Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
January 2010

Human Biology HBIO4

Unit 4 Bodies and cells in and out of control

Monday 25 January 2010 1.30 pm to 3.30 pm

For this paper you must have:
- a ruler with millimetre measurements
- a calculator.

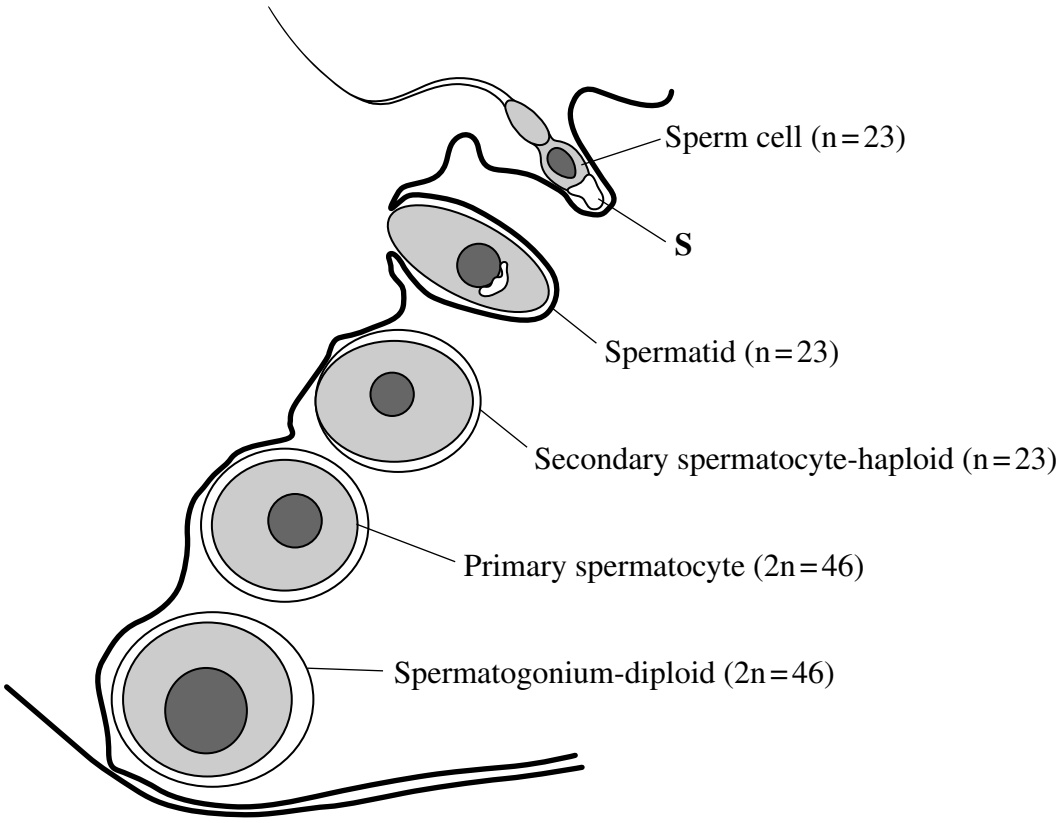
Time allowed
- 2 hours

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. Answers written in margins or on blank pages will not be marked.
- 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 accurate scientific terminology.

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

1 The diagram shows stages in the formation of a sperm cell.



1 (a) (i) Where in the testis do these stages take place?

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(1 mark)

1 (a) (ii) Name the part of the sperm cell labelled **S**.

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(1 mark)

1 (a) (iii) Use the letter **M** to identify the cell or cells that divide by mitosis.

(1 mark)

1 (b) Give **two** ways in which oogenesis is different from spermatogenesis.

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(2 marks)

5

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

2 (a) Describe the role of each of the following in muscle contraction.

2 (a) (i) Tropomyosin

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(2 marks)

2 (a) (ii) ATP

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2 (b) Explain how muscles maintain posture.

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7

3 (a) Explain how insulin lowers the concentration of blood glucose.

