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Surname

StemUp Model Solution

Forename(s)

Candidate signature

I declare this is my own work.

AS BIOLOGY

Paper 2

Thursday 22 May 2025 Morning Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator.

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).
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

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

For Examiner's Use	
Question	Mark
1	
2	
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5	
6	
7	
8	
9	
TOTAL	



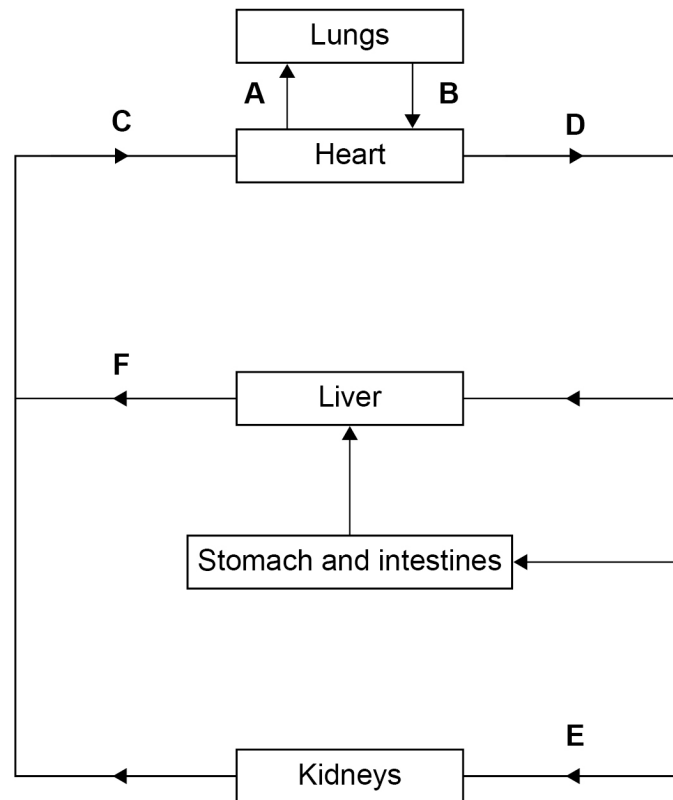
J U N 2 5 7 4 0 1 2 0 1

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

0 1

Figure 1 shows the arrangement of some of the blood vessels in a mammalian circulatory system.

Figure 1



0 1 . 1

Name the blood vessels labelled **B** and **E** in **Figure 1**.

[2 marks]

B Pulmonary vein

E Renal artery

0 1 . 2

Give the letters of all the blood vessels shown in **Figure 1** that transport deoxygenated blood.

[1 mark]

A, C, F



0	1	3
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Many animals are adapted to their environments by having different types of haemoglobin with different tertiary structures.

Using your knowledge of the structure of proteins, explain how different types of haemoglobin can have different tertiary structures.

[3 marks]

Different types of haemoglobin have polypeptides with different sequences of amino acids, so they have different primary structures.

This means the hydrogen bonds form in different positions, giving a different secondary structure (different alpha-helices and beta-pleated sheets).

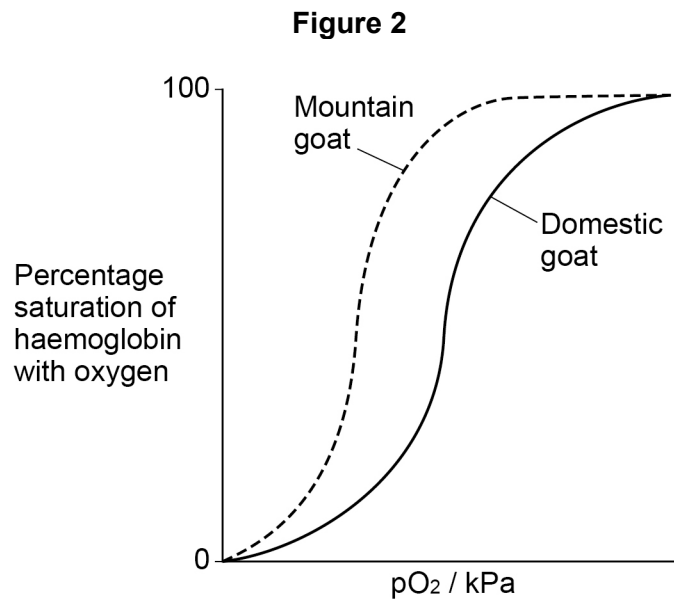
The polypeptide then folds differently because different hydrogen bonds, ionic bonds and disulfide bridges form between the R groups, so the tertiary structure (3D shape) is different.

Question 1 continues on the next page

Turn over ►



Figure 2 shows the oxyhaemoglobin dissociation curve for two species of goat.



0 1 . 4

The mountain goat lives at high altitudes where the pO_2 is lower than where the domestic goat lives.

Use **Figure 2** to explain how the mountain goat is adapted to living at high altitudes.

