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Carbohydrates

Introduction

- Optically active polyhydroxy aldehydes or ketones, or compounds yielding these on hydrolysis.
- General formula: $C_x(H_2O)_y$, considered hydrates of carbon.
- Examples: glucose, sucrose, starch, lactose.
- Also called saccharides (Greek: sakcharon = sugar).

Classification

- **Based on hydrolysis:**
  - Monosaccharides: Simple sugars, cannot be hydrolyzed further (e.g., glucose, fructose).
  - Oligosaccharides: 2-10 monosaccharide units (e.g., sucrose, maltose).
  - Polysaccharides: Many monosaccharide units (100+), e.g., starch, cellulose.
- **Based on reducing properties:**
  - Reducing sugars: Contain free aldehyde or ketone groups; reduce Fehling's and Tollens' reagents (e.g., maltose, lactose).
  - Non-reducing sugars: No free aldehyde/ketone groups; do not reduce Fehling's or Tollens' reagents (e.g., sucrose).

Monosaccharides

- Classified by number of carbons and functional group:
  - Aldoses: Contain aldehyde group.
  - Ketoses: Contain ketone group.
  - Examples: trioses, pentoses, hexoses.
- **Glucose ($C_6H_{12}O_6$)**
  - Aldohexose: 6 carbons, aldehyde group.
  - Found in fruits, honey, grapes.
  - Preparation:
    - From sucrose by acid hydrolysis (dilute HCl/H_2SO_4): glucose + fructose.
    - From starch by acid hydrolysis (dilute H_2SO_4, 393 K, pressure): glucose.

    - Structure:
        - Open chain confirmed by reactions with HI, NH_2OH, HCN, bromine water, acetic anhydride, nitric acid.
        - Fischer gave exact spatial arrangement of -OH groups.
        - Open chain fails to explain absence of 2,4-DNP, Schiff's test, and hydrogensulphite addition.
        - Exists as cyclic hemiacetal (pyranose) forms: α and β anomers differ at anomeric carbon (C-1).
        - Haworth projection used to represent cyclic forms.
    - Other reactions:
        - Reduction to D-sorbitol (Na-Hg).
        - Oxidation to gluconic acid (Fehling's, Tollens').
        - Derivatives: glucose pentaacetate, pentachloroglucose, methylglucosides.
- **Fructose ($C_6H_{12}O_6$)**
    - Ketohexose: 6 carbons, ketone group at C-2.
    - Obtained with glucose by hydrolysis of sucrose.
    - Natural sweetener in fruits, honey, vegetables.
    - Exists in two cyclic furanose forms (five-membered rings): α and β anomers.
    - Haworth structures represent cyclic forms.

Disaccharides

- Two monosaccharides linked by glycosidic bond (oxygen bridge) formed by loss of water.
- **Sucrose ($C_{12}H_{22}O_{11}$)**
    - Hydrolysis yields equimolar D-(+) glucose and D-(-) fructose.
    - Hydrolysis changes optical rotation from dextrorotatory to laevorotatory (invert sugar).
    - Glycosidic linkage between C-1 of glucose and C-2 of fructose.
- **Maltose ($C_{12}H_{22}O_{11}$)**
    - Two α-D-glucose units linked by α-1,4 glycosidic bond.
    - Has free aldehyde group; reducing sugar.
- **Lactose ($C_{12}H_{22}O_{11}$)**
    - β-D-galactose and β-D-glucose linked by β-1,4 glycosidic bond.
    - Found in milk.

Polysaccharides

- **Starch**
  - Main plant storage polysaccharide.
  - Polymer of α-D-glucose units.
  - Two components: amylose (linear, α-1,4 linkages) and amylopectin (branched, α-1,4 and α-1,6 linkages).
  - Amylose is water soluble, 15-20% of starch.
- **Cellulose $(C_6H_{10}O_5)_n$**
  - Linear polymer of β-D-glucose units linked by β-1,4 glycosidic bonds.
  - Major component of plant cell walls, provides strength.
- **Glycogen $(C_6H_{10}O_5)_n$**
  - Animal storage polysaccharide, similar to amylopectin but more branched.
  - Found in liver, muscles, brain, yeast, fungi.
  - Broken down enzymatically to glucose on demand.

Importance of Carbohydrates

- Essential for life of plants and animals.
- Major food source and energy storage (starch in plants, glycogen in animals).
- Cell walls of plants and bacteria contain cellulose.
- Wood and cotton fibers are cellulose-based.
- Nucleic acids contain ribose sugars.
- Most natural sugars are D-form.
- Bacteria convert sucrose to dextran polysaccharide.
- Mercerisation of cotton with NaOH imparts lustre.

Solved Examples

- **Ex 1:** Hydrolysis of sucrose with dilute acid yields glucose and fructose in equal amounts.
- **Ex 2:** Hydrolysis of starch with dilute H_2SO_4 at 393 K under pressure yields glucose.
- **Ex 3:** Identify reducing sugar: Maltose has free aldehyde group, so it is reducing; sucrose is non-reducing.

Practice Set

- Q1: Which of the following is a reducing sugar?
  - A. Sucrose
  - B. Maltose
  - C. Sucrose and Maltose
  - D. None
- Q2: Glucose is classified as:
  - A. Ketohexose
  - B. Aldohexose
  - C. Aldopentose
  - D. Ketopentose
- Q3: Which glycosidic linkage is present in cellulose?
  - A. α-1,4
  - B. β-1,4
  - C. α-1,6
  - D. β-1,6

Answer Key

- Q1: B - Maltose has free aldehyde group, so it is a reducing sugar; sucrose is non-reducing.
- Q2: B - Glucose is an aldohexose (6 carbons, aldehyde group).
- Q3: B - Cellulose has β-1,4 glycosidic linkages.

Memory Aids

- Carbohydrates = Carbon + Water ($C_x(H_2O)_y$).
- Reducing sugars have free aldehyde/ketone groups; non-reducing sugars do not.
- Glucose = Aldohexose; Fructose = Ketohexose.
- Starch = Amylose (linear α-1,4) + Amylopectin (branched α-1,4 & α-1,6).
- Cellulose = β-1,4 linked glucose units.
- Glycogen = Highly branched α-D-glucose polymer.

Proteins

Overview

- Proteins are polymers of □-amino acids linked by peptide bonds.
- Derived from Greek word "Proteins" meaning primary or of prime importance.
- Main sources: milk, cheese, pulses, peanuts, fish, meat.
- Essential for structure, function, growth, and maintenance of the body.

Solved Examples

- **Ex 1:** Identify the monomer of proteins.
  Answer: □-amino acids.

Practice Set

- Q1: What is the monomeric unit of proteins?
  A. Fatty acids
  B. □-amino acids
  C. Monosaccharides
  D. Nucleotides
- Q2: Which of the following is NOT a source of protein?
  A. Milk
  B. Cheese
  C. Glucose
  D. Meat
- Q3: Proteins are primarily responsible for:
  A. Energy storage
  B. Structure and function of life
  C. Genetic information
  D. Photosynthesis

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Answer Key

- Q1: B - Proteins are polymers of □-amino acids.
- Q2: C - Glucose is a carbohydrate, not a protein source.
- Q3: B - Proteins provide structure and function in living organisms.

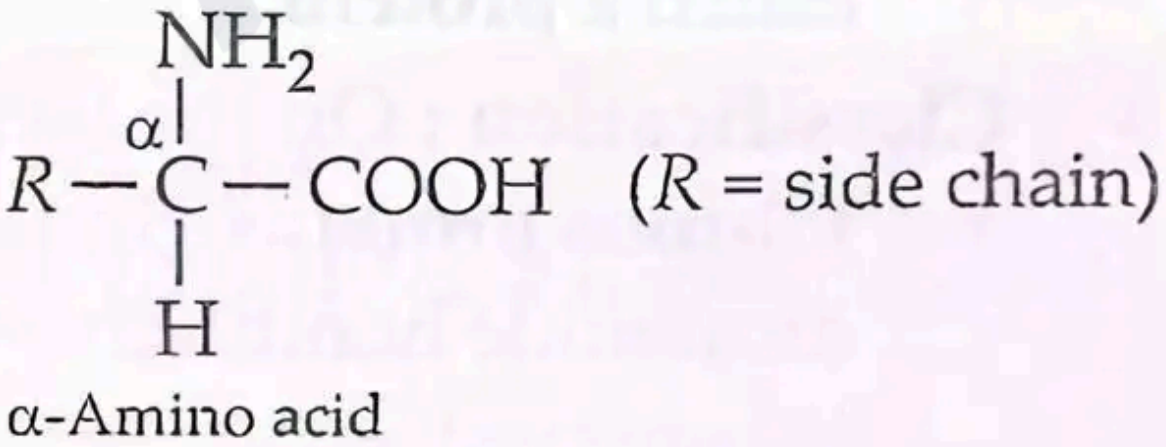
Memory Aids

- Protein = Primary importance (Greek origin).
- Sources: Milk, Meat, Pulses, Fish.
- Monomer = □-amino acids.

