Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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1624630727

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

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 A student investigated the effect of wind speed on the rate of transpiration. The student used the flowering plant Japanese spiraea, *Spiraea japonica*.

The student used the apparatus shown in Fig. 1.1 to measure the rate of transpiration.

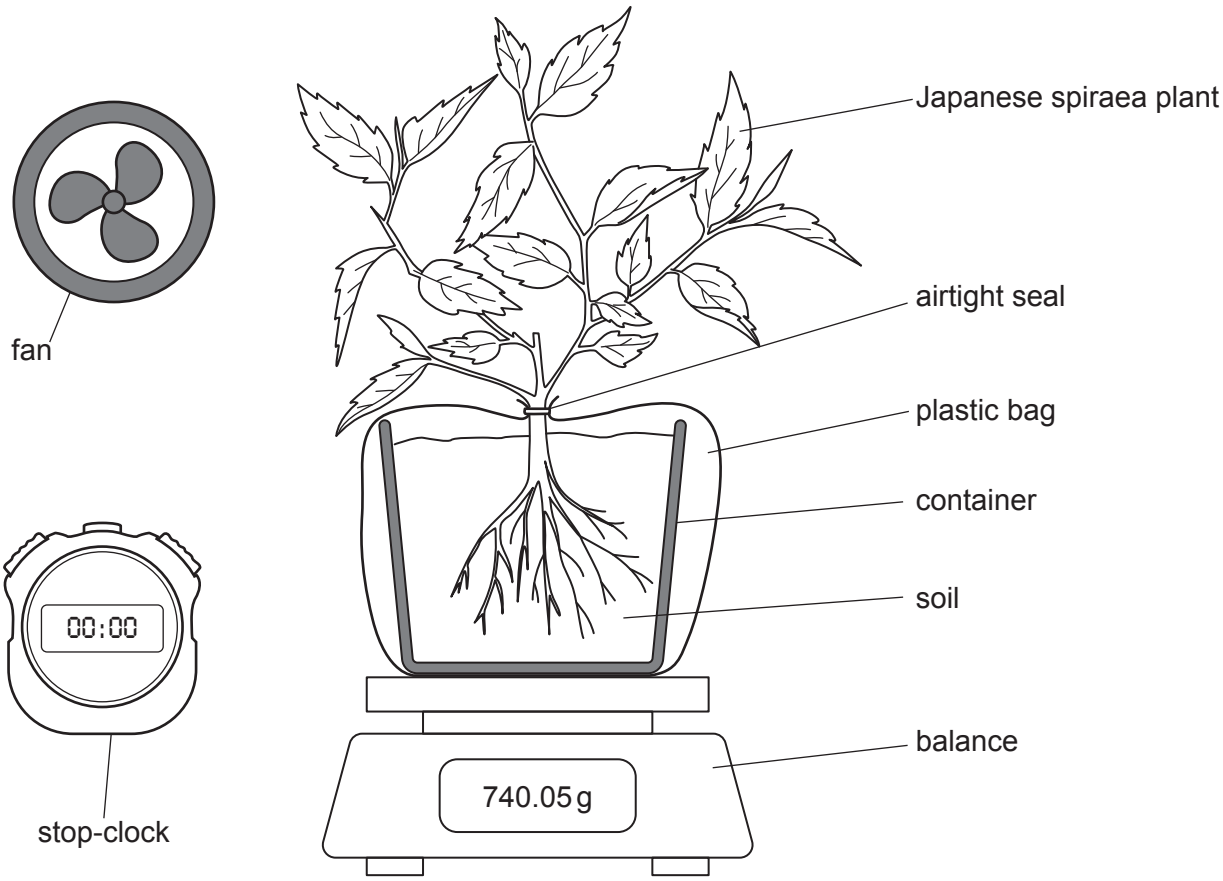


Fig. 1.1

To set up the apparatus the student:

- obtained a Japanese spiraea plant growing in a container of soil
- added 200 cm^3 of water to the soil
- placed a plastic bag around the container of soil to prevent water loss from the soil
- placed the plant and container on the balance
- switched on the fan to a low setting.

The roots of the Japanese spiraea plant absorbed water from the soil. Water was carried in the xylem and water vapour was lost by transpiration from the leaves of the plant. This caused the reading on the balance to decrease during the investigation.

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

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..... [1]

(ii) The student carried out the investigation in a laboratory with standard laboratory apparatus.

Describe a method, using the apparatus shown in Fig. 1.1, that the student could use to investigate the effect of wind speed on the rate of transpiration by Japanese spiraea.

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 set up the apparatus shown in Fig. 1.1 should **not** be included.

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(iii) Predict the effect of wind speed on the results of the investigation using the method you have given in **(a)(ii)**.

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(b) The student used a different method to measure the rate of transpiration of Japanese spiraea.

Fig. 1.2 shows the apparatus used. The leaf remained attached to the plant during the investigation.

