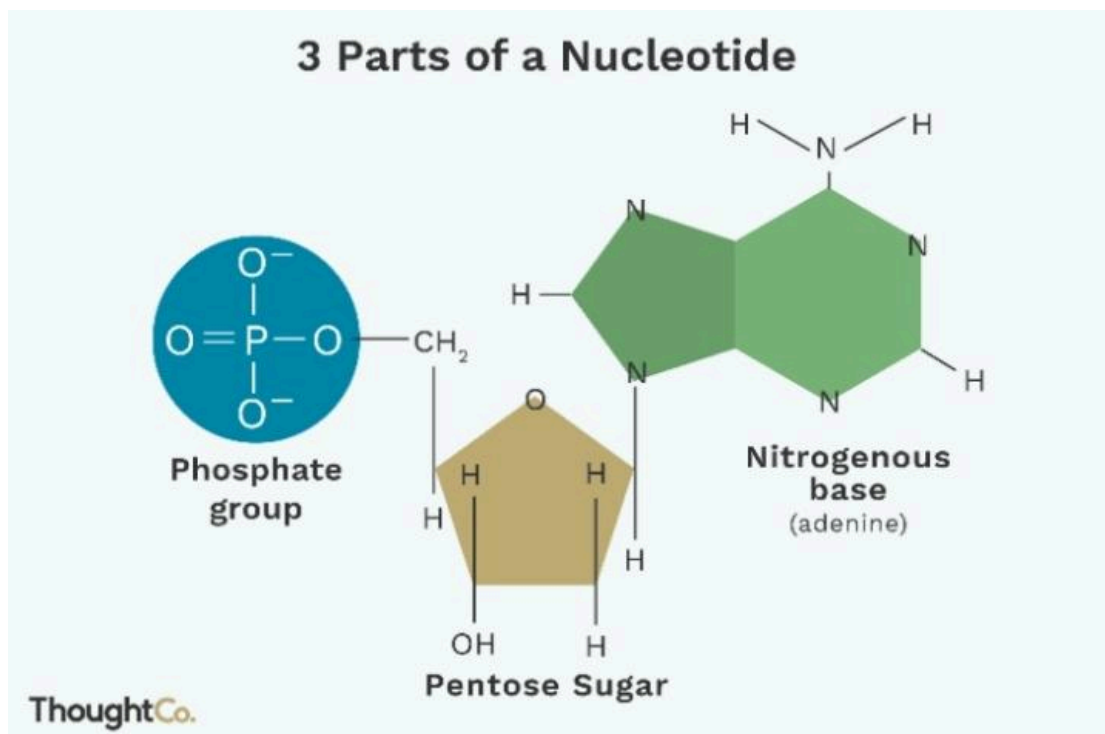
- Nucleotides connect through phosphate groups to form long polynucleotide chains.
- A phosphate group of one nucleotide bonds with the C3 hydroxyl group of another sugar via an ester bond, called a phosphodiester bond.

- This creates the sugar-phosphate backbone of nucleic acids, with nitrogenous bases projecting outward.

Additional Features

- Nucleoside = sugar + nitrogenous base (without phosphate).
- Nucleotides are energy carriers (e.g., ATP) or cofactors (e.g., NAD⁺).
- They store genetic information (DNA) and carry it to ribosomes (RNA) for protein synthesis.

Diagram of a Nucleotide:



◆ Summary:

- Nucleotides are composed of pentose sugar, nitrogenous base, and phosphate group.
- They form the sugar-phosphate backbone of DNA and RNA.

-
- Connected by phosphodiester bonds, nucleotides enable the storage and transmission of genetic information.
 - **Functionally**, nucleotides also act as energy molecules and enzyme cofactors.

☀ Q11. Explain the Double Helical Structure of DNA as Proposed by Watson and Crick

❖ Introduction:

The double helical structure of DNA was proposed by James D. Watson and Francis Crick in 1953, based on the X-ray diffraction data of Rosalind Franklin and Maurice Wilkins, and the base-pairing rules of Chargaff. This model explains how DNA stores genetic information and replicates accurately.

◆ Structural Features of DNA

1. Two Polynucleotide Chains

- DNA consists of two long polynucleotide chains that run in opposite directions (antiparallel).
- One strand runs from 5' → 3' while the other runs 3' → 5'.

2. Double Helix Shape

- The two strands coil around each other to form a right-handed double helix, resembling a twisted ladder.
- The sugar-phosphate backbone forms the outer poles of the ladder, providing structural stability.

