

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
June 2011

Human Biology

HBIO4

Unit 4 Bodies and cells in and out of control

Monday 13 June 2011 1.30 pm to 3.30 pm

For this paper you must have:

- a ruler with millimetre measurements
- a calculator.

Time allowed

- 2 hours

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.
- 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 90.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use scientific terminology accurately.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
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8	
9	
10	
TOTAL	



J U N 1 1 H B I O 4 0 1

WMP/Jun11/HBIO4

HBIO4

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

- 1 (a)** Give **two** ways in which the placenta is adapted to supply large amounts of oxygen to a developing fetus.

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(2 marks)

- 1 (b)** Name **one** hormone responsible for maintaining the placenta throughout pregnancy.

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(1 mark)

- 1 (c) (i)** Explain how an intrauterine device (IUD) works as a contraceptive.

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(1 mark)

- 1 (c) (ii)** One religious group objects to the use of the IUD although they do not object to the use of other forms of contraception. Suggest why.

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(1 mark)



- 2** Surgeons sometimes use a drug called pancuronium to stop muscles contracting during an operation.

Pancuronium binds to acetylcholine receptors on muscle fibres.

- 2 (a)** Suggest why pancuronium is able to bind to acetylcholine receptors.

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(2 marks)

- 2 (b)** Pancuronium causes muscle paralysis. Explain how.

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(3 marks)

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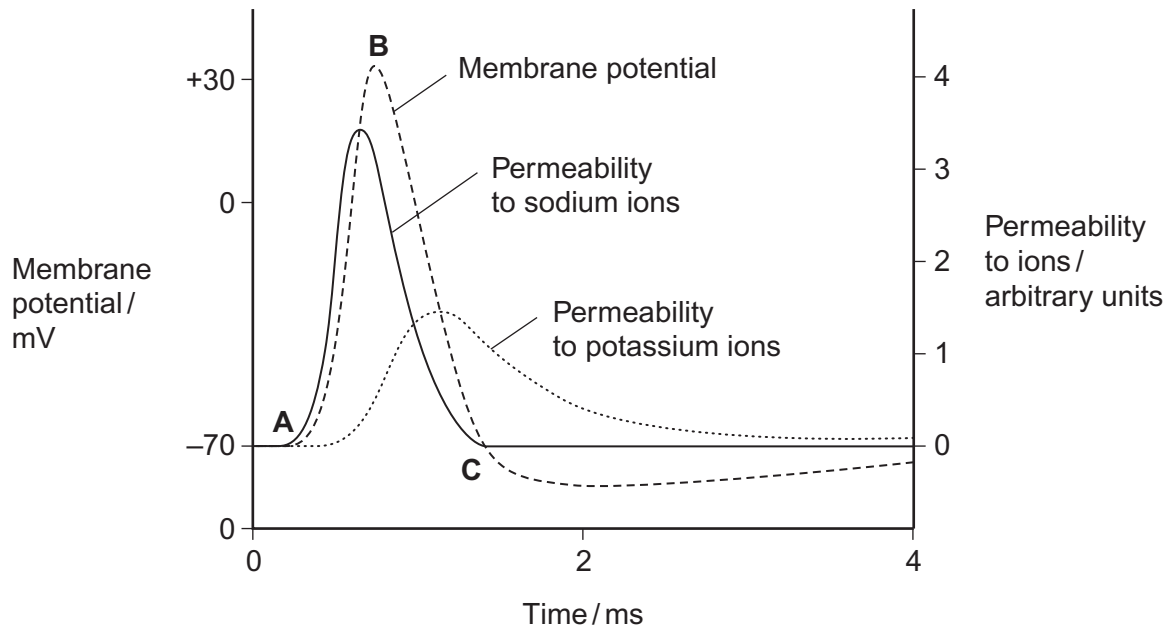
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Turn over for the next question

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- 3** The graph shows changes in membrane potential that occur during an action potential. It also shows changes in the permeability of the axon membrane to sodium and potassium ions.



- 3 (a)** Explain what causes

- 3 (a) (i)** the change in membrane potential between points **A** and **B**,

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- 3 (a) (ii)** the change in membrane potential between points **B** and **C**.

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(4 marks)



- 3 (b)** When a neurone transmits a series of impulses, its rate of oxygen consumption increases. Explain why.