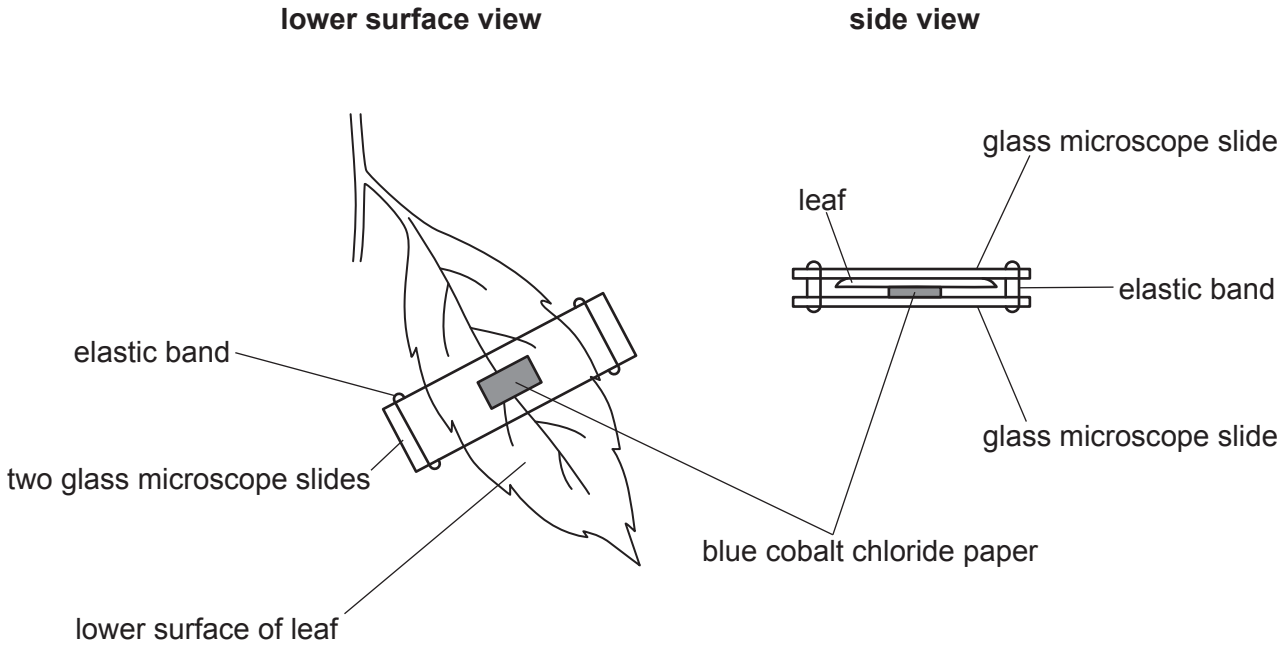


Fig. 1.2

A piece of blue cobalt chloride paper was attached to the lower surface of a leaf, as shown in Fig. 1.2. Blue cobalt chloride paper changes colour to pink if water is added.

The student measured the time taken for the blue cobalt chloride paper to change colour.

This procedure was repeated with two more leaves of the Japanese spiraea plant. The plant was kept in controlled conditions at all times.

Table 1.1 shows the results obtained using blue cobalt chloride paper.

Table 1.1

leaf tested	time taken for blue cobalt chloride paper to change colour / s
1	122
2	137
3	74

Fig. 1.3 shows the formula the student used to calculate the rate of transpiration in units of h^{-1}.

$$\text{rate of transpiration} = \frac{3600}{\text{time taken in seconds}}$$

Fig. 1.3

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(i) Using the information given in Table 1.1 and Fig. 1.3, calculate the rate of transpiration for leaf **2** of the Japanese spiraea plant.

Give your answer to **three** significant figures.

rate of transpiration = ... h^{-1}

[1]

(ii) To improve the validity of the results, the student decided to measure the time taken for blue cobalt chloride paper to change colour on a greater number of leaves of the Japanese spiraea plant.

State **one** other change the student could make to the method to improve the validity of the results.

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..... [1]

[Total: 10]

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2 The responses of plant species to water stress can be classified as either isohydric or anisohydric.

- Isohydric plant species close stomata during times of water stress. This behaviour minimises water loss by transpiration but also reduces carbon dioxide uptake for photosynthesis.

- Anisohydric plant species do not close stomata during times of water stress. This behaviour maximises carbon dioxide uptake for photosynthesis but also increases water loss by transpiration.

A biologist studied 10 tree species from Australia. The biologist studied the effect of water stress **and** high environmental temperatures on five isohydric tree species and five anisohydric tree species.

For each tree species studied:

- The biologist obtained 20 young trees.
- The young trees were grown in containers of soil in controlled conditions in a glasshouse.
- The environmental conditions in the glasshouse were chosen to represent summer conditions in Australia. The mean glasshouse temperature was 28 °C.
- All the young trees were given a good supply of water for 10 weeks, so that the young trees acclimatised to the environmental conditions in the glasshouse.

(a) State **three** environmental conditions in the glasshouse that should be standardised in the 10-week period of acclimatisation, **other than** the temperature of the glasshouse.

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After the 10-week period of acclimatisation, the biologist divided the young trees from each species into four groups of five trees.

Table 2.1 shows the experimental conditions used by the biologist for the next five weeks.

Table 2.1

group	experimental conditions
1	The young trees were given a good supply of water for five weeks. The mean glasshouse temperature during weeks 1 to 5 was 28 °C.
2	The young trees were given a good supply of water for five weeks. The mean glasshouse temperature during weeks 1 to 4 was 28 °C. During week 5, the mean glasshouse temperature was increased to 35 °C.
3	The young trees were given a reduced supply of water for five weeks (water stress). The mean glasshouse temperature during weeks 1 to 5 was 28 °C.
4	The young trees were given a reduced supply of water for five weeks (water stress). The mean glasshouse temperature during weeks 1 to 4 was 28 °C. During week 5, the mean glasshouse temperature was increased to 35 °C.

At the end of week 5, the biologist measured the stomatal conductance of three leaves from each young tree at 12:00 (midday).

Stomatal conductance is a measure of water vapour loss from the intercellular air spaces of leaves to the atmosphere through the stomata.

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The biologist processed the data to compare the results from the isohydric and anisohydric tree species in the four experimental conditions, as shown in Table 2.1.

The results are shown in Fig. 2.1.

