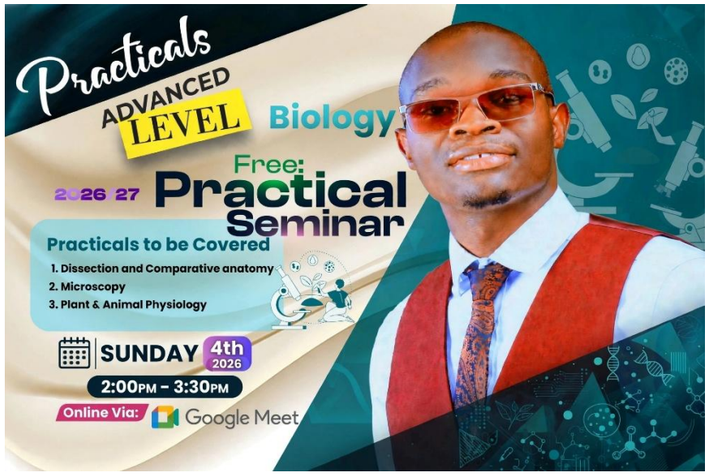
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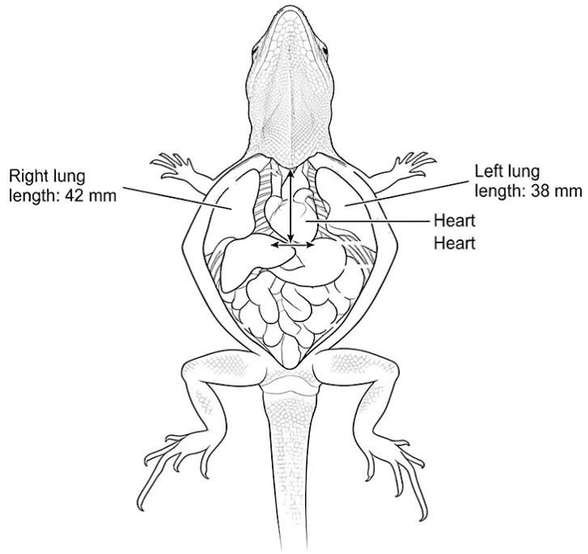
❶ Environmental researchers investigated organisms living within the same agricultural ecosystem. A rat, a lizard and *Commelina* spp. were selected to investigate how specialised structures support the survival of organisms under changing environmental conditions.

The rat and lizard occupy different parts of the ecosystem and differ in the organisation of their respiratory and circulatory systems. The researchers proposed that differences in their lungs and hearts could influence oxygen uptake, transport and delivery to body tissues.

The researchers also observed *Commelina* spp. plants growing in the same environment. Some plants showed poor growth, wilting and yellowing of leaves. When affected plants were carefully uprooted, their roots showed visible damage. The researchers proposed that damage to the roots could reduce the absorption and transport of water and mineral nutrients, thereby affecting plant growth and survival.

Table 1: The researcher obtained the following measurements from the lizard.

Structure	Measurement (mm)
Right lung length	42
Left lung length	38
Heart length	18
Heart width	12



You are provided with:

- freshly killed rat labelled **specimen X**;
- *Commelina* spp. showing root damage labelled **specimen Z**;

(a) (i) Describe the procedure you would follow to expose the gas-exchange system and heart of specimen X.

