P530/1
S.5 BIOLOGY
Paper 1
2026
3 hours

EXODUS COLLEGE SCHOOL

END OF TERM II EXAMINATION

S.5 BIOLOGY

(THEORY)

Paper 1

3 hours

INSTRUCTIONS:

This paper consists of two sections: **A** and **B**. It has six examination items.

Section **A** has two compulsory items.

Section **B** has two Parts: I and II. Answer one item from each part.

Answer four items in all.

SECTION A

Answer all the items in this section.

Item 1:

David, a 26-year-old athlete, had abused performance-enhancing drugs for two years. During a routine fitness assessment at a sports club, he developed early fatigue, weak muscle contractions, and experienced palpitations and chest pain after completing only a light workout. At the hospital, doctors discovered that the drugs had lowered the activity of a specific respiratory enzyme and had damaged the structural proteins that anchor filaments within his muscle fibres.

Tables 1 and 2 show additional results from the medical examination of David.

Table 1: Structural and physiological characteristics of cardiac muscle cells

Parameter	**Healthy athlete**	**David**
Intercalated discs (per microscopic field)	48	25
State of heart beat rate	Normal	Higher than normal

Table 2: Respiratory and skeletal muscle characteristics

Parameter	**Healthy athlete**	**David**
Alpha-actin-3 protein (mg g^{-1} muscle)	18	8
Succinate dehydrogenase activity (%)	92	46
Amount of ATP produced (arbitrary units)	100	54

Alpha-actin-3 protein anchors actin filaments within skeletal muscle fibres, allowing efficient transmission of the force of contraction.

The doctor at the hospital proposed that David immediately stop taking performance-enhancing drugs, take a supplement of flavoproteins, and also take beta-blockers (beta-blockers slow down the activity of the sino-atrial node in the cardiac muscle).

Task:

(a) Analyse the information in the tables to explain David's reduced athletic performance.

(b) Evaluate the effectiveness of the proposed interventions in improving David's athletic performance.

Item 2:

The S.6 students of Kita High School grow tomatoes on the school farm. During the last rainy season, cloudy conditions reduced the average daily light period to 10 hours. The tomato plants became infested with a fungus that secreted a black alkaline substance covering most leaf surfaces. The students observed that affected plants remained short, wilted during hot afternoons, formed few flowers and fruits, and produced low yields.

The students reported the matter to the school farm manager, who compared affected and normal plants and obtained the following results, shown in Table 3:

Table 3: Comparison of affected and normal tomato plants.

Parameter	**Affected plants**	**Normal plants**
State of chloroplast matrix	Rigid	Fluid
Average stomatal opening during daytime	20%	80%
Concentration of glucose during the day	Low	High
Solute concentration in guard cells	Low	High
Rate of transpiration (g water/hour)	2.1	8.4
Average root hair density per root	200	1000

The manager further observed that the black alkaline substance was also present in the chloroplast matrix, around guard cells of stomata, and on the root surfaces of affected plants, and that tomatoes grow well when the ratio of photoperiod to dark period is above 2:1.

The manager concluded that seasonal conditions, fungal infestation, and impaired osmoregulation were responsible for the low yields. He advised the students to apply fungicides, cut down all the affected plants, or improve irrigation by increasing soil water availability around the root zone.

Task:

(a) Analyse the conclusion of the farm manager.

(b) Evaluate the recommendations of the farm manager

SECTION B

Part I

Answer only one item from this section.

Item 3:

Mr. Otieno, a 58-year-old man who had complained of excessive thirst, frequent urination, and unexplained weight loss over the past year, was found unconscious in his kitchen by his son during a cold morning. Investigations later revealed that a charcoal stove had been burning overnight in the poorly ventilated room. Mr. Otieno was rushed to hospital, where he was found to be shivering uncontrollably, confused, and breathing rapidly.

At the hospital, doctors recorded his blood parameters on admission and compared them with those of a healthy individual, as shown in Table 1. They also recorded additional blood parameters relating to his long-term metabolic state, shown in Table 4.