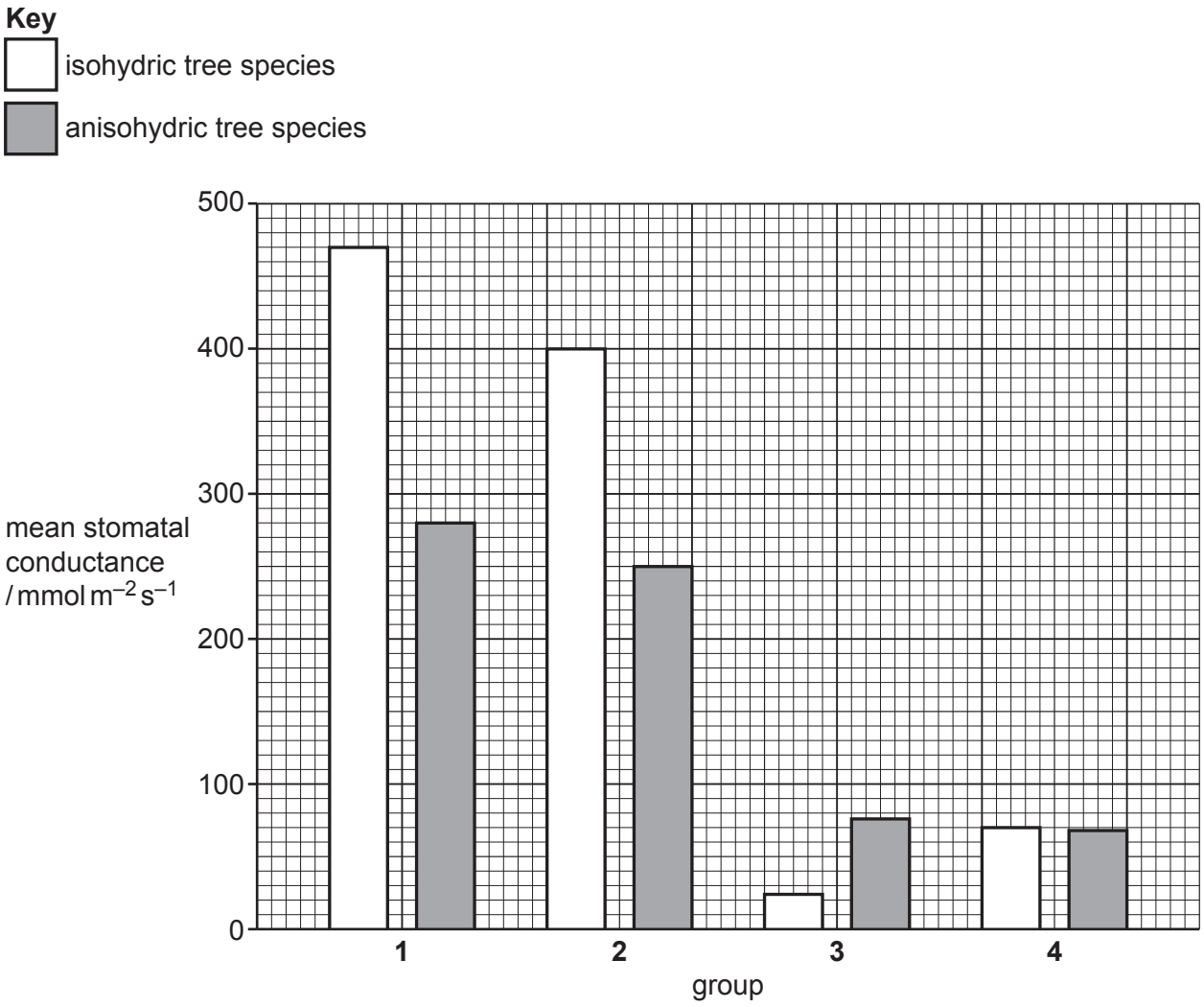


Fig. 2.1

(b) Using Fig. 2.1, state the effect of a high mean temperature on the mean stomatal conductance of young trees that were given a good supply of water.

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..... [1]

(c) The biologist then compared the young trees from group **3** and group **4** that were exposed to water stress.

The biologist carried out statistical tests on the data to see if the difference between the mean stomatal conductance of young trees in group **3** and the mean stomatal conductance of young trees in group **4** was significant.

Table 2.2 shows the probability values (*p*) from the results of the statistical tests.

Table 2.2

tree species	value of *p*	significance
isohydric tree species	0.046	significant
anisohydric tree species	0.788	not significant

With reference to Fig. 2.1 and Table 2.2, suggest **and** explain the conclusions that can be made about the effect of water stress **and** a high environmental temperature on isohydric **and** anisohydric tree species.

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Question 2 continues on page 12.

(d) The biologist noticed that the young trees in group **4** had some dead leaves at the end of week 5.

The biologist determined the percentage of leaves on the young trees that were dead at the end of week 5.

The results from the isohydric tree species and the anisohydric tree species are shown in Table 2.3.

Table 2.3

type of tree species	**group 4: water stress + high mean temperature**	
	mean percentage of leaves that were dead	**standard error (SE)**
isohydric	19.0	8.3
anisohydric	3.5	1.3

(i) The biologist then analysed these data using a *t*-test to compare the mean percentage of leaves that were dead on the young trees of the isohydric and anisohydric species.

State a null hypothesis for the *t*-test.

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(ii) The formula for the *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)

The biologist calculated $\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}$ = **8.231**

Use this value and Table 2.3 to calculate the value of *t* for these data.

Show your working.

t = ... [2]

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(iii) The degrees of freedom for this *t*-test are 48. Table 2.4 shows the probability table for the *t*-test.

Table 2.4

degrees of freedom	critical values		
	p = 0.10 (10%)	p = 0.05 (5%)	p = 0.01 (1%)
48	1.677	2.011	2.682

Using Table 2.4 and the calculated value of *t* from **(d)(ii)**, describe what the biologist can conclude from the results shown in Table 2.3.

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..... [3]

[Total: 14]

3 Female mosquitoes feed on human blood. Some species of mosquitoes are vectors of human pathogens. For example, female mosquitoes of the species *Aedes aegypti* transmit the pathogen that causes the disease yellow fever.

Mosquitoes have sensory receptors that can detect chemicals in the air. Mosquito repellents contain chemicals that are sprayed onto the skin of humans to prevent mosquitoes taking blood meals.

(a) Some scientists investigated the effectiveness of different mosquito repellents using a human volunteer. The scientists carried out the investigation on this person in a laboratory.

Fig. 3.1 is a diagram of the experiment before the start of the investigation.

