

Please write clearly in block capitals.

Centre number

Candidate number

Surname StemUp Model Solution

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 5 Synoptic paper

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a pencil
- 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.
- In Question 6, 2 marks will be awarded for the quality of your written communication. You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Question	Mark
1	
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4	
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6	
TOTAL	

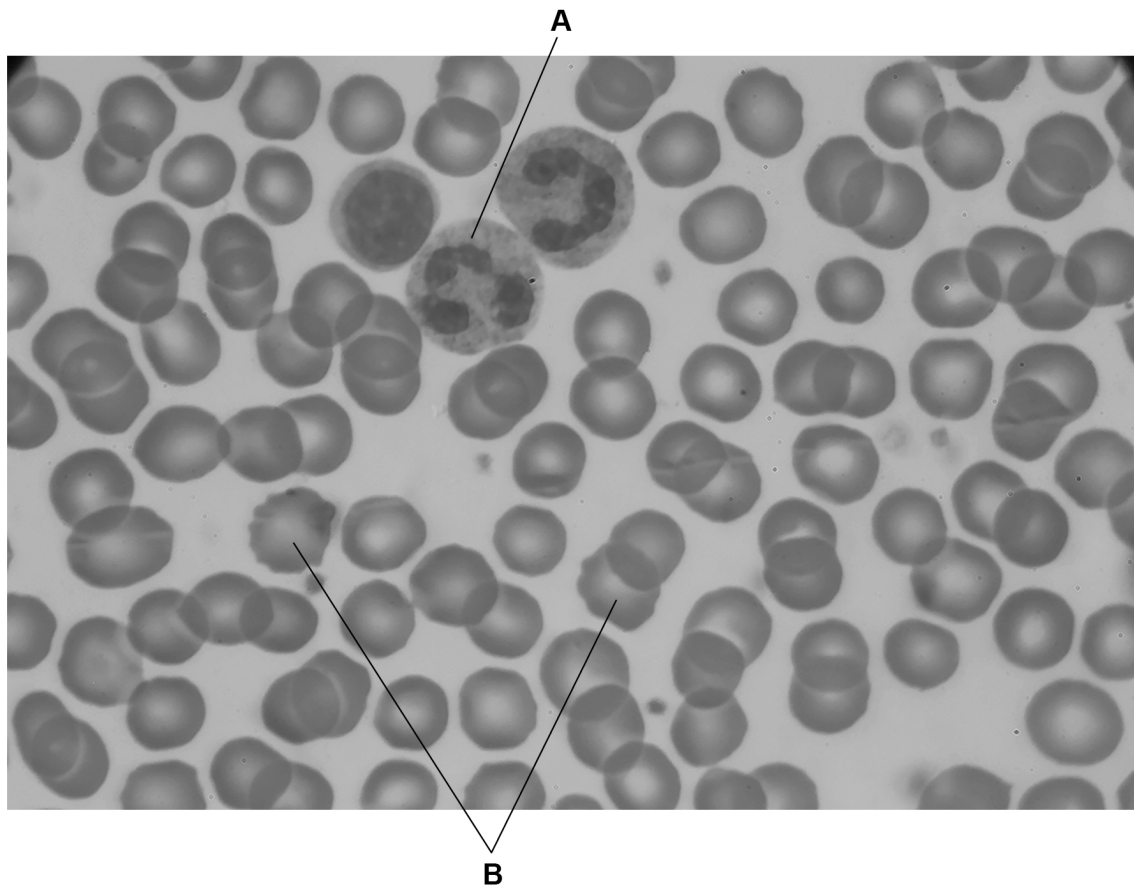


Answer **all** questions in the spaces provided.

0 1

Figure 1 shows blood cells viewed under an optical microscope.

