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Centre number

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Candidate number

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Candidate signature _____

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 3 Populations and genes

Monday 14 January 2019 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	



Answer **all** questions in the spaces provided.

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0 1 . 1 A species occupies a niche within a habitat.

Explain why it is an advantage for different species to occupy different niches.

[2 marks]

There is less (interspecific) competition for food, space and light, as each species uses different resources.

If two species occupied the same niche, one (or both) species would not survive (competitive exclusion).

0 1 . 2 Fish occupying different niches have differently-shaped mouths.

Suggest **one** reason why mouth shape is an adaptation to their niche.

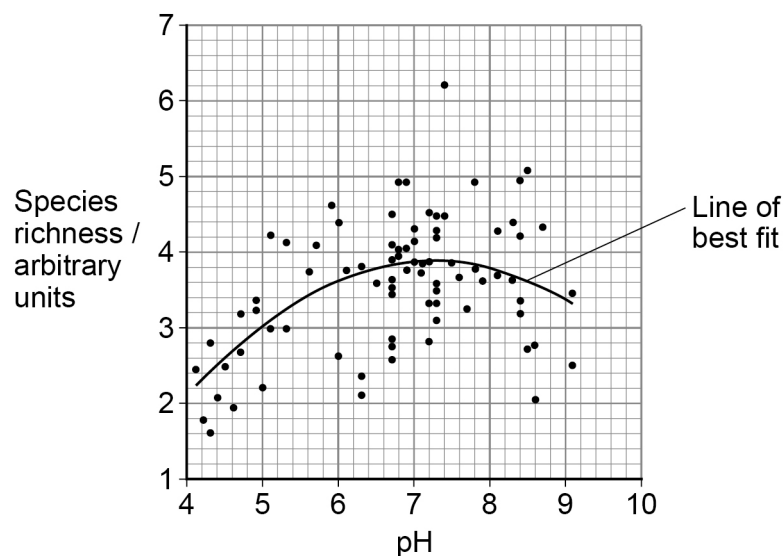
[1 mark]

Different mouth shapes allow different types of food to be eaten (different methods of feeding).

Species richness is the number of different species in a given area.

Figure 1 shows the effect of pH on species richness of fish in a large number of lakes in one area.

Figure 1



0 1 . 3

A student concludes that pH 7.3 gives the highest species richness.

Evaluate the student's conclusion.

Use data from **Figure 1**.

[4 marks]

The curve of best fit does show a peak at around pH 7.3 (about 4 arbitrary units).

But there is a lot of variation in species richness at each pH, e.g. at about pH 7.3 values range from about 2.7 to 6.2 arbitrary units.

Species richness is very similar over a wide range of pH (about 3.8 to 4.0 units from pH 6.5 to pH 8), so the peak is not clear.

Correlation does not mean a causal relationship; other factors could affect species richness.

0 1 . 4

pH is one abiotic factor that affects species richness.

Explain how **two** other abiotic factors could affect the species richness of fish.

[2 marks]

1 *Light intensity: affects photosynthesis, so the availability of food for fish.*

2 *Temperature: affects enzymes, so the rate of respiration, metabolism and growth in fish.*

9

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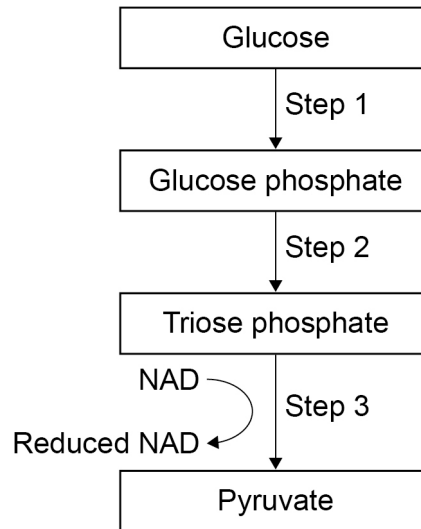
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0 2

Figure 2 shows some of the steps in glycolysis.

Figure 2



0 2 . 1

Describe what happens to the reduced NAD produced during Step 3 in aerobic respiration.

[3 marks]

The reduced NAD enters the mitochondrion and goes to the electron transfer chain, where it is oxidised to NAD.

The hydrogen atoms are split into H^+ and electrons; the electrons are passed on to the next carrier (and finally to oxygen).

So the reduced NAD is used to produce ATP (oxidative phosphorylation).

0 2 . 2

In anaerobic conditions, some bacteria use reduced NAD to convert pyruvate to ethanol.

Explain why this is an advantage to the bacteria.

[2 marks]

NAD is regenerated (reduced NAD is oxidised).

So glycolysis (Step 3) can continue and ATP production can continue.



0 2 . 3

Pyruvate enters mitochondria through mitochondrial pyruvate carriers (MPCs).

Suggest why an MPC inhibitor would decrease the rate of oxygen uptake by a mammalian cell.

