Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

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9001420673

BIOLOGY **9700/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

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Answer **all** questions.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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1 (a) *Chlorella* is a photosynthetic, single-celled protoctist that lives in ponds.

A group of students decided to investigate the effect of temperature on respiration in *Chlorella*.

The students were provided with:

- test-tubes
- metal foil
- flat-bottomed tubes with lids
- glass beakers
- hot water supply
- thermometers
- timer
- pH probe and meter
- hydrogencarbonate indicator solution in a closed container
- a pump connected to an oxygen supply
- a pump connected to a carbon dioxide supply
- a suspension of *Chlorella* with a known cell density.

Carbon dioxide is an acidic gas so it causes the pH of the hydrogencarbonate indicator solution to change. The indicator solution changes colour as pH changes.

Fig. 1.1 shows the range of colours seen in hydrogencarbonate indicator exposed to different carbon dioxide concentrations.

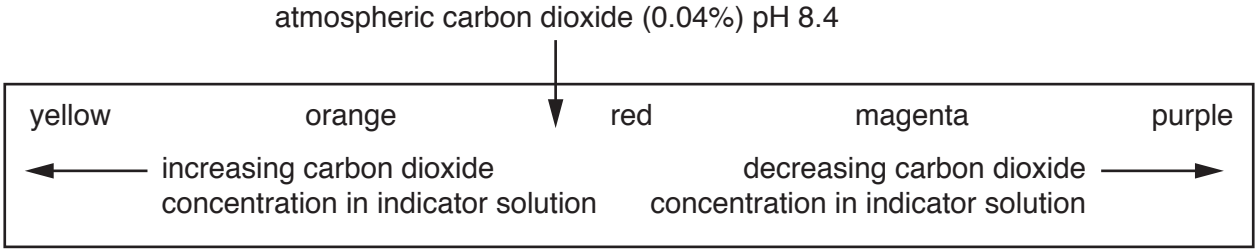


Fig. 1.1

The students made a series of colour standards from yellow to purple by bubbling different volumes of carbon dioxide gas into the indicator solution. The pH was measured with a pH meter for each colour and the solutions were sealed in flat-bottomed tubes labelled with their pH.

The students used the indicator solution to investigate the effect of temperature on carbon dioxide production during respiration in *Chlorella*.

(i) Suggest a hypothesis that the students could test in this investigation.

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..... [1]

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

independent variable .....

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dependent variable .....

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[2]

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(iii) Describe how the students could use the apparatus provided to investigate the effect of temperature on carbon dioxide production during respiration in *Chlorella*.

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

Details of making the colour standards should **not** be included in your method.

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(b) (i) State how the students could calculate the rate of respiration from their results.

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(ii) Sketch a graph on Fig. 1.2 to show the expected result of the effect of temperature on the rate of respiration of *Chlorella*.

Include suitable axes labels and units on your graph.



Fig. 1.2

[3]

(c) The students carried out a second investigation to determine the effect of cell density on the carbon dioxide production of suspensions of *Chlorella*. All the suspensions were kept at a constant temperature. The students used a probe to measure the production of carbon dioxide in the suspensions of *Chlorella*.

The results are shown in Table 1.1.

Table 1.1

cell density in suspension / arbitrary units	carbon dioxide concentration after 15 min / mg dm^{-3}	rate of carbon dioxide production / mg min^{-1}
10	2.0	0.13
20	2.4	0.16
30	3.0	0.20
40	4.7	
50	7.4	0.49

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(i) Complete Table 1.1 by calculating the rate of carbon dioxide production for the cell density of 40 arbitrary units. [1]

The students used Pearson's linear correlation to test the hypothesis:

As cell density increases the rate of carbon dioxide production increases.

(ii) Suggest a null hypothesis for this test.

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..... [1]

(iii) The Pearson's linear correlation coefficient (r) was calculated as 0.85.

State what the calculated value, $r = 0.85$, indicates about the results.

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..... [2]

(iv) The students concluded that the results showed that their hypothesis is correct.

Explain why this conclusion may not be valid.

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..... [2]

[Total: 20]

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[Turn over

2 A fungal pathogen infects melon plants and causes the leaf cells to lose turgor. The melon plant then becomes permanently wilted.

(a) Suggest a tissue in which the fungal pathogen may be found **and** suggest a reason for your answer.

tissue .....

reason .....

.....