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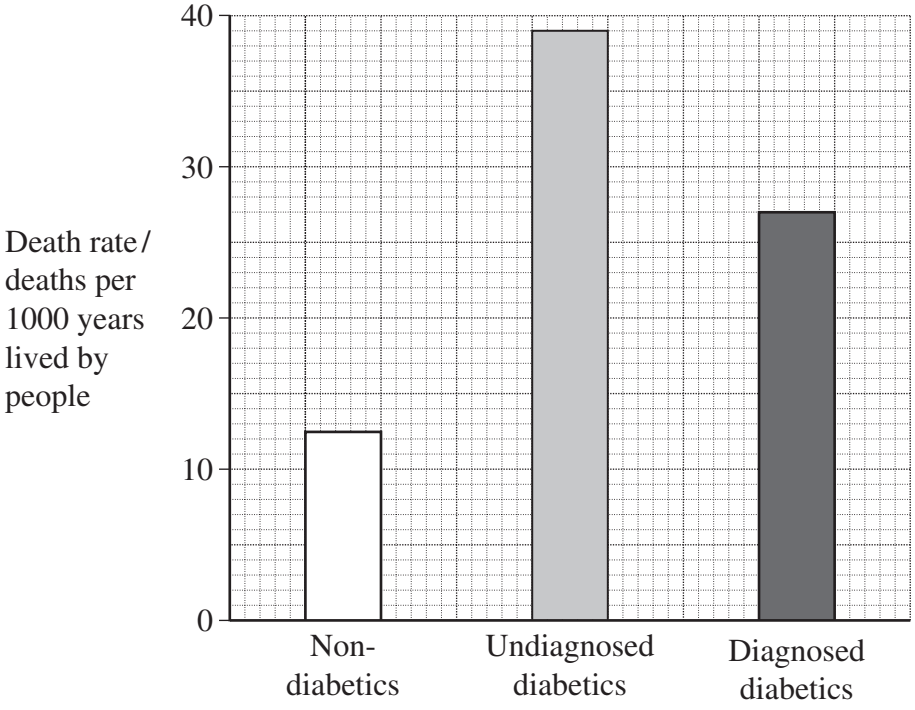
3 (b) Doctors studied a large group of people. They recorded the death rates for non-diabetic people, undiagnosed diabetics and diagnosed diabetics. They gave the death rates as deaths per 1000 years lived by people. The graph shows these death rates.



3 (b) (i) Calculate the ratio of the death rate of diagnosed diabetics to undiagnosed diabetics.

Ratio .....

(2 marks)

3 (b) (ii) People with undiagnosed diabetes were not receiving treatments, such as insulin injections. Suggest **one** reason for the difference in death rates for undiagnosed and diagnosed diabetics.

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(2 marks)

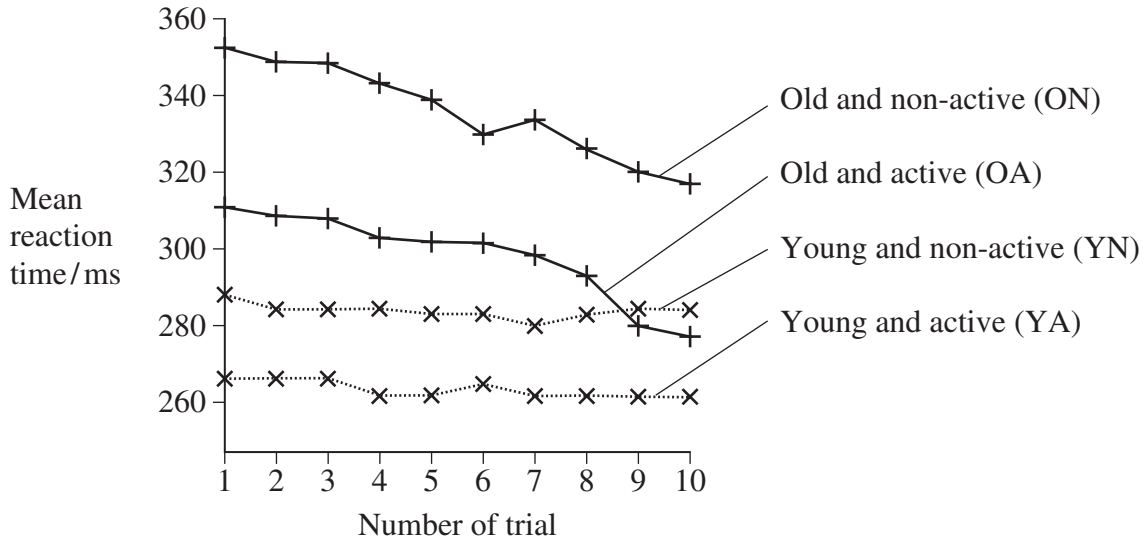
7

Turn over ▶

4 (a) Scientists investigated the effects of ageing on reaction time. They recruited four groups of volunteers with different life styles.