[3 marks]

Less pyruvate enters the mitochondria, so less acetyl coenzyme A and less Krebs cycle (fewer Krebs cycle intermediates).

So fewer reduced coenzymes (reduced NAD and reduced FAD) are passed to the electron transfer chain.

So fewer H^+ and electrons are passed to oxygen, the final electron acceptor, so less oxygen is taken up.

0 2 . 4

Scientists can calculate the maximum theoretical yield of ATP from the aerobic respiration of one molecule of glucose.

Suggest how an increase in membrane permeability would reduce this yield of ATP. Use your knowledge of the passage of protons across mitochondrial membranes.

[2 marks]

Some H^+ move back across the inner mitochondrial membrane, so there is a reduced proton gradient between the intermembrane space and the matrix.

So less diffusion (movement) of protons through ATP synthase, so less ATP is made.

10

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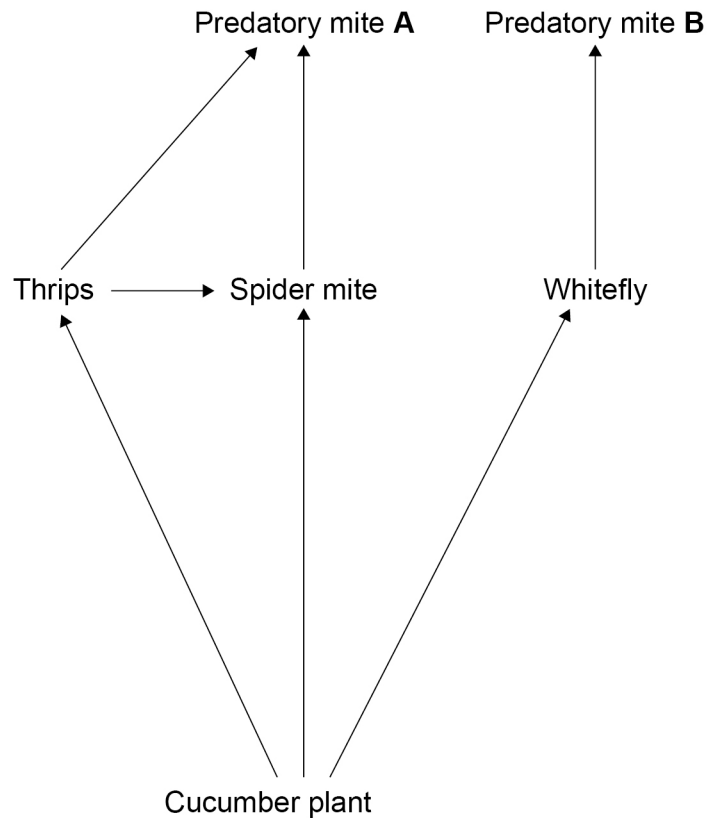


0 3

Cucumbers are crop plants. In some countries, cucumbers are grown in glasshouses. **Figure 3** shows part of a food web in a glasshouse.

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Figure 3



0 3 . 1

Thrips are insects that feed using their mouthparts to pierce plant cells and suck the cell contents.

The damage to cells causes white patches to develop on the plant leaves.

Explain how thrips decrease the productivity of a cucumber crop growing in a glasshouse.

[2 marks]

The damaged cells mean fewer chloroplasts, less chlorophyll and less photosynthetic (mesophyll) tissue in the leaves.

So less photosynthesis, so less glucose, sucrose, amino acids and other organic molecules are made, so less growth.



0 3 . 2

Biological pest control can be used to reduce the numbers of thrips.

Describe **two** advantages of using biological pest control rather than chemical pesticides.

[2 marks]

1 *Pests do not develop resistance to biological agents.*

2 *Biological agents are specific, so they are not harmful to beneficial organisms and are non-toxic to humans eating the crop.*

0 3 . 3

Suggest **one** disadvantage of using only predatory mite **B** for biological pest control. Use information from **Figure 3**.

[2 marks]

Predatory mite B only feeds on whitefly; it does not feed on thrips or spider mites.

So the populations of thrips and spider mites increase, and they still cause damage to the crop plant.