[1]

(b) Breeding experiments between a pure-breeding resistant variety of melon plant, Hemed, and a pure-breeding non-resistant variety, Dulce, were carried out to find out how resistance to the fungal pathogen is inherited.

All the F1 and F2 plants were inoculated with the fungal pathogen.

The numbers of resistant and non-resistant plants were counted 18 days after inoculation with the fungal pathogen.

Fig. 2.1 shows the results of this large-scale breeding programme, involving several thousand melon plants.

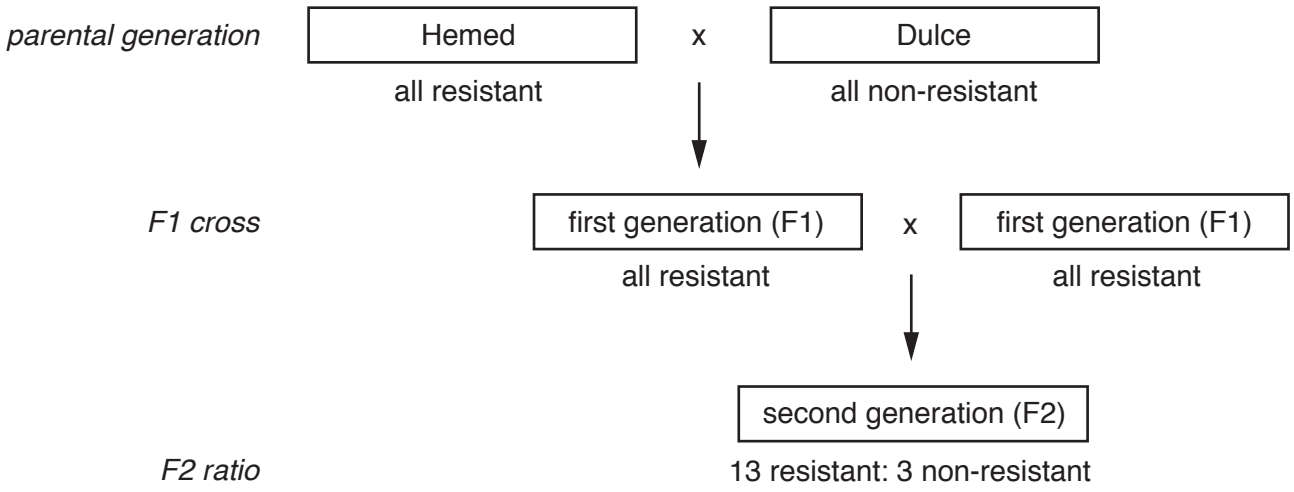


Fig. 2.1

The results in the F2 generation gave a ratio of 13 resistant: 3 non-resistant.

The results in the F2 generation were considered to be anomalous.

Explain why the results for the F2 generation were considered to be anomalous **and** suggest a reason for this ratio.

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..... [2]

(c) Melon plants can be resistant to another fungal pathogen, which has four strains.

Microarrays can be used to study gene expression by detecting mRNA in plant samples.

(i) Outline how microarrays are used to detect mRNA in studies of gene expression in resistant and non-resistant plants.

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..... [3]

Question 2 continues on page 8

Table 2.1 shows the results of a microarray analysis made after the fungal pathogen had infected a resistant variety of melon and a non-resistant variety of melon.

Table 2.1

time after infection with fungal pathogen / hours	number of genes expressed	
	resistant variety	non-resistant variety
24	2461	882
48	821	2237

(ii) Calculate the ratio of the number of genes expressed at 24 hours for the resistant variety of melon and the non-resistant variety of melon.

Give your answer in whole numbers.

ratio ..... [1]

(iii) Calculate the percentage change of the genes expressed between 24 hours and 48 hours in the resistant variety.

percentage change = ... % [1]

(iv) State what the results in Table 2.1 indicate about resistance to the fungal pathogen.

