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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3814970882

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

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1 Pepsin is an enzyme that is present in gastric juice. Gastric juice is secreted into the stomach of humans and many other animals.

Pepsin catalyses the hydrolysis of proteins into peptides, as shown in Fig. 1.1.

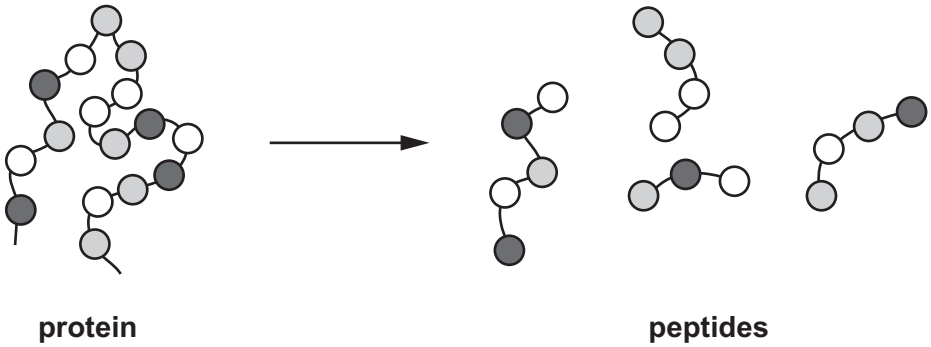


Fig. 1.1

Egg albumen (egg white) contains a high proportion of protein.

10% albumen solution is a cloudy-white colour. This becomes colourless when pepsin is added to the 10% albumen solution.

A student used a colorimeter to follow the progress of the hydrolysis of protein by pepsin.

(a) (i) The student used a blue filter in the colorimeter.

Outline **one other** step the student should carry out to prepare the colorimeter so that correct measurements of absorbance can be obtained.

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(ii) After preparing the colorimeter, the student:

- made a pH 2.0 albumen solution by mixing 10 cm^3 of 10% albumen solution with 10 cm^3 of pH 2.0 buffer solution
- added 3.0 cm^3 of the pH 2.0 albumen solution to a colorimeter tube
- added a small volume of pepsin solution to the colorimeter tube
- immediately placed the colorimeter tube in the colorimeter
- recorded the absorbance of the mixture every 20 seconds for 5 minutes
- calculated the rate of change in absorbance as a measure of the rate of protein hydrolysis.

The results are shown in Fig. 1.2.

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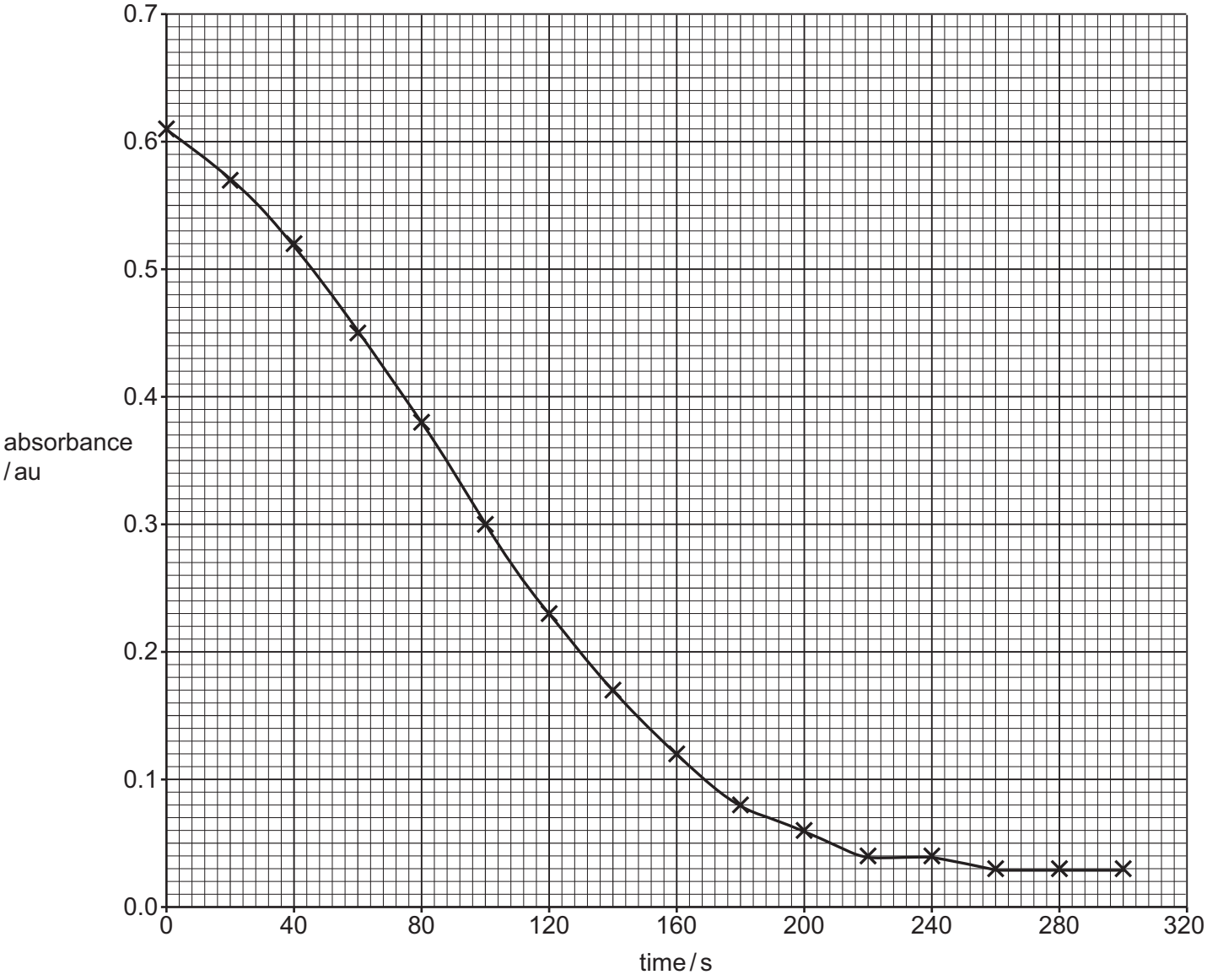


Fig. 1.2

Use Fig. 1.2 to calculate the rate of change in absorbance at pH 2.0 between 40 s and 120 s.

Show your working **and** include appropriate units.

rate of change in absorbance at pH 2.0 = ... [3]

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(b) The student decided to investigate the effect of pH on the rate of protein hydrolysis by pepsin.

From the internet the student found out that pepsin is **inactive** at **pH 6.5 and above**.

(i) The student was provided with a colorimeter and standard laboratory apparatus.

Describe a method that the student could use to investigate the effect of pH on the rate of protein hydrolysis by pepsin **and** to determine the optimum pH of pepsin.

Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

Details of how to prepare and use the colorimeter should **not** be included.

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(ii) Complete the sketch graph in Fig. 1.3 to predict the effect of pH on the rate of protein hydrolysis by pepsin.

Include a label for the *y*-axis in your answer.

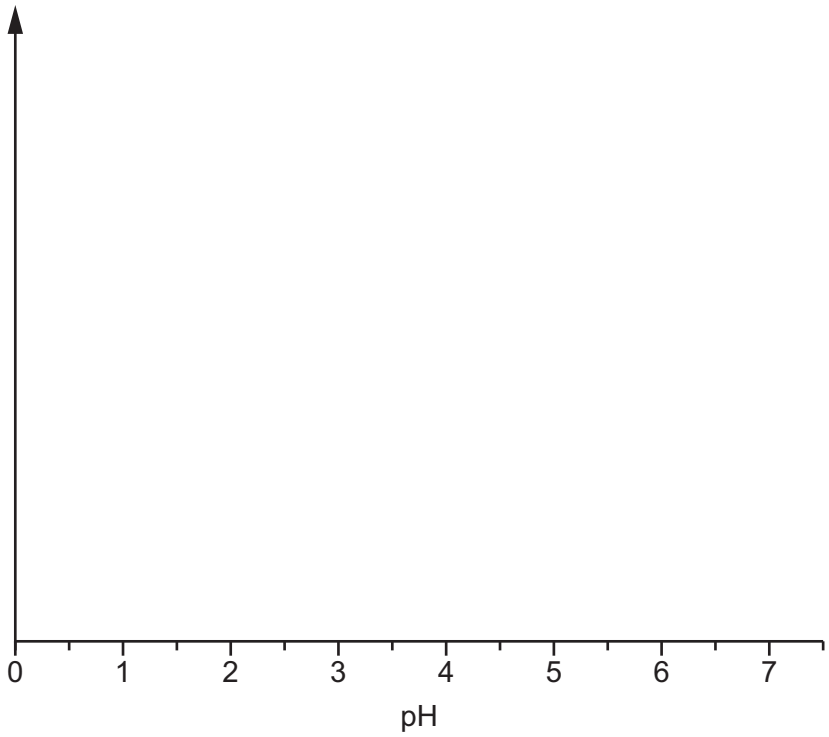


Fig. 1.3

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(c) (i) Laryngopharyngeal reflux (LPR) is a disease that occurs when gastric juice from the stomach moves up the oesophagus and into the larynx, as shown in Fig. 1.4.

