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: 2024.**

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) A Form Five student was provided with a sample containing globular protein to identify its features. Which five features did the student identify?

Answer:
Globular proteins have the following features:
i. Solubility in water: Globular proteins are soluble in water, forming colloidal solutions due to their hydrophilic outer layer.
ii. Spherical shape: They are compact and spherical in shape, allowing them to carry out specific biological functions.
iii. Presence of tertiary structure: Globular proteins exhibit a complex three-dimensional tertiary structure stabilized by various bonds like hydrogen and ionic bonds.
iv. Specific biological function: They perform various biological roles, such as enzymes, hormones, and antibodies, due to their specific active sites.
v. Sensitivity to environmental changes: They are sensitive to changes in pH, temperature, and ionic strength, which may lead to denaturation.

1. (b) Denatured protein molecules lose both their three-dimensional structure and functions. Explain five ways which you would use to prevent denaturation.

Answer:
i. Maintain optimal temperature: Proteins should be kept within their functional temperature range to prevent thermal denaturation caused by excessive heat.
ii. Control pH levels: The pH of the surrounding environment should be kept within the protein's optimal range to avoid denaturation caused by acidic or basic conditions.
iii. Avoid exposure to harmful chemicals: Proteins should be protected from strong detergents, heavy metals, or organic solvents that disrupt their structure.
iv. Use stabilizing agents: Stabilizing agents like glycerol or specific salts can be added to protect proteins from unfolding.
v. Prevent mechanical agitation: Excessive shaking or stirring should be avoided, as it can disrupt the delicate bonds maintaining the protein’s structure.

2. (a) Explain how water is used in each of the following processes in the human body:

(i) Transportation
Water serves as a primary medium for transporting various substances within the human body. In the bloodstream, water constitutes a significant portion of plasma, the liquid component of blood, facilitating the movement of nutrients, hormones, and gases to cells and tissues. Additionally, water aids in the transport of waste products from cells to excretory organs for elimination. The solvent properties of water enable it to dissolve a wide range of substances, ensuring efficient distribution and delivery throughout the body.

(ii) Removal of wastes
Water plays a crucial role in the excretion of metabolic waste products. In the kidneys, water assists in filtering blood, allowing waste products like urea and creatinine to be dissolved and excreted in urine.

Adequate hydration ensures that these waste products are effectively removed from the body, maintaining homeostasis and preventing the accumulation of harmful substances. Furthermore, water is involved in perspiration, where waste products are expelled through sweat glands, contributing to detoxification and temperature regulation.

(iii) Secretion
Water is essential in the production and release of various secretions in the body. Glandular secretions, such as saliva, mucus, and digestive juices, rely on water as a solvent and medium. For instance, saliva contains water that aids in the initial digestion of food and facilitates swallowing. Mucus, which lines various body cavities, is composed primarily of water and serves to protect and lubricate surfaces. In the digestive system, water is a key component of gastric and intestinal fluids, enabling the breakdown and absorption of nutrients.

(iv) Hearing and balance
Water is integral to the auditory and vestibular systems responsible for hearing and balance. In the inner ear, the cochlea contains a fluid called endolymph, which transmits sound vibrations to sensory hair cells, facilitating hearing. Similarly, the semicircular canals, part of the vestibular system, are filled with endolymph that moves in response to head movements. This movement stimulates hair cells, sending signals to the brain to maintain balance and spatial orientation.

(b) Use one point in each case to justify the need for animal cells to possess each of the following organelles/structures.

(i) Peroxisomes
Peroxisomes are essential for the detoxification of harmful substances within animal cells. They contain enzymes that break down reactive oxygen species, such as hydrogen peroxide, into harmless water and oxygen, protecting the cell from oxidative damage. Additionally, peroxisomes are involved in lipid metabolism, including the beta-oxidation of fatty acids, contributing to energy production and maintaining cellular health.

