YISHUN INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CG

INDEX NO.

H2 BIOLOGY

9744/04

22 Aug 2025

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.

Write in dark blue or black pen only.
You may use a soft pencil for any diagrams or graphs.
Do not use 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.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/21
2	/16
3	/18
Total	/55

This document consists of **18** printed pages and **2** blank pages.

1 Plant extracts contain molecules which have many uses in industry and as medicines.

It is important for scientists to be able to estimate the concentration of these molecules in plant extracts.

You will estimate the concentration of molecule **R** in a sample of plant extract **U**.

You are provided with the materials shown in Table 1.1.

Table 1.1

labelled	contents	hazard	volume / cm^3
10R	10% solution of molecule R	None	100
W	Distilled water	None	100
U	Unknown concentration of molecular R in a plant extract	None	40
A	Sulfuric acid solution	Harmful irritant	20
K	Potassium manganate (VII) solution	Irritant	20

If any of the solutions come in contact with your skin, wash off immediately under cold water.

It is recommended that you wear suitable eye protection and wear gloves to protect your hands when using **A** and **K**.

(a) You will need to carry out a **serial** dilution of the 10% molecule **R** solution, **10R**, to reduce the concentration by **half** between each successive dilution.

You will need to prepare **four** concentrations of molecule **R** solution in addition to the **10% molecule R** solution, **10R**.

After the serial dilution is completed, you will need to have 10 cm^3 of each concentration available for use.

(i) Complete Table 1.2 to show how you will prepare your serial dilution.

Table 1.2 shows the first two beakers you will use to make your serial dilution.

You will need to complete the table for **three** additional beakers.

For each beaker, state:
- the concentration of molecule **R** solution.
- the concentration of molecule **R** solution transferred.
- the volume of molecule **R** solution transferred.
- the volume of distilled water, **W**, added.

Table 1.2

Concentration of molecule **R** solution / %	Concentration of molecule **R** solution transferred / %	volume of molecule **R** solution transferred / cm^3	volume of distilled water, **W**, added / cm^3
10	-	0.0	0.0
5	10	10.0	10.0
2.5	***5***	***10.0***	***10.0***
1.25	***2.5***	***10.0***	***10.0***
0.625	***1.25***	***10.0***	***10.0***

[3]

EITHER

1. ***each concentration of molecule R solution filled in correctly; 1 mark each;***

OR

2. ***correct concentrations (2.5, 1.25, 0.625) and correct concentration transferred (5, 2.5, 0.625);***
3. ***shows transfer of 10.0 (cm3) to each beaker from the previous beaker;***
4. ***shows 10.0 (cm3) of water added to each beaker; 1 mark each***

Precision to be penalised at most once for MP3 and MP4
AWARD using the higher credit criteria

Molecule **R** will decolourise the purple acidified potassium manganate(VII) solution, **K**.

The lower the concentration of molecule **R**, the greater the volume of **R** is needed to cause a colour change in potassium manganate(VII).

Carry out step 1 to step 12.

Step 1 Prepare the concentrations of molecule **R** solution, as decided in **(a)(i)**, in the beakers provided.

Step 2 Label 5 test-tubes with the concentrations of **R** you prepared in step 1.

Step 3 Put 1 cm^3 of **A** into the test-tube labelled 10%.

Step 4 Put 1 cm^3 of **K** into the same test-tube and mix well.

Step 5 Put the nozzle of a clean 10 cm^3 syringe into the beaker containing 10% **R**.

Step 6 Pull the plunger out to the 5 cm^3 mark so that 5 cm^3 of 10% **R** enters the syringe.

Step 7 Put the syringe containing 10% **R** into the test-tube from step 4 as shown in Fig. 1.2.

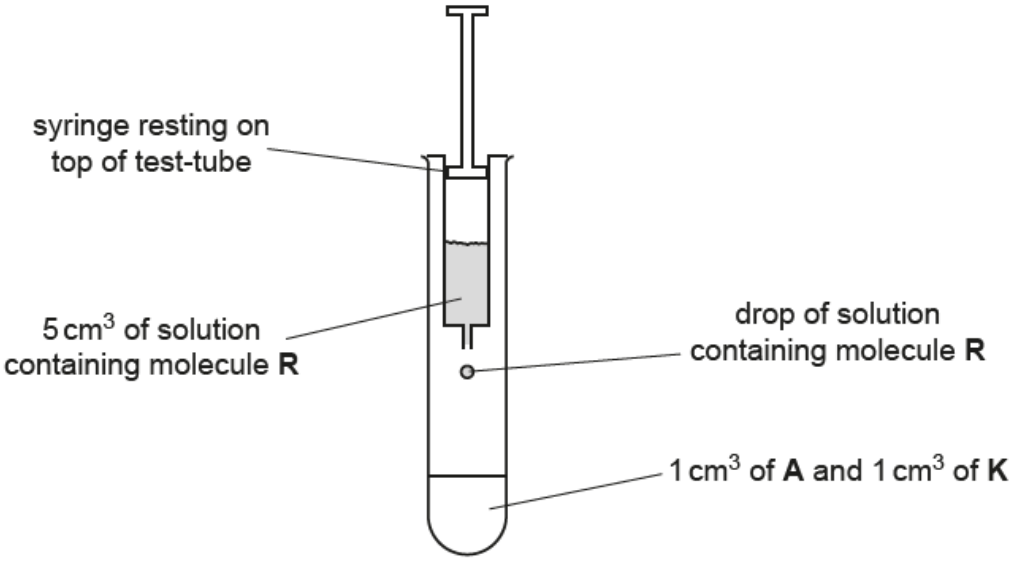


Fig. 1.2

You will be counting the number of drops needed for the first instance of colour change in **K**.

Step 8 Gently press the plunger to add one drop of solution containing molecule **R**.

Step 9 Mix well.

Step 10 If the mixture stays purple repeat step 8 and step 9. Count the number of drops released to reach the first instance of colour change. If the number of drops needed to reach the first instance of colour change is more than 100, record as 'more than 100'.

Step 11 Record the results in **(a)(ii)**.

Step 12 Repeat step 3 to step 11 for each of the concentrations of molecule **R** prepared in step 1.

(ii) Record your results in an appropriate table.

