CBCS SCHEME

USN 2VD22ME446

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.

		Module – 1	M	L	C
Q.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			
Q.2	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			
Q.3	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			
Q.4	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			
Q.5	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			
Q.6	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			
Q.7	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			
Q.8	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			
Q.9	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			
Q.10	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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Biology for Engineers (BBOK407)

1a What is a biomolecule? Explain the classification of biomolecule.

A biomolecule is molecule produced by a living organism. These molecules are crucial for life as they participate in various biological processes essential for the functioning and survival of organism.

The classification of biomolecules are.

1. Carbohydrates:

1. Carbohydrates are organic compounds made up of carbon, hydrogen and oxygen.

2. They serve as a primary source of energy for living organisms and it is classified into three main groups: Monosaccharides, disaccharides and polysaccharides.

Ex: Glucose, sucrose, cellulose.

2. Lipids

Lipids are hydrophobic molecules composed mainly of carbon and hydrogen atoms. They include fats, oils, phospholipids and steroids. It is classified into triglycerides, phospholipids, steroids and waxes.

3. Proteins :

Proteins are complex molecules composed of amino acids linked together by peptide bonds. They play vital roles in cellular structure, function and regulation. Examples include enzymes, antibodies and structural proteins like collagen

4. Nucleic acids :

Nucleic acids are macromolecules that store and transmit genetic information. There are two types of nucleic acids: DNA and RNA. DNA carries genetic information, while RNA is involved in protein synthesis and gene regulation.

5. Other biomolecules:

a. Vitamins

b. Hormones

c. Coenzymes and cofactors

d. Pigments.

b. Explain the role of DNA vaccine for rabies and RNA vaccine for COVID-19.

DNA vaccines for rabies and RNA vaccines for COVID-19 are the two different approaches to vaccination that utilize the genetic material of the respective pathogens to trigger an immune response in the body.

DNA Vaccine for Rabies:

1. DNA vaccines work by introducing a small, circular piece of DNA containing genes that encode antigens

2. For rabies, the DNA vaccine contains genes encoding the surface glycoprotein of the rabies virus.

3. Once the DNA is taken up by cells, they use their own machinery to produce the viral antigen.

4. The viral antigen is then displayed on the surface of the cells, triggering an immune response.

5. This immune response involves the activation of T cells and B cells, which recognize the viral antigen as foreign and mount a response to eliminate it.

6. Memory T and B cells are also generated providing long term immunity against rabies infection.

RNA Vaccine for COVID-19:

1. RNA vaccines work similarly to DNA vaccines but use messenger RNA (mRNA) instead of DNA to deliver genetic instructions to cells.

2. For COVID-19, the mRNA vaccine contains the genetic code for the spike protein found on the surface of the SARS-CoV-2 virus.

3. Once the mRNA is delivered into cells, they use their own machinery to translate the mRNA into the spike protein

4. The spike protein is then displayed on the surface of the cells, triggering an immune response similar to natural infection.

5. The immune system recognizes the spike protein as foreign and mounts an immune response, including the production of antibodies and activation of T cells.

c Write a short note on cellulose based bio filters.

Cellulose based biofilters are innovative filtration systems that utilize cellulose, a natural polymer found in plants to remove contaminants from air or water. These biofilters harness the unique properties of cellulose, such as its porous structure and high surface area, to create an effective and sustainable filtration solution.

Cellulose-based biofilters are composed of cellulose fibers or cellulose-derived materials. These materials may include cellulose fibers sourced from wood pulp, cellulose nanocrystals or cellulose-based membranes.

Cellulose based biofilters find applications in various industries and environmental settings. They can be used for air purification in HVAC systems, industrial emissions control, wastewater treatment and point of use water filtration.

2 a Explain the DNA finger printing in forensic applications.

DNA fingerprinting also known as DNA profiling or DNA typing is a forensic technique used to identify individuals based on their unique DNA characteristics. It involves analyzing specific regions of an individuals DNA to create a genetic profile that is distinct to that person.