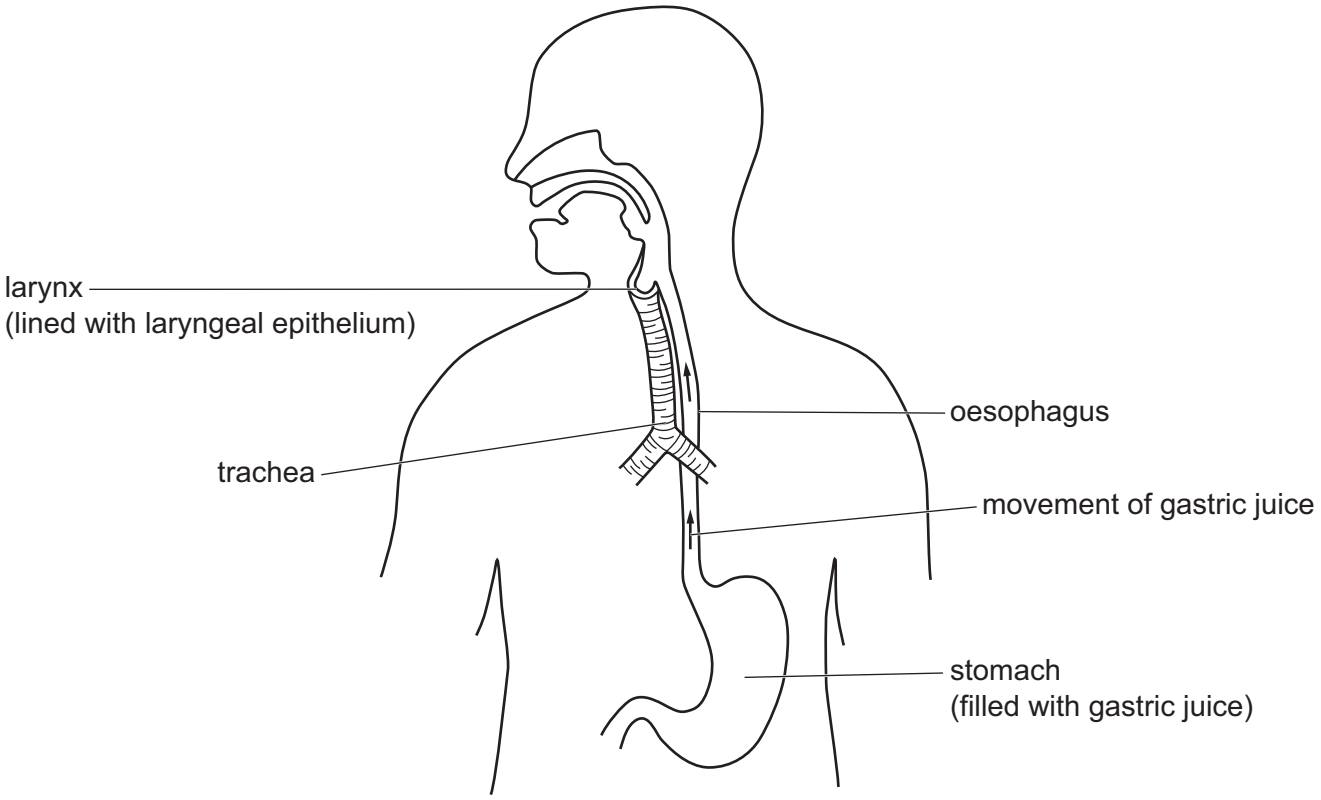


Fig. 1.4

Gastric juice can damage the laryngeal epithelium. Gastric juice contains hydrochloric acid and pepsin.

Some scientists identified a reduction in the quantity of two proteins, CA3 and Sep70, present in the laryngeal epithelium of people with LPR.

The scientists obtained 6 sections of mammalian laryngeal epithelium to investigate how different test conditions affect the quantity of CA3 and Sep70 in the laryngeal epithelium.

Each section of laryngeal epithelium was exposed to different test conditions for 20 minutes, as shown in Table 1.1.

Pepsin is inactive in the presence of the inhibitor, pepstatin.

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Table 1.1

treatment used	test condition					
	1	2	3	4	5	6
pepsin	yes	yes	yes	yes	no	no
pepstatin (inhibitor)	no	no	yes	yes	yes	yes
pH buffer	7.4	4.0	7.4	4.0	7.4	4.0

Proteins were then extracted from the sections of laryngeal epithelium. The proteins were separated using electrophoresis. CA3 and Sep70 were identified using fluorescent antibodies.

Fig. 1.5 shows the results of the protein electrophoresis.

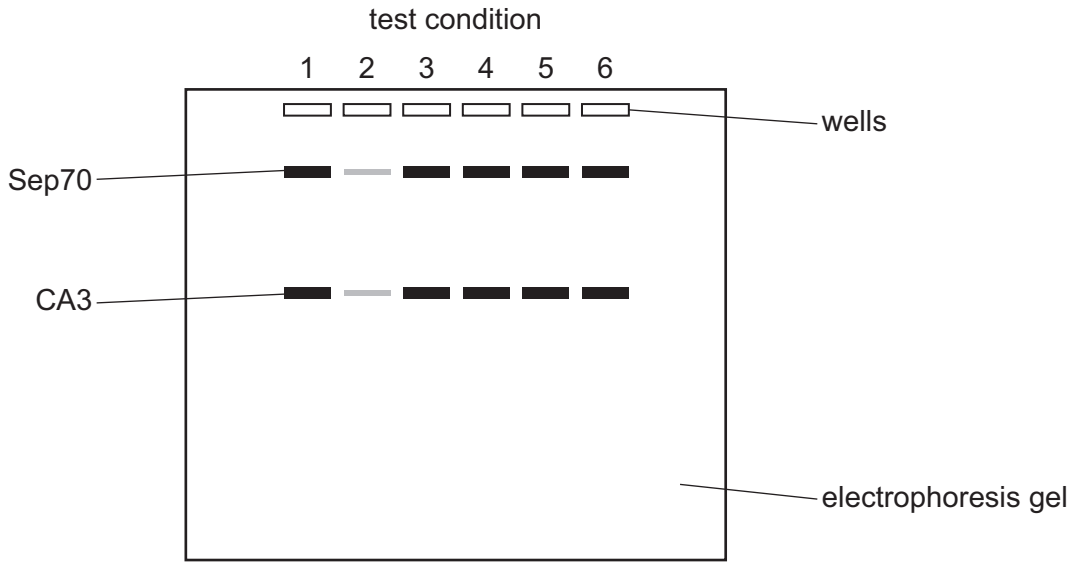


Fig. 1.5

Use Table 1.1 and Fig. 1.5 to state the conclusions that can be made from the results of the protein electrophoresis.

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(ii) The results of this investigation were published in a scientific paper.

A student who read the scientific paper concluded that pepsin causes damage to the laryngeal epithelium in people with LPR.

Suggest why the results of this investigation might **not** support this conclusion.

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2 Golden orb weaver spiders, *Nephila pilipes*, are found in East Asia, South-east Asia and Australia. They are active in the day and at night. Golden orb weaver spiders build webs in trees and shrubs to catch different species of insects for food.