Amino Acids

Structure and Classification

- Bifunctional molecules with acidic carboxyl (—COOH) and basic amino (—NH_2) groups attached to the same carbon (alpha carbon).
- General structure:



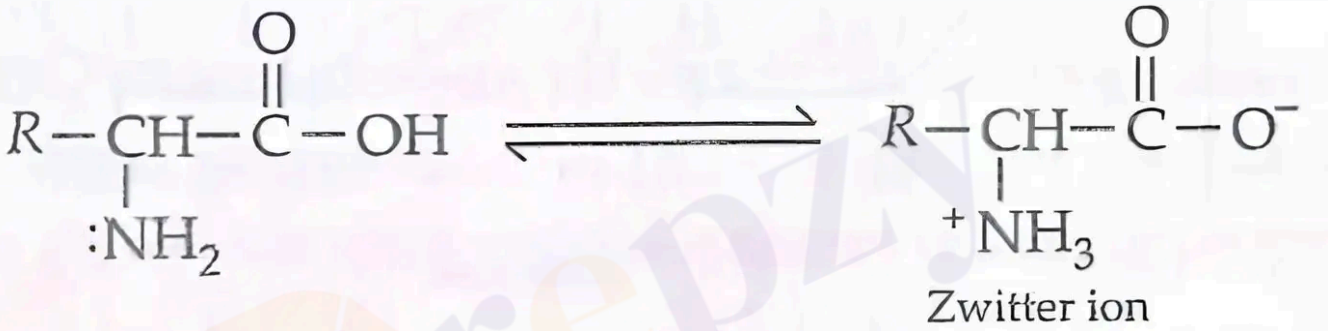
- Side chain (R) varies, defining different amino acids.
- Classification by groups:
  - Neutral: Equal —COOH and —NH_2 groups (e.g., glycine, alanine).

- Acidic: More —COOH than —NH_2 (e.g., aspartic acid).
- Basic: More —NH_2 than —COOH (e.g., lysine).

- Classification by synthesis:
  - Essential: Not synthesized in body, must be dietary (e.g., valine, leucine).
  - Non-essential: Synthesized in body (e.g., glycine, alanine).

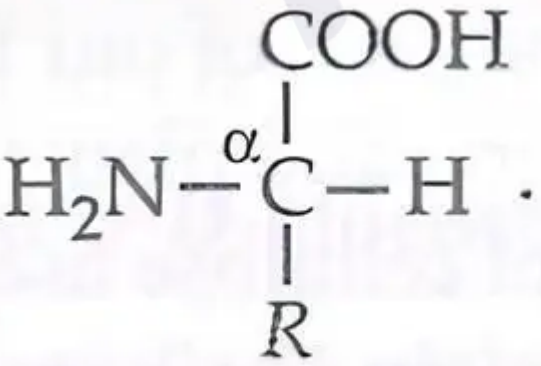
Properties

- Colorless, crystalline, water-soluble, high melting solids.
- Behave like salts due to acidic and basic groups.
- Form salts with acids and bases; reactions similar to primary amines and carboxylic acids.
- Zwitterion form in aqueous solution: dipolar ion with both + and - charges but overall neutral.



Zwitter ion

- Isoelectric point: pH where zwitterion is neutral and amino acid has least solubility.
- Except glycine, all □-amino acids are optically active due to chiral carbon.
- L-form amino acids have —NH_2 group on left side.



L-α-Amino acid

Solved Examples

- **Ex 1:** Classify alanine based on acidic/basic groups.
  Answer: Neutral amino acid (equal —COOH and —NH_2).
- **Ex 2:** What is the zwitterion form?
  Answer: Dipolar ion with + and - charges, overall neutral.

Practice Set

- Q1: Which group is acidic in amino acids?
  A. —NH_2
  B. —COOH
  C. —R
  D. —H
- Q2: Amino acids that cannot be synthesized in the body are called:
  A. Neutral
  B. Essential
  C. Basic
  D. Non-essential
- Q3: At isoelectric point, amino acid:
  A. Has net positive charge
  B. Has net negative charge
  C. Exists as zwitterion with no net charge
  D. Is insoluble in organic solvents

Answer Key

- Q1: B - Carboxyl group is acidic.
- Q2: B - Essential amino acids must be obtained from diet.
- Q3: C - Zwitterion form with equal + and - charges.

Memory Aids

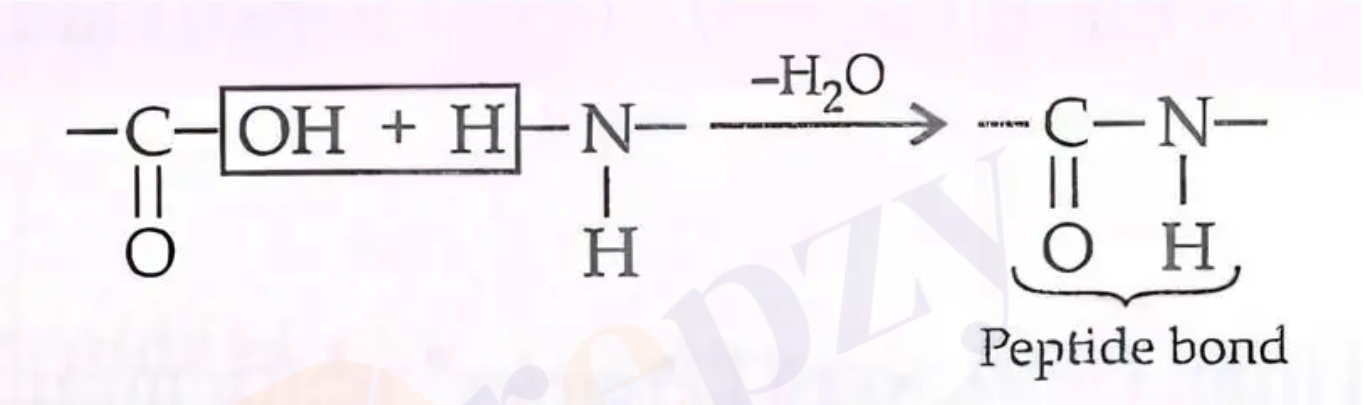
- Acidic group = —COOH, Basic group = —NH_2.
- Essential amino acids = must eat (dietary).

- Zwitterion = both charges, overall neutral.

Peptide Bond

Formation and Properties

- Peptide bond is an amide bond formed between —COOH of one amino acid and —NH_2 of another.
- Formed by condensation reaction with elimination of H_2O.
- Links amino acids to form peptides and proteins.
- Example:



- Peptides:
  - Dipeptides, tripeptides, tetrapeptides based on number of amino acids.
  - Oligopeptides: 2-10 amino acids.
  - Polypeptides: >10 amino acids.
  - Proteins: Polypeptides with >100 amino acids and molecular mass >10,000 u.

Solved Examples

- **Ex 1:** What is released during peptide bond formation?
  Answer: Water molecule (H_2O).
- **Ex 2:** Define polypeptide.
  Answer: Chain of >10 amino acids linked by peptide bonds.

