Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
January 2013

Human Biology HBIO4

Unit 4 Bodies and cells in and out of control

Friday 11 January 2013 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 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.

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

1 (a) Human body temperature is regulated by negative feedback.
What is negative feedback?

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(2 marks)

1 (b) Thermoreceptors in the brain detect changes in blood temperature.
Name the part of the brain that contains thermoreceptors.

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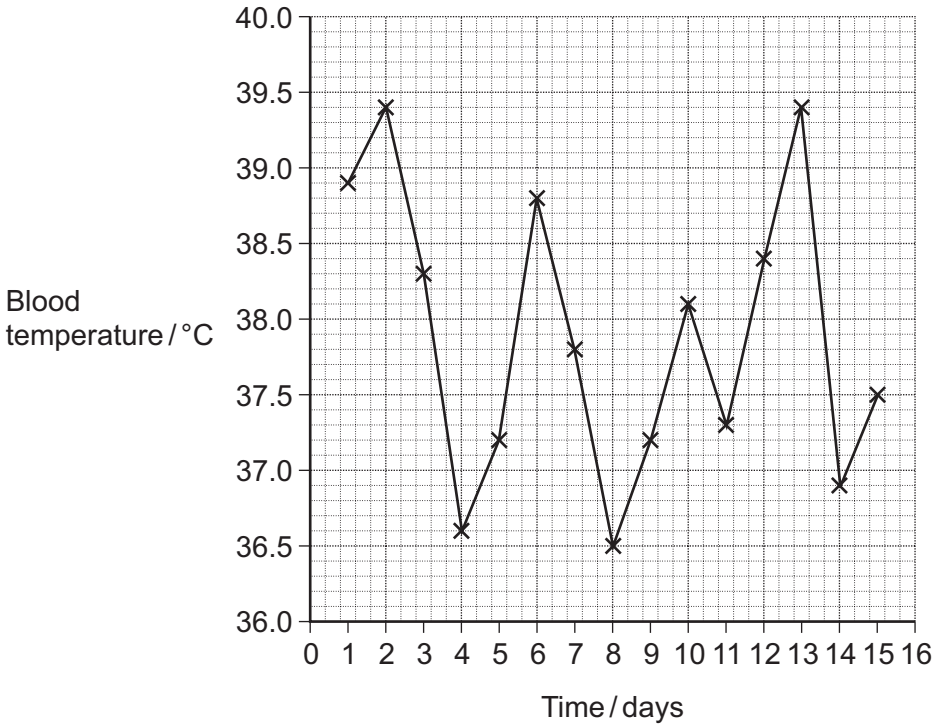
(1 mark)

1 (c) The graph shows changes in the blood temperature of a child suffering from an infection.



1 (c) (i) Give **two** days on which you would expect the rate of sweating to be the highest.

Day ..... and day .....

(1 mark)

1 (c) (ii) A high rate of sweating on these two days would help to reduce the child's blood temperature. Explain how.

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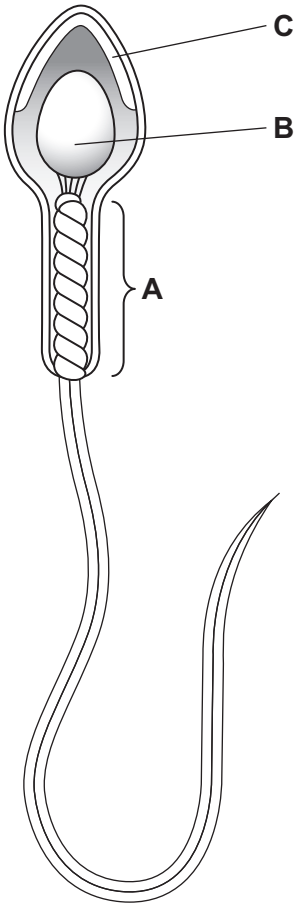
(2 marks)

6

2 The drawing shows a human sperm cell.



2 (a) Part **A** contains a large number of mitochondria.

How does a large number of mitochondria help the sperm cell to function?

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(2 marks)

2 (b) The diploid chromosome number in humans is 46.

2 (b) (i) How many chromosomes are found in part **B**?

(1 mark)

2 (b) (ii) Why is it important that part **B** contains this number of chromosomes?

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(1 mark)

2 (c) Part **C** is the acrosome.