All female golden orb weaver spiders are black with yellow spots on their legs and body. Biologists think that this adaptation evolved due to natural selection. Spiders with yellow spots may be able to attract more insects to their webs.

Fig. 2.1 shows a female golden orb weaver spider sitting on a web.



Fig. 2.1

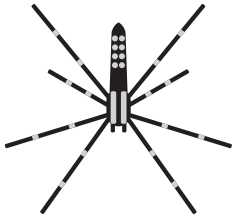
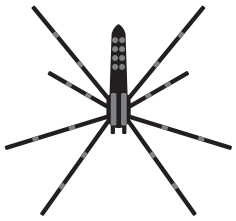
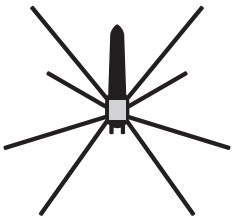
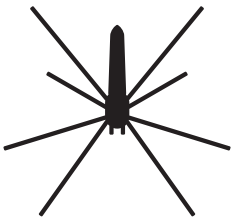
Some biologists visited a forest in East Asia in July 2008. The biologists found five webs that were approximately the same size. Each web belonged to a female golden orb weaver spider.

The biologists decided to investigate how the colour and pattern of spots on the spiders affect the number of insects attracted per hour to each web (insect attraction rate).

The biologists made two-dimensional (2D) models of spiders, as shown in Table 2.1.

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Table 2.1

model	description	diagram
A	• black body with yellow spots • black legs with yellow spots • same colour and pattern of spots as golden orb weaver spiders	
B	• black body with blue spots • black legs with blue spots • same pattern of spots as golden orb weaver spiders	
C	• black body with large yellow spot • black legs • total area of yellow colour is the same as model **A**	
D	• yellow body • yellow legs	
E	• black body • black legs	

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At the first web, the biologists:

- removed the living golden orb weaver spider from the web
- placed model **A** in the centre of the web
- placed a video camera 1 m from the web
- filmed the web and model for 6 hours
- recorded an insect attraction event whenever an insect flew towards the model, touched the model, or touched the web
- calculated the insect attraction rate of model **A**.

The procedure was repeated by placing models **B**, **C**, **D** and **E** on the four other webs.

The whole investigation was repeated 25 times, and a mean insect attraction rate for each model was calculated.

(a) (i) Identify the **dependent** variable in this investigation.

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(ii) The pattern of spots on models **A** and **B** was the same as the pattern of spots on female golden orb weaver spiders.

Identify **two other** variables that the biologists should standardise when making the models for this investigation.

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(iii) Suggest a suitable control for this investigation.

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(b) Fig. 2.2 shows the mean insect attraction rates for the five models. The error bars show ± one standard error (SE).

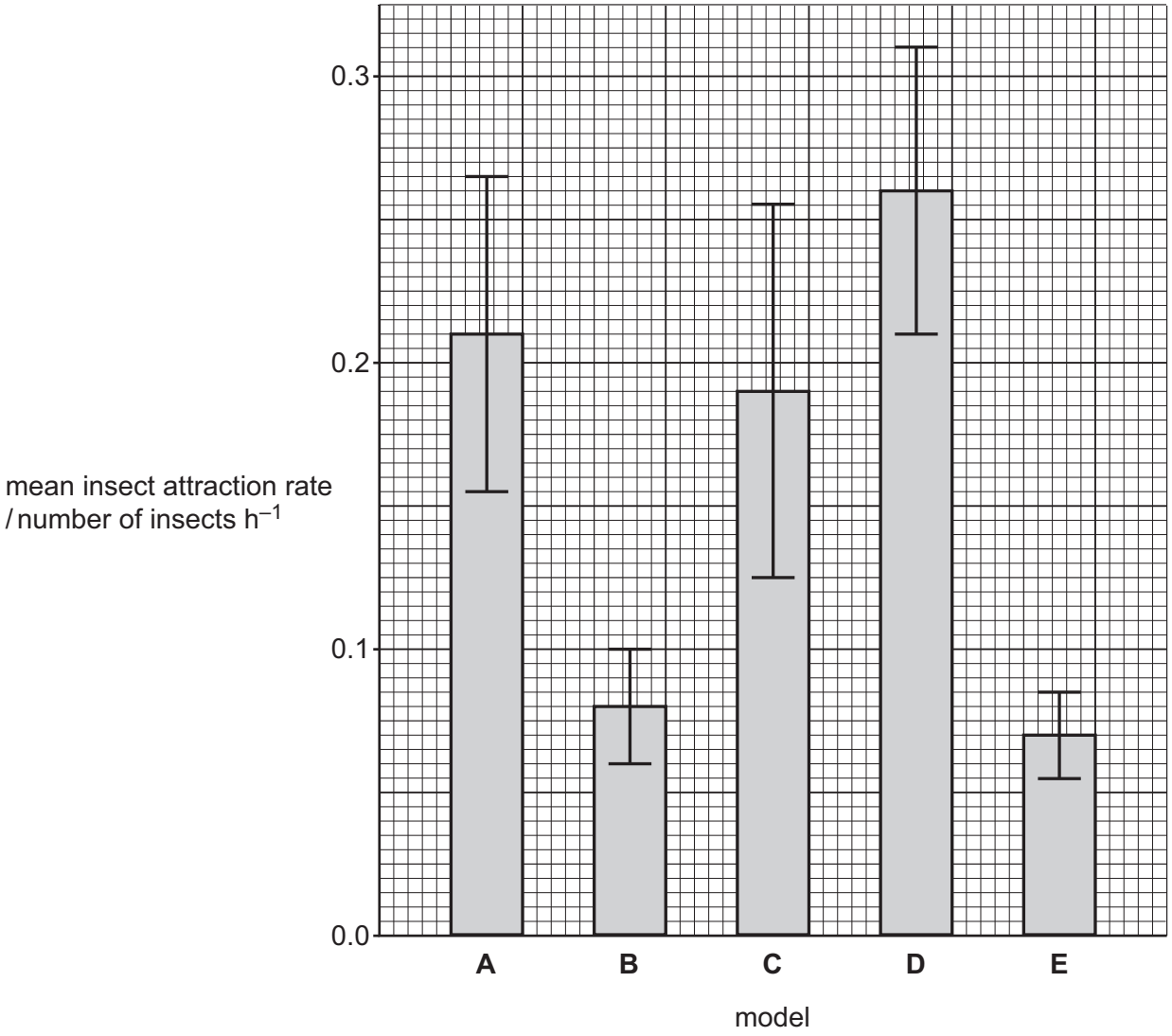


Fig. 2.2

(i) Use the information shown in Table 2.1 and Fig. 2.2 to discuss the conclusions that can be made about the effect of colour **and** pattern of spots on the models on insect attraction rates.

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(ii) The biologists decided to analyse the data in Fig. 2.2 using *t*-tests.

State a null hypothesis the biologists could make before carrying out the *t*-tests.

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(iii) State **two** reasons why the *t*-test is suitable for analysing the data shown in Fig. 2.2.

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(c) A student thought that the investigation did not provide enough information about how the colour and pattern of spots on female golden orb weaver spiders help to attract insects to their webs.

Suggest how this investigation could be improved to increase confidence in the results.

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[Total: 13]

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BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

1 hour 15 minutes

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No additional materials are needed.

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INFORMATION

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1 Phosphatases are enzymes that catalyse the removal of phosphate from other molecules, releasing inorganic phosphate (P_i). A phosphatase can be extracted from mung bean seedlings, *Vigna radiata*.

Fig. 1.1 shows mung bean seedlings.

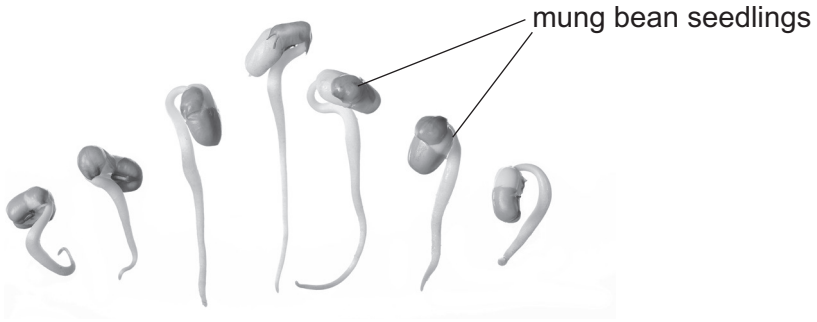


Fig. 1.1

A student found a published method to extract phosphatase from mung bean seedlings.

