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Internal Assessment Test 2 – May 2025

Sub:	**Biology for Engineers**					Sub Code:	**BBOK407**	Branch:	**ECE**
Date:	**23/05/2025**	Duration:	90 Minutes	Max Marks:	50	Sem/Sec:	**4/A, B, C, D**		**OBE**

	Answer Any 5 Questions	MARKS	CO	RBT
1	Explain the process of biomining via microbial surface adsorption.	[10]	CO5	L2
2	Deliberate the functioning of brain as CPU system.	[10]	CO3	L2
3	Explain the process of Bioremediation	[10]	CO5	L2
4	Explain about pace makers and defibrillators	[10]	CO3	L2
5	Explain with neat sketch about the architecture of rod & cone cells and the materials used for Lens Materials	[10]	CO3	L2
6	Explain the process of removal of heavy metals like Lead, Cadmium, Mercury, Arsenic.	[10]	CO4	L3
7	Write a short note on 3D printed of ear, bone and skin and 3D printed foods	[10]	CO5	L2

CI CCI HOD

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Answers:

1. Explain the process of biomining via microbial surface adsorption.

Biomining via Microbial Surface Adsorption is a bio hydrometallurgical process that uses microorganisms to extract valuable metals from ores through adsorption mechanisms on their cell surfaces.

Biomining

Biomining is the extraction of metals from ores using biological systems, particularly microorganisms. One key mechanism in biomining is microbial surface adsorption, where metal ions bind to microbial cell surfaces through biochemical interactions rather than being dissolved by metabolic activity.

Microbial Surface Adsorption Process

a. Selection of Microorganisms

Bacteria and fungi with cell walls containing negatively charged functional groups (e.g., carboxyl, phosphate, hydroxyl) are preferred.

Common species: *Bacillus subtilis*, *Pseudomonas spp.*, and *Aspergillus niger*.

b. Metal Ion Binding

When these microorganisms are introduced to ore or metal-containing waste, metal ions in solution (e.g., Cu^{2+}, Zn^{2+}, UO_2^{2+}) interact with the negatively charged cell wall components.

Passive adsorption occurs via electrostatic attraction, ion exchange, complexation, and micro-precipitation.

c. Biofilm Formation

Some microbes form biofilms on mineral surfaces, enhancing stability and increasing adsorption capacity through the accumulation of extracellular polymeric substances (EPS) which also bind metals.

d. Metal Recovery

After metal ions are adsorbed onto microbial surfaces, they can be recovered through:

Desorption techniques (using acid or salt solutions to strip metals from biomass)

Biomass harvesting followed by metal extraction.

Advantages of Microbial Surface Adsorption

Environmentally friendly alternative to chemical leaching.

Effective even with low-grade ores or e-waste.

Low energy requirement and cost-effective for certain applications.

Applications

Recovery of metals like gold, uranium, copper, cobalt, lead, and rare earth elements.

Used in mine drainage treatment, e-waste recycling, and industrial effluent purification.

2. Deliberate the functioning of brain as CPU system.

The human brain and a computer's central processing unit (CPU) are both complex information-processing systems. Though vastly different in structure and mechanism, they share conceptual similarities in how they process, store, and transmit information. Here's a deliberate breakdown of how the brain can be viewed as functioning like a CPU:

1. Central Processing Role

CPU Function:

The CPU is the “brain” of the computer—it receives instructions, processes data, and manages control over all hardware components.

Brain Parallel:

The cerebral cortex, especially the prefrontal cortex, plays a similar role in decision-making, planning, and directing actions by processing sensory inputs and controlling responses.

2. Input and Output Mechanisms

CPU:

Receives input from devices like keyboard and mouse; sends output to display, speakers, etc.

Brain:

Receives input through sensory organs (eyes, ears, skin, etc.); generates output via motor functions, speech, and hormonal responses.

3. Memory Systems

CPU:
Uses RAM (temporary memory for active tasks)
Has ROM for permanent, built-in instructions
Accesses storage devices for long-term data
Brain:
Working memory is like RAM (short-term memory tasks)
Implicit memory is like ROM (automated functions)
Long-term memory stored in hippocampus and cortex is akin to hard drive storage

4. Data Processing
CPU:
Executes instructions via a clock cycle and arithmetic/logic unit (ALU), operating in binary (0s and 1s).
Brain:
Processes data through neural networks using electrochemical signals. Information is coded in spike patterns, not binary, but still allows for logic, computation, and reasoning.

5. Bus System / Communication Pathways
CPU:
Uses data buses to transfer data between CPU, memory, and other components.
Brain:
Utilizes neurons and synapses to transmit signals between different brain regions and to the body via the spinal cord and nerves (like a biological bus system).

