



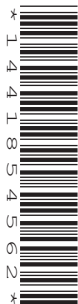
Oxford Cambridge and RSA

Thursday 23 May 2024 – Morning

AS Level Biology B (Advancing Biology)

H022/02 Biology in depth

Time allowed: 1 hour 30 minutes



You can use:

- a scientific or graphical calculator
- a ruler (cm/mm)



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

First name(s)

--

Last name

StemUp Model Solution

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for a correct method, even if your answer is wrong.

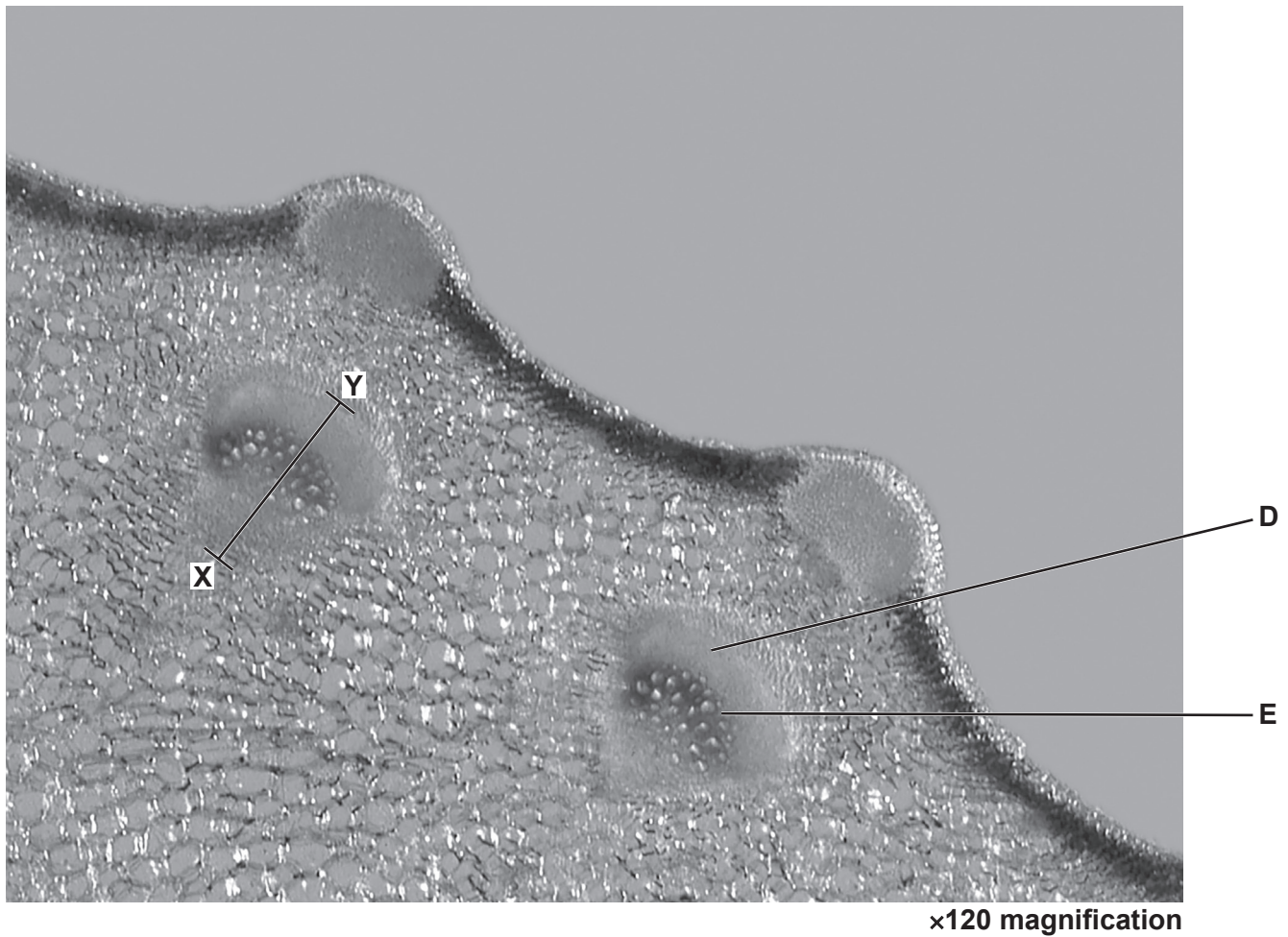
INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [].
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE

- Read each question carefully before you start your answer.

- 1 The image below shows a transverse section of stem from a celery plant seen through a light microscope.



