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Biology for Engineers

Department of CHEMISTRY

Date: 17.01.2025

MODULE - 2
BIOMOLECULES AND THEIR APPLICATIONS (QUALITATIVE)

•Carbohydrates (cellulose-based water filters, PHA and PLA as bioplastics),

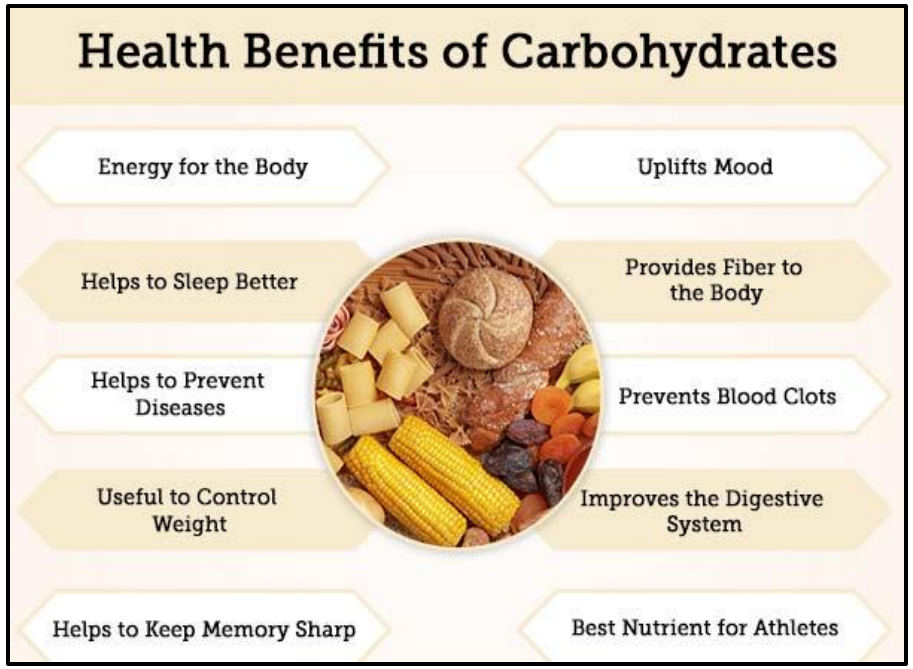
•Nucleic acids (DNA Vaccine for Rabies and RNA vaccines for Covid19, Forensics – DNA fingerprinting),

• Proteins (Proteins as food – whey protein and meat analogs, Plant based proteins), lipids (biodiesel, cleaning agents/detergents),

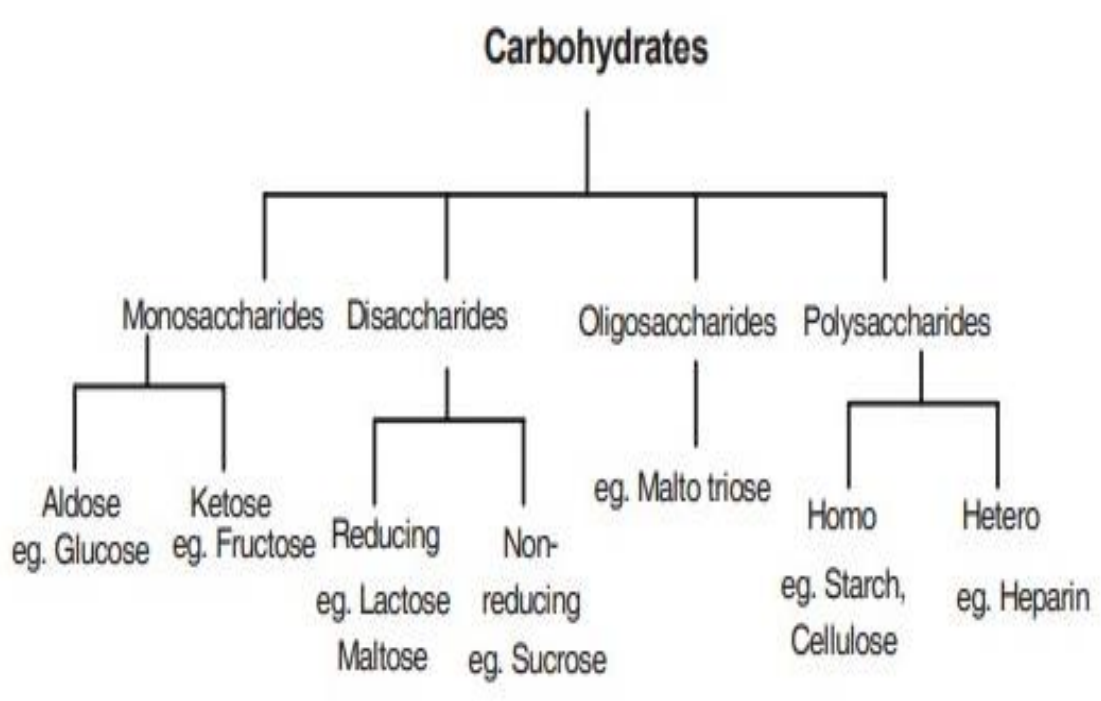
•Enzymes (glucose-oxidase in biosensors, lignolytic enzyme in bio-bleaching).