3. Nitrogenous Base Pairing (Rungs of the Ladder)

Bases are located inside the helix and pair specifically:

- Adenine (A) pairs with Thymine (T) via 2 hydrogen bonds
- Guanine (G) pairs with Cytosine (C) via 3 hydrogen bonds

These base-pairing rules explain Chargaff's rule: %A = %T and %G = %C.

4. Hydrogen Bonding

- Weak hydrogen bonds between complementary bases hold the two strands together.
- These bonds allow strand separation during replication and transcription.

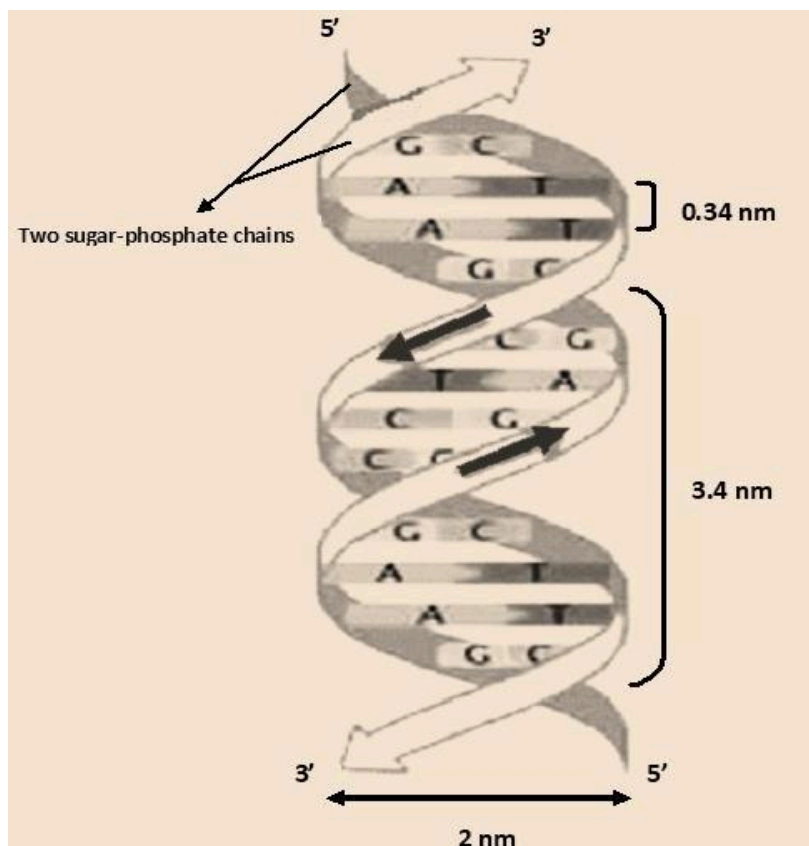
5. Major and Minor Grooves

- The helix has major and minor grooves that serve as binding sites for proteins, such as transcription factors and enzymes.

6. Location and Function

- In eukaryotes, DNA is located in the nucleus; in prokaryotes, DNA is in the cytoplasm.
- DNA stores genetic information in the sequence of its bases (genes).
- A gene is transcribed into RNA and translated into proteins, controlling cellular activities.

Diagram:



◆ Summary:

- DNA is a double-stranded antiparallel helix with sugar-phosphate backbone outside and complementary nitrogenous bases inside.
- Base-pairing (A-T and G-C) is stabilized by hydrogen bonds, allowing faithful replication.
- The double helix structure explains how DNA stores genetic information and acts as a template during replication and transcription.
- It is the hereditary material of all living organisms.

★ Q12. Explain the General Structure of RNA and Differentiate Between the Three Types of RNA

❖ Introduction:

RNA (Ribonucleic Acid) is a nucleic acid that plays a key role in gene expression and protein synthesis. It is a polymer of ribonucleotides, each consisting of a pentose sugar (ribose), a nitrogenous base, and a phosphate group. RNA is usually single-stranded, unlike DNA, and can fold into specific 3D shapes necessary for its function.

General Structure of RNA

1. Single-Stranded Polymer

- RNA is composed of ribonucleotides linked by phosphodiester bonds between the 3'-OH of one sugar and the 5'-phosphate of the next nucleotide.

2. Nitrogenous Bases

- RNA contains adenine (A), guanine (G), cytosine (C), and uracil (U) (instead of thymine).
- These bases allow RNA to form hydrogen bonds in local secondary structures.

3. Pentose Sugar

- The sugar is ribose, which has an OH group at the 2' carbon, making RNA more reactive and less stable than DNA.

4. Phosphate Backbone

- The phosphate-sugar backbone forms the outer framework, giving RNA its structural integrity.

