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: 2021**

Instructions:

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

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1. (a) Viruses are considered to be non-living entities. Justify this statement by giving their five non-living characteristics.

Viruses are often classified as non-living entities due to the following characteristics:
I. Acellular Structure: Viruses lack a cellular structure; they do not possess cytoplasm, organelles, or plasma membranes, which are essential components of living cells.

II. Absence of Metabolism: Viruses do not carry out metabolic processes such as energy production or nutrient assimilation. They rely entirely on a host cell's machinery for replication and do not exhibit metabolic activity outside a host.

III. Inability to Reproduce Independently: Viruses cannot reproduce on their own; they must infect a host cell and utilize its replication mechanisms to produce new virus particles.

IV. Lack of Growth and Development: Viruses do not grow or undergo developmental changes. They are assembled in their complete form within host cells and remain unchanged until they infect another host.

V. Ability to be Crystallized: Viruses can be crystallized, a property characteristic of non-living chemical molecules, indicating their non-living nature.

(b) Giving one example in each case, describe ten economic importances of protoctists.

Protoctists, or protists, play significant roles in various economic sectors. Here are ten examples illustrating their diverse contributions:

I. Primary Producers in Aquatic Ecosystems: Phytoplankton, such as diatoms, perform photosynthesis, forming the foundation of aquatic food chains and contributing substantially to global oxygen production.

II. Source of Agar and Carrageenan: Red algae, like Gelidium species, are harvested to extract agar and carrageenan, which are widely used as gelling agents in the food industry and as culture media in microbiological research.

III. Biofuel Production: Certain algae, such as Chlorella, are explored for biofuel production due to their high lipid content, offering a renewable energy source.

IV. Medical Applications: The protist Plasmodium is studied extensively to understand malaria, leading to the development of treatments and preventive measures against this disease.

V. Industrial Uses: Diatoms have silica-rich cell walls that are utilized in producing diatomaceous earth, employed as a filtration aid, abrasive, and in other industrial applications.

VI. Food Source: Seaweeds, such as Laminaria (kelp), are consumed as food in various cultures, providing essential nutrients and serving as a dietary staple.

VII. Wastewater Treatment: Protozoa like Paramecium play a role in wastewater treatment processes by consuming bacteria and helping to purify water.

VIII. Agricultural Benefits: Some protists, such as mycorrhizal fungi, form symbiotic relationships with plants, enhancing nutrient uptake and promoting soil fertility.

IX. Biotechnological Applications: Green algae like Chlamydomonas reinhardtii are used as model organisms in genetic research and have potential applications in biotechnology, including recombinant protein production.

X. Environmental Indicators: Certain protists serve as bioindicators; for example, the presence or absence of specific foraminifera species can indicate environmental changes and pollution levels in marine ecosystems.

2. (a) Explain the role of major components of the homeostatic system.

Homeostasis is the process by which biological systems maintain stability while adjusting to changing external conditions. The major components involved in homeostatic regulation include:

I. Receptors: These are sensory structures that detect changes in the internal or external environment, known as stimuli. For example, thermoreceptors in the skin sense temperature variations.

II. Control Center: Often the brain or specific regulatory regions within it, the control center processes information received from receptors and determines the appropriate response. It sets the desired range, or set point, for various physiological parameters.

III. Effectors: These are organs, tissues, or cells that carry out the responses directed by the control center to restore balance. For instance, sweat glands act as effectors by producing sweat to cool the body when overheating is detected.

IV. Feedback Mechanisms: Homeostasis primarily operates through negative feedback loops, where the response to a stimulus reduces its initial effect, thereby maintaining equilibrium. Positive feedback loops, which amplify responses, are less common but play crucial roles in specific processes like blood clotting.

(b) Describe how the hypothalamus controls body temperature in the human body.

The hypothalamus serves as the body's thermostat, regulating core temperature through the following mechanisms:

I. Temperature Detection: Thermoreceptors in the skin and within the hypothalamus itself monitor external and internal temperature changes, respectively.

