

Tuesday 20 October 2020 – Afternoon

A Level Biology B (Advancing Biology)

H422/03 Practical skills in biology

Time allowed: 1 hour 30 minutes

You must have:

- the Insert
- a ruler (cm/mm)

You can use:

- a scientific or graphical calculator



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

Centre number

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Candidate number

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First name(s)

Last name

StemUp Model Solution

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- 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.
- 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.

INFORMATION

- The total mark for this paper is **60**.
- 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.

Answer **all** the questions.

- 1 A student used the following method to investigate the effect of increasing duration of exercise on pulse rate.

1. Two sample groups of ten people were selected.
2. The resting pulse rate was recorded for each person, using the radial artery on the wrist.
3. Each person ran on a treadmill for 1 min.
4. The pulse rate was taken immediately after exercise.
5. The measurements were repeated for exercise durations of 2-10 min.
6. All measurements were repeated.

- (a) (i) State **two** variables that the student would need to control when planning this investigation. For each variable give one reason why that variable must be controlled.

Variable *speed and gradient of the treadmill*

Reason *a higher speed or gradient creates higher energy demands for the body, so a higher heart (pulse) rate*

Variable *age of the participants*

Reason *older people have lower heart rates, so age would affect the pulse rate*

[4]

- (ii) The student also used secondary data in this investigation.

Explain **two** advantages of using secondary data in investigations.

Secondary data is often from a larger sample, so it is more reliable.
It has usually been peer reviewed, so the conclusions are more valid;
data collected using different methods shows the results are reproducible.

[2]

(b) Fig. 1.1 shows the heart rate of an athlete before and during a race.

- Stage 1 is at rest.
- Stage 2 is immediately before the starting pistol is fired.
- Stage 3 is immediately after the race has finished.

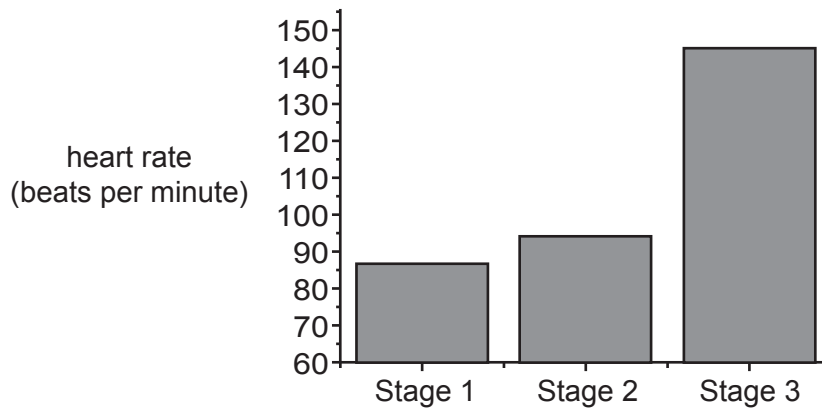


Fig. 1.1

- (i) Describe and explain the effect of Stage 2 on heart rate.

Heart rate increases slightly at Stage 2, from about 87 to about 95 beats per minute.
This is an anticipatory response: adrenaline and noradrenaline are released, increasing delivery of oxygen to the muscles in anticipation of exercise. [2]

- (ii) The following measurements were made of the athlete during the race:

Stroke volume = 165 cm^3

Heart rate = 145 bpm

Calculate the cardiac output for this athlete.

$$\text{cardiac output} = \text{stroke volume} \times \text{heart rate} = 165 \times 145$$

$$\text{cardiac output} = 23.925 \text{ units } \text{cm}^3 \text{ min}^{-1} [1]$$

- (iii) Explain why cardiac output decreases at very high heart rates.

There is less time for the ventricles to fill between beats, so the stroke volume is lower.

[1]

- (c) Fig. 1.2 shows an electrocardiogram (ECG) trace for a normal heartbeat. Fig. 1.3 shows an ECG trace of a patient suffering a heart attack.

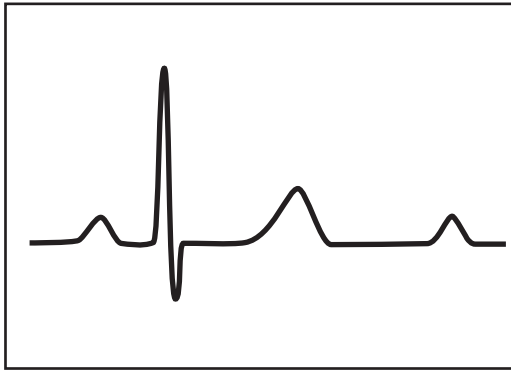


Fig. 1.2

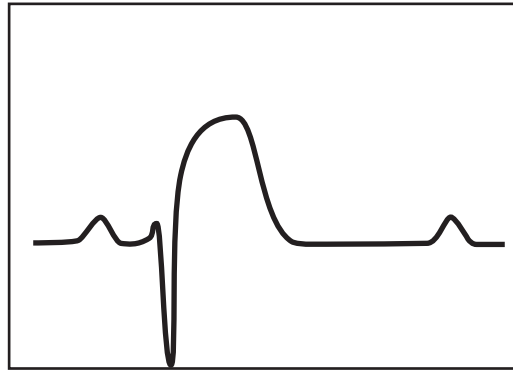


Fig. 1.3

- (i) Which **one** of the following patterns, visible in Fig. 1.3, would indicate that the patient may be having a heart attack.

