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: 2016**

Instructions:

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

1. (a) Give five reasons to justify the class to which cockroach belongs.

Cockroaches are classified under the class Insecta (insects) due to the following characteristics:

(i) Body Segmentation: Their bodies are divided into three distinct regions: head, thorax, and abdomen.

(ii) Exoskeleton: They possess a hard, chitinous exoskeleton that provides structural support and protection.

(iii) Jointed Appendages: Cockroaches have jointed legs and other appendages, facilitating movement and interaction with their environment.

(iv) Antennae: They feature long, thread-like antennae, which are sensory organs used to detect environmental cues.

(v) Wings: Most cockroach species have two pairs of wings attached to the thorax, a common trait among insects.

(b) Using examples, explain seven advantages of insects to human beings.

Insects offer numerous benefits to humans, including:

(i) Pollination: Insects such as bees and butterflies play a crucial role in pollinating flowering plants, including many crops and fruit trees. In the United States alone, the value of insect pollination was estimated to be about $34 billion.

(ii) Decomposition and Nutrient Recycling: Insects like beetles and flies contribute to the decomposition of dead materials, reintroducing nutrients into the ecosystem.
(iii) Pest Control: Predatory insects, such as ladybugs and certain wasps, help control populations of agricultural pests, reducing the need for chemical pesticides.

(iv) Food Source: In many cultures, insects like crickets and mealworms are consumed as a rich source of protein, vitamins, and minerals.

(v) Silk Production: The silkworm (Bombyx mori) produces silk, a valuable textile material that has been harvested and used by humans for thousands of years.

(vi) Medical Applications: Maggot therapy, which uses fly larvae to clean wounds, has been employed to prevent or stop gangrene, as the larvae consume only dead tissue.

(vii) Biodiversity Indicators: The presence and diversity of certain insect species can serve as indicators of environmental health and biodiversity, aiding in ecological monitoring and conservation efforts.

2. Classify bacteria on the basis of their morphology.

Bacteria are commonly classified based on their shape and arrangement. The primary morphological categories include:

(i) Cocci: Spherical or oval-shaped bacteria. They can exist as single cells or in specific arrangements:

Diplococci: Pairs of cocci (e.g., Neisseria gonorrhoeae).

Streptococci: Chains of cocci (e.g., Streptococcus pyogenes).

Staphylococci: Grape-like clusters of cocci (e.g., Staphylococcus aureus).

(ii) Bacilli: Rod-shaped bacteria. They may appear as:

Single Bacilli: Individual rod-shaped cells (e.g., Escherichia coli).

Streptobacilli: Chains of rods (e.g., Streptobacillus moniliformis).

(iii) Spiral Bacteria: Spiral or helical-shaped bacteria, subdivided into:

Spirilla: Rigid spiral forms with external flagella (e.g., Spirillum volutans).

Spirochetes: Flexible spirals with internal flagella (e.g., Treponema pallidum).

(iv) Vibrios: Comma-shaped, curved rods (e.g., Vibrio cholerae).

These morphological classifications aid in the identification and study of bacterial species.

3. (a) Explain four major roles of the kidney.

The kidneys are vital organs that perform several essential functions to maintain the body's internal environment. Four major roles include:

(i) Filtration and Excretion of Waste Products:

The kidneys filter blood to remove metabolic waste products, such as urea and creatinine, as well as excess water and electrolytes. These waste materials are excreted from the body in the form of urine, thereby preventing the accumulation of harmful substances in the bloodstream.

(ii) Regulation of Blood Pressure:

By managing the volume of extracellular fluid and secreting the enzyme renin, the kidneys play a crucial role in regulating blood pressure. Renin activates the renin-angiotensin-aldosterone system (RAAS), which adjusts blood vessel constriction and sodium balance, ultimately influencing blood pressure levels.

(iii) Maintenance of Electrolyte and Acid-Base Balance:

The kidneys help maintain the balance of electrolytes, such as sodium, potassium, and calcium, by filtering these substances from the blood and reabsorbing the necessary amounts. They also regulate the body's pH by excreting hydrogen ions and reabsorbing bicarbonate, thus maintaining acid-base equilibrium.