The steps in DNA finger printing are.

1. Sample collection:

The first step in DNA fingerprinting is the collection of biological samples from the crime scene. This could include blood, saliva, semen, hair

or tissue samples.

2. DNA extraction:

Once collected, the DNA is extracted from the biological sample using various laboratory techniques.

3. PCR Amplification:

It is then used to amplify specific regions of the DNA known as Short Tandem Repeats. These regions contain repeating sequences of DNA that vary in length between individuals.

4. Gel Electrophoresis:

The amplified DNA fragments are separated based on their size using a technique called gel electrophoresis.

5. DNA profiling

After gel electrophoresis, the DNA fragments are visualized using a staining technique. The resulting pattern of DNA fragments known as DNA profile.

6. Comparison and identification.

The DNA profile is then compared to known DNA profiles, such as those obtained from suspects. If there is a match between the crime scene DNA and a known individual, it provides strong evidence linking that individual to the crime.

2b. Lipids play a significant role in the formulation of cleaning agents due to their unique properties, which contribute to the effectiveness and versatility of these products.

The applications of Lipids in cleaning agents are

1. Surfactant Properties
2. Emulsification
3. Solubilization
4. Moisturizing and Conditioning
5. Formulation Flexibility
6. Biodegradability
7. Scent and Aesthetic Appeal

2c Write a short note on biosensors and bioplastics

Biosensors :

Biosensors are analytical devices that integrate biological sensing elements with transducer to detect specific biological or chemical substances. These devices utilize the recognition properties of biological molecules such as enzymes, antibodies or nucleic acids to selectively bind to target analytes, generating a measuring signal that is proportional to the concentration of the analyte. Biosensors find applications in various fields including health care, environmental monitoring, food safety and bioprocess monitoring

Bioplastics :

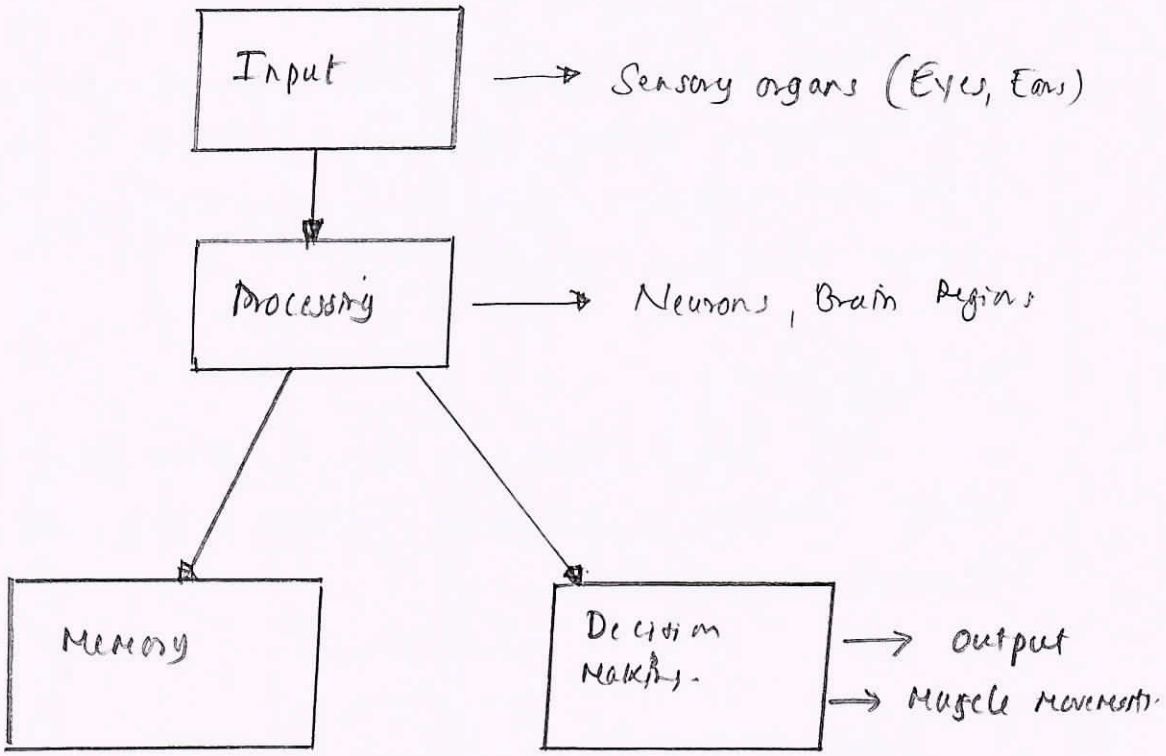
Bioplastics are a type of plastic derived from renewable biomass sources such as plants, algae or microorganisms. Unlike traditional plastics which are