- Young and active (YA)
- Young and non-active (YN)
- Old and active (OA)
- Old and non-active (ON).

Each volunteer sat in front of a light bulb and was asked to press a button when it lit up. Each volunteer repeated the trial 10 times, with a few seconds between each trial. The time between the bulb lighting and pressing the button was the reaction time. The graph shows the mean reaction time for each trial for each group.



4 (a) (i) Describe the effects of age and life style on reaction time.

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(2 marks)

4 (a) (ii) Suggest **one** reason for the differences between the results for old and active people and young and active people.

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(2 marks)

4 (b) Other than functions relating to the nervous system, give **two** physiological functions that decline with age.

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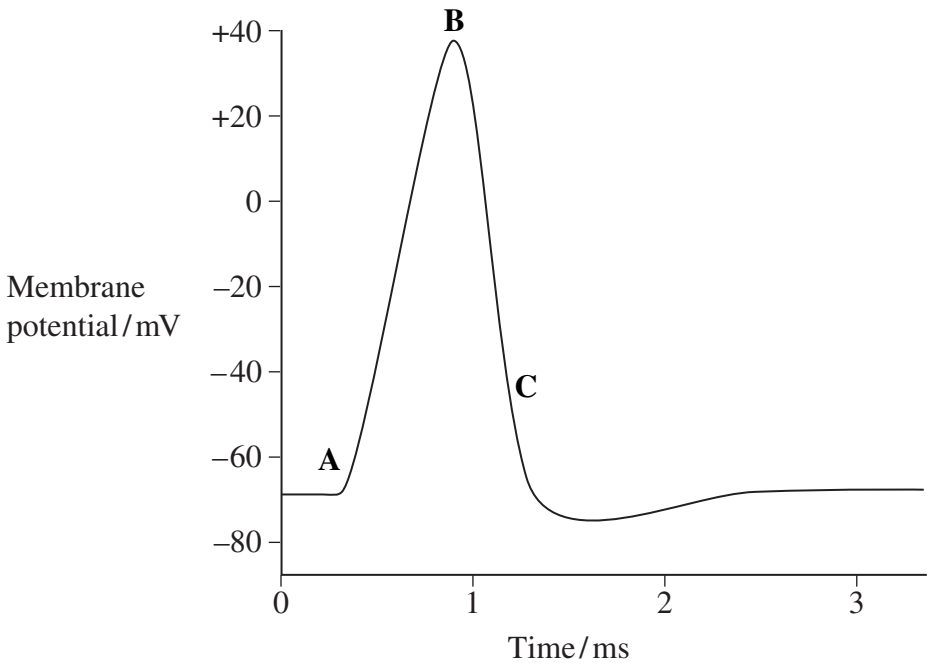
Turn over for the next question

5 **Figure 1** shows changes in the membrane potential of a neurone during one action potential.

Figure 1



5 (a) What happens in the membrane to cause the change in membrane potential at time **B**?

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(2 marks)

5 (b) No further action potential can be produced between times **A** and **C**.
What is the name given to the period between times **A** and **C**?