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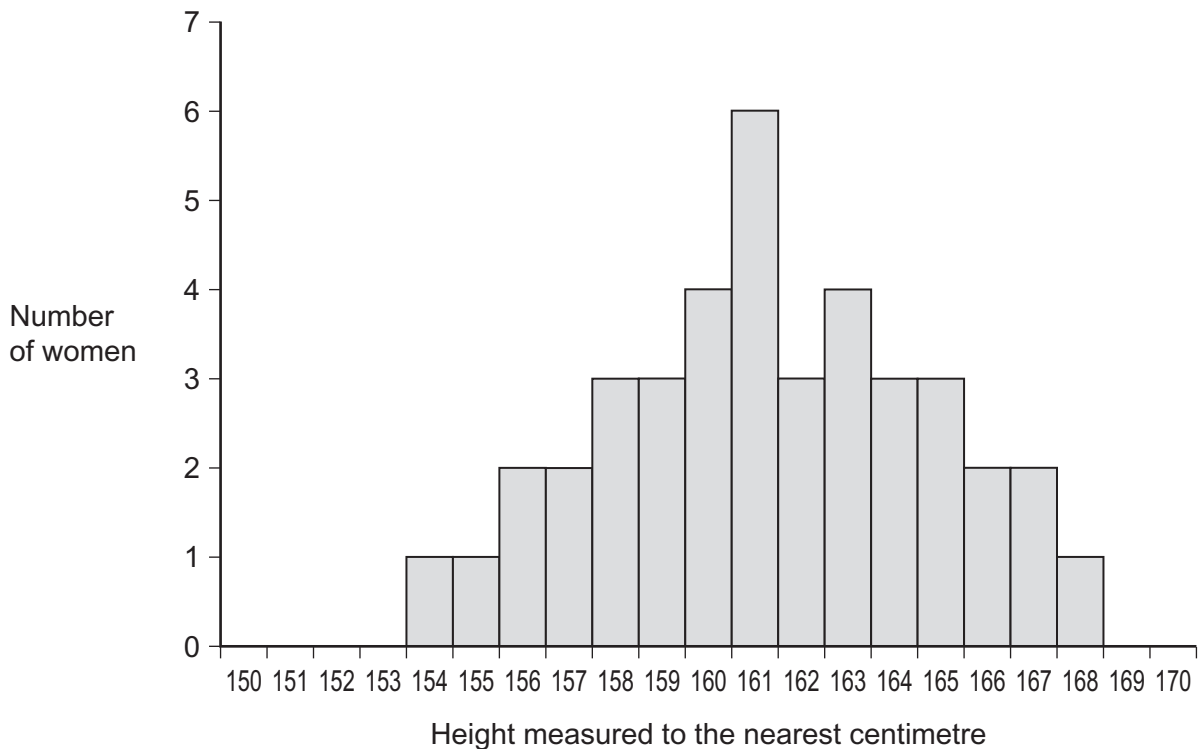
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- 4** The graph shows the heights of a group of 40 women.



- 4 (a)** The mean height is 161.3 cm.

- 4 (a) (i)** What is the modal height? cm

(1 mark)

- 4 (a) (ii)** The median height is 161 cm.
Explain what is meant by the median height.

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(1 mark)

- 4 (a) (iii)** Do these data show a normal distribution?
Give evidence for your answer.

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(2 marks)



4 (b) Explain what these data suggest about the genetic control of human height.

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(3 marks)

