NAME: _____ CLASS: _____ INDEX: _____

CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
Higher 2

BIOLOGY
Paper 4 Practical

9744 / 04
25 August 2023
2 hours 30 min

Candidates answer on the Question Paper
Additional Materials:

READ THESE INSTRUCTIONS FIRST

Write your index number 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 HB pencil for any diagrams or graphs.

Do not use staples, paper clips, 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, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
TOTAL	

This document consists of **19** printed pages and **3** blank page.

[Turn over

Answer **all** questions.

1 During photosynthesis in leaves, carbon dioxide enters through stomata and diffuses through intercellular air spaces to the mesophyll.

Leaf discs submerged in solution can be used to investigate photosynthesis.

To investigate the effect of carbon dioxide concentration on the rate of photosynthesis in leaf discs, you will:

- prepare different concentrations of sodium hydrogencarbonate solution, as a source of dissolved carbon dioxide.
- measure the rate of photosynthesis by recording the time taken for submerged leaf discs to reach the surface due to the build-up of oxygen in the air spaces.

You are provided with:

- 30 cm^3 of 10.0 g dm^{-3} sodium hydrogencarbonate solution, labelled **H1**
- distilled water, labelled **W**
- fresh, green leaves from plant species **A**, in a Petri dish labelled **A**

(a) Carry out a serial dilution of the 10.0 g dm^{-3} sodium hydrogencarbonate solution, **H1**, to reduce the concentration of the sodium hydrogencarbonate solution by **half** between each of three successive dilutions, to give **H2**, **H3** and **H4**.

You are required to make up a sufficient volume of each concentration of sodium hydrogencarbonate solution in the specimen tubes provided so that, once the serial dilution has been completed, there is at least a volume of 10 cm^3 for each solution.

(i) Complete Fig. 1.1 on page 3 to show how you will carry out your serial dilution.

For each specimen tube,

- draw one curved arrow with a label, above the specimen tube, to show the **volume** and **concentration** of hydrogencarbonate solution added from the previous tube.
- state the **volume** of **W** added to prepare the concentration.
- state, under the specimen tube, the **volume** and **concentration** of hydrogencarbonate solution left for use in the investigation.

