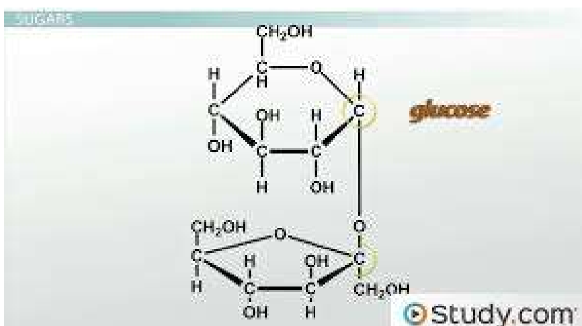
A T M E
College of Engineering

Biology for Engineers BBOK407

Module 2: BIOMOLECULES AND THEIR APPLICATIONS



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Dept. of Chemistry,
ATMECE, Mysuru

Module-2(8 Hours)
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).

BIOMOLECULES

Biomolecule is a molecule in all living organisms involved in the maintenance and metabolic process.

- All Biomolecule contain CARBON
- Carbon is the most versatile and prominent element of life
- Other elements –
  - **HYDROGEN(H)**
  - **OXYGEN(O)**
  - **NITROGEN (N)**
  - **SULPHUR (S)**
  - **SODIUM (Na)**
  - **CALCIUM (Ca)**
  - **MAGNESIUM (Mg)**

BIOMOLECULES

INORGANIC

ORGANIC

These are very large molecules of many **ATOMS** covalently bonded.

ENERGY is stored in the **COVALENT BONDS.** When we eat, we get ENERGY to lives because chemical reactions within our bodies break these bonds

CARBOHTDRATES

LIPIDS

PROTEINS

NUCLEIC ACIDS

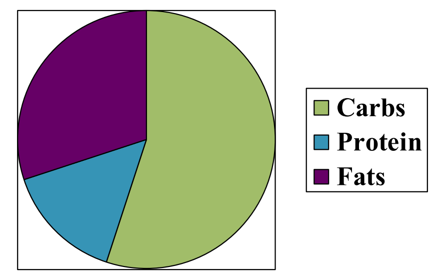
ENZYMES

VITAMINS

What are Carbohydrates?

- Carbohydrates are organic biomolecules abundantly present in nature.
- Found in the cells of plants and animals.
- The term "**Carbohydrate**" was coined by "Karl Schmidt".
- A carbohydrate is a biomolecule consisting of carbon (C), hydrogen (H) and oxygen (O) atoms, usually with a hydrogen–oxygen atom ratio of 2:1 (as in water) and thus with the empirical formula Cm(H2O)n.

Carbohydrates give the body energy. They are the best source of fuel for the body. Carbohydrates also help to digest protein and fat.



<u>45-65%</u> of our food should come from carbohydrates.

Carbohydrates Biosynthesis

Plants predominantly biosynthesize carbohydrates through **photosynthesis**.

Glucose is synthesized in plants from CO_2, H_2O, and solar energy from the sun.

Photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6O_2$$

Sugars (Simple carbohydrate)

$$\text{Sugars} \rightleftharpoons \text{Starch or Cellulose}$$

Complex carbohydrates of plants

Animals and **Human beings cannot biosynthesize Carbohydrates** predominantly.

To fulfil metabolic and structural roles in human beings, **It is essential to intake carbohydrates through food** substances of plant and animal origin. Thus, Carbohydrates **are chief constituents** of **human food** in the form of grains, fruits, vegetables, legumes and sugar.

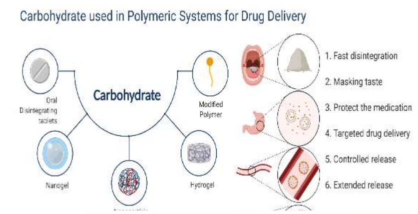
Carbohydrate (Glucose) is **oxidised** in living cells of the human body to **produce CO_2, H_2O,** and **energy(ATP)**

Industrial Applications of Carbohydrates

Carbohydrates have a wide range of applications in various industries, including:

Food and Beverage: Carbohydrates are widely used as sweeteners, thickeners, and stabilisers in food and beverage products. They are used as energy sources in sports drinks & energy bars.

Pharmaceuticals: Carbohydrates are used as excipients in pharmaceutical formulations to improve drug stability and solubility, and they are also used as a source of energy in medical nutrition products.



Cosmetics: Carbohydrates are used in cosmetic products, such as moisturisers, shampoos, and conditioners, to provide hydration and improve skin and hair health.

Biotechnology: Carbohydrates are widely used to produce biodegradable plastics, biofuels, and other renewable energy sources.

Research: Carbohydrates are widely used as research tools in immunology, virology, and cellular biology. Used as ligands in protein-carbohydrate interactions and as probes to study cellular signalling pathways.

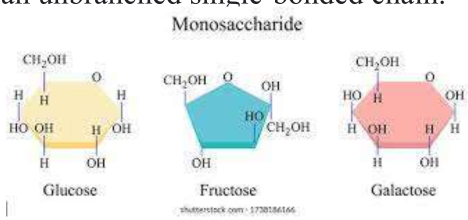
Carbohydrates

Simple sugars

Complex sugars

Monosaccharides

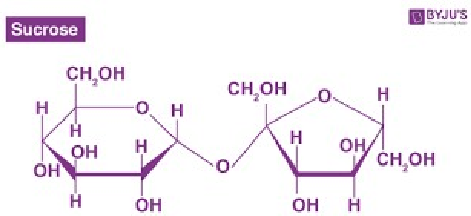
The simplest carbohydrates are termed simple sugars. The monosaccharides most commonly contain three to six carbon atoms in an unbranched single-bonded chain.



Glucose, Fructose

Disaccharides

two monosaccharides are joined by glycosidic linkage

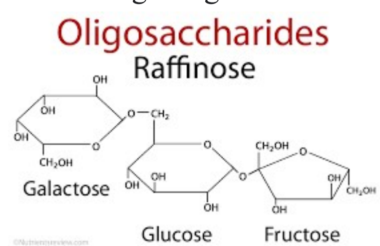


Sucrose

Lactose

Oligosaccharides

Carbohydrates that contain between 3 and 10 single sugar residues

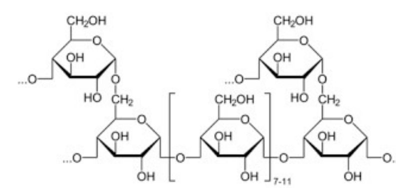


raffinose,

stachyose

Polysaccharides

long chains of carbohydrate molecules, composed of several smaller monosaccharides.



Starch

Cellulose

Carbohydrates

Simple sugars

They are simple carbohydrates that can be added to foods, such as the sugar in candy, desserts, processed foods, and regular soda. They also include the kinds of sugar found naturally in fruits, vegetables, and milk.

Sugar

Glucose

Sucrose

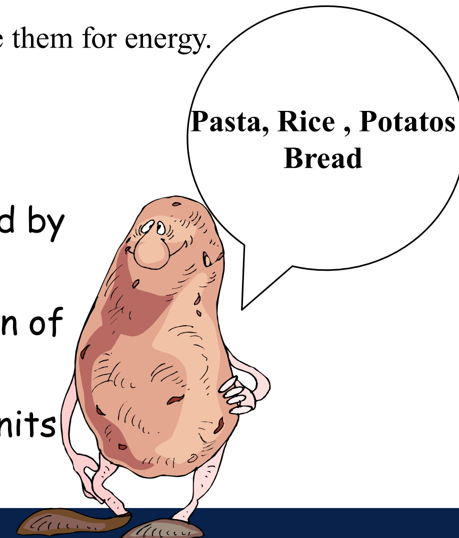
Starch

These are the Complex carbohydrates obtained by joining simple sugars together. Our body needs to break starches down into sugars to use them for energy.

Energy storage used by plant

Long repeating chain of a-D-glucose

Chain up to 4000 units



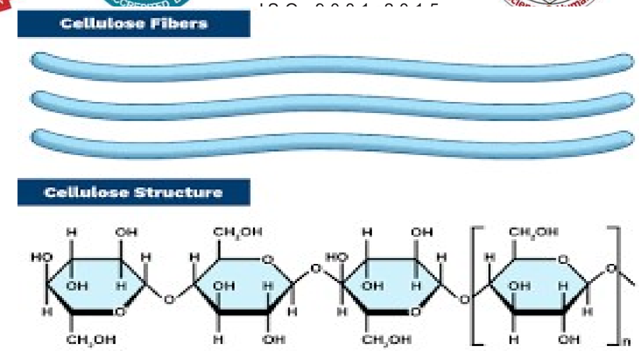
Fibers

Fibers are complex carbohydrate that cannot be broken down, so eating foods with fiber can help us feel full and reduces overeating. They help prevent constipation and help lower cholesterol and blood sugar.

Non-digestible carbohydrate

Cellulose serves as dietary Fiber.

Cellulose



Cellulose **is an abundant complex carbohydrate, or polysaccharide, consisting of 3,000 or more glucose units.** Exclusively present in a **Plant's cell wall**. They are insoluble in water, easily renewable and biodegradable.

Structure and properties

1. Cellulose has no taste, is odourless, is **insoluble in water** and most **organic solvents**, is chiral and is biodegradable.

2. It can be broken down chemically into glucose units by treating it with concentrated acids at high temperatures.

3. Cellulose is derived from D-glucose units condensed through glycosidic bonds.

5. Cellulose is a straight-chain polymer: unlike starch, no coiling or branching occurs, and the molecule adopts an extended and rather stiff rod-like conformation aided by the equatorial conformation of the glucose residues.

6. The multiple hydroxyl groups on the glucose from one chain form hydrogen bonds with oxygen atoms on the same or a neighbour chain, holding the chains together side-by-side and forming *microfibrils* with high tensile strength.

7. This confers tensile strength in cell walls, where cellulose microfibrils mesh into a polysaccharide *matrix*.

Cellulose was discovered in 1838 by the French chemist Anselme Payen, who isolated it from plant matter and determined its chemical formula. **Chemically, cellulose is a polysaccharide almost insoluble in water, with a linear chain configuration consisting of numerous glucose units.** Due to its biological origin, low-cost, and tunable surface chemistry, cellulose has been used for centuries in the paper industry, food packaging, and water and air filtration, to mention a few.

Taking benefit of these advantages of cellulose, we have a best application of cellulose, that is,

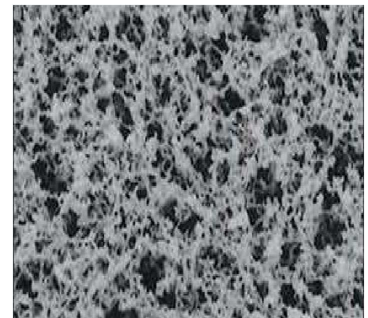
Cellulose-based water filters.

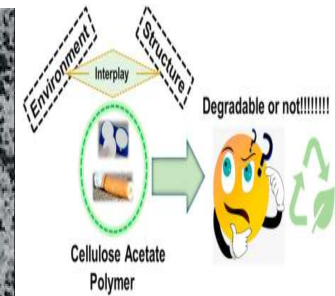
Cellulose-based water filters are filters made from cellulose, a carbohydrate polymer found in plant cell walls. They remove impurities and contaminants from water and are an alternative to traditional synthetic polymer filters. The **high mechanical strength** and **hydrophilic properties** of cellulose make it an ideal material for **water filtration**. Cellulose filters can effectively remove particles, pathogens, and other contaminants from water, making it safer and more potable. Cellulose-based water filters are widely used in developed and developing countries for household, industrial, and agricultural applications. They are also an **environmentally friendly alternative to traditional filters**, as they are **biodegradable** and can be produced from renewable resources.

Properties of cellulose based water filter

Cellulose-based water filters have several properties that make them an attractive choice for water filtration:

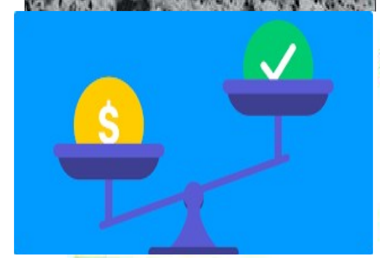
High Porosity: They have a high porous structure allowing them to remove impurities and contaminants efficiently from water.

