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Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

INTERNATIONAL AS BIOLOGY (9610)

Unit 2 Biological systems and disease

Wednesday 16 May 2018 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.
- 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
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TOTAL	



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

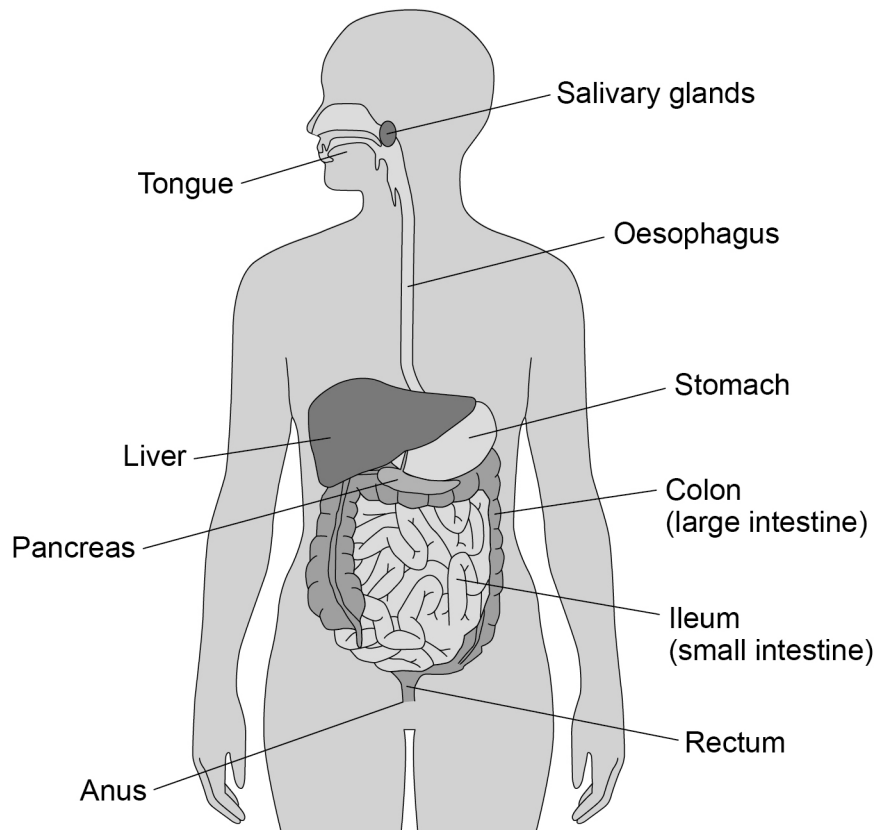
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0 1

Amylase is a digestive enzyme.

Figure 1 shows the human digestive system.

Figure 1



0 1 . 1

Name **two** organs that produce the enzyme amylase.

[1 mark]

1 Salivary glands

2 Pancreas



0 1 . 2

A student carries out an experiment to investigate the action of amylase on starch. Bread contains starch.

Volunteers chew a small piece of bread for 30 seconds. The chewed bread mixed with saliva is collected into a test tube. As a control, a piece of bread is also blended with distilled water and put in a test tube. Both test tubes are heated with Benedict's reagent.

The results are shown in **Table 1**.

Table 1

	Colour after heating with Benedict's reagent
Bread in saliva	Brick red
Bread in distilled water	Pale blue

The student concludes that starch must be directly broken down into glucose by salivary amylase.

Evaluate this conclusion.

[3 marks]

The conclusion could be correct, as the brick red colour with Benedict's reagent shows that the chewed bread contains a reducing sugar, which could be glucose.

However, the conclusion is not valid, because glucose is not the only reducing sugar: maltose is also a reducing sugar.

Amylase hydrolyses starch to maltose (a reducing sugar), so this would also give a positive (brick red) result; the test does not show that glucose is produced directly.

Turn over ►



0	1	.	3
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Absorption occurs in the ileum.

Give **three** ways in which the walls of the ileum are adapted for absorption of glucose.
[3 marks]

- 1 Villi and microvilli provide a large (increased) surface area for absorption.
- 2 Thin walls (one cell thick epithelium, capillaries near the surface) decrease the diffusion pathway.
- 3 Channel and carrier proteins for glucose in the membranes for facilitated diffusion and co-transport (active transport); a good blood supply (many capillaries) maintains a concentration gradient.

7



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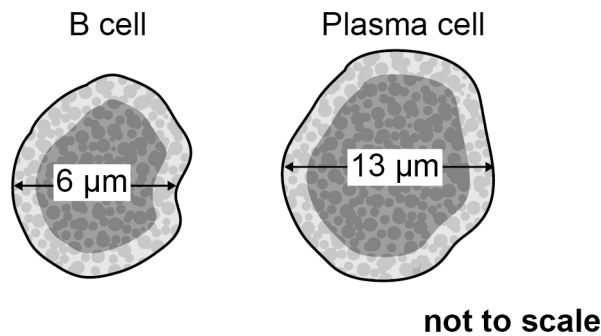


0 2

B cells are white blood cells. Once activated they can develop into plasma cells which produce large numbers of antibodies. Plasma cells are larger than the original B cells they are derived from.