◆ Three Types of RNA

1. Messenger RNA (mRNA)

- **Structure:** Single-stranded linear molecule.
- **Function:** Carries genetic instructions from DNA to ribosomes for protein synthesis.
- **Proportion:** ~3–4% of total cellular RNA.

2. Transfer RNA (tRNA)

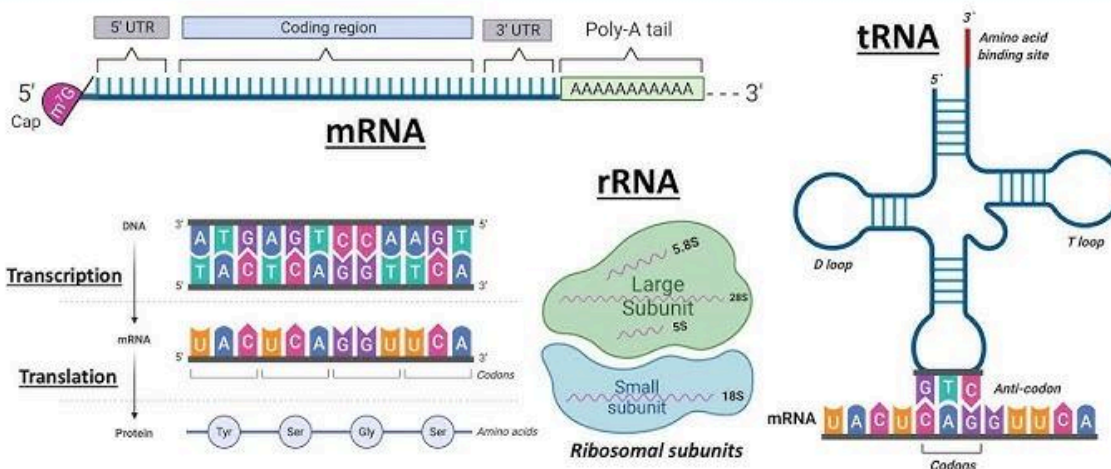
- **Structure:** Small, folded into a cloverleaf secondary structure with an anticodon loop.
- **Function:** Transports specific amino acids to ribosomes during translation.
- **Proportion:** ~10–15% of total RNA.

3. Ribosomal RNA (rRNA)

- **Structure:** Part of the ribosome; combines with proteins to form ribosomal subunits.
- **Function:** Forms the catalytic and structural core of ribosomes, facilitating protein synthesis.
- **Proportion:** ~80% of total RNA in the cell.

Diagram:

What are different types of RNA? mRNA, tRNA and rRNA – Structure and Function



The diagram shows mRNA linear strand, tRNA cloverleaf, and rRNA in ribosome.

◆ Summary:

- RNA is a single-stranded nucleic acid made of ribose sugar, nitrogenous bases (A, U, G, C), and phosphate groups.
- It acts as a link between DNA and protein synthesis, performing different roles depending on its type.
- mRNA carries genetic code, tRNA transports amino acids, and rRNA forms ribosomes and catalyzes protein assembly.
- RNA's structure allows it to fold and interact with other molecules, making it essential for gene expression.

☀ Q13. Define Conjugated Molecules and Describe the Roles of Common Conjugated Molecules

❖ Definition of Conjugated Molecules

Conjugated molecules are biological molecules in which a non-protein group is covalently attached to a protein or other organic molecule. These non-protein groups are called prosthetic groups, and their attachment enables the molecule to perform specialized functions that proteins alone cannot.

- They are also called conjugated biomolecules.
- Conjugated molecules include glycoproteins, lipoproteins, phosphoproteins, and metalloproteins.

Roles of Common Conjugated Molecules

1. Glycoproteins

Structure: Protein + carbohydrate (sugar) groups.

Function:

- Act as cell surface markers for recognition (e.g., blood groups).
- Play roles in cell signaling and immune response.
- Present in mucus, hormones, and enzymes.

2. Lipoproteins

Structure: Protein + lipid.

Function:

- Transport lipids in blood (cholesterol, triglycerides).
- **Examples:** HDL (good cholesterol) and LDL (bad cholesterol).

3. Phosphoproteins

Structure: Protein + phosphate group.

Function:

- Involved in cell signaling and regulation.
- Examples: casein in milk (provides phosphate for bone growth).

4. Metalloproteins

Structure: Protein + metal ion (e.g., Fe, Zn, Cu).

Function:

- Help in enzyme catalysis and oxygen transport.
- Examples: hemoglobin (Fe), cytochromes (Fe), carbonic anhydrase (Zn).