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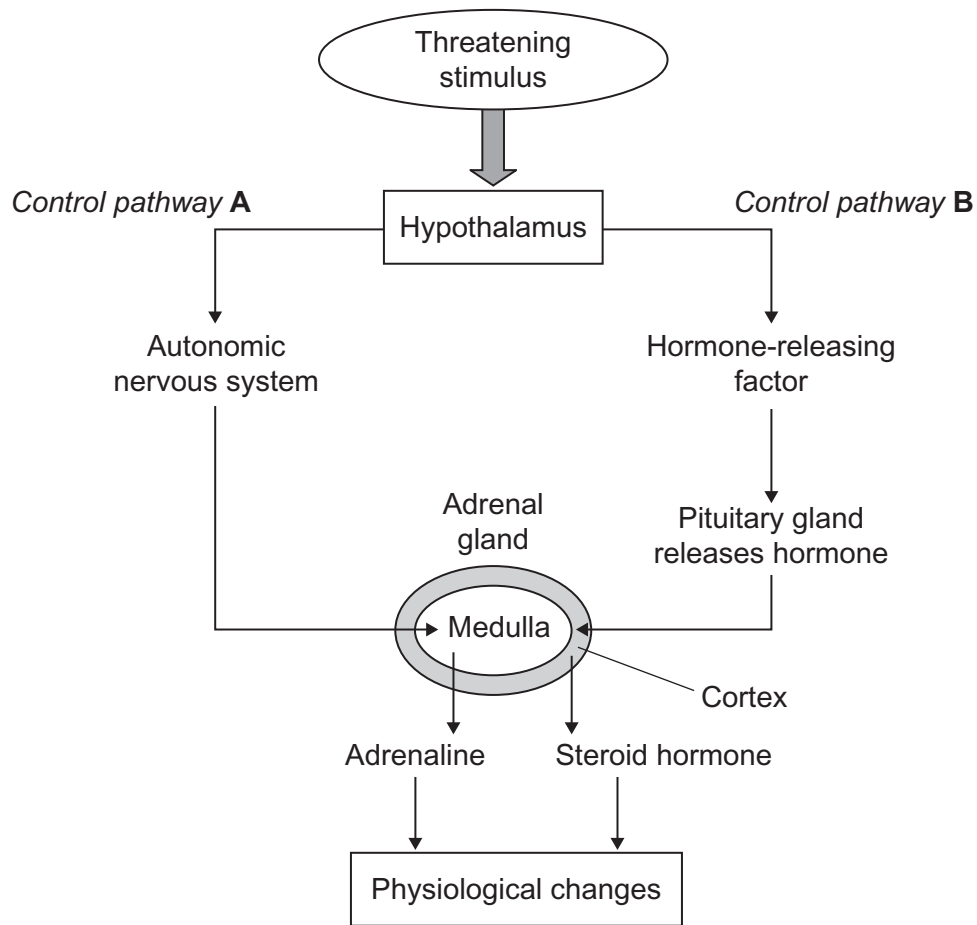
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- 5** The diagram shows two control pathways, **A** and **B**. The body uses these pathways to coordinate responses to a threatening stimulus.



- 5 (a)** Which branch of the autonomic nervous system carries impulses from the hypothalamus to the adrenal gland in response to stress?

..... (1 mark)

- 5 (b)** What effect does adrenaline have on

blood flow to the skin surface,

heart rate?.....

(1 mark)



- 5 (c)** Pathway **B** takes longer to produce physiological changes than pathway **A**.
Explain why.

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(4 marks)

(Extra space)

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6

Turn over for the next question

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- 6** Exenatide is a drug used for treating Type 2 diabetics. Scientists investigated the effects of exenatide on insulin production.

The scientists used three groups of volunteers who were treated in the following ways.

Group 1: healthy, non-diabetics who were injected with exenatide in salt solution

Group 2: Type 2 diabetics who were injected with exenatide in salt solution

Group 3: Type 2 diabetics who were injected with salt solution.

Three hours after these injections, the scientists injected the same amount of glucose into the blood of each volunteer.

The scientists measured the rate of insulin production by each person before and after injecting the glucose.

- 6 (a) (i)** **Group 1** and **Group 3** were control groups in this investigation.

Explain why each group was used.

Group 1

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Group 3

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(2 marks)

- 6 (a) (ii)** The scientists measured the rates of insulin production per unit body mass.

Explain why.

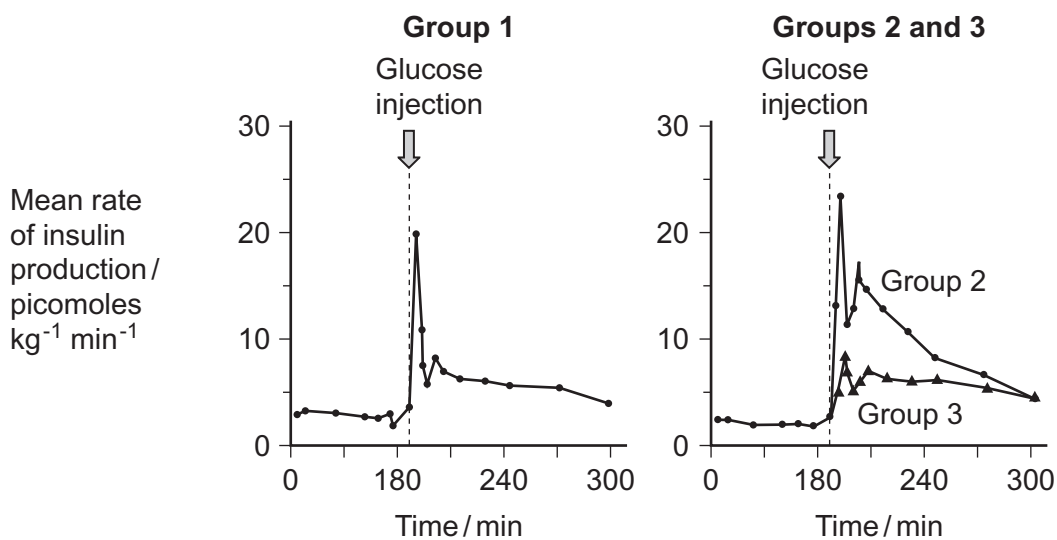
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(1 mark)



6 (b) The graphs show the mean rates of insulin production for each group.



