1.a.What is a biomolecules?

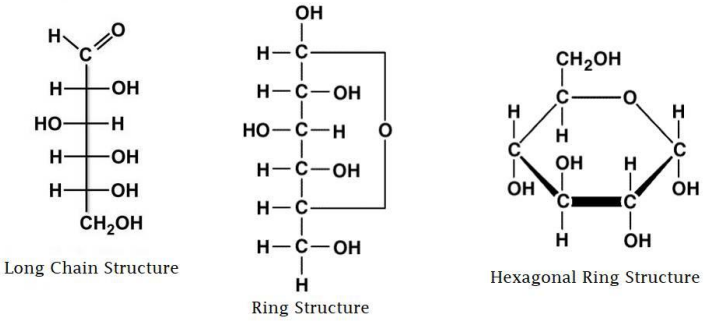
A biomolecule refers to any molecule that is produced by living organisms. As such, most of them are organic molecules. The four major groups of biomolecules includes polysaccharides, proteins, nucleic acids (DNA and RNA), and lipids. They are found in and produced by living organisms.

Classification of biomolecules

Carbohydrates are a class of organic compounds that play a crucial role in biology and are an important source of energy for living organisms. They are composed of carbon (C), hydrogen (H), and oxygen (O) atoms and are classified based on their molecular structure and function. General formula is Cn(H2O)n.

Monosaccharides

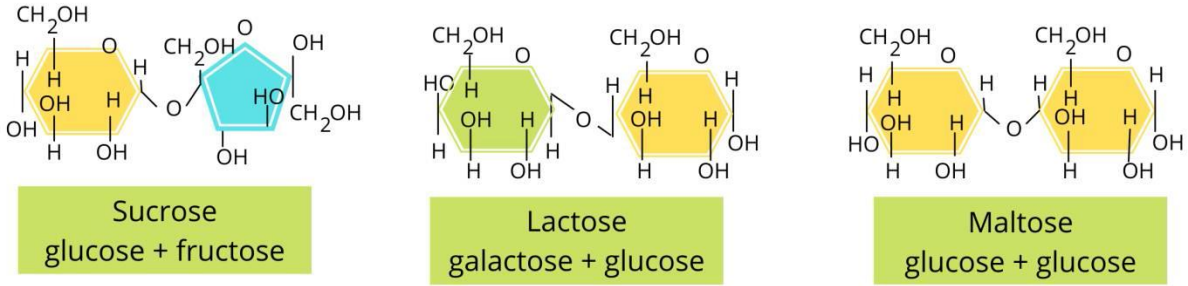
These are the simplest form of carbohydrates and include glucose and fructose. They are easily soluble in water and serve as the primary source of energy for the body.



Glucose

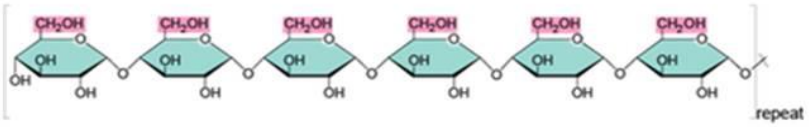
Disaccharides

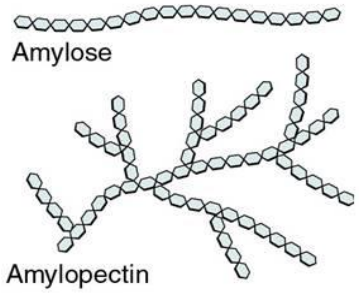
These are formed by the condensation of two monosaccharides and include sucrose, lactose, and maltose. They are commonly found in sugar and are broken down into monosaccharides during digestion.



Polysaccharides

These are long chains of monosaccharides linked together. They serve as storage molecules for energy, such as glycogen in animals and starch in plants, and also provide structure and support, such as cellulose in plant cell walls. In addition to their role as energy sources, carbohydrates also play important roles in cellular processes, such as cellular signalling and recognition, and in regulating gene expression.





Starch

Overall, carbohydrates are essential components of biological systems and play a crucial role in maintaining the health and survival of living organisms.

1.b Role of DNA vaccine for Rabies and RNA vaccine for covid-19.

DNA Vaccine for Rabies

A DNA vaccine for rabies is a type of vaccine that uses a piece of rabies virus DNA to stimulate an immune response against the virus. The vaccine works by introducing the rabies virus DNA into the body, where it is taken up by cells and used to 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.

Importance of DNA vaccine for rabies

DNA vaccines offer several advantages over traditional vaccines, including their ability to stimulate a strong and long-lasting immune response with fewer doses required, as well as their ease of manufacture and storage. These advantages make DNA vaccines particularly useful for preventing the spread of infectious diseases like rabies. In the case of rabies, DNA vaccines have several key advantages:

- Efficacy: DNA vaccines have been shown to be highly effective in preventing rabies infection in both animal and human trials. In one study, a DNA vaccine was found to be as effective as a traditional vaccine in protecting dogs against rabies.
- Long-lasting protection: DNA vaccines can stimulate a strong and long-lasting immune response, which means that they can provide protection against rabies for extended periods of time.
- Ease of administration: DNA vaccines are easy to administer, as they can be given via injection or even delivered orally, which can be particularly useful in areas where access to medical facilities is limited.
- Cost-effective: DNA vaccines are relatively inexpensive to produce compared to traditional vaccines, which can make them more accessible in areas where resources are limited.
- Reduced risk of side effects: DNA vaccines do not contain live virus particles, which means that they are generally safer and have a lower risk of side effects compared to traditional vaccines.

RNA Vaccines for Covid19

RNA vaccines for COVID 19 are a type of vaccine that 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 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 of people worldwide.

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 vaccine approaches. Here are some of the main reasons why RNA vaccines are important in the fight against COVID-19:

· High efficacy: RNA vaccines have been shown to be highly effective at preventing COVID-19 infections. The Pfizer-BioNTech and Moderna mRNA vaccines, for example, have reported efficacy rates of around 95% in clinical trials.

· Rapid development: RNA vaccines can be rapidly developed and manufactured, making them particularly useful in the context of a pandemic. 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 authorization 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 that is resistant to the existing vaccines, it is possible to quickly modify the vaccine to provide protection against the new strain.

· Safe: RNA vaccines are generally considered safe, as they do not contain any live virus particles. They work by instructing cells to produce a harmless piece of the virus (in this case, the spike protein), which triggers an immune response that provides protection against the virus.

· Potential for broader use: RNA vaccines have the potential to be used in the prevention of other infectious diseases, such as influenza, HIV, and Zika, as well as in the treatment of cancer.

1.c.Cellulose based bio-filters

Cellulose-based water filters are filters made from cellulose, a carbohydrate polymer found in plant cell walls. They are used to 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 both 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: Cellulose-based water filters have a high porosity structure, which allows them to efficiently remove impurities and contaminants from water.

· Biodegradability: Cellulose-based water filters are made from a biodegradable material, cellulose, which reduces their impact on the environment compared to synthetic polymer filters.
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 of cellulose based water filters

Cellulose-based water filters have some limitations that need to be considered when choosing a water filtration solution:

· Low resistance to high temperature: Cellulose-based water filters have low resistance to high temperature 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 to be replaced more frequently compared to 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.

Construction of cellulose-based water filters

Construction of cellulose-based water filters involves the following steps:

1. 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 fibers.
2. Cellulose Preparation: The cellulose material is prepared by cutting it into small pieces, washing it to remove impurities, and drying it for use.
3. Cellulose Layer Formation: The cellulose material is formed into a layer by either stacking it or compacting it using heat and pressure.
4. 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.
5. Chemical Treatment: The cellulose layer may be chemically treated to modify its properties, such as increasing its hydrophilicity or adding antimicrobial agents.

2a.DNA Finger printing in forensic applications

DNA fingerprinting, also known as 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.

Working of DNA fingerprinting for forensic applications

· Sample collection: DNA is extracted from a biological sample, such as blood, semen, or hair. The sample is then purified and processed to isolate the DNA.

DNA amplification: The extracted DNA is then amplified using a technique called polymerase chain reaction (PCR). PCR produces many copies of a specific DNA region, which allows for more accurate analysis.

· DNA analysis: The amplified DNA is then analyzed using a technique called 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.

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 the development of automated DNA profiling systems.

The DNA profile consists of a series of bands on a gel, which represent 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.

Forensic DNA fingerprinting has become a critical tool in criminal investigations, allowing investigators to link individuals to crime scenes and to exonerate innocent individuals who may have been wrongly accused. It has also been used to identify victims of natural disasters and mass casualties, and to resolve paternity disputes.

2.b. Role of Lipid and its application in cleaning agents.

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.

Lipids have several properties that make them suitable as cleaning agents, including their ability to emulsify and dissolve grease and oils. Additionally, lipids can form micelles, which are tiny spherical structures that can surround and trap dirt particles, making it easier to remove them.

However, it is important to note that not all lipids are equally effective as cleaning agents and that the specific properties of each lipid can impact its performance. Further research is lipids for this purpose.

Examples of lipids used as cleaning agent

· Soap: Soap is a traditional cleaning agent made from the reaction of an alkali with a fat or oil. Soaps are made from various types of lipids, including animal fats and vegetable oils.

· Fatty acids: Fatty acids, such as stearic acid, can be used as cleaning agents in personal care Products, such as bar soaps and shampoos.

· Glycerol: Glycerol is a by product of soap production and can be used as a cleaning agent in a variety of applications, including household cleaners and industrial cleaning solutions.

· Fatty alcohols: Fatty alcohols, such as lauryl alcohol, can be used as cleaning agents in personal care products and industrial cleaning solutions.

These are a few examples of lipids that are used as cleaning agents. There are many other lipids with different properties that can be used for cleaning, depending on the specific requirements of each application.

Advantages of lipids as cleaning agents/detergents

· Biodegradability: Lipids are derived from natural sources, such as plants and animals, and are biodegradable, which makes 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.

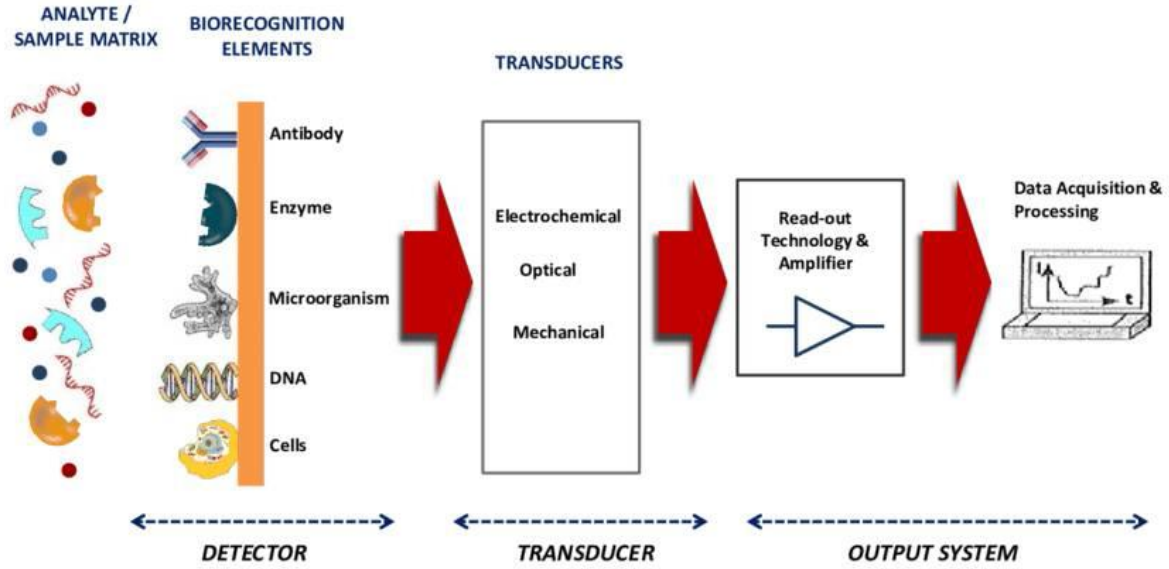
· Mildness: Lipids are typically mild and gentle, making them suitable for use in personal care products, such as soaps and shampoos, and for cleaning delicate materials, such as silk and wool.

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

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

However, it is important to note that not all lipids are equally effective as cleaning agents and that the specific properties of each lipid can impact its performance. Further research is needed to optimize the use of lipids as cleaning agents and to identify new and more effective lipids for this purpose.