Question 3 continues on the next page

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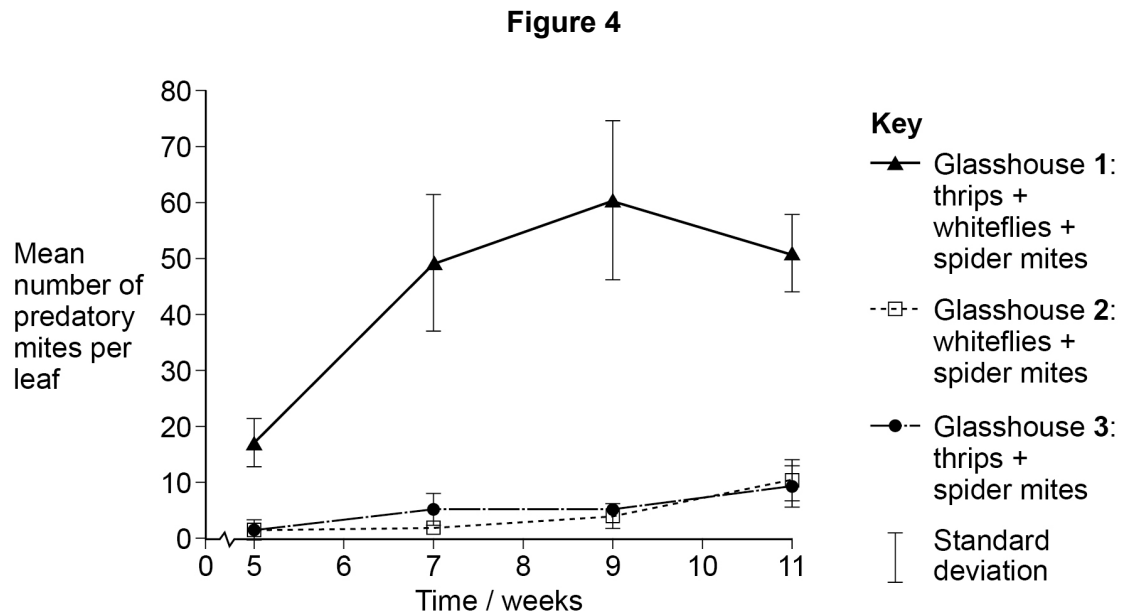


A scientist investigates the effect of pest species on the mean number of predatory mites per leaf.

The scientist:

- grows cucumber plants in three identical glasshouses for 5 weeks
- adds thrips, whiteflies and spider mites to glasshouse 1, whiteflies and spider mites to glasshouse 2, and thrips and spider mites to glasshouse 3
- adds predatory mites **A** and **B** to all three glasshouses
- counts the mean number of predatory mites every 2 weeks.

The results are shown in **Figure 4**.



0 3 . 4

A student concludes that the mean number of predatory mites per leaf peaks at 9 weeks and then decreases.

Evaluate this conclusion.

Use only the data from glasshouse 1.

[3 marks]

The highest mean number of predatory mites per leaf is at 9 weeks

(about 60).

But there are no intermediate data for 8 and 10 weeks, so the true peak is unknown.

The standard deviation bars for 7, 9 and 11 weeks overlap, so the difference is not significant (it may be due to chance).



0 3 . 5

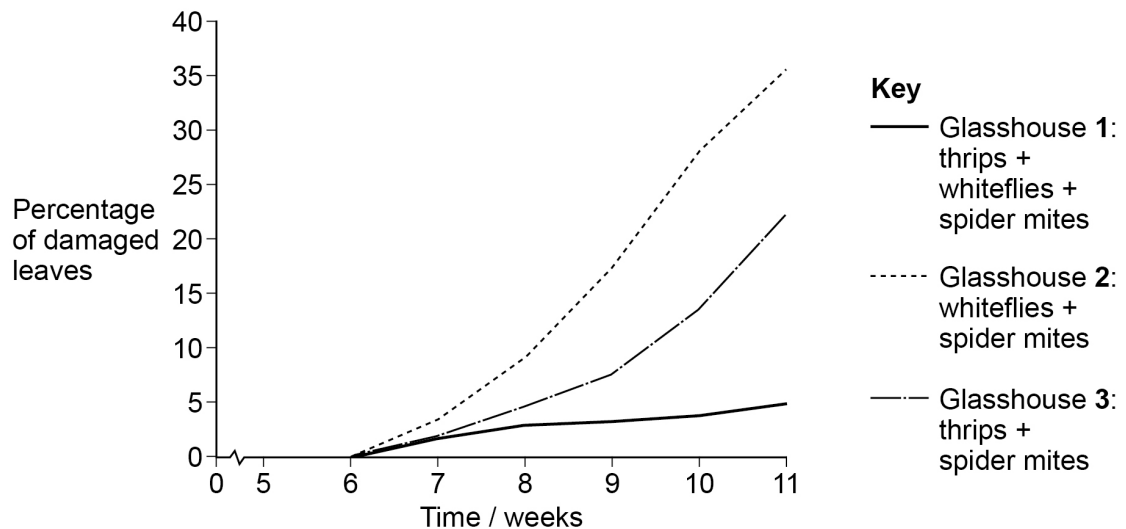
The scientist also investigates the effect of pest species on the leaf damage caused by spider mites.

The scientist:

- counts the number of damaged and undamaged leaves every week
- calculates the percentage of damaged leaves.

The results are shown in **Figure 5**.

Figure 5



The scientist concludes that increased diversity of pest species improves biological pest control.

Explain how the data in **Figure 4** and **Figure 5** support this conclusion.

[4 marks]

In glasshouse 1, where all three pest species are present (greatest diversity), the mean number of predatory mites increases (to about 60 per leaf at 9 weeks).