6. Parallel Processing
CPU:
Traditional CPUs process one or a few tasks at a time, but multi-core processors allow parallel processing.
Brain:
Naturally excels at parallel processing—it can process visual, auditory, emotional, and decision-making inputs simultaneously.

7. Operating System & Software
CPU:
Runs an OS and software programs, which guide behaviour and actions.
Brain:
Operates with cognitive frameworks, instincts, learned behaviours, and conscious thought—like internal "programming" shaped by genetics and experience.

Key Differences

Aspect	Brain	CPU
Medium	Electrochemical	Electronic
Speed	Slower but parallel	Faster but mostly serial
Energy Efficiency	Very high (20W)	Varies (often higher)
Self-Repair	Some neuroplasticity	No inherent repair mechanism
Learning	Adapts and rewires	Needs external reprogramming

3. Explain the process of Bioremediation

Bioremediation is a natural, environmentally friendly process that uses microorganisms or biological agents to remove or neutralize pollutants from a contaminated site. It is widely used to clean up oil spills, heavy metals, pesticides, and industrial waste from soil, water, and air. Bioremediation involves stimulating the growth of specific microbes that can degrade or transform hazardous substances into less toxic or non-toxic forms.

Types of Bioremediations

Type	Description	Example
In Situ	Performed directly at the contamination site	Cleaning oil from soil without excavation
Ex Situ	Contaminated material is removed and treated elsewhere	Pumping out polluted groundwater for treatment

Key Microorganisms Used
Bacteria (e.g., *Pseudomonas*, *Bacillus*)
Fungi (e.g., *Phanerochaete chrysosporium*)
Algae and plants (in phytoremediation)

Steps in the Bioremediation Process

1. ***Site Assessment***
- ❖ Identify type and concentration of contaminants
- ❖ Study soil, water, temperature, pH, and oxygen levels

2. ***Selection of Microorganisms***
- ❖ Naturally occurring or genetically modified microbes selected for their ability to degrade specific pollutants

3. ***Optimization of Conditions***
- ❖ Nutrients (nitrogen, phosphorus), oxygen, pH, moisture, and temperature are adjusted to enhance microbial activity

4. ***Biodegradation Process***
- ❖ Microorganisms metabolize pollutants:
- ❖ Organic compounds (like oil) are broken down into CO_2, H_2O, and biomass
- ❖ Heavy metals may be converted into less mobile or less toxic forms

5. ***Monitoring and Evaluation***
- ❖ Periodic sampling to measure degradation efficiency and ensure environmental safety

4. Explain about pace makers and defibrillators

Both pacemakers and defibrillators are life-saving electronic medical devices used to manage heart rhythm disorders (arrhythmias), but they serve different purposes and operate in distinct ways.

Pacemaker

A pacemaker is a small medical device implanted in the chest or abdomen that helps control abnormal heart rhythms by sending electrical impulses to prompt the heart to beat at a normal rate.

Pacemakers are used for bradycardia (a heart rate that is too slow), heart block, or atrial fibrillation with slow ventricular response.

Working:

- ❖ Electrodes (leads) are placed in the heart chambers.
- ❖ When the heart rate drops below a preset limit, the pacemaker sends electrical signals to stimulate contraction.
- ❖ Modern pacemakers are programmable and responsive to physical activity (rate-responsive pacemakers).

Types of Pacemakers:

- ❖ Single-chamber: Stimulates one heart chamber (usually right ventricle).
- ❖ Dual-chamber: Stimulates both atrium and ventricle, maintaining synchrony.
- ❖ Biventricular (CRT device): For heart failure patients, stimulates both ventricles to improve pumping efficiency.

Defibrillator (Implantable Cardioverter Defibrillator - ICD)

An ICD is a device implanted in the chest that detects life-threatening arrhythmias like ventricular fibrillation (VF) or ventricular tachycardia (VT) and delivers an electric shock to restore normal rhythm.

ICDs are used in patients at risk for sudden cardiac arrest due to:

- ❖ Previous heart attack
- ❖ Heart failure
- ❖ Inherited arrhythmias (e.g., Long QT syndrome)

Working:

- ❖ Continuously monitors heart rhythm.
- ❖ If a dangerous arrhythmia is detected, it:
- ❖ Paces the heart (for mild VT),
- ❖ Delivers a shock (defibrillation) for severe arrhythmias.
- ❖ Can also act like a pacemaker if bradycardia occurs.