derived from fossil fuels, bioplastics are biodegradable or compostable, offering environmental benefits such as reduced reliance on non renewable resources and decreased accumulation of plastic waste in the environment.

Types of bioplastics are.

1. Bio based plastics
2. Biodegradable Plastics
3. Compostable plastics

Q3 a Explain brain as a CPU system.



It consist of

1. Input:

Just like a CPU system receives input from various sources, the brain receives input from sensory organs such as eyes, ears. These sensory inputs include visual information, tactile sensations and smell.

2. Processing:

The CPU processes data it receives, performing calculations, executing instructions and making decisions. Similarly the brain processes sensory information through neurons which are the basic units of the nervous system.

3. Memory:

The brain stores information in different forms of memory, including short-term memory, long term memory and sensory memory.

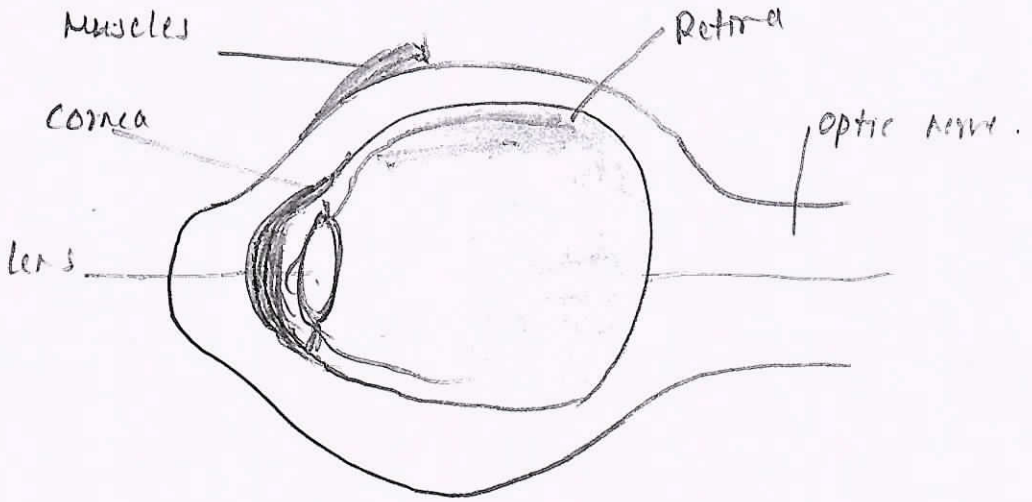
4. Decision making:

Brain makes decisions based on the processed sensory information, previous experiences stored in memory and various cognitive processes such as reasoning, problem solving and emotional responses.

5. Output:

The brain produces output signals that control muscle movements, glandular secretions and other physiological responses.

3b Explain eye as a camera system.



It consists of

1) Lens system
2) Aperture
3) Retina
4) Optic Nerve
5) Image processing

Lens system

The main components of the eye's lens system include the cornea which is the transparent outer layer covering the eye, and the crystalline lens, which is located behind the pupil and can change shape to adjust focus.

