Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

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0182937036

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

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

INFORMATION

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

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1 *Chlorella* is a green, single-celled protoctist that is photosynthetic. Some students immobilised cells from a culture of this protoctist using the same method as used for immobilising enzymes.

(a) Outline how the students could immobilise cells of *Chlorella*.

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The students used the respirometer shown in Fig. 1.1 to measure oxygen uptake by the immobilised *Chlorella* cells.

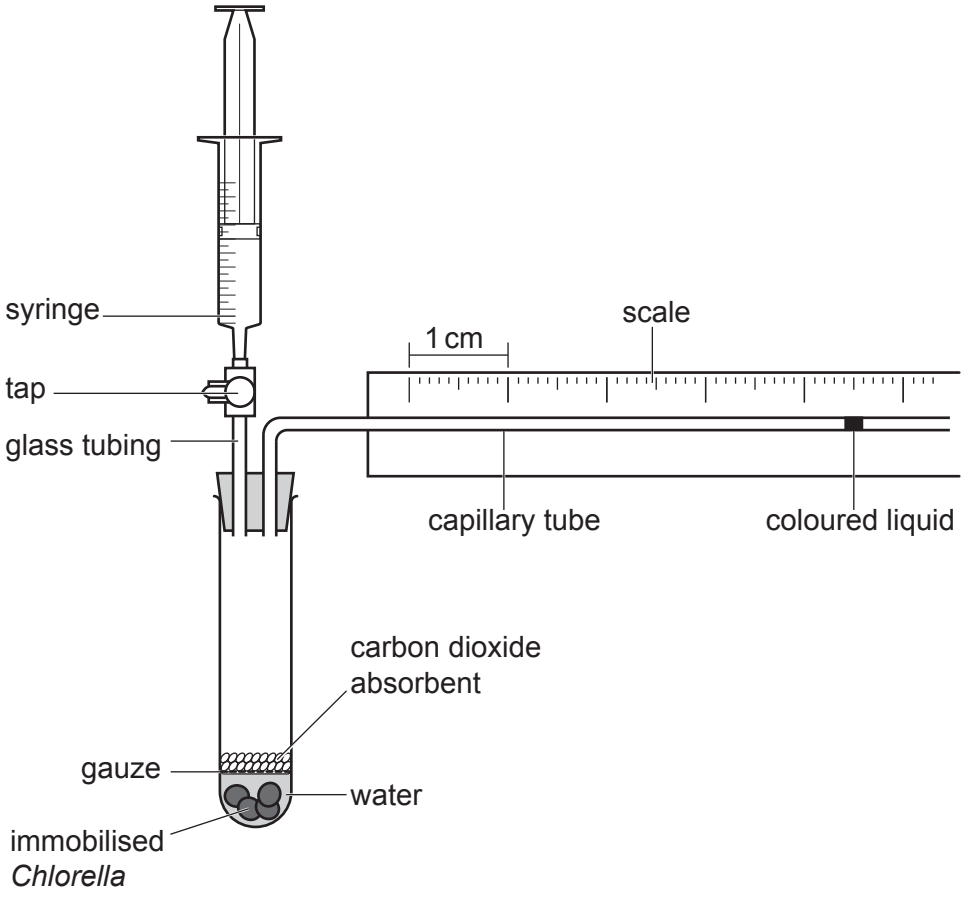


Fig. 1.1

The students used the respirometer to test the hypothesis:

> The volume of oxygen taken up by respiration in immobilised *Chlorella* increases with an increase in temperature.

(b) (i) State the independent variable and the dependent variable in this investigation.

independent variable .....

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dependent variable .....

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[2]

(ii) The students decided to measure oxygen uptake for 5 minutes using a range of temperatures from 10 °C to 50 °C.

Discuss whether the range of temperatures used by the students was suitable for their investigation.

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(iii) Describe a method by which the students could set up the respirometer **and** use it to test their hypothesis:

The volume of oxygen taken up by respiration in immobilised *Chlorella* increases with an increase in temperature.

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

Details of immobilising *Chlorella* are **not** required.

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(c) The students calculated the oxygen uptake for each temperature.

Their results are shown in Table 1.1.

