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 structures to perform a vast array of functions. The four major types of biomolecules are carbohydrates, lipids, nucleic acids, and proteins. Among biomolecules, nucleic acids, namely DNA and RNA, have the unique function of storing an organism's genetic code—the sequence of nucleotides that determines the amino acid sequence of proteins, which are of critical importance to life on Earth.

There are 20 different amino acids that can occur within a protein. Proteins themselves are major structural elements of cells. They also serve as transporters, moving nutrients and other molecules in and out of cells, and as enzymes and catalysts many chemical reactions that take place in living organisms. Proteins also form antibodies and hormones, and they influence gene activity.

Carbohydrates are made up primarily of molecules containing atoms of carbon, hydrogen, and oxygen, are essential energy sources and structural components of all life, and they are among the most abundant biomolecules on Earth. They are built from four types of sugar units — monosaccharides, disaccharides, oligosaccharides, and polysaccharides.

Lipids, another key biomolecule of living organisms, fulfill a variety of roles, including serving as a source of stored energy and acting as chemical messengers. They also form membranes, which separate cells from their environments and compartmentalize the cell interior, giving rise to organelles, such as the nucleus and the mitochondrion, in higher (more complex) organisms. Examples include cytidine, uridine, adenosine, guanosine, and thymidine.

The main applications of biomolecules are: The biomolecules may involve in several processes such as energy storage (carbohydrates), catalyzing the biochemical reactions (hormones), storing/transmitting the genetic codes (RNA/DNA), or altering biological and neurological activities (neurotransmitter/hormones).

CARBOHYDRATES:

Carbohydrates, or carbs, are sugar molecules. Along proteins and fats, carbohydrates are one of three main nutrients found in foods and drinks. Body breaks down carbohydrates into glucose. Glucose, or blood sugar, is the main source of energy for your body's cells, tissues, and organs. Glucose can be used immediately or stored in the liver and muscles for later use.

1) Sugars: They are also called simple carbohydrates because they are in the most basic form. They can be added to foods, the sugar in candy, desserts, processed foods, and regular soda. They also include the kinds\6f sugar that are found naturally in fruits, vegetables, and milk. Starches. They are complex carbohydrates, which are made of lots of simple sugars strung together. Your body needs to break starches down into sugars to use them for energy. Starches include bread, cereal, and pasta.

2) Cellulose: 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, despite being hydrophilic, 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.

The interest in the use of biobased filters for water purification has increased in recent years, as such filters have the potential to be affordable, lightweight and biodegradable. Research has been focused on creating biobased membranes for micro- and ultrafiltration from cellulose nanofibrils (CNF5s).

Filters based on cellulose pulp fibers do usually have large pores that facilitate water percolation but they do not sufficiently remove bacteria through size exclusion; other techniques are therefore needed to achieve a bacteria-reducing effect. Several groups have addressed this issue 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. All alternative method to physically remove bacteria from water, while keeping the inner pore size larger than bacteria, is to use positively charged filters that adsorb 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 foremoving 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.

Methods used for the same are:

- LBL [Layer By Layer]
- MODIFICATION NITROGEN ANALYSIS
- SEM [Scanning Electron-Microscope]
- FLOW RATE FOR EREE FLOW FILTRATION
- BACTERIAL REMOVAL EFFICIENCY OF FILTRATION
- FILTRATION OF NATURAL WATER SAMPLES
- FLOURESCENCE MICROSCOPY

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

POLY LACTIC ACID [PLA] AND POLYHYDROXYALKANOATES [PHA]:

Just like, how we introduced biodegradable water treatment plant from cellulose, we also have a replacement for toxic, non-biodegradable plastics which we are using in our daily life. That is, Bioplastics.

Bioplastics are one type of plastic which can be generated from natural resources such as starches and vegetable oils: Bioplastics are basically classified as bio based and/or biodegradable. Not all bio-based plastics are biodegradable and similarly not all biodegradable plastics are bio based. Bioplastics are referred to as bio based when the focus of the material is on the origin of the carbon building, block and not by where it ends up at the end of its cycle life.

Bio plastics are said to be biodegradable if they are broken down with the effect of the right environmental conditions and microbes which in turn use them as a food source. The bioplastics are considered compostable if within 180 days, a complete microbial assimilation of the fragmented food source takes place in a compost environment.

Based upon this, we have PHA and PLA.

PLA is both: biobased and biodegradable under industrial co rh 'ng conditions (at a high temperature, around 58 °C). Because of its good mechanical properties, processability, renewability, and non-toxicity, PLA is considered today, one of the most commercially promising bioplastics. When compared with most other biodegradable polymers, PLA has better durability, transparency, and mechanical strength.

