THE UNINTED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION AND CULTURE

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

133/2 **BIOLOGY 2**

Time: 2:30 Hours **ANSWERS** **Year: 2013**

Instructions:

1. this paper consists of six questions
2. answer five questions
3. Each question carries twenty marks.

1. (a) By using suitable examples, explain the economic importance of bacteria.

Bacteria play a significant role in various economic activities, which can be both beneficial and harmful. The economic importance of bacteria can be explained as follows:

i. Decomposition
Bacteria decompose organic matter, recycling nutrients in the environment. For example, Bacillus subtilis helps in breaking down organic waste in composting, producing nutrient-rich manure.

ii. Nitrogen Fixation
Bacteria such as Rhizobium fix atmospheric nitrogen into nitrates that plants can absorb, enhancing soil fertility. This is critical in agriculture for crops like legumes.

iii. Industrial Fermentation
Bacteria like Lactobacillus are used in the production of yogurt, cheese, and other fermented products. Clostridium acetobutylicum is used in the production of solvents like acetone.

iv. Biotechnology and Genetic Engineering
Bacteria like Escherichia coli are utilized in producing insulin and other pharmaceutical products through genetic engineering.

v. Harmful Effects
Pathogenic bacteria cause diseases in plants, animals, and humans, leading to economic losses. For example, Xanthomonas causes citrus canker, reducing fruit yields.

(b) Give four reasons to justify the class in which tick belongs.

Ticks belong to the class Arachnida for the following reasons:

i. Body Segmentation
The body of ticks is divided into two main parts: the cephalothorax and abdomen, characteristic of Arachnids.
ii. Presence of Four Pairs of Legs
Adult ticks have four pairs of legs, which is a defining feature of the class Arachnida.

iii. Lack of Antennae
Unlike insects, ticks do not have antennae, which is a distinguishing feature of Arachnids.

iv. Specialized Mouthparts
Ticks have chelicerae and hypostomes for piercing and sucking blood, a trait common in Arachnids.

2. With illustrations, describe the main events of bacteriophage replication in bacteria.

Bacteriophage replication occurs in the following stages:

i. Attachment
The bacteriophage attaches to the bacterial cell wall using tail fibers, recognizing specific receptor sites.
ii. Penetration
The phage injects its DNA or RNA into the bacterial cell while the protein coat remains outside.
iii. Replication
The phage genome hijacks the bacterial machinery to synthesize new viral components, including nucleic acids and proteins.
iv. Assembly
Newly synthesized viral components are assembled into complete bacteriophage particles.
v. Lysis and Release
The bacterial cell wall is lysed, releasing newly formed phages to infect other bacteria.

3. Describe the process of protein synthesis in plants.

Protein synthesis in plants follows the same general process as in other organisms and occurs in two main stages: transcription and translation.

i. Transcription
This process occurs in the nucleus, where DNA is used as a template to produce messenger RNA (mRNA).
- The DNA double helix unwinds and separates into two strands.
- RNA polymerase binds to the template strand and assembles a complementary mRNA strand by adding nucleotides (adenine pairs with uracil instead of thymine).
- After the mRNA strand is fully synthesized, it detaches from the DNA and undergoes modification such as capping and splicing to remove introns.
- The mature mRNA exits the nucleus through nuclear pores and moves to the cytoplasm.

ii. Translation
This process occurs in the ribosomes in the cytoplasm.
- The mRNA binds to the ribosome, and the translation begins at the start codon (AUG).
- Transfer RNA (tRNA) molecules, carrying specific amino acids, bind to the codons on the mRNA through complementary base pairing between codons and anticodons.
- The ribosome facilitates the formation of peptide bonds between amino acids, creating a polypeptide chain.
- The process continues until the ribosome encounters a stop codon, at which point the polypeptide chain is released.
- The polypeptide chain folds into a functional protein.

Protein synthesis in plants is crucial for the production of enzymes, structural proteins, and other functional molecules necessary for growth and development.