- Use a pestle and mortar to grind mung bean seedlings, with a small volume of distilled water, to make a paste.
- Add distilled water to the paste to make a mixture with a total volume of 50 cm^3.
- Filter the mixture and put the filtrate into a clean centrifuge tube.
- Centrifuge the filtrate until a solid pellet is formed, as shown in Fig. 1.2.
- Pour the liquid extract containing phosphatase into a clean test-tube.

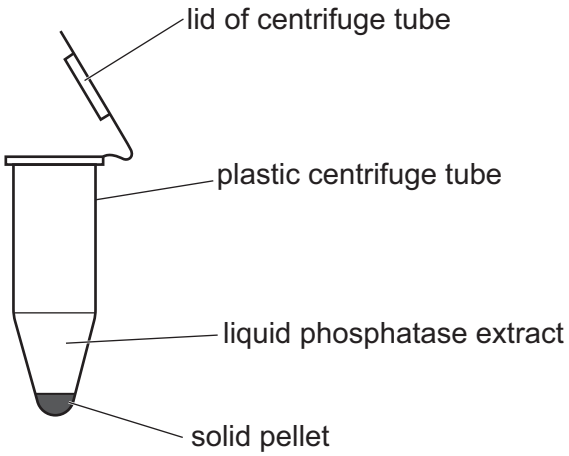


Fig. 1.2

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(a) State **two** other variables that should be standardised in the published method so that extracts with the same concentration of phosphatase can be produced.

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(b) The student read that the optimum pH for phosphatase extracted from mung bean seedlings is less than pH 7.0.

The student decided to investigate phosphatase activity, using the substrate phenolphthalein phosphate (PPP).

In the first four steps of the method, the student:

- mixed 5 cm^3 of pH 6.0 buffer solution with 1 cm^3 of a 1.0% solution of PPP in a test-tube
- added 1 cm^3 of the phosphatase extract to the test-tube and started a timer
- incubated the test-tube for 10 minutes in a water-bath at 30 °C
- stopped the enzyme reaction after 10 minutes, by adding 5 cm^3 of 10.0% solution of sodium carbonate. Sodium carbonate solution is alkaline.

(i) The buffered PPP solution and the phosphatase extract were mixed and then placed in the water-bath. The student identified this as a source of error in the method.

Explain why this is a source of error **and** state how you would modify the method to remove this source of error.

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(ii) Suggest how the addition of 10.0% solution of sodium carbonate stops the enzyme reaction.

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(c) The phosphatase catalyses the removal of inorganic phosphate from PPP as shown by:

$$\text{PPP} \xrightarrow{\text{phosphatase}} \text{phenolphthalein + inorganic phosphate}$$

The 10.0% solution of sodium carbonate added at the end of the experiment also causes any phenolphthalein to turn pink. The intensity of the pink colour is an indication of the concentration of phenolphthalein.

To estimate the concentration of phenolphthalein produced by the reaction, the student decided to make a proportional dilution using a 2.0% stock solution of phenolphthalein.

The student made 50 cm^3 of each diluted solution.

Describe a method the student could use to make a proportional dilution of the 2.0% stock solution of phenolphthalein to get a range of concentrations.

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(d) Describe how the student could use the dilutions from **(c)** and a colorimeter to estimate the concentration of phenolphthalein in a reaction mixture.

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(e) The student decided to determine the optimum pH for phosphatase extract from the mung bean seedlings.

Describe a method the student could use to determine the optimum pH for phosphatase.

Your method should be set out in a logical order and be detailed enough to allow another person to follow it.

Details of how to extract phosphatase from the mung bean seedlings **and** how to make the dilutions of phenolphthalein solutions should **not** be included.

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(f) The student investigated the effect of a competitive inhibitor on the activity of a phosphatase.

Fig. 1.3 shows a graph of the initial rates of enzyme reaction against PPP concentration for the enzyme with no inhibitor and the enzyme with inhibitor.

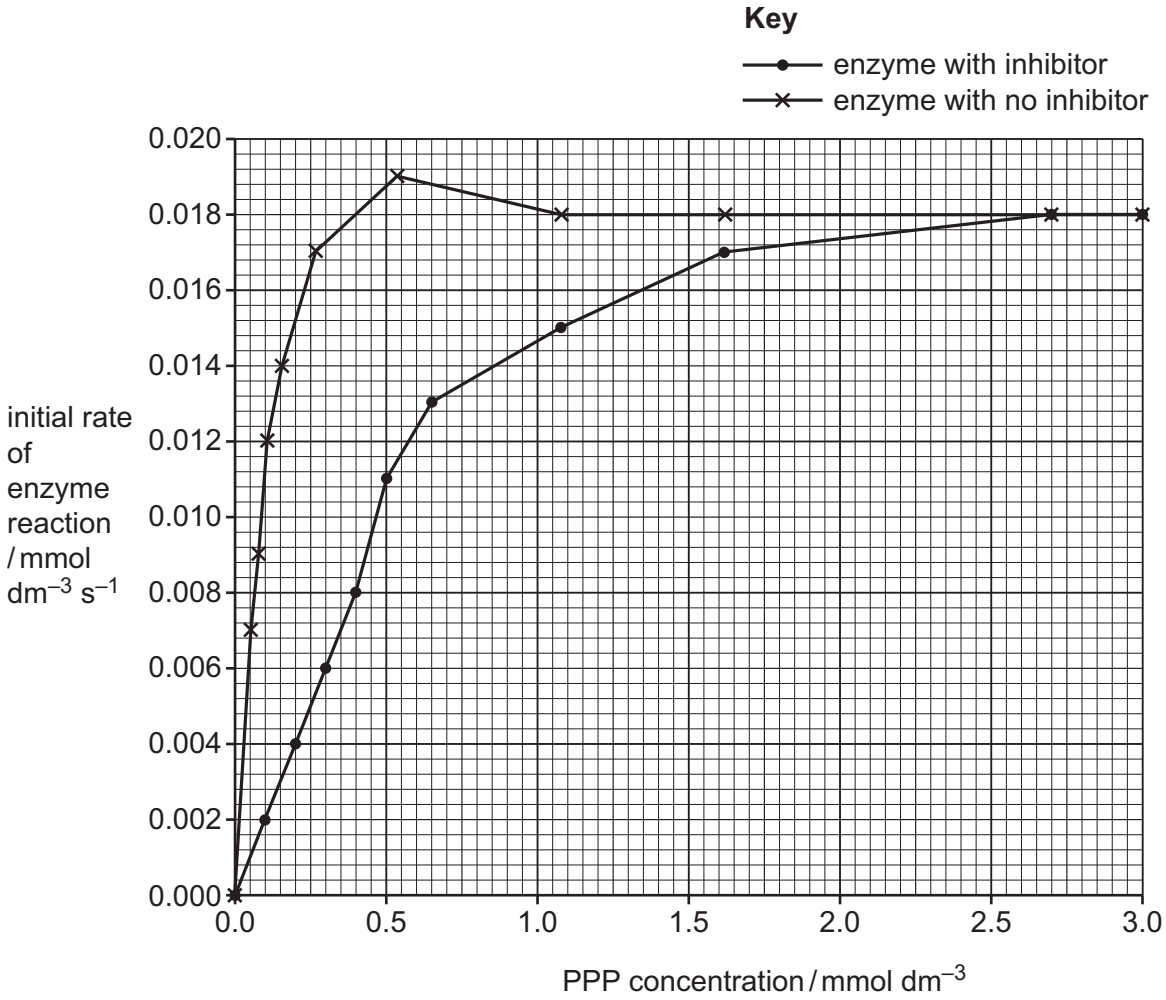


Fig. 1.3

(i) One of the data plots in Fig. 1.3 is anomalous.

Circle the anomalous data plot in Fig. 1.3 **and** explain why you think it is anomalous.

