

CBCS SCHEME

BBOK407



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Fourth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025 Biology for Engineers

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.	Define cell. Explain the structure and function of plant cell with neat diagram.	08	L2	CO1
	b.	Define Stem Cell. Discuss the types and application of stem cells.	06	L2	CO1
	c.	Describe the properties and functions of hormones.	06	L2	CO1
OR					
Q.2	a.	Discuss the properties and functions of nucleic acids in cellular processes.	07	L2	CO1
	b.	Discuss the properties and functions of enzymes.	07	L2	CO1
	c.	Discuss the properties of vitamins and its supplies.	06	L2	CO1
Module – 2					
Q.3	a.	Apply the knowledge of nucleic acid in DNA finger printing in forensic applications.	08	L3	CO1
	b.	Discuss whey protein and plant based protein as protein based food.	06	L2	CO1
	c.	Write a note on PLA as bioplastic.	06	L1	CO1
OR					
Q.4	a.	Apply your knowledge of lipids and outline the process of obtaining biodiesel from lipids.	07	L3	CO1
	b.	Define vaccine. Discuss the mechanism of RNA vaccine for COVID-19.	07	L2	CO1
	c.	Write a note on enzyme based biosensors.	06	L1	CO1
Module – 3					
Q.5	a.	Compare human brain with computer's CPU.	07	L3	CO2
	b.	Explain lungs as a purification system.	07	L2	CO2
	c.	Write a note on dialysis systems of kidney.	06	L1	CO2
OR					
1 of 2					

Q.6	a.	Illustrate the engineering solutions available for Parkinson's disease.	07	L3	CO2
	b.	Explain heart as a pumping system.	07	L2	CO2
	c.	Write a note on optical correction and materials used for lens.	06	L1	CO2

Module – 4

Q.7	a.	Illustrate the HBOCs and PFCs as human substituents.	07	L3	CO3
	b.	Explain how the structure of shark skin reduces drag and how these properties have been applied to improve swim suit.	07	L2	CO3
	c.	Explain the term GPS and aircrafts technology as bio inspired by bird fly.	06	L2	CO3

OR

Q.8	a.	Compare the uses of ultrasonography and sonars.	07	L3	CO3
	b.	Discuss the king fisher beak shaped bullet train to the reduction of noise and improve the stability.	06	L2	CO3
	c.	Explain the term superhydrophobic and self-cleaning in lotus leaf effect.	07	L2	CO3

Module – 5

Q.9	a.	Explain bioimaging and artificial intelligence technique in disease diagnosis.	08	L2	CO4
	b.	Explain the working principles of electrical tongue and electrical nose in food industry.	06	L2	CO4
	c.	Write a note on bioengineering of Muscular dystrophy and osteoporosis.	06	L1	CO4

OR

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Q.10	a.	Explain the process of biomining via microbial surface adsorption.	07	L2	CO4
	b.	Describe the concept of DNA origami and its role in bio-computing.	06	L2	CO4
	c.	Write a note on self healing bio-concrete and bio-mineralization processes.	07	L1	CO4

→ vacuole

Large central vacuole stores water, nutrients, & waste maintaining turgor pressure.

→ Endoplasmic Reticulum (ER) & Golgi Apparatus

Involved in protein and lipid synthesis + modification, & transport.

Functions :-

→ Photosynthesis :- Chloroplasts convert light energy into chemical energy (glucose).

→ Structural Integrity :- The rigid cell wall provides shape and prevents bursting due to osmotic pressure.

→ Storage :- The vacuole stores water & maintains turgor.

→ Energy production :- Mitochondria produce ATP for cellular activities.

→ Genetic control :- The nucleus directs cell growth and reproduction.

2b) stem cells are undifferentiated or partially differentiated biological cells that can differentiate into various specialized cell types and proliferate indefinitely to produce more of the same stem cell.

Types

- Embryonic stem cell (ESCs):- pluripotent, meaning they can differentiate into any cell type in the body.
- Adult stem cells (ASCs):- multipotent, generally limited to differentiating into the cell types of their tissue of origin (e.g., hematopoietic stem cells in bone marrow produce blood cells).
- Induced pluripotent stem cells (iPSCs):- Adult cells genetically reprogrammed to an embryonic stem cell-like state.

