GOVERNMENT COLLEGE (A)

RAJAHMUNDRY

MICROBIOLOGY DEPARTMENT

III SEMESTER

COURSE 6

BIOMOLECULES AND ENZYMOLOGY

III SEMESTER

COURSE 6: - BIOMOLECULES **AND ENZYMOLOGY**

CREDITS - 3

UNIT-I: Carbohydrates No. of hours: 9

General characters and outline classification of Carbohydrates
Monosaccharides- Glucose, fructose, ribose; Stereo isomerism of monosaccharides, epimers, mutarotation and anomers of glucose
Disaccharides- concept of reducing and non-reducing sugars;
Sucrose, Lactose
Polysaccharides-Storage-Starch,glycogen,Structural- Cellulose peptidoglycan and chitin
Sugar derivatives- glucosamine.

UNIT-II: Lipids and fatty acids No.of hours: 9

Definition and classification of lipids. Structure and properties of lipids. Importance of lipids in biological systems.
Introduction to fatty acids: definition, structure, and nomenclature. Saturated and unsaturated fatty acids.
Triglycerides: structure, function, and metabolism. Phospholipids: structure, function, and role in cell membranes. Steroids: structure, biosynthesis, and physiological roles.Waxes: structure, functions, and applications.

UNIT-III: Amino acids and Proteins.No. of hours:9

Biochemical structure and notation of standard protein amino acids
General characteristics of amino acids and proteins.
Primary, secondary, tertiary and quaternary structures of Protein
Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D-glutamic acid.

UNIT-IV: **Nucleic acids and Vitamins No. of hours:9**

Structure and functions of DNA and RNA.
Base composition. A+T and G+C rich genomes. Basic concept of nucleic acids protein interactions.
Concept and types of vitamins and their role in metabolism.

UNIT-V: Enzymes No. of hours: 9

Structure of enzyme, Apoenzyme and cofactors, prosthetic group- TPP, coenzyme -NAD, metal cofactors; Definitions of terms – enzyme unit, specific activity and turnover number
Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis.
Effect of pH and temperature on enzyme activity.
Inhibition of enzyme activity- competitive, noncompetitive, uncompetitive and allosteric.

PRACTICALS

1.Qualitative tests for sugars
2.Qualitative Analysis of Aminoacids.
3.Colorimetric estimation DNA by diphenylamine method.
4.Colorimetric estimation of proteins by Biuret/Lowry method

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UNIT-I: Carbohydrates

1.Write notes on General Characteristics of Carbohydrates

ESSAY 8 MARKS

Carbohydrates are a group of organic compounds occurring in living tissues and foods in the form of starch, cellulose, and sugars.
Carbohydrates consist of carbon, hydrogen, and oxygen.The general structure is $(CH_2O)_n$. The term carbohydrate is a combination of the "hydrates of carbon". The ratio of oxygen and hydrogen in carbohydrates is the same as in water i.e. 2:1.
Carbohydrates break down in the to release energy.
They are mainly classified into four groups:

- **Monosaccharides**
- **Disaccharides**
- **oligosaccharides**
- **Polysaccharides**

MONOSACCHARIDES

- they cannot be further hydrolyzed. They have only one simple sugar.
- They possess a free aldehyde or ketone group.
- The general formula is $C_n(H2O)_n$or $C_nH_{2n}O_n$.
- Examples are Glucose, Fructose, Erythrulose, Ribulose.
- They have either Aldehyde or Ketone Group

Carbon Chain Length.

  - Trioses. They have 3 carbons in them ex Gylceraldehyde
  - Tetroses. They have 4 carbons in them ex Erythrose
  - Pentoses. They have 5 carbons in them. ex Ribose
  - Hexoses. They have 6 carbons in them. ex Glucose

DISACCHARIDES

- Disaccharides have two molecules of sugars on hydrolysis.
- They are joined by glycosidic linkage.
- The general formula of disaccharides is $C_n(H2O)_{n-}$
- Examples : Disaccharides include sucrose, lactose, maltose etc.
- Sucrose is one of the most common disaccharides .
- Maltose and Lactose (also known as milk sugar) are other two important disaccharides.

OLIGOSACCHARIDES

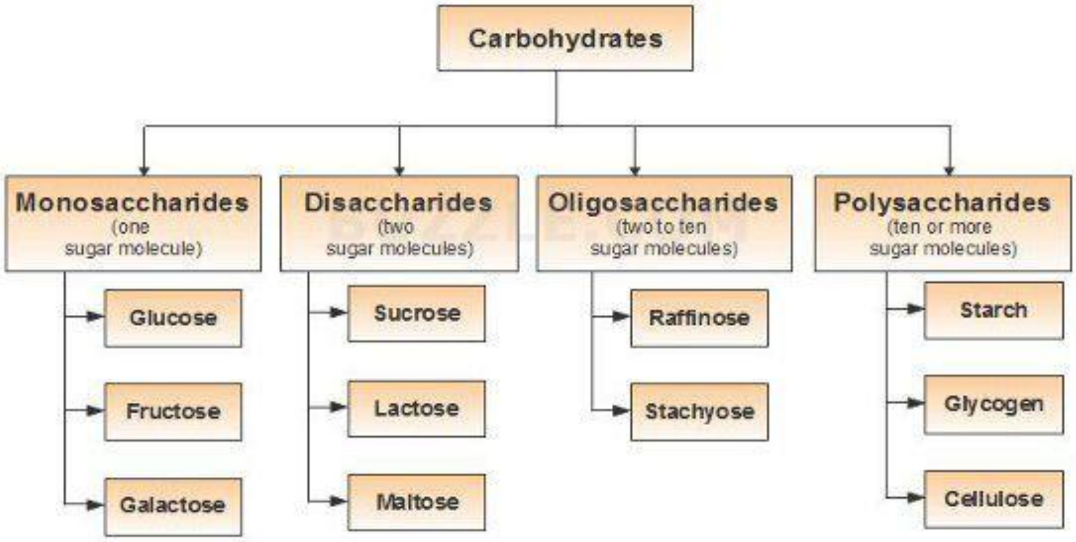
- Oligosaccharides are compound sugars that yield 2 to 10 molecules of a monosaccharides on hydrolysis.
- The monosachharide units are joined by glycosidic linkage.

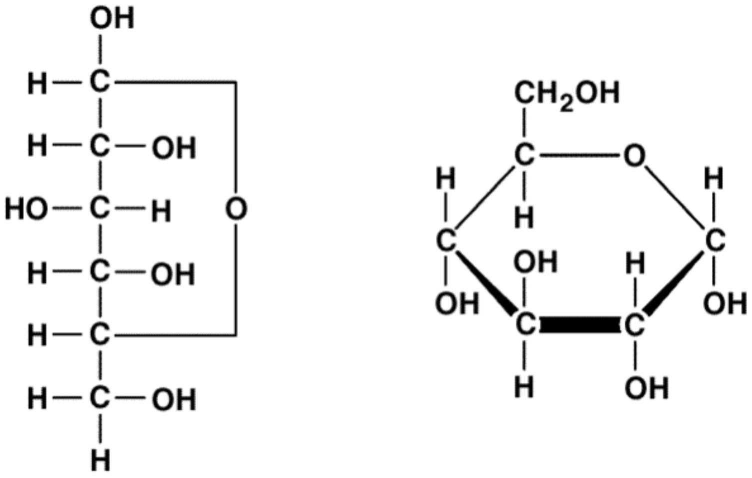
- Oligosaccharides yielding 3 or 4 monosaccharides are known as trisaccharides and tetrasaccharides.
- examples are Raffinose, Rabinose.

POLYSACCHARIDES

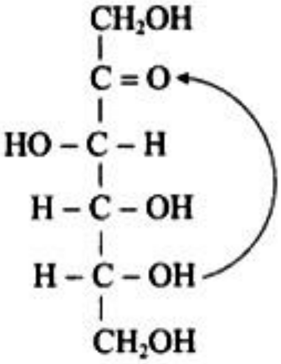
- Polysaccharides yield more than 10 molecules of monosaccharides on hydrolysis.
- They have Structural functions and the storage of energy.
- They maybe **homopolysaccharides**e, containing monosaccharides of the same type or **heteropolysaccharides** i.e., monosaccharides of different types.
- Example of Homopolysaccharides are starch, glycogen, cellulose, pectin.
    - Heteropolysaccharides are Hyaluronic acid, Chondrotin.

Classification of Carbohydrates

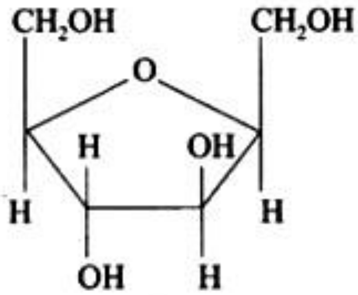




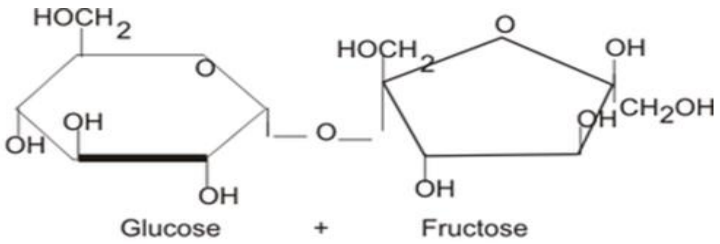
Glucose



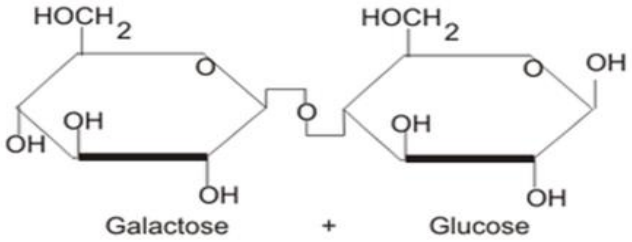
D - Fructose



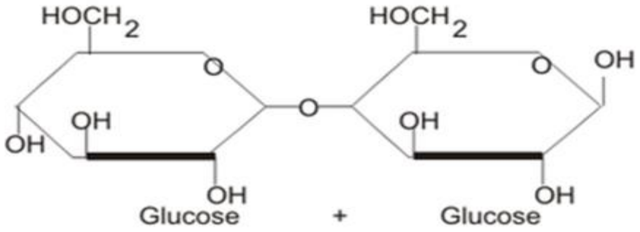
α – D Fructose



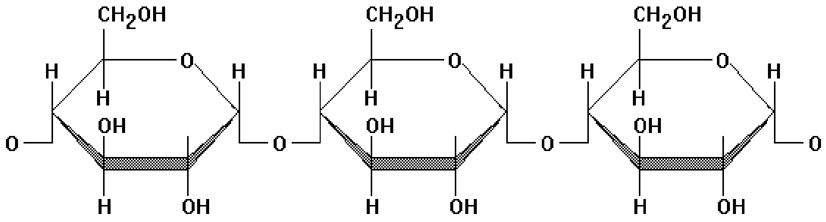
Sucrose



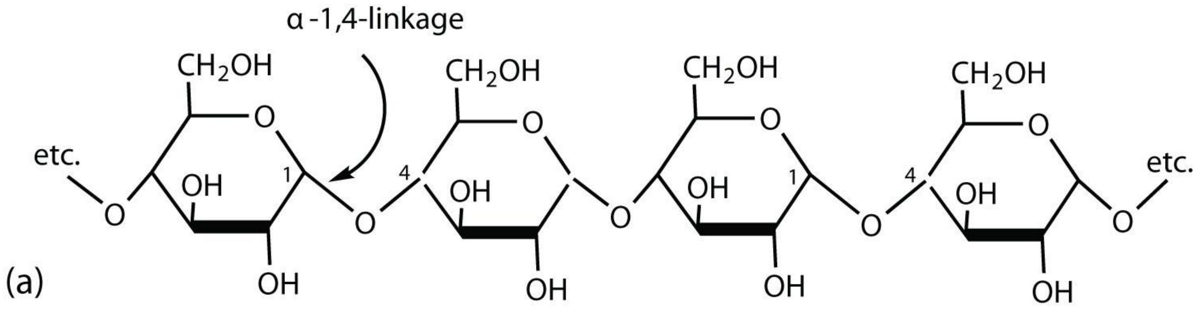
Lactose



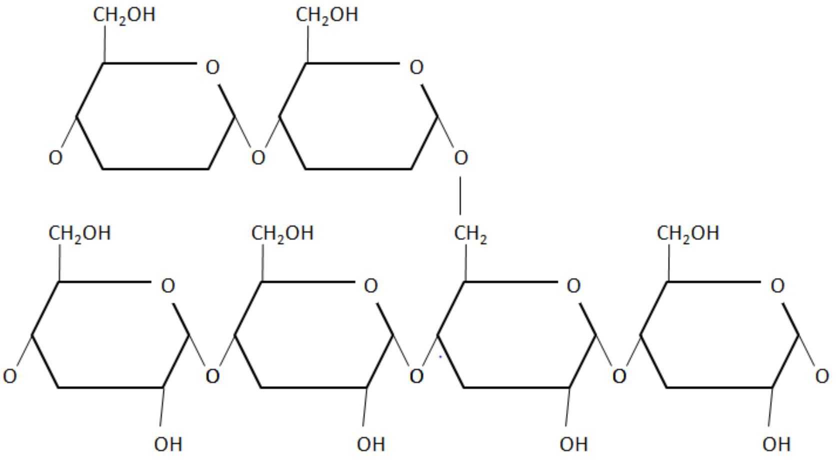
Maltose



STARCH



STARCH



GLYCOGEN

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2. Write a note on Monosaccharides

Monosaccharides are the simplest form of carbohydrates. They consist of a single sugar molecule. They are the building blocks of carbohydrates such as disaccharides and polysaccharides. Monosaccharides can be classified based on the number of carbon atoms they contain:

- **Trioses**: 3 carbon atoms (e.g., glyceraldehyde)
- **Tetroses**: 4 carbon atoms (e.g., erythrose)
- **Pentoses**: 5 carbon atoms (e.g., ribose, xylose)
- **Hexoses**: 6 carbon atoms (e.g., glucose, fructose, galactose)
- **Heptoses**: 7 carbon atoms (e.g., sedoheptulose)

GLUCOSE

- Molecular Formula: C6H12O6
- Type: Aldohexose . It contains an aldehyde group- OH
- Glucose can exist in both a linear form and a cyclic form. In its cyclic form, it forms a six-membered ring (pyranose).
- It Exists as D-glucose and L-glucose, with D-glucose being the biologically active form.
- It is Primary energy source for cells. It is metabolized via glycolysis, the citric acid cycle, and oxidative phosphorylation to produce ATP.
- It is Stored as glycogen in animals and as starch in plants.
- Blood Sugar Levels are tightly regulated by hormones such as insulin and glucagon.

FRUCTOSE

- **Molecular Formula**: C6H12O6
- **Type**: Ketohexose . It contains a ketone group- CO
- Fructose can exist in a linear form and a cyclic form. In its cyclic form, it forms a five-membered ring (furanose).
- It Exists as D-fructose and L-fructose. D-fructose is the biologically active form.
- It is the sweetest natural sugar, commonly found in fruits, honey, and root vegetables.
- It is Metabolized by the liver into glucose and other metabolites that can enter glycolysis.
- **It is** Utilized in the fructose metabolism pathway, involving phosphorylation to fructose-1-phosphate.

