THE UNINTED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION AND CULTURE

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

133/1 **BIOLOGY 1**

Time: 2:30 Hours **ANSWERS** **Year: 2021.**

Instructios:

1. this paper consists of sections A, and B with total of ten questions
2. answer all questions in section A, and two questions in section B.
3. Section A carries seventy marks and section B carries thirty marks.

1. (a) Briefly describe the stages of the oestrus cycle.

The oestrus cycle comprises four main stages:

i. Proestrus: This is the preparatory stage where the follicles in the ovaries begin to mature, and estrogen levels rise. The uterine lining thickens, preparing for potential implantation.

ii. Estrus: Also known as the "heat" phase, the female is sexually receptive, and ovulation occurs. This stage is characterized by the release of an egg from the ovary, and estrogen levels are at their peak.

iii. Metestrus: During this stage, the ruptured follicle transforms into a corpus luteum, which secretes progesterone to prepare the uterus for pregnancy. If fertilization does not occur, the corpus luteum begins to regress.

iv. Diestrus: This is the final stage where the corpus luteum fully develops if pregnancy occurs. If fertilization does not happen, hormone levels drop, and the cycle restarts.

1. (b) Justify the need for the oestrus cycle in female animals.

The oestrus cycle is vital for the reproductive process in female animals due to the following reasons:

i. Synchronization of mating: The cycle ensures that mating occurs when the female is most fertile, increasing the chances of successful reproduction.

ii. Preparation of the reproductive system: It prepares the uterus for implantation by thickening the endometrial lining, ensuring a suitable environment for the embryo.

iii. Regulation of hormonal balance: The cycle maintains the balance of reproductive hormones such as estrogen and progesterone, which are critical for ovulation and pregnancy.

iv. Continuous reproduction: The cycle allows female animals to reproduce regularly, ensuring the survival and continuity of the species.

2. (a) Find the Respiration Quotient (RQ) for a complete respiration of glucose.

The Respiration Quotient (RQ) is the ratio of carbon dioxide produced to oxygen consumed during respiration. For the complete oxidation of glucose, the equation is:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

RQ = CO_2 produced / O_2 consumed = 6 / 6 = 1

Thus, the RQ for the complete respiration of glucose is 1.

2. (b) Giving seven points, justify the need for fermentation processes in animals.
i. Energy production under anaerobic conditions: Fermentation provides a means for cells to produce ATP when oxygen is unavailable, such as during intense physical activity.
ii. Regeneration of NAD+: During fermentation, NADH is oxidized to NAD+, allowing glycolysis to continue and generate ATP.
iii. Temporary survival mechanism: Fermentation enables cells to survive temporarily in oxygen-deprived environments, such as in muscles during strenuous exercise.
iv. Waste product removal: Fermentation converts pyruvate into waste products like lactic acid, preventing the accumulation of toxic intermediates.
v. Adaptation to low oxygen environments: Some animals, such as those living in hypoxic conditions, rely on fermentation to meet their energy needs.

vi. Specialized processes: In some species, fermentation supports specific physiological functions, such as the production of certain metabolites.
vii. Maintenance of metabolic pathways: Fermentation maintains the flow of metabolic processes when aerobic respiration is not possible.

3. Give four points to support each of the following facts:

(a) Natural system of classification has never been achieved in the fullest sense.

Natural classification has limitations due to the following reasons:

i. Evolutionary gaps: The natural system relies on evolutionary relationships, but incomplete fossil records and unknown ancestral forms make it difficult to fully understand and categorize all organisms accurately.

ii. Phenotypic variations: Similar physical traits can arise independently through convergent evolution, leading to confusion in grouping organisms based on their evolutionary relationships.

iii. Constant discovery of species: New species are continually discovered, which might challenge or require revisions in existing classifications, preventing the system from being fully comprehensive.

iv. Molecular complexities: Advances in genetic and molecular analysis often reveal hidden variations and relationships that the natural system may not initially account for.

(b) Scientists prefer to use natural rather than artificial systems of classification.