Describe the function of the acrosome in fertilisation.

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(2 marks)

6

Turn over for the next question

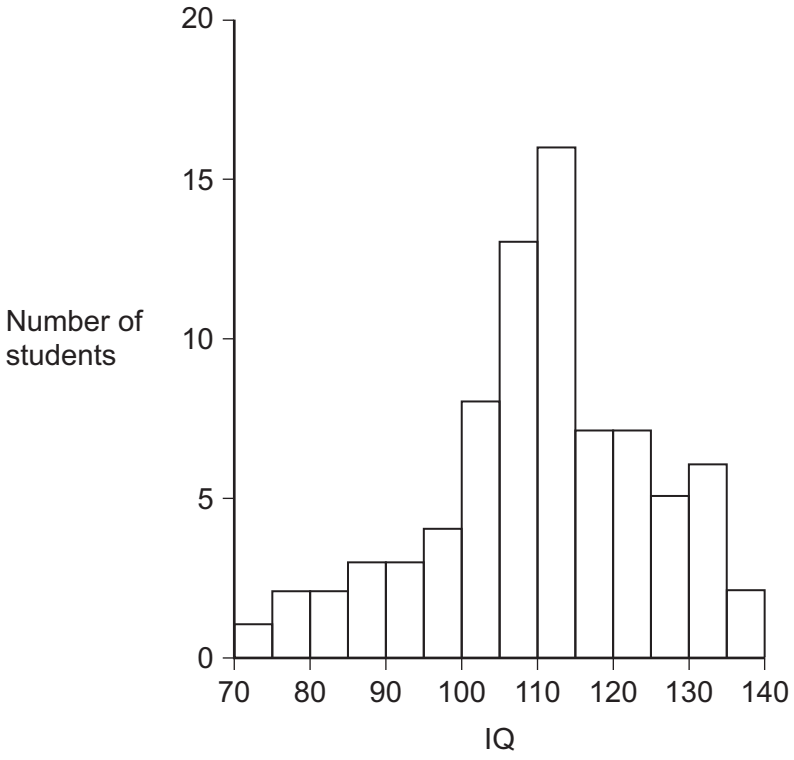
3 (a) A gene has two alleles. One allele is dominant and the other is recessive.

3 (a) (i) How many different genotypes are possible with these two alleles? ☐ *(1 mark)*

3 (a) (ii) How many different phenotypes are possible with these two alleles? ☐ *(1 mark)*

3 (b) Polygenic inheritance is where one characteristic is controlled by several genes.

The graph shows the variation in intelligence quotient (IQ) for a group of 13-year-old students.



3 (b) (i) What is the evidence in the graph that IQ is controlled by polygenic inheritance?

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(1 mark)

3 (b) (ii) Apart from genetic factors, give **one** other factor that might influence IQ.

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(1 mark)

3 (c) IQ is defined as $\frac{\text{mental age}}{\text{actual age}} \times 100$

Use this information to explain why a student of average intelligence has an IQ = 100.

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(1 mark)

5

Turn over for the next question

4 Cancer is a disease that affects cells.

4 (a) What is cancer?

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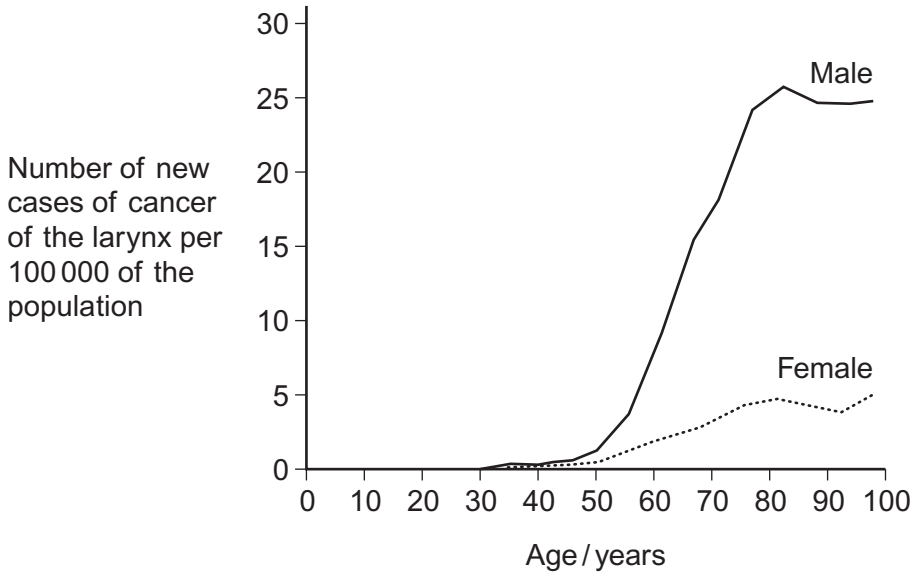
(1 mark)

4 (b) The larynx is found at the top of the trachea.