Table 1.1

temperature / °C	10	20	30	40	50
oxygen uptake / mm^3	200	400	800	750	680

(i) Outline how the students calculated the volume of oxygen uptake.

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(ii) State **and** explain **two** conclusions about the trends shown by these results.

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[2]

[Total: 18]

2 **(a)** The cotton bollworm, *Helicoverpa armigera*, is an insect pest of cotton.

The adult cotton bollworm is a moth. The adult female moth lays eggs on cotton plants. The eggs hatch into larvae. The larvae feed on cotton plants by boring holes into the base of flower buds and developing fruits, causing extensive damage and reduction in yield.

Fig. 2.1 shows a mature cotton fruit (cotton boll) from an uninfested plant.

Fig. 2.2 shows a cotton bollworm inside a developing cotton boll.



Fig. 2.1

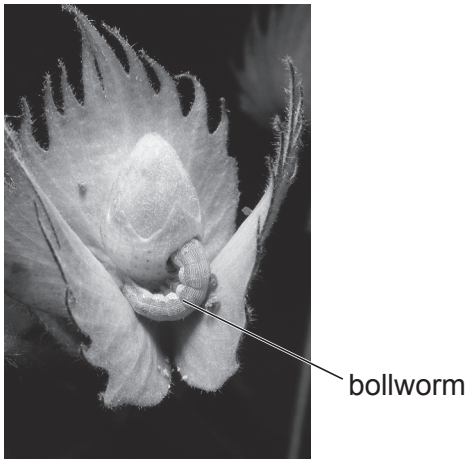


Fig. 2.2

A gene, *cry*, from the bacterium *Bacillus thuringiensis* (Bt), can be inserted into the cotton genome to produce Bt cotton.

- The protein coded by *cry* is toxic to some insects.
- This toxicity gives cotton plants some resistance to cotton bollworm.

Bt cotton was first approved for commercial use in China in 1997. By 2001, Bt cotton had been planted extensively in northern China.

A long-term study on the effect of planting Bt cotton on the occurrence of *H. armigera* was carried out at an experimental field station in northern China from 1998 to 2007.

Two varieties of Bt cotton, v1 and v2, and two varieties of non-Bt cotton, v3 and v4, were used.

A number of fields, covering over 2000 hectares, were divided into standard sized plots. Bt cotton or non-Bt cotton were planted in randomised plots.

Fig. 2.3 shows **one** possible arrangement of the plots in **one** field.

v3	v1	v1	v3
v4	v2	v4	v1
v2	v4	v2	v3

Fig. 2.3

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- Sampling was carried out every 4 days during the breeding season of *H. armigera*.
- Five fields were selected at random and a total of 100 plants in each plot were examined.
- The total number of eggs and larvae on each plant was counted.

(i) State **two** ways in which the design of the field study contributes to the validity of the results.

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[2]

(ii) Suggest **two** variables which **cannot** be standardised in this field study.

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[2]

(b) Table 2.1 shows the results of this study.

Table 2.1

year	density of eggs / mean number of eggs per 100 plants		density of larvae / mean number of larvae per 100 plants	
	Bt cotton (v1 + v2)	non-Bt cotton (v3 + v4)	Bt cotton (v1 + v2)	non-Bt cotton (v3 + v4)
1998	810	920	18	500
1999	995	930	18	340
2000	620	595	72	237
2001	730	782	12	240
2002	200	180	15	173
2003	52	50	24	61
2004	6	5	15	54
2005	120	120	27	75
2006	422	420	33	144
2007	195	190	8	8

(i) The researchers decided to calculate the standard error for each of the mean values shown in Table 2.1.

State why they decided to calculate standard error.

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..... [1]

(ii) The *t*-test could be used to find out if the difference in the mean number of larvae on Bt cotton and non-Bt cotton in each year is significant.

Explain why the *t*-test could be used to analyse the data in Table 2.1.

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(iii) A trend is a change over time.

Describe **three** trends shown by the data in Table 2.1.

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Question 2 continues on page 10

(c) *H. armigera* is a pest on a variety of other crop plants in Asia such as peanuts, soya and rice.

Another long-term field study was carried out to investigate the effect of growing Bt cotton on the density of the larvae of *H. armigera* on other crop plants growing in the same region of northern China.

Table 2.2 shows the results of this study.