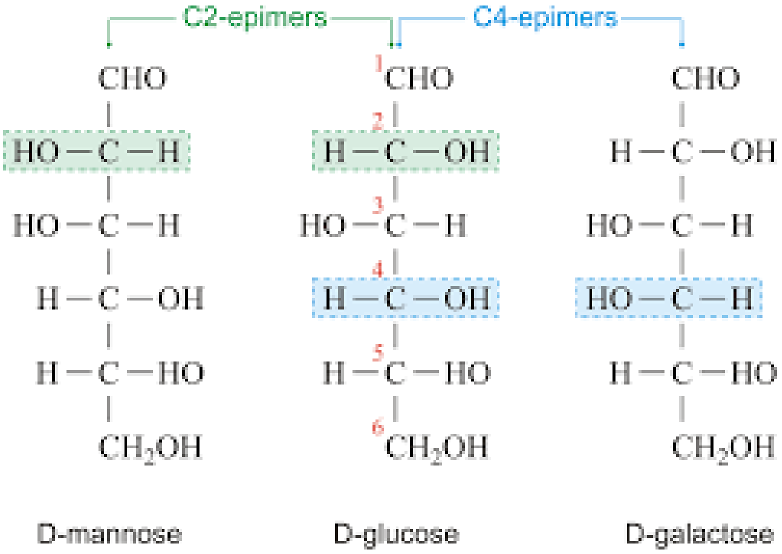
RIBOSE

- **Molecular Formula**: C5H10O5
- **Type**: Aldopentose . it contains an aldehyde group-OH
- Ribose is a five-carbon sugar that can exist in both linear and cyclic forms. In its cyclic form, it forms a five-membered ring (furanose).
- It Exists as D-ribose and L-ribose, with D-ribose being the biologically active form.
- It is important component of ribonucleic acid (RNA).
- It is Part of important energy molecules such as ATP (adenosine triphosphate), NADH, and FADH2.
- It Plays a role in the pentose phosphate pathway, which is crucial for nucleotide synthesis and redox balance.

Stereoisomerism of Monosaccharides

Stereoisomers are molecules that have the same molecular formula but differ in the three-dimensional orientations of their atoms.

- **Enantiomers**: These are pairs of stereoisomers that are non-superimposable mirror images of each other. For example, D-glucose and L-glucose.
- **Diastereomers**: These are stereoisomers that are not mirror images of each other. For instance, D-glucose and D-mannose are diastereomers.
- **Epimers :**Epimers are a subtype of diastereomers. They are monosaccharides that differ in configuration around only one specific carbon atom.For example:
- **D-glucose and D-galactose** are epimers with respect to carbon 4.
- **D-glucose and D-mannose** are epimers with respect to carbon 2.



Mutarotation

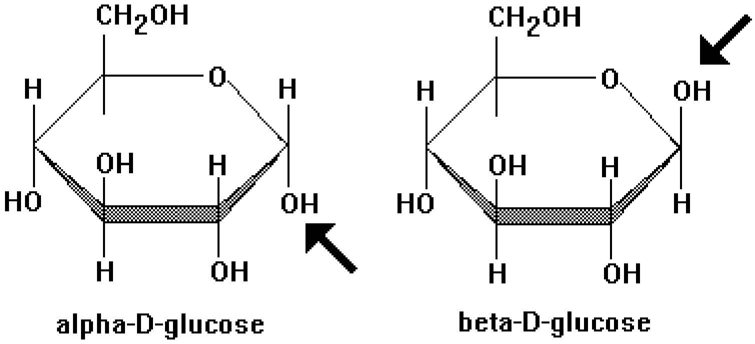
Mutarotation refers to the change in the optical rotation that occurs when an alpha (α) form of a monosaccharide is converted into a beta (β) form and vice versa. It is observed when monosaccharides are dissolve in water.

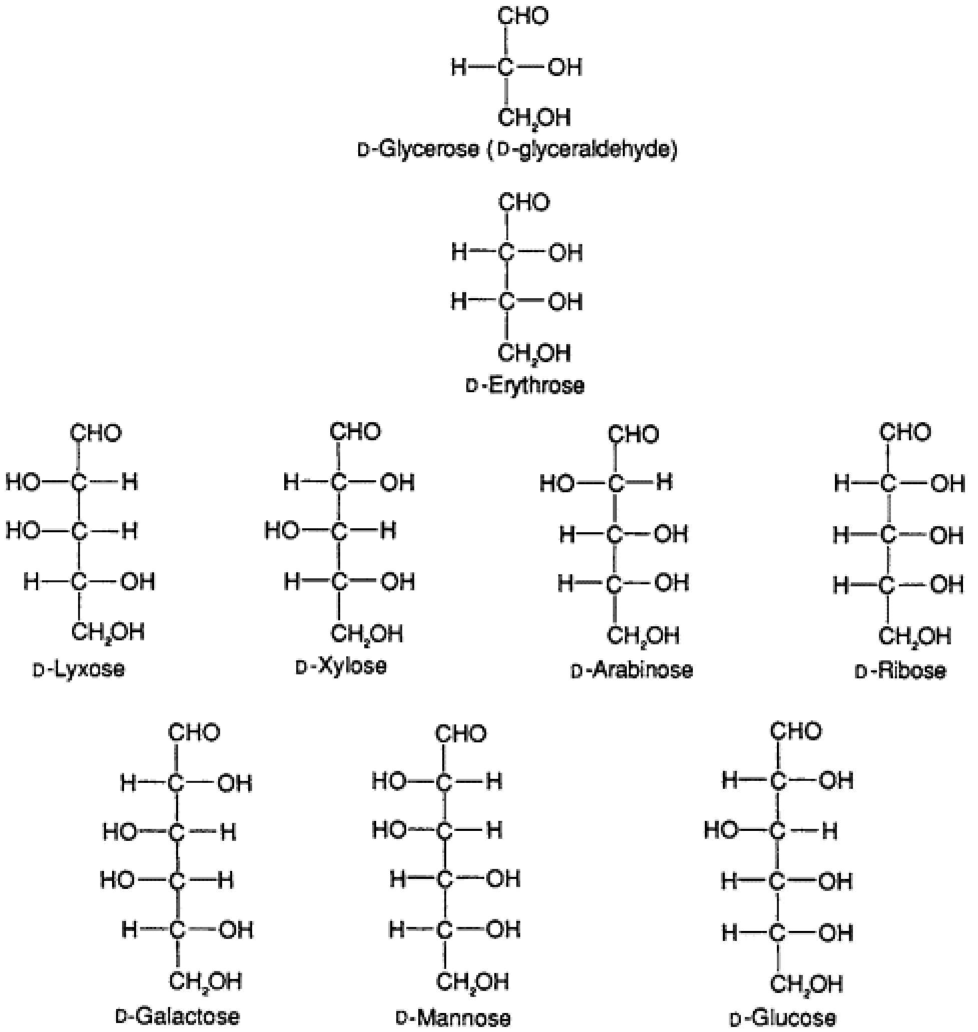
Anomers of Glucose

Anomers are a type of stereoisomer specific to cyclic monosaccharides. They differ in configuration only at the anomeric carbon.

- **α-D-glucose**: The OH group on Carbon (C1) is below the plane of the ring.

- **β-D-glucose**: The OH group on Carbon (C1) is above the plane of the ring.





D-Glycerose (D-glyceraldehyde)

D-Erythrose

D-Lyxose

D-Xylose

D-Arabinose

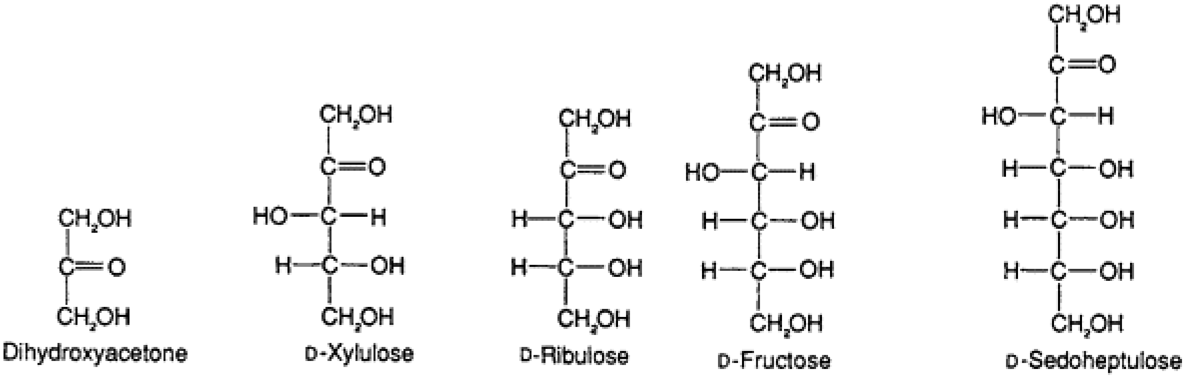
D-Ribose

D-Galactose

D-Mannose

D-Glucose

Aldoses



Dihydroxyacetone

D-Xylulose

D-Ribulose

D-Fructose

D-Sedoheptulose

Ketoses

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3. Explain Disaccharides, reducing & non reducing sugars along with sucrose & lactose

Disaccharides are carbohydrates made of two monosaccharide linked together by a glycosidic bond. Disaccharides consist of two monosaccharide residues connected by a glycosidic bond, which can be alpha (α) or beta (β) depending on the anomeric carbon involved in the bond.

Sucrose

- **Molecular Formula**: $C_{12}H_{22}O_{11}$
- It is made of Glucose and fructose
- **Glycosidic Bond**: α(1→2)β linkage between the anomeric carbon of glucose and the anomeric carbon of fructose
- It is Non-reducing sugar, as both anomeric carbons are involved in the glycosidic bond
- It known as table sugar, sucrose is a major sweetener used in food and beverages.
- Sucrose is hydrolyzed into glucose and fructose in the small intestine by the enzyme sucrase, providing a quick source of energy.
- Sucrose is a primary product of photosynthesis in plants and is used for transport and storage of energy.

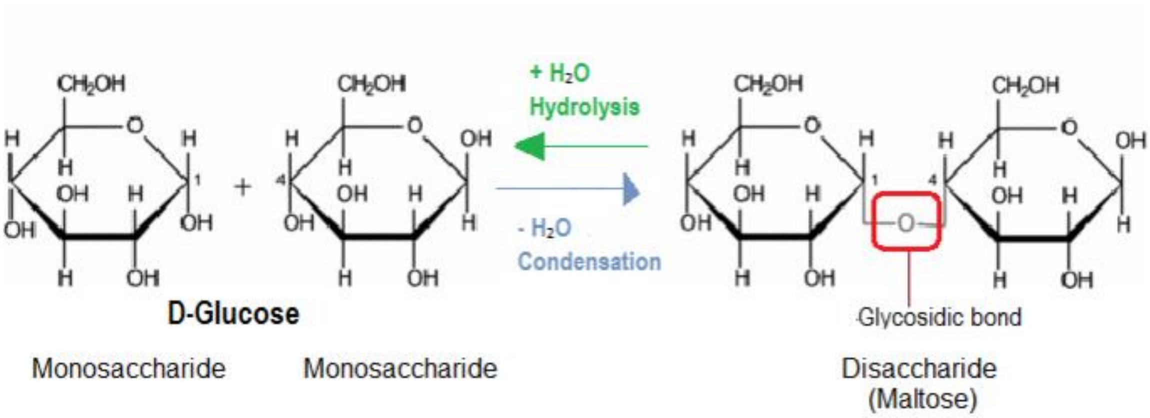
Lactose

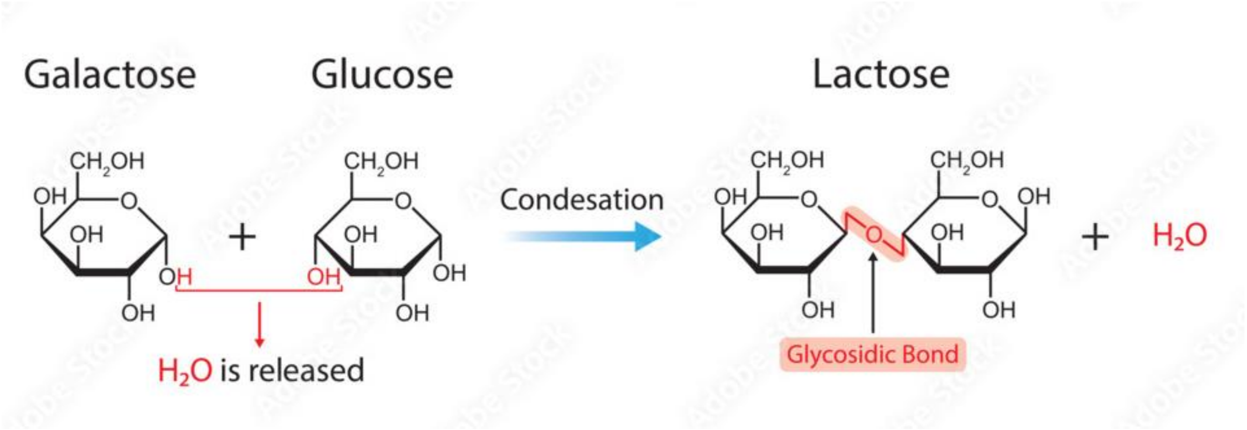
- **Molecular Formula**: $C_{12}H_{22}O_{11}$
- It is made of Glucose and galactose
- **Glycosidic Bond**: β(1→4) linkage between the Carbon 1 of Galactose and the hydroxyl group of glucose at C4
- It is a Reducing sugar, as the glucose component has a free anomeric carbon
- **Milk Sugar**: Lactose is the primary carbohydrate found in milk, providing energy to infants.
- Lactose is hydrolyzed into glucose and galactose in the small intestine by the enzyme lactase.
- Lactose aids in the absorption of calcium and other minerals in the intestines.

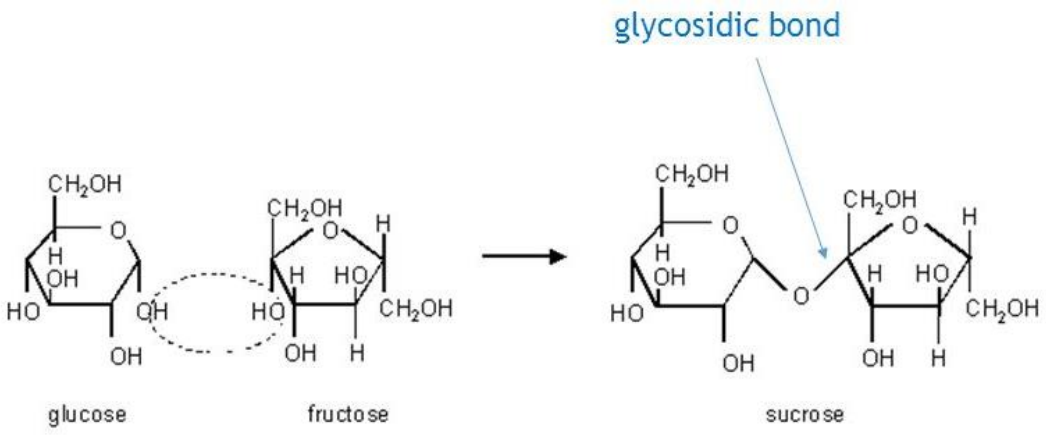
Reducing and Non-Reducing Sugars

- **Reducing Sugars**: Disaccharides in which at least one of the monosaccharide units retains a free anomeric carbon, capable of acting as a reducing agent.

- Examples include maltose and lactose. These sugars can open into a linear form and have a free aldehyde or ketone group that can reduce other compounds.
    - **Non-Reducing Sugars**: Disaccharides in which both anomeric carbons are involved in the glycosidic bond, making them unable to open into a linear form or act as reducing agents. An example is sucrose.







4. Explain Polysaccharides. Storage polysaccharides starch, glycogen and structural polysaccharides cellulose, peptidoglycan and chitin.

