

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
January 2011

Human Biology

HBIO4

Unit 4 Bodies and cells in and out of control

Monday 24 January 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	
7	
8	
9	
10	
TOTAL	



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

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

1 (a) What is the *trichromatic theory* of colour vision?

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(2 marks)

1 (b) A woman looked at a distant object and then looked at a close object. Changes occurred in her eyes which brought the image of the close object into focus on the retina.

Explain how the ciliary muscles caused these changes.

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(3 marks)

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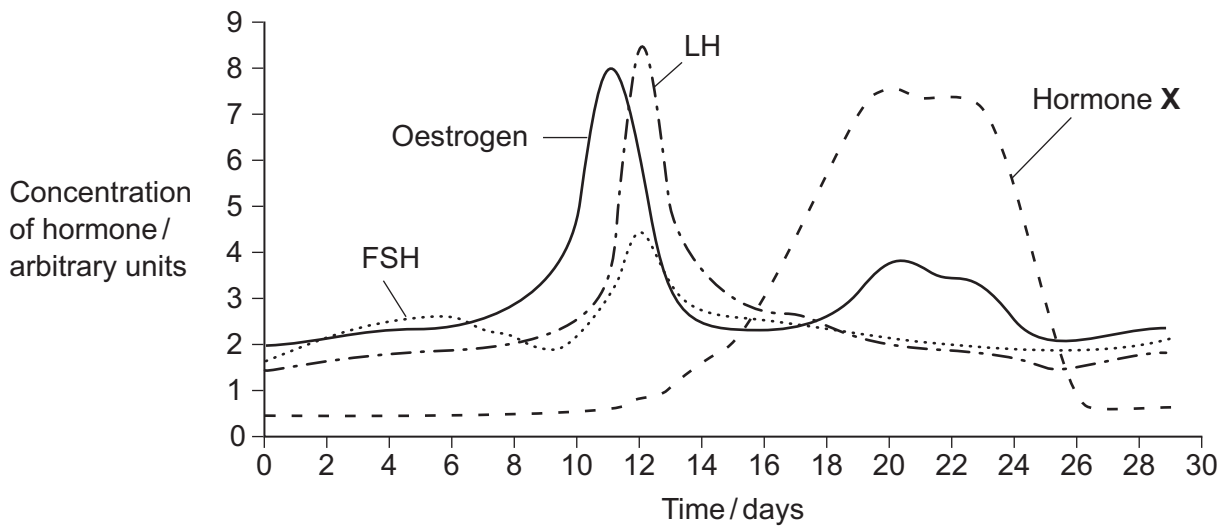
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- 2** The concentrations of various hormones in a woman's blood change during the menstrual cycle. The graph shows these changes.



- 2 (a) (i)** Name hormone X. (1 mark)

- 2 (a) (ii)** On which day did ovulation occur in *this* cycle?
Give evidence from the graph to support your answer.

Day

Evidence

..... (2 marks)

- 2 (b)** Oestrogen is present in some contraceptive pills.
Explain how oestrogen acts as a contraceptive.

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..... (2 marks)



- 3 (a)** The table shows the base sequence in part of one of the strands of a DNA molecule. Complete the table to show the base sequence in the mRNA that is transcribed from this DNA sequence.

Base sequence in DNA	T	A	C	T	G	T
Base sequence in mRNA						

(1 mark)

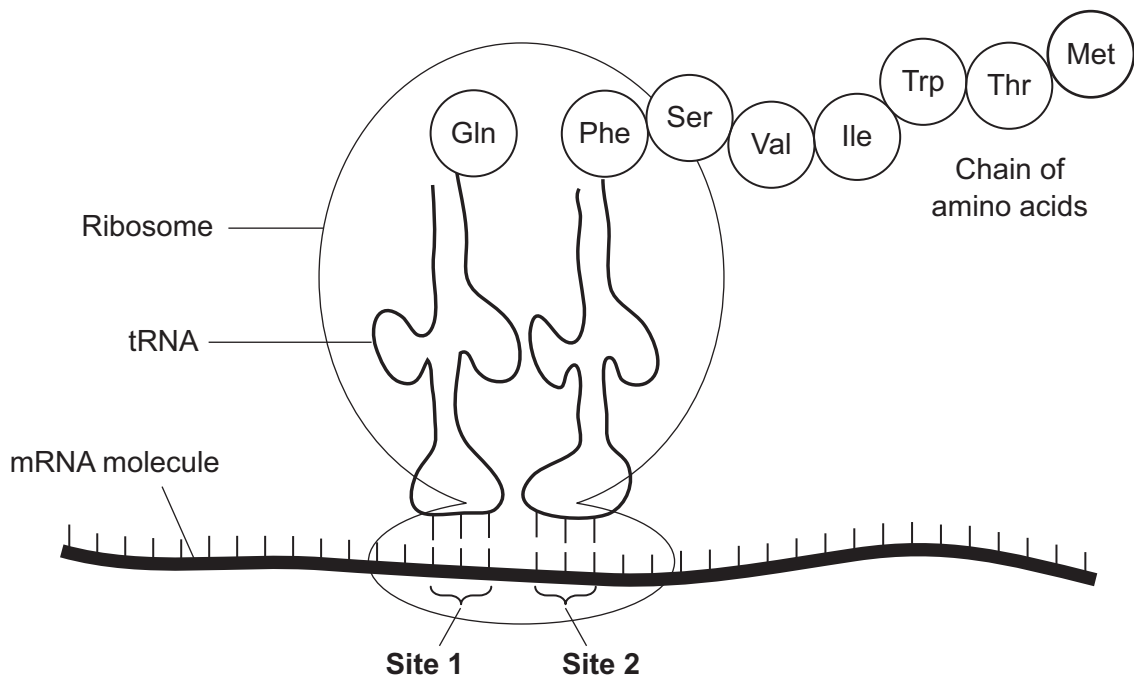
- 3 (b)** mRNA molecules are processed before they are used for translation. Describe how.