Place a tick (✓) in the appropriate box.

Elevation of the ST section	✓
Abnormally shaped P-wave	
Deep S wave	

[1]

- (ii) The ECG trace in Fig. 1.4 was recorded using a smartphone app.

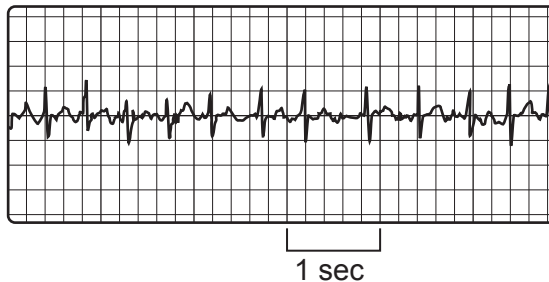


Fig. 1.4

Using Fig. 1.4 and your knowledge suggest why atrial fibrillation could lead to a cardiac arrest.

The atrial muscle contracts arrhythmically (uncoordinated), so the ventricles fill inefficiently and the heart cannot pump enough blood.

[1]

5
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PLEASE DO NOT WRITE ON THIS PAGE

- (d)* An investigation was carried out into the effectiveness of smartphone apps for early diagnosis of heart conditions.

Two statements that were provided in this investigation.

Statement 1:

- Patients with compatible smartphones were issued with a smartphone app.
- The sample was composed of 148 patients 53 male, 95 female; average age 41 years, range 7 to 78, with two patients over 75.
- Patients were asked to record an ECG when they experienced symptoms of palpitations.
- Patients were linked to doctors via a secure website and could upload ECGs.
- Median time from symptoms to diagnosis was 9 days.
- In most cases no significant cardiac rhythm disturbance was found.

Statement 2:

- My patient was a 68 year old man with atrial fibrillation. He had previously been using cardiac event monitors to check his heart rhythm and started to use a smartphone app instead.
- Cardiac event monitors require the patient to wear electrodes attached to the chest, continuously for 30 days and to avoid the use of anything that may disrupt the signal, such as electric toothbrushes, metal detectors or mobile phones.
- With the smartphone app, I provide feedback so that the patient knows what his cardiac rhythm is doing and whether he is having symptoms.

Statement 1 was made by the scientists who carried out the investigation.

Statement 2 was made by a GP who was interviewed during the investigation.

Using the information given in Statements 1 and 2, evaluate the use of the smartphone app in the monitoring of heart conditions. [6]

Benefits: Statement 1 shows a relatively short median time from symptoms to diagnosis (9 days), as ECGs are uploaded to doctors via a secure website, so results are immediately available.

Statement 2 shows the app causes less disruption to lifestyle than a cardiac event monitor, which needs chest electrodes worn continuously for 30 days and stops the use of phones or electric toothbrushes. No specialist fitting is needed, so it costs the NHS less and saves GP time.

Feedback reassures patients (most had no significant rhythm disturbance),
 avoiding anxiety and further tests, and doctors can make more informed
 treatment decisions, e.g. medication dosage.
 Drawbacks: only patients with compatible smartphones took part; older
 people, who are at greater risk of heart disease, may not have one or may
 lack confidence in technology (only two patients were over 75). Patients
 may use the app incorrectly or not recognise symptoms, so less data is
 collected than with continuous recording.

Additional answer space if required.

The trace may be poorer quality than a 12-electrode hospital ECG, battery
 life may limit long-term use. Statement 2 is one GP's view of a single
 patient, and the app has not been tested over many years.
 Overall, the app is useful but should support, not replace, standard ECGs.

2 Plants are usually adapted to living in conditions of different light intensities.

The leaf of a plant that is adapted to living in shade will differ from the leaf of a plant that is adapted to living in sunlight.

A student investigated the correlation between leaf and petiole sizes of two species of ivy plants. The following procedure was carried out:

- a random sampling technique was used to collect 10 samples of species A and 10 samples of species B
- the variables of leaf width and petiole length, shown in Fig. 2.1, were measured.