Suggest how exenatide could help people with Type 2 diabetes.

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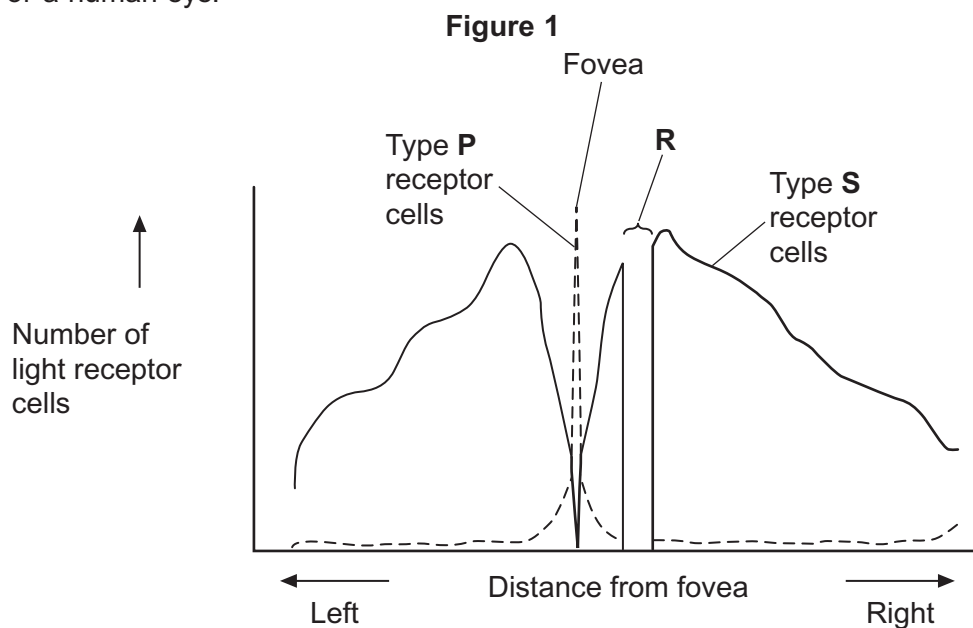
(3 marks)

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- 7 **Figure 1** shows where two types of light receptor cells, **P** and **S**, are found in the retina of a human eye.



- 7 (a) A person cannot see an object if its image falls on **R**. Explain why.

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(1 mark)

- 7 (b) At night, a man saw a faint star at the edge of his vision. When he moved his eyes to look straight at the star, he could no longer see it.

Use information from **Figure 1** to explain

- 7 (b) (i) why he could see the star at the edge of his vision,

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- 7 (b) (ii) why he could not see the star when he looked straight at it.

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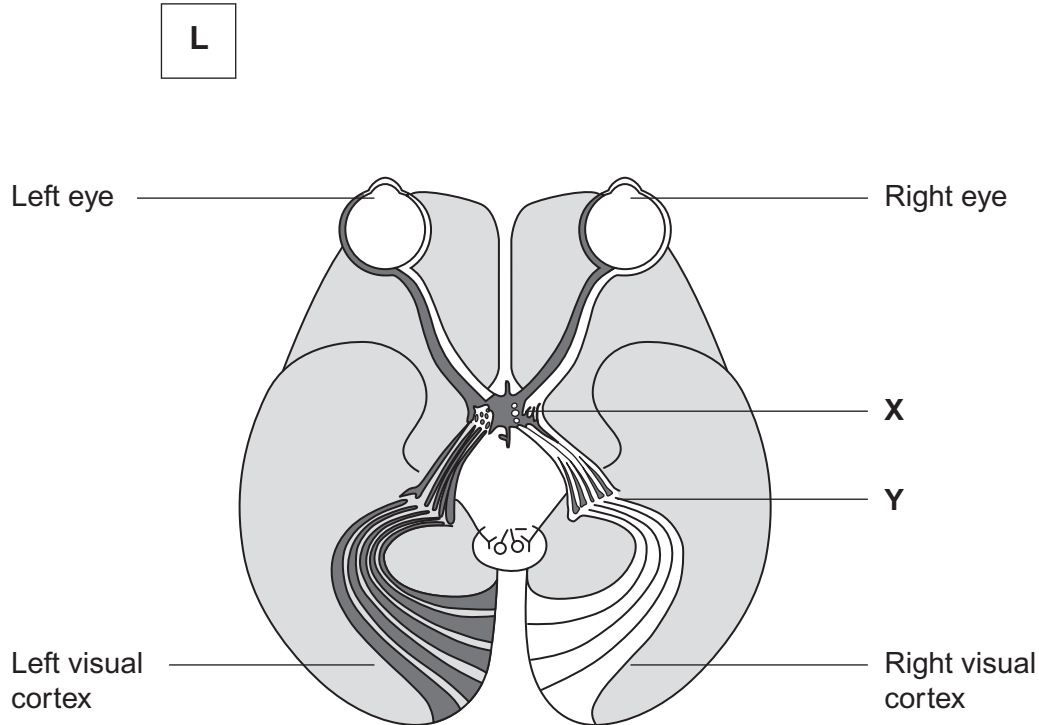
(4 marks)