Figure 2 shows a B cell and a plasma cell.

Figure 2



0 2 . 1

Calculate the ratio of the volume of the plasma cell to the volume of the B cell in **Figure 2**. Assume that both cell types are spheres.

$$\text{Volume of a sphere} = \frac{4}{3}\pi r^3$$

[2 marks]

$$B \text{ cell: } r = 3 \mu\text{m}, V = \frac{4}{3} \times \pi \times 3^3 = 113 \mu\text{m}^3$$

$$Plasma \text{ cell: } r = 6.5 \mu\text{m}, V = \frac{4}{3} \times \pi \times 6.5^3 = 1150 \mu\text{m}^3$$

$$\text{ratio} = 1150 \div 113 = 10.17$$

$$\text{Ratio} = 10.2 : 1$$

0 2 . 2

Give **one** way that antibodies cause the destruction of bacterial cells.

[1 mark]

Antibodies cause agglutination (clumping) of the bacteria, which stimulates phagocytosis.



Patients with common variable immunodeficiency (CVID) suffer from recurrent infections. One of the causes of CVID is a reduced number of plasma cells resulting in low antibody production.

Diagnosis of CVID can be difficult. One way is to measure the number of antibodies a patient produces in response to a vaccination. This value is compared with the minimum amount of antibody needed to provide immunity.

0 2 . 3 Define the term 'vaccination'.

[1 mark]

The deliberate introduction of an antigen (or weakened / attenuated pathogen) into the body to cause an immune response.

0 2 . 4 **Table 2** shows information about two different vaccines.

Table 2

	Tetanus vaccine	BCG vaccine
Vaccine contains	Cell-free purified toxin	Live, weakened bacteria

Not all vaccines are suitable for use in CVID diagnosis.

Suggest why the BCG vaccine is unsuitable for CVID diagnosis testing. Use information in **Table 2**.

[1 mark]

BCG contains live bacteria, so it may cause disease (tuberculosis) in people with CVID, who are immunocompromised.

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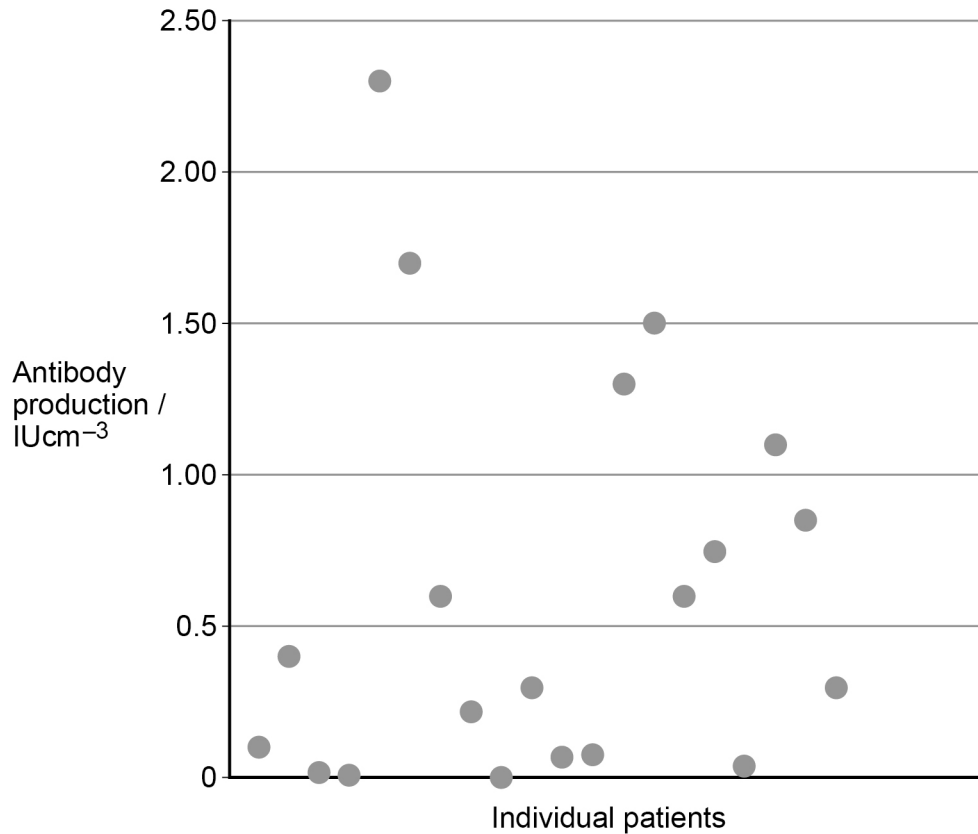


Twenty patients with suspected CVID were injected with the same batch of tetanus vaccine.

The minimum amount of antibody needed to provide immunity against tetanus is 1.0 IUcm^{-3} .