PHAs are a significant polymer family that are100% bio-based and bio-degradable. PHAs are microbiologically produced polyesters that has tunable physical and mechanical properties. This is accompanied by low environmental impact due to their biodegradability and non-toxicity to nature. Therefore, they are promising candidate sustainable future manufacturing. Ranging from brittle thermoplastics to gummy elastomers, PHAs' properties can be altered by the selection of bacteria, fermentation conditions, ana substrate. Due to their flexible properties, PHAs can eventually substitute PP, polyethylene (PE), and polystyrene (PS), which are the main polymers of today's global polymer market.

NUCLEIC ACID:

Nucleic acids are biopolymers, macromolecules, essential to known forms of life. They are composed of nucleotides, which are the monomers made of components: a 5-carbon sugar, a phosphate group and a nitrogenous base. The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). If the sugar is ribose, the polymer is RNA; if the sugar is the ribose derivative deoxyribose the polymer is DNA.

Nucleic acids are naturally occurring chemical, compounds that serve as the primary information-carrying molecules in cells and make up the genetic material. Nucleic acids are found in abundance in all living things, where they create, encode, and then store information of every living cell of every life-form on Earth. In turn, they function to transmit and express that information inside and outside the cell nucleus to the interior Operations of the cell and ultimately to the next generation of each living organism. The encoded “information is contained and conveyed via the nucleic acid sequence, which provides the ‘ladder-step' ordering of nucleotides within the molecules of RNA and DNA. They play an especially important role in directing protein synthesis.

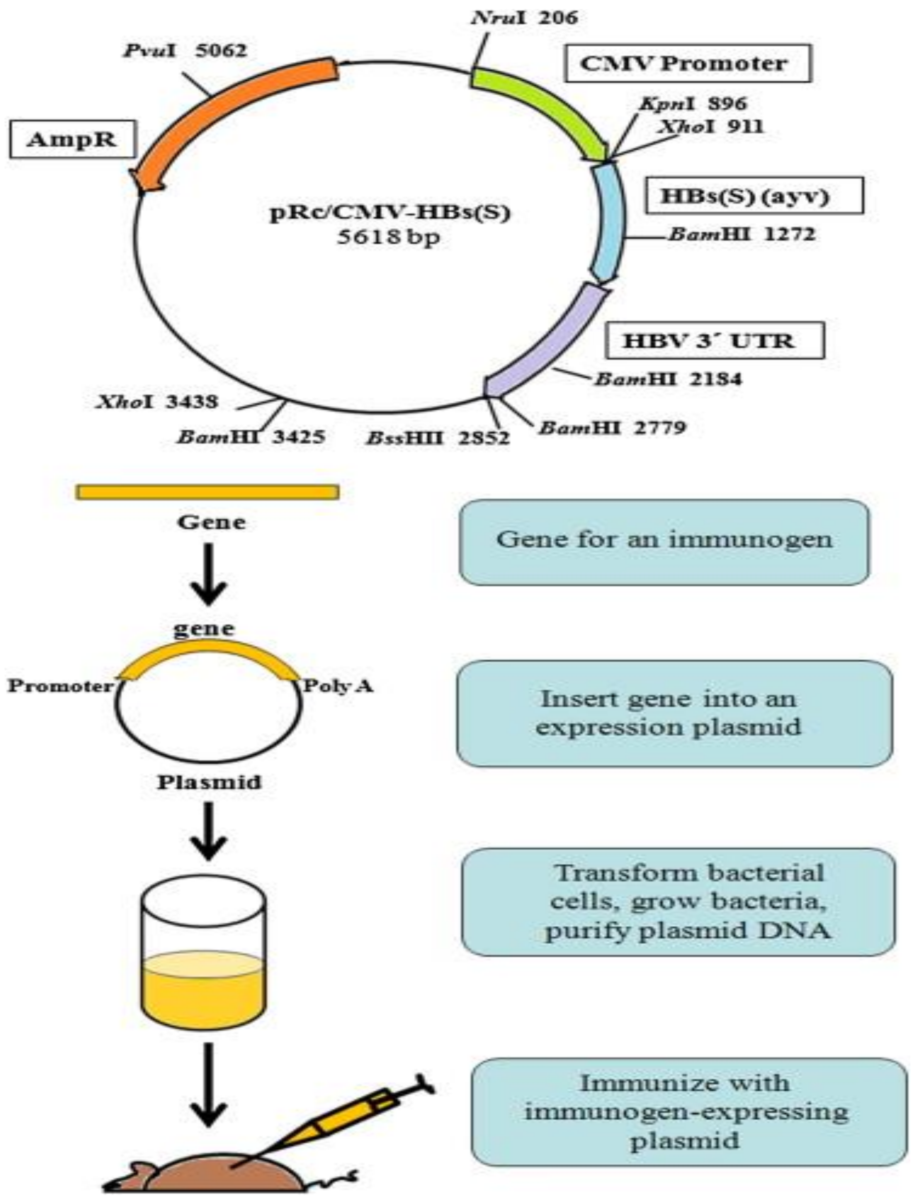
The two main nucleic acids are DNA and RNA, which is the fundamental unit of any living organisms Based on these factors, there are many applications for the same, some of which are explained, below:

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, 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. The worldwide incidence of rabies and high rates of therapy failure, despite availability of effective vaccines indicate the need for timely and improved prophylactic approaches. DNA vaccination based on optimized formulation of lysosome-targeted glycoprotein of the rabies virus provides potential platform for preventing and controlling rabies. A range of parameters including physical, physiological, clinical, immunological, haematological along with histopathology profiles of target organs was monitored to assess the impact of vaccination.