7 (c) **Figure 2** shows a horizontal section through the eyes and the brain.

Box **L** is an object, approximately one metre from the person.

Figure 2



7 (c) (i) The optic nerves from both eyes meet at structure **X**.

Name structure **X**. (1 mark)

7 (c) (ii) At structure **Y**, neurones from the optic nerves synapse with more neurones that connect to the visual cortex.

Name structure **Y**. (1 mark)

7 (c) (iii) Will the image of box **L** be perceived via the left or via the right visual cortex?
Use information from **Figure 2** to explain your answer.

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(2 marks)



- 8 Sports scientists investigated the effect of drinking iced water on heat loss from the body.

A man sat still in a hot, dry room for 25 minutes. He then drank a glass of iced water and remained sitting still for another 25 minutes.

During the investigation, scientists measured

- his internal body temperature near his brain
- his skin temperature
- the energy he lost by evaporation of sweat from his skin.

The table shows the results.

Time / min	Internal temperature / °C	Skin temperature / °C	Energy loss by evaporation of sweat / joules s ⁻¹
0	37.6	36.9	215
5	37.5	36.8	226
10	37.5	36.8	226
15	37.5	36.8	215
20	37.6	36.8	210
25	37.6	36.8	216
Drank iced water → 30	37.3	37.0	202
35	37.0	37.5	95
40	37.2	37.4	134
45	37.4	37.1	190
50	37.6	37.0	200

- 8 (a) Describe the relationship between the man's skin temperature and his internal body temperature **after** he drank the iced water.

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(2 marks)



- 8 (b)** Explain the relationship between the man's skin temperature and his internal temperature after he drank the iced water.

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(2 marks)

- 8 (c)** Blood flowing through vessels in the stomach wall reaches the brain within one minute. Explain how this leads to responses in the skin to drinking iced water.

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(3 marks)

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- 8 (d)** Evaporation of 1 cm^3 of water at 37.0°C requires 2412 joules of energy. Calculate what volume of water was evaporated from the skin of this person at 50 minutes.

Give your answer in $\text{cm}^3 \text{ min}^{-1}$. Show your working.

Volume of water evaporated = $\text{cm}^3 \text{ min}^{-1}$
(2 marks)



9 Scientists found a correlation between prostate cancer and exposure to cadmium ions.

The scientists investigated the effects of cadmium ions on cells from a human prostate gland.

They grew a culture of these cells in liquid growth medium and removed samples at intervals.

For each sample they measured

- how much DNA was not methylated,
- the activity of the enzyme methyltransferase.

Methyltransferase is an enzyme that adds methyl groups to some of the bases in DNA. The addition of a methyl group is called methylation.

9 (a) The scientists set up another culture as a control.

Describe how the scientists would have set up a control experiment for this investigation.

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(2 marks)

9 (b) Figures 3 and 4 show the scientists' results.

