

RAFFLES INSTITUTION
2025 Year 6 Preliminary Examination

Higher 2

CANDIDATE
NAME

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CIVICS
GROUP

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INDEX
NUMBER

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BIOLOGY

Paper 4 Practical

9744/04

22nd August 2025

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your index number, CT group and name on all the work you hand in.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

Write in dark blue or black pen.

You may use a 2B pencil for any diagrams or graphs.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, hand in the Question Paper containing your answers.

The number of marks is given in brackets [] at the end of each question or part of the question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **19** printed pages.



Raffles Institution
Internal Examination

Answer **all** questions.

Question 1

- (a) Before you proceed, read carefully through **the whole** of Question 1(a).

You are provided with a blue solution, labelled **I**, which is alkaline.

I is blue because it contains an indicator.

Carbon dioxide reacts with **I** when bubbled into it. When enough carbon dioxide reacts with **I**, the indicator will change from blue to yellow (even if the solution is cloudy). This is the end-point.

Hydrochloric acid, **H**, can also turn indicator **I** yellow. If only a small volume of carbon dioxide is bubbled into **I** then the indicator will remain blue. Hydrochloric acid, **H**, can then be added slowly until the indicator turns from blue to yellow.

- (i) What is the expected trend of volume of **H** that needs to be added to reach end point with increased volume of carbon dioxide that has reacted with indicator, **I**.

.....
[1]

You are provided with:

labelled	contents
YA	yeast cell suspension
I	alkaline solution (blue)
H	hydrochloric acid

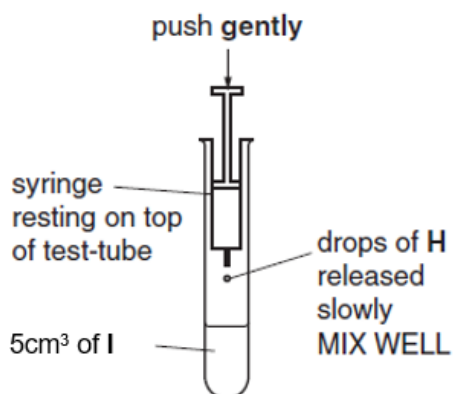
I and H are irritants. Suitable eye protection should be worn. If I or H comes into contact with your skin, wash it off immediately under tap water.

You are first required to find the volume of **H** needed to reach the end-point, when **no** carbon dioxide has been bubbled into **I**.

Proceed as follows:

1. Put 5 cm³ of **I** into a test-tube.
2. Use a syringe, containing 2 cm³ of **H**, to put drops of **H** into **I** as shown in Fig. 1.1.

Mix well as you add **H**, until the end-point is reached. You may need to fill the syringe again.

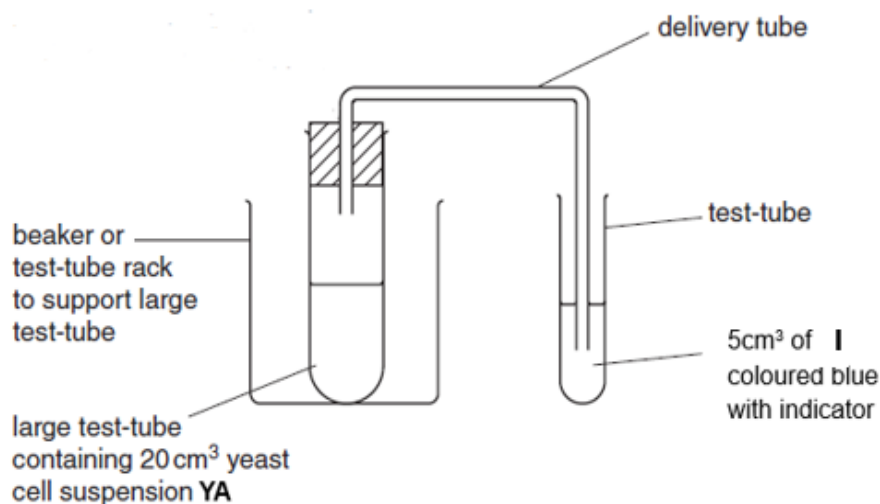
**Fig 1.1**

- (ii) Record the volume of **H** needed to reach the end-point.

volume of **H**[1]

Yeast cells release carbon dioxide from some of their metabolic reactions.