1. ***heading for independent variable: percentage concentration of molecule R (before heading for dependent variable) and no units in body of table AND heading dependent variable: number of drops ;***

2. ***results recorded for all concentrations ;***

3. ***number of drops recorded for the highest concentration of R is fewer than for the lowest concentration of R ;***

4. ***results recorded as whole drops ;***

percentage concentration of molecule R	***number of drops***
10	***Increasing trend***
5	
2.5	
1.25	
0.625	

[4]

(iii) State **two** significant sources of error when measuring the dependent variable in this investigation.

drop size varies ;

difficult to judge endpoint ;

Any valid point

[2]

ER: Poor practices (e.g. contamination, plunger hard to control) are not significant sources of error.

(iv) Suggest how you could improve the procedure to reduce **one** of the errors stated in **(a)(iii)**.

any one improvement and must be linked to an error in 1(a)(iii), e.g.:

1. (drop size varies) measure the volume used instead of the number of drops ;

2. (difficult to judge endpoint) use a colorimeter / spectrometer ; [1]

ER: When colour change is hard to determine, a colour chart does not resolve the problem. Mention of light intensity instead of colorimeter /spectrometer is not accepted, it is the spectrum /wavelength of the specific colour that should be quantified. Burette is used to measure volume not number of drops.

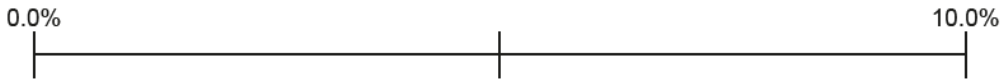
There is no error carried forward, i.e. students who were awarded the mark was based on (iv) answer. It may not be accurate.

Step 13 Repeat step 3 to step 10 with **U**, the unknown concentration of molecule **R**.

Step 14 Record your result in **(a)(v)**.

(v) State the number of drops of **U** needed to reach the end-point ..... [1]
records a number for U that is less than that recorded for 10 and more than that recorded for the lowest concentration ;

(vi) Complete Fig. 1.3 to show the positions of each of the percentage concentrations of molecule **R** solution recorded in **(a)(ii)**.



percentage concentration of molecule **R**

Fig. 1.3

1. correctly labels scale bar with different concentrations of molecule **R** ;
2. *concentrations must match to those listed in **1(a)(ii)***

[1]

(vii) Use your results in **(a)(ii)** and **(a)(v)** to estimate the concentration of molecule **R** in solution **U**.

Show this estimate of the concentration of **U** on Fig. 1.3, by placing the letter **U** on the line in the correct position.
estimates the correct concentration of R in U by placing U in the correct position on the scale bar ;

[1]

ER: U should identified properly, not necessarily mid point between two known concentration.

(b) A student investigated the concentration of molecule **R** in extracts from different plants.

The student added a fixed volume of the extract to acidified potassium manganate(VII) and timed how long it took to reach the end-point.

The results are shown in Table 1.2.

Table 1.2

plant extract	time / s
B	15
C	59
D	42
E	10
F	7

Plot a bar chart of the data shown in Table 1.2 on the grid in Fig. 1.4.

Use a sharp pencil.

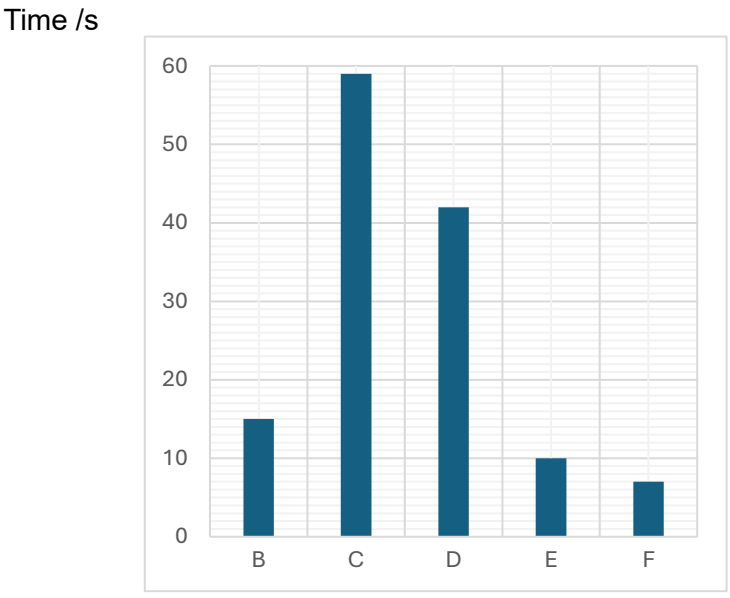


Fig. 1.4

1. *1. x-axis: plant extract and bars labelled B, C, D, E and F and y-axis: time / s ;*
2. *x-axis: even width of bars and scale on y-axis: 10 seconds to 2 cm, labelled at least each 2 cm ;*
3. *correct plotting of all five bars ;*
4. *five separate bars drawn and with horizontal and vertical lines joined precisely ;*

[4]

(c) Scientists have suggested that a different molecule in the plant extract might act as an antibiotic.

The scientists tested this by:
- spreading bacteria over the surface of agar gel containing nutrients
- putting small drops (3 μm^3) of different concentrations of the plant extract into separate wells in the agar gel
- incubating the agar gel for 20 hours
- measuring the inhibition area (where the bacteria were not observed) for each concentration of plant extract.

The results are shown in Fig. 1.5.