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(1 mark)

- 3 (c)** The diagram shows translation.



There are two sites on the ribosome, **Site 1** and **Site 2**.

- 3 (c) (i)** The tRNA carrying the amino acid Gln is the only tRNA that will bind to the mRNA at **Site 1**. Explain why.

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(2 marks)

(Extra space)

- 3 (c) (ii)** A reaction will occur to join Gln to the chain of amino acids. Name this type of reaction.

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(1 mark)

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Turn over ►



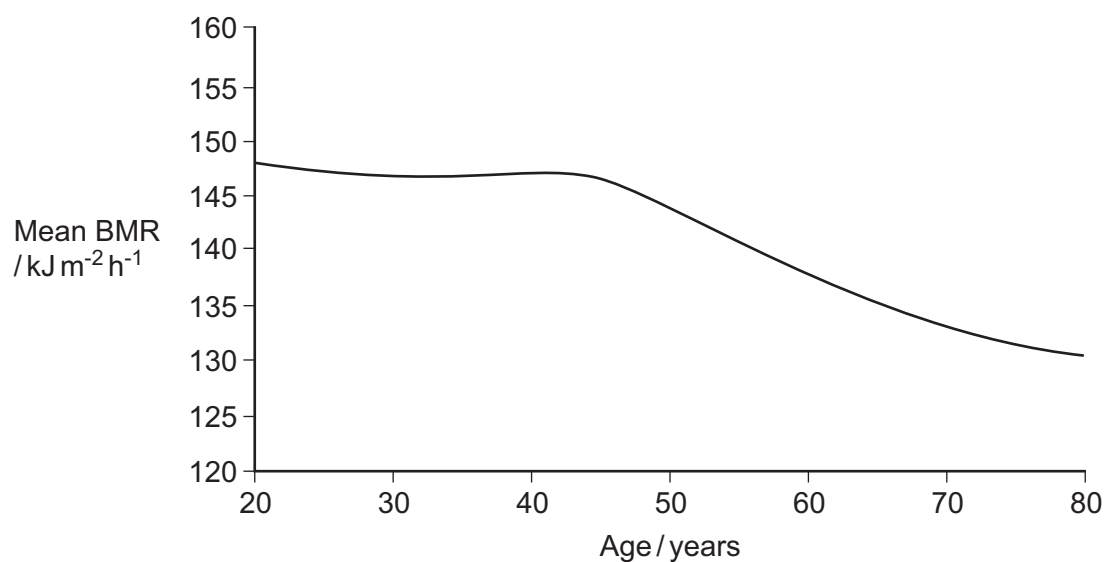
4 (a) What is basal metabolic rate (BMR)?

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(1 mark)

4 (b) Doctors investigated the effect of age on the BMR of women.
The graph shows their results.



4 (b) (i) Why was the BMR measured per unit surface area?

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(2 marks)

4 (b) (ii) Give **one** reason for the decline in BMR after the age of 45 years.

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(1 mark)



4(c)Apart from BMR, give **two** other physiological functions that decline with age.

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(2 marks)

Turn over for the next question**6****Turn over ►**

5 (a) Describe how calcium ions are involved in synaptic transmission.