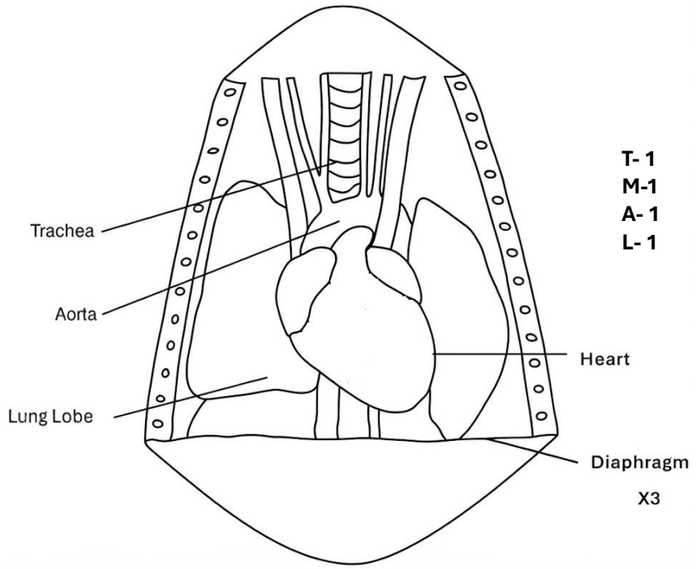
Procedure

- **Specimen X was placed with its dorsal side uppermost on the dissecting board.**
- **The four limbs were securely pinned.**
- **The skin was lifted along the mid-ventral line using forceps.**
- **A longitudinal incision was made through the skin towards the neck.**
- **The skin was separated from the body wall, and the skin flaps were pinned aside.**
- **The abdominal and thoracic body walls were carefully opened.**
- **The thoracic wall was reflected to expose the thoracic cavity.**
- **The thymus gland was displaced where necessary to expose the heart clearly.**
- **The right and left lungs were identified.**
- **The relative size and organisation of the lungs and heart were observed.**
- **The required structures were measured, and the results were recorded.**

(ii) Table 2: Measurements obtained from specimen X (rat)

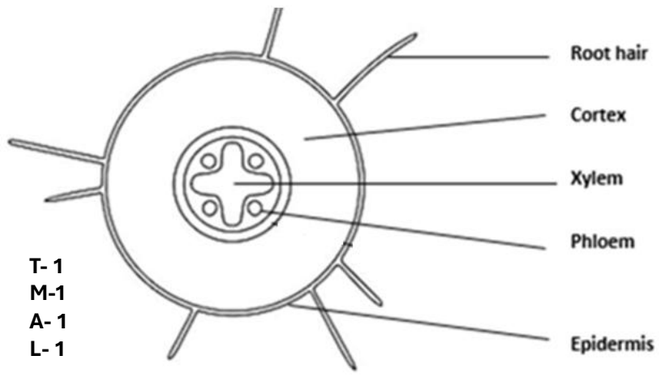
Structure	Measurement (mm)
Right lung length	
Left lung length	
Heart length	
Heart width	

(iii) Make **biological drawing** of the exposed thoracic region of specimen X.



(b) (i) Prepare a suitable **transverse section of the root** of specimen Z for microscopic observation. Make a support drawing of the tissue plan.

Drawing of the transverse section of the damaged *Commelina* root.



(e) Analyse how the exposed features of the rat, influence its ability to obtain, transport and use essential substances for survival.

- **The rat/ specimen X has paired lungs in the thoracic cavity, providing a larger respiratory surface for gaseous exchange; this enables oxygen to enter the blood and carbon dioxide to be removed efficiently.**
- **The right lung is divided into several lobes while the left lung is relatively less subdivided, allowing the lungs to occupy the thoracic cavity effectively while providing more extensive respiratory tissue for gaseous exchange.**
- **The trachea connects the external environment to the lungs, providing a passage through which air enters and leaves the respiratory system; this ensures a continuous supply of oxygen for aerobic respiration.**
- **The lungs are located close to the heart, reducing the distance over which oxygenated blood needs to be transported from the lungs to the heart; this supports efficient circulation of oxygenated blood.**
- **The diaphragm is positioned beneath the lungs, and its movement changes the volume of the thoracic cavity; this helps ventilate the lungs by drawing air in and expelling air out.**
- **The heart is muscular, enabling it to contract and pump blood through the pulmonary and systemic circulations; this transports oxygen, nutrients and other essential substances to body tissues.**
- **The four-chambered heart consists of two atria and two ventricles, allowing oxygenated and deoxygenated blood to remain completely separated; highly oxygenated blood can therefore be delivered efficiently to body tissues.**

