

Scenario Item

LO 1a : analyse the properties and functions of chemical compounds (water, lipids, proteins including enzymes from mammals) in a cell, focusing on their roles in maintaining cellular structure and metabolic processes in living organisms.

Scenario: A pharmaceutical company is developing a new diagnostic test for liver damage that measures the activity of the enzyme Alanine Aminotransferase (ALT), a protein released from damaged liver cells. A technician performs a test at 40°C instead of the optimal 37°C and notices the enzyme's activity drops significantly after 30 minutes.

Task: Use your knowledge of the structural categories and properties of proteins (enzymes) to explain why a slight temperature increase from optimum causes denaturation and loss of function. Furthermore, analyze the role of water's thermal properties in maintaining the stable internal environment necessary for this enzyme's function in a healthy cell.

LO 1b: Analyse the principles, use, and limitations of light and electron microscopy for studying cellular structures.

Scenario: A forensic scientist is tasked with identifying a single, very fine bacterial spore found on a contaminated surgical tool. The lab has a Transmission Electron Microscope (TEM) and an advanced Phase Contrast Light Microscope.

Task: Justify which microscope is most appropriate for a definitive identification based on the required magnification and resolution. Then, explain two critical structural details (like the cell wall layers or ribosome distribution) visible only with the TEM that would aid in the identification, outlining the trade-offs between the two technologies.

LO 1c : Compare the ultrastructure of plant, animal, and bacterial cells and relate organelle structure to function.

Scenario: An agricultural scientist is investigating a newly discovered soil microorganism that can fix nitrogen and photosynthesize, but lacks a nucleus. A micrograph reveals internal membrane structures and a cell wall.

Task: Compare and contrast this organism's ultrastructure with a typical eukaryotic plant cell, focusing on the roles of the chloroplast, mitochondrion, and cell wall. Analyze how the compartmentalization (or lack thereof) affects the efficiency of photosynthesis and protein synthesis in the two cell types.

LO 1d : Analyse the diversity of tissues in organisms and relate their specific structures to their functions.

Scenario: A pathologist receives two tissue samples: one from a mouse's small intestine lining and another from its skeletal muscle.

Task: Compare the structural features of the epithelial tissue (small intestine) and the muscle tissue, highlighting how the arrangement and type of cells are specialized for their primary functions (absorption/protection vs. movement). Predict the rate of mitosis and repair in each tissue type following a minor injury and justify your prediction based on their cellular characteristics.

Learning Outcome

Scenario Item

LO 2a: Analyse the light-dependent and light-independent stages of photosynthesis and explain the advantage of C4 over C3 plants in certain environments.

Scenario: A research team is cultivating two species of crops, a C3 plant (rice) and a C4 plant (maize), in a sealed greenhouse where the CO₂ concentration is intentionally kept low and the temperature is high (35°C).

Task: Explain the specific biochemical reason (involving the initial CO₂ fixing enzymes and the Calvin cycle) why the C4 plant's net photosynthetic rate would be significantly higher than the C3 plant's under these conditions. Then, justify why this difference makes C4 plants more suitable for arid, hot climates.

LO 2b : assess the influence of environmental factors on the photosynthetic efficiency of plants to optimise photosynthetic rates and crop yields.

Scenario: A vertical farm manager notices that one crop bed, despite having identical light and nutrient conditions as others, shows significantly slower growth. Data reveals a slight but constant layer of condensation on the leaves in that specific bed.

Task: Hypothesize how the condensed water layer could influence the key environmental factors (light intensity and gas exchange) affecting the photosynthetic efficiency. Propose a controlled experiment to quantitatively assess the effect of this water layer on the plant's rate of photosynthesis, and suggest two practical measures to optimize the photosynthetic rate and crop yield in that bed.

Learning Outcome

Scenario Item

LO 3a : assess the role of the human heart in blood circulation and the role of haemoglobin in the transportation of gases in blood under various physiological conditions.

Scenario: A geologist from a coastal region is conducting a three-month field study at a base camp high in the Andes mountains (4,500m above sea level). After one week, their resting heart rate is significantly elevated, and their oxygen dissociation curve has shifted to the right.

