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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

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BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **October/November 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.

DC (PB/CB) 336400/3

1 In the light-dependent stage of photosynthesis, electrons and hydrogen ions are accepted by the coenzyme NADP, which becomes reduced.

DCPIP is a dye that can act as an electron and hydrogen ion acceptor. The dye is blue when oxidised and colourless when reduced. In laboratory experiments, DCPIP can be used to follow the progress of the light-dependent stage because it can replace NADP as the acceptor molecule for electrons and hydrogen ions, as shown in Fig. 1.1.

oxidised DCPIP + electrons + hydrogen ions ⟶ reduced DCPIP
(blue) (colourless)

Fig. 1.1

The effects of various factors on the light-dependent stage of photosynthesis can be investigated by using suspensions of isolated chloroplasts (chloroplast suspensions) and DCPIP.

A student used DCPIP to investigate the effect of temperature on the rate of the light-dependent stage of photosynthesis in spinach, *Spinacia oleracea*.

The student prepared a leaf extract to make a stock chloroplast suspension and then carried out a preliminary experiment to determine a suitable concentration of chloroplast suspension to use in the investigation.

To carry out the preliminary experiment, the student followed a set of instructions, steps 1 to 11.

1 Cut spinach leaves into small pieces and place these pieces in a blender containing ice-cold 10% sucrose solution buffered at pH 7.0.

2 Turn on the blender for 15 seconds and then filter the extract to remove all the small pieces of leaf.

3 Place the leaf extract in a centrifuge and spin at low speed.

4 Pour off the supernatant that contains the chloroplasts. Keep this **stock chloroplast suspension** ice cold and in the dark.

5 Prepare 5 different concentrations of the chloroplast suspension using 10% sucrose solution. The percentage concentrations are 10%, 20%, 30%, 40% and 50% of the stock chloroplast suspension.

6 Wrap 5 flat-bottomed tubes in black plastic film to prevent light entering.

7 Put 10 cm^3 of each concentration of stock chloroplast suspension into a flat-bottomed tube, and add 1 cm^3 of DCPIP solution to each tube. The chloroplast suspension is now blue-green in colour.

8 Place 1 of the tubes beneath a light source as shown in Fig. 1.2.

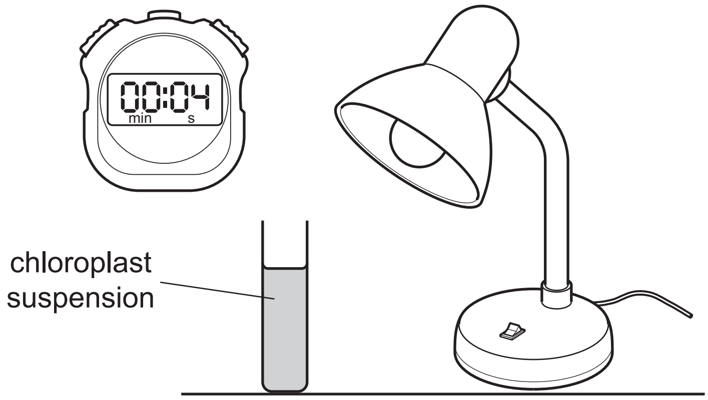

Fig. 1.2

9 Start a timer. Remove the black plastic film from the tube. Record the time taken for the DCPIP to decolourise so that the chloroplast suspension is green.

10 Calculate the rate of the light-dependent stage of photosynthesis by using the formula:

$$\text{rate} = \frac{1000}{t}$$

t = time taken in seconds for the chloroplast suspension to reach a green colour when all the DCPIP is decolourised.

11 Repeat step 8 to step 10 for the other tubes.

(a) Suggest **two** suitable control experiments that the student should carry out as part of the preliminary experiment.

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[2]

(b) The results of the preliminary experiment are shown in Table 1.1.

Table 1.1

percentage concentration of chloroplast suspension	time taken for DCPIP to decolourise / s	rate of light-dependent stage of photosynthesis / s^{-1}
10	351	....
20	59	....
30	21	....
40	10	....
50	5	....

(i) Complete Table 1.1 by calculating the rate of the light-dependent stage of photosynthesis for each concentration of chloroplast suspension.

Give your answers to **one** decimal place.

[2]

(ii) Plot a line graph of the data in Table 1.1 on the grid in Fig. 1.3 to show the effect of changing the concentration of the chloroplast suspension on the rate of the light-dependent stage of photosynthesis.