ESSAY – 8 MARKS

Polysaccharides are long chains of monosaccharide units linked by glycosidic bonds. They can be linear or branched and serve in energy storage and structural support.

Types of Polysaccharides

1. **Storage Polysaccharides**
2. **Structural Polysaccharides**

Storage Polysaccharides

Starch

- Starch is a mixture of two polysaccharides, amylose and amylopectin.
- **Amylose**: it is a linear polymer of glucose units connected by α(1→4) glycosidic bonds. It makes up 20-30% of starch.
- **Amylopectin**: it is a highly branched polymer of glucose units with α(1→4) glycosidic bonds in the linear chains and α(1→6) glycosidic bonds at the branch points. It makes up 70-80% of starch.
- It is Found in plants, particularly in seeds, tubers, and roots.
- It Serves as an energy reserve for plants.

Glycogen

- **Structure** is Similar to amylopectin but more extensively branched, with branches occurring every 8-12 glucose units.
- It is made up of glucose units connected by α(1→4) glycosidic bonds in the linear portions and α(1→6) glycosidic bonds at the branch points.
- It is Found in animals, primarily in liver and muscle tissues.
- It acts as a storage form of glucose, providing energy during periods of high demand.

Structural Polysaccharides

Cellulose

- It is a linear polymer of β-D-glucose units connected by β(1→4) glycosidic bonds.
- It is composed of thousands of glucose units.

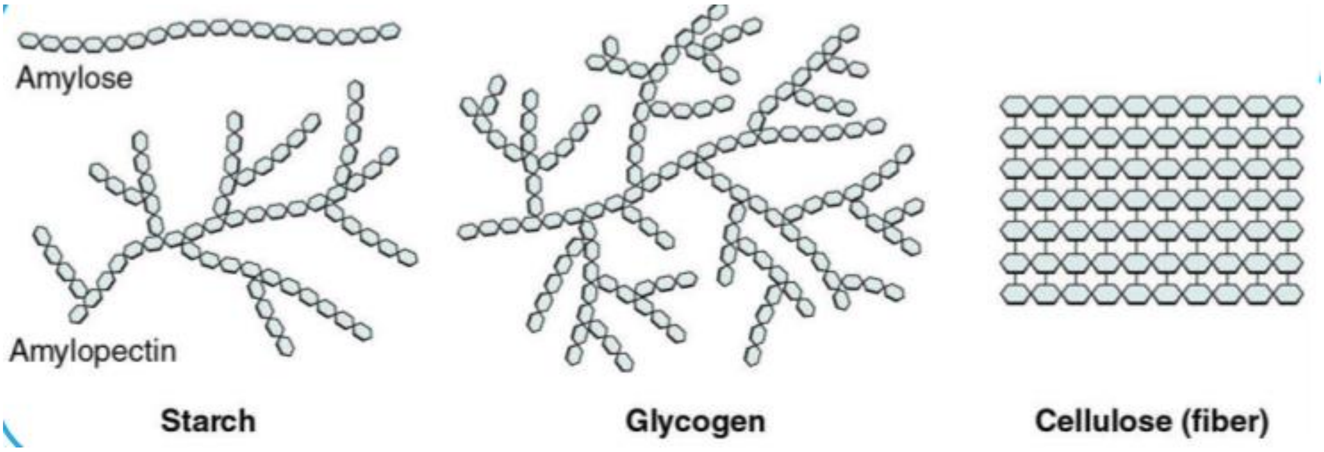
- It is found in the cell walls of plants.
- It provides structural support and rigidity to plant cell walls. The β(1→4) linkages allow the formation of long, straight chains that can form strong fibers through hydrogen bonding.

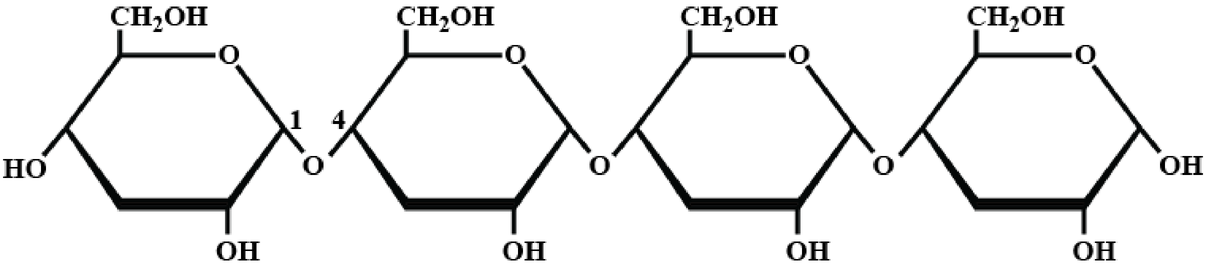
Peptidoglycan

- It is polymer consisting of sugars and amino acids.
- It is made of N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- It is found in the cell walls of bacteria.
- It Provides shape to bacterial cell walls, protecting against osmotic pressure and environmental stresses.

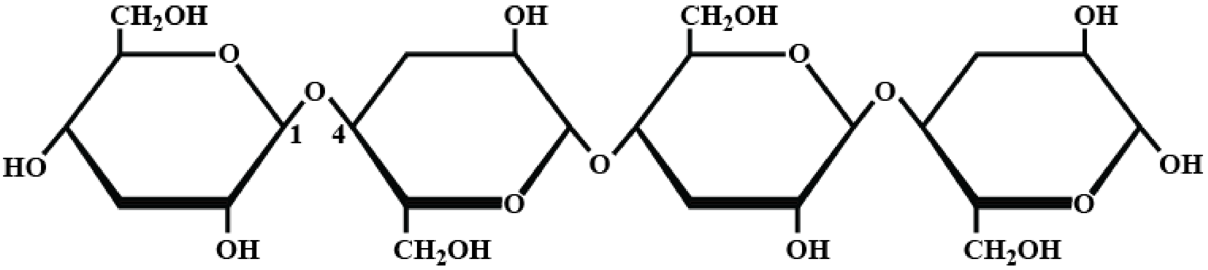
Chitin

- It is a linear polymer of N-acetylglucosamine (GlcNAc) units connected by β(1→4) glycosidic bonds.
- It is composed of repeating units of GlcNAc.
- It is found in the exoskeletons of arthropods (e.g., insects, crustaceans) and the cell walls of fungi.
- It provides structural strength and protection.
- In fungi, it gives rigidity to the cell wall, and in arthropods, it forms a protective exoskeleton.





(b) Starch: 1-4 linkage of α glucose monomers



(c) Cellulose: 1-4 linkage of β glucose monmers

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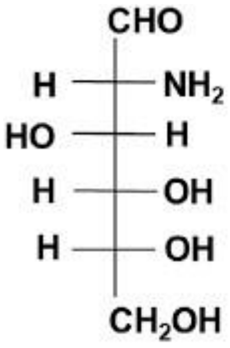
Write a note on Glucosamine **SPLIT ESSAY 4 MARKS**

Glucosamine is a naturally occurring amino sugar .
It is a derivative of glucose.
It plays an important role in the synthesis of glycosylated proteins and lipids.
Glucosamine is naturally found in the shells of shellfish, animal bones, and bone marrow.
Glucosamine is available as health supplement in various forms such-

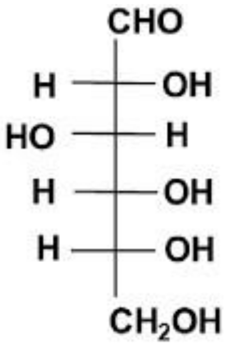
- **Glucosamine Sulfate**
- **Glucosamine Hydrochloride**
- **N-Acetylglucosamine (GlcNAc)**

Importance

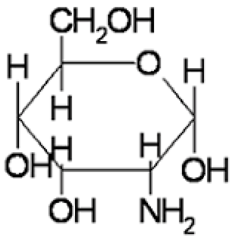
- **Chitin and Chitosan**: Glucosamine is an important component of chitin.
- **Glycosaminoglycans (GAGs)**: Glucosamine is used in the biosynthesis of glycosaminoglycans, such as hyaluronic acid, heparan sulfate, and chondroitin sulfate. These molecules are essential for the structure & function of connective tissues, cartilage, and synovial fluid.
- **Cartilage and Joint Health**: Glucosamine is important for healthy cartilage. It is used in the treatment of osteoarthritis .
- **Wound Healing**: glucosamine is useful in wound healing and tissue repair.



GLUCOSAMINE



GLUCOSE



GLUCOSAMINE

SUCROSE – SPLIT ESSAY 4 MARKS

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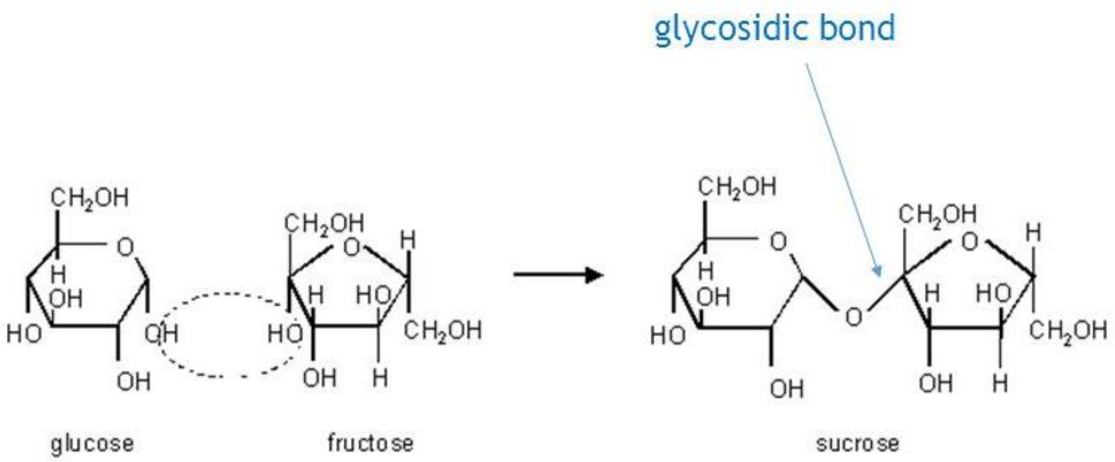
- It known as table sugar, sucrose is a major sweetener used in food and beverages.
- Sucrose is hydrolyzed into glucose and fructose in the small intestine by the enzyme sucrase, providing a quick source of energy.
- Sucrose is a primary product of photosynthesis in plants and is used for transport and storage of energy.



SHORT QUESTIONS

Multiple Choice Questions (MCQs)

1. Which of the following is a monosaccharide?

   a.Sucrose b. Glucose c. Lactose d. Maltose (Answer:Glucose)

2. Which of the following is a disaccharide?

   a. Fructose b. Starch c. Sucrose d. Cellulose (Answer:Sucrose)

3. Which of the following is NOT a common monosaccharide?

   a. Glucose b. Fructose c. Galactose d. Maltose(Answer:Glucose)

4. Glucosamine is a type of:
   a. Monosaccharide b. Disaccharide c. Amino sugar d. Polysaccharide (Answer:Amino sugar)

5. Which of the following sugars is known as milk sugar?

   a. Glucose b. Fructose c. Lactose d. Sucrose (Answer:Lactose)

Fill in the Blanks

6. The storage form of glucose in animals is __________. (Answer:Glycogen)
7. The main structural component of plant cell walls is __________.
8. __________ is the monosaccharide commonly found in fruit. (Answer:Fructose)

9. The process by which polysaccharides are broken down into monosaccharides is called __________. (Answer:Hydrolysis)

True or False

11. Cellulose is a type of disaccharide. T/F(Answer:False)
12. Glucosamine is commonly found in joint supplements. T/F (Answer:True)

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UNIT-II: LIPIDS AND FATTY ACIDS

1. **Write Definition of Lipids**

Lipids: Lipids are a group of naturally occurring molecules that are primarily made of carbon, hydrogen, and oxygen. They are characterized by their insolubility in water but are soluble in non-polar solvents like oils and alcohols. Lipids play essential roles in energy storage, cell structure, and signaling.

Classification of Lipids

Lipids can be broadly classified into the following categories:

1. **Simple Lipids**
    - **Triglycerides**: These are fats and oils composed of glycerol and three fatty acids. They are the primary form of energy storage in the body.
    - **Waxes**: Made of fatty acids and long-chain alcohols, waxes are used for protection and waterproofing in plants and animals.
2. **Complex Lipids**
    - **Phospholipids**: Contain glycerol, two fatty acids, and a phosphate group. They are key components of cell membranes.
    - **Glycolipids**: Similar to phospholipids but contain a carbohydrate group instead of a phosphate group. They are important in cell recognition and signaling.
3. **Derived Lipids**
    - **Steroids**: Lipids with a structure of four fused carbon rings, including cholesterol and hormones like testosterone and estrogen.
    - **Fatty Acids**: Basic building blocks of many lipids, which can be saturated (no double bonds) or unsaturated (one or more double bonds).
    - **Vitamins**: Fat-soluble vitamins like A, D, E, and K are also classified as lipids.

Functions of Lipids

- **Energy Storage**: Lipids, especially triglycerides, are a major form of energy storage in animals.

- **Structural Components**: Phospholipids and cholesterol are essential components of cell membranes.
- **Insulation and Protection**: Fats insulate body organs against shock and maintain body temperature.
- **Regulatory Roles**: Steroid hormones and some vitamins (A, D, E, K) are lipids and are crucial for various biological processes.

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2. **Explain Structure and properties of lipids**

Structure of Lipids

Lipids: Lipids are a group of naturally occurring molecules that are primarily made of carbon, hydrogen, and oxygen. They are characterized by their insolubility in water but are soluble in non-polar solvents like oils and alcohols. Lipids play essential roles in energy storage, cell structure, and signaling. Lipids are made primarily of carbon (C), hydrogen (H), and oxygen (O) atoms.

Hydrocarbon Chains: Most lipids contain long hydrocarbon chains or rings, which make them non-polar (they don't mix with water).

Varied Structures: Depending on the type of lipid, the structure can vary:

  - **Triglycerides**: Composed of one glycerol molecule and three fatty acid chains.
  - **Phospholipids**: Contain a glycerol backbone, two fatty acids, and a phosphate group.
  - **Steroids**: Consist of four interconnected carbon rings with various side chains.

Properties of Lipids

- **Hydrophobic**: Lipids are generally hydrophobic (water-repelling), meaning they do not dissolve in water. This property is due to their non-polar hydrocarbon chains.
- **Solubility in Non-Polar Solvents**: Lipids dissolve easily in non-polar solvents like oils, alcohols, and other organic solvents.
- **Energy-Rich**: Lipids contain a high amount of energy per gram, more than carbohydrates and proteins. This makes them excellent for long-term energy storage.
- **Melting Point**: The melting point of lipids depends on the type of fatty acids they contain:
  - **Saturated Fats**: Have higher melting points and are usually solid at room temperature (e.g., butter).
  - **Unsaturated Fats**: Have lower melting points and are usually liquid at room temperature (e.g., olive oil).

- **Amphipathic Nature**: Some lipids, like phospholipids, have both hydrophilic (water-attracting) and hydrophobic regions, allowing them to form structures like cell membranes.
- **Role in Membrane Fluidity**: The fluidity of cell membranes is influenced by the types of lipids present, with unsaturated fatty acids making membranes more fluid and flexible.

Functions of Lipids

- **Energy Storage**: Lipids, especially triglycerides, are a major form of energy storage in animals.
- **Structural Components**: Phospholipids and cholesterol are essential components of cell membranes.
- **Insulation and Protection**: Fats insulate body organs against shock and maintain body temperature.
- **Regulatory Roles**: Steroid hormones and some vitamins (A, D, E, K) are lipids and are crucial for various biological processes.