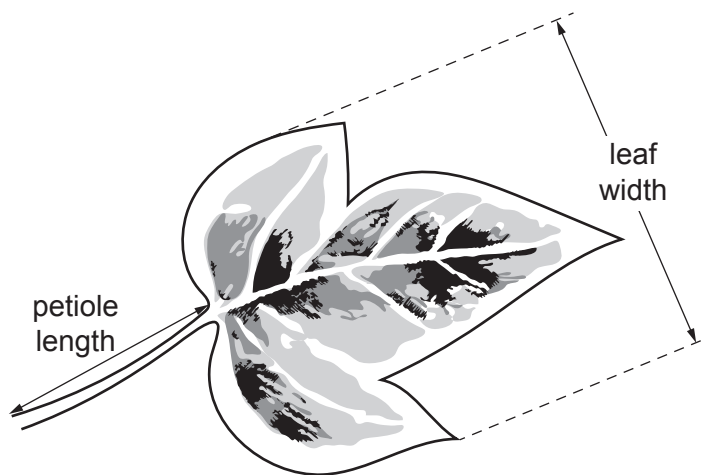


Fig. 2.1

Some of the student's results are shown in Table 2.1.

Sample	Species A					
	Petiole length (mm)	Rank	Leaf width (mm)	Rank	d	d ²
1	28	2	52	3.5	-1.5	2.25
2	30	3	55	5	-2	4
3	17	1	31	1	0	0
4	31	4	52	3.5	0.5	0.25
5	35	6	56	6	0	0
6	45	7	61	7	0	0
7	46	8	62	8	0	0
8	77	10	98	10	0	0
9	33	5	40	2	3	9
10	57	9	69	9	0	0
					Total	15.50

Table 2.1

(a) (i) Complete the missing values in **Table 2.1** for species A. [2]

(ii) Calculate Spearman's rank correlation coefficient (r_s).

Use the formula: $r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$

$$\sum d^2 = 15.50, \quad n = 10$$

$$r_s = 1 - (6 \times 15.50) \div (10 \times (10^2 - 1))$$

$$r_s = 1 - 93 \div 990 = 1 - 0.0939$$

$$r_s = \dots\dots\dots 0.9061 \dots\dots\dots [2]$$

(iii) The null hypothesis for this investigation was:

'There is no significant correlation between leaf width and petiole length.'

Write a conclusion for the results.

Your conclusion should explain whether the null hypothesis should be rejected or accepted at the 5% level of probability.

	10%	5%	2%	1%
<i>n</i>				
1	—	—	—	—
2	—	—	—	—
3	—	—	—	—
4	1.0000	—	—	—
5	0.9000	1.0000	1.0000	—
6	0.8286	0.8857	0.9429	1.0000
7	0.7143	0.7857	0.8929	0.9286
8	0.6429	0.7381	0.8333	0.8810
9	0.6000	0.7000	0.7833	0.8333
10	0.5636	0.6485	0.7455	0.7939

The critical value for $n = 10$ at $p = 0.05$ is 0.6485. The calculated value (0.9061) is greater than the critical value, so the null hypothesis is rejected.

There is a significant, strong positive correlation between leaf width and petiole length; the results are not due to chance. [2]

(b) Xerophytic plants are plants that are adapted to living in very dry conditions.

The table below gives a description of some adaptations of xerophytic plants.

Complete the table by indicating with a tick (✓) whether the adaptation is **behavioural**, **physiological** or **anatomical**.

Adaptation	Behavioural	Physiological	Anatomical
Stomata open only at night	✓		
Stem becomes more rounded with fewer folds when water is available		✓	
Stomata are located in sunken pits			✓

[3]

- (c) *Metasequoia occidentalis* is an extinct species of redwood tree that grew in forests approximately 39 million years ago.

A group of students wanted to find out if the leaves of *M. occidentalis* were adapted to sun or shade conditions.

They obtained three electron micrographs showing the ultrastructure of chloroplasts that had been extracted from:

- fossilised leaf samples of *M. occidentalis*
- leaf samples of *M. glyptostrobooides*, a living *Metasequoia* species that had been growing in sun conditions
- leaf samples of *M. glyptostrobooides* that had been growing in shade conditions.

- (i) Suggest **one** reason for using a living species of *Metasequoia* in this investigation.

As a control, to allow comparison of the fossil chloroplasts with
chloroplasts from leaves known to have grown in sun or in shade
conditions.

[1]

- (ii)* One of the students made drawings of a chloroplast from each of the three electron micrographs. These are shown in Fig. 2.2a, Fig. 2.2b and Fig. 2.2c.

