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: 2013**

Instructios:

1. this paper consists of eleven questions
2. answer all questions in section A, and three questions in section B.
3. the marks allocation is indicated at the beginning of each section.

1. (a) List two roles of the cell membranes.

i. The cell membrane regulates the movement of substances in and out of the cell, maintaining homeostasis.
ii. It provides structural support and defines the boundary of the cell, protecting its internal components.

(b) Mention one function for the following organelles and briefly explain how each organelle is adapted to its function.

i. Golgi body. It modifies, packages, and transports proteins and lipids. It is adapted through its stack of membrane-bound cisternae that allow efficient processing and sorting of materials.
ii. Endoplasmic reticulum. It facilitates the synthesis of proteins (rough ER) and lipids (smooth ER). It is adapted by having extensive membranes that provide a large surface area for these processes.
iii. Chloroplast. It carries out photosynthesis by converting light energy into chemical energy. It is adapted through the presence of thylakoid membranes containing chlorophyll for light absorption.
iv. Mitochondrion. It produces ATP through aerobic respiration. It is adapted by having a double membrane structure, with the inner membrane folded into cristae to increase the surface area for energy production.

2. (a) Explain the characteristic features of a respiratory surface.

i. Respiratory surfaces are thin to facilitate efficient diffusion of gases.
ii. They have a large surface area to increase the rate of gas exchange.
iii. They are moist to allow gases to dissolve and diffuse more easily.
iv. They are richly supplied with blood vessels to transport gases rapidly.

(b) The equation for respiration of the fat tripalmitin is:
$2C_{51}H_{98}O_6 + 145O_2$ ----------→ $102CO_2 + 98H_2O$
What is the RQ of tripalmitin?

- Respiratory quotient (RQ) = Volume of CO2 produced / Volume of O2 consumed
RQ = 102 / 145
RQ = 0.7

3. (a) (i) Name the parts labelled A, B, C, D, E, F, G, and H.

A: Scala vestibuli
B: Scala tympani
C: Basilar membrane
D: Reissner's membrane
E: Tectorial membrane
F: Hair cells
G: Spiral ganglion
H: Organ of Corti

(ii) Which parts make up the organ of Corti?
The organ of Corti consists of hair cells, the basilar membrane, and the tectorial membrane.

(b) Explain how the organ of Corti is adapted to its function.

The organ of Corti is adapted for sound perception through:
i. Hair cells with stereocilia that detect vibrations and convert them into electrical signals.
ii. The tectorial membrane, which interacts with the stereocilia for sound detection.
iii. The basilar membrane, which vibrates at different frequencies to distinguish sounds.
iv. Its location within the cochlea, ensuring it is exposed to pressure changes in the inner ear.

4. (a) What is the meaning of meristematic tissue?

Meristematic tissue consists of undifferentiated cells capable of continuous division, enabling plant growth in length and girth.

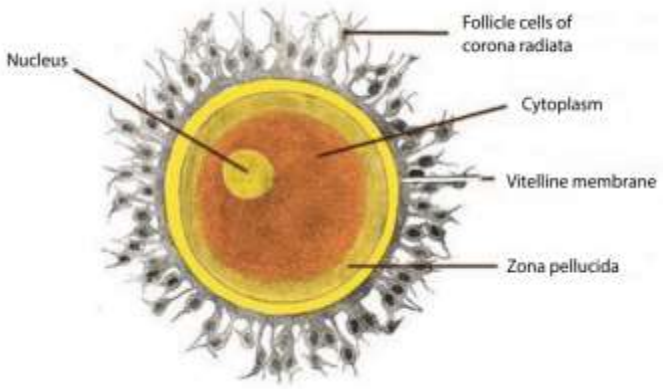
(b) Mention the types of meristematic tissues in dicot plants. Where is each located?

i. Apical meristem. Found at the tips of roots and shoots, facilitating primary growth.
ii. Lateral meristem. Found in the vascular cambium and cork cambium, facilitating secondary growth.
iii. Intercalary meristem. Found at the base of leaves or internodes, aiding regrowth and elongation.