Natural classification is preferred for the following reasons:

i. Reflects evolutionary relationships: It groups organisms based on common ancestry and evolutionary history, providing a clearer understanding of their development over time.

ii. Predictive value: By grouping organisms with shared evolutionary traits, scientists can predict characteristics of unknown species based on their classification.

iii. Universal consistency: Natural classification is universally accepted as it relies on objective criteria like genetic information and evolutionary traits, making it more reliable.

iv. Facilitates scientific research: It provides a framework for studying biodiversity, understanding ecological roles, and exploring evolutionary processes.

4. Eukaryotic cells possess many organelles with special structures suitable for performing specific functions. How does each of the following structures enable the respective organelle to perform its role?

(i) Tonoplast in vacuole

The tonoplast is a selectively permeable membrane surrounding the vacuole. It regulates the movement of ions, nutrients, and waste products between the cytoplasm and the vacuole, helping maintain osmotic balance and store important compounds such as pigments and metabolites.

(ii) Glycocalyx in plasma membrane

The glycocalyx is a carbohydrate-rich layer on the plasma membrane that facilitates cell recognition, adhesion, and communication. It also protects the cell from mechanical damage and pathogens by acting as a barrier.

(iii) DNA in nucleus

DNA in the nucleus stores genetic information essential for the synthesis of proteins and the regulation of cellular functions. The nuclear envelope protects the DNA and controls the exchange of materials between the nucleus and cytoplasm.

(iv) Cristae in mitochondria

Cristae are folds in the inner mitochondrial membrane that increase the surface area for housing the electron transport chain and ATP synthesis machinery, enabling efficient energy production through oxidative phosphorylation.

(b) Describe the "lock and key" model of enzyme action.

The "lock and key" model explains enzyme specificity. The enzyme's active site is shaped precisely to fit a specific substrate, similar to how a key fits into a lock. When the substrate binds to the active site, an enzyme-substrate complex forms, facilitating the catalytic reaction. After the reaction, the products are released, and the enzyme remains unchanged.

5. State digestive roles that will be impaired if the pancreas is severely damaged. Give four points.

i. Protein digestion: The pancreas secretes proteolytic enzymes like trypsin and chymotrypsin, which break down proteins into peptides. Damage impairs protein digestion, leading to malnutrition.
ii. Carbohydrate digestion: Amylase, produced by the pancreas, is essential for breaking down starch into maltose. Pancreatic damage disrupts this process, causing incomplete carbohydrate digestion.
iii. Fat digestion: Lipase, responsible for breaking down triglycerides into glycerol and fatty acids, is produced by the pancreas. Damage results in undigested fats and steatorrhea.
iv. Neutralization of stomach acid: The pancreas secretes bicarbonate ions that neutralize acidic chyme entering the duodenum. Impairment causes damage to the intestinal lining and improper enzyme activity.

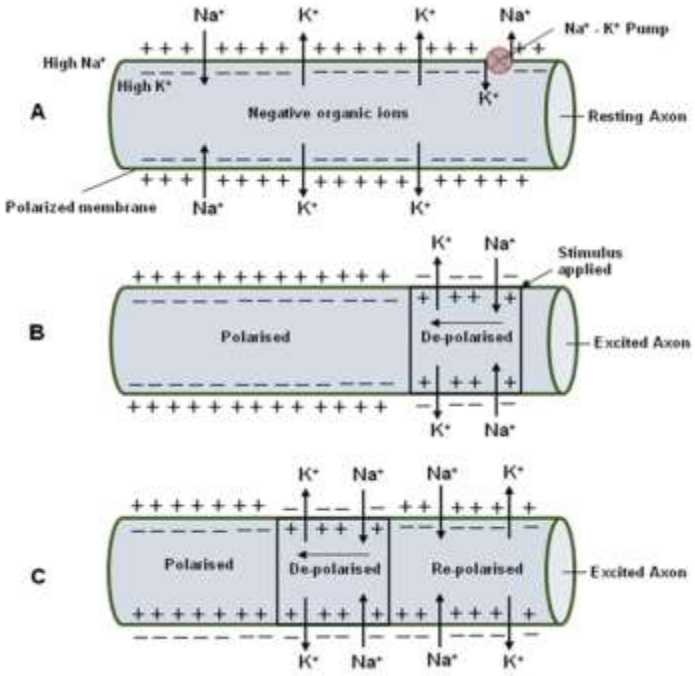
(b) Briefly describe what would happen to duodenal enzymes if the pH in the duodenum remained at 2.