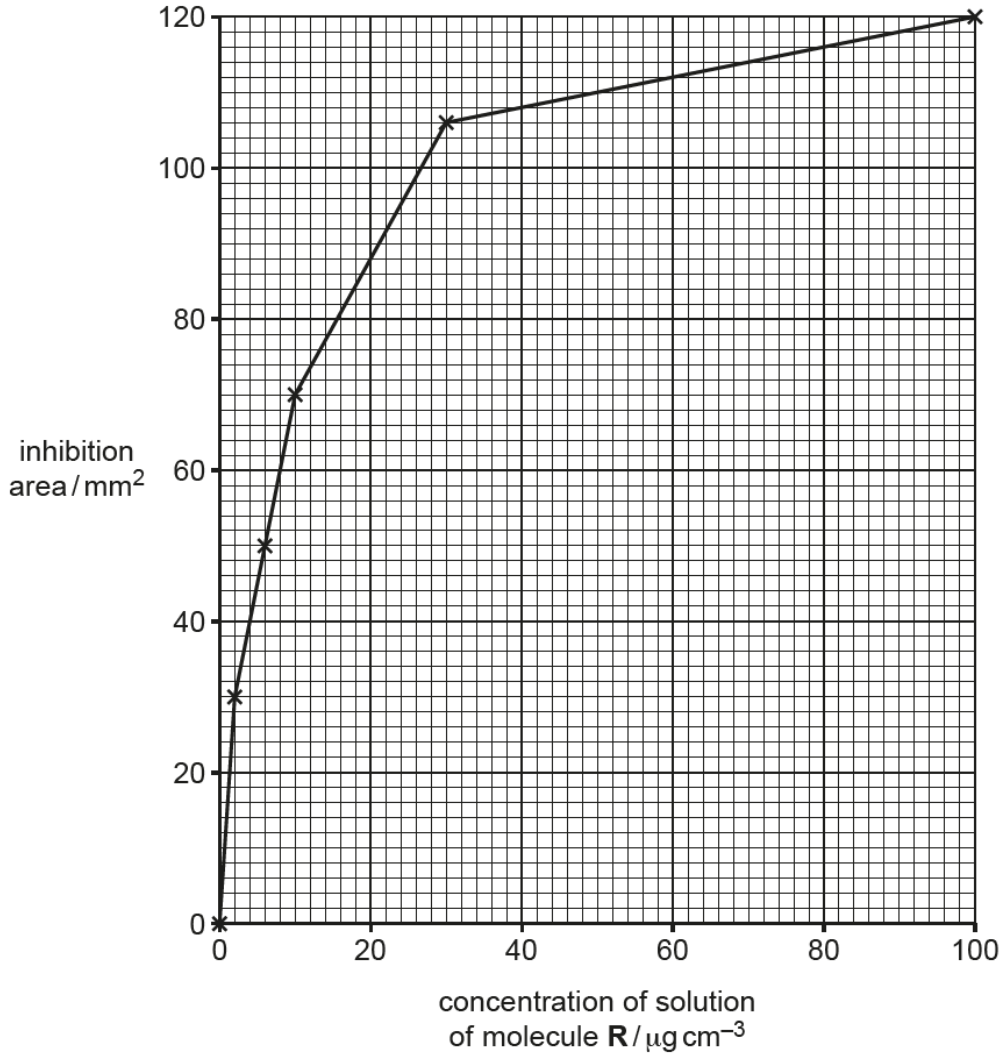


Fig. 1.5

(i) Use the graph in Fig. 1.5 to estimate the concentration of plant extract that results in an inhibition area of 92 mm^2.

concentration of plant extract = ***22 μg cm^{-2}*** [1]

(ii) Describe the trend shown in Fig. 1.5.

As concentration of solution of molecule R increases from 0 to 30 µg cm^{-3},

inhibition area increases rapidly from 0 to 106 mm^2;

As concentration of solution of molecule R increases from 30 to 100 µg cm^{-3},

inhibition area increases gradually from 106 to 120 mm^2; [2]

ER: Most students can get this question correct. Some common mistakes include:

- Wrong data points (e.g. 30 µg becomes 28 µg)
- Not quoting specific trends (e.g. sharp increase, gradual increase)

(iii) Suggest how the molecule in the plant extract may inhibit the growth of the bacteria. ***any one from:***

1. prevents formation of cell, wall / membrane ;

2. cell / bacterial, lysis or cells / bacteria, burst ;

3. inhibits, transcription / translation / protein synthesis ;

4. inhibits cell division ;

5. acts as an enzyme inhibitor ;

6. inhibits DNA, replication / synthesis ; [2]

ER: This question required candidates to suggest a plausible mechanism by which a molecule in a plant extract could inhibit bacterial growth. While this was a straightforward application-based question, several candidates did not attempt the question or offered vague and generalised responses such as "the molecule kills the bacteria", which lacked the biological specificity required at the H2 level.

A number of candidates demonstrated misconceptions about bacterial inhibition mechanisms. Some responses incorrectly described the molecule as directly binding to the operon or preventing nutrient uptake by absorbing or competing for nutrients in the medium. These ideas reflect a misunderstanding of how antimicrobial agents function at the molecular or cellular level. Antibacterial agents typically act through more direct interference with bacterial structure or function, such as disrupting the cell wall, inhibiting protein synthesis, or preventing DNA replication.

To close this learning gap, candidates are encouraged to:

- Revise key bacterial targets of antibiotics such as the **cell wall**, **plasma membrane**, **ribosomes** (protein synthesis), **DNA replication machinery**, and **enzymes** critical for metabolism or reproduction.
- Practice using **precise biological terms** in their answers, especially when describing mechanisms of action (e.g. “inhibits DNA replication” rather than “affects DNA”).
- Make a habit of attempting all questions, especially 1-mark questions, as they contribute directly to the total score and are usually designed to assess accessible content.

A stronger response would have clearly identified a specific target or process, such as “inhibits protein synthesis” or “prevents formation of the bacterial cell wall.” Candidates should strive to provide concise yet biologically accurate suggestions in such questions.

[Total: 21]

2 Antibiotic resistance in bacteria is a global problem that has caused scientists to research into novel antibacterial substances other than antibiotics. Honey has properties that make it a good antibacterial substance. For example, honey contains hydrogen peroxide, which is known to kill bacteria.

The most effective honey tested so far for antibacterial activity is Manuka honey. It contains less hydrogen peroxide than many other types of honey, but it does contain an antibacterial compound, methylglyoxal (MGO), which is not found in other types of honey.

A student decided to investigate the effect of two antibacterial substances on the bacterium *B. subtilis*, which respires aerobically:
• MGO in Manuka honey
• an antibiotic solution used in cell cultures to prevent contamination.

The student wanted to find the lowest concentration of each antibacterial substance that would kill or inhibit the growth of *B. subtilis*.

(a) The student used a broth culture for the investigation. In order to make a broth culture, a small quantity of *B. subtilis* is added to a clear nutrient solution. A fresh (newly made) broth culture of *B. subtilis* is also clear.