Application

- ~~Reg~~ Regenerative medicine:- Repairing damaged tissues & organs (e.g., skin grafts for burns, bone marrow + transplants).
- Disease Treatments:- Treating conditions like Parkinson's disease, type 2 diabetes, & heart disease by replacing damaged cells.

→ Drug Testing :-

used to test the safety & efficacy of new drugs on differentiated cell types.

→ Research :-

studying disease mechanisms & early human development.

2c) Hormones are chemical messengers produced by endocrine glands that are transported by the circulatory system to target distant organs & to regulate physiology & behavior.

properties :-

→ Chemical messengers :-

Act as signals between cells & organs.

→ potent :-

Effective in very low concentrations.

→ Specific :-

Act on specific target cells or tissues that have appropriate receptors.

→ transported via Blood :-

Travel through the bloodstream to reach targets.

Functions:-

→ Regulation of Metabolism:-

Hormones like insulin and glucagon control blood sugar levels.

→ Growth and Development:-

Growth hormone regulates body size and development.

→ Reproduction:-

Hormones (e.g., estrogen, testosterone) regulate reproductive cycles and development of secondary sexual characteristics.

→ Homeostasis:-

Maintain stable internal body conditions, such as blood pressure & electrolyte ~~balance~~ balance.

2 a) Nucleic acids (DNA and RNA) are large macromolecules essential for all known forms of life, primarily involved in the storage and expression of genetic information.

Properties: -

→ Polymers of Nucleotides:-
composed of nucleotide monomers (sugar, phosphate, nitrogenous base).

→ Genetic information storage:-
DNA stores the long-term ~~genetic~~ genetic blueprint.

→ Information Transmission:-
RNA transmits genetic information from DNA to proteins.

→ Structure:-
DNA is typically a double helix;
RNA is typically single stranded.

Functions: -

→ Genetic code:-
store the instructions for building and operating an organism.

→ Protein synthesis:-
RNA molecules (mRNA, tRNA, rRNA) play crucial roles in translating the genetic code into proteins.

Regulation :-

Some RNA molecules regulate gene expression.

Energy transfer :-

ATP is nucleotide derivative that acts as the primary energy currency of the cell.

2b) Enzymes are proteins that act as biological catalysts, accelerating the rate of specific biochemical reactions without being consumed in the process.

Properties :-

Catalytic efficiency :- significantly increase reaction rates compared to uncatalyzed reactions.

Specificity :- highly specific to their substrates due to unique active sites.

Optimal conditions :- function best within narrow range of temperature and pH; extreme conditions can denature them.

Functions :-

→ Digestion :- Break down large food molecules (carbohydrates, proteins, fats) into smaller, absorbable units.

metabolism :- Regulate metabolic pathways like glycolysis and cellular respiration.

DNA Replication & Repair :- Essential for copying and repairing genetic material.

cell signalling :- Involved in signal transduction pathways within cells.

Qc) 2c) vitamins are essential organic micronutrients that the body needs in small quantities for proper functioning, growth, & development.

properties :-

→ Essential nutrients :- cannot be synthesized by the body & must be obtained from the diet.

→ organic :- carbon-containing compounds.

→ Categorization :- Divided into water soluble (B vitamins, C) & fat-soluble (A, D, E, K) vitamins.

Sources :-

Fruits & vegetables :- Rich in vitamins C, A, K & folic acid (B9).

Whole grains :- Good source of various B vitamins.

Dairy products :- Provide vitamins A, D & B12.

Meats & Fish :- Rich B vitamins (especially B12) and D.

Supplements :- used when dietary intake is insufficient.

Q3

3(a)

DNA fingerprinting is a forensic technique used to identify individuals by analyzing unique patterns in their DNA, utilizing ~~unique patterns in their~~ knowledge of nucleic acids.

Application process :-

→ DNA extraction :- DNA is isolated from a sample. (eg:- blood, hair, saliva)

→ Amplification :- Specific DNA segments (like short tandem repeats or STRs) are amplified using PCR (polymerase chain reaction).

→ Separation :- The amplified fragments are separated by size using gel electrophoresis.

3(b)

When protein, derived from milk, and plant-based proteins, sourced from plants, are both popular ~~for~~ protein sources used as food supplements.

When

→ Whey protein :-

Source :- Milk (byproduct of cheese making)

Properties :- Complete protein, high in essential amino acids (especially BCAAs), fast-digesting.

Uses :- muscle building, recovery after exercise, easy absorption.

