MODULE 2

APPLICATION OF BIOMOLECULES

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.

BIOMOLECULES AND THEIR APPLICATIONS:

What is a biomolecule?

Biomolecule, also called biological molecule, any of numerous substances that are produced by cells and living organisms.

Biomolecules have a wide range of sizes and structure and perform a vast array of functions. The four major types of biomolecules are

- ❖ Carbohydrates
- ❖ Lipids
- ❖ Nucleic acids
- ❖ Proteins

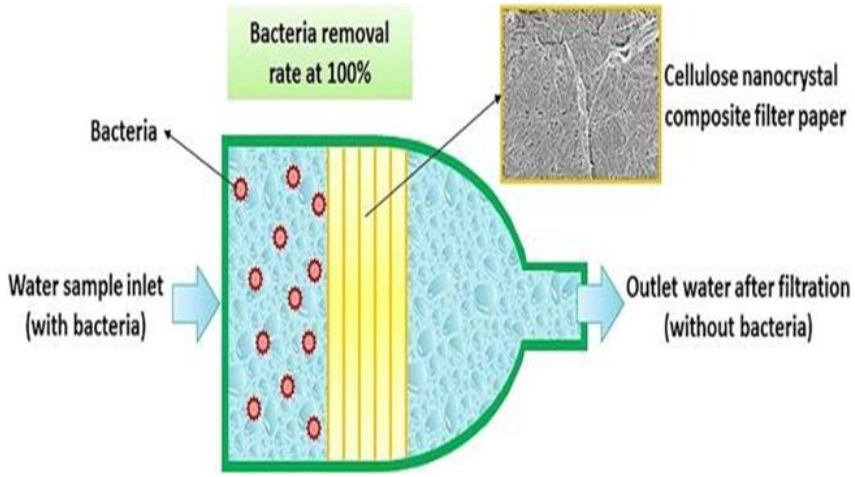
CARBOHYDRATES:

- Carbohydrates or carbs, are sugar molecules. Which are primarily of molecules containing atoms of carbon, hydrogen, and oxygen are essential energy sources and structural components of all life. They are built from four types of sugar units – monosaccharides, disaccharides, oligosaccharides and polysaccharides.
- Body breaks down carbohydrates into glucose. Glucose is the main source of energy for body's cells, tissues, and organs. Glucose can be used immediately or stored in the liver and muscles for later use.
- Sugars are called simple carbohydrates because they are in the most basic form. Starches are complex carbohydrates which are made of lots of simple sugars stung together.

CELLULOSE - BASED WATER FILTERS

- Cellulose is a complex carbohydrate or polysaccharide, consisting of 3,000 or more glucose units. It is extremely abundant, easily renewable, and biodegradable.
- Due to inter- and intramolecular hydrogen bonding between the hydroxyl groups of the neighbouring cellulose chains, cellulose is insoluble in water and is difficult to dissolve with common organic solvents.
- Taking benefit of these advantages of cellulose, we have a best application of cellulose, that is, **Cellulose-based water filters**.
- Filtration is a common way to obtain pure drinking water by removing particles and microorganisms based on size exclusion.
- Cellulose-based filters are affordable and biobased option for the removal of particles but bacteria are usually too small to be removed by size exclusion alone.

- One of the way to remove bacteria is by incorporating antibacterial metal Nanoparticles into cellulose- based water filters both silver nanoparticles (AgNPs) and copper nanoparticles (CuNPs) are known to have good antibacterial effects.
- An alternative method to physically remove bacteria from water while keeping the filter pore size larger than bacteria is to use positively charged filters that absorb negatively charged bacteria onto the surfaces of the filters.
- This allows negatively charged particles much smaller than the filter pore size to be efficiently removed from water and this is an interesting approach for removing bacteria from water without adding any toxic chemicals or reducing the flow by reducing the pore size.
- Both Gram-positive and Gram-negative bacteria have a negative net surface charge on the cell envelope, due to peptidoglycans, liposaccharides and proteins in the cell wall, and this makes their removal non-selective and efficient for most types of bacteria.



