

**TR JOELPCM ACADEMIC COUNCIL****0788477510****SENIOR FIVE (S5) — END OF TERM ONE EXAMINATION****BIOLOGY — PAPER 1 (THEORY)**

Time Allowed: 3 Hours

**FOR EXAMINER'S USE:**

Section A	Section B Part I	Section B Part II	TOTAL
40	20	20	80
<i>Score</i>			

<b>SUBJECT:</b> BIOLOGY <b>PAPER:</b> 1 (THEORY) <b>LEVEL:</b> ADVANCED SECONDARY — S5	<b>TERM:</b> END OF TERM ONE <b>DURATION:</b> 3 HOURS <b>SET BY:</b> TR JOELPCM ACADEMIC COUNCIL
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**INSTRUCTIONS TO CANDIDATES**

1. This paper consists of two Sections: A and B.
2. Answer ALL items in Section A.
3. In Section B, answer ONE item from Part I and ONE item from Part II.
4. All items are scenario-based. Read each scenario carefully before answering.
5. Write your answers in the spaces provided or in the answer booklet given.
6. All working must be clearly shown where applicable.
7. Unnecessary repetition of the scenario will not earn marks.

**SECTION A**

*Answer ALL items in this section. Each item carries 20 marks. (Total: 40 marks)*

**ITEM 1 (Construct 1 — Cellular Organisation, Respiration and Molecular Analysis)**

*Mulago National Referral Hospital has a biomedical research unit investigating a rare metabolic disorder that affects young patients. Doctors referred a 14-year-old patient whose symptoms include extreme fatigue, muscle weakness, and an inability to metabolise food normally. Laboratory scientists prepared electron micrographs of liver cells sampled from the patient and from a healthy individual. The micrographs*

revealed that the patient's liver cells had abnormally swollen mitochondria with disrupted cristae, an unusually enlarged rough endoplasmic reticulum, and a greater-than-normal number of lysosomes. Biochemical tests on blood samples also revealed abnormally low levels of phospholipids and an elevated concentration of undigested intracellular materials.

You are part of the biomedical research team tasked with investigating this patient's condition.

**Task:**

- (a) Using your knowledge of cell ultrastructure, explain how disruption of the cristae in the mitochondria would account for the symptoms of fatigue and muscle weakness in the patient. **(7 marks)**
- (b) Account for the significance of each of the following organelles in the normal functioning of liver cells, relating their structure to function: **(10 marks)**
- (i) Rough endoplasmic reticulum **(3 marks)**
  - (ii) Golgi apparatus **(3 marks)**
  - (iii) Lysosomes, and explain why their increased number in the patient's cells is significant. **(3 marks)**
- (c) Phospholipids are among the chemicals of life critical to cell structure and function. Describe the molecular structure of a phospholipid and explain how its properties make it suitable as the main component of the cell membrane. **(4 marks)**

**Total: 20 marks**

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**ITEM 2 (Construct 2 — Plant Physiology and Adaptation)**

*Agricultural researchers at the National Crops Resources Research Institute (NaCRRI) in Namulonge set up a controlled experiment to investigate the effect of mineral deficiencies on crop productivity. Tomato seedlings of the same variety were grown in three groups of culture solutions for six weeks: Group A received a complete nutrient solution containing all essential mineral ions; Group B received a solution deficient in magnesium ions only; and Group C received a solution deficient in nitrate ions only. At the end of the experiment, Group A plants were tall, deep green, and produced numerous healthy flowers. Group B plants showed yellowing between leaf veins (interveinal chlorosis) especially on older leaves, and produced fewer flowers. Group C plants were stunted with pale yellow leaves throughout and produced no flowers.*

*You are a plant scientist advising the research team on the findings of this experiment.*

**Task:**

- (a) Using your knowledge of mineral nutrition in plants, explain the specific roles of magnesium and nitrate ions, and account for the different symptoms observed in Groups B and C compared to Group A. **(8 marks)**
- (b) Describe the mechanisms by which mineral ions are absorbed from the culture solution into root hair cells, clearly distinguishing between active and passive uptake. **(6 marks)**
- (c) Explain how the mineral deficiencies in Groups B and C would ultimately affect the rate of photosynthesis in the tomato plants, and suggest how the researchers could modify the experiment to test whether increasing light intensity compensates for the reduced photosynthesis. **(6 marks)**

**Total: 20 marks**

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## **SECTION B**

*Answer ONE item from Part I and ONE item from Part II. Each item carries 20 marks.  
(Total: 40 marks)*

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### **PART I — Construct 3: Organismal Systems and Homeostasis**

*(Answer ONE item from Item 3 and Item 4)*

#### **ITEM 3 (Transport in Animals)**

*A sports physician at the Uganda Athletics Federation is monitoring physiological changes in athletes during a 10,000-metre race at Namboole Stadium. Blood samples collected at three time points — before the race, at the midpoint, and immediately after the race — showed progressive changes: the haemoglobin oxygen saturation dropped from 98% (before) to 72% (midpoint) to 65% (after); the concentration of dissolved carbon dioxide and lactic acid in the blood increased significantly; and the blood pH fell from 7.4 to 7.1 by the end of the race. The physician also recorded that the athletes' heart rate rose from a resting value of 70 beats per minute to over 180 beats per minute during the race.*

