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BBOC407 BIOLOGY FOR ENGINEERS

Model Question Paper with Solution

MODULE-1

1. a) Justify the requirements of why protein for human body

Important Functions of protein in your Body:-

→ protein helps repair and build your boby's tissues. It drives metabolic reactions, maintain PH and fluid balance, and keeps the immune system strong. It also transports & stores nutrients and can act as an energy source.

→ protein is crucial to good health.

→ Growth and Maintenance: protein is required for the grawth and maintenance of tissues. your body's protein needs are dependent upon your health & activity level.

→ Causes Biochemical Reaction: Enzymes are proteins that allow key chemical reactions to take place within your body.

→ Provides Structure: A class of protein known as fibrous proteins provide various parts of your body with structure, strength and elasticity.

→ Balance fluids: proteins in your blood maintain the fluid balance between your blood and the surrounding tissues.

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"Keep going - Everything you need will come at perfect time"

-> Provides Energy: protein can serve as a valuable energy source but only in situtions of fasting, exhaustive exercise or inadequete calorie intake.

b) Explain with neat sketch: Structure & function of cell.

Understanding cell structure and function is key to understanding life processes.

Structure:-

1. plasma Membrane: Surrounds the cell, regulating the passage of substance.

2. Cytoplasm: Jelly-like substance filling the cell, Containing organelles.

3. Nucleus: Houses genetic material (DNA), Controlling cell activities for preliminary reference.

4. Organelles: Specialized structure:
   a) Endoplasmic Reticulum: Involved in protein and lipid metabolism.

   b) Golgi Apparatus: Modifies, Sorts, and packages molecules.

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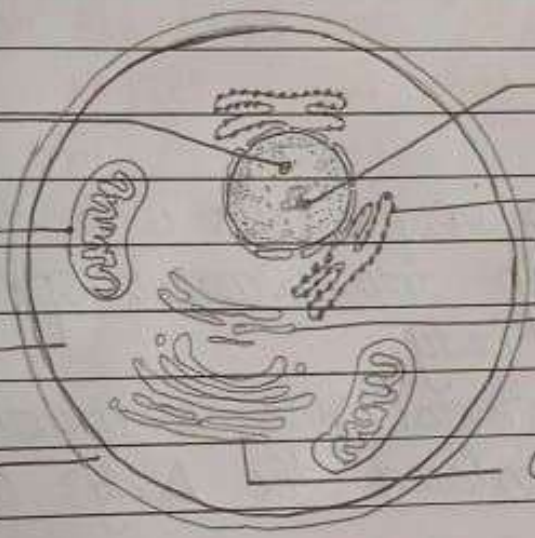
c. Mitochondria: Generates energy through respiration

d. Lysosomes: Break down waste materials

e. Ribosomes: Sites of protein synthesis

f. Centrioles: (In animals): Assist in cell division.

g. Cytoskeleton: Provides structural support and aids in cell movement.



Functions:-

1. Respiration: Converts glucose into ATP for energy.

2. Protein Synthesis: Translates genetic information into proteins.

3. Storage and processing: Synthesizes, modifies, and transport molecules.

4. Cellular Communication: Signals between cells via various molecules.

5. Waste Management: Breaks down and recycles cellular waste.

6. Cell Division: Replicates cells for growth, repair, and reproduction.

OR

2) a) How stem cells can be used to treat various real time health issues

Stem cells are unique cells with the remarkable ability to develop into various specialized cell types in the body.
They play a crucial role in growth, tissue, repair and maintaing the body's overall health

They possess two main characteristics

1. Self-Renewal: The ability to divide and produce more stem cells; maintaining a renewable source for further differentiation.

2. Differentiation: The potential to differentiate into various cell types depending on their environment and the signals they receive.

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Uses:-

1. Regenerative Medicine: Tissue repair: Stem cells are used to regenerate damaged or diseased tissue, aiding in organ repair.

* Orthopedic Treatments: Applied in bone and joint disorder for enhanced healing.

2. Treatment of Disease:

* Blood Disorder: Stem cells are used in treating condition like leukemia and anemia.

* Neurological Disorders: Research explores their potential for treating conditions like parkinson's and Alzheimer's.

3. Drug Development and Testing

* Stem cells serve as a valuable model for testing new drugs, predicting their effects on human cells.