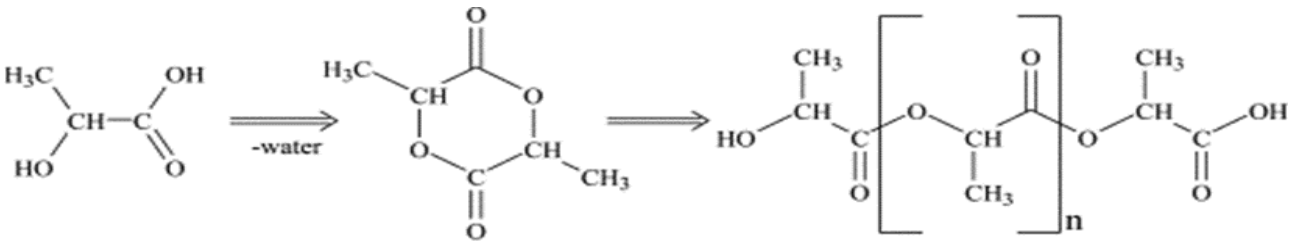
Cellulose filter papers are versatile and diverse tools for microfiltration, that work by trapping Particulates -Within a random matrix of cellulose fibres. Cellulose filter papers can be categorized as quantitative or qualitative, depending on their application.

- Advantages Renewable fiber sources
- High strength and durability
- Large surface area
- Chemical stability
- Temperature stability
- Strong adhesion to glass

BIOPLASTIC are one type of plastic which can be generated from natural resources such as starches and vegetable oils

POLY LACTIC ACID OR PLA AS BIOPLASTICS

- PLA is classified as a 100% biosourced plastic: it's made of renewable resources such as corn or sugar cane.
- Lactic acid is produced by bacterial fermentation of sugarcane or from the conversion of starch from corn.
- The lactic acid is oligomerized and then catalytically dimerized to make thelactide monomer.
- High molecular weight PLA is produced from the lactide monomer by ring opening polymerization using a **stannous octoate catalyst**



Lactic Acid cyclic lactide monomer Poly (Lactic Acid)

Application of PLA

- **Electronic Devices:** PLA is used for the production of biodegradable components in electronic devices such as smartphones and laptops.
- **Aerospace:** PLA is used for the production of biodegradable parts in aerospace applications such as insulation and cable management.
- **Sporting Goods**: PLA is used for the production of biodegradable sporting goods such as golf tees and fishing lures.
- **Construction:** PLA is used for the production of biodegradable insulation and soundproofing materials.
- **Agricultural Equipment:** PLA is used for the production of biodegradable parts in agricultural equipment such as seed trays and greenhouse film.
- **Medical :** PLA Widely used as a material for drug delivery system**,** used in tissue engineering or regenerative medicine**,** used in cardio vascular implants .

Properties of PLA as bioplastic

- **Biodegradable:** PLA can be broken down by microorganisms in industrial composting facilities, reducing waste in landfills.
- **Renewable:** PLA is derived from renewable resources such as corn starch or sugarcane, reducing dependence on finite petroleum resources.
- **Clear/Transparent:** PLA has a clear and transparent appearance, making it suitable for packaging applications.
- **Heat-resistant**: PLA has a relatively low melting temperature and is not recommended for high heat applications, but it can maintain its shape and stability up to 60°C.
- **Biocompatible:** PL.A is non-toxic and biocompatible, making it suitable for food packaging and medical devices.

- **Stiffness and Strength:** PLA has good stiffness and strength, but not as strong as traditional petroleum-based plastics.

POLYHYDROXY ALKANOATES (PHA AS BIOPLASTICS)

- PHA are produced by bacteria and micro-organisms. It's more appropriate to refer to it as biosynthesis than production.
- To make PHA, a culture of a micro-organism 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 micro-organism to synthesize PHA. PHA is be stored by the micro-organisms.
- The PHA can weight as much as 80 % of the organism's dry weight.
- The biosynthesis of PHA is usually caused by certain deficient conditionssuch as the lack of macro elements (phosphorus, nitrogen, trace elements, oxygen) and the excess supply of carbon sources.

Applications of PHA

- **Medical Devices:** PHA is biocompatible and can be used in the manufacture of medical devices such as sutures, implants, and drug delivery systems.
- **Textiles:** PHA is used in the production of biodegradable textiles, as well as for the production of biodegradable composites for use in construction and furniture.
- **Agricultural Mulch Films**: PHA is used in the production of biodegradable mulch films for agriculture to reduce soil erosion and conserve moisture.
- **Consumer Goods**: PHA is used in the production of various consumer goods, such as toys, phone cases, and water bottles.
- **Automotive Parts:** PHA is used for the production of biodegradable automotive parts such as air ducts and headlamp covers.

