

Centre Number						Candidate Number				
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Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
June 2012

Human Biology

HBIO4

Unit 4 Bodies and cells in and out of control

Friday 15 June 2012 9.00 am to 11.00 am

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 are expected to use a calculator where appropriate.
- 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	
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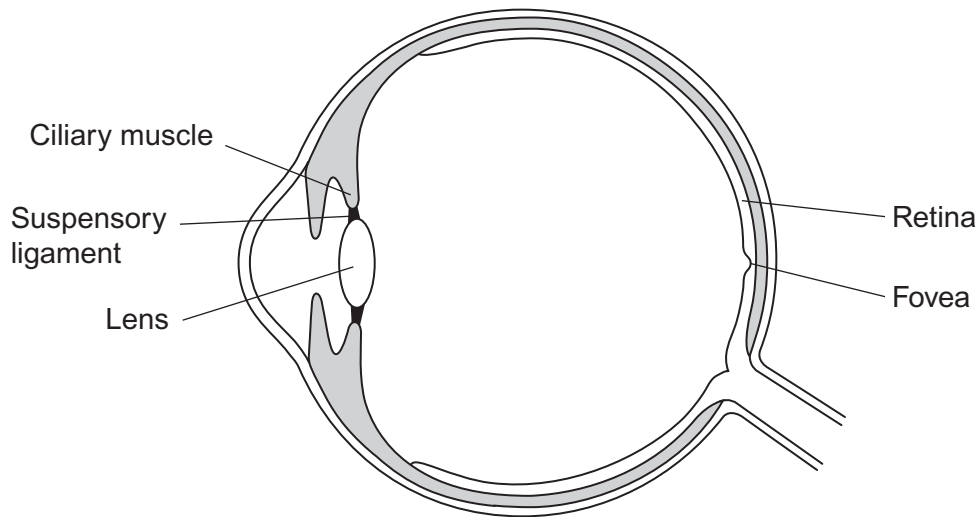
J U N 1 2 H B I O 4 0 1

WMP/Jun12/HBIO4

HBIO4

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

- 1** The diagram shows a section through an eye.



- 1 (a)** A student looked at a distant object and then looked at a close object.

Describe the changes that occurred in the ciliary muscle, suspensory ligament and lens in order to focus the image of the close object on the retina.

Ciliary muscle

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Suspensory ligament

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Lens

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(3 marks)



- 1 (b)** When an image is focused on the fovea, it is seen in greater detail than when the image is focused on any other part of the retina. Explain why.

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(2 marks)

5

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED**



2 (a) What is a hormone?

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(2 marks)

2 (b) Adrenaline is a hormone that is released in times of stress.

Give **three** changes that adrenaline causes in the body.

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(3 marks)

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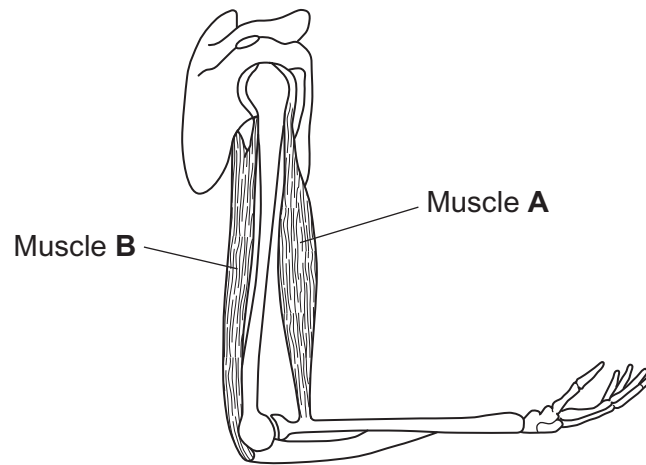
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3 (a) **Figure 1** shows the bones of the arm and two muscles, **A** and **B**.

Figure 1



Muscles **A** and **B** are an antagonistic pair of muscles.

Explain the advantage of skeletal muscles being arranged in antagonistic pairs.