2.c. Biosensors and Bioplastics



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

levels in patients with diabetes, detect contaminants in water and food, and monitor environmental pollutants. Biosensors have several advantages over traditional analytical methods, including rapid response time, high sensitivity, specificity, and portability. Additionally, they can be designed to be disposable and cost-effective, making them a useful tool in various industries and applications.

Enzymes Used in Biosensors

Enzymes are commonly used in biosensors as the biological recognition element. Here are some examples of enzymes used in biosensors:

· Glucose oxidase (GOx): Used in blood glucose monitoring for people with diabetes. The enzyme oxidizes glucose to gluconic acid and hydrogen peroxide, which is then detected by a transducer to quantify glucose levels in the blood.

· Lactate oxidase (LOx): Used in the determination of lactate levels in biological fluids, such as blood and urine. LOx oxidizes lactate to pyruvate, which is then detected by a transducer.

· Cholinesterase (ChE): Used in the detection of organophosphorus pesticides and nerve agents. ChE hydrolyzes acetylcholine, and the decrease in acetylcholine levels is detected by a transducer to quantify the presence of the toxic substances.

· Alkaline phosphatase (ALP): Used in the detection of inorganic phosphates, such as those found in wastewater and fertilizers. ALP catalyzes the hydrolysis of phosphates to produce a signal that can be quantified.

· Urease: Used in the detection of urea levels in biological fluids, such as urine. Urease catalyzes the hydrolysis of urea to produce ammonium and carbon dioxide, which can be quantified by a transducer.

These are just a few examples of the many enzymes that can be used in biosensors to detect and quantify a wide range of target analytes.quantified and interpreted. Biosensors have a wide range of applications in the fields of medicine, environmental monitoring, and food safety. For xample, biosensors can be used to monitor blood glucose levels in patients with diabetes, detect contaminants in water and food, and monitor environmental pollutants. Biosensors have several advantages over traditional analytical methods, including rapid response time, high sensitivity, specificity, and portability. Additionally, they can be designed to be disposable and cost- ffective, making them a useful tool in various industries and applications.

quantified by a transducer.

These are just a few examples of the many enzymes that can be used in biosensors to detect and quantify a wide range of target analytes.

Bioplastics

Plastics which are derived from crude oil such as petroleum , when they burned the carbon dioxide contained in the petroleum into the atmosphere, leading to global warming.

STEPS:

1. A little colony of bacteria are grown in plates
2. Now, feed the bacteria with sugar solution or glycerol or fatty acids (to get more oxygen).
3. Bacteria will grow only with sufficient carbon, nitrogen and phosphorus.
4. Next process is fermentation
5. In fermentation, the supply of nitrogen and phosphorus stops, the bacteria get stressed and started generating granules of polymer inside the cells.
6. Hence pearls of polymers will produce and will be dried and mixed with acetone and the resulting cocktail will be filtered.
7. This stressing moment will happen only during the process of fermentation, and hence they produce bioplastic as a stress related response

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.

They are made from renewable resources, such as sugar and cornstarch, and are considered to be an environmentally friendly alternative to traditional petroleum-based plastics

Properties of PHA

PHAs have several properties that make them ideal for use as bioplastics, including:

Biodegradability: PHAs are biodegradable and can break down into water and carbon dioxide, reducing their impact on the environment.

Biocompatibility: PHAs are biocompatible and can be used in medical devices, such as sutures and implants, without causing adverse reactions in the body.

Mechanical properties: PHAs have similar mechanical properties to traditional petroleum based plastics, making them suitable for various applications.

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

MODULE -2

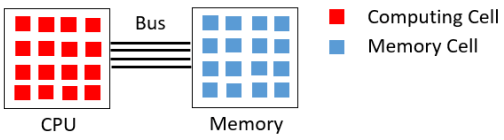
3.a. Brain as a CPU system

The human brain can be thought of as a highly sophisticated and complex information processing system, similar to a computer's Central Processing Unit (CPU). Both the brain and CPU receive and process inputs, store information, and perform calculations to produce outputs. However, there are significant differences between the two, such as the way they store and process information and the fact that the human brain has the ability to learn and adapt, while a computer's CPU does not. Additionally, the human brain is capable of performing tasks such as perception, thought, and emotion, which are beyond the scope of a computer's CPU.

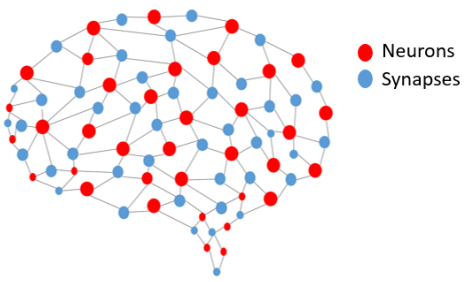
BASIS OF COMPUTER	BRAIN	COMPUTER
Construction	Neurons and synapses	ICs, transistors, diodes, capacitors, transistors, etc
Memory growth	Increases each time by connecting synaptic links	Increases by adding more memory chips
Backup systems	Built-in backup system	Backup system is constructed manually
Memory power	100 teraflops (100 trillion calculations/seconds)	100 million megabytes
Energy consumption	12 watts of power	Gigawatts of power
Information storage	Stored in electrochemical and electric impulses.	Stored in numeric and symbolic form (i.e. in binary bits).

Architecture

The architecture of the human brain as a CPU system can be compared to that of a parallel distributed processing system, as opposed to the Von Neumann architecture of traditional computers.



(a) Von Neumann Computing System



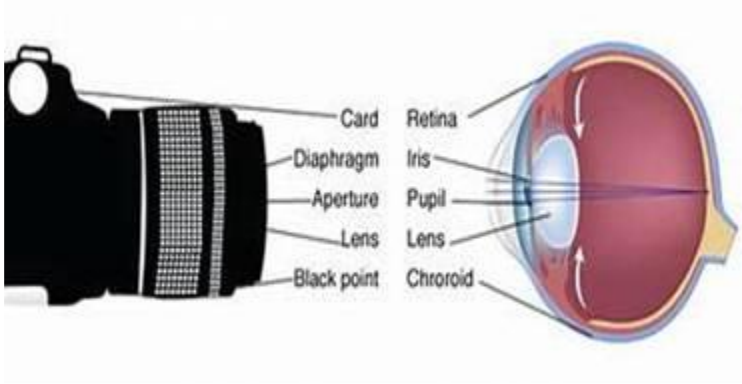
(b) Brain Computing System

In the human brain, information is processed in a distributed manner across multiple regions, each with specialized functions, rather than being processed sequentially in a single centralized location.
Just like how a computer's CPU has an arithmetic logic unit (ALU) to perform mathematical calculations, the human brain has specialized regions for processing mathematical and logical operations. The prefrontal cortex, for example, is responsible for higher-level cognitive functions such as decision making and problem solving.

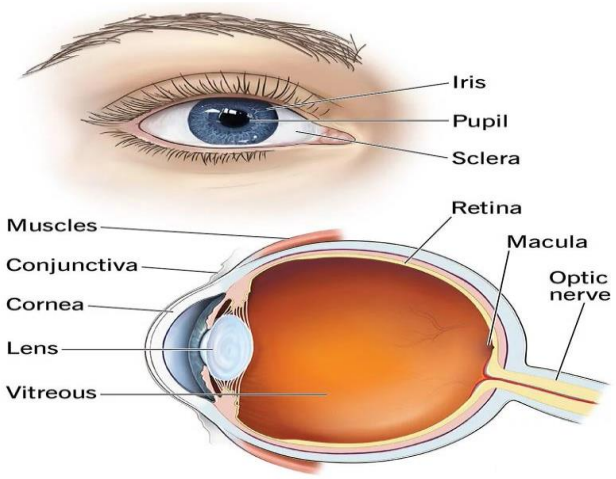
3.b. Eye as a camera system

The human eye can be analogized to a camera system, as both the eye and a camera capture light and convert it into an image.
The main components of the eye that correspond to a camera system include:

- The Cornea: This transparent outer layer of the eye functions like a camera lens, bending light to focus it onto the retina.
- The Iris: The iris functions like the diaphragm in a camera, controlling the amount of light that enters the eye.
- The Pupil: The pupil functions like the aperture in a camera, adjusting the size to control the amount of light entering the eye.
- The Retina: The retina functions like the camera film or sensor, capturing the light and converting it into electrical signals that are sent to the brain.
- The Optic Nerve: The optic nerve functions like the cable connecting the camera to a computer, transmitting the electrical signals from the retina to the brain.



In both the eye and a camera, the captured light is transformed into an image by the lens and the light-sensitive component. The eye processes the image further, allowing for visual perception, while a camera stores the image for later use.
It's important to note that the eye is much more complex than a camera and has several additional functions, such as adjusting for different levels of light and adjusting focus, that are not found in a camera. The eye also has the ability to perceive depth and color, as well as adjust to movements and provide a continuous, real-time image to the brain.



Optical Corrections

Optical corrections refer to devices or techniques used to improve or correct vision problems caused by a refractive error in the eye.

Refractive errors occur when light entering the eye is not properly focused on the retina, leading to blurred vision. There are several types of refractive errors, including:

- Myopia (nearsightedness): Light is focused in front of the retina, making distant objects appear blurry.
- Hyperopia (farsightedness): Light is focused behind the retina, making near objects appear blurry.
- Astigmatism: Light is not focused evenly on the retina, leading to blurred or distorted vision.

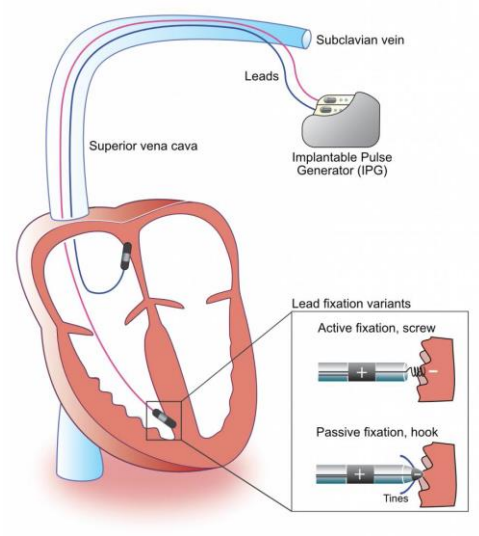
The most common optical corrections include:

- Eyeglasses: Glasses with corrective lenses can be used to refocus light onto the retina, improving vision.
- Contact lenses: Corrective lenses in the form of contacts sit directly on the cornea and work similarly to eyeglasses.
- Refractive surgery: Surgical procedures, such as LASIK and PRK, can reshape the cornea to correct refractive errors.

Optical corrections can greatly improve visual acuity and quality of life for people with refractive errors. However, it is important to have regular eye exams to determine the appropriate correction and monitor eye health.

3.c. Cardiac Pacemaker

A pacemaker is a small device that is surgically implanted in the chest to regulate the heartbeat. It is used to treat heart rhythm disorders, such as bradycardia (a slow heartbeat) or arrhythmias (abnormal heart rhythms), by delivering electrical impulses to the heart to regulate its rhythm.



The basic design of a pacemaker consists of:

· Generator: The generator is the main component of the pacemaker and contains a battery and electronic circuitry to generate and control the electrical impulses.

· Leads: Leads are thin wires that connect the generator to the heart and carry the electrical impulses from the generator to the heart.

· Electrodes: The electrodes are located at the end of the leads and are used to deliver the electrical impulses to the heart.

Pacemakers can be designed to work in different ways, including:

· Single-chamber pacemaker: A single-chamber pacemaker delivers electrical impulses to either the right atrium or the right ventricle of the heart to regulate its rhythm.

· Dual-chamber pacemaker: A dual-chamber pacemaker delivers electrical impulses to both the right atrium and the right ventricle of the heart to regulate its rhythm.

· Biventricular pacemaker: A biventricular pacemaker delivers electrical impulses to both ventricles of the heart to coordinate their contractions and improve heart function in people with heart failure.

Construction of a Pacemaker

The construction of a pacemaker involves the use of high-quality materials and specialized manufacturing processes to ensure their safety and reliability. Materials used in the construction of pacemakers include:

· Medical-grade plastics: Medical-grade plastics, such as polycarbonate, are used to construct the exterior of the device and to provide insulation and protection for the internal components.

· Metals: Metals, such as stainless steel and titanium, are used in the construction of the leads and electrodes to ensure their durability and long-lasting performance.

· Electronic components: Electronic components, such as microprocessors, batteries, and capacitors, are used to control the delivery of the electrical impulses and to provide power to the device.