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3. **Discuss importance of lipids in biological systems.**

Lipids: Lipids are a group of naturally occurring molecules that are primarily made of carbon, hydrogen, and oxygen. They are characterized by their insolubility in water but are soluble in non-polar solvents like oils and alcohols. Lipids play essential roles in energy storage, cell structure, and signaling.

Importance of Lipids in Biological Systems

1. **Energy Storage**
    - **Efficient Energy Source**: Lipids store large amounts of energy, providing more than twice the energy per gram compared to carbohydrates and proteins. This makes them essential for long-term energy reserves in the body.
    - **Stored in Fat Cells**: Triglycerides, a type of lipid, are stored in fat cells (adipocytes) and can be broken down to release energy when needed.
2. **Structural Role in Cell Membranes**
    - **Membrane Formation**: Phospholipids are key components of cell membranes, forming a lipid bilayer that acts as a barrier, protecting the cell's contents and regulating what enters and exits.
    - **Membrane Fluidity**: Lipids help maintain the fluidity and flexibility of cell membranes, allowing cells to change shape and move while maintaining their integrity.

3. **Insulation and Protection**
    - **Thermal Insulation**: Lipids, especially those stored in adipose tissue, help insulate the body, maintaining body temperature by reducing heat loss.
    - **Cushioning**: Lipids cushion and protect vital organs from physical shock and injury.
4. **Chemical Signaling**
    - **Hormones**: Many hormones, such as steroid hormones (e.g., estrogen, testosterone), are lipids. They play crucial roles in regulating various physiological processes, including growth, metabolism, and reproduction.
    - **Cell Signaling**: Lipid molecules are involved in transmitting signals within and between cells, helping coordinate various biological functions.
5. **Vitamin Absorption**
    - **Fat-Soluble Vitamins**: Lipids aid in the absorption of fat-soluble vitamins (A, D, E, and K) from the diet, which are essential for processes like vision, bone health, antioxidant protection, and blood clotting.
6. **Waterproofing**
    - **Skin and Feathers**: Lipids like waxes provide a waterproof layer on the skin, fur, and feathers, helping to prevent water loss and protect against environmental elements.

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4. **Explain functions of lipids**

Lipids: Lipids are a group of naturally occurring molecules that are primarily made of carbon, hydrogen, and oxygen. They are characterized by their insolubility in water but are soluble in non-polar solvents like oils and alcohols. Lipids play essential roles in energy storage, cell structure, and signaling.

Functions of Lipids in Biological Systems

1. **Energy Storage -** Lipids store energy in fat cells (adipose tissue) and provide a dense energy source that the body can use when needed.
2. **Cell Membrane Structure**
    - **Barrier Formation**: Phospholipids form the main structure of cell membranes, creating a protective barrier that controls what enters and exits the cell.
    - **Membrane Fluidity**: Lipids keep cell membranes flexible and able to adapt to changes in shape and environment.
3. **Insulation and Protection**

    - **Thermal Insulation**: Lipids help maintain body temperature by insulating against heat loss.
    - **Organ Cushioning**: Stored fats cushion and protect vital organs from physical damage.

4. **Chemical Signaling**
    - **Hormone Production**: Many hormones, like steroids (e.g., estrogen, testosterone), are derived from lipids and regulate various bodily functions such as metabolism, growth, and reproduction.
    - **Cell Communication**: Certain lipids are involved in transmitting signals within and between cells, helping coordinate biological processes.
5. **Vitamin Absorption**
    - **Fat-Soluble Vitamins**: Lipids assist in absorbing fat-soluble vitamins (A, D, E, and K) from food, which are essential for various bodily functions, including vision, immune response, and blood clotting.
6. **Waterproofing**
    - **Protection against Water Loss**: Lipids like waxes provide a waterproof barrier on the skin, fur, and feathers, helping prevent dehydration and protect against environmental elements.
7. **Buoyancy**
    - **Floatation Aid**: In some aquatic animals, lipids help increase buoyancy, making it easier for them to float and swim.

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5. **Write Definition of Fatty Acids**

- **Fatty Acids**: Fatty acids are long chains of carbon and hydrogen atoms with a carboxyl group (-COOH) at one end. They are key building blocks of lipids, such as triglycerides and phospholipids.

Structure of Fatty Acids

- **Hydrocarbon Chain**: The main part of a fatty acid is a long chain of carbon atoms bonded to hydrogen atoms. This chain can be:
    - **Saturated**: No double bonds between carbon atoms, leading to a straight chain.
    - **Unsaturated**: One or more double bonds between carbon atoms, causing kinks or bends in the chain.
- **Carboxyl Group**: At one end of the chain is a carboxyl group (-COOH), which makes the fatty acid slightly acidic and reactive.

Nomenclature of Fatty Acids

- **Based on Carbon Atoms**: The number of carbon atoms in the chain determines the fatty acid's name. For example, a fatty acid with 16 carbon atoms is called palmitic acid.
- **Saturation**:
    - **Saturated Fatty Acids**: No double bonds; named without the term "unsaturated" (e.g., stearic acid).
    - **Unsaturated Fatty Acids**: One or more double bonds; named with the position and number of double bonds indicated (e.g., oleic acid is a monounsaturated fatty acid with one double bond).

Systematic (IUPAC) Nomenclature:

- In the IUPAC system, fatty acids are named based on the parent hydrocarbon with the suffix "-oic acid" added to indicate the carboxyl group.
    - **Example**: Octadecanoic acid (Stearic acid).

Δ (Delta) System:

- Indicates the number of carbons, the number of double bonds, and the position of the double bonds from the carboxyl end.
    - **Example**: 18:1 Δ^9 for oleic acid (18 carbons, 1 double bond at the 9th carbon).

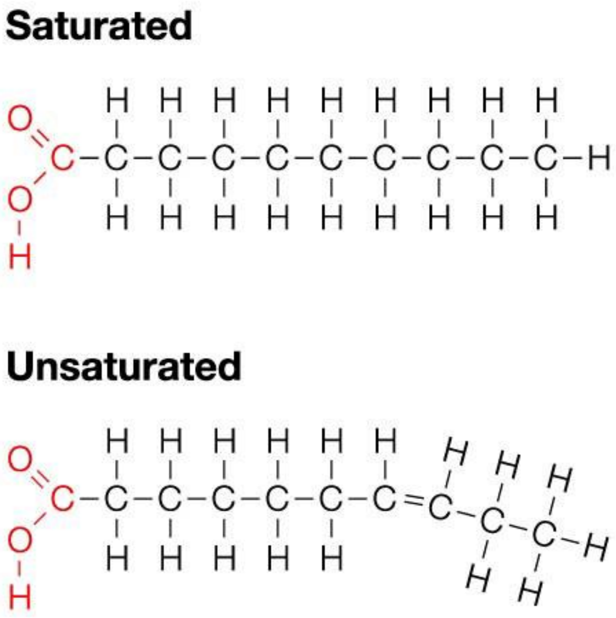
Omega Naming System: Unsaturated fatty acids are also named based on the position of the first double bond from the methyl (CH_3) end of the chain:

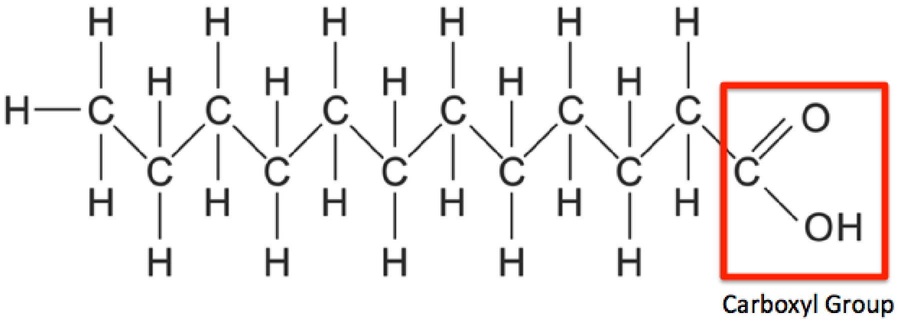
- **Omega-3**: First double bond is at the third carbon from the end (e.g., alpha-linolenic acid).
- **Omega-6**: First double bond is at the sixth carbon from the end (e.g., linoleic acid).

Importance

Fatty acids are essential for various biological functions, including:

- **Energy Storage**: Stored as triglycerides in adipose tissue.
- **Cell Membranes**: Components of phospholipids and glycolipids.
- **Signaling Molecules**: Precursors for eicosanoids (e.g., prostaglandins).
- **Metabolism**: Involved in metabolic pathways like β-oxidation.





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6. Write Notes on Saturated and Unsaturated Fatty Acids

Fatty acids (FA) consist of carbon, hydrogen, and oxygen, arranged as a linear carbon chain of variable length, with an even number of atoms, with a carboxyl group at one end

CLASSIFICATION OF FATTY ACIDS
On the basis of the absence/presence of double/triple bonds they can be grouped into two broad classes:

Saturated FA, if there are no double bonds in the carbon chain;
Unsaturated FA, if there are one or more double bonds in the carbon chain.

SATURATED FATTY ACIDS

Saturated fatty acids have no double bonds between the carbon atoms in their hydrocarbon chain. All the carbon atoms are fully "saturated" with hydrogen atoms, leading to a straight, rigid structure.

Physical Properties:

- **Solid at Room Temperature**: Due to their straight structure, saturated fatty acids can pack closely together, making them solid at room temperature. Examples include butter and animal fat.
- **Higher Melting Point**: Saturated fats generally have a higher melting point compared to unsaturated fats.

Examples

- **Stearic Acid** found in Animal fats, cocoa butter.
- **Palmitic Acid** found in Palm oil, meat, dairy products.

Health Impact:

Associated with Higher Cholesterol: Excessive intake of saturated fats can raise levels of LDL (bad) cholesterol in the blood, potentially leading to heart disease.

UNSATURATED FATTY ACIDS

Structure: Unsaturated fatty acids have one or more double bonds between the carbon atoms in their hydrocarbon chain. These double bonds introduce kinks or bends in the chain, preventing tight packing.

Types:

- **Monounsaturated Fatty Acids**: Have one double bond in the chain (e.g., oleic acid found in olive oil).
- **Polyunsaturated Fatty Acids**: Have two or more double bonds (e.g., linoleic acid found in vegetable oils, and omega-3 fatty acids found in fish oil).

Physical Properties:

- **Liquid at Room Temperature**: Due to their bent structure, unsaturated fatty acids are usually liquid at room temperature. Examples include olive oil and fish oil.
- **Lower Melting Point**: Unsaturated fats have a lower melting point compared to saturated fats.

Types and Examples

Monounsaturated Fatty Acids (MUFA):

- **Structure**: One double bond.
- **Example**: Oleic Acid found in Olive oil, avocados, nuts.

Polyunsaturated Fatty Acids (PUFA):

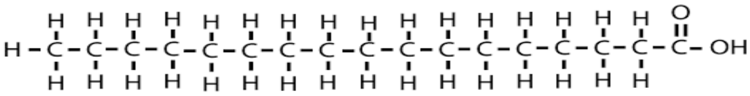
- **Structure**: Two or more double bonds.
- **Examples**:

- **Linoleic Acid** (Omega-6) found in Vegetable oils, nuts, seeds.
- **Alpha-Linolenic Acid (ALA)** (Omega-3) found in Flaxseeds, walnuts, chia seeds.

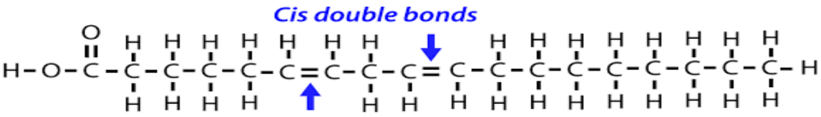
Health Impact

- **Heart-Healthy**: Unsaturated fats are generally considered healthier for the heart. They can help reduce LDL (bad) cholesterol levels .
- **Dietary Benefits**: Consumption of unsaturated fats, especially omega-3 and omega-6 fatty acids, is associated with many health benefits, including reduced inflammation, improved heart health, and better brain function.
- **Essential Fatty Acids**: Some polyunsaturated fatty acids, like omega-3 and omega-6, are essential and must be obtained from the diet because the body cannot synthesize them.

SATURATED FAT (Stearic Acid)



UNSATURATED FAT (Linoleic Acid)



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7. **Write Notes on Triglycerides. Essay – 8 marks**

Definition: Triglycerides, also known as triacylglycerols, are the most common type of fat found in the body and in foods. They are esters derived from glycerol and three fatty acids.

Structure of Triglycerides

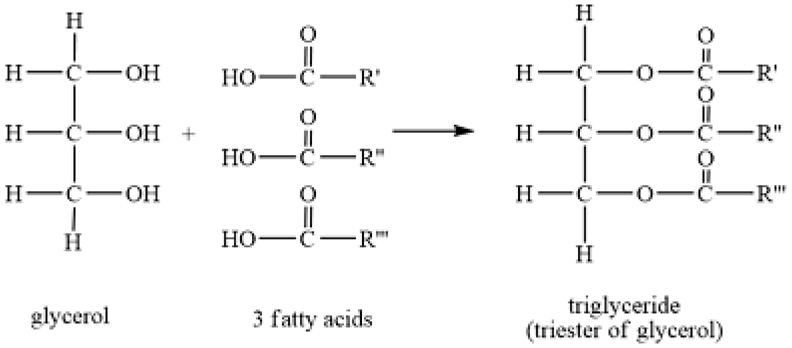
- **Basic Structure**: Triglycerides are composed of one glycerol molecule and three fatty acid chains.
- **Glycerol**: Glycerol is a small, three-carbon molecule that serves as the backbone.
- **Fatty Acids**: The three fatty acids attached to the glycerol can vary in length and saturation (whether they have double bonds or not), affecting the properties of the triglyceride.

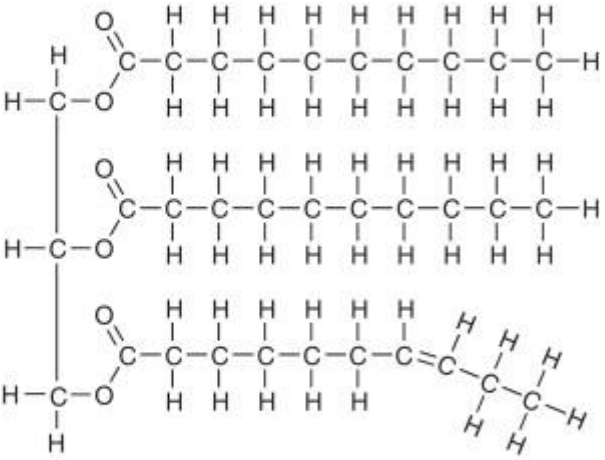
Functions of Triglycerides

- **Energy Storage**: Triglycerides are the main form of energy storage in the body. They are stored in fat cells (adipocytes) and can be broken down to provide energy when needed.
- **Insulation and Protection**: Triglycerides help insulate the body against temperature changes and protect vital organs by cushioning them.
- **Source of Fatty Acids**: Provide essential fatty acids that are necessary for various bodily functions, including cell membrane structure and hormone production.
-

Metabolism of Triglycerides

1. **Digestion**: Triglycerides are broken down in the digestive system by enzymes called lipases into glycerol and free fatty acids.
2. **Absorption**: These components are absorbed in the small intestine and then reassembled into triglycerides within the cells of the intestinal lining.
3. **Transport**: Reformed triglycerides are transported through the bloodstream in particles called lipoproteins (e.g., chylomicrons).
    - **Chylomicrons**: Transport dietary triglycerides from the intestines to other tissues.
    - **VLDL (Very Low-Density Lipoproteins)**: Transport endogenous triglycerides synthesized in the liver to peripheral tissues.
4. **Energy Release**: When the body needs energy, triglycerides stored in fat cells are broken down again into glycerol and fatty acids, which are then used by cells to produce ATP (the energy currency of the cell).
5. **Storage :Adipose Tissue**: Excess triglycerides are stored in adipose cells (adipocytes).