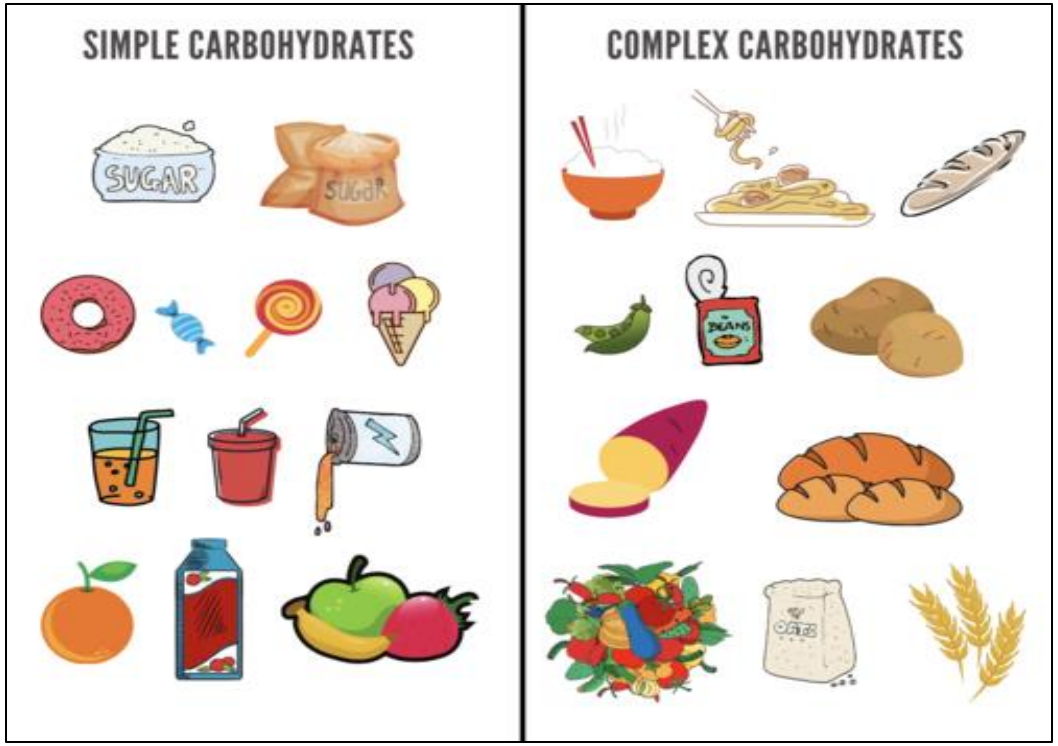
WHAT ARE CARBOHYDRATES

•Carbohydrates are macronutrients and are one of the three main ways by which our body obtains its energy.
•They are called carbohydrates as they comprise ***carbon***, ***hydrogen*** and ***oxygen*** at their chemical level.
•Carbohydrates are essential nutrients which include sugars, fibers and starches.
•They are found in grains, vegetables, fruits and in milk and other dairy products.
•They are the basic food groups which play an important role in a healthy life.



CLASSIFICATION



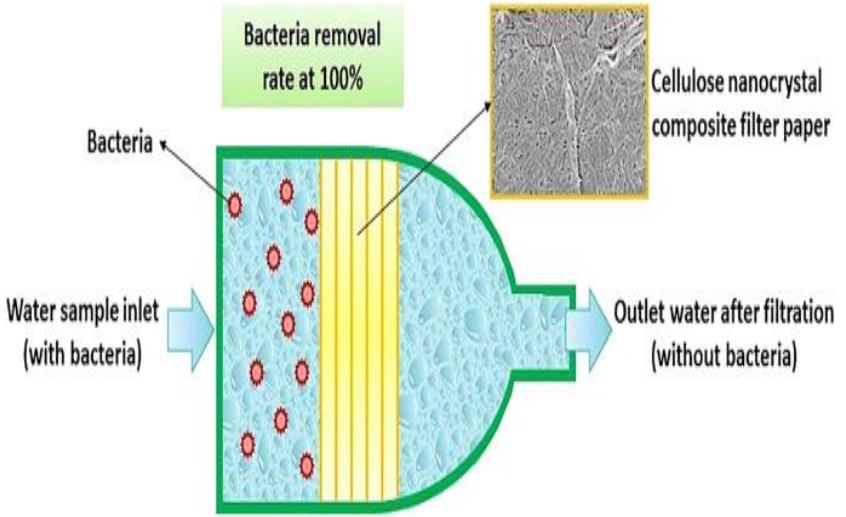


APPLICATIONS

➢**Cellulose-Based Water Filters:**

•Cellulose is a polymer made up of glucose subunits.
•Cellulose filter papers are versatile and diverse tools for microfiltration, that work by trapping particulates within a random matrix of cellulose fibers.
•Cellulose is among the most commonly used fibers in filtration media.

•Cellulose filter media is widely used in a range of applications.