[2 marks]

The mountain goat's curve is to the left of the domestic goat's, so its haemoglobin has a higher affinity for oxygen and loads (associates with) oxygen more readily at the lower partial pressures of oxygen found at high altitude.

So its haemoglobin is still highly saturated in the lungs, and enough oxygen is supplied to its tissues for aerobic respiration.

8



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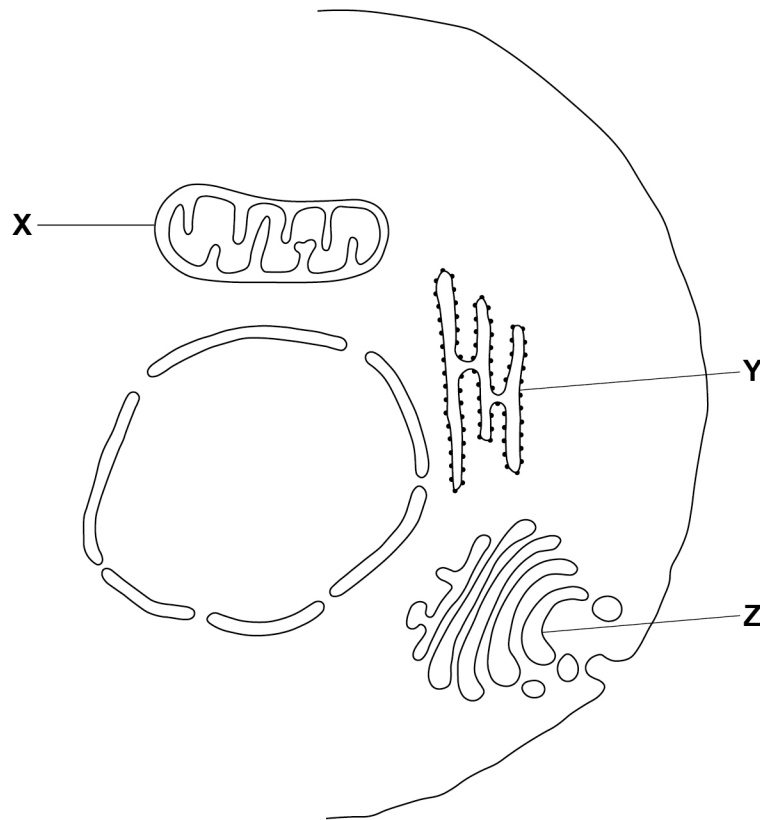


0 5

0 2

Figure 3 shows part of a eukaryotic cell.

Figure 3



0 2 . 1

Name the organelle labelled X and state its function.

[2 marks]Name MitochondrionFunction The site of aerobic respiration (the Krebs cycle and oxidative phosphorylation), which releases energy to make ATP.

0 2 . 2

Pancreatic cells produce and secrete digestive enzymes.

Explain why pancreatic cells contain large numbers of organelles **Y** and **Z**.**[4 marks]**

Digestive enzymes are proteins, and the cells make and secrete large amounts of them.

Y is the rough endoplasmic reticulum: the ribosomes on its surface synthesise the proteins (enzymes), and the RER transports them to the Golgi apparatus in vesicles.

Z is the Golgi apparatus, which modifies (e.g. adds carbohydrate to) and packages the proteins / enzymes.

Golgi vesicles then transport the modified enzymes to the cell-surface membrane, where they are released by exocytosis.

Question 2 continues on the next page

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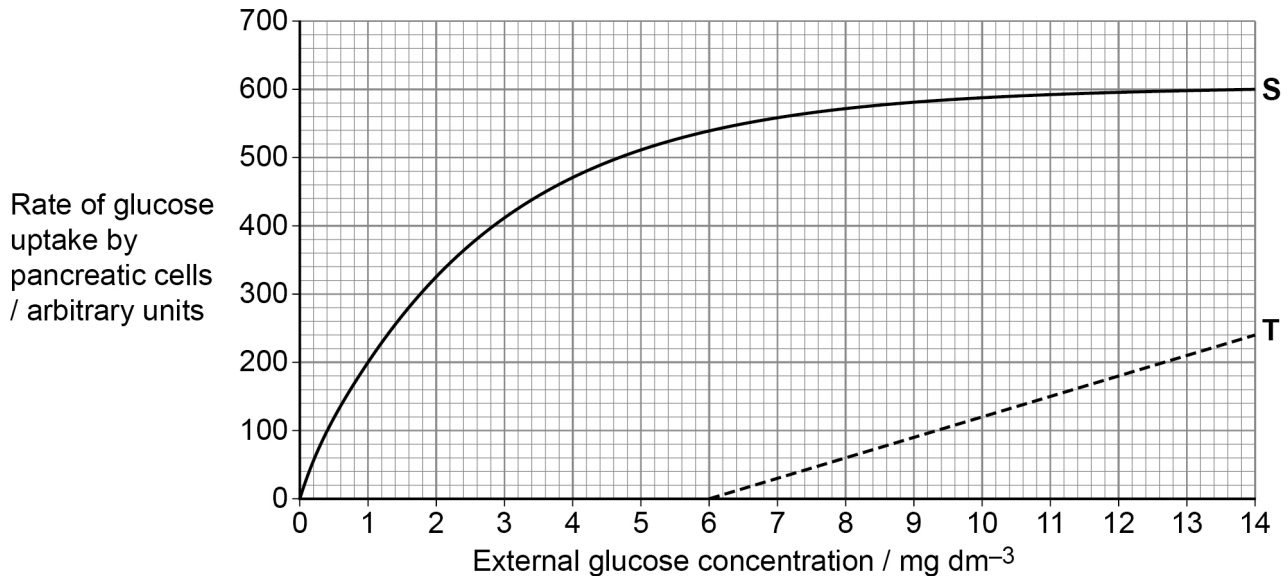