A student investigated the release of carbon dioxide from a yeast cell suspension, using the apparatus shown in Fig. 1.2.

**Fig 1.2**

The student set up this apparatus and left it for 10 minutes.

The student observed that during the 10 minutes the bubbles of carbon dioxide were not released at a constant rate.

- (iii) Suggest an explanation for the student's observation on the rate of release of carbon dioxide.

.....
[1]

You are required to investigate this observation using the apparatus set up as in Fig. 1.2.

You will move the delivery tube to different test-tubes containing **I**, at different times during the 10 minutes.

- (iv) Decide the length of time you will leave the delivery tube in each test-tube containing **I**.
 State the length of time.

time..... [1]

- (v) State **one** significant source of error that may occur when the delivery tube is moved from one test-tube to the next.

Describe how you will reduce this error.

source of error.....

description.....

.....[2]

Read steps **3** to **10** before proceeding:

3. Put 5 cm³ of **I** into a test-tube. Repeat for the number of test-tubes you need to use for your times in **(a)(iv)**.
4. Obtain **YA** by placing the nozzle of a large syringe below any froth on the surface.
5. Put 20 cm³ of **YA** into the large test-tube.
6. Put the bung containing the delivery tube into the large test-tube. It **must** be airtight.
7. Put the end of the delivery tube into the first test-tube containing **I**. Immediately start timing.
8. After the time you decided in **(a)(iv)**, move the delivery tube to the next test-tube containing **I**.
9. Repeat step **8** for all the test-tubes which you set up in step **3**.
10. After removing the delivery tube from the last test-tube, repeat step **2** with any of the test tubes where there is still a blue colour.

Unplug the rubber bung from the large test tube after step 10 is completed.

Record your results in **(vi)**.

For any test-tubes where I is yellow (even if the solution is cloudy) record '0'.

- (vi)** Prepare the space below to record your results.

[4]

- (vii)** Explain whether your results in **(vi)** support the student's observation.

.....

.....

[1]

- (b) Before you proceed, read carefully through **the whole** of Question 1(b).

Yeast cells also contain enzymes that hydrolyse sucrose into reducing sugars, as shown in Fig. 1.3.

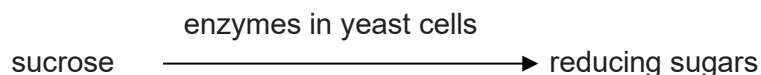


Fig.1.3

You will investigate the activity of the enzymes in yeast cells.

To immobilise the yeast cells in sodium alginate beads, yeast and alginate should be in equal proportions. (You will need no more than 20 cm³ of the mixture).

Alginate will solidify when released into calcium chloride solution, and should be left in the solution for 5 min.

You are provided with the following which you **must** use:

labelled	contents
YB	15 cm ³ yeast cell suspension
A	15 cm ³ sodium alginate solution
C	20 cm ³ calcium chloride solution

Alginate and calcium chloride are irritants. Suitable eye protection should be worn. If A or C comes into contact with your skin, wash it off immediately under tap water.

You are also provided with the following which you may use:

Apparatus:

100 cm³ beaker

5 cm³ syringes

glass rod

- (i) Describe the steps you would carry out to make 30 yeast alginate beads of similar size and shape.

.....

.....

.....

.....[2]

You are also provided with the following which you **must** use:

labelled	contents
B	10 cm ³ Benedict solution
S	50 cm ³ sucrose solution

Apparatus:

Bunsen burner

forceps

test-tubes

Thermometer

(ii) Describe the steps to carry out a quantitative experiment to investigate the effect of enzyme concentration on the rate of hydrolysis of sucrose solution, **S**. You are required to use the yeast-alginate beads prepared in **(b)(i)**. You are not required to plan for replicates and safety precautions.

[4

- (iii) Carry out your planned procedure using 8 yeast-alginate beads. Calculate the relative rate of yeast activity. Show your working.

relative rate of yeast enzyme activity = [1]

- (c) Pectinases are enzymes that are used to increase the volume of fruit juice extracted from apples. Pectinases can be immobilised and placed inside a container with apple pulp as shown in Fig. 1.4. The fruit juice is then collected.

