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: 2015**

Instructions:

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

1. (a) Give five reasons to justify the kingdom to which Agaricus belongs.

Agaricus is a genus of fungi, and its classification within the Kingdom Fungi is supported by the following characteristics:

(i) Eukaryotic Cells: Members of Agaricus possess cells with a true nucleus and membrane-bound organelles, a defining feature of eukaryotes.

(ii) Chitinous Cell Walls: The cell walls of Agaricus species are composed of chitin, distinguishing them from plants, which have cellulose-based cell walls.

(iii) Heterotrophic Nutrition: Agaricus fungi obtain nutrients through the decomposition of organic matter, absorbing nutrients from their environment, unlike autotrophic organisms that produce their own food.

(iv) Spore Production: Reproduction in Agaricus occurs via the production of spores, a common reproductive strategy among fungi.

(v) Mycelial Growth: Agaricus species develop a network of hyphae called mycelium, which infiltrates the substrate to absorb nutrients, a characteristic growth form of fungi.

(b) With examples, explain five advantages of kingdom Plantae to human beings.

The Kingdom Plantae provides numerous benefits to humans, including:

(i) Food Source: Plants are primary producers in the food chain, supplying fruits, vegetables, grains, and legumes essential for human nutrition. For example, rice (Oryza sativa) and wheat (Triticum aestivum) are staple crops consumed worldwide.

(ii) Oxygen Production: Through photosynthesis, plants release oxygen into the atmosphere, which is vital for human respiration. Forests, such as the Amazon rainforest, play a significant role in maintaining atmospheric oxygen levels.

(iii) Medicinal Resources: Many plants have medicinal properties and are used in traditional and modern medicine. For instance, the willow tree (Salix spp.) is the natural source of salicin, which led to the development of aspirin.

(iv) Raw Materials: Plants provide materials like timber for construction, fibers for textiles (e.g., cotton from Gossypium species), and rubber from the rubber tree (Hevea brasiliensis), supporting various industries.

(v) Environmental Benefits: Plants help in soil conservation by preventing erosion through root systems and contribute to the water cycle by transpiring water vapor, influencing climate patterns.

2. (a) (i) Identify divisions of the kingdom Plantae.

The Kingdom Plantae is divided into several divisions, including:

- Bryophyta
- Pteridophyta
- Coniferophyta
- Anthophyta (Angiosperms)

(ii) State three general characteristics of each division identified in 2(a)(i).

- Bryophyta:
  Non-vascular plants lacking true xylem and phloem.
  Reproduce via spores instead of seeds.
  Exhibit a dominant gametophyte generation in their life cycle.

- Pteridophyta:
  Vascular plants possessing xylem and phloem tissues.
  Reproduce through spores, not seeds.
  Display a dominant sporophyte generation in their life cycle.

- Coniferophyta:
  Vascular plants with needle-like or scale-like leaves.
  Produce seeds within cones (conifers).
  Generally evergreen, retaining leaves throughout the year.

- Anthophyta (Angiosperms):
  Vascular plants that produce flowers.
  Seeds are enclosed within fruits.
  Exhibit a wide range of forms and habitats, representing the largest plant division.

(b) Draw the structure of a moss plant and show sporophyte and gametophyte generations.

Gametophyte Generation: This is the dominant, green, leafy part of the moss plant. It anchors to the substrate using rhizoids (root-like structures) and is responsible for sexual reproduction.

Sporophyte Generation: Arising from the gametophyte, the sporophyte consists of a slender stalk (seta) topped with a capsule (sporangium) where spores are produced. The sporophyte is dependent on the gametophyte for nutrients.

3. Explain four common disorders of the urinary system in humans, their causes, and symptoms.

The human urinary system is susceptible to various disorders that can affect its function and overall health. Four common disorders include:

(i) Urinary Tract Infections (UTIs):
Causes: UTIs are typically caused by bacteria, most commonly Escherichia coli, entering the urinary tract through the urethra. Factors such as poor hygiene, sexual activity, and urinary retention can increase the risk.
Symptoms: Common symptoms include a strong, persistent urge to urinate, a burning sensation during urination, cloudy or strong-smelling urine, and pelvic pain. In some cases, there may be blood in the urine.