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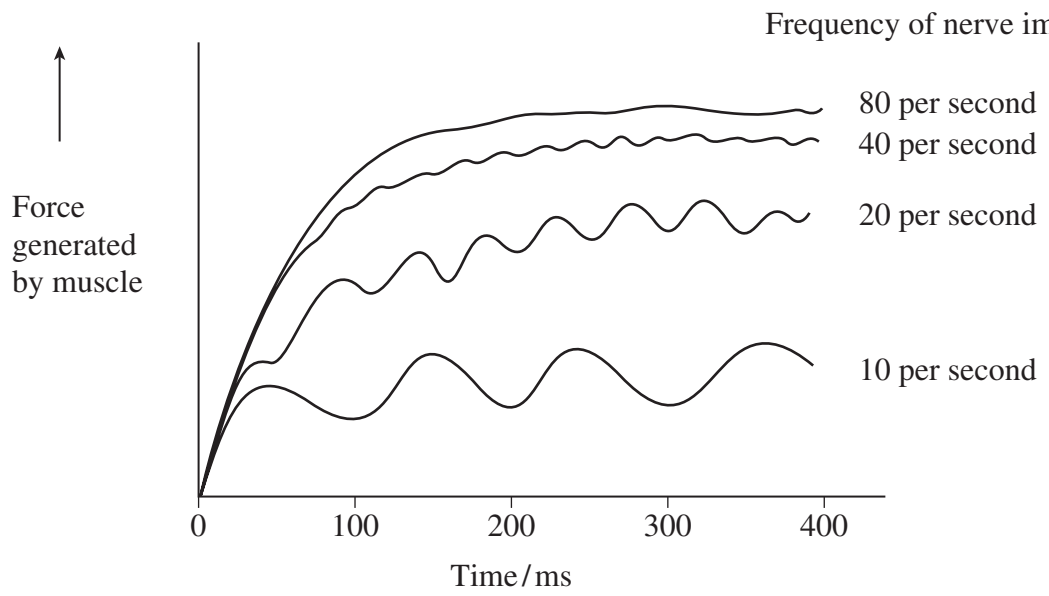
(1 mark)

5 (c) **Figure 2** shows the force generated by a muscle when it was stimulated by different frequencies of nerve impulse.

Figure 2



A taser is a device used by the police to arrest violent suspects. It fires electrical impulses very similar to action potentials into a suspect. The frequency of the impulses is between 15 and 20 per second.

5 (c) (i) Suggest the effect a taser has on a suspect's muscles.

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(2 marks)

5 (c) (ii) Tasers with frequencies of between 40 and 80 per second are not used, because they are considered too dangerous. Suggest how they might be dangerous to a suspect.

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(2 marks)

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6 Asthma causes the airways to the lungs to become narrower and inflamed. The result is difficulty in breathing.

Doctors investigated the effects of genes and the environment on the risk of developing asthma. They obtained data from identical and non-identical twins. They used these data to calculate a correlation coefficient for both of the twins in a pair having asthma. The value of the correlation coefficient is between 0 and 1. The twins of each pair were raised together. The results are shown in the table.

Type of twins	**Number of pairs of twins**	**Number of cases of asthma**	**Correlation coefficient**
Identical twins – male	526	75	0.73
Identical twins – female	777	131	0.70
Non-identical – both male	397	52	0.28
Non-identical – both female	655	109	0.09

6 (a) Describe the results.

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6 (b) Explain what these data suggest about the causes of asthma.

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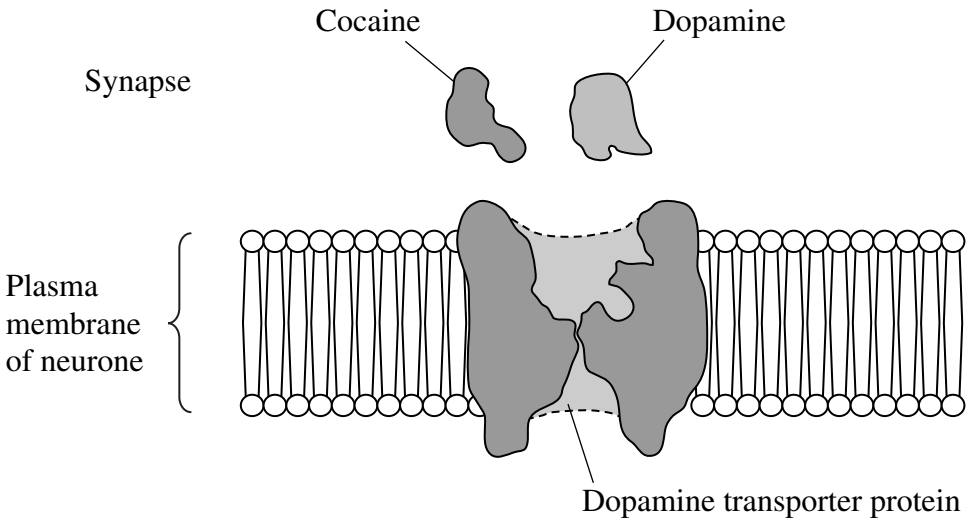
Turn over for the next question