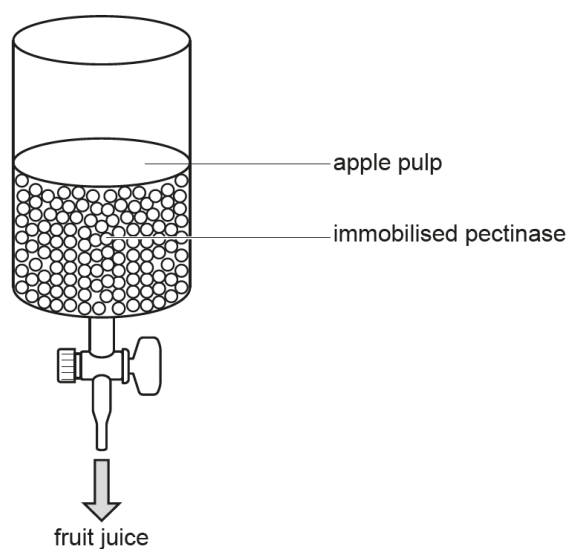


Fig. 1.4

A scientist carried out an investigation to determine the effect of temperature on the activity of immobilised pectinase by measuring the volume of fruit juice extracted. All other variables were kept constant.

The results are shown in Table 1.1.

Table 1.1

immobilised pectinase	
temperature / °C	volume of fruit juice / cm ³
30	38
40	54
50	79
60	98
70	62
80	4

The scientist repeated the investigation replacing the immobilised pectinase with the same amount of pectinase but not immobilised in beads (free pectinase).

The results are shown in Table 1.2.