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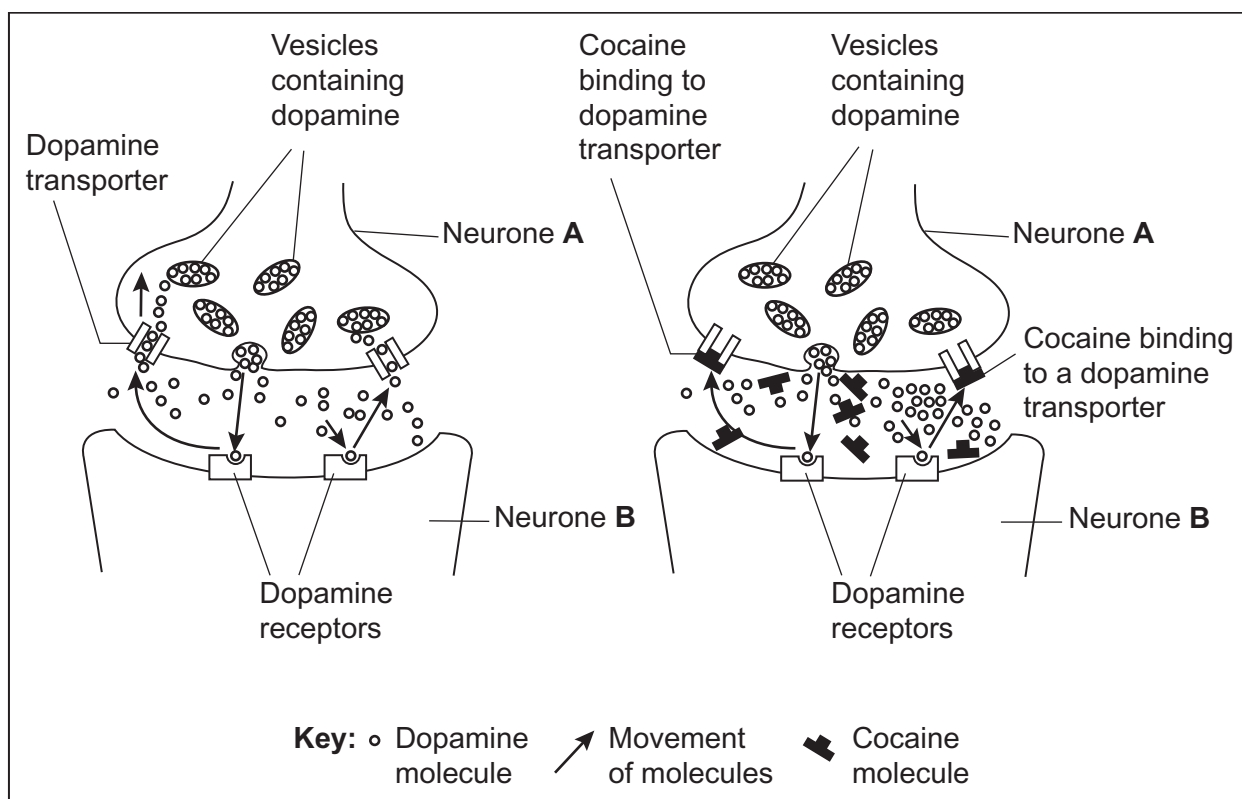
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(2 marks)

Cocaine changes the way some synapses function.

Figure 1 shows a synapse in part of the brain. This synapse uses a neurotransmitter called dopamine.

Figure 1



5 (b) This synapse only transmits information from neurone **A** to neurone **B** and not from **B** to **A**. Give **one** reason why.

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(1 mark)



- 5 (c) **Figure 2** shows the structures of molecules of dopamine and cocaine.

Figure 2



- 5 (c) (i) Explain why cocaine is able to bind to the dopamine transporter, as shown in **Figure 1**.

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(2 marks)

- 5 (c) (ii) Dopamine is released at synapses in parts of the brain where pleasure is perceived.

Using information from **Figures 1** and **2**, explain how the use of cocaine can result in feelings of pleasure.

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(3 marks)

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6 (a) What is *negative feedback*?

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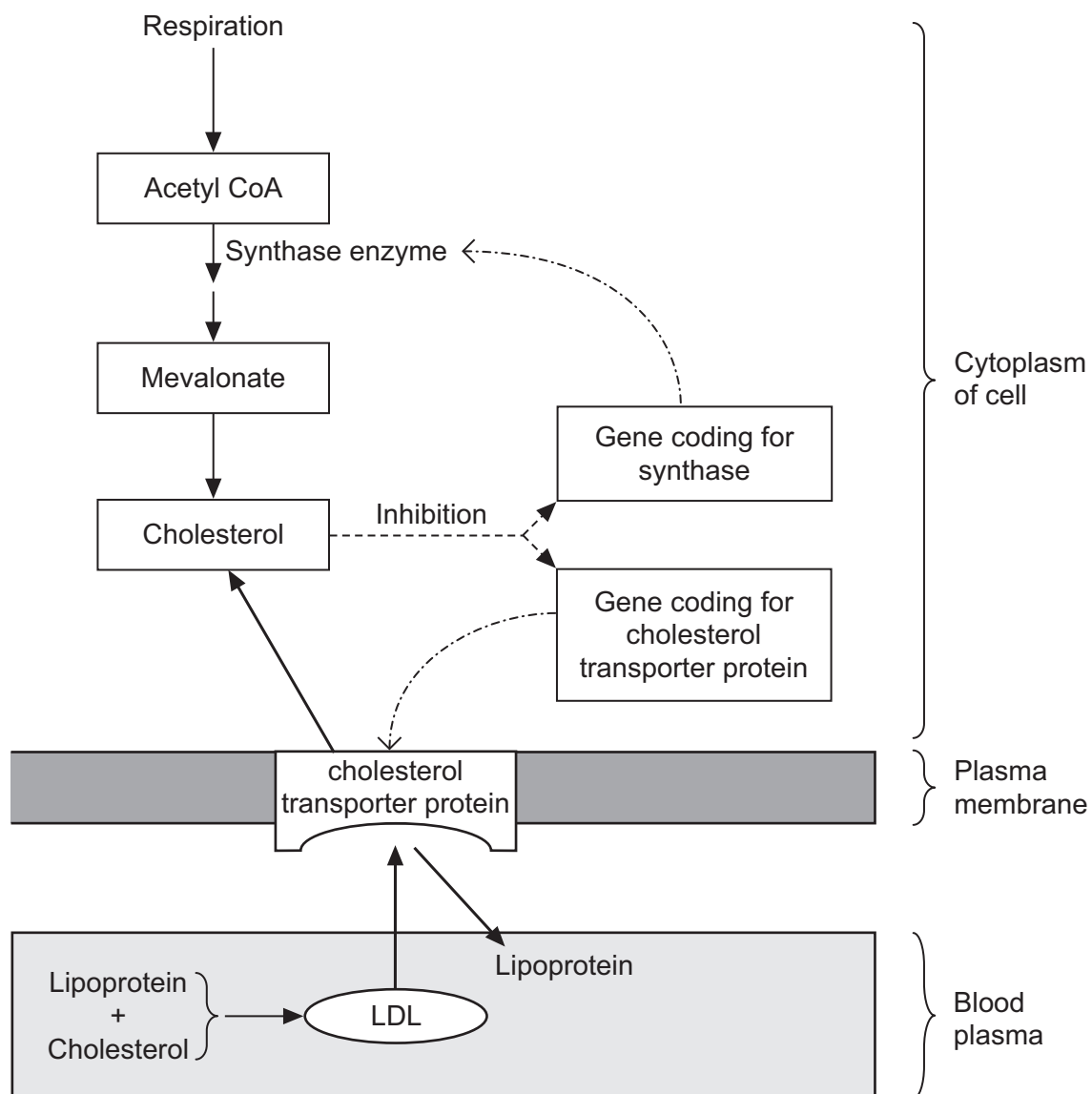
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(2 marks)