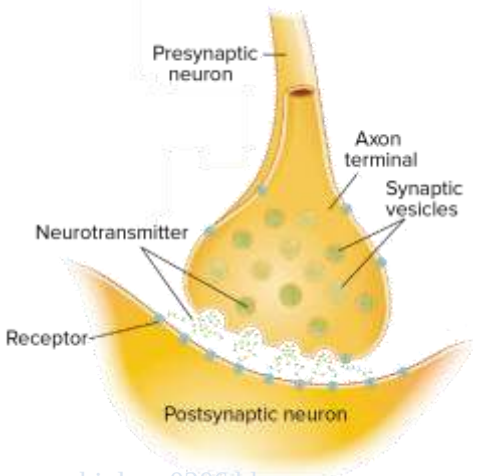
(ii) Lysosomes
Lysosomes function as the digestive system of the cell, containing hydrolytic enzymes that degrade macromolecules, damaged organelles, and pathogens. This degradation process is vital for cellular maintenance, recycling of cellular components, and defense against infections. By breaking down waste materials and cellular debris, lysosomes help maintain cellular homeostasis and prevent the accumulation of potentially toxic substances.

(iii) Rough endoplasmic reticulum
The rough endoplasmic reticulum (RER) is studded with ribosomes and plays a pivotal role in the synthesis of proteins destined for secretion or for use in the cell membrane. The RER provides a site for ribosomes to translate mRNA into polypeptide chains, which are then folded and modified within its lumen. This process ensures that proteins are correctly assembled and directed to their appropriate destinations, which is crucial for cell function and communication.

(iv) Glycocalyx

The glycocalyx is a carbohydrate-rich layer that covers the exterior of animal cell membranes. It plays a significant role in cell recognition, adhesion, and protection. The glycocalyx facilitates interactions between cells and their environment, mediating processes such as immune responses, tissue development, and protection against mechanical damage. By contributing to cell signaling and structural integrity, the glycocalyx is essential for proper cellular function and communication.

3. (a) Draw a diagram of a synapse and label its four parts.



A synapse is the junction between two neurons that facilitates the transmission of nerve impulses. The four main components of a typical chemical synapse are:

Presynaptic neuron is the transmitting neuron that sends the signal. It contains synaptic vesicles filled with neurotransmitters, which are released into the synaptic cleft upon arrival of an action potential.

Synaptic cleft is a small gap (approximately 20 nanometers wide) between the presynaptic and postsynaptic neurons. Neurotransmitters diffuse across this space to transmit the signal to the receiving neuron.

Postsynaptic neuron is the receiving neuron that accepts the signal. Its membrane contains receptor sites that bind to the neurotransmitters released from the presynaptic neuron, leading to the initiation of a new electrical signal.

Receptor sites are specific proteins located on the postsynaptic neuron's membrane. They bind to neurotransmitters, triggering ion channels to open and generate an electrical response in the postsynaptic neuron.

3. (b) Use four points to show how the structure of a synapse is adapted for transmission of impulses.

The structure of a synapse is highly specialized to facilitate the rapid and precise transmission of nerve impulses from one neuron to another or to an effector cell.

i. Presence of synaptic vesicles: The presynaptic terminal contains synaptic vesicles filled with neurotransmitters, which are chemical messengers responsible for transmitting signals across the synaptic cleft. These vesicles ensure that neurotransmitters are released quickly and efficiently when an impulse arrives.

ii. Synaptic cleft: The synaptic cleft is a narrow gap that separates the presynaptic and postsynaptic neurons. Its small size ensures that neurotransmitters diffuse rapidly across it, allowing for the swift transmission of signals.

iii. Receptors on the postsynaptic membrane: The postsynaptic terminal has specialized receptors that bind specifically to neurotransmitters. This ensures that the signal is received accurately and triggers the appropriate response in the receiving neuron or effector cell.
iv. Presence of calcium channels: The presynaptic terminal contains voltage-gated calcium channels that open in response to an incoming action potential. The influx of calcium ions triggers the fusion of synaptic vesicles with the membrane, releasing neurotransmitters into the synaptic cleft. This mechanism ensures precise timing and coordination of signal transmission.