0 2 . 3

A scientist placed pancreatic cells in solutions containing different concentrations of glucose. The scientist measured the rate of uptake of glucose by these cells.

Figure 4 shows the scientist's results.

Figure 4



Key

- Curve S
Cells in solution with oxygen
- Curve T
Cells in solution without oxygen

Using **Figure 4**, what can you conclude about the processes involved in the uptake of glucose molecules by pancreatic cells?

[3 marks]

With oxygen (curve S) glucose is taken up at all concentrations, even low ones, so glucose is taken up by active transport (co-transport), as the cells use ATP from aerobic respiration.

Curve S levels off at about 600 arbitrary units because all of the carrier proteins are in use.

Without oxygen (curve T) there is no ATP from aerobic respiration, so uptake is only by facilitated diffusion through channel / carrier proteins.

Uptake in curve T only starts above 6 mg dm⁻³, when the glucose concentration outside the cells is greater than inside the cells.



0 2 . 4 Use **Figure 4** to calculate the ratio

rate of glucose uptake with oxygen : rate of glucose uptake with no oxygen
at an external glucose concentration of 14 mg dm^{-3}

[1 mark]

With oxygen = 600, without oxygen = 240

600 : 240 = 2.5 : 1

Ratio = 2.5 : 1

10

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0 3

Table 1 shows the names of three biological molecules and different combinations of elements.

Table 1

	Cellulose	Triglyceride	Antibody	
A	C, H, O	C, H, O	C, H, O, N	
B	C, H, O	C, H, O	C, H, O, N, S	✓
C	C, H, O	C, H, O, N	C, H, O, N, S	
D	C, H, O, N	C, H, O	C, H, O, N, P	

0 3

1

Which row identifies the correct elements in each molecule?

Tick (✓) **one** box.

[1 mark]

0 3

2

Describe the biochemical test used to confirm the presence of lipid in a sample.

[2 marks]

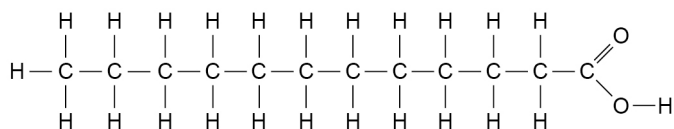
Add ethanol to the sample and shake it to dissolve any lipid, then pour it into water and shake / mix.

A white (milky) emulsion forms if lipid is present.

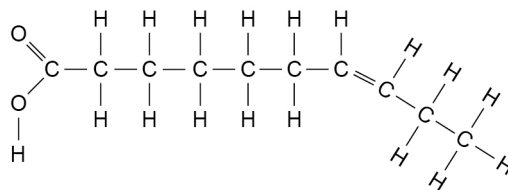


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Figure 5



Fatty acid **A**



Fatty acid **B**

State which fatty acid in **Figure 5** is unsaturated **and** explain your answer.

[1 mark]

Unsaturated fatty acid *Fatty acid B*

Explanation It has a double bond ($C=C$) between two carbon atoms,
where two carbons have only one hydrogen each.

Question 3 continues on the next page

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0 3 . 4

Cholesterol is a type of lipid transported in the blood. High blood cholesterol concentrations can lead to cardiovascular disease.

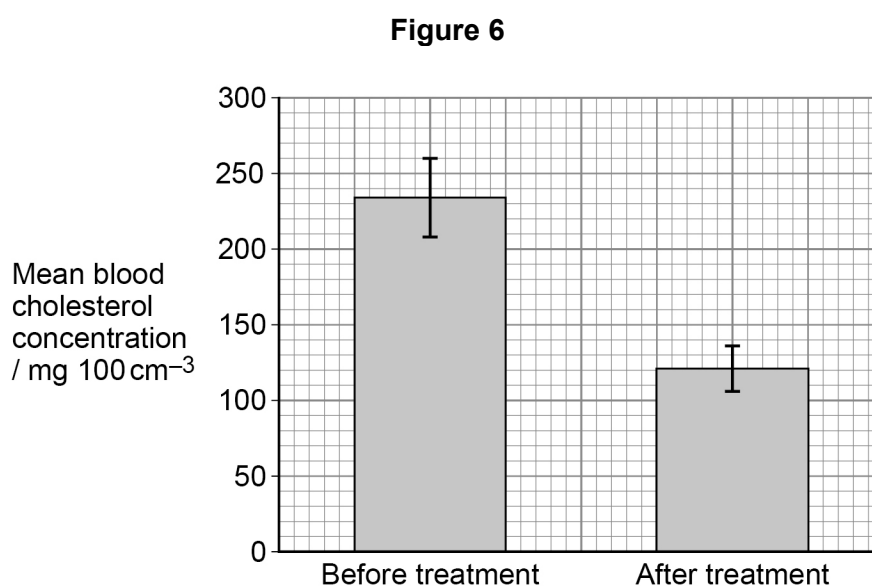
Scientists studied the effectiveness of the drug cholestyramine (CA) in lowering blood cholesterol concentration.