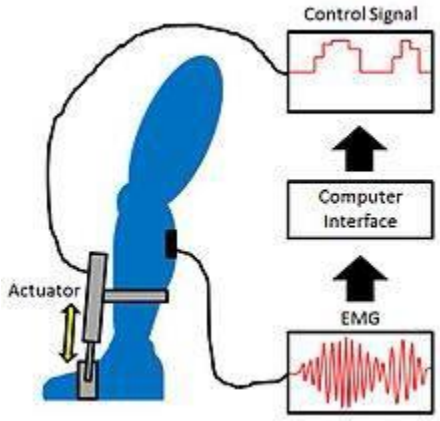
· Adhesives: Adhesives, such as cyanoacrylate and epoxy, are used to secure the components of the device and to provide insulation and protection for the internal components.

The manufacturing process for pacemakers includes multiple quality control measures to ensure their safety and reliability. This includes testing of individual components and final assembly testing to verify the proper operation of the device before it is released for use.

4.a. Robotic Arms for Prosthetics

Robotic arms for prosthetics are advanced prosthetic devices that use robotics technology to restore functionality to individuals with upper limb amputations.
These devices typically use motors, actuators, and sensors to mimic the movements of a human arm and hand, allowing the wearer to perform tasks such as reaching, grasping, and manipulating objects.
Robotic arms for prosthetics can be controlled in a variety of ways, including direct control through muscle signals (myoelectric control) or brain-machine interfaces, which use electrodes implanted in the brain or placed on the scalp to detect and interpret brain activity.

Robotic Arm Prosthetic Direct Control through Muscle Signals (myoelectric control)
Myoelectric control of a robotic arm prosthetic involves using the electrical signals generated by the wearer's remaining muscles to control the movement of the prosthetic. The system typically involves electrodes placed on the skin over the remaining muscle that are used to detect and interpret the electrical signals generated by the muscle contractions.

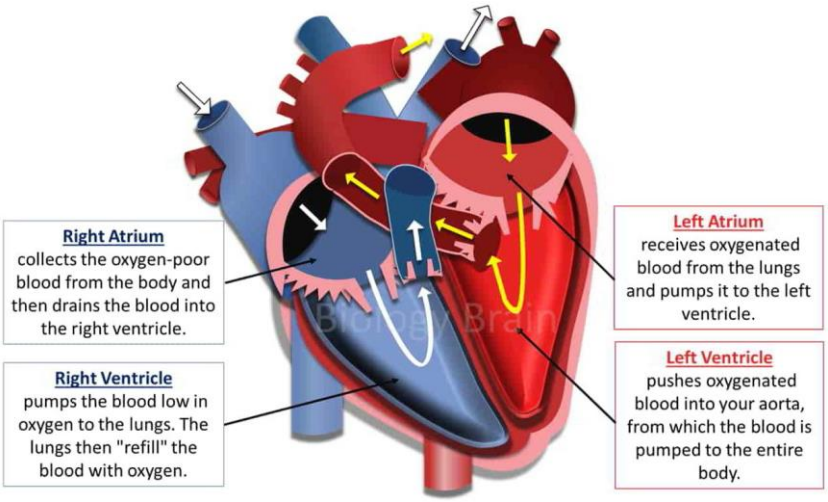


When the wearer contracts their muscles, the electrodes detect the electrical signals and send them to a control unit, which interprets the signals and uses them to control the movement of the robotic arm. Depending on the specific design, the control unit may use pattern recognition algorithms to determine which movement the wearer is intending to perform, or the wearer may use a combination of muscle signals to control specific degrees of freedom in the prosthetic arm.
Myoelectric control has the advantage of being directly controlled by the user, allowing for a more intuitive and natural interaction with the prosthetic. It can also provide a high level of control and precision, as the electrical signals generated by the muscles are unique to each individual and can be used to perform a wide range of movements.
However, myoelectric control systems can be complex and may require extensive rehabilitation and training to use effectively, as well as ongoing maintenance to ensure proper function. Additionally, the system may not be suitable for individuals with muscle weakness or other conditions that affect the ability to generate strong electrical signals.

4.b. Heart as a Pump System

Architecture

The heart is a complex pump system that circulates blood throughout the body.

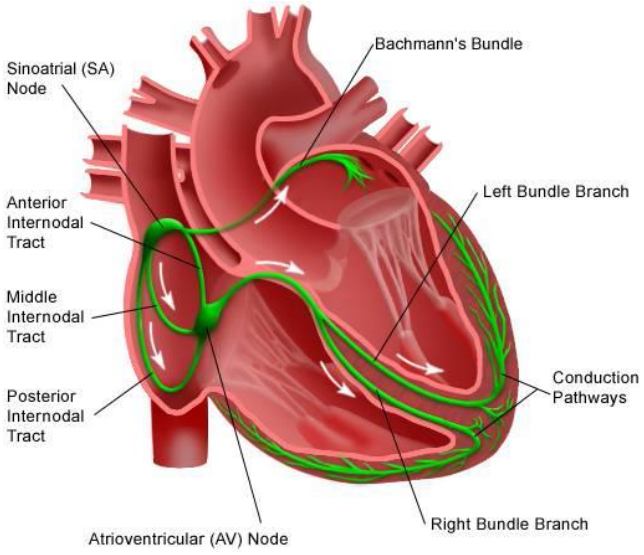


It consists of four chambers: the right atrium, the left atrium, the right ventricle, and the left ventricle. Blood enters the right atrium from the body and is pumped into the right ventricle, which then pumps the blood to the lungs for oxygenation. Oxygenated blood returns to the heart and enters the left atrium, which pumps the blood into the left ventricle. The left ventricle then pumps the oxygenated blood out to the rest of the body.

Between each chamber, there are one-way valves that ensure the blood flows in the correct direction and prevent backflow. The heart is also surrounded by the pericardium, a sac that contains a small amount of fluid and helps to protect and lubricate the heart as it beats.

The Heart Beat

The heart's pumping action is controlled by a complex network of electrical and chemical signals, which generate the rhythm of the heartbeat.



An electrical stimulus is generated in a special part of the heart muscle called the sinus node. It's also called the sinoatrial node (SA node). The sinus node is a small mass of special tissue in the

right upper chamber of the heart (right atrium). In an adult, the sinus node sends out a regular electrical pulse 60 to 100 times per minute. This electrical pulse travels down through the onduction pathways and causes the heart's lower chambers (ventricles) to contract and pump out blood. The right and left atria are stimulated first and contract to push blood from the atria into the ventricles. The ventricles then contract to push blood out into the blood vessels of the body.

4.c. Engineering solutions for Parkinson's Disease

Parkinson's disease is a neurodegenerative disorder that affects movement and motor function. There are several engineering solutions aimed at improving the quality of life for individuals with Parkinson's disease, including:

- Deep Brain Stimulation (DBS): DBS involves the implantation of electrodes into specific regions of the brain to deliver electrical stimulation, which can help to relieve symptoms such as tremors, stiffness, and difficulty with movement.
- Exoskeletons: Exoskeletons are wearable devices that provide support and assistance for individuals with mobility issues. Some exoskeletons have been developed specifically for people with Parkinson's disease, and can help to improve balance, reduce tremors, and increase overall mobility.
- Telerehabilitation: Telerehabilitation involves the use of telecommunication technology to provide physical therapy and rehabilitation services to individuals with Parkinson's disease, without the need for in-person visits to a therapist.
- Smartwatch Applications: Smartwatch applications can be used to monitor symptoms of Parkinson's disease, such as tremors, and provide reminders and prompts for medication and exercise.
- Virtual Reality: Virtual reality systems can be used for rehabilitation and therapy for individuals with Parkinson's disease, providing interactive and engaging environments for patients to practice movements and improve coordination and balance.

These engineering solutions have the potential to significantly improve the quality of life for individuals with Parkinson's disease, and ongoing research and development is aimed at improving their effectiveness and accessibility. However, it is important to note that these technologies are not a cure for Parkinson's disease and should be used in conjunction with other forms of treatment and care.

MODULE-3

5.A. Lungs as a Purification system

Lungs as Purifier

The lung purifies air by removing harmful substances and adding oxygen to the bloodstream. The process of purifying air in the lungs can be described as follows:

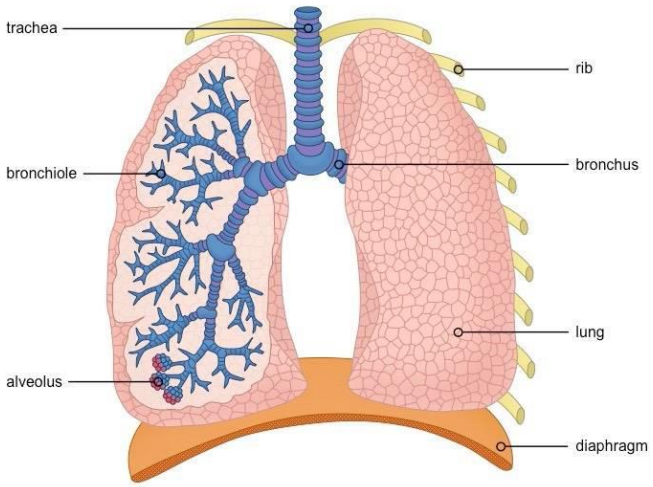
- Filtration: The nose and mouth serve as a first line of defense against harmful substances in the air, such as dust, dirt, and bacteria. The tiny hairs in the nose, called cilia, and the mucus produced by the respiratory system trap these substances and prevent them from entering the lungs.
- Moisturization: The air is also humidified as it passes over the moist lining of the respiratory tract, which helps to keep the airways moist and prevent them from drying out.
- Gas Exchange: Once the air reaches the alveoli, the gas exchange process occurs, where oxygen diffuses across the thin alveolar and capillary walls into the bloodstream, and carbon dioxide diffuses in the opposite direction, from the bloodstream into the alveoli to be exhaled. This process ensures that the bloodstream is supplied with fresh, oxygen-rich air, while waste carbon dioxide is removed from the body.

Overall, the lung serves as a vital purification system, filtering out harmful substances, adding oxygen to the bloodstream, and removing waste carbon dioxide. It plays a critical role in maintaining the body's homeostasis and supporting life.

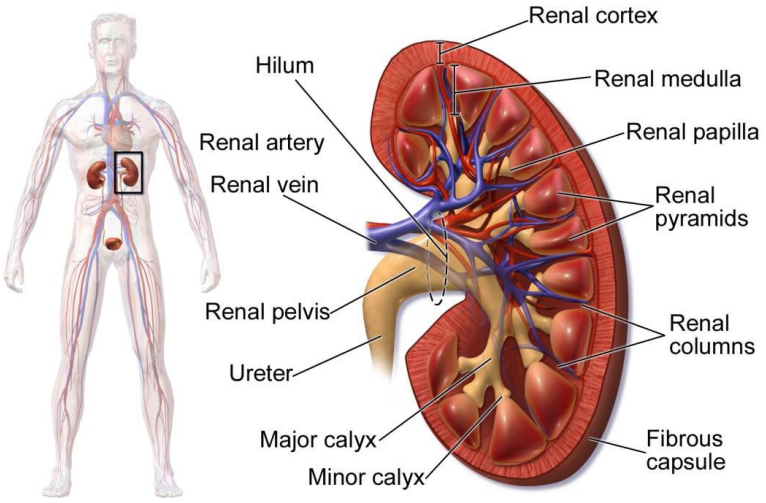
Gas Exchange Mechanism of Lung

The gas exchange mechanism in the lung involves the transfer of oxygen from the air in the alveoli to the bloodstream, and the transfer of carbon dioxide from the bloodstream to the air in the alveoli. This process is known as diffusion and occurs due to differences in partial pressures of oxygen and carbon dioxide.