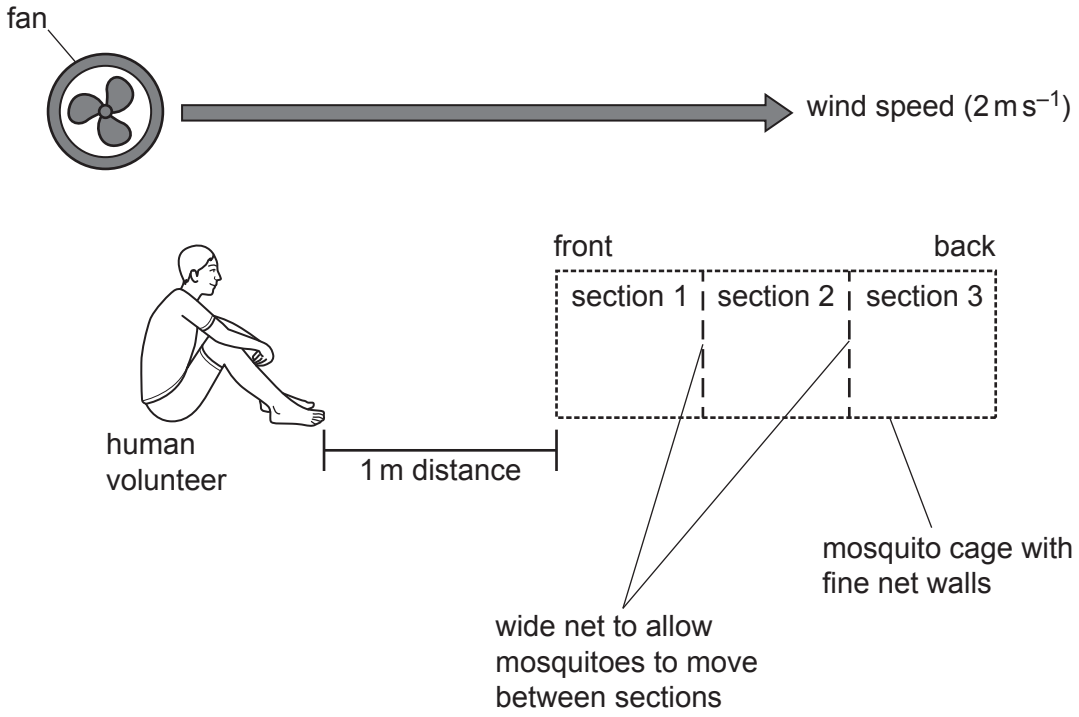


Fig. 3.1

The same procedure was used for each mosquito repellent studied.

- A human volunteer sat 1 m from a mosquito cage, as shown in Fig. 3.1.
- The person sprayed some mosquito repellent onto the skin of both arms.
- A fan was turned on so that air moved from the person towards the mosquito cage. The moving air carried chemicals, including the mosquito repellent, from the person into the mosquito cage.
- The scientists added 100 female mosquitoes of *A. aegypti* to section 2 of the mosquito cage.
- The mosquitoes were left in the mosquito cage for 15 minutes. The walls of the mosquito cage were made of fine net to prevent mosquitoes leaving the cage. The mosquitoes moved freely between sections 1, 2 and 3.
- After 15 minutes, the scientists counted the number of mosquitoes in each section of the mosquito cage. The percentage of mosquitoes in section 1 of the mosquito cage was calculated.
- This procedure was then repeated three times on different days, using the same person.

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(i) State a suitable control for this investigation.

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(ii) Suggest **one** risk to the **scientists** when carrying out this investigation **and** state a suitable precaution they should take.

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(b) Table 3.1 shows the results of the investigation.

Table 3.1

chemical in mosquito repellent	percentage concentration of chemical in mosquito repellent	percentage of mosquitoes in section 1 of the mosquito cage mean ± standard error (SE)
DEET	40	68.55 ± 6.42
DEET	98	33.70 ± 4.06
lemon eucalyptus oil	30	29.62 ± 6.31
picaridin	10	78.65 ± 6.00

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

A student who read this paper concluded that the most effective mosquito repellents contained DEET or lemon eucalyptus oil.

The student was planning to travel to a country where malaria is present. The student decided to use a mosquito repellent that contained DEET to prevent malaria infection.

Explain whether the procedure **and** the data in Table 3.1 support or do **not** support this decision to use a mosquito repellent that contained DEET.

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[Total: 6]

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Cambridge International AS & A Level

CANDIDATE NAME

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5180956942

BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

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INFORMATION

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[Turn over

1 Tree plantations are areas where trees are planted for a particular purpose. Some tree plantations increase the supply of wood for construction and fuel. In many plantations, fast-growing, alien tree species are planted.

Undergrowth is found in and around plantations, increasing plant biodiversity. Undergrowth is mainly made up of indigenous (native) small plants and shrubs.

Fig. 1.1 shows part of a plantation of eucalyptus trees.



Fig. 1.1

Bangladesh has many tree plantations as part of a national tree-planting programme.

Two fast-growing, alien tree species planted in Bangladesh are acacia, *Acacia auriculiformis*, and eucalyptus, *Eucalyptus camaldulensis*.

Acacia and eucalyptus are considered to be invasive species as they outcompete indigenous tree species such as sal tree, *Shorea robusta*, and mango, *Mangifera indica*.

Scientists carried out an investigation into the biodiversity of plant species in the undergrowth in plantations of alien trees compared with the undergrowth in plantations of indigenous trees.

The hypothesis that the scientists tested was stated as:

The undergrowth in plantations of alien tree species will have a lower biodiversity of plant species than the undergrowth in plantations of indigenous tree species.

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

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For the investigation, plantations were selected within the same region of Bangladesh with the same environmental conditions.

- Three plantations of each tree species were selected: acacia, eucalyptus, sal tree and mango.
- A plot measuring 36 m by 36 m was studied within each plantation.
- For each plot, belt transects were used to collect the data needed to determine Simpson's index of diversity (*D*).

For each type of plantation, Simpson's index of diversity (*D*) was calculated for the plant species in the undergrowth.

Each plot was studied in April, July and November.

(ii) Identify **two** variables the scientists standardised in this investigation.

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(b) The scientists used belt transects to investigate the undergrowth of each plot.

Describe how you could use belt transects to collect the data needed to determine Simpson's index of diversity (*D*) of the undergrowth in each of the plots.

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

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Table 1.1 shows the Simpson's index of diversity (*D*) values the scientists obtained for the different plantations during April, July and November.

Table 1.1

month	Simpson's index of diversity (*D*) for undergrowth plant species in plantation			
	acacia	eucalyptus	sal tree	mango
April	0.90	0.87	0.94	0.90
July	0.86	0.86	0.94	0.86
November	0.87	0.83	0.94	0.88
mean	0.88	0.85	0.94	0.88
± *s*	± 0.02	± 0.02	± 0.00	± 0.02

s = standard deviation

(c) State **and** explain whether the data in Table 1.1 support the hypothesis:

The undergrowth in plantations of alien tree species will have a lower biodiversity of plant species than the undergrowth in plantations of indigenous tree species.