Pacemaker vs. Defibrillator: Key Differences

Feature	Pacemaker	Defibrillator (ICD)
Primary Function	Correct slow heart rate	Correct fast/life-threatening rhythms
Shock Delivery	No	Yes (when needed)
Rhythm Monitoring	Yes	Yes
Target Conditions	Bradycardia, heart block	VT, VF, risk of cardiac arrest
Can Pace the Heart	Yes	Yes (some ICDs also pace)

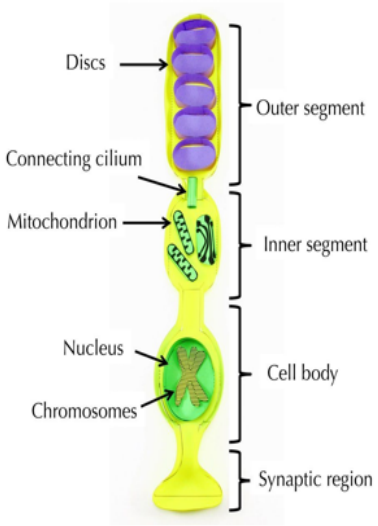
- ❖ Pacemakers maintain a normal heart rate by stimulating slow or irregular heartbeats.
- ❖ Defibrillators (ICDs) prevent sudden death by detecting and correcting dangerous fast arrhythmias through shocks or pacing.
- ❖ Some devices combine both functions in a CRT-D (Cardiac Resynchronization Therapy with Defibrillator) for heart failure patients.

5. Explain with neat sketch about the architecture of rod & cone cells and the materials used for Lens Materials

Rods

Rods are cylindrical-shaped photoreceptors. They are more numerous than cone cells, with an estimated 92 million rod cells located in the human retina. They function best in low-intensity light (scotopic) and are thus responsible for vision in dimly lit surroundings, such as at dusk. Rod outer segments are cylindrical in shape, consisting of around 1000 flat, lobulated, membranous discs.

Rod cell summary	
Shape	Cylindrical
Number	High
Light sensitivity	High
Visual acuity	Low
Vision type	Night vision
Present at fovea	No
Cell types	Single type
Photopigment types	Achromatic (one type)

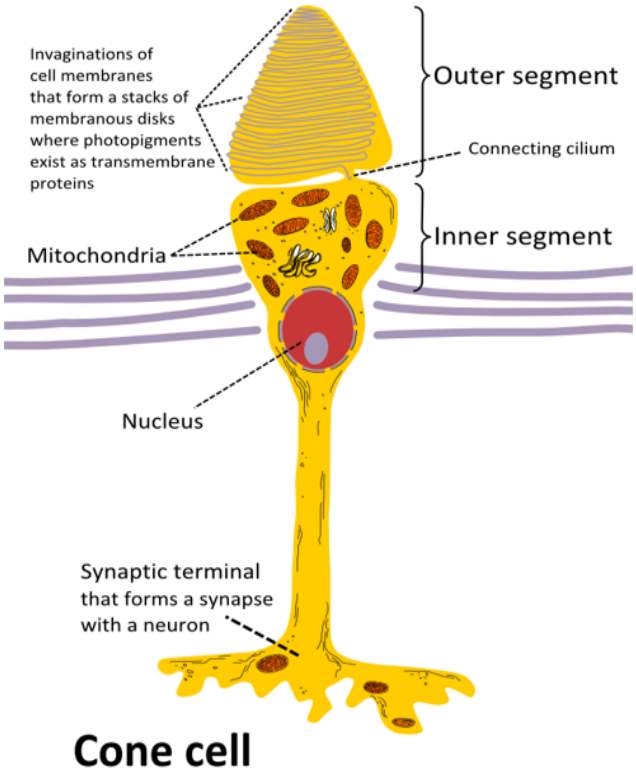


- The inner segment of the rod cell is divided into an outer mitochondria-rich part and an inner part containing endoplasmic reticulum. The structure of the rod cell is consistent across all areas of the retina.
- Rod cells are located across the retina except at the center of the fovea.
- The density of rod cells increases as you move away from the fovea, reaching a peak and declining again towards the periphery.
- Rod vision provides high sensitivity to light, but with relatively low spatial discrimination and no ability to distinguish different wavelengths of light. This is why they are not capable of detecting different colour. Compared to cone cells, rods have poor visual acuity, or the ability to distinguish fine detail.

Cones

- Cones are conical-shaped cells that operate best in high-intensity lighting (photonic) and are responsible for the perception of colour.
- There are far fewer cone cells in the human retina compared to rod cells, numbering approximately 4.6 million.
- Cone outer segments are generally shorter than that of rods and, as their name implies, are often conical. As is the case of rod cells, the inner segment of the cone cells has an outer mitochondria-rich part and an inner part containing endoplasmic reticulum.

