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: 2001**

Instructions:

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

1. (a) Distinguish between structural and functional proteins.

Proteins are essential macromolecules that perform a wide array of functions within living organisms. They can be broadly categorized into structural and functional proteins based on their roles:

Structural Proteins: These proteins provide support, strength, and protection to cells and tissues. They are typically fibrous and insoluble, forming the framework of various biological structures. Examples include:
Collagen: A primary component of connective tissues such as skin, tendons, and bones, offering tensile strength.
Keratin: Found in hair, nails, and the outer layer of skin, providing rigidity and protection.

Functional Proteins: Also known as globular proteins, these molecules are involved in dynamic processes within organisms. They are generally soluble and have specific binding sites that allow them to interact with other molecules. Examples include:
Enzymes: Catalysts that accelerate biochemical reactions, such as amylase, which aids in starch digestion.
Hemoglobin: A transport protein in red blood cells that carries oxygen from the lungs to tissues.
Antibodies: Proteins of the immune system that identify and neutralize foreign pathogens.

(b) Draw a large diagram of a typical plant cell as seen under the electron microscope. Indicate, using the letters below, the cellular structures concerned with:

Nucleus: Contains the cell's genetic material and regulates activities such as growth and reproduction.
Mitochondria: Sites of cellular respiration, generating ATP through the breakdown of organic molecules.

Chloroplasts: Organelles where photosynthesis occurs, converting light energy into chemical energy stored in glucose.

Rough Endoplasmic Reticulum (RER): Studded with ribosomes; involved in the synthesis and initial modification of proteins destined for secretion or membrane insertion.

Smooth Endoplasmic Reticulum (SER): Lacks ribosomes; involved in lipid and steroid synthesis, as well as detoxification processes.

Golgi Apparatus: Modifies, sorts, and packages proteins and lipids for storage or transport out of the cell.

Plasma Membrane: Semi-permeable barrier that controls the exchange of substances between the cell and its environment.

Cell Wall: Provides structural support and protection; composed mainly of cellulose.
Plasmodesmata: Channels between adjacent plant cells that allow for the transport of materials and communication.

Centrosome (Microtubule Organizing Center): Involved in organizing microtubules and regulating the cell cycle, including cell division.

(c) What are the possible roles of the cell wall?

The cell wall is a rigid layer that surrounds the plasma membrane of plant cells, providing several essential functions:

Structural Support: Maintains the shape of the cell and prevents it from bursting under osmotic pressure.

Protection: Acts as a barrier against mechanical injury and pathogens.

Regulation of Growth: Controls the direction of cell growth and expansion by constraining the cell's volume.

Transport Regulation: Contains pores (plasmodesmata) that facilitate the movement of water, nutrients, and signaling molecules between cells.

Storage: Houses carbohydrates that can be used as energy sources.

Communication: Participates in cell signaling processes, helping the plant respond to environmental changes.

2. Outline the distinctive features of the various divisions of the plant kingdom. How are the members of the division to which a bean plant belongs adapted to terrestrial life?

The plant kingdom is categorized into several divisions, each characterized by unique features related to their morphology, reproduction, and adaptation strategies. Below is an overview of these divisions:

Bryophyta (Mosses):
Structure: Non-vascular, small, and simple plants lacking true roots, stems, and leaves.
Reproduction: Depend on water for fertilization; produce spores instead of seeds.
Habitat: Typically found in moist environments due to their reliance on water for reproduction.

ii. Pteridophyta (Ferns):
Structure: Vascular plants with true roots, stems, and leaves (fronds).
Reproduction: Produce spores on the undersides of fronds; require water for fertilization.
Habitat: Commonly inhabit shaded, moist areas.

iii. Gymnospermae (Gymnosperms):
Structure: Vascular plants with needle-like or scale-like leaves; possess woody stems.
Reproduction: Produce naked seeds not enclosed in fruits; typically bear cones.
Examples: Conifers like pines and spruces.

iv. Angiospermae (Angiosperms):
Structure: Vascular plants with a wide variety of forms, including herbaceous and woody species.
Reproduction: Produce flowers and seeds enclosed within fruits.

Examples: Flowering plants such as roses, grasses, and bean plants.