Figure 1

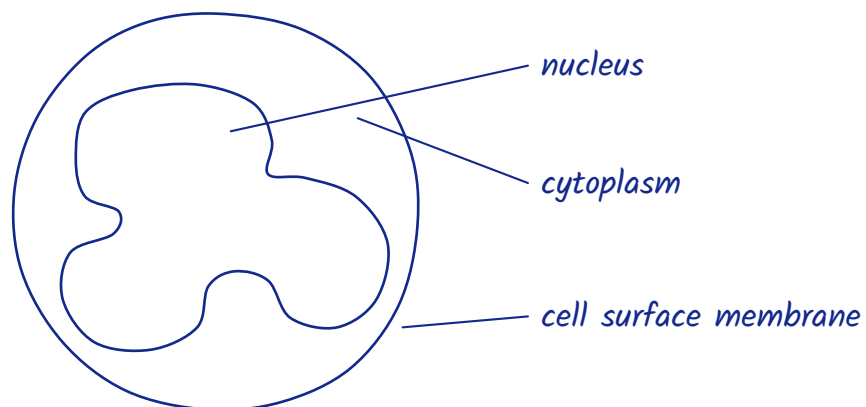


0 1 . 1

Draw cell **A**.

Label your drawing.

[3 marks]



0 1 . 2 The actual diameter of cell **A** is $10.5 \mu\text{m}$

Calculate the magnification of **Figure 1**.

Give your answer to 3 significant figures.

[3 marks]

diameter of cell A in Figure 1 = $18 \text{ mm} = 18\,000 \mu\text{m}$

magnification = $18\,000 \div 10.5 = 1714.29$

= 1710 (3 s.f.)

Magnification = $\times 1710$

0 1 . 3 Cell **A** is a phagocyte.

Describe how phagocytes help to protect the body from disease.

Include the role of lysosomes in your answer.

[3 marks]

*The phagocyte engulfs the pathogen (microorganism) by phagocytosis,
extending its cell surface membrane around it.*

This forms a phagosome (vesicle) around the pathogen.

*Lysosomes fuse with the phagosome and release hydrolytic enzymes, e.g.
lysozyme, proteases and lipases, which digest (hydrolyse) the pathogen
inside the vesicle.*

Question 1 continues on the next page

Turn over ►



Different red blood cells have slightly different water potentials.
Most red blood cells have a water potential between -400 kPa and -300 kPa

0 1 . 4

The two red blood cells labelled **B** are a different shape from most of the other red blood cells in **Figure 1** (on page 2).

When preparing the microscope slide, the cells are mounted in a solution of sodium chloride.

The sodium chloride solution has a water potential of -400 kPa

Explain what causes the cells labelled **B** to have a different shape from the other red blood cells.

[3 marks]

The cells labelled B have a water potential higher than -400 kPa (e.g.

-300 kPa), so higher than that of the sodium chloride solution.

*Water moves out of the cells by osmosis, from a higher to a lower
water potential, across the partially permeable cell surface membrane.*

The cells lose water, so they shrink and become crenated (shriveled).

0 1 . 5

Suggest why most of the red blood cells in **Figure 1** (on page 2) are **not** the same shape as the cells labelled **B**.

[2 marks]

*Most cells may have a water potential of about -400 kPa, the same as
(isotonic with) the sodium chloride solution.*

*So water enters and leaves these cells at the same rate; no net
movement of water by osmosis, so they keep their shape.*

*They may also have slightly different proteins in the cell membrane,
making the membrane more rigid (stable).*

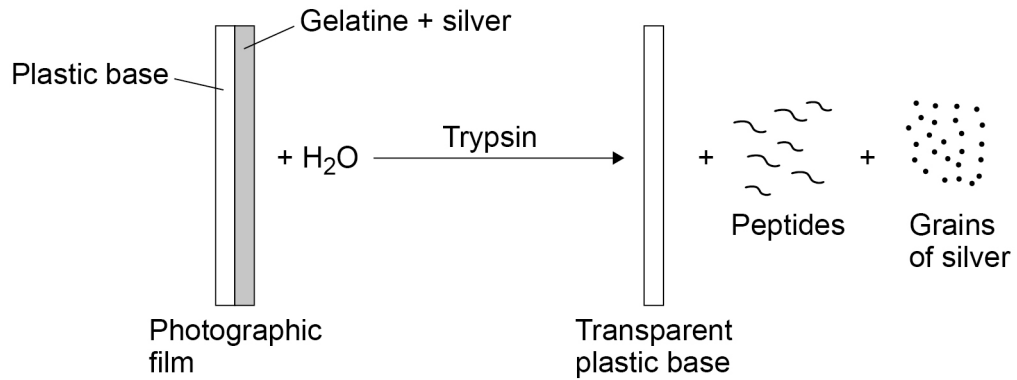


0 2

Trypsin is a protease enzyme made by the pancreas. Gelatine is a protein.