Fig. 2.1 is a diagram of a fresh broth culture of *B. subtilis*.

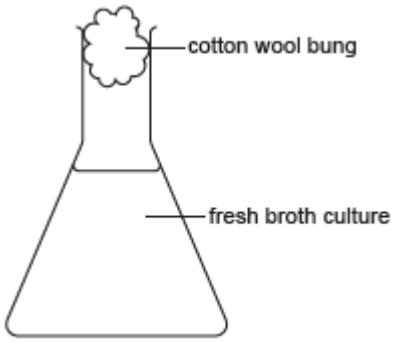


Fig. 2.1

(i) A sterile cotton wool bung was used in the top of the flask containing the fresh broth culture of *B. subtilis* to protect the culture from contamination.

Explain why it is better to use a sterile cotton wool bung in a flask containing broth culture of *B. subtilis*, rather than using a sterile rubber bung.

to allow, oxygen / air, to enter for respiration OR

because bacterium / B. subtilis, respires aerobically / AW ; [1]

ER: Most students can get this question correct. Some common mistakes include:
- The production of CO2 by the bacteria will cause the conical flask to explode should a rubber bung be used, as CO2 cannot escape
- Sterile cotton wool can help to prevent contamination

(ii) Before comparing the two antibacterial substances, the student carried out a trial experiment. The student transferred a sample of fresh broth culture to a culture tube and incubated the tube at 25 °C for 24 hours.

Fig. 2.2 summarises the results of the trial experiment.

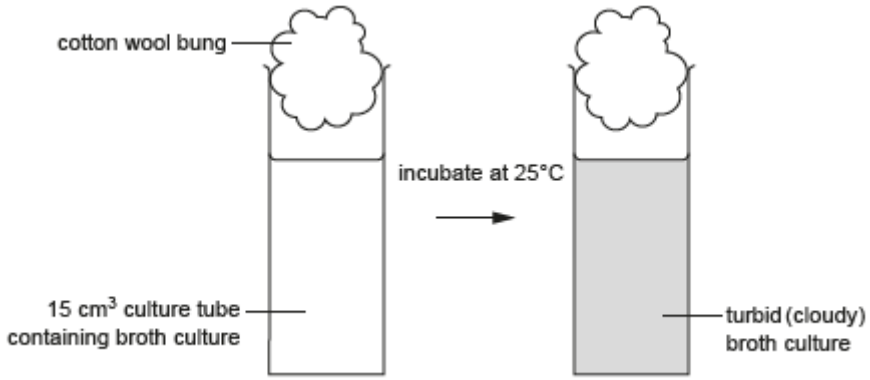


Fig. 2.2

The student decided that turbidity of the broth culture is a measure of bacterial population growth (bacterial growth).

Explain how this concept can be used in an investigation to measure the extent of bacterial growth.

as, population growth of bacteria / bacterial growth, increases / AW, the, cloudier / more turbid, the culture broth OR

measuring the, turbidity / cloudiness, by eye against a cross in background / with a colorimeter / turbidity meter / colour chart ; [1]

ER: Most students can get this question correct.

(b) The student decided to test the antibiotic solution before testing the Manuka honey.

In addition to normal laboratory apparatus and materials, the student was provided with:

- a fresh broth culture of *B. subtilis*
- a clear antibiotic stock solution
- nutrient solution to dilute the antibiotic stock solution
- 15 cm^3 flat-bottomed glass culture tubes with sterile cotton wool bungs
- a choice of graduated pipettes to measure volumes accurately: 0.2 cm^3, 2.0 cm^3, 10.0 cm^3, 25.0 cm^3.

The student:

- prepared dilutions of the antibiotic stock solution and added a volume of each to different culture tubes
- added a volume of fresh broth culture of *B. subtilis* to each culture tube
- incubated the culture tubes in an incubator
- allowed time for bacterial growth to occur and then checked each culture tube
- recorded and analysed the results
- decided on the lowest concentration of antibiotic solution that appeared to kill or inhibit the growth of *B. subtilis*.

Outline a control for this part of the investigation.

replace antibiotic with, (distilled) water / nutrient solution ; [1]

ER: Question was not well-done. There are 3 main mistakes that were made:

(1) Students do not know the purpose of a control set-up.

- For a normal experiment, we are investigating how the independent variable (antibiotic solution) affects the dependent variable (turbidity, bacteria growth)

- A control set-up is to test if the independent variable (antibiotic solution), truly affects the dependent variable (turbidity, bacteria growth), or some other factor is at play, for instance, contamination has occurred.

- The independent variable (antibiotic solution) should be replaced with distilled water, so in the absence of the independent variable, there should be no change to the dependent variable (normal bacteria growth).
    - If bacteria growth is affected even when antibiotic solution is absent, there must be another contaminant that is antibacterial.
    - This shows that

(2) Students did not replace with distilled water

- Same set-up without antibiotic solution – Wrong as the volume of the entire mixture would not be the same as a normal experimental set-up. Volume of the set-up should be kept constant

- Same set-up with boiled antibiotic solution – Wrong as antibiotics may not be protein in nature, high temperatures may not 'denature them', and they can still inhibit bacteria growth

- Same set-up with nutrient solution – Wrong as the volume of nutrient solution should be kept constant. Having more nutrient solution may spur bacterial growth.

(3) Students confused controlled set-up for control variables

- Control set-up ≠ Control variable/ Constant
- Some students mention that a thermostatic water bath should be introduced.

Moving Forward:

1. **Definition of Control Set-up** – A parallel set-up without the independent variable, used for comparison.

2. **Identify Variables** – Always state the **independent variable** (what you change) and the **dependent variable** (what you measure).

3. **Independent Absent** – Replace the independent variable (e.g., antibiotic) with a neutral substitute (e.g., distilled water) while keeping all other variables constant.

Possible Writing Frame:

The control set-up replaces the [independent variable] with _____ (keeping all other conditions the same). [1]

If the independent variable truly affects the dependent variable, then _____ will be observed. If changes still occur in the control set-up, this suggests _____. [Optional]

(c) In the next part of the investigation, the student used a stock solution of Manuka honey. The student remembered that hydrogen peroxide could be present but could not think of a way to break down the hydrogen peroxide to remove it from the solution.