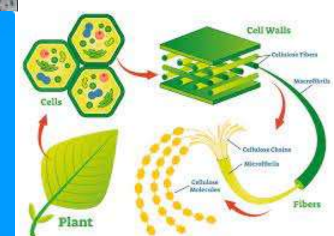




Biodegradability: Cellulose-based water filters are biodegradable; thereby reducing the impact on environment compared to synthetic polymer filters.

Cost-effective: Cellulose-based water filters are less economical than traditional synthetic polymer filters.

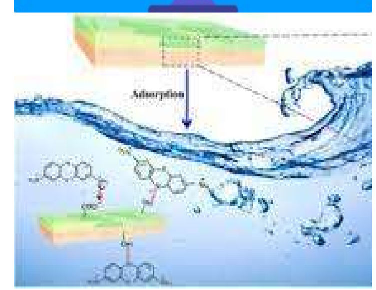




Renewable resource: Cellulose-based water filters are made from a renewable resource; this reduces the dependency on non-renewable resources.

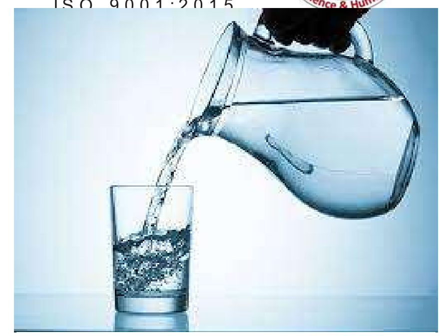
Good mechanical strength: They pose good mechanical strength, allowing them to maintain their structure and perform effectively over time.

Chemical resistance: Cellulose-based water filters resist most chemicals, including acids and bases, and hence can be used in various water treatment applications.



Large surface area: Cellulose-based water filters have a large surface area, enhancing filtration capabilities and reducing filter replacement frequency.

Importance of cellulose-based water filters



Safe and clean water: Cellulose-based water filters effectively remove impurities and contaminants from water, making it safer and more potable for various applications, including household, industrial, and agricultural use.

Sustainability: Cellulose-based water filters are made from a renewable resource, cellulose, and are biodegradable, reducing their environmental impact and promoting sustainability in water treatment processes.

Affordability: Cellulose-based water filters are often more affordable than traditional synthetic polymer filters, making them accessible to a wider range of consumers and communities, especially in developing countries.

Versatility: Cellulose-based water filters can be used in various types of filtration systems and can be produced in different sizes and shapes to fit specific needs.

Alternative to synthetic filters: Cellulose-based water filters provide an environmentally friendly alternative to traditional synthetic polymer filters, reducing the dependency on nonrenewable resources and reducing waste.

Construction of cellulose-based water filters

Cellulose Material Selection: The type of cellulose material used in the water filter will depend on the desired properties, such as strength, porosity, and chemical resistance. Common cellulose materials include paper, cotton, and wood fibres.

Cellulose Preparation: It is prepared by cutting it into small pieces, washing it to remove impurities, and drying it.

Cellulose Layer Formation: The cellulose material is made into a layer by either stacking or compacting it using heat & pressure.

Filter Medium Attachment: The cellulose layer is attached to a filter medium, such as a mesh or a support structure, to provide stability and increase the filter surface area.

Chemical Treatment: The cellulose layer may be chemically treated to modify its properties, such as increasing its hydrophilicity or adding antimicrobial agents.

Housing Assembly: The filter medium is assembled into a housing that can attach it to a water source & collect the filtered water.

Filter Testing: The completed filter is tested to ensure it meets the desired specifications, such as filtration efficiency & flow rate.

Construction of cellulose-based water filters

Cellulose Material Selection

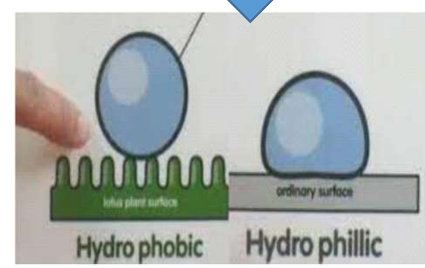
Cutting / Washing

Cellulose Preparation

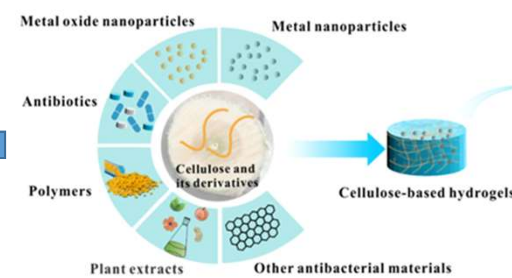
Stacking/ compacting

Cellulose Layer Formation

Chemical treatment to enhance hydrophillicity



Addition of antimicrobial agents



Housing Assembly

Filter testing

filtration efficiency & flow rate

Advantages

- **Environmentally friendly:** Cellulose-based water filters are made from a renewable resource, cellulose, and are biodegradable, reducing their impact on the environment compared to synthetic polymer filters.
- **Cost-effective:** Cellulose-based water filters are often more affordable than traditional synthetic polymer filters, making them accessible to a wider range of consumers and communities.
- **High porosity**: Cellulose-based water filters have a high porosity structure, which allows them to remove impurities efficiently and contaminants from water.
- **Versatile:** Cellulose-based water filters can be used in various types of filtration systems and can be produced in different sizes and shapes to fit specific needs.
- **Good mechanical strength:** Cellulose-based water filters have good mechanical strength, allowing them to maintain their structure and perform effectively over time.
- **Chemical resistance:** Cellulose-based water filters are resistant to most chemicals, including acids and bases, and can be used in a wide range of water treatment applications.
- **Large surface area:** Cellulose-based water filters have a large surface area, which enhances their filtration capabilities and reduces the frequency of filter replacement.

Limitations

Low resistance to high temperature: Cellulose-based water filters have a low resistance to high temperatures and can lose their structural integrity when exposed to high temperatures.

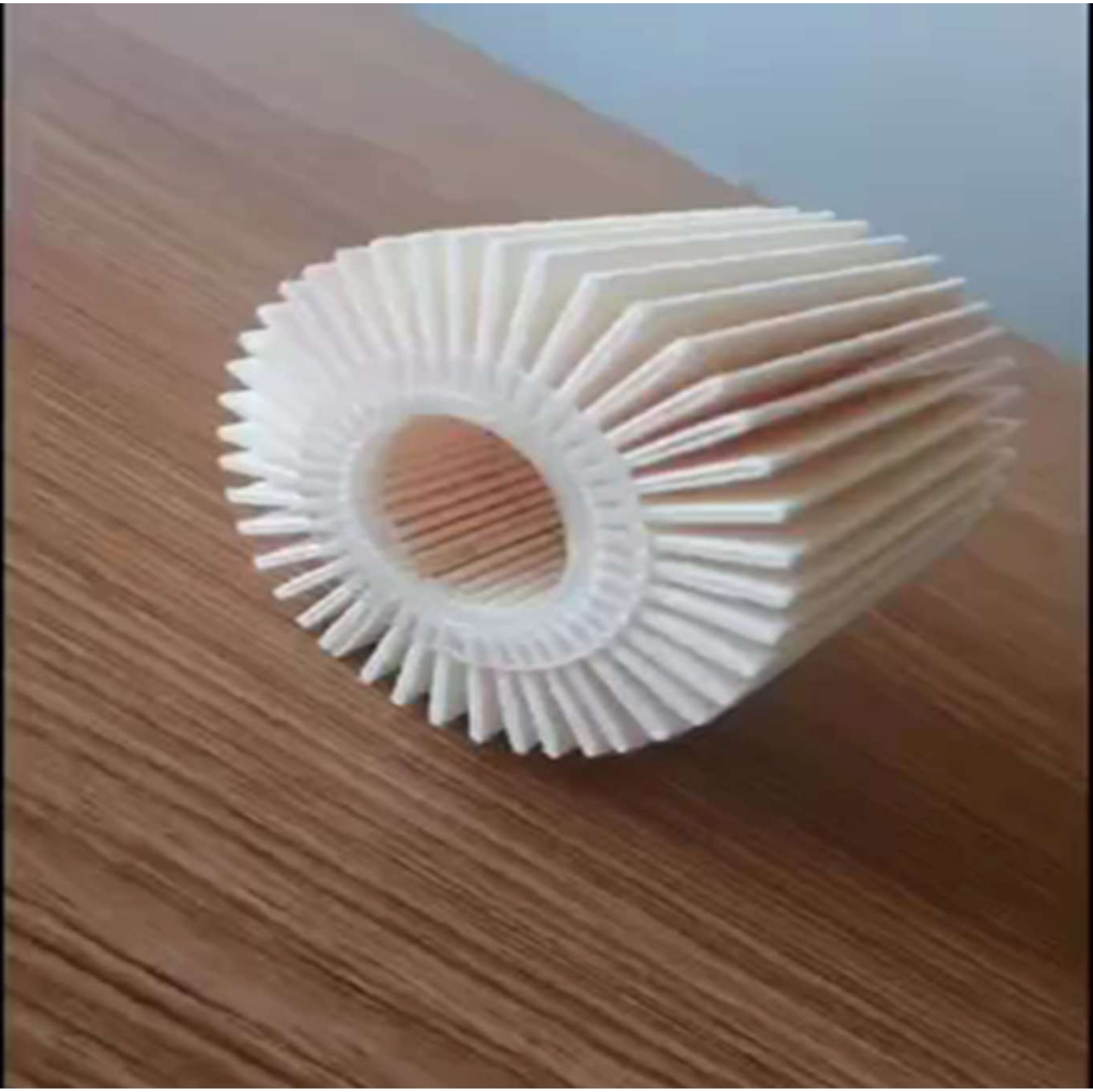
Low filtration efficiency for certain contaminants: Cellulose-based water filters may not be efficient in removing certain contaminants, such as heavy metals, from water.

Limited lifespan: Cellulose-based water filters have a limited lifespan and may need replacing more frequently than synthetic polymer filters.

Difficult to sterilize: Cellulose-based water filters may be difficult to sterilize effectively, increasing the risk of contamination.

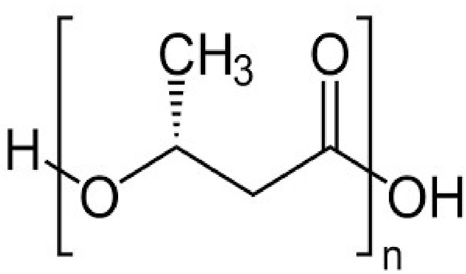
May clog easily: Cellulose-based water filters may clog easily when exposed to high levels of contaminants, reducing their filtration efficiency and requiring frequent replacement.

May affect water taste: Cellulose-based water filters may affect the taste of water by absorbing or releasing certain chemicals or minerals, reducing the quality of the purified water.