Bean plants (Phaseolus species) belong to the division Angiospermae. Members of this division have developed several adaptations to thrive in terrestrial environments:
Vascular Tissue: The presence of xylem and phloem facilitates efficient transport of water, nutrients, and photosynthates throughout the plant, supporting growth and development.
Root Systems: Well-developed root systems anchor the plant and absorb water and minerals from the soil.
Cuticle: A waxy layer covering aerial parts reduces water loss through evaporation.
Stomata: Pores on leaf surfaces regulate gas exchange and transpiration, aiding in photosynthesis and water conservation.
Seeds Enclosed in Fruits: The development of seeds within fruits protects the embryonic plant and aids in dispersal mechanisms, enhancing reproductive success.

3. Describe the mode of action of a neurotransmitter at a synapse, including how it is stored and destroyed.

Neurotransmitters are chemical messengers that facilitate communication between neurons at specialized junctions called synapses. The process of neurotransmission involves several key steps:

I. Synthesis and Storage:
Neurotransmitters are synthesized within the neuron, often in the cell body or axon terminal, from precursor molecules. Once synthesized, they are stored in synaptic vesicles—membrane-bound compartments located in the presynaptic terminal. This storage ensures that neurotransmitters are readily available for release upon neuronal activation.

II. Release:
When an action potential (an electrical impulse) reaches the presynaptic terminal, it causes the opening of voltage-gated calcium channels. The influx of calcium ions triggers the fusion of synaptic vesicles with the presynaptic membrane, leading to the release of neurotransmitters into the synaptic cleft—a process known as exocytosis.
III. Binding to Receptors:
The released neurotransmitters diffuse across the synaptic cleft and bind to specific receptors on the postsynaptic membrane. This binding can result in either excitation or inhibition of the postsynaptic neuron, depending on the type of neurotransmitter and receptor involved.

IV. Termination of Signal:
To prevent continuous activation of the postsynaptic neuron, neurotransmitter action must be terminated. This is achieved through several mechanisms:

Reuptake: Specialized transporter proteins on the presynaptic membrane reabsorb neurotransmitters from the synaptic cleft, allowing them to be repackaged into vesicles for future use.
Enzymatic Degradation: Enzymes present in the synaptic cleft break down neurotransmitters into inactive components. For example, acetylcholine is hydrolyzed by acetylcholinesterase into acetate and choline.
Diffusion: Some neurotransmitter molecules simply diffuse away from the synaptic cleft and are eventually metabolized elsewhere.

4. Discuss the sensory and hormonal control of secretions of the digestive system in humans.

The human digestive system's secretions are meticulously regulated through both neural (sensory) and hormonal mechanisms to ensure efficient digestion and nutrient absorption.
Neural Regulation:
The nervous system modulates digestive secretions via the enteric nervous system (ENS) and autonomic nervous system (ANS):
Enteric Nervous System (ENS): Often termed the "second brain," the ENS operates independently within the gastrointestinal tract. It manages local reflexes that adjust enzyme secretion and peristalsis in response to the presence of food.
Autonomic Nervous System (ANS): The ANS, comprising the sympathetic and parasympathetic branches, influences digestive activities. The parasympathetic nervous system, primarily through the vagus nerve, enhances digestive secretions and motility. In contrast, sympathetic activation generally suppresses these processes.
Hormonal Regulation:
Several hormones play pivotal roles in controlling digestive secretions:
Gastrin: Produced by G-cells in the stomach lining, gastrin stimulates the secretion of gastric acid (HCl) in response to food intake, aiding protein digestion.
Secretin: Released by the small intestine's S-cells when acidic chyme enters from the stomach, secretin prompts the pancreas to secrete bicarbonate-rich fluid, neutralizing the acid.
Cholecystokinin (CCK): Also secreted by the small intestine, CCK responds to fats and proteins by stimulating the gallbladder to release bile and the pancreas to secrete digestive enzymes.
Gastric Inhibitory Peptide (GIP): This hormone inhibits gastric acid secretion and slows gastric emptying when fats and carbohydrates are present in the small intestine.

5. Describe how various factors help to maintain a constant body temperature in a mammal, irrespective of environmental changes.

Mammals maintain a stable internal body temperature through a combination of physiological and behavioral mechanisms, collectively known as thermoregulation.

Physiological Mechanisms:
Hypothalamic Regulation: The hypothalamus acts as the body's thermostat, receiving input from thermoreceptors and initiating responses to temperature deviations.