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..... [1]

In China, a different group of scientists investigated whether the roots of invasive plant species produce chemicals that have an effect on the growth of other plants.

The scientists prepared an extract of the roots of staghorn sumac, *Rhus typhina*. Staghorn sumac is an invasive plant species.

The scientists prepared a stock solution of the root extract with a concentration of 10 mg cm^{-3}. The scientists then used the stock solution to prepare solutions with different concentrations of root extract.

(d) (i) Describe how the scientists could use the stock solution to prepare **50 cm^3** of solutions of the root extract with concentrations of 2.5 mg cm^{-3} and 7.5 mg cm^{-3}.

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In some regions of China, marigold plants, *Tagetes erecta*, are grown commercially.

In the investigation into the effect of staghorn sumac root extract on the growth of marigolds, the scientists carried out the procedure described in step 1 to step 5.

step 1 Prepare five containers, each with five marigold plants grown from seed.

step 2 Add 20 cm^3 of distilled water to one of the containers. This is the control.

step 3 Add 20 cm^3 of the root extract concentrations to the other four containers, so that each container has a different concentration of root extract.

step 4 Repeat step 2 and step 3 each day for 60 days.

step 5 After 60 days, remove the marigold plants from the soil and untangle the roots. Measure the length of the longest root for each plant.

The scientists replicated this procedure twice and calculated the mean maximum root length for the control and for the root extract concentrations.

The results are shown in Table 1.2.

Table 1.2

root extract concentration / mg cm^{-3}	mean maximum root length after 60 days / mm
control	163.0
2.5	153.2
5.0	156.4
7.5	152.0
10.0	141.6

(ii) Using the data in Table 1.2, calculate the percentage change in the mean maximum root length between the control and the roots treated with 10 mg cm^{-3} root extract concentration.

Show your working and record your answer to 3 significant figures.

percentage change ..... [3]

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(e) A student suggested that this investigation could be improved.

With reference to the method used and the data in Table 1.2, state **and** explain **three** ways to improve confidence in the results.

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(f) To investigate the effect of the different root extract concentrations on the diversity of the microorganisms in soil, the scientists:

- took samples of soil from each of the containers
- identified and counted the number of species of microorganism present in the samples
- calculated the Simpson's index of diversity (*D*) values for the species of microorganism in each of the soil samples.

State **two** variables the scientists should have standardised when taking the soil samples.

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[Total: 19]

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2 Tumours may be described as benign or malignant. Malignant tumours can lead to greater complications for the person with the tumour.

Early identification of tumours, particularly malignant tumours, is important for effective treatment. Benign tumour cells and malignant tumour cells can look similar when viewed using a light microscope.

Some scientists wanted to develop a diagnostic test to identify tumour cells as benign or malignant. The scientists investigated whether the diameter of the cell nucleus could be used to identify the type of tumour cell as benign or malignant.

The scientists used a light microscope with a calibrated eyepiece graticule to measure the diameter of the nuclei of stained tumour cells.

Fig. 2.1 shows a photomicrograph of stained tumour cells viewed using a light microscope.

An eyepiece graticule was placed across the nucleus of one of the tumour cells.

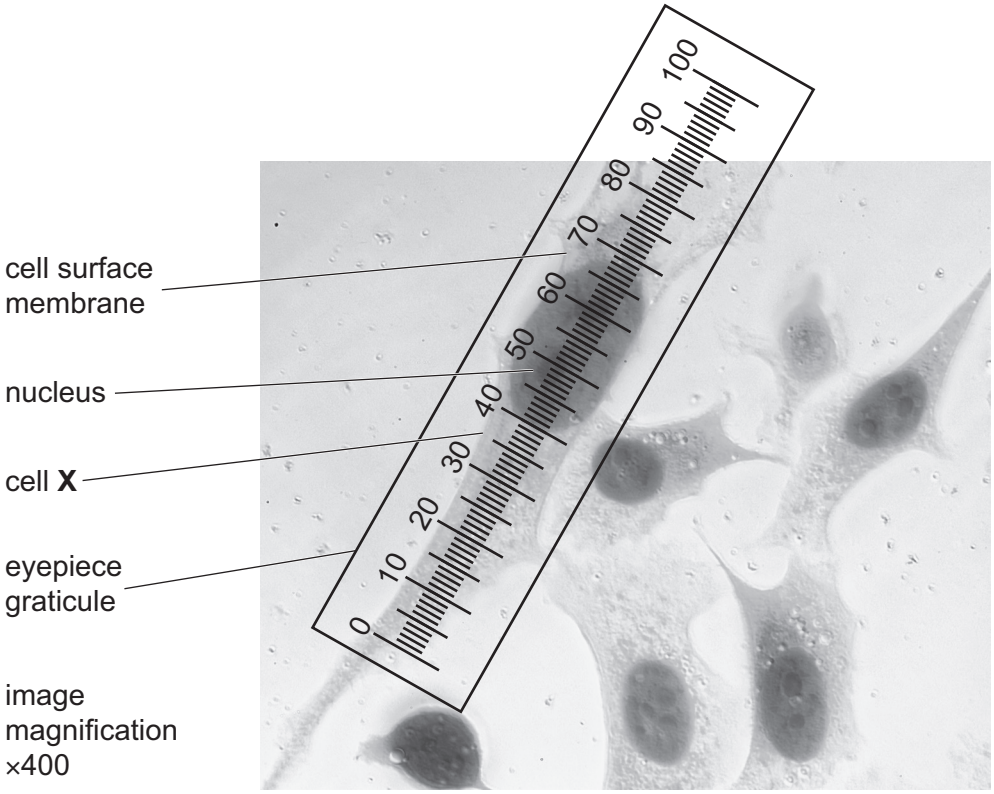


Fig. 2.1

The calibration of the eyepiece graticule scale is:

one eyepiece graticule division = 320 nm

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(a) Use the calibration of the eyepiece graticule scale to calculate the actual diameter of the nucleus of cell **X**, shown in Fig. 2.1.

Show your working and state your answer in μm.

actual diameter of the nucleus of cell **X** = ... μm [3]

(b) For the investigation into whether the diameter of the nucleus could be used to identify the type of tumour cell, tumours of the thyroid gland (an endocrine gland) were used.