7 Cocaine is a highly addictive and illegal drug.
The release of the neurotransmitter dopamine in specific synapses in the brain leads to feelings of pleasure. Dopamine is removed from synapses by dopamine transporter proteins in the plasma membrane of neurones. Cocaine binds to the dopamine transporter protein.
Figure 3 shows a dopamine transporter protein and molecules of cocaine and dopamine.

Figure 3



7 (a) Using all of the information, suggest how cocaine leads to feelings of pleasure.

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7 (b) (i) Scientists isolated a mutated gene for the dopamine transporter protein.
Name **one** method that the scientists could have used to produce many copies of the mutated gene in the laboratory.

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(1 mark)

7 (b) (ii) Copies of the gene were then inserted into early embryos of mice. When these mice were born, samples of their DNA were tested using DNA probes to make sure that the mutated gene was present in the mice.
What is a DNA probe?

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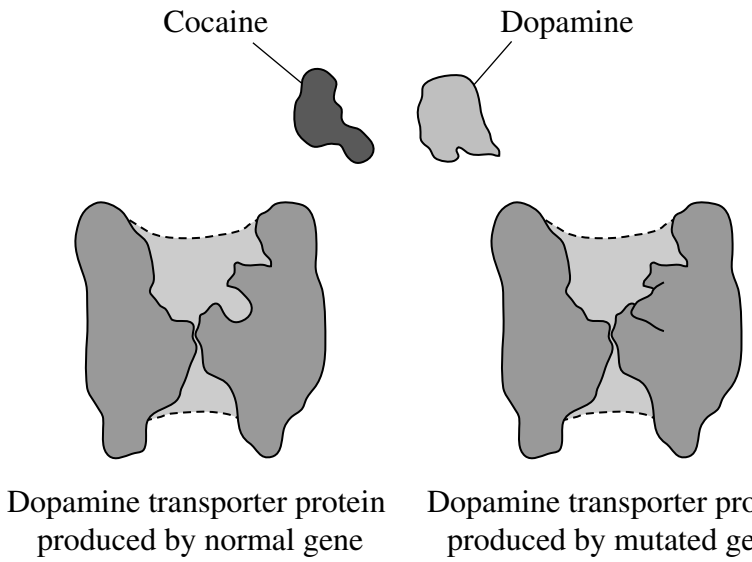
(2 marks)

Question 7 continues on the next page

7 (c) **Figure 4** shows dopamine transporter proteins produced from the normal gene and from the mutated gene.

Figure 4



Explain how the mutation leads to the production of a protein that transports dopamine but is **not** affected by cocaine.

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8 *Plasmodium* is the parasite that causes malaria. Researchers have been working to determine the genome of *Plasmodium*.

8 (a) What is the genome of an organism?

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(2 marks)

Scientists isolated the gene from *Plasmodium* for a protein called Pfs25. They used it to synthesise Pfs25 which the scientists then injected into rabbits.
The rabbits then produced antibody that binds to Pfs25.

8 (b) Explain what causes the rabbits to produce antibody against Pfs25.