The mean number of predatory mites is significantly higher with thrips + whiteflies + spider mites than in glasshouses 2 and 3 (about 5 to 10 per leaf); the SD bars do not overlap.

Increased diversity of pest species decreases the percentage leaf damage by spider mites: less than 5% of leaves damaged with thrips + whitefly + spider mites, compared with about 22% and 36% in glasshouses 3 and 2 at 11 weeks.

13

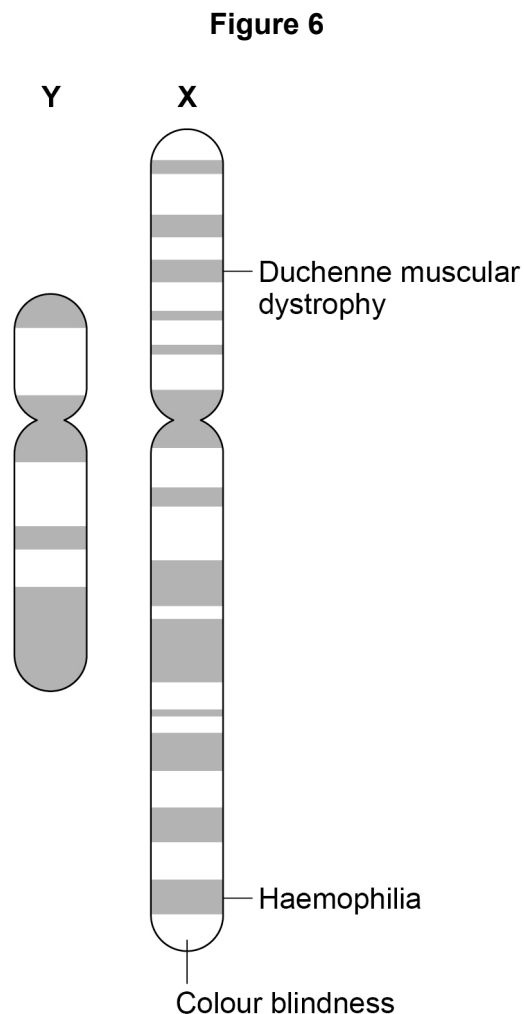
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0 4

Duchenne muscular dystrophy, haemophilia and colour blindness are sex-linked conditions.

Figure 6 shows a Y chromosome and an X chromosome.



0 4 . 1

Explain why sex-linked conditions are more common in males than in females.
Use information from **Figure 6**.

[3 marks]

Males have one X and one Y chromosome (only one X), whereas females have two X chromosomes (XX).

A recessive allele on the non-homologous portion of the X chromosome has no equivalent allele on the Y chromosome.

So the recessive allele on the X chromosome is always expressed in males: a male needs to inherit only one recessive allele, whereas a female needs to inherit two.



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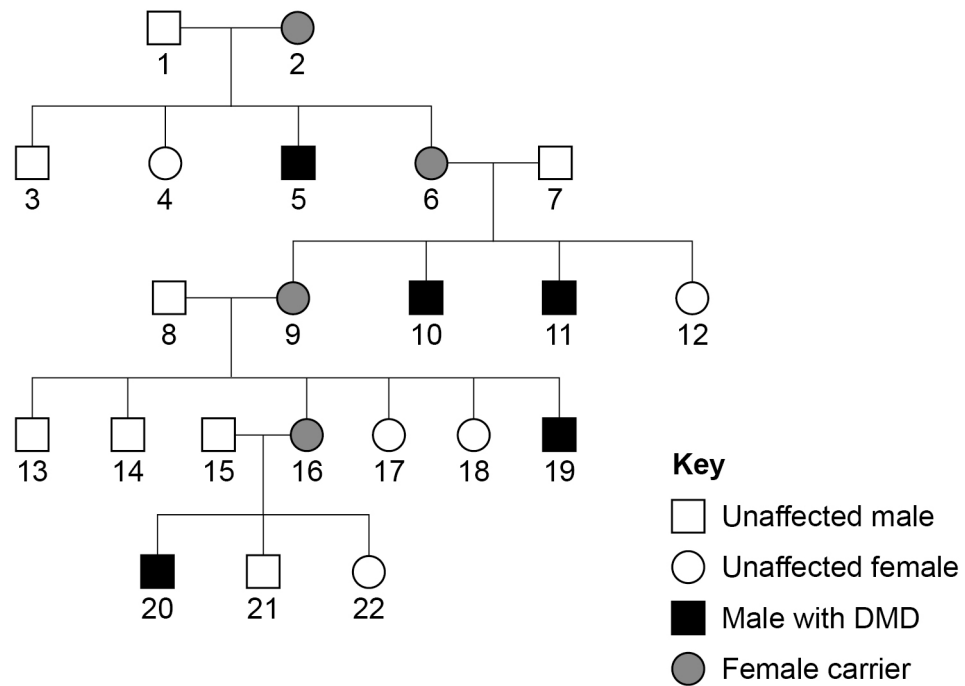


Duchenne muscular dystrophy (DMD) is an inherited condition that causes muscles to become progressively weaker.