4. Understanding Disease Mechanisms.

* Studying stem cells provides insights into the development and progression of diseases.

5. Cell-Based Therapies:

* Stem cells offer a foundation for developing cell-based therapies, addressing various medical conditions.

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b) List the differences between Prokaryotic and Eukaryotic cells.

Characteristic	Prokaryotes	Eukaryotes
Size of cell	Typically 0.2-2.0 mm in diameter	Typically 10-100mm in diameter
Nucleus	No nuclear membrane or nucleoli (nucleoid)	True nucleus, consisting of nuclear membrane & nucleoli
Membrane-enclosed organelles	Absent	Present: example include lysosomes, Golgi Complex, endoplasmic reticulum, mitochondria and chloroplasts.
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	present as a capsule or slime layer	Present in some cells that lacks a cell wall.

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Cell wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple
Plasma Membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrate that serve as receptors present
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton, cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); Smaller size (70S) in organelles.
Chromosome (DNA) arrangement	Single circular chromosome, lacks histones	Multiple linear chromosomes with histones.
Cell division	Binary fission	Mitosis
Sexual reproduction	No meiosis, transfer of DNA fragments only (Conjugation)	Involves Meiosis

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MODULE-2

3) a) Explain the properties of cellulose, justify cellulose as an effective water filter.

Cellulose-based water filter

* Made from cellulose - a carbohydrate polymer found in plant cell walls.
* Properties Cellulose - high mechanical strength, hydrophilic
* It removes particles, pathogens, and other contaminants from water

Properties of cellulose based water filter

1. High porosity: efficiently remove impurities and contaminants from water

2. Biodegradability: made from cellulose, which reduces their impact on the environment Compared to synthetic polymer filters.

3. Cost-effective: more affordable than traditional synthetic polymer filters; making them accessible to a wider range of consumer and communities.

4. Renewable resource: cellulose, reducing the dependency on non-renewable resources.

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5. Good mechanical strength: allowing them to maintain their structure and perform effectively over time.

6. Chemical resistance: resistant to most acids and bases, and can be used in a wide range of water treatment applications.

7. Large surface area: enchances their filtration capabilities and reduce the frequency of filter replacement.

* The cellulose material - cellulose acetate -synthetic from of cellulose.
* properties - good chemical resistance, high porosity and high flow rate, low cost material.
* other cellulose materials such as paper, cotton, and wood fibers may also be used.

b) Explain the structure of Glucose Oxidase (GOx) is biosensors.

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

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

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Glucose-Oxidase in Biosensors

* Glucose oxidase (GOx) - for the detection of glucose levels in blood and urine

* GOx is typically immobilized on a substrate, such as a polymeric film, to ensure stability and specificity.

* The transducer in the biosensor can be an electrode, a fluorescence-based system, or other type of sensor, depending on the desired level of sensitivity and specificity.

Structure:

* GOx is a dimeric protein, the 3D structure of which has been elucidated.

* The active site where glucose binds is in a deep pocket. The enzyme, like many protein that act outside cell, is converted with Carbohydrate chain.

* It is a dimeric glycoprotein consisting of two subunits each weighing 80 KDa.

[OR]

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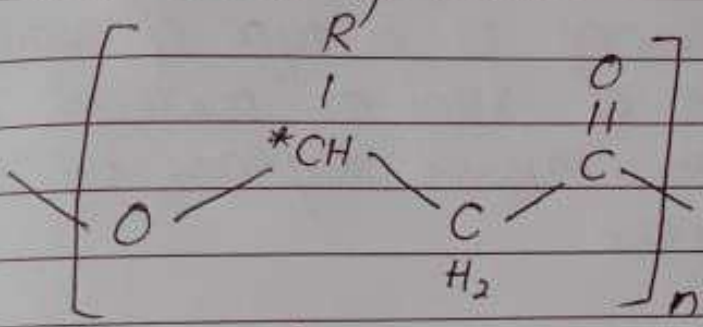
Why PHA's are biodegradable - Justify with an example.