Task: Explain the physiological reason for the resting heart rate elevation, linking it to the role of the human heart in maintaining blood circulation. Then, analyze the adaptive significance of the right-shift in the haemoglobin oxygen dissociation curve in high-altitude conditions, and predict the difference in oxygen concentration in the venous blood of the high-lander vs. a low-lander after a bout of exercise.

LO 3b : analyse the role of antibodies in vaccination and allergic reactions in relation to human body immunity.

Scenario: A patient receives a vaccine for a new strain of influenza. Six months later, they accidentally receive a booster shot for a completely different disease. The next day, they have an acute allergic reaction to a peanut.

Task: Differentiate between the primary immune response (elicited by the first vaccine) and the secondary immune response (if a booster were given for the same strain), explaining the specific role of antibodies in each. Then, analyze how an allergic reaction to peanuts, though involving antibodies, differs fundamentally in its mechanism and consequence from

the protective immunity provided by the vaccine.

Learning Outcome

Scenario Item

LO 4a: Analyse the ultrastructure of the mitochondrion and relate its compartments to the major stages of aerobic respiration.

Scenario: A patient is diagnosed with a rare genetic disorder where the proteins that form the folds (cristae) of the mitochondrial inner membrane are structurally defective, leading to a massive decrease in surface area.

Task: Explain how this structural defect would specifically impair the efficiency of oxidative phosphorylation (electron transport chain and chemiosmosis). Predict the compensatory mechanism the cell would most likely use for ATP production, and discuss the consequence of this compensation for the cell's energy efficiency.

LO 4b: Compare the stages of ATP production (Glycolysis, Krebs cycle, Oxidative Phosphorylation) in aerobic and anaerobic respiration and evaluate their relative efficiency.

Scenario: A world-class cyclist completes a 100-meter sprint and immediately transitions into a 10-kilometer endurance race.

Task: Compare and contrast the primary pathway of ATP production (including key metabolites like lactate) during the intense 100-meter sprint versus the endurance phase. Calculate the theoretical maximum ATP yield per glucose molecule in each phase and justify why the body switches to the less efficient pathway (anaerobic) for high-intensity, short-burst activity.

Learning Outcome

Scenario Item

LO 5a : analyse the homeostatic control system, focusing on the role of negative feedback mechanisms in maintaining internal stability.

Scenario: A student drinks a large, sugary soda immediately after a long fast. Their blood glucose level rises sharply, triggering the release of insulin, which eventually brings the glucose level back down to the normal range.

Task: Map out the entire negative feedback loop for this process, clearly identifying the stimulus, the receptor (sensor), the coordinator (control centre), and the effector(s). Explain why this mechanism is described as "negative feedback" and predict what would happen if the receptor cells in the pancreas failed to respond to the initial stimulus.

LO 5b: Analyse the homeostatic control of core body temperature (thermoregulation) and blood glucose levels (glucoregulation).

Scenario: A person is trapped in a blizzard, and their core body temperature drops to 34°C (hypothermia).

Task: Describe the sequence of physiological responses (e.g., shivering, peripheral vasoconstriction) initiated by the body's thermoregulatory centre to counteract this drop. Explain the underlying mechanism (including the role of effectors and the heat-generating

processes) by which these responses attempt to restore normal body temperature.

LO 5c : Analyse the role of the kidney and ADH in osmoregulation and excretion.

Scenario: A hiker is lost in the desert for two days and is severely dehydrated.

Task: Explain the specific homeostatic response to the low water potential of the blood, focusing on the release and action of Antidiuretic Hormone (ADH) on the collecting duct of the kidney nephron. Predict the consequences for the hiker's water balance if their Loop of Henle was unable to maintain the osmotic gradient in the medulla.

Learning Outcome

Scenario Item

LO 6a : Analyse the roles of plant hormones in growth, development, and response to environmental stimuli.

Scenario: A student wants to develop a protocol to produce taller, sturdier, and more abundant fruits on a new hybrid tomato plant.

Task: Design a plan for the strategic application of two major plant hormone groups: auxins and gibberellins. Justify the timing and location of application for each hormone based on its specific function (e.g., cell elongation, apical dominance, fruit set) and how it will contribute to the desired outcome.

LO 6b: analyse impulse transmission in relation to the structure of a neurone, a chemical synapse, and the factors that influence neural activity in response to environmental stimuli.