A recessive allele (d) on the X chromosome causes DMD.

Figure 7 is a pedigree chart showing the inheritance of DMD in one family.

Figure 7



0 4 . 2 Identify the genotypes of individuals **15** and **16**.

Tick (✓) **one** box.

[1 mark]

Individual 15	Individual 16	
X^dX	XY^d	
X^DX	X^dY	
X^dY	X^DX^d	
X^DY	X^DX^d	✓

0 4 . 3 Individuals **15** and **16** have another child.

State the probability of their child being a boy with DMD.

[1 mark]

1 in 4 (0.25)

0 4 . 4 Explain why individual **22** could never have a son with DMD.

[2 marks]

Individual 22 can only pass on an X chromosome to her son, and the son gets his Y chromosome from his father.

Individual 22 is not a carrier: she only has dominant alleles (X^DX^D) and does not have the recessive allele for DMD, so she cannot pass it on.

Question 4 continues on the next page

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0 4 . 5

Cystic fibrosis (CF) is another inherited condition.

A recessive allele causes CF. The CF allele is **not** carried on the sex chromosomes.

The frequency of the CF allele in a population is 0.025

Calculate the percentage of the population who are carriers of CF.

Use the Hardy-Weinberg equation.

[3 marks]

$$q = 0.025, p + q = 1 \text{ so } p = 1 - 0.025 = 0.975$$

$$p^2 + 2pq + q^2 = 1; \text{ carriers (heterozygotes) } = 2pq$$

$$2pq = 2 \times 0.975 \times 0.025 = 0.04875$$

$$0.04875 \times 100 = 4.875 \%$$

Percentage of population who are carriers 4.875 %

0 4 . 6

Suggest **one** reason why the actual percentage of carriers of CF is different from the value you calculated in question **04.5**.

[1 mark]

Hardy-Weinberg assumes no selective advantage or disadvantage, but CF gives a selective disadvantage; there may also be movement into or out of the population (migration).

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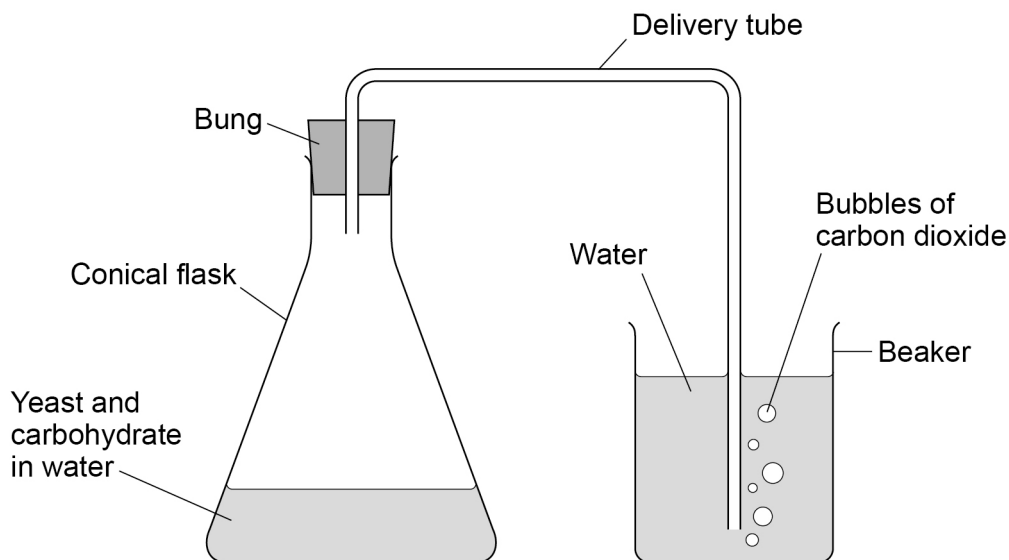


0 5

A student investigates the effect of different carbohydrates on the number of bubbles of carbon dioxide produced by yeast.

The student uses the apparatus shown in **Figure 8**.

Figure 8



The student:

- adds 5 g yeast to 100 cm³ water in a 250 cm³ conical flask
- adds 1 g glucose to the conical flask and mixes thoroughly
- seals the conical flask using the bung and delivery tube
- waits for 5 minutes
- counts the number of bubbles of carbon dioxide released in 1 minute
- repeats the investigation using sucrose instead of glucose in step 2
- repeats the investigation again using starch instead of glucose in step 2.

0 5 . 1

The student keeps the mass of yeast, the mass of carbohydrate, and the volume of water constant when repeating the investigation.

State **two** other variables that the student should control.

Describe how each variable could be controlled.