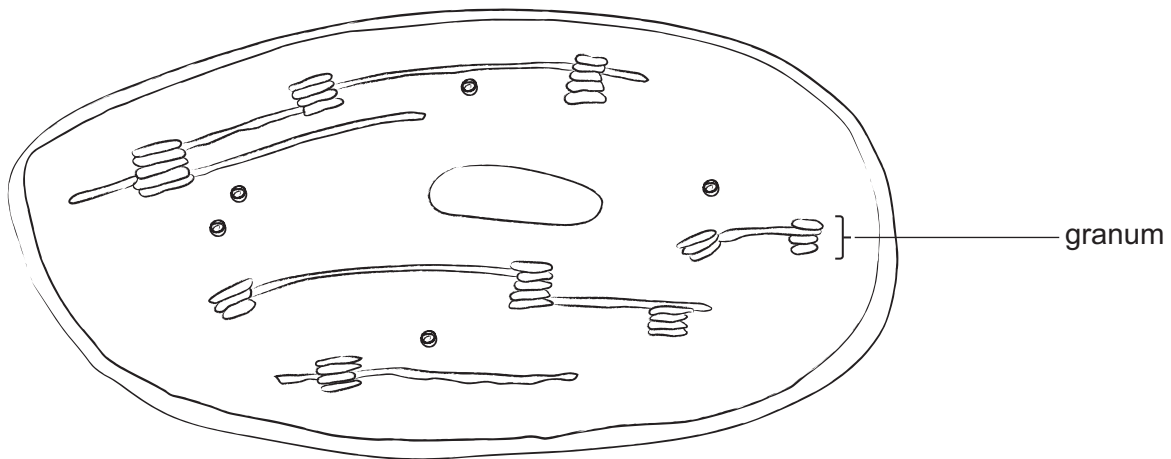


Fig. 2.2a chloroplast from *M. occidentalis*

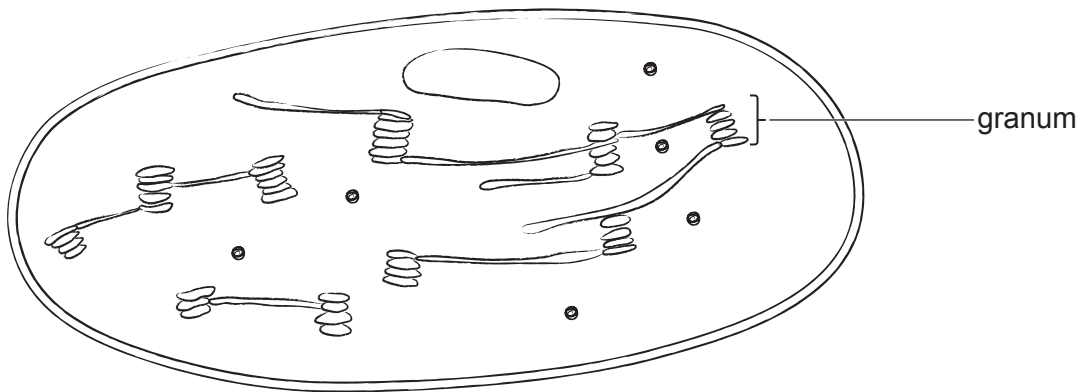


Fig. 2.2b chloroplast from *M. glyptostroboides* in sun conditions

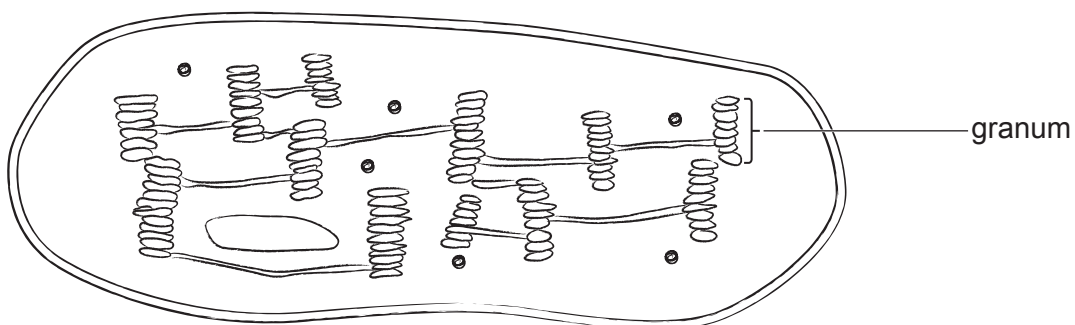


Fig. 2.2c chloroplast from *M. glyptostroboides* in shade conditions

The student concluded that:

M. occidentalis is likely to have grown in sun conditions with high light intensity.

Evaluate this conclusion.