The graph shows the number of new cases of cancer of the larynx diagnosed for men and women of different ages in England and Wales in 2001.



Give **two** conclusions from the data in the graph.

1 .....

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2 .....

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(2 marks)

4 (c) Doctors have found that cancer of the larynx is associated with high levels of tobacco use.

Describe **one** type of evidence that could have led them to make this association.

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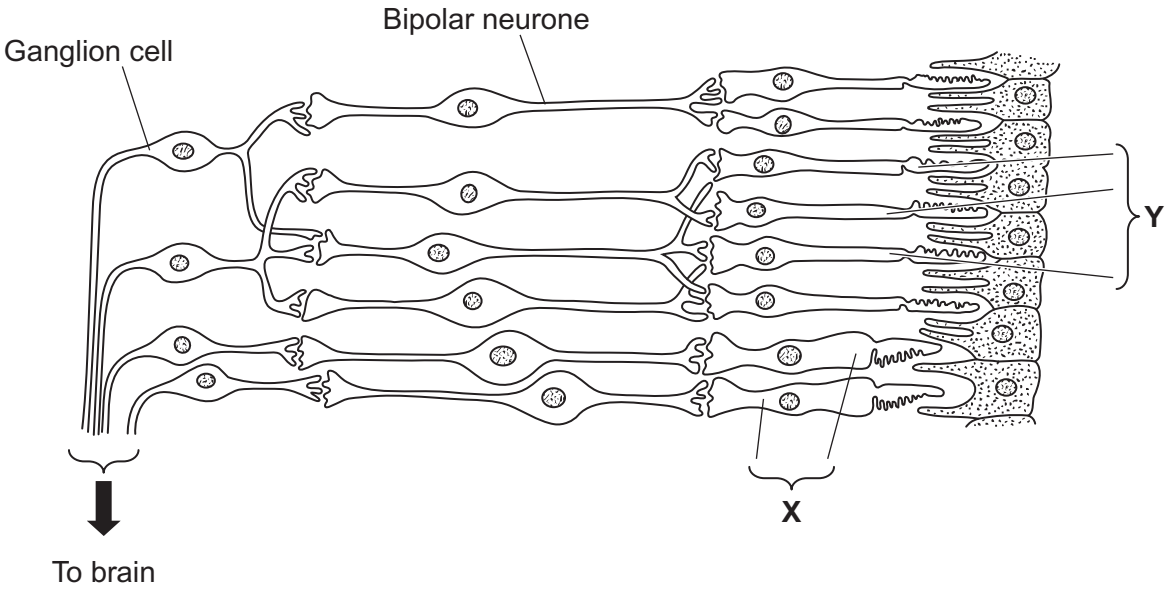
(2 marks)

5

Turn over for the next question

5 The diagram shows part of the retina in a human eye.



5 (a) Name the types of receptor cell labelled **X** and **Y**.

X .....

Y .....

(1 mark)

5 (b) The part of the retina shown in the diagram is **not** in the fovea.

How does the diagram show that this part of the retina is **not** in the fovea?

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(1 mark)

5 (c) (i) The way in which the cells labelled **X** are connected to the brain allows high visual acuity. Explain how.

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(2 marks)

5 (c) (ii) The way in which the cells labelled **Y** are connected to the brain allows vision in low light intensities. Explain how.

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(3 marks)

(Extra space) .....