[2 marks]

1 *Temperature: keep the conical flask in a (thermostatically controlled) water bath.*

2 *pH: add the same volume of buffer solution to the flask.*



0 5 . 2

One source of error in the student's investigation is that the bubbles vary in size.

Describe how the student could reduce this error.

[1 mark]

Collect the gas in a gas syringe and measure the volume of gas produced.

The student's results are shown in **Table 1**.

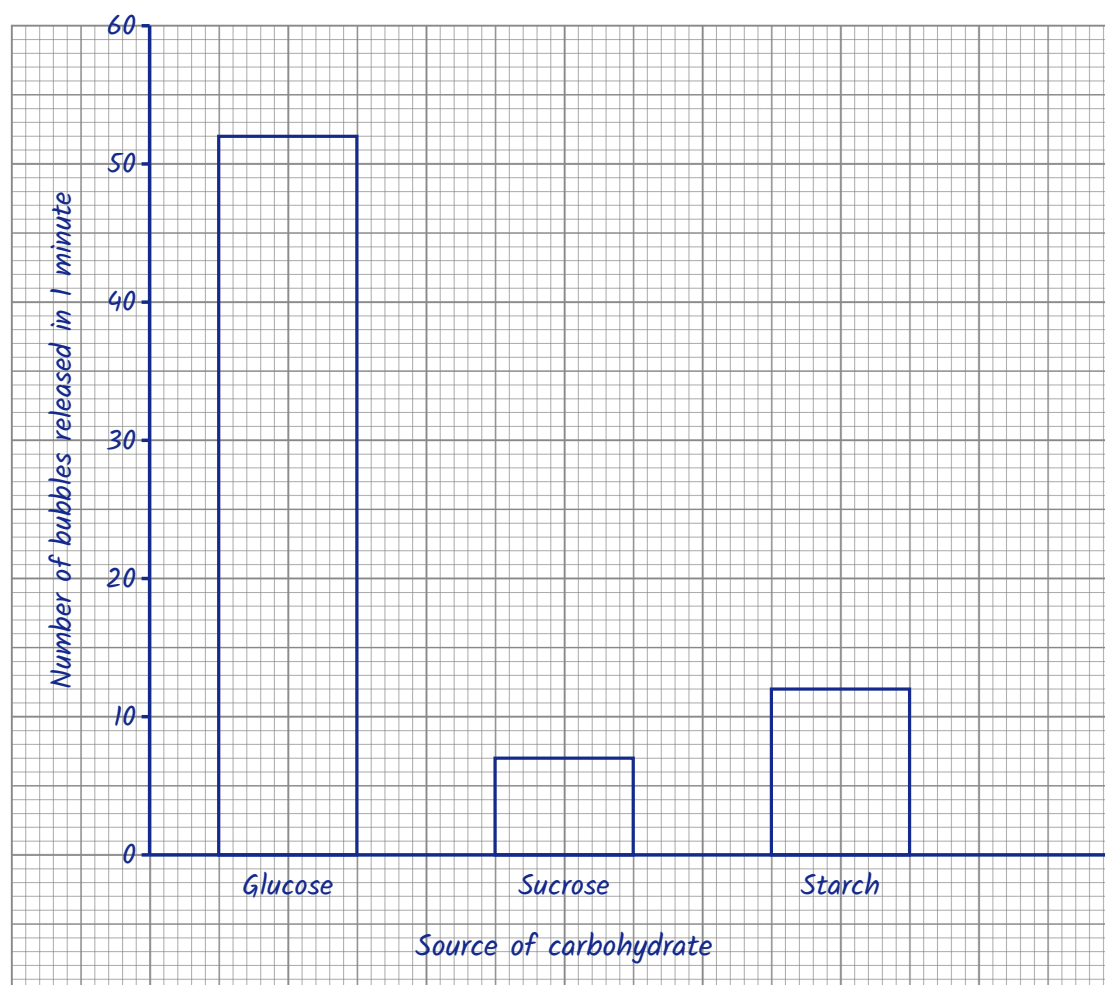
Table 1

Source of carbohydrate	Number of bubbles released in 1 minute
Glucose	52
Sucrose	7
Starch	12

0 5 . 3

Plot a suitable graph of the results.

[2 marks]



