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: 2012**

Instructions:

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

Prepared by: Maria Marco for TETEA

1. (a) Explain the general characteristics of viruses.
Viruses are microscopic infectious agents that exhibit unique characteristics distinguishing them from other microorganisms:

Acellular Structure: Viruses lack cellular components and are composed of genetic material (either DNA or RNA) encased within a protective protein shell called a capsid. Some viruses also possess an outer lipid envelope.

Obligate Intracellular Parasitism: They cannot replicate independently and must infect a host cell to reproduce, utilizing the host's cellular machinery for replication.

Size: Viruses are typically ultramicroscopic, ranging from 20 to 900 nanometers in length, making them much smaller than most bacteria.

Genetic Material: A virus contains either DNA or RNA as its genetic material, but not both.

Lack of Metabolism: They do not possess the machinery for energy production or metabolism and rely entirely on the host cell for these functions.

(b) Give reasons to justify the class in which spider belongs.
Spiders belong to the class Arachnida within the phylum Arthropoda. This classification is justified by specific morphological and physiological traits:
Exoskeleton and Segmented Body: As arthropods, spiders possess a chitinous exoskeleton and a segmented body divided into two main parts: the cephalothorax and abdomen.
Eight Legs: Unlike insects, spiders have eight legs, a characteristic feature of arachnids.
Lack of Antennae and Wings: Spiders do not have antennae or wings, distinguishing them from many other arthropods.

Presence of Chelicerae: They possess specialized mouthparts called chelicerae, which often end in fangs used to inject venom into prey.
Silk Production: Spiders have specialized glands that produce silk, which they use to construct webs, capture prey, or create egg sacs.

2. (a) Some fungi are useful and others are detrimental to man. Explain this fact and give one example in each case.

Fungi play diverse roles in human life, offering both benefits and posing risks:

Beneficial Fungi: Certain fungi are integral to food production and medicine. For instance, Saccharomyces cerevisiae, commonly known as baker's yeast, is essential in baking and brewing industries for fermentation processes.

Detrimental Fungi: Conversely, some fungi can cause health issues. Aspergillus species, for example, can lead to respiratory problems and other illnesses in humans.

(b) Explain how saprophytic organisms adapted to its mode of nutrition.

Saprophytic organisms, such as certain fungi and bacteria, have developed specific adaptations to thrive on decomposing organic matter:

Enzyme Secretion: They produce extracellular enzymes that break down complex organic compounds into simpler molecules, facilitating absorption.

Extensive Hyphal Networks: In fungi, the development of extensive hyphal networks increases surface area, enhancing nutrient absorption from the environment.
Rapid Growth: Many saprophytes exhibit rapid growth rates, allowing them to quickly colonize and decompose available organic material.

3. With reference to the first and second Mendel's laws, describe how the ratios of 3:1 and 1:1 in a monohybrid cross; 9:3:3:1 and 1:1:1:1 in a dihybrid cross are obtained.

First Mendel's Law (Law of Segregation):
This law states that during gamete formation, the two alleles of a gene segregate independently and each gamete receives only one allele.

Second Mendel's Law (Law of Independent Assortment):
This law states that genes for different traits are inherited independently of one another, provided the genes are on separate chromosomes.

Ratios in a Monohybrid Cross:

i. 3:1 Ratio:
This ratio is obtained when two heterozygous individuals are crossed. For example, if 'T' represents the dominant allele for tallness and 't' represents the recessive allele for dwarfness:
- Parental genotypes: Tt × Tt.
- Punnett Square:

	T	t
T	TT	Tt
t	Tt	tt

The offspring genotypes are:
- TT: homozygous dominant (tall),
- Tt: heterozygous (tall),

- tt: homozygous recessive (dwarf).

Phenotypic ratio:
- Tall: 3 (TT + Tt),
- Dwarf: 1 (tt).

ii. 1:1 Ratio:
This ratio occurs when a heterozygous individual is crossed with a homozygous recessive individual. For example, Tt × tt:
- Punnett Square:

	T	t
t	Tt	tt
t	Tt	tt

The offspring genotypes are:
- Tt: heterozygous (tall),
- tt: homozygous recessive (dwarf).

Phenotypic ratio:
- Tall: 1 (Tt),
- Dwarf: 1 (tt).