There were no observational adverse effects despite high dose administration of the DNA vaccine formulation. Thus, the safety of next generation of vaccines as well as highlights their potential application.

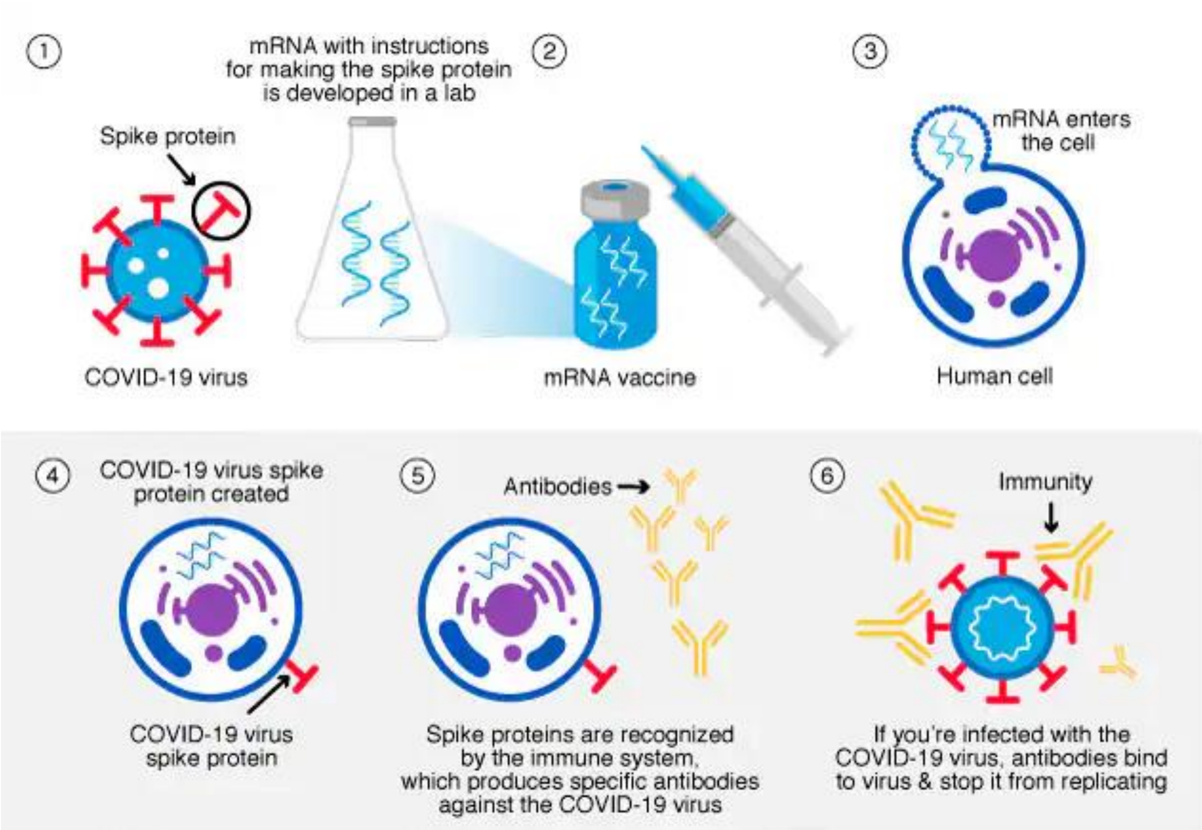


2) RNA VACCINE FOR COVID-19

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.

Messenger ribonucleic acid (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 cannot 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.



3) FORENSIC-DNA FINGERPRINTING:

