SUBJECT: BIOLOGY FOR ENGINEERS (CSE STREAM)

SUBJECT CODE: BBOC407

MODULE 1 - CELL BASIC UNIT OF LIFE

SYLLABUS:
Introduction: Structure and functions of a cell. Stem cells and their application. Biomolecules: Properties and functions of Carbohydrates, Nucleic acids, proteins, lipids. Importance of special biomolecules: Properties and functions of enzymes, vitamins and hormones**.**

Cell: A cell is defined, as the smallest, basic unit of life that is responsible for all of life's processes.Cells are the structural, functional, and biological units of all living beings. A cell can replicate itself independently. Hence, they are known as the building blocks of life.

Robert Hooke was the first Biologist who discovered cells.

Characteristics of Cells:

- Cells provide structure and support to the body of an organism.
- The cell interior is organized into different individual organelles surrounded by a separate membrane.
- The nucleus (major organelle) holds genetic information necessary for reproduction and cell growth.
- Every cell has one nucleus and membrane-bound organelles in the cytoplasm.
- Mitochondria, a double membrane-bound organelle is mainly responsible for the energy transactions vital for the survival of the cell.
- Lysosomes digest unwanted materials in the cell.
- Endoplasmic reticulum plays a significant role in the internal organization of the cell by synthesizing selective molecules and processing, directing and sorting them to their appropriate locations.

Types of Cells:

1)Prokaryotic Cells

- Prokaryotic cells have no nucleus. Instead, some prokaryotes such as bacteria have a region within the cell where the genetic material is freely suspended. This region is called the nucleoid.
- They all are single-celled microorganisms. Examples include archaea, bacteria, and cyanobacteria.

- The cell size ranges from 0.1 to 0.5 μm in diameter.
- The hereditary material can be either DNA or RNA.
- Prokaryotes generally reproduce by binary fission, a form of asexual reproduction

2) Eukaryotic cells

- They are characterized by a true nucleus.
- The size of the cells ranges between 10–100 μm in diameter.
- This broad category involves plants, fungi, protozoans, and animals.
- The plasma membrane is responsible for monitoring the transport of nutrients and
- Electrolytes in and out of the cells. It is also responsible for cell-to-cell communication.
- They reproduce sexually as well as asexually.
- There are some contrasting features between plant and animal cells. For eg. The plant cell contains chloroplast, cell wall, central vacuoles, and other plastids, whereas the animal cells do not.

STRUCTURE AND FUNCTIONS OF A CELL

Understanding cell structure and functions is key to understanding life processes.

Structure: Cell consists of

1. Plasma Membrane (cell membrane): Surrounds the cell, regulating the passage of substances.

2. Cytoplasm: Jelly-like substance filling the cell, containing organelles. Most of the biochemical reactions occurs in it.

3. Nucleus: Houses genetic material (DNA), controlling cell activities.

4. cell wall : it is found in plant cell. It lies outside the cell membrane and protects and cell membrane also gives the rigid structures. Cell wall is made up of cellulose, hemicellulose and pectin.

5. Organelles: Specialized structures:

a. Endoplasmic Reticulum: Involved in protein and lipid metabolism.there are two types of ER. One is rough ER and another is smooth ER.

b. Golgi Apparatus: Modifies, sorts, and packages molecules.

c. Mitochondria: Generates energy through respiration. These are called **powerhouses of cell.**

d. Lysosomes: Break down waste materials. These are called **suicide bags of cell** as it digest the unwanted cell.

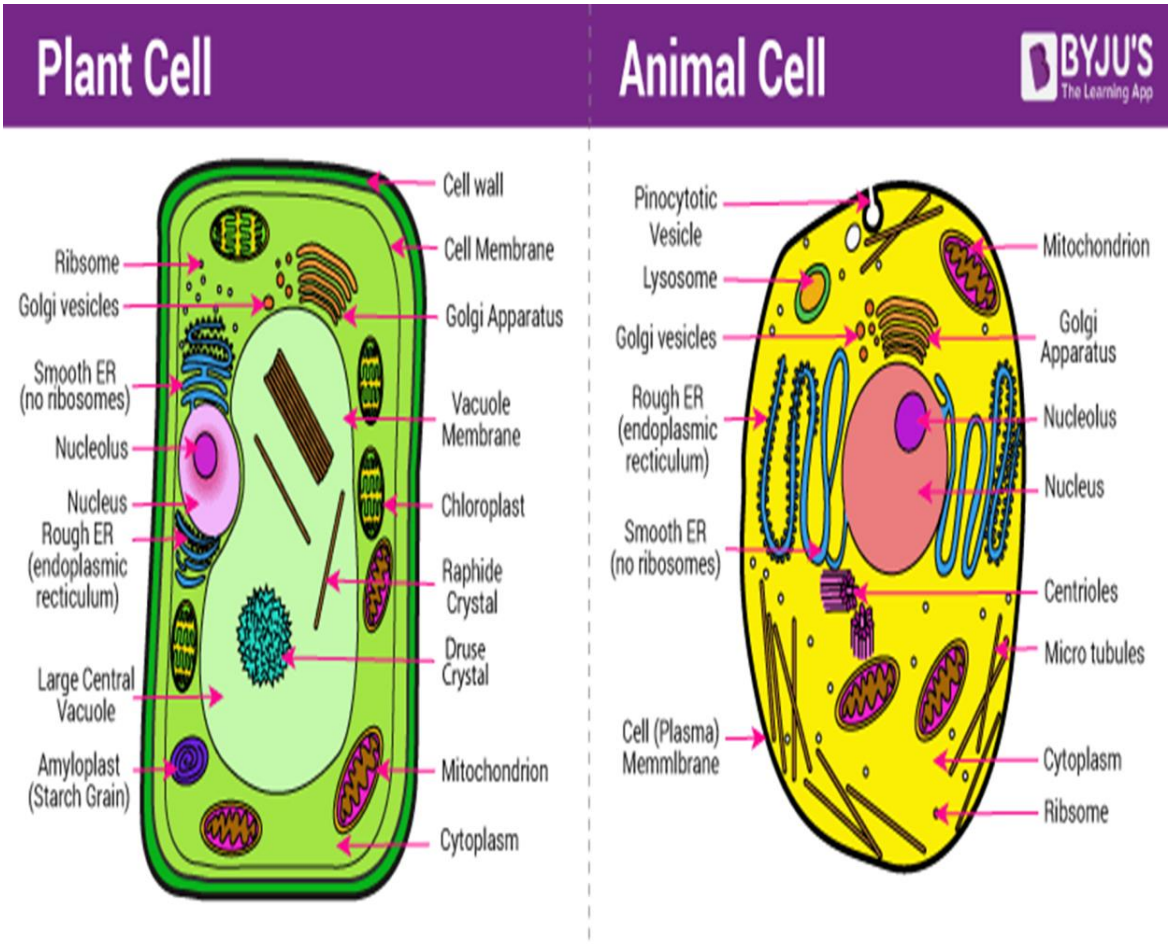
e. Ribosomes: Sites of protein synthesis.

f. Centrioles (in animals): Assist in cell division.

g. Cytoskeleton: Provides structural support and aids in cell movement.

h. vacuoles: these are found exclusively in plant cell which helps in storage of food, air water etc.

i. chloroplast: these are also only in plant cell which a pigment and plays a major role in photosynthesis .



Functions of cell:

1. Respiration: Converts glucose into ATP for energy.thus cell helps in energy production.
2. Protein Synthesis: cells helps in synthesis of .proteins. ribosomes are called protein factory of the cell.
3. Storage and Processing: Synthesizes, modifies, and transports molecules.
4. Cellular Communication: Signals between cells via various molecules.
5. Waste Management: Breaks down and recycles cellular waste.
6. Cell Division: Replicates cells for growth, repair, and reproduction

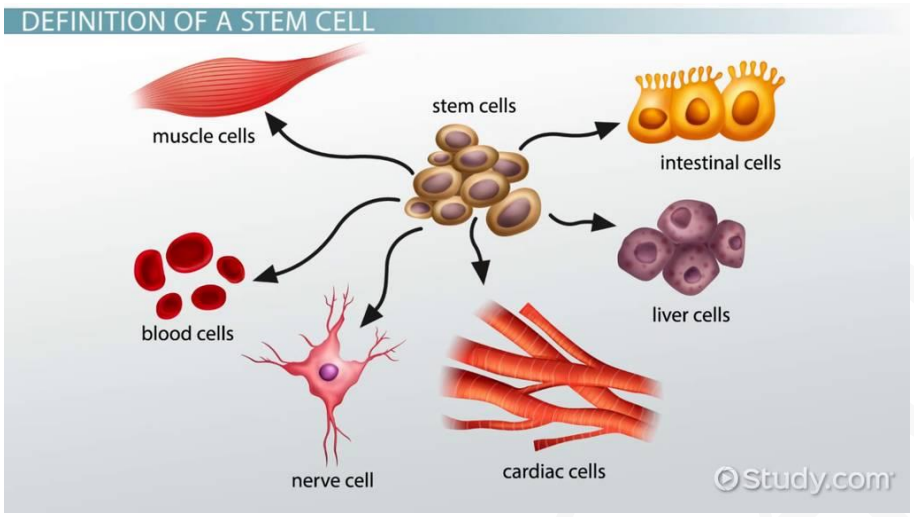
7. Movement: supports cell movements and shape changes.