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(ii) Use Fig. 1.3 to determine the Michaelis–Menten constant (K_m) for the enzyme with no inhibitor and for the enzyme with inhibitor.

Include the correct units in your answers.

K_m for the enzyme with no inhibitor = ...

K_m for the enzyme with inhibitor = ...
[1]

(iii) Calculate the percentage increase in the K_m that occurs in the presence of the inhibitor.

Show your working.

percentage increase = ... % [2]

[Total: 20]

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2 Sponges are immobile, aquatic animals that live on rocks and sediment at the bottom of salt water environments.

Fig. 2.1 shows an example of a sponge, growing on the seabed, in a marine habitat.

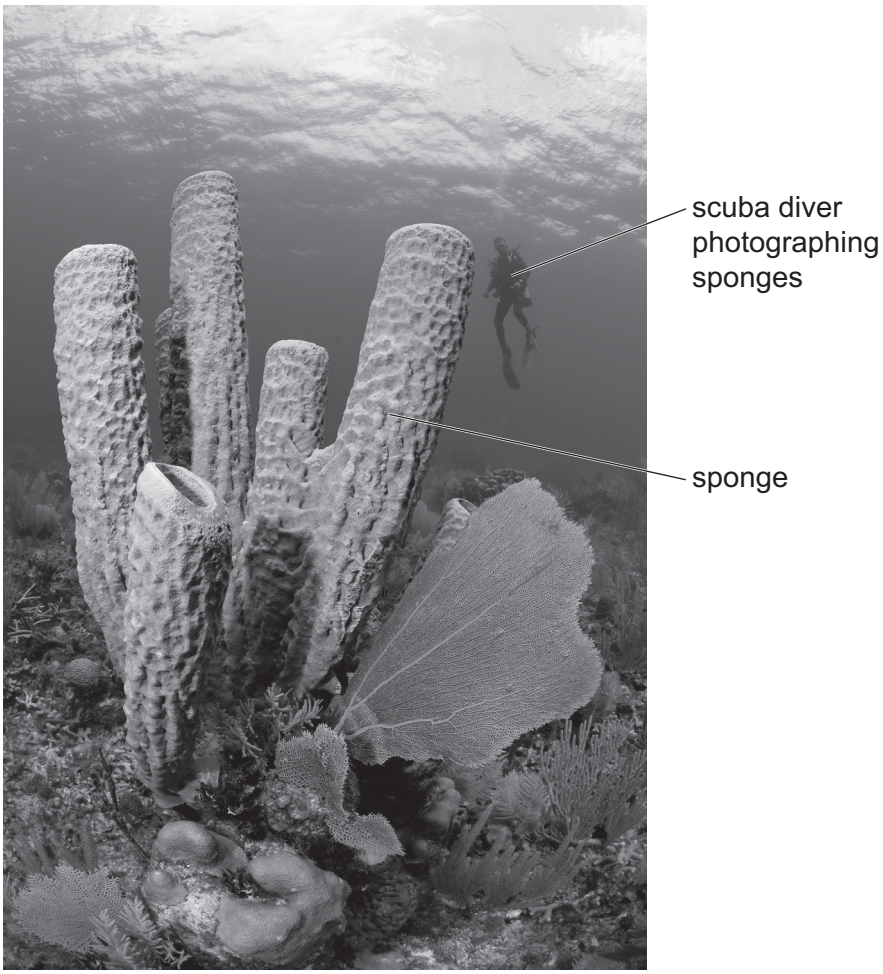


Fig. 2.1

There are many different species of sponge. Most species of sponge are sensitive to environmental stress. Human activity causes some environmental stress.

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Scientists sampled the marine habitats along a length of coastline in Algeciras Bay in southern Spain to study the species diversity of sponges.

The scientists selected 12 sampling stations, **A** to **L**, as shown in Fig. 2.2. The scientists noted the land use or human activity along the coast next to each sampling station.

Key to diagram:

sampling station	type of land use or human activity
A	natural habitat
B	natural habitat
C	tourist beach
D	housing
E	shipping port
F	tourist beach
G	thermal power station
H	oil industry
I	ship building and repairs
J	tourist boats
K	tourist boats
L	natural habitat

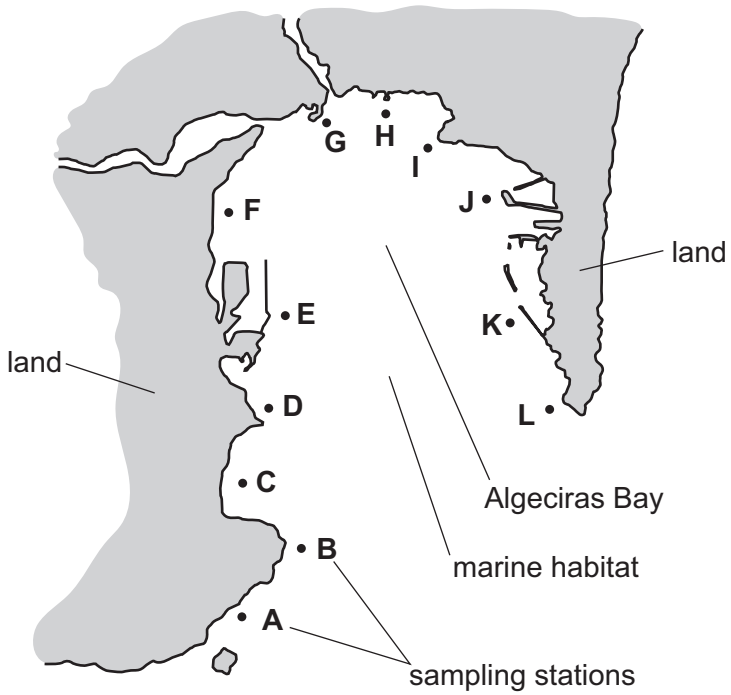


Fig. 2.2

The sampling stations were chosen to compare the effects of land use or human activity on the species diversity of sponges in the bay.

At each marine sampling station, the scientists:

- placed permanent line transects, 50 m in length, on the seabed
- photographed all sponges sighted at a distance of 1 m either side of the transect
- sampled each transect for the same length of time
- sampled each transect four times a year.

(a) The scientists standardised some variables.

State **two other** variables that the scientists should standardise in this investigation.

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(b) The scientists compared the species diversity of sponges between different sampling stations using an index of diversity known as beta diversity.

The higher the beta diversity index, the higher the species diversity at a sampling station.

Fig. 2.3 shows a graph of the beta diversity index for each sampling station.