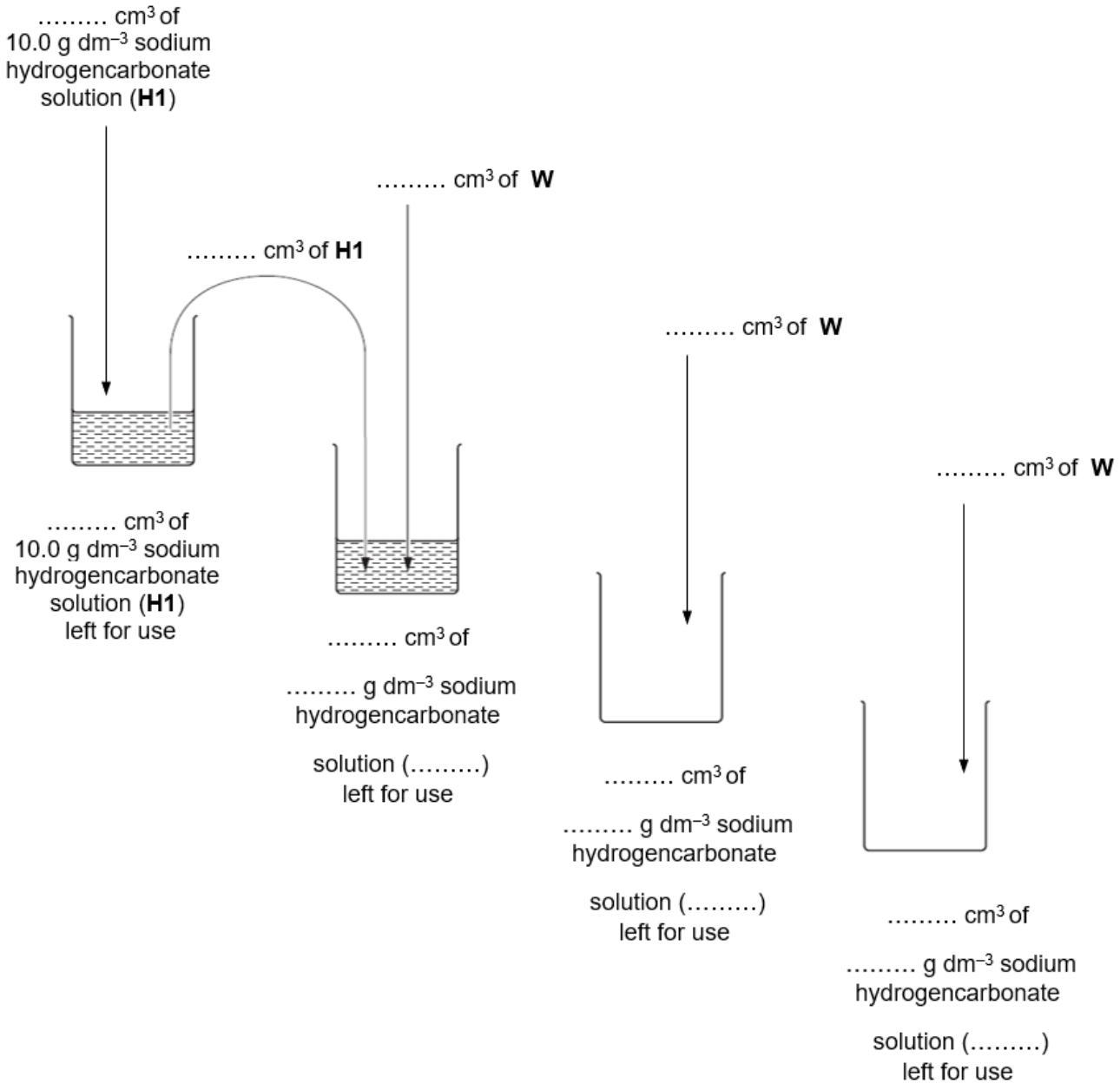
..... cm³ of
10.0 g dm⁻³ sodium
hydrogencarbonate
solution (H1)
..... cm³ of W
..... cm³ of H1
..... cm³ of W
..... cm³ of W
..... cm³ of
10.0 g dm⁻³ sodium
hydrogencarbonate
solution (H1)
left for use
..... cm³ of
..... g dm⁻³ sodium
hydrogencarbonate
solution (.....)
left for use
..... cm³ of
..... g dm⁻³ sodium
hydrogencarbonate
solution (.....)
left for use
..... cm³ of
..... g dm⁻³ sodium
hydrogencarbonate
solution (.....)
left for use

Fig. 1.1

[3]

*Read steps **1–14** and prepare the table in **(a)(iii)** before proceeding.*

1 Using a plastic drinking straw, cut out a leaf disc by placing an open end of the straw on a leaf from plant species **A**, while supporting the leaf from behind with your finger. Push the straw through the leaf on to your finger to cut out a disc. The disc will stick onto the end of the straw. Repeat until you have 12 leaf discs of uniform size.

2 Place the discs in a Petri dish containing distilled water, **W**. You may need to tap the straw a few times to detach the discs.

3 Remove the plunger of a 10 cm^3 syringe.

4 Place all the leaf discs in the barrel of the syringe, using forceps. Make sure that the leaf discs are at the bottom of the syringe barrel. Replace the plunger of the syringe and push it down until it almost touches the leaf discs.

5 Draw up 5 cm^3 of distilled water, **W**, from the Petri dish into the syringe.

6 Turn the syringe so that the nozzle is pointing upwards and tap the sides so that air bubbles rise to the top. Push the plunger in until the nozzle of the syringe is filled with water.

7 Place a finger tightly over the nozzle of the syringe to form an airtight seal. Firmly draw out the plunger as far as you can, as shown in Fig. 1.2, and then gently allow the plunger to return to its starting position.

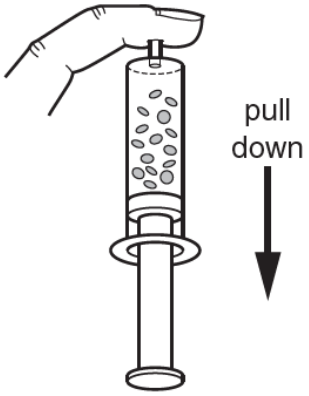

Fig. 1.2

8 Remove your finger from the nozzle and shake the syringe gently or tap the side to remove gas bubbles. The leaf discs should sink.

9 If discs are still floating on the surface, repeat steps **6-8** until nearly all leaf discs have sunk. You may have to repeat steps **6-8** several times.

(ii) State the purpose of steps **6** to **8**.

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[1]

10 Carefully pull the plunger out of the syringe and pour the water and leaf discs back into the Petri dish. If any leaf discs remain in the syringe, use the glass rod to remove them.