II. Activation of Heat-Loss Mechanisms: When the body's temperature rises above the set point (approximately 37°C or 98.6°F), the hypothalamus initiates responses to dissipate heat:

Vasodilation: Blood vessels near the skin surface widen, increasing blood flow and promoting heat loss through radiation.
Sweating: Sweat glands produce perspiration, which evaporates from the skin, carrying heat away and cooling the body.

III. Activation of Heat-Gain Mechanisms: If the body's temperature drops below the set point, the hypothalamus triggers actions to conserve and generate heat:

Vasoconstriction: Blood vessels constrict, reducing blood flow to the skin and minimizing heat loss.
Shivering: Involuntary muscle contractions generate heat to raise body temperature.
Behavioral Responses: The hypothalamus can influence behaviors such as seeking warmth or increasing physical activity to generate heat.

3. (a) Describe the process of primary growth in plants.

Answer:
Primary growth in plants refers to the increase in length of the shoot and root systems, enabling the plant to extend upwards and downwards. This process is driven by cell division in the apical meristems, which are regions of actively dividing cells located at the tips of roots and shoots.

In stems, primary growth occurs in the apical bud at the tip of the stem. The apical meristem produces new cells that elongate and differentiate into various tissues, leading to the lengthening of the stem. This process also involves the formation of leaves and the establishment of axillary buds, which can develop into lateral branches.
In roots, primary growth is facilitated by the root apical meristem, located just behind the root cap. The root cap protects the delicate meristematic tissue as the root pushes through the soil. Cells produced by the root apical meristem elongate and differentiate into specialized tissues, contributing to root lengthening and the formation of root hairs, which enhance water and nutrient absorption.
Overall, primary growth allows plants to explore new environments above and below ground, establishing the foundational structure necessary for further development.

(b) Explain how lateral branches and lateral roots are formed.

The formation of lateral branches and lateral roots involves distinct developmental processes in shoots and roots, respectively.

Lateral Branch Formation:
Lateral branches arise from axillary buds, which are located at the nodes where leaves attach to the stem. These axillary buds contain dormant meristematic cells that have the potential to develop into new branches. The growth of axillary buds is regulated by hormonal signals, particularly auxins produced by the apical

bud. High auxin levels from the apical bud suppress the growth of axillary buds, a phenomenon known as apical dominance. When the influence of the apical bud is reduced, either through pruning or natural factors, the suppression is lifted, allowing the axillary buds to activate and grow into lateral branches.

Lateral Root Formation:
Lateral roots originate from the pericycle, a layer of cells located just inside the endodermis of the root. The initiation of lateral roots begins with the reactivation of cell division in specific pericycle cells. These dividing cells form a lateral root primordium, which continues to grow and eventually pushes through the overlying root tissues to emerge as a new lateral root. Hormonal signals, especially auxin, play a crucial role in regulating the initiation and development of lateral roots.

4. An experiment was conducted on pure breeding varieties of goats. The black-haired male and white-haired female goats were crossed, and all the F_1 were black-haired. When the F_1 were selfed, F_2 had the following phenotypes:
418 black-haired goats
106 grey-haired goats
36 white-haired goats
Use a Punnett square to show the formation of F_1 and F_2.
The observed phenotypic ratios in the F_2 generation suggest that hair color in these goats is determined by two genes exhibiting a dihybrid inheritance pattern with incomplete dominance. Let's denote the alleles as follows:

B: Allele for black hair

b: Allele for white hair

In this scenario, the black-haired male (BB) and white-haired female (bb) are homozygous for their respective traits. When crossed, all F_1 offspring are heterozygous (Bb) and exhibit black hair, indicating that the black allele (B) is dominant over the white allele (b).

When the F_1 individuals (Bb) are self-crossed, the F_2 generation exhibits a phenotypic ratio of approximately 12:3:1 (black:grey:white), which deviates from the typical 9:3:3:1 ratio expected in dihybrid crosses. This suggests the involvement of gene interaction, possibly epistasis, where one gene's expression masks or modifies the effect of another gene.