Stem Cells: Stem cells are cells with the potential to develop into many different types of cells in the body**.** Stem cells are undifferentiated cells with the remarkable ability to differentiate into specialized cell types.

Stem cells are classified based on their potency or potential to differentiate into different cell types:

1. Totipotent: Can differentiate into all cell types, including embryonic and extraembryonic tissues. Examples include cells in the early embryo.
2. Pluripotent: Can differentiate into cells of all three germ layers: ectoderm, endoderm, and

Mesoderm. Examples include embryonic stem cells (ESCs).
3. Multipotent: Can differentiate into a limited range of cell types within a particular lineage or Tissue. Examples include adult stem cells.



Applications of stem cell:

1. Self-renewal: Stem cells can divide and produce identical copies of themselves, maintaining a pool of undifferentiated cells.

2. Differentiation: They can differentiate into specialized cell types with specific functions, such as nerve cells, muscle cells, blood cells, and more.

3. Repair and regeneration: Stem cells play a crucial role in tissue repair and regeneration by replacing damaged or diseased cells with healthy ones.

4. Research and therapy: They are valuable tools in scientific research for studying development, disease modeling, and drug testing. In medicine, stem cell therapies hold promise for treating a wide range of diseases and injuries

5. Embryonic development: During embryonic development, stem cells give rise to all the different cell types in the body, forming tissues and organs

6. Adult tissue maintenance: In adult organisms, stem cells are responsible for maintaining and repairing tissues throughout life, ensuring their proper function.

7. Regenerative medicine: Stem cell therapies are being developed to regenerate damaged tissues and organs, offering potential treatments for conditions such as heart disease, spinal cord injury, Parkinson's disease, and diabetes.

8. Cell-based therapies: Stem cells can be used in cell-based therapies to replace damaged or dysfunctional cells with healthy ones, offering hope for treating degenerative diseases and injuries.

9. Gene editing: Stem cells can be genetically modified using techniques such as CRISPR-Cas9, allowing researchers to study gene function and develop potential treatments for genetic disorders.

10. Biotechnology: Stem cells are used in biotechnology for producing specialized cells and tissues for research, drug discovery, and tissue engineering applications.

BIOMOLECULES

Biomolecules, also known as biological molecules, are chemical compounds found in living organisms that are essential for the survival of living cells and all life processes. They are the building blocks of life and perform important functions in living organisms, such as reproduction, growth, and sustenance. Biomolecules include large macromolecules such as proteins, carbohydrates, lipids, and nucleic acids, as well as small molecules such as vitamins and hormones.

CARBOHYDRATES:

Carbohydrates are a class of organic compounds composed of only carbon, hydrogen, and oxygen.

The name carbohydrate is of French origin (hydrate de carbone) as the carbohydrates were considered as hydrates of carbon.

The carbohydrates can be represented by the general formula Cx(H2O)y

Definition: Carbohydrates are defined as the polyhydroxy aldehydes or polyhydroxy ketones and those substances that give these compounds on hydrolysis

Properties of Carbohydrates:

Property	**Description**
1)Chemical Composition	Composed of carbon, hydrogen, and oxygen atoms in a ratio of 1:2:1, respectively.
2)Structure	Consists of chains or rings of sugar molecules.
3)Types	Divided into three main groups: monosaccharides, disaccharides, and polysaccharides.
4)solubility	Most carbohydrates are soluble in water due to their hydrophilic nature, except for some larger polysaccharides.
5)Sweetness	Monosaccharides and disaccharides are generally sweet tasting, while polysaccharides are not.
6)Energy Source	The primary source of energy for living organisms, providing 4 calories per gram upon digestion.
7)Storage	Stored as glycogen in animals and as starch in plants for energy reserves.
8)Structural Function	Act as building blocks for cell walls in plants (cellulose) and exoskeletons in arthropods (chitin).
9)Biological Significance	Essential for cellular processes such as metabolism, cell signaling, and immune system functioning.

10)Gel formation	Certain carbohydrates, such as pectin and agar, have the ability to form gels when mixed with water, leading to applications in food thickening, stabilizing, and gelling agents
11)Dietary Fiber	Some carbohydrates, such as cellulose and certain oligosaccharides, contribute to dietary fiber, promoting digestive health, regulating blood sugar levels, and aiding in weight management.
12)Chemical Reactivity	Carbohydrates undergo various chemical reactions, including oxidation, reduction, and hydrolysis, which play critical roles in energy metabolism and biosynthesis

Functions of Carbohydrates:

1) They serves as a **major source of energy:**They are the principal source of energy supplying 45-65% of the calorie requirements of the body.Glucose is used as fuel by your body's cells, tissues, and organs.
2) **Protein sparing action**: Protein perform a specialized function of bodybuilding and growth. The wasteful expenditure of protein to meet the energy needs of body should be avoided. Carbohydrates comes to the rescue and spare the protein from being misused for caloric purpose.
3) **Supplies energy for muscle work:**
   In muscle, glycogen is broken down to lactic acid to provide energy for muscle contraction.
4) **Synthesis of Pentose:**
   Pentose(eg: Ribose) are the constituents of several components in the body eg: Nucleic acid(RNA and DNA), and coenzymes (NAD+, FAD).These pentose's are produced in carbohydrate metabolism.
5) **Synthesis of non-essential amino acid:**
6) **Synthesis of fat**
   Excess consumption of carbohydrates leads to the formation of fat, which is stored in the adipose tissue.
7) **Special function in liver**
   The liver is the central organ that integrates the body's metabolism. Carbohydrates play an active role in this metabolic integration.
8) **Importance of non-digestible carbohydrates**
   Some carbohydrates are not digested by the body, but Very important, as they help in bowel motility, prevents constipation, lowers cholesterol and helps in maintaining normal blood glucose level.
9) Carbohydrates are essential for the production of serotonin – serotonin is a neurotransmitter that regulates mood
10) Complex carbohydrates can increase healthy gut bacteria.

PROTEINS:

- Protein is one of three macronutrients, which are nutrients the body needs in larger amounts. The other macronutrients are fat and carbohydrates.
- **Protein is made up of long chains of amino acids.**
- Proteins may be either 1)**complete** OR **2. incomplete**.
- **Complete proteins** are proteins that contain all essential amino acids. Animal products, soy, and quinoa are complete proteins.
- **Incomplete proteins** are proteins that do not contain all essential amino acids. Most plant foods are incomplete proteins, including beans, nuts, and grains.

PROPERTIES OF PROTEINS:

1)Structure	**Proteins exhibit a structure, consisting of primary, secondary, tertiary, and quaternary levels of organization**. The primary structure refers to the linear sequence of amino acids linked by peptide bonds. Secondary structure involves folding patterns such as alpha helices and beta sheets, while tertiary structure refers to the three-dimensional arrangement of the entire polypeptide chain. Quaternary structure arises when multiple polypeptide chains assemble to form a functional protein molecule.

2)Amino Acid Composition	Proteins are composed of amino acids, which are organic molecules containing an amino group, a carboxyl group, and a variable side chain.

3)Functional Diversity	Proteins exhibit remarkable functional diversity, serving as enzymes, structural components, transporters, receptors, antibodies, hormones, and molecular motors, among other roles..
4)Folding and Stability	Proteins undergo folding into their native three-dimensional structures, driven by interactions between amino acid side chains and the surrounding environment. The folding process is crucial for protein function, as it determines the specific binding sites and active sites necessary for interactions with other molecules.
5)Denaturation	Proteins can undergo denaturation, a process in which their native structure is disrupted, leading to loss of function. Denaturation can be induced by various factors, including heat, pH extremes, organic solvents,
6)Solubility	The solubility of proteins varies depending on their amino acid composition and the surrounding environment. Some proteins are soluble in water, while others are insoluble and may form aggregates or precipitates.