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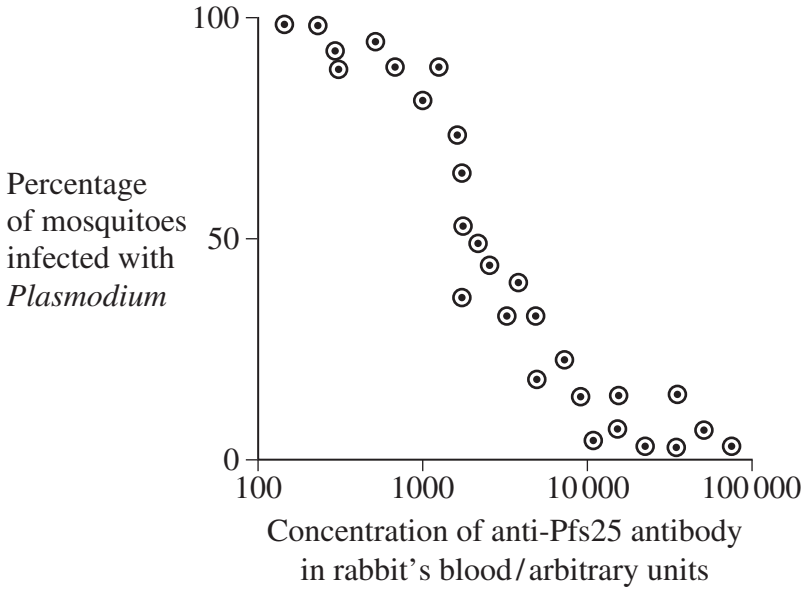
(2 marks)

Question 8 continues on the next page

Plasmodium is transmitted by mosquitoes that feed on human blood. The Pfs25 protein is only produced by *Plasmodium* when it is in a mosquito's gut. It allows *Plasmodium* to get from the gut into the rest of the mosquito's body. Scientists hoped that anti-Pfs25 antibody would stop this.

The scientists fed blood from different rabbits, containing different concentrations of anti-Pfs25 antibody, to groups of mosquitoes. The scientists then recorded the percentage of mosquitoes in each group that became infected with *Plasmodium*.

The graph shows their results.



8 (c) Describe the results.

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(2 marks)

8 (d) The scientists hope to develop Pfs25 protein into a vaccine that can be given to humans. Explain how this vaccine could reduce the number of cases of malaria in humans.

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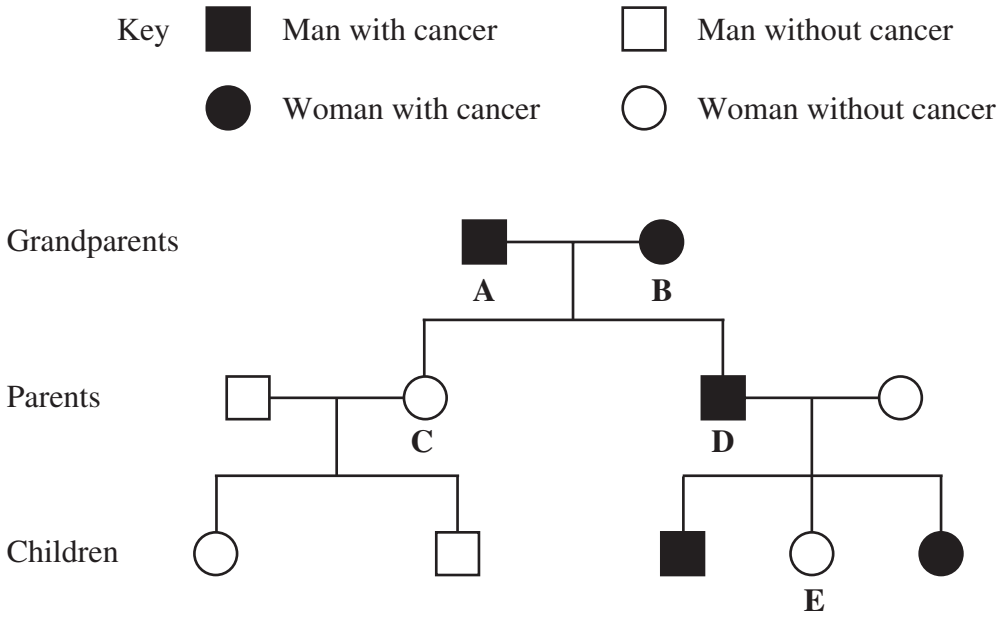
Turn over for the next question

9 Li-Fraumeni syndrome is a rare inherited condition. It makes someone much more likely to develop cancer at an early age. The diagram shows part of the family history of a family affected by Li-Fraumeni syndrome. Li-Fraumeni syndrome is caused by the dominant allele of a gene. The gene is not sex-linked.