4. Explain eight causes of variation in living things.

Variation in living organisms arises due to genetic and environmental factors. The following are the causes:

i. Mutation
Mutations are changes in the DNA sequence, which can lead to the formation of new traits. For example, a mutation in a gene can result in different flower colors in plants.

ii. Genetic Recombination
During sexual reproduction, genetic material is reshuffled in processes like crossing over and independent assortment in meiosis, creating unique combinations of traits in offspring.

iii. Fertilization
The random fusion of male and female gametes during fertilization introduces variation. Each offspring receives a unique combination of genes from both parents.

iv. Independent Assortment
The random alignment and separation of homologous chromosomes during meiosis result in the distribution of different alleles to gametes.

v. Environmental Factors
External conditions such as temperature, light, and nutrition can influence the expression of traits. For example, the color of hydrangea flowers changes based on soil pH.

vi. Epigenetic Changes
Modifications to DNA or histones that do not change the genetic code can affect gene expression and lead to variation. These changes can be influenced by environmental factors.
vii. Migration and Gene Flow
Movement of individuals between populations introduces new genetic material, increasing genetic diversity.

viii. Hybridization
Crossbreeding between different species or varieties results in offspring with traits from both parents, increasing variation.
These factors collectively ensure diversity within populations, enabling organisms to adapt to changing environments.

5. (a) What advantages do animals living in arid conditions have in the excretion of uric acid as a nitrogenous waste?

Animals inhabiting arid environments have evolved the excretion of uric acid as a nitrogenous waste due to several advantages:

(i) Water Conservation:

Uric acid is relatively insoluble in water and is excreted as a semi-solid paste, minimizing water loss. This adaptation is crucial for survival in habitats where water is scarce.

(ii) Reduced Toxicity:
Unlike ammonia, which is highly toxic and requires dilution, uric acid is less toxic, allowing it to be stored in the body longer without causing harm. This reduces the frequency of excretion and further conserves water.

(iii) Energy Efficiency in Water-Limited Environments:
Although the synthesis of uric acid is more energy-intensive than urea production, the trade-off favors water conservation over energy expenditure in arid conditions. The ability to excrete nitrogenous waste with minimal water loss provides a significant survival advantage.

(b) Explain how animals in terrestrial environments overcome their osmotic problems.

Terrestrial animals face challenges in maintaining water and electrolyte balance due to the risk of dehydration and fluctuating environmental conditions. They have developed various strategies to overcome these osmotic problems:

(i) Behavioral Adaptations:
Nocturnal Activity: Many desert animals are active during the cooler night hours to reduce water loss through evaporation.
Seeking Shade or Burrowing: Animals may seek shelter during the hottest parts of the day to minimize water loss.

(ii) Physiological Adaptations:
Efficient Kidneys: Mammals possess kidneys capable of producing concentrated urine, allowing for the excretion of waste products with minimal water loss.
Salt Glands: Some birds and reptiles have specialized glands that excrete excess salts, enabling them to maintain osmotic balance without losing significant amounts of water.

(iii) Morphological Adaptations:
Waterproof Skin or Exoskeletons: The development of impermeable body coverings reduces water loss through evaporation. For example, reptiles have scales that minimize water loss, and insects possess waxy cuticles serving a similar function.

(iv) Metabolic Water Production:
Some animals rely on water produced through the metabolism of food. For instance, the kangaroo rat obtains most of its water from the metabolic breakdown of seeds, reducing its dependence on free water sources.

(v) Dietary Adaptations:
Consuming foods with high water content, such as succulent plants or prey with substantial body water, helps maintain hydration levels.
Through these adaptations, terrestrial animals effectively manage osmotic challenges, ensuring their survival in environments where water availability is limited.

6. (a) Describe the growth pattern in arthropods.

Arthropods, including insects, crustaceans, and arachnids, exhibit a distinctive growth pattern characterized by periodic molting due to their rigid exoskeletons. This process leads to a stepwise growth curve rather than a continuous one.