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7

Turn over for the next question

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

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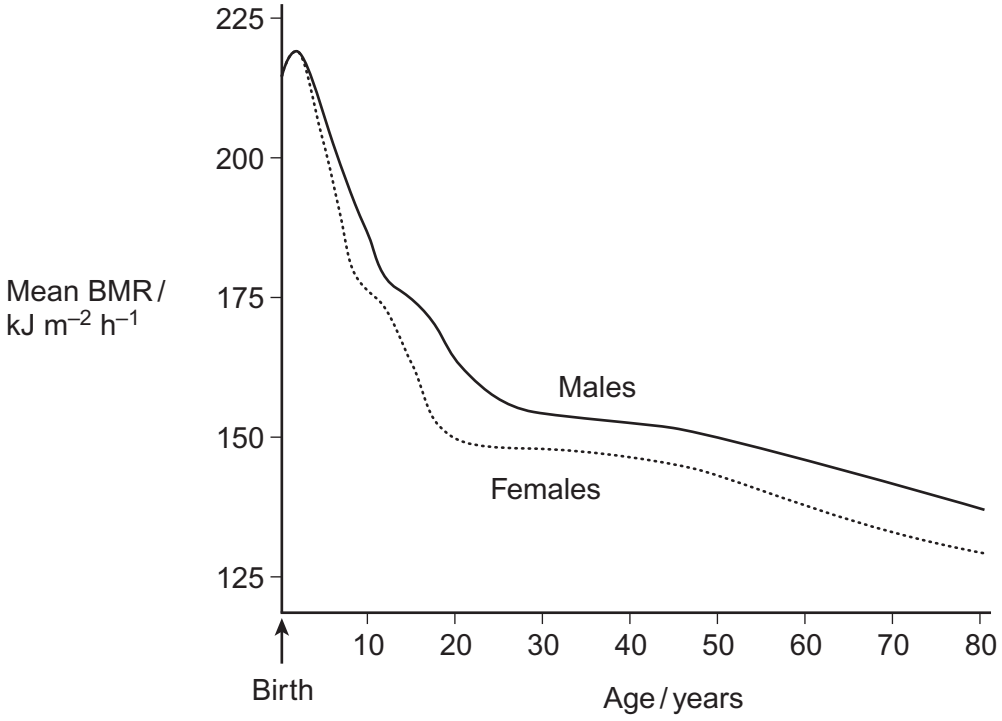
(1 mark)

6 (b) The graph shows how the mean BMR changes with age in human males and females.



6 (b) (i) Why was the BMR measured per m^2?

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(2 marks)

6 (b) (ii) Above the age of 5 years, the mean BMR is greater in males than in females.

Explain **one** reason why.

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(2 marks)

6 (b) (iii) In both males and females, BMR declines with age.
Give **one** reason why.

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(1 mark)

6 (b) (iv) Apart from BMR, give **two** other physiological functions that decline with age in both males and females.

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2 .....

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(2 marks)

8

7 Oxytocin is a hormone that leads to several effects in human females.

One effect of oxytocin is to cause the release of LRF (luteinising hormone releasing factor) from the hypothalamus. LRF then stimulates the release of LH into the blood.

7 (a) (i) Other than stimulating the release of LRF, give **two** effects of oxytocin in human females.

1 .....

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2 .....

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(2 marks)

7 (a) (ii) Describe **one** effect of LH in human females.

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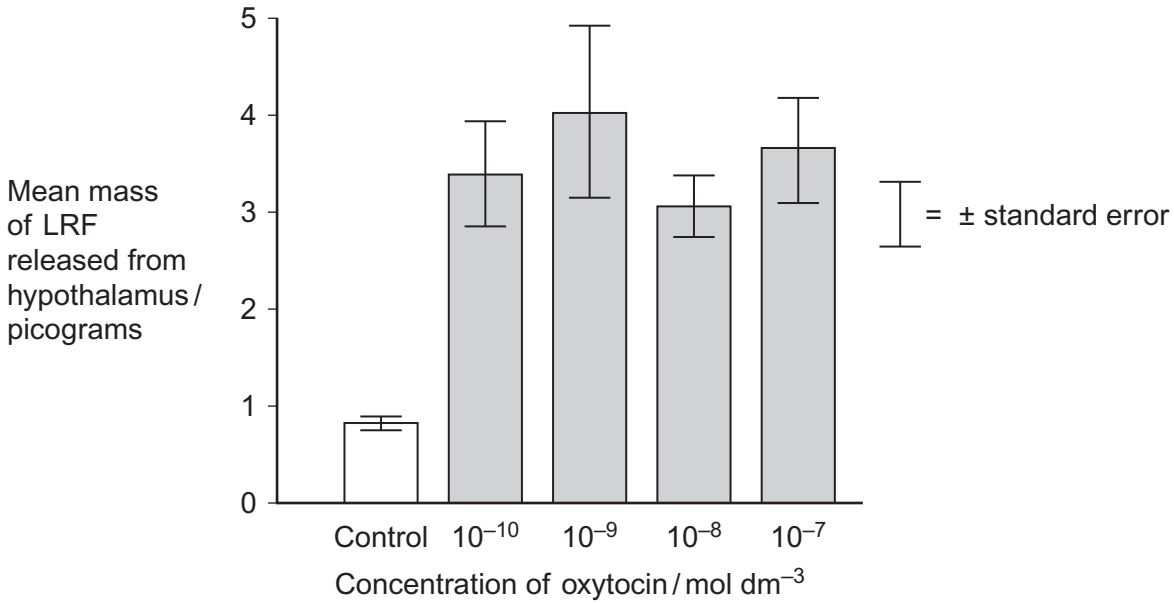
(1 mark)