After three days, a sample was taken to measure the antibody levels in their blood. The results are shown in **Figure 3**. Each spot represents the antibody level in the blood of one patient.

Figure 3



0 2 . 5

A student concluded that five of the patients did not have CVID.

Evaluate this conclusion.

[5 marks]

For: five patients have antibody levels at or above 1.0 IU cm^{-3} , the minimum needed for immunity, so they might not have CVID.

Against: only one measurement of antibody was taken and only one batch of vaccine (one antigen, tetanus) was tested.

There was no control group of people with a normal immune system, so the vaccine may be defective.

The time before measuring antibodies (three days) is too short for a full response.

The high levels could be a secondary response, as these patients may already have had tetanus or a tetanus vaccine.

CVID is variable, so sufferers may sometimes produce a normal antibody response (there is lots of variation in the levels).

The patients may still have CVID caused by something other than a lack of plasma cells, e.g. a lack of T helper cells.

10

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0 3

Oral rehydration solution (ORS) is an effective treatment for the dehydration caused by cholera and other diarrhoeal diseases.

0 3 . 1

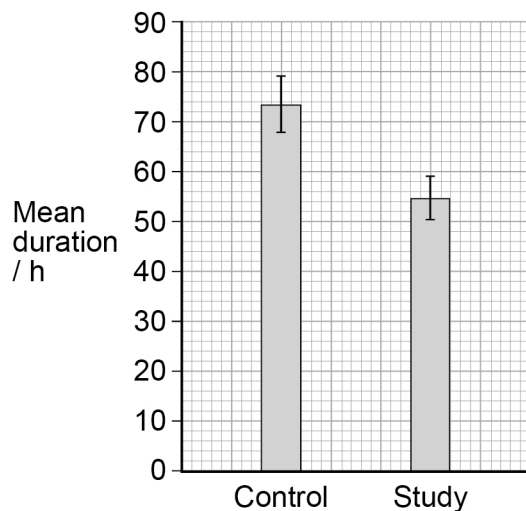
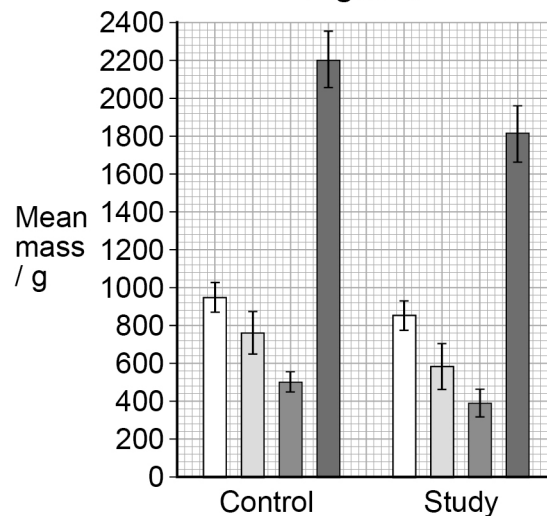
Name **two** substances that are dissolved in water to form an oral rehydration solution. **[2 marks]**

- 1 Glucose
- 2 Salts (ions / electrolytes), e.g. sodium chloride (Na^+ and Cl^- ions)

Although standard ORS is effective there is ongoing research to try to improve it. Scientists investigated the addition of soluble fibre to standard ORS using a large sample of malnourished children who had watery diarrhoea.

The children were treated with either standard ORS (control) or standard ORS plus soluble fibre PHGG (study).

The mean duration (**Figure 4**) and mean mass of watery diarrhoea (**Figure 5**) were measured. Standard deviation bars are shown on the graphs.

Figure 4**Figure 5**

Key: □ Day 1 □ Day 2 □ Day 3 ■ Total day 1-3



0 3 . 2

Describe the data in **Figure 4** and **Figure 5**.**[4 marks]**

Standard ORS plus PHGG (study) shortens the mean duration of diarrhoea, from about 73 h in the control to about 55 h.

The mass of watery diarrhoea decreases from day 1 to day 3 in both the control and the study groups.

There is a larger reduction in the mass of watery diarrhoea over the 3 days in the study group than in the control (total about 1800 g compared with 2200 g).

The differences in duration and total mass are significant (not due to chance) because the standard deviation bars do not overlap.

0 3 . 3

Soluble fibre increases sodium ion uptake in the large intestine (colon).

Explain how this would help reduce watery diarrhoea.

[2 marks]

More sodium ions are taken into the cells of the colon wall, which lowers the water potential of the cells (and the blood).

So water is taken in from the lumen of the colon by osmosis.

0 3 . 4

The control group was given standard ORS instead of pure water.

Suggest **one** ethical reason why.**[1 mark]**

Standard ORS is known to work, so it is not ethical to withhold an effective treatment (water is not effective) as the children could become worse or die.



0 4

Prokaryotic cells divide by binary fission. Eukaryotic cells divide by mitosis.

0 4 . 1

Complete the table to compare these two processes.