Cholesterol synthesis and cholesterol uptake by cells are controlled by the negative feedback mechanisms shown in the diagram.



- 6 (b)** A high concentration of cholesterol in the cytoplasm of the cell leads to a decrease in the production of mevalonate.

Use information from the diagram to explain how.

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(2 marks)

(Extra space)

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- 6 (c)** Lovastatin is a drug used to lower the concentration of cholesterol in blood plasma. Lovastatin inhibits one of the enzymes needed for mevalonate synthesis in cells.

Explain how Lovastatin lowers the concentration of cholesterol in blood plasma.

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(3 marks)

(Extra space)

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7

Turn over for the next question

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- 7 One way of rewarming people suffering from hypothermia is the RES-Q-AIR system. This system uses a small, battery-powered pump to supply warm air, saturated with water vapour, for a person to breathe.

- 7 (a) The RES-Q-AIR system helps to reduce the heat loss that occurs when breathing.

Explain **one** way in which the inhalation of warm, water-saturated air can help reduce the amount of heat lost when breathing.

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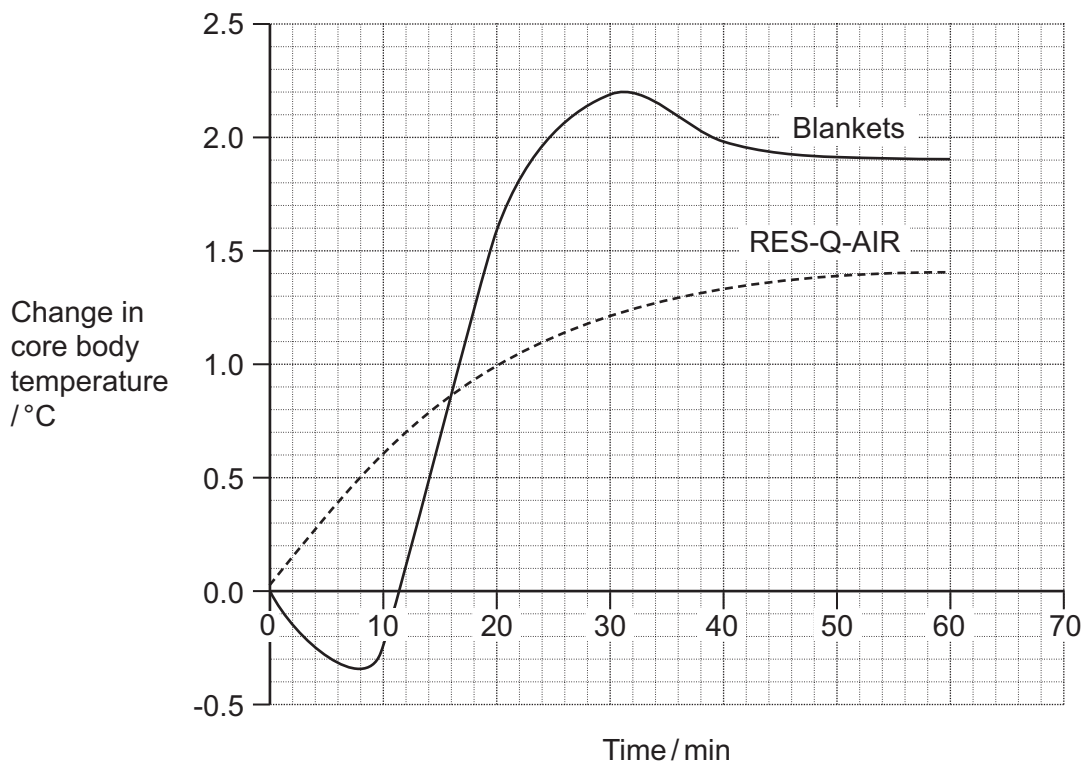
(2 marks)

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- 7 (b) Paramedics investigated two ways of rewarming people suffering from hypothermia.