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(3 marks)

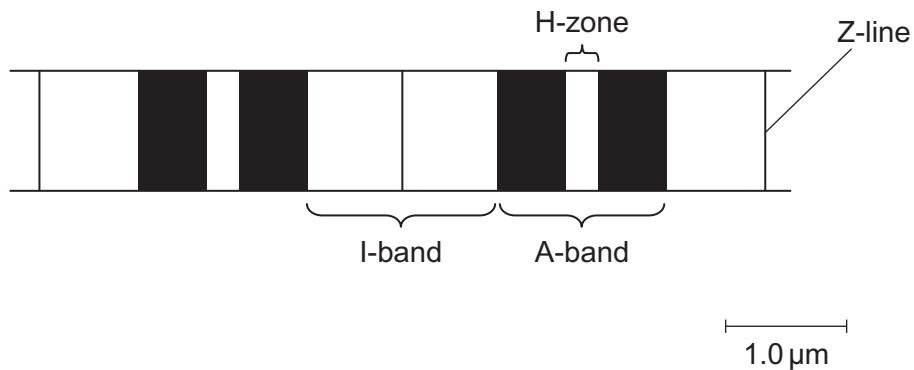
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- 3 (b) **Figure 2** shows two sarcomeres from a relaxed skeletal muscle.

Figure 2



- 3 (b) (i) What happens to the length of the A-band, I-band and H-zone during contraction?

A-band

I-band

H-zone

(2 marks)

- 3 (b) (ii) When the muscle contracted, the length of each sarcomere shown in **Figure 2** was two-thirds of its relaxed length.

Use information from **Figure 2** to calculate the length of **one** contracted sarcomere in micrometres (μm). Show your working.

Length of **one** contracted sarcomere = micrometres
(2 marks)

7

Turn over ►



4 (a) What is meant by negative feedback?

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(2 marks)

In very cold conditions, a person may develop hypothermia as the core body temperature starts to fall.

4 (b) As the core temperature falls from 37 °C to 35 °C, the rate of shivering increases. Shivering is a response produced by the body that may reverse the fall in core temperature.

Explain how shivering helps to reverse the fall in core temperature.

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(2 marks)



- 4 (c)** Below 35°C, normal temperature regulation mechanisms begin to fail. The body is in hypothermia.

Doctors can treat patients with hypothermia by getting them to breathe in warm, humid air.

Explain how breathing in warm, humid air would help a person to recover from hypothermia.

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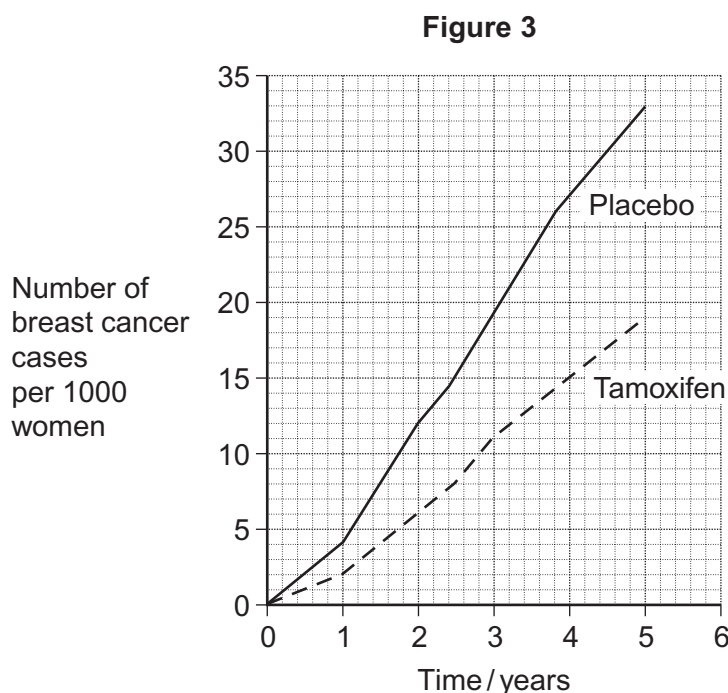
- 5 Scientists investigated the effect of a drug called tamoxifen on the risk of developing breast cancer. They recruited 13 000 healthy women volunteers and divided them into two groups at random.

The women in

- one group took a tablet containing tamoxifen each day
- the other group took a placebo (a tablet not containing tamoxifen) each day.

The scientists recorded the number of cases of breast cancer in each group over 5 years.

Figure 3 shows the results.



- 5 (a) After 2 years, the ratio of breast cancer cases in the women taking the placebo compared with those taking tamoxifen was 2:1.

Use the information from **Figure 3** to calculate this ratio after 4 years.

Show your working.