For the diagnostic test the scientists carried out a procedure using two different stains.

step 1 50 people diagnosed with benign tumours and 24 people diagnosed with malignant tumours were selected.

step 2 A sample of tumour cells was removed from the thyroid gland of each person.

step 3 The cells were stained with either Papanicolaou stain (Pap) or haematoxylin and eosin stain (H&E).

step 4 Samples were viewed using a light microscope with a magnification of ×400.

step 5 In each sample, the diameters of 100 nuclei were measured.

step 6 The measurements were made by one of the scientists who did not know the type of tumour cell they were measuring.

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Table 2.1 shows the results of the investigation.

Table 2.1

category	mean nuclear diameter / μm	standard deviation / μm	standard error / μm
total benign cells (50 people) 5000 cells:	7.3	±0.8	±0.011
• Pap-stained cells (41 people) 4100 cells	7.3	±0.7	±0.011
• H&E-stained cells (9 people) 900 cells	7.2	±1.0	±0.033
total malignant cells (24 people) 2400 cells:	9.0	±0.6	±0.122
• Pap-stained cells (18 people) 1800 cells	9.0	±0.7	±0.016
• H&E-stained cells (6 people) 600 cells	8.8	±0.5	±0.020

(i) Suggest how the scientists can standardise the method of measuring the diameter of the 100 nuclei in step 5, so that valid comparisons can be made between benign and malignant tumour cells.

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..... [1]

(ii) Identify **one** variable that the scientists have standardised in step 1 to step 6, **other than** details of the method of measurement of the nuclei.

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..... [1]

(iii) The scientists used a *t*-test to compare the mean nuclear diameter of the Pap-stained cells and the H&E-stained cells in Table 2.1.

State a null hypothesis for the *t*-test.

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(iv) The *t*-value the scientists calculated had a probability (*p*) value greater than 0.25 ($p > 0.25$).

State **one** conclusion that can be made about the effect of using the two stains, Pap and H&E, on the mean nuclear diameter of the cells.

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(v) State **and** explain **one** conclusion that can be made from the data in Table 2.1 when comparing the results for the 5000 benign cells and the 2400 malignant cells.

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..... [2]

(vi) At the end of the investigation, the scientists evaluated their procedure and results. They identified some disadvantages of using the procedure as a diagnostic test.

Suggest **and** explain **two** disadvantages of this procedure as a diagnostic test.

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..... [2]

[Total: 11]

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Cambridge International AS & A Level

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BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2024**

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[Turn over

1 Blood vessels must be able to withstand and maintain varying blood pressures.

There are several methods that could be used to determine the strength of a blood vessel. One method is called the circumferential tensile strength (CTS) test, as shown in Fig. 1.1.

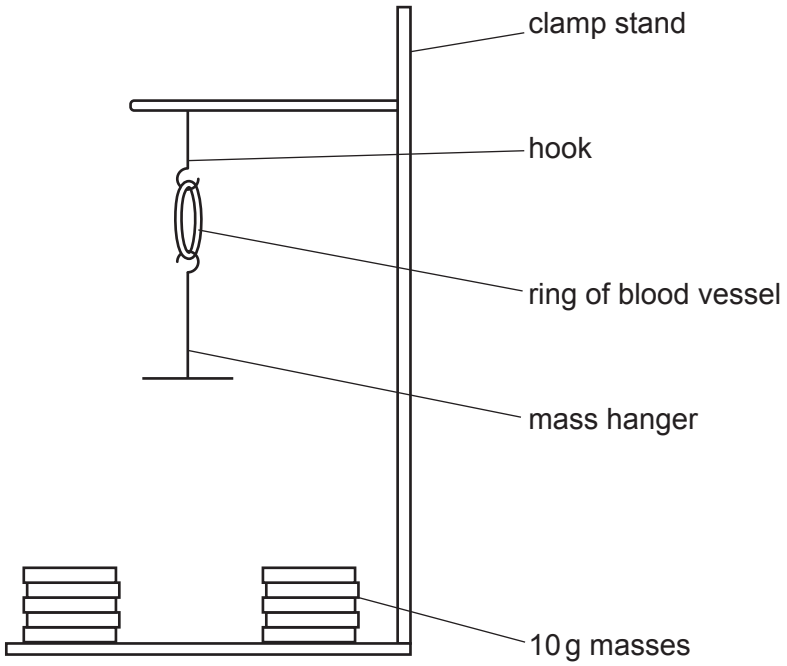


Fig. 1.1

The ring of blood vessel, shown in Fig. 1.1, was cut from a length of artery or vein that was prepared by removing surrounding tissues.

A student wanted to use the apparatus in Fig. 1.1 to determine the mass needed to break an artery and the mass needed to break a vein.

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

independent variable .....

.....

dependent variable .....

.....

[1]

(ii) The student was provided with lengths of a large artery, lengths of a large vein and standard laboratory apparatus.

Describe how the student could use the CTS test to determine the mass needed to break an artery and the mass needed to break a vein.

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

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..... [6]

Another student investigated how the length of a ring of vein and the length of a ring of artery increases as more mass is added.

The student used the apparatus shown in Fig. 1.2 with the ring of vein.