4. (a) Anaerobic respiration is a wasteful process, especially in animal cells, where it produces only 2 ATP from the breakdown of a glucose molecule. Propose a way in which the process can be prevented.

Anaerobic respiration can be minimized by ensuring an adequate oxygen supply to the cells. This can be achieved through the following measures:

i. Improving blood circulation: Regular physical exercise and a healthy cardiovascular system ensure efficient oxygen delivery to tissues and organs. Improved circulation prevents oxygen deprivation, which triggers anaerobic respiration.

ii. Maintaining proper respiratory function: Conditions like asthma or chronic obstructive pulmonary disease (COPD) should be managed effectively to maintain sufficient oxygen intake and delivery.

iii. Enhancing hemoglobin levels: Adequate hemoglobin levels in the blood allow for efficient oxygen transport. Iron-rich diets and addressing conditions like anemia help optimize oxygen-carrying capacity.

iv. Reducing physical overexertion: Avoiding activities that demand excessive oxygen beyond what the body can deliver prevents oxygen debt and the initiation of anaerobic processes.

4. (b) Evaluate the number of ATP produced in each stage of respiration (Glycolysis, Krebs' cycle, and Electron transport chain) when a glucose molecule is completely oxidized to make a total of 38 ATP.

i. Glycolysis: In glycolysis, one glucose molecule is broken down into two molecules of pyruvate. This process occurs in the cytoplasm and produces a net gain of 2 ATP. Additionally, 2 NADH molecules are generated, each contributing to ATP production in later stages.

ii. Krebs' cycle: The Krebs' cycle occurs in the mitochondrial matrix, where acetyl-CoA, derived from pyruvate, is oxidized. Each cycle produces 2 ATP directly (via substrate-level phosphorylation), along with 6 NADH and 2 FADH2 per glucose molecule. These coenzymes play a significant role in the electron transport chain.

iii. Electron transport chain (ETC): The ETC is located in the inner mitochondrial membrane, where NADH and FADH2 donate electrons. Each NADH generates approximately 3 ATP, and each FADH2 produces 2 ATP. This stage yields the majority of ATP, approximately 34 ATP molecules, through oxidative phosphorylation.
Overall, the complete oxidation of one glucose molecule yields 38 ATP: 2 from glycolysis, 2 from the Krebs' cycle, and 34 from the ETC.

5. (a) A woman gave birth to three babies in a single pregnancy (triplets). The two babies were genetically identical, while one was different. She wondered how it was possible. In seven points, explain how the triplets resulted.

The triplets likely resulted from a combination of monozygotic and dizygotic twinning. Here are the possible explanations:
i. Monozygotic twins: Two of the babies were genetically identical because they originated from the same fertilized egg. This single zygote split during the early stages of development to form two embryos with identical genetic material.
ii. Dizygotic twin: The third baby was genetically different because it resulted from the fertilization of a separate egg by a different sperm. This process is common when a woman releases two eggs during ovulation, which are fertilized independently.
iii. Independent fertilization events: Two ova were released simultaneously and fertilized by different sperms, leading to the formation of a dizygotic embryo alongside the monozygotic twins.
iv. Timing of zygote splitting: The splitting of the monozygotic zygote occurred at an early stage, leading to identical twins that share the same genetic information, while the third zygote developed independently.
v. Shared placenta for identical twins: The monozygotic twins might share the same placenta, as they originated from the same fertilized egg, whereas the dizygotic twin has its own placenta.
vi. Genetic recombination: The dizygotic twin underwent unique genetic recombination during fertilization, resulting in a distinct genetic makeup from the identical twins.
vii. Influence of assisted reproductive technologies: If fertility treatments such as in-vitro fertilization were used, multiple embryos could have been implanted, leading to a combination of identical and fraternal triplets.