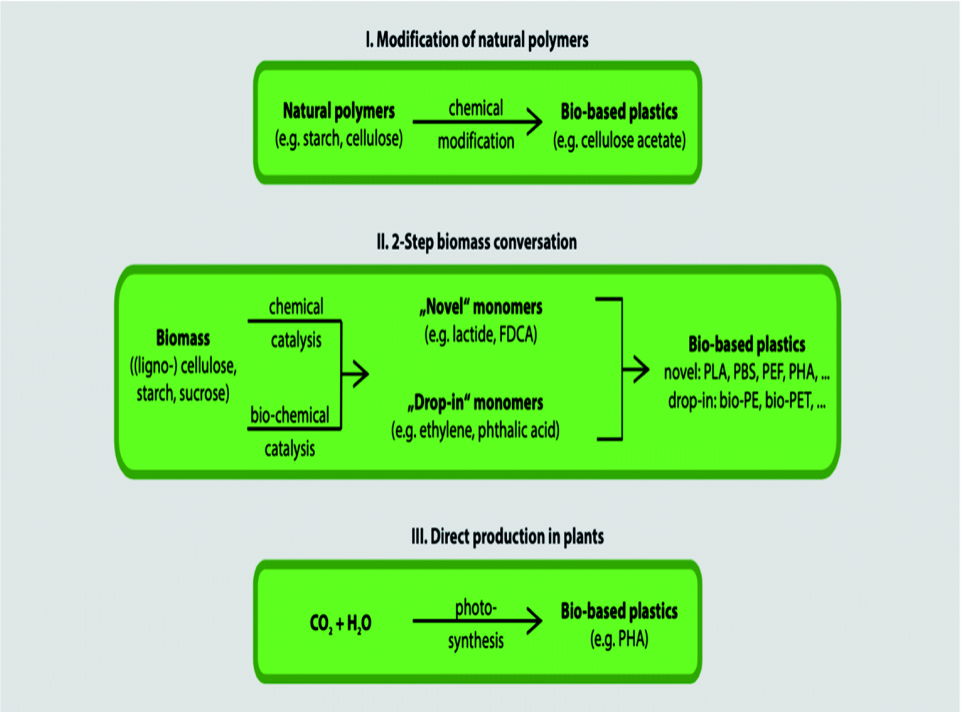
➢ PHA and PLA as bioplastics:

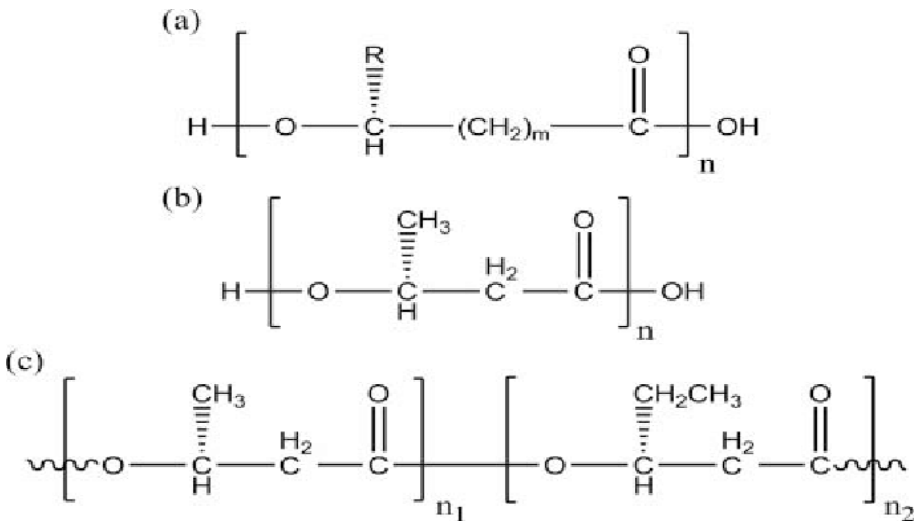
Bioplastics are one type of plastic which can be generated from natural resources such as starches and vegetable oils.

1. PHA- (Polyhydroxyalkanoates)

PHAs can be defined as a family of intracellularbiopolymers that are synthesized via various bacteria as intracellular carbon and energy storage granules.

bio based and biodegradable under industrial composting conditions (at a high temperature, around 58 °C).





•Each product platform has been highly engineered to optimize fiber content, structure, resin chemistry, and other characteristics. Common applications for cellulose media are:

•Gas turbine filtration

•Fuel and oil filtration

•Engine air intake filters

•

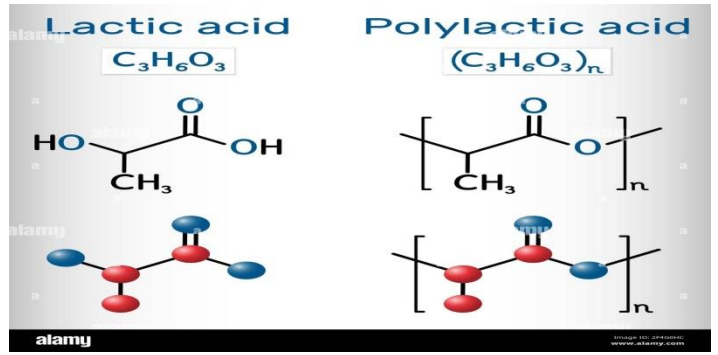
•Coalescing filters

•Hydraulic filters

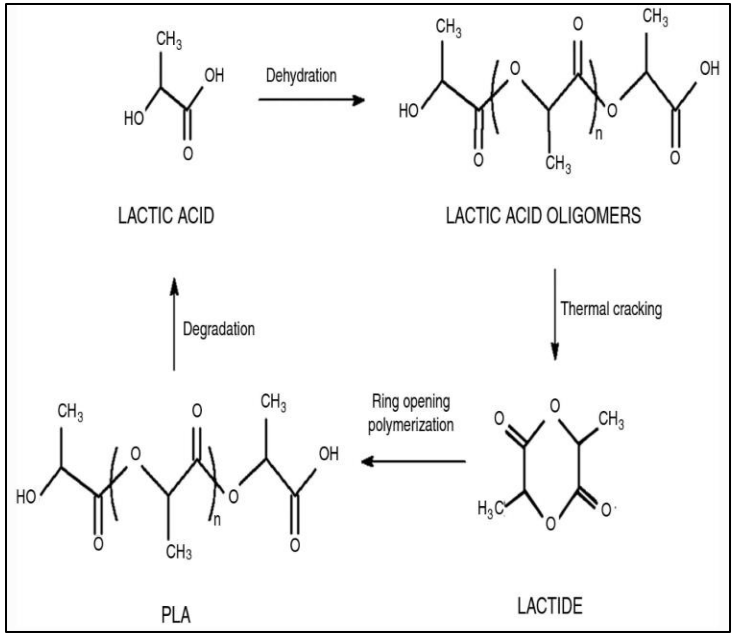
•Process liquid operations

2. PLA- (Polylactic acid)

- Polylactic acid or polylactide (PLA) is a polyester derived from renewable biomass, typically from fermented plant starch, such as corn, cassava, sugarcane or sugar beet pulp.
- PLA is a polyester (polymer containing the ester group) made with two possible monomers or building blocks: lactic acid, and lactide.



- PLA is biodegradable under appropriate conditions and is generally regarded as food safe since it decomposes back into its lactic acid building blocks, which are non-toxic.
- PLA decomposes into carbon dioxide, lactic acid, and water.
- PLA is used in food packaging and disposable cutlery and can be formed into fibers for clothing. It is also one of the most widely used 3D printing filaments for fused deposition modeling (FDM) due to its low melt temperature and its ease of use.
- Compared to PLA, PHAs are both compostable and biodegradable in marine environments. On the other hand, PLA is compostable but may stay for up to a thousand years in the marine environment



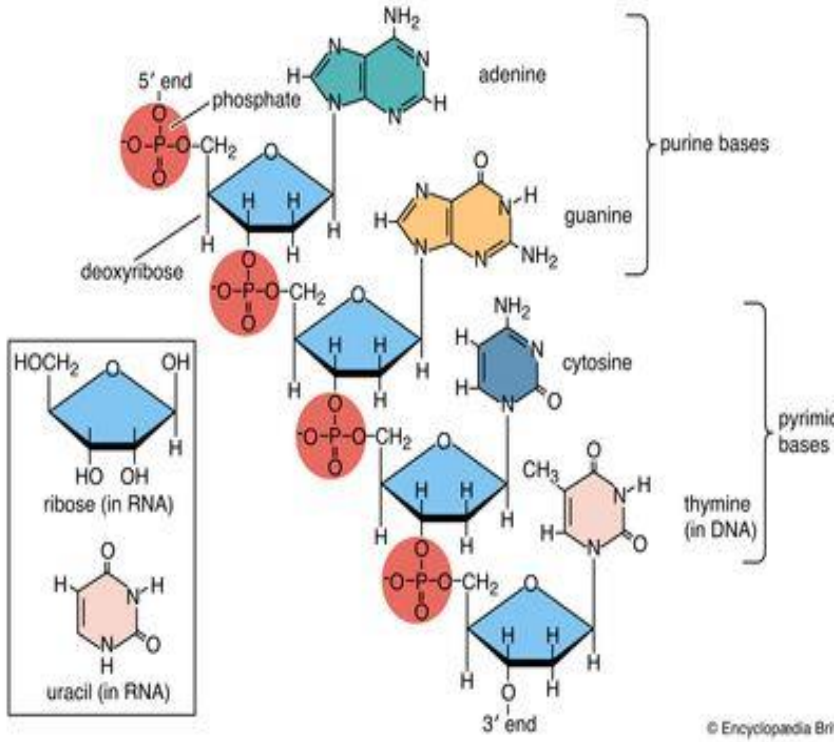
Because of its good mechanical properties, process ability, renewability, and non-toxicity, PLA is considered today as one of the most commercially promising bioplastics. When compared with most other biodegradable polymers, PLA has better durability, transparency, and mechanical strength.

Due to their biodegradable nature, PHAs are intended to replace synthetic nondegradable polymers for various applications, such as:

- packaging,
- fast food,
- medicine,
- biomedical, and
- agricultural applications

NUCLEIC ACIDS

- 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 chainlike 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.



