Oxford Cambridge and RSA

Monday 11 October 2021 – Morning

A Level Biology B (Advancing Biology)

H422/01 Fundamentals of biology

Time allowed: 2 hours 15 minutes

You can use:
- a ruler (cm/mm)
- a scientific or graphical calculator

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 using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- 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 **40** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a maximum of 40 minutes on this section.

Write your answer for each question in the box provided.

Answer **all** the questions.

1 Mammals have mass transport systems to move substances around the body.

Which feature of mammals, **A** to **D**, explains why they need mass transport systems?

A low metabolic rates

B large surface area to volume ratios

C short diffusion distances

D small surface area to volume ratios

Your answer D

[1]

2 Which of the biofluids, **A** to **D**, is **not** an extracellular fluid?

A cell sap

B lymph

C plasma

D urine

Your answer A

[1]

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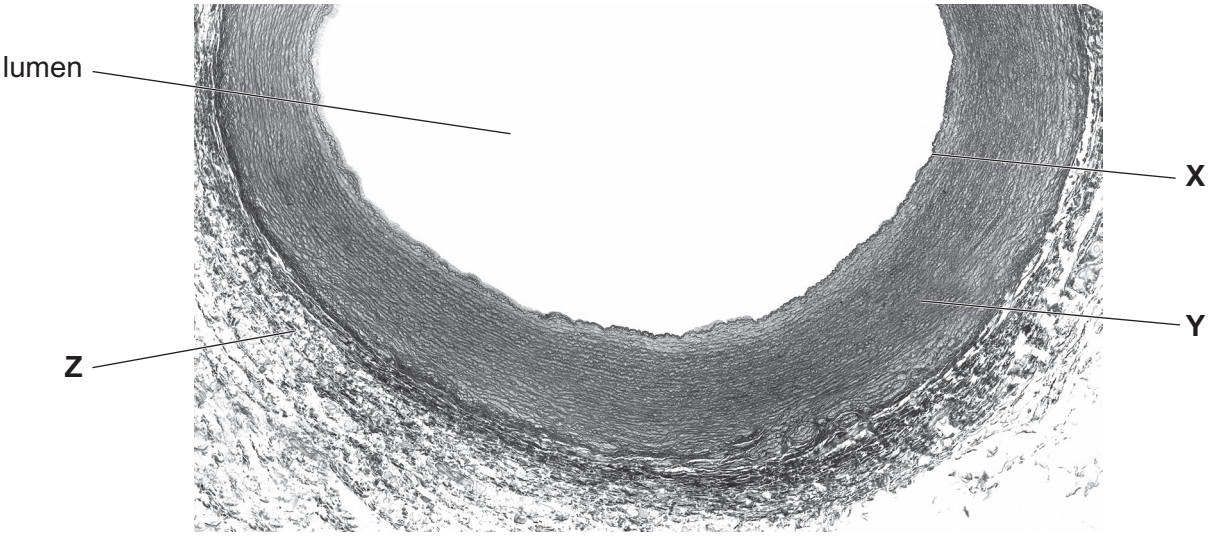
3 The photomicrograph shows part of a transverse section through a mammalian aorta.



Which of the rows, **A** to **D**, correctly identifies some of the tissues that would be found in the areas labelled **X**, **Y** and **Z** in the photomicrograph?

	X	Y	Z
A	endothelium	collagen fibres and connective tissue	smooth muscle tissue
B	smooth muscle tissue	elastic tissue	endothelium
C	endothelium	smooth muscle tissue	collagen fibres and connective tissue
D	smooth muscle tissue	endothelium	elastic tissue

Your answer C

[1]

4 Which of the options, **A** to **D**, is the site of initiation of action potentials that lead to the contraction of heart muscle?

A accelerator nerve

B Purkyne fibres

C sinoatrial node

D vagus nerve

Your answer C

[1]

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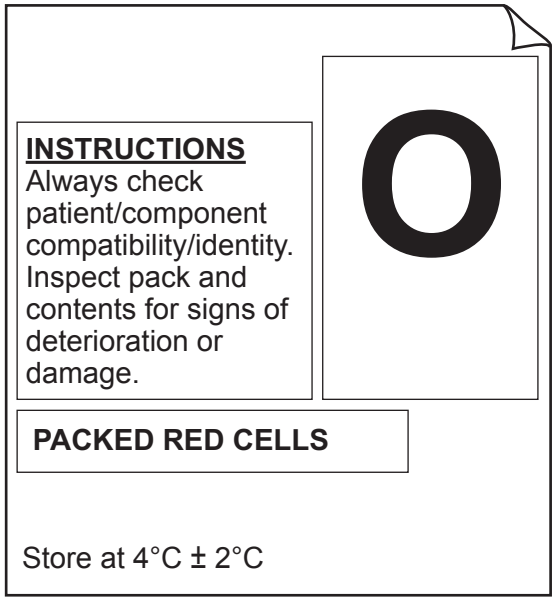
5 The diagram shows a blood bag label with information about the stored blood product contained in the bag.



Which of the options, **A** to **D**, about this stored blood product is correct?

A Contains plasma and erythrocytes with no A or B glycoprotein antigens in the plasma membrane.

B Contains plasma with anti- A and anti-B antibodies and erythrocytes.

C Contains concentrated erythrocytes with A and B glycoprotein antigens in the plasma membrane.

D Contains concentrated erythrocytes with no A and B glycoprotein antigens in the plasma membrane.

Your answer D

[1]

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6 The table shows the results from an analysis of some of the organic compounds found in a human urine sample.

	Concentration ($g\,dm^{-3}$)				
	Carbon (C)	**Nitrogen (N)**	**Oxygen (O)**	**Hydrogen (H)**	**Sulfur (S)**
Organic compounds	5.15	7.46	4.78	1.24	0.13

Which of the molecules, **A** to **D**, would contain the sulfur shown in the analysis?

A amino acids

B nucleic acids

C pyruvate

D urea

Your answer A

[1]

7 A pregnant woman has been advised to increase her daily intake of protein by 15% to 53 g.

Which of the options, **A** to **D**, is her normal daily intake of protein?

A 28 g

B 8 g

C 46 g

D 38 g

Your answer C

[1]

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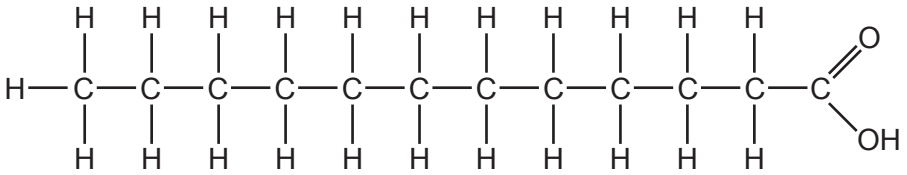
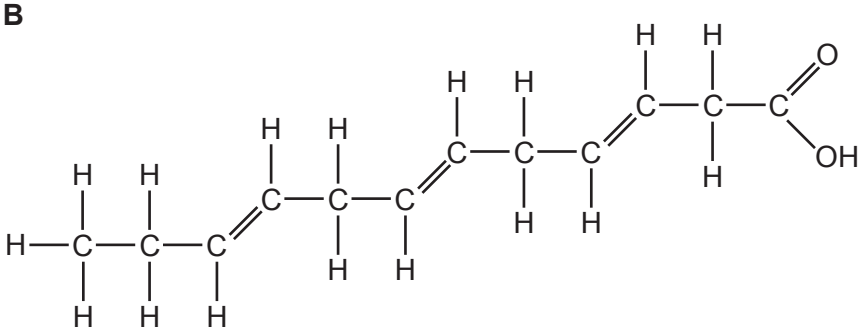
8 Milk fat contains many different types of triglycerides. The molecules that make up these triglycerides can affect the flavour and nutritional properties of milk fat.