Aperature :

The pupil of the eye serves as the aperature, regulating the amount of light entering the eye.

Retina :

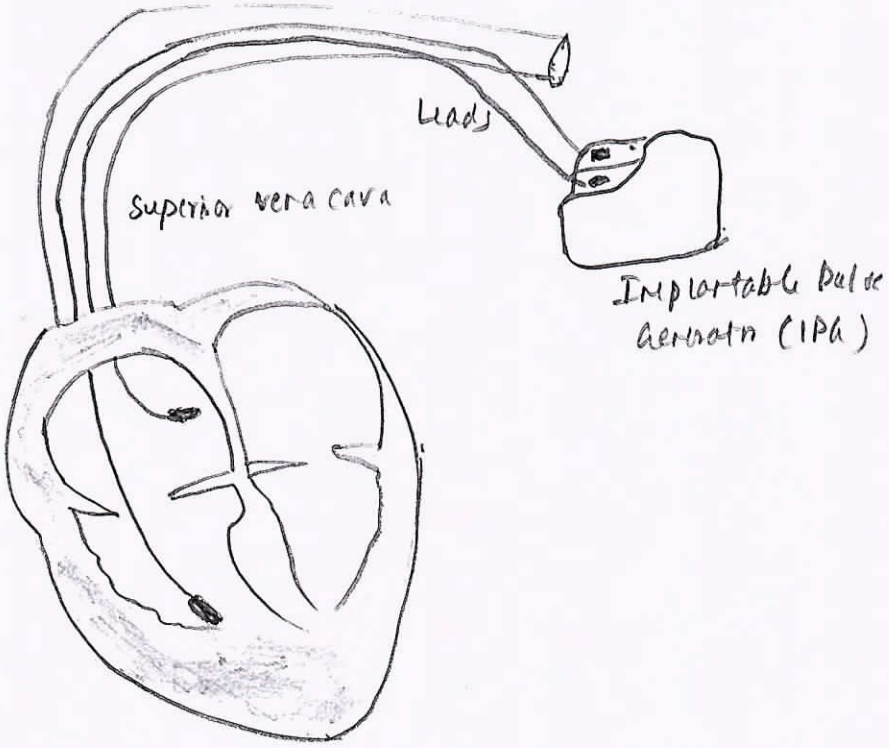
The retina functions like the camera film or digital sensor, capturing the focused light and converting it into electrical signals that the brain can interpret.

Optic nerve.

It carries the electrical signals generated by the retina to the brain's visual processing centers where the signals are interpreted to create the perception of sight.

3c Write a short note on cardiac pacemaker:

A cardiac pacemaker is a medical device implanted in the chest to regulate the heart beat.



1. Pulse Generator:

This is the brain of the pacemaker. It houses the circuitry that monitors the heart rhythm and generates electrical pulses when needed.

2. Battery:

The power source for the pacemaker. Modern pacemakers use long lasting lithium batteries that can last for several years.