Question 5 continues on the next page

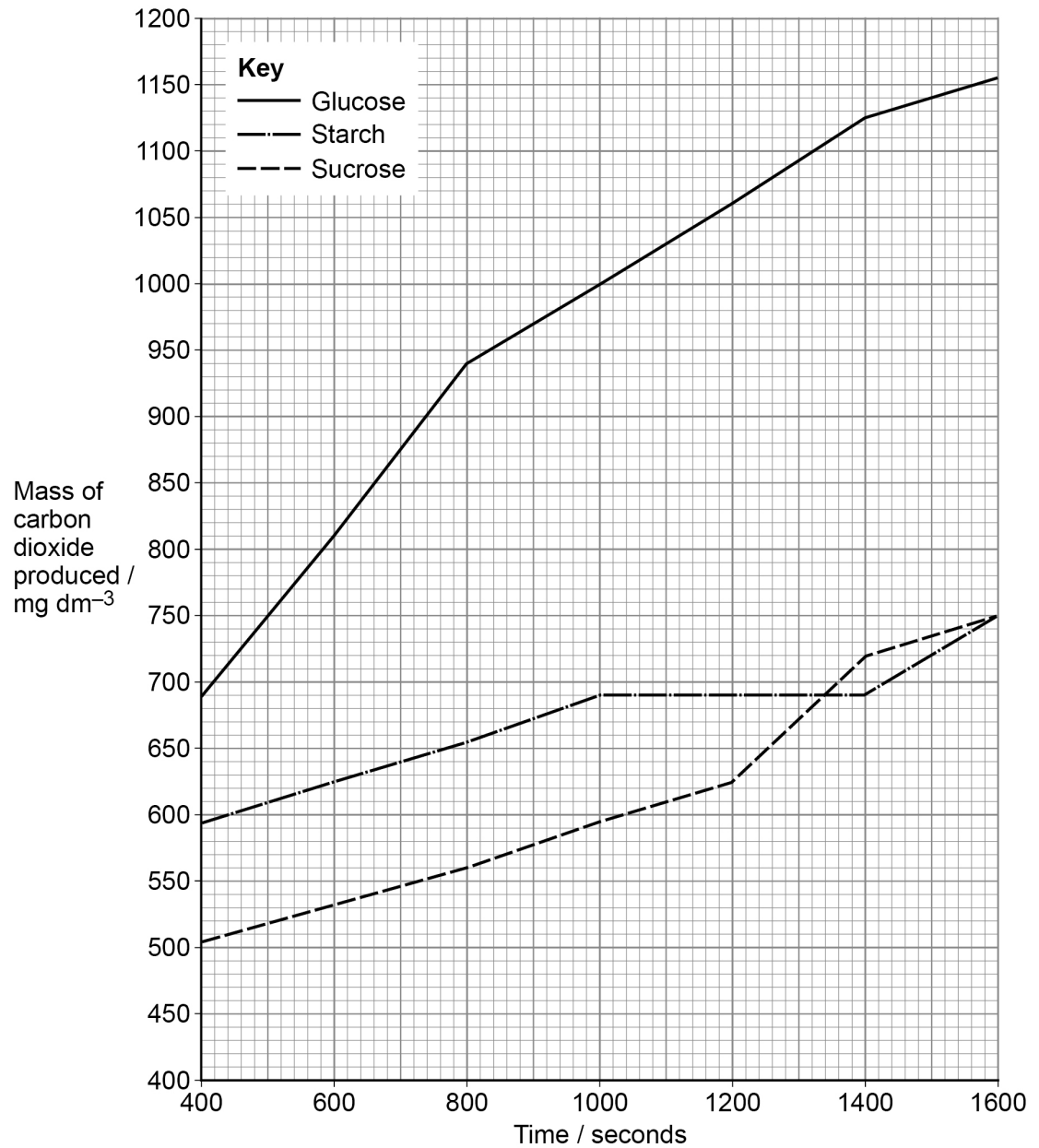
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A scientist measures the change in carbon dioxide production in yeast over time. The only variable the scientist changes is the type of carbohydrate.

The results are shown in **Figure 9**.

Figure 9



0 5 . 4

Calculate the rate of carbon dioxide production at 500 seconds using glucose.

Give your answer in $\text{mg dm}^{-3} \text{ min}^{-1}$ correct to 2 significant figures.

[3 marks]

$$\begin{aligned}\text{Tangent at 500 s: rate} &= (810 - 690) \div (600 - 400) \\ &= 120 \div 200 = 0.6 \text{ mg dm}^{-3} \text{ s}^{-1} \\ 0.6 \times 60 &= 36.0 \text{ mg dm}^{-3} \text{ min}^{-1}\end{aligned}$$

36 $\text{mg dm}^{-3} \text{ min}^{-1}$

0 5 . 5

Explain the differences in the rate of carbon dioxide production for the different carbohydrates from 400 to 800 seconds.

[3 marks]

Glucose gives the highest rate because it enters glycolysis immediately;
it can be used as a respiratory substrate straight away.

Starch has to be hydrolysed (digested) to glucose before it can be used
for respiration, so its rate is lower.

Sucrose is hydrolysed (digested) to glucose and fructose, but this
produces less glucose, so sucrose gives the lowest rate of respiration.

0 5 . 6

The scientist continues the investigation and finds the production of carbon dioxide from the glucose solution decreases after 2000 seconds.

Suggest **one** reason why carbon dioxide production decreases.

[1 mark]

The substrate (glucose) is used up, or ethanol (toxins) builds up.

12

Turn over for the next question

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0 6

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Figure 10 shows a female salmon. Female salmon lay their eggs in nests. A scientist investigates the effect of the size of females on behaviour, nest depth and egg diameter.