Scenario: A patient is administered a local anesthetic like Lidocaine during a dental procedure. The drug acts by blocking the voltage-gated sodium channels on the membrane of sensory neurons.

Task: Explain the sequence of events during normal impulse transmission along the axon of a neuron (resting potential, depolarization, repolarization). Then, analyze how the action of the anesthetic prevents the transmission of pain signals, linking the structural component it targets (sodium channels) to the factor that initiates the action potential (depolarization).

LO 6c: Analyse the structure and function of sensory receptors, particularly the eye and ear.

Scenario: An ophthalmologist is examining a patient with difficulty seeing in dimly lit conditions, despite normal vision in bright light. The initial diagnosis suggests a defect in the patient's retinal cells responsible for scotopic (low light) vision.

Task: Identify the specific photoreceptor cells likely affected. Compare and contrast the structure and pigment of this cell type with the other photoreceptor type. Then, explain the phenomenon of dark adaptation, detailing the chemical changes in the photoreceptor that allow for increased sensitivity in low light.

LO 6d: examine the adaptive significance of diverse animal behaviour in promoting survival and reproductive success.

Scenario: Two species of migratory birds use different hunting strategies: Species A exhibits innate behaviour (solitary hunting based on instinct), while Species B demonstrates learned behaviour (group hunting passed down through generations). A sudden, widespread

drought drastically alters the local food source distribution.

Task: Predict the long-term impact of this environmental change on the survival and reproductive success of both species. Justify your prediction by analyzing the adaptive significance of innate versus learned behaviour in rapidly changing ecological conditions.

Learning Outcome

Scenario Item

LO 7a: analyse the structural and functional significance of nucleic acids in meiosis and mitosis, their role in cellular functions, and how mutations in nucleotide sequences can contribute to disease (cancer).

Scenario: A new mutation is discovered in a patient's p53 gene, a tumor suppressor, that alters a single base pair in the coding sequence. This leads to an improperly folded, non-functional p53 protein and the onset of cancer.

Task: Explain the functional significance of the sequence change, detailing how a mutation in the nucleotide sequence impacts the processes of protein synthesis (transcription and translation). Analyze the normal role of the p53 protein in regulating mitosis, and describe how its malfunction leads to uncontrolled cell division and cancer.

LO 7b : assess gene technology techniques, their applications in various fields, and the associated ethical implications.

Scenario: A farmer proposes planting Genetically Modified Organisms (GMOs) that are engineered for insect resistance using Recombinant DNA Technology. A neighboring organic farmer is strongly opposed due to concerns about gene flow.

Task: Describe the basic steps of Recombinant DNA Technology used to create the insect-resistant gene. Then, present a balanced ethical assessment of the GMO's application, discussing the benefits (e.g., food security, reduced pesticide use) versus the potential risks and ethical implications (e.g., gene flow to wild relatives, long-term health and environmental effects).

LO 7c : apply Mendelian principles to predict inheritance patterns and utilise mathematical models to analyse allele frequencies and genotype distributions within populations.

Scenario: In a stable population of 10,000 birds, 3,600 individuals exhibit a recessive trait (e.g., blue feathers).

Task: Assuming the population is in Hardy-Weinberg equilibrium, calculate the frequency of the recessive allele, the dominant allele, and the percentage of heterozygous individuals. Identify and explain three factors that, if introduced to this bird population, would cause the actual genotype distribution to deviate from the predictions of the Hardy-Weinberg model.

LO 7d : examine different forms of allele interactions (autosomal linkage, multiple alleles, codominance and incomplete dominance), including their examples and influence on phenotypic expression.

Scenario: A poultry breeder is trying to understand the inheritance of feather color in chickens. Crossing a white-feathered chicken with a black-feathered chicken results in 100% speckled (black and white) offspring (F1). A cross between two F1 individuals produces black, speckled, and white offspring in a 1:2:1 ratio.

Task: Identify the type of allele interaction governing feather color inheritance in this case, and justify your answer using the observed phenotypic ratios. Then, compare and contrast this interaction with a trait governed by multiple alleles (like human ABO blood groups) regarding the number of alleles and the possible genotypes.

LO 7e: analyse evolutionary advancements in key life processes (circulation, reproduction, gaseous exchange, coordination, movement, and excretion), as well as their suitability for survival across different species.