11 Put one leaf disc into each of the specimen tubes containing the same volume of sodium hydrogencarbonate solutions. Swirl each tube and use a glass rod to push the leaf disc to the bottom. If any leaf disc floats it should be removed and replaced with a fresh leaf disc that sinks.

12 When all specimen tubes contain a leaf disc that has sunk to the bottom, place the specimen tubes 10 cm from a bench lamp.

13 Switch on the bench lamp and start a stopwatch.

14 Record the time taken for each leaf disc to reach the surface, in **(a)(iii)**.
If any leaf discs have not reached the surface after 15 minutes, record 'more than 900'.

(iii) Record your results in a suitable table in the space below.

[3]

(iv) Describe a suitable control that could have been used for this investigation.

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[1]

(v) The validity of your results can be increased by performing replicates.

State and explain **one other** improvement to this procedure that could improve the validity of your results.

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[2]

(vi) A student used this method to investigate photosynthesis in a different species of plant, **B**. She found that the higher the concentration of sodium hydrogencarbonate, the faster the leaf discs reached the surface.

Explain this relationship.

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[3]

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(b) Global warming and associated precipitation changes will negatively impact on many agricultural ecosystems. Major food production areas are expected to experience reduced water availability and increased frequency of drought over the coming decades.

Almost all water used for plant growth is lost to the atmosphere by transpiration through stomatal pores on the leaf epidermis.

Several approaches to improve drought tolerance and water-use efficiency through the modification of stomatal traits have been tested in the model plant *Arabidopsis thaliana*. The *SDD1* gene is involved in the regulation of stomatal density and distribution in *Arabidopsis thaliana*. A loss of function mutation in *SDD1* gene was shown to increase stomatal density in mutant plants in a previous study.

A student investigated the stomatal density in two lineages of plants, **A** and **B**, to find out if overexpression of *SDD1* gene can decrease stomatal density. Plants in lineage A overexpressed *SDD1* gene, while plants in lineage B expressed *SDD1* gene at normal levels.

Table 2.1 shows the results of the investigation.

Table 2.1

sample number	stomatal density / mm^{-2}	
	lineage A	lineage B
1	181	190
2	182	191
3	190	192
4	178	193
5	184	194
6	183	194
7	181	196
8	179	197
9	190	190
10	179	192
mean ($\bar{x}$)	182.7	193.1
standard deviation (s)	4.27	2.81
variance (s^2)		

(i) Complete Table 2.1 by calculating the variance (s^2) for the stomatal density of two lineages: lineage **A** and lineage **B**. [1]

(ii) A *t*-test can be used to determine whether there is any significant difference between the stomatal density in lineage **A** and lineage **B**.

Calculate the value of *t* and the number of degrees of freedom, using these formulae:

standard deviation $$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

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

key to symbols

s = standard deviation
$\bar{x}$ = mean
n = sample size (number of observations)
ν = degrees of freedom

Show your working.

value of *t* = ...

number of degrees of freedom = ...
[2]

(iii) State the null hypothesis.

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[1]

Table 2.2 shows the critical values for t at different probabilities and degrees of freedom for one-tailed test and two-tailed test.

Table 2.2

degrees of freedom	probability, *p*, for one-tailed test			
	0.25	0.05	0.025	0.005
	probability, *p*, for two-tailed test			
	0.5	0.1	0.05	0.01
1	1.00	6.31	12.71	63.66
2	0.82	2.92	4.30	9.92
3	0.76	2.35	3.18	5.84
4	0.74	2.13	2.78	4.60
5	0.73	2.02	2.57	4.03
6	0.72	1.94	2.45	3.71
7	0.71	1.89	2.36	3.50
8	0.71	1.86	2.31	3.36
9	0.70	1.83	2.26	3.25
10	0.70	1.81	2.23	3.17
11	0.70	1.80	2.20	3.11
12	0.70	1.78	2.18	3.05
13	0.69	1.77	2.16	3.01
14	0.69	1.76	2.14	2.98
15	0.69	1.75	2.13	2.95
16	0.69	1.75	2.12	2.92
17	0.69	1.74	2.11	2.90
18	0.69	1.73	2.10	2.88
19	0.69	1.73	2.09	2.86
20	0.69	1.72	2.09	2.85

(iv) Use Table 2.2 and your answers to **(b)(ii)** to decide whether the null hypothesis should be accepted or rejected.