The grandparents, **A** and **B**, had two children, girl **C** and boy **D**. Explain how the phenotypes of these children provide evidence that Li-Fraumeni syndrome is

9 (a) caused by a dominant allele

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(2 marks)

9 (b) **not** sex-linked.

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(2 marks)

9 (c) This family's history of cancer was investigated when person **E** asked for genetic counselling. At the time she was 25 years old. What advice could a genetic counsellor give her about her probability of developing cancer?

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(2 marks)

9 (d) Li-Fraumeni syndrome is caused by a mutation affecting a tumour suppressor gene called TP53. This gene codes for a protein that initiates the death of cells where damaged DNA cannot be repaired. The mutated TP53 gene leads to the production of a non-functional protein. Suggest how the non-functional protein may lead to cancer.

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Turn over for the next question

10 (a) A man's sperm count is the number of sperm cells per cm^3 of semen.

Explain how a man's sperm count affects his fertility.

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(2 marks)

Doctors investigated the accuracy of two methods, **A** and **B**, used to measure sperm counts. They obtained samples of semen from 500 men. They used both methods to obtain a sperm count for each sample.

- Method **A** required the semen to be diluted by a factor of 2 before counting.
- Method **B** required dilution by a factor of 20.

10 (b) Method **B** involved counting the number of sperm cells seen in small squares on a special glass microscope slide. Each square contained $0.25 \times 10^{-6}\,cm^3$ semen. For one diluted sample of semen, the mean number of sperm cells per square was 1.05.

Calculate the mean number of sperm cells per cm^3 of semen. Show your working.

answer ..... mean number of sperm cells per cm^3 of semen

(2 marks)

The doctors also used both methods to determine the concentration of very small plastic beads in a suspension. They knew that the suspension contained 35×10^6 beads cm^{-3}.

Table 1 shows all of the doctors' results.

Table 1

Objects counted	Mean number per cm^3 (± standard deviation)	
	Method A	**Method B**
Sperm cells	$54.3 (\pm 39.6) \times 10^6$	$79.3 (\pm 56.7) \times 10^6$
Plastic Beads	$36.0 (\pm 3.3) \times 10^6$	$45.4 (\pm 4.9) \times 10^6$

10 (c) Explain the evidence from the table that method **A** was more accurate than method **B**.

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10 (d) Using all of the information given, suggest **one** reason why method **B** might produce less accurate results.

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(2 marks)

Question 10 continues on the next page

10 (e) Before starting the investigation, the doctors left samples of semen for a day in the solutions and apparatus used in each method. They did a sperm count at the start and end of the day. Suggest why they did this.

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(2 marks)

In some countries, cattle are given oestrogen to increase growth. Scientists investigated the relationship between a mother eating beef from these cattle during pregnancy and her son's sperm count as an adult.
They used method **B** to measure the sperm counts of over 300 men. They estimated the beef intake of each man's mother while she was pregnant using a questionnaire. If a mother ate beef 7 or more times a week when pregnant, they called the amount high. If she ate beef fewer than 7 times a week, they called the amount low.
For mothers with high and low beef intakes, the doctors calculated the percentage of their sons who had a low sperm count.

Table 2 shows their results.

Table 2

	Amount of beef eaten by mother		**Probability value from statistical test comparing the values for high and low**
	High	**Low**	
Mean sperm count per cm^3	43.1×10^6	56.9×10^6	0.014
Percentage of sons with a low sperm count	17.7	5.7	0.002

10 (f) Are the results of the statistical tests significant? Explain your answer.

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(1 mark)

10 (g) Suggest how giving oestrogen to cattle could have resulted in changes to sperm counts in these men.

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10 (h) How could doctors decide what is a low sperm count?

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(2 marks)

Question 10 continues on the next page

10 (i) One scientist concluded that the results of this investigation were not reliable. Using only the information given, suggest **two** reasons why they may not be reliable.

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(4 marks)

10 (j) Using all of the information, should pregnant women in the UK be advised not to eat beef from countries that give this hormone to cattle? Give reasons for your answer.

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(4 marks)

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