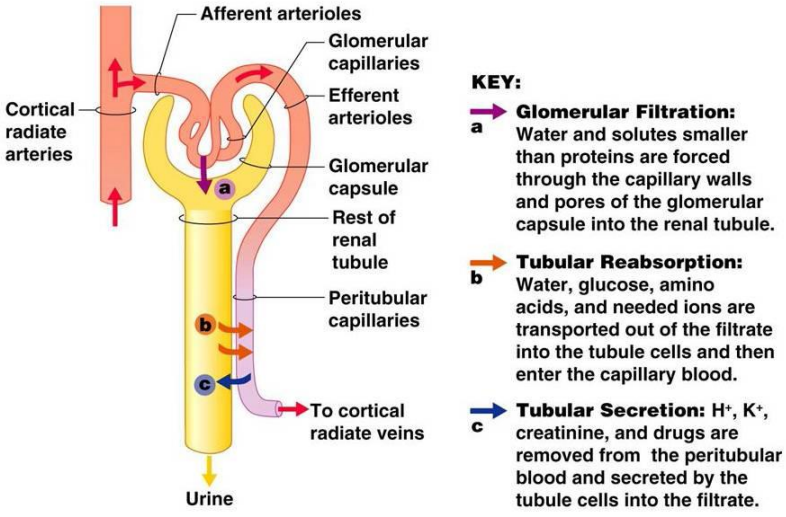
- Oxygen Diffusion: The partial pressure of oxygen in the air in the alveoli is higher than the partial pressure of oxygen in the bloodstream. This difference creates a gradient that causes oxygen to diffuse from the alveoli into the bloodstream, where it binds to hemoglobin in red blood cells to form oxyhemoglobin.
- Carbon Dioxide Diffusion: The partial pressure of carbon dioxide in the bloodstream is higher than the partial pressure of carbon dioxide in the air in the alveoli. This difference creates a gradient that causes carbon dioxide to diffuse from the bloodstream into the alveoli, where it is exhaled.



5.b. Kidney as Filtration system



The kidney is a complex organ that acts as a filtration system for the body. It removes waste and excess fluid from the bloodstream and maintains a delicate balance of electrolytes, hormones, and other substances that are critical for the body's normal functioning.
The kidney also plays an important role in regulating blood pressure by secreting the hormone renin, which helps control the balance of fluid and electrolytes in the body. It also regulates red blood cell production and the levels of various minerals in the blood, such as calcium and phosphorus. Without the kidney, waste and excess fluid would accumulate in the body, leading to serious health problems.



The mechanism of filtration in the kidneys is a complex process that involves multiple steps to remove waste and excess fluids from the bloodstream. The following is a summary of the steps involved in the filtration process:

· Blood enters the kidney through the renal arteries and flows into tiny filtering units called glomeruli.

· At the glomerulus, the pressure in the blood vessels causes a portion of the plasma and dissolved substances to filter out and enter a structure called Bowman's capsule.

· In Bowman's capsule, the filtrate is then transferred into the renal tubules, which are the main filtering units of the kidneys.

· In the renal tubules, the filtrate passes through a series of specialized cells, such as proximal tubular cells and distal tubular cells, which reabsorb important substances such as glucose, amino acids, and electrolytes back into the bloodstream.

· At the same time, the renal tubules secrete waste products, such as urea and creatinine, back into the filtrate.

· Finally, the filtered fluid, now known as urine, is transported through the renal pelvis and ureters to the bladder, where it is eventually eliminated from the body.

This process of filtration, reabsorption, and secretion helps to maintain the proper balance of fluids and electrolytes in the body, as well as to remove waste and excess substances.

5.C. Spirometry and Ventilator

Spirometry

Spirometry is a diagnostic test that measures the function of the lungs by measuring the amount and flow rate of air that can be exhaled. The test is commonly used to diagnose lung conditions such as asthma, chronic obstructive pulmonary disease (COPD), and interstitial lung disease.

Principle: The principle behind spirometry is to measure the volume of air that can be exhaled from the lungs in a given time period. By measuring the volume of air exhaled, spirometry can provide information about the functioning of the lungs and the ability of the lungs to move air in and out.

Working: Spirometry is performed using a spirometer, a device that consists of a mouthpiece, a flow sensor, and a volume sensor. The patient is asked to exhale as much air as possible into the spirometer, and the spirometer measures the volume and flow rate of the exhaled air. The volume of air exhaled is displayed on a graph called a flow-volume loop, which provides information about the lung function.

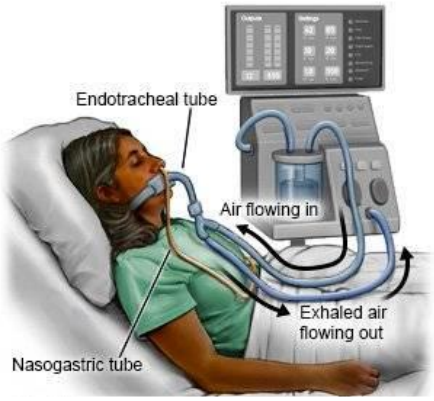
Interpretation of Results

The results of spirometry can be used to determine if the lungs are functioning normally and to diagnose lung conditions. For example, a decrease in the volume of air exhaled or a decrease in the flow rate of the exhaled air can indicate a restriction in the airways, which can be a sign of a lung condition such as asthma or COPD.

Ventilators

Ventilators are medical devices used to assist or control breathing in individuals who are unable to breathe adequately on their own. They are commonly used in the treatment of acute respiratory failure, which can occur as a result of a variety of conditions such as pneumonia, severe asthma, and chronic obstructive pulmonary disease (COPD). There are several different types of ventilators, including volume-controlled ventilators, pressure-controlled ventilators, and bilevel positive airway pressure (BiPAP) devices. The type of ventilator used depends on the patient's individual needs and the type of respiratory failure being treated. Ventilators work by delivering pressurized air or oxygen into the lungs through a breathing tube or mask. The pressure can be adjusted to match the patient's needs and to help maintain adequate oxygen levels in the blood.

While ventilators can be lifesaving for individuals with acute respiratory failure, they also come with potential risks and complications. For example, prolonged use of a ventilator can increase the risk of ventilator-associated pneumonia, and patients may experience discomfort or pain from the breathing tube. The use of ventilators is carefully monitored and managed by healthcare professionals to ensure that the patient receives the appropriate level of support while minimizing potential risks and complications.



6.a. Muscular skeletal system as scaffolds

The use of muscular systems as scaffolds in regenerative medicine is an area of active research and development. Muscles have the potential to be used as scaffolds for the regeneration of tissues due to their inherent mechanical properties and ability to support cell growth and tissue formation.

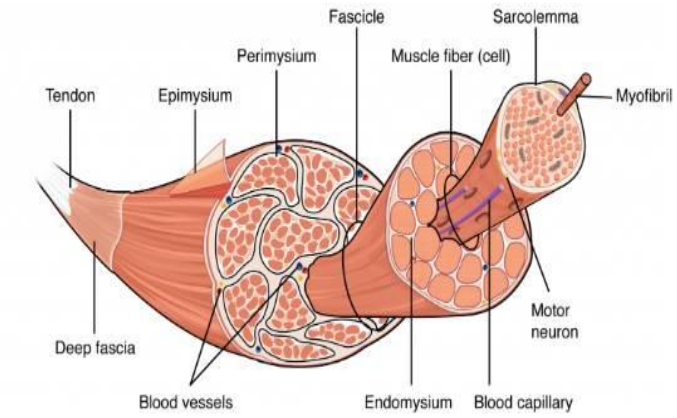
One example of using muscular systems as scaffolds is in the treatment of damaged or diseased heart tissue. Researchers have developed methods for using muscle cells to create a functional, three-dimensional scaffold that can support the growth of new heart tissue. In this approach, muscle cells are harvested from the patient and then seeded onto a scaffold, such as a hydrogel or artificial matrix. The scaffold provides a framework for the cells to grow and differentiate into new heart tissue, which can help to repair the damaged or diseased tissue.

Another example is in the treatment of skeletal muscle injuries, such as those caused by trauma or disease. In this case, muscle cells can be harvested and seeded onto a scaffold, which can then be implanted into the damaged muscle to promote the growth of new, functional tissue.

While the use of muscular systems as scaffolds is still in the experimental stage, it holds great promise for the treatment of a variety of conditions and represents an area of active research and development in the field of regenerative medicine.

Inside each skeletal muscle, muscle fibers are organized into bundles, called fascicles, surrounded by a middle layer of connective tissue called the perimysium. This fascicular organization is ommon in muscles of the limbs; it allows the nervous system to trigger a specific movement of a muscle by activating a subset of muscle fibers within a fascicle of the muscle. Inside each fascicle, each muscle fiber is encased in a thin connective tissue layer of collagen and reticular fibers called the endomysium. The endomysium surrounds the extracellular matrix of the cells and plays a role in transferring force produced by the muscle fibers to the tendons.

Inside the muscle fibers, there are tiny structures called myofibrils. Myofibrils are made up of smaller units called sarcomeres, which are responsible for muscle contraction.



6.b. Bioengineering solutions for muscular dystrophy and osteoporosis

Muscular dystrophy is a group of genetic disorders that result in progressive weakness and degeneration of the skeletal muscles, which are responsible for movement. The disorders are caused by mutations in genes that encode proteins needed for muscle function. The most common type of muscular dystrophy is Duchenne muscular dystrophy, which typically affects young boys and leads to severe disability by early adulthood. Other forms of the disease include Becker muscular dystrophy, limb-girdle muscular dystrophy, and faciosca pulohumeral dystrophy, among others.

Bioengineering solutions for muscular dystrophy aim to improve the lives of individuals affected by the disease by addressing the underlying genetic mutations and muscle weakness.
Some of the approaches being explored include:

- Gene therapy: This involves delivering a functional copy of the missing or mutated gene to the affected muscle cells. The goal is to restore the production of the missing protein and improve muscle function.
- Stem cell therapy: This involves using stem cells to replace the damaged muscle cells and promote repair and regeneration of the muscle tissue. Stem cells can be taken from the patient's own body (autologous stem cells) or from a donor (allogenic stem cells).
- Exoskeleton technology: This involves using wearable devices, such as robotic exoskeletons, to support and enhance the movement of individuals with muscular dystrophy. The devices use motors and sensors to mimic the movements of the wearer and help improve mobility.
- Tissue engineering: This involves using a combination of materials, such as scaffolds and growth factors, to promote the growth and repair of muscle tissue. The goal is to create functional muscle tissue that can replace the damaged tissue in individuals with muscular dystrophy.

These approaches are still in the early stages of development, but hold promise for the future treatment of muscular dystrophy. Clinical trials and further research are needed to determine the safety and efficacy of these therapies.

Bioengineering solutions for osteoporosis

Bioengineering solutions for osteoporosis aim to improve bone health and prevent fractures. Some of the approaches being explored include:

- Tissue engineering: This involves using scaffolds and growth factors to stimulate the growth of new bone tissue and promote the repair of damaged bones. The goal is to create functional bone tissue that can replace the lost bone mass and density in individuals with osteoporosis.
- Stem cell therapy: This involves using stem cells to replace the damaged bone cells and promote the repair and regeneration of bone tissue. Stem cells can be taken from the patient's own body (autologous stem cells) or from a donor (allogenic stem cells).
- Biomaterials: This involves using synthetic or natural materials to replace or augment damaged bone tissue. Biomaterials can be designed to mimic the properties of natural bone and promote the growth of new bone tissue.
- Gene therapy: This involves delivering a functional copy of a gene involved in bone growth and repair to the affected bone cells. The goal is to restore the production of the missing protein and improve bone health.

These approaches are still in the early stages of development, but hold promise for the future treatment of osteoporosis. Clinical trials and further research are needed to determine the safety and efficacy of these therapies.
In addition, traditional treatments for osteoporosis, such as medication, exercise, and lifestyle changes, will likely continue to play an important role in preventing fractures and maintaining healthy bones in individuals with osteoporosis.

6.c. **Chronic Obstructive Pulmonary Disease**

Chronic Obstructive Pulmonary Disease (COPD) is a group of progressive lung diseases that cause breathing difficulties. It's cause breathing difficulties. It's characterized by persistent airflow limitation that is not fully reversible. The two main forms of COPD are chronic bronchitis

and emphysema. In COPD, the airways and small air sacs (alveoli) in the lungs become damaged or blocked, leading to difficulty in exhaling air. This results in a decrease in lung function, leading to shortness of breath, wheezing, and coughing. Over time, these symptoms can get worse and limit a person's ability to perform everyday activities.

The primary cause of COPD is long-term exposure to irritants such as tobacco smoke, air pollution, and dust. Other risk factors include a history of frequent lung infections, a family history of lung disease, and exposure to second-hand smoke.

There is no cure for COPD, but treatment can help manage the symptoms and slow the progression of the disease. Treatment options include medication, such as bronchodilators and steroids, oxygen therapy, and lung rehabilitation. In severe cases, surgery may also be an option.

In addition, quitting smoking and avoiding exposure to irritants is crucial in managing COPD.