FUNCTIONS OF PROTEINS:

1) The major function of protein is to build muscle mass and other tissues.
2) Protein can also provide energy as Carbohydrates
3) Proteins serve as enzymes, catalyzing biochemical reactions within cells and Organisms.
4) Protein as transport proteins.
   Transport proteins as the name suggest bind to metal ions, organic molecules or gases like oxygen and transport them into individual organs.
5) Proteins provide structural support to cells, tissues, and organs in living organisms. Structural proteins such as collagen, elastin, and keratin contribute to the Mechanical strength, elasticity, and integrity of various biological structures, Including bones, skin, hair, and connective tissues.
6) Proteins play crucial roles in cellular signaling pathways, transmitting and Modulating signals that regulate various physiological processes.
7) Proteins are essential components of the immune system, participating in the Recognition, response, and defense against pathogens and foreign substances.
8) Proteins play a central role in muscle contraction, enabling movement and Locomotion in animals.

LIPIDS:

Lipids are a diverse group of organic molecules that are insoluble in water but soluble in nonpolar solvents. They include fats, oils, phospholipids, steroids, and waxes. Lipids serve various essential functions in living organisms, such as providing energy storage, forming cell membranes, serving as signaling molecules etc.

PROPERTIES OF LIPIDS:

1) Lipids are insoluble in water and soluble in non-polar solvents like benzene ,ether etc.
2) Lipids exhibit **structural diversity**, encompassing a wide range of molecules with distinct chemical compositions and functions.
3) Some lipids display **amphipathic properties**, containing both hydrophilic (water-attracting) and hydrophobic (water-repelling) regions within the same molecule. For example Phospholipids, have hydrophilic phosphate heads andhydrophobic fatty acid tails.
4) Lipids serve as efficient **energy storage molecules**, storing energy in the form of chemical bonds within their hydrocarbon chains. Triglycerides, the primary storage form of lipids, accumulate in adipose tissues.
5) lipids **act as insulators,** helping to maintain body temperature and protect vital organs from temperature fluctuations and mechanical damage.ex: adipose tissue.
6) Certain lipids, such as waxes and oils, possess **lubricating properties** that reduce friction and facilitate movement in biological systems.

FUNCTIONS OF LIPIDS:

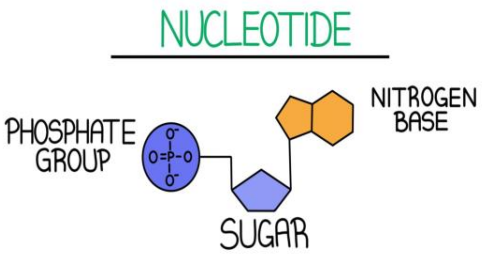
1)Energy Storage	Lipids serve as a concentrated energy reserve in the body, providing more than twice the energy per gram compared to carbohydrates or proteins.
2) Structural Role	Lipids contribute to the structural integrity of cell membranes, forming a lipid bilayer that encloses and protects the contents of cells.
3) Insulation	Lipids act as insulators, helping to maintain body temperature and protect vital organs from temperature fluctuations and mechanical damage
4) Hormone Regulation	Lipids play a crucial role in hormone synthesis and regulation, serving as precursors for steroid hormones such as estrogen, testosterone, and cortisol.
5) Cell Signaling	Lipids function as signaling molecules in intercellular communication pathways, modulating cellular responses to environmental cues and stimuli
6) Absorption Of Nutrient	Lipids facilitate the absorption and transport of fat-soluble vitamins (A, D, E, and K) and other hydrophobic nutrients in the digestive system.
7) Nervous System Function:	Lipids, particularly phospholipids, are essential for the structure and function of nerve cells. Myelin, a specialized lipid-rich substance, forms a sheath around nerve fibers, facilitating the rapid transmission of nerve impulses.

NUCLEIC ACID:

Nucleic acids are long-chain polymeric molecules, the monomer (the repeating unit) is known as the nucleotides and hence sometimes nucleic acids are referred to as polynucleotides.

Discovery: Friedrich Miescher discovered nucleic acids in 1869.

The **basic components** of a nucleic acid include three different entities, namely a **nitrogenous base, a sugar moiety and a phosphate group**. These combine to give one unit of a nucleotide,



Properties of Nucleic Acids:

1. **Polarity:** Nucleic acids exhibit polarity, it is due to the presence of phosphate group.
2. **Double helix structure:** DNA molecules possess a double helix structure, characterized by two complementary polynucleotide strands winding around each other in a right-

handed manner. This structure provides stability and protection to the genetic information encoded within the DNA molecule and facilitates replication and transcription processes.

3. **Base Pairing:**Nucleic acids exhibit specific base pairing rules, where adenine (A) pairs with thymine (T) in DNA or uracil (U) in RNA via hydrogen bonds, and cytosine (C) pairs with guanine (G). This complementary base pairing ensures the accurate replication and transmission of genetic information during cellular processes.
4. **Hydrogen Bonding**: Hydrogen bonding plays a crucial role in stabilizing the structure of nucleic acids.
5. **Acidic Nature:** Nucleic acids are acidic molecules due to the presence of phosphate groups in their structure.
6. **Chemical Stability and Reactivity:** Nucleic acids are chemically stable molecules under physiological conditions but can undergo specific chemical reactions, such as hydrolysis of phosphodiester bonds between nucleotides or enzymatic modifications, crucial for their functions in cellular processes.

FUNCTIONS OF NUCLEIC ACID:

Function	**Description**
1)Genetic Information Storage	Nucleic acids, particularly DNA (deoxyribonucleic acid), serve as the primary carrier of genetic information in living organisms. DNA contains the instructions necessary for the development, growth, functioning, and reproduction of organisms.
2)Protein Synthesis	Nucleic acids, specifically RNA (ribonucleic acid), play a crucial role in protein synthesis. RNA molecules, including messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA), are involved in various stages of protein production.
3)Gene Expression Regulation	Nucleic acids participate in the regulation of gene expression, controlling when and how genes are turned on or off.
4)Energy Transfer	Nucleic acids, particularly adenosine triphosphate (ATP), function as carriers of chemical energy within cells. ATP molecules store and transfer energy generated during cellular metabolism, providing the necessary energy for cellular activities such as muscle contraction, biosynthesis, and transport processes.
5)Catalysis	Some nucleic acids, such as ribozymes, exhibit catalytic activity, enabling them to facilitate specific biochemical reactions within cells. Ribozymes participate in processes such as RNA splicing, peptide bond formation, and RNA cleavage,.
6)Immune Response	Nucleic acids, both DNA and RNA, can trigger immune responses when recognized as foreign molecules by the immune system.

7)Chemical Signaling	Certain nucleic acids, such as small non-coding RNAs, are involved in chemical signaling pathways within cells. These regulatory RNAs modulate gene expression by interacting with specific target molecules.

ENZYMES:

Enzymes are biological catalysts that accelerate biochemical reactions by lowering the activation energy required for the conversion of substrates into products.

PROPERTIES:

1. **Enzymes are proteins**: They are made up of many amino acids linked together and folded into specific shapes.
2. **Enzymes are reusable:** Enzymes speed up chemical reactions, but do not take part in the reactions.
3. **Enzymes are substrate specific.** Can react with certain food/nutrients based on their shapes.
4. **Enzymes are sensitive to pH.:** The shapes of enzymes can be changed if pH levels are too high or low.
5. **Enzymes are denatured by high heat:** High temperatures will change the shapes of enzymes.
6. **Enzymes are inhibited by poisons**: Poisons can bind to the structure of enzymes and prevent effective binding at the active site.

FUNCTIONS OF ENZYMES:

1. Catalyzing chemical reactions: Enzymes accelerate biochemical reactions by lowering the activation energy required for the reaction to occur.

2. Metabolism regulation: Enzymes control metabolic pathways by regulating the rate of specific reactions, ensuring proper energy production and utilization.

3. Digestion: Digestive enzymes break down large molecules such as carbohydrates, proteins, and fats into smaller, absorbable molecules during digestion.

4. Synthesis of biomolecules: Enzymes facilitate the synthesis of complex biomolecules like proteins, DNA, and RNA by linking smaller building blocks together.

5. Detoxification: Some enzymes aid in the detoxification of harmful substances by converting them into less toxic forms that can be excreted from the body.

6. Signal transduction: Enzymes participate in cellular signaling pathways by modifying proteins or molecules to transmit signals within cells.

Overall, enzymes play crucial roles in maintaining the biochemical balance and functionality of living organisms.

VITAMINS:

Vitamins are essential micronutrients that play diverse roles in maintaining health and supporting

Various physiological functions in the body.