* Biodegradable and biocompatible polyesters produced by microorganisms - bacteria and fungi
* Made from renewable resource - sugar and cornstarch.
* Environmentally friendly alternative - traditional petroleum-based plastics



poly(3-hydroxyalkanoate)

Properties of PHA

1. Biodegradability: break down into water and carbon dioxide - reducing their impact on the environment.
2. Biocompatibility: used in medical devices - sutures and implants, without causing adverse reactions in the body.
3. Mechanical properties: similar as traditional petroleum based plastics - suitable for various applications.

4. processing: processed using conventional plastic processing techniques - injection molding, blow molding, and extrusion.

5. Agricultural Mulch films: production of biodegradable mulch films to reduce soil erosion and conserve moisture

b) Explain the development of DNA Vaccine

* A DNA vaccine is a type of vaccine that uses a piece of viral or bacterial DNA to stimulate an immune response against the pathogens

* The vaccine works by introducing the pathogen's DNA into the body, where it is taken up by cells and used to produce viral or bacterial proteins.

* These proteins are then displayed on the surface of the cells, which triggers an immune response and the production of antibodies against the pathogen.

* DNA vaccines are being actively researched and developed for a range of disease.

Cancer, rabies, influenza, and human immunodeficiency virus (HIV).

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* The technology is still in its early stages, it has the potential to revolutionize the field of vaccine development and provides new treatment options for a range of disease.

Advantages:

1. Efficacy: highly effective in preventing rabies infection in both animal and human trials - as a traditional vaccine in protecting dogs against rabies.

2. Long-lasting protection: stimulate a strong and long-lasting immune response - provide protection for extended periods of time.

3. Ease of administration: they can be given via injection or even delivered orally - useful in areas with medical facilities are limited

4. Cost-effective: inexpensive to produce compared to traditional vaccines.

5. Reduced risk of side effects: DNA vaccines do not contain live virus particles - safer and have a lower risk of side effects compared to traditional vaccines.

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MODULE-3

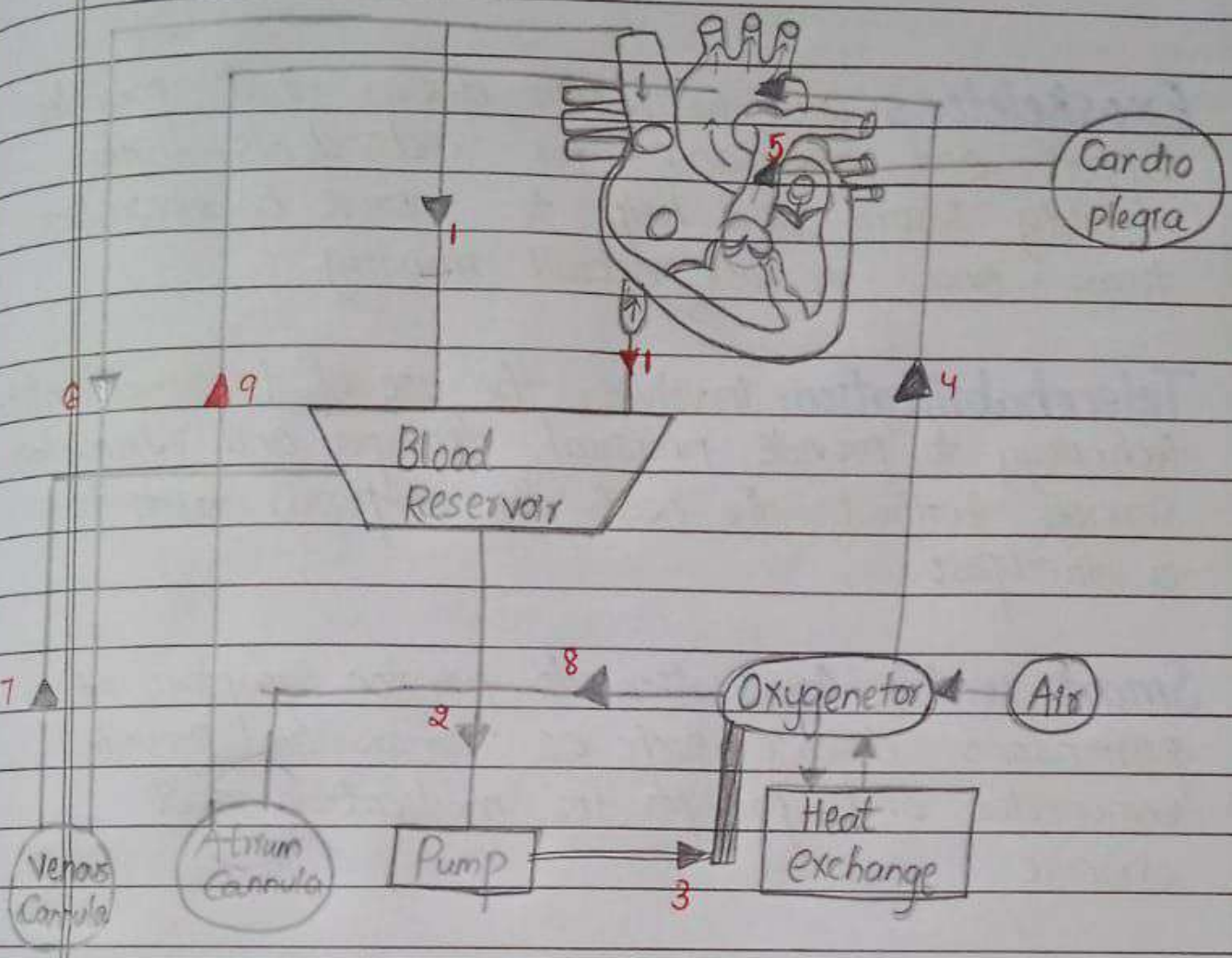
5)a With a neat sketch explain the working principle of Heart-Lung Machine.