Vasodilation and Vasoconstriction: In response to heat, blood vessels near the skin surface dilate (vasodilation), increasing heat loss. Conversely, in cold conditions, they constrict (vasoconstriction) to conserve heat.
Sweating and Panting: To dissipate excess heat, mammals employ evaporative cooling mechanisms like sweating and panting.
Shivering and Non-Shivering Thermogenesis: In cold environments, shivering generates heat through muscle activity, while non-shivering thermogenesis, particularly in brown adipose tissue, produces heat via metabolic processes.

Behavioral Mechanisms:
Seeking Shelter: Mammals may seek shade or burrows to avoid temperature extremes.
Adjusting Activity Levels: Altering activity patterns, such as being nocturnal in hot climates, helps regulate body temperature.
Huddling: Social animals may huddle together to conserve warmth in cold conditions.

6. (a) Distinguish between oestrus and menstrual cycles.
The oestrus and menstrual cycles are reproductive cycles observed in female mammals, each with distinct characteristics:

I. Oestrus Cycle:
Occurrence: Found in non-primate mammals such as dogs, cats, cows, and horses.
Phases: Includes proestrus, oestrus, metoestrus, and dioestrus.
Sexual Receptivity: Females are receptive to mating only during the oestrus phase, commonly referred to as "heat."
Endometrial Shedding: The endometrium (uterine lining) is reabsorbed if fertilization does not occur; visible bleeding is minimal or absent.
Cycle Frequency: Varies among species; for example, dogs typically have two cycles per year, while rodents may have cycles every few days.

II. Menstrual Cycle:
Occurrence: Primarily observed in primates, including humans.
Phases: Consists of the follicular (proliferative), ovulatory, and luteal (secretory) phases.
Sexual Receptivity: Females can be sexually receptive throughout the cycle, not limited to a specific phase.
Endometrial Shedding: If fertilization does not occur, the endometrium is shed through menstruation, resulting in noticeable bleeding.
Cycle Frequency: Typically occurs every 28 days, though it can range from 21 to 35 days in humans.
(b) Discuss the hormonal interactions involved in the control of the menstrual cycle in human females.
The menstrual cycle is regulated by a complex interplay of hormones produced by the hypothalamus, pituitary gland, and ovaries. This hormonal regulation ensures the proper timing of ovulation and preparation of the uterus for potential pregnancy. The cycle can be divided into several phases, each characterized by specific hormonal changes:

I. Follicular (Proliferative) Phase:
Gonadotropin-Releasing Hormone (GnRH): Secreted by the hypothalamus, GnRH stimulates the anterior pituitary gland to release follicle-stimulating hormone (FSH) and luteinizing hormone (LH).
Follicle-Stimulating Hormone (FSH): Promotes the growth and maturation of ovarian follicles. As follicles develop, they produce estrogen.
Estrogen: Rising estrogen levels stimulate the thickening of the endometrial lining in the uterus, preparing it for potential implantation. High estrogen levels also exert negative feedback on FSH production to prevent the maturation of additional follicles.

II. Ovulatory Phase:
Luteinizing Hormone (LH) Surge: A significant increase in estrogen levels leads to a positive feedback mechanism, causing a surge in LH secretion. This LH surge triggers the release of a mature egg from the dominant follicle, a process known as ovulation.
III. Luteal (Secretory) Phase:

Corpus Luteum Formation: After ovulation, the ruptured follicle transforms into the corpus luteum, which secretes progesterone and some estrogen.
Progesterone: Maintains and further enhances the endometrial lining, making it receptive to a fertilized egg. It also inhibits GnRH, FSH, and LH production to prevent additional ovulations during this cycle.

IV. Menstruation:

Decline in Hormones: If fertilization does not occur, the corpus luteum degenerates, leading to a decrease in progesterone and estrogen levels. This hormonal decline causes the shedding of the endometrial lining, resulting in menstruation. The reduced hormone levels also remove the inhibitory feedback on GnRH, allowing the cycle to begin anew.

(c) In what ways is menstruation prevented if pregnancy occurs?

If fertilization and implantation occur, the body initiates several mechanisms to prevent menstruation and support the developing embryo:

I. Human Chorionic Gonadotropin (hCG):
The developing placenta produces hCG, which maintains the corpus luteum, ensuring continued production of progesterone and estrogen. These hormones keep the endometrial lining intact and prevent menstruation.