Practice Set

- Q1: Peptide bond is formed between:
  A. Two amino groups
  B. Two carboxyl groups
  C. —COOH and —NH_2
  D. Side chains
- Q2: What is the product of two amino acids linked by peptide bond?
  A. Protein
  B. Peptide
  C. Monomer
  D. Salt
- Q3: Polypeptides contain how many amino acids?
  A. 2-10
  B. >10
  C. >100
  D. 1

Answer Key

- Q1: C - Peptide bond forms between —COOH and —NH_2.
- Q2: B - Peptides are products of amino acid linkage.
- Q3: B - Polypeptides have more than 10 amino acids.

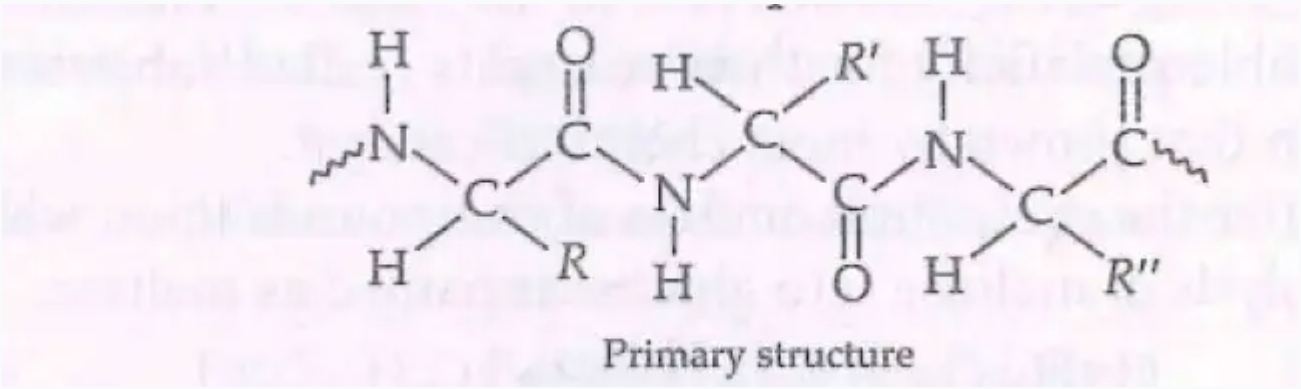
Memory Aids

- Peptide bond = amide bond + water loss.
- Peptides: di-, tri-, oligo-, poly- based on amino acid count.
- Proteins = polypeptides >100 amino acids.

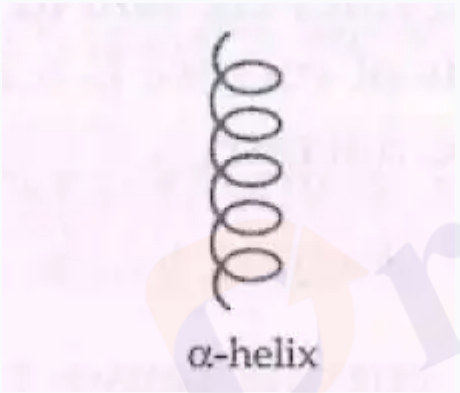
Protein Structure

Levels of Structure

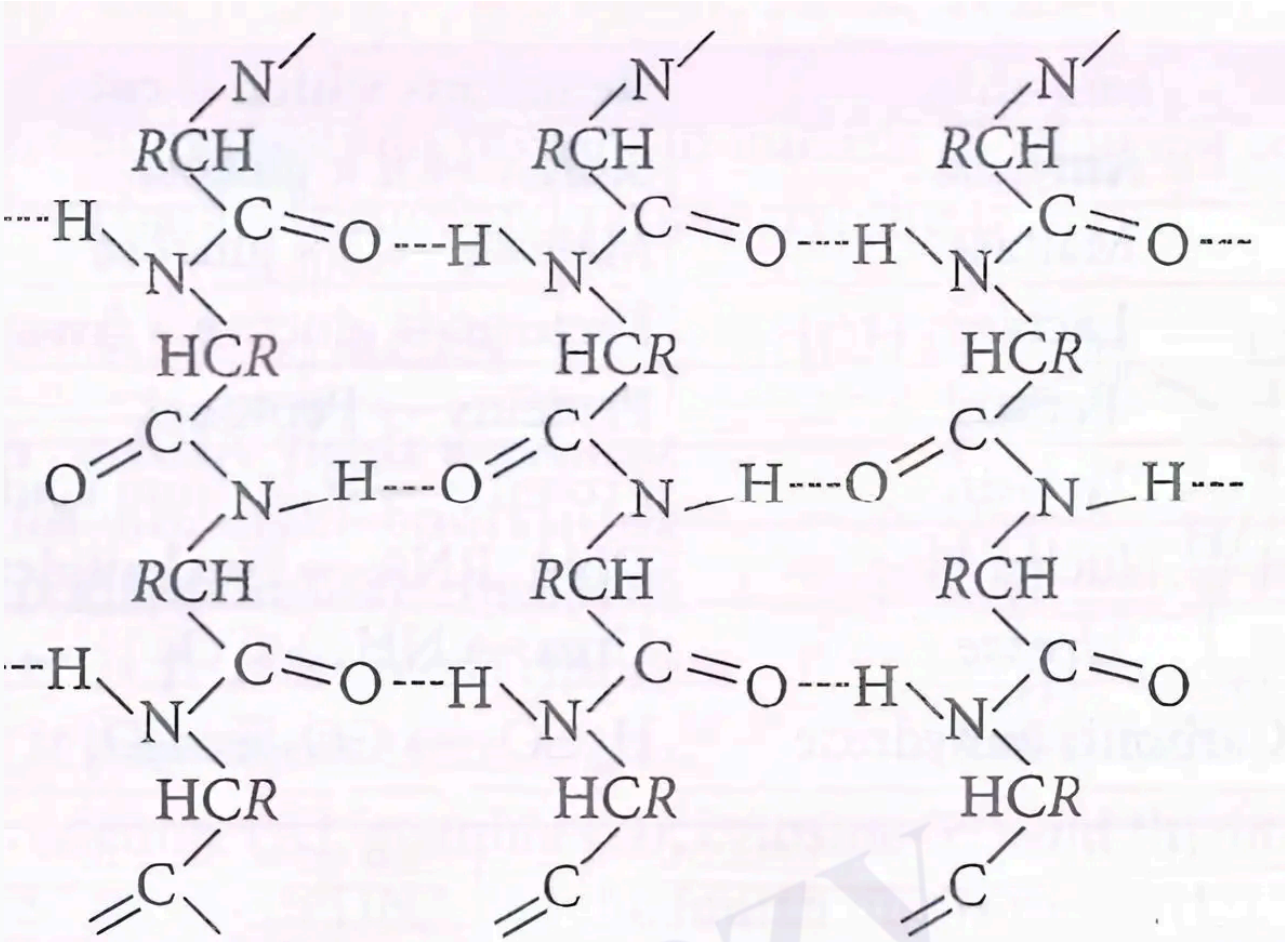
- Primary: Linear sequence of amino acids linked by peptide bonds.



- Secondary: -helix and -pleated sheet formed by hydrogen bonding.
  - -helix: Right-handed coil stabilized by H-bonds within chain.



  - -pleated sheet: Chains stretched and aligned side-by-side, stabilized by intermolecular H-bonds.



- Tertiary: Overall 3D folding of polypeptide chain stabilized by H-bonds, disulphide, van der Waals, electrostatic forces.
- Quaternary: Spatial arrangement of multiple polypeptide subunits.
- Protein types:
  - Fibrous: Parallel chains, insoluble, e.g., keratin, myosin.
  - Globular: Coiled chains, soluble, e.g., insulin, albumin.

Solved Examples

- **Ex 1:** Name two types of secondary structures.
  Answer: -helix and -pleated sheet.
- **Ex 2:** What stabilizes tertiary structure?
  Answer: Hydrogen bonds, disulphide linkages, van der Waals, electrostatic forces.

Practice Set

- Q1: Primary structure of protein is:
  A. 3D folding
  B. Sequence of amino acids
  C. Multiple polypeptide chains
  D. □-helix formation
- Q2: □-helix is stabilized by:
  A. Ionic bonds
  B. Hydrogen bonds
  C. Covalent bonds
  D. Peptide bonds
- Q3: Fibrous proteins are:
  A. Soluble
  B. Insoluble
  C. Spherical
  D. Enzymes

Answer Key

- Q1: B - Primary structure is amino acid sequence.
- Q2: B - □-helix stabilized by hydrogen bonds.
- Q3: B - Fibrous proteins are insoluble.