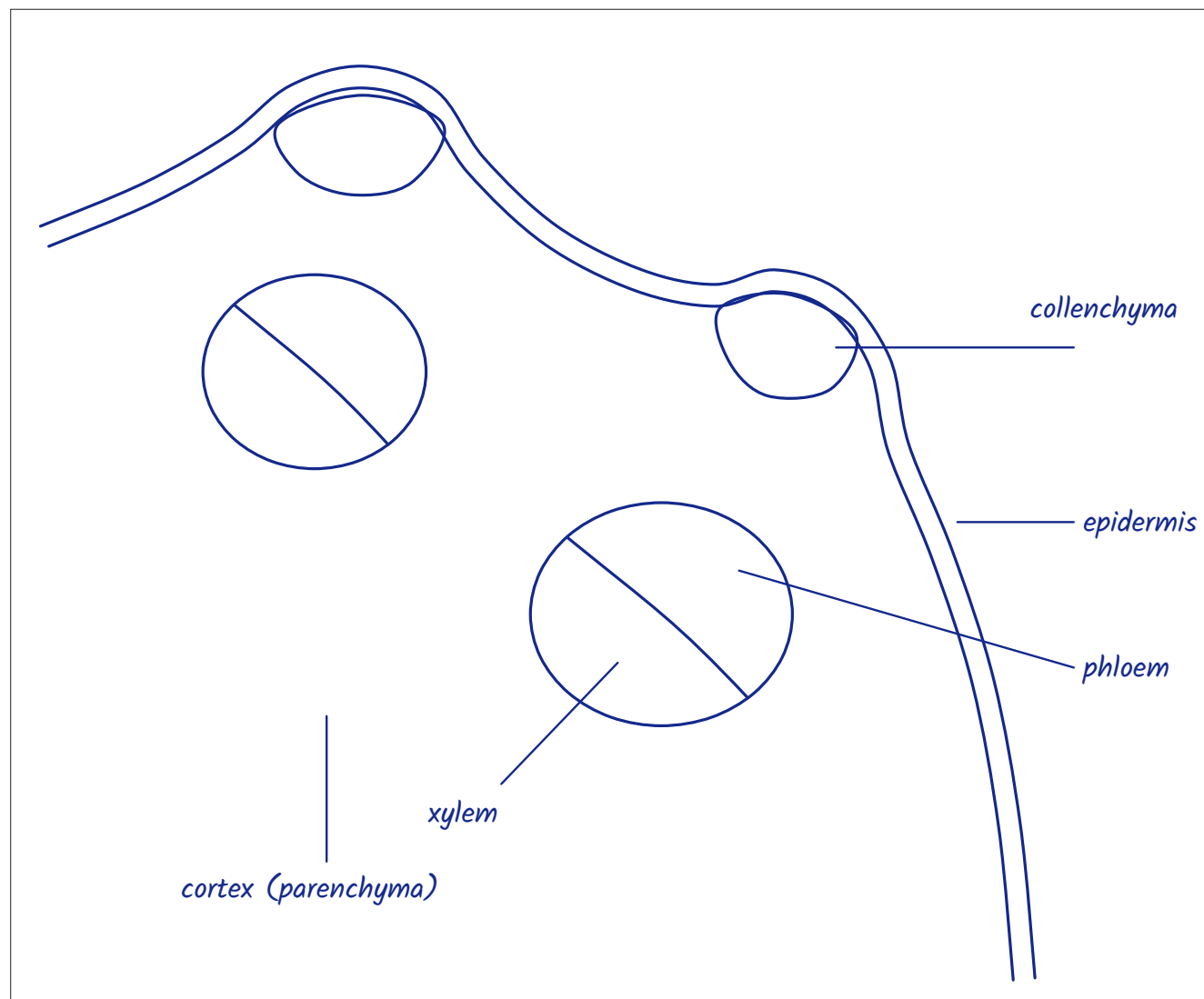
- (a)
(i) State the functions of tissues **D** and **E**.

D *phloem: transports assimilates, e.g. sucrose (translocation)*.....

E *xylem: transports water and mineral ions*.....

[2]

(ii) Using this image, produce a low power plan drawing of the stem tissues.



[3]

(iii) Calculate the actual length of the structure between X–Y.

$$\text{length of X to Y on image} = 27 \text{ mm} = 27\,000 \mu\text{m}$$

$$\text{actual length} = \text{image length} \div \text{magnification}$$

$$= 27\,000 \div 120 = 225 \mu\text{m}$$

Actual length = ...225..... μm [2]

- (b)* A teacher wanted their students to investigate how the presence of leaves changes the rate of transpiration in celery plants.

The teacher supplied the students with the following equipment and materials to choose from.

Balance	Beaker	Celery plant
Food colouring	Ruler	Scalpel
Stop clock	Vegetable oil	Water

Using only the equipment and materials supplied, plan a method to investigate how the presence of leaves changes the rate of transpiration in celery stems.

Include details of the variables involved.

Independent variable: presence or absence of leaves. Dependent variable: change in mass of the beaker of water over a set time.

Cut two celery stems of the same length with the scalpel, cutting at an angle and under water so no air enters the xylem. Remove all the leaves from one stem; leave the leaves on the other.

Dry off any surface water. Stand each stem in a beaker with the same volume of water, then add a layer of vegetable oil on top of the water to stop evaporation from the water surface.

Place the beaker on the balance, record the starting mass and start the stop clock. Record the mass again after a set time, e.g. every 10 min for 1 hour.