Put a tick (✓) if the statement is true **or** a cross (X) if it is untrue.

[2 marks]

	Binary fission	Mitosis
Genetically identical cells are produced	✓	✓
Nuclear membrane breaks down	X	✓
Chromosomes are arranged on the spindle	X	✓

0 4 . 2

During interphase of the cell cycle, DNA is replicated.

A mutation may occur spontaneously during DNA replication.

What is a mutation?

[1 mark]

A change in the DNA base sequence (of a gene).



0 4 . 3

Mutation is one way that bacteria can gain antibiotic resistance. Another way is by conjugation.

Which statement best describes conjugation?

[1 mark]

Tick (✓) **one** box.

Asexual reproduction

☐

Horizontal and vertical gene transmission

☐

Horizontal gene transmission

☒

Vertical gene transmission

☐

0 4 . 4

The rate of mutation in *E.coli* bacteria is 1×10^{-3} per generation.

The generation time is 30 minutes.

The conjugation rate is 10^5 times faster than the rate of mutation.

Calculate the conjugation rate per minute.

Give your answer to 2 significant figures.

[2 marks]

$$\text{mutation rate per minute} = 1 \times 10^{-3} \div 30 = 3.33 \times 10^{-5}$$

$$\text{conjugation rate} = 3.33 \times 10^{-5} \times 10^5 = 3.33$$

Answer = 3.3 per minute

Turn over ►



0 4 . 5

The spread of antibiotic resistance in bacteria is a concern. Bacteriophage M13 could be used to reduce this spread. Bacteriophage M13 is a virus that infects bacterial cells and produces large amounts of a protein called g3p. This protein builds up and blocks tubes in the infected bacteria.

Evaluate the use of bacteriophage M13 to prevent the spread of antibiotic resistance. Use the information and your own knowledge.

[3 marks]

For: protein g3p would block the pili (conjugation tubes), which would stop conjugation (horizontal gene transfer).

So it would prevent or reduce the transfer of plasmids carrying antibiotic resistance genes from bacterium to bacterium.

Against: not all conjugation tubes may be blocked, so some transfer of plasmids may still occur.

It would not prevent bacteria gaining antibiotic resistance by mutation, and resistant bacteria can still reproduce by binary fission, giving large numbers of resistant bacteria.

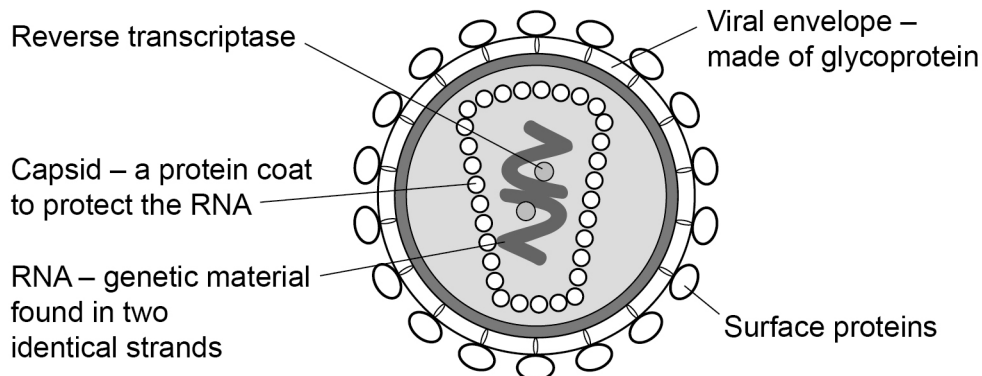
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0 5

Figure 6 shows the structure of the HIV virus.

Figure 6



0 5 . 1

HIV is described as a retrovirus.

Give the reason why.

[1 mark]

Its genetic material is RNA, which is used to synthesise DNA (using reverse transcriptase).

0 5 . 2

Describe the function of the surface proteins.

[1 mark]

To attach to receptors (CD4 receptors) on the host (human) cells.

0 5 . 3

Which type of white blood cell has CD4 receptors on its cell membrane?