DNA VACCINES

- 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, and potentially cancer.
- 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.
- Plasmid DNA (pDNA) is inexpensive, stable, and relatively safe, thereby allowing this non-viral platform to be considered an excellent option for gene delivery. Some of the different virus vectors that have been used to source pDNA include onco-retroviruses, lentiviruses, adenoviruses, adeno-associated viruses, and Herpes simplex-1.
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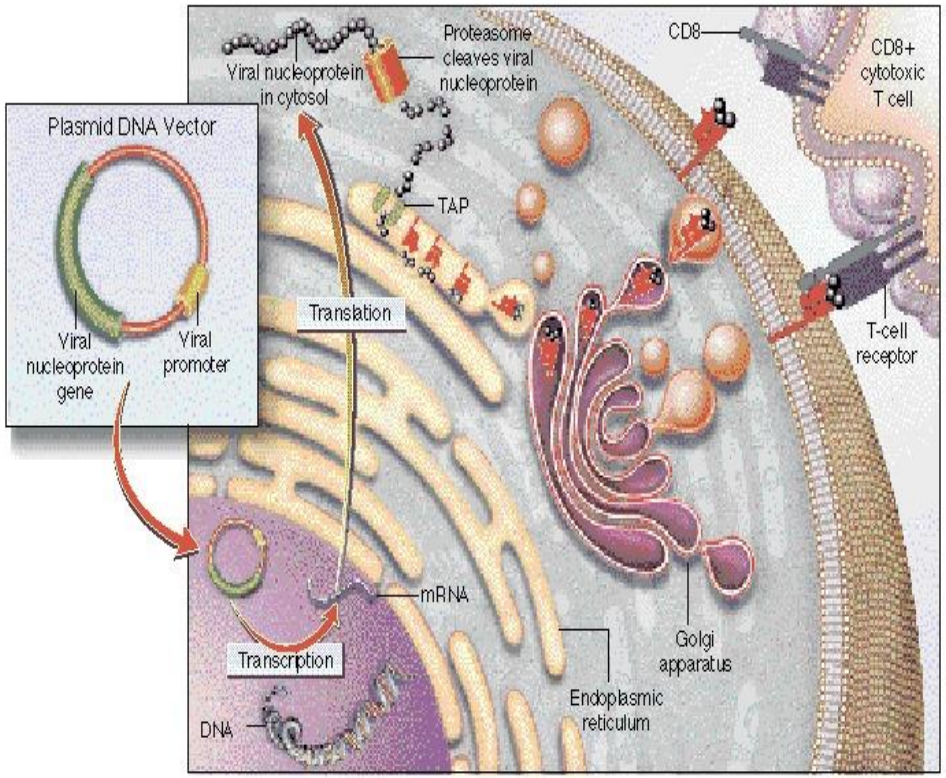
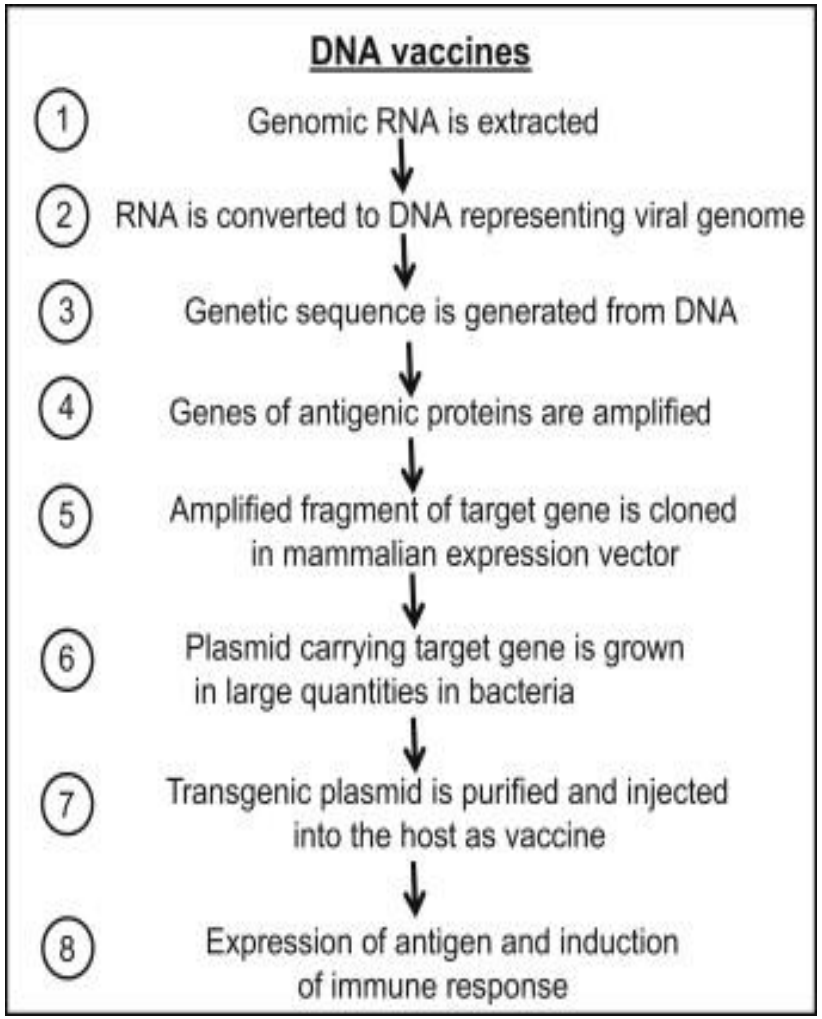