They:

- gave 10 patients CA for 1 month
- measured the blood cholesterol concentrations at the start of the study and after 1 month of treatment with CA.

Figure 6 shows the scientists' results.

The error bars represent ± 2 standard deviations from the mean, which includes over 95% of the data.



Use the information provided to evaluate the effectiveness of the drug CA in reducing blood cholesterol concentration.

[5 marks]

The mean blood cholesterol concentration fell from about 235 to about 120 mg 100 cm⁻³ after one month of CA, roughly halving.

The error bars (plus or minus 2 standard deviations) do not overlap, so the decrease is significant and the difference is not due to chance. This supports CA being effective.

However, it was only investigated for 1 month, so the time scale is too short to know whether the effect lasts or whether it reduces cardiovascular disease in the long term.

The sample size is small, only 10 patients, so the results may not be representative.

There are no details of the patients' sex, age or diet, and there was no control group given a placebo, so other factors could have lowered cholesterol.

Any side effects of the treatment are unknown.

9

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0 4

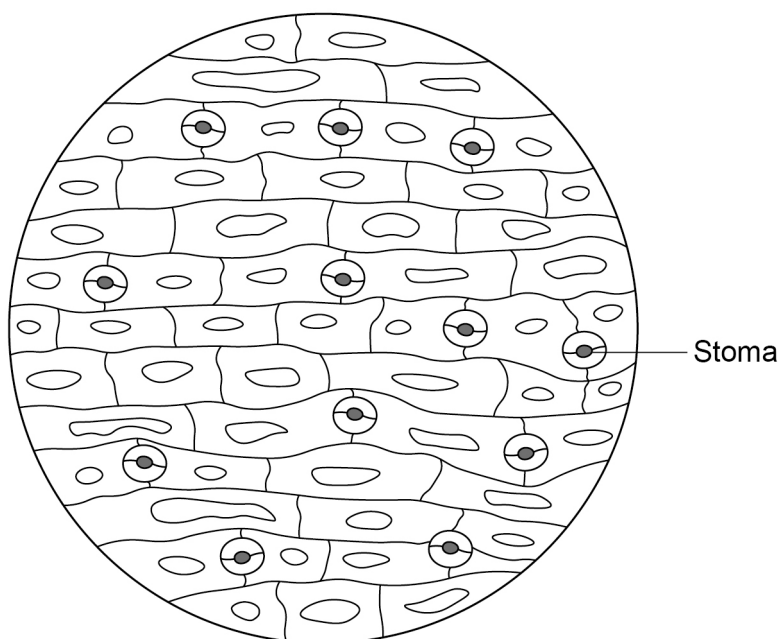
A student investigated the distribution of stomata on a leaf.

The student:

- observed one area of the lower surface of a leaf using an optical microscope
- counted all the stomata.

Figure 7 shows the area of the leaf the student observed.

Figure 7



The diameter of the field of view was 0.36 mm

0 4 . 1

Use **Figure 7** and the information provided to calculate the stomatal density of the lower leaf surface.

The area of a circle can be calculated using the formula πr^2

For π use 3.14

Give your answer to 2 significant figures.

[3 marks]

$$r = 0.36 / 2 = 0.18 \text{ mm}$$

$$\text{Area} = 3.14 \times 0.18^2 = 0.1017 \text{ mm}^2$$

$$12 \text{ stomata} / 0.1017 = 117.96 \text{ stomata mm}^{-2}$$

Answer 120 stomata mm^{-2}



0 4 . 2

Suggest **one** improvement the student could make to obtain a more reliable value for stomatal density.