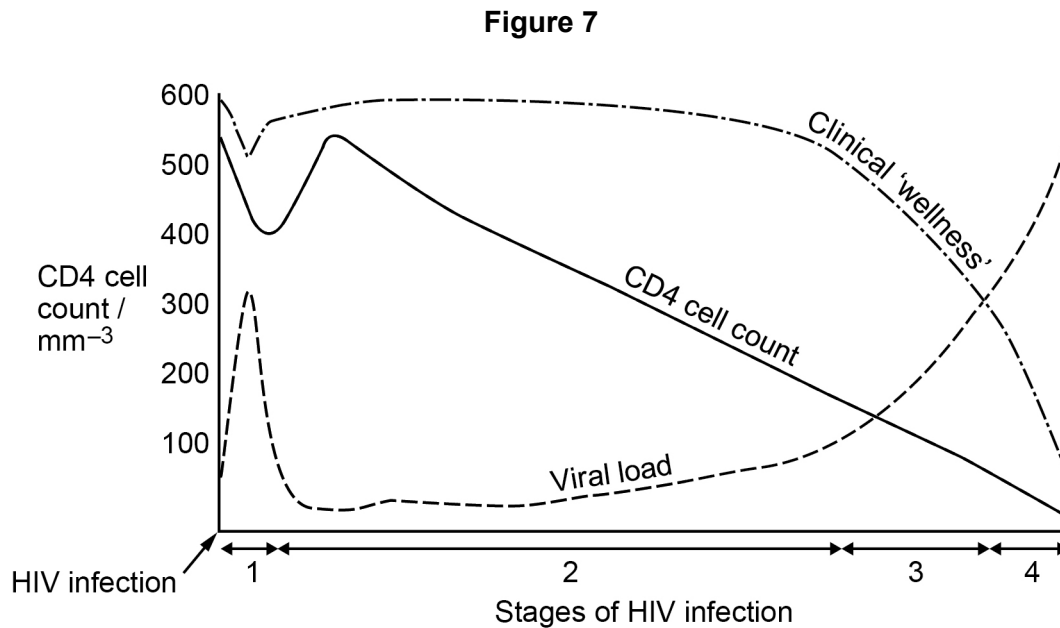
[1 mark]

Helper T cells (T_H cells)

Turn over ►



Figure 7 shows typical progress of an HIV infection. Clinical wellness and viral load are in arbitrary units.



0 5 . 4

Describe the effect of HIV on the CD4 cell count through stages 1–2. Use the data in **Figure 7**.

[2 marks]

The CD4 cell count first decreases (from about 550 to a trough of 400 mm^{-3}), then increases again (returns to near normal) to a peak of about 540 mm^{-3} .

It is then followed by a steady decrease through stage 2, to about 150 mm^{-3} at the end of stage 2.



0 5 . 5

Clinical wellness is a measure of AIDS symptoms.

Explain how HIV reduces the clinical wellness value during stages 3 and 4 in **Figure 7**.

[3 marks]

HIV replicates, so the viral load increases, and the virus infects and destroys helper T (CD4) cells, reducing their number.

Helper T (CD4) cells are required for the immune response, e.g. to stimulate B cells to produce antibodies (plasma cells).

AIDS is a series of opportunistic diseases (infections) caused by the immune system not working because there are insufficient helper T (CD4) cells.

8

Turn over for the next question

Turn over ►



0 6

A student investigates the effect of caffeine on heart rate on a group of students using the following procedure:

1. Counts the pulse rate, by pressing two fingers against an artery and records the number of beats per minute.
2. Drinks a can of caffeinated soft drink as quickly as possible.
3. Records the pulse rate immediately.
4. 5 minutes after drinking the soft drink, measures the pulse rate again.
5. Continues to measure pulse every 2 minutes for 35 minutes.

0 6**. 1**

The experiment was carried out on a group of 20 students.

Give **three** control variables that should have been considered.

[3 marks]

- 1 *Age (age range) and gender of the students*
- 2 *Level of fitness (and smoker or non-smoker)*
- 3 *Volume of drink (dose of caffeine)*

0 6**. 2**

The experiment was repeated after two hours with a control drink.

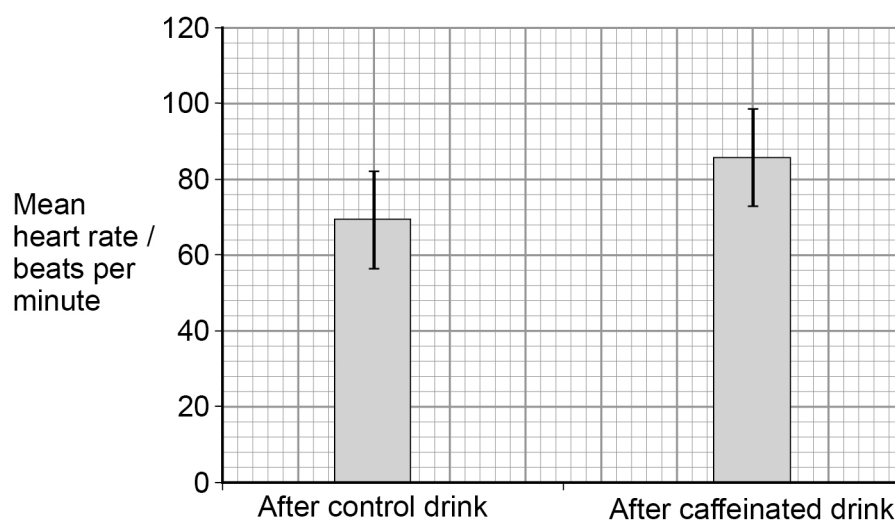
State the composition of this control drink.

[1 mark]

A soft drink with identical ingredients minus caffeine (decaffeinated)

The mean heart rate after 20 minutes was calculated.

Figure 8 shows the results. The lines on the bars represent standard deviations.