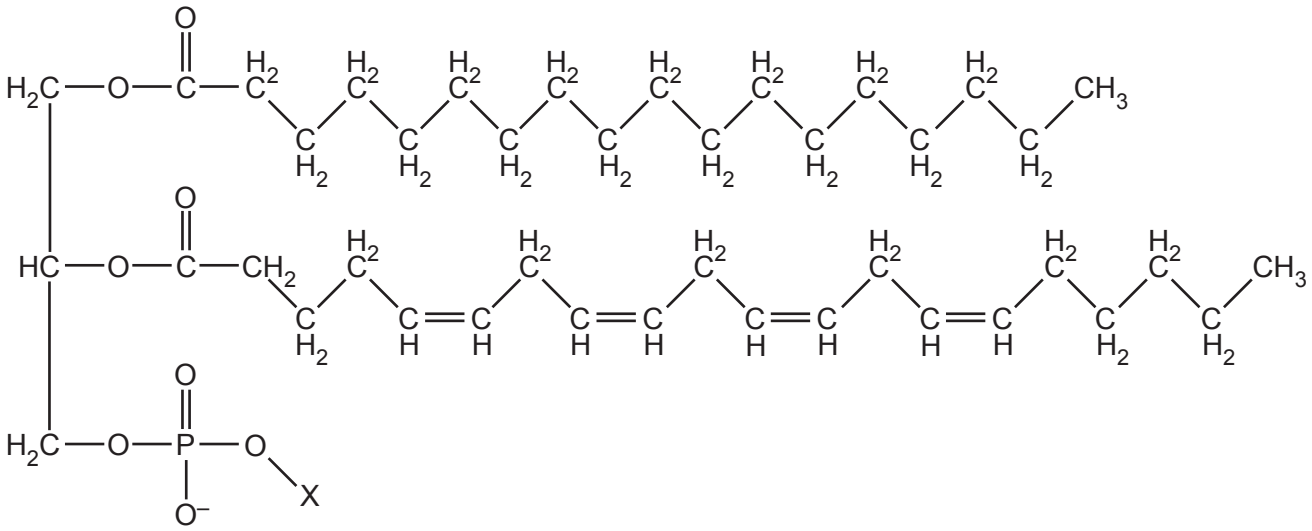
A



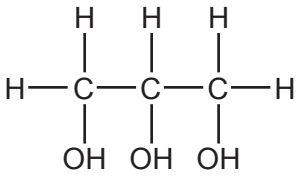
B



C



D



Which of the molecules, **A** to **D**, would **not** be found in a triglyceride?

Your answer C

[1]

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9 A 45-year-old patient was admitted to hospital with a lung infection.

The patient was tested for tuberculosis (TB) using a Mantoux skin test. The Mantoux skin test is performed by injecting an extract from the TB pathogen under the skin.

After 48 hours, the patient had developed a large, red lump at the site of the test.

Which of the following statements is/are correct?

1: The patient's blood contained antibodies against TB antigens.

2: The patient did not have immunity to TB.

3: The patient had an inflammatory response to live TB pathogens present in the extract.

A 1, 2 and 3 are correct

B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer D

[1]

10 Diphtheria is a bacterial disease of humans that can be treated by vaccination using an antitoxin. The antitoxin is a solution of antibodies specific to the antigens on the surface of the bacterium.

Which of the options, **A** to **D**, describes the type of immunity provided by the antitoxin?

A artificial active

B artificial passive

C natural passive

D natural active

Your answer B

[1]

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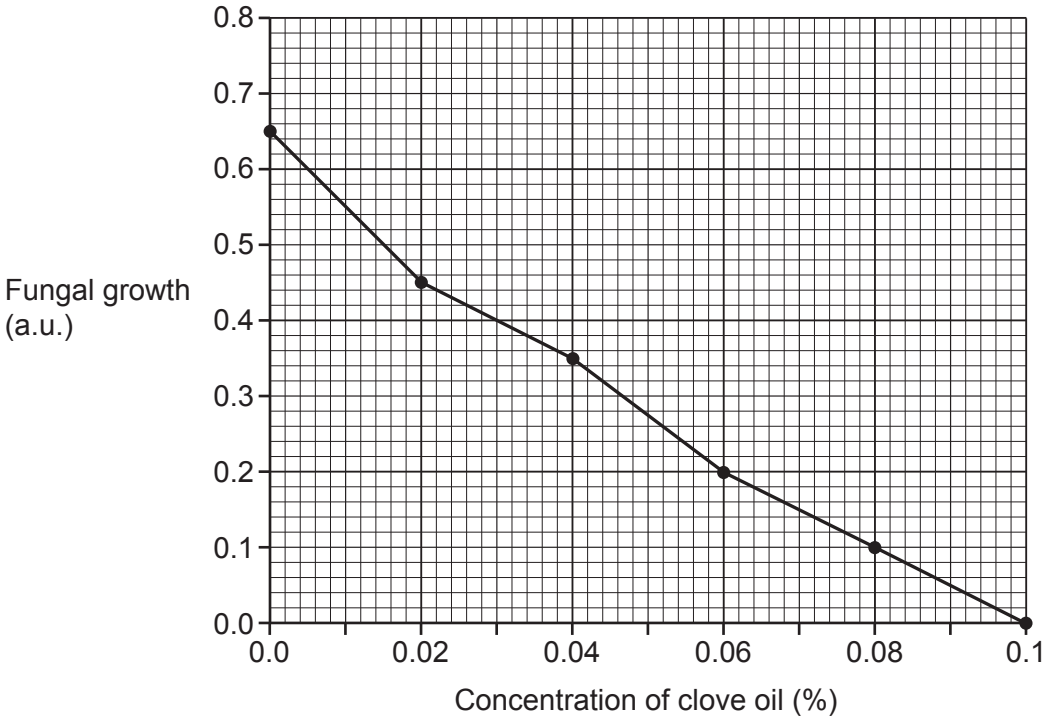
11 Oils from the clove tree, *Syzygium aromaticum*, have been found to have antifungal properties and are a potential source of medicinal drugs.

The graph shows the results of a study into the effect of concentration of clove oil on the growth of fungi on cooked meat.



Which of the options, **A** to **D**, is the correctly calculated percentage decrease in growth of fungi as the concentration of clove oil increases from 0.02 to 0.04%?

A 71%

B 22%

C 78%

D 29%

Your answer B

[1]

12 Which of the options, **A** to **D**, explains why viruses are not destroyed by antibiotics?

A Viruses do not have DNA.

B Viruses do not have nuclei.

C Viruses do not have plasmids.

D Viruses do not have cell walls.

Your answer D

[1]

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13 Which of the options, **A** to **D**, is formed by the fusion of a cell membrane around a microorganism?