Some cameras use a photographic film to record an image. The image on the photographic film is made of grains of silver in a layer of gelatine stuck to a plastic base. Gelatine is hydrolysed by trypsin. Hydrolysis releases the grains of silver and the film becomes uniformly transparent, as shown in **Figure 2**.

Figure 2

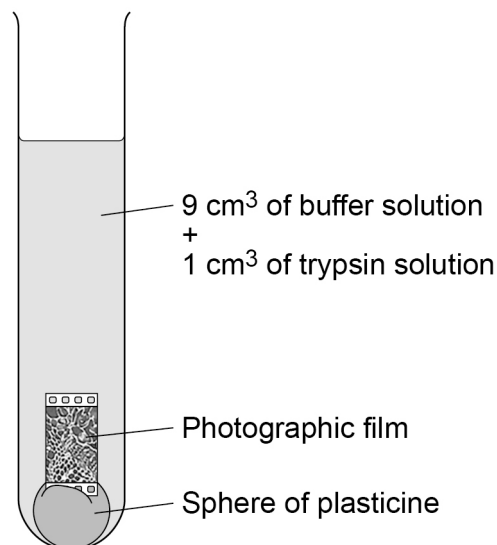


Students investigate the effect of pH on the activity of trypsin.

The students:

- put 9 cm³ of buffer solution of different pH into 5 different test tubes
- add 1 cm³ of trypsin solution to each tube
- fix a piece of a photographic film into each of 5 small spheres of plasticine (modelling clay) as shown in **Figure 3**
- put 1 sphere with its piece of photographic film into each of the 5 test tubes as shown in **Figure 3**
- measure the time taken for the photographic film to become transparent
- repeat the investigation 6 times.

Figure 3



Turn over ►



Table 1 shows the students' results.

Table 1

pH	Mean time taken / min	Rate of reaction $= \frac{1}{\text{Time taken}} / \text{min}^{-1}$	Standard deviation of rate
2	No reaction	0.000	0.000
4	20	0.050	0.025
6	8	0.125	0.055
8	3	0.333	0.020
10	8	0.125	0.070

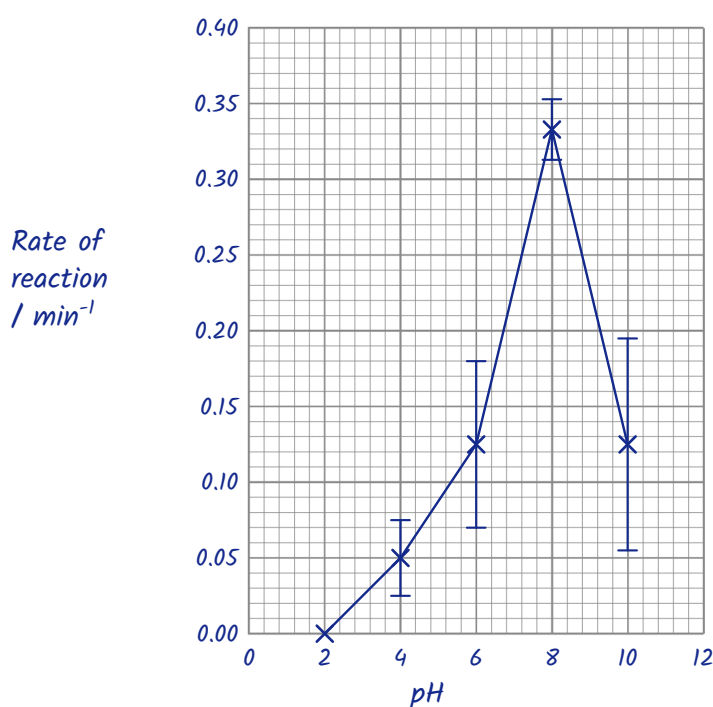
0 2 . 1 Calculate the rate of reaction for each pH.