Explain your answer.

accept or reject null hypothesis ……..

explanation …….

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[2]

[Total: 19]

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2 Bromelain is a proteolytic enzyme that catalyses the hydrolysis of proteins into their amino acid building blocks. This enzyme can be found in fruits such as pineapple.

Gelatin contains structural proteins derived from animal tissues high in collagen. It sets into a gel-like structure upon cooling after dissolving in warm water. The action of bromelain on gelatin gel results in liquification of the gel.

(a) Design an experiment to investigate the effect of different concentrations of bromelain on gelatin breakdown.

In your plan, you must use:

- gelatin gel that has been prepared by dissolving 54 g of gelatin powder in 100 cm^3 of hot water and the mixture transferred into 5 separate large specimen tubes and allowed to set in an ice water bath for 15 minutes
- a piece of pineapple
- mortar and pestle
- tea filter bag
- small specimen tubes
- syringes

Your plan method should:

- have a clear and helpful structure so that the method described could be repeated by anyone reading it
- include details to ensure that results are accurate and repeatable as possible
- identify the dependent and independent variables
- use the correct technical and scientific terms
- only make use of the apparatus and materials provided

[6]

(i) State and explain one variable that is kept constant in this investigation.

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[2]

(ii) State one possible source of error in your investigation and suggest how this can be improved.

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[2]

(iii) Suggest a suitable control experiment to show that bromelain is the cause of liquification of gelatin.

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[1]

(iv) Rennin is a protease. However, it does not cause gelatin to liquefy. Suggest and explain why rennin does not breakdown gelatin.

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[2]

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(b) A student performed a similar experiment at 30°C to investigate the effect of different pH on bromelain activity.

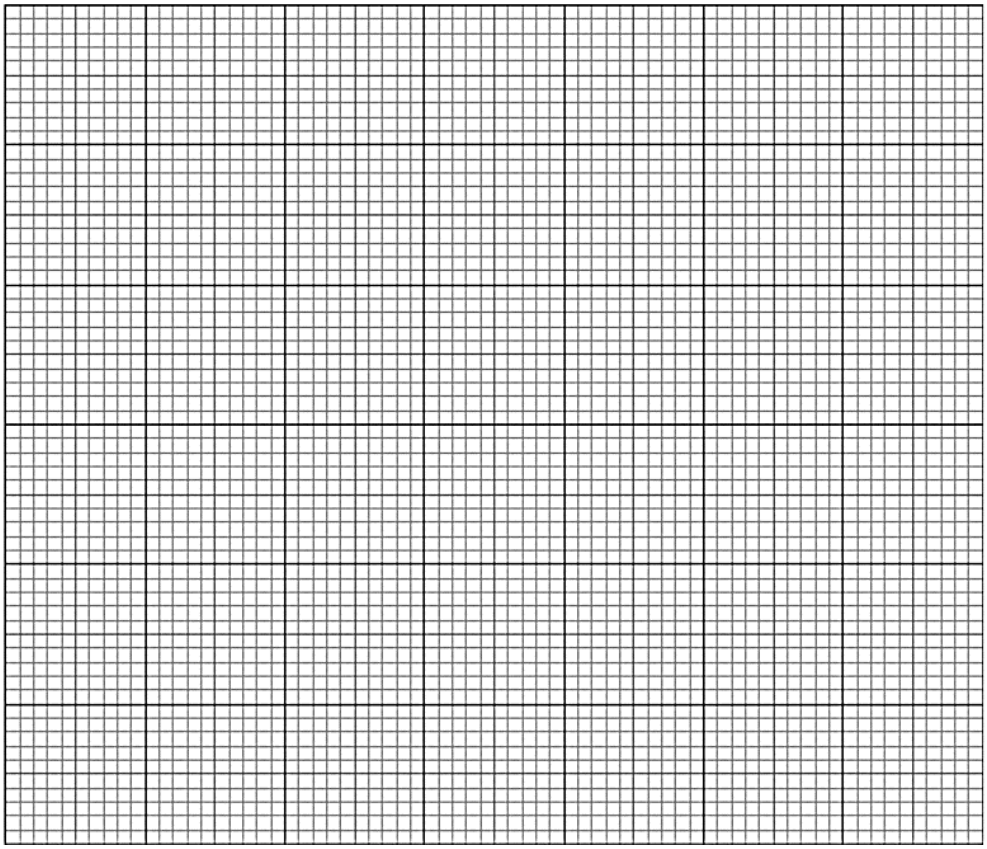
The pineapples were first blended into a juice, and pH buffer added. The time taken for gelatin with the different juice and pH buffer to set were recorded. If the gelatin did not set after 600 seconds, the time recorded will be 'more than 600'.