Triglycerol

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8. **Write Notes on Phospholipids**

Phospholipids are a major class of lipids that form the structural basis of cell membranes. They consist of two fatty acids, a glycerol backbone, a phosphate group, and an additional polar group.

Structure of Phospholipids

- **Basic Structure**: Phospholipids consist of two main parts: a hydrophilic (water-loving) "head" and two hydrophobic (water-fearing) "tails."
- **Head**: The head is made of a phosphate group and glycerol, making it polar and soluble in water.
- **Tails**: The tails are made of fatty acids, which are non-polar and insoluble in water.

General Structure

1. **Glycerol Backbone**:
    a. It is a three-carbon alcohol that serves as the central molecule to which other groups are attached.
2. **Fatty Acid Chains**:
    a. Two fatty acids are esterified to the first two hydroxyl groups of the glycerol backbone.
    b. The fatty acids can be saturated or unsaturated.
3. **Phosphate Group**:
    a. It is attached to the third hydroxyl group of glycerol.
    b. The phosphate group is negatively charged and hydrophilic.
4. **Polar Head Group**:
    - It is attached to the phosphate group. This can be a simple molecule like choline, ethanolamine, or serine, or a more complex group like inositol.

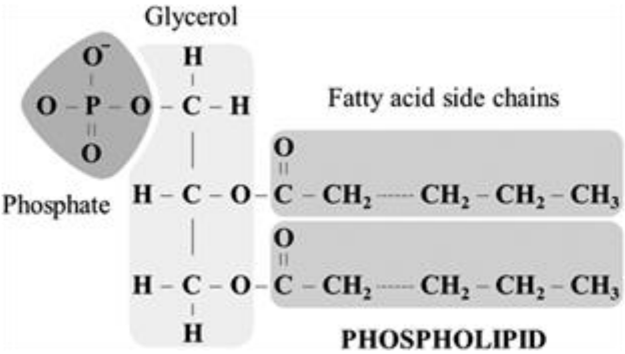
  - The polar head group is hydrophilic (water-attracting).

Functions of Phospholipids

- **Cell Membrane Formation**: Phospholipids are essential for forming cell membranes. They create a bilayer that acts as a barrier, protecting the cell's interior from the external environment.
- **Signal Transmission**: Some phospholipids are involved in cell signaling, helping cells communicate and respond to external signals.
- **Energy Storage**: Although not the primary function, phospholipids can also serve as a source of energy when needed.
- **Emulsification**:**Lipid Digestion**: Phospholipids in bile help emulsify dietary fats, increasing their surface area for digestion by lipases.

Role in Cell Membranes

1. **Bilayer Formation**: Phospholipids arrange themselves into a double layer (bilayer) in water, with the hydrophobic tails facing inward and the hydrophilic heads facing outward. This arrangement forms the basic structure of cell membranes.
2. **Selective Permeability**: The phospholipid bilayer is selectively permeable, allowing certain molecules to pass through while keeping others out, thus regulating what enters and exits the cell.
3. **Membrane Fluidity**: Phospholipids contribute to the fluid nature of the membrane, allowing it to change shape, move, and adapt to different conditions while maintaining its integrity.
4. Membrane Dynamics:Endocytosis and Exocytosis: Phospholipids are involved in the processes of endocytosis (cell membrane engulfs external substances) and exocytosis (vesicles fuse with the membrane to release contents).



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9. Write Notes on Steroids   Split Essay – 4 Mark

Steroids are organic compounds made up of four connected rings of carbon atoms. These rings are arranged in a "steroid nucleus" or "steroid backbone."Examples of steroid include-

- Cholesterol
- Testosterone
- Estrogen
- Cortisol

1. Cholesterol:
Cholesterol is a type of steroid .It is an important component of cell membranes. Cholesterol is the starting material for the synthesis of other important steroids, including hormones like testosterone, as well as bile acids and vitamin D.

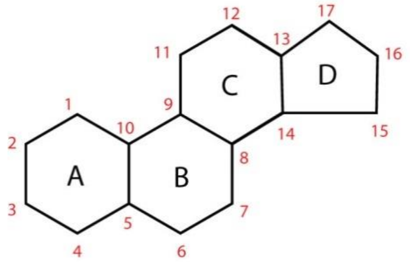
2. Testosterone:
Testosterone is a steroid hormone primarily produced in the testes in males. It is responsible for the development of male secondary sexual characteristics. It plays a role in bone density, muscle strength.

3. Estrogen:
Estrogen is a group of steroid hormones. It is produced in the ovaries
It regulates the menstrual cycle, supports pregnancy, and promotes the development of female secondary sexual characteristics.
It helps maintain bone density

4. Cortisol:

- Cortisol is a steroid hormone produced by the adrenal glands.
- It is known as the "stress hormone,”. It helps the body respond to stressful situations.
- It regulates metabolism&It has anti-inflammatory effects.

5. Steroids help in Vitamin D Synthesis.



(a) Steroid skeleton

10. **Write Notes on Waxes** **Split Essay – 4 Marks**

Waxes are a group of simple or neutral lipids. These are formed by the combination of a long chain fatty acid with a long alcohol.

Function of Waxes

1. **Waterproofing**: Waxes provide a waterproof coating for plants and animals.
    - **Examples**: Wax coatings on leaves and fruits, earwax in humans (cerumen).
2. **Structural Function**:
    - **Beeswax**: Used by bees to build honeycombs.
3. **Lubrication**:
    - **Cosmetic Applications**: Waxes are used in cosmetics and personal care products such as lipsticks, body creams and body lotions.
4. **Coating**:
    - **Food Packaging**: Waxes are used in coatings for food products to improve shelf life and maintain freshness.
    - **Pharmaceuticals**: Used as coatings and fillers in tablets and capsules.
5. **Industrial Applications**:
    - **Candles**
    - **Polishes**
6. **Art and Craft**:
    - **Wax Seals**: used for sealing letters and documents .
    - **Sculpture**: Waxes are used in art for casting and mold-making.

Some examples of waxes

Animal waxes

- Beeswax – produced by honey bees

Vegetable waxes

- Rice bran wax – obtained from rice bran (*Oryza sativa*)
- Soy wax – from soybean oil

Mineral waxes

- Montan wax – extracted from lignite and brown coal
- Peat waxes

Petroleum waxes

- Paraffin wax – made of long-chain alkane hydrocarbons
- Microcrystalline wax – with very fine crystalline structure

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SHORT QUESTIONS

Multiple Choice Questions

1. **Which type of lipid is the main component of cell membranes?**
   - a) Triglycerides
   - b) Phospholipids
   - c) Steroids
   - d) Waxes
   - **Answer**: b) Phospholipids
2. **What is the main function of triglycerides in the body?**
   - a) To form cell membranes
   - b) To store energy
   - c) To act as hormones
   - d) To waterproof surfaces
   - **Answer**: b) To store energy
3. **Which component is found in a phospholipid molecule?**
   - a) Three fatty acids
   - b) A phosphate group
   - c) Cholesterol
   - d) A steroid ring structure
   - **Answer**: b) A phosphate group
4. **Which of the following is a type of steroid?**
   - a) Glycogen
   - b) Cholesterol
   - c) Triglyceride
   - d) Waxy cuticle
   - **Answer**: b) Cholesterol
5. **What is the primary role of waxes in nature?**
   - a) To provide energy
   - b) To serve as a hormone precursor
   - c) To waterproof surfaces
   - d) To store genetic information
   - **Answer**: c) To waterproof surfaces

Fill in the Blanks

- Saturated fatty acids have _______ double bonds between the carbon atoms in their hydrocarbon chains. (Answer**: no)**
- _______ fatty acids have one or more double bonds, making them less tightly packed and typically liquid at room temperature. (Answer**: Unsaturated)**

6. Triglycerides are composed of three fatty acids esterified to a _______ molecule.

(Answer**: glycerol)**

True or False

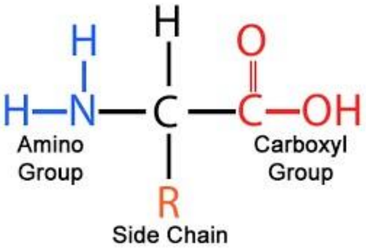
7. Unsaturated fatty acids are typically found in animal fats and are solid at room temperature.
   - Answer**: False (This describes saturated fatty acids)**
8. Phospholipids contain both hydrophobic and hydrophilic regions, making them essential for forming cell membranes.
   - Answer**: True**

UNIT-III: AMINO ACIDS AND PROTEINS

Q.AMINO ACIDS SPLIT ESSAY – 4 MARKS

Amino acids are the building blocks of proteins. They contain both amino (-NH_2) and carboxyl groups (-COOH) .Each amino acid has a central carbon atom (called the alpha carbon) attached to four groups:

1. **Amino Group (-NH_2)**: Contains nitrogen.
2. **Carboxyl Group (-COOH)**: Makes the molecule acidic.
3. **Hydrogen Atom (H)**.
4. **R Group (Side Chain)**: This is what makes each amino acid unique.



Function of Amino Acids

- **Protein Building**: Amino acids link together to form proteins, which are crucial for most functions in the body.
- **Energy Source**: Some amino acids can be used for energy when carbohydrates and fats are low.
- **Signal Molecules**: Certain amino acids are involved in cell signaling and regulation.

Classification of Amino Acids

1. **Based on R Group (Side Chain)**:
    - **Nonpolar (Hydrophobic)**: Example: Leucine, Valine.
    - **Polar (Hydrophilic)**: Example: Serine, Threonine.
    - **Acidic**: Example: Aspartic acid, Glutamic acid.
    - **Basic**: Example: Lysine, Arginine.
2. **Based on Nutritional Requirement**:
    - **Essential Amino Acids**: Must be obtained from food because the body cannot produce them. Example: Lysine, Methionine.
    - **Non-Essential Amino Acids**: Can be synthesized by the body. Example: Alanine, Glutamine.
3. **Based on Metabolism**:
    - **Glucogenic Amino Acids**: Can be converted into glucose. Example: Alanine.
    - **Ketogenic Amino Acids**: Can be converted into ketone bodies. Example: Leucine.
    - **Both Glucogenic and Ketogenic**: Example: Isoleucine.

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Q.**PROTEINS** ESSAY QUESTION – 8 MARKS

Proteins are made of amino acids . Proteins are important part of organisms and participate in every process within cells.

1. **Structure Levels**: Proteins have four levels of structure:
    - **Primary**: The sequence of amino acids.
    - **Secondary**: Local folding into structures like alpha-helices and beta-sheets.
    - **Tertiary**: The overall 3D shape of a single protein molecule.
    - **Quaternary**: The structure formed when multiple protein molecules (subunits) come together.

Proteins can be divided into three main classes,:

1. **Globular Proteins**: Almost all globular proteins are soluble and many are enzymes.Example of globular proteins are :

- **Antibodies,**
- **Serum Albumin**

    - **Haemoglobin**.

2. **Fibrous Proteins**: Fibrous proteins are physically tough and insoluble in water and in dilute salt solutions.they are the basic structural elements in the connective tissues is higher animal. Examples are:
    - **Collagen** -found in tendons and bone matrix
    - **Keratin** -the protein component of hair, nails, feathers, hooves.

3. **Membrane Proteins :** Membrane proteins serve as receptors or provide channels for polar or charged molecules to pass through the cell membrane.

Functions of proteins:

1.) Proteins as Enzymes. : catalyze all the reactions in the body. Ex hexokinase.

2.) Storage Proteins: help in storage of energy and food material .
    - **Ovalbumin-**Egg Protein
    - **Casein**—Milk Protein

3.) Protective proteins: protects body against infections and injury.
    - **Antibodies** ,**Fibrinogen** and **Thrombin** .

4.) Transport proteins: helps in transport.
    - **Haemoglobin** – transports oxygen
    - **Myoglobin** – transports oxygen in muscles
    - **Serum albumin** - transports fatty acids in blood.

5.) **Contractile proteins** : helps in movement. Example is **Actin** and **Myosin**

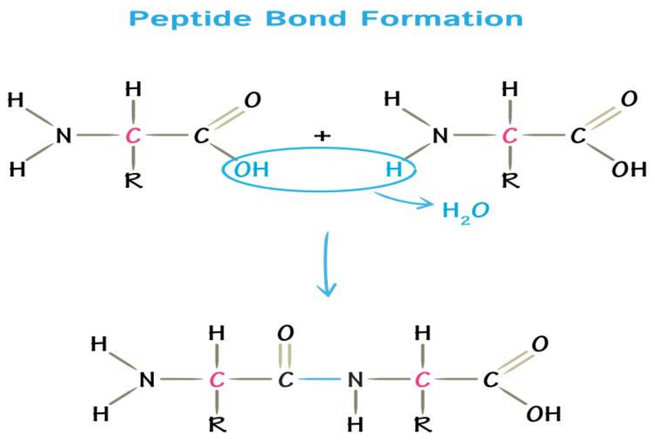
6.) **Proteins as Harmones**: example is **Insulin** – glucose metabolism

7.) Structural proteins – they make stiff and rigidity biological components. Most structural proteins are fibrous proteins . example are Actin and Tubulin .

Collagen and **Elastin.** Keratin is found hair, nails, feathers, hooves.

8.) Some Proteins are Toxins : Snake venom ,Diphtheria toxin

9.) Many Proteins function in Cell signaling and ligand binding:



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Q.Primary secondary tertiary and quaternary strucuture of proetins- ESSAY QUESTION 8 MARKS

Proteins are biomolecules and made of amino acids . Proteins are important part of organisms and participate in every process within cells.A peptide bond is formed between two amino acids.

1. PRIMARY STRUCTURE

Primary structure is made up of amino acid linked by peptide bonds in a linear sequence. **Peptide Bonds**: Amino acids are linked by peptide bonds, forming a polypeptide chain.The sequence of amino acids in the primary structure determines the protein's structures and its function.

2. SECONDARY STRUCTURE

The secondary structure refers to local folded structures that form within a polypeptide due to interactions between atoms in the backbone (not the side chains). **Types**:

Alpha-Helix (α-helix):

- It is a right-handed coil where each amino acid forms a hydrogen bond with the fourth amino acid ahead of it in the sequence.
- This creates a spiral structure.

Beta-Pleated Sheet (β-sheet):

- It consists of strands that lie adjacent to each other, forming a sheet-like structure.
- The strands are connected by hydrogen bonds between the carbonyl oxygen of one amino acid and the amide hydrogen of another.
- **Example**: Keratin (α-helix), silk (β-sheets).

3. TERTIARY STRUCTURE

The tertiary structure is the overall 3D shape of a single protein molecule.This shape allows the protein to carry out its specific function, like binding to other molecules.

Types of Interactions:

- **Hydrophobic Interactions**: Nonpolar side chains tend to cluster together in the interior of the protein, away from water.
- **Hydrogen Bonds**: Form between polar side chains.
- **Ionic Bonds (Salt Bridges)**: Form between oppositely charged side chains.
- **Disulfide Bonds**: Covalent bonds between the sulfur atoms of cysteine.
- **Van der Waals Forces**: Weak interactions between nonpolar side chains.

The tertiary structure determines the protein's function because it creates specific active sites, binding sites, or other functional regions.

Example: Myoglobin, collagen.