Table 2.2

	year	mean population density per year of larvae on other crop plants / number per hectare
before the commercial use of Bt cotton	1992 to 1996	5865
after the commercial use of Bt cotton	1997 to 2001	2011
	2002 to 2006	761

(i) State **one** variable that should be standardised in this field study.

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..... [1]

(ii) Suggest **one** conclusion about the effect of Bt cotton on *H. armigera* that could account for the results in Table 2.2.

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..... [1]

[Total: 12]

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CANDIDATE NAME

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6745933853

BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2020**

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.
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[Turn over

1 (a) Woodlice are small invertebrates that live in cool, damp places under wood and stones.

Some students determined the respiration rate of woodlice at different temperatures.

Fig. 1.1 shows a single woodlouse.

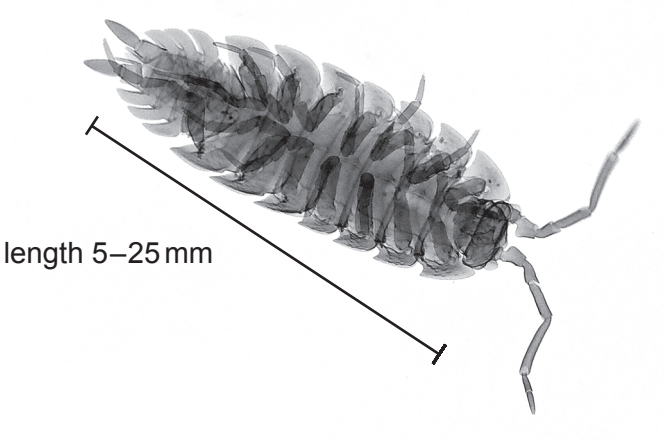


Fig. 1.1

The students tested the hypothesis:

For each 10 °C increase in temperature the volume of oxygen absorbed will double.

Fig. 1.2 shows the respirometer that the students used.

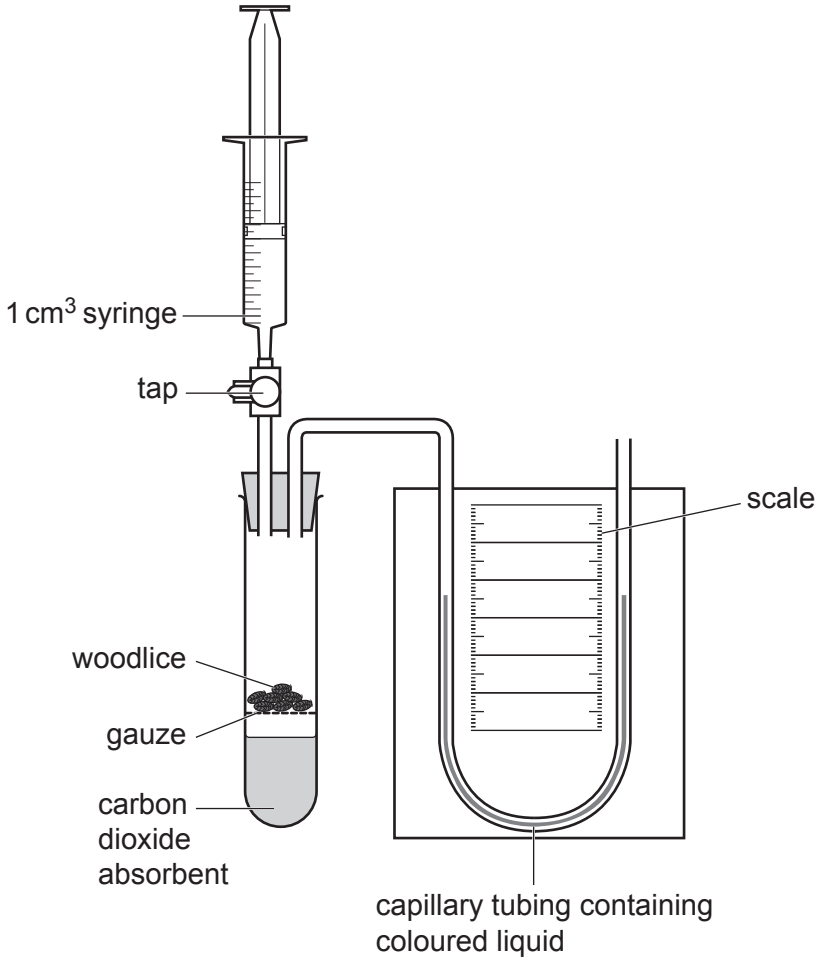


Fig. 1.2

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(i) State the independent variable and the dependent variable in this investigation.

independent variable .....