[6]

Supporting: the chloroplast from *M. occidentalis* (Fig. 2.2a) has a very similar ultrastructure to the chloroplast from *M. glyptostroboides* grown in the sun (Fig. 2.2b). Both have similar numbers of grana (about 10) of a similar small size, with only 3 to 4 thylakoids per granum. The shade chloroplast (Fig. 2.2c) has more, larger grana with up to about 10 thylakoids per granum, so there are fewer thylakoids in both 2.2a and 2.2b. In high light intensity fewer thylakoids and grana are needed for light capture, so this supports the conclusion that *M. occidentalis* grew in the sun.

Undermining: there is only one drawing of a chloroplast from each micrograph, and the student's drawings may be inaccurate. The fossil chloroplasts or leaves from an extinct species may have been damaged, the electron micrographs may have been poor quality, and the methods of obtaining the leaf samples may have been different.

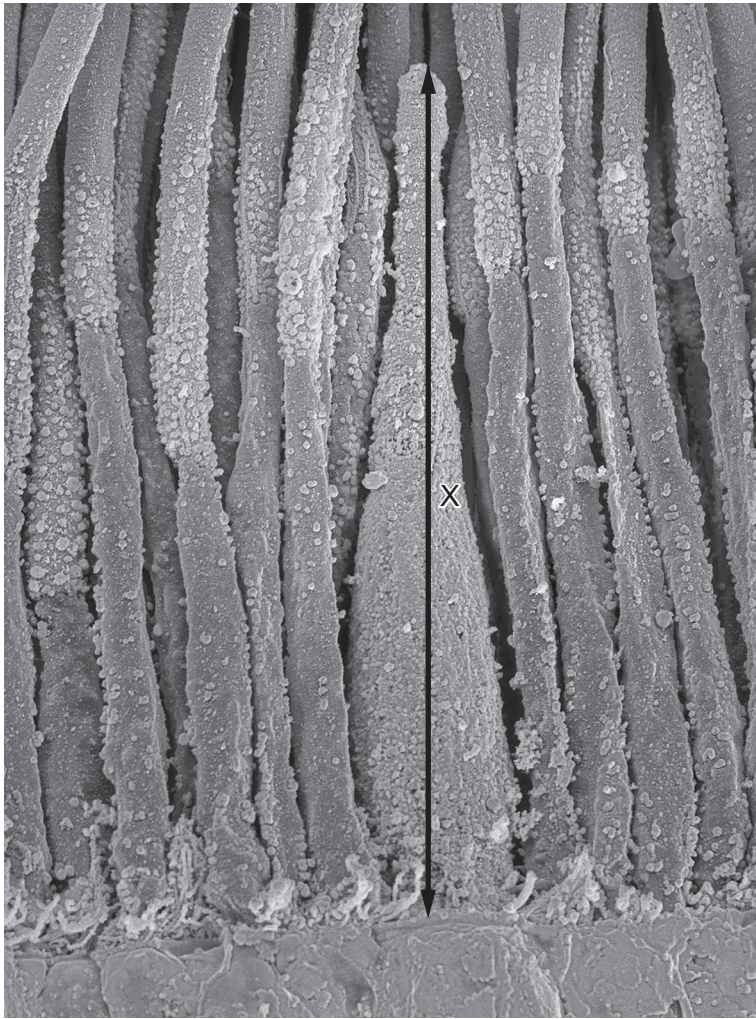
There may be different numbers of chloroplasts per cell, or different

Additional answer space if required.

numbers of leaves, in the two species, and *M. glyptostroboides* may not respond to light in the same way as the extinct species.

Overall, the evidence supports the conclusion, but more data (more chloroplasts from more leaves) is needed before it can be accepted.

- 3 Fig. 3.1 is a scanning electron micrograph of receptor cells in the retina of the human eye.



×4000 magnification

Fig. 3.1

- (a) (i) Calculate the actual height of the cone cell using line X.

Give your answer to **3 significant figures**.

$$\text{length of line X} = 113 \text{ mm} = 113\,000 \mu\text{m}$$

$$\text{actual size} = \text{image size} \div \text{magnification} = 113\,000 \div 4000 = 28.25 \mu\text{m}$$

$$\text{height of cone cell} = \dots\dots\dots 28.3 \dots\dots\dots \mu\text{m} \quad [2]$$

- (ii) Name the photosensitive pigment found in cone cells.

iodopsin..... [1]

- (iii) Give **two disadvantages** of the technique used to prepare the image in Fig. 3.1.

The preparation procedure is more technical and requires advanced practical skills, e.g. complex staining (coating with heavy metal).

Artefacts may occur during preparation.

[2]

(b) Fig. 3.2 is a light micrograph of a section through a mammalian eye.