Duodenal enzymes, such as pancreatic amylase and lipase, require an alkaline pH to function optimally. If the pH remains at 2, these enzymes become denatured, losing their structure and activity. This leads to the cessation of digestion, malabsorption of nutrients, and damage to the intestinal lining due to excessive acidity.

6. Why most of the reactions of the cell take place in the cytoplasm? Give four points.
i. Abundance of enzymes: The cytoplasm contains various enzymes that catalyze metabolic reactions such as glycolysis, facilitating energy production.
ii. Medium for transport: It provides a medium for the diffusion and transport of substrates, products, and cofactors necessary for cellular processes.
iii. Site of organelle interactions: The cytoplasm surrounds organelles, enabling coordinated interactions for metabolic pathways such as the exchange of molecules between the mitochondria and the cytosol.
iv. Structural support: The cytoplasm maintains the structural integrity of the cell, ensuring optimal conditions for biochemical reactions.

(b) Why is cytoplasm an important part of the cell? Give six points.
i. Medium for biochemical reactions: The cytoplasm provides an aqueous environment for enzymatic and metabolic reactions essential for cell survival.
ii. Storage of molecules: It stores vital molecules such as ions, amino acids, and carbohydrates, which are used in cellular processes.
iii. Organizes cellular components: The cytoplasm helps position organelles and molecules, ensuring their efficient functioning.
iv. Facilitates intracellular transport: Cytoskeletal elements within the cytoplasm assist in transporting vesicles, organelles, and molecules.
v. Maintains cell shape: The cytoplasm, along with the cytoskeleton, provides structural support to maintain the cell's shape.
vi. Acts as a buffer: It helps regulate intracellular pH and ion concentrations, protecting the cell from environmental changes.

7. Using well-labeled diagrams, describe the conduction of a nerve impulse along an unmyelinated neuron.



In unmyelinated neurons, nerve impulses are conducted through a process called continuous conduction. This involves the sequential depolarization and repolarization of adjacent segments of the neuron's membrane along the entire length of the axon.

At rest, the neuron's membrane maintains a resting potential of approximately -70 millivolts (mV), with the inside of the neuron being negatively charged relative to the outside. This polarization is maintained by the sodium-potassium pump, which actively transports sodium ions (Na^+) out of the cell and potassium ions (K^+) into the cell.

When a stimulus reaches a threshold level, voltage-gated sodium channels at the initial segment of the axon open, allowing Na^+ to rush into the neuron. This influx of positive ions causes depolarization, reversing the membrane potential to approximately +30 mV.

The local depolarization creates a current that flows to the adjacent resting membrane areas, causing them to reach the threshold and open their voltage-gated sodium channels. This process repeats along the length of the axon, resulting in the propagation of the action potential.

Following depolarization, voltage-gated potassium channels open, allowing K^+ to exit the neuron. This efflux of positive ions repolarizes the membrane, restoring the negative resting potential. The sodium-potassium pump then re-establishes the original ion distribution, preparing the neuron for the next impulse.

8. Describe the adaptation of the mammalian foetus, mountain dwellers, and divers to oxygen uptake.

The mammalian fetus, high-altitude dwellers, and divers have developed remarkable adaptations to optimize oxygen uptake in their respective environments.

Mammalian Fetus.

The mammalian fetus thrives in a low-oxygen environment within the womb, relying on several key adaptations to ensure adequate oxygen supply.

One primary adaptation is the presence of fetal hemoglobin, which has a higher affinity for oxygen compared to adult hemoglobin. This allows the fetus to effectively extract oxygen from the maternal blood supply.

Additionally, the placental structure facilitates efficient gas exchange, enabling the transfer of oxygen and nutrients from the mother to the fetus while removing waste products. The fetal circulatory system also includes shunts, such as the ductus arteriosus and foramen ovale, which direct oxygen-rich blood to vital organs, ensuring optimal development even under low oxygen conditions.

High-Altitude Dwellers.

Populations residing at high altitudes, such as those in the Himalayas and Andes, have undergone physiological and genetic adaptations to cope with reduced oxygen availability.

One significant adaptation is an increased red blood cell count and hemoglobin concentration, enhancing the blood's oxygen-carrying capacity.

Moreover, these individuals often exhibit larger lung volumes, allowing for greater oxygen intake per breath.