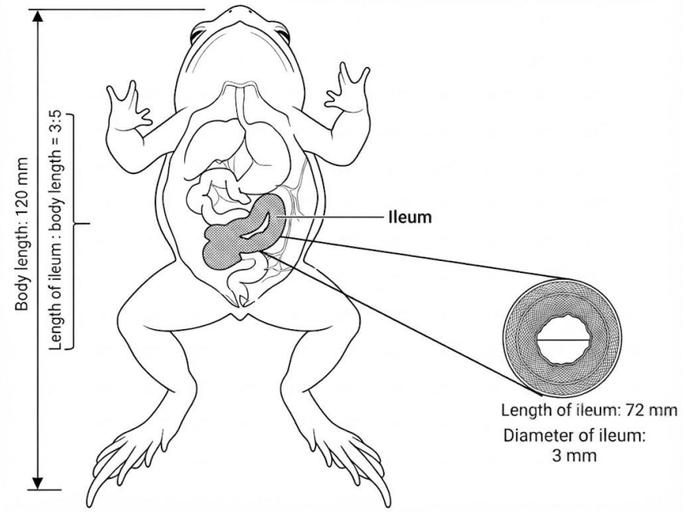
Assessment Criteria And Rubric

Basis Code	Parameter	Detailed Objectives / Criteria	Number of Items	Performance Level and Indicators
DS 1AP=3, Ae=2, Al=1	**Orientation & Pinning**	Position specimen X correctly and secure it appropriately for dissection.	2	**Ap** – Correct orientation and appropriate pinning. **Ae** – Correct orientation or appropriate pinning. **Al** –Limited/ incorrect attempt.
	Dissection & Exposure	Expose and display the lungs, heart, trachea, major blood vessels and diaphragm without unnecessary damage.	6	**Ap** – 5–6 correct displacements/exposures. **Ae** – 3–4. **Al** – 1–2.
DM 1AP=3, Ae=2, Al=1	**Measurement of Rat Structures**	Accurately measure and record the right lung, left lung, heart length and heart width.	4	**Ap** – 4 correct measurements. **Ae** – 2–3. **Al** – 1.
DR 1AP=3, Ae=2, Al=1	**Rat Biological Drawing**	Produce a clear, proportional, unshaded and accurately labelled drawing of the exposed thoracic region.	5–8	**Ap** – 5–8 relevant attributes. **Ae** – 3–4. **Al** – 1–2.
DS 1AP=3, Ae=2, Al=1	**Examination of *Commelina***	Identify visible evidence of root damage in specimen Z.	4	**Ap** – 4 valid observations. **Ae** – 2–3. **Al** – 1.
DR 1AP=3, Ae=2, Al=1	**Microscopic Drawing**	Produce a clear, proportional, unshaded and accurately labelled drawing of the damaged *Commelina* root section.	6–8	**Ap** – 6–8 relevant attributes. **Ae** – 3–5. **Al** – 1–2.
ST 1AP=3, Ae=2, Al=1	**Suitability for Survival—Rat**	Explain how the exposed lungs, trachea, diaphragm, heart and associated blood vessels influence gas exchange, transport and use of oxygen for survival.	5-7	**Ap** – 5–7 valid structure–function–survival explanations. **Ae** – 3–4 explanations involving at least two relevant structures. **Al** – 1–2 relevant explanations.

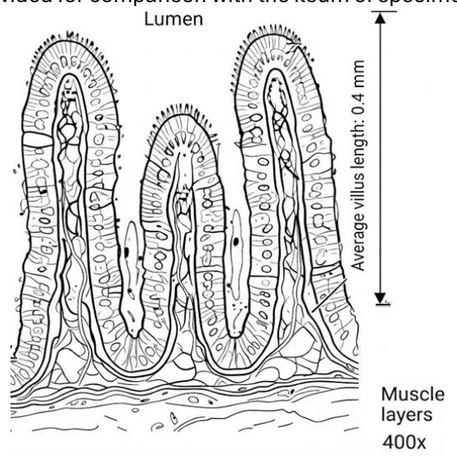
❷ **Mastery Drill:** A group of agricultural scientists working with a commercial vegetable-growing cooperative noticed that some farmers were experiencing unexplained losses in their crops. The affected farms produced **sweet potatoes, onions and leafy vegetables**, which were supplied to schools, markets and food-processing businesses.
The farmers observed that some plants had damaged leaves, stems and underground storage organs. In several fields, the damage was severe enough to reduce plant growth and crop yields. Since the damage occurred mainly at night, the farmers suspected that small animals were feeding on the crops.
To establish the animal responsible, the farmers placed harmless traps at different points in the fields. Two animals were captured and designated **specimen W and specimen X**.
The agricultural scientists identified:

- **Specimen W – Rat**
- **Specimen X – Toad**

The scientists explained that the two animals could be compared using their digestive systems to determine how effectively they could obtain nutrients from food. Particular attention was given to the **ileum**, since its structure is closely related to the absorption of digested food and how these absorbed nutrients reach the heart.
The following measurements were obtained from **specimen X (toad)**.



A prepared **micrograph of the inner lining of the ileum of specimen X** was also provided for comparison with the ileum of specimen W.



The scientists further suspected that the animals were attracted to the fields because some of the crops contained specialised tissues for **storing food reserves**. An onion bulb, designated **specimen Z**, was therefore selected for microscopic investigation.
Task
(a) Using specimen W, dissecting instruments and suitable measuring instruments:
(i) Describe the procedure you would follow to expose the ileum of specimen W and how absorbed nutrients reach the heart. .
Procedure
Drawing
(ii) Measure the exposed ileum and other appropriate anatomical structures of specimen W.

Parameter	Rat – Specimen W
Length of ileum	

Body length	
Length of ileum : body length	
Diameter of ileum	
Average length of an intestinal villus	

(b) Using specimen Z (onion) and a microscope: The scientists suspected that the crops were being damaged partly because of their stored food reserves. Make a support drawing of

(c) Analyse of the investigation

❸ The quality personnel of **Riham industrial limited** is always mindful of the appropriate concentrations of the pancreatic extracts as well as media solutions to enable complete breakdown of **sample W** used in generating sugars for processing **Riham biscuits**

He normally extracts whole pancreatic tissues from **specimen T**, grinds it in a mortar, mixes it with **10cm³ of water** that he decants in a clean boiling tube mixing the extract with distilled water in separate test tubes in the following proportions

Volume of pancreatic extract (cm^3)	**1**	**2**	**3**	**4**
Volume of water (cm^3)	4	3	2	1

He later establishes the suitable extracts to break down **solution W** and then examines the suitability of **solutions E** and **solution F** in providing suitable media for the best extract in breaking down **sample W** into sugars used in processing **Riham biscuits**

Task

Using the pancreatic tissue from **specimen T**, reagents of food test, and any other laboratory material, carry out similar investigations done by the quality personnel of **Riham industries LTD**, on the composition of **sample W**, concentrations of pancreatic extract as well as suitable media conditions of **solutions E** and **solution F** needed to making sugars for processing Riham biscuits and provide necessary recommendations.

Scientific Report

Aim

An investigation to determine whether sample W contains starch or non-reducing sugars, the most suitable concentration of pancreatic extract from specimen T for the complete breakdown of sample W into sugars, and which of solutions E and F provides the most suitable medium for the pancreatic enzyme to break down sample W.

Hypothesis

Sample W contains starch, the most concentrated pancreatic extract breaks down sample W fastest because it contains a higher concentration of digestive enzymes, resulting in more enzyme-substrate complexes being formed per unit time, and Solution E provides a more suitable medium for pancreatic enzyme activity than solution F.

Variables

Independent Variables

- Concentration of pancreatic extract.
- Type of medium: solution E or solution F.

Dependent Variables

- Rate of breakdown of sample W.
- Presence or amount of reducing sugar produced, determined using a food test.
- Change in colour of the reaction mixture.