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[Total: 10]

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CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0327972921

BIOLOGY **9700/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2019**

1 hour 15 minutes

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[Turn over

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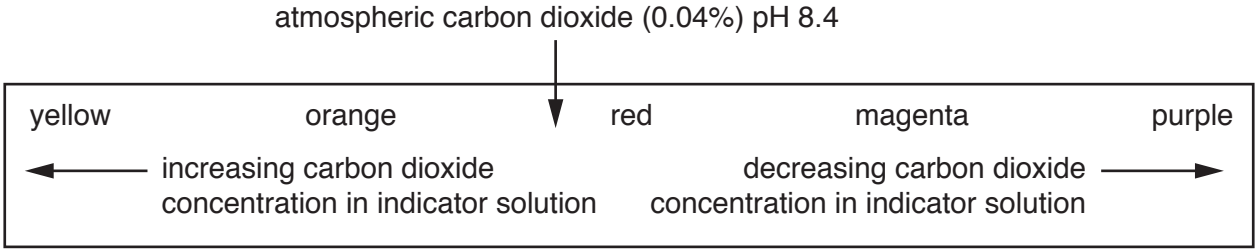


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Fig. 1.2

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2 A fungal pathogen infects melon plants and causes the leaf cells to lose turgor. The melon plant then becomes permanently wilted.

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reason .....

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Fig. 2.1 shows the results of this large-scale breeding programme, involving several thousand melon plants.

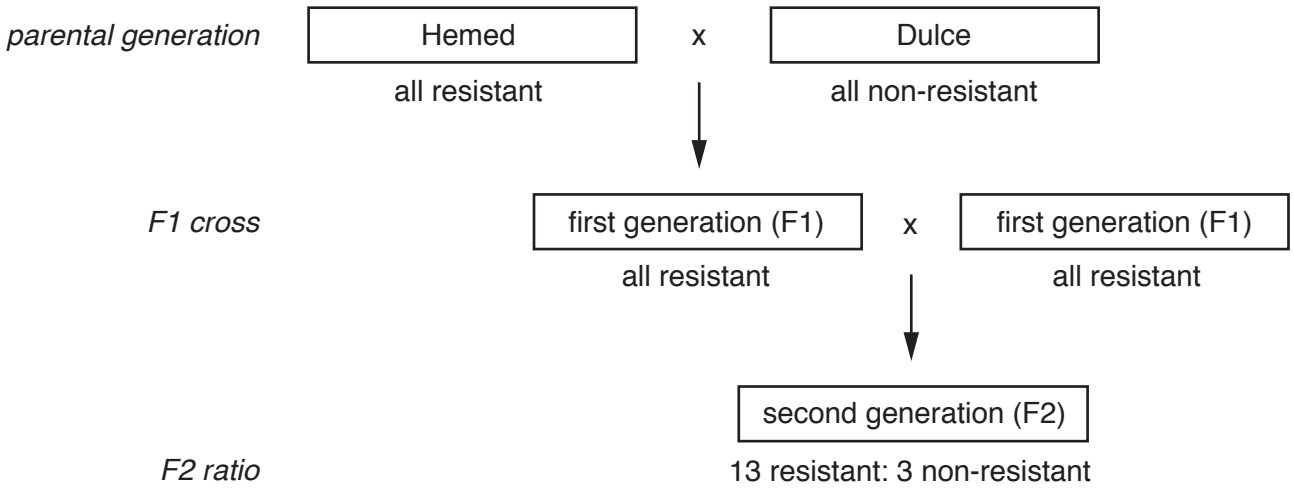


Fig. 2.1

The results in the F2 generation gave a ratio of 13 resistant: 3 non-resistant.

The results in the F2 generation were considered to be anomalous.

Explain why the results for the F2 generation were considered to be anomalous **and** suggest a reason for this ratio.

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(iii) Calculate the percentage change of the genes expressed between 24 hours and 48 hours in the resistant variety.

percentage change = ... % [1]

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[Total: 10]

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CANDIDATE NAME

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CANDIDATE NUMBER

0852382201

BIOLOGY **9700/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2019**

1 hour 15 minutes

Candidates answer on the Question Paper.

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1 A group of students investigated the growth of different varieties of yeast.

The students learned that the rate of respiration in a yeast culture is proportional to the biomass of the culture. Respiration rate can be used as a measure of the growth of a yeast culture.

Respiration rates can be measured using the redox indicator TTC.

- During respiration, hydrogen ions are removed from glucose to reduce hydrogen carriers such as NAD and FAD.
- A redox indicator can be used as a hydrogen carrier in experimental conditions instead of NAD or FAD.
- The colour change of the redox indicator can be measured using a colorimeter.

(a) The students carried out a preliminary experiment using a redox indicator to monitor the growth of a yeast culture over time.

The yeast was grown in a liquid culture in a conical flask, as shown in Fig. 1.1.