Vitamins are organic compounds that are essential for normal growth, metabolism, and overall health. They are micronutrients.

They are classified into two categories: fat-soluble vitamins (A, D, E, and K) and water-soluble vitamins (B vitamins and vitamin C).

PROPERTIES:

1. All are complex organic substances.
2. The molecular weight is low.
3. Essential vitamins for one species may not be essential for another.
4. Some vitamins are synthesized in the body.
5. Vitamins are not destroyed in the digestive processes and are absorbed as such.
6. The daily requirement for any vitamin is increased during growth, pregnancy and lactation.
7. Vitamins are not act as antigenic.

FUNCTIONS OF VITAMINS:

1. **Antioxidant Activity**: Vitamins such as vitamin C, vitamin E, and beta-carotene act as antioxidants, protecting cells from damage caused by free radicals.
2. **Energy Metabolism:** B vitamins (e.g., B1, B2, B3, B5, B6, B7, B9, B12) are essential for converting food into energy and for supporting various metabolic processes.
3. **Bone Health:** Vitamin D is crucial for calcium absorption and bone mineralization, helping to maintain strong and healthy bones.
4. **Immune Function**: Vitamins A, C, D, and E play important roles in supporting the immune system, helping the body fight off infections and diseases.
5. **Vision:** Vitamin A is essential for vision, particularly for maintaining the health of the retina and promoting good vision in low light.
6. **Collagen Synthesis**: Vitamin C is necessary for collagen synthesis, which is important for skin health, wound healing, and maintaining the integrity of connective tissues.
7. **Blood Clotting:** Vitamin K is essential for blood clotting and bone metabolism.
8. **Nervous System Function**: Vitamins B6, B12, and folate (B9) are important for the proper functioning of the nervous system, including the synthesis of neurotransmitters and the maintenance of nerve cells.
9. **DNA Synthesis and Repair:** Folate (B9) and other B vitamins are necessary for DNA synthesis and repair, which is important for cell growth and division.
10. **Heart Health**: Certain vitamins, such as vitamin E and folate, have been associated with heart health and may help reduce the risk of cardiovascular diseases.

1. Vitamin A: Supports vision, especially in low light conditions. - Promotes healthy skin and mucous membranes. - Supports immune function. - Plays a role in growth and development.
2. Vitamin B complex: Helps convert food into energy (metabolism). - Supports nerve function and neurotransmitter synthesis. - Aids in red blood cell formation. - Important for DNA synthesis and repair. - Supports healthy skin, hair, and eyes.

3. Vitamin C: Acts as an antioxidant, protecting cells from damage caused by free radicals. - Supports immune function. - Facilitates collagen synthesis, which is crucial for wound healing and skin health. - Enhances iron absorption from plant-based sources.

4. Vitamin D: Facilitates calcium and phosphorus absorption, promoting bone health. - Supports immune function. - May have roles in reducing inflammation and regulating cell growth.

5. Vitamin E: Acts as an antioxidant, protecting cell membranes and other fat-soluble parts of the body from damage. - Supports immune function. - Promotes skin health and wound healing.

6. Vitamin K: - Essential for blood clotting, as it helps activate proteins involved in the clotting process. - Supports bone health by regulating calcium deposition in bones and preventing calcification of soft tissues.

HORMONES:

Hormones are chemical messengers that are produced by various glands in the endocrine system and are released into the bloodstream.

Hormones play crucial roles in regulating numerous physiological processes, including growth and development, metabolism, reproduction, mood, and stress response.

PROPERTIES OF HORMONES:

1. **Chemical Nature:** Hormones can be classified based on their chemical structure into three main groups: steroids, peptides/proteins, and amines..
2. **Specificity:** Each hormone interacts with specific target cells or organs that have receptors capable of binding to the hormone.
3. **Regulation of Secretion:** Hormone secretion is tightly regulated by various factors such as feedback mechanisms, neural signals, and environmental cues. For example, insulin secretion increases in response to high blood sugar levels after a meal, helping to regulate glucose levels in the bloodstream.
4. **Transport:** Hormones are transported through the bloodstream to target tissues or organs..
5. **Half-Life**: Hormones have varying half-lives, which determine how long they remain active in the bloodstream. Some hormones, like adrenaline, have short half-lives and

exert rapid effects, while others, such as thyroid hormones, have longer half-lives and exert slower, more prolonged effects.

6. **Feedback Mechanisms:** Hormonal secretion is often regulated by feedback mechanisms that help maintain homeostasis. For example, the release of thyroid-stimulating hormone (TSH) from the pituitary gland is inhibited by high levels of thyroid hormones in the bloodstream.
7. **Synergistic and Antagonistic Effects**: Hormones can interact with each other to produce synergistic or antagonistic effects on target tissues. Synergistic effects occur when two hormones act together to produce a greater response than either hormone alone. Antagonistic effects occur when one hormone opposes the action of another hormone.

FUNCTIONS OF HORMONES:

Some common hormones and their functions include:

1. Insulin: Regulates blood sugar levels by facilitating the uptake of glucose into cells.
2. Testosterone: Plays a key role in male reproductive development and maintenance of male characteristics.
3. Estrogen: Regulates the menstrual cycle and is involved in female reproductive development and secondary sexual characteristics.
4. Thyroid hormones (T3 and T4): Regulate metabolism and energy production.
5. Adrenaline (epinephrine): Increases heart rate, blood pressure, and glucose levels in response to stress.
6. Cortisol: Helps regulate metabolism, immune function, and the body's response to stress.
7. Progesterone: Prepares the uterus for pregnancy and helps maintain pregnancy.
8. Homeostasis: Hormones play key roles in maintaining homeostasis by regulating various physiological processes, including blood pressure, electrolyte balance, body temperature, and water balance.

Imbalances in hormone levels can lead to various health problems. For example, diabetes results from a deficiency in insulin production or insensitivity to insulin. Hormonal imbalances can occur due to factors such as aging, stress, diseases, medications, or genetic conditions. Hormone replacement therapy and other medical interventions are often used to manage hormonal imbalances and related health issues.

QUESTION BANK:

1. **Define cell. Explain the structure and functions of cell.**
2. **What are carbohydrates? Explain the properties and functions of it.**
3. **What are proteins? Explain the properties and functions of protein.**
4. **What are lipids? Explain the properties and functions of lipids.**
5. **What are nucleic acids? Explain the properties and role of nucleic acid.**
6. **What are vitamins? Explain the functions and properties of it.**
7. **What are hormones? Explain the properties and functions of hormones.**

Course Title: Biology for Engineers (CSE Stream)

Course Code: BBOC407

Module 2: APPLICATION OF BIOMOLECULES

Syllabus:

Carbohydrates in cellulose-based water filters production, PHA and PLA in bioplastics production, Nucleic acids in vaccines and diagnosis, Proteins in food production, lipids in biodiesel and detergents production, Enzymes in biosensors fabrication, food processing, detergent formulation and textile processing

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Carbohydrates and their applications:

Cellulose-based water filters:

- Derived primarily from plant sources such as wood pulp, cotton, and hemp, cellulose possesses remarkable properties that make it an ideal candidate for water filtration applications. Its fibrous structure, composed of long chains of glucose molecules, forms a porous matrix capable of trapping contaminants while, allowing water molecules to pass through.

  Composition and Construction:

  Cellulose-based water filters are typically composed of **cellulose fibers** woven into various forms, including membranes, papers, and cartridges. These filters may be contain additional materials like **activated carbon** or **nanoparticles** to enhance their filtration efficiency.

  The manufacturing process involves converting cellulose pulp into thin sheets or membranes through techniques such as papermaking or casting. These sheets are then treated to modify pore size, surface chemistry, and other properties to optimize filtration performance

- **Properties** :

- Biodegradability: Cellulose-based filters are derived from natural cellulose fibers, making them biodegradable and environmentally friendly.
- Pore **Size Control**: Manufacturers can control the pore size of cellulose-based filters, allowing for precise filtration tailored to specific applications.
- Chemical **Resistance**: Cellulose-based filters exhibit good resistance to a wide range of chemicals, making them suitable for filtering various substances.
- High **Absorption Capacity**: Cellulose fibers have a high surface area and can absorb significant quantities of liquids, making them effective in filtration processes.

- Low **Protein Binding**: These filters typically have low protein binding properties, making them suitable for applications in the biopharmaceutical industry where protein adsorption is a concern.
- Sterilizable: Cellulose-based filters can often be sterilized through methods such as autoclaving or gamma irradiation, making them suitable for use in sterile environments.