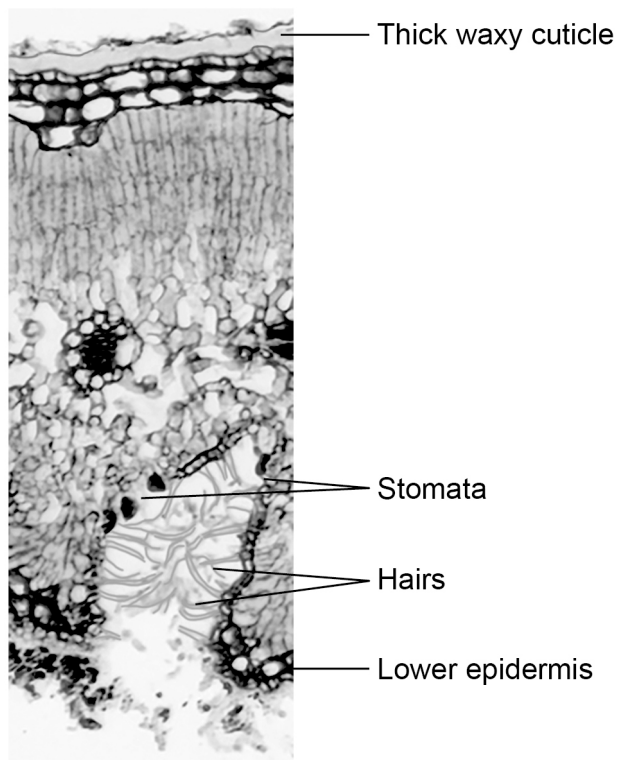
[1 mark]

Count the number of stomata in many (at least 10) different fields of view across the leaf and calculate a mean.

0 4 . 3

Figure 8 shows a transverse section of a leaf from a xerophytic plant.

Figure 8



Explain how **one** feature shown in **Figure 8** reduces water loss from the leaf.

[1 mark]

Feature *Sunken stomata with hairs*

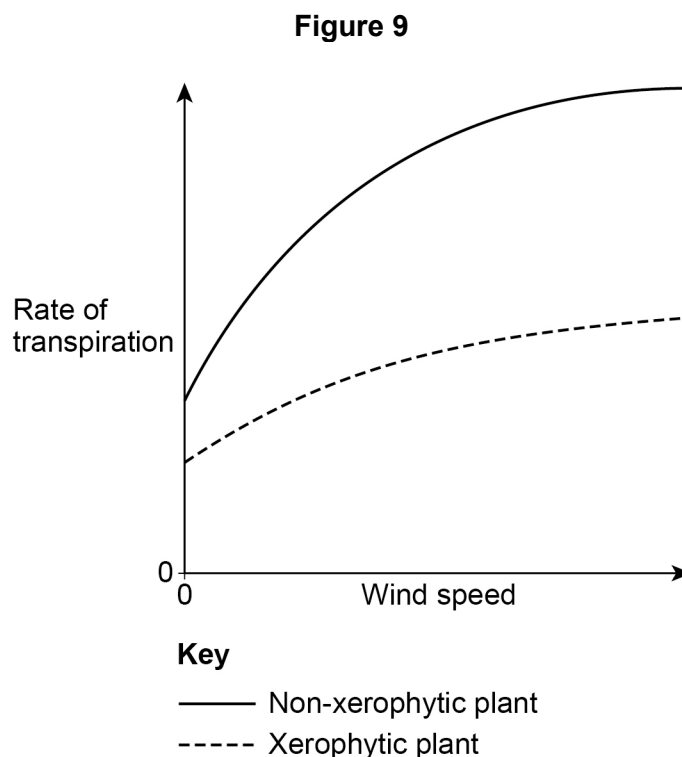
How it reduces water loss *The stomata are in pits surrounded by hairs which trap water vapour, so the air stays humid and the water potential gradient is reduced, so less water evaporates out.*

Question 4 continues on the next page

Turn over ►



Figure 9 shows the effect of wind speed on the rate of transpiration of a xerophytic plant and a non-xerophytic plant.



0 4 . 4

Give **two** conclusions that can be made from **Figure 9**.

[2 marks]

1 *As wind speed increases, the rate of transpiration increases in both plants, but at a slower and slower rate (it levels off).*

2 *The rate of transpiration is always higher in the non-xerophytic plant, and higher wind speed has a greater effect on it; some transpiration happens in both even in still air.*



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0 5 . 1

Name the **two** types of molecule from which a ribosome is made.**[1 mark]**1 *Ribosomal RNA (rRNA)*2 *Protein***Table 2** shows some of the features of the phases of the eukaryotic cell cycle.**Table 2**

Phase	Features
First phase of interphase	Ribosomes synthesised Proteins synthesised
Second phase of interphase	DNA replicated Histones synthesised DNA associates with histones
Third phase of interphase	Accuracy of DNA replication is checked Membrane-bound organelles replicated
Stages of mitosis	Prophase, metaphase, anaphase, telophase
Cytokinesis	Cytoplasm divides Cell-surface membrane formed



0 5 . 2

Use the information in **Table 2** to give **two** similarities and **two** differences between the eukaryotic cell cycle and binary fission.

[4 marks]

Similarity 1 *Both involve DNA replication before division.*

(Both also synthesise proteins and ribosomes.)

Similarity 2 *In both the cytoplasm divides (cytokinesis), and a cell-surface membrane forms, so one cell divides into two cells.*

Difference 1 *In binary fission no histones are synthesised or associated with DNA, as prokaryotic DNA is not bound to histones.*

Difference 2 *Binary fission has no mitosis (no prophase, metaphase etc.) and no membrane-bound organelles (e.g. mitochondria) are replicated.*

0 5 . 3

The accuracy of DNA replication is checked in the third phase of interphase.

