Name:.....**Stream**.....

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P530/1
BIOLOGY
PAPER 1
(Theory)
2 Hours 30 minutes

SELF-STUDY: BIOCLASS UG
Uganda Advanced Certificate of Education
BIOLOGY
Paper 1
SENIOR FIVE
2 HOURS 30 Minutes

INSTRUCTTIONS TO CANDIDATES:

This paper consists of **two** *sections:* **A** *and* **B.** *It has* **five** *examination items.*
Section **A** *has* **Two Compulsory** *items.*
Section **B** *has* **two** *ITEMS: Answer* **one ITEM**.
Answers to section **A must** *be written in the spaces provided while answers to* **Section B** *must be written in the answer booklet(s) provided.*
Answer **three** *items in all.*
Any additional item(s) answered will **not** *be scored*

SECTION A

Attempt all items in this section in the spaces provided

ITEM 1

A researcher is studying a new strain of bacteria found in a hot spring near Fort Portal. The water is consistently 85°C and has a high sulphur content. She is trying to classify it and understand how its cell structure enables it to survive. For comparison, she also examines a sample of *E. coli* from a student's lab culture.

TABLE 1: CELLULAR ANALYSIS OF BACTERIAL STRAINS

Feature	Hot Spring Bacterium	*E. coli* (for comparison)
Peptidoglycan layer in cell wall	Present	Present
Organelles surrounded by membranes	Absent	Absent
Presence of a nucleus	Absent	Absent
Cell membrane lipid composition	Branched hydrocarbon chains	Unbranched fatty acid chains
Optimal growth temperature	80°C	37°C

TASK:

(a) (i) Classify both types of cells as prokaryotic or eukaryotic, justifying your answer with evidence from the table.

Classification: Prokaryotes

Reasons: No membrane-bound organelles, No nucleus, Presence of a peptidoglycan cell wall.

(ii) Analyse how the difference in cell membrane lipid composition contributes to the survival of the hot spring bacterium in its extreme environment.

The hot spring bacterium has branched hydrocarbon chains in its membrane, while E. coli has unbranched fatty acid chains. At high temperatures (80°C), normal unbranched fatty acid chains become too fluid and unstable, which would cause the cell membrane to break down. The branched hydrocarbons pack together more tightly and strongly, creating a more stable and less fluid membrane. This prevents the membrane from melting, allowing the bacterium to survive in the extreme heat of the hot spring.

(b) The researcher wants to estimate the size of the hot spring bacterium. Describe the steps she must take to make this measurement using a light microscope with a known field of view diameter.

- *Place the specimen on a slide and view it under the high-power objective.*
- *Measure the diameter of the field of view (e.g., using a stage micrometer).*
- *Estimate how many of the bacterium cells, placed end-to-end, would fit across the diameter. For example, if 10 cells fit across, the estimated cell length would be: Field of View Diameter ÷ Number of Cells.*
- *Repeat the estimation several times and calculate an average for a more accurate result.*

ITEM 2

Coffee farmers on the slopes of Mt. Elgon have seen a reduction in bean quality. An agronomist suspects it is related to changing rainfall patterns and increased sunny days. The farmer noted that on a recent very hot, sunny day, the leaves of his coffee plants (C3 plants) curled inwards, and some developing berries dropped. The agronomist explained this involves ABA and photorespiration.

The farmer provided a diagram of a coffee leaf cell chloroplast and a summary of the photosynthesis process:

(Image description: A chloroplast with stacked grana (site of light-dependent reactions) and stroma (site of Calvin cycle where carbon dioxide is fixed into sugar using ATP and NADPH).)

Task:

(a) Explain the sequence of events, from high light/temperature to leaf curling and berry drop, mentioning the role of stomata, ABA, and photorespiration.

On a hot, sunny day, the coffee plant is at risk of losing too much water, to conserve water, the plant closes its tiny leaf pores, called stomata. The hormone ABA (abscisic acid) is produced, which signals the stomata to close. With the stomata closed, oxygen levels build up inside the leaf and carbon dioxide cannot enter. The key enzyme for photosynthesis, RuBisCO, starts binding with oxygen instead of Carbon dioxide (photorespiration). This photorespiration uses up RuBisCO, and energy (ATP) and sugars instead of producing them. The plant producing less sugar for energy and growth. The plant sacrifices its less essential parts, like developing berries, causing them to drop. Leaf curling occurs; water loss exceeds water absorption; curling reduces surface area exposed to water loss.