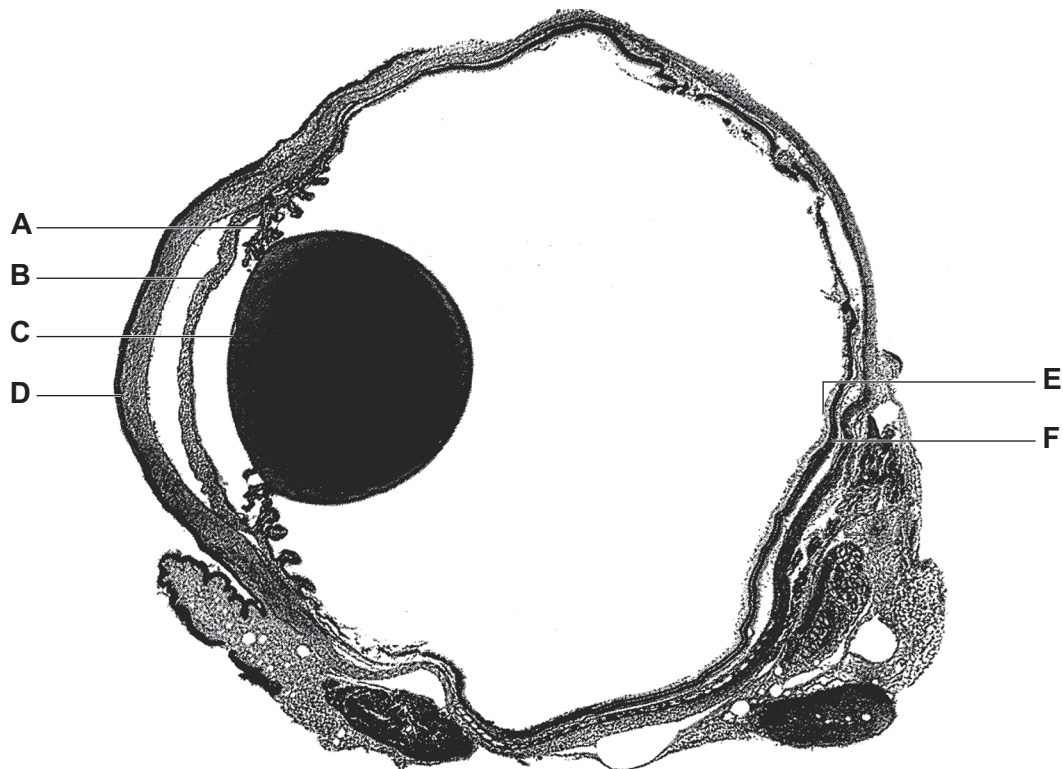


Fig. 3.2

Complete the table below about the structures labelled A to F in Fig. 3.2.

Label	Name	Function
A	ciliary muscle	<i>alters the shape of the lens</i> <i>(for focusing)</i>
B	<i>iris</i>	Controls amount of light entering the eye
C	<i>lens</i>	Focuses light rays
D	cornea	<i>refracts light onto the retina</i>
E	retina	<i>contains photoreceptors (rods, cones);</i> <i>converts light to action potentials</i>
F	<i>choroid</i>	Pigmented layer to prevent internal reflection

[3]

- (c) A student is performing a dissection of a sheep's eye and wishes to extract the lens. The eye is covered in fatty tissue.

Describe how the items of equipment are to be used in the dissection and the actions that should be taken to ensure safe working in a dissection procedure.

Use scissors to cut away the fatty tissue from around the eye. Use a
scalpel to make an incision in the sclera and remove the muscles, then use
a blunt seeker to separate the lens.
Wear gloves and use a dissecting mat to prevent contamination from tissue
or fluid; disinfect instruments, wash hands and use a biological waste bin.
Always cut away from the body to prevent injury from the scalpel or
scissors, and check for allergies before starting the dissection.

[3]