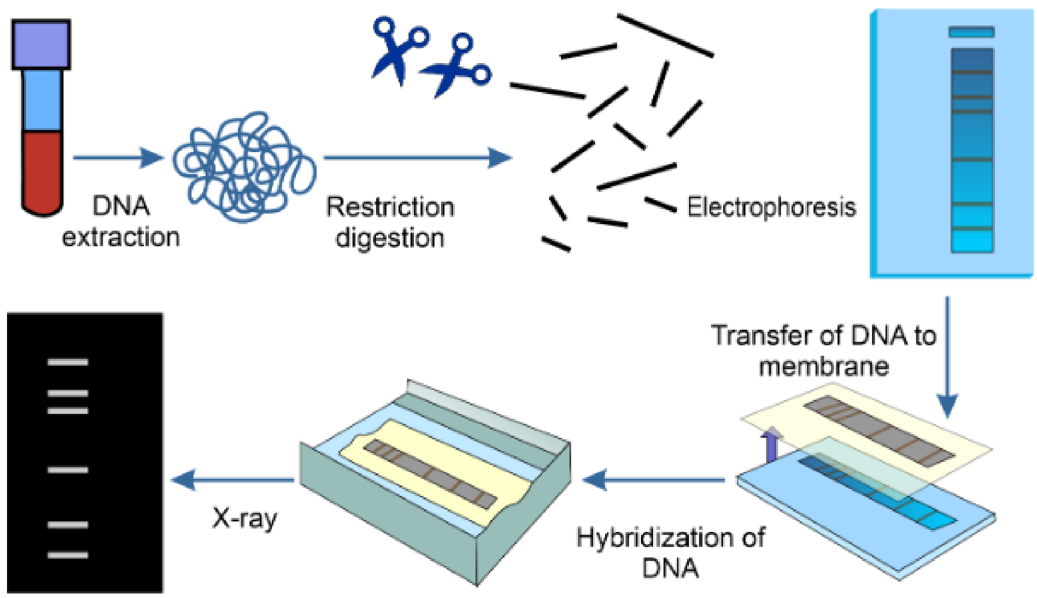
DNA fingerprinting, also called DNA typing, DNA profiling, genetic fingerprinting, genotyping, or identity testing, in genetics, method of isolating and identifying variable elements within the base-pair sequence of DNA (deoxyribonucleic acid).

The procedure for creating a DNA fingerprint consists of first obtaining a sample of cells, such as skin, hair, or blood cells, which contain DNA. The DNA is extracted from the cells and purified; the DNA was then cut at specific points along the strand with proteins known as restriction enzymes. The enzymes produced fragments of varying lengths that were sorted by placing-them on a gel and then subjecting the gel to an electric current (electrophoresis): the shorter the fragment, the more quickly it moved toward the positive pole (anode).

The sorted double-stranded DNA fragments were then subjected to a blotting technique in which they were split into single strands and transferred to a nylon sheet. The fragments underwent autoradiography in which they were exposed to DNA probes —pieces of synthetic DNA that were made radioactive and that bound to the minisatellites. A piece of X-ray film was then exposed to the fragments, and a dark mark was produced at any point where a radioactive probe had become attached. The resultant pattern of marks could then be analysed.

The DNA testing process is comprised of four main steps, including extraction, quantitation, amplification, and capillary electrophoresis. DNA fingerprinting is a laboratory technique used to determine the probable identity of a person based on the nucleotide sequences of certain regions.6f human DNA that are unique to individuals.

Forensic genetic fingerprinting can be defined "as the comparison of the DNA in a person's nucleated cells with that identified in biological matter found at the scene of a crime or with the DNA of another person for the purpose-of identification or exclusion. The application of these techniques introduces new factual evidence to criminal investigations and court cases.



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 catalysing 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.

Proteins are assembled from amino acids using information encoded in genes. Each protein has its own unique amino acid sequence that is specified by the nucleotide sequence of the gene encoding this protein. The genetic code is a set of three-nucleotide sets called codons and each three-nucleotide combination designates an amino acid.

The process of synthesizing a protein from an mRNA template is known as translation. The mRNA is loaded onto the ribosome and is read three nucleotides at a time by matching each codon to its base pairing anticodon located on a transfer RNA molecule, which carries the amino acid corresponding to the codon it recognizes. The enzyme aminoacyl tRNA synthetase "charges" the tRNA molecules with the correct amino acids. The growing polypeptide is often termed the nascent chain. Proteins are always biosynthesized from N-terminus to C-terminus.

Proteins are the chief actors within the cell, said to be carrying out the duties specified by the information encoded in genes. Except for certain types of RNA, most other biological molecules are relatively inert elements upon which proteins act.

PROTEIN AS FOOD:

Protein is a key part of any diet. The average person needs about 7 grams of protein every day for every 20 pounds of body weight. 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.