Scientists investigated the effect of oxytocin on the release of LRF from the hypothalamus. The scientists placed pieces of hypothalamus in different concentrations of oxytocin.
The oxytocin was in a pH 7.4 buffer solution.
After 30 minutes, the scientists measured the amount of LRF in each solution.

The scientists investigated the effects of concentrations of oxytocin between 10^{-10} and 10^{-7} mol dm^{-3}.

The graph shows the scientists' results.



7 (b) Suggest how the scientists would have set up a suitable control for this investigation.

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(2 marks)

7 (c) Use information from the graph to explain your answer to the following.

Does the concentration of oxytocin have a significant effect on the release of LRF from the hypothalamus:

7 (c) (i) at 10^{-10} mol dm^{-3} compared with the control

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(2 marks)

7 (c) (ii) between 10^{-10} mol dm^{-3} and 10^{-7} mol dm^{-3}?

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(2 marks)

9

8 Linagliptin is a new drug for the treatment of type 2 diabetes. It is taken in tablet form.

Doctors demonstrated that the drug was safe and effective in trials with over 5000 volunteers with type 2 diabetes.

Each trial was double-blind and placebo-controlled. Double-blind means that neither the doctors nor the volunteers knew which volunteers received the drug and which received a placebo. The placebo was a tablet that did not contain linagliptin.

8 (a) (i) Why was it necessary to carry out a double-blind trial to test the effectiveness of this new drug?

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(2 marks)

8 (a) (ii) Why was it important to carry out the study on a large number of patients?

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(1 mark)

8 (a) (iii) Give **two** ethical implications of this type of study.

1 .....

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2 .....

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(2 marks)

8 (b) After a meal, the small intestine releases a hormone called GLP-1.

- GLP-1 stimulates the release of insulin from the pancreas.
- GLP-1 inhibits the release of glucagon.
- GLP-1 is inactivated by an enzyme, DPP-4, found on the cell membranes of most cells.

Linagliptin works by inhibiting the DPP-4 enzyme.

Explain how linagliptin can help to regulate the blood glucose concentration in a person with type 2 diabetes.

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(4 marks)

(Extra space) .....

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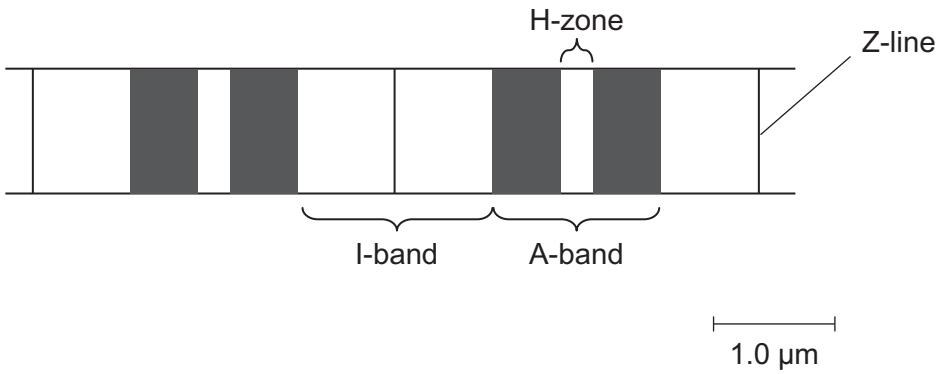
9

9 The diagram shows two sarcomeres in a relaxed myofibril.



9 (a) Actin and myosin are two types of protein found in the myofibril.