.....

dependent variable .....

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[2]

(ii) The students decided to measure oxygen uptake for 5 minutes using a range of temperatures from 5 °C to 35 °C.

Suggest why the students chose this range of temperatures **and** suggest a suitable interval that the students should use.

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(iii) State a suitable control for this investigation.

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..... [1]

(iv) State why the carbon dioxide absorbent solution was placed in the tube.

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..... [1]

(v) Suggest **one** variable in this investigation that **cannot** be standardised.

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..... [1]

(b) (i) Describe a method by which the students could set up the respirometer **and** use it to test their hypothesis:

For each 10°C increase in temperature the volume of oxygen absorbed will double.

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

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(ii) Each 1 cm length of the capillary tubing containing coloured liquid in Fig. 1.2 has a volume of 10 mm^3.

Describe how the students could use their results to calculate the rate of respiration for each temperature from their results.

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..... [3]

(iii) Use the axes in Fig. 1.3 to show the expected shape of the curve if the hypothesis is correct.

For each 10°C increase in temperature the volume of oxygen absorbed will double.

Include the labels and units for each axis.



Fig. 1.3

[3]

(c) The students used the same apparatus to determine the output of carbon dioxide by the woodlice at 35 °C. The students used this result and the result for oxygen uptake at 35 °C to calculate the respiratory quotient (RQ).

The RQ was calculated as 0.95.

State what conclusion can be made from this RQ value.

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..... [1]

[Total: 21]

2 **(a)** Cotton bollworms, *Helicoverpa* spp., are insect pests of cotton.

Adult cotton bollworms are moths. The adult female moths lay eggs on cotton plants. The eggs hatch into larvae. The larvae feed on cotton plants, causing extensive damage and reduction in yield.

Fig. 2.1 shows a mature cotton fruit (cotton boll) from an uninfested plant.

Fig. 2.2 shows a cotton bollworm larva inside a damaged cotton boll.



Fig. 2.1

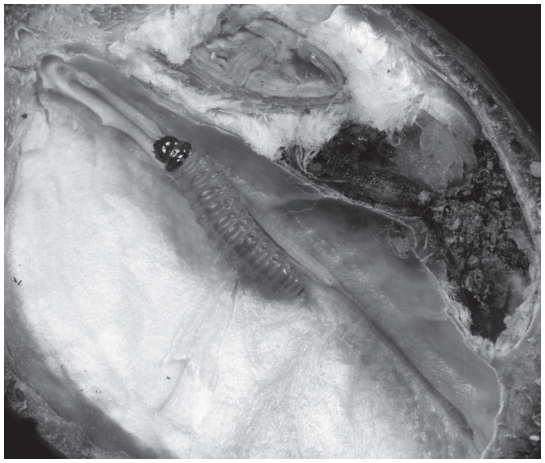


Fig. 2.2

A gene, *cry1Ac*, from the bacterium *Bacillus thuringiensis* (Bt), can be inserted into the cotton genome to produce Bt cotton.

- The protein, Cry1Ac, coded by *cry1Ac* is toxic to some species of bollworm.
- This toxicity gives cotton plants some resistance to cotton bollworm.

Studies of the effectiveness of the protein Cry1Ac showed that older plants produced less of the protein. As a result, spraying with insecticide was still needed when larval density increased.

An improved Bt cotton with two genes, *cry1Ac* and *cry2Ab*, produced two different proteins and was expected to give protection from *Helicoverpa* spp. for the whole growing season.

This improved Bt cotton was introduced into Australia in 2004. An investigation was carried out to determine whether this improved Bt cotton would also need spraying with insecticide.

Two different farms were used. In each farm, a standard-sized plot at the centre of a cotton field was marked out.

- Each plot measured 20 m^2.
- Each plot was divided into 3 sets of 8 rows of cotton.
- Each row of cotton was divided into 1 metre sections, each with 8–10 plants.

