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: 2023.**

Instructions:

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

1. Describe lytic and lysogenic life cycles of a bacteriophage (diagram is not required).

Bacteriophages, or phages, are viruses that infect bacteria and can follow two distinct life cycles: the lytic cycle and the lysogenic cycle.

Lytic Cycle:

Attachment: The phage attaches to the surface of the bacterial cell.
Penetration: The phage injects its genetic material (DNA or RNA) into the host cell.
Biosynthesis: The phage's genetic material commandeers the host's cellular machinery to synthesize phage components, including nucleic acids and proteins.
Maturation: New phage particles are assembled from the synthesized components.
Release: The host cell lyses (breaks open), releasing the newly formed phages to infect other bacteria.

Lysogenic Cycle:
Attachment and Penetration: Similar to the lytic cycle, the phage attaches to the bacterial cell and injects its genetic material.
Integration: The phage's DNA integrates into the bacterial chromosome, becoming a prophage.
Replication: The prophage is replicated along with the host's DNA during cell division, passing the phage DNA to daughter cells.
Induction: Under certain conditions (e.g., environmental stress), the prophage may excise itself from the bacterial chromosome and enter the lytic cycle, leading to the production of new phages and lysis of the host cell.

2. In five points, describe ways in which mammals are adapted to cold and hot environments.

Mammals have evolved various adaptations to survive in extreme temperatures:

Adaptations to Cold Environments:
i. Insulation: Development of thick fur or blubber to retain body heat.
ii. Reduced Extremities: Shorter limbs and appendages minimize heat loss.
iii. Countercurrent Heat Exchange: Blood vessels are arranged to warm blood returning to the body core, conserving heat.
iv. Hibernation: Some mammals enter a state of reduced metabolic activity during cold periods.
v. Behavioral Strategies: Seeking shelter and reducing activity to conserve energy.

Adaptations to Hot Environments:
i. Evaporative Cooling: Mechanisms like sweating or panting to dissipate heat.
ii. Nocturnal Activity: Being active during cooler night hours to avoid daytime heat.
iii. Longer Extremities: Increased surface area aids in heat dissipation.

iv. Burrowing: Living in underground burrows to escape high temperatures.
v. Concentrated Urine: Reducing water loss by excreting minimal water in urine.

3. Describe growth patterns of fish, human beings, and arthropods.
Fish: Fish typically exhibit indeterminate growth, meaning they continue to grow throughout their lives, though the rate of growth decreases with age. Their growth can be influenced by factors such as environmental conditions, food availability, and species-specific traits.

Human Beings: Humans display determinate growth, characterized by rapid growth during early life stages (infancy and adolescence) followed by a cessation of growth upon reaching adulthood. This growth pattern is regulated by genetic and hormonal factors.

Arthropods: Arthropods, including insects and crustaceans, grow through a process called molting (ecdysis). They periodically shed their exoskeleton to allow for growth, forming a new, larger exoskeleton. This results in a stepwise growth pattern, with size increasing abruptly after each molt.

4. Using genetic crosses, describe the mode of inheritance of haemophilia and sickle cell anaemia.

Haemophilia

Haemophilia is a sex-linked recessive disorder carried on the X chromosome. Since males (XY) have only one X chromosome, they are more likely to be affected if they inherit the defective gene. Females (XX), on the other hand, need two defective X chromosomes to exhibit the disorder, as one functional X chromosome is sufficient to mask the effects of the defective gene. Females with one defective X chromosome are carriers.

Example cross:
Consider a carrier mother (XHXh) and a normal father (XHY):

	XH (mother)	Xh (mother)
X (father)	XHX (normal female)	XhX (carrier female)
Y (father)	XHY (normal male)	XhY (haemophiliac male)

Offspring:
- 25% normal females (XHXH)
- 25% carrier females (XHXh)
- 25% normal males (XHY)
- 25% haemophiliac males (XhY)

This example illustrates how haemophilia primarily affects males and how carrier females can pass the defective gene to their offspring.

Sickle Cell Anaemia

Sickle cell anaemia is an autosomal recessive disorder caused by a mutation in the HBB gene, which encodes the beta-globin subunit of haemoglobin. Individuals with two copies of the defective allele (HbS HbS) have the disease. Those with one normal allele and one defective allele (HbA HbS) are carriers, exhibiting no symptoms or mild symptoms but able to pass the defective gene to offspring.

Example cross:
Consider two carrier parents (HbA HbS):

	HbA (mother)	HbS (mother)
HbA (father)	HbA HbA (normal)	HbA HbS (carrier)
HbS (father)	HbA HbS (carrier)	HbS HbS (sickle cell anaemia)

Offspring:
- 25% normal (HbA HbA)
- 50% carriers (HbA HbS)
- 25% affected by sickle cell anaemia (HbS HbS)

Carriers (HbA HbS) are protected against malaria, giving this allele a selective advantage in malaria-endemic regions. However, individuals with HbS HbS experience symptoms such as reduced oxygen transport and pain due to the sickle shape of red blood cells.
In both haemophilia and sickle cell anaemia, understanding genetic crosses helps predict the probability of inheritance and the likelihood of the disorder manifesting in offspring.

5. (a) Explain six essential features of natural selection.