Write your answers in Table 1.

[2 marks]

0 2 . 2 Draw a graph to show how the rate of reaction varies with pH.

[4 marks]



0 2 . 3 Draw error bars on your graph to show $\pm$ standard deviation for each value.

Use the values given in Table 1.

[2 marks]



0 2 . 4

The students state there is no significant difference in rate between pH 4 and pH 6.

Give evidence for this statement from your graph.

[1 mark]

The error bars ($\pm$ standard deviation) for pH 4 and pH 6 overlap.

0 2 . 5

The students conclude that the optimum pH for the action of trypsin is pH 8.

Suggest improvements the students could make to their method to find a more accurate value of the optimum pH for the action of trypsin.

[3 marks]

Repeat using more pH values at smaller (closer) intervals, e.g. every 0.5 pH unit, between pH 6 and pH 10 (around pH 8).

Control the temperature by keeping the tubes in a thermostatically controlled water bath, e.g. at 37 °C.

Use a standard (a piece of film that is already transparent) for comparison to judge the end point, or use a colorimeter to measure the increase in light transmission as the silver is released.



0 3

Caffeine is a stimulant drug found in coffee.

0 3 . 1

Design an investigation to find the effect of caffeine on human heart rate.

You should include:

- how you would change the independent variable
- how you would make sure any other variables are kept constant
- how you would measure the dependent variable
- a suitable control.

[6 marks]

Give volunteers drinks containing a range of concentrations of caffeine, e.g. 0, 50, 100, 150 and 200 mg of caffeine dissolved in 250 cm³ of decaffeinated coffee.

Use a large number of volunteers, e.g. at least 10 in each group.

Keep other variables constant: volunteers of the same age, gender and body mass (BMI), all healthy non-smokers who have had no coffee or caffeine for 12 hours; the same volume and type of drink; the same activity (all seated, resting); a blind trial so volunteers do not know which drink they have.

Before the drink, record each volunteer's resting pulse rate (beats per minute) by counting the pulse at the wrist for 60 s, or with a heart rate monitor.

Record the pulse rate again at set times after the drink, e.g. every 10 minutes for 60 minutes, and calculate the change from the resting rate.

Control: a group given the same volume of decaffeinated coffee (a drink with no caffeine), treated in exactly the same way.



You could use a graph and a statistical test to analyse your results.

0 3 . 2

Describe how you would show your results in a graph. Give a reason for your choice.

[4 marks]

Calculate the mean change in heart rate for each group (each caffeine concentration).

Plot a line graph with caffeine concentration / mg on the x-axis and mean heart rate / beats min⁻¹ on the y-axis, including the control (0 mg), joining the points.

Add error bars to show $\pm$ standard deviation of each mean.

Reason: a line graph because caffeine concentration and heart rate are both continuous variables.

0 3 . 3

Give a statistical test you would use to compare experimental and control results from your investigation. Give a reason for your choice.

[2 marks]

Statistical test *t-test (Student's t-test)*

Reason *Because I am looking for a significant difference between two means (mean heart rate of a caffeine group and of the control group), to show whether the difference is not due to chance.*

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Turn over ►



0	4
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Many neurones have a fatty myelin sheath around the axon.

0	4	.	1
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Describe the function of this myelin sheath in nerve impulse conduction.

You should refer to the movement of sodium ions and potassium ions in your answer.

[3 marks]

The myelin sheath is an electrical insulator: it prevents the movement of sodium ions and potassium ions across the axon membrane where it is myelinated.

So sodium ions and potassium ions can only pass through the membrane at the nodes of Ranvier (gaps in the sheath), so depolarisation only occurs at the nodes.

The action potential jumps from node to node (saltatory conduction), so the impulse is conducted faster than in non-myelinated neurones.



Tay–Sachs disease is a human inherited condition. Tay–Sachs disease is common in some groups of people with a tradition of marrying within their own community.

Tay–Sachs disease is caused by a recessive mutation. The mutation interferes with fat metabolism in neurones in the brain. Children with Tay–Sachs disease usually die before they are 4 years old.