(ii) Kidney Stones:
Causes: Kidney stones form when minerals and salts in the urine crystallize, often due to dehydration, certain diets, obesity, or genetic factors. These stones can vary in size and may cause blockages in the urinary tract.
Symptoms: Symptoms include severe pain in the side and back, below the ribs, pain that radiates to the lower abdomen and groin, fluctuating pain intensity, painful urination, pink, red, or brown urine, nausea, vomiting, and frequent urination.
(iii) Benign Prostatic Hyperplasia (BPH):
Causes: BPH is a non-cancerous enlargement of the prostate gland in men, commonly associated with aging. The exact cause is not well understood but may involve hormonal changes.
Symptoms: Symptoms include frequent or urgent need to urinate, increased frequency of urination at night (nocturia), difficulty starting urination, weak urine stream, or a stream that stops and starts, and inability to completely empty the bladder.

(iv) Urinary Incontinence:
Causes: Urinary incontinence can result from weakened or overactive bladder muscles, nerve damage, certain medications, or conditions such as pregnancy, childbirth, and menopause in women, or prostate problems in men.
Symptoms: The primary symptom is the unintentional leakage of urine. This can range from occasional leaks when coughing or sneezing (stress incontinence) to a sudden, intense urge to urinate followed by involuntary loss of urine (urge incontinence).

4. (a) Describe five general roles of the liver in the mammalian body.

The liver is a vital organ in mammals, performing numerous essential functions to maintain overall health and homeostasis. Five key roles include:

(i) Detoxification and Metabolism of Toxins:

Prepared by: Maria Marco for TETEA

The liver filters and detoxifies blood, metabolizing drugs, alcohol, and environmental toxins into less harmful substances for excretion. This process protects the body from potential harm caused by these compounds.

(ii) Synthesis of Plasma Proteins:
The liver synthesizes vital plasma proteins, including albumin, which maintains blood osmotic pressure, and clotting factors necessary for blood coagulation. These proteins are crucial for maintaining fluid balance and preventing excessive bleeding.

(iii) Bile Production and Secretion:
The liver produces bile, a fluid that aids in the digestion and absorption of dietary fats. Bile is stored in the gallbladder and released into the small intestine during digestion, facilitating the emulsification of fats.

(iv) Regulation of Blood Glucose Levels:
The liver helps maintain blood sugar levels by storing glucose as glycogen and releasing it into the bloodstream when needed. This process ensures a steady supply of energy to the body, particularly between meals.

(v) Storage of Vitamins and Minerals:
The liver stores essential nutrients, including vitamins A, D, E, K, and B12, as well as minerals like iron and copper. These stored nutrients are released into the bloodstream as needed, supporting various physiological functions.

(b) Explain how urea is formed in the mammalian liver.
Urea formation in the mammalian liver occurs through the urea cycle, also known as the ornithine cycle.

This metabolic pathway converts toxic ammonia, produced from the breakdown of amino acids, into urea, which is less toxic and can be safely excreted by the kidneys. The process involves the following steps:

1. Ammonia Production: When proteins are metabolized, amino acids are deaminated, releasing ammonia.
2. Carbamoyl Phosphate Formation: Ammonia combines with carbon dioxide in the mitochondria of liver cells to form carbamoyl phosphate, catalyzed by the enzyme carbamoyl phosphate synthetase I.
3. Citrulline Synthesis: Carbamoyl phosphate enters the urea cycle and combines with ornithine to form citrulline, facilitated by the enzyme ornithine transcarbamylase.
4. Argininosuccinate Formation: Citrulline moves to the cytosol, where it combines with aspartate to form argininosuccinate, catalyzed by argininosuccinate synthetase.
5. Arginine Production: Argininosuccinate is then cleaved by argininosuccinate lyase to produce arginine and fumarate.
6. Urea Formation: Finally, arginine is hydrolyzed by arginase to release urea and regenerate ornithine, which re-enters the cycle.

The urea produced is then transported to the kidneys via the bloodstream, where it is excreted in the urine, effectively removing excess nitrogen from the body.

5. Figure 1 shows a typical cell cycle of higher plants and animals. Identify five events which take place in each stage indicated by letters G1, S, G2, and M respectively.