* Is a device used in cardiovascular surgery to temporarily take over the functions of the heart and lungs
* The hearts-lung machine is used during open-heart surgery, such as coronary artery bypass graft (CABG) surgery and volva replacement surgery, to support the patient's circulatory and respiratory functions while the heart is stopped.

The heart-lung machine works by circulating blood outside of the body through a series of tubes and pumps.

* Blood is taken from the body, oxygenated, and then returned to the body.
* This allows the heart to be stopped during the surgery without causing any harm to the patient.
* The use of a heart-lung machine during surgery carries some risks, including the potential for blood clots, bleeding, and infections.

Additionally, there may be some long-term effects on the body, such as cognitive decline, that are not yet fully understood.



b) What are the engineering solutions for Parkinson's disease?

Parkinson's disease is a neurodegenerative disorder that affects movement and motor function.

1. **Deep Brain Stimulation (DBS)**: involves the implantation of electrodes into specific regions of the brain to deliver electrical stimulation- help to relieve symptoms like tremors, stiffness, and difficulty with movement.

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2. **Exoskeletons:** are wearable devices that provides support and assistance for individuals with mobility issues and help to improve balance, reduce tremors, and increase overall mobility.

3. **Telerehabilitation:** involves the use of telecommunication technology to provide physical therapy and rehabilitation services without the need for in-person visits to a therapist.

4. **Smart watch Application:** to monitor symptoms of parkinson's disease, such as tremors, and provide remainder and prompts for medication and exercise

5. **Virtual Reality:** Is a system used for rehabilitation and therapy, providing interactive and engaging environments for patients to practice movements and improve coordination and balance.

* These engineering solutions have to potential to significantly improve the quality of life for individuals with parkinson's disease.

* Ongoing research and development is aimed at improving their effectiveness and accessibility.

* However, these technologies are not a cure for

parkinson's disease and should be used in conjunction with other forms of treatment and care.

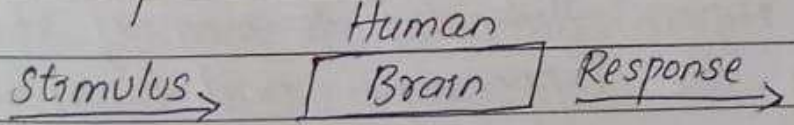
OR

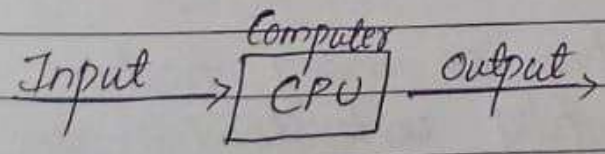
6(a) Explain Brain as a CPU.

* Both the brain and CPU receive and process inputs, store information, and perform calculations to produce outputs.