The methods were: 1 wrapping the person in blankets,
2 the 'RES-Q-AIR' system.

The graph shows their results.



- 7 (b) (i)** Wrapping a person in blankets leads to an immediate warming of the skin. This stimulates thermoreceptors in the skin.

This stimulation of thermoreceptors in the skin causes the fall in core body temperature seen in the first ten minutes. Suggest how.

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(3 marks)

(Extra space)

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- 7 (b) (ii)** This fall in core body temperature can sometimes lead to cardiac arrest. Suggest how.

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(2 marks)

Question 7 continues on the next page

Turn over ►



- 7 (c)** The paramedics concluded that the RES-Q-AIR system was better than the blanket method for rewarming people suffering from hypothermia. Evaluate this conclusion.

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(Extra space) (4 marks)

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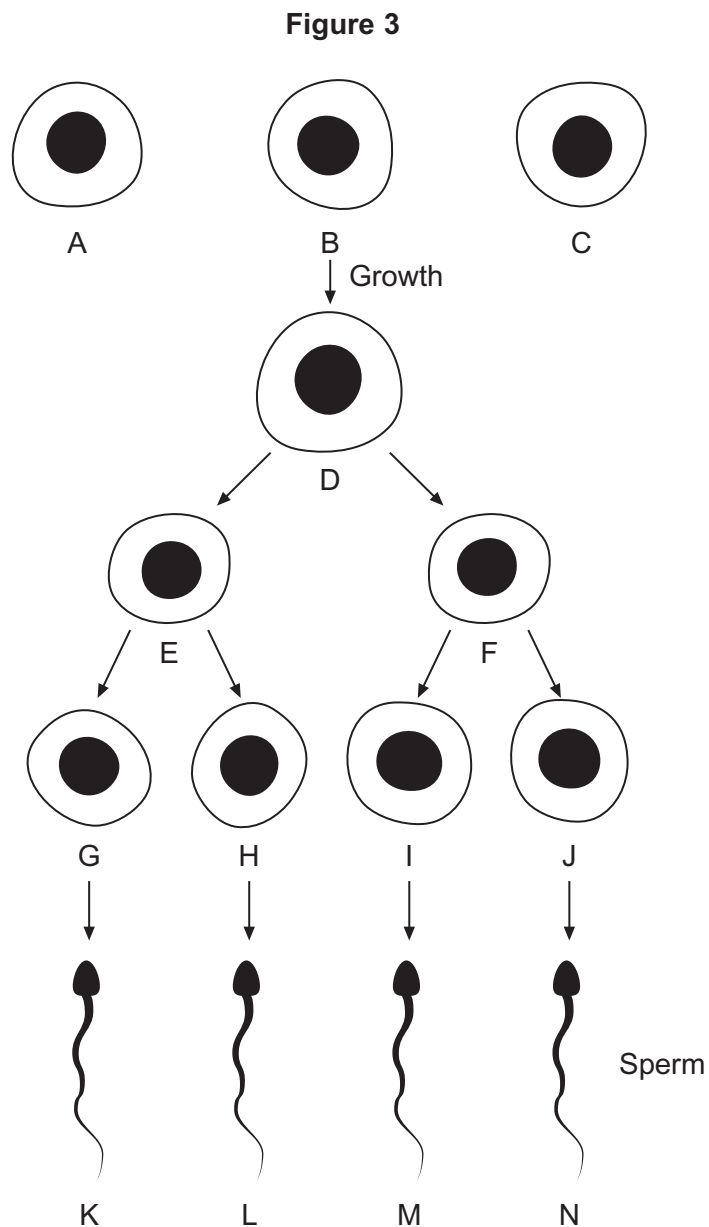
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8 **Figure 3** shows spermatogenesis.



8 (a) (i) Give the letter of **one** cell in **Figure 3** which is haploid and **one** cell which is diploid.

Haploid cell

Diploid cell

(1 mark)

8 (a) (ii) Describe **one** way in which spermatogenesis is different from oogenesis.

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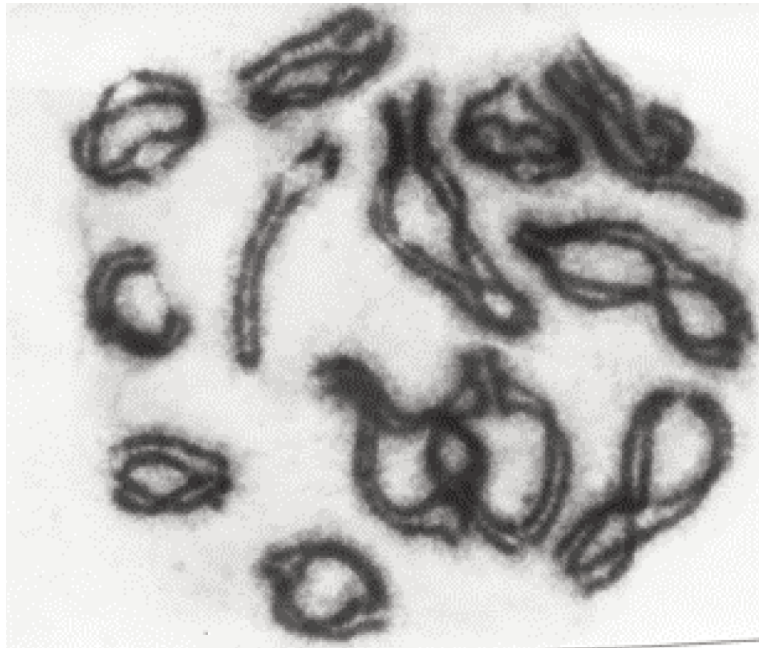
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(1 mark)