(c) State any four adaptations of xylem tissue to the functions it performs.

i. Xylem vessels are elongated and hollow to facilitate unimpeded water transport.
ii. They are lignified for structural support and to prevent collapse under pressure.
iii. Pits in the walls allow lateral movement of water.
iv. The absence of cytoplasm reduces resistance to water flow.

5. (a) Draw a diagram of a mature mammalian ovum and label its parts.



A mature mammalian ovum, or egg cell, is a spherical structure specialized for reproduction. Its anatomy is designed to support fertilization and subsequent embryonic development.
i. Nucleus. Located centrally, it contains the haploid genetic material (23 chromosomes in humans) necessary for combining with the sperm's DNA during fertilization.

ii. Cytoplasm (ooplasm). The dense, nutrient-rich substance surrounding the nucleus, providing essential materials to support early embryonic development.

iii. Zona pellucida. A glycoprotein-rich extracellular matrix encasing the oocyte, playing a crucial role in species-specific sperm binding and preventing polyspermy by undergoing structural changes after fertilization.

iv. Corona radiata. The innermost layer of cumulus cells adhering to the zona pellucida, supplying vital proteins to the oocyte and facilitating sperm entry during fertilization.

v. Plasma membrane (oolemma). The cell membrane beneath the zona pellucida, regulating the entry of ions and molecules, and undergoing changes post-fertilization to prevent additional sperm from entering.

vi. Cortical granules. Secretory vesicles located just beneath the plasma membrane, releasing their contents upon fertilization to modify the zona pellucida and block polyspermy.
(b) Describe the events which take place during fertilization of a mature mammalian ovum.

i. The sperm binds to the zona pellucida of the ovum.
ii. The acrosome reaction occurs, releasing enzymes that digest the zona pellucida.
iii. The sperm penetrates the ovum membrane, and its nucleus enters the cytoplasm.
iv. The cortical reaction occurs, preventing polyspermy.
v. The nuclei of the sperm and ovum fuse, forming a diploid zygote.

6. (a) Briefly explain why it is important that active transport is employed in the absorption of the end products of digestion.

Active transport is important because it allows the absorption of nutrients against their concentration gradient. This ensures that essential nutrients like glucose, amino acids, and ions are absorbed into the bloodstream even when their concentration is higher in the intestinal cells than in the intestinal lumen. Without active transport, nutrient absorption would be inefficient, especially when nutrient levels in the gut are low.

(b) Elaborate the role of the liver in the digestion and metabolism of the end products of digestion.

The liver plays a critical role in digestion and metabolism:
i. It processes absorbed nutrients, such as converting excess glucose into glycogen for storage.
ii. It produces bile, which emulsifies fats, aiding in their digestion and absorption.
iii. It detoxifies harmful substances, such as converting ammonia into urea.

iv. It metabolizes lipids by synthesizing cholesterol and breaking down fatty acids for energy.
v. It stores vitamins and minerals, such as vitamin A and iron, for future use.

7. (a) Suggest the conditions in which the following may be the limiting factors in photosynthesis.

(i) Light intensity. Low light intensity limits the rate of light-dependent reactions, reducing ATP and NADPH production needed for the Calvin cycle.
(ii) Carbon dioxide concentration. A low concentration of carbon dioxide reduces the substrate availability for RuBisCO, limiting the rate of carbon fixation.
(iii) Temperature. Low temperatures slow down enzyme activity in photosynthesis, while high temperatures may denature enzymes like RuBisCO.

(b) Briefly explain how photorespiration affects the rate of photosynthesis.

Photorespiration reduces the rate of photosynthesis by competing with the Calvin cycle. When oxygen binds to RuBisCO instead of carbon dioxide, the Calvin cycle produces less glucose and releases carbon dioxide. This process wastes energy and reduces overall photosynthetic efficiency, particularly under high oxygen and low carbon dioxide conditions.

8. (a) Justify why a cell is said to be the basic unit of life.