Properties of PLA as bioplastic

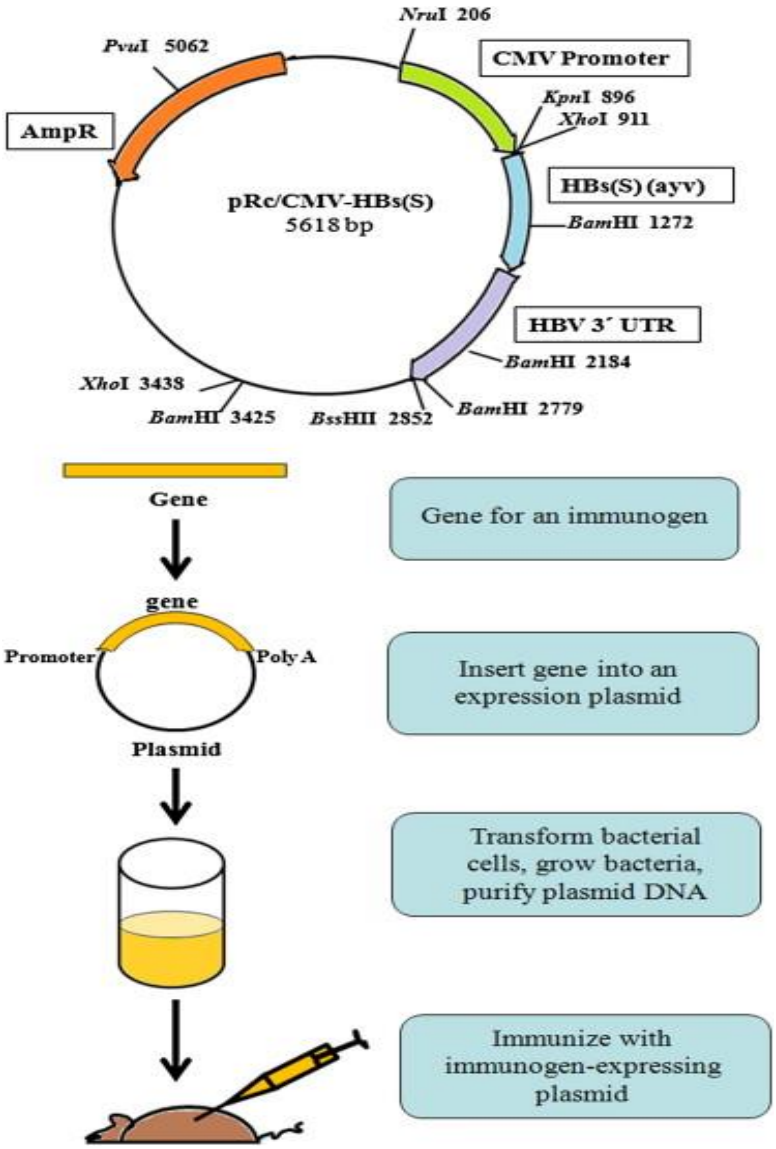
- **Biodegradability:** PHAs are biodegradable and can break down into water and carbon dioxide, reducing their impact on the environment.
- **Biocompatibility:** PHAs are biocompatible and can be used in medical devices, such as sutures and implants, without causing adverse reactions in the body.
- **Mechanical properties**: PHAs have similar mechanical properties to traditional petroleum- based plastics, making them suitable for various applications.
- **Processing:** PHAs can be processed using conventional plastic processing techniques, such as injection molding, blow molding, and extrusion.

NUCLEIC ACID:

- Nucleic acids are naturally occurring chemical compounds that serve as the primary information-carrying molecules in cells. They play an especially important role in directing protein synthesis. The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA)
- Nucleic acids are long chain like molecules composed of a series of nearly identical building blocks called nucleotides. Each nucleotide consists of a nitrogen-containing aromatic base attached to a pentose (five- carbon) sugar, which is in turn attached to a phosphate group.
- Each nucleic acid contains four of five possible nitrogen- containing bases: adenine (A), guanine (G), cytosine (C), thymine (T), and uracil (U). A and G are categorized as purines, and C, T, and U are called pyrimidines. All nucleic acids contain the bases A, C, and G; T, however, is found only in DNA, while U is found in RNA.
- The two main nucleic acids are DNA and RNA which is fundamental unit of any living organisms. Based on these factors there are many applications which are given below:

1) DNA VACCINE FOR RABIES:

- Rabies is a preventable viral disease most often transmitted through the bite of a rabid animal.
- The rabies virus infects the central nervous system of mammals, ultimately causing disease in the brain and death. Most rabies cases reported to the Centres for Disease Control and Prevention (CDC) each year occur in wild animals like bats, raccoons, skunks, and foxes, although any mammal can get rabies.
- A DNA vaccine is a type of vaccine that transfects a specific antigen-coding DNA sequence into the cells of an organism as a mechanism to induce an immune response.
- DNA vaccines, which are often referred to as the third-generation vaccines, use engineered DNA to induce an immunologic response in the host against bacteria, parasites, viruses.
- Like any other type of vaccine, DNA vaccines induce an adaptive immune response. The basic working principle behind any DNA vaccine involves the use of a DNA plasmid that encodes for a protein that originated from the pathogen in which the vaccine will be targeted.
- DNA vaccine, using a pCI-neo plasmid encoding the glycoprotein gene of a Mexican isolate of rabies virus, was developed to induce long-lasting protective immunity against rabies virus in dogs.
- DNA vaccination based on optimized formulation of lysosome-targeted glycoprotein of the rabies virus provides potential platform for preventing and controlling rabies
- There were no observational adverse effects despite high dose administration of the DNA vaccine formulation. Thus, this indicates the safety of next generation of vaccines as well as highlights their potential application.



ADVANTAGES

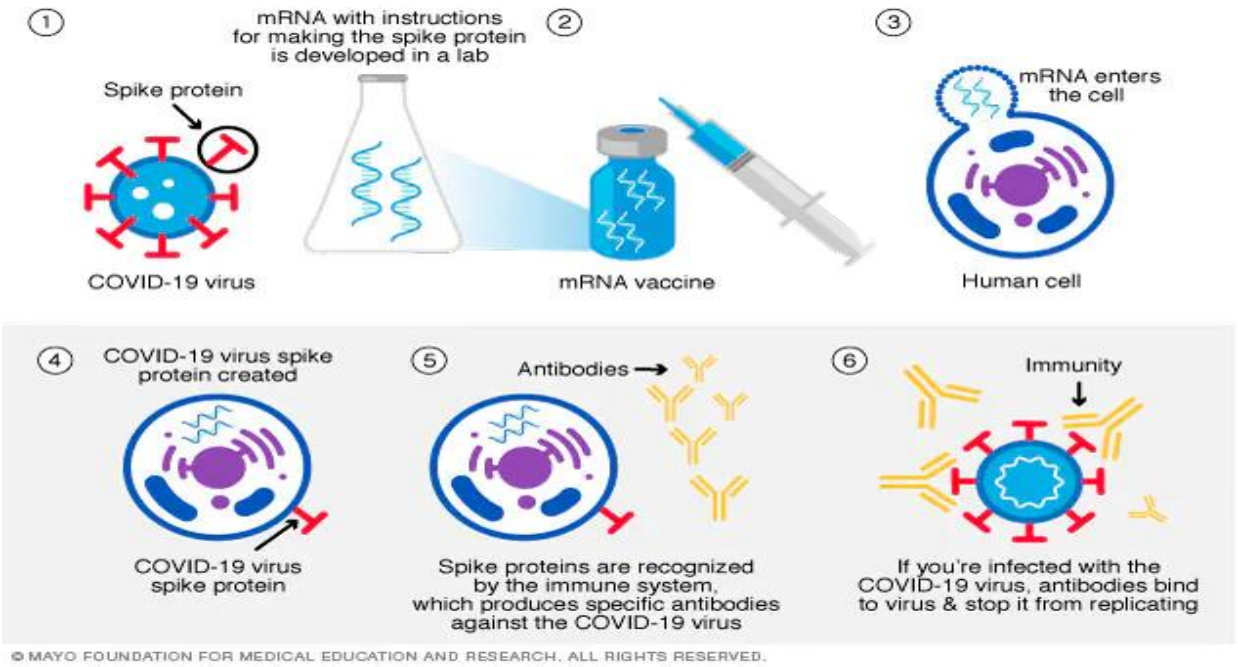
- **Efficacy:** DNA vaccines have been shown to be highly effective in preventing rabies infection in both animal and human trials. In one study, a DNA vaccine was found to be as effective as a traditional vaccine in protecting dogs against rabies.
- **Long-lasting protection:** DNA vaccines can stimulate a strong and long-lasting immune response, which means that they can provide protection against rabies for extended periods of time.
- **Ease of administration:** DNA vaccines are easy to administer, as they can be given via injection or even delivered orally, which can be particularly useful in areas where access to medical facilities is limited.
- **Cost-effective:** DNA vaccines are relatively inexpensive to produce compared to traditional vaccines, which can make them more accessible in areas where resources are limited.