Memory Aids

- Primary = sequence, Secondary = □-helix/□-sheet, Tertiary = folding, Quaternary = subunits.
- Fibrous = insoluble, Globular = soluble.
- □-helix = right-handed coil.

Denaturation

Concept and Effects

- Denaturation: Loss of protein's native structure due to physical (temperature) or chemical (pH) changes.
- Disrupts hydrogen bonds, unfolds globules, uncoils helices.
- Primary structure remains intact.
- Examples: Coagulation of egg white on boiling, curdling of milk, cheese formation.
- Denatured proteins lose biological activity.
- Some proteins act as antibodies defending against foreign organisms.
- Change in amino acid sequence can cause diseases (e.g., sickle cell anemia: glutamic acid replaced by valine in hemoglobin).

Solved Examples

- **Ex 1:** What happens to protein on boiling?
  Answer: Denaturation, loss of structure and function.
- **Ex 2:** Disease caused by amino acid substitution in hemoglobin?
  Answer: Sickle cell anemia.

Practice Set

- Q1: Denaturation affects which protein structure?
  A. Primary
  B. Secondary and tertiary
  C. Quaternary only
  D. None
- Q2: Which causes denaturation?
  A. Cooling
  B. Boiling
  C. Neutral pH
  D. Normal conditions
- Q3: Sickle cell anemia is caused by:
  A. Deletion of amino acid
  B. Substitution of glutamic acid by valine

C. Addition of amino acid

D. Protein folding

Answer Key

- Q1: B - Denaturation changes secondary and tertiary structures.
- Q2: B - Boiling causes denaturation.
- Q3: B - Sickle cell anemia caused by glutamic acid to valine substitution.

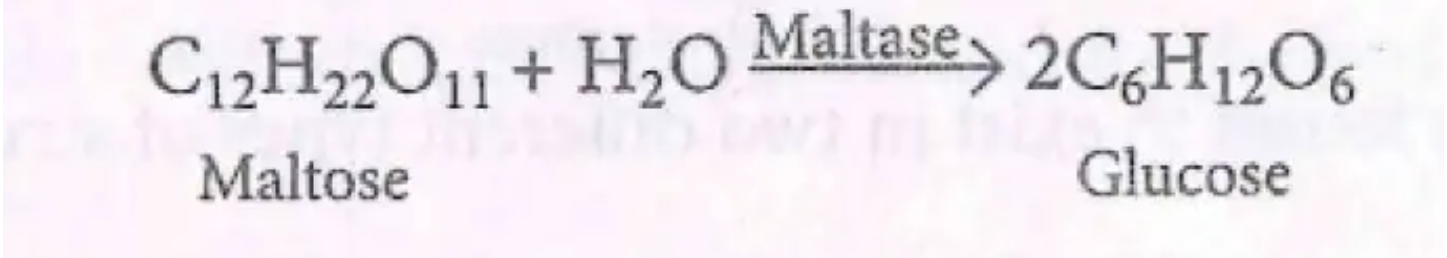
Memory Aids

- Denaturation = loss of shape, primary intact.
- Heat and pH changes cause denaturation.
- Sickle cell = Glu Val substitution.

Enzymes

Overview

- Biological catalysts that speed up biochemical reactions.
- Mostly globular proteins.
- Increase reaction rates significantly.
- Show high specificity for substrates and products.
- Named after the substrate or reaction they catalyze (e.g., maltase hydrolyzes maltose).



Explanation of Maltose Hydrolysis

- Maltose consists of two glucose units.

- Water (H_2O) is added during the reaction.
- Maltase enzyme catalyzes the breakdown.
- Maltose splits into two glucose molecules.
- This reaction is called hydrolysis (breaking with water).

Solved Examples

- **Ex 1:** Write the reaction catalyzed by maltase.
  - Maltose + H_2O □1865 glucose + glucose (catalyzed by maltase)

Practice Set

- Q1: What type of biomolecule are most enzymes?
  - A. Carbohydrates
  - B. Lipids
  - C. Globular proteins
  - D. Nucleic acids
- Q2: Which enzyme catalyzes the hydrolysis of maltose?
  - A. Amylase
  - B. Maltase
  - C. Lactase
  - D. Sucrase
- Q3: Hydrolysis of maltose produces:
  - A. Two fructose molecules
  - B. Two glucose molecules
  - C. Glucose and fructose
  - D. Glucose and galactose

Answer Key

- Q1: C - Enzymes are mostly globular proteins that act as biological catalysts.
- Q2: B - Maltase specifically catalyzes maltose hydrolysis.
- Q3: B - Maltose hydrolysis yields two glucose molecules.

Memory Aids

- Enzymes end with '-ase' named after their substrate (e.g., maltase for maltose).
- Hydrolysis means breaking bonds using water.
- Most enzymes are globular proteins.

Mechanism of Enzyme Action

Key Points

- Enzymes are required in small amounts.
- They lower activation energy of reactions.
- Example: Acid hydrolysis of sucrose requires 6.22 kJ mol^{-1}, but with sucrase enzyme, only 2.15 kJ mol^{-1}.
- Deficiency of enzymes causes diseases:
  - Phenylalanine hydroxylase deficiency causes phenylketonuria.
  - Tyrosinase deficiency causes albinism (reduced melanin pigment).

Solved Examples

- **Ex 1:** Calculate the reduction in activation energy when sucrose hydrolysis is catalyzed by sucrase.
  - Activation energy without enzyme = 6.22 kJ mol^{-1}
  - With enzyme = 2.15 kJ mol^{-1}
  - Reduction = 6.22 - 2.15 = 4.07 kJ mol^{-1}

Practice Set

- Q1: What is the main role of enzymes in reactions?
  - A. Increase activation energy
  - B. Decrease activation energy
  - C. Change equilibrium constant
  - D. Get consumed in reaction
- Q2: Deficiency of which enzyme causes phenylketonuria?

    - A. Tyrosinase
    - B. Phenylalanine hydroxylase
    - C. Sucrase
    - D. Maltase
- Q3: Activation energy for acid hydrolysis of sucrose is 6.22 kJ mol^{-1}. What is it when catalyzed by sucrase?
    - A. 6.22 kJ mol^{-1}
    - B. 4.07 kJ mol^{-1}
    - C. 2.15 kJ mol^{-1}
    - D. 0 kJ mol^{-1}

Answer Key

- Q1: B - Enzymes lower activation energy to speed up reactions.
- Q2: B - Phenylalanine hydroxylase deficiency causes phenylketonuria.
- Q3: C - Sucrase reduces activation energy to 2.15 kJ mol^{-1}.

Memory Aids

- Enzymes lower activation energy, not change equilibrium.
- Phenylketonuria = phenylalanine hydroxylase deficiency.
- Albinism = tyrosinase deficiency.

Common Enzymes

Important Enzymes and Their Reactions

Enzymes	Reactions which is catalysed
Amylase	Starch $\rightarrow n \times$ glucose
Maltase	Maltose $\rightarrow 2 \times$ glucose
Lactase	Lactose $\rightarrow$ glucose + fructose
Pepsin	Proteins $\rightarrow$ Peptones
Trypsin	Proteins $\rightarrow \alpha$–Amino acids
Nucleases	DNA, RNA $\rightarrow$ Nucleotides
Urease	Urea $\rightarrow NH_3 + CO_2$
Carbonic anhydrase	$H_2CO_3 \rightarrow CO_2 + H_2O$

- Amylase: Starch □1865 glucose.
- Maltase: Maltose □1865 2 glucose molecules.
- Lactase: Lactose □1865 glucose + fructose.
- Pepsin and Trypsin: Proteins □1865 smaller peptides.
- Nucleases: DNA/RNA □1865 nucleotides.
- Urease: Urea □1865 NH_3 + CO_2.
- Carbonic anhydrase: H_2CO_3 □1865 CO_2 + H_2O.