3. Leads.

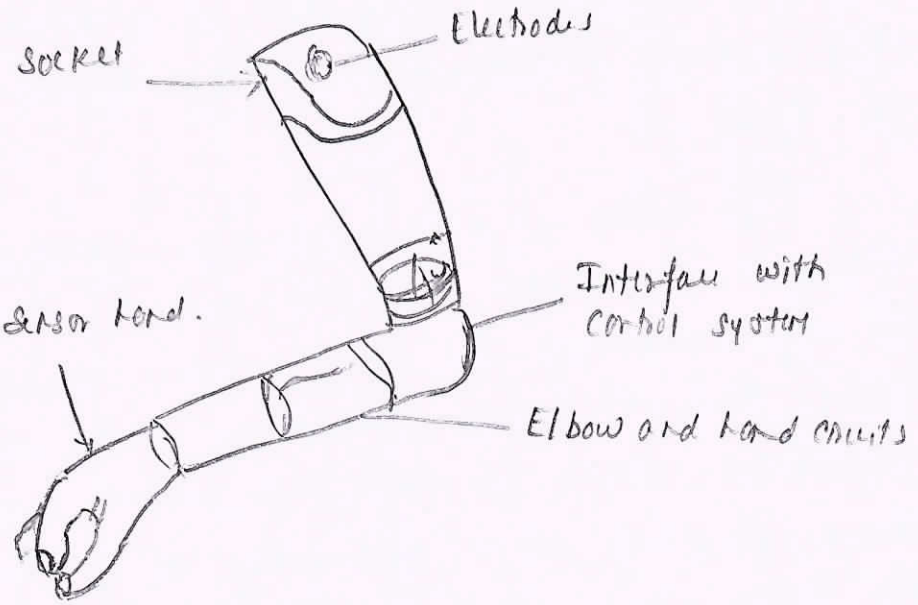
These are thin, insulated wires that connect the pacemaker to the heart. They sense the heart's electrical activity and deliver electrical pulses to stimulate the heart muscle.

4. Electrodes

The ends of the leads that are positioned in contact with the heart tissue.

4a

Robotic arms for prosthetics:



Components are.

1) Mechanical arm

This is the core structure, resembling a human arm with multiple joints. These joints are powered by motors that enable various movements.

2). Sensors:

Sensors embedded in the arm detect residual muscle movements or electrical signals in the user's residual limb.

3.) Microprocessor:

This is the brain of the prosthetics. It receives signals from the sensors, interprets them and sends instructions to the motors to control the arms movement.

4) End effector

This is the attachment at the end of the arm which can be prosthetic hand, gripper or specialized tool depending on the user's needs.

4b Explain heart as a pump system.

The human heart acts as a remarkable double pump system, continuously circulating blood throughout the body.

The heart is a muscular organ divided into four chambers: two upper chambers and two lower chambers. The right side of the heart receives deoxygenated blood from the body and pumps it to lungs for oxygenation, while the left side receives oxygenated blood from the lungs and pumps it to the rest of the body.

Blood flows through the heart in a specific pathway known as the cardiac cycle. Deoxygenated blood enters the right atrium from the body via the superior and inferior vena cavae.

The pumping action of heart is driven by rhythmic contractions of its muscular walls. The ventricles contract pumping blood out of the heart.

Valves within the heart ensure one-way flow of blood through the chambers and prevent backflow. These valves open and close in response to changes in pressure within the heart chambers, allowing blood to flow in the correct direction.

4c Short note on engineering solutions for Parkinson's disease.

Parkinson's disease disrupts the brain's ability to control movement. Engineers are developing solutions to address these challenges from various angle.

1) Deep Brain Stimulation:

This existing technology uses implanted electrodes to deliver electrical pulses to brain regions involved in movement control. Engineers are working on refining DBS for better targeting, reducing side effects and creating adaptive stimulation based on real time brain activity

2) Biomedical Engineering:

Researchers are exploring possibilities for replacing lost dopamine-producing neurons with stem cell therapies or engineered cells. This is a developing field with the potential to offer a more permanent solution.

3) Diagnostic Tools:

Biomedical engineers are developing advanced brain imaging techniques and wearable sensors to enable earlier and more precise diagnosis of Parkinson's disease. This can lead to earlier intervention and improved disease management.

5a The lungs acts as the body's purification system by performing two main functions: gas exchange and filtration.

1. Gas exchange:

We breathe in air through our nose or mouth. The air travels down the trachea and splits into two bronchi, each leading to a lung.

The bronchi is divided into smaller tubes called bronchioles which end in tiny air sacs called alveoli.

oxygen from the inhaled air diffuses through the thin walls of the alveoli and enters the bloodstream in the capillaries. We then exhale, expelling the air rich in carbon dioxide and other waste gases.

Filtration:

Our respiratory system also has built in filtration mechanisms to prevent harmful substances from entering the lungs.