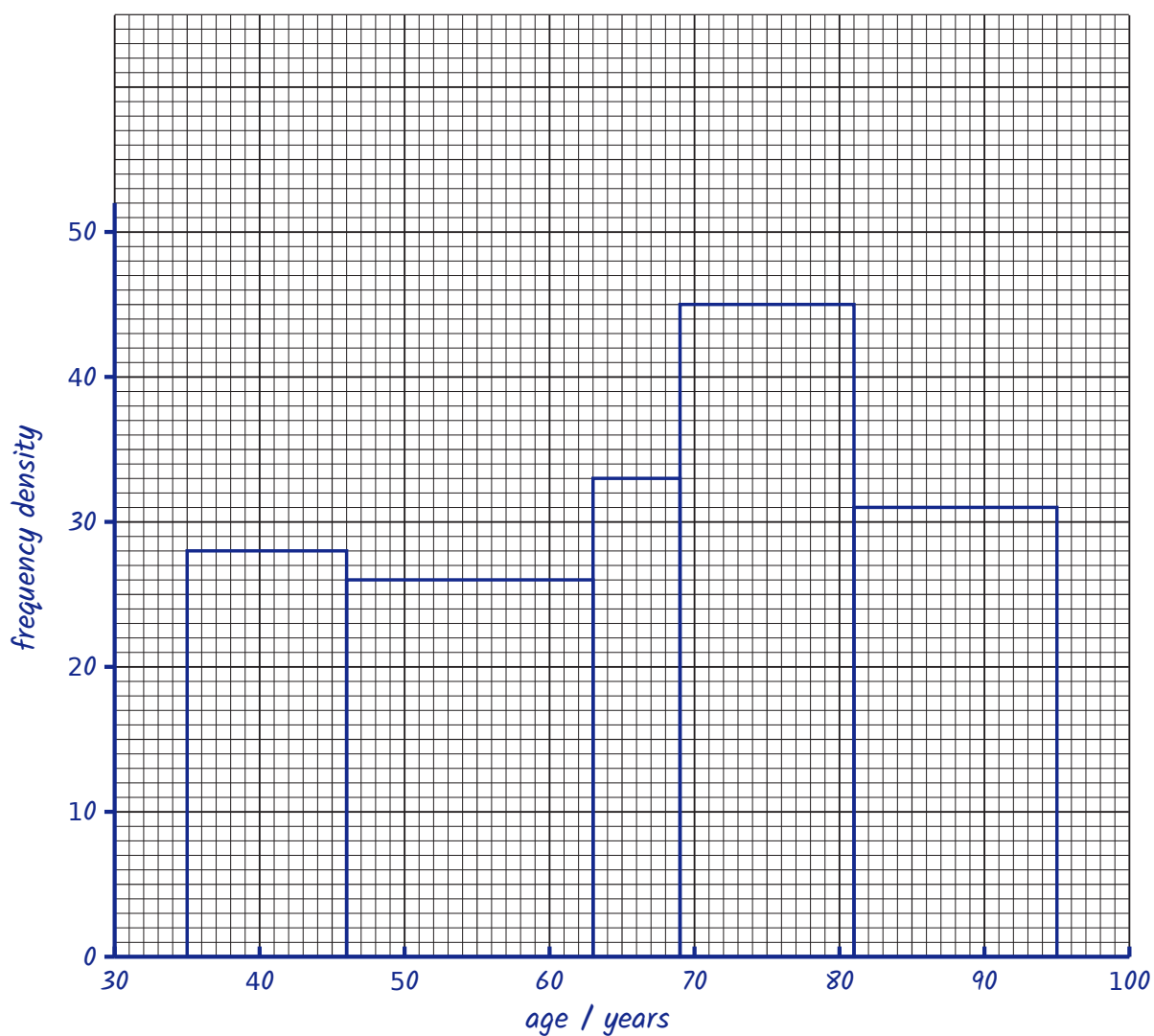
- (d) Retinopathy is an eye condition which can be caused by diabetes.

An investigation into the incidence of diabetic retinopathy in the UK was carried out.

Some of the data from the study are shown in the table below.

Age (years)	Frequency density
$35 \leq X < 46$	28
$46 \leq X < 63$	26
$63 \leq X < 69$	33
$69 \leq X < 81$	45
$81 \leq X < 95$	31

- (i) Using the data in the table, plot a histogram on the grid provided.



[3]

- (ii) Calculate how many cases of diabetic retinopathy were found between the ages of 63 and 81.

$$63 \text{ to } 69: 6 \times 33 = 198$$

$$69 \text{ to } 81: 12 \times 45 = 540$$

$$\text{total} = 198 + 540 = 738$$

number of cases = ...738..... [2]

- (iii) Explain why it is an advantage to use large sample sizes.

..A large sample is more representative of the population, so it gives a
..more accurate mean and reduces the impact of anomalous results.....

..... [1]

- (iv) A key finding of the study was large regional variation in the incidence of retinopathy, after accounting for age, gender, deprivation and ethnicity.

Suggest a reason for the large regional variation.