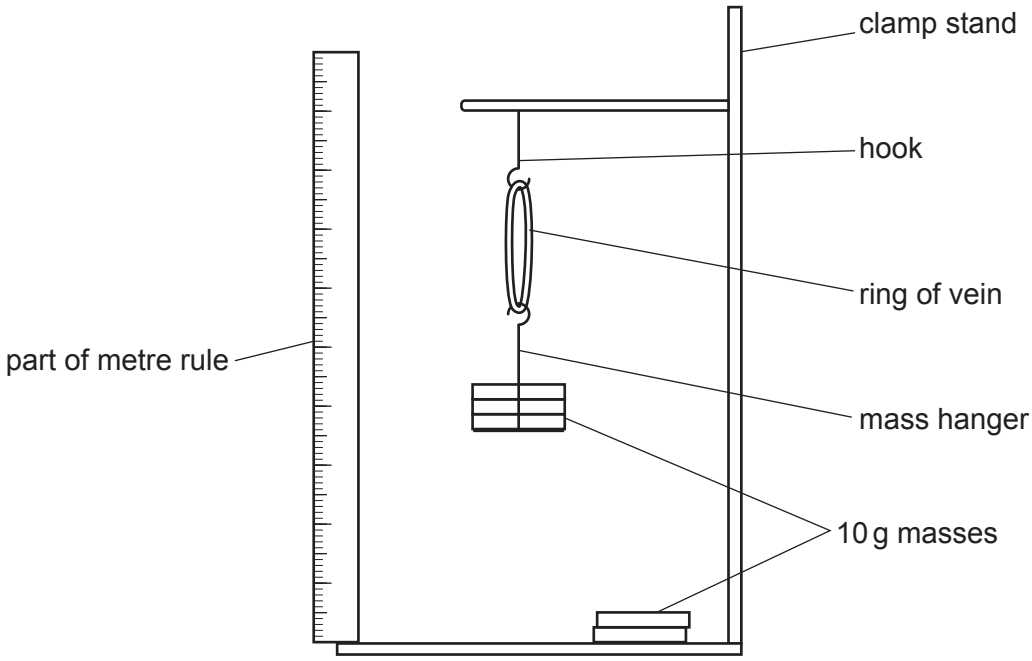


Fig. 1.2

The results for the ring of vein are shown in Table 1.1.

Table 1.1

mass added / g	length of ring of vein / mm	percentage increase in length of ring of vein
0	21	0
10	36	……..
20	38	81
30	40	90
40	41	……..
50	41	……..

(b) (i) Complete Table 1.1 by calculating the percentage increase in length of the ring of vein for 10 g, 40 g and 50 g. [2]

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(ii) Explain why the student calculated the percentage increase in length of the ring of vein.

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..... [1]

(iii) On the grid in Fig. 1.3, plot a graph of the data shown in Table 1.1.

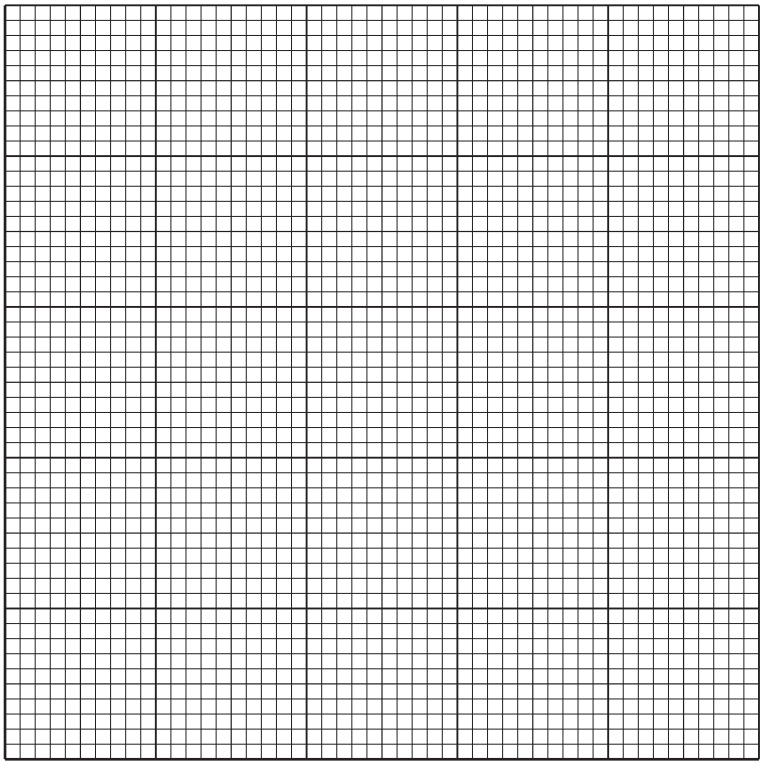


Fig. 1.3

[3]

(iv) The student carried out the same investigation using a muscular artery instead of a vein.

Predict the shape of the curve you would expect for the muscular artery.

On Fig. 1.3:

- sketch the curve you predicted for the muscular artery
- label this curve with the word **artery**.

[2]

(v) Explain the shape of the curve you sketched for the muscular artery in Fig. 1.3.

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..... [2]

(vi) Another student suggested that the experiment should be repeated with more rings from the same blood vessels.

Suggest **two other** ways the student could modify the method to improve the quality of the results.

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..... [2]

[Total: 19]

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2 Gibberellins are a group of plant hormones that are involved in the elongation of plant stems.

A student investigated the effect of two different concentrations of a gibberellin, known as GA_3, on stem elongation of 10-day old pea seedlings.

The student was given a stock solution of GA_3 with a concentration of 2.85×10^{-4} mol dm^{-3}.

(a) Describe a method the student could use to make a solution of GA_3 with a concentration of 1.90×10^{-6} mol dm^{-3} **and** state the dilution factor used.

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..... [2]

(b) In the investigation, the student:

- used the two concentrations of GA_3: 2.85×10^{-4} mol dm^{-3} (high concentration GA_3) and 1.90×10^{-6} mol dm^{-3} (low concentration GA_3)
- applied the high concentration GA_3 to one batch of 10-day-old pea seedlings
- applied the low concentration GA_3 to another batch of 10-day-old pea seedlings
- applied distilled water to a third batch of 10-day-old pea seedlings, as a control
- standardised all other variables
- measured the length of the stem of each seedling every two days until the seedlings were 20 days old
- calculated the rate of stem elongation in cm day^{-1}.

State **one** way in which the student could standardise the measuring of stem length.

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..... [1]

(c) The results of the investigation are shown in Table 2.1.

Table 2.1

age of seedling / days	mean stem length with high concentration GA_3 added / cm	mean stem length with low concentration GA_3 added / cm	mean stem length with distilled water added / cm
10	2	2	2
12	4	2	3
14	7	5	4
16	6	12	7
18	20	15	8
20	25	21	8
rate of stem elongation / cm day^{-1}	2.3	.....	0.6

(i) Complete Table 2.1 by calculating the rate of stem elongation in cm day^{-1} for the seedlings with low concentration GA_3 added.

[1]

(ii) A scientist stated that they did not have enough confidence in the results in Table 2.1 to make any conclusions.

State **one** reason to support the statement made by the scientist.

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..... [1]

(iii) Describe how the student could modify the investigation to increase confidence in the results.

.....