- 8 (b) **Figure 4** shows chromosomes in a cell at one stage of spermatogenesis.

Figure 4



- 8 (b) (i) The cell in **Figure 4** is undergoing meiosis.

Give **two** pieces of evidence that support this.

1.....

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2.....

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(2 marks)

- 8 (b) (ii) One cell in **Figure 3** would have chromosomes arranged in a way similar to the chromosomes shown in **Figure 4**.

Give the letter of this cell.

(1 mark)

Question 8 continues on the next page

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- 8 (c)** Scientists investigated sperm production in a large number of men. Some of the men were cigarette smokers and some were non-smokers. The men were divided into groups according to the number of cigarettes they smoked each day.

For each man the scientists measured the following factors:

- sperm concentration
- semen volume
- percentage of motile sperm.

For each factor they calculated the mean value and recorded the range within each group.

The results are given in the table.

The values in the table are the mean values, with ranges of values given in brackets.

Number of cigarettes smoked per day	None	1 to 10	11 to 20	> 20
Number of men in each group	1490	436	522	94
Mean sperm concentration $\times 10^6$ per cm^3	56.3 (50 to 63)	54.1 (47 to 62)	55.6 (48 to 64)	45.6 (36 to 57)
Mean semen volume / cm^3	3.2 (3.0 to 3.4)	3.1 (2.9 to 3.4)	3.0 (2.7 to 3.2)	3.1 (2.7 to 3.5)
Mean percentage of motile sperm	32 (24 to 40)	31 (23 to 39)	30 (22 to 39)	28 (18 to 37)



The scientists concluded that smoking reduces male fertility.

Evaluate this conclusion.

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(3 marks)

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- 9** Scientists manufactured large quantities of human insulin using genetic engineering. They started by isolating mRNA from pancreas cells. From this they produced DNA which coded for insulin.

- 9 (a) (i)** Suggest **two** reasons why it was better to start with mRNA from pancreas cells rather than with the DNA from these cells.

1.....

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2.....

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(2 marks)

- 9 (a) (ii)** The scientists used two enzymes, **Enzyme 1** and **Enzyme 2**, to produce DNA from mRNA.

The reactions catalysed by these enzymes are shown below.

mRNA $\xrightarrow{\text{Enzyme 1}}$ single-stranded DNA

single-stranded DNA $\xrightarrow{\text{Enzyme 2}}$ double-stranded DNA

Name enzymes **1** and **2**.

Enzyme 1

Enzyme 2

(2 marks)

- 9 (a) (iii)** In a double-stranded DNA molecule, the two strands are held together by weak bonds.

Name this type of bond.

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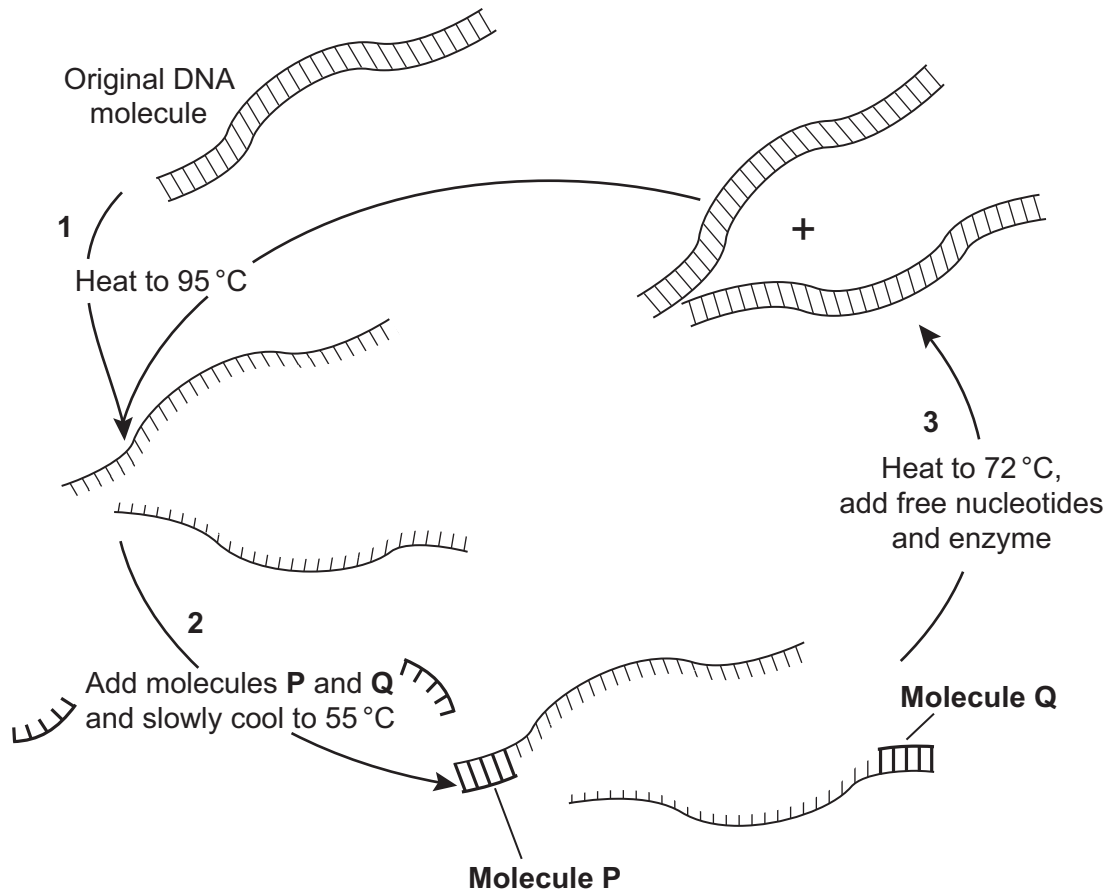
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- 9 (b)** The scientists used the polymerase chain reaction (PCR) to make copies of the DNA. The diagram shows the stages of the PCR.