(iv) Hormone Secretion:

The kidneys produce and secrete hormones that are vital for various bodily functions. For example, they release erythropoietin, which stimulates the production of red blood cells in the bone marrow, and calcitriol, the active form of vitamin D, which helps maintain calcium levels for bone health.

(b) Describe the structure of the mammalian nephron.

The nephron is the functional unit of the kidney, each consisting of several components that work together to filter blood and form urine. The main structures include:

(i) Renal Corpuscle:

Glomerulus: A network of capillaries where blood filtration begins. The glomerular blood pressure provides the driving force for water and solutes to be filtered out of the blood plasma and into the Bowman's capsule.

Bowman's Capsule: A double-walled, cup-shaped structure that surrounds the glomerulus. It collects the filtrate from the glomerulus and channels it into the renal tubule.

(ii) Renal Tubule:

Proximal Convoluted Tubule (PCT): Located in the renal cortex, this segment reabsorbs a significant portion of water, sodium, and nutrients from the filtrate back into the bloodstream.

Loop of Henle: A U-shaped structure that extends into the renal medulla, consisting of descending and ascending limbs. It plays a crucial role in concentrating urine and conserving water by creating a concentration gradient in the medulla.

Distal Convoluted Tubule (DCT): Located in the cortex, this segment further adjusts the composition of the filtrate by reabsorbing sodium and calcium while secreting potassium and hydrogen ions, thus contributing to electrolyte and acid-base balance.

Collecting Duct: This duct receives processed filtrate from multiple nephrons and transports it through the medulla to the renal pelvis. It plays a final role in adjusting water reabsorption under the influence of antidiuretic hormone (ADH), thereby determining the final concentration of urine.

Each nephron functions through processes of filtration, reabsorption, secretion, and excretion to maintain the body's fluid and electrolyte balance, as well as to remove waste products.

4. Explain different ways used by endotherms to keep their body temperature constant.

Endotherms, such as mammals and birds, maintain a stable internal body temperature through various physiological and behavioral mechanisms. These strategies enable them to thrive in diverse environmental conditions. Key methods include:
(i) Metabolic Heat Production:
Endotherms generate heat internally through metabolic processes. By increasing their metabolic rate, they can produce more heat to maintain body temperature, especially in cold environments.

(ii) Insulation:
Many endotherms possess insulating features such as fur, feathers, or blubber. These adaptations reduce heat loss by trapping a layer of air or fat close to the body, providing a barrier against cold temperatures.

(iii) Vasodilation and Vasoconstriction:
Endotherms regulate blood flow to the skin to control heat exchange with the environment. In response to cold, they constrict blood vessels (vasoconstriction) to reduce heat loss. Conversely, in warm conditions, they dilate blood vessels (vasodilation) to increase heat dissipation.

(iv) Evaporative Cooling:
To prevent overheating, endotherms employ evaporative cooling mechanisms. Sweating and panting are common methods that facilitate heat loss through the evaporation of water from the skin or respiratory surfaces.

(v) Behavioral Adaptations:
Endotherms engage in behaviors that help regulate their body temperature. Seeking shade, altering activity levels, or changing body orientation relative to the sun are examples of actions taken to maintain thermal balance.

(vi) Shivering Thermogenesis:
In cold conditions, endotherms may initiate shivering—rapid, involuntary muscle contractions that generate heat to raise body temperature.

(vii) Non-Shivering Thermogenesis:
Some endotherms utilize brown adipose tissue to produce heat without shivering. This process involves the metabolism of fat to generate warmth, aiding in temperature regulation.

5. (a) Explain the following types of growth; give one example in each case.

(i) Intermittent Growth:
Intermittent growth refers to a pattern where growth occurs in stages, with periods of rapid development followed by pauses. This is commonly observed in arthropods, such as insects and crustaceans, which undergo molting. For example, a crab grows by shedding its exoskeleton during molting periods, allowing for a sudden increase in size, followed by a phase with no growth as the new exoskeleton hardens.

(ii) Allometric Growth:
Allometric growth describes the differential growth rates of different parts of an organism, leading to changes in shape or proportion as the organism matures. An example is the human head, which is relatively large at birth compared to the rest of the body but grows at a slower rate than the limbs and torso, resulting in adult proportions.

(iii) Isometric Growth:
Isometric growth occurs when all parts of an organism grow at the same rate, maintaining the same proportions throughout development. For instance, certain fish species exhibit isometric growth, where their body shape remains consistent as they increase in size.