*You are a member of the physiological support team at the federation.*

#### **Task:**

- (a) Describe the structural adaptations of red blood cells that make them efficient at transporting oxygen, and explain the role of haemoglobin in oxygen loading and unloading using the concept of the oxygen dissociation curve. **(8 marks)**
- (b) Account for the drop in haemoglobin oxygen saturation and the fall in blood pH observed in the athletes during the race, clearly explaining the Bohr effect and its physiological significance. **(7 marks)**

- (c) Explain the mechanisms responsible for the increase in heart rate during the race and describe how the structure of the heart enables it to increase cardiac output in response to exercise. (5 marks)

**Total: 20 marks**

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#### **ITEM 4 (Histology in Animals)**

*A pathology student at Makerere University College of Health Sciences is examining tissue slides from various organs sampled post-mortem. During her practical session, she identifies several tissue types: slide A shows a single layer of flat, scale-like cells lining the interior of a blood vessel; slide B shows tall cells with hair-like projections on their apical surface, with many small oval structures near their base, obtained from the trachea; slide C shows multiple layers of flattened cells with the outermost layers appearing dead and filled with a fibrous protein, from the skin surface; and slide D shows densely packed cylindrical cells with visible striations and multiple nuclei, from the thigh muscle. Her supervisor asks her to relate each tissue's structure to its specific function.*

*You are the student's supervisor. Help her analyse the tissue slides.*

#### **Task:**

- (a) For each tissue slide (A, B, C, and D), identify the specific tissue type and describe how its structural features (as observed) are adapted to its function in the body. (12 marks)
- (b) The student also examines a slide of compact bone tissue. Describe the structural organisation of compact bone at the microscopic level, naming the key structural units and their components. (5 marks)
- (c) Distinguish between the structure and function of smooth muscle tissue and the striated (skeletal) muscle tissue seen in slide D. (3 marks)

**Total: 20 marks**

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### **PART II — Construct 4: Genetic, Evolutionary and Ecological Dynamics**

*(Answer ONE item from Item 5 and Item 6)*

#### **ITEM 5 (Ecology — Ecosystems and Human Impact)**

*Scientists from the National Environment Management Authority (NEMA) are investigating an alarming change in Lake Kayumba, a freshwater lake in western Uganda. Historically, the lake supported a rich diversity of fish species, aquatic plants, and invertebrates. However, over the past two years, following the rapid expansion of farming on the steep hillsides surrounding the lake, large amounts of*

fertiliser runoff have been entering the water. Scientists now observe a dense mat of algae and cyanobacteria on the lake surface, greatly reduced water clarity, and mass fish deaths in the deeper zones of the lake. Water quality data collected shows: dissolved oxygen near the surface = 8.2 mg/L; dissolved oxygen at 3 m depth = 0.4 mg/L; nitrate concentration = 28 mg/L (well above natural levels of ~1 mg/L).

You are a NEMA scientist reporting on the ecological status of Lake Kayumba.

**Task:**

- (a) Using the data provided, explain the ecological processes responsible for the observed changes in the lake, including the roles of producers, decomposers, and nutrient cycling. Name the process causing the fish deaths in the deeper zones. (9 marks)
- (b) Construct a simple food web that could have existed in Lake Kayumba before the pollution, using these organisms: phytoplankton, zooplankton, tilapia, catfish, kingfisher, aquatic insects, and frogs. Use arrows to show the direction of energy flow, and explain why only about 10% of energy is transferred between trophic levels. (7 marks)
- (c) Recommend four specific, practical strategies that farmers and NEMA could implement to restore the ecological balance of Lake Kayumba and prevent future occurrences. (4 marks)

**Total: 20 marks**

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**ITEM 6 (Ecology — Population Dynamics and Field Techniques)**

Biology students from St Mary's College Kisubi conducted a field study in a savanna grassland on the outskirts of Entebbe town. Their objectives were to estimate the population of a native grass species (*Themeda triandra*) and to study the feeding relationships among organisms in the ecosystem. During their study, they observed the following organisms: *Themeda triandra* (grass), acacia shrubs, grasshoppers, aphids, African catfish (in a nearby stream), frogs, monitor lizards, eagles, and weaver birds. They also noticed an unusual absence of snakes in the area, which locals attributed to recent intensive clearing of bushes for charcoal burning. The students used 0.5 m × 0.5 m quadrats randomly placed across a 100 m × 50 m study area.

You are the biology teacher guiding the students in their analysis of the field data.

**Task:**

- (a) Describe the full procedure the students should follow to use the quadrat method to estimate the population density and percentage cover of *Themeda triandra* in

their 100 m × 50 m study area. Include how they would calculate their results. **(8 marks)**

- (b)** Using the organisms listed in the scenario, construct a food web for this ecosystem. Using the food web, explain the concept of trophic levels and distinguish between a food chain and a food web. **(7 marks)**
- (c)** The absence of snakes from this ecosystem has been observed. Using the food web you constructed, predict and explain the likely effects of the removal of snakes on at least three other populations in the ecosystem. **(5 marks)**

**Total: 20 marks**

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**\*\*\* END OF EXAMINATION \*\*\***

*Compiled and set by Tr JoelPCM Academic Council | S5 End of Term One Biology*