The nose acts as a first line of defense with hairs filtering out large particles like dust and pollen. Tiny hair like structures called cilia line the airways. They move mucus upwards, trapping dust, allergens and germs. The mucus is then swallowed or coughed up, removing these unwanted elements.

5b Kidney as filtration system:

The kidneys are body's tireless filtration system working around the clock to remove waste products, regulate fluids and maintain a healthy chemical balance in our blood.

Each kidney houses millions of microscopic filtering units called nephrons. These tiny powerhouses are responsible are responsible for the intricate filtration process.

Blood enters the nephron through a tiny vessel called the glomerulus. The glomerulus acts as as selective sieve. Blood pressure pushed fluid, wastes and some small molecules through the glomerular walls, while blood cells and proteins stay behind

5c

Spirometry:

This is a diagnostic test that measures lung function. It involves breathing into a mouthpiece connected to a machine that records air volume and flow rates. Spirometry can help diagnose lung diseases like asthma, chronic obstructive pulmonary disease (COPD) and cystic fibrosis by identifying abnormal breathing patterns.

Ventilator:

A ventilator is a life-saving machine that provides mechanical ventilation to patients who are unable to breathe adequately on their own. It uses a mask or tube inserted into the airway to pump oxygen-rich air into the lungs and remove carbon dioxide. Ventilators are used in critical care settings for various conditions like respiratory failure, severe pneumonia and during surgery when muscle relaxants prevent breathing.

6 a

Muscular system:

Muscles are attached to bones by tendons and acts as the motors of the body. They contract and relax, generating force to move the bones and create movement

The bones provide a stable structure for the body's organs, tissues and soft tissues. Muscles wouldn't have anything to pull on without this bone work.

Muscles use the bones as levers to generate movement. The bones provides a stable base for the muscles to exert their force.

Skeletal system:

The bones form the rigid framework of the body providing a strong and stable base for movement and support. Cartilage pads and cushions the joints between bones, allowing for smooth movement while absorbing shock.

6b. Muscular dystrophy and osteoporosis are two distinct conditions affecting the musculoskeletal system, but bioengineering offers promising solutions for both.

Muscular dystrophy

Muscular dystrophy is a group of inherited diseases that cause progressive muscle weakness and loss of muscle mass. Bioengineering approaches aim to address the underlying genetic defect or regenerate damaged muscle tissue.
Here are some potential solutions.

1) Gene Therapy
2) Exon Skipping
3) Stem cell Therapy
4) Myoblast transplantation.

Osteoporosis:

Osteoporosis weakens bones, making them more susceptible to fractures. Bioengineering focuses on stimulating bone growth and improve bone density.
Here are some approaches.

1) Bone Morphogenetic Proteins
2) Tissue Engineering
3) Bioactive Implants
4) Exoskeletons.

6c Chronic obstructive pulmonary disease (COPD) is a common lung disease that makes it difficult to breathe. It is often caused by long term exposure to irritants in the lungs, primarily cigarette smoke.

Symptoms.

People with COPD experience symptoms like coughing, wheezing, shortness of ~~death~~ breath and chest tightness.

Causes:

Smoking is the leading cause of COPD, but long-term exposure to air pollution or dust can also contribute.

Various approaches to manage COPD:

1) Medication
2) Pulmonary Rehabilitation.
3) Oxygen Therapy
4) Lifestyle changes.

7a Echolocation:

It is a biological ability used by some animals like bats and dolphins, to navigate and locate objects in their environment. Animals emit high frequency sound waves and listen for the echoes reflected off objects. By analyzing the returning echoes, the animal can determine the direction, distance and size of the object.

Ex: Bats emit squeaks through their mouths or noses, and the returning echoes help them locate insects in the dark.

Ultrasonography:

Ultrasonography is a medical imaging technique that uses sound waves to create images of internal organs and tissues.