DNA VACCINES FOR RABIES

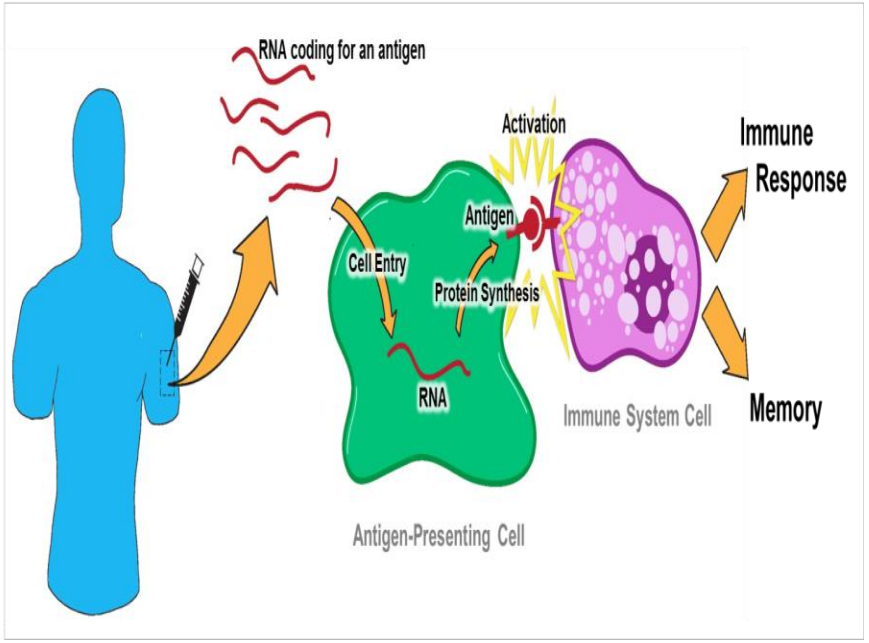
- Rabies is a simple, negative-stranded RNA virus that encodes five structural proteins, that is, the nucleoprotein (NP), the glycoprotein (G), the phosphoprotein (P), the matrix protein (M), and the polymerase (L). Correlates of protection are well defined, and virus-neutralizing antibodies (VNAs) present in serum at titers of or above 0.5 international units (IU)/mL provide protection.
- Protection from rabies is commensurate with the presence of adequate amounts of virus neutralizing anti- bodies, principally targeted against the rabies virus gly- coprotein. The tools of recombinant DNA technology allow facile cloning of the glycoprotein gene into suit- able expression vectors which mediate efficient in vivo expression of glycoprotein.
- DNA vaccination has been proposed as a cheaper and efficient strategy for rabies prophylaxis, and its feasibility has been demonstrated in a number of animal models including companion animals, since 1994.



RNA VACCINES

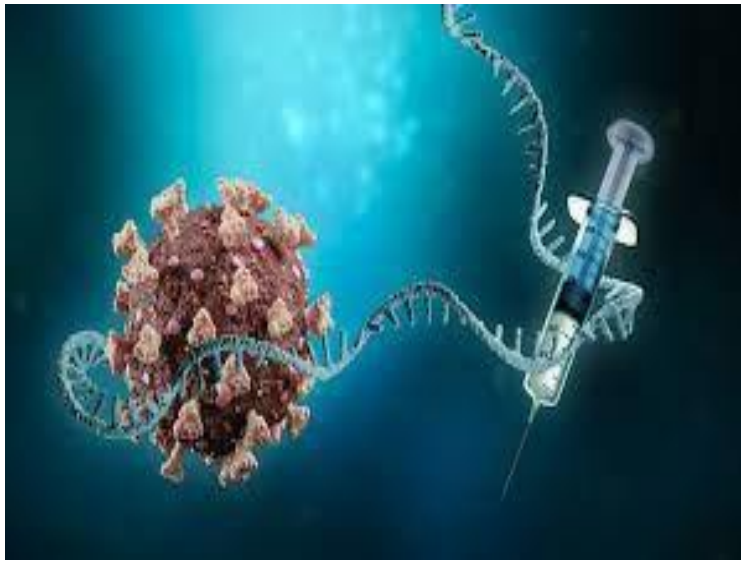
- Vaccines help prevent infection by preparing the body to fight foreign invaders (such as bacteria, viruses, or other pathogens). All vaccines introduce into the body a harmless piece of a particular bacteria or virus, triggering an immune response. Most vaccines contain a weakened or dead bacteria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

Figure 1: RNA Vaccine Technology



RNA VACCINES FOR COVID-19

- 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.
- 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.



STEPS INVOLVED IN DNA FINGERPRINTING

Isolating the DNA.

↓

Digesting the DNA with the help of restriction endonuclease enzymes.

↓

Separating the digested fragments as per the fragment size by the process of electrophoresis.

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Blotting the separated fragments onto synthetic membranes like nylon.

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Hybridising the fragments using labelled VNTR probes.