Filtration Mechanism:

The filtration mechanism of cellulose-based filters relies on physical barriers and adsorption phenomena. As water flows through the porous structure of the filter, contaminants such as bacteria, viruses, sediment, and organic compounds are mechanically trapped within the cellulose matrix. Additionally, certain filters incorporate activated carbon, which adsorbs chemical impurities and improves taste and odor. This synergistic approach ensures comprehensive purification while maintaining high water flow rates.

Advantages of Cellulose-Based Filters:

***Sustainability*:** Derived from renewable plant sources, cellulose-based filters offer an eco-friendly alternative to synthetic materials, reducing reliance on non-renewable resources and minimizing environmental impact.

***Biodegradability*:** Unlike plastic-based filters, cellulose filters are biodegradable, posing minimal risk to ecosystems and reducing landfill waste.

Cost-effectiveness: Cellulose is widely available and relatively inexpensive, making cellulose based filters a cost-effective option, particularly for large-scale water treatment.

***Versatility*:** Cellulose filters can be tailored to target specific contaminants, offering versatility in addressing diverse water quality challenges.

***Compatibility*:** Cellulose-based filters are compatible with existing filtration systems and can be seamlessly integrated into various water treatment processes.

Applications:

Cellulose-based water filters find applications across a spectrum of settings, including:

1. Household water purification systems
2. Industrial water treatment facilities
3. Emergency relief efforts in disaster-stricken areas
4. Remote or off-grid communities lacking access to centralized water infrastructure.
5. Recreational activities such as camping and hiking.

Bioplastics:

Bioplastics are moldable plastics made from renewable resources, such as corn, sugarcane, vegetable oils, and starches. They may break down naturally or remain intact and are sourced from chemical compounds created by microorganisms or genetically engineered plants. They are more sustainable alternatives to traditional petroleum-based plastics and offer several environmental advantages over their conventional counterparts.

Poly lactic acid (PLA)

PLA, or polylactic acid, is a bioplastic that has gained significant attention recently due to its renewable nature and potential to replace traditional petroleum-based plastics.

Chemical Composition: PLA is a thermoplastic polymer derived from renewable resources such as corn starch or sugarcane. It is composed of repeating lactic acid units.

Properties: It is generally transparent, biodegradable under certain conditions, and can have mechanical properties comparable to traditional plastics.

General Production steps are as follows.
Step 1 - Lactic Acid Production: Lactic acid, the precursor to PLA, can be produced through the fermentation of sugars derived from renewable resources such as corn, sugarcanetc

Step 2- Lactide Formation: Lactic acid undergoes dehydration to form lactide, a cyclic dimer.

Step 3-**Polymerization**: Lactide monomers are then polymerized through ring-opening polymerization (ROP) to form PLA chains catalyzed by metal catalysts or enzymes.

Step 4 - **Processing:** The resulting PLA can be further processed into pellets, fibers, or films using conventional polymer processing techniques like extrusion, injection molding, or blow molding.

Applications:
1**. Packaging**: PLA is commonly used in packaging applications such as food containers, cups, In addition, films due to its transparency, barrier properties, and biodegradability.
2. Textiles: PLA fibers are used in textile applications including clothing, nonwoven fabrics.
3. Medical Devices: PLA's biocompatibility and biodegradability make it suitable for medical Applications such as sutures, implants, and drug delivery systems.
4. 3D Printing: PLA is a popular material for 3D printing due to its ease of processing, Biodegradability, and wide availability in filament form.
5. Disposable Items: PLA is used in disposable items like cutlery, plates, etc.

Limitations:

- Limited **Chemical Compatibility:** Cellulose filter paper may not be compatible with certain aggressive chemicals or solvents, as it can degrade or dissolve when exposed to them.
- **Low Temperature Resistance:** Cellulose filter paper typically has a relatively low resistance to high temperatures. It may degrade or lose its structural integrity when subjected to elevated temperatures.
- **Particle Retention Size:** The pore size distribution of cellulose filter paper limits its effectiveness in filtering out very fine particles. While it can effectively capture larger particles, it may not be effective for microorganism with very minute size.
- **Moisture Sensitivity:** Cellulose filter paper can absorb moisture from the environment, affecting its filtration performance and structural integrity.
- **Biological Contaminant Growth:** Cellulose filter paper provides a favorable environment for the growth of biological contaminants such as bacteria and fungi, especially when exposed to moisture.

Polyhydroxyalkanoates or PHAs are polyesters produced in nature by numerous microorganisms, including through bacterial fermentation of sugars or lipids.
When produced by bacteria they serve as both a source of energy and a carbon store.
More than 150 monomers can be combined within this family to give materials with extremely different properties.
These plastics are biodegradable and are used in the production of bioplastics.

Features of PHA

1. Biodegradability: One of the key advantages of PHA is its biodegradability. Unlike traditional plastics derived from fossil fuels, which can persist in the environment for hundreds of years, Bacteria will break down PHA into carbon dioxide and water. This property makes PHA an attractive option for reducing plastic pollution and addressing environmental concerns.
2. Renewable Source: PHA can be produced from renewable resources such as sugars, vegetable oils, and agricultural by-products.
3. Versatility: PHA can be produced with varying degrees of stiffness, flexibility, and durability, making it suitable for diverse applications including packaging, agriculture, medical devices, and consumer goods.
4. Biocompatibility: PHA is generally considered biocompatible and non-toxic, making it suitable for medical and biomedical applications such as sutures, implants, drug delivery systems, and tissue engineering scaffolds.

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5. Production Process: The production of PHA typically involves fermentation processes using microorganisms such as bacteria, yeast, or algae. These microorganisms are engineered or selected for their ability to convert renewable carbon sources into PHA.

Synthesis:

Production of PHA bioplastic

- Bacteria and microorganisms produce PHA. It is more appropriate to refer to it as biosynthesis Than production.
- To make PHA, a culture of a microorganism are fed with nutrients so that they multiply rapidly.
- Once the population has reached a certain level, the nutrient composition is changed to force the microorganism to synthesize PHA.and stored by the microorganisms.
- The PHA can weigh as much as 80 % of the organism's dry weight.
- The biosynthesis of PHA is usually caused by certain deficient conditions such as the lack of macro elements (phosphorus, nitrogen, trace elements, and oxygen) and the excess supply of carbon sources 8.Drying: Finally, the purified PHAs are dried to remove any remaining solvent and water.

Properties of PHA:

1. **Biodegradability:** PLA is biodegradable under industrial composting conditions, breaking down into water and carbon dioxide.
2. **Renewable Resource Base:** Made from renewable resources such as cornstarch or sugarcane, reducing reliance on petroleum.
3. **Mechanical Properties:** PLA has good tensile strength and rigidity but is more brittle compared to other plastics like ABS.
4. **Thermal Properties:** PLA has a low glass transition temperature (~60°C) and a melting temperature around 150-160°C, limiting its thermal resistance.
5. **Ease of Processing:** Easily processed using standard equipment for injection molding, extrusion, and 3D printing.

6. **Environmental Impact:** Lower carbon footprint compared to conventional plastics, thanks to its renewable origins and biodegradability.

Common applications of PHA:

1. **Packaging Materials:** Used for making biodegradable packaging, including food containers, wrappers, and disposable cutlery.
2. **3D Printing:** Popular as a filament for 3D printers due to its ease of use and environmentally friendly properties.
3. **Disposable Tableware:** Employed in the production of disposable plates, cups, and utensils that are compostable and eco-friendly.
4. **Medical Implants:** Used in bioresorbable medical implants such as sutures, screws, and stents, which safely degrade within the body.
5. **Agricultural Films:** Applied in agricultural mulch films that biodegrade, reducing the need for plastic waste disposal.
6. **Textiles:** Utilized in the manufacture of biodegradable fibers and fabrics for clothing and other textile products

NUCLEIC ACIDS AND THEIR APPLICATIONS

DNA VACCINE FOR RABIES

Rabies is a viral disease that affects wild and domestic animals and is transmitted to humans through animal contact

.Mechanism:

➔ **DNA Encoding Rabies Antigen**: The DNA vaccine contains a small circular piece of DNA that encodes specific antigens from the rabies virus. These antigens, typically the rabies virus glycoprotein (RVG), are crucial for producing an immune response.

➔ **Intramuscular Injection**: The vaccine is given via injection into muscle tissue. Once they are inside the muscle cells, the DNA is taken up and begins the process of antigen expression.

➔ **Antigen Production**: Within the host cells, the DNA is transcribed into mRNA, which is then translated into the rabies virus antigen protein(s). The antigen proteins are then presented on the surface of the host cells.