Figure 10



An adult female:

- arrives at the place where she will lay her eggs
- digs a nest in her territory
- releases eggs into the nest for the male to fertilise
- covers the fertilised eggs with stones
- guards her territory.

Females cover their eggs to protect them from predators and physical damage.

The scientist measures the lengths of 13 female salmon, the depth of the nest for each fish and the mean diameter of the eggs in the nest.

The results are shown in **Table 2**.

Table 2

Length of female salmon / cm	Depth of nest / cm	Mean egg diameter / mm
46.5	8.9	6.2
50.0	14.0	6.4
53.0	11.4	6.3
53.5	12.7	6.6
56.0	12.7	6.6
56.0	9.0	7.0
58.0	10.5	7.2
61.5	14.0	7.1
65.5	22.8	7.8
67.0	15.2	8.1
68.0	17.8	8.5
69.0	20.3	8.4
74.0	26.7	8.5



0 6 . 1

The scientist plots a graph of the length of female salmon and the depth of nest. State the type of graph the scientist should use.

Give **one** reason for your choice.

[1 mark]

A scatter graph, as he is looking for a correlation between two variables.

0 6 . 2

The scientist wants to use a statistical test to determine if there is a link between the length of female salmon and the depth of their nests.

Name a test that the scientist could use and describe how he would interpret the value obtained.

[2 marks]

Use the Spearman rank correlation test (calculate a correlation coefficient).

The value gives the strength of the correlation: close to +1 is a positive correlation, close to -1 is a negative correlation.

Question 6 continues on the next page

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There is competition between female salmon for nesting territory.

Female salmon spend almost all of their breeding life defending their territory to prevent other female salmon from digging up the eggs to use the nesting site.

The scientist monitors the behaviour of the female salmon during the time they are breeding.

The scientist records the lengths of the female salmon and the outcome of fights between female salmon.

The results are shown in **Table 3**.

Table 3

Length of female salmon defending territory (D) / cm	Length of female salmon attacking territory (A) / cm	Winner of fight (D or A)
59.0	67.0	A
61.0	70.0	A
61.5	72.5	A
62.0	68.5	A
65.0	69.0	A
67.5	68.5	A
68.0	71.0	D
68.0	69.0	D

0 6 . 3

The scientist concludes that larger female salmon have a selective advantage.

Evaluate this conclusion.

Use data from **Table 2** (on page 20) and **Table 3**.

[4 marks]

For: larger females dig deeper nests (74.0 cm: 26.7 cm deep vs 46.5 cm: 8.9 cm deep), have larger eggs (8.5 mm vs 6.2 mm) and are more likely to win fights (the attacker was larger and won in 6 of 8 fights). So their eggs are more likely to survive (protected from predators and damage).

Against: small sample size, only 13 fish; length is not the only indication of size; the number of eggs laid in each nest and the survival of eggs or young are not given; no statistical test, so the results may not be significant.



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07

Table 4 shows the changes in atmospheric carbon dioxide concentration, atmospheric methane concentration and temperature over 20 years.

Table 4

	Year		
	1990	2000	2010
Global mean atmospheric CO ₂ concentration / parts per million	354	370	389
Global mean atmospheric methane concentration / parts per million	1.67	1.73	1.75
Global mean temperature difference compared with the mean for the 20th century / °C	+ 0.43	+ 0.44	+ 0.70

07.1

Explain how changes in levels of carbon dioxide and methane in the atmosphere can cause climate change.

[4 marks]

Carbon dioxide and methane are greenhouse gases.

Greenhouse gases absorb heat (infrared radiation) radiated from the Earth's surface.

The heat is radiated back to Earth, so less heat escapes into space.

The increased levels of carbon dioxide (354 to 389 ppm) and methane (1.67 to 1.75 ppm) increase the amount of heat absorbed and re-radiated, so global temperature rises (+0.43 to +0.70 °C), causing climate change.



0 7 . 2

Explain how the change in global mean temperature in **Table 4** could increase or decrease the yield of crop plants.

[6 marks]

Increased yield *Increased temperature increases the rate of chemical reactions, e.g. photosynthesis, as molecules have more kinetic energy, so more collisions and more enzyme-substrate complexes form.*

So more sugars, amino acids and other organic molecules are produced for growth.

Decreased yield *Temperature may not be the optimum for enzyme action in some crops; it increases transpiration (evaporation of water) and water is needed for metabolism, transport and support.*

Increased predation by insect pests; unpredictable effects on rainfall.

0 7 . 3

Humans have been selectively breeding crop plants for thousands of years.

Explain how selective breeding has reduced the ability of crop plants to adapt to climate change.

[3 marks]

Selective breeding has removed some of the alleles (for less desirable characteristics) from the population.

So the variety of alleles (genetic diversity) in the population is reduced.

With fewer alleles, the population is less able to adapt to change, as there is less variation for natural selection to act on.

END OF QUESTIONS



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