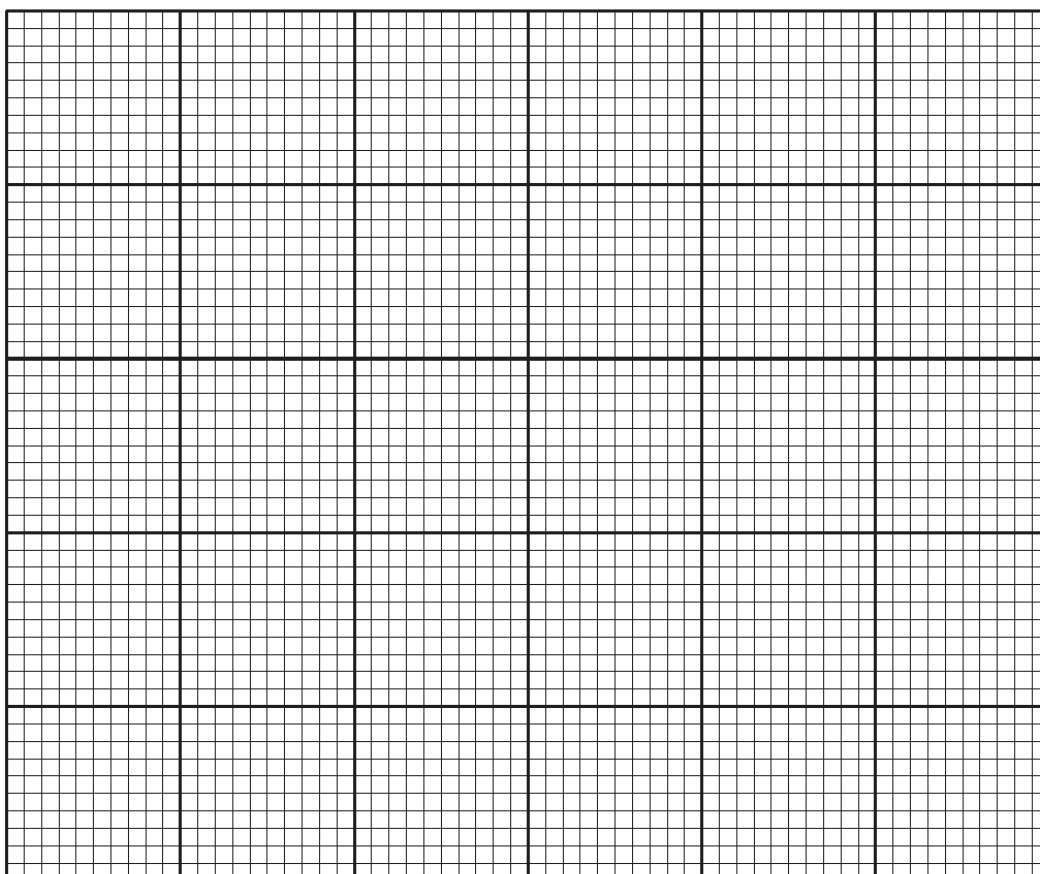
Table 1.2

free pectinase (not immobilised)	
temperature / °C	volume of fruit juice/cm ³
30	52
40	85
50	98
60	41
70	12
80	4

Plot 2 graphs based on the data in Table 1.1 and Table 1.2 on the grid below.

Use a sharp pencil.

(i)



[4]

- (ii) Using your graph, estimate the volume of the fruit juice extracted at 45°C.

Show on your graph how you obtained your answer.

volume of fruit juice extracted from immobilized pectinase

.....[1]

volume of fruit juice extracted from free pectinase

.....[1]

- (iii) Suggest an explanation for the difference in volume of fruit juice obtained when using the free pectinase at 45°C and when using immobilised pectinase.

.....
.....[1]

- (iv) Suggest why more fruit juice was obtained when using immobilized pectinase between the temperatures of 60°C and 70°C than when using the free pectinase.

.....
.....[1]

- (d) More readings were taken at 50 °C of the immobilised pectinase and the free pectinase and the results are shown in Table 1.3.

Table 1.3

sample number	immobilised pectinase	free pectinase
1	78	99
2	73	97
3	72	96
4	77	98
5	75	96
6		100
7		100
Mean	75	98
Standard deviation	2.28	1.73

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

The t test value is 17.49.

Table 1.4

degrees of freedom	probability, p				
	0.5	0.1	0.05	0.01	0.001
1	1.00	6.31	12.71	63.66	636.62
2	0.82	2.92	4.30	9.92	31.60
3	0.76	2.35	3.18	5.84	12.92
4	0.74	2.13	2.78	4.60	8.61
5	0.73	2.02	2.57	4.03	6.87
6	0.72	1.94	2.45	3.71	5.96
7	0.71	1.89	2.36	3.50	5.41
8	0.71	1.86	2.31	3.36	5.04
9	0.70	1.83	2.26	3.25	4.78
10	0.70	1.81	2.23	3.17	4.59
11	0.70	1.80	2.20	3.11	4.44
12	0.70	1.78	2.18	3.05	4.32
13	0.69	1.77	2.16	3.01	4.22
14	0.69	1.76	2.14	2.98	4.14
15	0.69	1.75	2.13	2.95	4.07
16	0.69	1.75	2.12	2.92	4.01

- (i) Use Table 1.4 and the t test value to decide whether the null hypothesis should be rejected.

Explain your answer.

.....

.....

.....

.....[2]

- (ii) Other than the effect of temperature, suggest an advantage of using immobilised enzymes in industrial processes.

.....

.....[1]

[Total: 29]

Question 2

- (a) **R1** is a slide of a stained transverse section through a leaf.

Draw a large plan diagram of the region of the leaf on **R1** indicated by the shaded area in Fig. 2.1. This region must include **two** vascular bundles.

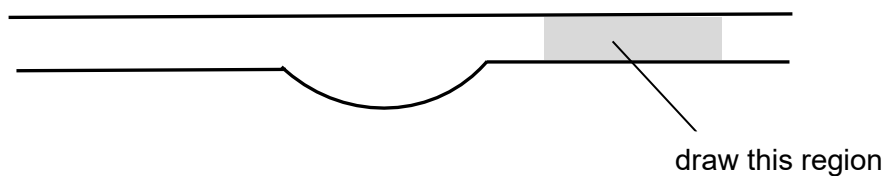


Fig. 2.1

Use a sharp pencil. No cells should be drawn.

Use **one** ruled label line and a label to identify **one** vascular bundle.

[4]

- (b) (i) Observe the upper epidermis of the slide **R1**. This layer is one-cell thick. There are specialised cells which are larger and bubble shaped, called bulliform cells. They are involved in the rolling and unrolling of leaves.