* Differences between the two - 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.





Architecture

* The human brain as a CPU system can be compared to that of parallel distributed processing

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system, as opposed to the Von Neumann architecture of traditional computers.

* 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 region 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

* Computer's CPU also has memory units for storing information, and the human brain has several regions dedicated to memory storage, including the hippocampus and amygdala.

* Human brain has so many functions that are still not fully understood.

b) Explain the architecture of rod and cone cells.

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Architecture of Rod and Cone cells

* Rod cells are photoreceptor cells in the retina of the eye that are responsible for detecting light and transmitting signals to the brain for the perception of vision, especially in low light conditions.

* They contain a protein called 'rhodopsin' that absorbs light and triggers a chain of events leading to the activation of neural signals.

* Rods are more sensitive to light than cone cells but do not distinguish color as well.

* Cone cells are photoreceptor cells in the retina of the eye that are responsible for color vision and visual acuity (sharpness of vision).

* There are three types of cone cells, each containing a different photo pigment sensitive to different wavelengths of light (red, green, and blue), which allow for the perception of color.

* Cones are less sensitive to light than rod cells but provide better visual acuity and color discrimination.

* They are concentrated in the fovea, the central part of the retina responsible for detailed and sharp vision.

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* Architecture Rod and Cone cells have a similar basic structure, but there are some difference that are crucial for there different functions

* Outer segment contains photoreceptors and the inner segment contains the cell's organelles, including the nucleus and mitochondria

* The major difference between rod and cone cells is there shape

* Rod cells are elongated and cylindrical, while cone cells are shorter and more conical in shape

* Rod cells have a single long outer segment, while cone cells have several shorter segments.

MODULE-4

7) a) What is Echolocation? Explain Ultrasonography

Echolocation is a sophisticated technique evolved by animals such as bats, dophins, whales, oilbirds and certain shrews to navigate in darkness, hunt prey, identify objects, and avoid obstacles. These animals emit high-frequency sound waves (ultrasound) ranging from 10 kHz to over 200kHz. By analyzing the echoes of these sound waves bouncing off objects, animals can determine distance, size, shape and texture

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Ultrasonography:

- Design principle : Utilizes high-frequency sound waves (ultrasound) to create detailed images of internal body structures.
- Functional Use: Diagnoses medical conditions, monitors pregnancies, and guides procedures without ionizing radiation.

Advantages:

- Precision and Resolution: Provides high-resolution images for accurate diagnosis and treatment planning.
- Non-invasive Nature : Non-ionizing and safe for imaging, minimizing risks associated with other imaging modalities.

challenges and Future Directions

- Technological Advancements : Enhance imaging resolution and sensitivity in ultrasonography.
- Integration with AI : Explore AI-driven algorithm for improved data interpretation in ultrasonography.

b) What are the potential applications of shark skin-Inspired swim suits?

Shark skin has a unique structure that significantly reduces drag and enhances swimming efficiency. The skin is covered with tiny, tooth-like scales called dermal denticles, which are aligned in a way that reduces

turbulence and allows water to flow smoothly over the shark's body. The natural design minimizes friction and prevents the growth of algae & barnacles, keeping the shark streamlined.

* Improved Swimming Efficiency: Mimicking shark skin can reduce drag in water, leading to faster swimming and improved performance in competitive swimming.
* Reduced Energy Consumption: By reducing drag, athletes can maintain higher speeds with less effort, potentially improving endurance and reducing fatigue during long-distance swims.
* Hydrodynamic Design: Shark skin-inspired textures can be applied to wetsuits and swimsuits for recreational swimmers, enhancing their hydrodynamic properties and making swimming more enjoyable.
* Triathlon Performance: Triathletes could benefit from reduced drag during both swimming and transitioning to biking, improving overall race times.
* Water Resistance: Beyond swimming, shark skin-inspired materials could be used in the other water sports gear, such as kayaking or surfing suits, to improve maneuverability and speed.
* Medical Applications: The texture of shark skin has antimicrobial properties that could be beneficial in medical textiles, potentially reducing infections in wound dressings or surgical attire.
* Underwater Robotics: Biomimetic design inspired by shark skin could be utilized in underwater robots, improving their agility and energy efficiency.