Controlled Variables

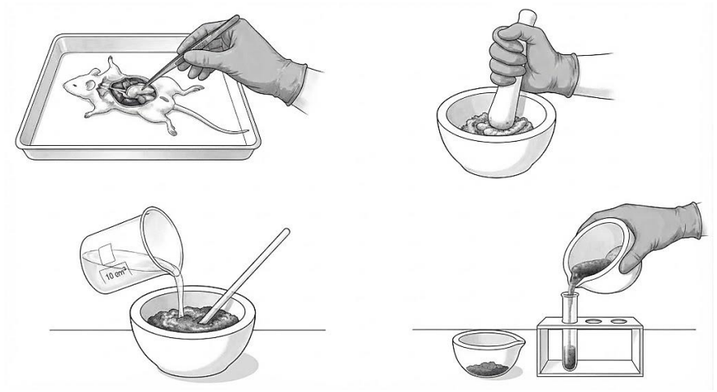
- Volume of sample W.
- Volume of pancreatic extract.
- Volume of solutions E and F.
- Temperature.
- Duration of the experiment.
- Concentration of sample W.

Risks and Mitigation

- Handling animal tissue exposes the learner to harmful microorganisms, minimized by wearing gloves and a laboratory coat and avoiding direct contact with the tissue.
- Glass apparatus breaks and cause cuts, should be handled carefully.
- The mortar and pestle cause injury if handled carelessly, used carefully.
- Solution E and F may irritate or burn the skin, eye, protective gloves and eye protection should be used and the solution handled carefully.

Preparation of Pancreatic Extract

Pancreatic tissue is obtained from specimen T and ground using a mortar and pestle. The ground tissue is mixed with **10 cm^3 of water**. The mixture is stirred and decanted into a clean boiling tube to obtain the pancreatic extract.



Part 1: Testing the nutrient Composition of Sample W

Test	Observation	Deduction
Starch test: To 1cm^3 of the test solution in a test tube was added 2 drops of iodine solution.	Turbid solution turned black solution.	Much Starch present.
Non-reducing sugar test: To 1cm^3 of the test solution in a test tube was added 1cm^3 of diluted hydrochloric acid and boiled for one minute, followed by 1cm^3 of dilute sodium hydroxide solution, followed by 2cm^3 of benedict solution and boiled again.	Turbid solution turned pale blue solution, on boiling remained.	Non-reducing sugars absent.

The reducing sugar test is irrelevant in this case, based on context of scenario.

Part 2: Determining the Suitable Concentration of Pancreatic Extract

- The pancreatic extract was diluted with distilled water in four separate test tubes to obtain extracts **A, B, C and D** as shown below.

Extract	**Pancreatic extract (cm^3)**	**Distilled water (cm^3)**
A	1	4
B	2	3
C	3	2
D	4	1

- Six clean test tubes were labelled **T1, T2, T3, T4, T5 and T6**, and mixtures were prepared as shown below before incubation.

Test tube	**Mixture before incubation**
T1	**1 cm^3 extract A + 1 cm^3 sample W**
T2	**1 cm^3 extract B + 1 cm^3 sample W**
T3	**1 cm^3 extract C + 1 cm^3 sample W**
T4	**1 cm^3 extract D + 1 cm^3 sample W**
T5	**1 cm^3 extract D + 1 cm^3 sample W + 1 cm^3 solution E**
T6	**1 cm^3 extract D + 1 cm^3 sample W + 1 cm^3 solution F**

- All the test tubes were incubated in a water bath at 37°C for 40mimutes.
- After incubation, small portions (1cm^3) from the reaction mixtures from each were tested for starch and reducing sugars according to the table below.

  Note: Learners can decide either to test for nutrient present initially or, one of the expected products to be formed but not all. However, the non-reducing sugar test is expected to remain **negative or show little evidence of non-reducing sugar** in the reaction mixtures unless sufficient reaction products are converted during the test. The main product being assessed in this investigation is the **reducing sugar produced from starch by pancreatic amylase**, so Benedict's test provides the more direct measure of the reaction.