Figure 8

0 6 . 3

What can you conclude about the effect of caffeine on heart rate?

[3 marks]

The mean heart rate is higher after the caffeinated drink (about 85 beats per minute) than after the control drink (about 69 beats per minute).

However, the standard deviations overlap.

So the difference between the means is not significant; the effect of caffeine may be due to chance (or another factor).

7

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0 7

Radioactive tracers have been used for investigating transport of sugars in plants.

Figure 9 shows a plant. The leaves labelled **A** were provided with radioactive carbon dioxide ($^{14}\text{CO}_2$) to be used in photosynthesis.

Figure 10 is an autoradiograph image produced by pressing the plant against photographic film one day after the radioactive carbon dioxide was supplied to the plant. Areas which contain radioactive substances appear dark.

Figure 9

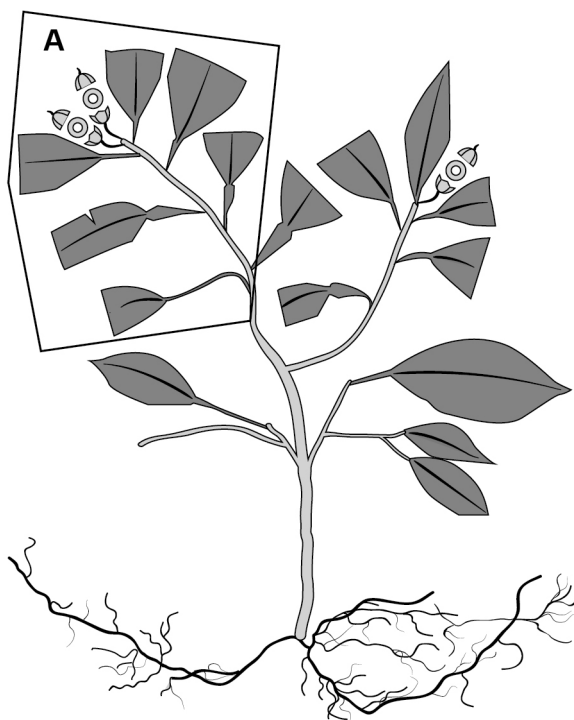
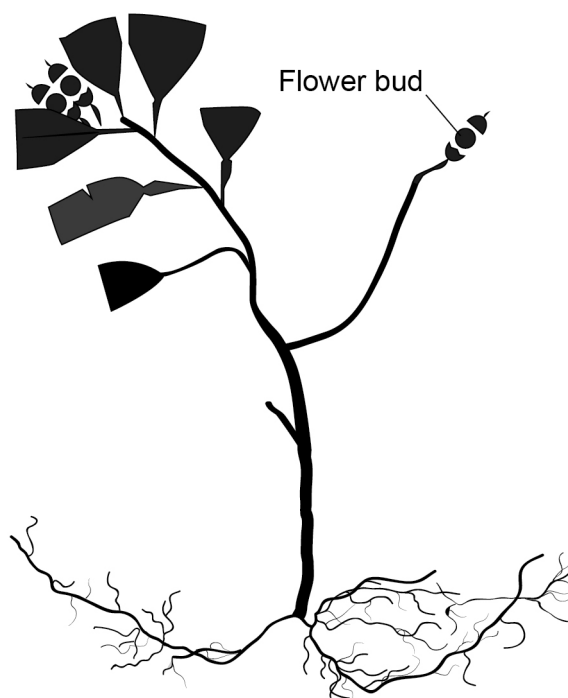


Figure 10



0 7 . 1

Name **one** radioactive organic substance which causes the dark areas in **Figure 10**.
[1 mark]

Sucrose (or glucose)



0 7 . 2

Describe the distribution of radioactive organic substances in **Figure 10**.**[3 marks]**

Radioactive substances are present in the leaves supplied with radioactive carbon dioxide (region A).

They are not present in the other leaves (leaves not supplied with radioactive carbon dioxide).

They are present in the stem, the roots and the flowers (flower buds).

0 7 . 3

Explain the pattern of radioactive organic substances in **Figure 10**.**[3 marks]**

Radioactive carbon dioxide is taken up by the leaves in region A and used in photosynthesis to make radioactive sugars.

Radioactive sucrose (organic substances) is translocated in the phloem to the roots and flowers, where it is used for respiration, growth or storage.

Other leaves (not in region A) use carbon dioxide from the air to make their own (non-radioactive) carbon compounds.

Turn over ►

07.4

Aphids are insects with mouthparts called stylets. They feed by inserting the stylets into phloem sieve tubes. Once the vessel is punctured, sap enters the aphid's gut under pressure.

Explain how this pressure is generated in the phloem sieve tubes.

[3 marks]

Sugars (sucrose) are moved into the phloem sieve tubes by co-transport (active transport) from companion cells in the source (leaf).

This lowers the water potential in the sieve tubes.