➔ **Immune Response Activation:** The presence of rabies virus antigens triggers the host immune system.

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➔ **Antigen Selection:** Researchers identify and select specific antigens from the rabies virus that are most effective at inducing an immune response. The RVG protein is a common choice due to its role in viral attachment and entry into host cells.

➔ **Plasmid Vector Construction**: The DNA sequence encoding the selected rabies antigens is cloned into a plasmid vector. This vector serves as a delivery vehicle for the DNA vaccine.

➔ **Purification:** The recombinant plasmid DNA is purified using various techniques to remove impurities and ensure a high-quality vaccine product.

➔ **Formulation:** The purified DNA vaccine is formulated into a suitable delivery system, such

as a saline solution or lipid nanoparticles, to facilitate its administration and uptake by host cells.

Immunization and Application:

Preventive Vaccination: DNA vaccines for rabies are administered to individuals or animals at risk of rabies exposure.

Post-Exposure Prophylaxis (PEP): DNA vaccines can also be used as part of post-exposure prophylaxis for individuals bitten or scratched by animals suspected of carrying the rabies virus. They complement traditional rabies vaccines and rabies immunoglobulin (RIG) administration.

Advantages:

Stability: DNA vaccines are stable at room temperature, eliminating the need for cold chain storage and transportation.

Ease of Production: DNA vaccines can be produced using recombinant DNA technology, offering a scalable and cost-effective manufacturing process.

Safety: DNA vaccines do not contain live viruses, reducing the risk of vaccine-associated adverse events.

Challenges:Immunogenicity: While DNA vaccines can induce strong immune responses, optimizing their efficacy, particularly in large-scale human populations, remains a challenge.

Regulatory Approval: Regulatory approval for DNA vaccines requires extensive data on safety, efficacy, and long-term effects, which may pose hurdles to their widespread use

RNA VACCINES FOR COVID-19

It represents a groundbreaking approach to vaccination that has been at the forefront of efforts to combat the pandemic. These vaccines utilize messenger RNA (mRNA) to instruct cells in the body to produce a protein like the *spike protein* found on the surface of the SARS-CoV-2 virus, which causes COVID-19. The immune system then recognizes this spike protein and mounts a response, including the *production of antibodies*, to protect against future infection. RNA vaccines for COVID-19 works typically as follows:

1. **mRNA Selection**: Scientists identify the genetic sequence encoding the spike protein of the SARS-CoV-2 virus. This sequence is used as the template for generating the mRNA vaccine.
2. **mRNA Formulation:** The mRNA encoding the spike protein is formulated into lipid nanoparticles. These nanoparticles protect the mRNA and help deliver it into cells once the vaccine is administered.
3. **Vaccination:** The mRNA vaccine is administered to individuals through intramuscular injection, typically into the upper arm. Once injected, the lipid nanoparticles deliver the mRNA into cells in the vicinity of the injection site.
4. **Cellular Uptake:** Cells take up the lipid nanoparticles containing the mRNA. Once inside the cell, the mRNA serves as a template for protein synthesis.
5. **Protein Production**: The cell's machinery reads the mRNA and produces copies of the spike protein encoded by the vaccine and are displayed on the surface of the cell.
6. **Immune Response**: The immune system recognizes the spike proteins as foreign and produces immune response. This includes the production of antibodies that specifically target the spike protein, as well as the activation of other immune cells, such as T cells.
7. **Immune Memory**: After vaccination, the immune system retains a memory of the spike protein. If the vaccinated individual is later exposed to the SARS-CoV-2 virus, their immune system can

quickly recognize and mount a response against it, preventing or reducing the severity of COVID-19.

PROTEINS AS FOOD
WHEY PROTEIN AND MEAT ANALOGS

Whey protein is a high-quality protein derived from whey, a byproduct of cheese production. It's one of the two main proteins found in milk, the other being **casein**. Whey protein is renowned for its excellent amino acid profile, including all nine essential amino acids required by the body. Benefits offered by Whey protein:

1. **Muscle Growth and Repair***:* Whey protein is rich in leucine, which plays a vital role in stimulating muscle protein synthesis. Consuming whey protein after exercise can help support muscle recovery and promote muscle growth.
2. Weight Management: whey protein, has been shown to promote feelings of fullness and satiety, which can help control appetite and support weight management goals.
3. Nutrient Absorption: Whey protein can enhance the absorption of certain nutrients, particularly in individuals with compromised digestive function.
4. Convenient Source of Protein: Whey protein supplements come in various forms, such as powders, bars, and ready-to-drink shakes, making them convenient options for increasing protein intake on the go or supplementing the diet with additional protein.
5. Versatility: Whey protein can be easily incorporated into recipes and beverages, making it a versatile ingredient for boosting protein content in meals and snacks.

Whey protein is obtained from the liquid portion of milk that separates during cheese production. When milk is coagulated to form curds and whey, the curds are used to make cheese, while the liquid whey is collected and processed further to extract whey protein.

The production of whey protein involves several steps:

➔ **Whey Separation**: After the curds are formed and removed during cheese production, the remaining liquid is whey.

➔ **Protein Concentration**: The whey is processed to concentrate the proteins by involving methods such as ultrafiltration, microfiltration, or ion exchange to remove water, lactose, and minerals, leaving behind a protein-rich liquid.

➔ **Purification**: The concentrated whey protein solution undergoes further purification to remove impurities like fat and carbohydrates. This is typically done through additional filtration steps or using enzymes or chemicals to isolate the protein fractions.

➔ **Drying:** Once purified, the whey protein solution is dried to create a powder form. This can be achieved through methods such as spray drying or freeze drying.

➔ **Packaging**: The dried whey protein powder is then packaged into containers for distribution and sale.

Meat analogs,

Meat analogs also known as meat substitutes, meat alternatives, or plant-based meats, are products designed to mimic the taste, texture, and appearance of traditional meat products while being entirely plant-based.

These products are typically made from various plant-based ingredients, such as soy, wheat gluten, pea protein, mushrooms, and other legumes, along with flavorings, seasonings, and binding agents.

Soy Protein: Soy protein is often used as a base ingredient in meat analogs due to its high protein content and ability to mimic the texture of meat when processed.
Wheat Gluten (Seitan): Wheat gluten, also known as seitan, is another protein-rich ingredient commonly used in meat analogs. It has a chewy texture that resembles meat when cooked. *Pea* ***Protein*****:** Pea protein is derived from yellow peas and is often used in meat analogs for its protein content and neutral flavor profile.
Mushrooms: Mushrooms, particularly varieties like shiitake or portobello, can be used to add meaty texture and umami flavor to meat analogs.
Legumes: Other legumes, such as lentils, chickpeas, and black beans, can also be used to provide protein, texture, and flavor to meat analogs.
Flavorings and Seasonings: Meat analogs may contain various flavorings, seasonings, and spices to enhance their taste and aroma, mimicking the flavor of traditional meat products.
Production Process:
The production process for meat analogs typically involves several steps:
➔ Ingredient Mixing: Plant-based ingredients are mixed with water, flavorings, and seasonings to form a dough or slurry.
➔ Texturization: The dough or slurry may undergo texturization processes, such as extrusion or molding, to create the desired meat-like texture.
➔ Cooking: The meat analogs are cooked using methods such as baking, frying, or steaming to achieve the desired taste and texture.
➔ Packaging: Once cooked, the meat analogs are packaged and may be sold fresh, frozen, or refrigerated, depending on the product and distribution requirements.

Benefits of meat analogs:
Plant-Based: Meat analogs provide a cruelty-free and environmentally friendly alternative to traditional meat products, as they do not require the use of animals for production.
Healthier Option: Meat analogs are often lower in saturated fat and cholesterol compared to traditional meat products, making them a healthier option for individuals looking to reduce their intake of animal products.
Variety: Meat analogs come in a wide range of flavors, textures, and forms, providing consumers with options to suit their taste preferences and dietary needs.
Sustainability: Producing meat analogs typically requires fewer resources, such as water and land, compared to traditional meat production, making them a more sustainable choice

PLANT-BASED PROTEINS
Plant-based proteins are protein-rich foods derived from plants. They offer a nutritious and sustainable alternative to animal-based proteins and are a crucial component of vegetarian,
Sources
Legumes: Legumes are a diverse group of plants that include beans, lentils, chickpeas, and peas. They are rich in protein, fiber, vitamins, and minerals. Examples include black beans, kidney beans, chickpeas, lentils, and split peas.
Soy Products: Soybeans are a complete source of protein, meaning they contain all nine essential amino acids. Soy products include tofu, , soy milk, and soy protein powder.
Whole Grains: Whole grains such as quinoa, brown rice, oats, barley,

Nuts and Seeds: Nuts and seeds are high in protein, healthy fats, vitamins, minerals, and fiber. Examples include almonds, walnuts, peanuts, cashews, chia seeds, flaxseeds, hemp seeds, and pumpkin seeds.
Seitan (Wheat Gluten): Seitan is a meat substitute made from wheat gluten. It has a chewy texture and is a popular ingredient in vegetarian and vegan dishes. Seitan is particularly high in protein and is often used as a meat alternative in recipes.
Nutritional Yeast: Nutritional yeast is a deactivated yeast that is commonly used as a flavoring agent in vegan and vegetarian dishes. It is rich in protein and B vitamins, including vitamin B12.
Vegetables:. Some vegetables, such as spinach, broccoli, Brussels sprouts, and peas, contain moderate amounts of protein.