(iv) Limited Growth:
Limited growth refers to a growth pattern where an organism or a part of it grows to a certain size and then stops. Most animals, including humans, exhibit limited growth; they grow until they reach adulthood, after which growth ceases.
(v) Unlimited Growth:
Unlimited growth is characterized by continuous growth throughout an organism's life. Many plant species display this pattern, particularly those with indeterminate growth habits. For example, tomato plants can keep growing and producing new leaves and flowers as long as environmental conditions remain favorable.

(b) State the roles of the following factors in seed germination.

(i) Water:
Water is essential for seed germination as it activates metabolic processes within the seed. Upon imbibition, or water absorption, the seed swells, breaking the seed coat and initiating enzyme activity that mobilizes stored nutrients to support the growing embryo.

(ii) Air (Oxygen):

Oxygen is crucial for aerobic respiration during germination, providing the energy required for cell division and growth. Adequate soil aeration ensures that seeds receive sufficient oxygen; waterlogged or compacted soils can impede oxygen availability, hindering germination.

(iii) Optimum Temperature:
Temperature influences the rate of metabolic and enzymatic activities in seeds. Each species has an optimal temperature range for germination, within which these processes function efficiently. Temperatures outside this range can slow down or inhibit germination.

6. In guinea pig (Cavia), there are two alleles for hair color (black and white) and two alleles for hair length (short and long). In a breeding experiment, all F1 phenotypes produced from a cross between pure-breeding short-black haired and pure-breeding long-white haired parents had short black hair.

(a) Which alleles are dominant? Give reasons for your answer.

The dominant alleles are as follows:
i. Black (B) is dominant over white (b): This is evident because all the F1 offspring had black hair despite one parent being pure-breeding for white hair. The expression of black hair in the F1 generation indicates that the allele for black is dominant.

ii. Short hair (S) is dominant over long hair (s): This is shown because all the F1 offspring had short hair, even though one parent was pure-breeding for long hair. The expression of short hair in the F1 generation confirms that the allele for short hair is dominant.

(b) Use cross diagrams to show both F1 and F2 results.

Parental Genotypes:
- Parent 1: Pure-breeding short-black haired (SSBB)
- Parent 2: Pure-breeding long-white haired (ssbb)

F1 Cross:

1. Gametes from Parent 1: SB
2. Gametes from Parent 2: sb

Cross:

	sb	sb	sb	sb
SB	SsBb	SsBb	SsBb	SsBb
SB	SsBb	SsBb	SsBb	SsBb

F1 Phenotype:
All offspring have the genotype SsBb and phenotype short-black hair.

F2 Cross:
F1 genotypes are crossed (SsBb x SsBb).

F2 Gametes:
1. From F1 (SsBb): SB, Sb, sB, sb.

Cross:

	SB	Sb	sB	sb
SB	SSBB	SSBb	SsBB	SsBb
Sb	SSBb	SSbb	SsBb	Ssbb
sB	SsBB	SsBb	ssBB	ssBb
sb	SsBb	Ssbb	ssBb	ssbb

F2 Phenotypic Ratio:
1. Short-black hair (dominant for both traits): 9/16
2. Short-white hair (dominant for short, recessive for color): 3/16
3. Long-black hair (recessive for length, dominant for color): 3/16
4. Long-white hair (recessive for both traits): 1/16

Thus, F2 offspring display Mendelian dihybrid inheritance, following the 9:3:3:1 phenotypic ratio.

7. Explain how different abiotic factors affect population distribution.

Abiotic factors are non-living components of the environment that significantly influence the distribution and abundance of organisms. These factors determine the suitability of habitats and can limit or promote the presence of species in various ecosystems. Key abiotic factors include:

(i) Temperature:

Temperature is a critical determinant of species distribution. Each organism thrives within a specific temperature range, known as its thermal tolerance. For instance, reptiles are more abundant in warmer climates due to their ectothermic nature, which relies on external heat sources to regulate body temperature. Conversely, polar bears are adapted to cold environments and are found exclusively in Arctic regions. Extreme temperatures can limit the distribution of species by affecting their metabolic rates and survival.