Ratio of breast cancer cases, placebo : tamoxifen =
(2 marks)

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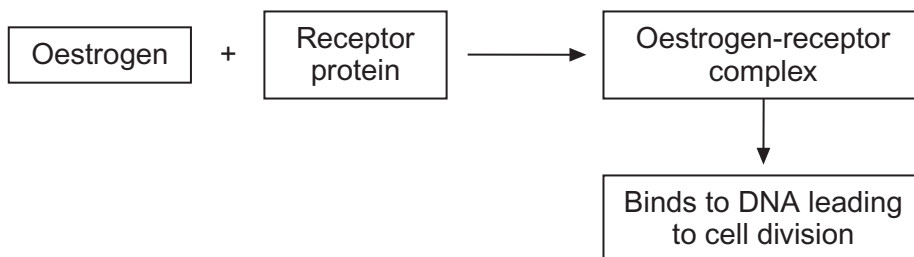
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- 5 (b)** The growth of some breast tumours is increased by oestrogen.

Figure 4 shows how oestrogen affects the rate of cell division in breast tissue.

Figure 4



Some breast tumours are stimulated to grow by oestrogen. Tamoxifen is used to treat these breast tumours. In the liver, tamoxifen is converted into an active substance called endoxifen.

Figure 5 shows a molecule of oestrogen and a molecule of endoxifen.

Figure 5



Oestrogen



Endoxifen

- 5 (b) (i)** Endoxifen is able to bind to the oestrogen receptor protein. Explain why.

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(2 marks)



5 (b) (ii) Tamoxifen reduces the effect of oestrogen on cells in breast tissue.

Use information from **Figures 4** and **5**, and your own knowledge, to suggest how.

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(3 marks)

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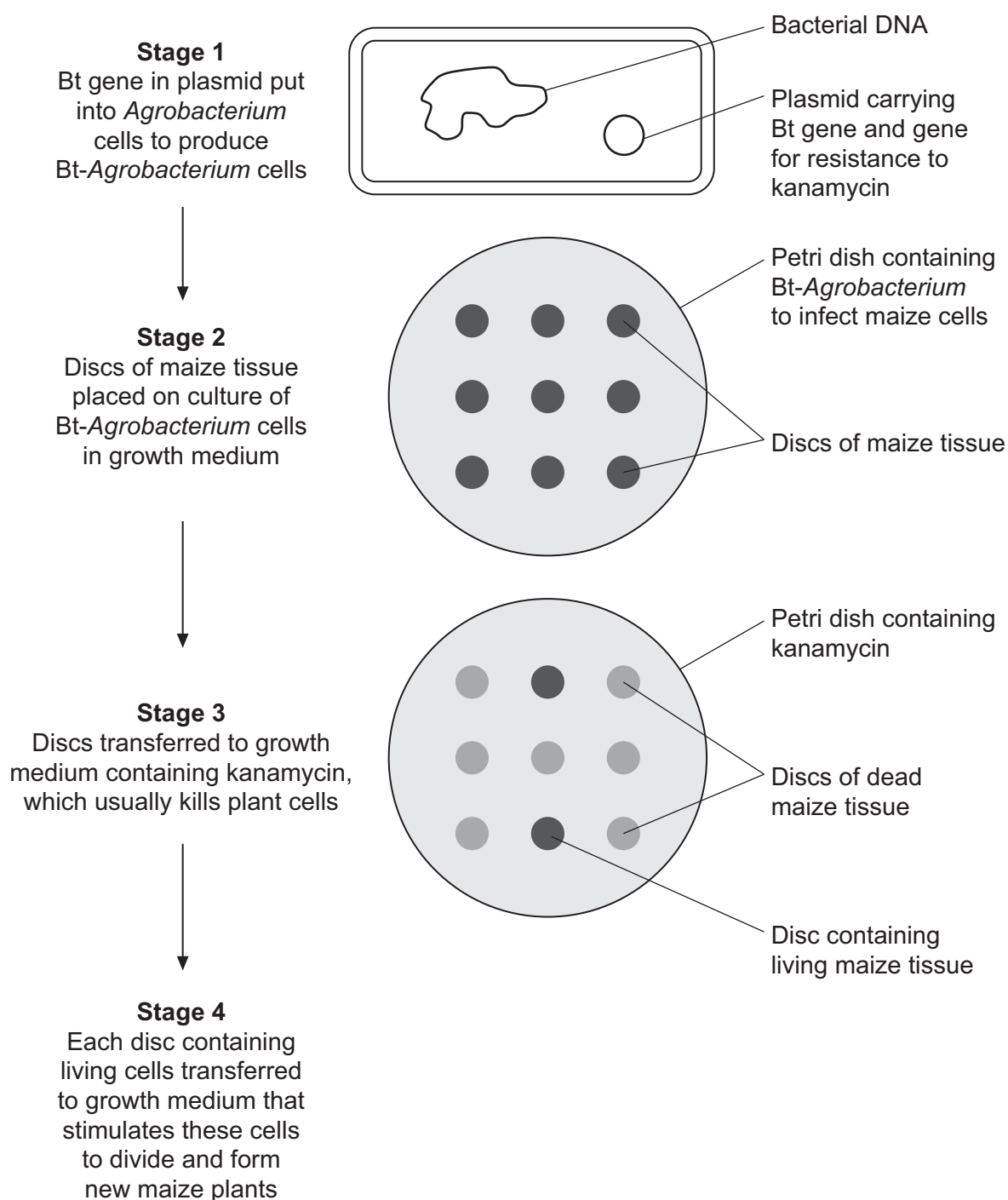
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- 6 'Bt maize' is a crop plant that contains the Bt gene from a bacterium. This gene produces a protein that poisons insects that eat the maize.