Ratios in a Dihybrid Cross:

i. 9:3:3:1 Ratio:
This ratio is obtained when two heterozygous individuals for two traits are crossed. For example, if 'R' represents the dominant allele for round seeds, 'r' for wrinkled seeds, 'Y' for yellow seeds, and 'y' for green seeds:
- Parental genotypes: RrYy × RrYy.
- Punnett Square:

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Phenotypic ratio:
- Round yellow: 9,
- Round green: 3,

- Wrinkled yellow: 3,
- Wrinkled green: 1.

ii. 1:1:1:1 Ratio:
This ratio occurs when a heterozygous individual is crossed with a homozygous recessive individual. For example, RrYy × rryy:
- Punnett Square:

	RY	Ry	rY	ry
ry	RrYy	Rryy	rrYy	rryy

Phenotypic ratio:
- Round yellow: 1,
- Round green: 1,
- Wrinkled yellow: 1,
- Wrinkled green: 1.

4. (a) Describe the advantages of applying genetic engineering in plant and animal breeding.

Genetic engineering offers several benefits in the breeding of plants and animals:

Enhanced Traits: It allows for the direct introduction of desirable traits, such as disease resistance, improved nutritional content, or faster growth rates.

Precision and Efficiency: Unlike traditional breeding methods, genetic engineering enables precise modifications without introducing unwanted traits, accelerating the development of improved varieties.

Environmental Benefits: Genetically engineered crops can be designed to require fewer chemical inputs, such as pesticides or fertilizers, reducing environmental impact.

(b) Explain why farmers are not advised to plant hybrid seeds such as tomatoes from one season to another.

Farmers are generally discouraged from replanting hybrid seeds for several reasons:

Genetic Segregation: Hybrid seeds (F1 hybrids) result from crossing two genetically distinct parent lines. In subsequent generations (F2), the offspring exhibit genetic segregation, leading to unpredictable and often undesirable traits.
Reduced Performance: The vigor and uniformity characteristic of F1 hybrids diminish in later generations, potentially resulting in lower yields and inconsistent crop quality.

5. (a) Explain how feedback system works to bring about homeostatic conditions in animals.

Homeostasis refers to the maintenance of a stable internal environment within an organism, ensuring optimal functioning despite external fluctuations. This stability is achieved through feedback systems, primarily involving negative feedback mechanisms.

Negative Feedback Mechanism:

In negative feedback, a change in a physiological variable triggers a response that counteracts the initial fluctuation, thereby maintaining equilibrium. The process involves several components:

- Receptor: Detects changes in the internal environment (stimuli) and sends information to the control center.
- Control Center: Processes the information and determines the appropriate response.
- Effector: Executes the response to restore the variable to its set point.

Example: Regulation of body temperature in mammals.

Stimulus: A rise in body temperature.

Receptor: Thermoreceptors in the skin and brain detect the increase.

Control Center: The hypothalamus processes this information.

Effector: Sweat glands are activated to release sweat, and blood vessels in the skin dilate to dissipate heat.

This coordinated response lowers body temperature back to its normal range.

Positive feedback mechanisms also exist but are less common. They amplify the initial stimulus, leading to a greater response. An example is the release of oxytocin during childbirth, which intensifies contractions until delivery.

(b) Describe the counter-current multiplier system in the loop of Henle.

The counter-current multiplier system in the loop of Henle is a mechanism in the kidneys that concentrates urine, conserving water and maintaining electrolyte balance. This system involves the interaction between the descending and ascending limbs of the loop of Henle, creating a concentration gradient in the renal medulla.

Key Features:

Descending Limb: Permeable to water but not to solutes. As filtrate descends, water exits into the surrounding medullary interstitium, increasing the filtrate's osmolarity.

Ascending Limb: Impermeable to water but actively transports sodium and chloride ions out of the filtrate into the medullary interstitium, decreasing the filtrate's osmolarity.

This arrangement establishes a hyperosmotic environment in the medulla, allowing for the reabsorption of water from the collecting ducts under the influence of antidiuretic hormone (ADH), thereby concentrating the urine.

6. (a) Describe the population growth shown in a sigmoid and J-shaped growth curves.

Population growth patterns are often represented by two distinct curves:

J-Shaped Curve (Exponential Growth): This curve illustrates a situation where a population grows without constraints, leading to a rapid, unchecked increase. Initially, the population size is small, resulting in a slow growth rate. As the population increases, the growth rate accelerates exponentially, forming a J-shaped curve. This pattern assumes unlimited resources and no environmental resistance. However, in natural ecosystems, such conditions are rare, and such growth is typically unsustainable in the long term.

S-Shaped Curve (Sigmoid or Logistic Growth): This curve represents a more realistic model of population growth, accounting for environmental limitations. It consists of three phases:

- Lag Phase: A period of slow growth as the population adapts to the environment.

- Log (Exponential) Phase: A period of rapid growth where the population size increases exponentially.

- Stationary Phase: Growth rate slows as the population reaches the environment's carrying capacity (K), where birth and death rates equilibrate, and the population size stabilizes.

This S-shaped curve reflects the impact of environmental resistance factors, such as limited resources and increased competition, which slow and eventually halt population growth as it approaches the carrying capacity.