5. (b) In mammals, giving birth involves three processes, namely dilation of the cervix, expulsion of the fetus with the head first, and expulsion of the placenta. Give an importance of each stage.

i. Dilation of the cervix: The cervix dilates to allow the fetus to pass from the uterus into the birth canal. This stage ensures that the birth canal widens enough for the fetus to be delivered safely, reducing the risk of complications during labor.
ii. Expulsion of the fetus with the head first: Delivering the fetus headfirst is crucial as it minimizes the chances of injury to the baby and the mother. The head is the largest part of the fetus and, once it is delivered, the rest of the body follows more easily.
iii. Expulsion of the placenta: The placenta is expelled after the baby is delivered. This stage is essential to prevent postpartum complications such as infection or excessive bleeding. The removal of the placenta also ensures the uterus begins contracting to its normal size.

6. (a) Use five points to show the importance of classifying organisms.

i. Facilitates identification and study: Classification provides a systematic framework for identifying and studying organisms, enabling scientists to group them based on similarities and differences, which simplifies the study of biodiversity.
ii. Predicts characteristics: By grouping organisms with shared traits, classification helps predict characteristics of an unknown organism if its group is known, aiding in understanding its role in ecosystems.
iii. Aids in understanding evolution: Classification reveals evolutionary relationships by grouping organisms based on shared ancestry. It highlights how species have evolved and diversified over time.
iv. Facilitates communication: Scientific names assigned through classification ensure that organisms are universally recognized and understood, eliminating confusion caused by local or common names.
v. Supports conservation efforts: Classification highlights biodiversity and helps identify species that are endangered, guiding conservationists to prioritize their protection.

6. (b) Use five points to support the statement that artificial systems of classification are not preferred by scientists.

i. Lack of evolutionary basis: Artificial classification is based on superficial characteristics like size or habitat, ignoring evolutionary relationships and genetic similarities, making it less reliable for understanding ancestry.
ii. Ignores internal features: Artificial systems often focus only on external features, neglecting internal anatomy, physiology, and molecular biology, which are crucial for accurate classification.
iii. Limited scope: Artificial systems fail to account for variations within species or among closely related species, leading to inaccuracies in grouping organisms.
iv. Hinders scientific research: By relying on arbitrary characteristics, artificial classification does not provide meaningful insights into organisms' functions, roles, or ecological importance.
v. Inconsistent groupings: Organisms with similar external features may be placed together despite significant genetic differences, leading to misleading conclusions about their relationships.

7. (a) Hydrochloric acid is one of the components of gastric juice produced by the stomach wall during digestion of food. Give seven points to show its importance in digestion of food in human being.

i. Activation of pepsinogen: Hydrochloric acid converts inactive pepsinogen into active pepsin, an enzyme that digests proteins into smaller peptides. This activation is crucial for protein breakdown in the stomach.

ii. Creates an acidic environment: Hydrochloric acid provides the optimal pH for the activity of gastric enzymes, particularly pepsin, which functions best in highly acidic conditions.

iii. Denatures proteins: The acidic environment created by hydrochloric acid denatures the tertiary structure of proteins, making them easier for enzymes to digest.

iv. Kills harmful microorganisms: Hydrochloric acid acts as a defense mechanism by killing bacteria, viruses, and other pathogens ingested with food, reducing the risk of infections.

v. Facilitates the absorption of certain minerals: The acid helps solubilize minerals like iron and calcium, making them more available for absorption in the small intestine.

vi. Stimulates the secretion of other digestive enzymes: The presence of hydrochloric acid triggers the release of other gastric and pancreatic enzymes, which are vital for complete digestion.

vii. Assists in breaking down food particles: The acidic environment softens food, aiding mechanical digestion and enhancing the efficiency of digestive enzymes.

7. (b) Give three points to justify the need for secretion of mucus in the stomach epithelial and gastric glands.

i. Protection of the stomach lining: Mucus forms a protective barrier that shields the epithelial lining of the stomach from the corrosive effects of hydrochloric acid and digestive enzymes like pepsin, preventing the development of ulcers.

ii. Lubrication of food: Mucus ensures that food moves smoothly through the stomach and into the small intestine, reducing friction and facilitating digestion and absorption.

iii. Maintenance of an optimal environment: The mucus layer traps bicarbonate ions, creating a slightly alkaline microenvironment at the epithelial surface, which protects the stomach lining from acid damage.