Two treatments were used in each plot in a random pattern.

- In treatment 1, the researchers removed all the larvae from the plants.
- In treatment 2, the researchers made sure that there were 3 medium-sized larvae (9–16 mm in length) per metre section.

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Fig. 2.3 shows the arrangement of a 20 m^2 plot in a cotton field.

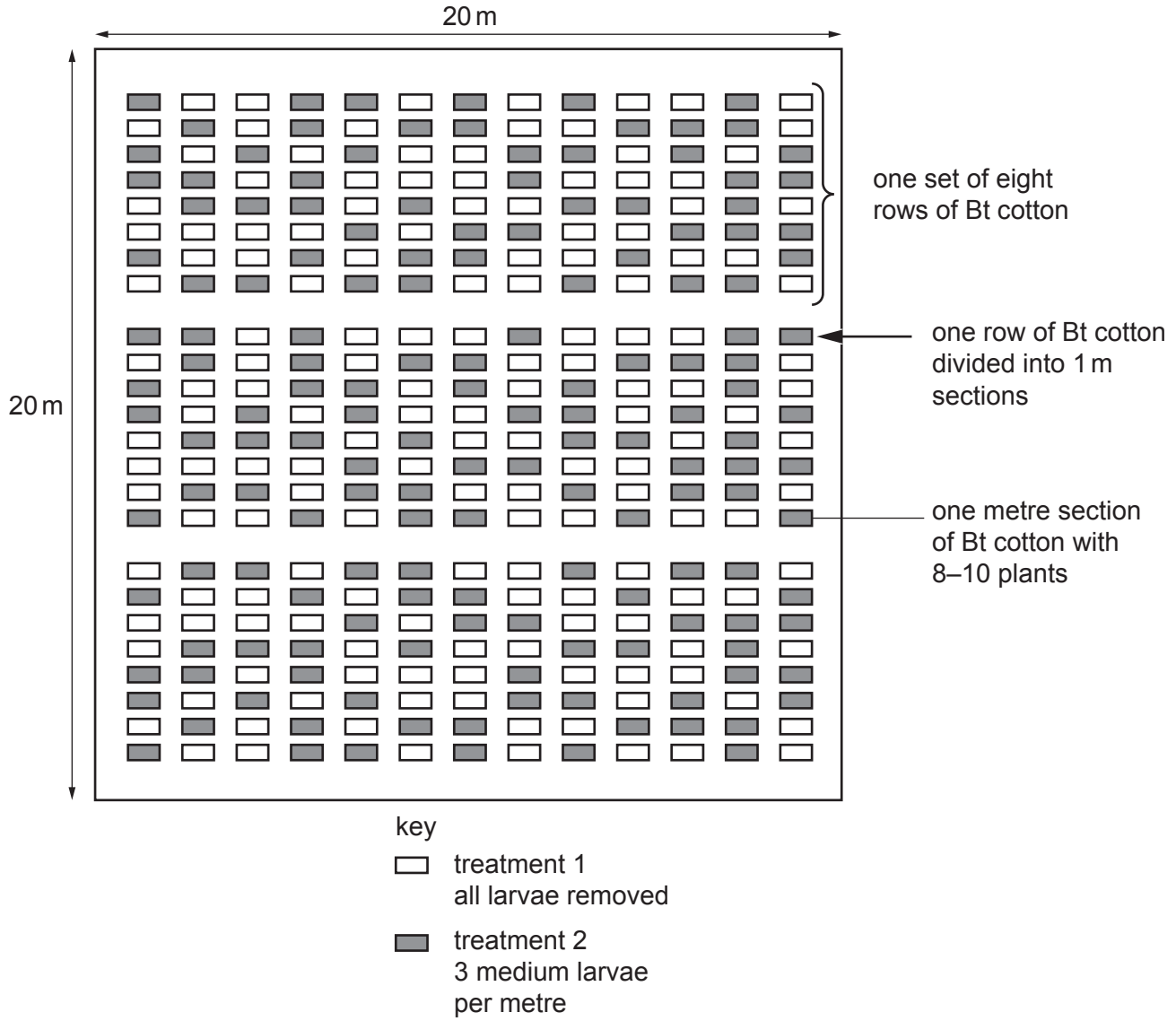


Fig. 2.3

- After three days, the plot on one farm was sprayed with an insecticide and the plot on the other farm was not sprayed with an insecticide.
- The cotton bolls were picked at the same time, when all the bolls in each plot were open.
- The cotton bolls were weighed.
- The cotton fibres were separated from the cotton bolls and weighed.