Similar to echolocation, it uses high frequency sound waves inaudible to the human ear. A handheld probe transmits sound waves into the body. The reflected echoes are picked up by the probe and converted into a visual image on a screen.

Sonar:

Sonar is a technology used to detect and locate objects underwater. It's essentially underwater echolocation. Similar to the above, sonar transmits sound waves into the water and analyzes the returning echoes to determine the presence, location and size of underwater objects.

7b

Photosynthesis

It is a natural process used by plants, algae and some bacteria to convert light energy from the sun into chemical energy. This chemical energy is stored in the form of glucose (sugar) which is the fuel for these organisms.

A pigment present in chloroplasts that absorbs specific wavelengths of sunlight: provides the energy source for the reaction. Taken in form the atmosphere through tiny openings in leaves called stomata. Absorbed from the soil by the plants roots.

Photovoltaic cells:

Photovoltaic cells are human made devices that convert sunlight directly into electricity. When sunlight strikes the solar cell, photons are absorbed by the silicon atoms. The absorbed energy excites electrons in the silicon, bumping them to a higher energy state. The excited electrons flow across the P-N junction, generating an electric current. The current flows through a circuit producing electricity.

7c

Bionic leaf:

It mimics the natural process of photosynthesis. Artificially captures sunlight and converts it into clean fuel (hydrogen) or usable energy sources provides a sustainable way to generate clean energy by mimicking the natural process plants use.

GPS (Global Positioning System):

It is based on biological navigation used by birds and some insects. It utilizes a network of satellites to pinpoint location on Earth. Similar to how birds navigate using the sun and Earth's magnetic field, GPS relies on signals from satellites to determine position.

Bird Flight:

The study of bird anatomy and wing aerodynamics has informed aircraft design. The shape of bird wings, feathers for lift and control and lightweight bone structure all influenced aircraft design. Understanding bird flight principles has led to more efficient and aerodynamic aircraft.

8 a

1. Lotus leaf effect:

The lotus leaf effect refers to the remarkable self cleaning property of lotus leaves and other plants like pitcher plants. These surfaces are superhydrophobic, meaning they strongly repel water.

2. Plant Burrs

Plant burrs are the spiky or hooked seed pods of certain plants like burdock or cocklebur. These clever structures help plants disperse their seeds in a unique way. The design of burrs has inspired the development of fasteners like velcro. The tiny hooks on velcro mimic the burr's barbs, creating a strong yet easily detachable connection

3. Superhydrophobic

Superhydrophobic describes a surface that repels water very effectively. Water droplets on such surfaces will bead up and roll off easily, minimizing wetting of the surface. Superhydrophobic coatings are used in various material to create self cleaning properties.

4. Self-cleaning Surfaces:

Self cleaning surfaces are those that can remove dirt, dust or other contaminants with minimal external intervention. The lotus leaf effect is a prime example of self cleaning surface in nature. Self cleaning surfaces offer numerous advantages such as reduced maintenance needs, improved hygiene and potentially longer product life spans.

8b. Spark skin and swimsuits :

This is a new type of swimsuit material inspired by the microscopic features of shark skin. It has tiny ridges called dermal denticles that reduce drag as the shark swims.

Swimsuit manufacturers are incorporating similar textures into swimsuit fabrics. These textured surfaces aim to mimic the shark skin effect, potentially reducing drag for competitive swimmers.

Bullet trains using Biological concepts :

Bullet trains also known as high speed trains, are constantly evolving to achieve greater speeds and efficiency, Here are two biological concepts influencing bullet train design:

i) kingfisher beak.

2) Cheetah's flexibility.

8c Hemoglobin Based oxygen carriers (HBOCs)

It is the artificial oxygen carriers designed as potential alternatives to blood transfusions. They aim to mimic the role of red blood cells by carrying oxygen throughout the body.

HBOCs are primarily derived from hemoglobin, the iron containing protein in red blood cells responsible for oxygen transport.