Figure 3

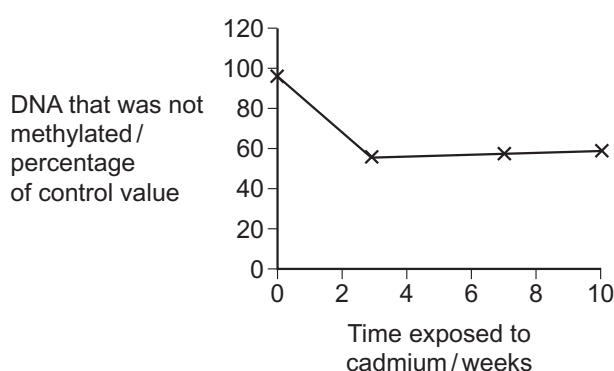
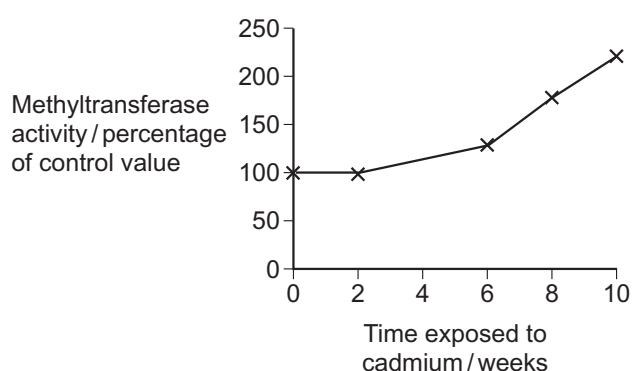


Figure 4



- 9 (b) (i) The scientists expressed their results as percentages of the control values. Suggest why.

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(1 mark)

- 9 (b) (ii) Use information from **Figure 3** to describe how exposure to cadmium ions affected the methylation of DNA.

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(1 mark)

- 9 (b) (iii) Use information from **Figure 4** to suggest what caused the change to the DNA shown in **Figure 3**.

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(1 mark)

Question 9 continues on the next page

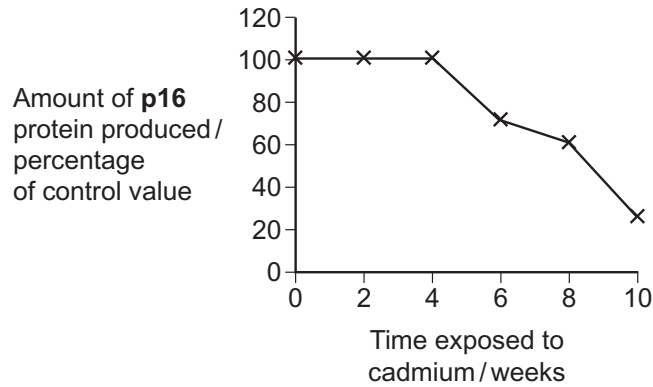
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- 9 (c)** Prostate gland cells contain a tumour suppressor gene called **p16**. During the investigation, the scientists also measured the amount of **p16** protein produced.

Figure 5 shows their results.

Figure 5



The scientists found that the promoter DNA of the **p16** gene had become methylated. The promoter is the sequence of bases where the enzyme RNA-polymerase binds to a DNA molecule.

Explain how methylation of the promoter sequence of the **p16** gene could cause the changes shown in **Figure 5**.

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(2 marks)

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- 9 (d)** Each week of the investigation, the scientists took samples of the cadmium-treated prostate cells from the laboratory cultures. They injected these cells into mice and monitored the mice for the growth of tumours.

It was only the samples taken in the tenth week that caused tumours to begin to grow in the mice.

Use information from **Figures 3, 4 and 5** to suggest why.

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(4 marks)

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10 Doctors used data from two clinics to investigate whether the success rate for *in vitro* fertilisation (IVF) was related to

- the ages of the women being treated
- the size of the clinic.

Figure 6 shows their results.

Figure 6

Woman's age / years	Success rate / percentage of live births after IVF treatment in a	
	large clinic	small clinic
<30	26	10
30 to 34	30	11
35 to 36	26	14
37 to 38	22	16
>38	13	14

10 (a) Do these results show any difference in success rates between large and small clinics?

Give reasons for your answer.