A bleb

B phagosome

C vacuole

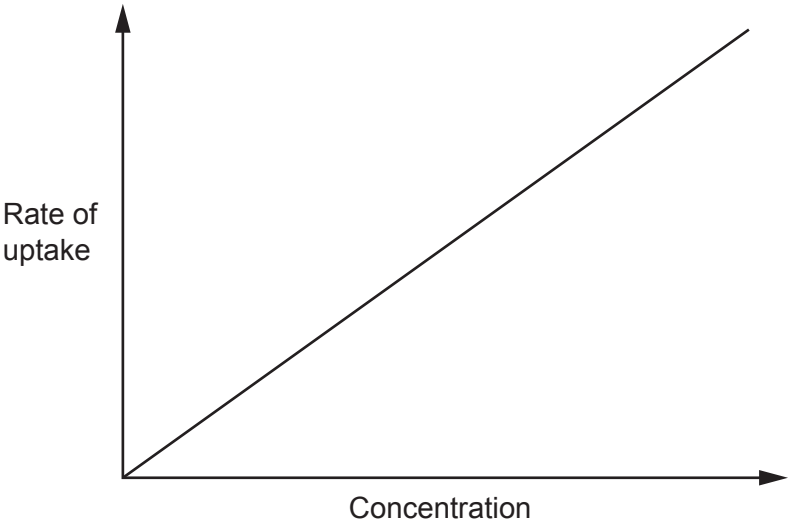
D virus

Your answer B

[1]

14 An investigation was carried out into the effect of concentration of a substance on its rate of uptake into cells.

The cells were placed in solutions of the substance at different concentrations and rate of uptake was measured.



Which of the options, **A** to **D**, is the mechanism being used by the cells to transport the substance across the cell membrane?

A active transport

B facilitated diffusion

C osmosis

D simple diffusion

Your answer D

[1]

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15 Which of the eukaryotic cell membranes, **A** to **D**, is used to isolate enzymes that could cause cellular damage?

A lysosome membrane

B mitochondrial membrane

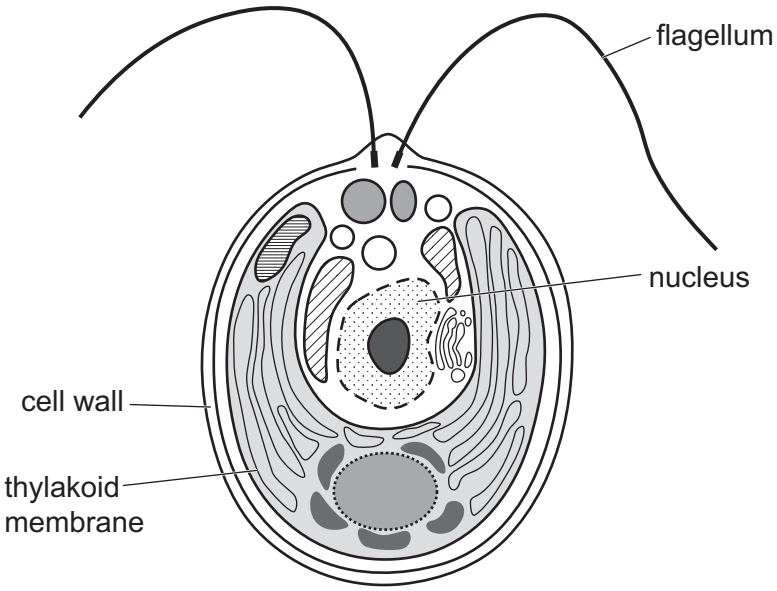
C nuclear membrane

D tonoplast

Your answer A

[1]

16 The structure and part of the classification of *Chlamydomonas reinhardtii*, a single-celled organism, is shown below.



Phylum: Chlorophyta	Chlorophyceae	Chlamydomonadales	Chlamydomonadaceae	**Genus:** *Chlamydomonas*

Which of the following statements is/are correct?

1: *C.reinhardtii* would be classified in the Kingdom, Bacteria.

2: *C.reinhardtii* is a photosynthetic organism.

3: Chlamydomonadaceae is the family taxon for *C.reinhardtii*.

A 1, 2 and 3 are correct

B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer C

[1]

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17 The *cytochrome c oxidase* gene is a good DNA barcode.

Which of the features, **A** to **D**, are needed for a good DNA barcode?

A low interspecific variation

B high intraspecific variation

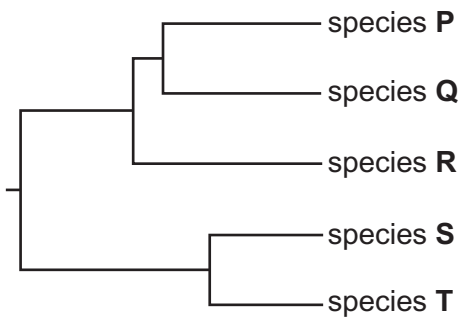
C short sequences of DNA

D species specificity

Your answer C

[1]

18 A phylogenetic tree for five species is shown below.



distance scale = 0.5

The evolutionary distance between two species is calculated as the sum of the lengths of all the horizontal branches between the two species.

Which of the options, **A** to **D**, is the estimated evolutionary distance between species **R** and species **T**?

A 8.0

B 4.0

C 2.0

D 16.0

Your answer B

[1]

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19 Two heterozygous individuals with the genotype, HhRr, were crossed during an investigation of dihybrid inheritance.

Which of the options, **A** to **D**, shows the probability of offspring having the genotype, HHRR?

A 1 in 4

B 3 in 4

C 1 in 16

D 1 in 2

Your answer C

[1]

20 Somatic cell gene therapy has been used for treating people with mitochondrial myopathy, a disease of the muscles caused by damage to the mitochondria.

Which of the following statements is/are correct?

1: DNA sequences coding for the functional gene are placed into muscle cells.

2: Meiosis will ensure that all muscle cells receive a copy of the functional gene.

3: The functional gene will be passed on to the offspring of the treated individual.

A 1, 2 and 3 are correct

B only 1 and 2 are correct

C only 2 and 3 are correct

D only 1 is correct

Your answer D

[1]

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21 *Taq* polymerase is an enzyme used during the polymerase chain reaction (PCR).

- At optimum temperature, *Taq* can replicate DNA at a rate of 150 nucleotides per second.
- The error rate of *Taq* has been measured at 1 in 9000 nucleotides.

Which of the options, **A** to **D**, is the estimated number of errors that could be produced by *Taq* during 20 minutes of PCR at optimum temperature?

A 180

B 60

C 20

D 1200

Your answer C

[1]

22 Which of the options, **A** to **D**, about the onset of menopause and secretion of female hormones is correct?

A Secretion of follicle-stimulating hormone (FSH) increases.

B Secretion of luteinising hormone (LH) decreases.

C Secretion of oestrogen increases.

D Secretion of progesterone increases.

Your answer A

[1]

23 Which of the statements, **A** to **D**, about why respiration in animals and plants is dependent on photosynthesis is correct?

A Triose phosphate (TP) can be hydrolysed into glucose.

B Triose phosphate (TP) can form 6-carbon sugars.

C Triose phosphate (TP) and glycerate-3-phosphate (GP) can be joined to form sucrose.

D Triose phosphate (TP) can be converted into fatty acids.

Your answer B

[1]

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24 Which of the structures, **A** to **D**, in the ruminant digestive system secretes hydrochloric acid and digestive enzymes?

A abomasum

B omasum

C reticulum

D rumen

Your answer A

[1]

25 The table shows the roles of three different chemicals in the transmission of nerve impulses across a synaptic cleft.

Which of the rows, **A** to **D**, is correct?