PHA as Bioplastic

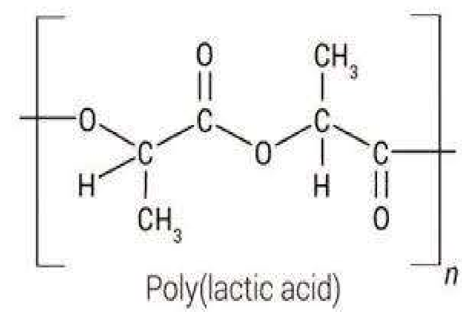
Polyhydroxyalkanoates (PHAs) are a class of biodegradable and biocompatible polyesters produced by microorganisms, such as bacteria and fungi. They are a type of bioplastic and elastomers. They are made from renewable resources, such as sugar and cornstarch, and are an environmentally friendly alternative to traditional petroleum-based plastics. PHA is used for preparing either thermoplastic or elastomeric materials, with melting points ranging from **40 to 180 °C.**

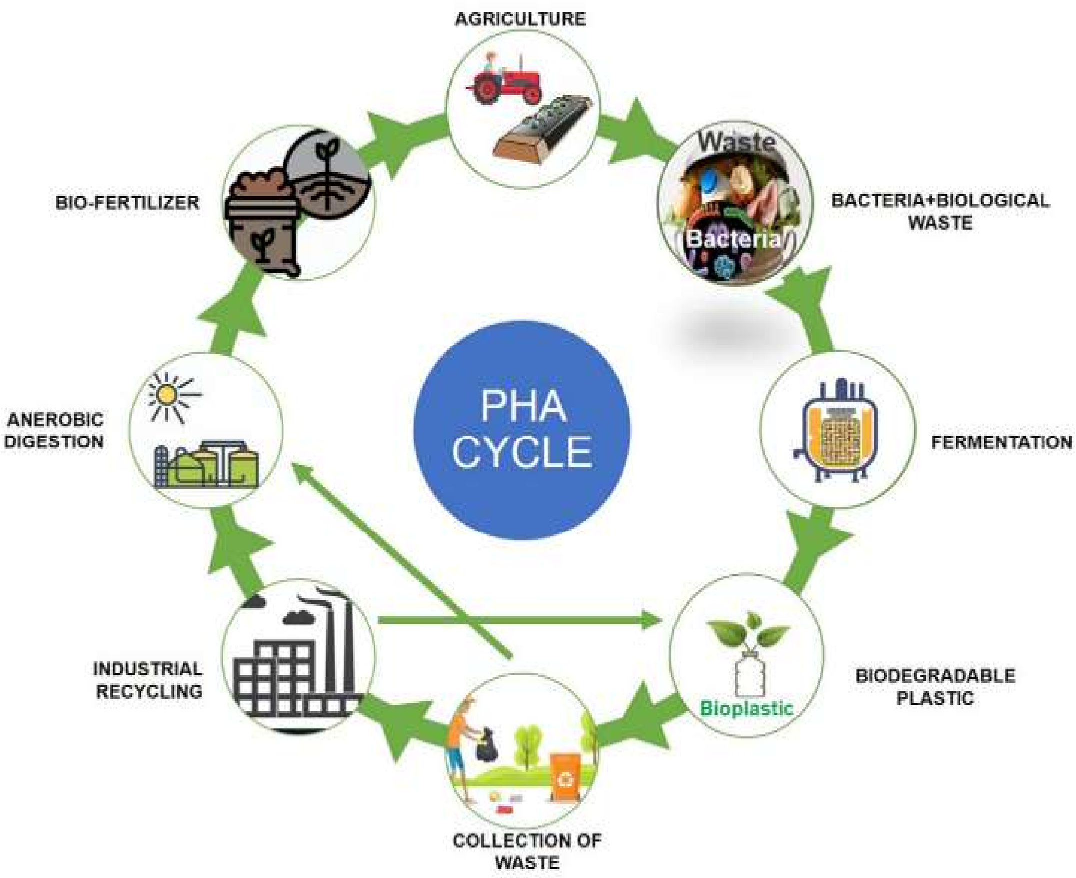


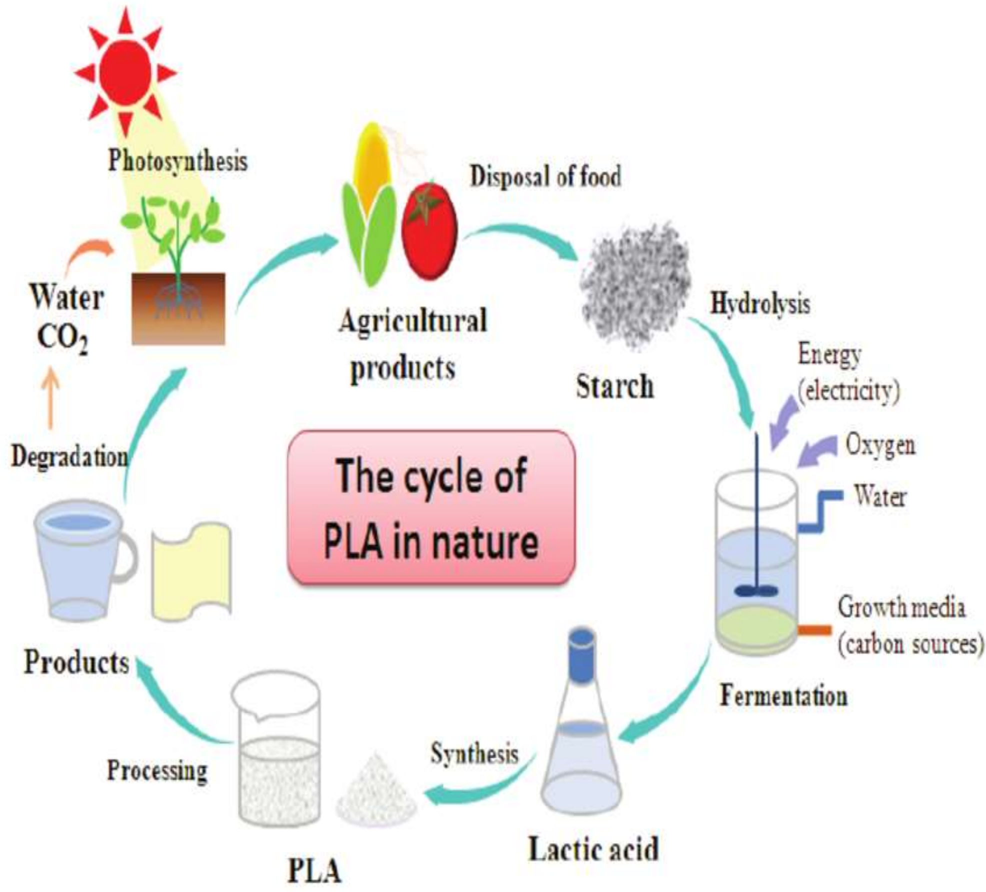
PLA as Bioplastic

Polylactic Acid (PLA) is a biodegradable and bio-based plastic made from corn starch, sugarcane, or other natural resources.

PLA is formally obtained by condensation of lactic acid with loss of water. Its low melting point, high strength, low thermal expansion, good layer adhesion, and high heat resistance when annealed make it an ideal material for 3D printing




AGRICULTURE
BACTERIA+BIOLOGICAL WASTE
Waste
Bacteria
FERMENTATION
BIODEGRADABLE PLASTIC
Bioplastic
COLLECTION OF WASTE
INDUSTRIAL RECYCLING
ANEROBIC DIGESTION
BIO-FERTILIZER
PHA CYCLE


Photosynthesis
Disposal of food
Agricultural products
Starch
Hydrolysis
Energy (electricity)
Oxygen
Water
Growth media (carbon sources)
Fermentation
Lactic acid
Synthesis
PLA
Processing
Products
Degradation
Water
CO_2
The cycle of PLA in nature

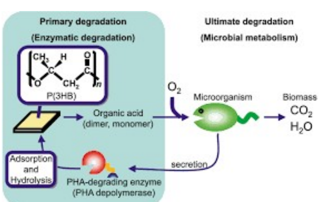
Properties of PHA

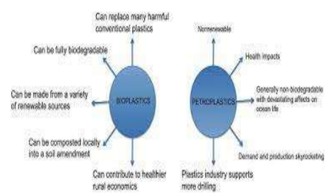
Biodegradability: Can break down into water and carbon dioxide, reducing their environmental impact.

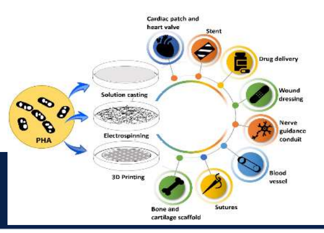
Biocompatibility: Used in medical devices due to its zero adverse reactions in the body.

Mechanical properties: Similar mechanical properties as traditional petroleum-based plastics.

Processing: It can be processed using conventional plastic processing techniques, such as injection moulding, blow moulding, and extrusion.







Properties of PLA

Biodegradable: It can be broken down by microorganisms in industrial composting facilities, thereby reducing waste in landfills.

Renewable: Reduces dependence on finite petroleum resources.

Clear/Transparent: PLA has a clear and transparent appearance.

Biocompatible: No adverse affect hence can be used in medical application.

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

Printability: Used in 3D printing due to its good printability and ease of use.

Engineering applications of PHA bioplastic


Packaging: Food containers, beverage cups, and clamshell containers.

Medical Devices: In medical devices such as sutures, implants, and drug delivery systems.


Textiles: Biodegradable textiles & composites in construction and furniture.

Agricultural Mulch Films: Biodegradable mulch films for agriculture to reduce soil erosion and conserve moisture.


Consumer Goods: Consumer goods, such as toys, phone cases, and water bottles.

Electronic parts: In biodegradable components in electronic devices such as smartphones and laptops.

Aerospace: In aerospace applications, such as insulation and cable management.


Sporting Goods: Biodegradable sporting goods such as golf tees and fishing lures.

Construction: Biodegradable insulation and soundproofing materials.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scientific

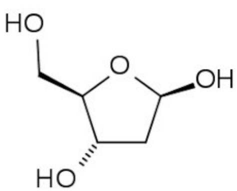
ECO CONCEPTS

ECO attitude

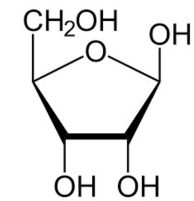
EQUAL responsibilities

Nucleic Acids

Nucleic acids are biopolymers that are crucial in storing and transferring genetic information in all living organisms.



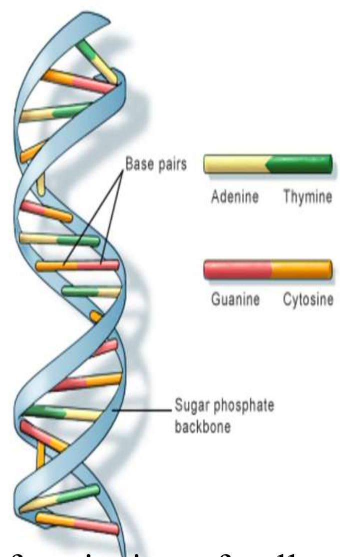
There are two types of nucleic acids



Deoxyribonucleic acid (DNA)

DNA is the genetic material that carries the instructions for all living organisms' development, functioning, and reproduction.

DNA is a double-stranded helix structure composed of nucleotides, which consist of a sugar (deoxyribose), a phosphate group, and a nitrogenous base (adenine, guanine, cytosine, or thymine)



Ribonucleic acid (RNA)

RNA is involved in the expression of the genetic information stored in DNA by carrying the message from the DNA to the ribosome, which is used to build proteins.

RNA is a single-stranded molecule composed of nucleotides consisting of a sugar (ribose), a phosphate group, and a nitrogenous base (adenine, guanine, cytosine, or uracil).

Both DNA and RNA play essential roles in the functioning of cells and organisms, and their structures and interactions with other molecules are the basis for many biological processes, such as replication, transcription, and translation.

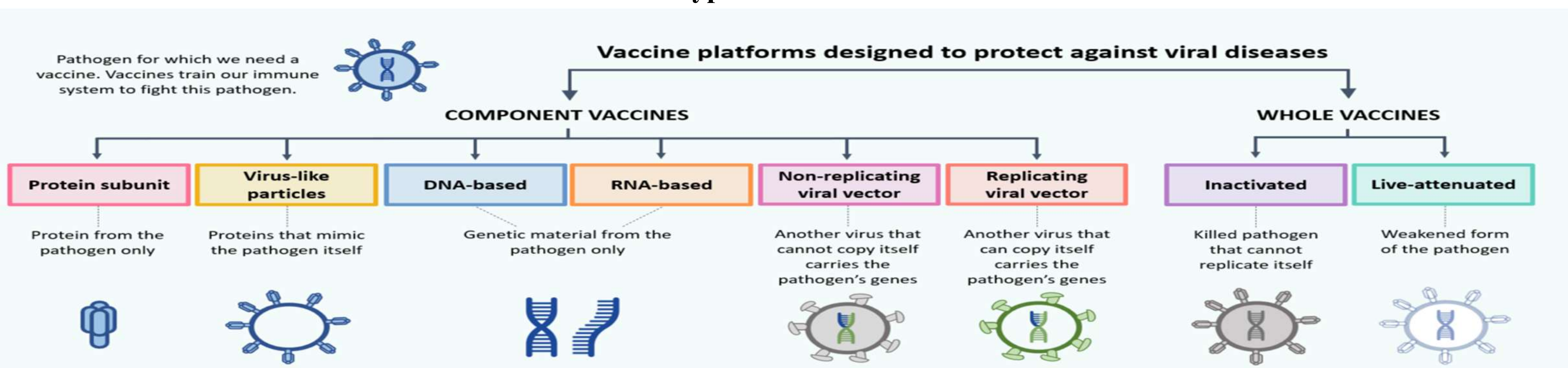
Vaccination

A vaccine is a biological preparation that provides active acquired immunity to a particular infectious disease.