8. Describe the process of water uptake from the soil to the xylem.

Water uptake in plants involves several processes that transport water from the soil to the xylem, ensuring the plant remains hydrated and nutrients are transported effectively.

i. Absorption by root hairs: Root hairs, which are extensions of root epidermal cells, increase the surface area for water absorption. Water enters root hairs from the soil through osmosis due to the lower water potential inside the root cells compared to the soil.

ii. Movement through the root cortex: Water travels across the root cortex towards the xylem through three pathways: the apoplast pathway (along cell walls), the symplast pathway (through cytoplasm and plasmodesmata), and the transmembrane pathway (across cell membranes).

iii. Passage through the endodermis: The endodermis regulates water entry into the xylem. The Casparian strip, a waxy barrier, forces water and dissolved minerals to pass through the symplast pathway, allowing selective absorption of essential nutrients.

iv. Entry into the xylem: Once water reaches the pericycle, it moves into the xylem vessels through osmosis or root pressure. Xylem vessels, being dead and hollow, serve as conduits for transporting water to the shoots.

v. Cohesion and adhesion: The cohesive forces between water molecules and the adhesive forces between water and xylem walls facilitate the upward movement of water in the xylem against gravity.

vi. Transpiration pull: Transpiration from the leaves creates a negative pressure in the xylem, pulling water upward through the plant. This process ensures a continuous flow of water from the roots to the leaves.

9. A certain couple stayed together for ten consecutive years and wishes to have children but they could not. Explain the possible causes of the problem for each partner.

i. Possible causes in the male partner:

- Low sperm count: A reduced number of sperm can decrease the likelihood of fertilization. This condition can result from hormonal imbalances, lifestyle factors, or underlying medical issues.

- Poor sperm motility: If sperm are unable to swim effectively, they may not reach and fertilize the egg. This condition can be caused by genetic factors, infections, or exposure to toxins.

- Erectile dysfunction: Difficulty in maintaining an erection can prevent successful intercourse, reducing the chances of conception.

- Blockage in reproductive tract: Blockages in the vas deferens or epididymis can obstruct the passage of sperm, making fertilization impossible.

ii. Possible causes in the female partner:

- Ovulation disorders: Conditions like polycystic ovary syndrome (PCOS) or hormonal imbalances can prevent the release of eggs, hindering fertilization.

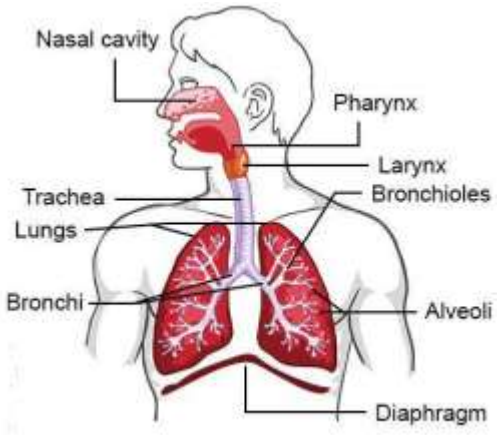
- Blocked fallopian tubes: Blockages due to infections or scar tissue can prevent the egg and sperm from meeting.

- Endometriosis: The growth of uterine-like tissue outside the uterus can interfere with implantation or damage reproductive organs.
- Uterine abnormalities: Issues such as fibroids or an irregular uterine shape can affect the implantation of a fertilized egg.
iii. Shared causes:

- Incompatibility: Genetic or immunological incompatibilities between partners can prevent successful fertilization or implantation.

- Lifestyle factors: Smoking, excessive alcohol consumption, poor diet, or stress can negatively impact fertility in both partners.