7.a. ECHOLOCATION, ULTRASONOGRAPHY AND SONARS
ECHOLOCATION

Echolocation is a biological or technological process that involves emitting sound waves and listening to the echoes that bounce back off of objects in the environment to determine their location, distance, and shape.

In biology, the use of echolocation by animals has been well documented for centuries. Ancient Greeks, for example, observed bats using echolocation to navigate and find food in the dark. The scientific study of echolocation in animals, however, only began in the early 20th century, with the pioneering work of British naturalist Donald Griffin. Griffin's research showed that bats were using echolocation to navigate and hunt and helped to lay the foundation for the modern study of biological echolocation.

In technology, the use of echolocation can be traced back to the early days of submarine warfare. During World War I, the British navy developed a primitive form of sonar (known then as "ASDIC") to detect submarines.

A comparison of biological echolocation and technological echolocation is given below:

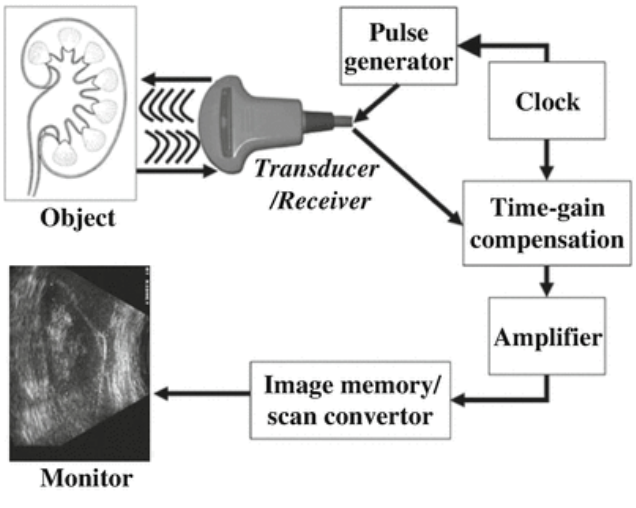
Biological Echolocation

- Found in various animals such as bats, dolphins, and some species of whales.
- Relies on the emission of sound waves, usually in the form of clicks or vocalizations.
- Animals emit sound waves and listen for the echoes produced when the sound waves bounce off objects in their environment.
- By analyzing the echoes, animals can determine the location, distance, and even the shape of objects around them.
- This ability is mainly used for navigation, hunting, and communication in the animal kingdom.
- Biological echolocation is a natural adaptation that has evolved over millions of years.

Technological Echolocation

- Replicates the concept of biological echolocation using technological devices.
- Utilizes sound waves, typically generated by artificial sources such as sonar or ultrasonic sensors.
- These devices emit sound waves and analyze the echoes that bounce back from objects.
- The information from the echoes is processed and interpreted by the technology to generate useful data, such as distance, location, and object recognition.
- Technological echolocation has applications in various fields, including navigation, robotics, obstacle detection, and medical imaging.
- It is a human-engineered solution inspired by the natur

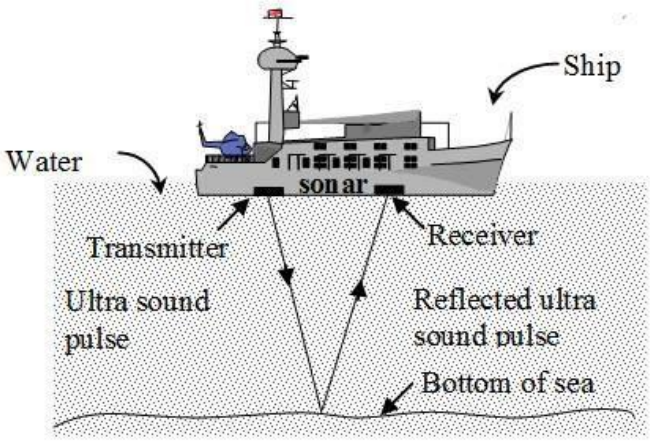
Ultrasonography



Ultrasonography is a medical imaging technique that uses high-frequency sound waves to roduce images of the internal organs and tissues of the body. It is also known as ultrasound imaging or sonography.
The ultrasound machine emits high-frequency sound waves (usually in the range of 2 to 18 MHz) that travel through the body and bounce back off of the internal organs and tissues. The returning echoes are captured by the ultrasound machine and used to create images of the internal structures. Ultrasonography is a non-invasive, safe, and painless imaging method that can be used to visualize a wide range of structures within the body, including the organs of the abdomen, pelvis, and chest, as well as the uterus, fetus, and other soft tissues. It is commonly used in renatal care to monitor the growth and development of the fetus and to diagnose any potential problems.
Ultrasonography has several advantages over other imaging methods, including its low cost, ease of use, and lack of ionizing radiation. It is also portable and can be used in a variety of settings, making it a valuable tool for medical professionals.

Sonars

Sonar, which stands for Sound Navigation and Ranging, is a technology that uses sound waves to detect and locate underwater objects.



Working Principle of Sonars
The working principle of sonar technology is based on the reflection of sound waves. Here's how it works:
 Transmitter: A sonar system consists of a transmitter that produces and emits a series of sound pulses into the water. These sound pulses are typically in the form of high- frequency, low-power acoustic signals, known as "ping."

Propagation of sound waves: The sound pulses propagate through the water, traveling to the arget object and bouncing back as echoes. The speed of sound in water is slower than in air, and it depends on the temperature, pressure, and salinity of the water.

 Receiver: The sonar system also includes a receiver that listens for the returning echoes. The receiver is typically placed far away from the transmitter to minimize interference from the transmitted signals.

 Calculation of range: The time it takes for the echoes to return to the receiver is used to calculate the range to the target object. The range is simply the product of the speed of sound in water and the time it takes for the echoes to return.

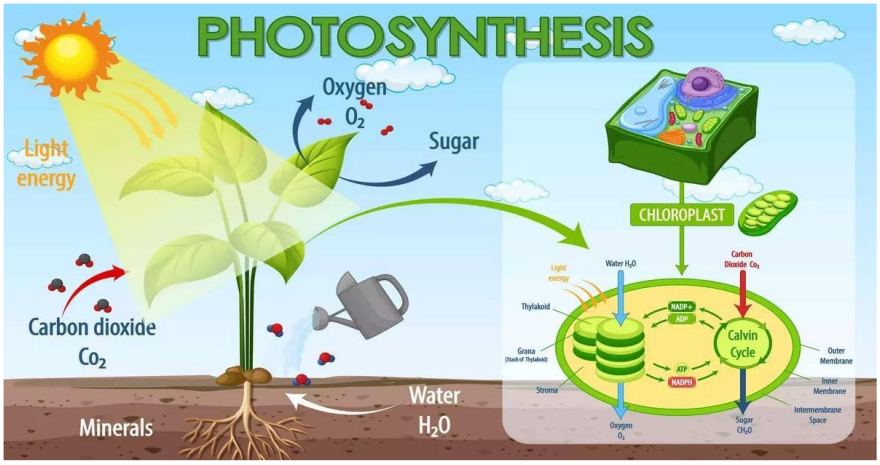
 Determination of target properties: The frequency and pattern of the echoes are used to determine the properties of the target object, such as its size, shape, and composition. For example, a large, solid object will produce a strong, low-frequency echo, while a small, porous object will produce a weaker, high-frequency echo.

 Display of results: The results of the sonar measurement are typically displayed on a screen or other output device, allowing the operator to visualize the target object and its location

7.b. Process of Photosynthesis and Photovoltaic cells

Process of Photosynthesis

Photosynthesis is the process by which plants, algae, and some bacteria convert light energy from the sun into chemical energy stored in organic molecules. This process is critical for life on Earth, as it provides the primary source of energy for all living organisms.



The Process of Photosynthesis in Plants and in Some Animals

The process of photosynthesis in plants and some animals differs in terms of the type of rganisms involved and the specific details of the process. However, the basic principle of converting light energy into usable forms of energy is the same in both.

In plants, photosynthesis takes place in the chloroplasts of the cells located in the leaves. The rocess starts with the absorption of light energy by pigments such as chlorophyll, which then excites electrons. These excited electrons are used to power the transfer of carbon dioxide into organic molecules, such as sugars and starches, through a series of chemical reactions. The end product of photosynthesis in plants is stored chemical energy in the form of organic compounds.

In some animals, such as algae, photosynthesis also takes place in chloroplasts. The process is essentially the same as in plants, with the absorption of light energy and the conversion of carbon dioxide into organic molecules.

In contrast, some animals, such as jellyfish, have a symbiotic relationship with photosynthetic organisms, such as algae. In this relationship, the animal provides a safe and stable environment for the photosynthetic organism, while the photosynthetic organism provides energy in the form of organic compounds produced through photosynthesis. Light-dependent reactions and light-independent reactions (also known as the Calvin cycle) are two interconnected processes that occur in the chloroplasts of plants and algae during photosynthesis.

Photovoltaic Cells

The connection between photosynthesis and photovoltaics lies in the conversion of light energy into usable forms of energy. In photosynthesis, light energy from the sun is converted into chemical energy stored in organic molecules, such as sugars and starches. In photovoltaics, light energy is converted into electrical energy.
Both photosynthesis and photovoltaics use the same basic principle of converting light energy into usable forms of energy, but the end products are different. In photosynthesis, the end product is stored chemical energy, while in photovoltaics, the end product is electrical energy.
However, the similarities between photosynthesis and photovoltaics go beyond just the conversion of light energy. Both processes also involve the use of specialized components and materials, such as chlorophyll in photosynthesis and silicon in photovoltaics, to absorb and convert light energy into usable forms of energy.
The development of photovoltaics has been heavily influenced by the natural process of photosynthesis, and many researchers have sought to mimic and improve upon the efficiency and effectiveness of photosynthesis in order to develop more advanced and efficient photovoltaic systems. The study of photosynthesis has thus played a significant role in the development of sustainable energy systems and continues to be an important area of research in the field of renewable energy.

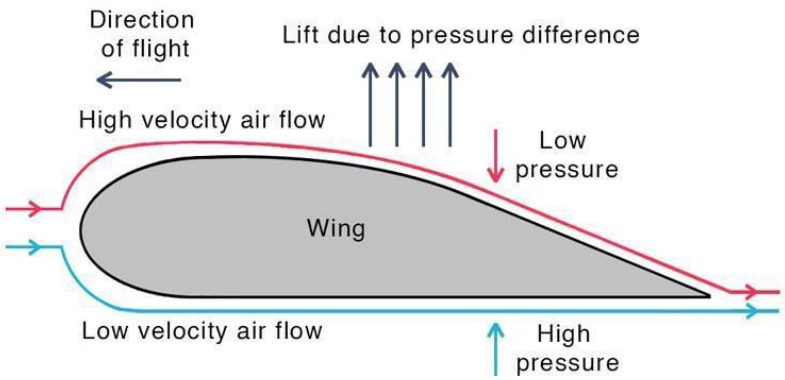
7.c. BIONIC LEAF, GPS, BIRD FLIGHT AND AIRCRAFT

BIONIC LEAF

A bionic leaf is a system that uses artificial photosynthesis to convert sunlight into usable forms of energy, such as hydrogen or other biofuels. The bionic leaf is designed to mimic the process of photosynthesis in plants, where light energy is used to split water molecules into hydrogen and oxygen, and the hydrogen can then be used as a source of energy.
The bionic leaf consists of a photovoltaic cell that captures sunlight and converts it into electrical energy, and a catalyst, such as a bacteria, that uses the electrical energy to split water molecules into hydrogen and oxygen. The hydrogen produced by the bionic leaf can then be stored and used as a source of energy for a variety of applications, such as powering vehicles or generating electricity.
The bionic leaf has the potential to be a highly sustainable and environmentally friendly energy source, as it uses renewable resources, such as sunlight and water, to produce energy. Additionally, the bionic leaf can be used in remote locations where there is limited access to electricity, and it can help to reduce our reliance on fossil fuels and mitigate the effects of climate change.

BIRD FLIGHT

Birds fly by flapping their wings and using their body weight and the movement of the air to stay aloft. They navigate using a combination of visual cues, the Earth's magnetic field, and celestial navigation. Aircraft, on the other hand, use engines to generate thrust and lift from the wings to stay in the air. They navigate using a combination of instruments and systems, including GPS (Global Positioning System), which uses satellite signals to determine the aircraft's position and help it navigate. Although birds and aircraft both fly, their mechanisms and methods of Navigation are quite different.
Birds flying influenced the invention of aircraft in that early aviation pioneers, such as the Wright brothers, observed and studied the flight of birds to develop their flying machines. They noted how birds used their wings and body to achieve lift and control their flight, and used this knowledge to design and improve aircraft.
The development of GPS technology was not directly influenced by birds, but rather by the need for accurate and reliable navigation systems for various purposes, including aviation. GPS uses a network of satellites to provide location and time information, which is used by aircraft for navigation, communication, and safety purposes.