Fig. 1.3

[3]

(c) The student initially trialled the experiment using ice-cold distilled water instead of ice-cold 10% sucrose to make the stock chloroplast suspension in step 1. The DCPIP did **not** decolourise.

Suggest why the procedure worked when 10% sucrose solution was used but did **not** work when distilled water was used in step 1.

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(d) The preliminary experiment was carried out at 17 °C.

To investigate the effect of temperature on the rate of the light-dependent stage of photosynthesis, the student added some details to the instructions in steps 7, 8 and 9 to make sure that accurate results were recorded.

Describe an investigation that the student could follow to determine the effect of temperature on the rate of the light-dependent stage of photosynthesis.

- Use the results shown in Table 1.1 to decide on a suitable chloroplast suspension for the investigation.
- Include details of how you would take accurate results.
- Do **not** include a risk assessment.

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

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[Total: 15]

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2 The two-spot ladybird, *Adalia bipunctata*, is a species of small, flying beetle that is found in northern Europe and other parts of the world. The wings of these beetles are covered by two tough structures known as elytra, as shown in Fig. 2.1.

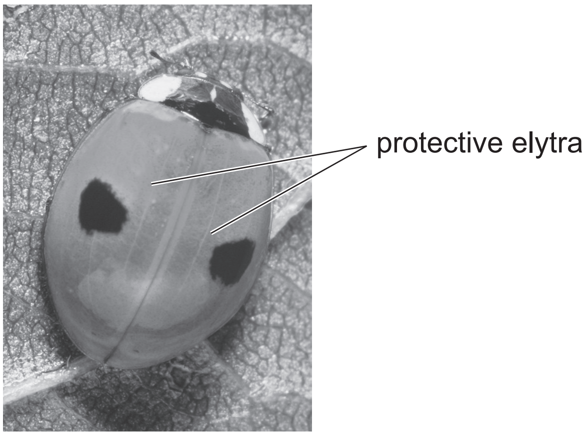

Fig. 2.1

A. bipunctata is an important predator of insect pests such as aphids. These insect pests feed on plants, including many crop species. Population numbers of *A. bipunctata* fluctuate in response to changes in the population numbers of their prey.

The elytra of *A. bipunctata* show phenotypic variation. The three most common morphs (forms) found in northern Europe are known as typica (**T**), quadrimaculata (**Q**) and sexpustulata (**S**).

- The typica morph, shown in Fig. 2.1, is mostly red with two black spots and is described as **non-melanic**.
- The other two morphs are described as **melanic** as they are mainly black with some red.
- The distribution of the colours in these three morphs is shown in Fig. 2.2.

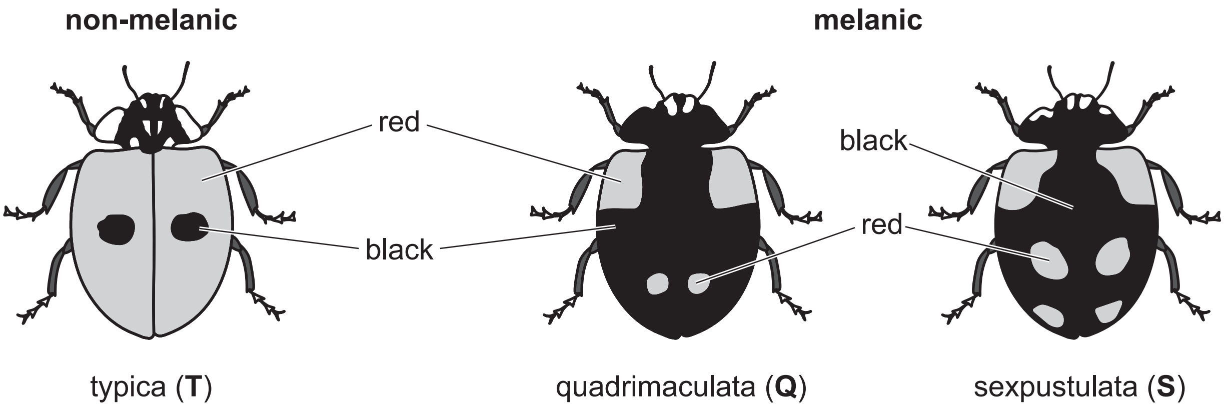

Fig. 2.2

In northern Europe, the populations of *A. bipunctata* hibernate (are inactive) during the winter. As the temperature increases in early spring, the populations become active. The populations remain active and produce three generations before the next winter begins.

(a) It was observed that in some areas in populations of *A. bipunctata*, the proportion of non-melanic to melanic phenotypes in the early spring was different to the proportion later in the year in the autumn.

