Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2013

Biology BIOL2

Unit 2 The variety of living organisms

Monday 3 June 2013 9.00 am to 10.45 am

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

Time allowed
- 1 hour 45 minutes

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.
- You may ask for extra paper. Extra paper must be secured to this booklet.
- Do all rough work in this book. Cross through any work you do not want to be marked.

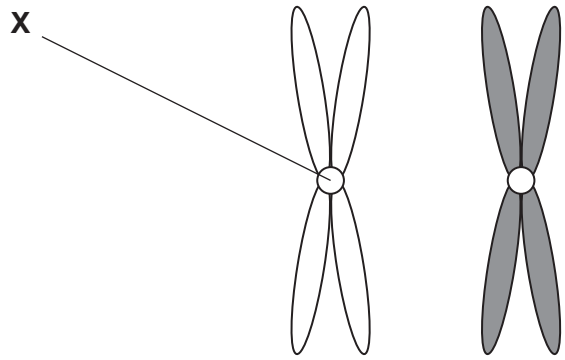
Information
- The maximum mark for this paper is 85.
- You are expected to use a calculator, where appropriate.
- The marks for questions are shown in brackets.
- Quality of Written Communication will be assessed in all answers.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use scientific terminology accurately.

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

1 (a) **Figure 1** shows one pair of homologous chromosomes.

Figure 1



1 (a) (i) Name **X**.

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(1 mark)

1 (a) (ii) Describe the role of **X** in mitosis.

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(2 marks)

1 (a) (iii) Homologous chromosomes carry the same genes but they are **not** genetically identical. Explain why.

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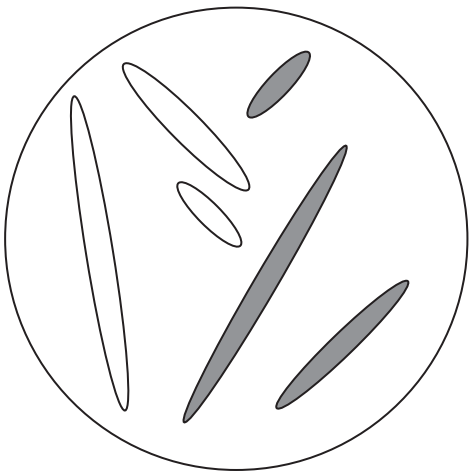
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(1 mark)

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1 (b) **Figure 2** shows three pairs of homologous chromosomes in a cell at the end of cell division.

Figure 2



1 (b) (i) The appearance of each chromosome in **Figure 2** is different from those shown in **Figure 1**. Explain why.

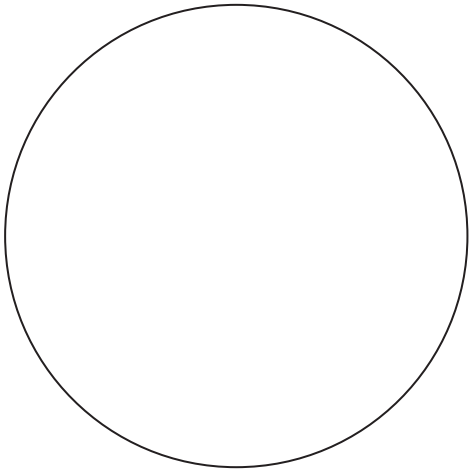
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(1 mark)

1 (b) (ii) Complete the diagram to show the chromosomes in one cell that could be produced from the cell in **Figure 2** as a result of meiosis.



(2 marks)

1 (b) (iii) Other than independent segregation, give **one** way in which meiosis allows the production of genetically different cells.

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(1 mark)

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Turn over ▶

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2 (a) What is a *species*?

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(2 marks)

2 (b) Scientists investigated the diversity of plants in a small area within a forest. The table shows their results.

Plant species	Number of individuals
Himalayan raspberry	20
Heartwing sorrel	15
Shala tree	9
Tussock grass	10
Red cedar	4
Asan tree	6
Spanish needle	8
Feverfew	8

The index of diversity can be calculated by the formula

$$d = \frac{N(N-1)}{\sum n(n-1)}$$

where

d = index of diversity
N = total number of organisms of all species
n = total number of organisms of each species

Do not write outside the box

2 (b) (i) Use the formula to calculate the index of diversity of plants in the forest. Show your working.

Answer .....
(2 marks)

2 (b) (ii) The forest was cleared to make more land available for agriculture.

After the forest was cleared the species diversity of insects in the area decreased. Explain why.

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(3 marks)

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3 Organisms can be classified using a hierarchy of phylogenetic groups.

3 (a) Explain what is meant by:

3 (a) (i) a hierarchy

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(2 marks)

3 (a) (ii) a phylogenetic group.