Scenario: A biologist is comparing the efficiency of gaseous exchange and circulation in a fish (gills and single-loop circulation) versus a mammal (lungs and double-loop circulation).
Task: Explain the evolutionary advancement represented by the double circulatory system in mammals. Analyze the suitability of each system to its respective environment and lifestyle, focusing on how the separation of oxygenated and deoxygenated blood in mammals contributes to the higher metabolic rate and greater efficiency required for endothermy and terrestrial life.

LO 7f: assess speciation and resistance, mechanisms driving them, and factors contributing to extinction events, through comparison of historical and contemporary examples.

Scenario: A population of insects is divided by a newly constructed highway (a physical barrier). Over many generations, the separated populations develop distinct mating rituals that prevent interbreeding. Simultaneously, a different insect population is developing pesticide resistance due to consistent chemical application.

Task: Identify the mechanism of speciation occurring in the highway-divided population and explain how the isolation and resulting pre-zygotic mechanism drive the formation of a new species. Then, compare and contrast this with the contemporary example of resistance, explaining how natural selection drives the change in allele frequency in the second population.

Learning Outcome

Scenario Item

LO 8a : analyse the pre- and post-germination stages during the growth and development of plants in relation to their significance in crop production.

Scenario: A seed bank stores seeds for decades to ensure crop diversity. However, to be effective, the seeds must overcome dormancy and germinate when planted.

Task: Analyse the biological significance of seed dormancy in a wild ecosystem versus its practical inconvenience in crop production. Explain two different natural or artificial methods (e.g., cold stratification, scarification) used to break dormancy and justify why these methods are effective by relating them to the physiological state of the seed.

LO 8b: analyse the role of insect growth stages in ecosystems, focusing on their contributions to waste management, food security, and water quality assessment.

Scenario: A commercial enterprise proposes using the larval stage of the Black Soldier Fly to convert municipal food waste into high-protein animal feed, addressing problems in both waste management and food security.

Task: Explain the ecological role of the insect larval stage in waste management (decomposition/bioconversion). Then, evaluate the dual contribution of this insect's life cycle to the global challenge of food security (e.g., as a direct protein source or indirect feed source).

Learning Outcome

Scenario Item

LO 9a : Analyse population growth patterns, factors limiting population size, and methods for measuring population density.

Scenario: A remote island's deer population grows rapidly from 50 to 500 individuals in five years (exponential growth) but then levels off at 1,200 individuals (logistic growth).

Task: Draw and label a graph illustrating these two phases of population growth. Explain the factors that initially permitted the exponential growth and the specific environmental factors (density-dependent limiting factors) that caused the population to reach and stabilize at the carrying capacity of 1,200 individuals.

LO 9b : Analyse the stages and processes of ecological succession and their application in ecological restoration.

Scenario: A massive volcanic eruption covers a forest with hardened lava, creating a bare, lifeless rock surface. Over hundreds of years, the area transforms into a thriving forest ecosystem.

Task: Describe the key stages and processes involved in this scenario, known as primary succession, from the arrival of pioneer species (e.g., lichens) to the establishment of the climax community. Explain the critical role that the pioneer species play in modifying the abiotic environment to pave the way for subsequent plant communities.

LO 9c : Apply principles of energy flow in the ecosystem and the concept of carbon footprint to contemporary environmental issues.

Scenario: A community is evaluating two options for protein consumption: Option A (Beef cattle) and Option B (Soybeans).

Task: Using the principle of the 10% rule for energy flow through trophic levels, calculate the difference in the amount of primary producer biomass required to support 1 kg of human biomass through Option A versus Option B. Then, analyze how this difference in energy transfer directly relates to the carbon footprint associated with each food source, justifying which option is more environmentally sustainable.

LO 9d : Analyse the impact of invasive species and environmental changes on food security.

Scenario: The introduction of a non-native, highly competitive water hyacinth to a major inland lake has drastically reduced the population of native fish that are the primary protein source for local communities.

Task: Explain how the water hyacinth, as an invasive species, negatively impacts the lake's ecosystem (e.g., light penetration, dissolved oxygen) and the native fish population. Evaluate the cascading effect of this ecological change on the food security and socio-economic well-being of the surrounding human population.

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