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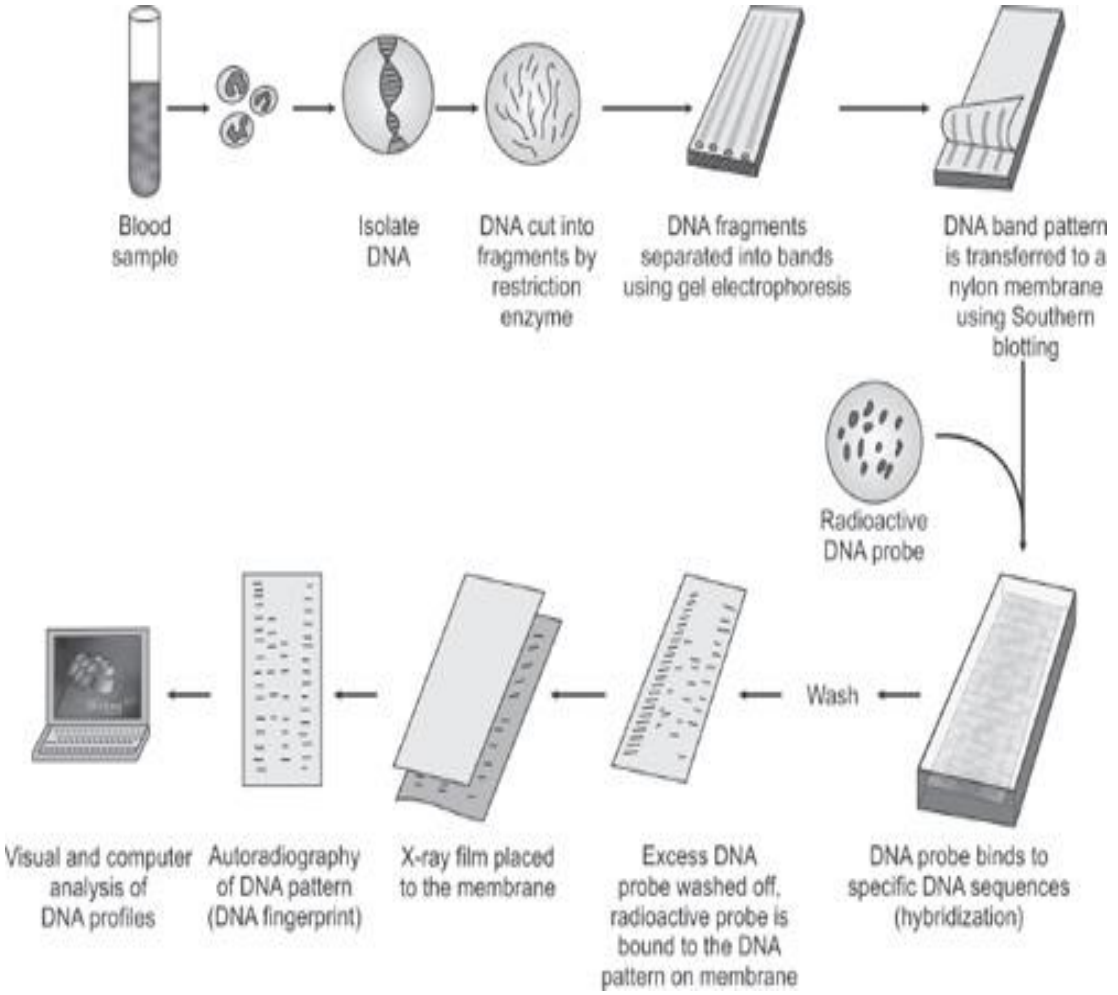
Analysing the hybrid fragments using autoradiography.



LIPIDS

- Lipids are **fatty, waxy, or oily compounds that are soluble in organic solvents and insoluble in polar solvents such as water**. Lipids include:

✓ Fats and oils (triglycerides)