Describe how the student can improve the investigation by removing hydrogen peroxide from the Manuka honey solution **and** explain why this improvement makes the results more valid.

can improve: add, catalase / peroxidase / manganese(IV) oxide/ $KMNO_4$

explain why:

results / effect / killing, B. subtilis / bacteria , is only due to, honey / MGO
or
results / effect / killing, B. subtilis / bacteria, is not due to hydrogen peroxide ; [2]

ER: Question was relatively well done.

Many students were unable to name the method to remove hydrogen peroxide. Students should use biological concepts (e.g. catalase) rather than chemistry concepts (e.g. oxidising/reducing agents) to answer this question.

Some common mistakes include

- Letting hydrogen peroxide sit in the air to decompose naturally – natural decomposition takes a very long time
- Adding distilled water to hydrogen peroxide – creates a diluted solution rather than promotes decomposition
- Heating hydrogen peroxide – MgO is also heat sensitive

Most students are able to state that hydrogen peroxide also kills bacteria, and it's removal is needed to prove that antibacterial effects are due to MgO only.

(d) The student was provided with a stock solution of Manuka honey containing an MGO concentration of 600 μg cm^{-3}. This was a clear solution, labelled '100% honey'.

The same apparatus and materials were available.

Describe how the student could prepare a 10% solution of honey using the stock solution.

Construct a table to show how the dilution is made for the 10% solution and the other concentrations that the student could use.

description or table or diagram for 10%:
1 Correct method to dilute stock (honey) solution to 10% ;

e.g. simple dilution OR serial dilution

Space for table.

table
2 At least five dilutions including 10% all with correct volumes of stock and nutrient solution including units ;

Percentage concentration of honey	***Volume of honey / cm^3***	***Volume of nutrient solution / cm^3***
100	***10.0***	***0.0***
90	***9.0***	***1.0***
80	***8.0***	***2.0***
70	***7.0***	***3.0***
60	***6.0***	***4.0***
50	***5.0***	***5.0***
40	***4.0***	***6.0***
30	***3.0***	***7.0***
20	***2.0***	***8.0***
10	***1.0***	***9.0***

[2]

ER: Question was not well done

- Many students confused serial and simple dilution
- Many students did not use nutrient broth to dilute the honey solution
- Wrong calculations, stating 8.0% instead of 80% for 8cm^3 of 100% honey and 2cm^3 of nutrient broth
- Lack of concentrations with equal intervals for simple dilutions
- Students did not use the apparatus provided in the question, which should be penalised.

(e) State the independent variable **and** dependent variable for the part of the investigation involving Manuka honey solution.

independent variable ***MGO / Manuka / honey, concentration ;***

dependent variable ***turbidity ;*** [2]

ER: Some students state that **the dependent variable is the growth of bacteria.**

- Dependent variable is something to be measured in an experiment, not analysed. The growth of the bacteria cannot be directly measured in an experiment, the turbidity is first measured, and growth is inferred from turbidity.

Some students state that the dependent variable is the time taken for flask to turn turbid. This is not a feasible experiment because the bacteria need to be incubated for 24 hours. Additionally, it can be subjective the endpoint turbidity is not specified.

(f) Predict the results the student would expect when investigating the effect of Manuka honey on *B. subtilis*.

Explain the reasoning behind the prediction.

predict:

lower concentration, tubes / AW, will be, turbid / cloudy or

higher concentration, tubes / AW, will be, clear / not cloudy or

the lower the concentration the more, turbid / cloudy, the tubes / AW ; ora

explain:

MGO / (Manuka) honey, inhibits the growth of / kills, B. subtilis / bacteria or

lower concentrations have less, ability / MGO, to, inhibit the growth of / kill, B. subtilis / bacteria ; ora

[2]

ER: Question is generally well done.
Some predictions **are not specific enough** (e.g. presence of Manuka honey will caused the bacteria culture broth to be clear)

(g) Describe how the student could determine the lowest concentration of Manuka honey solution that would kill or inhibit the growth of *B. subtilis*.

- Do **not** repeat any detail given in **(d)** of how to prepare the different concentrations of Manuka honey solution
- Do **not** give details of using aseptic technique (techniques to prevent contamination of the student, the environment or other people).

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

Key ideas/ General marking points

1 stated volume of, culture / broth used ;

2 stated volume of Manuka honey ;

3 mix honey and culture / broth (prior to starting) ;

4 method to measure turbidity ;

5 method to identify which is the lowest concentration of Manuka honey that would kill B. subtilis (concentration at which broth, is clearest)

6 method of maintaining temperature (10°C – 50°C if stated)

7 stated, time (left in incubator) (12–48 hours if stated)

8 use a buffer to maintain pH (pH 4–10 if stated)

9 repeat at least twice / 3 replicates and finding mean ;

10 named hazard and risk and precaution ; [10]

ER: Question is generally well done. Some common mistakes include

Students **not reading the requirements** of the question

- listing down the procedures of serial/ simple dilution instead.
- relisting down the independent and dependent variable, which is already stated under part (e) and not required for this 5-mark question.

Students **not using describing procedures properly (lack of key values)**

- Did not state the apparatus used
- Did not use apparatus specified by the question
- Did not state the volume of the various solutions transferred
- Added a higher volume of Manuka honey than bacteria broth (BOD)
- Did not state the values of important variables like temperature, time, pH

Students **not identifying the correct method to measure turbidity**

- Time taken for culture to turn turbid / Gaseous collection – Time taken for incubation is already 24hr, would not be a feasible experiment
- Using arbitrary standard (e.g. laminated sheet with letter "X", using "x"/"xxx", "colourless"/" less colourless") – Subjective
- Comparing to control (whichever concentration that has the same result as control is the lowest concentration) – Subjective, and control may not always be clear should the experimental set-up have contaminants

Students **not calculating the average of replicates ,** only mentioning increasing reliability

Students **stating insignificant hazards/ risk –** electrocution from the thermostatic water bath vs the handling of live microorganism.