Perfluorocarbons (PFCs)

PFCs are a group of synthetic compounds containing only carbon and fluorine atoms. They are unique in their ability to dissolve large amounts of oxygen

Medical applications:

1) Potential oxygen carriers.

2) liquid ventilation:

9a

DNA organic

DNA can store vast amounts of information in its sequence of nucleotides. Each base pair can be seen as a binary digit offering a compact and high-density storage medium.

DNA is a relatively stable molecule, especially when stored under the right conditions. This makes it potentially suitable for long term data storage.

DNA has the natural ability to replicate itself which could be beneficial for data redundancy and backup purposes.

Biocomputing:

Biocomputing is a cutting edge field that explores using biological molecules and processes for computation. Instead of silicon chips, it seeks to harness the power of DNA, proteins or even cellular pathways to perform calculations.

Applications includes medical diagnosis, Drug discovery and cryptography.

9b. Bio imaging

Bioimaging and artifical Intelligence (AI) are revolutionizing the field of disease diagnosis.

Bio-imaging techniques.

X-rays, CT scans, MRI, ultrasounds

These techniques provide detailed images of internal organs and tissues, allowing doctors to visualize potential abnormalities

The role of artifical intelligence.

1) Image Analysis

AI algorithms can analyze vast amounts of medical images much faster and more objectively than humans.

2) Pattern Recognition:

AI can be trained to recognize subtle patterns indicative of disease in medical scans, potentially leading to earlier and more accurate diagnoses.

10 a

Bio imaging

Bioimaging is a broad field encompassing various techniques that allow us to visualize biological processes and structures within living organisms.

Importance in Diagnosis and treatment:

1. Disease Detection:

Bioimaging technique like X-rays, CT scans, MRI and ultrasounds helps doctors diagnose a wide range of diseases. These images can reveal tumors, fractures, internal bleeding and other abnormalities.

2. Disease monitoring

Bioimaging can be used to monitor the progression of disease and treatment effectiveness.

3. Surgical planning:

Bioimaging helps visualize internal structures before surgery, allowing for precise planning and navigation during procedures.

10 b.

Microbial surface adsorption (MSA) is a key mechanism employed by some microorganisms in both bioremediation and biomining processes.

Microbial surface adsorption.

- Microbes (bacteria, fungi etc) have specialized structures on their cell walls that can bind and concentrate pollutants or target minerals from the surrounding environment.

These binding sites can be specific attracting certain pollutants or minerals or non-specific, attracting a wider range of contaminants

Bioremediation:

In bioremediation, MSA helps microbes remove pollutants like heavy metals, organic compounds, and even radioactive isotopes from contaminated soil, water or air. The pollutants get adsorbed onto the microbial surface, concentrating them and making them more accessible for degradation. The microbes then utilize enzymes to break down these pollutants into harmless or less harmful products.

The advantages is that it allows microbes to target and accumulate pollutants at high concentrations, enhancing the biodegradation process

Biomining:

Biomining utilizes microbes to extract valuable metals and minerals from their ores or other environmental sources. MSA plays a crucial role in biomining by helping microbes specifically bind to the desired metals or minerals. Once adsorbed onto the microbial surface, the metals can be further processed by the microbes or chemically desorbed for collection. MSA offers an eco-friendly alternative to traditional mining methods, as it is less energy intensive and has a lower environmental impact

10c.

Nanomedicine:

It is a rapidly evolving field that utilizes nanoparticles (particles in the range of 1-100 nanometers) for diagnosis, treatment and drug delivery in medicine.

Potential applications

1) Drug delivery
2) Imaging
3) Therapies.

Challenges:

1) Safety
2) Targeting
3) Cost:

Bioleaching:

It is a biotechnological process that uses microorganisms (bacteria or fungi) to extract metals from ores or other low grade resources.

Advantages:

1) Environmentally friendly
2) Efficiency

Limitations:

1) Slower process
2) Limited metal recovery
3) Process optimization.

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