II. Placental Hormone Production:
As pregnancy progresses, the placenta itself becomes the primary source of progesterone and estrogen, sustaining the uterine lining and inhibiting the menstrual cycle throughout gestation.

These hormonal adaptations are crucial for maintaining the uterine environment necessary for fetal development.

7. Identify and describe the vascular tissue in plants and explain how it is adapted for transport of materials.

Vascular tissue in plants consists of specialized conducting structures that facilitate the transport of water, minerals, and nutrients throughout the organism. The two primary vascular tissues are xylem and phloem.
I. Xylem

Function: Transports water and dissolved minerals from the roots to the leaves and other aerial parts of the plant.
Structure: Consists of dead, lignified cells at maturity, including tracheids and vessel elements.

Adaptations:
Tracheids: Long, tapered cells with thick walls and pits that allow water to move laterally between adjacent cells.
Vessel Elements: Shorter, wider cells stacked end to end, forming continuous tubes (vessels) that facilitate efficient water flow.
Lignification: Cell walls are reinforced with lignin, providing structural support and preventing collapse under the tension created by water transport.
Capillary Action and Transpiration Pull: The cohesion-tension mechanism ensures a continuous flow of water from the roots to the leaves.

II. Phloem

Function: Transports organic nutrients, mainly sucrose, from the leaves to other parts of the plant (translocation).
Structure: Consists of living cells, including sieve tube elements and companion cells.

Adaptations:
Sieve Tube Elements: Elongated cells with perforated sieve plates that allow the movement of sap. They lack nuclei to facilitate efficient transport.
Companion Cells: Support sieve tube elements by providing energy and assisting in nutrient loading and unloading.

Bidirectional Flow:
Phloem transports food both upwards and downwards, depending on the plant's needs.
Pressure Flow Mechanism: Osmotic pressure differences between source (leaves) and sink (roots, fruits, or storage organs) drive the movement of nutrients.

8. (a) Explain how a quadrat can be used to estimate population size with respect to the three aspects of species distribution, namely, species density, species frequency, and species cover.

A quadrat is a square frame of known dimensions used in ecological studies to sample and estimate population size and species distribution in a given habitat. It is particularly useful for immobile or slow-moving organisms like plants and sessile animals. The quadrat method provides estimates for species density, species frequency, and species cover.

I. Species Density

Definition: Species density refers to the number of individuals of a particular species per unit area.

Method:
A quadrat of known size (e.g., $1m^2$) is placed randomly or systematically within the study area.
The number of individuals of the species within the quadrat is counted.

Density is calculated using the formula:
Species Density = Total number of individuals counted / Total area sampled

Significance: Species density provides an estimate of population abundance in a given habitat.

II. Species Frequency

Definition: Species frequency refers to the proportion of quadrats in which a particular species is present, expressed as a percentage.

Method:
Multiple quadrats are placed at random locations within the habitat.
The number of quadrats in which the species appears is recorded.

Frequency is calculated using the formula:

Species Frequency (%) = (Number of quadrats with the species / Total number of quadrats) × 100
Significance: Species frequency indicates how widely a species is distributed in the habitat.

III. Species Cover
Definition: Species cover refers to the percentage of ground area covered by a particular species within a quadrat.
Method:
The proportion of the quadrat covered by the species is visually estimated and recorded.
The cover percentage is calculated based on observed coverage.

Significance: Species cover provides information about the dominance of a species and its contribution to the ecosystem structure.

By combining these three measures, ecologists can assess population distribution patterns, detect environmental changes, and make informed conservation decisions.

(b) In an attempt to estimate the number of grasshoppers in a secluded area, 775 grasshoppers were netted, marked, and released. On the second day, 1023 grasshoppers were netted, and of these, 279 had been marked. What was the estimated size of the grasshopper population?

Solution

□The population size can be estimated using the Lincoln-Petersen Index:

Estimated Population (N) = (M × C) / R

Where:
M = Number of grasshoppers initially marked and released (775)
C = Total number of grasshoppers caught in the second sample (1023)
R = Number of marked grasshoppers recaptured in the second sample (279)

Substituting the values:

N = (775 × 1023) / 279

The estimated population size of the grasshoppers in the secluded area is approximately 2842 (rounded to the nearest whole number).