Researchers carried out a study in one area of Germany to compare the proportion of non-melanic to melanic phenotypes in early spring with the proportion in autumn after three generations had been produced. The data were collected over a period of 12 years.

The results are shown in Fig. 2.3.

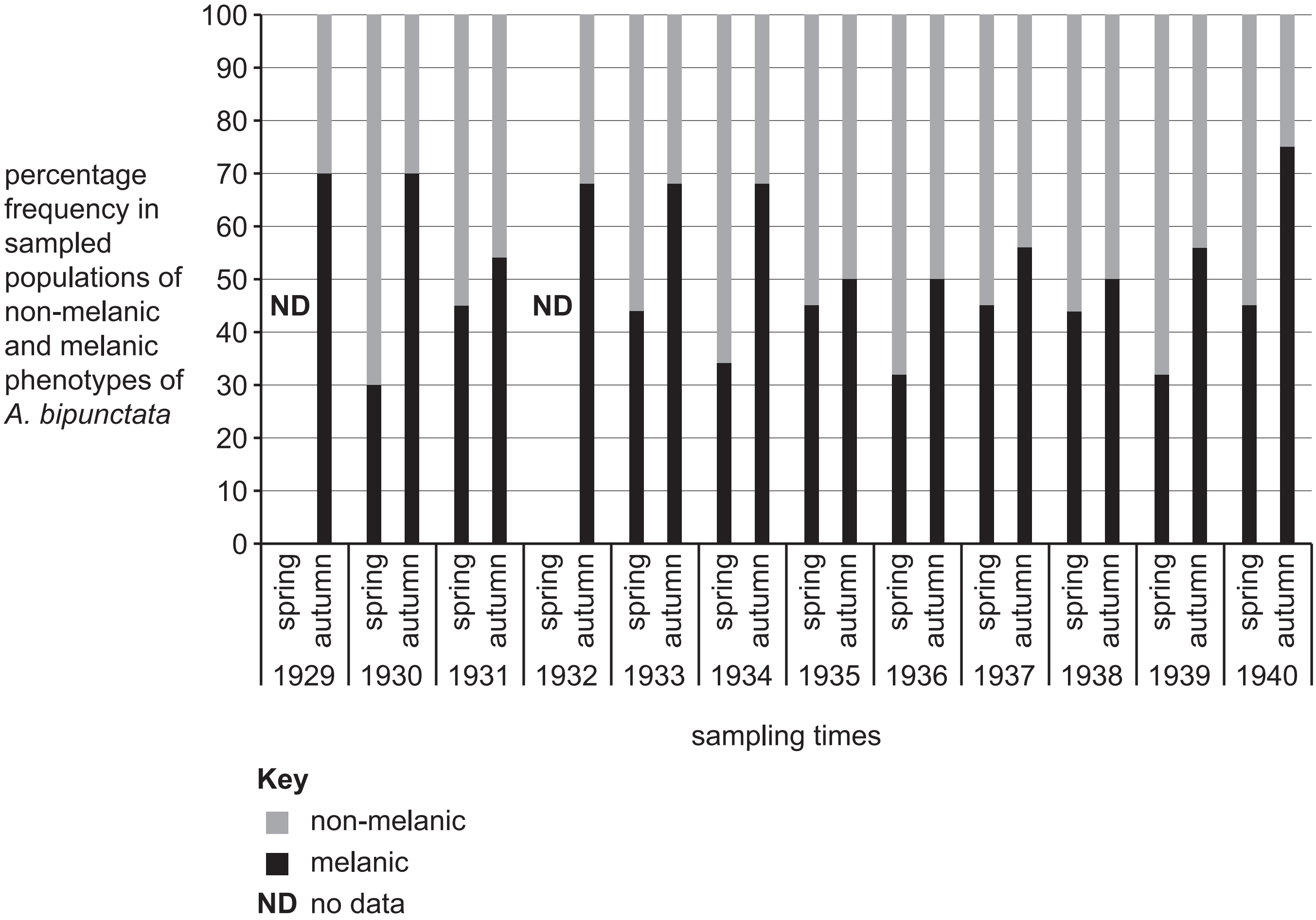

Fig. 2.3

(i) Outline a method that could be followed to collect the data shown in Fig. 2.3.

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(ii) The researchers concluded that there was a change in the proportion of the two phenotypes between spring and autumn, with the non-melanic phenotypes always showing a higher percentage frequency in the spring.

Suggest **two** pieces of extra information about the investigation that researchers should provide to improve confidence in their conclusion.