RNA VACCINES FOR COVID -19

- Vaccines help prevent infection by preparing the body to fight foreign invaders (such as bacteria, viruses, or other pathogens). All vaccines introduce into the body a harmless piece of a particular bacteria or virus,

triggering an immune response. Most vaccines contain a weakened or dead bacteria or virus.

- However, scientists have developed a new type of vaccine that uses a molecule called messenger RNA (mRNA) rather than part of an actual bacteria or virus. Messenger RNA is a type of RNA that is necessary for protein production. Once cells finish making a protein, they quickly break down the mRNA. mRNA from vaccines does not enter the nucleus and does not alter DNA.
- mRNA vaccines work by introducing a piece of mRNA that corresponds to a viral protein, usually a small piece of a protein found on the virus's outer membrane.
- Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Messenger RNA, or mRNA technology, instructs cells to make a protein that generates an immune response in the body, thus producing the antibodies that provide protection against a disease.
- It is the basis for the Pfizer/BioNTech and Moderna COVID-19 vaccines being used by governments worldwide, and in the UN-supported COVAX global vaccine solidarity initiative.
- mRNA is a molecule that provides cells with instructions for making proteins.
- mRNA vaccines contain the instructions for making the SARS-CoV-2 spike protein. This protein is found on the surface of the virus that causes COVID-19.
- The mRNA molecule is essentially a recipe, telling the cells of the body how to make the spike protein. COVID-19 mRNA vaccines are given by injection, usually into the muscle of the upper arm. After the protein piece is made, the cell breaks down the instructions and gets rid of them.
- The mRNA never enters the central part (nucleus) of the cell, which is where our DNA (genetic material) is found. Your DNA can't be altered by mRNA vaccines.
- The cell then displays the protein piece on its surface. Our immune system recognizes that the protein doesn't belong there and begins building an immune response and making antibodies.



ADVANTAGES

- **High efficacy:** RNA vaccines have been shown to be highly effective at preventing COVID-19 infections. The Pfizer-BioNTech and Moderna mRNA vaccines, for example, have reported efficacy rates of around 95% in clinical trials.
- **Rapid development:** RNA vaccines can be rapidly developed and manufactured, making them particularly useful in the context of a pandemic.
- **Easy to modify:** RNA vaccines can be easily modified to target new strains or variants of the virus. This means that if a new variant emerges that is resistant to the existing vaccines, it is possible to quickly modify the vaccine to provide protection against the new strain.
- **Safe**: RNA vaccines are generally considered safe, as they do not contain any live virus particles. They work by instructing cells to produce a harmless piece of the virus.

PROTEINS

- Protein is found throughout the body in muscle, bone, skin, hair, and virtually every other body part or tissue. It makes up the enzymes that power many chemical reactions and the hemoglobin that carries oxygen in your blood.
- Proteins are large biomolecules and macromolecules that comprise one or more long chains of amino acid residues. Proteins perform a vast array of functions within organisms, including catalyzing metabolic reactions, DNA replication, responding to stimuli, providing structure to cells and organisms, and transporting molecules from one location to another. Proteins differ from one another primarily in their sequence of amino acids, which is dictated by the nucleotide sequence of their genes, and which usually results in protein folding into a specific 3D

structure that determines its activity.

PROTEIN AS FOOD

- Protein is a key part of any diet.
- Because protein is found in an abundance of foods, many people can easily meet this goal. However, not all protein "packages" are created equal. Because foods contain a lot more than protein, it's important to pay attention to what else is coming with it.
- Animal-based foods (meat, poultry, fish, eggs, and dairy foods) tend to be good sources of complete protein, while plant-based foods (fruits, vegetables, grains, nuts, and seeds) often lack one or more essential amino acid.