(i) Suggest how the researchers made sure that there were 3 medium-sized larvae in each section for treatment 2.

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..... [2]

(ii) Identify **two** variables that have been standardised in this investigation.

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[2]

(iii) Explain why one of the plots was **not** sprayed with insecticide.

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..... [1]

(b) Table 2.1 shows the results of this study.

Table 2.1

plot	**not sprayed with insecticide**		**sprayed with insecticide**	
treatment	1 (larvae removed)	2 (3 larvae present)	1 (larvae removed)	2 (3 larvae present)
mean mass of cotton bolls per section / g ± *s*	521.2 ± 77.6	418.6 ± 74.2	615.5 ± 92.5	605.6 ± 118.1
mean mass of cotton fibre per section / g ± *s*	223.8 ± 30.9	203.7 ± 23.5	251.3 ± 38.6	240.0 ± 56.0

A *t*-test can be used to find out if treatment 2 has any effect on the yield of cotton fibre.

(i) State **one** reason why the *t*-test is suitable for the data in Table 2.1.

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..... [1]

(ii) State a null hypothesis for the *t*-test to compare the effect of insecticide on yield of cotton fibre when larvae are present.

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(c) The researchers were trying to find out if farmers growing improved Bt cotton will benefit from spraying the improved Bt cotton with insecticide to control cotton bollworm infestations.

Comment on whether the results in Table 2.1 show that improved Bt cotton should be sprayed with insecticide.

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[Total: 9]

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CANDIDATE NAME

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BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **May/June 2020**

1 hour 15 minutes

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No additional materials are needed.

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[Turn over

1 **(a)** Some students decided to find the respiratory quotient (RQ) of germinating pea seeds.

Pea seeds germinate best at temperatures between 13 °C to 18 °C.

Table 1.1 shows the main biological molecules in pea seeds that could be used to release energy for seed germination.

Table 1.1

biological molecule	g per 100 g of dry mass
carbohydrate	68
protein	25
fat	1

(i) Predict the RQ value for these seeds in aerobic conditions.

..... [1]

The students used the respirometer shown in Fig. 1.1.