Solved Examples

- **Ex 1:** Identify the enzyme that breaks down starch.
  - Answer: Amylase.
- **Ex 2:** What are the products of lactase action on lactose?
  - Answer: Glucose and fructose.

Practice Set

- Q1: Which enzyme breaks down proteins into smaller peptides?

    - A. Amylase
    - B. Pepsin
    - C. Lactase
    - D. Urease
- Q2: Urease catalyzes the breakdown of:
    - A. Urea
    - B. Starch
    - C. DNA
    - D. Lactose
- Q3: Carbonic anhydrase converts carbonic acid into:
    - A. Oxygen and water
    - B. Carbon dioxide and water
    - C. Ammonia and carbon dioxide
    - D. Glucose and fructose

Answer Key

- Q1: B - Pepsin breaks down proteins into peptides.
- Q2: A - Urease breaks down urea into NH_3 and CO_2.
- Q3: B - Carbonic anhydrase converts H_2CO_3 into CO_2 and H_2O.

Memory Aids

- Amylase for starch, maltase for maltose, lactase for lactose.
- Pepsin and trypsin digest proteins.
- Urease breaks urea; carbonic anhydrase acts on carbonic acid.

Vitamins

Definition and Importance

- Organic compounds needed in small amounts in diet.
- Essential for specific biological functions and normal growth.
- Maintain optimum health of the organism.

Solved Examples

- **Ex 1:** Identify the role of vitamins in the body.
  - Answer: Vitamins act as coenzymes or precursors for enzymes essential in metabolism.

Practice Set

- Q1: Vitamins are required in the diet in
  - A. Large amounts
  - B. Small amounts
  - C. No amounts
  - D. Variable amounts
- Q2: Vitamins mainly function as
  - A. Energy sources
  - B. Structural components
  - C. Coenzymes or precursors
  - D. Hormones
- Q3: Which of the following is NOT a vitamin?
  - A. Vitamin C
  - B. Vitamin B12
  - C. Glucose
  - D. Vitamin A

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Answer Key

- Q1: B - Vitamins are needed in small amounts for biological functions.
- Q2: C - Vitamins mainly act as coenzymes or their precursors.
- Q3: C - Glucose is a carbohydrate, not a vitamin.

Memory Aids

- Remember: "Vitamins = Vital amines" (historical term).
- Small amounts, big impact.

Classification of Vitamins

Types and Characteristics

- **Water Soluble Vitamins:**
  - Soluble in water.
  - Not stored in body (except B_{12}).
  - Regular supply needed as excess excreted in urine.
  - Examples: Vitamin B_1, B_2, B_6, B_{12}, C.
- **Fat Soluble Vitamins:**
  - Soluble in fats and oils.
  - Stored in liver and adipose tissues.
  - Examples: Vitamin A, D, E, K.
- Vitamin H (Biotin) is neither water nor fat soluble.

Solved Examples

- **Ex 1:** Classify Vitamin C.
  - Answer: Water soluble vitamin.
- **Ex 2:** Why must water soluble vitamins be supplied regularly?
  - Answer: They are excreted in urine and not stored.

Practice Set

- Q1: Which vitamin is fat soluble?
  - A. Vitamin B_1
  - B. Vitamin C
  - C. Vitamin A
  - D. Vitamin B_{12}
- Q2: Water soluble vitamins are
  - A. Stored in liver
  - B. Excreted in urine
  - C. Stored in adipose tissue
  - D. Not required in diet
- Q3: Vitamin H (Biotin) is

- A. Water soluble
- B. Fat soluble
- C. Neither water nor fat soluble
- D. Both water and fat soluble

Answer Key

- Q1: C - Vitamin A is fat soluble.
- Q2: B - Water soluble vitamins are excreted in urine.
- Q3: C - Vitamin H is neither water nor fat soluble.

Memory Aids

- Water soluble = B-complex + C, excreted in urine.
- Fat soluble = A, D, E, K, stored in fat.
- Vitamin H exception: neither soluble.

Vitamin Table

Overview

- Vitamins listed with chemical names, solubility, sources, and deficiency diseases.
- Sources include milk, eggs, vegetables, cereals.
- Deficiency causes diseases like night blindness (A), scurvy (C), beriberi (B1).

Vitamin name	Chemical name	Solubility	Sources	Deficiency disease
Vitamin A	Retinoids (retinol and carotenoids)	Fat	Milk, butter, eggs, fish, cod liver oil, green vegetables, etc.	Night-blindness, xerophthalmia
Vitamin B_1	Thiamine	Water	Pulses, nuts, cereals (rice, wheat, etc.), rice bran, yeast, egg yolk, fruits and green vegetables, etc.	Beri-beri, loss of appetite
Vitamin B_2	Riboflavin	Water	Milk, green vegetables, egg white, meat, liver, kidney, etc.	Anaemia, inflammation of tongue, dermatitis, cheilosis
Vitamin B_6	Pyridoxine	Water	Rice bran, whole cereal (wheat, gram), yeast, fish, meat, eggs, etc.	Affects central nervous system, causes weakness, convulsions, insomnia, anaemia
Vitamin H	Biotin	None	Milk, yeast, liver, kidney, etc.	Dermatitis
Vitamin B_{12}	Cyanocobalamine	Water	Eggs, milk, liver of ox, sheep, fish, etc.	Pernicious anaemia
Vitamin C	Ascorbic acid	Water	Citrus fruits, chillies, sprouted pulses, etc.	Pyorrhea, scurvy (bleeding of gums)
Vitamin D	Ergocalciferol and cholecalciferol	Fat	Butter, milk, eggs, fish liver oil, liver and meat	Rickets (bending of bones) and osteomalacia
Vitamin E	Tocopherol	Fat	Wheat germ oil, milk, nuts, peanut oil, cotton seed oil, eggs, fish, etc.	Loss of fertility in males, muscle degeneration
Vitamin K	Phylloquinone	Fat	Leafy vegetables like cabbage, spinach, etc.	Haemorrhages and lengthens time of blood clotting

Solved Examples

- **Ex 1:** Identify deficiency disease of Vitamin C.
  - Answer: Scurvy.
- **Ex 2:** Name source of Vitamin B_1.
  - Answer: Cereals and pulses.

Practice Set

- Q1: Deficiency of Vitamin A causes
  - A. Night blindness
  - B. Scurvy
  - C. Beriberi
  - D. Rickets
- Q2: Vitamin B_1 is also called
  - A. Riboflavin

    - B. Thiamine
    - C. Niacin
    - D. Ascorbic acid
- Q3: Which vitamin deficiency causes rickets?
    - A. Vitamin D
    - B. Vitamin E
    - C. Vitamin K
    - D. Vitamin C

Answer Key

- Q1: A - Vitamin A deficiency causes night blindness.
- Q2: B - Thiamine is Vitamin B_1.
- Q3: A - Vitamin D deficiency causes rickets.

Memory Aids

- Vitamin A = Night blindness; D = Rickets.
- B_1 = Thiamine, B_2 = Riboflavin.
- Scurvy = Vitamin C deficiency.

Vitamin Deficiency and Storage

Key Points

- Vitamin deficiency condition is called avitaminosis.
- Water soluble vitamins are not stored; excess excreted in urine.
- Excess fat soluble vitamins cause hypervitaminosis (toxicity).

Solved Examples

- **Ex 1:** What is avitaminosis?
    - Answer: Disease caused by vitamin deficiency.

- **Ex 2:** Why is hypervitaminosis caused by fat soluble vitamins?
  - Answer: Because they are stored in liver and fat tissues, excess accumulates.

Practice Set

- Q1: Avitaminosis means
  - A. Excess vitamins
  - B. Vitamin deficiency
  - C. Normal vitamin level
  - D. Vitamin overdose
- Q2: Which vitamins cause hypervitaminosis?
  - A. Water soluble
  - B. Fat soluble
  - C. Both
  - D. None
- Q3: Water soluble vitamins are
  - A. Stored in body
  - B. Excreted in urine
  - C. Cause toxicity on excess
  - D. Stored in fat

Answer Key

- Q1: B - Avitaminosis is vitamin deficiency.
- Q2: B - Fat soluble vitamins cause hypervitaminosis.
- Q3: B - Water soluble vitamins are excreted in urine.