Select a group of four bulliform cells found in slide **R1**.

Make a large, detailed drawing of 4 adjacent cells. Cells must be touching each other.

Labels are **not** required.

[3]

- (ii) Suggest the type of environment this plant is adapted to and explain the role of bulliform cells in this adaptation.

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.....

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.....[2]

- (c) (i) Fig. 2.2 is a photomicrograph of part of a stained transverse central section of a leaf from a different plant.

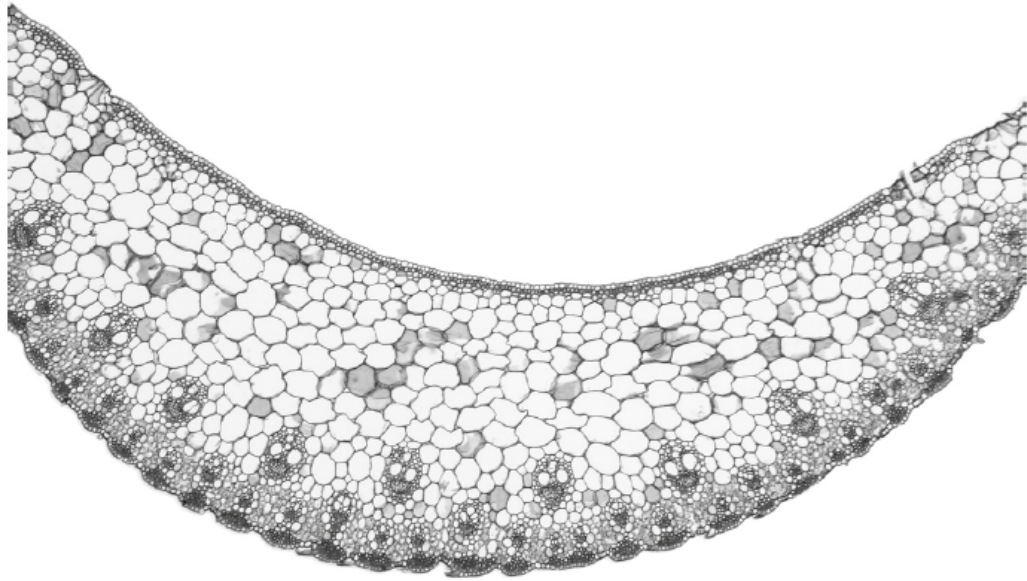


Fig. 2.2

Record in the space below **two** observable differences (other than size and reference to bulliform cells) between the specimen on slide **R1** and the leaf in Fig. 2.2.

[3]

- (ii) Fig. 2.3 is the same photomicrograph as that shown in Fig. 2.2.