Benefits of Plant-Based Proteins:
Nutrient-Rich: Plant-based proteins are often rich in fiber, vitamins, minerals, and antioxidants, providing a wide array of nutrients that support overall health.
Lower in Saturated Fat: Plant-based proteins are generally lower in saturated fat and cholesterol compared to animal-based proteins, which can help promote heart health and lower the risk of certain chronic diseases.
Sustainability: Producing plant-based proteins typically requires fewer resources, such as water and land, and generates fewer greenhouse gas emissions compared to animal agriculture, making them a more environmentally sustainable choice.
Versatility: Plant-based proteins can be incorporated into a variety of dishes, including soups, salads, stir-fries, sandwiches, wraps, and smoothies, providing flexibility and variety in the diet.

LIPIDS AND THEIR APPLICATIONS
BIODIESEL
Biodiesel is an animal fat-based or vegetable oil diesel fuel, including long-chain alkyl (methyl, ethyl, or propyl) esters. Biodiesel is generally made by esterifying lipids (e.g., soybean oil, vegetable oil, and animal fat (tallow)) with an alcohol generating fatty acid esters.

Here is why lipids are utilized as biodiesel:
➔ **High Energy Content:** Lipids, such as triglycerides found in vegetable oils and animal fats, Are rich in energy. When converted into biodiesel, they provide a high-energy source of fuel for various applications.
➔ **Renewable Resource**: Lipids used for biodiesel production are derived from renewable Sources such as plants (e.g., soybean, canola, palm) and animal fats, making biodiesel a sustainable alternative to fossil fuels.
➔ *Reduced Greenhouse Gas Emissions*: Biodiesel produced from lipids typically emits lower Levels of greenhouse gases compared to conventional petroleum diesel. It contributes to reducing carbon dioxide emissions and mitigating climate change.
➔ **Biodegradability**: Biodiesel derived from lipids is biodegradable, this property reduces the Environmental impact of biodiesel spills and leakage compared to petroleum-based fuels.
➔ **Domestic Production**: Many lipid sources for biodiesel production are grown domestically, Reducing dependence on imported fossil fuels, and enhancing energy security.
➔ **Compatibility with Existing Infrastructure**: Biodiesel can be used in existing diesel engines and infrastructure with little modifications.

➔ **Versatility:** Lipids can be sourced from a variety of feedstock, allowing for flexibility in Biodiesel production and reducing costs with locally available resources.

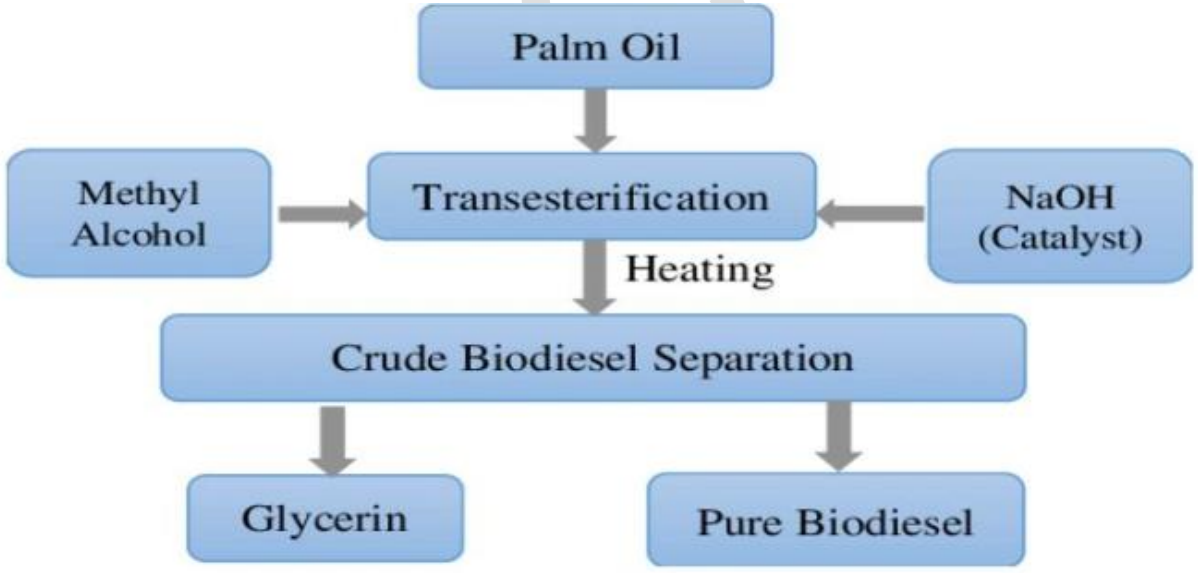
➔ **Potential for Waste Utilization**: Biodiesel can be produced from waste materials such as Used cooking oil, animal fats, and byproducts from food processing industries, contributing to waste reduction and resource efficiency.

➔ **Promotion of Rural Development**: Biodiesel production from lipid feedstock can stimulate Rural economies by creating jobs in agriculture, processing, and distribution sectors.

➔ **Technological Advancements**: Ongoing research and development efforts continue to Improve biodiesel production processes, enhance lipid feedstock availability, and optimize biodiesel performance, strengthening the viability of lipids as a source for biodiesel.

Synthesis of Biodiesel:

• Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, or animal fats.
• The fuel is produced by transesterification—a process that converts fats and oils into biodiesel And glycerin (a coproduct).
• Oil or fat are reacted with alcohol usually methanol in the presence of a catalyst such as sodium hydroxide [NaOH] or potassium hydroxide [KOH]) to form biodiesel and glycerin or Glycerol.
• Glycerin, a co-product, is a sugar commonly used in the manufacture of pharmaceuticals and Cosmetics.



Production of Biodiesel

LIPIDS AS CLEANING AGENTS

Lipids, such as vegetable oils and animal fats, can be used as cleaning agents or detergents, particularly in the form of soap. Here's how lipids function as cleaning agents:

1. Soap Formation: Soap is traditionally made by saponifying lipids with a strong base, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH), through a process known as

Saponification. This reaction converts triglycerides (the main component of fats and oils) Into glycerol and fatty acid salts, which are the active cleaning agents in soap.
2. Surfactant Properties: The fatty acid salts produced during saponification act as Surfactants, which are compounds that lower the surface tension between water and dirt, Allowing them to mix more easily. Surfactants helps in easy removal of oil, grease etc.
3. Emulsification: Lipids can emulsify oils and greases, breaking them down into smaller Droplets and dispersing them in water. Which will enhances the cleaning properties.
4. Biodegradability: These are biodegradable. They can be broken down by microorganisms in the environment into simpler compounds, reducing their impact on ecosystems.
5. Mildness: Lipid-based detergents are often gentler on the skin compared to harsher Synthetic detergents. They are less likely to cause irritation or dryness.
6. Natural Origins: Lipids derived from renewable sources, such as plant oils, offer a more Sustainable alternative to petroleum-based detergents.

These lipid detergents also have the same general structure as washing detergents i.e, a polar hydrophilic head group and a nonpolar hydrophobic tail.
These hydrophobic (water fearing) and hydrophilic (water-loving) regions, which allows them to surround emulsifying fats and oils such that enzymes effectively breaking them down into smaller particles that can be more easily removed. Thus depending on the concentration of the lipid,this biophysical interaction may result in the formation of micelles, liposomes, or lipid bilayers.