WHEY PROTEIN

- Is a mixture of proteins isolated from whey, the liquid material created as a by- product of cheese production. The proteins consist of alpha lactalbumin, ß-lactoglobulin, serum albumin and immunoglobulins. Glycomacropeptide also makes up the third largest component but is not a protein. Whey protein is commonly marketed as a protein supplement, and various health claims have been attributed to it.
- Whey is left over when milk is coagulated during the process of cheese production, and contains everything that is soluble from milk after the pH is dropped to 4.6 during the coagulation process.
  It is a 5% solution of lactose in water and contains the water soluble proteins of milk as well as some lipid content. Processing can be done by simple drying, or the relative protein content can be increased by removing the lactose, lipids and other non-protein materials.
- The primary usage of whey protein supplements is for muscle growth and development. Eating whey protein supplements before exercise will not assist athletic performance, but it will enhance the body's protein recovery and synthesis after exercise because it increases the free amino acids in the body's free amino acid pool.

MEAT ANALOGUES

- Meat analogues, can be defined as products that mimic meat in its functionality, bearing similar appearance, texture, and sensory attributes to meat.
- Meat analogues are plant-based products designed to replace meat
- The factors that lead to this shift is due to low fat and calorie foods intake, flexitarians, animal disease, natural resources depletion.
- Currently, available marketed meat analog products are plant-based meat in which the quality (i.e., texture and taste) are similar to the conventional meat. Examples are
- Mycoprotein – protein sourced from fungi:

Mycoprotein is a meat substitute made from a fungus called *Fusarium venenatum*. This species of fungus is high in protein, is able to be grown in large quantities and to be formed into a solid end-product.

- Tofu (bean curd) – made from coagulated soy milk: It is produced in a

similar way to cheese, with the most important step being the coagulation of proteins from soybeans then these coagulated proteins are pressed into blocks.

PLANT BASED PROTIENS

- Plant protein is simply a meaningful food source of protein which is from plants. This group can include pulses, tofu, soya, tempeh, nuts, seeds, certain grains and even peas. Pulses are a large group of plants, which include chickpeas, lentils, beans.
- Plant proteins are highly nutritious - not only as good sources of protein, but also because they provide other nutrients such as fiber, vitamins and minerals. Our intake of fiber tends to be too low, however by incorporating certain plant proteins into your diet, such as pulses, peas and nuts, you can easily boost your fiber intake.
- Consumer demand for plant protein-based products is high and expected to grow considerably in the next decade. Factors contributing to the rise in popularity of plant proteins include: (I)potential health benefits associated with increased intake of plant-based diets; (2) consumer concerns regarding adverse health effects of consuming diets high in animal protein (e.g., increased saturated fat); (3) increased consumer recognition of the need to improve the environmental sustainability of food production; (4) ethical issues regarding the treatment of animals; and (5) general consumer view of protein as positive nutrient.

Tofu, tempeh, and edamame

- Soya products are among the richest sources of protein in a plant-based diet. The protein content varies with how the soya is prepared:
- Firm tofu (soybean curds) contains about 10 g of protein per ½ cup
- Edamame beans (immature soybeans) contain 8.5 g of protein per ½ cup
- Tempeh contains about 15 g of protein per ½ cup.
- These soya products also contain good levels of calcium and iron, which makes themhealthful substitutes for dairy products.

Lentils

- Red or green lentils contain plenty of protein, fiber, and key nutrients, including iron and potassium.
- Cooked lentils contain 8.84 g of protein per ½ cup .Lentils are a great source of protein to add to a lunch or dinner routine. They can be added to stews, curries, salads, or rice to give an extra portion of protein.

Chickpeas

- Cooked chickpeas are high in protein, containing around 7.25 g per ½ cup.

Almonds

- Almonds offer 16.5 g of protein per ½ cup. They also provide a good amount ofvitamin E, which is great for the skin and eyes.

Spirulina

- Spirulina is blue or green algae that contain around 8 g of protein per 2 tablespoons. It is also rich in nutrients, such as iron, B vitamins — although

notvitamin B-12 — and manganese. It can be added to water, smoothies, or fruit juice.

LIPIDS

- Lipids are a broad group of naturally occurring molecules which includes fats, waxes, sterols, fat- soluble vitamins (such as vitamins A, D, E and K), monoglycerides, diglycerides, phospholipids, and others.
- The functions of lipids, include storing energy, signaling, and acting as structural components of cell membranes.
- Lipids are an essential component of the cell membrane. The structure is typically made of a glycerol backbone, 2 fatty acid tails (hydrophobic), and a phosphate group (hydrophilic). As such, phospholipids are amphipathic.
- In the cell membrane, phospholipids are arranged in a bilayer manner, providing cell protection and serving as a barrier to certain molecules. The hydrophilic part faces outward and the hydrophobic part faces inward. This arrangement helps monitor which molecules can enter and exit the cell.