The terms vaccine and vaccination are derived from Variolae vaccine (smallpox of the cow), the term devised by Edward Jenner (developed the concept of vaccines and created the first vaccine) to denote cowpox.

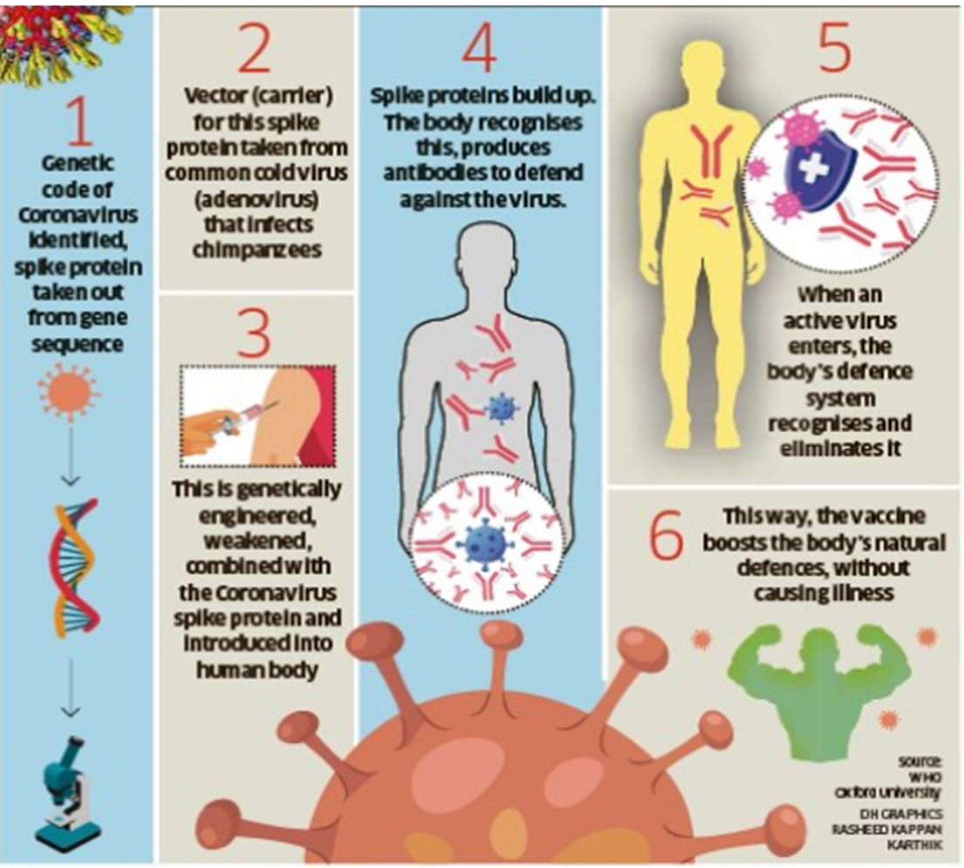
Vaccines typically contain dead or inactivated organisms or purified products derived from them., Vaccines are a very safe and effective way to fight and eradicate infectious diseases

Types of Vaccines

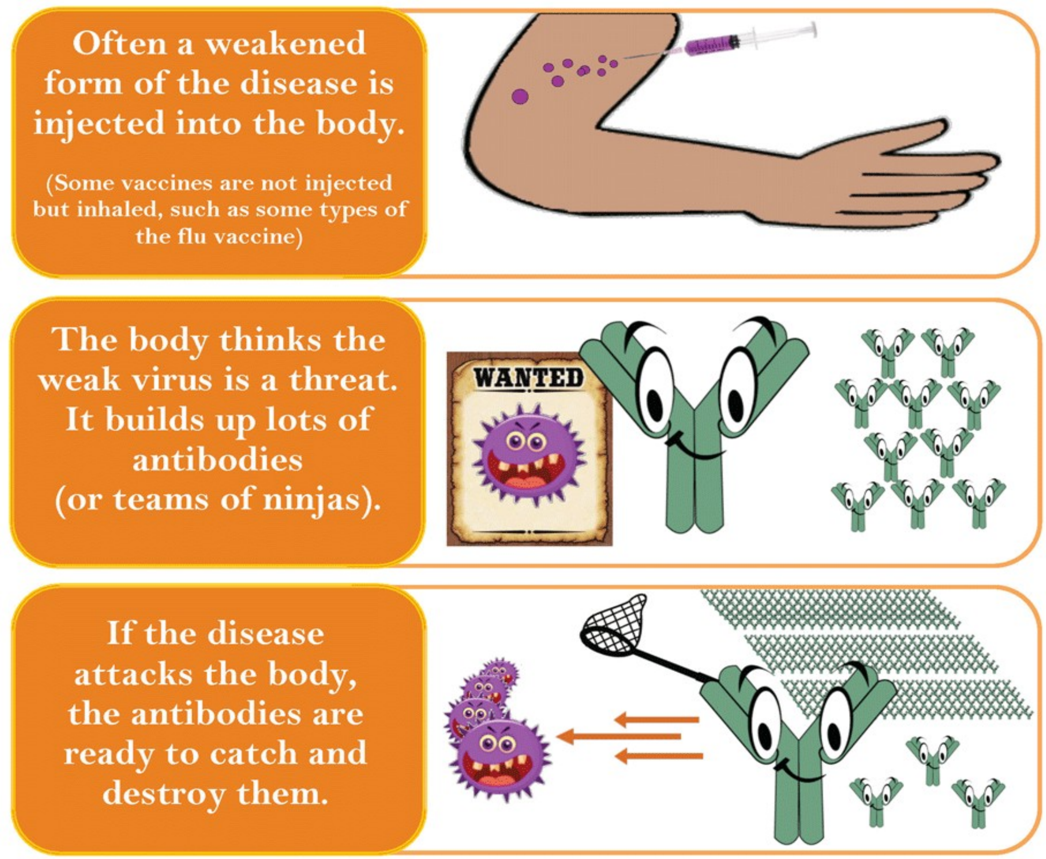


How Vaccines works

Component Vaccines

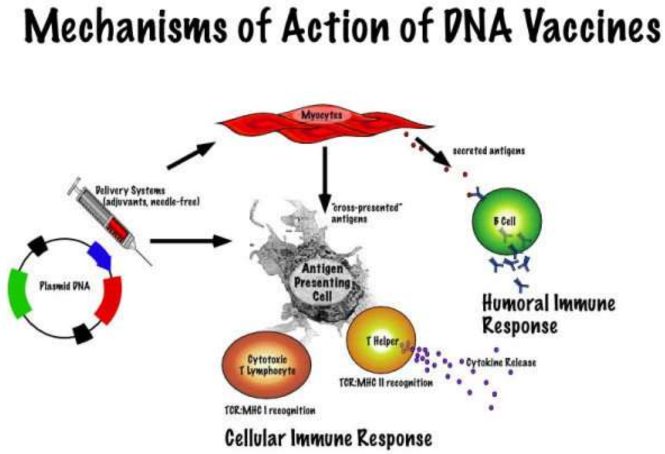


Whole Vaccines



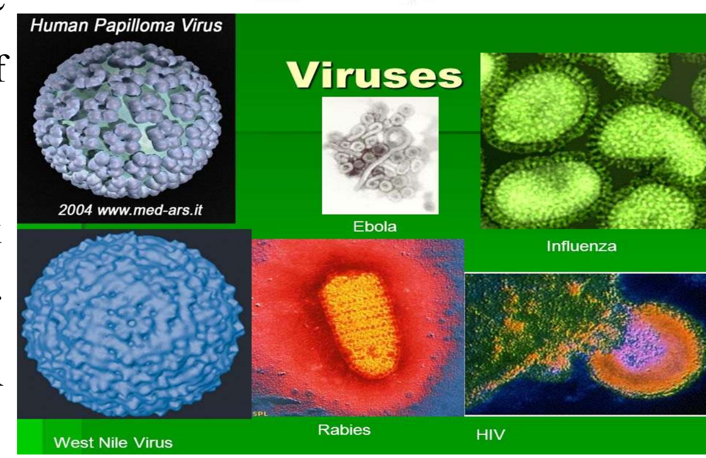
© Mechanisms in Medicine

DNA Vaccine



DNA vaccines are third-generation vaccines that use engineered DNA to stimulate an immune response in the body against either a specific pathogen or cancer cell. A DNA vaccine uses a piece of **viral or bacterial DNA** to **stimulate an immune response against the pathogen**.

DNA vaccines are being actively researched and developed for various diseases, including cancer, rabies, influenza, and human immunodeficiency virus (HIV). While the technology is still in its early stages, it has the potential to revolutionise the field of vaccine development and provide new treatment options for various diseases.



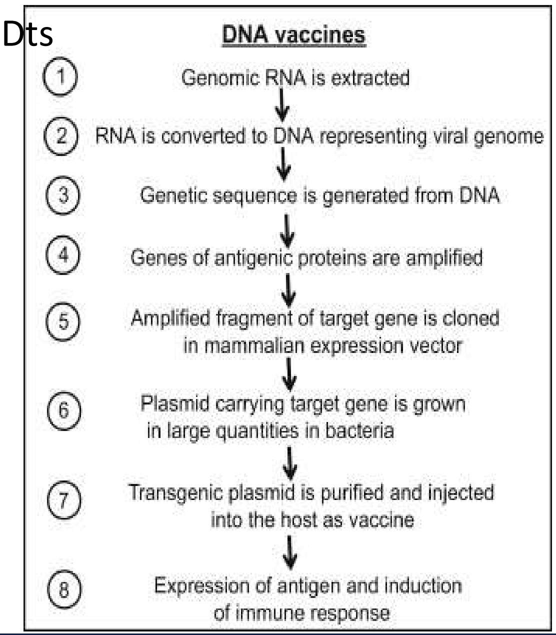
The goal of DNA vaccines is the same as that of traditional vaccines, but they work slightly differently. DNA vaccines, rather than injecting a weakened form of a virus or bacteria into the body, use genetically engineered plasmids of a specific DNA sequence into the infected organism to create an immune response..

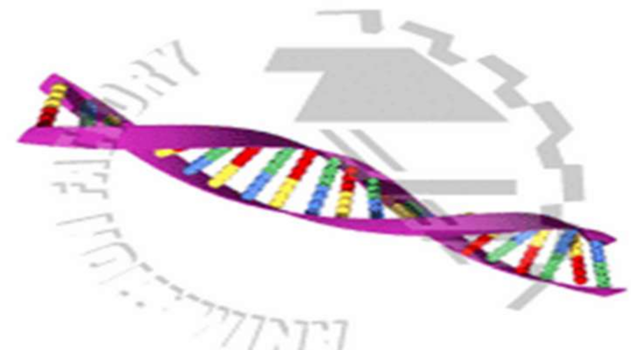
DNA Vaccine for Rabies

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 occur in wild animals like bats, raccoons, skunks, and foxes, although any mammal can get rabies.

https://www.youtube.com/watch?v=YhuW1-uMDts

A DNA vaccine for rabies uses a piece of rabies virus DNA to stimulate an immune response against the virus. The vaccine introduces the rabies virus DNA into the body, where cells take it up and produce viral proteins. These viral proteins are then displayed on the surface of the cells, which triggers an immune response and the production of antibodies against the rabies virus.





DNA vaccines advantages.

- **Efficacy:** DNA vaccines effectively prevent rabies infection in animal and human trials. In one study, a DNA vaccine was 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 they can protect against rabies for extended periods.
- **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.
- **Reduced risk of side effects:** DNA vaccines do not contain live virus particles, making them safer and less risky than traditional vaccines.
- **Safety:** DNA vaccines do not contain live or attenuated pathogens, reducing the risk of infection or disease caused by the vaccine.

DNA vaccines disadvantages.

- The risk of affecting genes that control cell growth.
- Repeated doses are required.
- Lower immunogenicity than an inactivated vaccine.
- Limited to the protein antigens.
- No mass application for animals, etc.

RNA Vaccines for Covid19

RNA vaccines for COVID-19 use genetic material from the SARS-CoV-2 virus in the form of RNA to stimulate an immune response against the virus.