◆ **Summary:**

- Conjugated molecules are proteins linked to non-protein groups (prosthetic groups) that enhance their function.
- They perform specialized biological roles such as transport, signaling, structural support, and catalysis.
- Common examples include glycoproteins (cell recognition), lipoproteins (lipid transport), phosphoproteins (regulation), and metalloproteins (catalysis and oxygen transport).

INQUISITIVE QUESTIONS

★ Q1. What happens if even one amino acid is substituted for another in a polypeptide chain? Provide a specific example.

Effect of Substituting One Amino Acid

The sequence of amino acids in a polypeptide chain determines the protein's primary structure, which directly affects its folding, shape, and function.

- Even a single amino acid substitution can alter the protein's structure, stability, or function.
- This is because the chemical properties of the new amino acid (size, charge, polarity) may be different, affecting:
 - Hydrogen bonding
 - Hydrophobic interactions
 - Ionic or disulfide bonding
 - Overall 3D folding

Specific Example: Sickle Cell Hemoglobin

- Normal hemoglobin contains glutamic acid at the 6th position of the beta chain.
- In sickle cell hemoglobin, valine replaces glutamic acid at this position.

This single substitution causes:

- Hemoglobin molecules to stick together and form fibers.
- Red blood cells to assume a sickle shape.
- Impaired oxygen transport and blockage of blood vessels, leading to sickle cell anemia.

◆ Conclusion:

- Even one amino acid change can have dramatic effects on protein structure and function.
- The sickle cell example shows that a single substitution can lead to serious disease, demonstrating the critical importance of amino acid sequence.

✨ Q2. How does the three-dimensional structure of a protein relate to its function?

Relationship Between Structure and Function

Proteins have four structural levels: primary, secondary, tertiary, and quaternary, each contributing to the final 3D shape. The three-dimensional structure is crucial because it determines how the protein interacts with other molecules and performs its biological role.

- **Primary structure:** Sequence of amino acids; sets the foundation.
- **Secondary structure:** Alpha helices and beta sheets; formed by hydrogen bonding, providing stability and flexibility.
- **Tertiary structure:** Folding into a globular shape, stabilized by hydrogen bonds, ionic bonds, disulfide bridges, and hydrophobic interactions.
- **Quaternary structure:** Aggregation of multiple polypeptide chains; needed for complex proteins like hemoglobin.

Functional Implications

1. **Enzymes:** The active site is formed by the 3D folding; even slight changes in structure can inactivate the enzyme.

2. Transport proteins: Hemoglobin's quaternary structure allows efficient oxygen binding and release.

3. Structural proteins: Collagen's triple helix gives strength and flexibility to connective tissues.

4. Signaling proteins: Receptors and hormones require specific shapes to recognize and bind ligands.

◆ **Conclusion:**

The three-dimensional structure of a protein is directly tied to its function. Any disruption in folding or shape (due to mutation, denaturation, or misfolding) can lead to loss of function or disease, emphasizing the importance of precise folding in biology.

★ **Q3. How do nucleic acids encode genetic information, and how is this information translated into proteins?**

Encoding Genetic Information by Nucleic Acids

Nucleic acids, DNA and RNA, are polymers of nucleotides. The sequence of nucleotides in DNA forms the genetic code, which carries instructions for building proteins.

- **DNA structure:** DNA is a double helix composed of complementary base pairs: adenine-thymine (A–T) and guanine-cytosine (G–C).
- Each gene is a sequence of nucleotides that codes for a specific polypeptide chain.
- The order of nucleotides determines the sequence of amino acids in a protein.

Transcription: From DNA to RNA

1. A specific gene in DNA is transcribed into messenger RNA (mRNA) in the nucleus.
2. RNA polymerase reads the template DNA strand and synthesizes a complementary mRNA strand.
3. In RNA, uracil (U) replaces thymine (T).
4. The mRNA carries the genetic message from the nucleus to the ribosomes in the cytoplasm.

Translation: From RNA to Protein

1. At the ribosome, the mRNA sequence is read in codons (three nucleotides per codon).
2. Transfer RNA (tRNA) molecules bring specific amino acids corresponding to each codon.
3. Peptide bonds link the amino acids together, forming a polypeptide chain.
4. The polypeptide folds into a functional protein, completing the flow of genetic information.

Central Dogma of Molecular Biology

The overall process can be summarized as:

DNA → RNA → Protein

This explains how genetic information stored in nucleic acids is ultimately expressed as proteins that perform cellular functions.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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