Test tube	**Test**	**Observation**	**Deduction/ interpretation**
T1	Iodine test	Black solution	Slow starch breakdown; little reducing sugar formed
	Benedict's test	Green solution	
T2	Iodine test	Blue solution	Moderate starch broken down;
	Benedict's test	Yellow precipitate	

			more reducing sugar formed
T3	Iodine test	Pale blue / brown solution	High starch breakdown; much reducing sugar formed
	Benedict's test	Orange precipitate	
T4	Iodine test	Brown colour	Much starch broken down; much reducing sugar produced
	Benedict's test	Orange precipitate	
T5	Iodine test	Black solution	medium reduces/inhibits pancreatic enzyme activity
	Benedict's test	Remained blue	
T6	Iodine test	Pale blue/ brown solution	medium provides more suitable conditions for pancreatic enzyme activity
	Benedict's test	Orange precipitate	

Analysis and Explanation

- Starch remaining decreased from T1 to T4 and , increase in reducing sugar formation was observed from T1 to T4; because volume of water decreased from test tube A to D in preparing the pancreatic extract, increasing the enzyme concentration from A to D, starch breakdown increased and more reducing sugar was formed.
- T4, containing the highest concentration of pancreatic extract, gave the highest starch breakdown among the four concentrations.
- T5 produced a black solution in the iodine test and the Benedict's test remained blue, little starch was broken down and little or no reducing sugar was formed. Therefore, the medium in T5 reduced or inhibits pancreatic enzyme activity.
- T6 produced a pale blue/brown solution in the iodine test, much starch breakdown than T5. Therefore, medium in T6 provided more suitable conditions for pancreatic enzyme activity.

Conclusion

- W contains starch,
- the pancreatic extract concentration in T4 (D/ Extract made of 4cm^3 pancreatic extract + 1cm^3 of water) was the most suitable.
- medium used in T6 was more suitable for pancreatic enzyme activity than the medium used in T5 because T6

Recommendation

Riham Industrial Limited should use the **highest pancreatic extract concentration represented by T4** for breaking down sample W.

The company should also use the **medium represented by T6**, since it provided more suitable conditions for pancreatic enzyme activity and resulted in much starch breakdown.

Basis of Assessment

Basis Code	Parameter	Detailed objectives / criteria	Number of Items	Performance Levels and Indicators
PE	**Aim**	Identifies the investigations: composition of W, suitable pancreatic extract concentration, and suitable medium.	3	**2 AP = 4:** Three investigations correctly identified. **1 AP = 3:** Two investigations correctly identified. **Ae = 2:** investigations mentioned but incompletely stated. **Al = 1:** One relevant investigation stated.
	Hypothesis	Predicts composition of W, suitable extract concentration and suitable medium, with scientific reasons.	3	**2 AP = 4:** At least two valid predictions with reasons. **1 AP = 3:** One prediction with a reason. **Ae = 2:** Two predictions without reasons. **Al = 1:** One prediction without a reason.
	Variables	Correctly identifies independent, dependent and controlled variables.	5–8	**AP:** 5+ variables correctly categorized into IV, DV and CV. **Ae:** 3–4 variables correctly categorized. **Al:** 1–2 relevant variables identified.
MG	**Risks and mitigation**	Identifies risks associated with animal tissue, HCl, NaOH, glassware and laboratory equipment and gives appropriate precautions.	2	**Ae = 2:** Two risks correctly identified and mitigated. **Al = 1:** One risk correctly identified and mitigated, or two risks identified without mitigation.
Procedure	**Preparation of pancreatic extract**	Describes grinding pancreatic tissue, adding 10 cm^3 water, mixing and decanting.	3	**AP:** Correct preparation with at least three relevant details. **Ae:** Two correct details. **Al:** One correct detail.
	Design	Correctly organizes the investigation into W testing, extract concentration testing and medium testing.	2	**Ae = 2:** Two coherent stages correctly linked. **Al = 1:** One coherent stage.
	Extract concentration preparation	Correctly prepares A, B, C and D using 1:4, 2:3, 3:2 and 4:1 extract-to-water proportions.	4	**AP:** All four proportions correct. **Ae:** Two or three correct. **Al:** One correct.
	Reaction mixture accuracy	Correctly uses **2 cm^3 of extract + 1 cm^3 W** for T1–T4 and **2 cm^3 D + 1 cm^3 W + 1 cm^3 medium** for T5–T6.	6	**AP:** All six mixtures correctly prepared. **Ae:** Four or five correct. **Al:** One to three correct.
	Incubation / controlled conditions	Maintains equal temperature and duration, specifically approximately **37°C for 40 minutes**.	2	**AP:** Both temperature and time correctly stated. **Ae:** One correctly stated. **Al:** General incubation stated