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[OR]

8(a) Write a note on HBOC's and PFC's

Human blood substitutes, also known as artificial blood or blood surrogates, are developed to replicates and fulfill some of the functions of natural blood, particularly oxygen transport. These substitutes are designed to be used in situations where blood transfusions are not available, feasible, or when there is a risk of blood-borne infections. There are two primary types of human blood substitutes: hemoglobin-based oxygen carriers (HBOCs) and perfluorocarbon emulsions (PFCs).

Hemoglobin-Based Oxygen Carriers (HBOCs)

HBOC's are derived from hemoglobin, the protein in red blood cells that carries oxygen. These substitutes can be made from human, bovine, or recombinant hemoglobin, the hemoglobin is modified and stabilized to function outside of red blood cells, providing the following benefits:

- Oxygen Delivery: HBOCs can efficiently transport oxygen to tissue and organs.
- Universal Compatibility: They can be used regardless of the recipient's blood type, reducing the need for blood type matching.

- Long shelf life: HBOCs are often more stable and have a longer shelf life compared to donated blood.

Perfluorocarbon Emulsions (PFCs)

PFCs are synthetic compounds capable of dissolving large amounts of gases, including oxygen and carbon dioxide. These emulsions can carry and release oxygen effectively, and they offer several advantages:

- High Oxygen Solubility: PFCs can carry significantly more oxygen than plasma.

- Reduced Risk of Disease Transmission: Being entirely synthetic, PFC's eliminate the risk of transmitting blood-borne infections.

- Versatile Applications: PFCs can be used in various medical situations, including trauma, surgery, and conditions requiring enchanced oxygen delivery.

6) Discuss the design structure of Bullet train inspired from Kingfisher's beak.

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* The bio-design of the kingfisher's beak has significantly influenced the design of bullet trains, particularly in reducing noise and improving aerodynamic efficiency.

* The kingfisher is known for its ability to dive into water with minimal splash to catch fish

* This ability is attributed to its long, slender and streamlined beak, which allows it to transition smoothly between different mediums (air and water) with minimal resistance

* By redesigning the front of the train to mimic the shape of the kingfisher's beak, engineer were able to significantly reduce this aerodynamic issue.

* The streamlined nose of the train allows it to cut through the air more effecientlly and transition smoothly into tunnels, reducing the air pressure changes and thus minimizing noise.

Advantages

Noise Reduction: The streamlined shape of the train's nose reduces the air pressure changes when entering tunnels, significantly minimizing the "tunnel boom" noise

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Energy Efficiency:- Reduced air resistance leads to lower energy requirements for maintaining high speed, resulting in more energy-efficient operations.

Passenger Comfort: The reduction in noise and vibration enhances the overall comfort and experience for passengers traveling at high speeds

Environmental Impact: Improved aerodynamic efficiency and reduced energy consumption contribute to lower greenhouse gas emissions, making the train more environmentally friendly.

Innovative Design: The bio-inspired approach demonstrate the potential of biomimicry in solving engineering challenges and advancing technology through natural principles.

MODULE-5

9) a) What is the role of Bio-imaging and AI in disease diagnosis?

Bioimaging encompasses a diverse set of techniques and technologies used to visualize biological structure and processes at various scales, from molecules to organs. These imaging methods play a crucial role in advancing our understanding of biology, medicine, and biomedical research

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MRI (Magnetic Resonance Imaging):

→ Non-invasive imaging: techniques that uses strong magnetic fields and radio waves to generates detailed images of soft tissues, organs, and structures inside the body.

→ **Functional MRI (fMRI)**: Measure brain activity by detecting changes in blood flow and oxygenation.

Ultrasound Imaging:

→ Uses high-frequency sound waves to create real-time images of organs, tissues, and blood flow inside the body

→ Non-invasive and widely used in obstetrics, Cardiology, and diagnostics

Nuclear imaging:

→ Includes techniques like PET (Positron Emission Tomography) and SPECT (Single photon Emission Computed Tomography)

→ Uses radioactive tracers to detect biological processes, such as metabolism or blood flow, in tissues

Artifical Intelligence for Disease Diagnosis.

Artificial Intelligence (AI) is revolutionizing disease diagnosis by leveraging advanced algorithm and machin learning techniques to analyze medical data and

assist healthcare professionals in identifying disease more accurately and efficiently.