Table 4: Blood parameters on admission

Parameter	**Mr. Otieno**	**Healthy reference**
Carboxyhaemoglobin (%)	32	<2
Blood oxygen saturation (%)	68	95–100
Fasting blood glucose (mmol/l)	13.8	4.0–6.0
Plasma insulin concentration (µU/mL)	4.2	15–20
Core body temperature (°C)	34.2	37.0

On examination, doctors noted that Mr. Otieno's skin was pale and his fingertips appeared unusually pink despite his evident distress. The medical team immediately administered 100% oxygen therapy via a tight-fitting face mask, wrapped him in warmed blankets, and started him on an intravenous insulin infusion alongside regular blood glucose monitoring.

Task:

(a) Analyse the physiological mechanisms responsible for Mr. Otieno's condition on admission.

(b) Evaluate the effectiveness of the interventions administered by the medical team.

Item 4:
Grace, a 29-year-old Rhesus-negative volunteer nurse from a non-malaria-endemic region, travelled to work in a malaria-endemic district. On arrival, she began taking a weekly antimalarial prophylactic drug as advised by the travel clinic. Two weeks later, shortly after her third dose, Grace developed a severe red rash over her arms.

While still recovering, Grace was involved in a road accident and required an emergency blood transfusion. Due to the urgency, the attending clinician transfused Rhesus-positive blood without crossmatching. Grace recovered from this transfusion without incident. Eight months later, Grace was involved in a second road accident and again required an emergency transfusion of Rhesus-positive blood. Three days after this second transfusion, Grace frequently passed out dark-coloured urine.

The medical team recorded the following physiological data during both episodes.

Table 5: Parameters recorded during the allergic episode

Parameter	**Grace**	**Normal reference**
Plasma histamine concentration (ng/mL)	18.5	0.3–1.0
Blood pressure (mmHg)	88/56	120/80
Core body temperature (°C)	37.9	37.0

Table 6: Parameters recorded following the second blood transfusion

Parameter	**Before second transfusion**	**3 days after second transfusion**
Anti-Rh (anti-D) antibody titre (units/mL)	6	42
Haemoglobin in urine (mg/dL)	0	35
ADH level (pg/mL)	2.0	6.8

The medical team responded with the following measures: immediately discontinuing the antimalarial drug and replacing it with an alternative prophylactic agent, administering intravenous antihistamines, and giving Grace an injection of anti-D immunoglobulin after her second transfusion.

Task:
(a) Analyse the physiological mechanisms responsible for Grace's response to the third dose of prophylactics and second blood transfusion.

(b) Evaluate the effectiveness of the interventions used by the medical team in managing Grace's condition.

Part II

Answer only one item from this section.

Item 5:

A volcanic eruption buried a large area of a wildlife reserve under molten lava. This destroyed all existing vegetation and animal habitats. Over the following decades, environmental scientists monitored ecological recovery as new communities gradually became established on the exposed rock surface. To determine changes in ecosystem development, environmental experts recorded changes in the amount of detritus, net primary productivity, and number of bird species at different stages of recovery.

Table 7: Changes in ecosystem development during recovery

Stage of ecosystem recovery	Amount of detritus (ha^{-1})	Net Primary Productivity ($gm^{-2}\ yr^{-1}$)	Number of bird species
Mosses stage	0.8	180	6
Shrub stage	5.6	760	18
Mature tree (climax) stage	14.2	620	42

The environmentalists also recorded the relationship between the recovery stages and pre-reproductive mortality of the mountain sheep (lamb) inhabiting the reserve.

Table 8: Changes in population structure of the mountain sheep (lamb)

Stage of succession	Total Population	Pre-reproductive mortality (%)
Mosses stage	62	82
Shrub stage	210	34
Mature (climax) tree	465	67

Several years after establishment of the climax community, park managers noticed a growing infestation of leaf-eating caterpillars damaging the mature trees and began periodic aerial spraying of an organochlorine pesticide to control them. Initially, the pesticide reduced the caterpillar population significantly, but wildlife officers later reported a sharp resurgence of the caterpillar population to levels higher than before spraying began, alongside a marked disappearance of birds of prey from the reserve.