(Alternatively add food colouring and use the ruler to measure the distance the colour moves up the stem in the set time.)

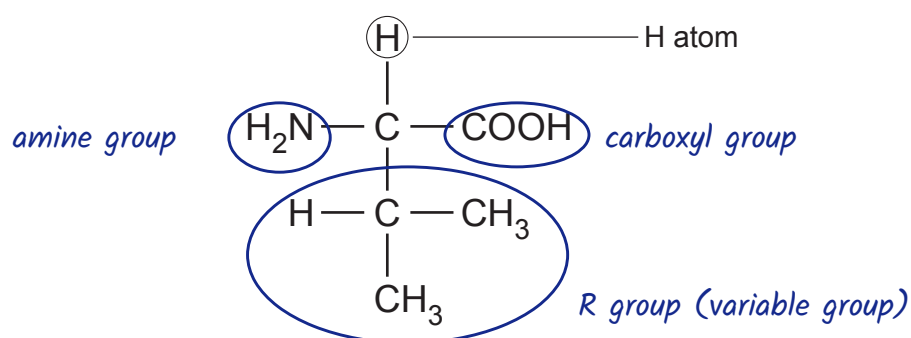
Rate of transpiration = mass lost $\div$ time (g min^{-1}). Repeat 3 times for each condition with new stems and calculate a mean; use a t-test to see if the difference between the means is significant. [6]

Extra answer space if required.

Control variables: temperature, humidity, light intensity and air movement, by doing all tests in the same room at the same time away from windows and fans; also use stems of the same size from the same celery plant.

- 2 Amino acids have the same general structure with four different chemical groups attached to a central carbon atom.

The structure of the amino acid valine is shown in the diagram.



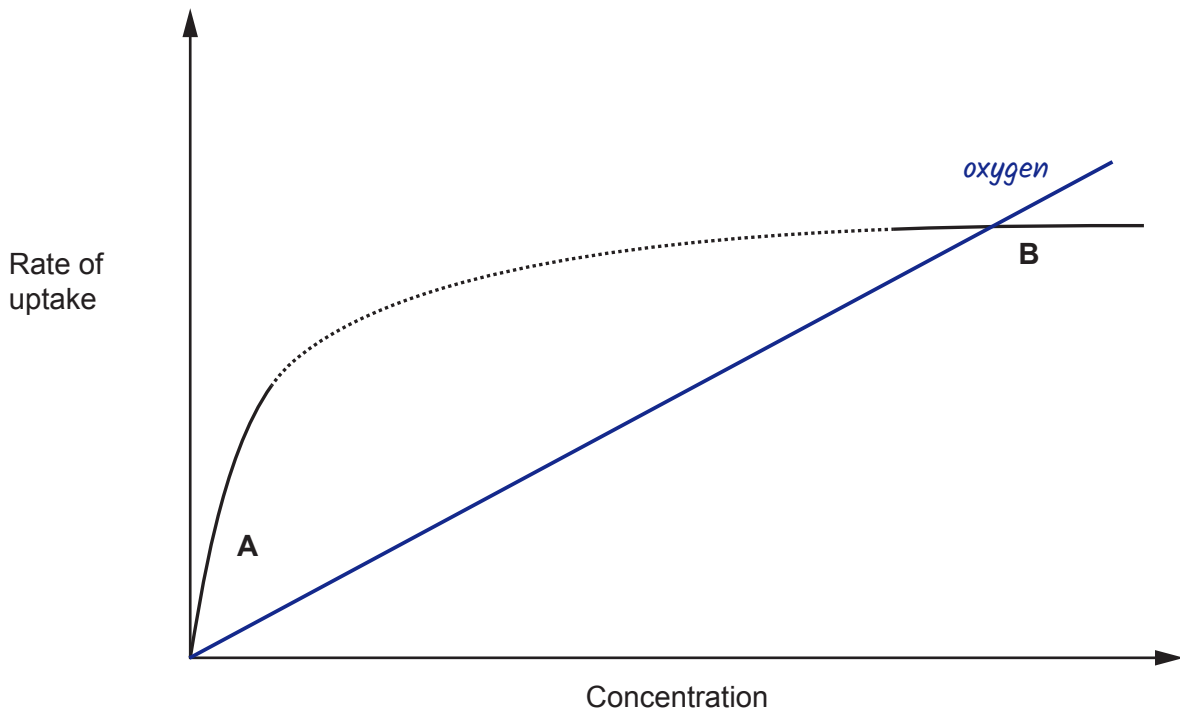
- (a) One of the chemical groups in valine has been labelled on the diagram.

Circle and label **two** other chemical groups in valine **on the diagram**.

[2]

- (b) Amino acids are taken up by some cells to produce enzymes.

The graph shows the rate of uptake of amino acids by cells in the salivary glands.



- (i) Using your knowledge of transport of molecules across membranes, explain the shape of the curve at region A and at region B.