→ Plant-Based proteins :-

Source :- Peas, rice, soy, hemp, etc.

Properties :- often ~~are~~ incomplete proteins, suitable for vegans/vegetarians, may contain more fiber.

Uses :- Dietary supplement for vegans, allergen alternative to dairy, general health.

3(c) PLA (Polylactic Acid) is a biodegradable & compostable thermoplastic polyester derived from renewable resources.

Notes :-

Sources :- made from fermented plant starch. (e.g. corn, sugarcane, cassava).

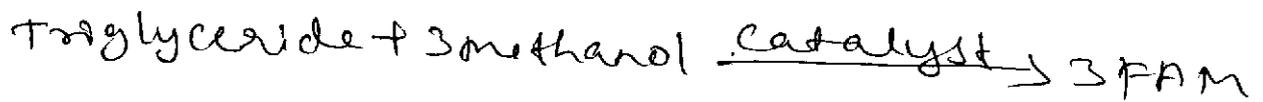
Properties :- Transparent, high strength, thermoplastic (can be molded when heated), biodegradable under industrial composting conditions.

Applications:- packing materials, disposable cutlery, 3D printing filament, medical implants (sutures, screws).

Advantage:- more environmentally friendly than traditional petroleum based plastics as it is derived from renewable sources and can biodegrade.

4(a) Step 1:- Transesterification process.

Biodiesel is produced from lipids through a chemical reaction called transesterification. In this process, the triglycerides in the lipids react with an alcohol in the presence of a catalyst to produce fatty acid methyl esters (FAME), which is biodiesel, & glycerol as a byproduct. The general chemical equation is:-



Step 2:- outline the process.

The process involves several key stages:-
→ feedstock preparation:- Lipids are filtered to remove impurities & dried to remove water.

→ transesterification :- The prepared oil is mixed with methanol & catalyst (like ~~mixed with methanol~~ sodium hydroxide or potassium hydroxide) in a reactor at moderate temperature & pressure.

→ Separation :- After the reaction, the mixture separates into two layers, the upper layer is crude biodiesel, & the lower layer is glycerol.

→ Purification :- The biodiesel layer is washed to remove residual catalyst, alcohol, & glycerol, then dried.

→ Quality control :- The final product is tested to ensure it meets biodiesel standards.

1(b) A vaccine is biological preparation that provides active acquired immunity to particular infectious disease.

The mechanism of the RNA vaccine for COVID-19 is as follows :-

1) mRNA Delivery :-

The vaccine contains messenger RNA (mRNA) encapsulated in a lipid nanoparticle (LNP) that is injected into the arm muscle.

2) Cellular uptake :-

The LNP fuses with muscle cells, delivering the mRNA into the cell cytoplasm.

3) protein production :-

The cell's machinery reads the mRNA instruction to produce the SARS-CoV-2 spike protein.

Q
4(c) Enzyme-based biosensors are analytical devices that use immobilized enzymes to detect specific biological or chemical analytes by converting a biological response into an electrical signal.

Notes :-

→ components :-

consist of biological recognition element (enzyme), a transducer, & signal processor or display.

→ mechanism :-

The enzyme reacts specifically with the target analyte (e.g. -glucose). This reaction produces a change that the transducer converts into a measurable electrical signal.

Applications -

Healthcare - Glucose monitoring for diabetics is the most common application.

Environmental monitoring :- Detecting pollutants in water or soil.

5a. The human brain and a Computer's Central processing Unit (CPU) can be compared based on their functions, structure and processing Capabilities.

<u>Feature</u>	<u>Human Brain</u>	<u>Computer CPU</u>
Processing style	Parallel and distributed processing	Sequential processing.
Speed	Slower individual signaling speed	Extremely fast signaling speed
Storage	Highly distributed massive capacity associative memory	Centralized (RAM storage drives) address based memory
Learning	Capable of self-learning adaptation	Requires programming and algorithms to learn.

5b. The lungs function as a vital purification system for the body, primarily by facilitating gas exchange and removing metabolic waste.

•) Mechanisms-

•) Gas exchange :- Lungs bring in oxygen from the air into the bloodstream and remove Carbon dioxide, a waste product of cellular metabolism, from the blood to be exhaled. This maintains the correct pH balance in the blood.

•) Filtration :- The airways are lined with mucus and tiny hair-like structures called cilia, which trap and sweep out dust, pathogens and pollutants from inhaled air.