Investigating the disappearance of birds of prey, researchers sampled organochlorine pesticide residue levels at different trophic levels of the reserve's food chain, shown in Table 9.

Table 9: Organochlorine pesticide residue concentration at different trophic levels

Trophic level	**Pesticide residue concentration (ppm)**
Vegetation	0.02
Caterpillars (primary consumers)	0.3
Small insectivorous birds	3.2
Birds of prey	28.5

In response to these findings, the wildlife authority and park management proposed the following measures:

(i) immediately banning the use of organochlorine pesticides and replacing them with a short-lived, biodegradable biological pesticide derived from a caterpillar-specific bacterium;

(ii) capturing and breeding birds of prey in captivity for gradual release back into the reserve once pesticide levels decline; and

(iii) fencing off the mature tree stage of the reserve to completely exclude mountain sheep grazing, in order to protect regenerating vegetation.

Task:

(a) Analyse the changes in ecosystem development and pre-reproductive mortality of the mountain sheep at different stages of ecosystem recovery, and the causes of the caterpillar resurgence and disappearance of birds of prey following pesticide use.

(b) Evaluate the effectiveness of the three measures proposed by the wildlife authority and park management in addressing the decline of the reserve's ecosystem and its bird populations.

Item 6:

A mountain ecosystem with a climax community was destroyed by a severe landslide after heavy floods. Bare rocky ground remained, and the natural recovery process took 20 years.

Table 10 shows a record of various organisms and other components of the ecosystem up to 20 years after the heavy floods.

Table 10: Changes in ecosystem components over 20 years

Years after heavy floods	Dominant vegetation type	Soil nutrients (ppm)	Amount of energy/Biomass (units)	Number of rabbits and climbing squirrels	Number of wolves
3	Mosses	2.1	0.5	0	0
7	Grasses	5.5	20.6	10	6
13	Shrubs	9.2	86.7	64	18
20	Forests	16.8	186.7	72	9

The climbing squirrels feed on tree fruits and spend most of their time in trees, while rabbits feed on vegetation. The ecosystem is often disturbed by rampant soil erosion and animal grazing.

Around year 15, as shrub and forest vegetation regenerated, farmers on the mountain slopes began cultivating crops and began spraying an organochlorine pesticide to control a population of leaf-eating beetles damaging their crops. Initially, the pesticide sharply reduced the beetle population, but farmers later reported a resurgence of the beetle population to levels higher than before spraying began, alongside a marked decline in the wolf population by year 20.

Investigating the wolf decline, scientists sampled organochlorine pesticide residue levels at different trophic levels of the ecosystem's food chain, shown in Table 11.

Table 11: Organochlorine pesticide residue concentration at different trophic levels (year 20)

Trophic level	Pesticide residue concentration (ppm)
Vegetation	0.03
Rabbits and climbing squirrels	0.4
Wolves	24.6

There is a need to improve the productivity of the ecosystem and address the decline of the wolf population.

In response to these findings, agricultural and wildlife authorities proposed the following measures:

(i) banning organochlorine pesticide use and replacing it with pheromone-baited attract-and-kill traps to control the beetle population;

(ii) declaring the forest zone a legally protected wildlife corridor connecting to a neighbouring mountain range, to allow wolves from outside populations to naturally migrate into and repopulate the reserve; and

(iii) constructing contour terraces and vegetated buffer strips along the farmed slopes to reduce soil erosion and runoff into the ecosystem.

Task

(a) Analyse the changes in ecosystem development and population of organisms over the 20-year period, and the causes of the beetle resurgence and decline of the wolf population following pesticide use.

(b) Evaluate the effectiveness of the three measures proposed by agricultural and wildlife authorities in improving the biomass and productivity of the mountain ecosystem and addressing the decline of the wolf population.

END