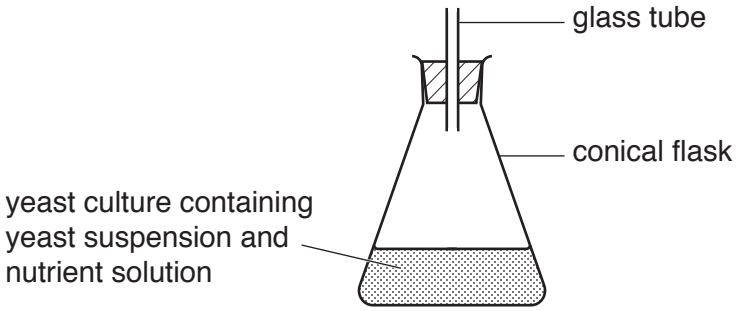


Fig. 1.1

- Different masses of yeast were added to a fixed volume of distilled water to give different concentrations of yeast in suspension.
- Each yeast suspension was added to a separate flask of nutrient solution containing glucose.
- A redox indicator was added to each flask and the flasks were incubated at a constant temperature for a fixed period of time.
- The colour of each suspension was monitored over the incubation period using a colorimeter.
- A colorimeter passes a beam of light through a coloured filter into a solution and measures the light absorbance of that solution.
- A standard solution is used to set the colorimeter scale to zero (0) before taking any measurements.

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

independent .....

dependent .....

[2]

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(ii) Identify **two** variables that the students have standardised in their investigation.

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(iii) Suggest a suitable control for this investigation.

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(iv) Samples were taken from the flask at intervals and the absorbance was measured in the colorimeter.

As the yeast respires, the redox indicator TTC changes from colourless to pink.

Sketch a graph on Fig. 1.2 to show the expected change in absorbance over time during the incubation of yeast. Label the axes.



[2]

Fig. 1.2

(b) Three different varieties of yeast, commonly used in food manufacture, are compressed yeast, active dry yeast and instant yeast.

The students decided to compare the growth rates of the three different varieties of yeast by measuring their respiration rate. They decided to use TTC as the redox indicator.

Describe a method that students could use to compare the respiration rates of the three varieties of yeast.

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

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Question 1 continues on page 6

(c) The students found that compressed yeast gave the highest rate of respiration.

The students then carried out two further experiments to find the best conditions for growth of compressed yeast.

In both experiments absorbance was measured in arbitrary units (a.u.). The higher the absorbance the greater the respiration rate. Respiration is proportional to the growth rate of the yeast.

In the first experiment they investigated the effect of changing pH and incubation time at a constant temperature of 30 °C.

The results of the first experiment are shown in Fig. 1.3.

