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S.5 BIOLOGY HOLIDAY PACKAGE
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ITEM 1

Farmers in Mbale District reported poor bean growth after spraying a new pesticide mixed with untreated river water. The pesticide contained compounds suspected to act as enzyme inhibitors. Some farmers also applied excessive amounts of the chemical.

Plants showed:

- Yellowing leaves
- Weak stems and soft tissues
- Reduced growth and yield
- Early wilting

A field officer suggested that the pesticide interferes with enzyme activity, chloroplast function, and cellular energy processes.

Table 1: Cellular and Physiological Observations in Bean Plants

Parameter	Control Plants	Exposed Plants
Chloroplast integrity (%)	100	55
Enzyme activity (%)	100	45
ATP level (%)	High	Low
Substrate utilisation rate (%)	High	Reduced
Leaf tissue damage (%)	0	40
Growth rate (cm/week)	6.5	2.8

Task

(a) Analyse how enzyme inhibition and reduced substrate utilisation affect cell structures, enzyme activity, and energy availability, leading to reduced plant growth and tissue damage.

(b) Suggest appropriate measures that could improve plant health and restore productivity under these conditions.

PART (a): *Pesticide acts as an enzyme inhibitor, binding to enzyme active sites or altering structure, reducing enzyme–substrate complex formation and lowering enzyme activity (45%). This slows key metabolic pathways in photosynthesis and respiration, reducing biochemical reactions, resulting in reduced growth and productivity.*

Low substrate utilisation limits availability of Carbon dioxide, water, and mineral ions for metabolic processes. Reduced activity of RuBisCO in the Calvin cycle lowers glucose synthesis, limiting substrates for respiration. This leads to reduced biomass formation and stunted growth (2.8 cm/week).

Reduced chloroplast integrity (55%) disrupts thylakoid membranes, impairing light-dependent reactions, including photolysis and electron flow through the electron transport chain. Reduced production of ATP and NADPH limits the Calvin cycle, causing chlorosis and reduced photosynthesis.

Low ATP results from impaired photophosphorylation and reduced activity of enzymes such as cytochrome c oxidase. Limited ATP restricts protein synthesis and active transport, leading to weak stems, soft tissues, and reduced growth.

Chemical toxicity damages cell membranes and denatures proteins, increasing permeability and disrupting cell function. Enzyme activity declines further, causing early wilting, tissue weakening, and reduced yield.

PART (b): Strategies / Solutions

- *Use of low-enzyme-inhibiting pesticides, prevents enzyme blockage, maintains enzyme activity and efficient photosynthesis and respiration, restoring growth.*
- *Application of correct pesticide concentration, avoids excess inhibitor accumulation, ensuring normal enzyme–substrate interactions and adequate ATP production.*
- *Controlled pesticide application frequency, reduces toxic buildup, protecting chloroplast structure and metabolic enzymes, maintaining energy production.*
- *Use of organic pest control methods, avoids enzyme inhibition, preserving metabolic pathways and substrate utilisation, improving plant health.*
- *Improvement of soil nutrient supply increases substrates , supporting photosynthesis and protein synthesis, enhancing growth.*
- *Farmer training on pesticide use, ensures proper handling and application, preventing metabolic disruption and maintaining plant productivity.*

ITEM 2

Workers in a plastic factory in Jinja reported fatigue, muscle weakness, and dizziness after prolonged exposure to fumes containing **heavy metals**, which act as **enzyme inhibitors**. Workers also had limited nutrient intake due to long working hours.

Some workers:

• Experienced rapid tiredness
• Showed weak muscle contraction
• Had delayed recovery
• Reported dizziness

A health officer suggested that the chemicals reduce enzyme concentration and activity, affecting cell membranes and muscle tissue function.

Table 1: Cellular and Physiological Indicators

Parameter	Healthy Workers	Exposed Workers
Mitochondrial activity (%)	100	45
ATP level (%)	High	Very low
Enzyme activity (%)	100	30
Enzyme concentration (%)	Normal	Reduced
Muscle tissue damage (%)	Low	High
Muscle contraction strength (%)	High	Low

Task

(a) Evaluate how enzyme inhibition and reduced enzyme concentration affect cell activity, membrane function, and muscle tissue performance, leading to reduced physical strength.

(b) Explain practical measures that could be applied to improve worker health and reduce these effects.

PART (a): *Heavy metals act as* ***enzyme inhibitors*** *by binding to enzyme active sites or altering enzyme shape, reducing* ***enzyme–substrate complex*** *formation. This lowers* ***enzyme activity from 100% to 30%****, slowing metabolic reactions in cells, leading to poor cell activity and rapid tiredness.*

Reduced ***enzyme concentration*** *means fewer enzyme molecules are available to catalyse reactions. This lowers the rate of* ***respiration****, reducing mitochondrial activity from* ***100% to 45%****, so less ATP is produced for muscle work and recovery.*

Very low ***ATP*** *limits active transport, protein repair, and muscle contraction. In mitochondria, inhibited respiratory enzymes reduce electron transfer and ATP formation by* ***ATP synthase****, causing weak contraction, delayed recovery, and reduced physical strength.*

Chemical exposure damages the ***phospholipid bilayer*** *and membrane proteins, disrupting selective permeability and ion movement. This affects movement of* ***calcium ions*** *and other ions needed for muscle contraction, causing poor muscle coordination and dizziness.*

High ***muscle tissue damage*** *reduces the number of functional muscle fibres. With low ATP and poor enzyme activity, actin and myosin interactions are weakened, reducing contraction strength from high to low and causing muscle weakness.*

PART (b): Practical measures

- ***Use protective equipment****, masks, gloves, and protective clothing reduce inhalation and contact with heavy metal fumes, preventing enzyme inhibition and membrane damage.*
- ***Improve factory ventilation****, exhaust fans and fume extractors remove toxic fumes, reducing heavy metal exposure and maintaining normal enzyme activity.*
- ***Reduce exposure time****, work rotation and rest breaks limit toxin accumulation, allowing ATP levels and muscle recovery to improve.*
- ***Provide balanced meals****, foods rich in carbohydrates, proteins, iron, vitamins, and minerals supply substrates for respiration, enzyme synthesis, tissue repair, and energy production.*
- ***Regular medical screening****, testing workers for heavy metal exposure and muscle damage allows early treatment before severe enzyme inhibition and tissue damage occur.*
- ***Replace toxic chemicals where possible****, safer industrial materials reduce heavy metal exposure, protecting mitochondria, enzymes, and muscle function.*

ITEM 3

In Wakiso District, poultry farmers supplying eggs to urban markets reported a steady decline in egg production and poor bird growth. Birds fed on low-cost feeds stored in humid conditions showed:

• Reduced body size and muscle weakness
• Low activity and poor feeding response
• Delayed recovery after stress

Veterinary officers suspected that poor feed storage led to toxin contamination and nutrient loss. Farmers who used freshly prepared balanced feeds observed improved bird strength and faster growth.
Samples from the birds were analysed.

Table: Metabolic and Tissue Performance Indicators

Parameter	Fresh Feed (Control)	Contaminated Feed
Digestive enzyme activity (%)	100	50
Mitochondrial ATP production (%)	100	55
Protein synthesis rate (%)	100	60
Muscle tissue strength (%)	Normal	Reduced

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Growth rate (%)	High	Low
Feed utilisation efficiency (%)	High	Low

Task

(a) Analyse how changes in enzyme activity, ATP production, and protein synthesis affect nutrient utilisation, muscle development, and overall growth in poultry.

(b) Propose appropriate and sustainable practices that can restore productivity and improve poultry health under such feeding conditions.