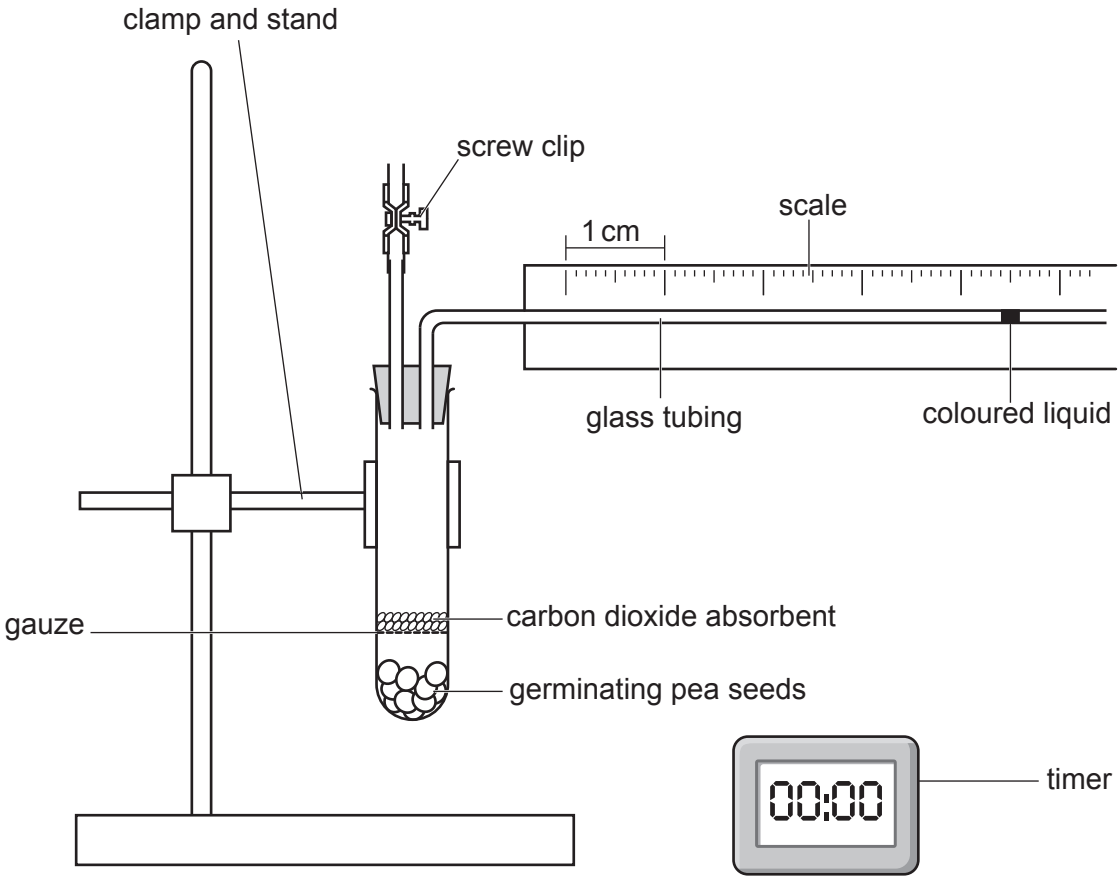


Fig. 1.1

(ii) Describe how the students could set up the respirometer **and** use it to make the measurements needed to calculate the RQ of germinating pea seeds.

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

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(b) Describe how the students should process their results to find the volumes of gases needed to calculate the RQ of germinating pea seeds.

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(c) **(i)** The students predicted that peas could also respire in anaerobic conditions, producing alcohol and carbon dioxide.

Outline how the students could use the respirometer in Fig. 1.1 in anaerobic conditions to find out if their prediction was correct.

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(ii) Table 1.2 shows the distance moved by the coloured liquid in anaerobic conditions in five different trials.

Table 1.2

trial	1	2	3	4	5
distance moved / mm	25	38	21	27	23

The students calculated a mean from the results in Table 1.2. They did not include one of the results in their calculation.

Identify the result that the students did not use **and** explain why they did not use it.

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..... [1]

[Total: 15]

2 The cotton bollworms, *Helicoverpa armigera* (old world bollworm) and *Pectinophora gossypiella* (pink bollworm), are insect pests of cotton.

Adult cotton bollworms are moths. The adult female moths lay eggs on cotton plants. The eggs hatch into larvae. The larvae feed on cotton plants, causing extensive damage and reduction in yield.

Fig. 2.1 shows a mature cotton fruit (cotton boll) from an uninfested plant.

Fig. 2.2 shows a cotton bollworm inside a developing cotton boll.



Fig. 2.1

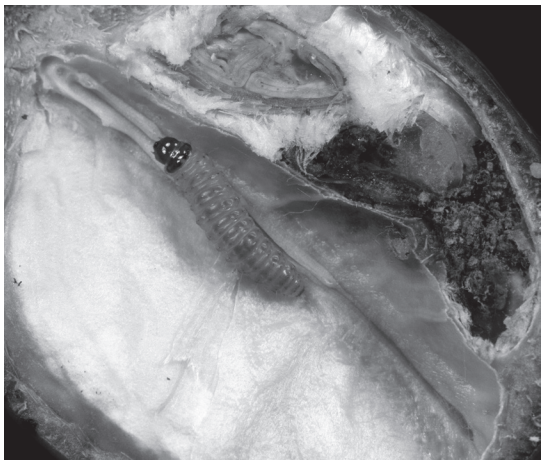


Fig. 2.2

A gene, *cry1Ac*, from the bacterium *Bacillus thuringiensis* (Bt), can be inserted into the cotton genome to produce 1 *cry* gene Bt cotton.

- 1 *cry* gene Bt cotton produces the protein Cry1Ac, which is toxic to some species of bollworm.
- This toxicity gives cotton plants some resistance to cotton bollworm.

An additional gene, *cry2Ab*, can be inserted into the cotton genome with *cry1Ac*. This produces 2 *cry* gene Bt cotton.