- Hazard should be included. Many students simply stated wear gloves, but did not mention the reason why (e.g. Manuka Honey is an irritant)

Suggested procedure:

1. ***Label 10 culture tubes with the 10 different concentrations of honey ;***
2. ***Using a 10.0 cm^3 graduated pipette, transfer 10.0 cm^3 of broth culture of B. subtilis into each culture tubes ;*** [1]
3. ***Using 1.0 cm^3 graduated pipette, transfer 1.0 cm^3 of 100% honey into culture tube labelled '100' ;*** [1]
4. ***Repeat step 3 for the remaining concentration of honey;***
5. ***Using 1.0 cm^3 graduated pipette, transfer 1.0 cm^3 of distilled water into culture tube labelled 'control' ;***
6. ***Mix the honey and the broth culture thoroughly;*** [1]
7. ***Use a pH buffer (pH 4 – 7) to maintain pH*** [1]
8. ***Transfer the culture tubes into the incubator for 24h where temperature to be pre-set at 25°C ;*** [2]
9. ***Using a spectrometer, measure the light transmission of each culture tube;*** [1]
10. ***Record in the table the concentration of honey and the amount of light transmission;***
11. ***Repeat step 1 to 9 two more times and calculate the average light transmission for each concentration of Manuka Honey*** [1]
12. ***The higher the light transmission, the less turbidity the culture tube; The less turbidity the culture tube, the less bacterial growth ;***
13. ***Plot a graph, with the x-axis as concentration of honey, and y-axis as amount of light transmission***
14. ***The concentration which gives the highest light transmission is the lowest concentration of Manuka honey that would kill or inhibit the growth of B. subtilis*** [1]
15. ***Live cultures of B. subtilis pose a risk of infection, irritation, or allergy, therefore and wear gloves and other PPE*** [1]

Manuka honey may cause allergic reactions; therefore and wear gloves and other PPE

Nutrient broth can act as an irritant or cause allergies, therefore and wear gloves and other PPE

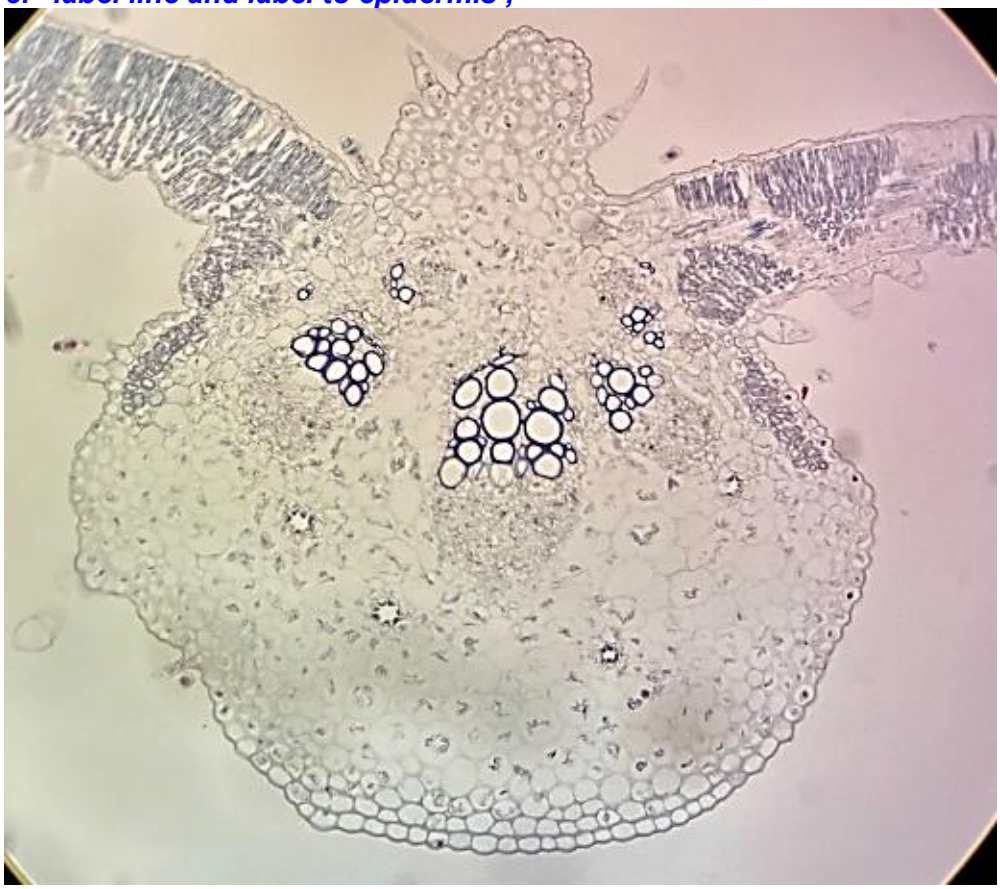
[Total: 16]

3 J1 is a slide of a transversed section through a plant leaf.

(a) **(i)** Draw a large diagram of the whole section on **J1**. Use a sharp pencil.

Use **one** ruled label line and label to identify the epidermis.

1. uses most of the available space and no shading ;
2. whole leaf section drawn and no cells drawn ;
3. correct shape of the leaf ;
4. correct proportion and layers of tissue ;
5. label line and label to epidermis ;



[5]

Examiner's comment:

Most candidates were able to produce a reasonably accurate plan drawing of the leaf section, and many demonstrated good practices such as using a sharp pencil, avoiding shading, and drawing to an appropriate size. The majority also remembered to label the epidermis correctly with a single, ruled label line, as instructed.

However, a common error that led to the loss of marks was the failure to distinguish clearly between the **palisade mesophyll** and **spongy mesophyll** layers. Candidates often presented the leaf interior as a single, undifferentiated layer, which does not reflect the structural organisation of a typical dicotyledonous leaf. This suggests a gap in understanding of basic leaf anatomy and its representation in plan drawings.

Additionally, a small number of candidates incorrectly included **individual cells** in their diagrams. This is inappropriate for a **plan drawing**, which should

depict tissue layers only and not cellular detail. Such responses indicate a misunderstanding of the conventions of biological drawing at A-Level.