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(b) Environmental temperature is one of many different selection pressures that could be acting on populations of *A. bipunctata*. The melanic phenotypes, morphs **Q** and **S**, are considered to be better adapted to the climate in northern Europe as they absorb heat energy more readily than the non-melanic phenotype, morph **T**.

Scientists investigated the effect of temperature on the body temperature of the two different phenotypes.

- The four individuals used in the investigation were collected while they were hibernating (inactive) and were kept outdoors for six weeks before the investigation.
- The individuals were weighed and arranged into pairs, each with approximately the same mass.
- A temperature sensor was fixed to the lower (ventral) surface of each individual.
- The temperature of each individual was recorded for 9 minutes. During that time, a heat-emitting lamp positioned directly above the individuals was switched on at 30 s and switched off at 5 minutes.

The results are shown in Fig. 2.4.

(i) The researchers concluded that melanic morphs warm up more quickly than non-melanic morphs.

Explain how the information shown in Fig. 2.4 supports this conclusion.

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(ii) State **two** further conclusions that can be made from the results shown in Fig. 2.4.

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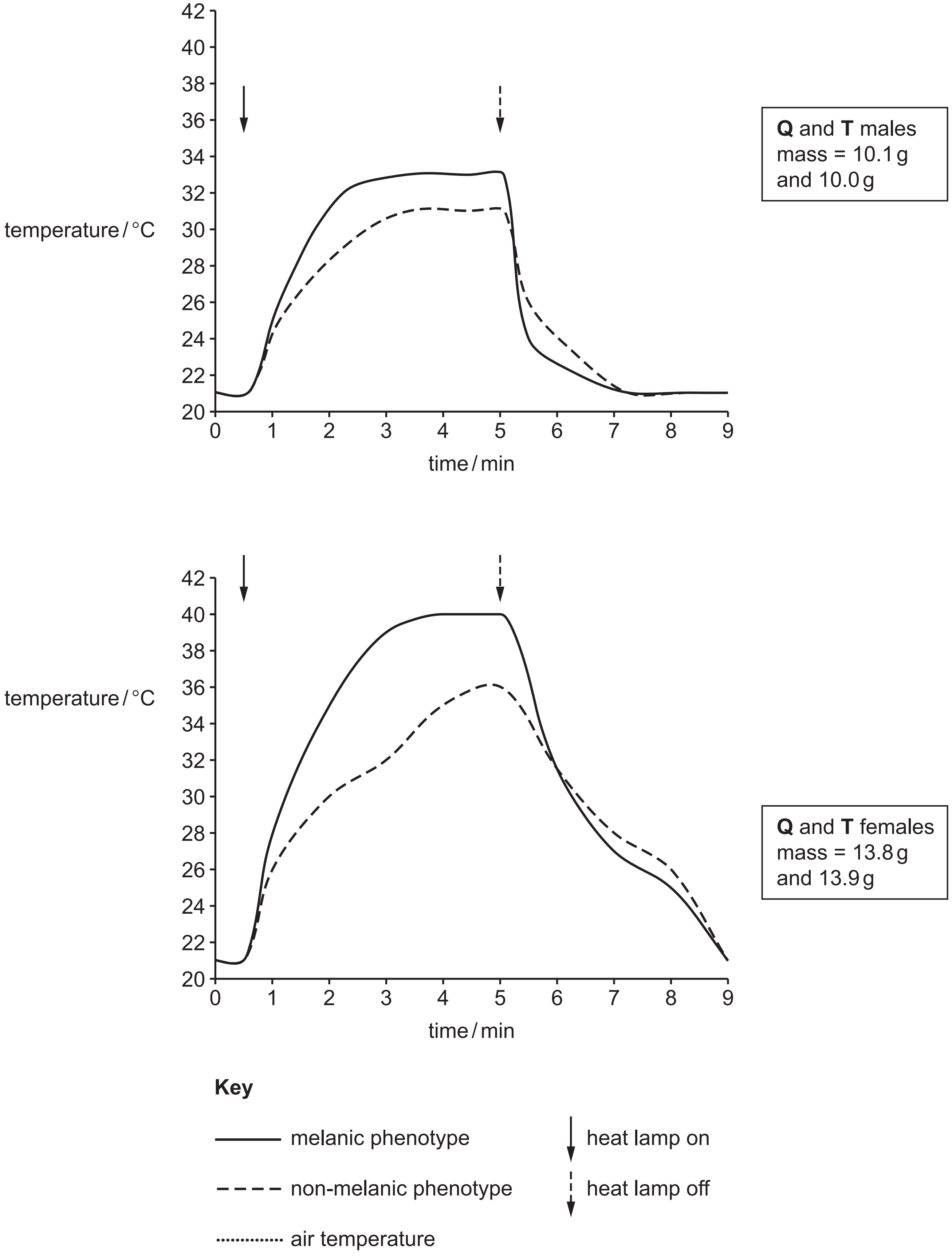
42
40
38
36
34
32
30
28
26
24
22
20
temperature / °C
0
1
2
3
4
5
6
7
8
9
time / min
Q and **T** males
mass = 10.1 g
and 10.0 g
Q and **T** females
mass = 13.8 g
and 13.9 g
Key
melanic phenotype
non-melanic phenotype
air temperature
heat lamp on
heat lamp off