Growth Pattern:

- Molting (Ecdysis): Arthropods grow by shedding their exoskeleton in a process called molting. Between molts, they remain the same size, resulting in a stepwise increase in size after each molt. This pattern produces a growth curve with horizontal plateaus (periods between molts) followed by vertical jumps (post-molt size increase).
- Instars: The stages between molts are termed instars. During each instar, the arthropod undergoes internal development but does not increase in size until the next molt. The number of instars varies among species.
- Dyar's Law: This principle states that the dimensions of certain body parts, like the head capsule in insects, increase by a relatively constant factor with each molt, often following a geometric progression. This predictable pattern aids in studying arthropod development.

(b) Differentiate allometric growth from isometric growth. Give one example in each case.

Allometric and isometric growth describe how different parts of an organism grow in relation to each other.

Allometric Growth:
Definition: Growth in which different parts of an organism grow at different rates, leading to changes in the organism's shape or proportions over time.
Example: In humans, the head grows at a slower rate compared to the rest of the body during development, resulting in a smaller head-to-body ratio in adults compared to infants.

Isometric Growth:
Definition: Growth in which all parts of an organism grow at the same rate, maintaining the same proportions throughout development.
Example: Certain salamanders exhibit isometric growth, where their body parts grow at the same rate, preserving their proportions from juvenile to adult stages.

(c) Describe the types, location, role, and effects of meristematic cells.

Meristematic cells are undifferentiated plant cells capable of division, leading to new cells that can differentiate into various specialized cell types.
Types of Meristematic Cells:

1. Apical Meristems:
Location: Found at the tips of roots and shoots.
Role: Facilitate primary growth, leading to an increase in length.
Effects: Enable plants to extend roots deeper into the soil and shoots higher towards light, aiding in resource acquisition.
2. Lateral Meristems:
Location: Present along the sides of stems and roots.
Role: Responsible for secondary growth, increasing the girth of the plant.
Effects: Strengthen and support the plant, allowing for increased vascular capacity.

3. Intercalary Meristems:
Location: Located at the base of leaves or internodes, particularly in monocots like grasses.
Role: Contribute to regrowth of tissues, especially after grazing or mowing.
Effects: Allow rapid elongation and regrowth, crucial for survival in environments with frequent disturbances.

Roles of Meristematic Cells:
Growth: Drive both primary and secondary growth, enabling plants to increase in size and girth.
Regeneration: Facilitate healing and replacement of damaged tissues.
Differentiation: Provide cells that can specialize into various tissue types, contributing to the formation of complex structures.

Effects of Meristematic Activity:
Plant Development: Continuous activity leads to the formation of new organs such as leaves, flowers, and roots.
Adaptation: Allows plants to adapt their growth patterns in response to environmental conditions, such as light and nutrient availability.

7. Use four appropriate theories to explain the origin of life and for each theory point out the strengths and weaknesses.

The origin of life on Earth has been a subject of extensive scientific inquiry, leading to the development of several theories. Below are four prominent theories, each accompanied by its strengths and weaknesses:

(i) Abiogenesis (Primordial Soup Hypothesis):

Explanation: This theory posits that life originated from simple organic compounds present in Earth's early oceans. Energy sources such as lightning or ultraviolet radiation facilitated chemical reactions that formed complex molecules, eventually leading to the first living organisms.

Strengths:
Experimental Support: The Miller-Urey experiment demonstrated that amino acids, the building blocks of life, could be synthesized under conditions mimicking early Earth's atmosphere.
Chemical Plausibility: Provides a feasible pathway for the formation of organic molecules from inorganic precursors.

Weaknesses:
Atmospheric Assumptions: The experiment assumed a reducing atmosphere, which is now debated among scientists.
Complexity Gap: Challenges remain in explaining the transition from simple organic molecules to complex life forms.

(ii) Hydrothermal Vent Hypothesis:
Explanation: Proposes that life began at hydrothermal vents on the ocean floor, where mineral-laden water provides the necessary conditions for chemical reactions.

Strengths:
Stable Environment: Deep-sea vents offer a stable environment with abundant chemical energy sources.
Mineral Catalysts: Minerals present at vents could have acted as catalysts for the formation of complex organic molecules.