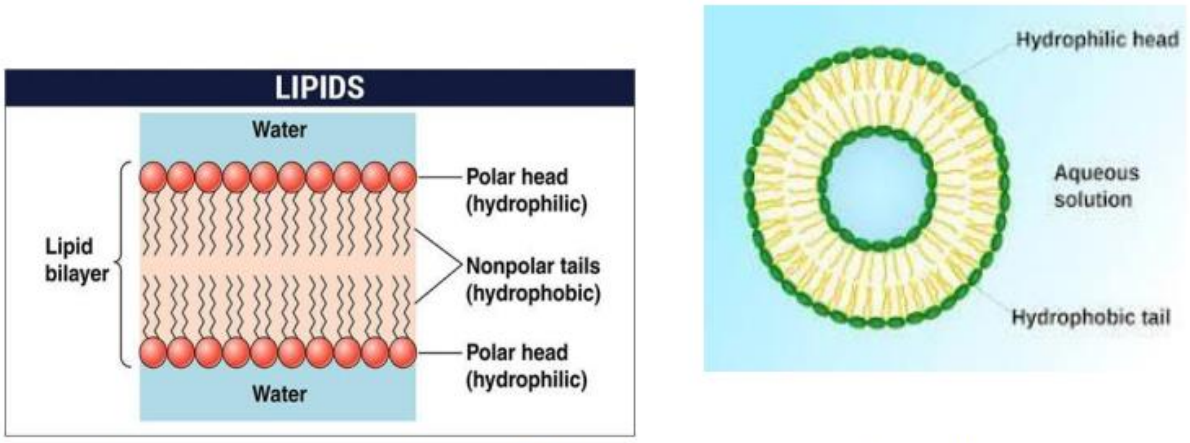
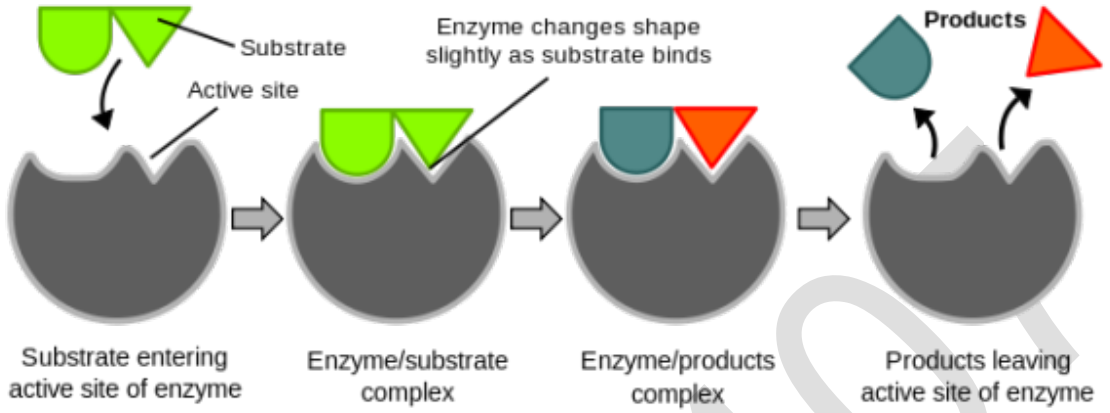


Figure: Schematic representation of lipid molecule, bilayer formation, and miscelle formation

ENZYMES
Enzymes are protein biomolecules that help to speed up metabolism or the chemical reactions in our bodies. These are also called biocatalysts..
The six kinds of enzymes are hydrolases, oxidoreductases, lyases, transferases, ligases and isomerases.
Function of enzymes:
Enzymes perform the critical task of lowering a reaction's activation energy—that is, the amount of energy that must be put in for the reaction to begin. Enzymes work by binding to reactant molecules and holding them in such a way that the chemical bond-breaking and bond-forming processes take place more readily

Enzyme possess active site where substrate will come and attach and forms the enzyme-substrate complex and once reaction is over enzyme- products complex is formed. Then the products formed will leave the active site of enzymes.



ENZYMES AND THEIR APPLICATIONS

Enzymes Glucose-oxidase in biosensors

Glucose oxidase is an enzyme commonly used in biosensors for the detection and quantification of glucose levels. Here is how it works within the context of biosensors:

Glucose biosensor was fabricated by immobilizing glucose oxidase (GOx). The immobilized GOx catalyzes the oxidation of glucose by molecular oxygen producing Gluconic acid and hydrogen peroxide. The Hydrogen peroxide is oxidized at a catalytic, classically platinum (Pt) anode. The electrode easily recognizes the number of electron transfers, and this electron flow is proportional to the number of glucose molecules present in blood.

Function: Glucose oxidase catalyzes the oxidation of glucose to produce gluconic acid and hydrogen peroxide (H2O2) according to the following reaction:

Glucose + O2 → Gluconic acid + H2O2

● **Substrate Specificity**: Glucose oxidase specifically acts on glucose molecules, making it highly selective for glucose detection.
● **Detection Principle**: In biosensors, glucose oxidase is immobilized within or on the surface of Electrodes in combination with a transducer. When glucose is present in a sample, it reacts With glucose oxidase, resulting in the production of hydrogen peroxide.
● **Electrochemical Detection**: The hydrogen peroxide generated in the enzymatic reaction serves as a measurable signal. Biosensors often utilize electrochemical methods to detect this signal.
● **Calibration:** Biosensors containing glucose oxidase require calibration to establish a Relationship between the measured signal (e.g., current or voltage) and the concentration of Glucose in the sample. Calibration curves are typically constructed using known concentrations Of glucose to determine the sensor's sensitivity and linear range.
● **Applications:** Glucose biosensors find widespread applications in medical diagnostics.

BIO BLEACHING

Bio-Bleaching is a process that uses biological agents, such as enzymes, to remove color and brighten fibers, paper, and textiles.
Ligninolytic enzymes play a key role in degradation and detoxification of lignocellulosic (Rice waste,corn waste,etc) waste in environment. The major ligninolytic enzymes are Ligninolytic fungi, lignin peroxidase, manganese peroxidase, and versatile peroxidase.

Bio-Bleaching Process and Role of Lignolytic Enzymes:

1. **Pulp Preparation**: Raw pulp obtained from wood or other lignocellulosic sources is prepared for bleaching.
2. **Enzyme Application:** Lignolytic enzymes (such as lignin peroxidase, manganese peroxidase, and laccase) are applied to the pulp mixture.These enzymes are typically produced by fungi or other microorganisms.
3. **Degradation of Lignin:** Lignolytic enzymes break down lignin, which is a complex polymer responsible for the coloration of pulp. Enzymes target and cleave the bonds within lignin molecules, resulting in its fragmentation into smaller and soluble.
4. **Removal of Lignin Fragments:** The fragmented lignin is solubilized and washed away from the pulp mixture. This process reduces the coloration and brightness of the pulp, resulting in a lighter and brighter final product.
5. **Paper Formation**:The bleached pulp is then used to produce paper or other cellulose-based products through various processing techniques, such as papermaking.

Benefits of Bio-Bleaching:

1. Environmentally Friendly: Reduces the use of harsh chemicals and minimizes environmental pollution associated with conventional bleaching methods.

2. Sustainable: Utilizes natural enzymes and microbial processes to achieve bleaching, promoting sustainability in the paper industry.

Role of enzymes In food processing:

Enzyme	Source	Applications	Benefits
Amylase	Fungi, bacteria, plants	Baking, brewing, corn syrup production	Breakdown of starch into sugars, improved dough handling, increased sweetness
Protease	Fungi, bacteria, plants, animal tissues	Meat tenderizing, cheese making, brewing	Breakdown of proteins into peptides and amino acids, improved texture and flavor

Lipase	Fungi, bacteria, plants	Dairy processing, flavor enhancement in cheese, baking	Breakdown of fats, improved flavor and texture, enhanced dough conditioning
Pectinase	Fungi, bacteria, plants	Juice clarification, wine production, fruit processing	Breakdown of pectin, improved juice yield, reduced viscosity
Cellulase	Fungi, bacteria	Juice extraction, wine production, coffee processing	Breakdown of cellulose, improved extraction efficiency, reduced turbidity
Lactase	Fungi, bacteria	Dairy processing (lactose free products)	Breakdown of lactose into glucose and galactose, reduced lactose content
Invertase	Yeast, fungi	Confectionery, soft drink production	Breakdown of sucrose into glucose and fructose, improved sweetness, and texture
Catalase	Fungi, bacteria, plants	Removal of hydrogen peroxide in milk processing, food preservation	Breakdown of hydrogen peroxide into water and oxygen, improved safety, and shelf life
Rennet (Chymosin)	Genetically engineered microorganisms	Cheese making	Coagulation of milk proteins, improved cheese yield and texture

Question bank:

1. Explain the composition, consyruction and filter mechanism in cellulose based water filter paper.
2. Illustrate the properties , advantages, applications and limitains of cellulose based water filter paper.