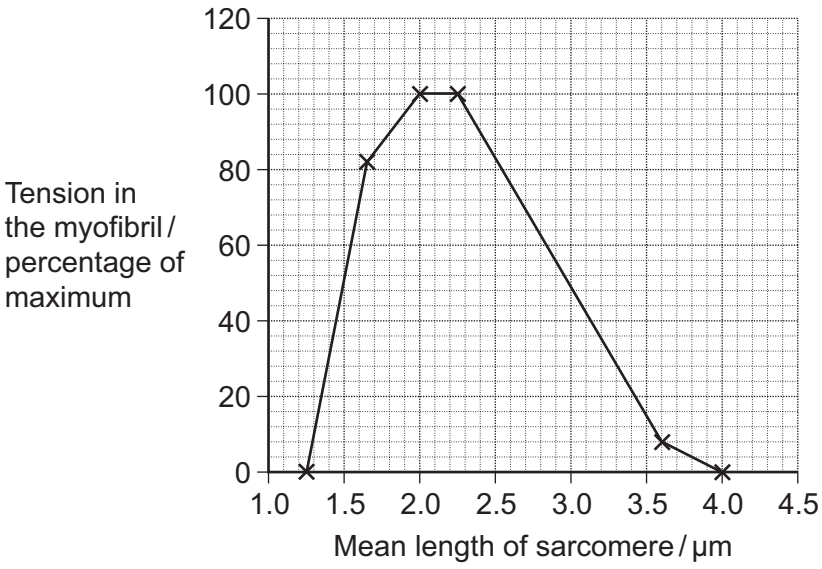
In which of the labelled regions in the diagram would actin and myosin be found?

Actin .....

Myosin .....

(2 marks)

9 (b) The graph shows how the tension developed in a myofibril varies with the mean length of the sarcomeres in the myofibril.



9 (b) (i) Calculate the length of **one** sarcomere in the myofibril shown in the diagram.
Show your working.

Length of one sarcomere = ... µm
(2 marks)

9 (b) (ii) What tension would be developed in the myofibril when it is the length you have calculated?
Use your answer to part (b)(i) and information from the graph.

Tension as percentage of maximum = ... %
(1 mark)

9 (c) Myofibrils are found in muscle fibres. The table gives some properties of two different types of muscle fibre, fast twitch and slow twitch, which are found in skeletal muscle.

9 (c) (i) Complete the table by writing the words 'high' or 'low' for the remaining two properties of each type of muscle fibre.

	Type of muscle fibre	
	Fast twitch	**Slow twitch**
Speed of contraction	high	low
Force generated	high	low
Activity of the enzymes of glycolysis	high	low
Number of mitochondria		
Rate of fatigue		

(2 marks)

Question 9 continues on the next page

9 (c) (ii) Fast twitch and slow twitch muscle fibres both contract due to the movement of actin past myosin. This movement requires the use of ATP. In fast twitch fibres, the ATP-ase action of myosin is faster than in slow twitch fibres.

Explain how this will help fast twitch muscle fibres to contract faster than slow twitch muscle fibres.

Use your knowledge of the mechanism of muscle contraction.

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(3 marks)

(Extra space) .....

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10

10 Haemophilia B is a sex-linked condition, caused by the recessive allele of a gene. Mr and Mrs Romanov do not suffer from haemophilia B. They have two sons. One son is healthy but the other son has haemophilia B.

10 (a) Complete the genetic diagram to find the probability that Mr and Mrs Romanov's next child will be a son with haemophilia B. Use the following symbols:

$\mathbf{X^H}$ = X chromosome carrying the dominant allele
$\mathbf{X^h}$ = X chromosome carrying the recessive allele for haemophilia B
Y = Y chromosome

	Mr Romanov	**Mrs Romanov**
Parental phenotypes	Unaffected	Unaffected
Parental genotypes	.....	.....
Gametes	....	....

Offspring genotypes ....

Offspring phenotypes ....

Probability of having a son with haemophilia = ...

(4 marks)

10 (b) The mutation that causes haemophilia B occurs in the gene coding for a blood-clotting protein called Factor IX. The mutation produces a triplet, **ACT**, in the gene for Factor IX in place of the normal triplet, **GCT**.