✓ Phospholipids

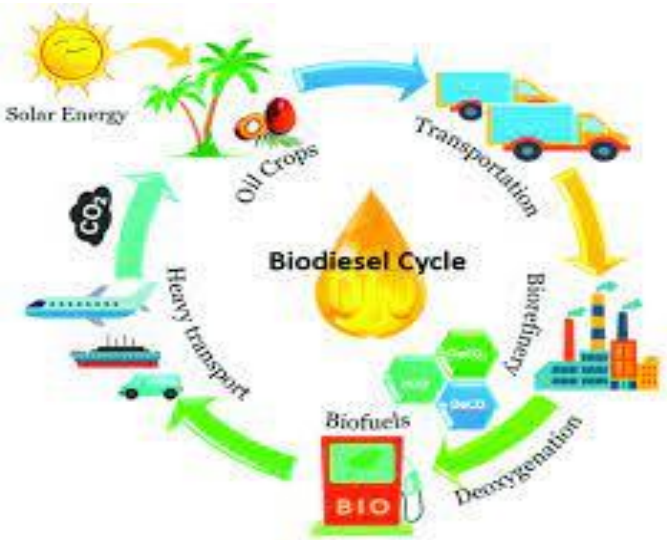
✓ Waxes

✓ Steroids

- 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

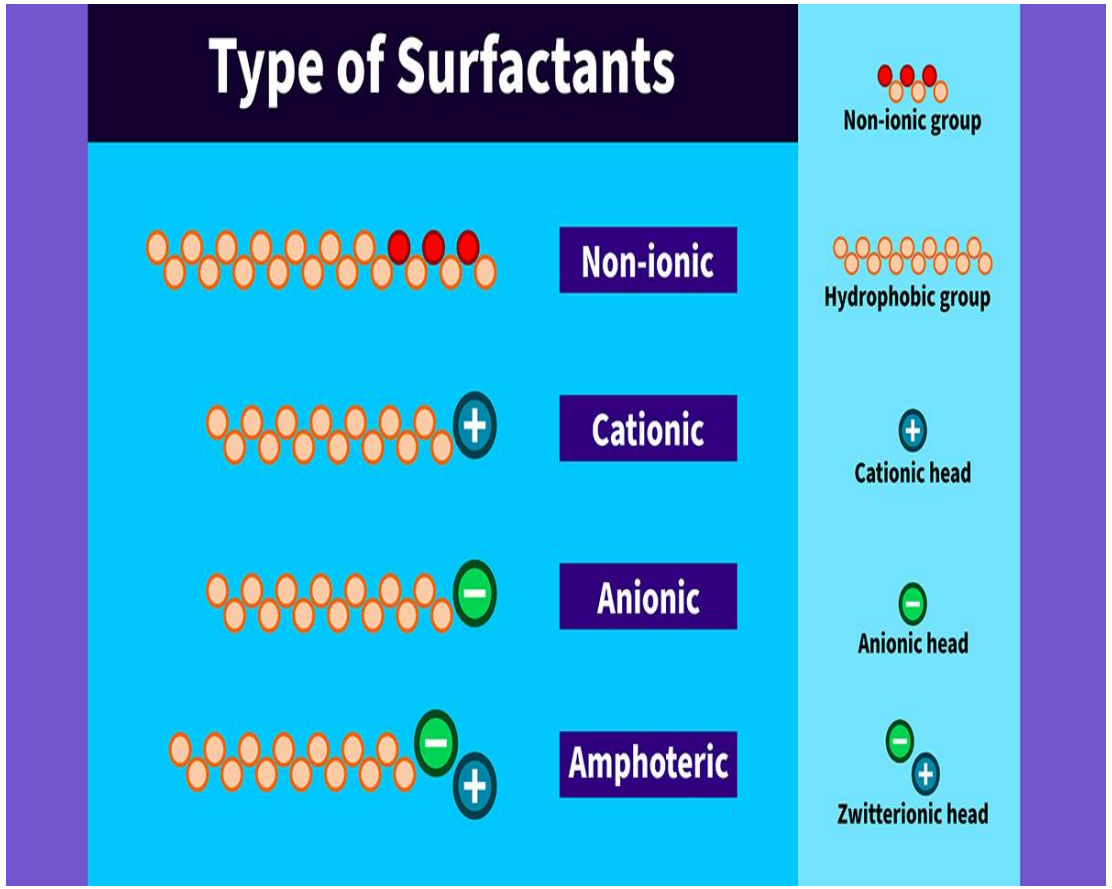
- Biodiesel is an alternative fuel similar to conventional or ‘fossil’ diesel. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. The process used to convert these oils to Biodiesel is called transesterification.
- The largest possible source of suitable oil comes from oil crops such as rapeseed, palm or soybean. In the UK rapeseed represents the greatest potential for biodiesel production. Most biodiesel produced at present is produced from waste vegetable oil sourced from restaurants, chip shops, industrial food producers such as Birdseye etc.
- Biodiesel has many environmentally beneficial properties. The main benefit of biodiesel is that it can be described as ‘carbon neutral’. This means that the fuel produces no net output of carbon in the form of carbon dioxide (CO2). This effect occurs because when the oil crop grows it absorbs the same amount of CO2 as is released when the fuel is combusted.



CLEANING AGENTS / DETERGENTS

- A **detergent** is a surfactant or mixture of surfactants that has cleaning properties in dilute solution with water. A detergent is similar to soap, but with a general structure $R\text{-}SO_4^-$, Na^+, where R is a long-chain alkyl group.
- Like soaps, detergents are amphiphilic, meaning they have both hydrophobic and hydrophilic regions. Most detergents are akyl benzenefulfonates.
- Detergents tend to be more soluble in hard water than soap because the sulfonate of detergent doesn't bind calcium and other ions in hard water as easily as the carboxylate in soap does.
- Types of Detergents
- **Anionic detergents**: Anionic detergents have a net negative electrical charge. Commercial anionic detergents are usually alkylbenezesulfonates. The alkylbenzene is lipophilic and hydrophobic, so it can interact with fats and oils. The sulfonate is hydrophilic, so it can wash away soiling in water.
- **Cationic detergents**: Cationic detergents have a net positive electrical charge. The chemical structures of cationic detergents are similar to those of anionic detergents, but the sulfonate group is replaced by quaternary ammonium.

- **Non-ionic detergents**: Non-ionic detergents contain an uncharged hydrophilic group. Usually, these compounds are based on a glycoside (sugar alcohol) or polyoxyethylene. Examples of non-ionic detergents include Triton, Tween, Brij, octyl thioglucoside, and maltoside.
- **Zwitterionicdetergents**: Zwitterionic detergents have equal numbers of +1 and -1 charges, so their net charge is 0. An example is CHAPS, which is 3-[(3-**ch**olamidopropyl) dimethyl**a**mmonio]-1-**p**ropane**s**ulfonate.



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Thank You