To improve, candidates should:

- Revise the structure of a dicot leaf, focusing on the distinction and arrangement of the tissue layers.
- Practice plan drawings regularly and develop the discipline of excluding cellular detail unless explicitly required.
- Remember the marking criteria: clear representation of overall shape, accurate number and relative thickness of tissue layers, and precise, labelled diagrams that follow instructions exactly.

Candidates are reminded that biological drawings are assessed not only on accuracy but also on adherence to scientific conventions. Attention to such details can help secure full marks in straightforward drawing tasks.

(ii) The leaf section on **J1** is from a plant that lives at high altitudes in very cold conditions. In the winter the ground is often frozen and plants are unable to take up water.

Suggest **one** observable feature of the leaf section on **J1** which enables it to survive in these conditions.

any one from:

1. cuticle ;

2. thin leaf blades ;

3. few stomata ;

4. hairy leaf surface (trichomes) ;

5. reduced intercellular air spaces ;

[1]

Examiner's Comment:

This question assessed candidates' ability to infer an **adaptive anatomical feature** from an observed leaf structure, specifically one that enhances survival in cold and water-scarce environments. While some candidates responded appropriately with observable features such as a thick cuticle or reduced air spaces, a large number provided biologically inaccurate or **unobservable** suggestions.

Common misconceptions included suggesting **more xylem vessels** or **increased vascular tissue** as adaptations. While vascular tissue is indeed involved in water transport, increasing its abundance does not directly address water conservation in frozen conditions, and such structures may not be visibly distinct or measurable in the section provided. Another misconception was that **trichomes (hair-like structures)** function to **absorb water from the air**—this is incorrect at the A-level standard, as trichomes primarily reduce transpiration by trapping a layer of moist air.

To improve, candidates should:

- Focus on features that are **visible in the section** and **known to reduce water loss**, such as thick cuticles, reduced intercellular spaces, and fewer stomata.
- Avoid over-interpreting the function of anatomical structures beyond what is biologically accurate or observable in the given diagram.
- Revisit the key structural adaptations of xerophytic or cold-climate plants, especially those that minimise **water loss** rather than enhance water uptake.

Candidates are reminded that when asked to suggest observable features, responses must be consistent with what can be **seen in the diagram or section** and grounded in biological reasoning.

(iii) Observe the cells in the epidermis of the section on **J1**.

Select a line of four adjacent cells that make up this tissue.

Each cell must touch at least one of the other cells.

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

• Use **one** ruled label line and label to identify the cell wall of **one** cell.

1. uses most of the available space and all lines sharp and continuous ;
2. draws only four whole cells
3. each cell touches at least one other cell ;
4. cell wall drawn as two lines around each cell and three lines where cells touch ;
5. label line and label to one cell wall ;

[5]

Examiner's report:

Many candidates were able to demonstrate good drawing skills and followed instructions well, accurately depicting four adjacent epidermal cells and using a proper label line. However, several common errors prevented some from achieving full marks.

One frequent issue was the **incorrect arrangement of cells**. Candidates were asked to draw a *line of four adjacent cells*, each touching at least one other. However, some presented clusters of cells arranged in two rows (e.g. 2 above and 2 below), which does not meet the criteria for adjacency along a single line.

Another common mistake was **inconsistent cell wall representation**. Accurate biological drawing requires that **each cell is enclosed by two distinct lines** (representing the cell wall), and **where cells touch**, a shared wall should be shown with **three lines**. Failure to observe this convention resulted in the loss of a key mark.

Additionally, a number of students either:

- Drew the **cells too small**, not utilising half to two-thirds of the space provided, which suggests a lack of drawing confidence or awareness of the expected scale.
- Included **unnecessary internal structures**, such as nuclei, despite this being a drawing of plant epidermal cells in plan view, not intended to show internal detail.
- Misrepresented the **shape of epidermal cells**, often drawing them too elongated or irregular, which does not reflect the typical structure of pavement cells in the epidermis.

To improve in such questions, candidates should:

- Carefully read and follow all drawing instructions, especially regarding the arrangement and number of cells.
- Practice drawing cell walls with correct line conventions (two lines around each cell, three lines where cells touch).
- Use the space provided effectively and draw large, clear diagrams.
- Avoid adding unrequested structures unless specified in the question.
- Review the typical morphology of different plant cell types to ensure realism in biological drawings.

Drawing tasks are an important component of H2 Biology that test observational accuracy and attention to detail. Consistent practice and awareness of drawing conventions will help candidates perform better in such questions.

(b) Fig. 3.1 is a photomicrograph of a stained transverse section through a different type of leaf from **J1**.

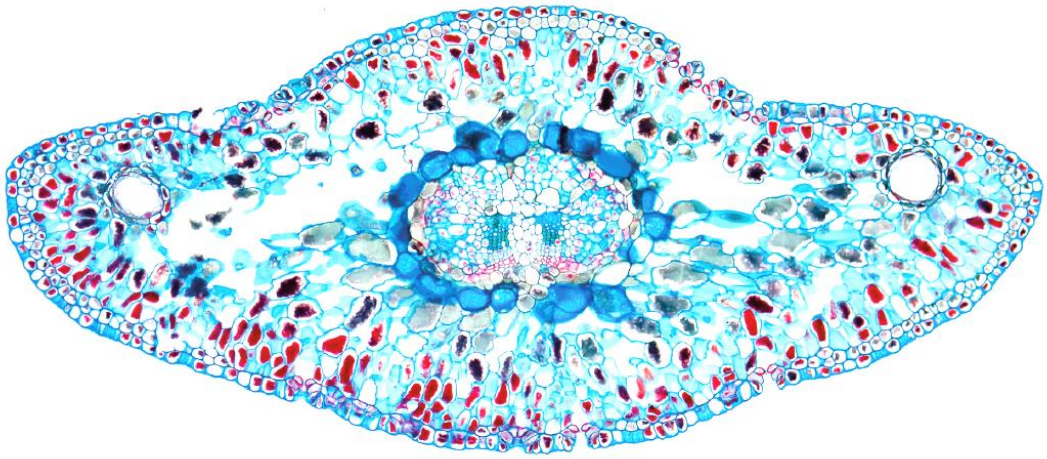


Fig. 3.1

Identify **three** observable **differences** between the leaf section on **J1** and the leaf section in Fig. 3.1.