Region A *the rate increases as concentration increases because there are free carrier proteins available, so the concentration of amino acids is the limiting factor*

Region B *the rate levels off because all the carrier proteins are saturated (occupied), so the number of carrier proteins is now the limiting factor*

[2]

- (ii) Cells in the salivary glands require oxygen for aerobic respiration.

Draw a line **on the graph** to show the rate of uptake of oxygen by the cells of the salivary glands as the concentration of oxygen increases.

[1]

(c)* Amylase is an enzyme produced by cells in the salivary glands.

Amylase is secreted from the cells to break down starch in the mouth.

Explain how the organelles in salivary cells work together to secrete amylase with the specific shape needed to break down starch.

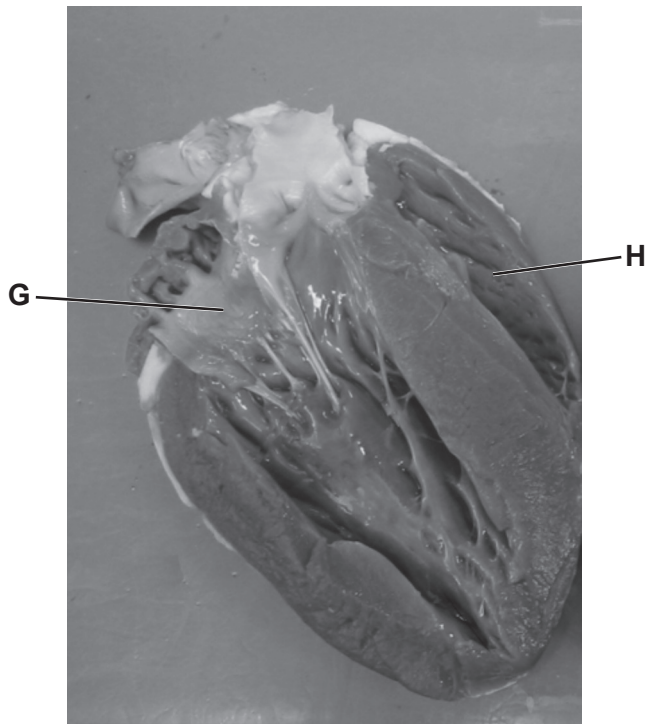
The amylase gene in the nucleus is transcribed into mRNA, which leaves the nucleus through a nuclear pore and attaches to ribosomes on the rough endoplasmic reticulum (RER). The ribosomes read the mRNA codons and join amino acids in a specific order by peptide bonds. This sequence of amino acids is the primary structure of amylase. The polypeptide is transported through the RER, where it folds into its secondary structure (alpha helices and beta pleated sheets held by hydrogen bonds). It then folds further into a specific 3D globular tertiary structure held by hydrogen, ionic and disulfide bonds between R groups. This folding forms the active site with a specific shape that is complementary to starch, so enzyme-substrate complexes can form. The RER packages the protein into vesicles which move to and fuse with the Golgi apparatus. The Golgi modifies the protein (e.g. adds carbohydrate) and [6]

Extra answer space if required.

repackages it into secretory vesicles. The secretory vesicles move to the cell surface membrane, fuse with it and release amylase by exocytosis. Mitochondria provide ATP for protein synthesis, vesicle movement and exocytosis.

3

(a) The image shows a dissected mammalian heart.



(i) Name the structures labelled **G** and **H**.

G *bicuspid valve (left atrioventricular valve)*

H *right ventricle*

[2]

(ii) State **two** safety precautions that should be taken during a heart dissection **and** explain why each is important.

Precaution 1 *use a sharp scalpel and cut away from yourself and others*

Explanation *a blunt scalpel is more likely to slip, so this reduces the risk of cutting yourself (injury)*

Precaution 2 *wear gloves, cover cuts, wash hands and disinfect equipment*

Explanation *the heart tissue may contain pathogens, so this reduces the risk of infection*

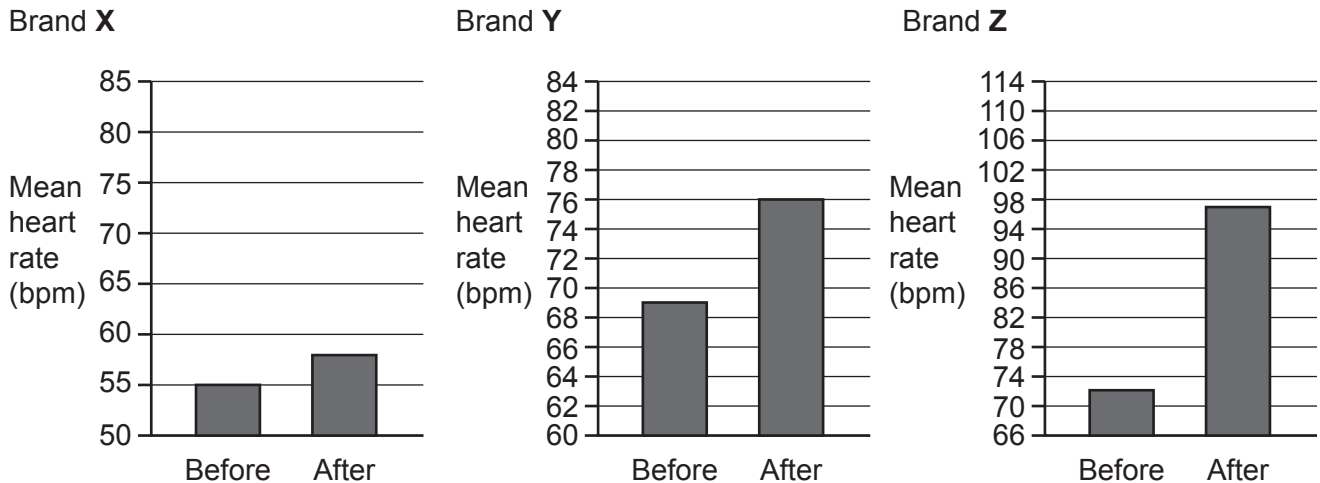
[2]