The vaccine works by introducing the virus's RNA into the body, where it is taken up by cells and used to produce viral proteins. These proteins are then displayed on the surface of the cells, which triggers an immune response and the production of antibodies against the virus.

The first RNA vaccine for COVID-19, the Pfizer-BioNTech vaccine, was authorized for emergency use in December 2020 and has been administered to millions worldwide. Another RNA vaccine, the Moderna vaccine, was also authorized for emergency use.

RNA vaccines have several advantages over traditional vaccines, including **faster production time** and the ability to **target multiple antigens**. RNA vaccines can be **manufactured quickly**, making them a good option for emergencies where many people need to be vaccinated quickly. RNA vaccines are also considered safer than traditional vaccines, as they do not contain any live virus or bacteria that could cause disease. RNA vaccines are being developed and tested for various diseases, including COVID-19, influenza, and cancer.

Importance of RNA vaccine for Covid-19

RNA vaccines have emerged as a promising tool for preventing the spread of COVID-19, offering several key advantages over traditional vaccines. Here are some of the main reasons why RNA vaccines are important in the fight against COVID-19:

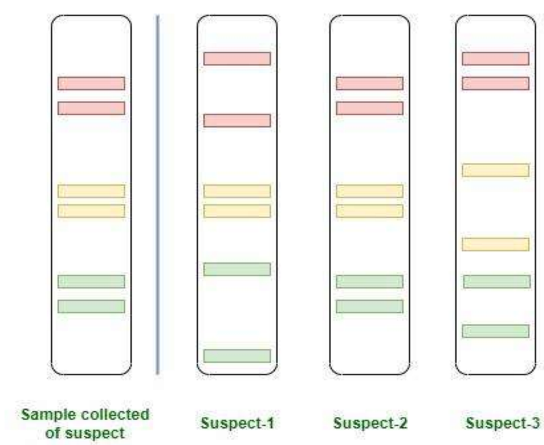
- **High efficacy:** RNA vaccines are highly effective at preventing COVID-19 infections. For example, the Pfizer-BioNTech and Moderna mRNA vaccines have reported **efficacy rates of around 95%** in clinical trials.
- **Rapid development:** RNA vaccines can be rapidly developed and manufactured, which is particularly useful in a pandemic. The Pfizer-BioNTech vaccine, for instance, was developed in under a year and went from the initial discovery of the viral genome to emergency use authorisation in less than 11 months.
- **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 resistant to the existing vaccines, it is possible to modify the vaccine to protect against the new strain quickly.
- **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 (in this case, the spike protein), which triggers an immune response providing protection against the virus.
- **Potential for broader use:** RNA vaccines can prevent other infectious diseases, such as influenza, HIV, and Zika, and treat cancer.

Forensics – DNA Fingerprinting

DNA fingerprinting, or DNA profiling or genetic fingerprinting, is a technique used in forensic science to identify an individual based on their unique DNA profile. The process involves analyzing specific regions of an individual's DNA, called markers, which can vary from person to person.

DNA comparison is typically done manually by forensic analysts, as it involves analyzing complex DNA profiles and comparing them to control samples to determine if there is a match. However, artificial intelligence (AI) is beginning to play a more prominent role in DNA analysis, particularly in developing automated DNA profiling systems.

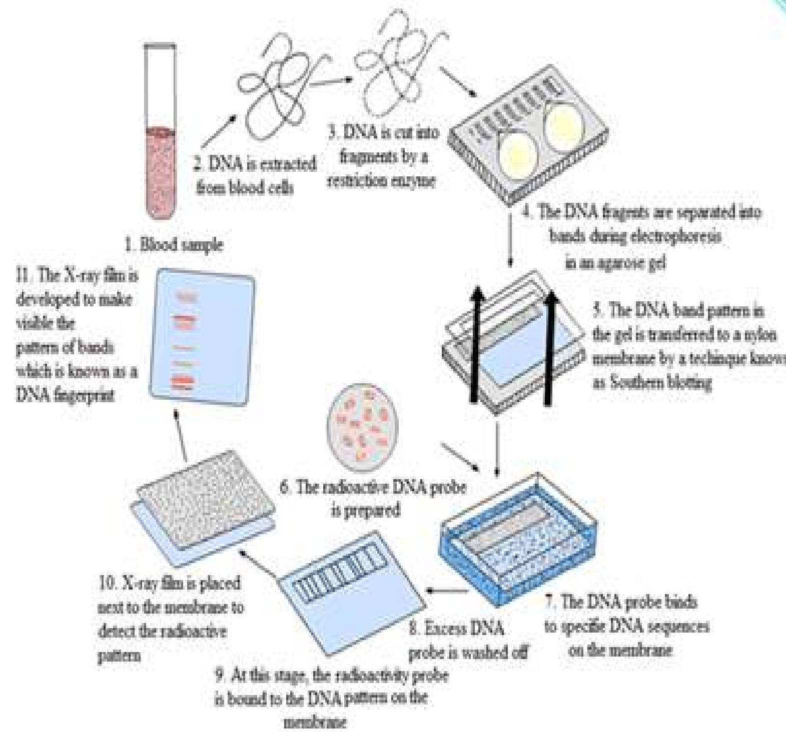
The DNA profile consists of a series of bands on a gel, which represents specific DNA fragments. The bands are compared to those from a control sample, such as blood or saliva from a suspect or victim, to see if there is a match. If there is a match, it is considered strong evidence that the biological sample came from that individual.



https://www.youtube.com/watch?v=TSJ-o-rFIlw

Working of DNA fingerprinting for forensic applications

- **Sample collection:** DNA is extracted from a biological sample, such as blood, skin, or hair. The sample is then purified and processed to isolate the DNA.
- **DNA amplification:** The extracted DNA is then amplified using a polymerase chain reaction (PCR) technique. PCR produces copies of a specific DNA region, allowing more accurate analysis.
- **DNA analysis:** The amplified DNA is then analysed using gel electrophoresis. The DNA fragments are separated based on size and charge, and a DNA profile is generated.
- **DNA comparison:** The DNA profile obtained from the biological sample is then compared to the DNA profiles of other individuals, such as suspects or victims, to determine if there is a match.



Advantages

Unobtrusive form of testing: A DNA sample is required for matching and comparison. Because DNA can be found in many body fluids and tissues, retrieving materials is simple and unobtrusive. Many collectors use a cotton swab to collect saliva from the mouth for testing. Hair follicles can be used as well. That reduces the cost of collection and eliminates the discomfort of needles to collect blood.

Used for more than criminal justice purposes: DNA fingerprinting may be used to create genetic profiles for suspects, but this technology can do more than serve the criminal justice system. Products like 23andMe and AncestryDNA can help people research their ancestry. DNA comparisons can identify people who belong to the same family. TV shows like *Maury* and the *Steve Wilkos Show* have used DNA testing to confirm parenthood for 10+ years.

Collected evidence can be stored indefinitely: DNA samples do not degrade over time like other forms of forensic evidence. As long as a proper chain of custody and storage is followed, the evidence collected with DNA can be stored indefinitely. The DNA from a tooth and thigh bone, fossilized in Spain, were sequenced by scientists in 2016 from samples that were believed to be over 400,000 years old.

It can be used to identify hereditary diseases: DNA fingerprinting is often used to identify certain hereditary diseases that may be life-threatening if not discovered immediately. One of the most important disorders to discover is PKU, or phenylketonria. This metabolic disorder may be very rare, with fewer than 20,000 cases per year, but it can also be a lifelong chronic diagnosis. Treatment of PKU involves a very strict diet with limited protein to prevent brain damage from occurring since the body cannot properly process phenylalanine.

Disadvantages

It creates privacy issues: With current technology, a collected sample of DNA that has been analyzed can be saved in a database indefinitely. Accessing this information could result in privacy issues, especially if the DNA was collected without permission. DNA is often collected during an investigation to exclude suspects, so a process must be in place that removes the information collected.

Hacking becomes a major concern: Databases of DNA information could be potentially accessible because of security vulnerabilities, creating third-party access to DNA fingerprinting information that could lead to a whole new form of identity theft.

Accuracy of DNA fingerprinting is overly influential: DNA fingerprinting is not 100% reliable; it is often marketed as an exact science. DNA matching is dependent upon the type of DNA test that is completed. An analyst with the Arizona state crime lab found that two unrelated people matched at 9 of 13 chromosome locations that are used to distinguish identities.

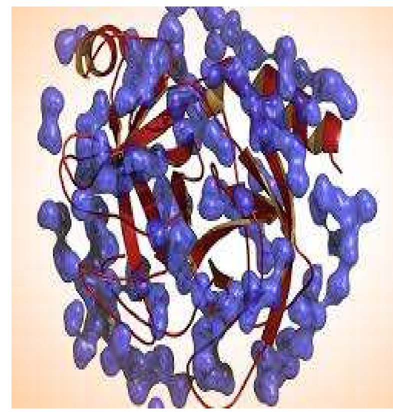
It could be used for exclusionary purposes: A DNA fingerprint can provide a lot of information about an individual. It may show the risks for developing cancer, obesity, or other health problems over time. This information could be used to exclude people from receiving certain medical coverage. Potential employers could even use it as a screening process to hire “healthy” individuals. Imagine receiving individualised advertising based on your DNA.

DNA banking begins at birth in the United States: In the United States, almost every newborn has their DNA examined almost immediately after being born. This is done to discover genetic disorders or birth defects, but this DNA information can also be stored in a database for future matching purposes. Some states hold onto the blood-dot cards indefinitely instead of destroying them. The ACLU reports that these blood cards are used for scientific research and even distributed to third parties in some instances.

Proteins

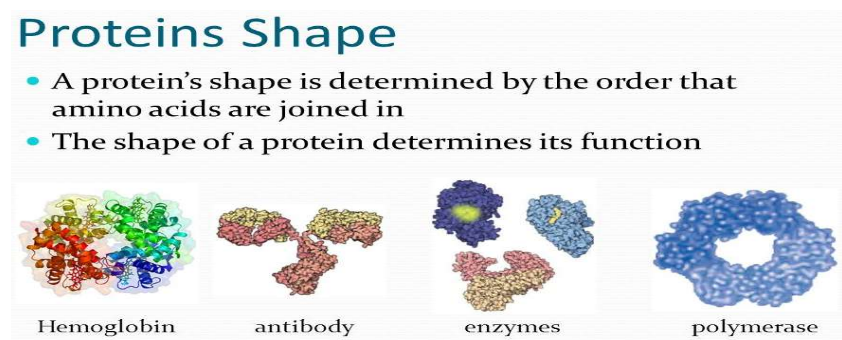
Proteins are large, complex molecules made up of chains of smaller building blocks called amino acids..

Proteins are essential nutrients that provide the body with amino acids, which are the building blocks of the body's tissues. Proteins are found in many foods, including meat, poultry, fish, dairy products, beans, lentils, tofu, and eggs.



The structure of a protein determines its function, and the sequence of amino acids in a protein determines its structure.

There are 20 different types of amino acids, and the specific sequence of amino acids in a protein determines its unique structure and function.

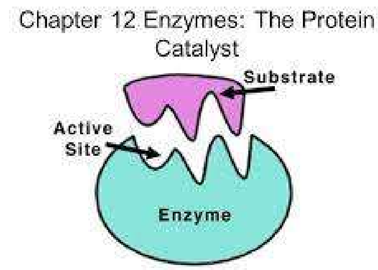


Understanding the structure and function of proteins is, therefore, a major focus of biomedical research, with the goal of developing new treatments and therapies for these diseases.

Functions of Proteins

Catalyzing chemical reactions

Example: Amylase, an enzyme found in saliva and pancreatic juice breaks down starch into simple sugars like glucose and maltose.

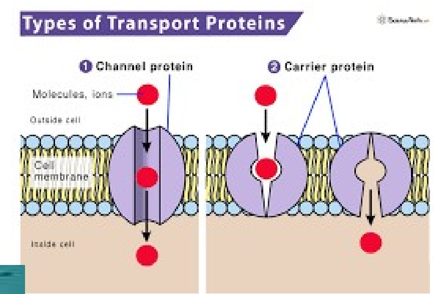


Transporting molecules

Example: Hemoglobin is a protein found in red blood cells that transports oxygen from the lungs to the tissues in the body.