	Binds to receptors on Na^+ channels in postsynaptic membrane	**Generates an action potential in postsynaptic membrane**	**Causes vesicles containing neurotransmitter to fuse with presynaptic membrane**
A	acetylcholine	calcium ions	sodium ions
B	calcium ions	sodium ions	acetylcholine
C	sodium ions	calcium ions	acetylcholine
D	acetylcholine	sodium ions	calcium ions

Your answer D

[1]

26 Existing treatments for kidney failure include dialysis and transplant surgery. Therapeutic cloning involves growing kidney tissue from the patient's stem cells and is another type of treatment which may be available in the future.

For which of the treatments, **A** to **D**, would the patient need to take immunosuppressant drugs?

A donation of a kidney from a living relative

B haemodialysis

C peritoneal dialysis

D therapeutic cloning

Your answer A

[1]

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27 The kidney has several functions as an endocrine organ.

Which of the options, **A** to **D**, is **not** an endocrine function of the kidney?

A osmoregulation to control the reabsorption of water

B secretion of erythropoietin to increase production of red blood cells

C secretion of renin to catalyse the formation of angiotensin to increase blood pressure

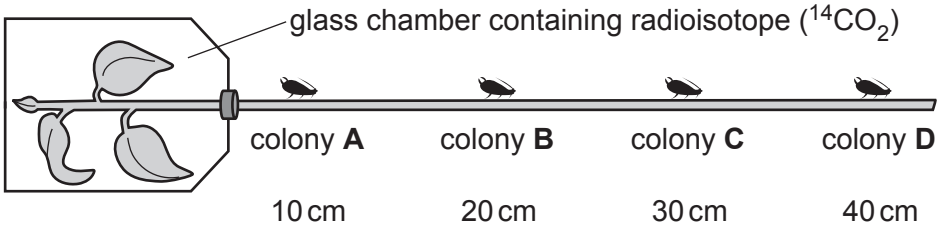
D selective reabsorption of glucose to prevent it being lost during excretion

Your answer D

[1]

28 A group of students were investigating the rate of translocation in plants using aphids.

The diagram shows the apparatus used in their investigation.



The sap from each colony of aphids was analysed for the presence of radioactively labelled sugars.

Rate of translocation was calculated based on the time taken for the radioactively labelled sugars to be detected in each of the colonies positioned along the length of the stem.

- Diameter of the phloem tube was 2 mm
- Mean translocation rate calculated by the students was 0.5 $cm^3 hr^{-1}$
- Volume of a cylinder = $\pi r^2 l$

In which of the aphid colonies, **A** to **D**, were radioactively labelled sugars first detected after 1.3 hours?

Your answer B

[1]

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29 Which of the statements, **A** to **D**, describes vernalisation in flowering plants?

A Exposure to high temperatures for an extended time period to encourage flowering.

B Exposure to high temperatures for an extended time period to encourage germination.

C Exposure to low temperatures for an extended time period to encourage flowering.

D Exposure to low temperatures for an extended time period to encourage germination.

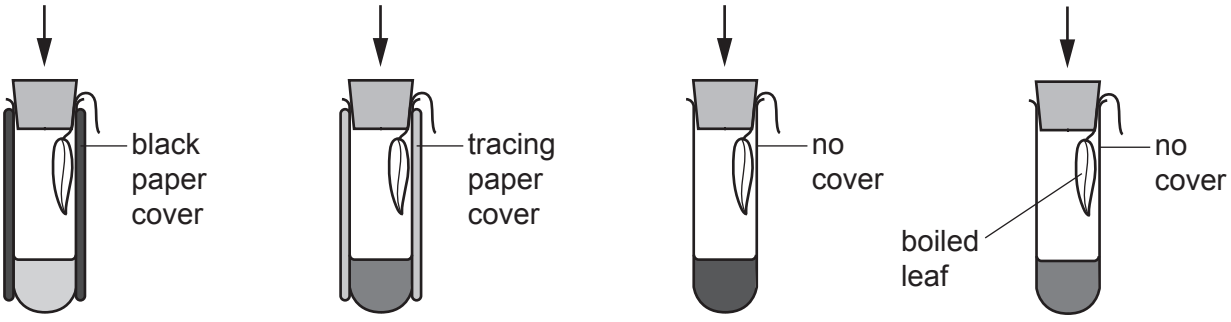
Your answer C

[1]

30 Hydrogen carbonate indicator was used to investigate gaseous exchange in plants by measuring the change in pH.

- The indicator ranges from yellow at pH 7.6 to purple at pH 9.2.
- The indicator is red in atmospheric air with normal carbon dioxide concentration.

Four test tubes containing 2 cm^3 of hydrogen carbonate indicator and equal-sized leaves from the same plant were prepared as shown in the diagram below. The test tubes were then illuminated under the same light source for 8 hours.



tube 1 **tube 2** **tube 3** **tube 4**

Test tube	**1**	**2**	**3**	**4**
Colour of indicator after 8 hours	yellow	red	purple	red

Which of the statements, **A** to **D**, about the outcome of the investigation is correct?

A Both photosynthesis and respiration are taking place in all four test tubes.

B The rate of photosynthesis is greater than the rate of respiration in test tube 2.

C The rate of photosynthesis is greater than the rate of respiration in test tube 3.

D The rate of photosynthesis is equal to the rate of respiration in test tube 3.

Your answer C

[1]

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SECTION B

Answer **all** the questions.

31 Spermatogenesis in human males produces haploid gametes, called spermatozoa (sperm cells).

The structure of a mature human spermatozoan consists of three sections: a head, a midpiece and a tail.

(a) For each of these sections, describe how its **internal** structure relates to the function of the spermatozoan.

Head Haploid nucleus, so the diploid number is restored at fertilisation; acrosome has hydrolytic enzymes to digest the zona pellucida.

Midpiece Contains many mitochondria, which release energy (ATP) by respiration for movement of the tail.

Tail Contains contractile fibres (microtubules) forming a flagellum, which make whip-like movements so the sperm can swim.

[3]

(b) During spermatogenesis, the chromatin in the nuclei of sperm cells undergoes a complex transition where histone is replaced by another protein, protamine, which binds to the DNA.

(i) Protamine contains large quantities of the polar amino acid, arginine.

Suggest why having large quantities of arginine enables protamine to bind effectively to DNA molecules.

DNA has phosphate groups in its sugar-phosphate backbone, and the phosphate groups are negatively charged. Arginine is positively charged, so there are forces of attraction between the opposite charges on the phosphate and arginine.

[2]

(ii) Substituting histone with protamine allows DNA to be more densely packaged.

Suggest **one** advantage of having densely packaged DNA in a sperm nucleus.

The sperm nucleus (and head) can be smaller, so it is more streamlined, and the DNA is better protected from damage. **[1]**

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(c) It has been found that protamine deficiency can lead to a severe disruption of spermatogenesis affecting male infertility.

An investigation was carried out into the effect of protamine deficiency on the production of healthy sperm cells.

Forty semen samples were collected from four groups of men as shown in the table.

Group	Sperm count	Motility of sperm
1	normal	normal
2	low	normal
3	normal	low
4	low	low

Microscope slides were prepared by fixing and staining a smear from each semen sample. The staining technique used distinguished between protamine deficient and normal sperm cells.

(i) The researchers concluded that the ages of the men in the groups would not affect the validity of the results of this investigation.

Explain how the researchers could have justified this conclusion.

Men of a similar age were used in all of the study groups.

A statistical test would show no significant difference in the mean age of the men between the groups.

..... **[2]**

(ii) What is the role of **Group 1** in this investigation?