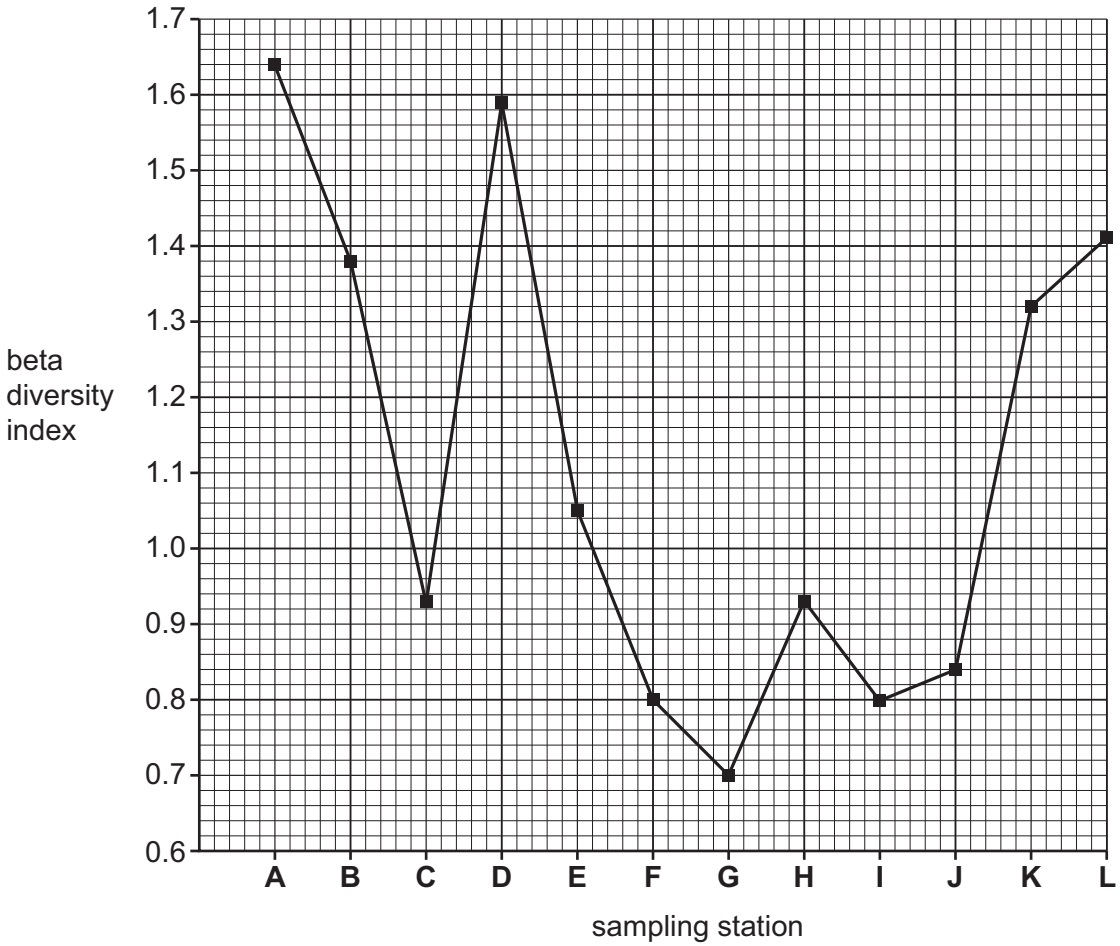


Fig. 2.3

A simplified formula for beta diversity is shown:

$$\text{beta diversity} = \frac{n}{\bar{x} - 1}$$

Key to symbols:

n = the number of sponge species recorded at a sampling station

$\bar{x}$ = the mean number of sponge species across all sampling stations

At sampling station **A**, 37 sponge species were recorded (n = 37).

Use Fig. 2.3 and the formula for beta diversity to calculate the mean number of sponge species across all sampling stations ($\bar{x}$).

Show your working. Write your answer to the nearest whole number.

mean number of sponge species across all sampling stations ($\bar{x}$) = ... [2]

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(c) (i) A student concluded that the species diversity of sponges was higher in the sampling stations where there was less human activity.

Using the information in Fig. 2.2 and in Fig. 2.3, evaluate this conclusion.

Use the values in Fig. 2.3 to support your answer.

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(ii) Use the information in Fig. 2.2 and in Fig. 2.3 to state **two other** conclusions about the species diversity of sponges in Algeciras Bay.

Use the values in Fig. 2.3 to support your answer.

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Cambridge Assessment International Education

Cambridge International AS & A Level

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BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

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1 *Drosophila melanogaster* is a species of fruit fly.

Fig. 1.1 shows a female fruit fly and a male fruit fly. A typical fruit fly is 3 mm in length.



Fig. 1.1

Scientists have studied the inheritance patterns of many genetic traits in fruit flies.

To carry out genetic crosses with fruit flies:

- a specimen tube is prepared with food for the fruit flies, as shown in Fig. 1.2
- adult male and female fruit flies are added to the specimen tube to allow mating to take place
- the specimen tube is kept in warm conditions for several days
- the eggs laid by female fruit flies develop into pupae
- adults are removed from the specimen tube before pupae mature into adult fruit flies
- offspring emerge as adult flies 10-15 days after eggs are laid.

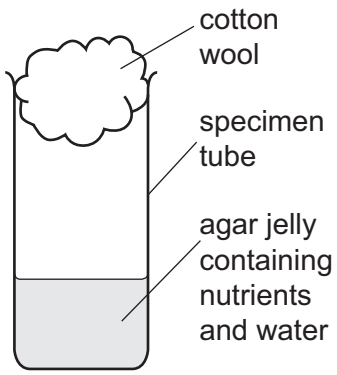


Fig. 1.2

One of the genetic traits studied in fruit flies is eye colour. The normal (wild type) eye colour of *D. melanogaster* is red.

Eye colour in *D. melanogaster* is controlled by several genes, including two genes that are located on separate chromosomes, **A/a** and **D/d**.

- Allele **A** is dominant to allele **a**.
- Allele **D** is dominant to allele **d**.

Table 1.1 summarises eye colour in *D. melanogaster* for these two genes.

Table 1.1

eye colour phenotype	genotypes
red	AADD, AaDD, AaDd, AADd
brown	AAdd, Aadd
scarlet (bright red)	aaDD, aaDd
white	aadd

(a) A student was provided with two populations of fruit fly:

- brown-eyed fruit flies with genotype AAdd
- scarlet-eyed fruit flies with genotype aaDD.

In each population, males and females were provided in separate specimen tubes.

The student decided to carry out two genetic crosses.

The first cross used fruit flies from the initial populations to produce offspring that are heterozygous for each of the two genes (double heterozygotes).

The second cross used the double heterozygotes produced from the first cross.

To carry out the genetic crosses, the student was provided with standard laboratory equipment and:

- specimen tubes containing food
- a chemical to anaesthetise the flies – this chemical, when given at a particular dose, makes the flies immobile for more than 30 minutes
- small brushes for sorting immobile flies without harming them.

(i) Identify a hazard in this investigation **and** state a risk associated with the hazard **and** state **one** precaution that the student should take.

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(ii) Describe a method the student could use to carry out:

- the first cross using fruit flies from the initial two populations to produce double heterozygotes (genotype AaDd)
- the second cross using the double heterozygotes produced from the first cross
- an analysis of the offspring phenotype ratio from the second cross.

The description of your method should be set out in a logical way and be detailed enough for another person to follow.

The method should include a description of how offspring phenotypes would be identified.

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(iii) Predict the ratio of offspring phenotypes from the cross between parents that are heterozygous for the two genes (AaDd).

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ratio .....

phenotypes.....

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(b) After crossing double heterozygotes (genotype AaDd), the student recorded the numbers of offspring in each of the four phenotypic groups.

The student used a chi-squared (χ^2) test to analyse these data.

The null hypothesis for this χ^2 test was:

There is no difference between the expected and observed numbers of offspring in each phenotypic group.

The calculated value of χ^2 was **4.798**.

The student compared **4.798** to the values in Table 1.2.

Table 1.2

degrees of freedom	probability level (*p*)		
	0.10	**0.05**	**0.01**
1	2.706	3.841	6.635
2	4.605	5.991	9.210
3	6.251	7.815	11.345
4	7.779	9.488	13.277
5	9.236	11.070	15.086

Using Table 1.2 and the calculated value of χ^2 of **4.798**, state **and** explain what the student can conclude about the results.

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2 Echidnas are mammals that live in Australia and New Guinea.

Fig. 2.1 shows an echidna.



Fig. 2.1

Scientists analysed the milk produced by female echidnas and identified a protein that they named EchAMP. The scientists predicted that EchAMP may have antibacterial properties.

The scientists tested the effect of EchAMP on the bacterium *Escherichia coli*.

1. 100 *E. coli* cells were added to each well on a cell culture plate with 96 wells.
2. A treatment solution that contained EchAMP was added to each well on the plate.
3. A chemical that causes living *E. coli* cells to fluoresce was added to each well.
4. The plate was incubated at 37°C.
5. Every hour for 7 hours, the fluorescence emitted by the *E. coli* on the plate was recorded as a measure of *E. coli* population growth.
6. Steps 1–5 were repeated eight times.

The scientists also carried out two control experiments.

- A negative control experiment repeated the procedure (steps 1–6), but the treatment solution did not contain EchAMP.

- A positive control experiment repeated the procedure (steps 1–6), but the treatment solution contained an antibiotic called bacitracin instead of EchAMP.

(a) Identify the **independent** variable in this investigation.

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(b) The scientists standardised the temperature and the initial number of *E. coli* cells.

State **two other** variables that the scientists should standardise in this investigation.

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(c) **(i)** Explain why the scientists included the negative control experiment in their investigation.

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(ii) Explain why the scientists included the positive control experiment in their investigation.

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(d) Some of the results are shown in Table 2.1.