Natural selection is a fundamental mechanism of evolution, explaining how traits that enhance survival and reproduction become more common in a population over successive generations. The six essential features are:

i. Variation: Individuals within a population exhibit differences in traits, such as morphology, physiology, or behavior. These variations arise from genetic mutations, recombination, and other genetic processes.

ii. Inheritance: Many variations are heritable, meaning they can be passed from parents to offspring through genetic material. This ensures that advantageous traits can persist in subsequent generations.

iii. Overproduction: Organisms often produce more offspring than the environment can support, leading to competition for limited resources.

iv. Competition: Due to limited resources, individuals must compete for necessities such as food, shelter, and mates. This struggle influences which individuals survive and reproduce.

v. Differential Survival and Reproduction: Individuals possessing traits that confer an advantage in a particular environment are more likely to survive and reproduce, passing those advantageous traits to the next generation.

vi. Adaptation: Over successive generations, the accumulation of advantageous traits leads to a population becoming better suited to its environment. This process results in the evolution of new adaptations.

These features collectively explain how natural selection drives the evolution of species by favoring traits that enhance survival and reproductive success.

(b) Describe how geographical, reproductive, and genetic isolations bring about speciation.

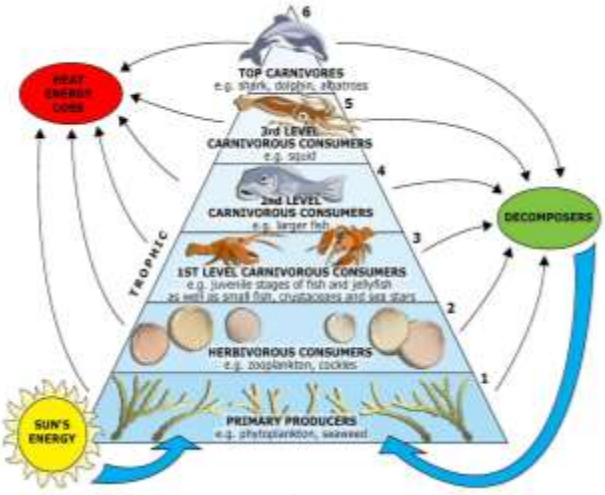
Speciation is the evolutionary process by which populations evolve to become distinct species. Isolation mechanisms play a crucial role in this process:

i. Geographical Isolation: Physical barriers such as mountains, rivers, or oceans can divide a population into separate groups. Over time, these isolated populations may experience different environmental pressures and accumulate genetic differences, leading to the emergence of new species.

ii. Reproductive Isolation: Even without physical barriers, differences in mating behaviors, timing, or anatomical structures can prevent interbreeding between populations. This isolation ensures that genetic material is not exchanged, allowing populations to diverge into distinct species.

iii. Genetic Isolation: Mutations, genetic drift, and selection can lead to genetic differences between populations. When these genetic changes result in incompatibilities, such as differences in chromosome numbers or gene sequences, interbreeding becomes less likely or produces non-viable offspring, promoting speciation.

6. (a) With the help of a diagram, describe a typical marine food chain.



A marine food chain illustrates the flow of energy and nutrients through various organisms in the ocean ecosystem. It begins with primary producers and progresses through multiple consumer levels.

i. Primary Producers: Phytoplankton
Phytoplankton are microscopic organisms that perform photosynthesis, converting sunlight into energy. They form the foundation of the marine food chain.

ii. Primary Consumers: Zooplankton
Zooplankton, including small crustaceans like copepods and krill, feed on phytoplankton. They serve as a crucial link between primary producers and higher-level consumers.

iii. Secondary Consumers: Small Fish
Small fish, such as sardines and anchovies, consume zooplankton. They are an essential food source for larger predators.

iv. Tertiary Consumers: Larger Predatory Fish
Larger fish, like tuna and mackerel, prey on smaller fish. They occupy higher trophic levels in the marine food chain.

v. Apex Predators: Sharks and Marine Mammals
At the top of the food chain are apex predators, including sharks and marine mammals like orcas. They have few natural predators and play a vital role in maintaining the balance of marine ecosystems.
This sequence demonstrates the transfer of energy from primary producers through various consumer levels, highlighting the interconnectedness of marine life.

(b) In six points, justify the fact that food chains in the ecosystem are limited to a certain number of trophic levels.

Food chains are typically limited to 3-5 trophic levels due to several factors:

i. Energy Loss: At each trophic level, energy is lost due to metabolic processes, resulting in less energy available for higher levels.

ii. Biomass Reduction: There is a decrease in biomass at successive trophic levels, limiting the number of consumers that can be supported.

iii. Accumulation of Toxins: Harmful substances can accumulate in higher concentrations at higher trophic levels, affecting the health and survival of top predators.

iv. Longer Food Chains Are Less Stable: Extended food chains can be more susceptible to disruptions, making them less stable.

v. Limited Energy Efficiency: The efficiency of energy transfer between trophic levels is typically low, often around 10%, constraining the length of food chains.

vi. Environmental Constraints: Factors such as habitat size and resource availability can limit the number of trophic levels an ecosystem can support.

These factors contribute to the limitation of trophic levels in ecosystems, ensuring energy flow and ecological balance are maintained.