Cells are considered the basic unit of life for several reasons:
Structural Basis: All living organisms are composed of cells, whether unicellular (single-celled) or multicellular. Each cell provides the fundamental structure necessary for life's processes.
Functional Unit: Cells carry out essential functions that define life, such as metabolism, energy production, and waste elimination.
Reproduction: Cells arise from pre-existing cells through processes like mitosis and meiosis, ensuring the continuity of life.
Genetic Information: Cells contain DNA, which holds the genetic blueprint for the organism, guiding development, functioning, and reproduction.

(b) Explain three roles played by each of the following organelles:

(i) Nucleus
Genetic Repository. The nucleus houses the cell's DNA, storing the genetic instructions essential for the development and functioning of the organism.

Transcription Regulation. Within the nucleus, DNA is transcribed into messenger RNA (mRNA), which then exits to the cytoplasm to guide protein synthesis.

Ribosome Production. The nucleolus, a structure within the nucleus, is responsible for assembling ribosomal subunits from ribosomal RNA and proteins.

(ii) Lysosomes

Macromolecule Digestion. Lysosomes contain hydrolytic enzymes that break down proteins, nucleic acids, carbohydrates, and lipids into their basic components.
Autophagy. They degrade damaged or obsolete organelles, recycling their components for cellular use.
Defense Mechanism. Lysosomes can digest pathogens like bacteria and viruses that enter the cell, contributing to the cell's defense system.

(iii) Microtubules
Structural Support. Microtubules form part of the cytoskeleton, maintaining cell shape and providing mechanical support.
Intracellular Transport. They serve as tracks for the movement of organelles and vesicles within the cell, facilitated by motor proteins like kinesin and dynein.
Cell Division. During mitosis and meiosis, microtubules form the mitotic spindle, which segregates chromosomes into daughter cells.

(c) Describe four advantages of membrane-bound organelles.

Compartmentalization Membrane-bound organelles create distinct environments within the cell, allowing specialized functions to occur efficiently without interference.
Increased Surface Area. The membranes of these organelles provide additional surface areas for biochemical reactions, enhancing the cell's metabolic capacity.
Concentration of Substrates and Enzymes. By confining specific molecules within organelles, cells can increase the local concentration of substrates and enzymes, accelerating reaction rates.
Isolation of Harmful Substances. Potentially damaging reactions or by-products can be sequestered within organelles, protecting the rest of the cell. For example, lysosomes contain enzymes that, if released into the cytoplasm, could cause damage.

9. (a) Explain four internal and four external factors affecting transpiration.

Internal Factors:
1. Leaf Surface Area: Larger leaf areas provide more surface for transpiration. Plants can regulate this by adjusting leaf size or shedding leaves.
2. Stomatal Density and Distribution: The number and placement of stomata influence transpiration rates. More stomata allow greater water vapor loss.
3. Cuticle Thickness: A thicker waxy cuticle reduces water loss by providing a barrier to evaporation.
4. Leaf Orientation: Leaves oriented to minimize direct sunlight exposure can reduce transpiration by lowering leaf temperature.

External Factors:

- Temperature: Higher temperatures increase the kinetic energy of water molecules, enhancing evaporation and thus transpiration rates.
- Humidity: Low atmospheric humidity creates a steeper gradient between the moisture inside the leaf and the external environment, increasing transpiration.

- Wind Speed: Wind removes the boundary layer of saturated air around the leaf surface, maintaining a gradient that favors transpiration.
- Light Intensity: Light stimulates stomatal opening to allow carbon dioxide entry for photosynthesis, which also permits water vapor to escape.

(b) Give an account of any five effects of transpiration in plants.

- Cooling: As water evaporates from leaf surfaces, it dissipates heat, helping to regulate plant temperature.
- Nutrient Uptake: Transpiration creates a negative pressure in the xylem, facilitating the upward movement of water and dissolved minerals from the roots.
- Turgor Maintenance: Continuous water flow maintains cell turgor, essential for structural support and growth.
- Stomatal Function: Transpiration influences stomatal behavior, balancing water loss with gas exchange needs for photosynthesis.
- Soil Moisture Depletion: High transpiration rates can reduce soil moisture levels, potentially leading to water stress if not balanced by water uptake.