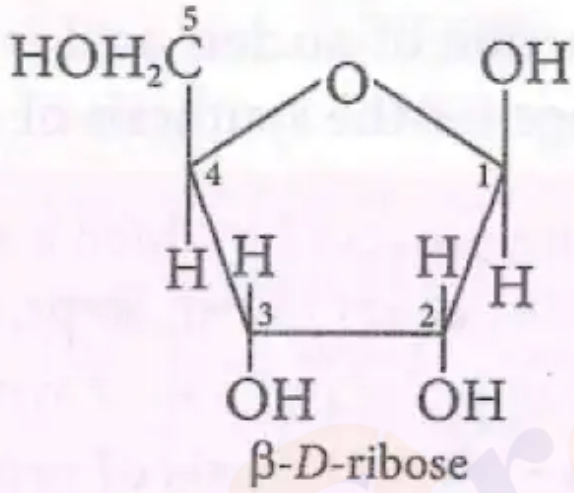
Memory Aids

- Avitaminosis = "A" for absence of vitamins.
- Fat soluble vitamins stored = risk of toxicity.
- Water soluble vitamins = no storage, no toxicity.

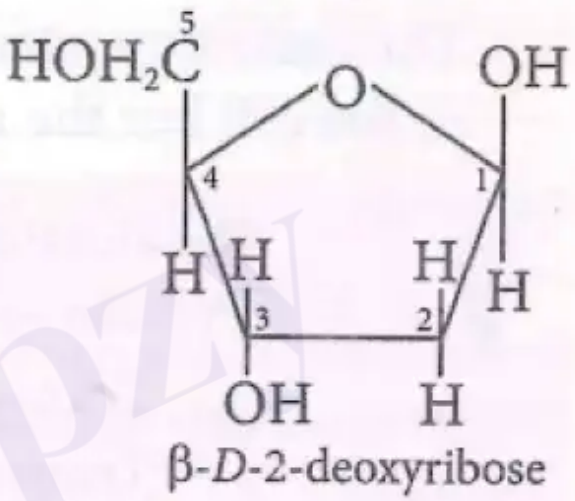
Nucleic Acids

Chemical Composition

- Nucleic acids are polymers of nucleotides found in the nucleus of living cells.
- Complete hydrolysis yields pentose sugar, phosphoric acid, and nitrogenous bases.
- DNA sugar: β-deoxyribose; RNA sugar: β-D-ribose.
- DNA bases: Adenine (A), Guanine (G), Cytosine (C), Thymine (T).
- RNA bases: Adenine (A), Guanine (G), Cytosine (C), Uracil (U) instead of Thymine.



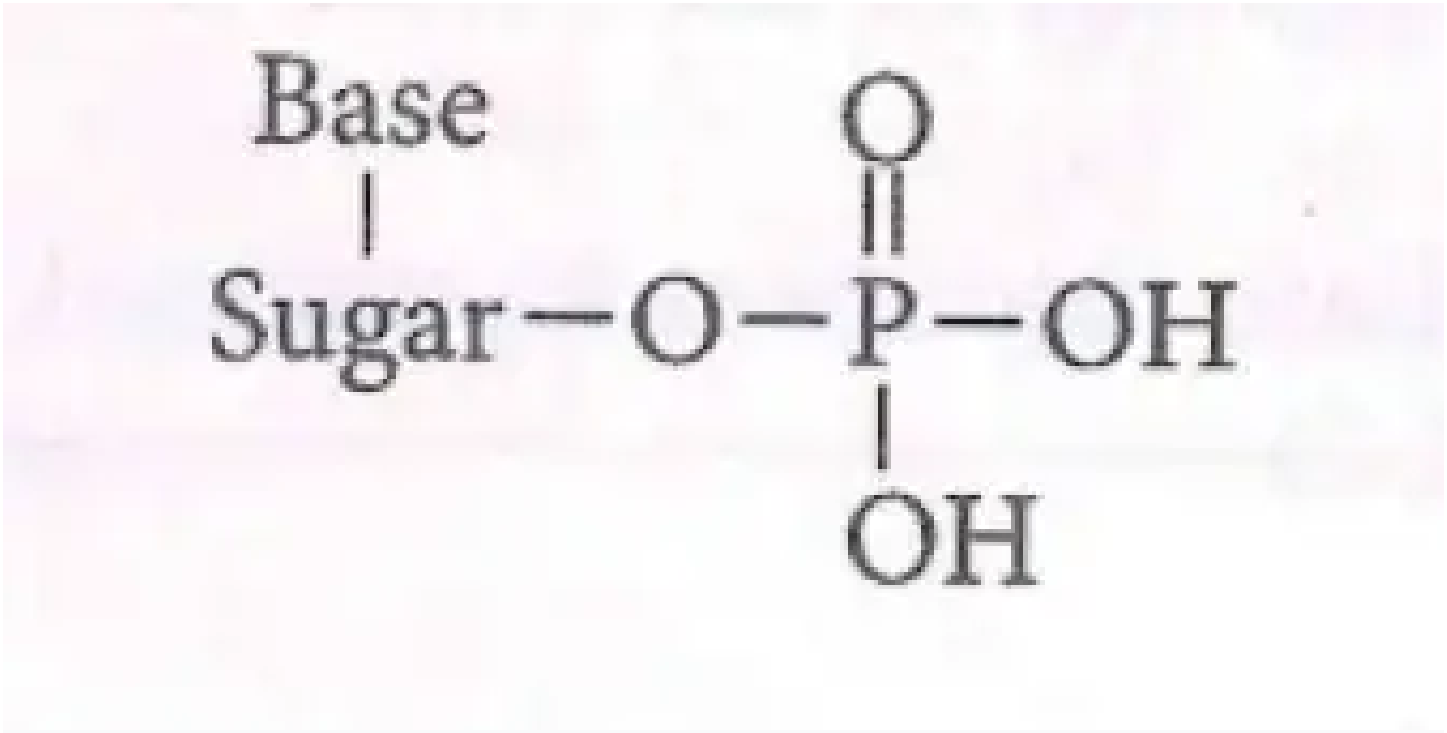
β-*D*-ribose



β-*D*-2-deoxyribose

Nucleosides and Nucleotides

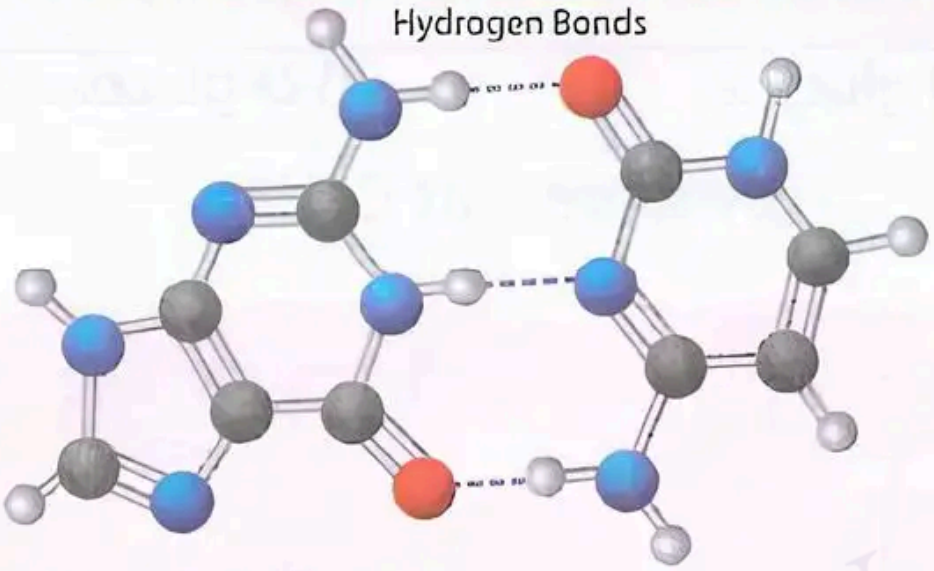
- Nucleoside = Pentose sugar + Nitrogenous base.
- Nucleotide = Nucleoside + Phosphate group.
- Nucleotides are building blocks of DNA and RNA.