Table 2.1

time / hours	mean fluorescence / arbitrary units (au)		
	EchAMP	**negative control**	**positive control**
0	10	10	10
1	11	11	11
3	15	15	15
6	20	35	20
7	100	140	70

(i) Use Table 2.1 to complete the graph in Fig. 2.2 by:

- plotting the three results at 7 hours
- adding axis labels
- completing the key.

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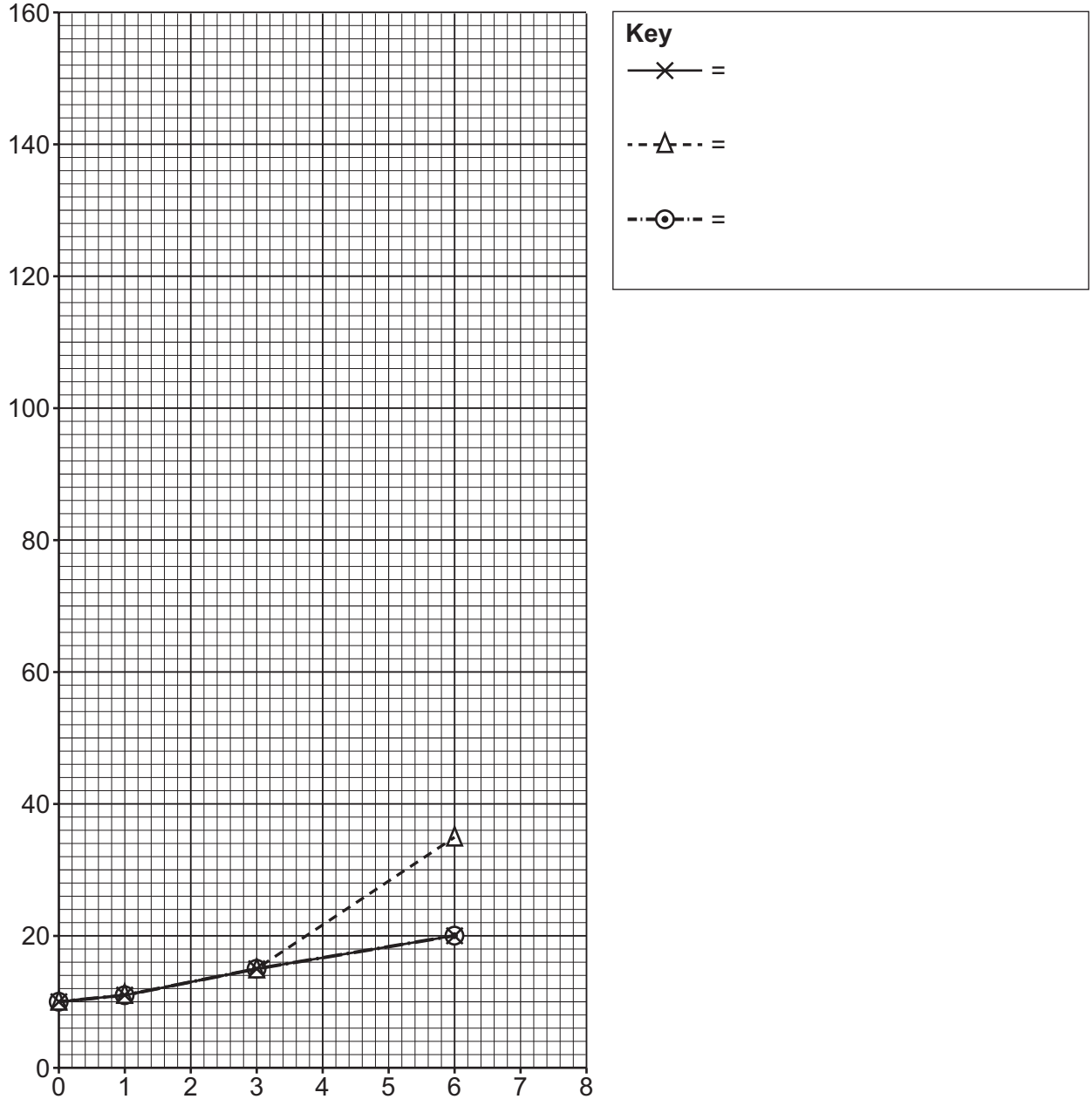


Fig. 2.2

[2]

(ii) Use Table 2.1 and Fig. 2.2 to compare the effect of EchAMP and bacitracin on the population growth of *E. coli*.

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(e) The scientists used *t*-tests to analyse the results.

The scientists compared the fluorescence emitted by *E. coli* after seven hours when exposed to:

- the negative control
- EchAMP.

(i) State a null hypothesis for this *t*-test.

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(ii) For *E. coli* exposed to the negative control, after seven hours:

- the mean of nine fluorescence measurements was 140 au
- the sample standard deviation was 8 au.

For *E. coli* exposed to EchAMP, after seven hours:

- the mean of nine fluorescence measurements was 100 au
- the sample standard deviation was 10 au.

The formula for calculating a *t*-test is:

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

key to symbols

$\bar{x}$ = mean

s = sample standard deviation

n = sample size (number of observations)

Calculate a value of *t* for these data.

Show your working and state your answer to **four** significant figures.

t = ... [3]

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(iii) The *t* value calculated by the scientists was significant.

After reading the scientific paper published by the scientists, a student wrote the conclusion:

EchAMP would make a good treatment for bacterial infections in the human digestive system.

Suggest **four** reasons why this conclusion might **not** be valid.

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Cambridge International AS & A Level

CANDIDATE NAME

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CANDIDATE NUMBER

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BIOLOGY **9700/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2025**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
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- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **8** pages.

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1 A student investigated the effect of gibberellin (GA) and abscisic acid (ABA) on the germination of wheat grains.

The student found out the following information.

- The molecular mass of GA is 346 g.
- The molecular mass of ABA is 264 g.
- The range of concentrations at which GA is active in plant tissues is from 1×10^{-6} to 1×10^{-5} mol dm^{-3}.
- The range of concentrations at which ABA is active in plant tissues is from 1×10^{-6} to 1×10^{-4} mol dm^{-3}.
- Newly formed wheat grains contain a high concentration of ABA which decreases over time.
- When the concentration of ABA falls low enough the GA is able to promote germination.
- Wheat germinates best at temperatures from 10 °C to 25 °C and without light.

Fig. 1.1 shows the germination and early growth of wheat.

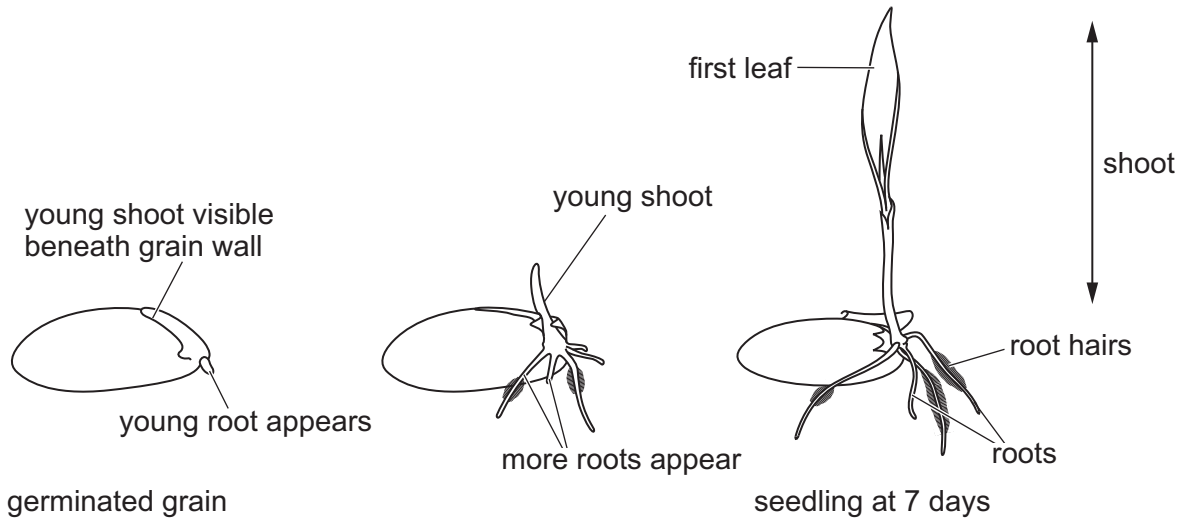


Fig. 1.1

To test the effects on germination of adding ABA, the student started by soaking wheat grains for 24 hours in a solution of 1×10^{-6} mol dm^{-3} GA. These were then split into several groups of 50 grains and a different concentration of ABA was added to each group.