(ii) Light Intensity:

Light availability influences photosynthetic organisms, primarily plants, which form the foundation of most ecosystems. In forested areas, the canopy structure creates varying light conditions, leading to stratification of plant species. Shade-tolerant plants occupy lower layers, while light-demanding species dominate the canopy. This vertical distribution affects the herbivores and predators that depend on these plants, thereby shaping the entire community structure.

(iii) Moisture Levels:

Water availability is essential for all living organisms. In arid regions, only species adapted to drought conditions, such as cacti and certain lizards, can survive. Wetlands, on the other hand, support a diverse array of organisms adapted to saturated soils. Variations in moisture levels can lead to distinct zonation patterns, with different species occupying niches based on their water requirements.

(iv) Soil pH and Mineral Content:

Soil characteristics, including pH and mineral composition, influence plant distribution. Certain plants thrive in acidic soils, while others prefer alkaline conditions. For example, blueberries are commonly found in acidic soils, whereas lilacs favor more alkaline environments. The distribution of these plants affects herbivores and decomposers that rely on them, thereby influencing the broader ecosystem.

(v) Salinity:

Salinity levels determine the types of organisms that can inhabit aquatic environments. Freshwater species are adapted to low salinity, while marine organisms thrive in higher salinity conditions. Estuarine areas, where freshwater mixes with seawater, support unique communities adapted to variable salinity levels. Changes in salinity, due to natural events or human activities, can lead to shifts in species composition and distribution.

(vi) Wind Intensity:

Wind influences the distribution of organisms by affecting temperature and moisture regimes, dispersal mechanisms, and physical damage. In coastal and mountainous regions, strong winds can limit tree growth, leading to the formation of krummholz (stunted trees) and treeless zones. Wind also aids in the dispersal of seeds and spores, facilitating colonization of new areas by plants and fungi.

In summary, abiotic factors play a crucial role in shaping the distribution patterns of populations. Organisms have evolved various adaptations to cope with these factors, but significant deviations from their optimal conditions can restrict their presence and abundance in certain habitats.

8. Describe types of communities (Biomes) and their global distribution.

Biomes are large ecological areas on Earth's surface, characterized by specific climate conditions, flora, and fauna. They represent distinct biological communities adapted to their environments. The primary biomes and their global distributions include:

(i) Tropical Rainforest:
Characteristics: High temperatures and significant year-round rainfall support dense, diverse vegetation.
Distribution: Located near the equator, prominent regions include the Amazon Basin in South America, the Congo Basin in Africa, and parts of Southeast Asia.

(ii) Savanna:
Characteristics: Grasslands interspersed with trees, experiencing distinct wet and dry seasons.
Distribution: Found in regions such as East Africa, northern Australia, and parts of South America.

(iii) Desert:
Characteristics: Arid environments with minimal precipitation, sparse vegetation, and extreme temperature variations.
Distribution: Major deserts include the Sahara in North Africa, the Arabian Desert in the Middle East, and the Gobi Desert in Asia.

(iv) Temperate Deciduous Forest:
Characteristics: Moderate climates with four distinct seasons; trees shed leaves annually.
Distribution: Common in eastern North America, Europe, and parts of East Asia.

(v) Temperate Grassland:
Characteristics: Dominated by grasses, these areas have hot summers, cold winters, and moderate rainfall.
Distribution: Known as prairies in North America, pampas in South America, and steppes in Eurasia.

(vi) Taiga (Boreal Forest):
Characteristics: Coniferous forests with cold climates, long winters, and short summers.
Distribution: Spanning across Canada, northern Europe, and Russia.

(vii) Tundra:
Characteristics: Extremely cold with permafrost soils, limited vegetation like mosses and lichens.
Distribution: Encircles the Arctic regions of North America, Europe, and Asia.

(viii) Mediterranean (Chaparral):
Characteristics: Hot, dry summers and mild, wet winters; vegetation includes shrubs and small trees.
Distribution: Found in the Mediterranean Basin, parts of California, central Chile, South Africa's Cape region, and southwestern Australia.

(ix) Aquatic Biomes:
Characteristics: Encompass freshwater (lakes, rivers) and marine (oceans, coral reefs) environments.
Distribution: Covering about 75% of Earth's surface, aquatic biomes are integral to global ecosystems.

These biomes collectively form the Earth's biosphere, each supporting unique communities adapted to their specific environmental conditions.