- (b) High energy caffeine drinks are becoming more popular with young adults.

A scientist investigated the effect of different brands of high energy caffeine drinks on the heart rate of 60 volunteers.

The resting heart rate of each volunteer was taken before drinking each brand of energy drink and again two hours later.

The results of the investigation are shown below.



- (i) All the volunteers were aged between 20–24 years of age.

State **one** other factor that should be controlled to make the results valid.

..the..volume..of..energy..drink..each..volunteer..drinks..... [1]

- (ii) The mean cardiac output of the group given brand Y was $4900 \text{ cm}^3 \text{ min}^{-1}$ before taking the drink and $5800 \text{ cm}^3 \text{ min}^{-1}$ two hours after taking the drink.

Calculate the increase in stroke volume two hours after taking the high energy caffeine drink.

$$\text{stroke volume} = \text{cardiac output} \div \text{heart rate}$$

$$\text{before: } 4900 \div 69 = 71 \text{ cm}^3$$

$$\text{after: } 5800 \div 76 = 76 \text{ cm}^3$$

$$\text{increase} = 76 - 71 = 5 \text{ cm}^3$$

$$\text{Increase in stroke volume} = \dots\dots\dots 5 \dots\dots\dots \text{ cm}^3 \text{ [2]}$$

- (iii) The difference in mean heart rate between the three groups could be due to the different glucose content of each drink.

Suggest how the scientist could improve the method to show that caffeine is responsible for increasing heart rate.

Give a reason for your answer.

Improvement *add a control group given a drink with the same glucose content but no caffeine (glucose drink only), all else kept the same*

Reason *to show that glucose does not increase heart rate, so any increase in heart rate is due to the caffeine*

[2]

- (iv) The cardiac output of all the volunteers increased after taking the high energy caffeine drink.

Caffeine can affect the activity of the sino-atrial node (SAN) of the heart.

Explain how caffeine could affect the coordination of heart activity leading to an increase in cardiac output.

Caffeine stimulates the SAN, so it sends out waves of excitation more frequently.

The wave of excitation spreads across the atria, so the atrial walls (cardiac muscle) contract more frequently.

The AV node picks up the impulse and, after a short delay, transfers it down the bundle of His and Purkyne fibres to the ventricles.

The ventricle walls contract more frequently, from the apex upwards, so the heart rate increases.

With stronger contractions the ventricles fill more and eject a greater volume of blood (stroke volume), so cardiac output (heart rate $\times$ stroke volume) increases. [4]

PLEASE DO NOT WRITE ON THIS PAGE

4

(a) Species can be classified based on a taxonomic hierarchy.

(i) What is meant by the term **hierarchy** in this context?

organisms are grouped by shared common features into ranks; small groups fit inside larger ones, getting smaller and more exclusive going up [1]

(ii) Two concepts used in classifying organisms are the biological species concept and the phylogenetic species concept.

Describe the difference between these two concepts.

Biological species concept: a species is a group of individuals that are able to interbreed to produce fertile offspring.

Phylogenetic species concept: a species is a group of individuals that share a recent common ancestor (the same evolutionary history), based on e.g. DNA similarity. [2]

(b) Cytochrome c is a protein found in mitochondria.

Scientists can sequence the order of amino acids in cytochrome c and use the results to show similarities between different species.

(i) State **one** other type of molecule, apart from proteins, that can be sequenced in order to classify organisms.

DNA (nucleic acid) [1]

- (ii) The table shows the number of differences in the amino acid sequence of cytochrome c of some animal species compared to humans.

Species	Number of differences in the amino acid sequence of cytochrome c compared to humans
Chimpanzee	1
Rabbit	4
Horse	5
Chicken	6
Frog	8
Shark	13

A scientist concluded that the chimpanzee is the most closely related species to humans.

Describe **one** reason why the information in the table supports the scientist's conclusion and **one** reason why it does **not** support the conclusion.

Conclusion **is** supported because *only one amino acid is different between chimpanzee and human cytochrome c, the fewest of all the species*

Conclusion **is not** supported because *only 6 species were investigated and only one protein (cytochrome c) was compared, so other species not studied may be closer*

[2]

- (iii) The scientist also concluded that rabbits and horses are as closely related to each other as humans are to chimpanzees.