Suggest and explain **one** advantage of checking the accuracy of DNA replication.

[2 marks]

It means mutations (changes in the base sequence) can be found and repaired before the cell divides.

Otherwise a mutation could change the amino acid sequence, so the protein's tertiary structure changes and a non-functioning protein / enzyme is made, or it could lead to uncontrolled cell division and a tumour (cancer).

7

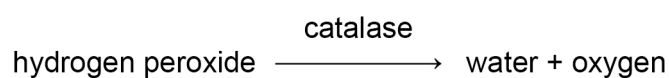
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0 6

The reaction catalysed by the enzyme catalase is shown below.

**0 6 . 1**

Use your knowledge of the induced-fit model to explain how catalase breaks down hydrogen peroxide.

[3 marks]

When hydrogen peroxide binds to catalase, the active site changes shape slightly so that it becomes complementary to the hydrogen peroxide (substrate), forming an enzyme-substrate complex.

This puts strain / tension on the bonds in the hydrogen peroxide, bending and twisting them.

So less energy is needed to break the bonds, which lowers the activation energy, and the hydrogen peroxide is broken down into water and oxygen.



Potato cells contain catalase.

A student investigates the effect of the surface area of potato pieces on the rate of the reaction of catalase.

0 6 . 2

Before starting the investigation, the student reads the following information.

Hydrogen peroxide:

- is a clear, colourless solution
- is harmful if swallowed
- causes serious eye damage
- may cause damage or irritation to the skin
- may cause respiratory irritation.

Use this information to suggest **two** safety precautions the student should take.

Give **one** reason for each safety precaution.

[2 marks]

Precaution 1 Wear safety goggles.

Reason To stop hydrogen peroxide splashing into the eyes and damaging them.

Precaution 2 Wear gloves (and a lab coat).

Reason To prevent hydrogen peroxide making contact with the skin and damaging / irritating it. (Also label all glassware, as it could be mistaken for water.)

Question 6 continues on the next page

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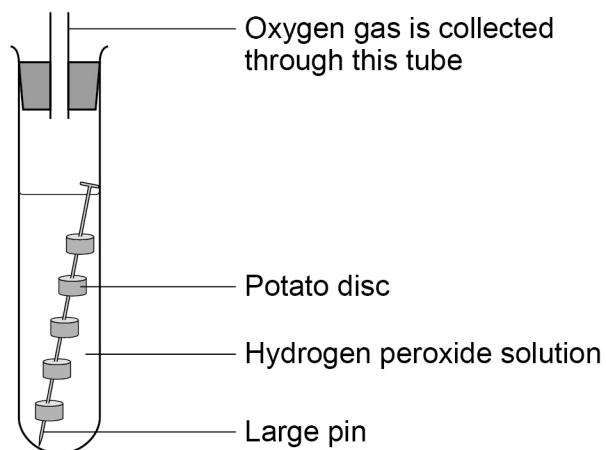


The student uses the following method.

1. Cut a 75 mm long cylinder of potato into 5 discs of equal size.
2. Arrange the discs on a large pin in a boiling tube.
3. Add 40 cm³ of 1.0 mol dm⁻³ hydrogen peroxide.
4. Record the volume of oxygen collected in 2 minutes.
5. Repeat steps 1 to 4 with an uncut cylinder of potato 75 mm long.

Figure 10 shows the equipment the student uses.

Figure 10



0 6 . 3

Suggest why the student arranges the potato discs on the pin as shown in **Figure 10**.
[1 mark]

So that all of the surface of every disc is exposed to the hydrogen peroxide (substrate), rather than discs lying on top of each other.



Table 3 gives measurements for one potato disc and the uncut potato cylinder used in the investigation.

Table 3

	Length (L) / mm	Diameter / mm
One potato disc	15	10
Uncut potato cylinder	75	10

0 6 . 4

Calculate how many times greater the total surface area of the five discs of potato is compared with the surface area of the uncut cylinder.

Use the information in **Table 3** and the formula below.

The formula for the surface area of a disc or cylinder = $2\pi r(r+L)$

where

r = radius

L = length

$\pi = 3.14$

[3 marks]

$$\text{One disc: } 2 \times 3.14 \times 5 \times (5 + 15) = 628 \text{ mm}^2$$

$$\text{Five discs: } 5 \times 628 = 3140 \text{ mm}^2$$

$$\text{Cylinder: } 2 \times 3.14 \times 5 \times (5 + 75) = 2512 \text{ mm}^2$$

$$3140 / 2512 = 1.25$$

1.25 times greater

0 6 . 5

The rate of reaction is faster with the five discs of potato than with the uncut potato cylinder.

Explain why.

[1 mark]

The five discs have a larger total surface area, so more catalase is exposed and more enzyme-substrate complexes form per second.