Scientists used a bacterium called *Agrobacterium* to get the Bt gene into the maize. This bacterium contained a plasmid with the Bt gene and a gene for resistance to a substance called kanamycin.

The diagram shows stages in the transfer of the Bt gene into the maize.



- 6 (a)** The growth medium containing kanamycin (**Stage 3**) is used to select for maize tissue that contains the Bt gene. Explain how.

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(1 mark)

- 6 (b)** All the cells of the maize plants produced at **Stage 4** contain the Bt gene. Explain why.

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(2 marks)

- 6 (c)** Kanamycin is an antibiotic. Some scientists are concerned about the gene for resistance to kanamycin being present in maize which is eaten by humans. Suggest why.

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(2 marks)

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- 6 (d)** The caterpillar of the European corn borer moth feeds on maize plants. When the corn borer caterpillar eats Bt maize, the Bt protein is activated by the unusually high pH (pH10) in the insect's mid-gut. This activated protein attaches to a specific receptor protein on the cell membranes of cells lining the insect's gut. This causes the gut cells to die and kills the insect. Scientists have demonstrated that the Bt protein is not poisonous to humans and that it is safe for humans to eat Bt maize.

Use this information to suggest why the Bt protein is not poisonous to humans.

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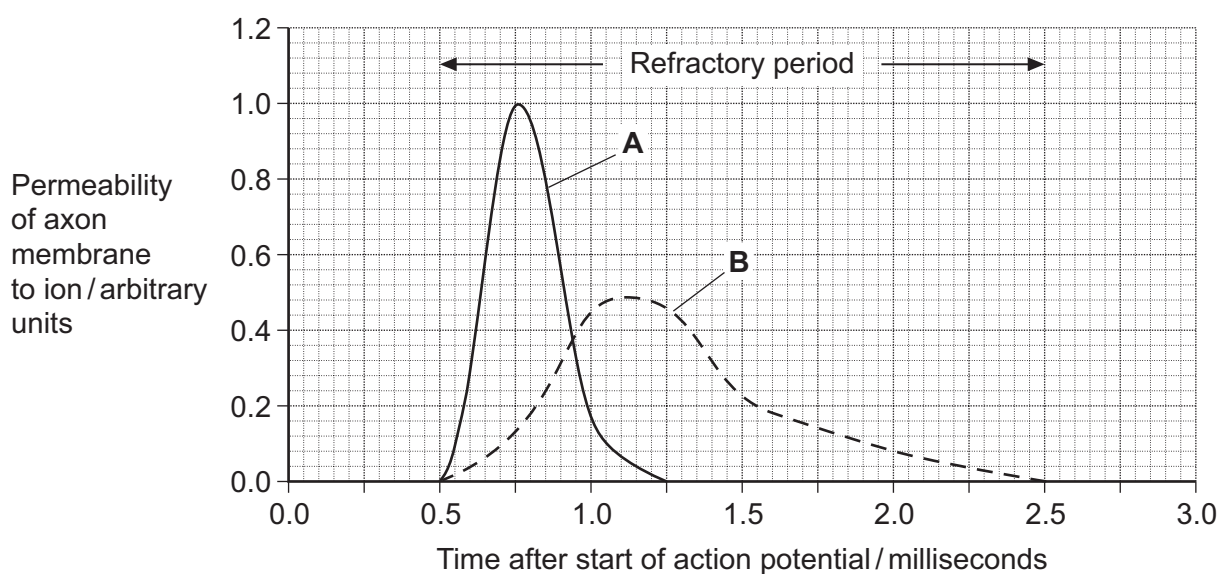
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- 7 The graph shows changes in the permeability of a section of axon membrane to two ions involved in producing an action potential.