BIODIESEL PRODUCTION

- Lipids can be converted into biodiesel, which is a renewable source of energy. Biodiesel is typically produced by transesterifying vegetable oils or animal fats with an alcohol, such as methanol, to form methyl esters. The resulting biodiesel can be used as a drop-in replacement for traditional diesel fuel in internal combustion engines.

Advantages

- **Renewability:** Lipids are a renewable resource, and they can be produced from a variety of sources, such as vegetable oils, animal fats, and microalgae.
- **Reduced emissions**: Biodiesel produces fewer emissions compared to traditional diesel fuel, reducing the impact on the environment and public health.
- **Improved performance:** Biodiesel can improve engine performance, increasing fuel efficiency and reducing engine wear and tear.
- **Biodegradability:** Biodiesel is biodegradable, which reduces the risk of environmental contamination in the event of a spill.

The Process of Obtaining Biodiesel from Lipids

- **Raw material preparation:** The lipids, such as vegetable oils or animal fats, are collected and purified to remove impurities.
- **Transesterification**: The purified lipids are mixed with an alcohol, such as methanol, and a catalyst, such as sodium hydroxide, to produce fatty acid methyl esters (FAME), which are the main components of biodiesel. This process is known as transesterification.
- **Separation**: The reaction mixture is then separated into two layers: the upper layer contains the FAME (biodiesel) and the lower layer contains the

glycerol (byproduct).

- **Washing and drying:** The biodiesel is washed with water to remove any residual alcohol and soap that was formed during the transesterification reaction.
  The biodiesel is then dried to remove any remaining moisture.
- **Purification:** The biodiesel is further purified to remove any impurities and improve its quality.

Lipids as Cleaning Agents/Detergents

- **Personal care products:** Lipids, such as fatty acids and glycerides, are commonly used as emulsifiers and surfactants in personal care products, such as shampoos, soaps, and lotions.
- **Industrial cleaning:** Lipids can be used as cleaning agents in various industrial applications, such as metal cleaning, degreasing, and stain removal.
- **Laundry detergents:** Lipids, such as fatty acids and glycerides, are used as ingredients in laundry detergents to improve their cleaning performance.
- Lipids have several properties that make them suitable as cleaning agents, including their ability to emulsify and dissolve grease and oils. Additionally, lipids can form micelles, which are tiny spherical structures that can surround and trap dirt particles, making it easier to remove them.

Working principle of lipids as cleaning agent

- The working principle of lipids as cleaning agents or detergents is based on their ability to dissolve grease and oils. Lipids are composed of hydrophobic (water-fearing) and hydrophilic (water-loving) regions, which allows them to surround grease and oils, effectively breaking them down into smaller particles that can be more easily removed.
- This is why lipids are commonly used in cleaning products such as soaps, shampoos, laundry detergents, and dishwashing liquids.
- When a lipid-based cleaning agent is applied to a surface, the hydrophobic regions of the lipid molecule surround and dissolve grease and oils, while the hydrophilic regions interact with water, allowing the mixture to be rinsed away.
- The combination of the lipid and water also forms an emulsion, which helps to suspend and remove dirt and debris. In addition, some lipids have additional properties, such as foaming or lathering capabilities, that can enhance their cleaning performance.
- For example, fatty alcohols can be used as foaming agents in shampoos, while soap is known for its lathering properties.

ENZYMES

- Are another important biomolecule, which are proteins that help speed up

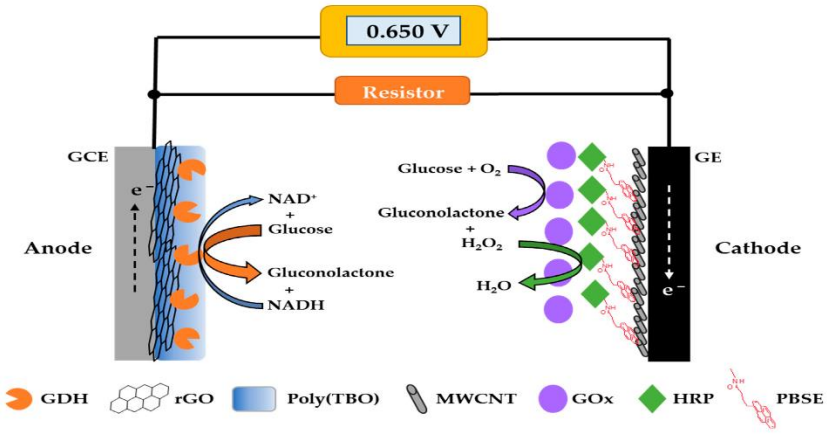
  metabolism, or the chemical reactions in our bodies. Our bodies naturally produce enzymes.
- Enzymes perform the critical task of lowering a reaction's activation

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.