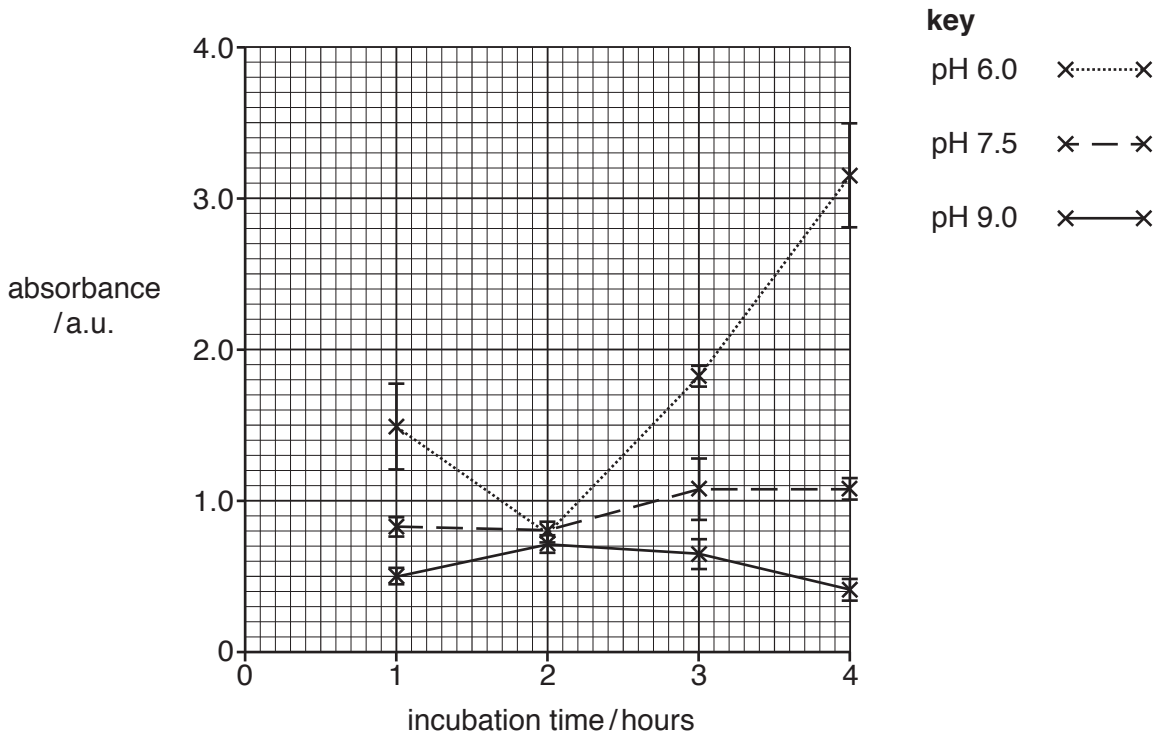


Fig. 1.3

In the second experiment the students investigated the effect of changing pH and temperature at a constant incubation time of 4 hours.

The results of the second experiment are shown in Table 1.1.

Table 1.1

temperature /°C	pH 6.0		pH 7.5		pH 9.0	
	absorbance /a.u.	S_M	absorbance /a.u.	S_M	absorbance /a.u.	S_M
22	2.28	+/– 0.60	1.10	+/– 0.28	1.40	+/– 0.72
30	3.16	+/– 0.28	0.50	+/– 0.04	0.94	+/– 0.02
40	1.10	+/– 0.52	0.40	+/– 0.04	0.54	+/– 0.04
50	0.48	+/– 0.08	0.40	+/– 0.04	0.28	+/– 0.02

(i) State what the standard error (S_M) shows.

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(ii) The graph in Fig. 1.3 shows the 95% confidence intervals for the data.

95% confidence interval = +/– 2 × S_M

State what this indicates about the data.

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(iii) After completing these two experiments the students concluded that the growth rate of yeast is highest when incubated at 30 °C and pH 6.0 for 4 hours.

State **two** ways in which the data support this conclusion.

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[Total: 18]

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[Turn over

2 Populations of European ash trees, *Fraxinus excelsior*, are susceptible to a chronic tree disease called ash dieback. Since 2012, this disease has spread through Europe causing large-scale loss of woodland.

- Ash dieback is caused by a fungal pathogen.
- Symptoms include stem lesions, death of growing shoots and wilting of leaves.
- To limit the spread of the disease, 693 hectares of ash woodland were cleared in the UK between 2012 and 2015. Clearing the woodland involved uprooting the trees and burying them.

Table 2.1 shows the numbers of new cases of ash dieback in a variety of different environments in the UK between 2013 and 2015.

Table 2.1

environment	number of new cases of ash dieback		
	2013	2014	2015
woodland	18	36	56
plant nurseries	16	8	5
private gardens	2	5	0
farmland	13	10	2
roadside	3	5	16
total	**52**	**64**	**79**

(a) (i) Calculate the percentage change in the number of new cases of ash dieback in plant nurseries, between 2013 and 2015.

Show your working and give your answer to the nearest whole number.

.....% [2]

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(ii) Describe **and** explain the differences between the changes in the numbers of cases of ash dieback from 2013 to 2015 in the environments shown in Table 2.1.

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Question 2 continues on page 10

(b) It was noticed that, in all woodlands infected with ash dieback, there were some trees that were not affected. Investigations were carried out across Europe to identify the genes responsible for tolerance to ash dieback, using a range of techniques including microarrays.

Using the results of this research scientists hope to be able to replant forests with ash trees tolerant to ash dieback.

- Microarrays are used to detect the expression of thousands of genes at the same time.
- A slide is printed with thousands of spots in defined positions.
- Each spot contains single-stranded DNA of known sequence, which acts as a probe to detect gene expression.
- mRNA samples are collected from healthy ash trees and from ash trees showing symptoms of ash dieback.
- Each sample of mRNA is converted to complementary DNA (cDNA) and fluorescently labelled.
- Different colour fluorescent dyes are used for the samples taken from the healthy and diseased trees.
- The two samples are added to the slide and allowed to hybridise onto the DNA on the microarray slide.
- The microarray slide is then scanned to measure the expression of each gene.