(b) Using the diagram, explain why the process of photorespiration is a problem for the coffee plant's growth and yield.

The light-dependent reactions in the grana produce ATP and NADPH. The Calvin cycle in the stroma uses this ATP and NADPH to fix Carbon dioxide into sugar. Photorespiration is a problem: It directly sabotages the Calvin cycle. When RuBisCO fixes oxygen instead of carbon dioxde, it starts a process that: Wastes Energy: It uses up RuBisCO, ATP and NADPH from the light reactions without making any sugar. Releases carbon dioxide: With less sugar being produced,

the plant has less energy and building material for growth and for developing coffee beans, leading to reduced yield and quality.

SECTION B

Attempt one item from this section

ITEM 3

During a malaria outbreak in Gulu, two students, Joan and Peter, were tested with rapid diagnostic kits (RDTs).

- Joan's test was positive.
- Peter's test was negative but later developed malaria symptoms.

Lab findings:

- Joan: Antibodies detected, high histamine levels during fever.
- Peter: No antibodies detected initially; parasites later confirmed in blood smear.

Task

(a) Explain how RDT kits detect malaria infection.

(b) Explain why Peter initially tested negative despite having malaria parasites.

(c) Relate Joan's high histamine levels to her fever and allergy-like symptoms.

(a). Rapid Diagnostic Test (RDT) kits detect specific malaria antigens (proteins) produced by the malaria parasite in a person's blood. A small blood sample is placed on the test strip. If these malaria antigens are present, they bind to specific antibodies in the test kit. This binding causes a coloured line to appear on the strip, indicating a positive result.

(b). *Peter tested negative initially because his body had not yet produced enough antibodies for the test to detect. When the malaria parasite first enters the body, it takes time for the immune system to recognize it and build up a detectable level of antibodies. Peter was tested very early in the infection, during this window period, when the parasite was present, but the antibody levels were still too low for the RDT to register.*

(c) *The malaria infection triggered a massive immune reaction, damaged cells and mast cells secreted histamine. The high histamine levels cause blood vessels to widen and become leakier. This leads to:*

- *Inflammation and fever as the body tries to fight the infection.*
- *Allergy-like symptoms (such as rash or itching), because histamine is the same chemical responsible for causing allergic reactions.*

ITEM

A Maasai pastoralist in Kenya notices his herd behaves strangely during a heatwave. The cows stop grazing during the day, stand in tight groups, and their noses feel dry. He is worried they are sick. A vet investigates and records:

Parameter	Herd during heatwave	Normal Values
Grazing Time	05:00-08:00 & 18:00-20:00	All day, with rest
Body Temperature (Late PM)	39.5°C	38.5°C
Water Consumption	Increased by 300%	Normal
Urine Output	Low volume, dark yellow	Normal

The pastoralist is puzzled because the animals are not sick but are clearly struggling.

Task

(a) Explain the behavioural and physiological adaptations the cows are using to regulate their temperature and conserve water.

(b) Predict physiological changes that would occur in the cows' blood if they could not find enough water to drink and explain the negative feedback mechanism that would attempt to correct it.

(a) *Behavioural Adaptations:*

- *Grazing only in early morning and evening: This avoids the hottest part of the day, reducing heat gained from the environment and from muscle activity (digestion).*
- *Standing in tight groups: This reduces the total body surface area exposed to the direct sun, providing some shade for each other.*

Physiological Adaptations:

- *Increased water consumption: Replenishes water lost through panting and sweating.*
- *Low volume, dark yellow urine: The kidneys reabsorb more water back into the body, concentrating the urine. This is a direct way to conserve water.*
- *Dry nose: Reduces water loss from moist surfaces.*

(b). *If the cows could not find enough water, they would become dehydrated. The blood would become more concentrated, leading to an increase in solute concentration and a decrease in blood volume and pressure. The brain detects the increased concentration of the blood. The pituitary gland responds by releasing more Antidiuretic Hormone (ADH). ADH travels to the kidneys and makes them reabsorb even more water back into the bloodstream from the filtering process. This produces a very small volume of highly concentrated urine and helps to raise blood volume and dilute the blood back towards its normal concentration.*

END