•) Immune Defense :- Alveolar macrophages in the lungs engulf and destroy harmful particles and bacteria protecting the body from infection.

•) blood clot filtration :- Lungs also filter small blood clots, preventing them from traveling to other vital organs.

50. Dialysis systems are medical treatments that perform the functions of healthy kidneys by removing waste products and excess fluid from the blood when the kidneys fail.

Kidney functions:-

Healthy kidneys filter blood to remove urea, creatinine, excess salts and water producing urine and maintaining electrolyte balance.

Dialysis types:-

•) Hemodialysis:- An artificial kidney machine is used to filter the blood outside the body.

Blood is circulated through the machine, cleaned and returned to body.

•) Peritoneal Dialysis:- A cleansing solution is put into the abdominal cavity through a catheter. The fluid is later drained out, along with waste products.

•) Purpose:- Essential for patients with end-stage renal disease to sustain life & maintain overall health.

6a. Engineering solutions for Parkinson's disease focus on managing symptoms through technology.

•) Focused ultrasound :- A non-invasive technique that uses highly focused ultrasound waves to precisely ablate a small target area in the brain to interrupt the neural circuits responsible for tremors and rigidity.

•) Wearable devices :- Smartwatches, sensors and other wearables can monitor symptoms in real-time. This data helps patients & clinicians track disease.

•) Medication Delivery Systems:- Engineering has improved drug administration, which provide a steady level of medication to reduce "off" periods.

•) Assistive Robotics:- Robotic devices are being developed to assist with daily living activities and mobility support.

6b. The heart is a four-chambered muscular organ that functions as a double pump to circulate blood throughout the body.

•) Structure :- It has two atria that receive blood and two ventricles that pump blood out.

•) Double Circulation :- The right side of the heart pumps deoxygenated blood to the lungs to pick up oxygen and release carbon-dioxide. The left side pumps oxygenated blood from the lungs to rest of the body.

•) Mechanism :- The cardiac muscle contracts and relaxes rhythmically driven by the heart's electrical conduction system. This action creates pressure differences that force blood through the chambers and blood vessels.

•) Valves :- four heart valves ensure unidirectional blood flow, preventing backflow, the tricuspid and aortic valves.

6c. Optical correction involve using lenses to compensate for vision impairments with various materials used for manufacturing these lenses.

•) Optical Corrections:- Common vision problems like myopia, astigmatism and presbyopia are corrected by placing a lens in front of the eye.

•) Materials used for lenses:-

•) Glass:- Traditional material, durable and scratch-resistant.

•) Plastic (CR-39):- Lightweight and less likely to break than glass a very common and affordable option.

•) High Index Plastic:- Thinner and lighter than other materials for strong prescriptions.

7a. Hemoglobin - based oxygen carriers are artificial substance used as temporary blood to transport oxygen.

•) Hemoglobin - Based oxygen carriers:- These are solutions containing modified hemoglobin derived from human, bovine or recombinant sources. They are designed to deliver oxygen to tissues.

•) Perfluorocarbons :- These are synthetic, inert organic molecules that can dissolve large amounts of gases including oxygen. They are typically administered as an emulsion.

•) Functions :- Both serve as bridge solutions in emergency situations, such as massive blood loss during surgery. They are temporary measures to maintain oxygenation.

7b. Shark skin reduces drag through microscopic structures called dermal denticles and this bio-inspiration has been used in high performance.

•) Structure :- Shark skin is covered in tiny V-shaped scales called dermal denticles, which are similar to teeth. These denticles create run parallel to the direction.

•) Application :- Engineers have developed swimmer fabric that mimic the pattern of denticles. feature fine, textured ridges. designed to channel water more efficiently over the body.

7c. GPS (Global Positioning System) is satellite based navigation system, certain aspects of aircraft technology that use flight mechanisms of birds.

•) GPS:- It is a technology that uses a network of satellites orbiting the earth to provide location and time information to a receiver anywhere on the planet.

•) Aircraft technology Inspired by Birds:-

•) wing shape :- The curved shape of wing airfoil is directly inspired by wings.

•) winglets :- The upturned ends of many aircraft wing. This design reduces drag.

8a. Ultrasonography and sonars both use sound waves to gather information but their applications & environments differ.

Feature :- Primary use, medical imaging, underwater navigation, maps, detection of object.