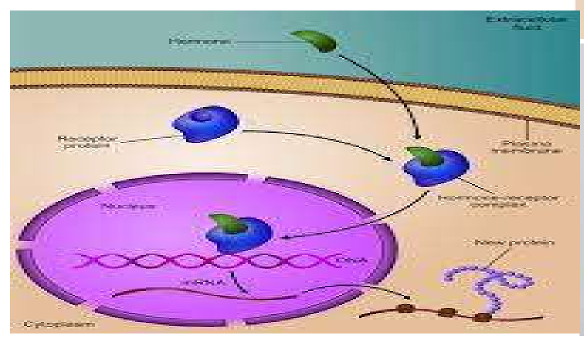
Providing mechanical support

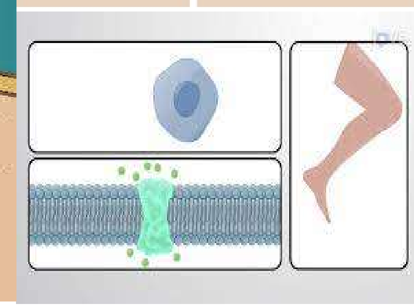
Example: Keratin is a protein that forms the structural basis of hair, nails, and the outer layer of skin.



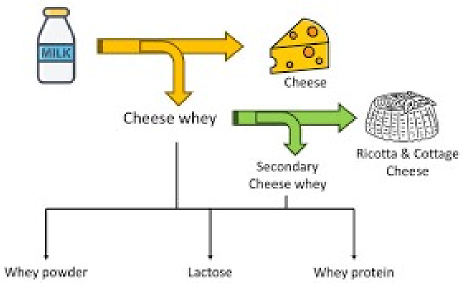
Regulating cell behavior

Example: Cytoskeleton proteins, such as actin and tubulin, are critical in regulating cell shape, movement, and division.

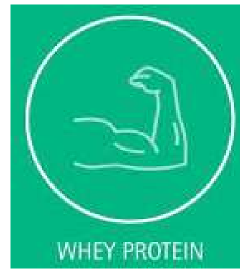




Whey Protein



Whey protein is derived from the liquid separating from milk during cheese-making. it contains all the essential amino acids the body needs to build and repair tissues



Whey protein is widely used as a dietary supplement, particularly by athletes, bodybuilders, and people looking to increase their protein intake.

The body rapidly absorbs whey protein and is high in branched-chain amino acids essential for muscle growth and repair.

Whey protein is available in various forms, including powders, bars, and drinks. It is often added to smoothies, baked goods, and other food products to increase the protein content.

However, it is essential to note that not all whey protein products are equal in quality, purity, and nutrient content. Some whey protein supplements may contain added sugars, artificial sweeteners, or other ingredients that can be harmful to health. Therefore, choosing a reputable brand and carefully reading the ingredient list before purchasing is important.

Use of whey protein as food

Sports nutrition: Athletes and fitness enthusiasts often use whey protein to help build and repair muscle tissue, support recovery after intense exercise, and increase overall muscle mass.

Weight management: It can be used to help manage weight by increasing satiety and reducing appetite. It can also help with weight loss by preserving muscle mass while reducing body fat.

Health promotion: Whey protein is rich in essential amino acids and has been shown to have various health benefits, including improved immune function, lower blood pressure, and reduced risk of cardiovascular disease.

Meal replacement: Whey protein can be used as a meal replacement, as a drink or in various food products. It provides a quick and convenient source of protein, making it a popular option for people with busy schedules or limited access to fresh foods.

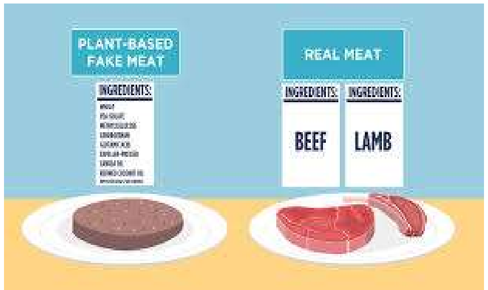
Meat analogues of protein

Meat analogues, or meat substitutes or alternatives, are plant-based foods designed to mimic meat's taste, texture, and appearance. They are made from various ingredients, including soy protein, wheat protein, pea protein, and other plant-based ingredients, and are often fortified with vitamins and minerals to provide a similar nutritional profile to meat.

Meat analogues are a popular alternative to meat for many people, including vegetarians, vegans, and those looking to reduce their meat consumption for health or ethical reasons.

Different meat analogues include burgers, sausages, meatballs, deli slices, and more. They can be a good protein source and help meet the body's needs.

Some are designed to mimic specific types of meat, such as chicken, beef, or pork



While others are marketed as a more generic "meat-like" product.

Purchase products that are high in protein and low in added sugars, fats, and other ingredients that can be harmful to health

Examples of meat analogues of protein as food

Made from soybeans is a versatile meat analogue that can be used in various dishes, including stir-fries, salads, and smoothies.

Tempeh is made from fermented soybeans and has a nutty flavour and firm texture. It can be sliced and used in sandwiches or salads and used as a meat substitute in tacos or spaghetti sauces.

Seitan is a wheat protein made from wheat gluten, having a chewy, meat-like texture. It can be used as a substitute for beef or pork in various dishes.

Meatless meatballs are a tasty and protein-rich alternative to traditional meatballs made from plant-based ingredients such as soy protein, grains, and vegetables.

Made from various plant-based ingredients, including soy protein, grains, and vegetables, They are a popular meat analogue that can be grilled or baked and served on a bun.

Made from soy protein, pea protein, or other plant-based ingredients, plant-based sausages are a convenient and protein-rich alternative to traditional sausages.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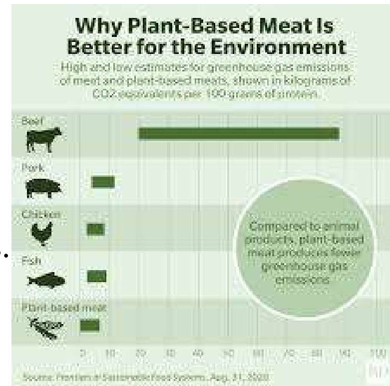
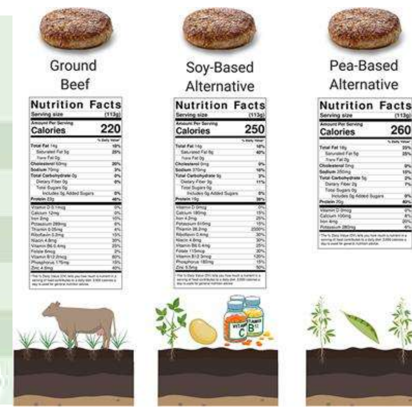
Plant-Based Proteins

Plant-based proteins are derived from plant sources, such as legumes, grains, nuts, and seeds. Used as an alternative to animal-based proteins, especially for those following a vegetarian or vegan diet.





Benefits of plant-based proteins

Sustainable — More environmentally sustainable than animal-based. Require fewer resources to produce hence emits fewer greenhouse gas.

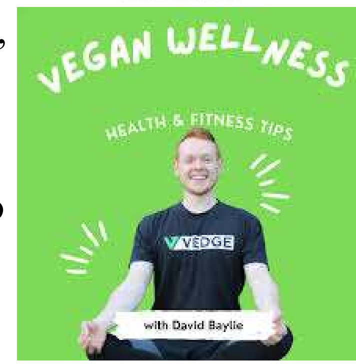
Nutrient-rich — Rich in other essential nutrients, such as fibre, vitamins, and minerals.

Versatile — Used as a protein supplement, in smoothies, or as an ingredient in various recipes

Hypoallergenic — Plant-based proteins are often better tolerated than animal-based proteins, making them a good option for people with food allergies or sensitivities.

Cost-effective — Plant-based protein sources are often more affordable than animal-based sources, making them a more accessible option for many people.

Uses of plant-based proteins



Dietary supplements: Plant-based proteins are often sold as powders, bars, and other supplements, making them a convenient way to add protein to a diet.

Food products: Plant-based proteins are used as ingredients in a variety of food products, including plant-based meat analogs, protein bars, and smoothies.

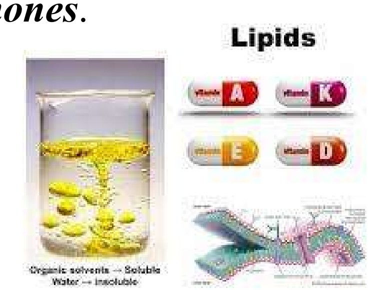
Health and wellness: Plant-based proteins are often marketed as a healthier alternative to animal-based proteins, due to their lower saturated fat and cholesterol content.

Vegetarian and vegan diets: Plant-based proteins are a popular source of protein for people following a vegetarian or vegan diet, as they do not contain animal products.

Fitness and sports nutrition: Plant-based proteins are also used by athletes and fitness enthusiasts to support muscle recovery and growth.

Lipids

***Lipids are a group of organic compounds that include fats, oils, waxes, and some hormones*.**



Lipids are hydrophobic, nonpolar molecules.

They are soluble in nonpolar solvents.

Insoluble in polar solvents, such as water.

Role of Lipid as biomolecule:

Energy storage: Lipids are a major source of stored energy in the body, and they can be broken down to release energy when needed.

Insulation: Lipids help to insulate the body, helping to regulate temperature and protect against heat loss.

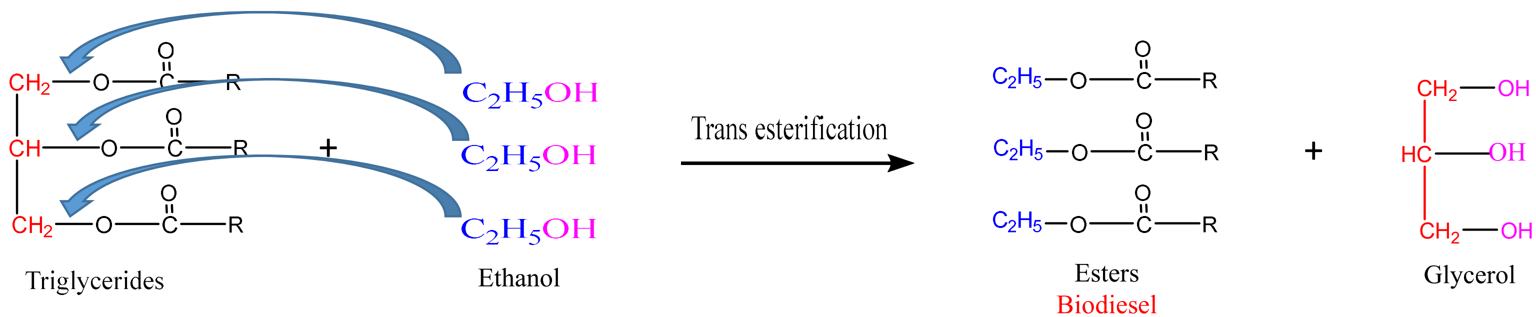
Cell membrane structure: Lipids are a major component of cell membranes, helping to maintain their fluidity and stability.

Hormone synthesis: Some lipids, such as cholesterol, are precursors to hormones, and are necessary for their production.

Transport: Lipids are soluble in fat, but not in water. This makes them ideal for carrying fat-soluble vitamins and other lipophilic compounds through the bloodstream.

Lipids as Biodiesel

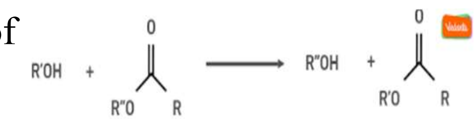
Lipids can be converted into biodiesel, a renewable energy source. Biodiesel is typically produced by transesterifying vegetable oils or animal fats with an alcohol, such as methanol, to form methyl esters. The resulting biodiesel can be used as a drop-in replacement for traditional diesel fuel in internal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



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), the main components of biodiesel. This process is known as transesterification.