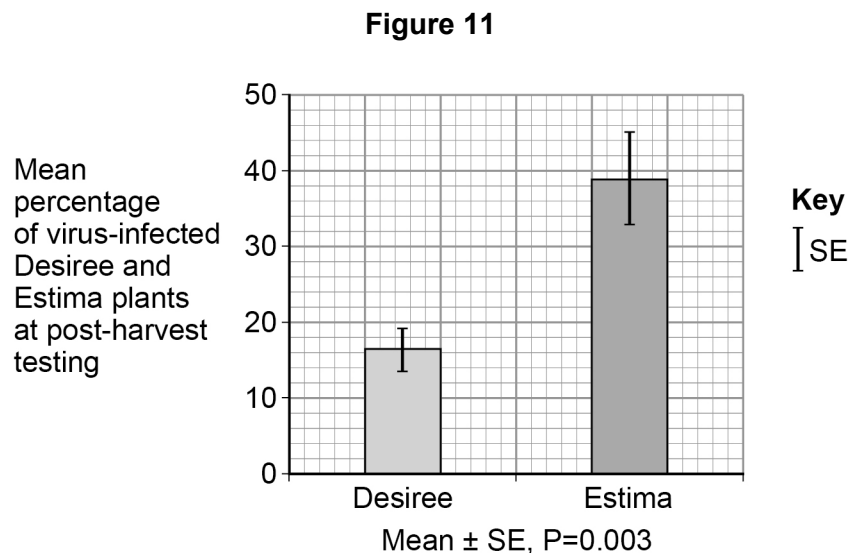
So water moves in by osmosis (from the xylem), increasing the hydrostatic pressure.



Aphids act as vectors for many plant viruses.

Figure 11 shows the percentage of two varieties of potato plants, Desiree and Estima, infected with a virus.

The figure shows the means from four years' data.



0 7 . 5

State why standard error and 95% confidence limits would be the most appropriate statistical test for this investigation.

[1 mark]

Comparing the difference between 2 means, to see if the difference is significant.

0 7 . 6

The P-value obtained from the statistical analysis was 0.003 (0.3%).

Explain what this shows.

Use the terms probability and chance in your answer.

[2 marks]

The probability of the differences between the sets of data being due to chance is 0.3%, which is less than 5% (0.05).

So the differences are significant, not due to chance, and we can reject the null hypothesis.



0 8

During exercise, the blood supply to the skeletal muscles is increased.

0 8 . 1

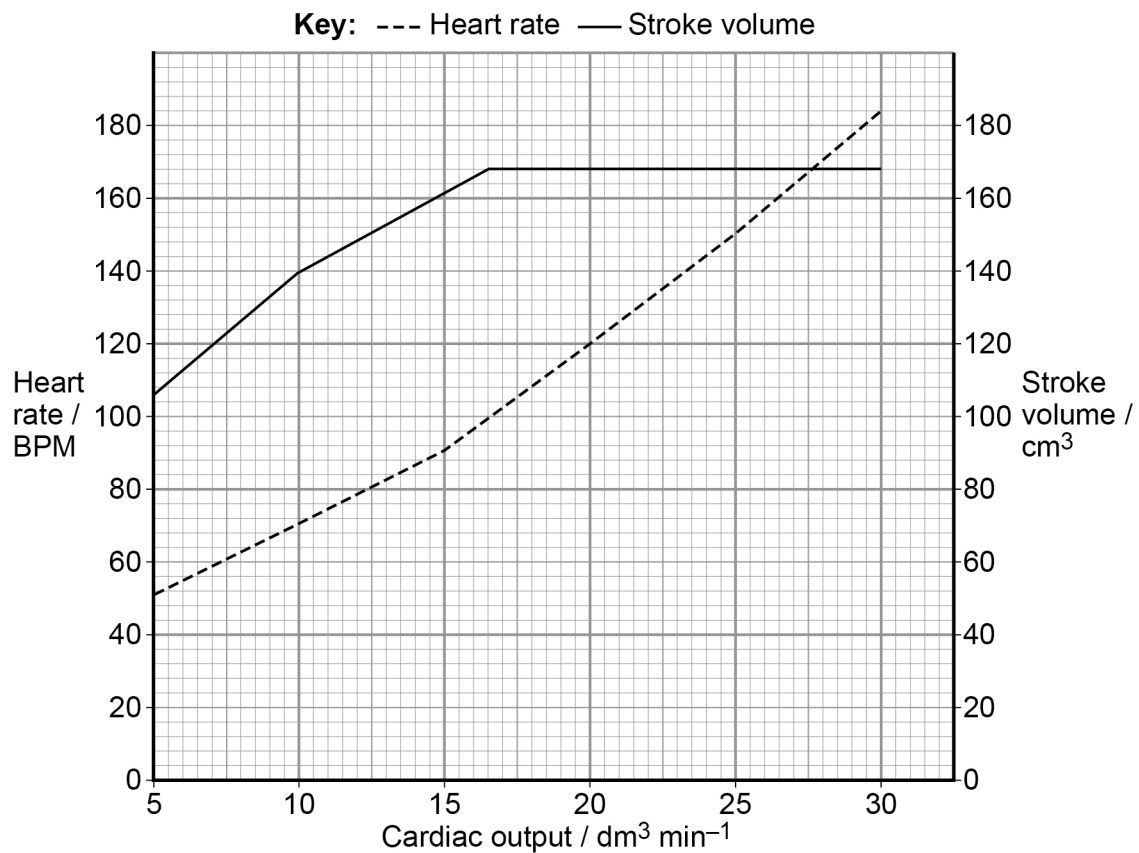
Give the equation which links cardiac output, stroke volume and heart rate.