Scientists in Brazil estimated that, in one community, 1 in every 29 people would be a carrier of Tay–Sachs disease. The scientists were able to make this estimate by knowing the frequency of babies born with Tay–Sachs disease in this community.

0 4 . 2

A student suggested that the scientists made their estimate using the Hardy–Weinberg equation.

Explain how the Hardy–Weinberg equation could be used for estimating the frequency of carriers of Tay–Sachs disease in this community.

[3 marks]

The frequency of babies born with Tay-Sachs disease (homozygous recessive) = q^2 , so the square root of this gives q , the frequency of the recessive allele.

Since $p + q = 1$, the frequency of the dominant allele is $p = 1 - q$.

The frequency of heterozygotes (carriers) = $2pq$, so 1 in 29 people is 1 in $1/2pq$.

0 4 . 3

Give **one** reason why the estimate made using the Hardy–Weinberg equation may **not** be accurate.

[1 mark]

Mating is not random (people marry within their own community), and homozygous recessives die before age 4 so cannot mate: Tay-Sachs is a selective disadvantage.

7

Turn over ►



0 5

2,4-dichlorophenoxyacetic acid (2,4-D) is a selective herbicide. Farmers can spray 2,4-D on cereal crops to kill broad-leaved weeds growing among the crop.

Scientists are concerned that 2,4-D might cause cancer in humans. In the USA, scientists found that farm workers who used large amounts of pesticides, including 2,4-D, had a higher occurrence of cancer than in the rest of the population. However, studies in Australia and New Zealand did not show similar results.

0 5 . 1

Use this information to suggest why the scientists cannot be sure that 2,4-D causes cancer.

[2 marks]

The evidence from the USA is contradicted by the studies in Australia and New Zealand, which did not show a higher occurrence of cancer.

The US farm workers also used other pesticides, so another pesticide or another factor could have caused the cancer: correlation does not mean causation.

Scientists tested the effect of 2,4-D on the rate of multiplication of cancer cells taken from a human male's prostate gland. The scientists compared the effect of 2,4-D with the effect of the male hormone dihydrotestosterone (DHT).

The scientists:

- put samples of prostate cancer cells into 19 separate flasks of tissue fluid
- add different concentrations of 2,4-D to flasks 1–9
- add different concentrations of DHT to flasks 10–18
- set up flask 19 as a control
- measure the number of cells in each flask after 4 days.

0 5 . 2

Suggest how the control flask should be set up.

[2 marks]

Add the same number of prostate cancer cells to the same volume of tissue fluid, kept in the same conditions (same temperature, pH, time) as the other flasks.

But add no 2,4-D and no DHT (only an equal volume of the solvent).



Question 5 continues on the next page

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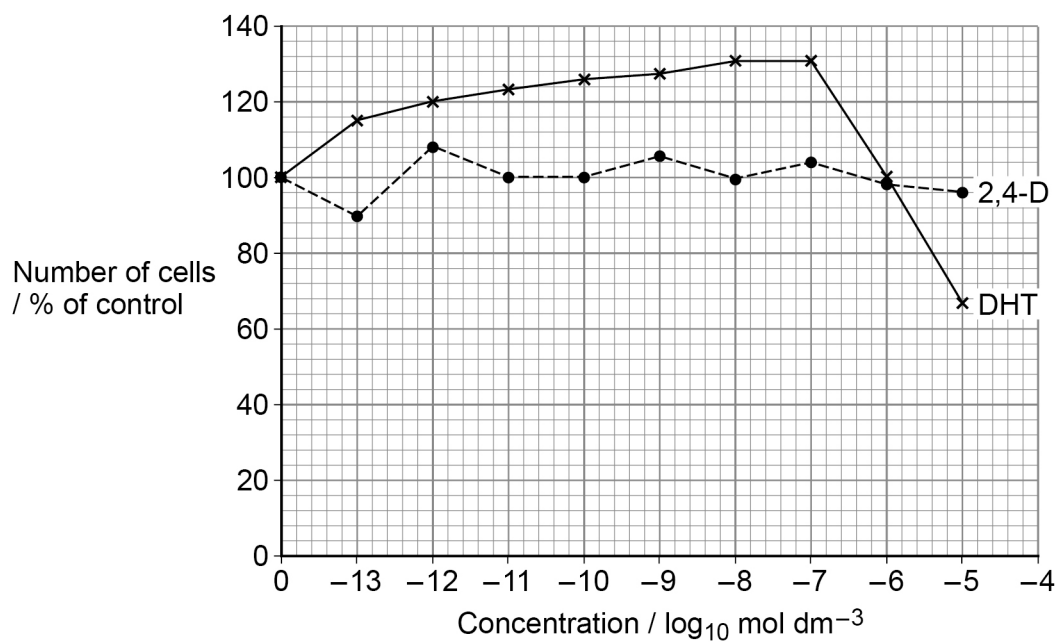
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Figure 4 shows the scientists' results.