GPS Technology

GPS (Global Positioning System) is a technology that uses a network of satellites to provide location and time information to users. The technology works by measuring the time it takes for signals to travel from satellites to a receiver on the ground or in a vehicle, and using this information to calculate the user's position.

Here are some key components of GPS technology:

 Satellites: The GPS satellite network consists of 24-32 satellites orbiting the Earth. These satellites continuously broadcast signals containing information about their location, time, and status.

 Receivers: GPS receivers, which are typically integrated into devices such as smartphones, navigation systems, and aircraft, receive signals from GPS satellites and use the information to calculate the user's position.

 Control segment: The control segment consists of ground-based monitoring stations that track the GPS satellites, check the accuracy of their signals, and make adjustments as needed.

 User segment: The user segment consists of the GPS receivers used by individuals and organizations to obtain location and time information.

GPS technology has a wide range of applications, including navigation, mapping, surveying, search and rescue, and military operations. The accuracy and reliability of GPS have improved over time, and the technology continues to evolve with new developments in satellite and receiver technology, as well as the integration of GPS with other technologies such as augmented reality and artificial intelligence.

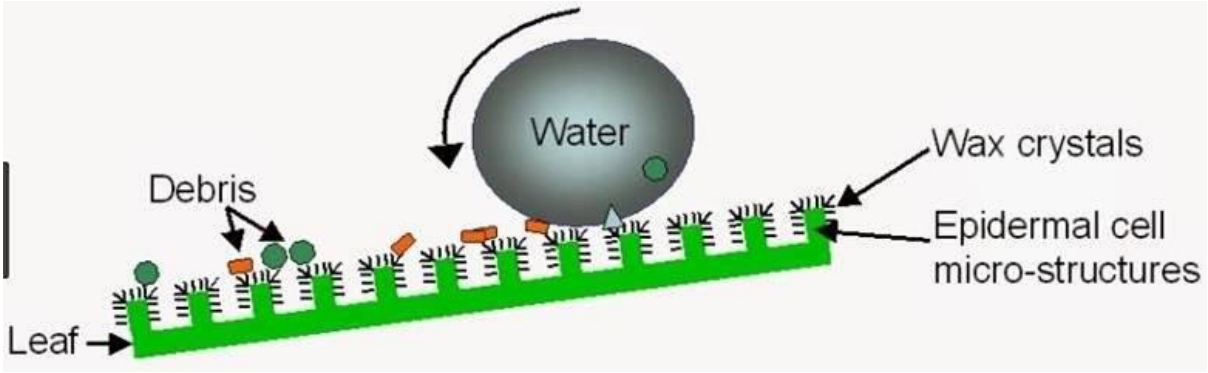
8.a. LOTUS LEAF EFFECT, PLANT BURRS, SUPER HYDROPHOBIC AND SELF CLEANING SURFACES

Lotus Leaf Effect:

Introduction

The lotus leaf effect, also known as the "lotus effect," refers to the ability of lotus leaves to repel water and self-clean through their unique surface structure. This effect has inspired the development of super hydrophobic and self-cleaning surfaces, which have a wide range of applications in various industries.

The lotus leaf surface has a microscale and nanoscale structure that consists of numerous small bumps and wax-coated hairs. This structure creates a high contact angle between the water droplets and the surface, causing the droplets to roll off and carry away any dirt or debris. This self-cleaning property is due to the lotus leaf's ability to repel water and resist adhesion.



Super hydrophobic and self-cleaning surfaces have applications in industries such as aerospace, automotive, building materials, and medical devices. For example, self-cleaning coatings can be used on the exterior of buildings to reduce the need for cleaning and maintenance, while super hydrophobic coatings can be used to prevent icing on aircraft wings.

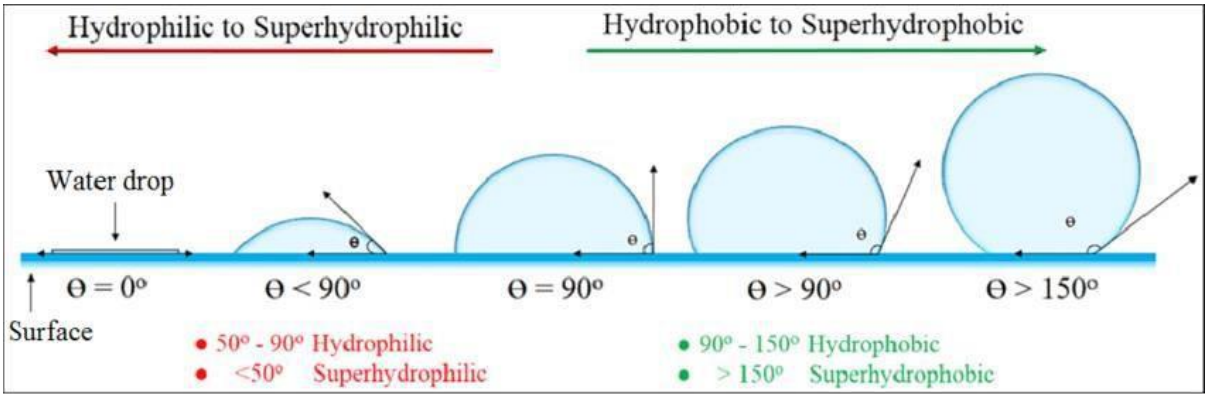
Super Hydrophobic Effect

The Principle of Super hydrophobic Surfaces

The super hydrophobic effect refers to the ability of certain surfaces to repel water and resist wetting. Super hydrophobic surfaces are characterized by a high contact angle between water droplets and the surface, typically over 150 degrees, and a low contact angle hysteresis, meaning that the droplets roll off the surface with ease.

Figure: Representing super hydrophobic and super hydrophilic effects

The super hydrophobic effect is achieved through the use of various techniques. These techniques create a surface structure that traps air between the surface and the water droplets, reducing the contact area between them and making it more difficult for the droplets to wet the surface



Self-Cleaning Surfaces

Self-cleaning surfaces are surfaces that are able to clean themselves without the need for manual cleaning. These surfaces are typically super hydrophobic and have a high contact angle with

water, which causes water droplets to bead up and roll off the surface, carrying away any dirt or debris.

Principle of Self Cleaning Surfaces

The principle of self-cleaning surfaces is based on two main mechanisms: the reduction of surface energy and the modification of surface texture. These mechanisms work together to minimize the adhesion of dirt, water, and other contaminants, enabling the self-cleaning effect. Here's a breakdown of the principle:

 Low Surface Energy: Self-cleaning surfaces often have low surface energy, which means they have a reduced affinity for liquid and solid particles. Materials with low surface energy repel water, oils, and other substances, preventing them from adhering to the surface. This property is typically achieved through the application of hydrophobic or oleophobic coatings, such as fluoropolymers or other low-surface-energy materials.

 Lotus Effect: The Lotus Effect is a phenomenon observed in nature on the leaves of lotus plants. It is a classic example of self-cleaning surfaces. Lotus leaves have a unique micro/nanostructured surface covered with hydrophobic wax crystals. When water droplets come into contact with the leaf surface, they form near-perfect spheres and roll off, collecting dirt and contaminants along the way. This is due to the combination of the surface's low surface energy and the presence of micro/nanostructures, which reduce the contact area and enable easy droplet

8.b. Spark skin and swimsuits, Bullet train

Spark skin and swimsuits

Shark Skin and Friction Reducing Swim Suits

The denticles on shark skin have evolved over millions of years to reduce drag and increase swimming efficiency. These structures disrupt the flow of water around the shark's body, reducing turbulence and minimizing the formation of vortices. As a result, sharks can swim faster and with less effort compared to other fish.

Arena Powerskin Carbon Ultra: Another example of a friction-reducing swim suit, the Arena Powerskin Carbon Ultra is made from a combination of polyurethane and high-tech fabrics to provide a hydrodynamic and form-fitting design.

 TYR Venzo: The TYR Venzo is a friction-reducing swim suit that incorporates a unique surface structure inspired by shark skin, as well as other advanced materials to improve swimmer performance.

Kingfisher Beak and Bullet Train

Figure: Indicating the shape similarities of kingfisher beak and design of the front of the bullet train

The kingfisher beak is an excellent example of nature's design for efficient diving and fishing. Its unique shape and structure enable the kingfisher to minimize the impact of water resistance and achieve a successful dive.

The Physics behind the Kingfisher Beak Streamlining:

The beak of a kingfisher is long, slender, and sharply pointed, which helps reduce drag or air resistance as the bird dives into the water. The streamlined shape allows the kingfisher to smoothly cut through the air and minimize the energy required for the dive.

Surface Tension:

When the kingfisher hits the water, it encounters the resistance caused by surface tension. Surface tension is the cohesive force between water molecules that creates a "skin" on the water's surface. The sharp beak of the kingfisher helps to pierce through the water's surface, breaking the surface tension and reducing the force required to enter the water.

Minimizing Splash:

As the kingfisher dives, it needs to enter the water with minimal disturbance to avoid scaring away the fish it intends to catch. The shape of the beak helps to reduce the splash generated upon entry. The beak's narrow and pointed design helps create a smooth entry by minimizing the disturbance of the water surface, allowing the kingfisher to enter silently and effectively.

Figure: Image of a Shinkasen bullet train of Japan

Technological Importance

The use of the kingfisher beak as a design inspiration for the front of the bullet train is an example of how nature-inspired engineering can lead to innovative solutions that improve the performance and efficiency of machines. Shinkansen bullet train of Japan is the best example which used the biomimicry of kingfisher's beak.

Aerodynamic Design:

The front of the Shinkansen is meticulously shaped to reduce air resistance and improve aerodynamic performance. The streamlined design minimizes drag as the train travels at high speeds, allowing it to maintain stability and efficiency. The smooth, tapered shape reduces the pressure difference between the front and rear of the train, reducing noise and vibration.

Pressure Wave Reduction:

When a high-speed train moves through a tunnel, it creates pressure waves that can cause noise and discomfort for passengers. The nose of the Shinkansen is designed to reduce these pressure waves by effectively managing airflow and minimizing the compression and expansion of air as the train enters and exits tunnels. This reduces the noise level and enhances passenger comfort.

8.c .Hemoglobin-Based Oxygen Carriers (HBOCs)

Hemoglobin-based oxygen carriers (HBOCs) are a type of human blood substitute that is designed to carry and deliver oxygen to the body's tissues. They are made by isolating hemoglobin, the protein responsible for carrying oxygen in red blood cells, and formulating it into a solution or suspension that can be infused into a patient's bloodstream.

Increased oxygen-carrying capacity:

HBOCs can potentially carry more oxygen per unit volume than whole blood. This can be advantageous in situations where there is a need for rapid oxygen delivery or when there is limited availability of blood for transfusion.

Universal compatibility:

Unlike blood transfusions, which require blood typing and cross-matching to ensure compatibility, HBOCs can potentially be universally compatible with any blood type. This can be particularly useful in emergency situations or in areas where blood matching facilities are limited.

Longer shelf life:

HBOCs have the potential for longer storage and shelf life compared to donated blood, which has a limited lifespan. This can improve the availability of oxygen-carrying substitutes in critical situations and reduce the need for frequent blood donations.

Reduced risk of infections:

Blood transfusions carry a small risk of transmitting infections, such as viruses or bacteria, from the donor to the recipient. Since HBOCs are synthetic and do not rely on human donors, the risk of infections associated with transfusion can be significantly reduced.

Availability in remote or challenging settings:

In remote or underdeveloped areas where access to safe blood transfusions may be limited, HBOCs can potentially provide a viable alternative for oxygen delivery. This can be particularly beneficial in military settings, disaster relief efforts, or during transport of patients where immediate access to blood is not feasible.

Perflourocarbons (PFCs)

Perfluorocarbons (PFCs) are a type of human blood substitute that are designed to deliver oxygen to the body's tissues. Unlike hemoglobin-based oxygen carriers (HBOCs), which are based on natural proteins, PFCs are synthetic chemicals that are similar in structure to some types of industrial solvents.

Advantages of PFCs

High oxygen-carrying capacity:

PFCs have the ability to dissolve a significant amount of oxygen, much higher than that of blood. This allows for efficient oxygen delivery to tissues, even in low-oxygen environments.