Structure of Nucleic Acids

- Primary structure: Nucleotides linked by phosphodiester bonds between 5' and 3' carbons.
- Secondary structure: Two polynucleotide strands form a double helix.
- Backbone: Sugar-phosphate units; bases face inward and pair via hydrogen bonds.
- Watson and Crick proposed double helix model for DNA.
- Base pairing: A pairs with T (DNA), A pairs with U (RNA), G pairs with C.
- RNA secondary structure: Single strands fold to form double helices.
- Chargaff's rule: Purines = Pyrimidines; A=T (2 H-bonds), G≡C (3 H-bonds).

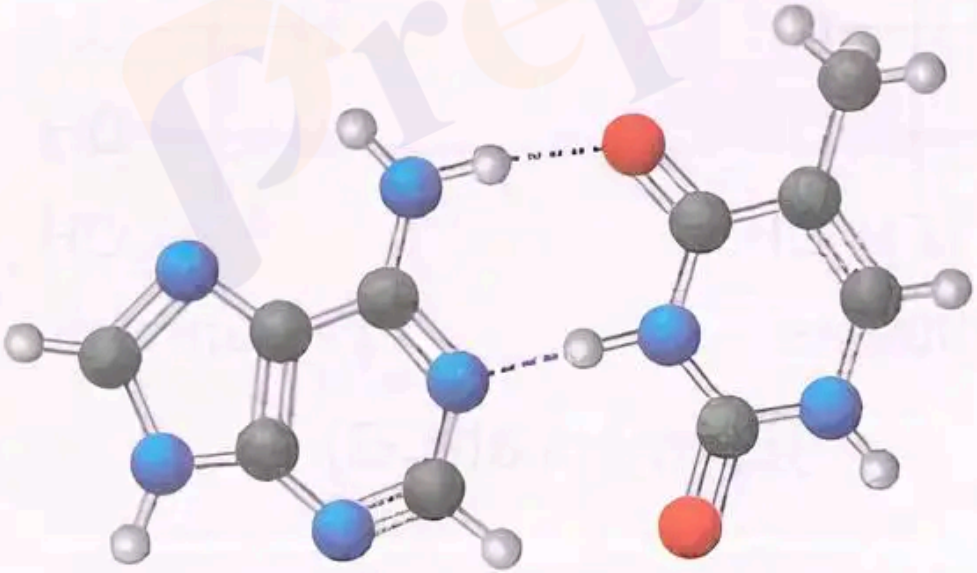
H-Bonding in Nitrogenous Bases (Chargaff's Rule)



Guanine
G

Cytosine
C

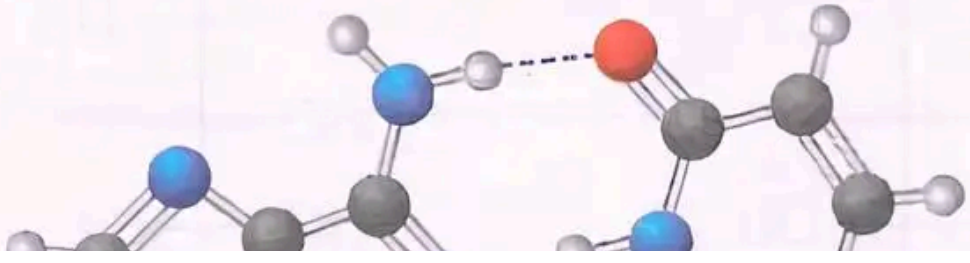
(Bonded by 3 hydrogen bonds)

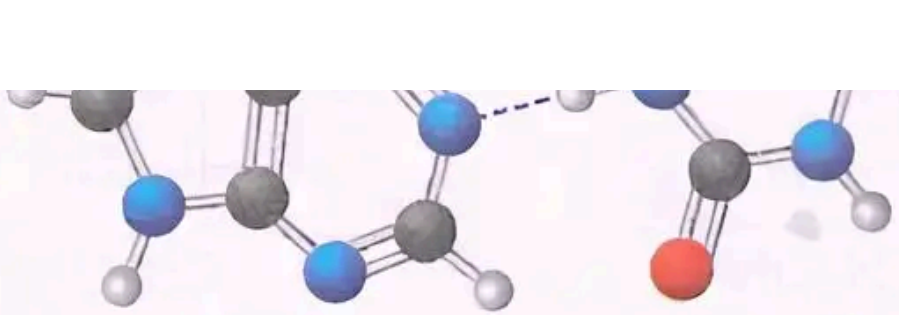


Adenine
A

Thymine
T

(Bonded by 2 hydrogen bonds)