G1 Phase (Gap 1):

i. The cell increases in size by synthesizing cytoplasmic organelles and proteins.

ii. RNA synthesis is at its peak to prepare for DNA replication.

iii. The cell performs its normal metabolic activities.

iv. The cell checks for any DNA damage from the previous cycle.

v. Preparation for the S phase begins by synthesizing replication enzymes.

S Phase (Synthesis).

i. DNA replication occurs, resulting in two identical copies of the genetic material.

ii. Histone proteins are synthesized to package the DNA into chromosomes.

iii. Chromosomes are converted into their sister chromatids state, connected at the centromere.

iv. The centrosome is duplicated, preparing for spindle formation.

v. The cell ensures accurate copying of genetic material to maintain genetic integrity.

G2 Phase (Gap 2).

i. The cell continues to grow in size to prepare for division.

ii. Synthesis of proteins, such as tubulin, required for spindle fiber formation.

iii. Energy reserves like ATP are accumulated for mitotic processes.

iv. Final checks are conducted to ensure DNA replication is error-free.

v. The mitotic spindle apparatus begins to form.

M Phase (Mitosis):

i. Prophase. Chromatin condenses into visible chromosomes, and the nuclear membrane breaks down.

ii. Metaphase. Chromosomes align at the metaphase plate.

iii. Anaphase. Sister chromatids are separated and pulled to opposite poles of the cell by spindle fibers.

iv. Telophase. Chromosomes de-condense, nuclear envelopes reform, and two nuclei are formed.

v. Cytokinesis occurs, dividing the cytoplasm and resulting in two genetically identical daughter cells.

6. (a) Give five differences between mitosis and meiosis.

Mitosis and meiosis are two distinct types of cell division processes in living organisms. They differ in several key aspects:

(i) Purpose:

Mitosis: Facilitates growth, tissue repair, and asexual reproduction by producing identical cells.

Meiosis: Generates gametes (sperm and eggs) for sexual reproduction, ensuring genetic diversity.

(ii) Number of Divisions:

Mitosis: Involves one division, resulting in two daughter cells.

Meiosis: Comprises two consecutive divisions (meiosis I and meiosis II), yielding four daughter cells.

(iii) Chromosome Number in Daughter Cells:
Mitosis: Daughter cells retain the same chromosome number as the parent cell (diploid).
Meiosis: Daughter cells possess half the chromosome number of the parent cell (haploid).

(iv) Genetic Variation:
Mitosis: Produces genetically identical daughter cells.
Meiosis: Generates genetically diverse daughter cells through processes like crossing over.

(v) Pairing of Homologous Chromosomes:
Mitosis: Homologous chromosomes do not pair during cell division.
Meiosis: Homologous chromosomes pair up during prophase I, facilitating genetic recombination.

(b) Analyze five significances of mitosis in living organisms.

Mitosis plays a crucial role in the life of multicellular organisms through the following functions:
(i) Growth:
Mitosis enables organisms to grow by increasing the number of cells, allowing a single fertilized egg to develop into a complex multicellular organism.
(ii) Tissue Repair and Regeneration:
Through mitosis, damaged or worn-out cells are replaced, maintaining tissue integrity and function.
(iii) Asexual Reproduction:
In certain organisms, mitosis serves as a means of asexual reproduction, producing offspring genetically identical to the parent.
(iv) Maintenance of Chromosome Number:
Mitosis ensures that each daughter cell receives an exact copy of the parent cell's chromosomes, preserving the species-specific chromosome number.

(v) Developmental Processes:
Mitosis is fundamental in developmental processes, such as embryogenesis, where it drives the formation of various tissues and organs from a single cell.

7. A homozygous purple-flowered short-stemmed plant was crossed with a homozygous red-flowered long-stemmed plant, and the F1 phenotypes had purple flowers and short stems. When the F1 was test crossed with a double homozygous recessive progeny, the following results were obtained:
- 52 purple flowers, short stem
- 47 purple flowers, long stem
- 49 red flowers, short stem
- 45 red flowers, long stem

(a) Which characters were dominant and why?

i. Purple flower color is dominant over red flower color.