Explain why this might **not** be true.

The data only compare each species with humans; rabbits and horses have not been compared directly with each other.
The different amino acids may be at different positions in the sequence, so rabbits and horses could have up to 9 differences from each other.

[2]

5

- (a) Snake venom is a type of poison injected into the body during a bite from a venomous snake.

Some snake bites can be treated using antivenom.

Antivenom contains antibodies that have been produced by a horse.

To make antivenom, horses are given a small dose of snake venom.

- (i) Explain how a horse produces antibodies when it is given snake venom.

Specific B lymphocytes with complementary receptors bind to the antigens on the venom proteins (clonal selection).

These B lymphocytes divide by mitosis (clonal expansion) and differentiate into plasma cells.

The plasma cells produce and secrete specific antibodies against the venom. [2]

- (ii) The horses produce a small quantity of antibody the first time they are used to produce antivenom.

When they are given doses of venom on future occasions they produce larger quantities of antibody.

Explain why the horses produce larger quantities of antibody after the first dose of antivenom.

After the first dose, memory cells specific to the venom are produced and stay in the blood.

On later doses the memory cells recognise the venom quickly, so the secondary response is faster and larger: more plasma cells are made, which produce more antibody. [2]

- (iii) The dose of venom given to different horses is calculated in $\mu\text{g kg}^{-1}$ of body mass.

Suggest why the dose is calculated based on the horse's body mass.

horses have different body masses, so the dose is matched to the size of each horse to give a comparable (standardised) dose. [1]

- (b) *Daboia siamensis* is a species of snake native to Southeast Asia.

To produce antivenom for *Daboia siamensis*, a 600 kg horse is given a dose of $3.5 \mu\text{g kg}^{-1}$ of body mass.

The venom yield of one snake is 78 mg.

Calculate the maximum number of antivenom doses that can be produced from one snake.

$$\text{dose per horse} = 600 \times 3.5 = 2100 \mu\text{g} = 2.1 \text{ mg}$$

$$\text{number of doses} = 78 \div 2.1 = 37.1$$

$$\text{maximum (whole doses)} = 37$$

Maximum number of antivenom doses = ...37..... [2]

- (c) There is a small risk that patients might have an allergic reaction to antivenom if they are given a particular antivenom more than once.

Explain what causes an allergic reaction.

..The patient's immune system recognises the horse antibodies as foreign (as
 ..antigens), causing an immune response.....
 ..Antibodies made after the first dose attach to mast cells; on a later dose the
 ..horse proteins bind to these antibodies on the mast cells, which release
 ..histamine, causing inflammation (the allergic reaction)..... [2]

- (d) Some snake venoms contain a toxin made of protein, called cytotoxin.

Cytotoxin can bind to the membrane of blood cells causing damage to the cell.

- (i) Suggest how antivenom acts on cytotoxin to prevent damage to the cell.

Antibodies in the antivenom bind to the specific (complementary) cytotoxin proteins in the venom, causing agglutination. This prevents the cytotoxin binding to or entering the blood cell membrane, and the clumped toxin is destroyed by phagocytes.

[2]

- (ii) Cytotoxin has both polar and non-polar regions.

Suggest how cytotoxin binds to the membrane and causes damage to the blood cells.

The non-polar region fits into the hydrophobic fatty acid tails of the phospholipid bilayer, while the polar region binds to the phosphate heads. This creates pores (holes) in the membrane, so the contents of the blood cell leak out and the cell lyses.

[2]

- (iii) Cytotoxin can cause the death of T lymphocytes.

Explain why even if a patient receives the correct antivenom immediately after a snake bite, they can be more vulnerable to other infections for months afterwards.