- 7 (a) Name ions **A** and **B**.

A

B

(1 mark)

- 7 (b) What is meant by the refractory period?

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(1 mark)

- 7 (c) (i) The maximum frequency of action potentials along this neurone is 500 per second. Use information from the graph to explain why.

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(2 marks)



- 7 (c) (ii)** The brain uses nerve impulses from sensory neurones to distinguish between stimuli of different intensities.

Explain how the length of the refractory period prevents the brain from distinguishing between stimuli that are above a certain intensity.

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(2 marks)

6

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- 8 (a)** Scientists can use restriction enzymes to cut a sample of DNA into shorter pieces. The lengths of the DNA pieces can be measured in units called 'base pairs'.

Explain why a 'base pair' is a suitable unit for measuring the length of a piece of DNA.

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(2 marks)

- 8 (b)** Sickle cell anaemia is caused by a point mutation in the haemoglobin gene. Doctors have developed a test for the allele causing sickle cell anaemia using a restriction enzyme called Ddel. The allele for normal haemoglobin, H^A , can be cut by Ddel. The allele for sickle-cell haemoglobin, H^S , cannot be cut by Ddel.

The method used by the doctors involves the following steps.

1. Take samples of cells from a person and extract the DNA.
2. Treat the DNA with restriction enzymes other than Ddel to cut the DNA into many fragments.
3. Carry out PCR (the polymerase chain reaction) using primers that are specific for part of the haemoglobin gene.
4. Add Ddel enzyme to the DNA produced by the PCR.
5. Find the lengths of the resulting DNA pieces.

- 8 (b) (i)** What is a primer?

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(1 mark)

- 8 (b) (ii)** How can a primer be specific to part of the haemoglobin gene (step 3)?

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(1 mark)

- 8 (b) (iii)** Why is it necessary to carry out PCR on the extracted DNA (step 3)?

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(1 mark)



- 8 (c)** Mustapha and Shahira are both carriers of sickle cell anaemia. Shahira is pregnant and they want to know if their baby will have sickle cell anaemia.

The doctors tested samples of DNA from Mustapha, from Shahira and from the fetus. They used the method described in part (b) to test for the allele responsible for sickle cell anaemia. The primers used in this method were specific for the base sequences that occur 55 base pairs before the point of mutation and 55 base pairs after the point of mutation in the haemoglobin gene.

The table shows the results.

Source of DNA	Length of DNA pieces after digesting with Ddel / base pairs
Mustapha	110 and 55
Shahira	110 and 55
Fetus	110 only

- 8 (c) (i)** Explain the results of the tests on Mustapha's and Shahira's DNA.

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- 8 (c) (ii)** What can the doctors tell Mustapha and Shahira about the risk of their baby having sickle cell anaemia? Explain your answer.

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10



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- 9** A young woman had a baby son. She claimed that a famous footballer was the father.

The baby had blood group O and was Rhesus positive (Rh+).

The woman had blood group A and was Rhesus negative (Rh-).

The footballer had blood group A and was Rhesus positive (Rh+).

- 9 (a) (i)** Explain how it is possible for the footballer to be the baby's father.
You may use a labelled genetic diagram, or diagrams, in your explanation.

Use the following symbols to represent alleles.

I^A = the allele for blood group A

I^B = the allele for blood group B

I^O = the allele for blood group O

D = the dominant allele for the D-antigen (Rhesus positive)

d = the recessive allele for Rhesus negative

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(4 marks)

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- 9 (a) (ii)** Your answer to part **(a) (i)** does **not** prove that the footballer was the baby's father. Explain why.

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- 9 (b) (i)** If this mother became pregnant again with a Rhesus positive fetus, she may produce an immune response against the fetus. Explain why.

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- 9 (b) (ii)** The mother was injected with antibodies specific to the D-antigen immediately after she gave birth. This was to prevent an immune response against a future fetus. Suggest how the injection of these antibodies would prevent a future immune response.