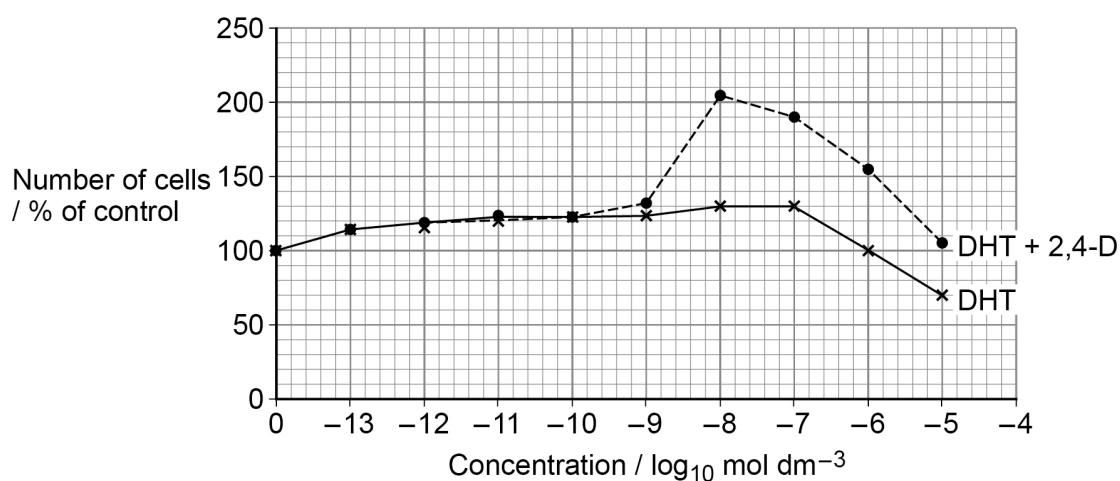
Figure 4



The scientists then added different concentrations of 2,4-D to $10^{-8} \text{ mol dm}^{-3}$ DHT and measured the effect of this combined treatment on the cancer cells.

Figure 5 shows the results compared to treatment with DHT on its own.

Figure 5



0 5 . 3

In **Figure 4** and **Figure 5**, the scientists use a logarithmic scale on the x-axis.

Suggest why.

[1 mark]

Because there is a large range of concentrations (10^{-13} to 10^{-5} mol dm $^{-3}$) to fit on the axis.

0 5 . 4

The scientists concluded:

- 2,4-D on its own has no effect on the multiplication of prostate cancer cells
- 2,4-D increases the effect of DHT on the multiplication of prostate cancer cells.

Give evidence to support this conclusion.

Use data from **Figure 4** and **Figure 5**.

[3 marks]

Figure 4: with 2,4-D on its own the number of cells stays at about 100% of the control (between 90% and 108%) at all concentrations, so 2,4-D alone does not stimulate cell multiplication.

DHT on its own increases the number of cells by up to about 30% (to about 130% of the control) at 10^{-8} to 10^{-7} mol dm $^{-3}$.

Figure 5: with 2,4-D added to the DHT the number of cells rises to about 205% of the control, about 75% more than with DHT alone (130%), so 2,4-D increases the effect of DHT.

This increase occurs at 2,4-D concentrations of about 10^{-8} to 10^{-7} mol dm $^{-3}$.