This conclusion is based on the F1 offspring all having purple flowers despite one parent being homozygous for red flowers. The purple allele masks the expression of the red allele.

ii. Short stem is dominant over long stem.
This is evident because all the F1 offspring exhibited short stems even though one parent was homozygous for long stems. The allele for short stem is dominant and suppresses the long stem allele.

(b) Carry out crosses to show the formation of F1 and F2.

F1 Generation
Parental Genotypes:
- Purple flower, short stem: PPSS
- Red flower, long stem: ppss

Gametes from Parents:
- Parent 1: PS
- Parent 2: ps

Cross:

	ps	ps	ps	ps
PS	PpSs	PpSs	PpSs	PpSs
PS	PpSs	PpSs	PpSs	PpSs

- F1 Genotype:
100% PpSs (Heterozygous for both traits).
- F1 Phenotype:
100% Purple flowers, short stems.

F2 Generation (Test Cross)

-F1 Genotype: PpSs
Test Cross Parent Genotype: ppss

-F1 Gametes: PS, Ps, pS, ps
Test Cross Gametes: ps

Cross:

	ps	ps	ps	ps
PS	PpSs	PpSs	PpSs	PpSs
Ps	Ppss	Ppss	Ppss	Ppss
pS	ppSs	ppSs	ppSs	ppSs
ps	ppss	ppss	ppss	ppss

Phenotypic Ratio:
i. Purple flowers, short stem: 52
ii. Purple flowers, long stem: 47
iii. Red flowers, short stem: 49
iv. Red flowers, long stem: 45

Explanation:
This 1:1:1:1 ratio confirms that the traits assort independently during meiosis, following Mendel's law of independent assortment.

Each phenotype results from a unique combination of dominant and recessive alleles for flower color and stem length.

8. Interpret ecological pyramids and state three limitations of each.
Ecological pyramids are graphical representations that illustrate the relationship between different trophic levels in an ecosystem. They provide insights into the structure and function of ecological communities. There are three primary types of ecological pyramids:

(i) Pyramid of Numbers:
Interpretation: This pyramid displays the number of individual organisms at each trophic level. Typically, it is upright, with a broad base representing numerous producers and narrowing at higher trophic levels. However, in certain ecosystems, such as forests, it can be inverted; for example, a single tree (producer) supports numerous herbivores like insects.

Limitations:
- Size Discrepancies: It does not account for the size of organisms; thus, a large number of small organisms may appear more significant than a few large ones.
- Inverted Structures: In ecosystems where a few large producers support many smaller consumers, the pyramid can be inverted, misrepresenting energy flow.
- Complex Food Webs: It oversimplifies complex food webs by assuming each organism occupies only one trophic level, ignoring omnivores and species that feed at multiple levels.

(ii) Pyramid of Biomass:
Interpretation: This pyramid illustrates the total biomass (the mass of living organisms) at each trophic level. It is usually upright, indicating a decrease in biomass at successive higher levels. However, in aquatic ecosystems, it can be inverted; for instance, the biomass of phytoplankton (producers) is less than that of zooplankton (primary consumers) due to rapid reproduction and turnover rates.
Limitations:

- Inverted Pyramids: In certain ecosystems, especially aquatic ones, the pyramid can be inverted, which may misrepresent the actual energy dynamics.
- Temporal Variations: It provides a snapshot in time and may not reflect seasonal or temporal changes in biomass.
- Dry Weight Measurement: Measuring biomass often involves drying organisms to obtain dry weight, which can be destructive and may not account for water content vital to living organisms.

(iii) Pyramid of Energy:
Interpretation: This pyramid represents the flow of energy through each trophic level over a specific period, measured in units such as kilocalories per square meter per year. It is always upright, as energy decreases at each successive trophic level due to the second law of thermodynamics.

Limitations:

- Data Collection Challenges: Accurately measuring the energy intake and expenditure of organisms is complex and labor-intensive.
- Temporal Variability: Energy flow can vary seasonally, and a single measurement may not capture these fluctuations.
- Exclusion of Decomposers: Like other pyramids, it often excludes decomposers, which play a crucial role in energy flow and nutrient cycling.

In summary, while ecological pyramids are valuable tools for understanding ecosystem structure and function, they have inherent limitations that can lead to oversimplification or misrepresentation of complex ecological dynamics.