10. Draw a diagram to show the path taken by the air from the nose to the alveolar and explain six adaptations of alveoli for gaseous exchange.



The path of air includes the following: nose -> nasal cavity -> pharynx -> larynx -> trachea -> bronchi -> bronchioles -> alveoli.

Air enters the respiratory system through the nostrils (nares) and passes into the nasal cavity, where it is filtered, warmed, and humidified. From the nasal cavity, air moves through the pharynx and then passes through the larynx into the trachea. The trachea divides into the right and left main bronchi, each entering a lung. Within the lungs, the bronchi branch into smaller bronchioles, which further subdivide and lead to the alveoli, the tiny air sacs where gas exchange occurs.

The alveoli are intricately designed to optimize gas exchange between the lungs and the bloodstream. Their structure and function are highly specialized to ensure efficient diffusion of oxygen into the blood and the removal of carbon dioxide. There are several key adaptations that contribute to their effectiveness in gaseous exchange.

One of the most significant adaptations of the alveoli is their large surface area. The human lungs contain approximately 300 million alveoli, providing an extensive surface area of about 70–80 square meters for gas exchange. This vast area allows more oxygen to diffuse into the blood and more carbon dioxide to be expelled efficiently.

The alveoli also have an extremely thin membrane, which facilitates rapid diffusion of gases. The walls of the alveoli are composed of a single layer of squamous epithelial cells, known as Type I pneumocytes. This thin barrier, along with the equally thin capillary walls, minimizes the distance gases must travel between the air in the alveoli and the blood in the capillaries, speeding up the exchange process.

Another important adaptation is the moist environment inside the alveoli. The inner surfaces of the alveoli are coated with a thin layer of fluid, which helps gases dissolve before diffusing through the membrane. This moisture is essential for efficient gas exchange, as oxygen needs to dissolve before it can pass into the blood, and carbon dioxide must dissolve before it can be exhaled.

The alveoli are surrounded by a dense network of capillaries, ensuring a rich blood supply. These tiny blood vessels transport oxygen-poor blood from the heart to the alveoli and carry oxygen-rich blood back to the heart. This continuous blood flow maintains a steep concentration gradient, which is necessary for efficient diffusion of oxygen into the bloodstream and carbon dioxide out of it.

Elastic properties of the alveoli also play a crucial role in gaseous exchange. The walls of the alveoli contain elastic fibers, which allow them to expand when air is inhaled and recoil when air is exhaled. This elasticity helps maintain lung function by allowing the alveoli to return to their original shape, ensuring a constant flow of fresh air into the lungs.
Efficient ventilation is supported by the branching structure of the respiratory tract, which ensures that air reaches the alveoli smoothly. The trachea, bronchi, and bronchioles work together to direct air into the alveoli, maintaining a steady supply of oxygen and preventing the build-up of carbon dioxide.
The alveoli also have small openings between adjacent structures known as the pores of Kohn. These pores allow collateral ventilation, ensuring even distribution of air among the alveoli. This feature is particularly important in preventing the collapse of certain areas of the lung and promoting uniform gas exchange.

Another key adaptation is the presence of protective mechanisms in the alveoli. Alveolar macrophages patrol the surface of the alveoli, engulfing pathogens, dust, and debris. This defense mechanism helps maintain a clean environment, reducing the risk of infections that could impair gas exchange.

The alveoli also have an adaptive capacity that allows them to meet the body's changing oxygen demands. During increased physical activity, the body can recruit additional alveoli to enhance gas exchange capacity.

This ensures that more oxygen is absorbed and transported to the muscles, while excess carbon dioxide is efficiently removed.

Each of these adaptations contributes to the efficiency of the alveoli in facilitating gaseous exchange. Their structure and function are highly specialized to support life by ensuring that the body receives a continuous supply of oxygen while efficiently expelling carbon dioxide. The combination of a large surface area, thin walls, moisture, rich blood supply, elasticity, surfactant production, ventilation efficiency, collateral air flow, immune defense, and adaptability makes the alveoli perfectly suited for their role in respiration.