Transesterification

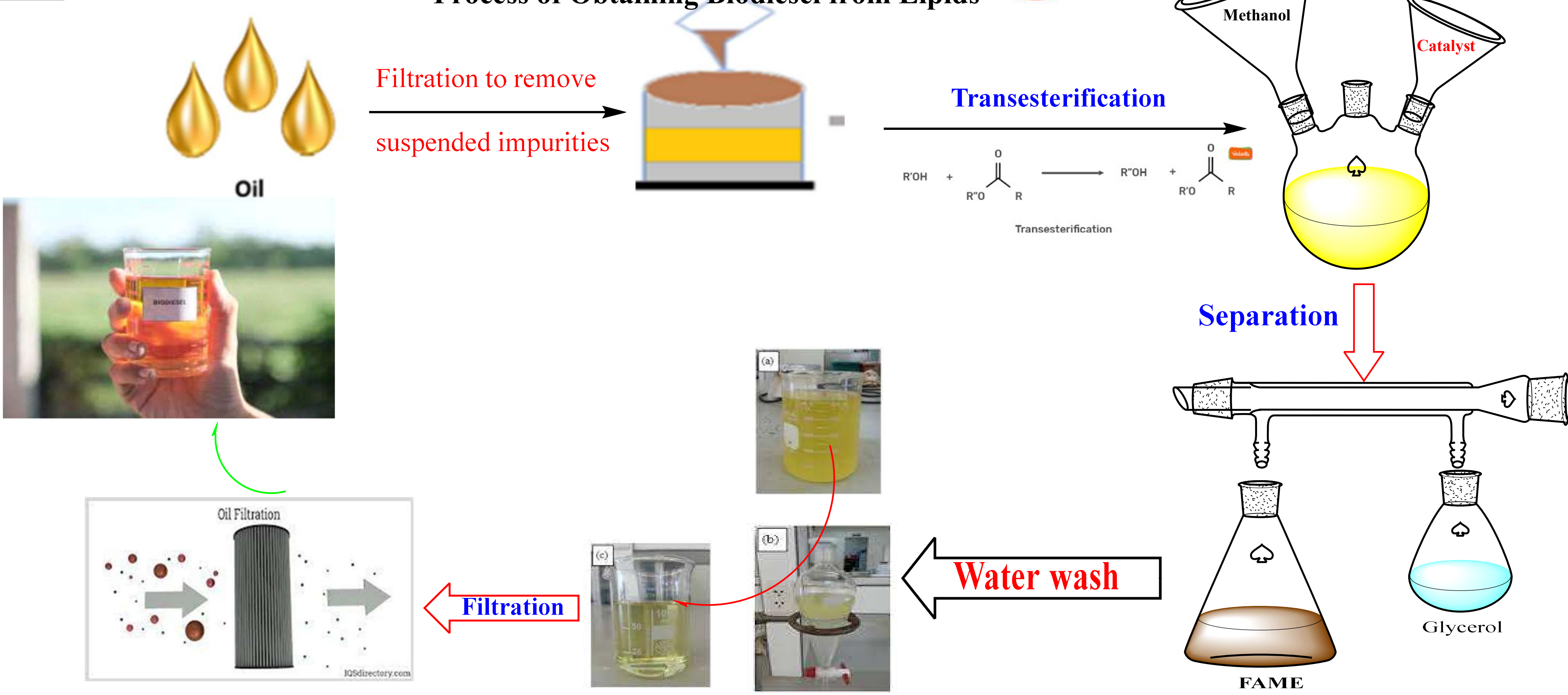
Separation: The reaction mixture is then separated into two layers: the upper layer contains the FAME (biodiesel) and the lower layer contains the glycerol (byproduct).

Washing and drying: The biodiesel is washed with water to remove any residual alcohol and soap formed during the transesterification reaction, then dried to remove any remaining moisture.

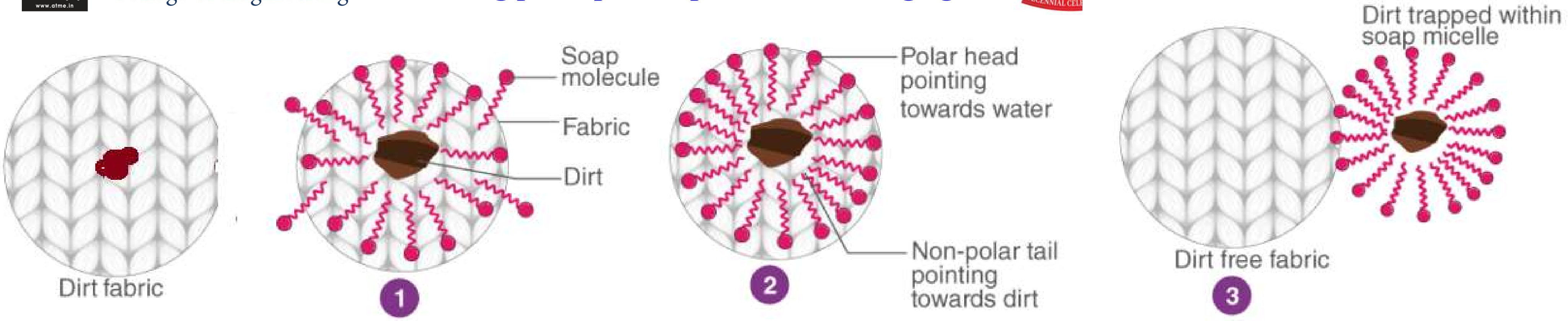
Purification: The biodiesel is further purified to remove impurities and improve quality.

Final product: The pure biodiesel is then stored and distributed as fuel.

Process of Obtaining Biodiesel from Lipids



Working principle of lipids as a cleaning agent



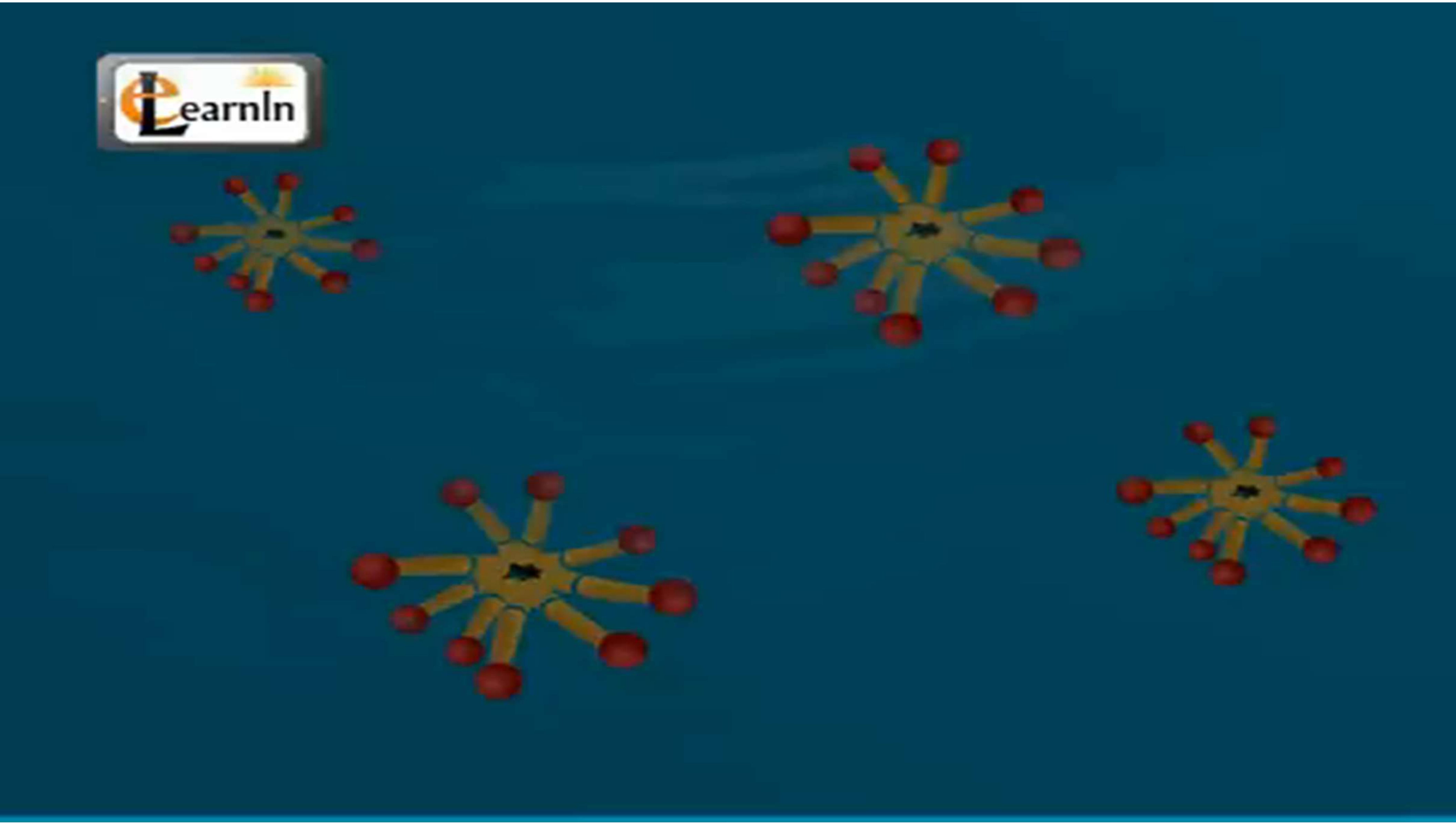
The dirt/grease on clothes is organic and insoluble in water. Therefore, it cannot be removed by only washing with water.

Step 1: When Lipid detergent is dissolved in water, its hydrophobic **Tail** ends attach to the dirt and remove it from the cloth.

Step 2: The molecules of Lipid detergent arrange themselves in **micelle formation** and **trap the dirt at the centre** of the cluster.

Step 3: These micelles remain suspended in the water. The dust particles are then easily rinsed away by water.

In addition, some lipids have additional properties, such as foaming or lathering capabilities, that can enhance their cleaning performance. These additional properties can help loosen and remove dirt and debris, making cleaning more effective.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Applications of 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 and sudsing performance.

Cleaning agents for hard surfaces: Lipids can be used as cleaning agents for hard surfaces, such as floors, countertops, and walls, to remove dirt and grime.

Advantages of lipids as cleaning agents/detergents

Biodegradability: Lipids are derived from natural sources, like plants and animals, and are biodegradable, making them more environmentally friendly than many synthetic cleaning agents.

Renewable resources: Lipids can be obtained from renewable resources, such as crops, and are not based on finite fossil fuels like some synthetic cleaning agents.

Effectiveness: Lipids have excellent grease-cutting and emulsifying properties, making them effective cleaning agents.

Mildness: Lipids are typically mild and gentle, making them suitable for personal care products, such as soaps and shampoos, and for cleaning delicate materials, such as silk and wool.

Cost-effective: Lipids can be less expensive than synthetic cleaning agents, especially when obtained from low-cost feedstocks, such as vegetable oils.

Customizability: Lipids can be modified and customized to improve their cleaning performance and to meet specific application needs.

Limitations of lipids as cleaning agents/detergents

Stability: Some lipids can be susceptible to oxidation and degradation, reducing their effectiveness as cleaning agents over time.

Compatibility: Some lipids may not be compatible with certain surfaces or materials and may cause staining or damage.

Cost: Although lipids can be less expensive than synthetic cleaning agents, the cost can vary depending on the source of the lipids and the processing methods used.

Availability: The availability of lipids for use as cleaning agents may be limited by the availability of feedstocks, such as crops and animal fats, and the need for processing and refining.

Performance: The cleaning performance of lipids can vary depending on the specific properties of each lipid and the type of soil or stain being removed. Some lipids may not perform as well as synthetic cleaning agents in certain applications.

Regulation: The use of lipids as cleaning agents is regulated by government agencies, and specific requirements may vary from country to country.

Enzymes

- **Enzymes are proteins that act as catalysts in biological reactions.**
- **They speed up the rate of chemical reactions.**
- **Enzymes are involved in various metabolic processes,** digestion, and cellular respiration**.**

Properties of Enzymes for Engineering Applications

Specificity: Enzymes are specific in performing specific tasks.

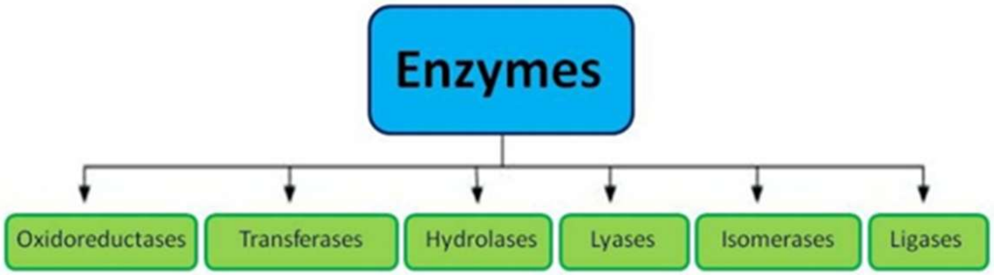
Reactivity: They speed up the rate of chemical reactions without being consumed.