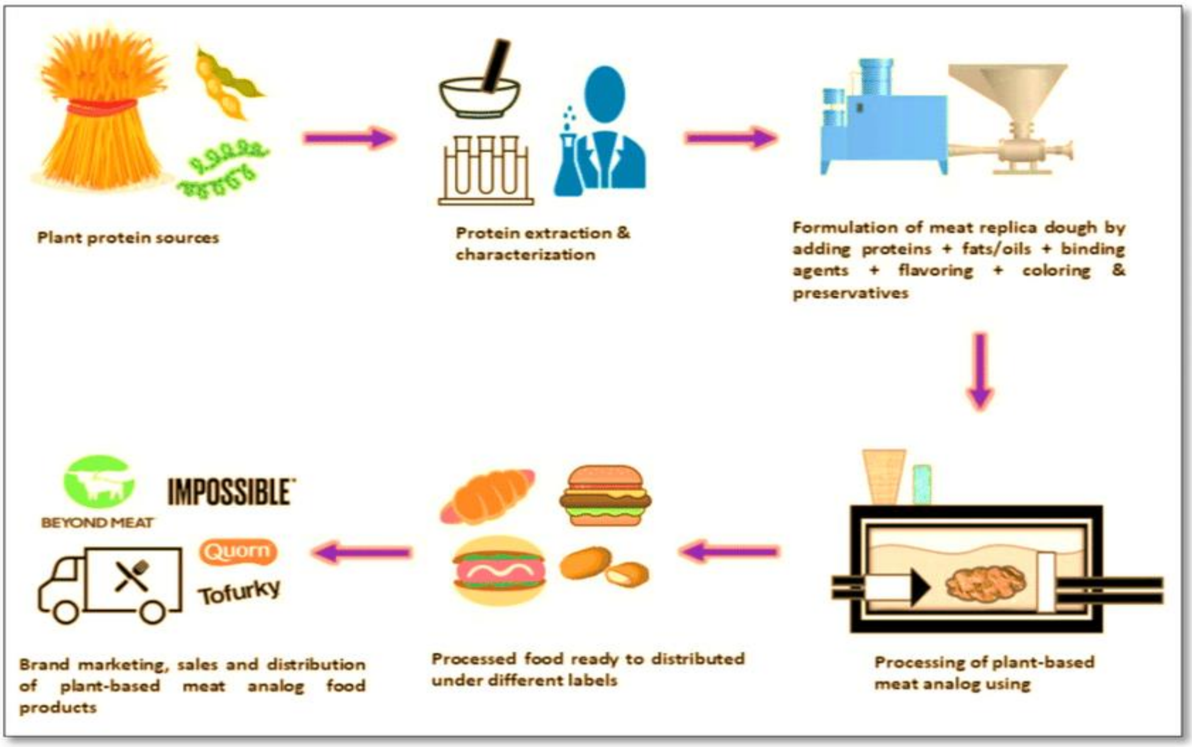
Animal-based foods (meat, poultry, fish, eggs, and dairy foods) tend to be good sources of complete protein, while plant-based foods (fruits, vegetables, grains, nuts, and seeds) often lack one or more essential amino acid.

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 a-lactalbumin, f-lactoglobulin, serum albumin and immunoglobulins. Whey protein is commonly marketed as a protein supplement, and various health.

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 if 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 find raising interest of many consumers who are looking for indulgent, healthy, low environmental impact, ethical, cost-effective, and/or new food products. High moisture extrusion cooking enables the production of fresh, premium meat analogues that are texturally like muscle meat-from plant or animal proteins. The appearance and eating sensation are like cooked meat while high protein content offers a similar nutritional value. This article focuses on plant-based meat analogues and covers process and product-related aspects including ingredients and structure formation, flavor, taste and nutritional value, post-extrusion processing, packaging and shelf life, consumer benefits, and product-related environmental impacts.

Meat analogues, can be defined as products that mimic meat in its functionality, bearing similar appearance, texture, and sensory attributes to meat. Production of meat analogues has been on the increase, targeted at satisfying consumers desire for indulgent, healthy, low environmental impact, and ethical meat substitutes. The factors that lead to this shift is due to low fat and calorie foods intake, flexitarians, animal disease, natural resources depletion, and to reduce greenhouse gas emission. Currently, available marketed meat analogue products are plant-based meat in which the quality (i.e., texture and taste) are similar to the conventional meat. The ingredients used are mainly soy proteins with novel ingredients added, such as mycoprotein and soy leghaemoglobin.



PLANT BASED PROTEINS:

Plant protein is simply a meaningful food source of protein which is from plants. This group can include pulses, tofu, soya, tempeh, seitan, nuts, seeds, certain grains and even peas. Pulses are a large group of plants, which-include chickpeas, lentils, beans (such as black, kidney and adzuki beans) and split peas.

Plant proteins are-highly nutritious — not only as good sources of protein, but also because they provide other nutrients such as fibre, vitamins and minerals. Our intake of fibre 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 fibre 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: (1) 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 a “positive” nutrient (more is better). While there is health and physical function benefits of diets higher in plant-based protein, the nutritional quality of plant proteins may be inferior in some respects relative to animal proteins.