10

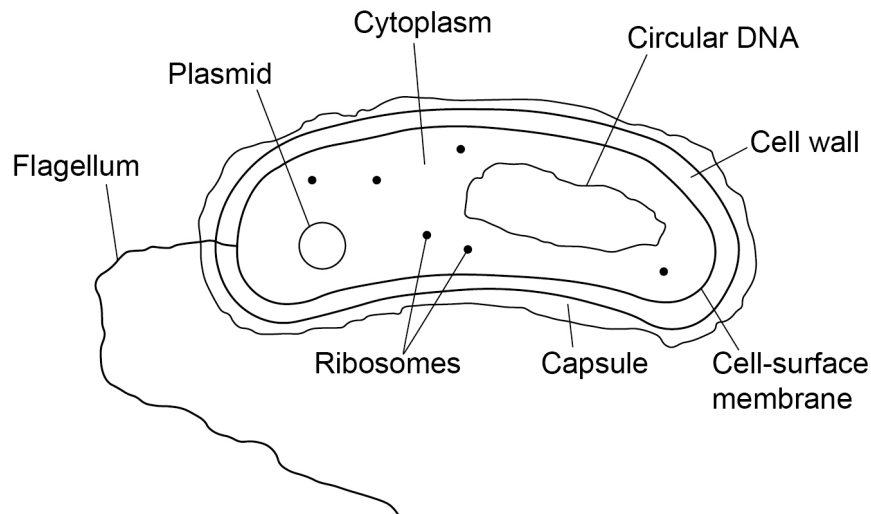
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0 7 . 1

Figure 11 shows the structure of the bacterium *Vibrio cholerae*.

Figure 11



Name **three** structures shown in **Figure 11** that are **not** found in all bacteria.

[2 marks]

1 Flagellum

2 Plasmid

3 Capsule

0 7 . 2

V. cholerae produces a toxin that only binds to the cell-surface membrane of epithelial cells lining the ileum. The toxin is a protein.

Explain why the toxin can only bind to the cell-surface membrane of epithelial cells in the ileum.

[2 marks]

The toxin is a protein, so it has a specific tertiary structure (shape).

Only the receptors on the cell-surface membrane of ileum epithelial cells

have a shape that is complementary to the toxin, so it can only bind to these.



07.3

The toxin causes chloride ion channels in the cell-surface membrane to open. Chloride ions diffuse into the ileum. This causes diarrhoea (watery faeces).

Use your knowledge of water potential to explain how an increase of chloride ions in the ileum results in diarrhoea.

[2 marks]

*The chloride ions lower the water potential of the contents of the ileum
(make it more negative) than in the epithelial cells.
So water moves out of the epithelial cells into the ileum by osmosis
(and is not absorbed back), making the faeces watery.*

Question 7 continues on the next page

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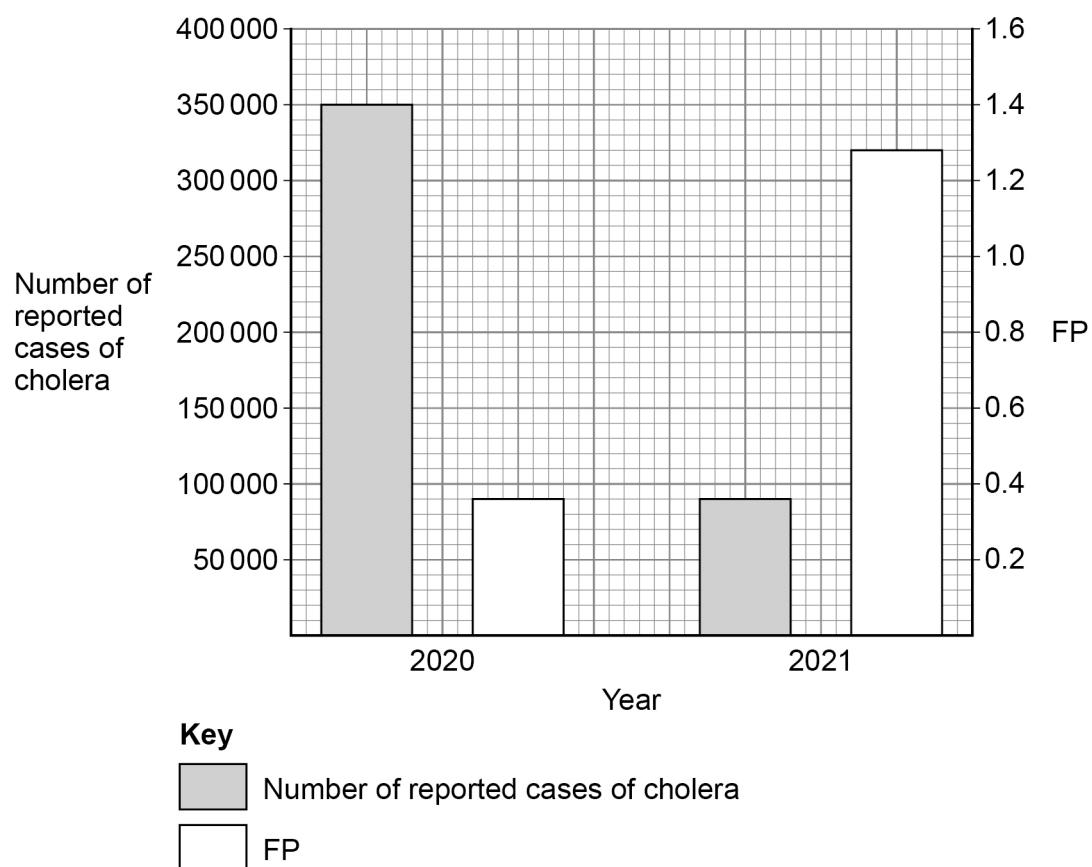
V. cholerae causes the disease cholera.