The results are shown in Table 1.1.

Table 1.1

pH of solution	time taken for gelatin to set / s
1	420
3	505
5	510
7	more than 600
9	585
11	515
13	470

(i) Plot a graph of your results from Table 1.1 in the grid below.



[4]

(ii) With reference to Table 1.1, explain the effect of pH on the rate of bromelain activity.

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[3]

(iii) Suggest why the enzyme bromelain does not digest the proteins in the stomach when fresh pineapple is eaten.

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[1]

[Total: 21]

3 During this question, you will need access to a microscope and slide **S1**.

S1 is a slide of a stained transverse section through a plant leaf.

You are not expected to be familiar with this specimen.

(a) Use the microscope to observe the different tissues in the leaf on **S1**.

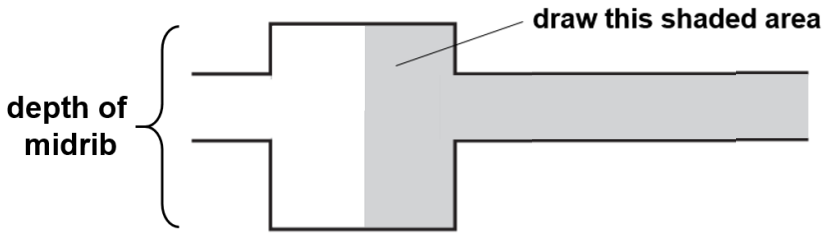

Fig. 3.1

(i) Draw a large plan diagram of the shaded area of the leaf on **S1** shown in Fig. 3.1.

A plan drawing shows the arrangement of different tissues. Your drawing should show the correct shapes and proportions of the different tissues.

No cells should be drawn.

[4]

(ii) Observe the cells of the leaf on **S1** that are directly involved in photosynthesis.

Select **four** adjacent cells that are arranged in a line.

Each cell must touch at least one other cell.

Make a large drawing of this line of **four** cells.

[3]

(b) Fig. 3.2 is a photomicrograph of a stained transverse section through a leaf of a different type of plant.

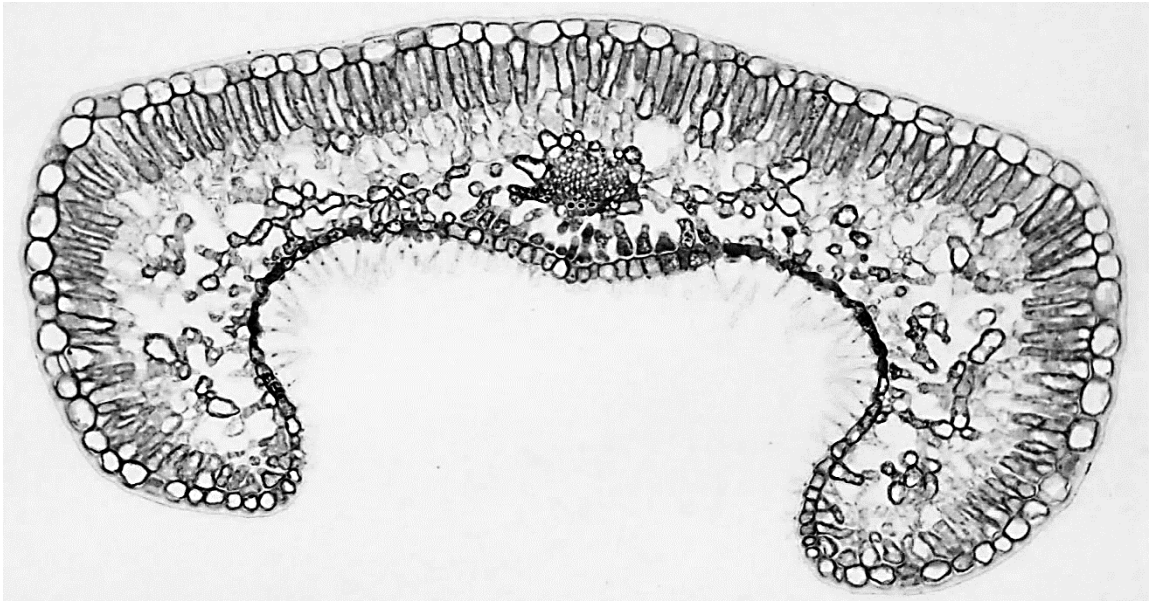

Fig. 3.2

The presence of a thick waxy cuticle in the leaf section in Fig. 3.2 supports the conclusion that the plant is adapted to live in a hot and arid environment.