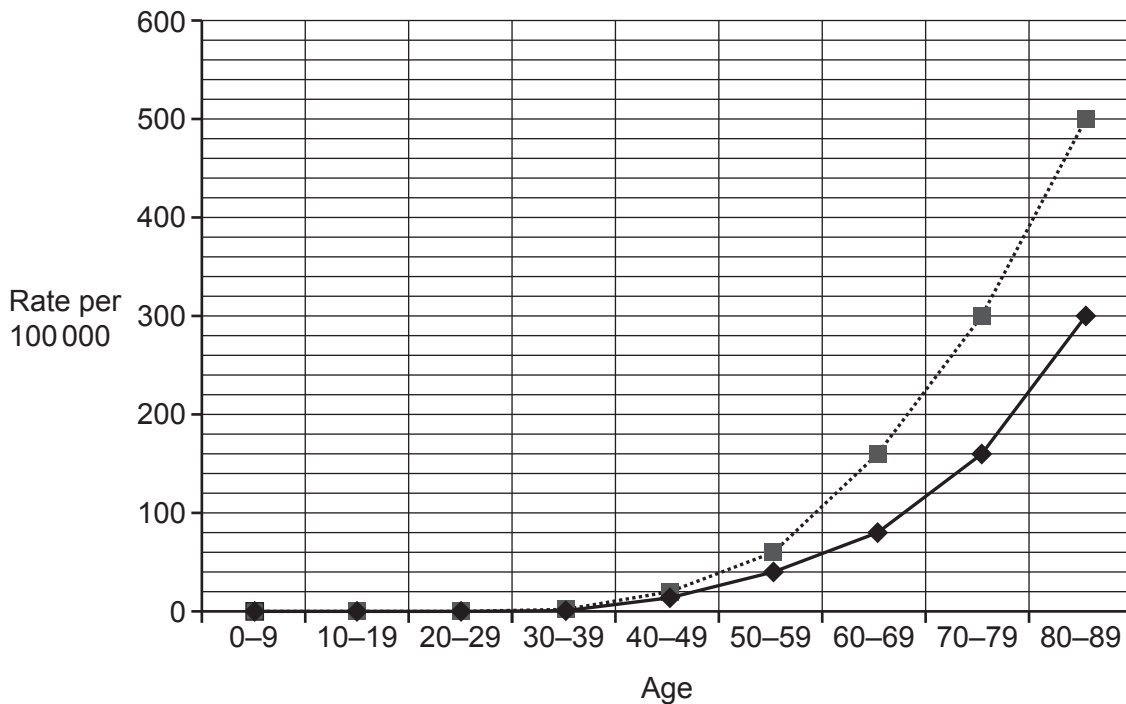
Fewer T helper cells, so fewer B lymphocytes are stimulated to divide and produce antibodies. Fewer cytotoxic T cells to destroy infected self cells, and fewer memory cells, so the response to a second infection takes longer.

[2]

6

- (a) Bowel cancer is the term used to describe the development of a tumour in the large intestine.

The graph shows the rate of bowel cancer in different age groups.



Key: —◆— Female ■..... Male

- (i) Calculate the percentage increase in the rate of bowel cancer in females from age 50–59 to age 80–89.

females 50 to 59 = 40; 80 to 89 = 300 per 100 000

increase = 300 – 40 = 260

% increase = (260 ÷ 40) × 100 = 650%

Percentage increase = ...650..... % [2]

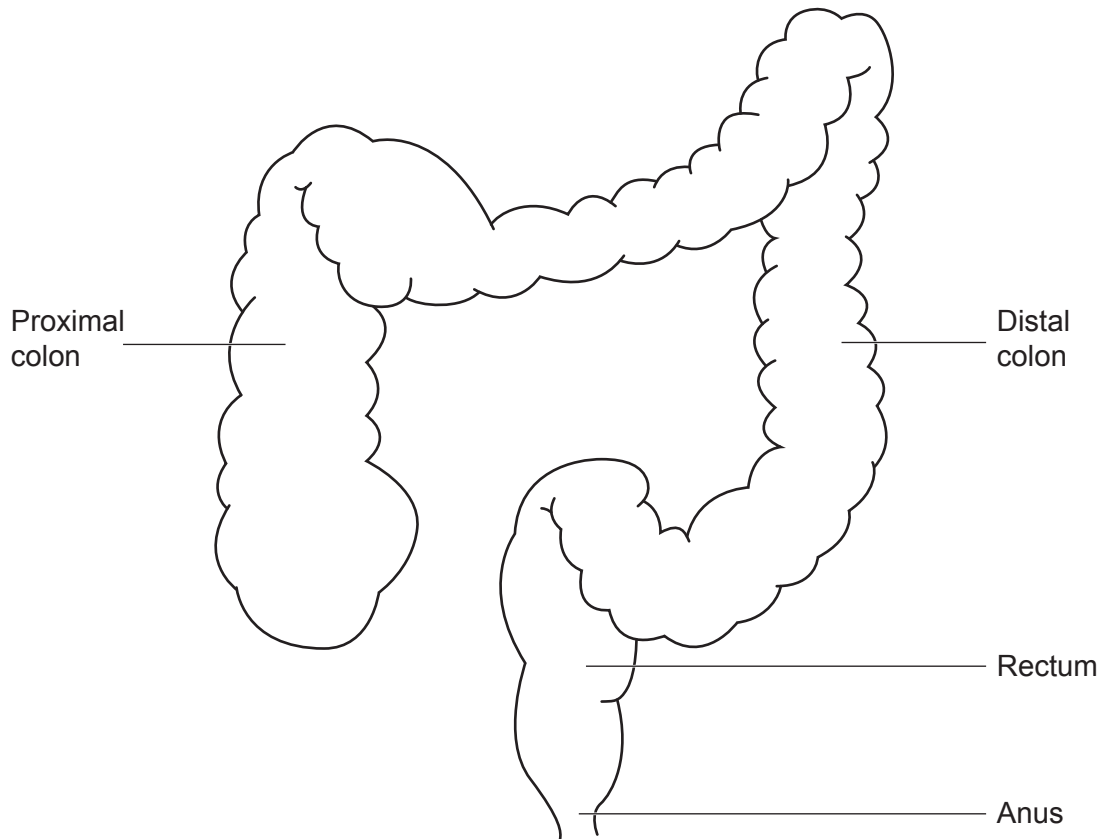
- (ii) 53% of patients survive for ten years after diagnosis.