- 9 (b) (i)** **P** and **Q** are short lengths of single-stranded DNA.

What name is given to molecules such as **P** and **Q**?

.....
(1 mark)

- 9 (b) (ii)** The mixture is cooled from 95 °C to 55 °C at step 2.

Explain why.

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(1 mark)



9 (b) (iii) Explain the function of molecules **P** and **Q**.

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(2 marks)

(Extra space)

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9 (b) (iv) How many copies of each original DNA molecule would be present after 5 cycles of PCR?

(1 mark)

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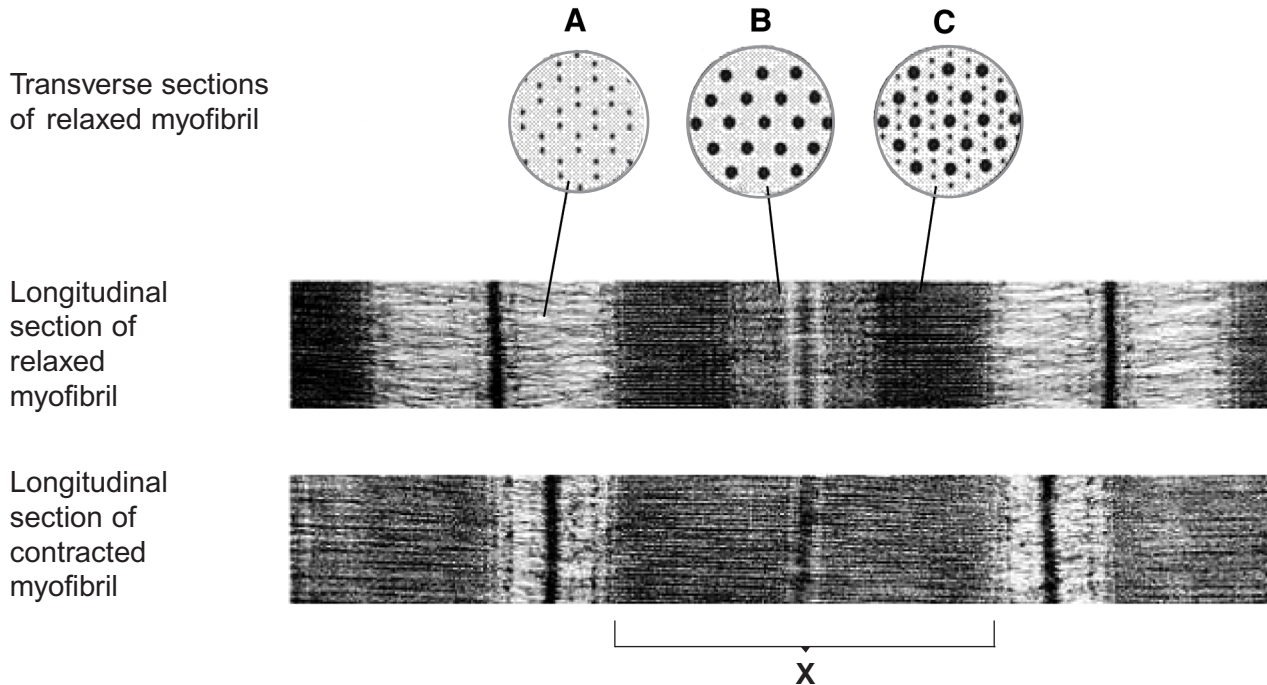
10

Turn over ►



- 10** **Figure 5** shows sections through relaxed and contracted myofibrils of a skeletal muscle. The transverse sections are diagrams. The longitudinal sections are electron micrographs.

Figure 5



- 10 (a) (i)** The electron micrographs are magnified 40 000 times. Calculate the length of band **X** in micrometres. Show your working.