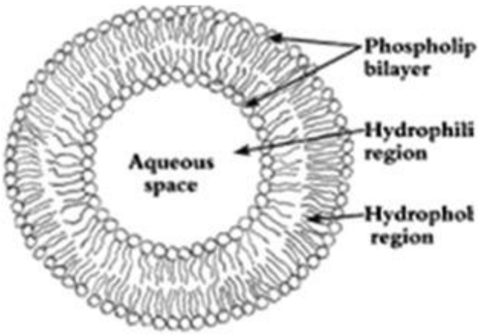
LIPIDS:

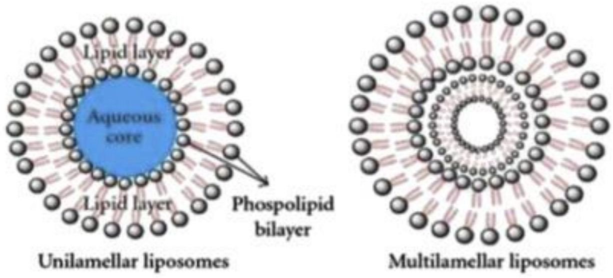
Lipids, are a broad group of naturally occurring molecules which includes fats, waxes, sterols, fat-soluble vitamins (such as vitamins A, D, E and K), monoglycerides, diglycerides, phospholipids, and others. The functions of lipids include storing energy, signalling, and acting as structural components of cell membranes. Lipids have applications in the cosmetic and food industries, and in nanotechnology.

Lipids may be broadly defined as hydrophobic or amphiphilic small molecules; the amphiphilic nature of some lipids allows them to form structures such as vesicles, multilamellar/unilamellar liposomes, or membranes in an aqueous environment. Biological lipids originate entirely or in part from two distinct types of biochemical subunits or "building-blocks": ketoacyl and isoprene groups.

Using this approach, lipids may be divided into eight categories: fatty acyls, glycerolipids, glycerophospholipids, sphingolipids, saccharolipids, and polyketidés (derived from condensation of ketoacyl subunits); and sterol lipids and prenol lipids (derived from condensation of isoprene subunits).

A biological membrane is a form of lamellar phase lipid bilayer. The formation of lipid bilayers is an energetically preferred process when the glycerophospholipids described above are in an aqueous environment. This is known as the hydrophobic effect. In an aqueous system, the polar heads of lipids align towards the polar, aqueous environment, while the hydrophobic tails minimize their contact with water and tend to together, forming a vesicle; depending on the concentration of the lipid, this interaction may result in the formation of micelles, liposomes, or lipid bilayers. Other are also observed and form part of the polymorphism of amphiphile behavior.

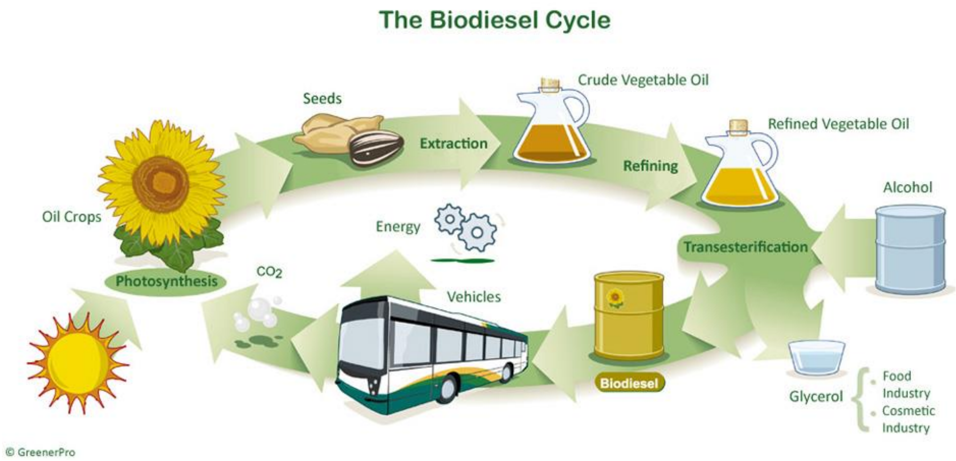




Some of the applications are: Within the body, lipids function as an energy reserve, regulate hormones, transmit nerve pulses, cushion vital organs, and transport fat-soluble nutrients. Fat source with high caloric density, adds texture and taste, and contributes in food serves as an energy to satiety.

Lipid obtained food waste was used as a potential feedstock for biodiesel production using catalyst and a biocatalyst. Base (KOH) catalyzed transesterification of the lipid conversion of biodiesel in 2 h; whereas, Novozyme-435 yielded 90% biodiesel in are having a main application in biodiesel production in 24 h.

Biodiesel demonstrates an animal fat-based or vegetable oil diesel fuel, including long-chain alkyl 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. Biodiesel is suggested to be utilized in standard diesel engines and is thus well defined from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used singly or blended with gasoline in any proportions. Biodiesel blends can also be utilized as heating oil.