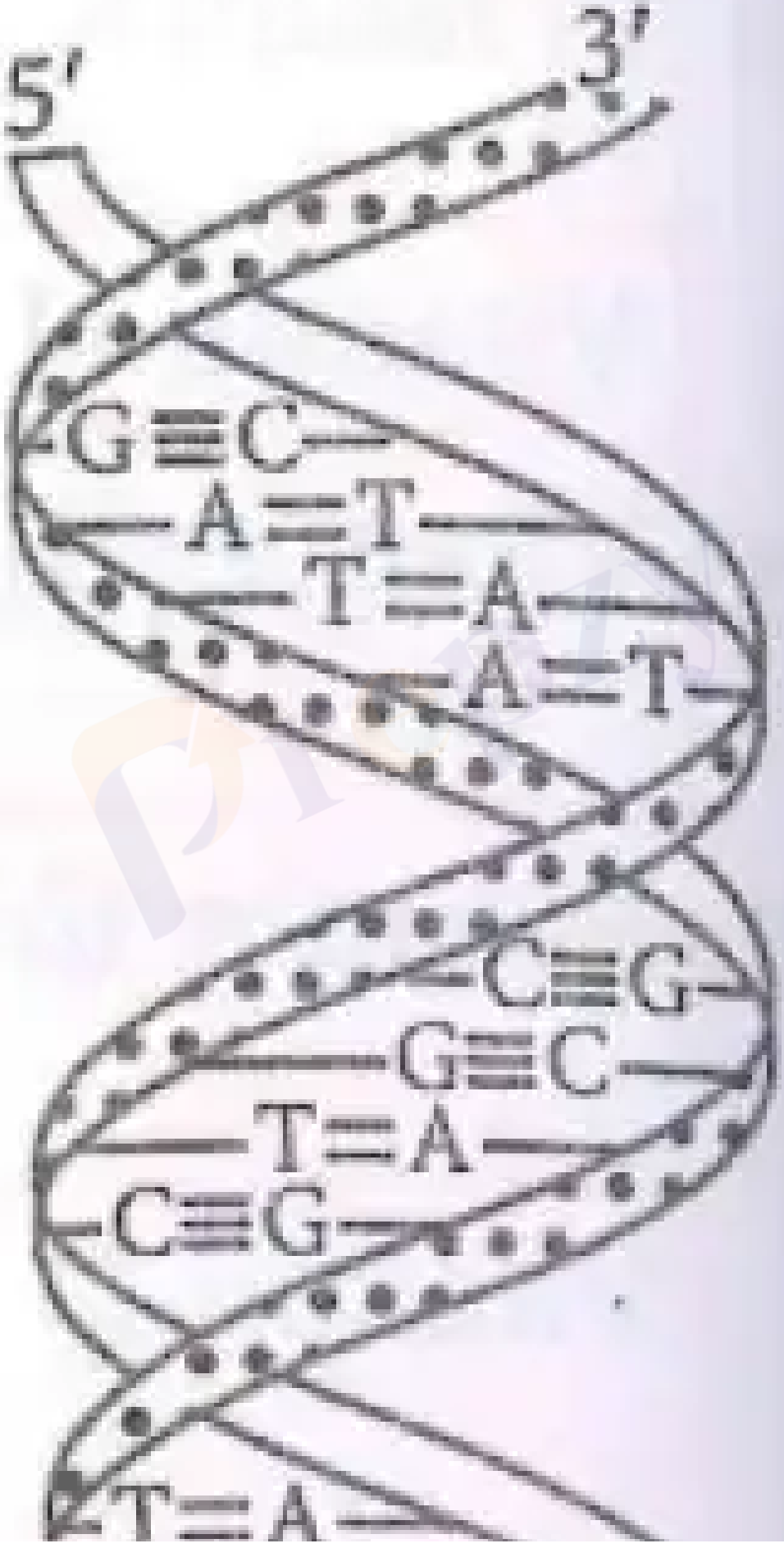


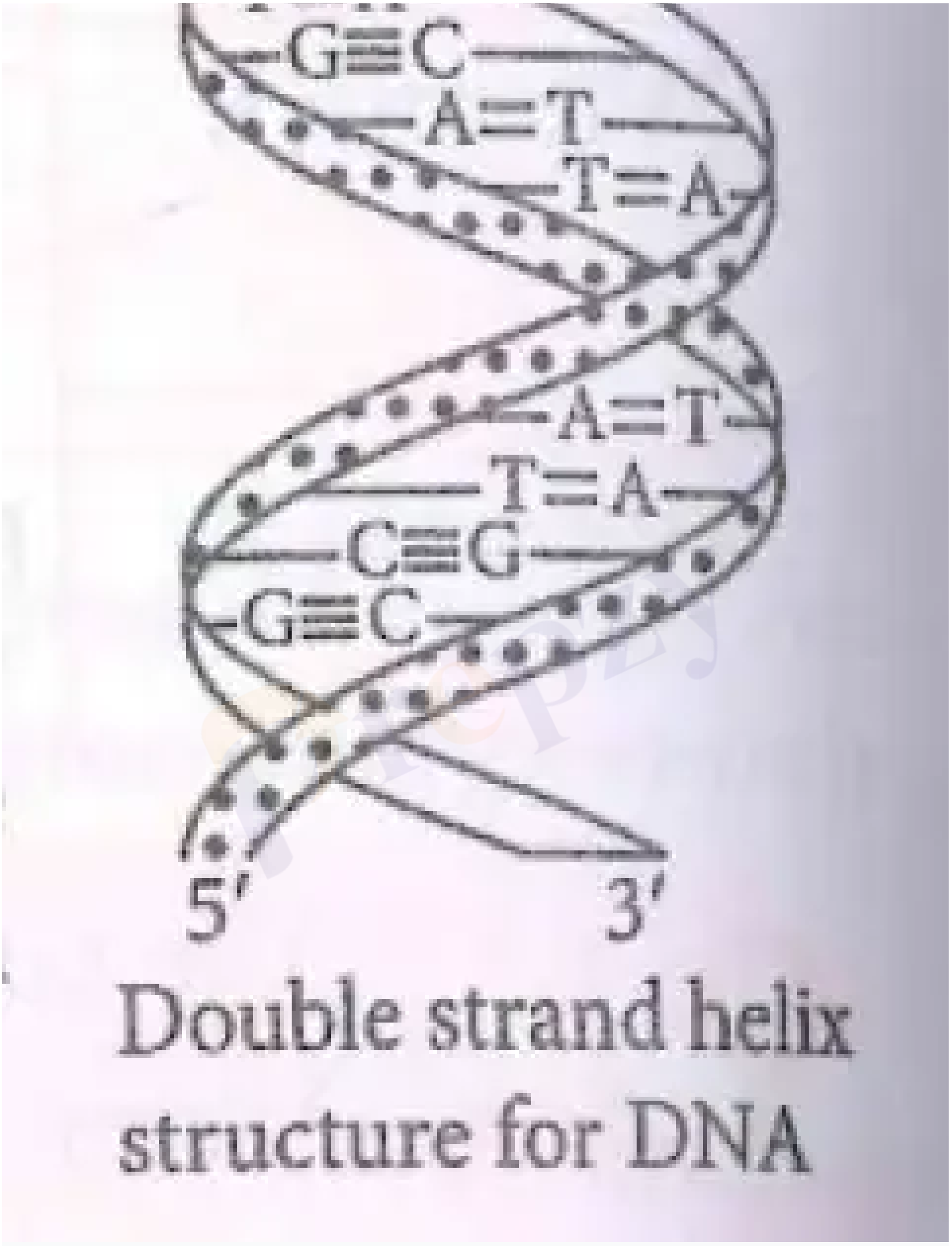


Adenine
A

Uracil
U

(Bonded by 2 hydrogen bonds)


5'
3'
G≡C
A=T
T=A
A=T
C≡G
G≡C
T=A
C≡G
T=A



Double strand helix structure for DNA

Biological Functions

- DNA stores genetic information and transmits heredity.
- Maintains species identity.
- Self-duplicates during cell division (replication).
- Protein synthesis directed by RNA; DNA contains the message.
- Replication: DNA produces two identical copies.
- Protein synthesis steps: Transcription (RNA synthesis) and Translation (protein synthesis in cytoplasm).
- Genetic code: Triplet nucleotide sequences determine amino acid sequence in proteins.

Solved Examples

- **Ex 1:** Identify sugar in DNA and RNA.
  Answer: DNA has β-deoxyribose; RNA has β-D-ribose.
- **Ex 2:** State base pairing in DNA.
  Answer: A pairs with T (2 H-bonds), G pairs with C (3 H-bonds).
- **Ex 3:** Define replication.
  Answer: Process where DNA makes two identical copies.

Practice Set

- **Q1:** Which sugar is present in RNA?
  A. β-deoxyribose
  B. β-D-ribose
  C. Glucose
  D. Fructose
- **Q2:** Which base is found in RNA but not in DNA?
  A. Thymine
  B. Uracil
  C. Adenine
  D. Guanine
- **Q3:** How many hydrogen bonds form between guanine and cytosine?
  A. One
  B. Two
  C. Three
  D. Four

Answer Key

- **Q1:** B. β-D-ribose - RNA contains ribose sugar.
- **Q2:** B. Uracil - Uracil replaces thymine in RNA.
- **Q3:** C. Three - G and C form three hydrogen bonds.

Memory Aids

- RNA sugar has an extra -OH group at 2' carbon compared to DNA.
- Base pairs: A-T (2 H-bonds), G-C (3 H-bonds), A-U in RNA.
- Chargaff's rule: Purines = Pyrimidines.

Hormones

Types of Hormones

- **Steroids:** Estrogens and androgens; lipid-soluble molecules derived from cholesterol.
- **Polypeptides:** Insulin and endorphins; chains of amino acids, water-soluble.
- **Amino Acid Derivatives:** Epinephrine and norepinephrine; derived from single amino acids.

Functions

- Act as intercellular messengers secreted directly into the bloodstream by endocrine glands.
- Maintain balance of biological activities in the body.
- Growth and sex hormones regulate growth and development.
- Insulin lowers blood glucose; glucagon raises blood glucose; together regulate blood sugar levels.
- Epinephrine and norepinephrine mediate responses to external stimuli.

Solved Examples

- **Ex 1:** Identify the hormone type: Insulin is a polypeptide hormone because it is a chain of amino acids.
- **Ex 2:** Explain glucose regulation: Insulin decreases blood glucose by promoting uptake; glucagon increases glucose by stimulating glycogen breakdown.

Practice Set

- **Q1:** Which hormone is a steroid?
  - A. Insulin
  - B. Estrogen
  - C. Epinephrine
  - D. Endorphin
- **Q2:** What is the main function of glucagon?
  - A. Decrease blood glucose
  - B. Increase blood glucose
  - C. Mediate stress response
  - D. Promote growth
- **Q3:** Which hormones are amino acid derivatives?
  - A. Insulin and endorphins
  - B. Estrogens and androgens
  - C. Epinephrine and norepinephrine
  - D. Growth hormone and insulin

Answer Key

- **Q1:** B. Estrogen — It is a steroid hormone derived from cholesterol.
- **Q2:** B. Increase blood glucose — Glucagon raises blood glucose by glycogen breakdown.
- **Q3:** C. Epinephrine and norepinephrine — These are amino acid derivative hormones.

Memory Aids

- Steroids: Think "-one" endings like estrogen, androgen.
- Polypeptides: Insulin is a classic example, remember as protein-based.

- Amino acid derivatives: Epinephrine and norepinephrine respond to stress.
- Insulin and glucagon work as a pair to regulate blood glucose.