Length of band **X** = μm

(2 marks)

- 10 (a) (ii)** Explain the difference in appearance between transverse sections **A** and **C** in **Figure 5**.

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(1 mark)



- 10 (b)** Explain what leads to the differences in appearance between the relaxed myofibril and the contracted myofibril.

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(4 marks)

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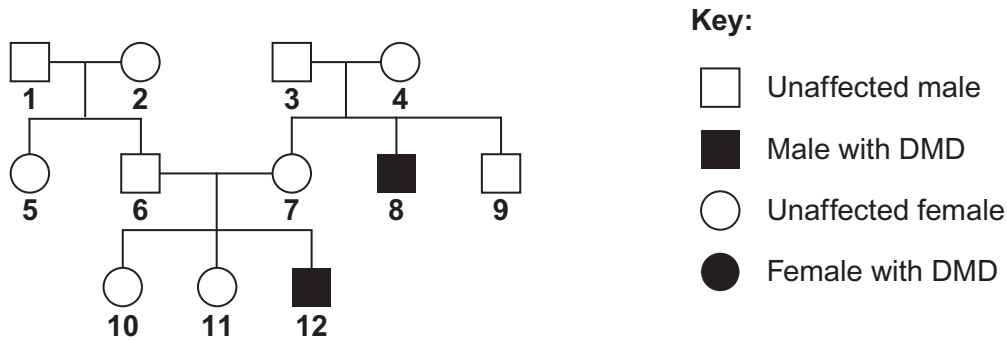
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- 10 (c)** Duchenne muscular dystrophy (DMD) is a condition caused by the recessive allele of a sex-linked gene. A couple have a son with DMD. They want to know the probability that they could produce another child with DMD. They consulted a genetic counsellor who produced a diagram showing the inheritance of DMD in this family. This is shown in **Figure 6**.

Figure 6



The couple who sought genetic counselling are persons **6** and **7**.

- 10 (c) (i)** Give the evidence to show that DMD is caused by a recessive allele.

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(1 mark)

- 10 (c) (ii)** Give the numbers of **two** people in **Figure 6** who are definitely carriers of muscular dystrophy.

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(1 mark)

10 (c) (iii) Complete the genetic diagram to find the probability that the next child of couple **6** and **7** will be a son with muscular dystrophy. Use the following symbols:

X^D = normal X chromosome

X^d = X chromosome carrying the allele for muscular dystrophy

Y = normal Y chromosome

	6	7
<i>Parental phenotypes</i>	Unaffected	Unaffected
<i>Parental genotypes</i>		
<i>Gametes</i>		
<i>Offspring genotypes</i>		
<i>Offspring phenotypes</i>		
<i>Probability of having a son with DMD</i>		

(4 marks)

Question 10 continues on the next page

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- 10 (d)** DMD is caused by a deletion mutation in the gene for a muscle protein called dystrophin. A deletion is where part of the DNA sequence of a gene is lost. People in different families may inherit mutations in different regions of this gene.

Scientists isolated the dystrophin gene from DNA samples taken from children **10**, **11** and **12**. They cut the gene into fragments using an enzyme. The scientists then used two DNA probes to identify the presence or absence of two of these fragments, called **F** and **G**. This allowed them to find the number of copies of each fragment in the DNA of a single cell from each child.

The table shows their results.

Child	Number of copies of gene fragment per cell	
	F	G
10 (unaffected girl)	2	1
11 (unaffected girl)	2	2
12 (boy with DMD)	1	0

- 10 (d) (i)** The number of copies of gene fragments **F** and **G** shows that person **12** has DMD. Explain how.

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(1 mark)

- 10 (d) (ii)** The number of copies of gene fragments **F** and **G** shows that person **12** is male. Explain how.

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(2 marks)



10 (d) (iii) The genetic counsellor examined the scientists' results. He concluded that person **10** is a carrier of DMD but her sister, **11**, is not.

Describe and explain the evidence for this in the table.

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(3 marks)

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10 (e) Person **12** took part in a trial of a new technique to help people with DMD.

Doctors took muscle cells from person **12**'s father and grew them in tissue culture.

They suspended samples of the cultured cells in salt solution and injected them into a muscle in person **12**'s left leg. They injected an equal volume of salt solution into the corresponding muscle in his right leg. Person **12** was given drugs to suppress his immune system throughout the trial.

Four weeks later, the doctors removed a muscle sample from near the injection site in each leg. They treated these samples with fluorescent antibodies. These antibodies were specific for the polypeptide coded for by gene fragment **G** of the dystrophin gene.

The results are shown in the table.

Location and treatment	Percentage of muscle fibres labelled with antibody
Left leg - injected with cultured cells suspended in salt solution	6.8
Right leg - injected with salt solution	0.0

10 (e) (i) Why was it necessary to treat person **12** with drugs to suppress his immune system?

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(1 mark)



- 10 (e) (ii)** Explain why salt solution was injected into one leg and cultured cells suspended in salt solution into the other.

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(1 mark)

- 10 (e) (iii)** This technique is at an early stage in its development. The doctors suggested that further investigations need to be carried out to assess its usefulness for treating people with DMD.

Explain why they made this suggestion.

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(4 marks)

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25

END OF QUESTIONS



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