Observe the leaf section in Fig. 3.2.

(i) Suggest and explain **one** other observable feature in the section in Fig. 3.2 which supports this conclusion.

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[1]

(ii) Plants with the same xerophytic features in their leaves seen in Fig. 3.2 are abundant in hot and arid environments.

Suggest how the abundance of these plants supports Darwin's theory of natural selection.

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[3]

(c) Fig. 3.3 is a photomicrograph of the same leaf section that is in Fig. 3.2.

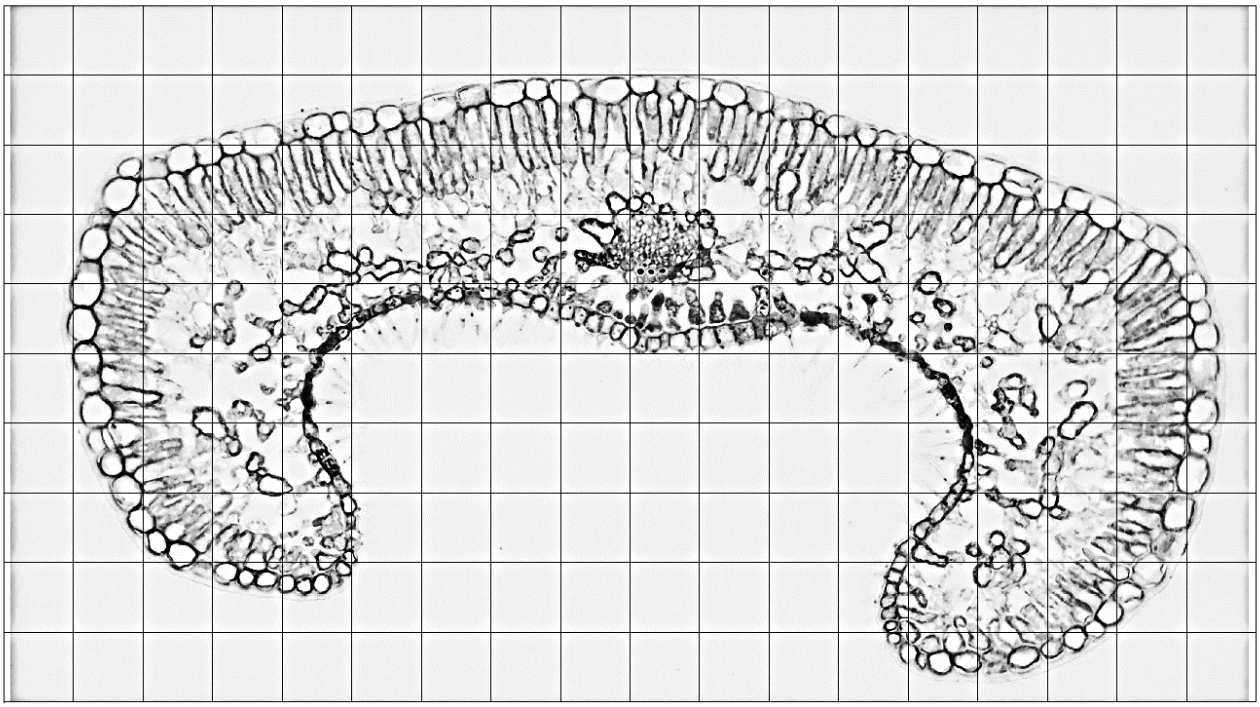

Fig. 3.3

You will need to use the grid to estimate the area of the palisade layer (layer of cells found below the upper epidermis of the leaf) **and** the total area of the leaf section in Fig. 3.3.

Each square of the grid is 1.0 cm^2.

In some squares the palisade layer or the leaf section does not fill the whole square.

(i) Describe the method you will use to decide which of these squares to include.

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[1]

(ii) State the area of the palisade layer and the total area of the leaf section in Fig. 3.3.

area of palisade layer = ... cm^2

total area of the leaf section = ... cm^2
[2]

(iii) Suggest how you could modify the procedure you have used in **(c)(i)** to give a more accurate estimate of the area of the leaf.

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[1]

[Total:15]