Key applications:

1. Medical Imaging Analysis:

-> Radiology: AI algorithm analyze medical images (X-rays, CT scans, MRI) to detect abnormalities, tumors, fractures, and other conditions with high accuracy.

-> Dermatology: AI helps in diagnosing skin conditions by analyzing images of moles, rashes, and lesions, often achieving performance comparable to dermatologists.

-> Pathology:- AI assists pathologists in analyzing tissue samples and identifying cancerous cell or other abnormalities

2. Clinical Decision Support:

-> Diagnostic Assistance:- AI systems provide recommendations based on patient data, symptoms, and medical history, aiding clinicians in making accurate diagnoses.

-> Risk Prediction:- Predicts the likelihood of developing specific disease based on genetics, lifestyles, and environmental factors.

b) Write a note on self-healing bio-concrete and bio-mining.

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Self-Healing Bioconcrete:

Self-healing bioconcrete is an innovative material that integrates biological components to automatically repair crack, significantly enhancing the durability and lifespan of concrete structure. This approach leverages the biomineralization capabilities of Bacillus spores, which are activated by Calcium lactate nutrients to produce Calcium Carbonate ($CaCO_3$) sealing the cracks.

Key Components and Mechanisms:

1. Bacillus Spores:-
   - → Microorganisms: Specific strains of Bacillus, such as Bacilus pasteurii or Bacilus sphaericos, are used for their ability to precipitate Calcium Carbonate
   - → Spore form:- These bacteria are introduced into the Concrete in spore form, which can survive the harsh environment of the Concrete matrix and remain dormant until activated by the presence of water.

2. Calcium Lactate Nutrients:
   - → Nutrients Source: Calcium Lactate is added to the Concrete mix as a nutrients Source for the Bacillus spores.
   - → Activation:- When cracks form and water enter the Concrete, it dissolves the Calcium lactate, providing the necessary nutrients for the Bacillus spores to germinate and become active.

3. Biomineralization Process:
-> Bacterial Activation: Upon activation by water and calcium lactate, the Bacillus spores germinates and metabolize the nutrients.
-> Calcium Carbonate Production: The bacteria convert the calcium lactate into calcium carbonate ($CaCO_3$) through a series of biochemical reactions.
-> Crack Sealing: The precipitated calcium carbonate fills the cracks, effectively sealing them and restoring the integrity of the concrete.

Advantages:
-> Enhanced Durability:- Self-healing bioconcrete significantly extends the lifespan of concrete structure by preventing the propagation of cracks and minimizing structural damage.
-> Cost-effective Maintenance:- Reduces the need for frequent repairs and maintenance, leading to long-term cost savings.
-> Environmental Benefits:- By reducing the need for new concrete and repairs, it lowers the overall environmental impact associated with construction activities.

Application:
-> Infrastructure:- Ideal for critical infrastructure such as bridges, tunnels, highways, and dams, where durability and longevity are essential.
-> Buildings:- Used in foundations, walls, and floors to enhance the structural integrity of residential

and commercial buildings.
-> Marine structures: Suitable for marine environments, including ports, piers, and off shore platforms, where structures are exposed to harsh condition and constant water explosure.

[OR]

a) Explain the technique of bio-printing and materials used bio-printing.

Bioprinting is an advanced form of 3D printing that involves the layer-by-layer deposition of biomaterials and living cells to create complex tissue structure. The technology holds great potential for regenerative medicine, drug testing and personalized medicine.

Bioprinting Techniques:

1) Inkjet Bioprinting:
Mechanism: Utilizes thermal or piezoelectric print heads to deposit droplets of bioink onto a substrate.
Advantages: High resolution, rapid printing, cost-effective
Applications: printing cells, growth factors, and other biomolecules for tissue engineering and drug testing

2. Extrusion Bioprinting:
Mechanism: Uses a continous stream of bioink extended through a nozzle to create 3D structures
Advantages: Capable of printing high cell densities and viscous materials, suitable for large-scale constructs.

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Application: Creating scaffolds, complex tissue structure, and organoids

3. Laser-Assisted Bioprinting (LAB):
   - Mechanism: Uses laser pulses to propel droplets of bioink onto a substrate.
   - Advantages: High precision, cell viability, and minimal mechanical stress on cells
   - Applications: printing intricate tissue patterns and high-resolution structure.