(b) Explain the causes of a step-like growth pattern in arthropods.

Arthropods, including insects, crustaceans, and arachnids, exhibit a step-like growth pattern due to their exoskeletal structure and the process of molting (ecdysis).

Causes:

Exoskeleton Constraint: The rigid exoskeleton provides protection and structural support but does not expand, limiting continuous growth.

Molting Process: To grow, arthropods must periodically shed their exoskeleton and form a new, larger one. After molting, the new exoskeleton is initially soft, allowing the organism to expand before it hardens.

This process results in a step-like growth pattern, where size increases occur abruptly following each molt, separated by periods of little to no growth as the exoskeleton hardens and the arthropod prepares for the next molting cycle.

7. a. Describe three observations and two deductions of Darwin's theory of natural selection.

i. Observations:

- Organisms produce more offspring than the environment can support.
  Populations tend to grow exponentially, but resources such as food, shelter, and space remain limited, creating competition for survival.

- Variation exists within populations.
  Individuals of the same species exhibit differences in traits, such as size, color, and behavior, and some of these traits are heritable.

- Not all offspring survive.
  Due to limited resources and environmental pressures, only a fraction of offspring survive long enough to reproduce.

ii. Deductions:

- Individuals with advantageous traits are more likely to survive and reproduce.
  These traits increase the chances of survival and passing on genes to future generations, leading to a gradual change in the population over time.

- Over time, favorable traits become more common in the population.

As individuals with advantageous traits reproduce more successfully, these traits accumulate, resulting in evolutionary adaptation.

b. A researcher sprayed DDT regularly for several years to a population of pests. He sampled the population every year of spraying. When the results were graphically represented, the graph obtained was as shown in Figure 1.

i. Explain this observation in terms of natural selection.

- Initially, the DDT was highly effective in killing most of the pest population, leading to a sharp decline in their numbers.
- Some pests, however, possessed genetic mutations that provided resistance to DDT. These resistant individuals survived the spraying.
- Over successive generations, the resistant pests reproduced and passed on the resistance genes to their offspring, leading to an increase in the proportion of resistant individuals.
- Eventually, the pest population rebounded and became predominantly resistant to DDT, rendering the pesticide less effective.
- This demonstrates natural selection, where environmental pressures (DDT) select for individuals with advantageous traits (resistance).

8. (a) Discuss how smoke and sulfur dioxide in the polluted atmospheric air (troposphere) affects living organisms.

Smoke and sulfur dioxide (SO_2) are significant air pollutants with detrimental effects on living organisms:

Smoke:

Respiratory Issues: Inhalation of smoke particles can irritate the respiratory tract, leading to coughing, wheezing, and exacerbation of conditions like asthma and bronchitis.

Cardiovascular Problems: Fine particulate matter in smoke can penetrate deep into the lungs and enter the bloodstream, increasing the risk of heart attacks and strokes.

Environmental Impact: Smoke can reduce air quality, impair visibility, and deposit harmful substances on plants, affecting photosynthesis and growth.

Sulfur Dioxide (SO_2):

Respiratory Effects: Short-term exposure to SO_2 can cause throat and eye irritation, coughing, and shortness of breath. It can also aggravate existing respiratory diseases, particularly asthma.

Environmental Damage: SO_2 contributes to acid rain formation, which can harm aquatic ecosystems, damage vegetation, and degrade soil quality.

Wildlife Impact: Acid rain resulting from SO_2 emissions can alter habitats, leading to reduced biodiversity and affecting food sources for various species.

Overall, the presence of smoke and sulfur dioxide in the atmosphere poses significant health risks to humans and animals and can lead to substantial environmental degradation.

(b) Explain any six importance of conserving forests in the ecosystem.

Conserving forests is crucial for maintaining ecological balance and supporting life on Earth. Key reasons include:

- Biodiversity Preservation: Forests are home to a significant portion of the world's terrestrial biodiversity, providing habitat for countless plant and animal species.

- Climate Regulation: Forests act as carbon sinks, absorbing CO_2 and helping to mitigate climate change. They also influence weather patterns and contribute to the global water cycle.

- Soil Conservation: Tree roots stabilize soil, preventing erosion and maintaining soil fertility, which is essential for agriculture and preventing landslides.

- Water Cycle Support: Forests play a vital role in the water cycle by facilitating groundwater recharge, maintaining watershed health, and ensuring clean water supplies.

- Air Purification: Trees filter pollutants from the air, improving air quality and contributing to human health.

- Livelihoods and Resources: Many communities rely on forests for resources such as timber, medicinal plants, and food, supporting economic activities and cultural practices.

Protecting forests ensures the continued provision of these essential services, highlighting the need for effective conservation strategies.