Fig. 2.4

(c) The scientists noticed that there appeared to be a relationship between body mass and the increase in body temperature. The scientists therefore continued to take results from another 17 individuals. They recorded the maximum difference between body temperature and the air temperature for each individual in their investigation.

All the results of the investigation are shown in Table 2.1 and Fig. 2.5.

Table 2.1

phenotype	morph	sex	mass / g	maximum temperature difference / °C
non-melanic	**T**	female	6.5	0.0
		male	8.4	1.1
		male	9.2	2.7
		male	10.0	2.9
		male	10.8	4.0
		female	11.5	5.4
		female	12.0	5.9
		female	13.1	5.3
		female	13.9	7.3
melanic	**Q**	male	8.4	3.5
		female	8.6	3.7
		male	10.1	5.3
		female	10.4	4.8
		female	11.0	8.5
		male	11.7	7.5
		female	13.1	7.3
		female	13.8	10.2
	S	male	8.6	4.1
		male	9.1	3.7
		male	10.8	5.9
		female	13.6	10.0

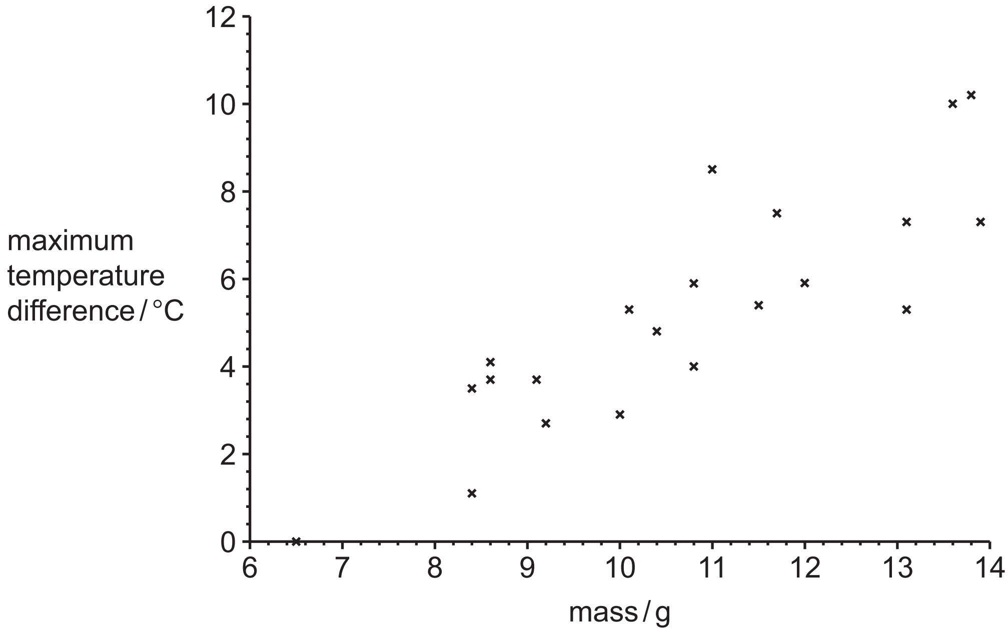

Fig. 2.5

State a statistical test that could be used to analyse the relationship shown in Table 2.1 and Fig. 2.5. Justify your choice.

statistical test ....

justification ....

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(d) The researchers assumed that the appearance of the elytra was controlled by a single gene with two alleles. Breeding experiments showed that the melanic phenotype is dominant to the non-melanic phenotype.

Researchers made the hypothesis:

Some melanics are homozygous dominant, and some melanics are heterozygous.

Outline a breeding experiment that could be carried out to test this hypothesis, and state the results you would expect if the hypothesis is supported.

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[Total: 15]