4. Stereolithography (SLA):
   - Mechanism: Uses UV light to cure and solidify photosensitive bioinks layer by layer.
   - Advantages: High resolution, smooth surface finish, and complex geometries
   - Applications: Fabricating detailed tissue constructs and biomimetic structure.

Bioprinting Materials (Bioinks)

1. Natural polymers:
   - Collagen: Major component of the extracellular matrix promotes cell adhesion and proliferation.
   - Alginate: Derived from seaweed, forms hydrogels and is biocompatible.
   - Gelatin: Derived from collagen, supports cell growth and differentiation.

2. Synthetic polymers:

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-> polyethylene Glycol (PEG): Biocompatible, tunable mechanical properties
-> polyactic Acid (PLA): Biodegradable, good mechanical strength.
-> polycaprolactone (PCL): Slow-degrading, suitable for long-term applications.

3. Decellularized Extracellular Matrix (dECM):
-> Source: Derived from decellularized tissue & organs.
-> Advantages: provides natural biochemical cues & structural support
-> Application: Creating biomimetic tissue constructs

4. Cell-Laden Bioinks:
-> Composition: Mixture of hydrogels and living cells.
-> Advantages: Enables direct printing of functional tissue constructs.
-> Applications: Regenerative medicine, organoids, and tissue models

Application of Bioprinting

1. Regenerative Medicine:
• Tissue and Organ Repair: Bioprinting functional tissue for implantation and repair of damaged organs.
• Wound Healing: Creating skin grafts and wound dressing.

2. Drug Testing and Development:

- Tissue Models: Printing tissue models for drug screening and toxicity testing.
- Personalized Medicine: Tailoring drug treatments based on patient-specific tissue models.

3. Research and Development:
   - Disease Models: Creating models of disease for research purposes.
   - Cell Biology Studies: Studying cell behavior in 3D environments.

b) Discuss the bio-engineering solutions for Muscular dystrophy.

Bioengineering is rapidly advancing solutions for muscular dystrophy and osteoporosis through groundbreaking innovations in gene editing, tissue engineering, drug delivery, and biomechanical engineering. These interdisciplinary approaches show great potential in enhancing quality of life, mobility, and treatment efficacy for individuals affected by these challenging conditions. Ongoing research and development are essential to harnessing these innovations for clinical use and overcome the multifaceted complexities of muscular dystrophy and osteoporosis.

Bioengineering solutins for muscular Dystrophy

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Muscular dystrophy refers to a group of genetic disorders characterized by progressive weakening and degeneration of skeletal muscles. It results from mutations in genes responsible for the structure and function of muscles, leading to muscle weakness, loss of muscle mass, and in some cases, mobility impairment. Symptoms typically manifest in childhood, and the severity and progression of the condition vary depending on the specific type of muscular dystrophy. Bioengineering solutions for muscular Dystrophy are as follows:

1. Gene Therapy:
   - CRISPR-Cas 9 Technology: Targeted gene editing to correct mutations responsible for muscular dystrophy, such as in the dystrophin gene for Duchenne muscular dystrophy (DMD).
   - Viral Vectors: Delivery of functional genes to muscle cells using viral vectors to replace or supplement defective genes.
2. Muscle Tissue Engineering
   - 3D Bioprinting: Fabrication of muscle tissue constructs using biocompatible materials and patient-derived cells to replace damaged muscle.
   - Cell Therapy: Transplantation of stem cells or myoblasts into affected muscles to promote regeneration and improve muscle function.
3. Exoskeletons and Assistive Devices:
   - Powered Exoskeletons: Wearable robotic devices that assist with movement and support weakened muscles, enhancing mobility and reducing fatigue

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- functional Electrical Stimulation (FES): Electrical Stimulation of muscles to induce contractions and maintain muscle strength.

4. Drug Delivery Systems:
- Localized Drug Delivery: Development of biomaterial-based systems for targeted delivery of therapeutic agents, such as growth factors or gene-editing tools, directly to affected muscle tissues.
- Drug Screening platforms: High-throughput screening platforms using muscle cells derived from patients samples to identify potential therapeutic compounds.