•) Medium soft tissues & fluids in the human body, water.

•) frequency very high frequency, typically lower frequency sound waves.

8b. The design of the Japanese Shinkansen bullet train nose cone, inspired by the kingfisher's beak.

- 1) Problem:- When early bullet trains entered tunnels they created a sonic boom, as they pushed a wave of air.
- 2) Engineer Eiji Nakatsu observed that the long slender and aerodynamically efficient beak allows it to dive into water.
- 3) The solution, the train's nose was redesigned to mimic the beak's section. The shape reduces air resistance.
- 4) The new design eliminated the tunnel boom, improved stability.

8c. Super hydrophobicity refers to extreme water repellency, which is the case of lotus leaf.

- 1) Self-cleaning due to the high surface tension and low contact with leaf. As they roll, they pick up dirt, dust & other contaminants, cleaning leaf without any external intervention.
- 2) Application:- This effect has inspired the development of self-cleaning paints.

9a. Bioimaging & AI are used to enhance the accuracy and speed of disease diagnosis.

•) This involves techniques such as MRI, CT scans, X-rays and ultrasound to create visual representations of the inside of body.

•) AI particularly machine learning & deep learning algorithms, analyzes bioimaging data.

•) It helps in the early detection of disease like cancer by comparing a patient's scan databases of diseased & healthy images. It's improving workflow efficiency in healthcare settings.

9b. Electronic Tongue:-

Principle:- Uses a set of electrochemical sensors designed to mimic human taste receptors.

Function:- It generates a unique fingerprint or data pattern for a specific liquid sample, which is then analyzed by pattern for a specified software to identify classify or compare tastes.

Electronic nose:-

Principle:- Employs an array of gas sensors that react to volatile organic compounds in air.

Function:- Similar to tongue, the pattern of response from the sensors array creates a unique odor signature ensuring product consistency in solid and liquid foods.

- 9c.
- 1) Muscular Dystrophy:- Bioengineering efforts include.
-) Gene therapy, developing methods to deliver healthy genes to replace or repair the faulty genes causing the diseases.
 -) Tissue engineering, creating lab grown muscles tissues to study the disease mechanisms and test new drugs.
 -) Designing advanced exoskeletons & robotic aids to improve mobility & quality of life for patients.
- 2) Osteoporosis :- Bio-engineering efforts include..
-) Biomaterial scaffolds, Developing novel biomaterials and scaffolds that can be implanted to encourage new bone growth & repair fractures.
 -) Drug delivery systems:- Engineering targeted drug delivery systems to the bone to increase bone density and reduce fracture risk.
 -) Biomechanics modeling :- Using Computational models to understand bone strengths and predict fracture risk in patients.

10a. Bio mining Process, certain bacteria naturally oxidize metal sulfides. This chemical reaction releases soluble metal ions into a solution, and processed to obtain the pure metal.

•) Mechanism:- Micro-organisms have negatively charged cell surfaces due to components like cell walls & membranes.

•) Functions:- This absorption concentrates the metal ions near the bacteria. It increases the efficiency of leaching process.

•) Application:- Used to extract metals like Copper, gold & Uranium from low grade ores not economically viable.

10b. •) Concept of DNA origami:- A long single strand of DNA is mixed with hundreds of short, synthetic DNA strands. These staple strands are designed to bind specific locations on scaffold.

Role in Bio-Computing:-

•) DNA structures can be used as scaffolds to precisely position under other molecules or molecular computing components.

•) Logic Gates researchers are creating DNA-based logic gates, that can perform simple or absence of specific input molecules.

•) Data Storage:- The high density and stability of DNA make it a potential medium for ultra-high density data storage.

10c. Self-healing bio-concrete is an innovative material that can repair its own cracks using bacteria, a process inspired by natural bio-mineralization.

•) Bio-mineralization, is a natural process where living organisms produce minerals to harden or stiffen existing tissues. Organism control the precipitation of minerals from a solution.

•) Self-Healing Bio-Concrete.

•) Mechanism :- a calcium based nutrient are embedded within the concrete mixture during production.

•) Healing process, when a crack forms and water seeps in, the bacteria activate, consume the nutrient and produce calcium carbonate as metabolic byproduct.

•) Result :- The produced calcium carbonate is a hard, insoluble material that precipitate and fills the crack, repairing the concrete and extending its lifespan.

Faculty Incharge

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