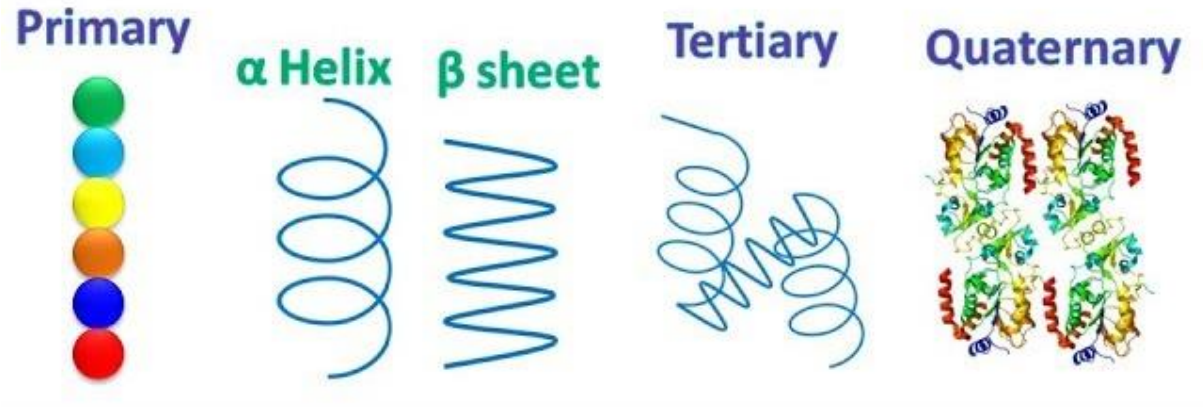
4. QUATERNARY STRUCTURE

The quaternary structure occurs when multiple protein chains (subunits) come together to form a larger complex.

These complexes allow proteins to perform more complex functions.

These subunits can be identical (homomeric) or different (heteromeric).

Example: Hemoglobin is made up of four subunits (two alpha and two beta chains).



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Non-Protein Amino Acids

Non-protein amino acids are amino acids that are not directly incorporated into proteins. Instead, they serve various other roles in biological systems, such as intermediates in metabolic pathways, building blocks of non-protein molecules, or as antibiotics.

1. Gramicidin SPLIT ESSAY -4 MARKS

- Gramicidin is produced by *Bacillus brevis*. The common forms are Gramicidin A, B, and C, which are linear peptides made of alternating D- and L-amino acids.
- **Function**:
  - Gramicidin acts as an antibiotic by forming ion channels in bacterial cell membranes, leading to the disruption of the bacterila cell membrane leading to bacterial cell death.
  - It primarily targets Gram-positive bacteria.
- **Use**:
  - Gramicidin is used as topical antibiotic to treat infections.

2. β-Alanine SPLIT ESSAY 4 MARKS

- **Structure**:
  - β-Alanine is a non-essential amino acid with the chemical formula NH_2-CH_2-CH_2-COOH.
  - It differs from the α-alanine by having the amino group attached to the β-carbon (the carbon next to the carboxyl group), rather than the α-carbon.

- **Function**:
  - **Carnosine Synthesis**: β-Alanine is a precursor to carnosine which is particularly important in skeletal muscles.
  - **Pantothenic Acid Synthesis**: It is also a component of pantothenic acid (vitamin B5), which is vital for the synthesis of coenzyme A, a important cofactor in metabolism.
- **Use**:
  - **Dietary Supplements**: β-Alanine is popular in sports supplements for its ability to increase muscle carnosine levels. It enhancing athletic performance by delaying muscle fatigue.

****

3. D-Alanine

- **Structure**:
  - D-Alanine is the D-enantiomer (mirror image) of the common amino acid L-alanine.
  - Unlike L-alanine, which is used in protein synthesis, D-alanine is not incorporated into proteins.
- **Function**:
  - **Peptidoglycan Synthesis**: D-Alanine is crucial in the synthesis of peptidoglycan, a major component of bacterial cell walls. It is involved in the cross-linking of peptidoglycan chains, which provides structural strength to the bacterial cell wall.
  - **Bacterial Resistance**: Some bacteria modify their peptidoglycan precursors with D-alanine to resist antibiotics like vancomycin.
- **Use**:
  - **Antibiotic Targeting**: The presence of D-alanine in peptidoglycan makes it a target for antibiotics and enzymes that disrupt cell wall synthesis in bacteria.

****

4. D-Glutamic Acid

- **Structure**:
  - D-Glutamic acid is the D-enantiomer of the common amino acid L-glutamic acid.
  - It has a similar structure to L-glutamic acid but with the opposite configuration at the chiral center.

- **Function**:
  - **Peptidoglycan Synthesis**: D-glutamic acid is found in the peptidoglycan layer of bacterial cell walls, particularly in Gram-positive bacteria.
  - It provides rigidity and protection to bacteria .
- **Special Properties**:
  - D-Glutamic acid is not commonly found in proteins but plays important role in bacterial physiology.
  - It helps bacteria resist degradation by host immune systems and other environmental factors.

Multiple Choice Questions

1. **Which of the following is a non-essential amino acid?**
   - a) Lysine
   - b) Valine
   - c) Glycine
   - d) Tryptophan
   - **Answer**: c) Glycine
2. **Which amino acid contains a sulfur atom?**
   - a) Alanine
   - b) Cysteine
   - c) Phenylalanine
   - d) Glutamine
   - **Answer**: b) Cysteine
3. **Which of the following is the main structural protein found in hair and nails?**
   - a) Hemoglobin
   - b) Keratin
   - c) Myosin
   - d) Albumin
   - **Answer**: b) Keratin

4. **Which type of protein acts as a biological catalyst to speed up chemical reactions?**
   - a) Hormones
   - b) Enzymes
   - c) Structural proteins
   - d) Antibodies
5. **Which of the following is a component of the antibiotic mixture known as gramicidin?**
   - a) D-Alanine
   - b) L-Glutamic acid
   - c) Gramicidin A

    - d) β-Alanine
  - **Answer**: c) Gramicidin A

6. **Which non-protein amino acid is a precursor to carnosine, a molecule important for buffering acid in muscles?**
    - a) D-Alanine
    - b) β-Alanine
    - c) Gramicidin
    - d) D-Glutamic acid
    - **Answer**: b) β-Alanine

Fill in the Blanks

7. **The protein _______ is responsible for oxygen transport in the blood.**
  - **Answer**: Hemoglobin
8. **The _______ structure of a protein refers to the overall 3D shape formed by folding the polypeptide chain.**
  - **Answer**: Tertiary

True or False

9. **All amino acids found in proteins are in the L-form.**
   TRUE
10. **Phenylalanine is a polar amino acid.**
    FALSE

****

UNIT-IV: NUCLEIC ACIDS AND VITAMINS

Q. Explain the structure and functions of DNA & RNA - ESSAY QUESTION 8 MARKS

DNA

Structure:

- DNA has a double-helix structure, which looks like a twisted ladder.

- The "sides" of the ladder are made of sugar (deoxyribose) and phosphate molecules. The "rungs" are pairs of nitrogen bases.
- **Nitrogen Bases:** There are four types of bases in DNA: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G).

Function:

- **Genetic Blueprint:** DNA contains the instructions needed for an organism's development, function, growth, and reproduction.

- **Replication:** Before a cell divides, it copies its DNA so that each new cell gets an exact copy.
- **Gene Expression:** Specific segments of DNA (genes) are used to make proteins, which do most of the work in cells.

RNA (Ribonucleic Acid)

Structure:

- RNA is usually single-stranded, unlike the double-helix structure of DNA.
- RNA also has a sugar-phosphate backbone, but the sugar is ribose instead of deoxyribose.
- **Nitrogen Bases:** RNA has Adenine (A), Cytosine (C), Guanine (G), and Uracil (U). Uracil replaces Thymine (T).

Function:

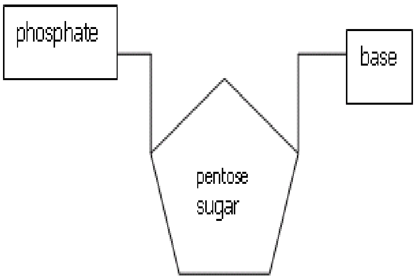
- **Messenger RNA (mRNA):** Carries the instructions from DNA to the ribosomes, where proteins are made.
- **Transfer RNA (tRNA):** Helps in proteins synthesis by bringing the correct amino acids to the ribosome according to the mRNA instructions.
- **Ribosomal RNA (rRNA):** it is a part of the ribosome, which makes protein..
- **Gene Regulation:** RNA can also help regulate which genes are turned on or off in a cell.

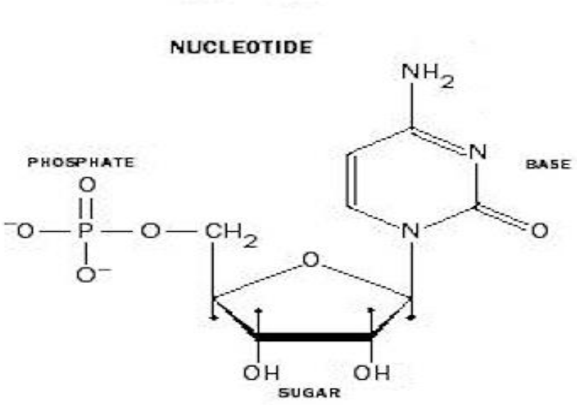
NUCLEOTIDES

Nucleotides are the building blocks of Nucleic acids. Nucleotides contain three parts:

- **A Five-Carbon Sugar**
- **A Nitrogenous Base**
- **A Phosphate Group**

The sugar is joined to the nitrogenous base by Glycosidic bond . The sugar is joined to the phosphate by ester bond.





Nucleotides are linked together to form polynucleotide chains.
Nucleotides are joined to one another by Phosphodiester bonds.
Phosphodiester bonds form the sugar-phosphate backbone of both DNA and RNA.

SUGAR -

The **sugar** in a nucleotide is a 5-carbon atom sugar in its ring form.
It will either be **ribose in RNA** or **deoxyribose in DNA**.
The "deoxy" means that the ribose molecule has lost an oxygen.

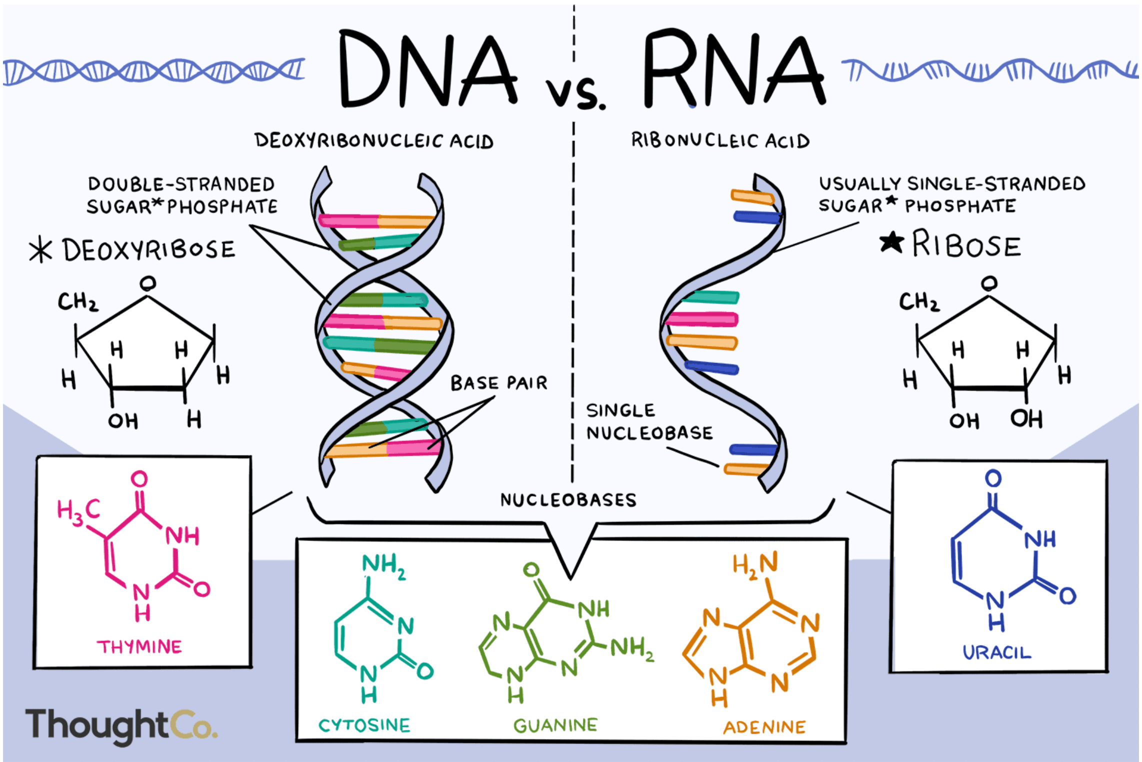
NITROGENOUS BASE -

The nitrogenous base is the central part of the nucleotide. There are two types of Nitrogenous Bases Purines and Pyrimidines.

Purines	Cytosine
Adenine	Thymine
Guanine	Uracil
Pyrimidines	

PHOSPHATE GROUP -

A phosphate group is formed by a phosphorus atom with four oxygen atoms around it.


DNA vs. RNA
DEOXYRIBONUCLEIC ACID
RIBONUCLEIC ACID
DOUBLE-STRANDED SUGAR* PHOSPHATE
* DEOXYRIBOSE
CH2
O
H
H
H
H
OH
H
BASE PAIR
USUALLY SINGLE-STRANDED SUGAR* PHOSPHATE
★ RIBOSE
CH2
O
H
H
H
H
OH
OH
SINGLE NUCLEOBASE
NUCLEOBASES
H3C
O
NH
N
H
O
THYMINE
NH2
N
N
H
O
CYTOSINE
O
N
NH
NH2
N
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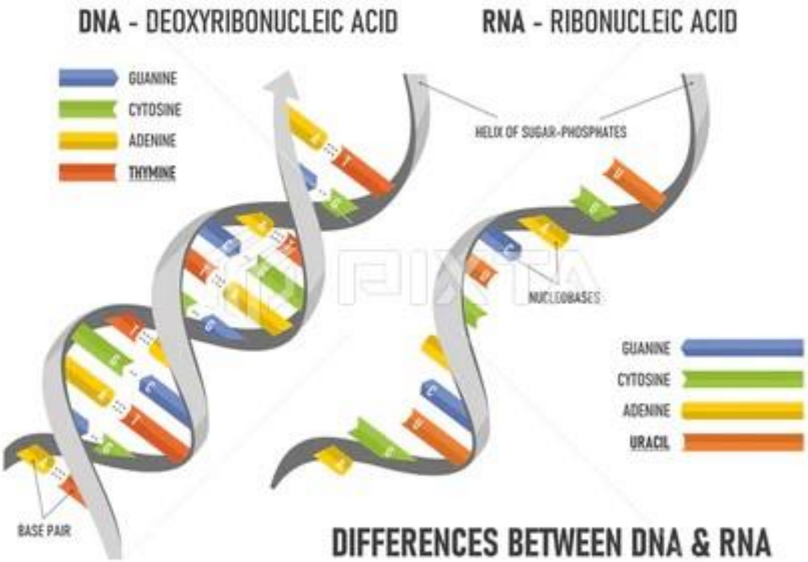

DNA - DEOXYRIBONUCLEIC ACID
RNA - RIBONUCLEIC ACID
GUANINE
CYTOSINE
ADENINE
THYMINE
HELIX OF SUGAR-PHOSPHATES
NUCLEOBASES
GUANINE
CYTOSINE
ADENINE
URACIL
BASE PAIR
DIFFERENCES BETWEEN DNA & RNA

****

Q.Discuss about base composition in DNA - **SPLIT ESSAY 4 MARKS**

Base Composition in DNA

The Four Nitrogenous Bases:

1. **Adenine (A)**
2. **Thymine (T)**
3. **Cytosine (C)**
4. **Guanine (G)**

Base Pairing Rules:

- **Complementary Pairing:**
  - **Adenine (A)** always pairs with **Thymine (T)**.
  - **Guanine (G)** always pairs with **Cytosine (C)**.
- **Hydrogen Bonds:**
  - **A-T Pair:** Adenine and Thymine are connected by **two** hydrogen bonds.
  - **G-C Pair:** Guanine and Cytosine are connected by **three** hydrogen bonds.