Improved oxygen solubility:

PFCs exhibit a high solubility for oxygen, meaning that oxygen molecules can readily dissolve in PFC solutions. This enables PFCs to transport and deliver oxygen more effectively than other alternatives.

Stability and long shelf life:

PFCs are chemically stable and have a long shelf life, making them suitable for storage and use in emergency situations where the availability of fresh blood or other oxygen carriers may be limited.

No blood typing or cross-matching required:

Unlike blood transfusions, which require compatibility testing and matching of blood types, PFCs are not dependent on blood typing. This makes them potentially universal oxygen carriers, suitable for use in individuals of any blood type.

Reduced risk of infection transmission:

PFCs are synthetic substances, eliminating the risk of transmitting infectious diseases associated with blood transfusions. This advantage can be particularly significant in situations where the availability of safe blood products is limited or in areas with a high prevalence of blood-borne infections.

Compatibility with diagnostic tests:

PFCs do not interfere with laboratory diagnostic tests, allowing for accurate interpretation of test results without potential complications from the presence of PFCs.

MODULE -5

9.a. DNA ORGANIC AND BIOIMAGING

DNA Origami:
DNA Origami is a technique in nanotechnology that involves folding DNA molecules into specific shapes. The process involves using a long, single strand of DNA, called the scaffold, to guide the folding of short, complementary DNA strands, called staples, into a desired shape.
The first DNA origami structures were developed in the mid-2000s and since then, the technique has been widely used in a variety of applications, including the creation of nanoscale structures, the study of molecular interactions, and the development of new drug delivery systems.

Technological Importance of DNA Origami
The technological importance of DNA origami lies in its potential to be used in a wide range of applications, including nanotechnology, materials science, and biomedicine. Some of the key ways in which DNA origami can impact technology include:
Nanoscale manufacturing:
DNA origami can be used as a template for the precise assembly of nanoscale structures, which have applications in areas such as electronics, photonics, and materials science.
Drug delivery:
DNA origami can be used to develop new approaches for drug delivery, as it can be designed to carry therapeutic agents directly to specific cells or tissues.
Biosensors:
DNA origami can be used to develop new biosensors that can detect specific biological molecules and signals in real-time.
Biomedical imaging:
DNA origami can be used as a tool for biomedical imaging, as it can be designed to target specific cells or tissues and provide high-resolution images.
Gene therapy:
DNA origami can be used as a delivery vehicle for gene therapy, as it can be programmed to target specific cells and deliver therapeutic genes to those cells.
Biocatalysis:
DNA origami can be used to develop new approaches for biocatalysis, as it can be designed to perform specific chemical reactions and act as a catalyst.
Nanopatterning:
DNA origami can be used as a tool for nanopatterning, as it can be programmed to arrange and position nanoscale structures with precise control.

BIOCOMPUTING

Bio-computing refers to the use of biological systems, such as cells, enzymes, and DNA, for computing and information processing. This field combines the principles of computer science, biology, and engineering to create novel systems for computing and data storage.
Technological Importance
The technological importance of bio-computing lies in its potential to provide new and innovative solutions for computing and information processing. Here are some of the key ways in which bio-computing can impact technology:
 Computational power: Bio-computing systems have the potential to provide new levels of computational power, as they can perform complex tasks and calculations using biological processes.

 Data storage: Bio-computing systems can be used to store and process large amounts of data, as DNA has a high information density [consider that a single gram of DNA can theoretically

store up to 215 petabytes (1 petabyte = 1 million gigabytes) of data] and can be easily synthesized and amplified.

 Medical applications: Bio-computing systems can be used to develop new diagnostic and therapeutic approaches in medicine, such as biosensors and gene therapies.

 Environmental monitoring: Bio-computing systems can be used to monitor and track environmental conditions, such as air and water quality, in real-time.

Energy efficiency: Bio-computing systems are energy-efficient, which is becoming increasingly important as we face the challenge of climate change and the need to reduce our energy consumption.

 Robustness: Bio-computing systems are highly robust, as they are less susceptible to errors and failures compared to traditional electronic systems.

 Versatility: Bio-computing systems can be programmed and reprogrammed to perform Different tasks, which makes them highly versatile and adaptable.

Advantages of Bio-computing:

 Biocompatibility: Bio-computing systems are made from biological components, which are biocompatible and less likely to cause an immune response compared to traditional electronic devices.

 Energy efficiency: Bio-computing systems use significantly less energy than traditional electronic computers, as they rely on biological processes that occur naturally and do not require external power.

 Scalability: Bio-computing systems can be easily scaled up or down, as they are based on biological processes that can be repeated and multiplied.

 Robustness: Bio-computing systems are often more robust and reliable than traditional electronic systems, as they are less susceptible to errors and failures.

 Flexibility: Bio-computing systems can be programmed and reprogrammed to perform different tasks, which makes them highly flexible and adaptable.

9.B. BIOIMAGING AND ARTIFICIAL INTELLIGENCE FOR DISEASE DIAGNOSIS

Bio-imaging for Disease Diagnosis

Bio-imaging is the use of imaging technologies to visualize biological processes and structures in living organisms. It plays a crucial role in disease diagnosis by providing detailed images of the body's internal structures and functions, and can help healthcare professionals to identify and diagnose a wide range of diseases and conditions.

Examples of Bio-imaging Techniques

Some examples of bio-imaging techniques used for disease diagnosis include X-rays, CT scans, MRI, PET scans, ultrasound, and optical imaging. These technologies can be used to visualize a wide range of structures and functions, including bones, tissues, organs, blood vessels, and more.

Technological Importance

The technological importance of bio-imaging for disease diagnosis lies in its ability to provide detailed images of the body's internal structures and functions, which can help healthcare professionals to make accurate diagnoses and provide effective treatments.

Some of the key technological advantages of bio-imaging include:

 Improved accuracy: Bio-imaging technologies can provide high-resolution images of the body's internal structures, which can help healthcare professionals to identify subtle changes and make accurate diagnoses.

 Early detection: Bio-imaging can be used to detect diseases in their early stages, when they are often more treatable. This can lead to earlier treatment and better outcomes for patients.

Multi-modality: Bio-imaging technologies can be combined to provide a multi-modal view of the body's internal structures and functions, which can provide a more comprehensive understanding of a disease or condition.

 Cost-effectiveness: Many bio-imaging technologies are relatively low-cost, which makes them accessible to a wider range of patients.

 Minimally invasive: Many bio-imaging techniques are non-invasive, which means that they do not require incisions or the insertion of instruments into the body. This makes them less painful and less risky than many traditional diagnostic procedures.

 Improved patient outcomes: By providing healthcare professionals with detailed images of the body's internal structures and functions, bio-imaging can help to improve patient outcomes by enabling earlier and more accurate diagnoses, and more effective treatments.

 Advancements in research: Bio-imaging technologies are also important in advancing medical research, by providing detailed images of the body's internal structures and functions, which can help researchers to better understand the underlying mechanisms of diseases and develop new treatments.

Advantages

Some of the key advantages of bio-imaging for disease diagnosis include:

 Non-invasive: Many bio-imaging techniques are non-invasive, which means that they do not require incisions or the insertion of instruments into the body. This makes them less painful and less risky than many traditional diagnostic procedures.

 High resolution: Bio-imaging technologies can provide high-resolution images of the body's internal structures, which can help healthcare professionals to identify subtle changes and make accurate diagnoses.

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 Cost-effective: Many bio-imaging technologies are relatively low-cost, which makes them accessible to a wider range of patients.

Artificial Intelligence for Disease Diagnosis

Artificial Intelligence (AI) has the potential to revolutionize the field of disease diagnosis by providing healthcare professionals with more accurate and efficient tools for identifying and treating various conditions.

Advantages

Some of the key ways in which AI is being used in disease diagnosis include:

 Image analysis: AI algorithms can analyze medical images, such as X-rays, CT scans, and MRIs, to detect signs of diseases. For example, AI algorithms can identify patterns in medical

images that may indicate the presence of a particular condition, such as a tumor or an injury. This type of image analysis is known as computer-aided diagnosis (CAD).

 Data analysis: AI algorithms can analyze large amounts of patient data, such as electronic health records, to identify patterns and trends that may indicate a disease. This type of data analysis is known as predictive analytics.

 Diagnosis: AI algorithms can be used to diagnose diseases by evaluating symptoms, test results, and other patient information. AI algorithms can help healthcare professionals make faster and more accurate diagnoses, reducing the risk of misdiagnosis.

 Personalized medicine: AI algorithms can be used to create personalized treatment plans for patients based on their specific medical histories, lifestyles, and other factors. For example, AI algorithms can analyze a patient's medical history, lifestyle habits, and genetic information to recommend the best course of treatment for their condition.

 Clinical decision support: AI algorithms can be integrated into electronic health records to provide healthcare professionals with real-time decision-making support. For example, AI algorithms can provide physicians with information about the best diagnostic tests to order, the most effective treatments to consider, and the best ways to manage patient care.

9.C Self-Healing Bio-concrete

Self-healing bio-concrete is a type of concrete that incorporates microorganisms, such as Bacillus fragments, into the mixture, along with calcium lactate as a nutrient source. The microorganisms are activated when the concrete cracks, and they produce calcium carbonate, which fills in the cracks and repairs the concrete. This process is known as bio-mineralization.

The benefits of self-healing bio-concrete include increased durability, reduced maintenance costs, and improved sustainability, as the concrete is able to repair itself without the need for human intervention. Additionally, because the microorganisms used in the concrete are naturally occurring and non-toxic, self-healing bio-concrete is considered to be environmentally friendly.

Self-healing bio-concrete is still a relatively new technology and is currently in the research and development phase. However, initial studies have shown promising results and have demonstrated the potential for self-healing bio-concrete to be a viable alternative to traditional concrete in certain applications.

Self-healing Process

Process Flow Chart

Mix Bacillus bacteria and calcium lactate with concrete

↓

Bacteria remain dormant within the concrete

↓

Concrete cracks

↓

Water and oxygen enter the crack

↓

Bacteria become activated

↓

Activated bacteria produce calcium carbonate

↓

Calcium carbonate fills in the cracks

↓

Concrete is repaired and structural integrity is restored

Self-healing bio-concrete works by incorporating Bacillus bacteria into the concrete mixture, along with calcium lactate as a nutrient source. The bacteria are dormant within the concrete and do not become active until the concrete cracks.

10.A. Importance of Bio-imaging

Technological Importance

The technological importance of bio-imaging for disease diagnosis lies in its ability to provide detailed images of the body's internal structures and functions, which can help healthcare professionals to make accurate diagnoses and provide effective treatments.

Some of the key technological advantages of bio-imaging include:

 Improved accuracy: Bio-imaging technologies can provide high-resolution images of the body's internal structures, which can help healthcare professionals to identify subtle changes and make accurate diagnoses.

 Early detection: Bio-imaging can be used to detect diseases in their early stages, when they are often more treatable. This can lead to earlier treatment and better outcomes for patients.

Multi-modality: Bio-imaging technologies can be combined to provide a multi-modal view of the body's internal structures and functions, which can provide a more comprehensive understanding of a disease or condition.

 Cost-effectiveness: Many bio-imaging technologies are relatively low-cost, which makes them accessible to a wider range of patients.

 Minimally invasive: Many bio-imaging techniques are non-invasive, which means that they do not require incisions or the insertion of instruments into the body. This makes them less painful and less risky than many traditional diagnostic procedures.

 Improved patient outcomes: By providing healthcare professionals with detailed images of the body's internal structures and functions, bio-imaging can help to improve patient outcomes by enabling earlier and more accurate diagnoses, and more effective treatments.

 Advancements in research: Bio-imaging technologies are also important in advancing medical research, by providing detailed images of the body's internal structures and functions, which can help researchers to better understand the underlying mechanisms of diseases and develop new treatments.

Advantages

Some of the key advantages of bio-imaging for disease diagnosis include:

 Non-invasive: Many bio-imaging techniques are non-invasive, which means that they do not require incisions or the insertion of instruments into the body. This makes them less painful and less risky than many traditional diagnostic procedures.

 High resolution: Bio-imaging technologies can provide high-resolution images of the body's internal structures, which can help healthcare professionals to identify subtle changes and make accurate diagnoses.

 Early detection: Bio-imaging can be used to detect diseases in their early stages, when they are often more treatable. This can lead to earlier treatment and better outcomes for patients.