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10 (a) Explain how hormones control the menstrual cycle.

[illegible]

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10 (b) Scientists measured the concentration of FSH in the urine of men and women of different ages.

10 (b) (i) The scientists were able to use the concentration of FSH in urine as a measure of the FSH being produced. Suggest why.

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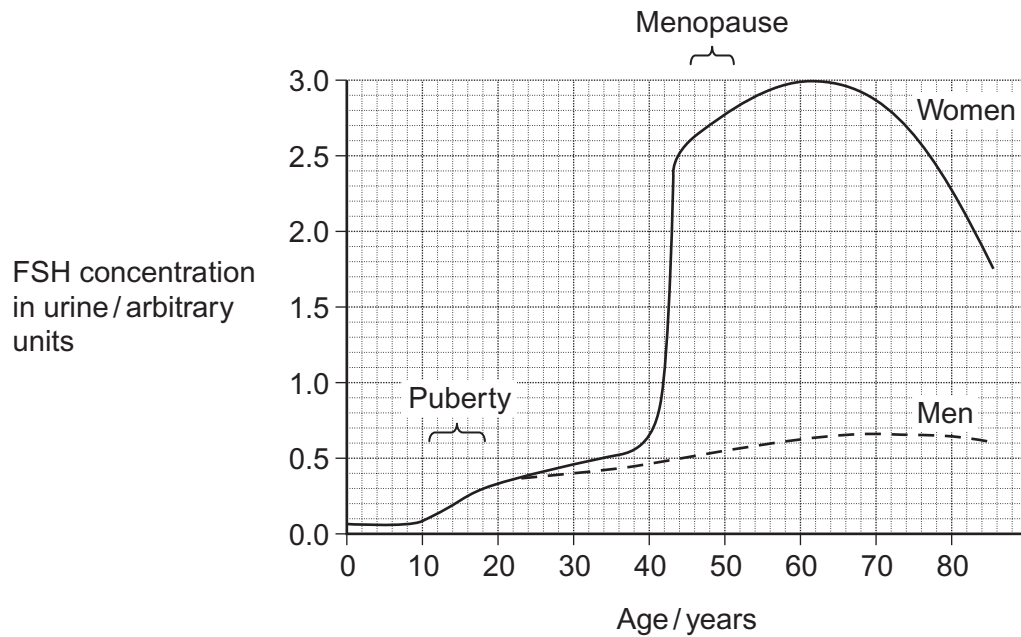
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Figure 6 shows the scientists' results.

Figure 6



- 10 (b) (ii)** Use information from **Figure 6** to describe the similarities and differences in FSH production in men and women.

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(4 marks)

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10 (b) (iii) Other than changes in FSH production, give **two** changes that occur in the bodies of most women between the ages of 40 and 50 years.

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2 (2 marks)

10 (c) Another group of scientists investigated the effects of the consumption of caffeine and alcohol on the production of FSH.
They recruited 93 women aged between 20 and 40 years. For each woman they measured

- the concentration of FSH in her urine
- the amount of caffeine she consumed each day
- the number of alcoholic drinks she had each week.

Figure 7 shows their results.

Figure 7

Caffeine consumption / mg per day	Number of women	Mean FSH concentration / arbitrary units ($\pm$ standard deviation)
0	35	0.35 ($\pm$ 0.23)
< 300	48	0.41 ($\pm$ 0.21)
> 300	10	0.48 ($\pm$ 0.21)

Alcohol consumption / drinks per week	Number of women	Mean FSH concentration / arbitrary units ($\pm$ standard deviation)
0	26	0.45 ($\pm$ 0.29)
1 – 3	64	0.38 ($\pm$ 0.19)
> 3	3	0.29 ($\pm$ 0.09)

10 (c) (i) The scientists only reported measurements of FSH concentration taken during the last 5 days of each woman's menstrual cycle.

Why did the scientists only report results taken at this stage of the menstrual cycle?

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(2 marks)

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- 10 (c) (ii)** The scientists used the standard deviation as a measure of the variability of their results.

Why is it better to use standard deviation rather than the range of results as a measure of variability?

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(3 marks)

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- 10 (d)** The scientists performed a statistical test to compare the mean concentration of FSH in those women consuming caffeine with those who consumed none.

- 10 (d) (i)** Give a suitable null hypothesis.

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(1 mark)



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