A student stated that, 'Almost half of all patients die from bowel cancer within ten years'.

Give **one** reason why the student's claim is unlikely to be true.

some of the patients who die within ten years may have died from other causes, not from bowel cancer [1]

(b) The diagram shows the different regions that make up the large intestine.



- (i) The mortality rate is higher in people suffering from cancer in the proximal colon than in the other regions.

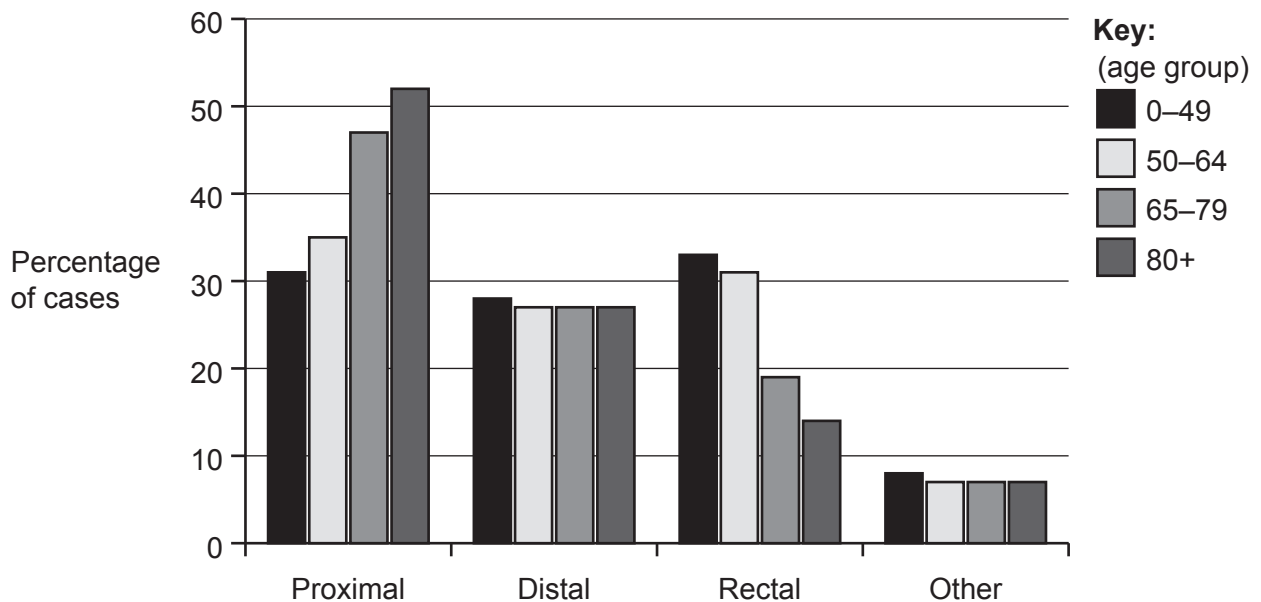
Suggest why a patient is at greater risk of death if they have a tumour in the proximal colon.

A tumour in the proximal colon is harder to diagnose, as symptoms (e.g. blood in faeces) are less noticeable, so medical help is sought later and the cancer is more likely to have spread (metastasised). It is also further from the anus, so it is harder to reach and treat.

[2]

(ii) The graph shows the percentage of bowel cancer cases in different regions of the large intestine.

The bars show the percentages in different age groups.



Until 2021 only people over the age of 60 were eligible for routine bowel cancer screening.

In 2021 the eligibility age was reduced to 56 years old.

Using the information in the graph, evaluate the decision to change the eligibility age.

Supports the change: the percentage of proximal tumours increases with age (from 35% at 50 to 64 to 52% at 80+), and distal tumours are similar in all age groups (about 27%), so people aged 56 to 60 also benefit from screening.

Does not support it: rectal tumours decrease with age (33% at 0 to 49, 14% at 80+), and the 50 to 64 group is similar to 0 to 49, so younger people are at similar risk and screening could start even earlier.

However, the graph shows percentages, not numbers of cases.

[3]

(iii) Bowel cancer can be diagnosed using a number of diagnostic techniques.

A biopsy or a PET scan are two common techniques.

Give **two** reasons why a doctor may choose to use a PET scan instead of a biopsy.

- 1 *a PET scan is less invasive (no tissue is removed), so it is less painful than a biopsy*
- 2 *a PET scan can detect smaller tumours and shows if the cancer has spread elsewhere*

[2]

END OF QUESTION PAPER

[illegible]

Copyright Information

If OCR has unwittingly failed to correctly acknowledge or clear any third-party content in this assessment material, OCR will be happy to correct its mistake at the earliest possible opportunity.

OCR is part of Cambridge University Press & Assessment, which is itself a department of the University of Cambridge.

stemup.co.uk