 Multi-modality: Bio-imaging technologies can be combined to provide a multi-modal view of the body's internal structures and functions, which can provide a more comprehensive understanding of a disease or condition.

 Cost-effective: Many bio-imaging technologies are relatively low-cost, which makes them accessible to a wider range of patients.

10.b. Bioremediation and Biomining via Microbial Surface

Bioremediation and bio-mining are two related but distinct processes that utilize living organisms to clean up contaminated environments or extract valuable minerals, respectively.
Bioremediation refers to the use of microorganisms, plants, or animals to clean up contaminated environments, such as soil, water, or air. This process occurs naturally over time, but can also be accelerated through the addition of specific microorganisms or other biotic agents. The goal of bioremediation is to remove contaminants from the environment and restore it to a healthy state.
Biomining, on the other hand, refers to the use of microorganisms to extract valuable minerals from ore deposits. This process involves the use of microorganisms to dissolve minerals from ore, creating a solution that can be separated and purified to obtain the valuable minerals. Biomining is often used in the extraction of metals such as copper, gold, and nickel, and has several advantages over traditional mining methods, including lower energy costs, reduced waste, and increased metal recovery.

Table: Comparing bioremediation via microbial surface adsorption and biomining via microbial surface adsorption

Aspect	**Bioremediation via Microbial Surface Adsorption**	**Biomining via Microbial Surface Adsorption**
Objective	To remove or neutralize pollutants/contaminants from the environment	To extract valuable metals or minerals from ores
Process	Microorganisms adsorb and degrade pollutants/contaminants	Microorganisms adsorb and extract metals from ores
Targeted Contaminants/Metals	Focuses on organic pollutants or contaminants	Focuses on desired metals or minerals
Microorganisms	Diverse range of microbial strains with pollutant-degrading capabilities	Specific microbial strains with metal adsorption capabilities
Surface Adsorption Mechanism	Microorganisms attach to pollutant surfaces	Microorganisms attach to metal surfaces
Environmental Impact	Can restore ecosystems and improve environmental quality	Can potentially cause some environmental disturbances
Timeframe for Results	Can take months to years for significant remediation	Quicker results for metal extraction in controlled conditions
Waste Generation and Disposal Considerations	May generate waste that requires proper disposal	Waste generation and disposal considerations in mining operations
Applications	Soil, water, and air pollution remediation	Mining operations for metal extraction

Bioremediation and biomining via microbial surface adsorption is a process that utilizes microorganisms to remove heavy metals like lead, cadmium, mercury, and arsenic from contaminated environments or ore deposits, respectively.

The process of removing polluting heavy metals using bioremediation or biomining via microbial surface adsorption

Identification of heavy metal-contaminated site:
Identify the site or area contaminated with heavy metals, such as soil, water, or industrial waste sites.

↓

Isolation and characterization of metal-resistant microbial strains:
Select and isolate microbial strains that have demonstrated resistance to heavy metals. These can include bacteria, fungi, or archaea.

↓

Culturing and enrichment of microbial strains:
Culture and propagate the selected microbial strains in a suitable growth medium under laboratory conditions. This step aims to obtain a sufficient quantity of active microbial biomass for subsequent applications.

↓

Preparation of microbial suspension:
Harvest the microbial biomass and prepare a suspension by suspending the biomass in a carrier solution, such as water or a nutrient broth. This suspension will serve as the delivery system for the microbes during application.

↓

Application of microbial suspension to the contaminated site:
Apply the microbial suspension to the heavy metal-contaminated area. This can be done through spraying, injection, or soil/water mixing, depending on the specific site conditions.

↓

Microbial adsorption and sequestration of metal:
The applied microbial strains adsorb to the surfaces of metal particles or form biofilms. Through their metabolic activity, the microbes produce extracellular compounds such as organic acids or biofilm matrix components that have an affinity for binding metal ions.

↓

Separation or removal of metals from the contaminated site can be achieved through different methods

10.c. NANOMEDICINES AND BIOLEACHING

NANOMEDICINES

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials and biological devices, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology such as biological machines. Current problems for nanomedicine involve understanding the issues related to toxicity and environmental impact of nanoscale materials

Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications. Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

Nanomedicine seeks to deliver a valuable set of research tools and clinically useful devices in the near future. The National Nanotechnology Initiative expects new commercial applications in the pharmaceutical industry that may include advanced drug delivery systems, new therapies, and in vivo imaging. Nanomedicine research is receiving funding from the US National Institutes of Health Common Fund program, supporting four nanomedicine development centers

BIOLEACHING

Leaching process was first observed in pumps and pipelines installed in mine pits containing acid water. This process was later on employed for recovering metals from ores containing low quantity of the metal. Presently certain metals from sulfide ores and other ores are extracted by employing only leaching method.

Extraction of metals from low-grade ores by employing microorganism is called as bioleaching. Large quantities of low-grade ores are produced during the separation of higher-grade ores and are generally discarded in waste heaps. Metals from such ores cannot economically be processed with chemical methods. There are large quantities of such low-grade ores especially copper ores, which can be processed profitably by bio-leaching.

Copper and Uranium are presently produced commercially by employing bioleaching process. However, problems may creep in when the large scale bioleaching process of a waste dump is improperly managed because seepage of leach fluids containing low pH and metals into natural water supplies and ground water causing metal pollution.

Mechanism of Bioleaching:

The process of bioleaching is accomplished by two ways:

(i) Direct bioleaching

(ii) Indirect bioleaching

(i) Direct Bioleaching:

Thiobacillus ferrooxidans is oftenly used in microbial leaching. It is an autotrophic, aerobic, gram (-) negative rod shaped bacterium. It synthesizes its carbon substances by CO_2 fixation. It derives the required energy for CO_2 fixation either from the oxidation of Fe^{2+} to Fe^{3+}or from the oxidation of elemental sulphur or reduced sulphur compounds to sulfates.

Thiobacillus thiooxidans oxidizes insoluble sulphur to sulphuric acid, which takes place in the periplasmic space. It is possible to dissolve iron through direct bacterial leaching as shown in the above reactions.

(ii) Indirect Bioleaching:

This leaching process takes place without direct involvement of microorganisms but they indirectly support the leaching by producing agents responsible for oxidation of minerals. It can be explained by the process of oxidation of pyrite. Pyrite is a common rock mineral that is found in association with many ores.

Thiobacillus thiooxidans and Thiobacillus ferrooxidans are generally seen associated with leaching dumps. In pilot plant reactors of 50 liter capacity, leaching can be performed continuously in a cascade series with recycling of cells and leachates.

In the laboratory better yields of bioleaching products can be obtained under optimal conditions, like control of temperature, O_2 and CO_2 adjustments, maintenance of pH between 2 and 3, and eh around –300mv with very finely ground ores in a tower (percolator). However, conditions and yield cannot be achieved in a commercial scale because it is expensive.

Thiobacillus thiooxidans and Thiobacillus ferrooxidans are generally used in bioleaching methods. However, a number of other microorganisms such as Thiobacillus concretivorus, Pseudomonas florescens, P.putida, Achromobacter, Bacillus licheniformis, B. cereus, B luteus, B. polymyxa, B. megaterium and several thermophilic bacteria like Thiobacillus thermophilica, Thermothrix thioparus, Thiobacillus TH1 and Sulfolobus acidocaldarius. Because of more rapid growth rate the thermophilic bacteria may significantly accelerate the bioleaching process.

Processes of Bioleaching:

i. Commercial Processes:

Methods described below are generally employed in large scale bioleaching processes:

(a) Slope Leaching:

In this method finely powdered ore, approximately 10,000 tons are made into large piles along the slopes of a mountain, and water containing Thiobacillus is continuously sprinkled. Metals are extracted from the water that collects at the bottom of the mountain.

(b) Heap Leaching:

The ore is arranged in a big heap, which is treated with water as in slope leaching. The recovery of metals and other processes are conducted just like in slope leaching

(c) In-Situ Leaching:

This process is carried with an ore which remains in its original location in the earth. The permeability of ore is increased by sub-surface blasting. Several passages, drilled through the ore. A well like pit is also made out at the bottom of the ore. Now acidic water containing Thiobacillus is pumped through drilled passages of the ore. The acidic water percolates through the ore and collects in the pit at the bottom of the ore. The water is pumped out from the pit and the minerals are extracted. The water after extraction of minerals, is reused after regeneration of bacteria.

ii. Copper Leaching:

To have an idea of bioleaching process copper leaching by bacteria is described as an example. Covellite, chalcocite and chalcopyrite are generally used as copper ores for bioleaching processes. Apart from containing copper, the ores also contain other elements like iron, zinc and sulphur. For example – Chalcopyrite contains 26% copper, 25.9% iron, 20.5% zinc and 33% sulphur.

Mechanism of Copper Leaching:

During the oxidation of Chalcopyrite the following reaction occurs:

$2CuFeS_2 + 8\ ½\ O_2 + H_2SO_4 \rightarrow 2\ CuSO_4 + Fe_2\ (SO_4)_3 + H_2O$

Similarly covellite is oxidized to copper sulphate

$CuS + 2O_2 \rightarrow CuSO_4$

Generally heap leaching process is employed in copper leaching process but sometimes a combination of heap leaching and in situ leaching processes are used. The solution (Sulphate/Fe^3 solution) is sprinkled over the heap which percolates through the ore and collects at the bottom pit. The solution collecting in the bottom pit will include copper metal, which is removed by precipitation. The

remaining water with Fe^{3+} is used again in the leaching process after adjusting the pH to 2.0 with the help of H_2SO_4.

CBCS SCHEME

USN | 1 | C | R | 2 | 1 | E | E | 0 | 3 | 2 |

21BE45

Fourth Semester B.E./B.Tech. Degree Examination, June/July 2023
Biology for Engineers

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.

		M	L	C
	Module – 1			
a.	What is a biomolecule? Explain the classification of biomolecule.	07	L2	CO1
b.	Explain the role of DNA vaccine for rabies and RNA vaccine for COVID-19.	07	L2	CO1
c.	Write a short note on cellulose based bio-filters.	06	L2	CO1
	OR			
a.	Explain the DNA finger printing in forensic applications.	07	L2	CO1
b.	Explain the role of lipids and its application in cleaning agents.	07	L2	CO1
c.	Write a short note on biosensors and bioplastics.	06	L2	CO1
	Module – 2			
a.	Explain brain as a CPU system.	07	L3	CO1
b.	Explain eye as a camera system.	07	L3	CO1
c.	Write a short note on cardiac pacemaker.	06	L2	CO1
	OR			
a.	Explain the robotic arms for prosthetics.	07	L3	CO1
b.	Explain heart as a pump system.	07	L3	CO1
c.	Write a short note on engineering solutions for Parkinson's disease.	06	L2	CO1
	Module – 3			
a.	Explain the lungs as a purification system.	07	L3	CO2
b.	Explain the kidney as filtration system.	07	L3	CO2
c.	Write a short note on spirometry and ventilator.	06	L2	CO2
	OR			
a.	Explain muscular and skeletal system as scaffolds.	07	L3	CO2
b.	Explain bio-engineering solutions for muscular dystrophy and osteoporosis.	07	L3	CO2
c.	Write a short note on Chronic Obstructive Pulmonary Disease (COPD).	06	L2	CO2
	Module – 4			
a.	Explain the terms Echolocation Ultrasonography and Sonars.	07	L3	CO3
b.	Explain the process of Photosynthesis and Photovoltaic cells.	07	L3	CO3
c.	Write a short note on Bionic leaf, GPS, Bird flight and aircraft.	06	L2	CO3
	OR			
a.	Explain the terms Lotus leaf effect, Plant Burrs and Super hydrophobic and self-cleaning surfaces.	07	L3	CO3
b.	Explain the terms Spark skin and Swimsuits, Bullet train using biological concepts.	07	L3	CO3
c.	Write a short note on Hemoglobin – Based Oxygen Carriers (HBOC's) and Perfluorocarbons (PFC).	06	L2	CO3
	Module – 5			
a.	Explain the DNA Organic and Biocomputing.	07	L3	CO4
b.	Explain the Bioimaging and Artificial intelligence for Disease Diagnosis.	07	L3	CO4
c.	Write a short note on Self healing Bioconcrete.	06	L2	CO4
	OR			
a.	Explain the importance of Bioimaging.	07	L3	CO4
b.	Explain Bioremediation and Bio-Mining via microbial surface adsorption.	07	L3	CO4
c.	Write s short note on Nanomedicines and Bioleaching.	06	L2	CO4

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