Weaknesses:
Temperature Extremes: High temperatures at vents may degrade organic molecules, posing a challenge for the stability of emerging life forms.
Energy Source Debate: Uncertainty exists regarding whether the energy available at vents is sufficient to drive the necessary chemical reactions.

(iii) Panspermia:
Explanation: Suggests that life did not originate on Earth but was instead brought here via comets, meteorites, or cosmic dust.

Strengths:
Explains Early Life Evidence: Accounts for the rapid emergence of life on Earth after its formation.
Cosmic Distribution: Provides a mechanism for the potential spread of life throughout the universe.

Weaknesses:
Lacks Mechanism for Origin: Does not explain how life initially originated elsewhere.
Survival Challenges: Questions arise about the survival of organisms during space travel and entry into Earth's atmosphere.

(iv) RNA World Hypothesis:
Explanation: Proposes that self-replicating ribonucleic acid (RNA) molecules were precursors to current life, serving both as genetic material and as catalysts for chemical reactions.

Strengths:
Dual Functionality: RNA's ability to store information and catalyze reactions supports its role in early life processes.
Experimental Evidence: Laboratory experiments have shown that RNA molecules can exhibit catalytic properties.

Weaknesses:
RNA Stability: RNA is chemically unstable and prone to degradation, raising questions about its persistence in prebiotic conditions.
Synthesis Challenges: The spontaneous formation of RNA molecules under prebiotic conditions remains difficult to demonstrate.

8. (a) Explain five effects of eutrophication in the ecosystem.

Eutrophication is the process by which water bodies become enriched with excess nutrients, particularly nitrogen and phosphorus, leading to several ecological consequences:
1. Algal Blooms:
The surplus of nutrients promotes rapid growth of algae, known as algal blooms. These blooms can decrease water clarity and limit sunlight penetration, affecting photosynthesis in submerged aquatic vegetation.

2. Hypoxia and Dead Zones:
As algal blooms die and decompose, the decomposition process consumes dissolved oxygen in the water, leading to hypoxic (low oxygen) conditions. This can result in "dead zones" where oxygen levels are too low to support most marine life, causing fish kills and loss of biodiversity.

3. Loss of Biodiversity:
Eutrophication can lead to decreased biodiversity as species sensitive to low oxygen levels or reduced light availability decline. Dominant algal species can outcompete and displace other aquatic plants and animals, altering the natural ecosystem balance.

4. Altered Food Web Dynamics:
Changes in species composition can disrupt food webs. For example, the decline of submerged vegetation affects herbivorous species, which in turn impacts predators, leading to cascading ecological effects.

5. Toxin Production:
Some algal blooms consist of harmful algal species that produce toxins, posing health risks to wildlife and humans. These toxins can accumulate in the food chain, affecting fish, shellfish, and other organisms.

(b) Describe five problems of eutrophication faced by human societies.
Eutrophication poses several challenges to human societies:

- Water Quality Degradation:
  Excessive algal growth can lead to unpleasant tastes, odors, and colors in drinking water, increasing treatment costs and potentially making water sources unsuitable for consumption.

- Economic Impacts:
  Fisheries and tourism industries can suffer due to fish kills, loss of recreational opportunities, and decreased aesthetic value of water bodies. The economic burden includes loss of income and increased costs for water treatment and ecosystem restoration.

- Health Risks:
  Toxins produced by certain algal blooms can contaminate drinking water and seafood, posing health risks such as gastrointestinal illnesses, neurological disorders, and skin irritations in humans.

- Infrastructure Damage:
  Decomposing algal biomass can produce gases like methane and hydrogen sulfide, which can corrode infrastructure and create foul odors, affecting the quality of life in nearby communities.
- Biodiversity Loss:
  The decline in aquatic biodiversity due to eutrophication can disrupt ecosystem services that humans rely on, such as water purification, fisheries, and recreational opportunities.

Addressing eutrophication requires comprehensive nutrient management strategies, including reducing nutrient runoff from agriculture, improving wastewater treatment, and restoring affected ecosystems to mitigate these ecological and societal impacts.