- Due to their high specificity, simplicity, and scalability, enzyme-based biosensors represent a fast, precise, and continuous monitoring of analytes. Additionally, the high specificity of enzymes enhances the ability to detect lower analyte concentration limits. So enzymes are used in biosensors.
- Biosensors are employed in applications such as disease monitoring, drug discovery and detection of pollutants, disease-causing micro-organisms. Various types of biosensors being used are enzyme-based, tissue-based, immune sensors, DNA biosensors, and thermal and piezoelectric biosensors. There are wide variety of enzymes used in biosensors. One such enzyme is glucose oxidase, mainly in amperometric glucose biosensor.

GLUCOSE OXIDASE IN BIOSENSORS:

- Glucose oxidase (GOx) is widely used enzyme in glucose biosensor due to its better stability and relatively inexpensive. GOx catalyses the redox reaction and transfer electrons from enzyme active sites to electrode for glucose level analysis in blood samples.
- Amperometric glucose biosensor was fabricated by immobilizing glucose oxidase (GOx). Glucose oxidase (GOx), the most popular enzyme used for glucose detection, is able to reduce oxygen to hydrogen peroxide while at the same time transforming glucose to d-glucono-1,5-lactone. Quantification of glucose can be achieved based on either the detection of the hydrogen peroxide produced or the oxygen consumed.



LIGNOLYTIC ENZYME IN BIO BLEACHING

- The use of bacteria or enzymes or biological agents in the removal of color is termed as bio bleaching.
- Biobleaching of newspaper pulp is a critical factor in the process of paper recycling. There are many chemically based technologies for deinking of paper pulp to remove the ink entrapped in it.
- Enzymatic deinking has to overcome these disadvantages of chemical treatment through its high efficiency and low environmental impact.

- Bio-bleaching using enzymes could replace the use of chlorine and chloride compounds in the bleaching process.
- The biological deinking method using microbial enzymes is quite promising and eco-friendly, but highly challenging when compared to chemical deinking.
- Researchers have identified the bio-bleaching potential and pulp modification properties of few microbial enzymes, such as cellulase, xylanase, pectinase, mannase, laccase, and lipase.
- Newspaper is composed of ligno-cellulosic material and the lignin content tends to decrease the paper brightness upon aging process.
- Larger lignin residues will lower brightness of paper and hence the paper brightness can be achieved by delignification, a process of lignin removal.
- Hence, the lignolytic systems are essential in the bio-bleaching process to achieve the paper brightness.
- Ligninolytic enzymes play a key role in degradation and detoxification of lignocellulosic waste in environment. The major ligninolytic enzymes are laccase, lignin peroxidase, manganese peroxidase, and versatile peroxidase.
- White-rot fungi are the main producers of lignin-oxidizing enzymes. These fungi secrete a number of oxidative enzymes
- The most important lignin-oxidizing enzymes are lignin peroxidases, manganese peroxidases and laccases. Lignin peroxidase and manganese peroxidase appear to constitute a major component of the ligninolytic system.

QUESTION BANK

BTL L1 QUESTIONS

1. What are carbohydrates?
2. What are bioplastics?
3. What are proteins?
4. What are Nucleic acids?
5. What are lipids?
6. Define DNA finger printing.
7. Define bio bleaching?
8. Define meat analogues.

BTL L2 QUESTIONS

1. How cellulose is used as water filters explain? Mention its advantages.
2. Briefly explain PLA as bioplastic. Mention its application and properties.
3. Briefly explain PLA as bioplastic. Mention its application and properties.
4. Write short note on DNA vaccines for rabies.
5. Write short note on RNA vaccines for COVID-19.
6. Explain DNA finger printing in brief.
7. What are meat analogues. Give examples
8. Explain plant based proteins with examples.
9. Explain the process of biodiesel production. Mention the advantages
10. Explain the role of glucose oxidase in biosensors.
11. Mention the role of lignolytic enzymes in bio bleaching.