- 2 *cry* gene Bt cotton produces two different proteins, both toxic to cotton bollworm.

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(a) Bt cotton was first introduced into India in 2002.

Table 2.1 shows the types of Bt cotton grown from 2005 to 2009. The table also shows pesticide use over the same period of time.

Table 2.1

year	total cotton planted / millions of hectares	Bt cotton planted / millions of hectares		percentage of Bt cotton in total cotton crop	pesticide use on bollworm / tonnes
		1 *cry* gene Bt cotton	2 *cry* gene Bt cotton		
2005	8.9	1.30	0.00	14.6	6454
2006	9.1	3.65	0.15	41.8	2923
2007	9.2	5.74	0.46	64.5	1201
2008	9.2	5.56	2.04	82.6	653
2009	9.6	3.58	4.82	87.5	500

(i) A trend is a change over time.

Describe **three** trends shown by the data in Table 2.1.

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(ii) Suggest an explanation for the relationship between growth of Bt cotton and pesticide use on bollworm.

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(b) Since 2009, the number of hectares used to grow cotton has risen to 12.5 million. More than 90% of this cotton is Bt cotton.

Resistance to the protein Cry1Ac has been observed in some species of bollworm since 2005. In India resistance of the bollworm to both Cry1Ac and Cry2Ab has been observed since 2015.

(i) Predict **and** explain the effect of resistance on cotton yield, if the planting of Bt cotton continues to increase.

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(ii) Experimental observations have shown that planting rows of non-Bt cotton between rows of Bt cotton slows the spread of resistance.

Suggest why this pattern of planting can slow the spread of resistance.

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..... [2]

(c) Research has been carried out to develop a new type of insect-resistant cotton.
This uses a different type of toxic protein, Vip3, which has been isolated from *B. thuringiensis*.

The gene, *vip3AcAa*, which codes the toxic protein Vip3AcAa, has been inserted into the cotton genome.

The effectiveness of the new type of insect-resistant cotton has been tested on two different types, **A** and **B**, of the bollworm *H. armigera*. Both types are resistant to Cry1Ac.

1. 20 leaves were cut from each of three types of cotton plants:
   non-Bt, Bt *cry1Ac* and Bt *cry1Ac* + *vip3AcAa*.
2. Each of the 60 leaves was placed in a separate glass tube with a lid.
3. Larvae of type **A** were placed on each leaf.
4. Steps 1–3 were repeated using type **B** larvae.
5. All the tubes were kept in a temperature-controlled room.
6. The effectiveness of Vip3AcAa was assessed by calculating the percentage of dead bollworm larvae on each type of leaf.

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

independent variable .....

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dependent variable .....

.....
[2]

(ii) Suggest **one** variable that should be standardised in this investigation.

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..... [1]

(iii) Non-Bt cotton plants and Bt *cry1Ac* cotton plants were included as controls in this investigation.

Explain why it is necessary to include these plants in this investigation.

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..... [2]

Question 2 continues on page 10

Table 2.2 shows the results of this investigation.

Table 2.2

type of cotton	mean percentage of dead bollworm larvae ± *s*	
	resistant type **A**	resistant type **B**
non-Bt	40.00 ± 6.07	29.00 ± 4.43
Bt *cry1Ac*	41.00 ± 7.21	38.00 ± 3.82
Bt *cry1Ac* + *vip3AcAa*	69.00 ± 3.42	67.00 ± 3.79

s = standard deviation

(iv) The researchers concluded that:

1. The presence of the toxin Vip3AcAa may cause a statistically significant increase in the number of deaths of Bt-resistant larvae.

2. The toxin Vip3AcAa may be equally effective in controlling both types of Bt-resistant larvae.

Explain how the data in Table 2.2 support these conclusions.

conclusion 1 .....

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conclusion 2 .....

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[2]

(d) Research has shown that the toxin Vip3AcAa is also effective against Bt-resistant types of *P. gossypiella* (pink bollworm).

Suggest a further investigation that could be carried out to find out if Bt *cry1Ac* + *vip3AcAa* cotton is more effective than Bt *cry1Ac* cotton in controlling pink bollworm.

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..... [1]

[Total: 15]

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