It is the control group (normal sperm count and motility), used for comparison with the other groups. **[1]**

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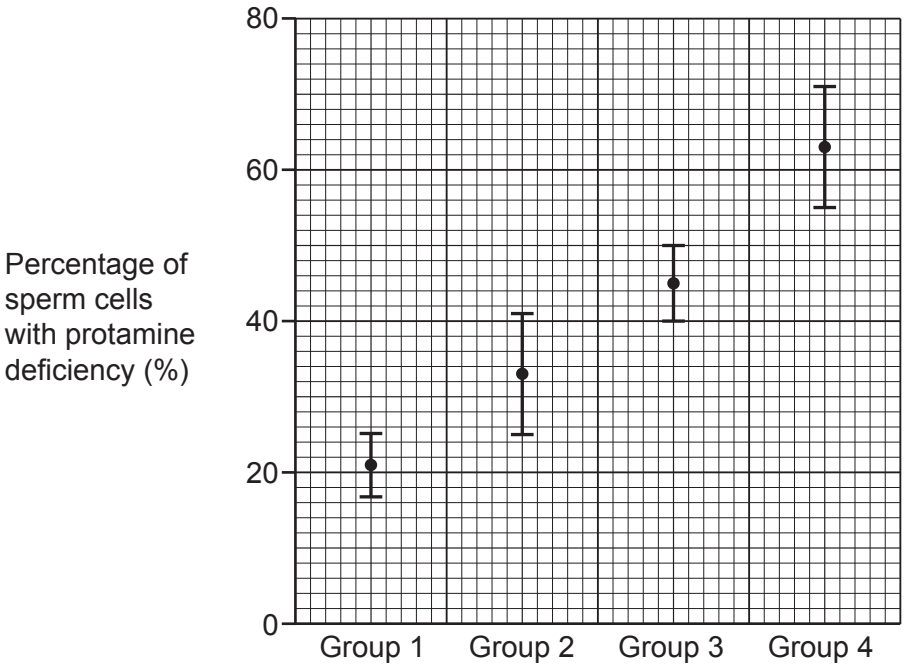
(iii) The results of the investigation are shown in the graph.



Using the information from the table and the graph, what conclusions can be made about the results of the investigation?

Group 1 (normal count and motility) had the lowest percentage of protamine deficient sperm (about 21%).

Group 4 (low count and low motility) had the highest percentage (about 63%).

Groups 3 and 4 show protamine deficiency affects sperm motility more than sperm count.

So protamine deficiency is higher in men with low fertility (infertility).

Error bars of groups 2 and 3 overlap, so this difference is not significant; groups 1 and 3, 2 and 4, and 1 and 4 do not overlap, so these differences are significant. **[4]**

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(d)* Female gametes, or ova, are produced during oogenesis.

Compare **and** contrast spermatogenesis and oogenesis in the production of gametes. Include reference to the role of hormones.

Similarities: both start from primordial germ cells and have a multiplication phase (mitotic divisions), a growth phase and a maturation phase with meiotic division, producing haploid gametes. Both are initiated at puberty by gonadotrophin releasing hormone (GnRH) from the hypothalamus, which stimulates the anterior pituitary to release FSH and LH, so both are affected by FSH and LH.

Differences: in spermatogenesis the second meiotic division is completed immediately after the first, and primary spermatocytes divide evenly to form two secondary spermatocytes of equal size, so no polar bodies form and four spermatozoa are made, which are much smaller than ova. It is a continuous process from puberty. FSH makes the cells in the testes more receptive to testosterone, and LH causes cells in the testes to release testosterone.

In oogenesis the primary oocyte divides unevenly, forming a large secondary oocyte and a polar body, so one large ovum and smaller polar bodies are formed. The second meiotic division only occurs after fertilisation. It is a **[6]**

Additional answer space if required.

staggered (cyclical) process. FSH and LH cause maturation of follicles in the ovary and the release of oestrogen, and a surge of LH causes ovulation, the release of the secondary oocyte.

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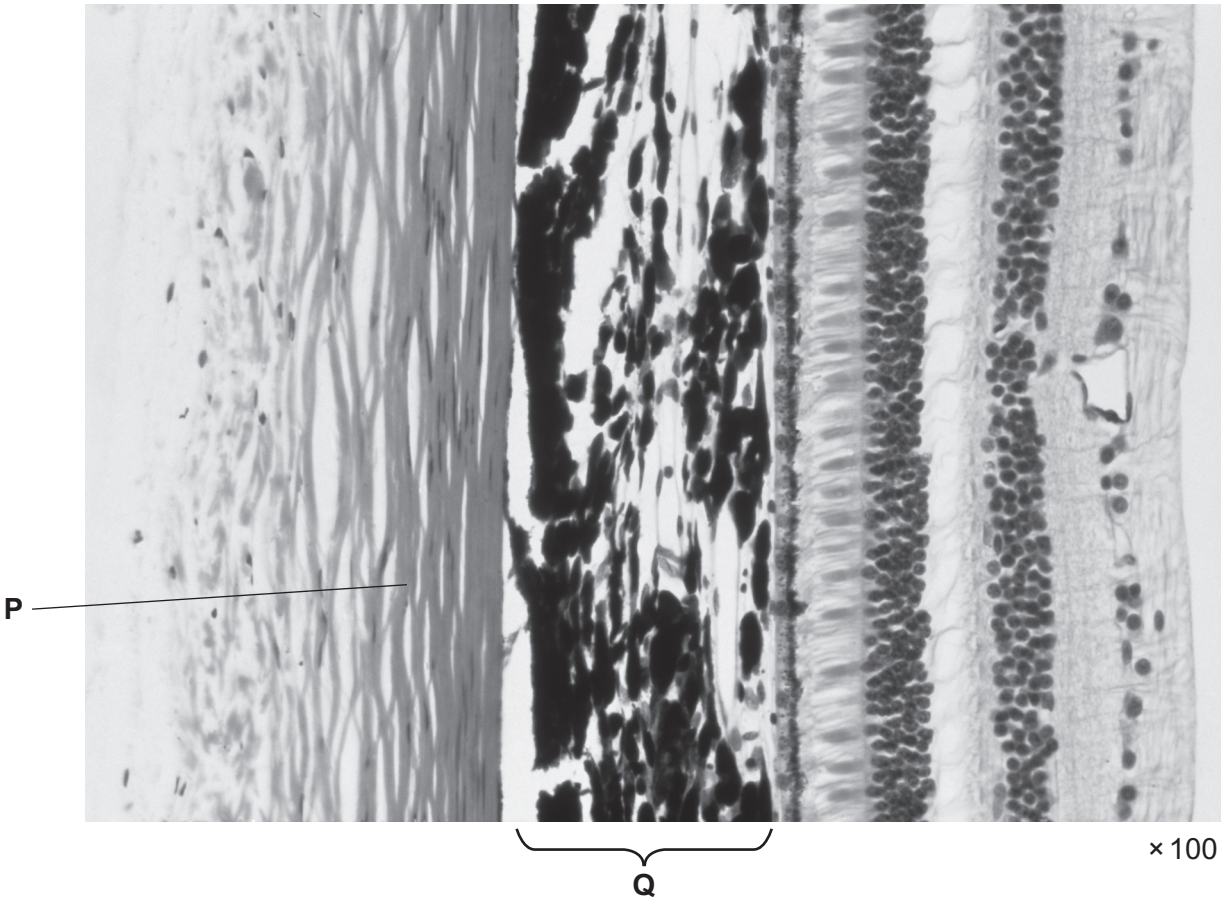
32 The photomicrograph below shows a section through the wall of a mammalian eye.