Record these three observable differences in Table 3.1.

Table 3.1

Feature	J1	Fig 3.1
Vascular tissue	*Smaller proportion*	*Large proportion;*
Shape of vascular tissue	*Cone*	*Oval ;*
No. of vascular tissues	*Many / More than 1*	*One ;*
Air spaces	*Less*	*More;*
Shape of leaf	*Circular w. 2 (lamina) ext*	*Elongated / Elliptical ;*
Stomata	*Fewer*	*More;*
Palisade mesophyll	*Under upper epidermis*	*Absent ;*
Spongy mesophyll	*Under palisade mesophy*	*Uniformly around V.B ;*
Mid rib	*Prominent*	*Absent ;*
Thickness of lamina/blade	*Thin*	*Thick ;*

[3]

Examiner's comment:

This comparative question required candidates to identify and clearly describe **three observable anatomical differences** between two transverse sections of leaves. Most candidates were able to identify at least one valid difference. However, several common issues reduced the quality and clarity of responses.

A key area for improvement is the **precision of feature descriptions**. Vague entries such as "shape" or "size" without specifying *what* is being described (e.g. "shape of mid-rib" or "thickness of leaf lamina") were not awarded marks. Such answers demonstrate a lack of anatomical clarity and fail to meet the standard of observational accuracy expected at H2 level.

Some candidates also made incorrect or **unobservable claims**, likely based on assumptions rather than actual visual differences. For example, referencing internal features like the number of xylem vessels or unseen cellular components does not align with the assessment of observable differences.

To do well in such questions, candidates should:

- Use **specific anatomical terms** (e.g. "presence of prominent mid-rib", "shape of vascular bundle", "distribution of palisade mesophyll") rather than vague descriptors.
- Ensure comparisons are made across the **same feature** in both samples, written clearly and in corresponding rows.
- Avoid making unsupported inferences or assumptions beyond what is observable from the section.

Practising structured comparisons in tabular form, with attention to clarity and specificity, will help candidates gain full marks in such questions. Candidates are encouraged to annotate diagrams during observations to aid in accurate feature recognition before answering.

(c) Fig. 3.2 is the same photomicrograph as that in Fig. 3.1, with the line **X**–**Y** drawn across its width.

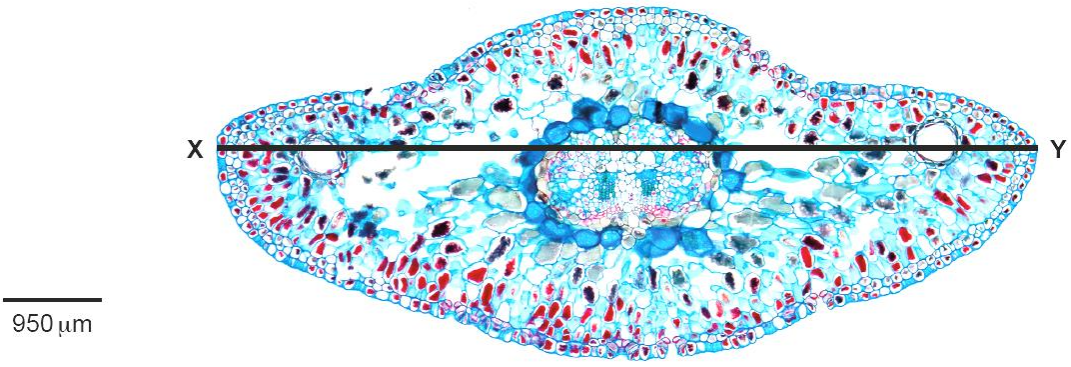


Fig. 3.2

In Fig. 3.2 the line **X**–**Y** is drawn across the width of the leaf. Use the line **X**–**Y** and the scale bar to calculate the actual width of the leaf.

Show your working.

1. ***measures and records the correct length of the scale bar ;***
2. ***measures and records the correct length of line X–Y ;***
3. ***shows the length of line X–Y divides by length of scale bar and multiply by 950 µm ;***
4. ***records the correct width of the leaf and units ;***

Examplar:

Length of scale bar = 1.3 cm
Length of XY = 10.8 cm

Magnification
= length of drawing / actual length
= 1.3 x 10 x 1000 µm / 950 µm

1.3 x 10 x 1000 µm / 950 µm = 10.8 cm / actual width of the leaf
Actual width of the leaf
= 10.8 cm / (1.3 x 10 x 1000 µm / 950 µm)
= 0.789 cm

actual width of leaf = ... [4]

Examiner's comment:
This question assessed candidates' ability to interpret a photomicrograph, take accurate measurements, and apply the appropriate mathematical calculation to determine the actual width of a leaf. While many candidates were able to arrive at a reasonable final value, a significant number lost marks due to **errors in working, measurement, or unit handling**.

One key issue was the **lack of proper written working**. Candidates are expected to **record the measured lengths** of both the scale bar and line X–Y clearly, with appropriate units. Simply writing numerical values without

indicating what they represent is insufficient. For example, “1.3 cm” must be accompanied by a clear statement such as “Length of scale bar = 1.3 cm”. Several candidates also made **reading errors** when measuring distances using a ruler—e.g. misreading 1.3 cm as 1.8 cm, or 10.8 cm as 11.0 cm. This points to a lack of attention to **measurement accuracy**, which is critical in biological drawing and analysis.

Another common error was in the **mathematical calculation step**. Candidates often divided measurements expressed in different units (e.g. centimetres and micrometres) without performing proper unit conversion or justifying why conversion was not needed. While micrometres are acceptable as the final unit, the **calculation must show clear, logical steps** that include unit consistency throughout.

To improve, candidates should:

- Clearly **label all measured values** (e.g. length of scale bar and X–Y) with units.
- Show **complete mathematical working**, including formula and substitution steps.
- Avoid mixing units in calculation without explanation—ensure that division or multiplication is done between values of the same unit or clearly indicate cancellation.
- Record the **final answer with appropriate units (μm)**—no need to convert to other units unless explicitly required.

Demonstrating scientific numeracy is a key component of the H2 Biology syllabus. Candidates should treat such calculations with the same rigour as biology content questions, showing precision in both measurement and mathematical reasoning.

[Total: 18]