To illustrate this, we can use a Punnett square to represent the cross between two F_1 heterozygous individuals (Bb):

The genotypic outcomes are:

BB: Black-haired

Bb: Black-haired (since B is dominant over b)

bb: White-haired

However, the presence of grey-haired goats in the F_2 generation suggests incomplete dominance or a separate gene influencing the expression of hair color. Further genetic analysis would be required to determine the exact mechanism behind the grey phenotype.

5. Giving examples, explain how the following evidences support organic evolution:

(a) Palaeontology

Palaeontology, the study of fossils, provides crucial evidence for organic evolution by documenting the existence of organisms that lived in the past and tracing their changes over time. Fossil records reveal a chronological succession of life forms, illustrating a progression from simple to more complex organisms. For instance, the fossilized remains of early horses show a gradual transition from small, multi-toed creatures (Eohippus) to the large, single-toed modern horse (Equus), demonstrating evolutionary adaptations over millions of years.

(b) Comparative Morphology and Anatomy

Comparative morphology and anatomy involve studying the structural similarities and differences among organisms. Homologous structures, such as the forelimbs of vertebrates, provide evidence for common ancestry. Despite serving different functions—like the wing of a bat, the flipper of a whale, and the human arm—these structures share a similar bone arrangement, indicating they evolved from a common ancestor. This suggests that diverse species have diverged from common lineages through evolutionary processes.

(c) Comparative Biochemistry

Comparative biochemistry examines the molecular similarities among organisms, particularly in DNA and protein sequences. The universality of the genetic code and the presence of similar biochemical pathways across diverse species suggest a shared evolutionary origin. For example, the enzyme cytochrome c, involved in cellular respiration, is found in many organisms, from yeast to humans. The similarities in its amino acid sequences across these species indicate a common ancestry and evolutionary relationships.

(d) Comparative Embryology

Comparative embryology studies the embryonic development of different organisms. Early embryonic stages of vertebrates, such as fish, reptiles, birds, and mammals, exhibit remarkable similarities, including features like pharyngeal pouches and tail structures. These shared embryonic traits suggest that these organisms have descended from a common ancestor. As development progresses, the embryos diverge, leading to the distinct adult forms observed in each species.

6. Describe how primary and secondary ecological successions are brought about in ecosystems.

Ecological succession is the process by which the structure of a biological community evolves over time. There are two main types of succession: primary and secondary.

Primary Succession

Primary succession occurs in lifeless areas where there is no soil or initial vegetation, such as regions newly formed by volcanic activity, areas exposed by retreating glaciers, or bare rock surfaces. The process begins with the colonization of pioneer species, like lichens and certain algae, which can survive in harsh conditions and contribute to soil formation by breaking down the substrate. As these organisms die and decompose, they create organic matter that combines with weathered rock particles to form the initial soil layer. This developing soil allows the establishment of mosses and small plants, which further enrich the soil as they decompose. Over time, grasses, shrubs, and eventually trees can take root, leading to a more complex community structure. This progression continues until a stable climax community is established, characterized by a diverse array of plant and animal species adapted to the environment.

Secondary Succession

Secondary succession takes place in areas where a disturbance has destroyed an existing community but left the soil intact, such as after wildfires, hurricanes, floods, or human activities like farming. Since the soil already contains seeds, nutrients, and microorganisms, the recovery process is typically faster than in primary succession. Initially, fast-growing, opportunistic species like grasses and weeds quickly colonize the disturbed area. These pioneer species stabilize the soil and create conditions favorable for other plants. As the community develops, shrubs and young trees begin to establish, eventually leading to the return of a mature forest or other climax community, depending on the regional climate and soil conditions. Secondary succession demonstrates the resilience of ecosystems and their capacity to recover from disturbances.

In both types of succession, the ecosystem undergoes a series of stages, each with its own characteristic communities of organisms, leading to increased biodiversity and ecological complexity over time.