(a) The tissues of the eye shown in the photomicrograph were stained using eosin, which binds to cytoplasmic proteins staining them pink, and haematoxylin, which stains cell nuclei dark blue.

Describe the advantages of this method of staining tissues for viewing under a microscope.

It is differential staining: different tissues and cell structures are stained different colours, so they can be distinguished and their location within the organ seen.

The dark blue haematoxylin allows the cell nuclei to be identified.

..... **[2]**

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(b) **(i)** Outline the structure and function of the outer layer, labelled **P**, in the photomicrograph.

P is the sclera, a tough layer containing collagen fibres.

It protects the eye and maintains the shape of the eye, and enables

attachment of the eye muscles (ligaments).

..... **[2]**

(ii) The layer labelled **Q** contains highly pigmented cells.

Name layer **Q** and state the importance of this layer to the functioning of the eye.

Name choroid

Importance Its pigment absorbs light, which prevents internal reflection

(scattering) of light inside the eye. **[2]**

(c) Four students were given copies of the photomicrograph and asked to measure the width of the retinal layer in the image using a mm ruler.

The students recorded their results in the table below.

Width of the retinal layer (mm)				
Student 1	**Student 2**	**Student 3**	**Student 4**	**Mean**
64	66	61	65	64

(i) Find the mean of the data and use it to calculate the actual width of the retinal layer.

Mean = (64 + 66 + 61 + 65) ÷ 4 = 64 mm

64 mm ÷ 100 = 0.64 mm = 640 μm

Width = 640 μm **[2]**

(ii) Calculate the uncertainty in the mean value for this data.

Use the equation:

$$\frac{R}{2\sqrt{N}}$$

R = 66 − 61 = 5 mm

5 ÷ (2 × √4) = 5 ÷ 4 = 1.25

R = difference between maximum and minimum values

N = number of measurements taken

Uncertainty = ± 1.25 mm **[2]**

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(d) Bardet-Biedl syndrome (BBS) is a human genetic disorder. One of the main symptoms is child-onset loss of vision.

Abnormalities of cilia are known to be related to a wide range of disease symptoms including those commonly seen in BBS patients. It is now accepted that mutated *BBS* genes affect microtubules and the normal functioning of cilia.

In the early childhood of individuals with BBS, deterioration of cone cells in the retina occurs, leading to poor visual acuity and colour blindness.

(i) Using your knowledge of the internal structure of photoreceptor cells, suggest why mutated *BBS* genes lead to deterioration of cone cells and poor visual acuity.

The cilium connects the inner and outer segments of the cone cell.

Mutated BBS genes cause production of non-functional proteins in the cilia (microtubules), so there is less or no transport of proteins between the segments.

So the outer segments (with iodopsin) deteriorate. **[2]**

(ii) Explain how cone cells enable humans to distinguish colour.

There are three types of cone cell, and different cone cells have a different type of iodopsin.

Each iodopsin absorbs either red, green or blue light, so the cone cells differ in their sensitivity to different wavelengths of light.

This is trichromatic vision; the brain compares the relative stimulation of the three types of cone to perceive a range of colours. **[3]**

(iii) Obesity, syndactyly, diabetes and kidney failure are other symptoms associated with BBS.

Suggest why BBS is described as a syndrome.

It has widespread effects in the body, affecting several organs and systems, not just one symptom. **[1]**

(iv) State the mechanism that prevents syndactyly occurring in healthy individuals.

Apoptosis (programmed cell death) of the cells between the digits. **[1]**

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33 The coronary artery supplies blood to the heart. If the coronary artery is blocked or damaged a heart attack may occur.

(a) When a person is suspected of having a heart attack it is a medical emergency and the first step of the emergency procedure is to call for an ambulance.

State **two** other steps in the emergency procedure for a person who is suspected of having a heart attack.

1 Sit the person down in an upright position with the knees bent (the W position).

2 Give them an aspirin tablet to chew, and monitor their breathing and pulse rates.

[2]

Question 33(b) begins on page 26

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(b) Alcohol is a drug known to reduce the heart rate in humans. A group of students wanted to find out if alcohol had the same effect on the heart rate of the water flea, *Daphnia magna*.

One of the students made the following notes about the investigation.

1. We put a sample of Daphnia on a depression slide containing deionised water (control).
2. We put the slide under a light microscope and recorded a live video of the Daphnia sample.
3. We replayed the video in slow motion and counted the number of heart beats in 20s for 12 different Daphnia.
4. We then calculated the heart rate and recorded our data as the number of beats per minute (bpm).
5. We put a sample of Daphnia on a slide containing 2.5% alcohol and waited two minutes.
6. After two minutes we measured the heart rate using the same method as before.
7. We also repeated the investigation with 5% alcohol but decided that we could not repeat our investigation using this concentration, so we chose to use 2.5% alcohol.
8. We concluded that alcohol lowers the heart rate of Daphnia but the difference is not significant.

(i) Give **one** reason why note 5, but **not** note 1, mentions that the students 'waited for two minutes'.

In note 1 the Daphnia were already in water (acclimatised); in note 5 time is needed for the alcohol to be taken in by the Daphnia. **[1]**

(ii) Suggest **one** reason why the students decided that they could not repeat the investigation using 5% alcohol concentration.

The Daphnia died at 5% alcohol, so the results would be invalid (and it would be unethical). **[1]**

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(c) The results of the students' investigation are shown in **Table 33.1**.

D. magna individual	Heart rate in water (bpm)	Heart rate in 2.5% alcohol (bpm)	Difference (d)	Difference from the mean ($d-\bar{d}$)	$(d-\bar{d})^2$
1	280	180	100	–7.3	53.29
2	295	185	110	2.7	7.29
3	283	181	102	–5.3	28.09
4	290	185	105	–2.3	5.29
5	289	180	109	1.7	2.89
6	291	183	108	0.7	0.49
7	293	185	108	0.7	0.49
8	289	182	107	–0.3	0.09
9	291	183	108	0.7	0.49
10	295	186	109	1.7	2.89
11	292	180	112	4.7	22.09
12	290	180	110	2.7	7.29
		Mean ($\bar{d}$) =	**107.3**	**Sum =**	**130.36**

Table 33.1

(i) Use the results in **Table 33.1** to carry out a Student's paired *t*-test for these data.

Use the equations:

Standard deviation $s_d = \sqrt{\frac{\Sigma(d-\bar{d})^2}{n-1}}$

$t = \frac{\bar{d}\sqrt{n}}{s_d}$

$s_d = \sqrt{(130.36 \div 11)} = \sqrt{11.85} = 3.44$

$t = (107.3 \times \sqrt{12}) \div 3.44$

$= 371.7 \div 3.44$

$= 108.1$

t = ...108.1..... **[3]**

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(ii) The table of critical values for 5% significance level is shown in **Table 33.2**.

Degrees of freedom	Critical value
4	2.78
5	2.57
6	2.48
7	2.37
8	2.31
9	2.26
10	2.23
11	2.20
12	2.18
13	2.16
14	2.15

Table 33.2

Using **Table 33.2** and your answer to **c(i)**, comment on the conclusion made by the students in note 8: 'We concluded that alcohol lowers the heart rate of Daphnia but the difference is not significant'.

The students are correct that alcohol lowers the heart rate, but incorrect that it is not significant: it is significantly lower. For 11 degrees of freedom the critical value is 2.20, which is much lower than t = 108.1, so the difference is significant ($p < 0.05$).