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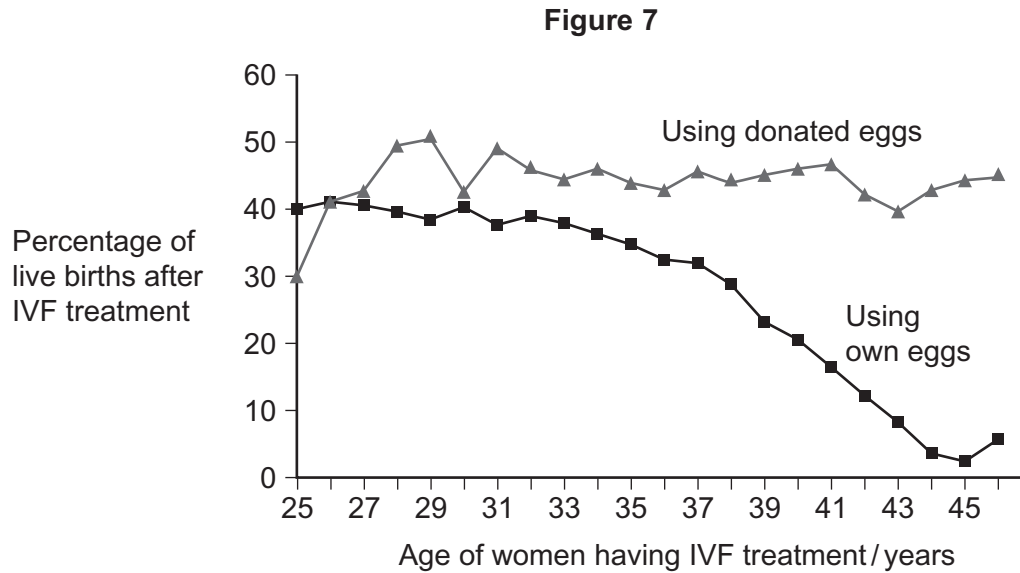
10 (b)

In another study, doctors investigated if the success of IVF depended on

- the ages of the women being treated
- whether the women used their own eggs or used eggs donated by another woman.

All the donated eggs came from women in their twenties.

Figure 7 shows the results.



The doctors concluded that the success of IVF depended more on the age of the egg donor than the age of the woman having IVF treatment.

Use information from the graph to evaluate the doctors' conclusions.

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(4 marks)

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- 10 (c)** Sickle cell anaemia is an inherited condition. It is caused by the production of faulty haemoglobin molecules.

Figure 8 shows part of the base sequence of the allele **H^A** for normal haemoglobin.

Figure 8

Base sequence of DNA	T	G	A	G	G	A	C	T	C	C	T	C
Base sequence of mRNA												
Amino acid sequence in polypeptide												

Figure 9 shows some of the mRNA codons for six different amino acids.

Figure 9

mRNA codons	Amino acid
GAA GAG	Glu
AAA AAG	Lys
AUG	Met
CCA CCC CCU	Pro
ACA ACG ACU	Thr
GUC GUG GUU	Val

- 10 (c) (i)** Complete **Figure 8**.

(2 marks)

- 10 (c) (ii)** In the sickle cell allele (**H^S**), the thymine (**T**) in the shaded box in **Figure 8** is replaced by the base adenine (**A**).

What new amino acid will be found at this position in sickle haemoglobin?

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(1 mark)

- 10 (c) (iii)** The mutation that produces sickle haemoglobin is a point mutation. Not all point mutations in DNA result in a change of one amino acid in a polypeptide.

Give **two** reasons why.

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(2 marks)



10 (d)

Amar and Lucia are a newly-married couple. Each has a relative who died of sickle cell anaemia. They consulted a genetic counsellor who determined that they are both carriers of sickle cell anaemia. The genetic counsellor told them that there was a probability of 1 in 4 that they could have a child with sickle cell anaemia.

Explain how this couple could have a child with sickle cell anaemia.
You may use a genetic diagram in your explanation.

Use the following symbols:

H^A = the allele for normal haemoglobin

H^S = the allele for sickle haemoglobin

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(3 marks)