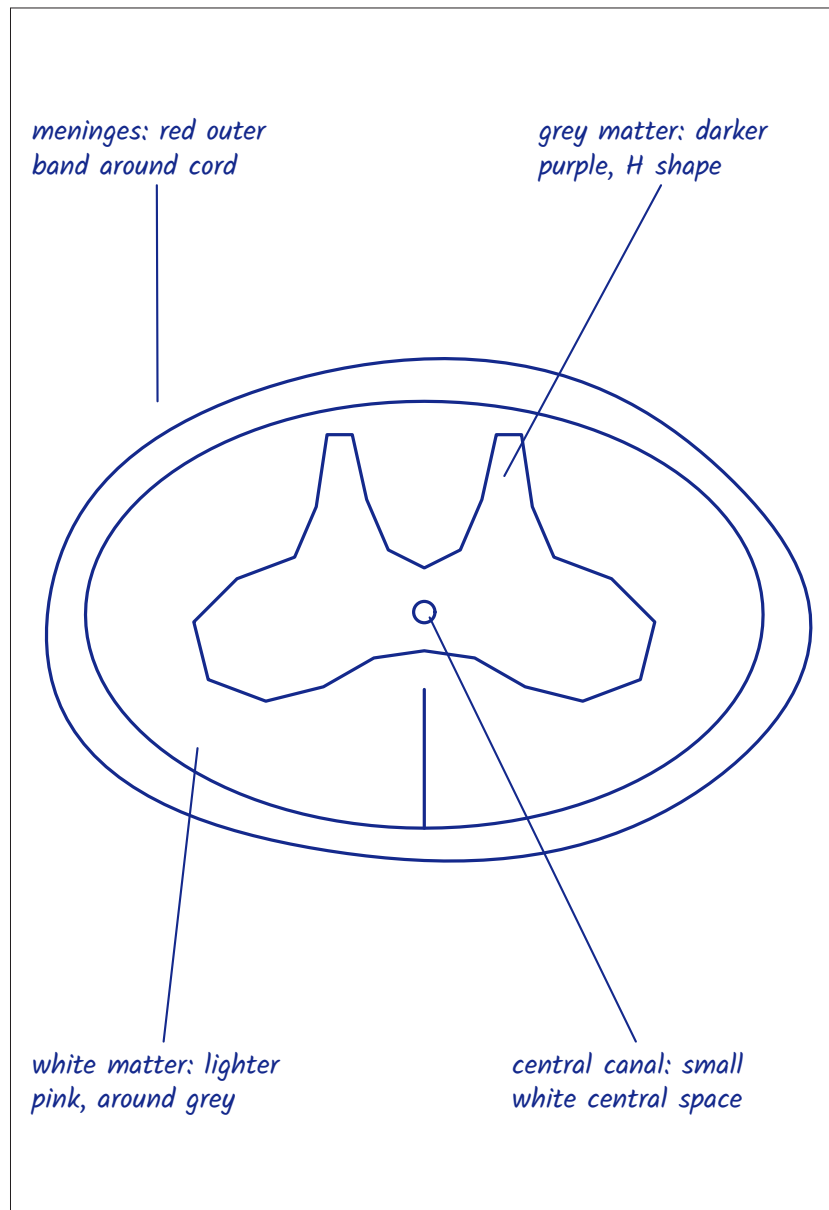
..Regional differences in the organisation and delivery of diabetic
..retinopathy screening programmes.....

..Uptake of screening, and so opportunities for diagnosis, may be lower in
..rural than urban areas because screening services are less accessible.....

..... [2]

- 4 Fig. 4.1, **on the insert**, is a light micrograph of a transverse section through a mammalian spinal cord.

(a) In the space below, draw an annotated tissue plan of Fig. 4.1. Include labels for the following structures: central canal, grey matter, white matter, and meninges.



[4]

- (b) Fig. 4.2 shows a light micrograph and Fig. 4.3 shows a scanning electron micrograph of nerve cells in the human brain.

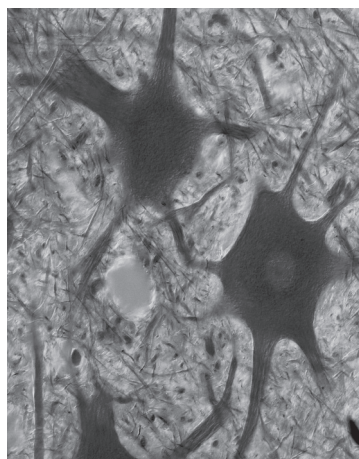


Fig. 4.2



Fig. 4.3

The images in Fig. 4.2 and Fig. 4.3 were taken from the same tissue and were produced at the same magnification.

Explain why the image in Fig. 4.3 shows greater detail compared with the image in Fig. 4.2.

Fig. 4.3 is an electron micrograph, which has a higher resolution, because electrons have a shorter wavelength than light. [1]

- (c) The autonomic nervous system is divided into two branches, the sympathetic and parasympathetic nervous systems.

Complete the table to compare the sympathetic and parasympathetic nervous systems.

Feature	Parasympathetic nervous system	Sympathetic nervous system
Neurotransmitter	<i>acetylcholine</i>	noradrenaline
Position of ganglion	ganglion is close to the effector	<i>ganglion is close to the spinal cord (CNS)</i>

[2]

END OF QUESTION PAPER

This image shows a blank sheet of white paper designed for handwriting practice. It features a series of horizontal dashed lines spaced evenly down the page. A single vertical solid line runs parallel to the left edge, creating a narrow margin. The rest of the page is open space between the margin line and the right edge, bounded by the horizontal dashed lines.

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