..... **[2]**

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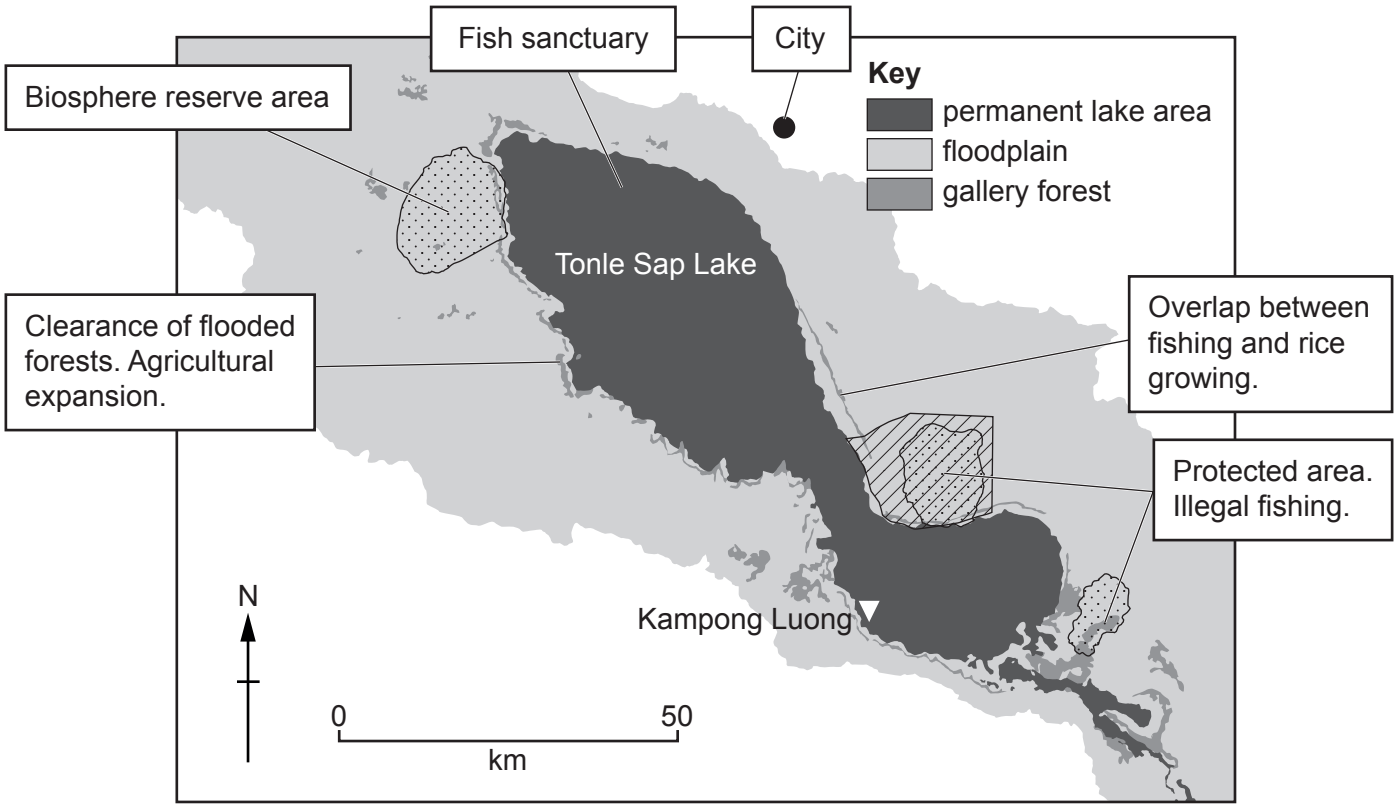
34 Tonle Sap Lake in Cambodia is one of the world's most productive and biodiverse freshwater ecosystems.

The human population of the Tonle Sap Lake live on floating villages that rise and fall with the water levels and depend on the traditional ways of living from rice farming, fishing and extracting forest resources.

The location map shows the Tonle Sap Lake with some of the human activities that take place.



(a)* Using the information, evaluate the possible impact of human activities on the ecosystem of the Tonle Sap Lake. **[6]**

Positive impacts: the biosphere reserve area will maintain biodiversity and habitats. The protected area and the fish sanctuary could limit the decline in fish stocks, allowing populations to recover. The city could provide ecotourism, which encourages maintaining biodiversity. The traditional ways of living in floating villages are more sustainable, and human waste from the villages could provide nutrients for fish, increasing some species (although it could also cause eutrophication).

Negative impacts: clearance of flooded forests could lead to the loss of tree-dwelling species, and could change the extent of the floodplain area,

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leading to a change in biodiversity. Agricultural expansion leads to loss of habitats. Where fishing and rice growing overlap there may be conflict between fishermen and rice growers, and over-fishing or over-planting could cause the decline or loss of certain species. Illegal fishing, even in the protected area, causes the decline of some species. Overall, the protected areas may reduce the impact, but habitat clearance and over-exploitation are likely to reduce biodiversity unless they are controlled.

Additional answer space if required.

(b) A team of ecologists recorded the number of animal species living in four different habitats provided by one region of the Tonle Sap Lake.

Their data are shown in the table below.

Habitat	**Number of different animal species**
Deep water	17
Abandoned rice fields	12
Floodplain shrubland and forest	92
Rice fields	4

(i) Suggest reasons for differences in the number of animal species in these habitats.

Fewest in rice fields due to disturbance and clearance of habitats for planting and harvesting (monoculture). Most in floodplain shrubland and forest, as more different types of habitat are available. Abandoned rice fields have more than rice fields due to repopulation (secondary succession). **[2]**

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(ii) State how the team of ecologists could calculate the **biodiversity** in each of these habitats **and** what additional data would be needed for the calculation.

Calculate Simpson's Diversity Index, $D = 1 - \Sigma(n/N)^2$, for each habitat.

They would also need the number of individuals of each species (species abundance) in each habitat.

[2]

(c) Cambodia is thought to have the largest wild population of the Siamese crocodile, *Crocodylus siamensis*.

C.siamensis is a critically endangered species that is now virtually extinct in the wild in most other countries of Southeast Asia.

Studies of genetic diversity amongst the Cambodian population of *C.siamensis* in protected areas have provided some evidence that there was a recent genetic bottleneck event in the Tonle Sap Lake area.

(i) Using this example, explain what is meant by the term, genetic bottleneck.

A chance event occurs, causing a significant reduction in the population (number of individuals) of C. siamensis in the Tonle Sap Lake area.

The surviving crocodile population has fewer alleles than the original population, so there is a decrease in genetic diversity.

The population then grows again from these few survivors, so the low genetic diversity remains.

[3]

(ii) Give **one** possible cause for the genetic bottleneck event that affected *C.siamensis*.

Habitat destruction, e.g. clearance of the flooded forests where they live.

[1]

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(d) Crocodile farms have been established on the Tonle Sap Lake to develop captive-breeding programmes for *C.siamensis*.

Genetic analysis data of *C.siamensis* populations from two different crocodile farms is shown in the table below.

	Population from crocodile farm 1	**Population from crocodile farm 2**
Number of individuals in the population	45	15
Number of gene loci studied	35	40
Number of monomorphic genes	28	26

(i) Using the data, calculate the percentage of polymorphic genes in the population of each crocodile farm.

Farm 1: polymorphic = 35 − 28 = 7; 7 ÷ 35 × 100 = 20%

Farm 2: polymorphic = 40 − 26 = 14; 14 ÷ 40 × 100 = 35%

Farm 1 .....20.....% Farm 2 .....35.....%

[2]

(ii) Using the table and your answers to **(d)(i)**, comment on the suitability of each of these crocodile farms for developing a captive-breeding programme for *C.siamensis*.