Question 10 continues on the next page

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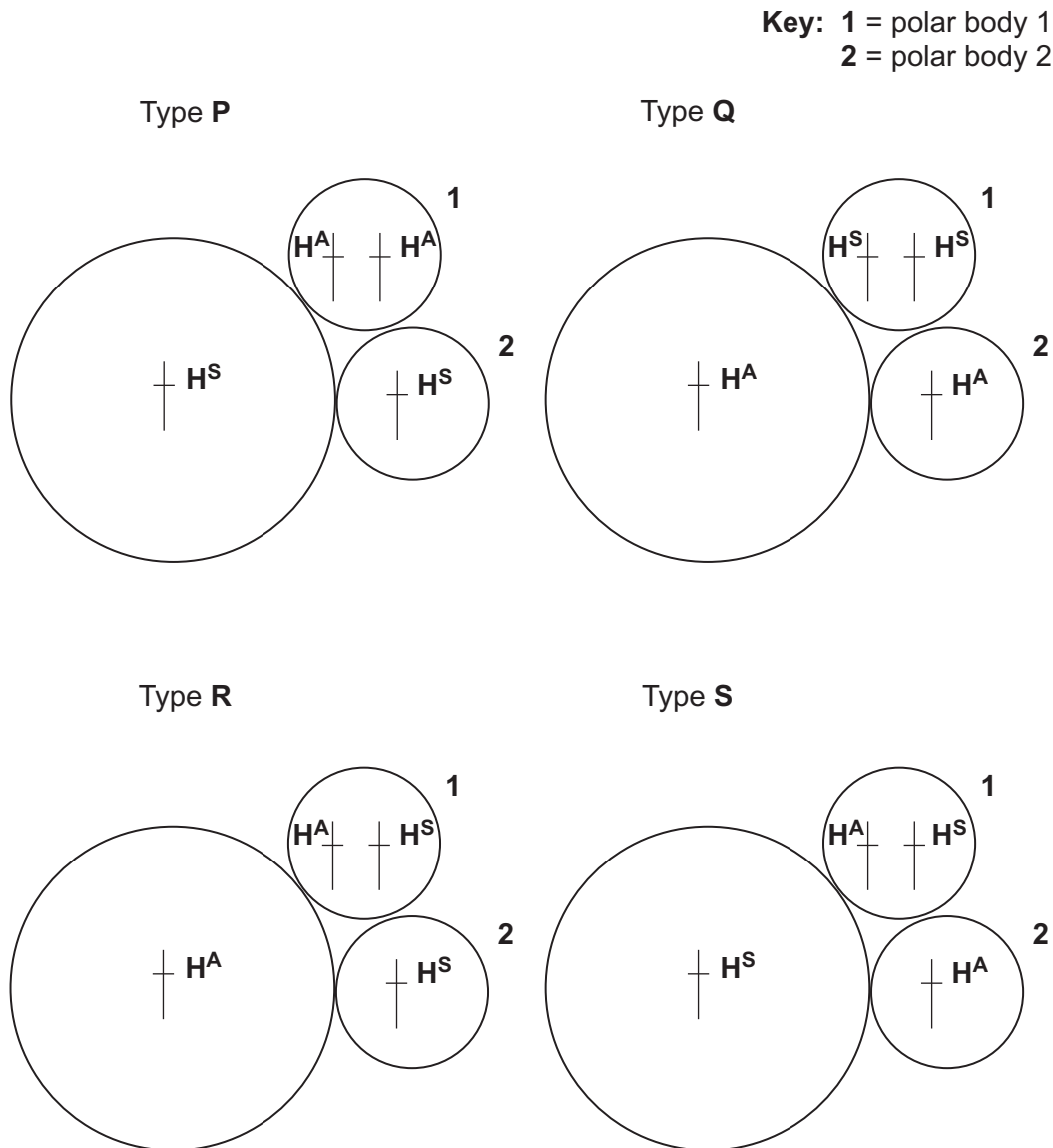


10 (e)

Amar and Lucia wished to avoid having a child with sickle cell anaemia. The genetic counsellor recommended analysis of the DNA in the polar bodies attached to each of Lucia's eggs, followed by IVF treatment.

In Lucia's ovaries, meiosis produces four possible distributions of H^A and H^S alleles in her eggs and their polar bodies.

Figure 10 shows the four possible types of eggs and their polar bodies, **P**, **Q**, **R** and **S**, that Lucia produces.

Figure 10

Explain how the process of meiosis produces the different combinations of alleles in **Figure 10**.

You may use diagrams to illustrate your answer.

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(4 marks)

Question 10 continues on the next page

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- 10 (f) (i)** The genetic counsellor recommended analysis of the DNA in the polar bodies of Lucia's eggs but not of the DNA in the eggs.

Explain the advantage of analysing the DNA in the polar bodies but not in the eggs.

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(1 mark)

- 10 (f) (ii)** A DNA probe was used to determine whether a polar body contained the **H^S** allele. Explain how the DNA probe did this.

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(3 marks)

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10 (f) (iii) Some of Lucia’s eggs would be suitable for implanting in her uterus.

Complete **Figure 11** to show which of the alleles, **H^A** and **H^S**, would be found in the polar bodies attached to **two** types of egg that were suitable for implantation.

For each egg, put two ticks (✓) in **Figure 11**, one for each polar body.

Figure 11

	Polar body 1			Polar body 2		
	H ^A only	H ^S only	H ^A and H ^S	H ^A only	H ^S only	H ^A and H ^S
1 st egg						
2 nd egg						

(2 marks)

25

END OF QUESTIONS



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