Chargaff's Rule:

- **Equal Proportions:**
  - The amount of Adenine (A) is always equal to the amount of Thymine (T).
  - The amount of Guanine (G) is always equal to the amount of Cytosine (C).
- **Formula:**
  - **%A = %T**
  - **%G = %C**
  - This means that in a DNA molecule, the total percentage of A + T is equal to the total percentage of G + C.

GC Content:

- **GC Content:** it is the proportion of Guanine (G) and Cytosine (C) in a DNA molecule. High GC content can make the DNA more stable because of the stronger bond (three hydrogen bonds) between G and C.

Importance of Base Composition:

- **Stability:** the GC content, affects the stability of the DNA molecule.
- **Genetic Information:** The specific sequence of these bases (A, T, C, G) encodes the genetic information needed to build and operate an organism.
- **DNA Analysis:** the base composition is useful to study genetic relationships, identify organisms, and volutionary patterns.

****

Q .Discuss about A+T Rich Genomes and G+C Rich Genomes **- SPLIT ESSAY 4 MARKS**

A+T Rich Genomes

A+T Rich: A genome is considered A+T rich when the proportion of Adenine (A) and Thymine (T) bases is higher than that of Guanine (G) and Cytosine (C).

Characteristics:

- **Lower Stability:** A+T rich regions have lower stability because A-T pairs are held together by only two hydrogen bonds .
- **Easier to Separate:** A+T rich regions are easier to separate because of the lower bond strength.
- **Non-Coding Regions:** A+T rich regions are often found in non-coding regions of DNA, such as regulatory elements or introns.

Examples:

- **Promoters (TATA Box**).

G+C Rich Genomes

G+C Rich : A genome is considered G+C rich when the proportion of Guanine (G) and Cytosine (C) bases is higher than that of Adenine (A) and Thymine (T).

Characteristics:

- **Higher Stability:** G+C rich regions are more stable because G-C pairs are held together by three hydrogen bonds, making them harder to denature.

- **Higher Melting Point:** G+C rich DNA regions have a higher melting temperature due to the stronger bonding between G and C.
- **Gene Density:** G+C rich regions have high gene density. More genes are packed into these areas of the genome.

Examples:

- **Coding Regions:** G+C rich regions are found in the coding regions of DNA, where proteins are encoded.

****

Q. Describe about Nucleic Acids-Protein Interactions

The interactons between biomolecules like DNA and RNA and **Proteins are called Nucleic Acids-Protein Interactions**.

Types of Interactions:

- **Specific Interactions:** Proteins recognize and bind to specific sequences or structures in nucleic acids. These interactions are highly selective and often involve hydrogen bonds, ionic interactions, and van der Waals forces.
- **Non-Specific Interactions:** Some proteins bind to nucleic acids without sequence specificity, usually based on the general shape or charge of the DNA or RNA.

Examples of Protein-Nucleic Acid Interactions:

1. **DNA-Protein Interactions:**
   - **Transcription Factors:** Proteins that bind to specific DNA sequences to regulate gene expression by promoting or inhibiting the transcription of genes.
   - **Histones:** these Proteins that DNA wraps around to form nucleosomes, helping to package and organize DNA in the cell nucleus.
   - **DNA Polymerase:** it is an enzyme that binds to DNA and synthesizes a new DNA strand.
2. **RNA-Protein Interactions:**
   - **Ribosomes:** Complexes made of RNA and protein that facilitate the translation of mRNA into proteins.
   - **RNA Polymerase:** An enzyme that binds to DNA and synthesizes RNA during transcription.

    - **RNA-Binding Proteins (RBPs):** Proteins that bind to RNA molecules and are involved in various processes like splicing, transport, and stability of RNA.

Importance of Nucleic Acids-Protein Interactions:

- **Gene Regulation:** Proteins that interact with DNA and RNA are essential for turning genes on or off, controlling when and where proteins are made in the cell.
- **DNA Repair:** Proteins involved in DNA repair recognize damaged DNA and initiate processes to fix it, maintaining genome integrity.
- **RNA Processing:** RNA-binding proteins help process and modify RNA after it's made, ensuring that the correct information is used to make proteins.

Applications:

- **Drug Design:** these interactions helps in designing drugs that can target specific proteins or nucleic acids. They are useful in treating diseases like cancer and viral infections.
- **Biotechnology:** These interactions are used in techniques like CRISPR-Cas9 for gene editing.

****

Q. Discuss the Concept and Types of Vitamins

Vitamins are essential nutrients that our body needs in small amounts to function properly. They play an important role in health, growth, and preventing diseases. Vitamins are not produced by the body in sufficient quantities, so they must be obtained from the diet or supplements.

Vitamins are classified into two main types based on their solubility:

1. **Fat-Soluble Vitamins**
    - **Vitamins A, D, E, and K** are fat soluble.
    - These vitamins dissolve in fats and are stored in the body's fatty tissues and liver.
    - Because they are stored, they don't need to be consumed every day, but taking too much of them can lead to toxicity.
2. **Water-Soluble Vitamins**
    - **Vitamins B and C** are water-soluble.

    - These vitamins dissolve in water and are not stored in the body.
    - They need to be consumed regularly because any excess is excreted in the urine, making toxicity rare.

Role of Vitamins in Metabolism

Vitamins are crucial for various metabolic processes in the body. They act as **coenzyme, which means** they help enzymes perform their functions more effectively.

1. **Vitamin A**
    - It is important for vision, immune function, and skin health.
    - It plays a role in cell growth and differentiation.
2. **Vitamin B Complex**
    - This group includes vitamins like

        - B1 (Thiamine)
        - B2 (Riboflavin),
        - B3 (Niacin),
        - B6 (Pyridoxine),
        - B9 (Folic Acid)
        - B12 (Cobalamin).

    - Vitamin B complex are important for -

        - Energy metabolism - they help convert carbohydrates, fats, and proteins into energy.
        - support nerve function
        - red blood cell production
        - DNA synthesis.

3. **Vitamin C**
    - It is important for the synthesis of collagen, a protein that helps in wound healing
    - It helps in maintaining healthy skin, cartilage, and bones.
    - It also helps in the absorption of iron and acts as an antioxidant.
4. **Vitamin D**
    - It is important for calcium and phosphorus absorption, which are important for bone health.
    - It supports immune function and has a role in cell growth.
5. **Vitamin E**
    - It is an antioxidant, protecting cells from damage caused by free radicals.
    - It also helps in immune function and skin health.

6. **Vitamin K**
    - It is important for blood clotting and bone health.
    - It helps activate proteins that play a role in these processes.

****

Multiple Choice Questions (MCQs)

1. **Which of the following is NOT a difference between DNA and RNA?**

   a) DNA is double-stranded, while RNA is single-stranded
   b) DNA contains thymine, while RNA contains uracil
   c) DNA has a ribose sugar, while RNA has a deoxyribose sugar
   d) DNA is more stable than RNA

2. **In a DNA molecule, the percentage of adenine (A) is always equal to the percentage of:**

   a) Cytosine (C)
   b) Thymine (T)
   c) Guanine (G)
   d) Uracil (U)

3. **In a G+C rich genome, which of the following statements is true?**

   a) The DNA is more stable
   b) The DNA is less stable
   c) The DNA has more A-T pairs
   d) The genome is more prone to mutations

4. **Which of the following best describes a nucleosome?**
    a) A segment of DNA wrapped around histone proteins
    b) A unit of RNA polymerase on DNA
    c) A protein complex that unwinds DNA
    d) A region of DNA that is highly transcribed
5. Vitamins are classified into two main types based on their solubility. Which of the following is a fat-soluble vitamin?
    a) a) Vitamin B6
    b) b) Vitamin C
    c) c) Vitamin K
    d) d) Vitamin B12

Answer: c) Vitamin K

6. Which vitamin can be synthesized by the body when exposed to sunlight?
   a) a) Vitamin A
   b) b) Vitamin C
   c) c) Vitamin D
   d) d) Vitamin B12
   e) Answer: c) Vitamin D

Fill in the Blanks

7. In DNA, guanine (G) pairs with ___________, and adenine (A) pairs with ___________.
8. In RNA, the base ___________ replaces thymine (T) found in DNA.
9. A segment of DNA rich in A+T pairs is likely to be ___________ (more/less) stable than one rich in G+C pairs.
10. Water-soluble vitamins, such as vitamin C and the B vitamins, must be consumed regularly because they are not _______ in the body.
    a) Answer: stored

True or False

11. In a double-stranded DNA molecule, the total number of purines is always equal to the total number of pyrimidines. (True/False)
    Answer: True
12. RNA is typically double-stranded like DNA. (True/False)
    Answer: False
13. Fat-soluble vitamins are stored in the body's fatty tissues and liver, and excess amounts can lead to toxicity. (True/False)
    Answer: True

****

UNIT-V: Enzymes

Describe the Structure of Enzymes along with apoenzyme and cofactors.

- **Enzymes** are proteins that act as catalysts, speeding up chemical reactions in the body.
- They have a specific three-dimensional shape, which includes an **active site** where the reaction occurs.
- The shape of the enzyme is crucial because it determines which substrates (reactants) can bind to it and how the reaction will proceed.

Apoenzyme

- The **apoenzyme** is the protein part of an enzyme.
- By itself, an apoenzyme is inactive. It requires a non-protein component, called a cofactor, to become active.
- When the apoenzyme binds to its cofactor, the enzyme becomes a **holoenzyme**, which is the fully active form.

Cofactors

- **Cofactors** are non-protein molecules or ions that help enzymes perform their catalytic activity.
- They can be organic molecules (coenzymes) or inorganic ions (metal cofactors).
- Cofactors are essential because they often assist in the enzyme's ability to bind to substrates or participate in the chemical reaction.

Prosthetic Group - TPP (Thiamine Pyrophosphate)

- A **prosthetic group** is a type of cofactor that is tightly bound to the enzyme and is essential for its activity.
- **Thiamine pyrophosphate (TPP)** is a prosthetic group derived from vitamin B1 (thiamine).
- TPP is crucial for enzymes involved in the metabolism of sugars and amino acids, helping in the transfer of certain chemical groups during reactions.

Coenzyme - NAD (Nicotinamide Adenine Dinucleotide)

- **Coenzymes** are organic cofactors that bind loosely to enzymes and are often involved in transferring chemical groups between different molecules.

- **NAD (Nicotinamide Adenine Dinucleotide)** is a coenzyme that plays a key role in oxidation-reduction (redox) reactions, where it helps transfer electrons.
- NAD can alternate between an oxidized form (NAD^+) and a reduced form (NADH), facilitating the production of energy in cells.

Metal Cofactors

- **Metal cofactors** are inorganic ions, such as zinc (Zn^{2+}), magnesium (Mg^{2+}), or iron (Fe^{2+}/Fe^{3+}), that assist enzymes.
- These metal ions can stabilize the enzyme structure, help in substrate binding, or participate directly in the catalytic process.
- For example, the enzyme **carbonic anhydrase** requires a zinc ion (Zn^{2+}) to help convert carbon dioxide and water into bicarbonate and protons.

These notes cover the basic concepts of enzyme structure and the role of apoenzymes, cofactors, prosthetic groups, coenzymes, and metal cofactors in enzyme function.

****

Enzyme Unit (U)

- An **enzyme unit (U)** is a measure of enzyme activity.
- It is defined as the amount of enzyme that catalyzes the conversion of one micromole (μmol) of substrate into product per minute under specific conditions (usually temperature, pH, and substrate concentration).
- This standardization allows for comparison of enzyme activities across different experiments and conditions.

Specific Activity

- **Specific activity** refers to the amount of enzyme activity (in units) per milligram of total protein in a sample.
- It is expressed as **units per milligram of protein (U/mg)**.
- Specific activity is used to measure the purity of an enzyme; as the enzyme is purified, the specific activity should increase, indicating that more of the sample is active enzyme.

Turnover Number (kcat)

- The **turnover number (kcat)** is a measure of the catalytic efficiency of an enzyme.
- It is defined as the number of substrate molecules that a single enzyme molecule can convert into product per unit of time when the enzyme is fully saturated with substrate.
- Turnover number is usually expressed in **per second (s^{-1})**, and it provides insight into how fast an enzyme can work under optimal conditions.
- For example, if an enzyme has a turnover number of 1000 s^{-1}, this means each enzyme molecule can catalyze 1000 reactions per second.

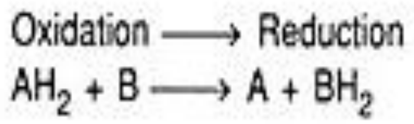
****

Q.EXPLAIN ENZYME CLASSIFICATION -
ESSAY QUESTION 8 MARKS

Enzymes are classified based on the reactions they catalyze into 6 groups: Oxidoreductases, Transferases, Hydrolases, Lyases, Isomearses, Ligases.

OXIDOREDUCTASES - Oxidoreductase are the enzymes that catalyze oxidation-reduction reactions. These emzymes are important as these reactions are responsible for the production of heat and energy. These enzymes carry out the specific energy-releasing reactions for the cell.

- Lactate Dehydrogenase (NAD+),
- Acyl Coa Dehydrogenase (FAD),
- Ketoacyl-ACP Reductase (NADPH/H+)



TRANSFERASES - Transferases are the enzymes that catalyze reactions where transfer of functional group between two substrates takes place.

- Kinases,
- Aminotransferases,
- Thiolases
- Glucokinase (ATP),
- Aspartate Aminotransferase

Group transfer

$$A-X+B \longrightarrow A+B-X$$

HYDROLASES - Hydrolases are also known as hydrolytic enzymes, they catalyze the hydrolysis reactions of carbohydrates, proteins and esters.

- Cellulases - hydrolyze cellulose to glucose
- Amylases - hydrolyze starch to maltose
- Proteases - hydrolyze proteins to amino acids
- Lipases - hydrolyze fats to glycerol and fatty acids
- Nucleases - hydrolyze RNA and acid DNA

Hydrolysis

$$A-B+H_2O \longrightarrow AH+BOH$$

LYASES - Lyases are enzymes that catlayze the reaction involving the removal of groups from substrates by processes other than hydrolysis by the formation of double bonds. · synthases, decarboxylases, dehydratases

- Citrate Synthase,
- Pyruvate Decarboxylase ,
- Fumarase

Addition ⟶ Elimination

$$A-B+X-Y \longrightarrow AX-BY$$

ISOMERASES - Isomerases are enzymes that catalyze the reactions where interconversion of cis-trans isomers is involved.

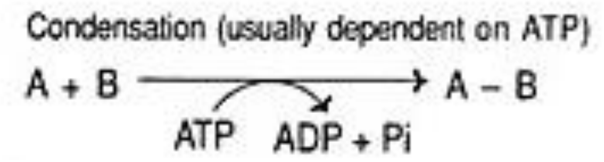
- Isomerases, Mutases
- Glucose-6-Phosphate Isomerase,
- Phosphoglycerate Mutase

Interconversion of isomers

$$A \longrightarrow A'$$

LIGASES - Ligases are also known as synthases, these are the enzymes that catalyze the Bond formation between two compounds . the bond formation reaction requires ATP.