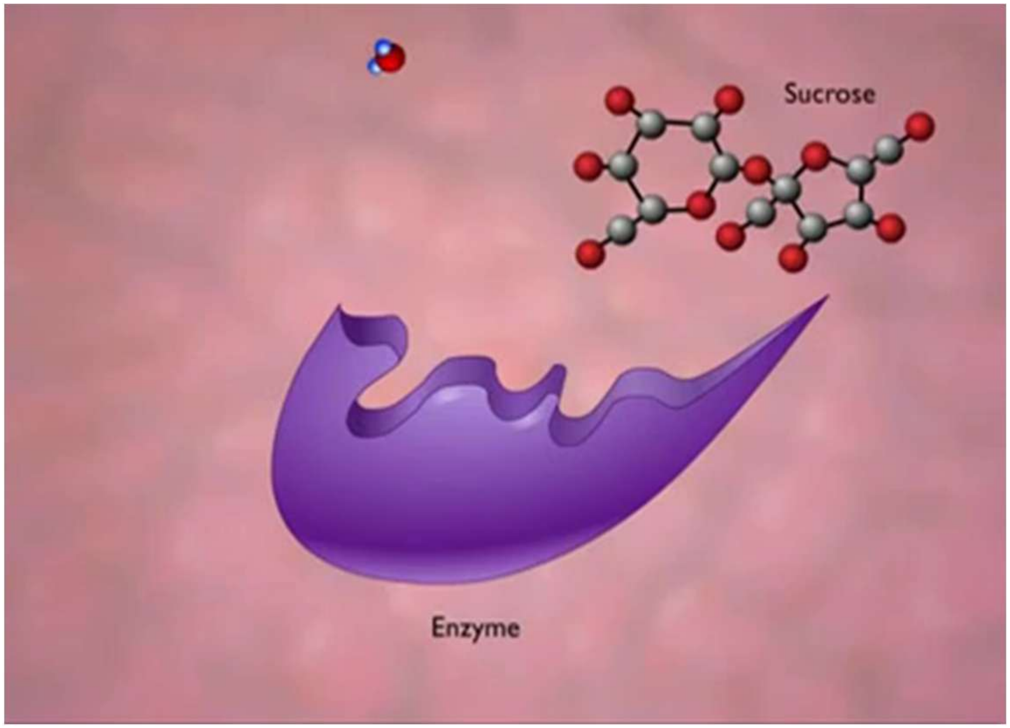
Renewability: Enzymes are biodegradable & obtained from renewable resources,

Cost-effectiveness: Enzymes can be produced in large quantities through fermentation, making them cost-effective.

Enzymes

Enzymes are biological polymers that catalyze biochemical reactions



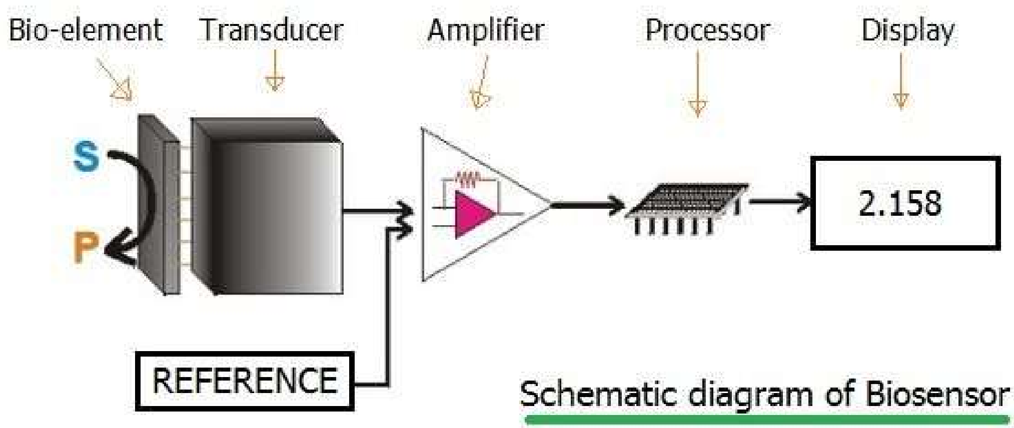


Engineering Applications of Enzymes

- **Biofuel production:** Enzymes are used to convert plant material into biofuels, such as ethanol and biodiesel.
- **Food and beverage production:** Enzymes are used in the food and beverage industry such as baking, cheese making, and juice production.
- **Textile production:** Enzymes are used to remove stains, whiten fabrics, and improve the softness of textiles.
- **Pharmaceuticals:** Enzymes are used to produce various pharmaceutical products, such as antibiotics and vaccines.

Biosensors

Biosensors are **analytical devices** that combine a **biological recognition element** with a **transducer** to **detect & quantify** target analytes.



Schematic diagram of Biosensor

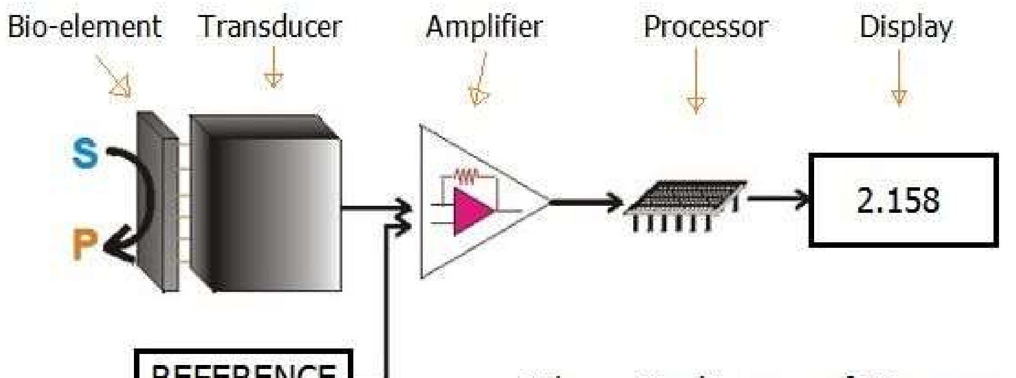
The biological recognition element can be an **enzyme, antibody, nucleic acid, or other biological molecule** that **specifically interacts** with the **target analyte**.

The **transducer** converts the **biological response into an electrical signal** that can be **quantified and interpreted**.

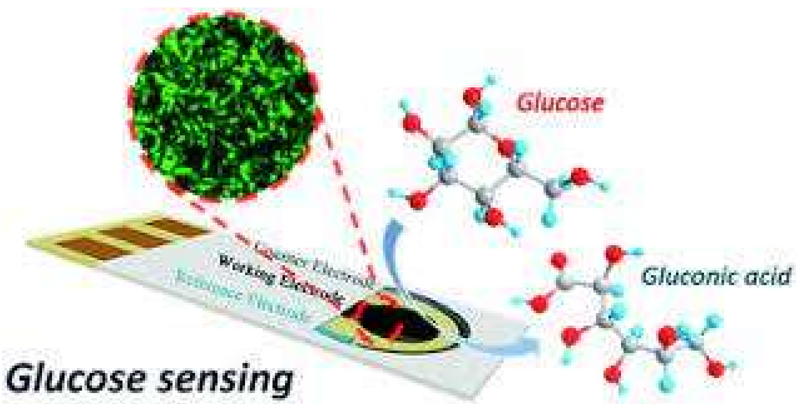
Glucose-Oxidase in Biosensors

- **Glucose oxidase (GOx) is an enzyme** commonly used in **biosensors** to detect glucose levels in biological fluids, such as blood and urine.
- The enzyme catalyzes glucose oxidation to **Gluconic acid** and **hydrogen peroxide (H_2O_2),** which a transducer can easily detect and quantify.

- In glucose biosensors, **GOx is typically immobilised on a polymer film**.
- The transducer in the biosensor is an electrode or other type of sensor.



Schematic diagram of Biosensor



Bleaching

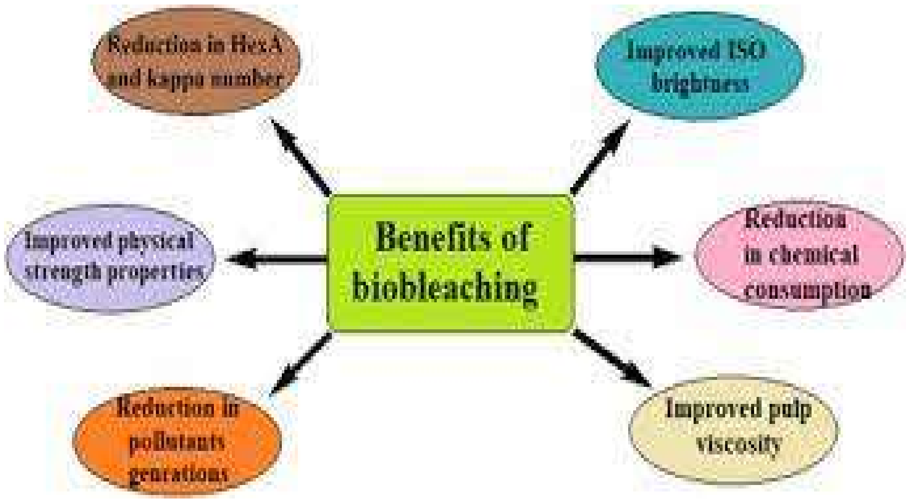
- Bleaching, a process of whitening fabric by removal of natural colour, such as the tan of linen, is usually carried out by means of chemicals selected according to the chemical composition of the fibre.
- Chemical bleaching is usually accomplished by oxidation, destroying colour by the application of oxygen, or by reduction, removing colour by hydrogenation.
- Cotton and other cellulosic fibres are usually treated with heated alkaline hydrogen peroxide; wool and other animal fibres are subjected to such acidic reducing agents as gaseous sulfur dioxide or to such mildly alkaline oxidizing agents as hydrogen peroxide.
- Synthetic fibres, when they require bleaching, may be treated with either oxidizing or reducing agents, depending upon their chemical composition. Cottons are frequently scoured and bleached by a continuous system.
- The pulp and paper industry is known to be a large contributor to environmental pollution due to the huge consumption of chemicals and energy.
- Several chemicals including H2SO4, Cl2, ClO2, NaOH, and H2O2 are used during the bleaching process.
- These chemicals react with lignin and carbohydrates to generate a substantial amount of pollutants in bleach effluents.

Ligno-lytic enzymes in bioleaching

- Bio-bleaching is a process that uses **biological agents**, such **as enzymes, to remove color** and **brighten fibers**, paper, and textiles.
- It is a sustainable alternative to **traditional chemical bleaching methods** that use **harsh chemicals**, such as hydrogen peroxide and chlorine.

- Ligno-lytic enzymes play a key role in the degradation and detoxification of waste.
- The ligno-lytic enzymes are also found in different types of organisms such as plants, bacteria, insects, and fungi

- The most important lignin-oxidizing enzymes are lignin peroxidases, manganese peroxidases and laccases



Ligno-lytic enzymes in bioleaching

- Lignolytic enzymes, such as laccases, peroxidases, are used in bio-bleaching to remove color and brighten fibers, paper, and textiles.
- These enzymes catalyze the oxidation of colored impurities in the fibers, resulting in a brighter and more uniform color.

- The ligno-lytic enzymes used in bio-bleaching are typically produced by fungi or bacteria, and are immobilized on a support, such as a ceramic material polymer film.
- The immobilized enzymes are then added to the fibers, where they catalyze the oxidation of colored impurities, resulting in a brighter and more uniform color.

Steps Involved in Hand Made Paper Making

Collection of Agro waste/Waste paper materials
↓
Sorting out for quality control
↓
Soaking
↓
Bio-Pulping/Bio-Bleaching
↓
Evenly spreading the pulp on a VAT
↓
Formation of sheet on cloth
↓
Screw pressing
↓
Drying
↓
Ironing
↓
Cutting
↓
Preparation of paper products

THANK YOU!