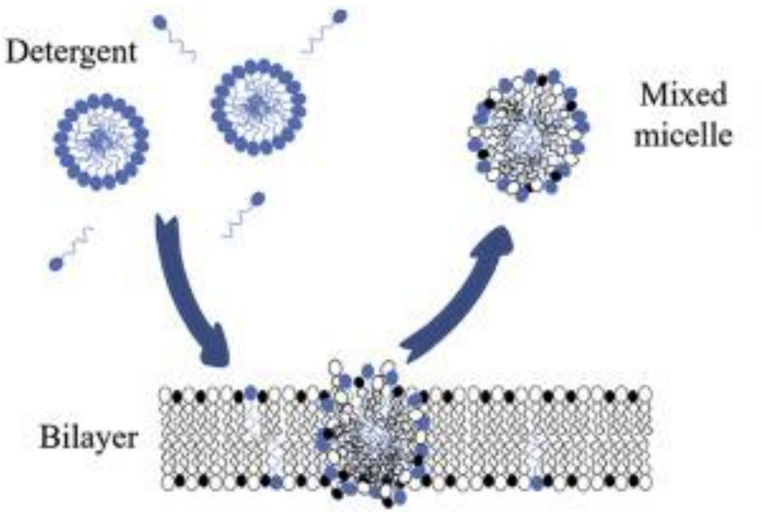
Lipids also has an interesting application in cleaning agents. Considering

DETERGENTS:

The hydrophobic end of the phospholipid bilayer stays away from the water. This avoids dissolution of cell membrane in water. But the detergent can bind to the hydrophobic end of the cell membrane and form a solution with water, thus cell membrane barrier.

Detergent monomers solubilize membrane proteins by partitioning into the membrane bilayer. With increasing amounts of detergents, membranes undergo various stages of solubilization. The initial stage is lysis or rupture of the membrane. the case of

While lipids also have the same structure as detergents—a polar hydrophilic head group and a nonpolar hydrophobic tail—lipids differ from detergents in the shape of the monomers, in the type of aggregates formed in solution, and in the concentration, range required for aggregation.



ENZYMES:

Are another important biomolecule, which are proteins that help speed up metabolism, or the chemical reactions in our bodies. They build some substances and break others down. All living things have enzymes. Our bodies naturally produce enzymes. The six kinds of enzymes are hydrolases, oxidoreductases, lyases, transferases, isomerases.

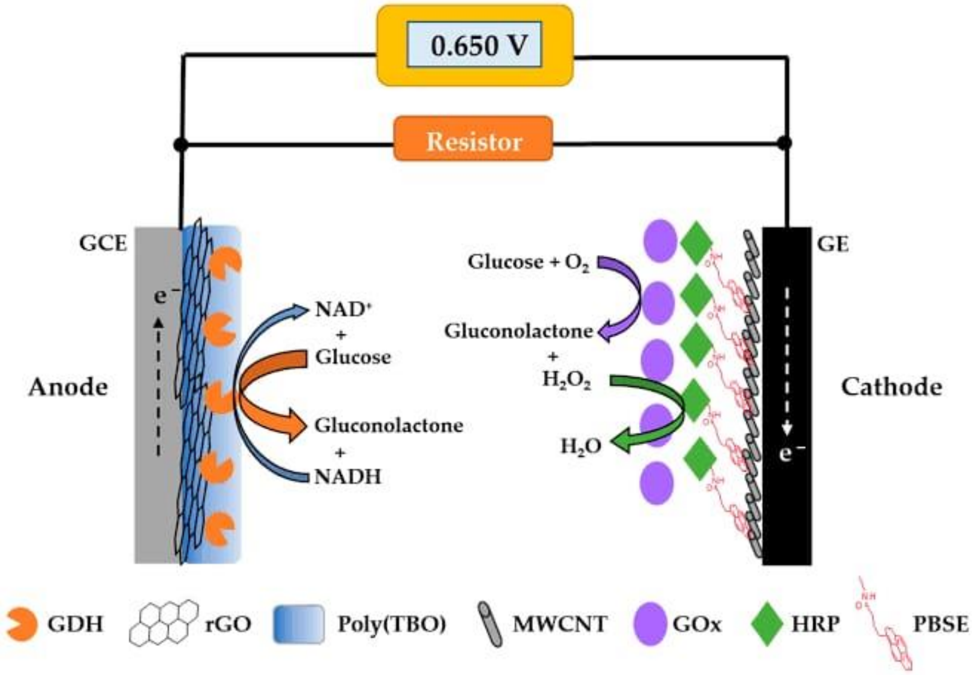
Enzymes perform the critical task of lowering a reaction's activation energy —that of energy that must be put in for the reaction to begin. Enzymes work by binding to reactant molecules and holding them in such a way that the chemical bond breaking and bond-forming processes take place more readily.