Question 5 continues on the next page

Turn over ►



0 5 . 5

Suggest **two** reasons why it is difficult to determine if 2,4-D causes prostate cancer in humans.

[2 marks]

- 1 *Results from cells in vitro (in a flask) may not apply in vivo: the concentration of 2,4-D in the body is not the same as in the lab, and many other factors affect the body.*
- 2 *It is unethical to experiment on humans by exposing them to 2,4-D; also, cancer cells may not show the effect on normal prostate cells or on the whole organ.*

10



You are reminded that 2 marks will be awarded
for the quality of your written communication in Question 6.

0 6

Various abiotic factors affect the distribution of plants.

0 6 . 1

Describe why abiotic factors affect plant growth.

Include named abiotic factors in your answer.

[7 marks]

Light: needed for photosynthesis; light energy excites electrons in chlorophyll and causes photolysis of water, producing ATP and reduced NADP for the light-independent reaction. Light also controls phototropism and photoperiodism.

Temperature: affects the rate of enzyme-controlled reactions, e.g. rubisco and respiratory enzymes, by changing kinetic energy and the frequency of enzyme-substrate collisions; high temperatures denature enzymes.

Water: gives support by turgor, is a solvent for transport in xylem and phloem and a medium for reactions, and is a reactant in photolysis and hydrolysis.

Mineral ions: Mg^{2+} is needed to make chlorophyll, NO_3^- for amino acids, proteins and DNA, and HPO_4^{2-} for DNA, RNA, ATP and phospholipids.

Soil pH (acid rain): affects enzyme activity (extremes denature enzymes) and the availability of ions.

Oxygen: needed by root cells for aerobic respiration to make ATP, as the final electron acceptor; waterlogged soil lacks oxygen.

Carbon dioxide: combines with RuBP to form GP in the Calvin cycle.

Heavy metals in soil inhibit enzymes.

Question 6 continues on the next page

Turn over ►



Fatsia japonica and *Fatsia polycarpa* are two species of woody plant.
The two species grow on different islands off the coast of Southeast Asia.

F. japonica grows well in shady forests.

F. polycarpa grows well in brighter light in the mountains.

0 6 . 2

Describe an experiment to find out if the leaves of *F. polycarpa* need a higher light intensity for photosynthesis than the leaves of *F. japonica*.

[4 marks]

Cut leaf discs of the same size, using a cork borer, from leaves of the same age of each species, F. japonica and F. polycarpa.

Place the same number of discs of each species in sealed tubes above the same volume of hydrogencarbonate indicator.

Vary the light intensity by placing a lamp at different distances from the tubes, e.g. 10, 20, 30, 40 and 50 cm, or by using lamps of different wattage.

Keep the temperature constant with a water bath (or a glass tank of water as a heat filter), and keep the CO₂ concentration the same.

Measure the rate of photosynthesis as CO₂ uptake from the colour change of the indicator after a set time, using a colorimeter; or measure the volume of O₂ released, or use an oxygen electrode.

Repeat at least three times at each light intensity and calculate mean rates; compare the light intensity each species needs, e.g. using a t-test.



0 6 . 3

Scientists believe that *F. japonica* and *F. polycarpa* evolved from a common ancestor that lived about 600 000 years ago.

Explain how these two different species of plant could have evolved from a common ancestor.

[7 marks]

The common ancestor colonised both islands, and the two populations were geographically isolated from each other by the sea (allopatric speciation), so there was no gene flow between them.

There was genetic variation within each population, and different random mutations occurred in each population, producing new alleles.

The environments on the two islands were different, giving different selection pressures: abiotic factors such as light intensity (shady forest vs bright mountains), temperature, water and soil ions, and biotic factors such as herbivores and competition with other plant species.

Individuals with beneficial alleles, e.g. for photosynthesising efficiently in shade or in bright light, were more likely to survive (natural selection) and reproduce, passing on their beneficial alleles to their offspring, so allele frequencies changed differently in each population.

Over a long time (600 000 years, many generations) more genetic differences and mutations accumulated.

Eventually the two populations could no longer interbreed to produce fertile offspring, so they became two separate species.

20

Quality of written communication [2 marks]

END OF QUESTIONS



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