The student made a stock solution of ABA with a concentration of 1×10^{-3} mol dm^{-3} which was then diluted to make the solutions needed for the investigation.

(a) (i) Using the information about ABA above, describe how the student made a stock solution of 1×10^{-3} mol dm^{-3} ABA.

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(ii) The student used the stock solution of 1×10^{-3} mol dm^{-3} ABA to prepare a range of dilutions from 1×10^{-4} mol dm^{-3} to 1×10^{-7} mol dm^{-3} to use in their investigation.

Each dilution had a volume of 100 cm^3.

Describe how the student prepared these dilutions.

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(b) (i) Identify the independent and the dependent variables in this investigation.

independent variable.....

dependent variable..... [2]

(ii) Describe a procedure that the student could use to complete the investigation to find the effect of different concentrations of ABA on the germination of wheat grains.

Your method should be detailed enough for another person to use and should **not** repeat any details from **(a)(ii)** of how to dilute the stock solution.

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(c) The student calculated the percentage germination of the grains in the different concentrations of ABA.

(i) Explain how the percentage germination was calculated.

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(ii) Complete Fig. 1.2 by sketching a graph to predict the results the student might expect. On the axes, show the range of values and the units that might be used to plot the graph.



Fig. 1.2

[3]

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(d) In another investigation the student tested the effect of gibberellin (GA) on the elongation of shoots. Five groups of 20 wheat grains were soaked in GA solution. Each group was treated with a different concentration of GA and then left to germinate and grow for 10 days. The length of each shoot was measured and a mean shoot length was calculated for each GA concentration.

Table 1.1 shows the results of this investigation.

Table 1.1

concentration of GA / mol dm^{-3}				
0	1×10^{-7}	1×10^{-6}	1×10^{-5}	1×10^{-4}
mean shoot length / mm ± SE				
120 ± 10	150 ± 5	175 ± 15	210 ± 12	180 ± 8

(i) Explain what standard error (SE) shows about the reliability of the results in Table 1.1.

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..... [2]

The student carried out a number of *t*-tests.

In each *t*-test, the student compared the mean shoot length of the seedlings grown from grains that were **not** treated with GA with those that were treated with GA.

(ii) Suggest a null hypothesis for the *t*-test between **no** GA treatment and those treated with 1×10^{-5} mol dm^{-3} GA.

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(iii) Explain how the student should use the values for *t* to determine if there is a significant difference between the mean shoot length of wheat grown with **no** GA treatment and the mean shoot length of wheat grown with GA treatment.

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[Total: 21]

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2 A student investigated the oxygen consumption of isolated mitochondria under different conditions.

Mitochondria were isolated by crushing liver cells in ice cold buffer and filtering to remove cell debris. The filtrate was centrifuged to separate the mitochondria. The mitochondria were suspended in ice cold buffer.

(a) State **one** reason for keeping the mitochondria in cold buffer solution during isolation.

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Fig. 2.1 shows the apparatus used to measure the oxygen consumption of the isolated mitochondria.

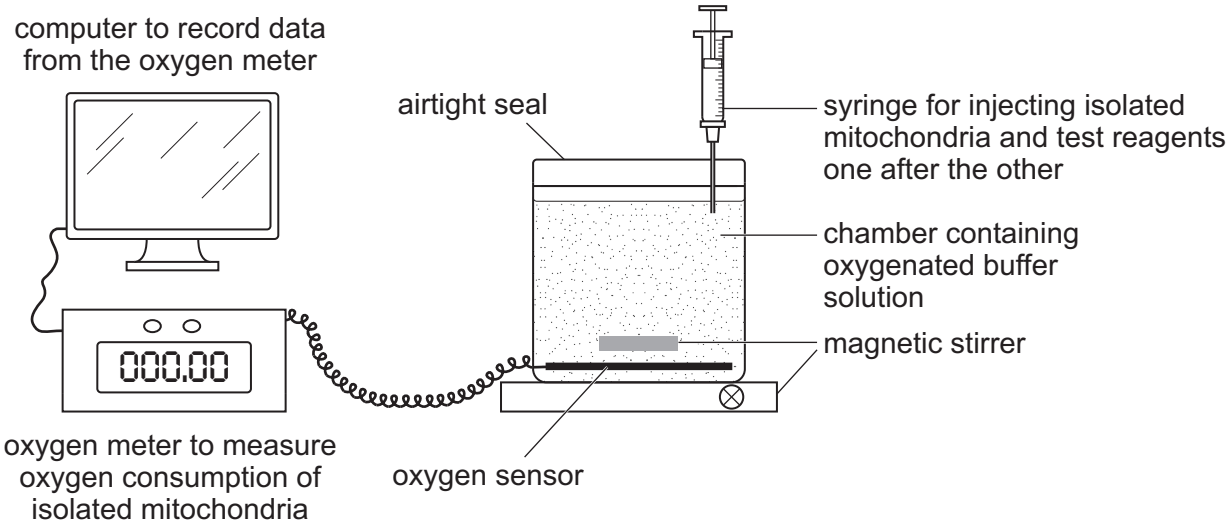


Fig. 2.1

The apparatus was used as follows.

- The apparatus was set up as shown in Fig. 2.1 and left for 1 minute to equilibrate.
- At 1 minute, a standard volume of mitochondria in buffer solution was injected through the seal.
- At 2 minutes, a solution of succinate, a Krebs cycle intermediate, was injected through the seal.
- At 5 minutes, a solution of ADP was injected through the seal.
- At 6 minutes, a solution of cyanide was injected through the seal.

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During this procedure the oxygen concentration in the chamber was measured continuously and displayed as a trace on the computer screen as shown in Fig. 2.2.

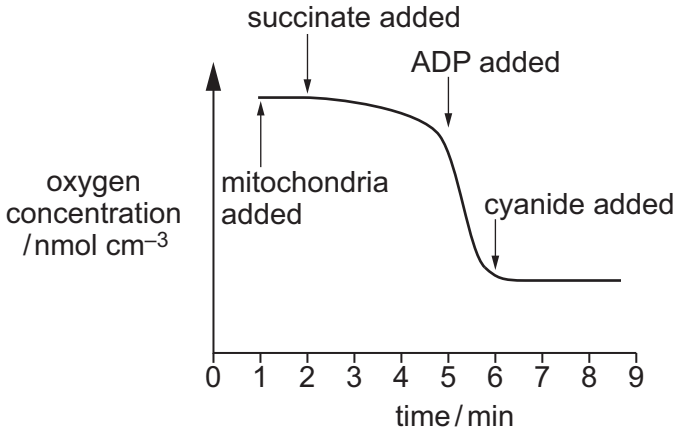


Fig. 2.2

Using the figures from the trace, the computer calculated the rate of oxygen consumption following each addition. This procedure was repeated three more times using fresh samples of mitochondria.

Table 2.1 shows the rates of oxygen consumption for each of the four trials.

Table 2.1

	rate of oxygen consumption / nmol min^{-1}				
	trial 1	**trial 2**	**trial 3**	**trial 4**	**mean**
mitochondria alone	0.03	0.02	0.03	0.01	0.02
mitochondria with succinate	50.22	49.10	48.53	50.15	
mitochondria with ADP and succinate	139.23	170.10	142.67	138.10	147.53
mitochondria with cyanide, ADP and succinate	0.00	0.10	0.00	0.01	0.03

(b) (i) Calculate the mean rate of oxygen consumption for mitochondria with succinate.

Write your answer in Table 2.1. [1]

(ii) On Table 2.1 indicate, by placing a circle around each value, **two** results that may be anomalous. [2]

(iii) State **two** ways that the student could have processed the results to allow for these possible anomalies.

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(c) Explain the results shown in Fig. 2.2 and Table 2.1.

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