Cone cell summary	
Shape	Conical
Number	Low
Light sensitivity	Low
Visual acuity	High
Vision type	Color vision
Present at fovea	Yes
Cell types	3 types: L, S, M
Photopigment types	Chromatic: Red, green, blue



6. Explain the process of removal of heavy metals like Lead, Cadmium, Mercury, Arsenic.

Heavy metals like Lead (Pb), Cadmium (Cd), Mercury (Hg), and Arsenic (As) are toxic environmental pollutants. Their removal from soil and water is critical for protecting ecosystems and human health. The removal can be achieved through biological, chemical, and physical methods.

1. Biological Methods (Bioremediation)

A. Biosorption

- Microorganisms (bacteria, algae, fungi) or biomass (dead or living) bind heavy metals on their cell walls.
- Functional groups like carboxyl, hydroxyl, phosphate, and amine attract metal ions.
- Example: *Aspergillus Niger*, *Chlorella*, and *Bacillus subtilis* used for Pb, Cd removal.

B. Bioaccumulation

- Living microbes actively uptake and accumulate metals inside their cells.
- Requires energy; more effective in low concentrations.

C. Phytoremediation

- Plants absorb heavy metals through roots and store them in tissues.
- Example: *Brassica juncea* (Indian mustard) for Pb and *Pteris vittata* for Arsenic

D. Microbial Precipitation

- Microbes convert soluble metals into insoluble forms (e.g., sulfides), which precipitate and settle.
- Sulfate-reducing bacteria convert metals into metal sulfides (e.g., CdS, PbS).

2. Chemical Methods

A. Chemical Precipitation

- Add chemicals (e.g., lime, sulfides, or hydroxide) to form insoluble metal compounds.
- E.g., $Pb(OH)_2$, CdS.

B. Ion Exchange

- Ion exchange resins swap metal ions with harmless ions (like Na^+ or H^+).
- Efficient but costly.

C. Coagulation-Flocculation

- Chemicals like alum or ferric chloride are added to clump metal particles, which are then removed by filtration or sedimentation.

D. Electrochemical Treatments

- Electrocoagulation and electrodialysis remove metals via electric current.

3. Physical Methods

A. Adsorption

- Activated carbon, zeolites, biochar, or nanomaterials adsorb heavy metals from water.
- Very effective and widely used.

B. Membrane Filtration

- Reverse osmosis, ultrafiltration, nanofiltration remove metal ions based on size and charge.

C. Filtration and Sedimentation

- Simple mechanical separation for suspended metal particles.

7. Write a short note on 3D printed of ear, bone and skin and 3D printed foods

3D Printed Ear:

3D printing technology has made significant strides in the biomedical field, including the fabrication of artificial ears. This involves using bio-inks composed of biodegradable materials and living cells, particularly chondrocytes, which are cartilage-forming cells. The goal is to recreate the shape, structure, and function of a natural human ear. These printed ears are particularly useful for individuals suffering from microtia, a congenital condition where the external ear is underdeveloped, or for those who have lost an ear due to trauma. One of the major advantages of 3D printed ears is the ability to customize them for individual patients, improving both appearance and biocompatibility, while reducing the risk of rejection.

3D Printed Bone:

In the field of orthopaedics and reconstructive surgery, 3D printed bones have become a groundbreaking innovation. These are typically created using biocompatible materials such as calcium phosphate, hydroxyapatite, or other ceramics that mimic the natural composition of bone. Sometimes, the scaffolds are seeded with osteoblasts or stem cells to encourage new bone growth. 3D printed bones are used in applications such as facial reconstruction, spinal surgery, and dental implants. Since they can be custom-designed to match a patient's anatomy, they offer a higher degree of precision, promote faster healing, and reduce the need for secondary surgeries.

3D Printed Skin:

The 3D printing of skin involves layering bio-inks that contain skin cells like keratinocytes and fibroblasts to replicate the epidermis and dermis layers of natural skin. This technology holds promise for burn victims, chronic wound patients, and cosmetic testing. Unlike traditional grafts, 3D printed skin can be custom-shaped to fit complex wound geometries. Advanced research even focuses on incorporating vascular networks into printed skin, which helps with graft survival and integration once implanted. This approach also offers ethical alternatives for cosmetic testing by reducing dependence on animal models.

3D Printed Foods:

In the realm of nutrition and culinary science, 3D food printing is an emerging innovation. It uses edible "inks" such as pureed vegetables, doughs, or plant-based proteins to create complex shapes and personalized meals. This technology has been explored by space agencies like NASA for use in long-duration space missions and is also being applied to create customized meals for people with specific dietary requirements, such as elderly patients with difficulty swallowing. Besides improving food aesthetics and personalization, 3D food printing can also reduce food waste and enable the use of alternative protein sources for a more sustainable food future.