Genetic adaptations also play a role; for instance, certain high-altitude populations possess genetic variations that lead to more efficient oxygen utilization and improved blood flow, reducing the risk of hypoxia-related complications.

Divers.

Diving mammals, such as seals and whales, have evolved unique adaptations to manage prolonged periods underwater where oxygen is scarce.

They possess elevated concentrations of myoglobin in their muscles, allowing for substantial oxygen storage and facilitating sustained muscle activity during dives.

Additionally, these animals exhibit a pronounced diving reflex, characterized by a significant reduction in heart rate (bradycardia) and selective vasoconstriction, which prioritizes oxygen delivery to essential organs like the brain and heart while conserving oxygen stores.

This reflex, combined with increased blood volume and enhanced oxygen-carrying capacity, enables divers to undertake extended submersion with remarkable efficiency.

In summary, through a combination of physiological and genetic adaptations, the mammalian fetus, high-altitude dwellers, and divers have each developed specialized mechanisms to optimize oxygen uptake and utilization in environments where oxygen availability is limited.

9. Why are the hormones shown in Figure 1 important in the menstrual cycle?
The hormones shown in the figure are vital for regulating the menstrual cycle. Each plays a specific role in ensuring the proper progression of the cycle and the preparation of the body for potential pregnancy.

Oestrogen is primarily responsible for the thickening of the uterine lining (endometrium) during the proliferative phase of the menstrual cycle. This hormone stimulates the growth of blood vessels and glands within the endometrium, creating a supportive environment for a fertilized egg. Oestrogen also plays a crucial role in positive feedback on the hypothalamus and pituitary gland, leading to a surge in luteinizing hormone (LH) levels, which triggers ovulation.
Luteinizing hormone (LH) is responsible for inducing ovulation. It causes the mature ovarian follicle to rupture and release an egg. LH also promotes the formation of the corpus luteum from the remnants of the follicle, which then secretes progesterone.

Progesterone, produced by the corpus luteum after ovulation, maintains the uterine lining during the luteal phase. It inhibits further thickening of the endometrium while ensuring it remains receptive for implantation. If pregnancy does not occur, progesterone levels drop, leading to the shedding of the uterine lining during menstruation.
Follicle-stimulating hormone (FSH) stimulates the growth and maturation of ovarian follicles during the follicular phase. FSH is critical for initiating the menstrual cycle and preparing the ovarian follicles for ovulation. Together, these hormones coordinate the menstrual cycle's phases, ensuring proper development and function.
If pregnancy occurred on the 18th day of the menstrual cycle, hormonal changes would have followed. Progesterone levels would remain elevated, as the corpus luteum would be maintained by human chorionic gonadotropin (hCG) secreted by the developing embryo. Oestrogen levels would also increase gradually to support uterine blood flow and placental development. FSH and LH levels would decrease due to negative feedback from elevated progesterone and hCG, preventing further ovulation and follicular development. These hormonal changes ensure the proper development of the embryo and the maintenance of pregnancy.

10. (a) How does xylem adapt to water transportation? Give six points

Xylem is well-adapted for water transportation in plants. The vessels are composed of elongated, hollow, and dead cells, which form continuous tubes from the roots to the leaves. These tubes facilitate the unobstructed flow of water. Additionally, the walls of xylem vessels are reinforced with lignin, a strong and waterproof substance, providing structural support and preventing collapse under the tension created during transpiration.

The narrow diameter of xylem vessels enhances capillary action, which assists in the upward movement of water. Pits within the walls of the vessels allow lateral movement of water between adjacent xylem cells, ensuring continuous flow even if one vessel becomes blocked. The cohesive properties of water molecules allow them to form a continuous column, while adhesive properties between water molecules and the xylem walls aid in water ascent.

(b) Explain how capillarity force governs the upward movement of water and mineral salts

Capillarity force governs the upward movement of water and mineral salts by relying on cohesion, adhesion, and surface tension. Cohesion refers to the attraction between water molecules, forming a continuous column within the xylem. Adhesion, the attraction between water molecules and the walls of the xylem, helps water move upward against gravity. The narrow diameter of xylem vessels amplifies capillary action, enabling the efficient transport of water and dissolved minerals from roots to leaves. This mechanism works in conjunction with root pressure and transpirational pull, ensuring the plant's hydration and nutrient supply.