10. Account for the mechanism of body balance in mammals.

Mammalian body balance, or equilibrium, is primarily maintained by the vestibular system located within the inner ear.
This system comprises three semicircular canals and two otolith organs, the utricle and saccule, which work together to detect rotational movements and linear accelerations, respectively.
The semicircular canals are filled with a fluid called endolymph; as the head moves, this fluid shifts, bending sensory hair cells within the canals. These hair cells then transmit signals to the brain, informing it of the head's motion and orientation.

In addition to the vestibular system, proprioception plays a crucial role in maintaining balance. Proprioception refers to the body's ability to sense its position and movement in space, facilitated by receptors in muscles, tendons, and joints. These receptors provide continuous feedback to the brain about limb position and muscle tension, enabling the coordination of movements and maintenance of posture.
Visual input also significantly contributes to balance by providing the brain with information about the body's position relative to its surroundings. The integration of visual cues with vestibular and proprioceptive information allows for the maintenance of stability and orientation. For instance, the vestibulo-ocular reflex (VOR) stabilizes vision during head movements by producing eye movements in the opposite direction, ensuring a steady gaze.

The central nervous system integrates data from the vestibular system, proprioceptive inputs, and visual cues to generate appropriate motor responses that maintain balance. This integration occurs in various brain regions, including the cerebellum, which fine-tunes movements and postural adjustments, and the brainstem, which mediates reflexive responses. Through this complex interplay, mammals can achieve and maintain balance during various activities.

11. (a) Definition of Oestrus

Oestrus, commonly referred to as "heat," is a phase in the reproductive cycle of female non-primate mammals during which they become sexually receptive and capable of conceiving. This period is characterized by specific hormonal changes that prepare the body for potential mating and pregnancy.

(b) Stages of the Oestrus Cycle
The oestrus cycle comprises four distinct stages:

- Proestrus: During this initial phase, ovarian follicles begin to mature, leading to an increase in estrogen production. The uterine lining starts to thicken in preparation for potential implantation. Females are not yet receptive to males during proestrus.

- Estrus: Also known as "heat," this stage is marked by peak estrogen levels, making the female sexually receptive. Ovulation typically occurs during estrus, allowing for the possibility of fertilization. Behavioral changes, such as increased restlessness and vocalizations, may be observed.

- Metestrus (or Diestrus): Following ovulation, the ruptured follicle transforms into the corpus luteum, which secretes progesterone. This hormone supports the maintenance of the uterine lining. If fertilization does not occur, the corpus luteum regresses, leading to a decline in progesterone levels.

- Anestrus: This is a period of sexual inactivity between oestrus cycles. During anestrus, the reproductive system undergoes rest and repair. The duration of anestrus varies among species and can be influenced by factors such as season, health, and environmental conditions.

(c) Significance of Oestrus

The oestrus cycle plays a crucial role in the reproductive success of many mammalian species. By synchronizing mating behavior with ovulation, it ensures that sexual activity occurs when the chances of conception are highest. This synchronization enhances reproductive efficiency and increases the likelihood of species survival.

(d) Distinction Between Oestrus Cycle and Menstrual Cycle

The oestrus cycle and the menstrual cycle are both reproductive cycles but differ in several key aspects:

Occurrence: The oestrus cycle is typical in non-primate mammals, such as dogs, cats, and cattle, whereas the menstrual cycle occurs in primates, including humans.

Endometrial Shedding: In the menstrual cycle, if fertilization does not occur, the uterine lining (endometrium) is shed through menstruation. In contrast, during the oestrus cycle, the endometrium is usually reabsorbed by the body if conception does not take place.

Sexual Receptivity: Females with an oestrus cycle are only sexually receptive during the estrus phase ("heat"), aligning with ovulation. In species with a menstrual cycle, females can engage in sexual activity throughout the cycle, regardless of fertility status.