[1 mark]

$$\text{Cardiac output} = \text{stroke volume} \times \text{heart rate}$$

Figure 12 shows the effect of exercise on cardiac output, stroke volume and heart rate for an athlete.

Figure 12



0 8 . 2

Use information from **Figure 12** to explain how stroke volume and heart rate can produce a cardiac output of approximately $20 \text{ dm}^3 \text{ min}^{-1}$.

[2 marks]

*At a cardiac output of $20 \text{ dm}^3 \text{ min}^{-1}$, heart rate is 120 beats per minute
and stroke volume is 168 cm^3 .*

$$120 \times 168 = 20\,160 \text{ cm}^3 \text{ min}^{-1}, \div 1000 = 20.2 \text{ dm}^3 \text{ min}^{-1}$$

Question 8 continues on the next page

Turn over ►



08.3

Describe the events in the cardiac cycle.

Include in your answer references to:

- pressure and volume changes
- role of the heart valves.

[6 marks]

During diastole the atria and ventricles are relaxed. Blood enters the atria from the pulmonary veins and vena cava, so volume and pressure in the atria increase.

In atrial systole the atria contract, and the increased pressure (higher in the atria than the ventricles) opens the atrioventricular (AV) valves, so blood flows into the ventricles and their volume increases.

In ventricular systole the ventricles contract, and the increased pressure in the ventricles closes the AV valves, preventing backflow of blood into the atria.

When ventricular pressure is higher than in the arteries, the increased pressure opens the semilunar valves.

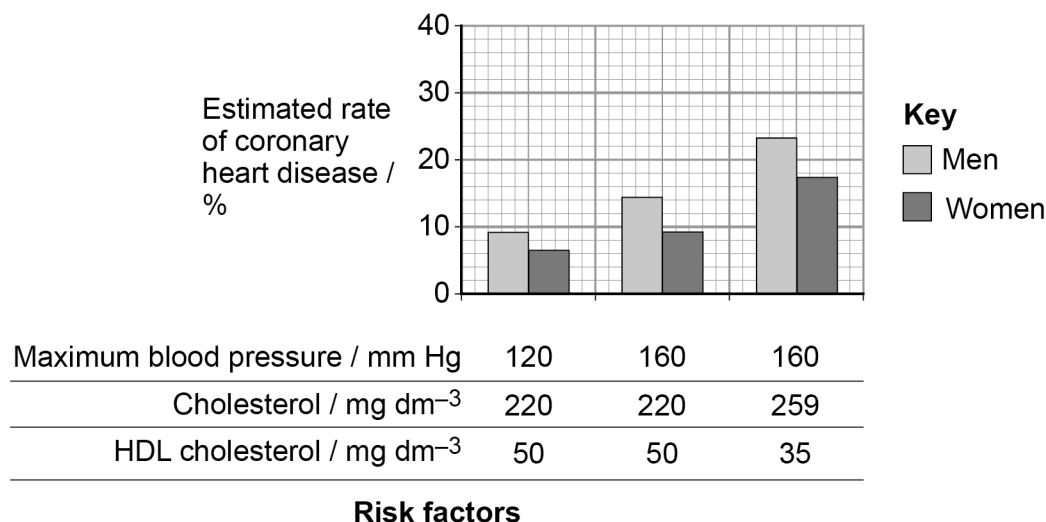
Blood is pumped into the aorta and pulmonary artery, so ventricular volume decreases. The ventricles then relax, ventricular pressure falls and the semilunar valves close, preventing backflow from the arteries.



Figure 13 shows the rate of coronary heart disease according to various risk factors.

Figure 13

Coronary heart disease rate according to various combinations of risk factors over 10 years



0 8 . 4

Describe and explain the rate of coronary heart disease in people who have:

- a maximum blood pressure of 160 mm Hg
- and a cholesterol concentration of 259 mg dm⁻³
- and a HDL concentration of 35 mg dm⁻³

[3 marks]

This group has the highest incidence of coronary heart disease, about 23% in men and 17% in women over 10 years.

Higher cholesterol and lower HDL concentration lead to atherosclerosis (atheroma, plaque or fatty deposits) forming in the coronary arteries.

Higher blood pressure may damage the walls of the coronary arteries, causing an aneurysm or thrombosis (blood clot), reducing blood flow to heart muscle.

12

END OF QUESTIONS



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