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 limit. 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 and that are indicators of a disease in bodily fluids (blood, urine, saliva, sweat). Various types of biosensors being used are enzyme-based, tissue-based, immunosensors, 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

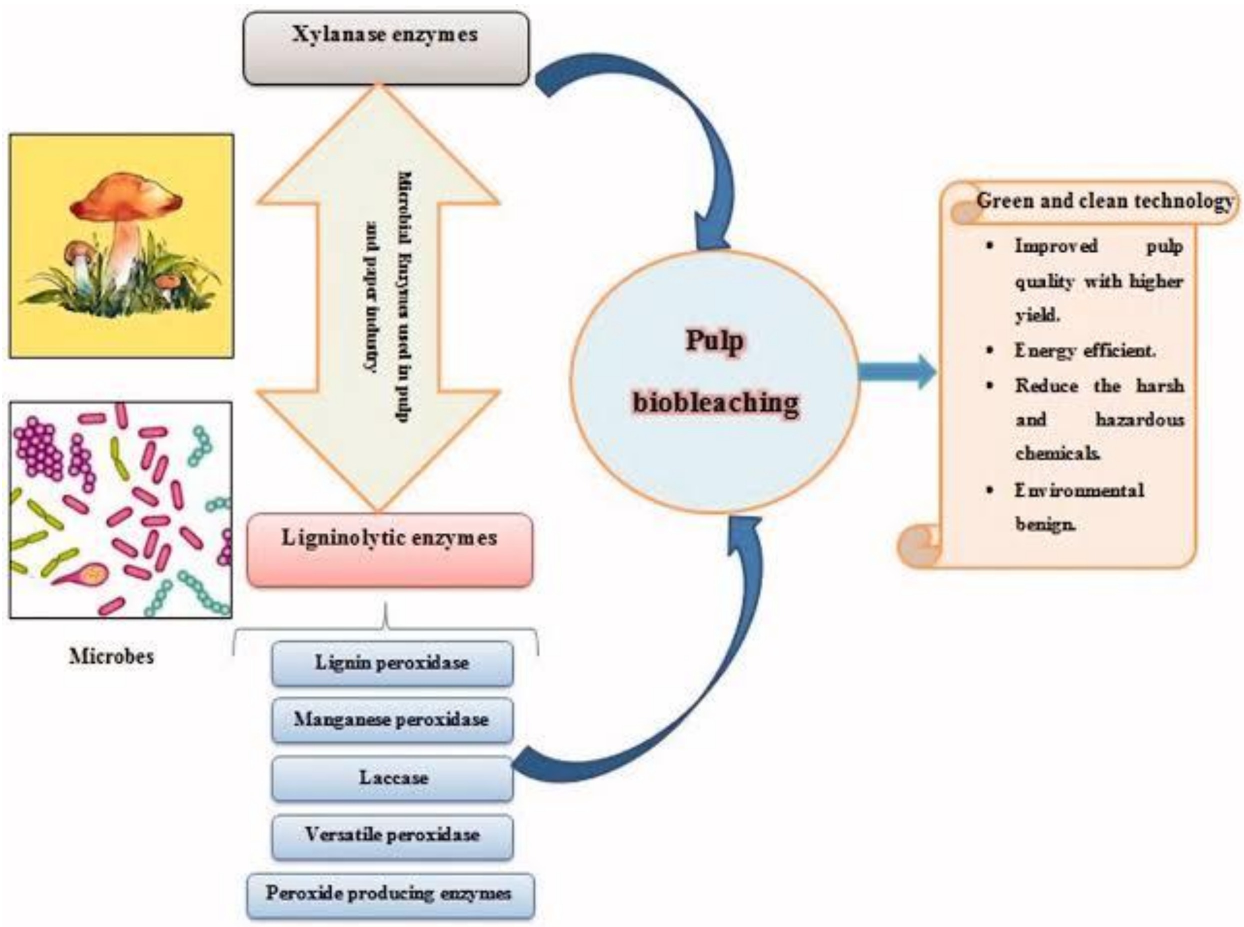
Glucose oxidase (GOX) is widely used enzyme in glucose biosensor due to its better stability and relatively inexpensive. Gox catalyses the redox reaction and transfer electrons from enzyme active sites to electrode for glucose level analysis in blood samples. Amperometric glucose biosensor was fabricated by immobilised glucose oxidase (GOx). Glucose oxidase (GOx), the most popular enzyme used for glucose detection, can reduce oxygen to hydrogen peroxide while at 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:

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. Ligninolytic fungi and enzymes (i.e., laccase, manganese peroxidase, and lignin peroxidase) have been applied recently in the production of second-generation biofuels.

White-rot fungi are the main producers of lignin-oxidizing enzymes. These fungi secrete a number of oxidative enzymes and some hitherto unknown substances (mediators) into their environment together effecting a slow but continuous degradation. The most important lignin-oxidizing peroxidases, manganese peroxidases and laccases. Lignin peroxidase and manganese peroxidases appear to constitute a major component of the ligninolytic system.



Xylanase enzymes
Microbial Enzymes used in pulp and paper industry
Microbes
Pulp biobleaching
Green and clean technology
Improved pulp quality with higher yield.
Energy efficient.
Reduce the harsh and hazardous chemicals.
Environmental benign.
Ligninolytic enzymes
Lignin peroxidase
Manganese peroxidase
Laccase
Versatile peroxidase
Peroxide producing enzymes