The Fatality Percentage (FP) is the percentage of people diagnosed with cholera who die from it.

Figure 12 shows:

- the number of reported cases of cholera in a population for the years 2020 and 2021
- the FP for cholera for the years 2020 and 2021.

Figure 12



07.4

Using **Figure 12** and the information provided, calculate the difference in the number of deaths from cholera in 2020 and 2021.

[2 marks]

$$2020: 350\,000 \times 0.36 / 100 = 1260 \text{ deaths}$$

$$2021: 90\,000 \times 1.28 / 100 = 1152 \text{ deaths}$$

$$1260 - 1152 = 108$$

Difference in the number of deaths 108

07.5

The calculated numbers of deaths from cholera, in 2020 and 2021, are lower than the true number of deaths.

Using the information suggest **one** reason why.

[1 mark]

Only reported cases are used; not all cases are reported or diagnosed as cholera (misdiagnosis), so some deaths are not counted.

9

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0 8

Table 4 shows the changes in the number of HIV RNA particles and helper T cells (T_H cells) in a person infected with HIV who was not receiving any treatment.

Table 4

Time after infection / years	HIV RNA particles per cm^3 of blood	T_H cell count / cells per mm^3 of blood
0	0	1000
1	80 000	305
2	20 000	854
6	22 000	812
10	70 000	597
11	120 000	150
12	135 000	5

0 8 . 1

A scientist concluded that other infections are more likely to develop in this person after 11 years.

Use the data in **Table 4** and your own knowledge of the immune response to explain the scientist's conclusion.

[3 marks]

After 11 years the number of helper T cells falls greatly, from 597 to 150 and then to only 5 cells per mm^3 at 12 years, as HIV particles rise to 120 000 to 135 000 per cm^3 .

Helper T cells stimulate B cells, so fewer B cells undergo clonal selection and divide by mitosis (clonal expansion).

So fewer plasma cells are produced to make antibodies (and fewer cytotoxic T cells are activated), so the person cannot fight off other pathogens.



One type of infection is pneumonia, caused by the bacterium *Streptococcus pneumoniae*.

A trainee microbiologist cultured *S. pneumoniae* on an agar plate.

The trainee microbiologist:

- disinfected the laboratory bench
- used a sterile pipette to transfer *S. pneumoniae* from a broth bottle to an agar plate
- took a glass spreader and spread the *S. pneumoniae* across the agar plate
- sealed the lid with four strips of tape.

0 8 . 2

Suggest **one** other action the trainee microbiologist took during this method to ensure the technique was aseptic.

Justify why this action was needed.

Do **not** refer to gloves, masks or safety glasses in your answer.

[2 marks]

Action Flamed the glass spreader (dipped in ethanol and passed through a Bunsen flame) before using it, and worked close to a Bunsen burner.

Justification To kill any microorganisms on the spreader so the plate is not contaminated and the culture stays pure; the flame's upward air current carries contaminants away from the dish.

5

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Describe how meiosis results in haploid cells and how it increases genetic variation.

[5 marks]

Meiosis involves two divisions (meiosis I and meiosis II) which produce four haploid cells from one diploid cell.

In the first division the homologous chromosomes pair up and are separated into two cells, halving the chromosome number.

In the second division the sister chromatids of each chromosome are separated, giving four haploid cells.

Genetic variation is increased by independent segregation (assortment) of homologous chromosomes: the maternal and paternal chromosomes of each pair line up randomly, so they are reshuffled into many different combinations.

Crossing over also occurs in meiosis I: chromatids of homologous chromosomes wrap around each other and exchange sections, so alleles are exchanged and new combinations of alleles are produced.



09.2

Describe **and** explain how tissue fluid is formed and how it is returned to the circulatory system.

[5 marks]

At the arterial end of a capillary the hydrostatic (blood) pressure is high, higher than the osmotic effect of the plasma proteins.

This forces water and small molecules such as glucose, amino acids and ions out of the capillary into the spaces between cells, forming tissue fluid.

Large plasma proteins (e.g. albumin) are too big to leave, so they remain in the capillary.

At the venous end the hydrostatic pressure is lower. The plasma proteins give the blood a lower (more negative) water potential than the tissue fluid, creating a water potential gradient.

So water moves back into the capillary by osmosis.

Excess tissue fluid enters the lymph capillaries and is returned to the blood through the lymphatic system.

10

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