				without control details.
DP	**Food-test procedure**	Correctly describes iodine test and appropriate sugar test after incubation.	3–5	**AP:** Three or more correct food-test details. **Ae:** Two correct details. **Al:** One correct detail.
	Data presentation / observations	Records expected results for T1–T6 and links observations to starch breakdown and sugar production.	6	**AP = 3:** Five or more correct observations. **Ae = 2:** Two to four correct observations. **Al = 1:** One correct observation.
AN	**Analysis**	Explains starch test, enzyme concentration, enzyme-substrate collisions, starch breakdown, reducing sugar production and effect of pH.	5–8	**AP = 3:** Five or more valid explanation points. **Ae = 2:** Three to four valid points. **Al = 1:** One to two valid points.
CR	**Conclusion**	Identifies W as starch, identifies D as the most suitable extract concentration and identifies the more suitable medium.	3	**AP = 3:** All three conclusions correctly supported by observations. **Ae = 2:** Two correct conclusions. **Al = 1:** One correct conclusion.
	Recommendation	Gives practical recommendations to Riham Industries based on the findings.	2	**AP:** Correct extract and medium recommended with scientific justification. **Ae:** Correct extract or medium recommended. **Al:** General recommendation without adequate evidence.

Important scoring interpretation

For the **concentration experiment**, the expected sequence is:

A → least enzyme → least starch breakdown → least reducing sugar

B → more enzyme → more starch breakdown → more reducing sugar

C → still more enzyme → greater starch breakdown → greater reducing sugar

D → highest enzyme concentration → greatest starch breakdown → greatest reducing sugar

For the **medium experiment**:

T5 = D + W + HCl → acidic → reduced pancreatic enzyme activity → more starch remains → less reducing sugar

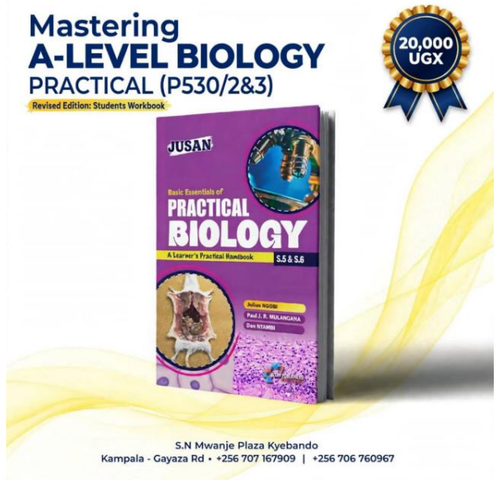
T6 = D + W + NaOH → alkaline → more suitable conditions under the stated investigation → less starch remains → more reducing sugar

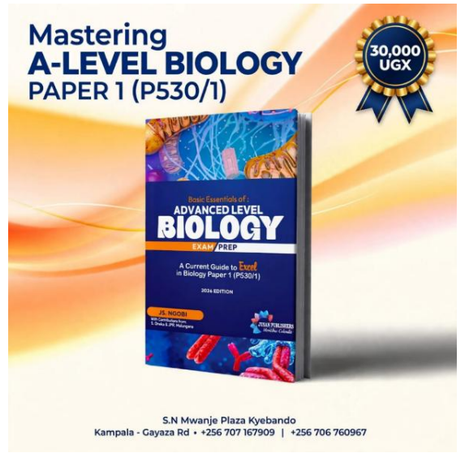
Thus, the central assessment relationship should be:

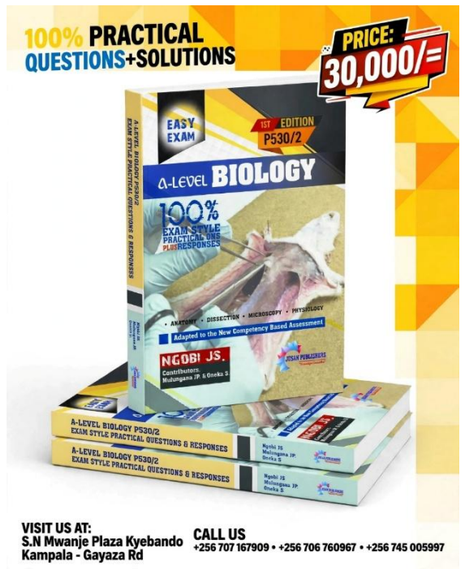
More suitable enzyme concentration/medium → greater starch breakdown → less starch detected by → more reducing sugar detected by Benedict's test. iodine

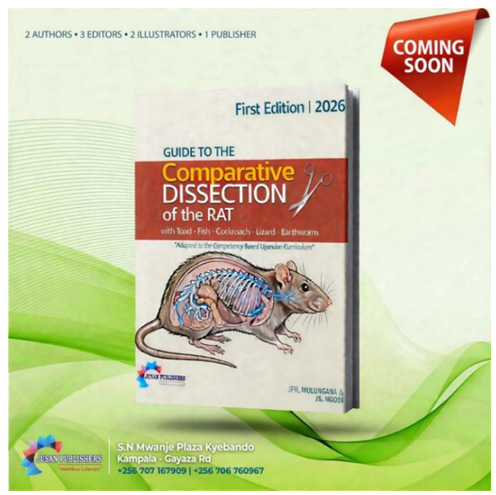
This makes the student's **observations, analysis, conclusion and recommendation flow directly from the experimental design**, rather than appearing as disconnected responses.

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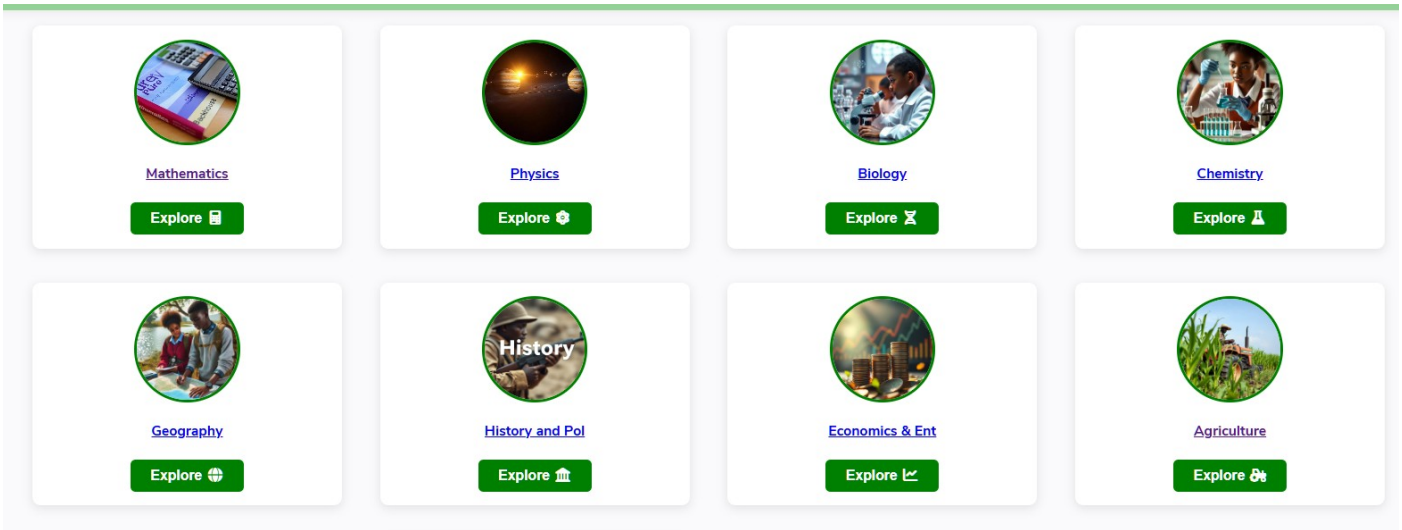








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