  - Synthetases
  - Carboxylases,
  - Polymerases



Q.WRITE AN ESSAY ON MECHANISM OF ACTION OF ENZYMES

ESSAY QUESTION 8 MARKS

Enzymes are globular proteins that speed up chemical reactions in cells, and regulate biochemical processes. The mechanism of enzyme action involves:

1. Active Site

- The **active site** is a specific region on the enzyme where the substrate binds.
- Once the substrate binds to the active site, it forms an **enzyme-substrate complex**.

2. Transition State Complex

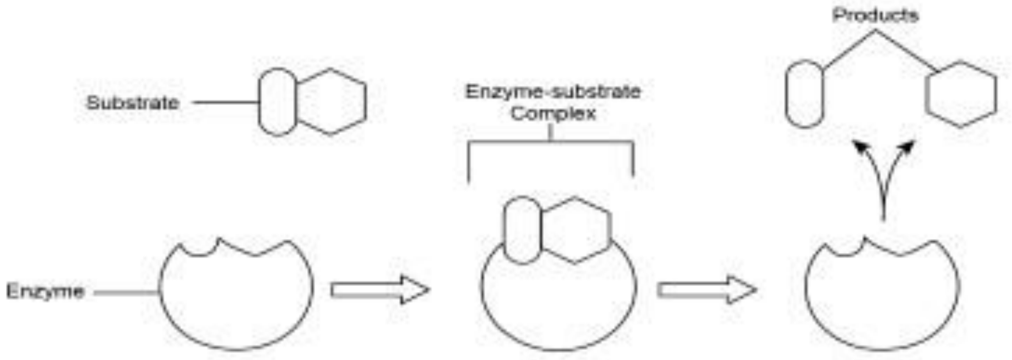
- When the substrate is bound in the active site, the enzyme helps convert it into a **transition state complex**.
- The **transition state** is a high-energy, unstable intermediate form between the substrate and the product.
- Enzymes stabilize this transition state, reducing the energy required for the reaction to proceed, which is critical for speeding up the reaction.
- The transition state is where old bonds are breaking, and new bonds are forming, leading to the final product.

3. Activation Energy

- **Activation energy** is the minimum amount of energy needed for a chemical reaction to occur.
- Enzymes lower the activation energy required for a reaction, making it easier for the reaction to happen.
- By lowering the activation energy, enzymes allow reactions that would normally be too slow to sustain life to occur rapidly enough to meet the needs of the cell.

Summary of the Mechanism:

1. **Substrate Binding**: The substrate binds to the enzyme’s active site, forming the enzyme-substrate complex.
2. **Formation of the Transition State**: The enzyme stabilizes the transition state, lowering the activation energy required for the reaction.
3. **Product Formation**: The transition state complex breaks down into the final product, which is released from the enzyme. The enzyme remains unchanged and can catalyze another reaction.



Basic Enzyme Reaction

[E] + [S] ---→ [ES] ---→ [EP] ---→ [E] + [P]

E= Enzyme
S= Substrate
ES = Enzyme Substrate Complex
EP = Enzyme Product Complex
P= Product

The Enzyme reacts with the Substrate to form Enzyme Substrate complex.
The Enzyme Substrate Complex forms an Enzyme Product Complex.
Finally the Enzyme and Product disassociate

****

Lock and Key Hypothesis **SPLIT ESSAY 4 MARKS**

- The **Lock and Key Hypothesis** is an early model used to explain how enzymes and substrates interact.
- According to this hypothesis, the **enzyme's active site** has a specific shape that perfectly matches the shape of its substrate, similar to how a key fits into a specific lock.
- When the substrate fits into the active site, it forms an **enzyme-substrate complex**, allowing the enzyme to catalyze the reaction.
- This model emphasizes the specificity of enzyme-substrate interactions: only the right substrate (the "key") can fit into the enzyme's active site (the "lock").
- **Limitation**: The Lock and Key Hypothesis doesn't account for the flexibility of enzymes, as it suggests the active site is rigid.

Basic Enzyme Reaction

[E] + [S] ---→ [ES] ---→ [EP] ---→ [E] + [P]

E= Enzyme

S= Substrate

ES = Enzyme Substrate Complex

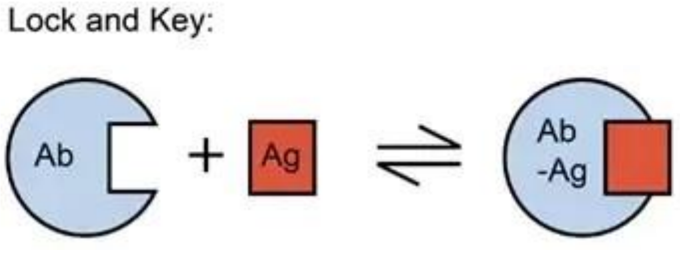
EP = Enzyme Product Complex

P= Product

The Enzyme reacts with the Substrate to form Enzyme Substrate complex.

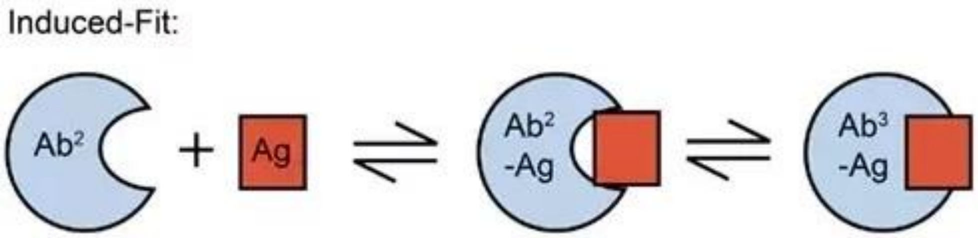
The Enzyme Substrate Complex forms an Enzyme Product Complex.

Finally the Enzyme and Product disassociate



Induced Fit Hypothesis

- The **Induced Fit Hypothesis** is a more refined model of enzyme action, proposed by Daniel Koshland in 1958.
- Unlike the Lock and Key model, the Induced Fit Hypothesis suggests that the enzyme's active site is **flexible**.
- When the substrate approaches the enzyme, the enzyme's active site undergoes a conformational change, molding itself around the substrate to fit it more snugly.
- This change forms the **enzyme-substrate complex** and stabilizes the transition state, enhancing the enzyme's catalytic ability.
- The Induced Fit model explains how enzymes can adapt to substrates with slightly different shapes and how this flexibility can contribute to the enzyme's catalytic efficiency.



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Q.Write about Effect of pH on Enzyme Activity

SPLIT ESSAY 4 MARKS

Optimal pH: Each enzyme has an optimal pH at which it functions most effectively. This is the pH at which the enzyme's active site is in the right shape to bind the substrate and catalyze the reaction.

Example:

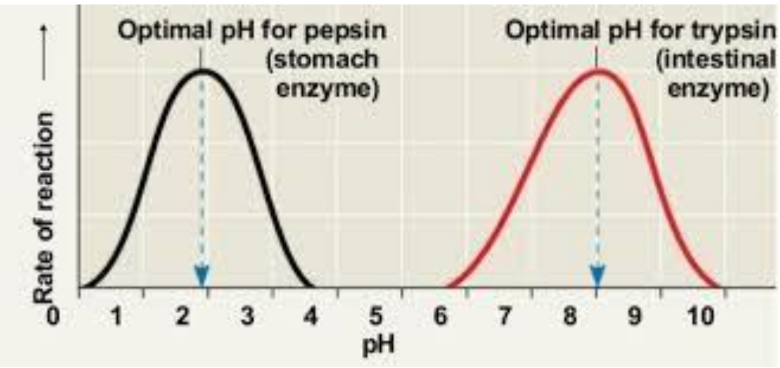
- **Pepsin** works at pH 2. It is an enzyme in the stomach.
- **Trypsin works at ph 8 . it is an enzyme** found in the small intestine.

Effect of pH Changes:

- **Decreased Activity**: If the pH moves away from the enzyme's optimal range (either too acidic or too alkaline), the enzyme’s activity decreases.
- **Denaturation**: Extreme pH levels can lead to denaturation, where the enzyme’s structure is altered, and the active site no longer binds the substrate effectively. This change is often irreversible.

pH Affects Enzyme Activity:

- **Ionization**: The pH affects the ionization of the amino acids at the active site, which is important for substrate binding and catalysis.
- **Structure**: Changes in pH can disrupt the enzyme's three-dimensional structure, leading to loss of function.



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Effect of Temperature on Enzyme Activity

- **Optimal Temperature**: Enzymes also have an optimal temperature at which they exhibit maximum activity.
  - For many human enzymes, this optimal temperature is around **37°C** (98.6°F), which is normal body temperature.
- **Effect of Temperature Changes**:
  - **Increased Activity**: As the temperature rises, enzyme activity typically increases because the molecules move faster, leading to more frequent collisions between enzymes and substrates.
  - **Peak Activity**: Enzyme activity peaks at the optimal temperature.
  - **Denaturation at High Temperatures**: If the temperature rises too much above the optimal range, the enzyme can denature, losing its specific shape and active site. This denaturation is usually irreversible and results in a sharp decrease in enzyme activity.
  - **Decreased Activity at Low Temperatures**: At low temperatures, enzyme activity decreases because molecular movement slows down, leading to fewer collisions between enzymes and substrates. However, this process is generally reversible; the enzyme can regain its activity if the temperature is raised back to the optimal level.

Temperature Affects Enzyme Activity:

  - **Kinetic Energy**: Temperature affects the kinetic energy of molecules. Higher temperatures increase kinetic energy, leading to more collisions between enzymes and substrates.
  - **Structural Stability**: Higher temperatures can disrupt the hydrogen bonds, ionic bonds, and hydrophobic interactions that maintain the enzyme’s structure, causing denaturation. Conversely, low temperatures may not provide enough energy for the enzyme to function efficiently.

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Q. ENZYME INHIBITORS

Inhibition of Enzyme Activity

Enzyme inhibitors are molecules that decrease the activity of enzymes, either by blocking the enzyme's active site or by altering its structure. There are different types of enzyme inhibition:

1. Competitive Inhibition

- **Mechanism**: In competitive inhibition, the inhibitor resembles the substrate and competes with it for binding to the enzyme's active site.
- **Effect on Enzyme Activity**:
  - When the inhibitor binds to the active site, it prevents the substrate from binding, thereby reducing enzyme activity.
  - **Reversible**: The inhibition can be overcome by increasing the concentration of the substrate. If there’s more substrate, it’s more likely to outcompete the inhibitor for the active site.

- Example: A drug, **disulfiram (Antabuse) inhibits** the aldehyde oxidase which causes the accumulation of acetaldehyde with subsequent unpleasant side-effects of nausea and vomiting. This drug is used to help people overcome the drinking habit.

2. Noncompetitive Inhibition

- **Mechanism**: In noncompetitive inhibition, the inhibitor binds to an enzyme at a site other than the active site (an allosteric site), causing a change in the enzyme's shape. This change reduces the enzyme's ability to catalyze the reaction, even if the substrate can still bind.

- **Effect on Enzyme Activity**:
    - The inhibitor affects enzyme activity regardless of the substrate concentration, so adding more substrate does not overcome the inhibition.

Q.Examples of Non-Competitive Inhibitors -Cyanide

This poison causes death by halting ATP production.

UNCOMPETITIVE INHIBITION

- **Mechanism**: In uncompetitive inhibition, the inhibitor binds only to the enzyme-substrate complex, not to the free enzyme. This binding typically occurs at a site distinct from the active site.
- **Effect on Enzyme Activity**:
    - The inhibitor effectively "locks" the substrate in the enzyme, preventing the reaction from proceeding to form the product.
    - This type of inhibition is often observed in enzymes with multiple substrates or steps in their catalytic cycle.
- **Effect on Kinetics**:
    - **Both Km and Vmax decrease**. Km decreases because the inhibitor stabilizes the enzyme-substrate complex, making the enzyme seem to have a higher affinity for the substrate. Vmax decreases because fewer enzyme-substrate complexes can form products.
- **Example**: Uncompetitive inhibition is less common but can be seen in enzymes like **alkaline phosphatase** in the presence of specific inhibitors.

Basic Enzyme Reaction

[E] + [S] ---→ [ES] ---→ [EP] ---→ [E] + [P]

E= Enzyme

S= Substrate

ES = Enzyme Substrate Complex

EP = Enzyme Product Complex

P= Product

The Enzyme reacts with the Substrate to form Enzyme Substrate complex.

The Enzyme Substrate Complex forms an Enzyme Product Complex.

Finally the Enzyme and Product disassociate

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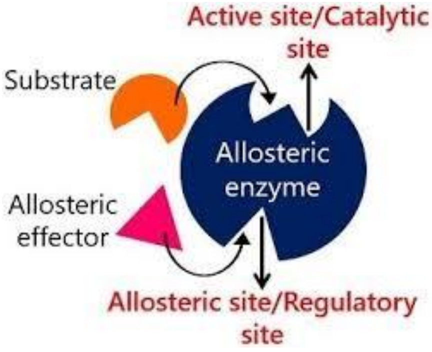
ALLOSTERIC INHIBITION

- **Mechanism**: Allosteric inhibitors bind to an enzyme at a site other than the active site, known as an allosteric site. This binding induces a conformational change in the enzyme that reduces its activity.
- **Effect on Enzyme Activity**:
  - Allosteric inhibitors can either decrease the enzyme's affinity for the substrate or reduce its catalytic efficiency.
  - The effect can be more complex than simple competitive or noncompetitive inhibition because allosteric enzymes often have multiple subunits and active sites.
- **Regulation**: Allosteric inhibition is often part of feedback regulation, where the end product of a metabolic pathway inhibits an enzyme that acts earlier in the pathway to control the overall process.
- **Example**: **ATP** acts as an allosteric inhibitor of **phosphofructokinase-1 (PFK-1)**, a key enzyme in glycolysis, thereby regulating the production of energy according to the cell's needs.



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Multiple Choice Questions (MCQs)

1. **Which part of an enzyme is responsible for binding to the substrate?**
   - A) Allosteric site
   - B) Active site
   - C) Inhibitory site
   - D) Cofactor

   Answer: B) Active site

2. **Which of the following is an example of a transferase enzyme?**
   - A) Amylase
   - B) Lactate dehydrogenase

- C) Alanine aminotransferase
    - D) DNA ligase

    Answer: C) Alanine aminotransferase

3. **Which type of enzyme inhibition can be overcome by increasing the concentration of the substrate?**
    - A) Noncompetitive inhibition
    - B) Uncompetitive inhibition
    - C) Allosteric inhibition
    - D) Competitive inhibition

    Answer: D) Competitive inhibition

4. **Which enzyme class catalyzes the rearrangement of atoms within a molecule?**
    - A) Oxidoreductases
    - B) Isomerases
    - C) Ligases
    - D) Lyases

    Answer: B) Isomerases

5. **What happens to enzyme activity when the pH is far from its optimal value?**
    - A) Increases
    - B) Decreases
    - C) Stays the same
    - D) Always becomes zero

    Answer: B) Decreases

6. **At very high temperatures, enzymes lose their activity because they:**
    - A) Become more active
    - B) Denature
    - C) Bind to more substrates
    - D) Increase their turnover number

    Answer: B) Denature

Fill in the Blanks

7. The Lock and Key Hypothesis suggests that the enzyme's active site is ________ in shape, perfectly matching the substrate.

    - Answer: rigid

8. The enzyme pepsin has an optimal pH around ________, making it well-suited for the acidic environment of the stomach.
    - Answer: 2

True or False

9. Allosteric inhibitors bind to the active site of an enzyme.
    - Answer: False (They bind to an allosteric site, not the active site.)
10. Enzymes typically function best at the same pH and temperature in all organisms.
    - Answer: False (Different enzymes have different optimal pH and temperature ranges, depending on the organism and environment.)