Farm 2 would be most suitable, as it has a higher percentage of polymorphic genes (35%), so greater genetic diversity. However, farm 1 has more individuals in the population (45), so there are more options for breeding pairs.

..... **[2]**

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35 Nucleic acids are required for the synthesis of proteins.

(a) For each of the nucleic acids below, describe its role in protein synthesis.

(i) Messenger RNA (mRNA)

It carries the genetic code (a copy of the gene) from the nucleus to the ribosomes. **[1]**

(ii) Transfer RNA (tRNA)

Each tRNA carries a specific amino acid, and its anticodon binds to the complementary codon on the mRNA. **[1]**

(b) DNA is the nucleic acid that provides the genetic information required for protein synthesis. This information is known as the genetic code.

Complete the passage below about the nature of the genetic code using the most appropriate word(s).

The sequence of bases in one strand of DNA provides the genetic code for making proteins.

Sections of DNA that code for specific polypeptides are known as .....genes..... .

A sequence of .....three..... nucleotide bases is required to form a DNA codon that codes for an amino acid. However, the genetic code is .....degenerate..... , which means that there is more than one codon for each amino acid. Each DNA codon is read separately which means that there is no .....overlap..... of bases in the sequence during transcription.

[4]

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(c) Avidin is a glycoprotein found in the whites of bird and reptile eggs. It has been investigated as an alternative insecticide for crop plants such as wheat.

In one study, researchers produced transgenic wheat plants containing the avidin gene. The expression of this gene was found to offer some protection against the wheat weevil, *Sitophilus granarius*.

Outline a method that the researchers could have used to produce transgenic wheat plants.

The avidin gene is identified and isolated from the bird genome using restriction enzymes (or made from mRNA using reverse transcriptase). The gene is inserted into a vector, e.g. a plasmid of Agrobacterium tumefaciens, using DNA ligase, with a marker gene. The vector is incorporated into wheat plant cells (or a gene gun is used to introduce the gene), so the gene is inserted into the genome (DNA) of the wheat plant. Transformed cells are selected and grown into plants by tissue culture. **[3]**

(d) Avidin acts as an insecticide by preventing wheat weevils from obtaining biotin in their diet. Biotin is an essential cofactor required by insects.

(i) Suggest how avidin prevents insects from obtaining biotin.

Avidin binds to biotin, preventing its absorption from the gut. **[1]**

(ii) Suggest why lack of biotin leads to the death of wheat weevils.

Biotin is a cofactor required for enzyme activity, so without it specific metabolic reactions stop, e.g. weevils cannot synthesise proteins (or respire). Weevils cannot synthesise biotin themselves, so they die. **[2]**

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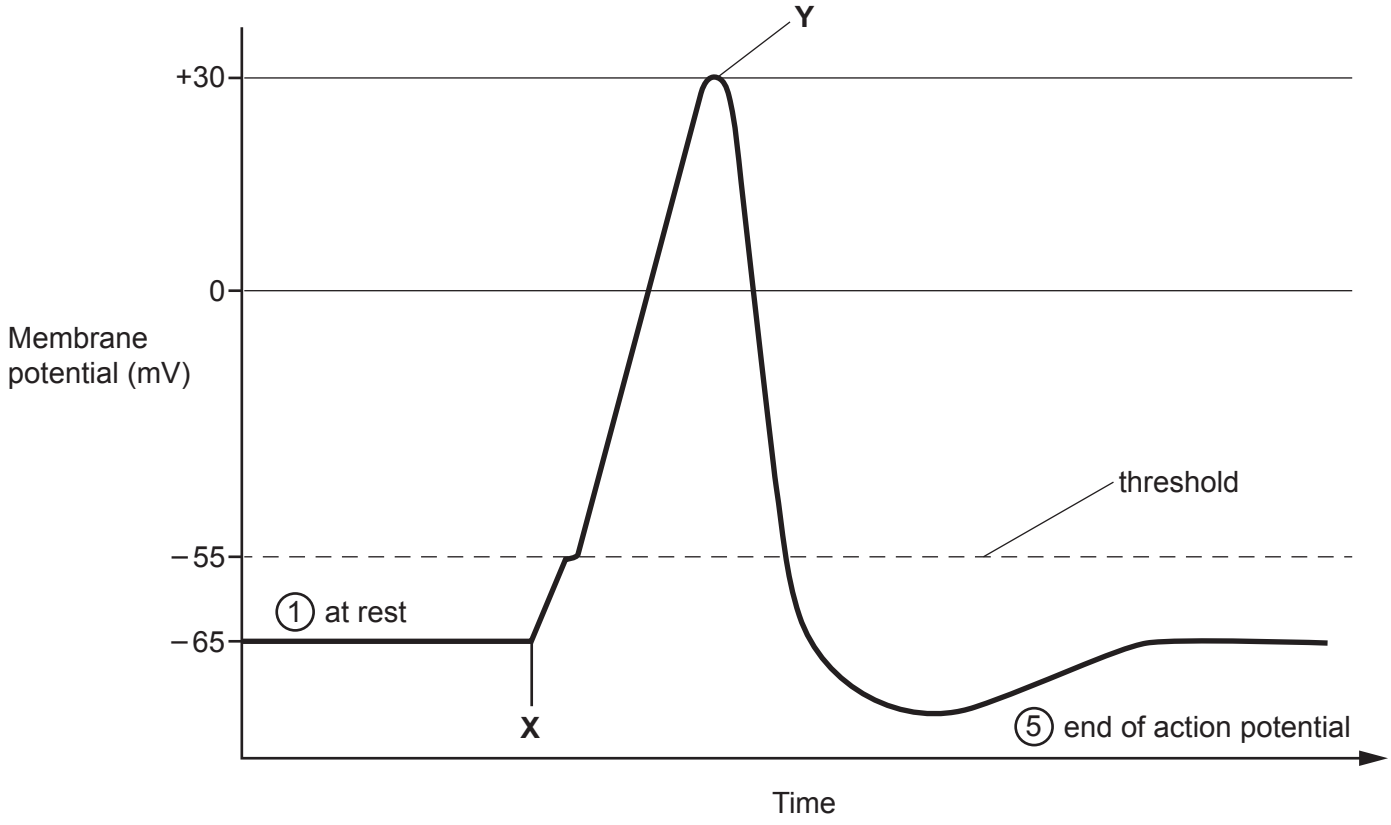
36 The resting potential of most neurones is maintained at about –65 mV.

(a) Complete the table by deciding whether each of the statements about maintaining the resting potential of a neurone is true **(T)** or false **(F)**.

Statement	True (T) or False (F)
ATP is used to pump Na^+ in and K^+ out of the axon	F
The inside of the axon membrane has a positive charge relative to the outside	F
The axon membrane is more permeable to K^+ than Na^+	T

[2]

(b) The graph shows the changes in potential across a neurone membrane during an action potential.



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Explain the feedback mechanism that causes the voltage to rise between points **X** and **Y**.

This is positive feedback.

A stimulus causes some voltage-gated Na^+ channels to open, so Na^+ ions enter the axon by diffusion, causing a generator potential (depolarisation). When the threshold (−55 mV) is reached, the entry of Na^+ causes more voltage-gated Na^+ channels to open, which leads to more Na^+ entering, so the membrane depolarises rapidly to +30 mV at Y.

[3]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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