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..... [1]

(d) The student found a study on the internet that considered the effect of different wavelengths of light on the concentration of two types of gibberellins, GA_1 and GA_8, in pea plants.

In the study, 60 pea seeds were germinated and kept in the dark (no light) for seven days.

The pea seedlings were divided into four batches of 15:

- batch 1 remained in the dark
- batch 2 was exposed to blue light (470 nm)
- batch 3 was exposed to red light (680 nm)
- batch 4 was exposed to far-red light (750 nm).

After 4 hours the concentrations of GA_1 and GA_8 in the seedlings were measured.

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[Turn over

Table 2.2 shows the results.

Table 2.2

batch	wavelength of light / nm	colour of light	mean GA_1 concentration ± standard deviation / ng g^{-1} fresh mass	mean GA_8 concentration ± standard deviation / ng g^{-1} fresh mass
1	–	dark	2.87 ± 0.72	3.07 ± 0.10
2	470	blue light	0.21 ± 0.05	3.90 ± 0.13
3	680	red light	0.31 ± 0.10	5.03 ± 0.21
4	750	far-red light	1.38 ± 0.26	4.00 ± 0.72

The student calculated the standard error (SE) and 95% confidence intervals (95% CI) for the data shown in Table 2.2. The formulae that the student used were:

$$SE = \frac{s}{\sqrt{n}}$$

95% CI = $\bar{x}$ ± (2 × SE)

key to symbols

s = standard deviation

n = sample size (number of observations)

$\bar{x}$ = mean

Table 2.3 shows the calculated values for SE and 95% CI for the data from Table 2.2.

Table 2.3

batch	SE for GA_1 / ng g^{-1} fresh mass	mean ± 95% CI for GA_1 / ng g^{-1} fresh mass	SE for GA_8 / ng g^{-1} fresh mass	mean ± 95% CI for GA_8 / ng g^{-1} fresh mass
1	0.186	2.87 ± 0.37	0.026	3.07 ± 0.05
2	0.013	0.21 ± 0.03	0.034	3.90 ± 0.07
3	0.026	0.31 ± 0.05	0.054	5.03 ± 0.11
4	……..	……..	0.186	4.00 ± 0.37

Complete Table 2.3 to show the calculated values for SE **and** mean ± 95% CI for the data from far-red light for GA_1 (batch 4). [2]

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(e) Fig. 2.1 shows the bar chart of the results from the study.

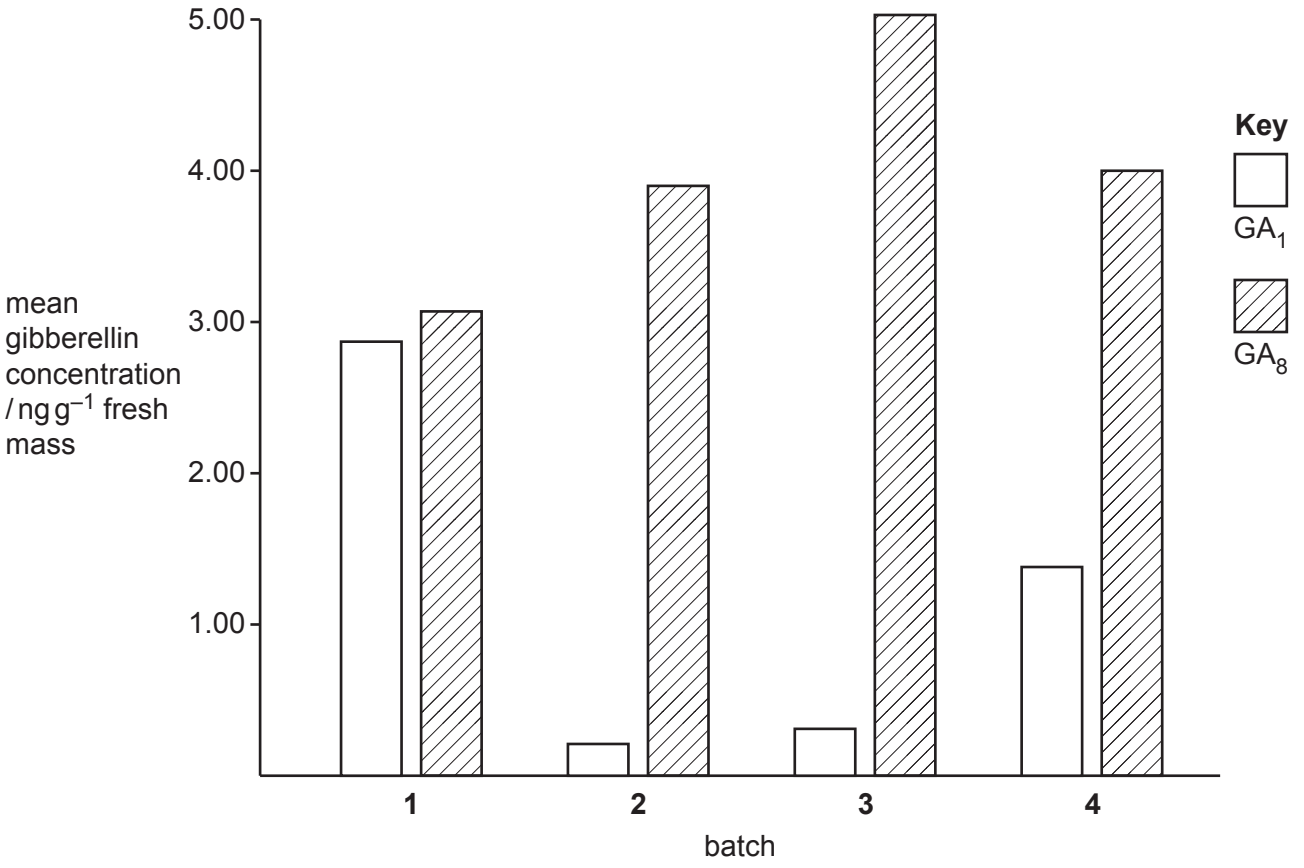


Fig. 2.1

Use Fig. 2.1, Table 2.2 **and** Table 2.3 to state **three** conclusions about the effect of different wavelengths of light on the concentrations of GA_1 and GA_8 in plants.

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..... [3]

[Total: 11]

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