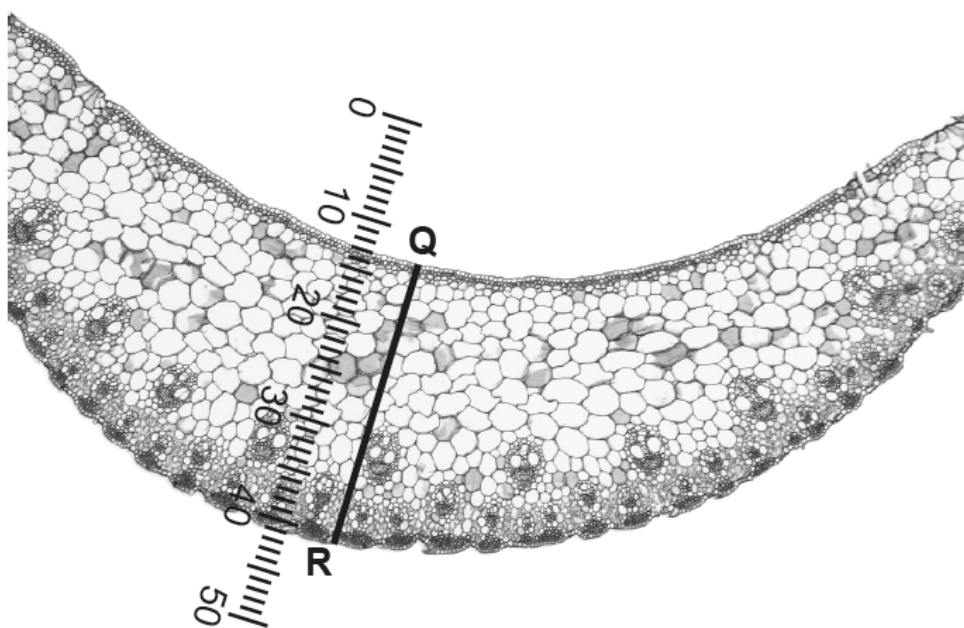


Fig. 2.3

An eyepiece graticule scale is shown in Fig. 2.3.

The calibration of the eyepiece graticule scale is:

$$1 \text{ eyepiece graticule division} = 34 \mu\text{m}$$

Use the calibration of the eyepiece graticule to calculate the actual width of the section in Fig. 2.3 shown by the line **Q–R**.

Show your working.

[2]

[Total: 14]

Question 3

- (a) Duck weed grows on the surface of pond water.

The plant has simple structures. It has leaf-like photosynthetic tissue called a thallus. Each plant has a single underwater root and a thallus which floats on the water. Stems may not be present. It reproduces mainly through asexual reproduction by buds that grow and split off to form separate plants.

Fig. 3.1 shows the appearance of three of these plants.

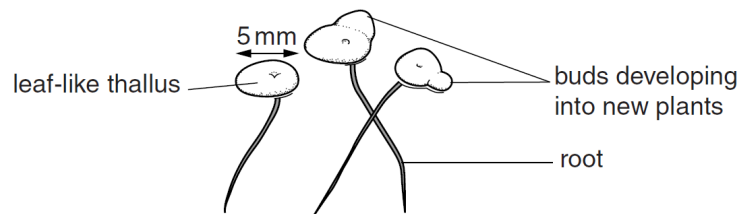


Fig. 3.1

Fig. 3.2 shows seven thalli of different sizes and stages of development.

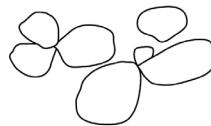


Fig. 3.2

Fig. 3.3 is an enlarged drawing of the same structure that is in Fig. 3.2. Each square of the grid is 1 cm^2 .

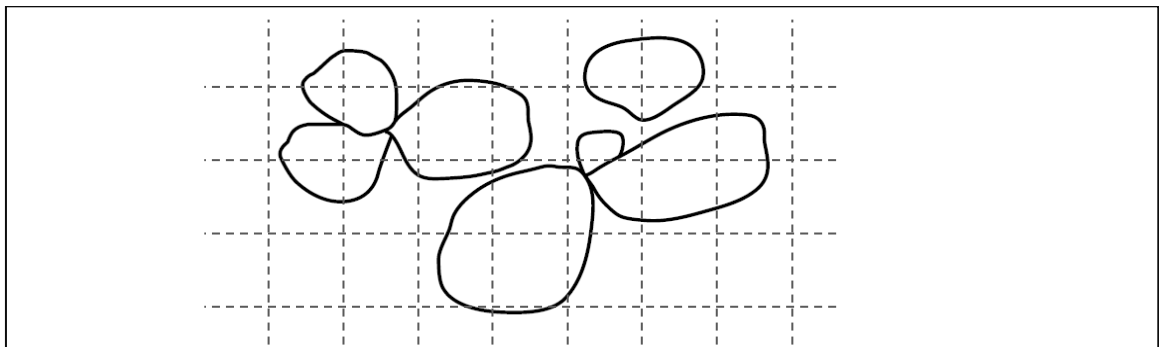


Fig. 3.3

- (i) Use the grid to estimate the total area of the thalli shown in Fig. 3.3.

total area = [1]

- (ii) Describe the method you used to decide which of these squares to include.

.....
 [1]

- (b) Duck weed can occur on the surface of water polluted by sewage which contains high levels of cadmium and copper ions.

A student wants to compare the effect of different concentrations of cadmium and copper ions on the growth rate of duckweed. In addition to standard laboratory equipment, you are provided with:

- stock solutions of 10 mg cm^{-3} cadmium sulfate and 10 mg cm^{-3} copper sulfate, and
- plants were collected from a pond and those with a thallus without buds were selected.