Fig. 2.1 shows a typical microarray slide.

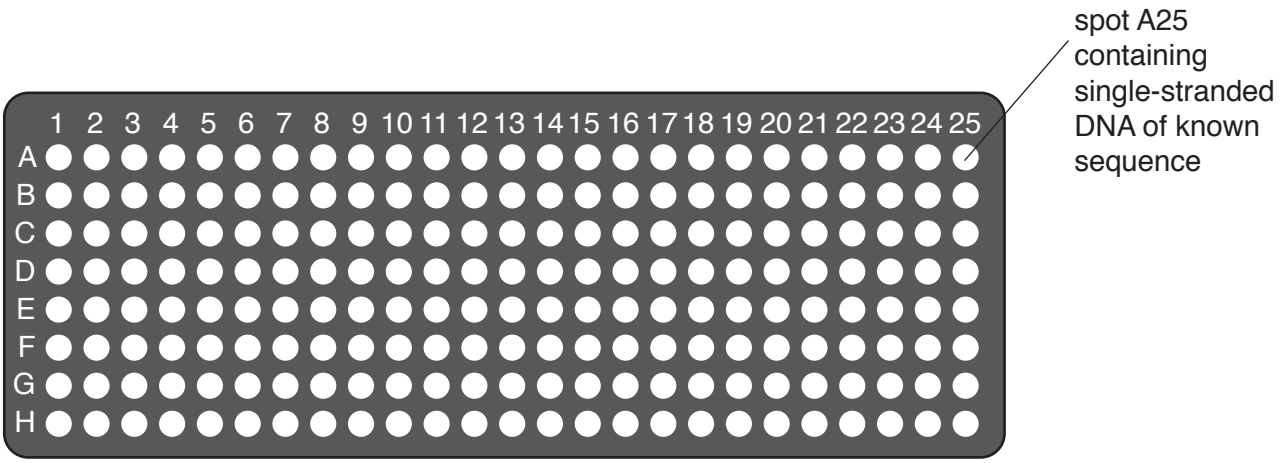


Fig. 2.1

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(i) Explain how the cDNA in samples from the ash trees hybridises onto the microarray slide.

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(ii) Suggest how the level of each gene expression is determined.

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Question 2 continues on page 12

(c) In a study, trees showing varying degrees of damage caused by ash dieback were assessed and samples were taken.
The trees used in the study were at four locations across Europe.

- Location 1 had 2200 ash trees. Some 10-year-old trees were identified and 44 were sampled.
- Location 2 had 600 ash trees. Some 14-year-old trees were identified and 20 were sampled.
- Location 3 had 379 ash trees and 19 trees of varying ages were sampled.
- Location 4 was the entire woodland in a small European country and 23 ash trees of varying ages were sampled.
- Healthy ash trees growing next to very heavily diseased trees in location 4 were identified and 96 of these trees were sampled.

(i) Explain why it was important that samples from healthy trees were taken from trees growing next to very heavily diseased trees.

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(ii) Describe how the study ensured that a diverse range of ash trees was selected for sampling.

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The scientists who carried out the study assessed the degree of damage caused by ash dieback in each ash tree using a six-point scale, as shown in Table 2.2.

Table 2.2

scale point	0	1	2	3	4	5
degree of damage to each tree	little	mild	moderate	high	severe	very severe

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(iii) Suggest why a numeric scale was used to record the degree of damage to the trees caused by ash dieback.

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The samples collected in the study were analysed by using microarrays. The scientists found that there was variation in one nucleotide location in the ash genome. This nucleotide variation was correlated to the tolerance of ash trees to ash dieback.

Table 2.3 shows a comparison of the base sequence of part of the genome of the European ash tree, *F. excelsior*, showing either low or high tolerance to ash dieback, together with the base sequences of the same part of the genome from other species of ash tree and their tolerance level.

Table 2.3

species of ash tree	tolerance to ash dieback	base sequence
F. excelsior	low	T T G A A A A C A
F. excelsior	high	T T G A A A G C A
F. mandshurica	high	T T G A A A G C A
F. americana	high	T T G A A A G C A
F. ornus	high	T T G A A A G C A

(d) (i) State which base is associated with tolerance to ash dieback.

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..... [1]

(ii) Suggest how a change in one nucleotide base could result in a change of tolerance to a pathogen.

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[Total: 12]

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