10 (b) (i) What new base would appear in the mRNA as a result of the mutation?

.....

(1 mark)

10 (b) (ii) What base occupied this position in the mRNA from the non-mutant DNA?

.....

(1 mark)

10 (b) (iii) This mutation is a type of point mutation.

What name do scientists give to this type of point mutation?

.....

(1 mark)

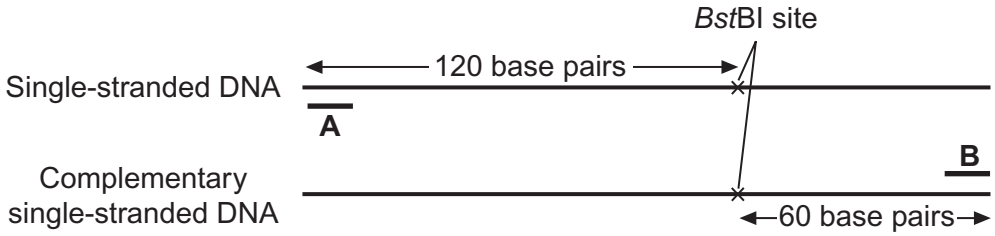
Question 10 continues on the next page

10 (c) Scientists have developed a diagnostic test to see whether a person has the allele for haemophilia B. The test involves the following steps.

1. The scientists take a sample of cells from the person.
2. They extract the DNA from these cells.
3. They isolate the Factor IX gene from this DNA.
4. They perform PCR (the polymerase chain reaction), with primers, on part of the Factor IX gene.
5. They use a restriction enzyme called *Bst*BI to break the PCR product into DNA fragments.
6. They check the sizes of these DNA fragments.

The scientists use two primers, **A** and **B**, at step **4** in the test.

The diagram shows where the primers bind to part of the Factor IX gene.



10 (c) (i) What is a primer?

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(2 marks)

10 (c) (ii) The scientists need to use two different primers to replicate this part of the Factor IX gene. Explain why.

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(3 marks)

(Extra space) .....

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10 (c) (iii) Using information from the diagram, what length of DNA would be replicated by PCR using primers **A** and **B**?

..... base pairs *(1 mark)*

Question 10 continues on the next page

10 (d) At step **5** in the diagnostic test, the enzyme *Bst*BI cuts the normal Factor IX allele at the point in the DNA base sequence where the haemophilia B mutation occurs.

10 (d) (i) The scientists chose to use enzyme *Bst*BI in the diagnostic test rather than any other restriction enzyme.

Explain why only *Bst*BI was suitable in the test to detect the allele for haemophilia B.

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(3 marks)

(Extra space) .....

10 (d) (ii) At step **6** in the diagnostic test, the scientists check the sizes of the DNA fragments.

The table shows the lengths of the DNA fragments produced when each member of the Romanov family was tested.

Complete the table by putting a tick (✓) in the correct boxes to show the lengths of the DNA fragments produced by each person.

You may tick one or more boxes for each person.
One line has been completed for you.

	Length of DNA fragment / base pairs		
	60	**120**	**180**
Mr Romanov	✓	✓	
Mrs Romanov			
Haemophiliac son			
Non-haemophiliac son			

(3 marks)

10 (e) The Romanovs wanted another child but did not want a child with haemophilia B. They consulted their doctor who told them about two methods of embryo screening for the condition. Both methods use the diagnostic test described in part 10 (c).

One screening technique is called PGD (pre-implantation genetic diagnosis). This starts with IVF to create embryos. Cells from each 3-day-old embryo are tested for the haemophilia B allele. An embryo which does not have the allele is then implanted. This method has a 25 per cent success rate, but the possibility of a false positive result is about 1 in 6. The cost is around £6000.

The other technique involves amniocentesis. At about 16 weeks into her pregnancy, a needle is used to remove cells from the woman's amniotic fluid. These cells are tested for the haemophilia B allele. If the allele is present, the woman is offered a termination of the pregnancy. About 1 per cent of women have a miscarriage after amniocentesis and the possibility of a false positive result is about 1 in 100. This method costs £160 for the amniocentesis, plus a further £900 for a termination if this is wanted.

The Romanov's doctor advised that he considered PGD to be a better option than amniocentesis for detecting the haemophilia B allele.

Evaluate the doctor's opinion.

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(6 marks)

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END OF QUESTIONS

25

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