- (i) The student used the stock solution provided to prepare the other concentrations of copper sulfate. Describe how this can be achieved using appropriate apparatus.

.....
.....
.....
.....[2]

- (ii) Based on the information given in (a) and (b), plan an investigation to compare the minimum concentrations of cadmium and copper ions in solutions that may inhibit the growth rate of duck weed.

Do **not** repeat any details of how the different concentrations of cadmium and copper ions in solutions are prepared and the method described in (a)(ii). You are not required to plan for repeats and replicates.

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.....
.....[4]

- (c) Fig. 3.4 shows a transmission electron micrograph of a cell from a closely-related aquatic plant, sago pondweed.

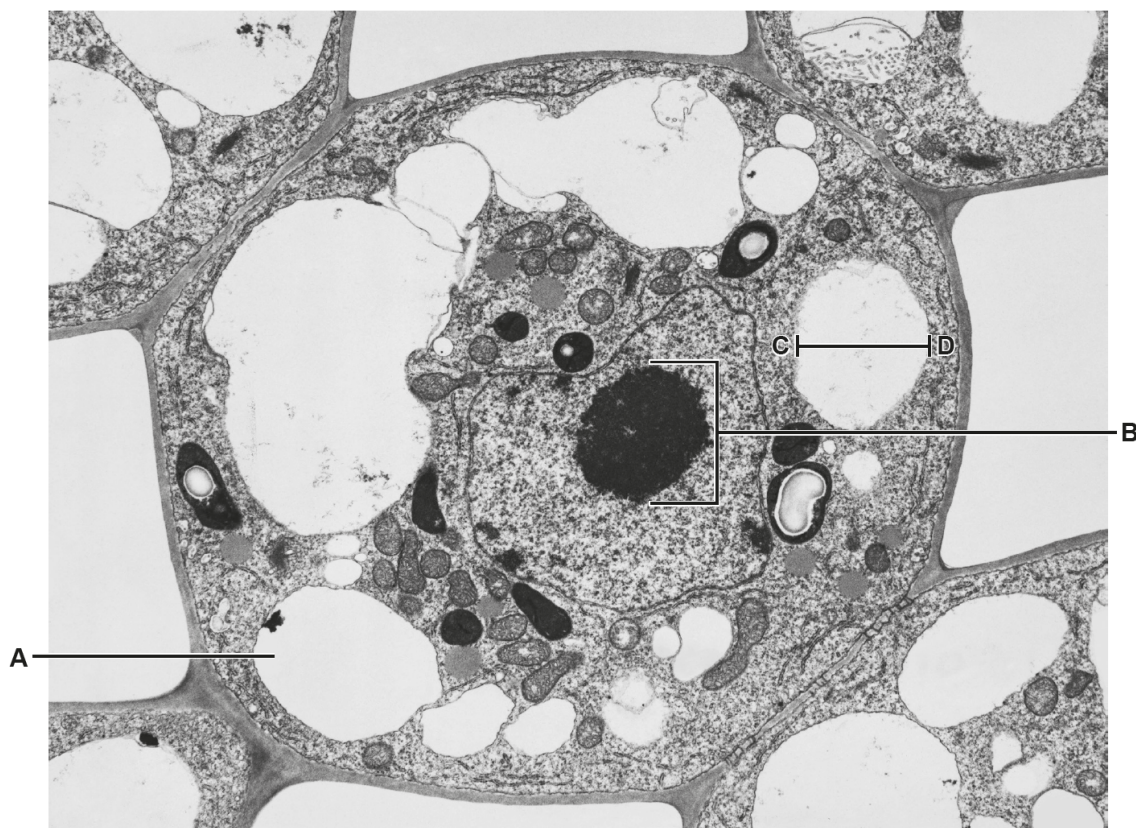


Fig. 3.4

- (i) Identify the cellular components shown at **A** and **B**.

A: **B:** [2]

- (ii) The real size of the line between **C** and **D** is 1.4×10^{-6} m. Calculate the magnification that was used to produce the image in Fig. 3.4. Give your answer to 2 significant figures.

Show your working.

Magnification = [2]

[Total: 12]

End of Paper