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(1 mark)

3 (b) Cytochrome c is a protein involved in respiration. Scientists determined the amino acid sequence of human cytochrome c. They then:

- determined the amino acid sequences in cytochrome c from five other animals
- compared these amino acid sequences with that of human cytochrome c
- recorded the number of differences in the amino acid sequence compared with human cytochrome c.

The table shows their results.

Animal	Number of differences in the amino acid sequence compared with human cytochrome c
A	1
B	12
C	12
D	15
E	21

Do not write outside the box

3 (b) (i) Explain how these results suggest that animal **A** is the most closely related to humans.

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(2 marks)

3 (b) (ii) A student who looked at these results concluded that animals **B** and **C** are more closely related to each other than to any of the other animals.

Suggest **one** reason why this might **not** be a valid conclusion.

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(1 mark)

3 (b) (iii) Cytochrome c is more useful than haemoglobin for studying how closely related different organisms are. Suggest **one** reason why.

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(1 mark)

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Turn over for the next question

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4 (a) DNA helicase is important in DNA replication. Explain why.

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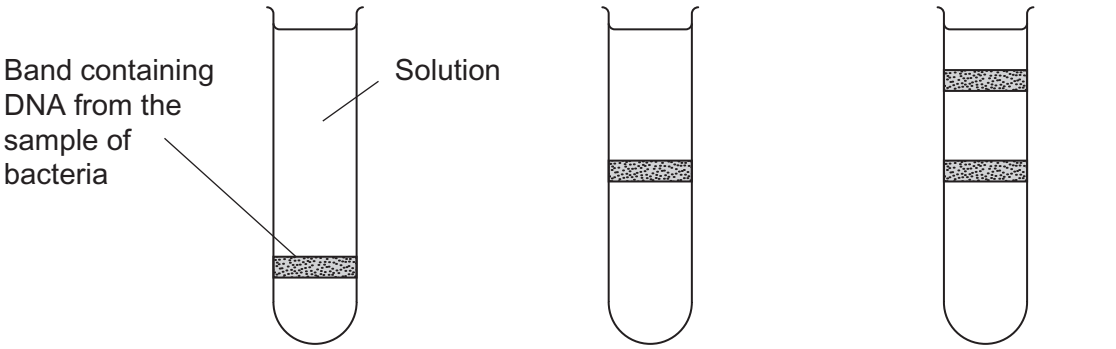
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(2 marks)

Scientists investigating DNA replication grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen (^{15}N). They obtained DNA from a sample of these bacteria.

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen (^{14}N). The bacteria were allowed to grow and divide twice. After each division, DNA was obtained from a sample of bacteria.

The DNA from each sample of bacteria was suspended in a solution in separate tubes. These were spun in a centrifuge at the same speed and for the same time. The diagram shows the scientists' results.



Sample **1**	Sample **2**	Sample **3**
Bacteria grown for several generations in a nutrient solution containing ^{15}N	Bacteria grown in a nutrient solution containing ^{14}N for one cell division	Bacteria grown in a nutrient solution containing ^{14}N for two cell divisions

Do not write outside the box

4 (b) The table shows the types of DNA molecule that could be present in samples **1** to **3**. Use your knowledge of semi-conservative replication to complete the table with a tick if the DNA molecule is present in the sample.

	Type(s) of DNA molecule present in each sample		
Sample	^{15}N ^{15}N 	^{15}N ^{14}N 	^{14}N ^{14}N 
1			
2			
3			

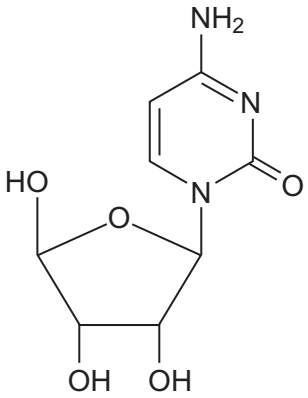
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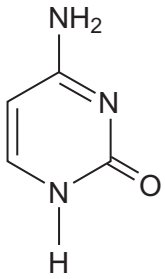
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4 (c) Cytarabine is a drug used to treat certain cancers. It prevents DNA replication. The diagram shows the structures of cytarabine and the DNA base cytosine.

cytarabine



cytosine



4 (c) (i) Use information in the diagram to suggest how cytarabine prevents DNA replication.

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(2 marks)

4 (c) (ii) Cytarabine has a greater effect on cancer cells than on healthy cells. Explain why.

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(1 mark)

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Do not write outside the box

5 (a) (i) Give **one** way in which antibiotics can prevent the growth of bacteria.

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(1 mark)

5 (a) (ii) Describe how bacteria can become resistant to antibiotics by *vertical* gene transmission.

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(1 mark)

Question 5 continues on the next page

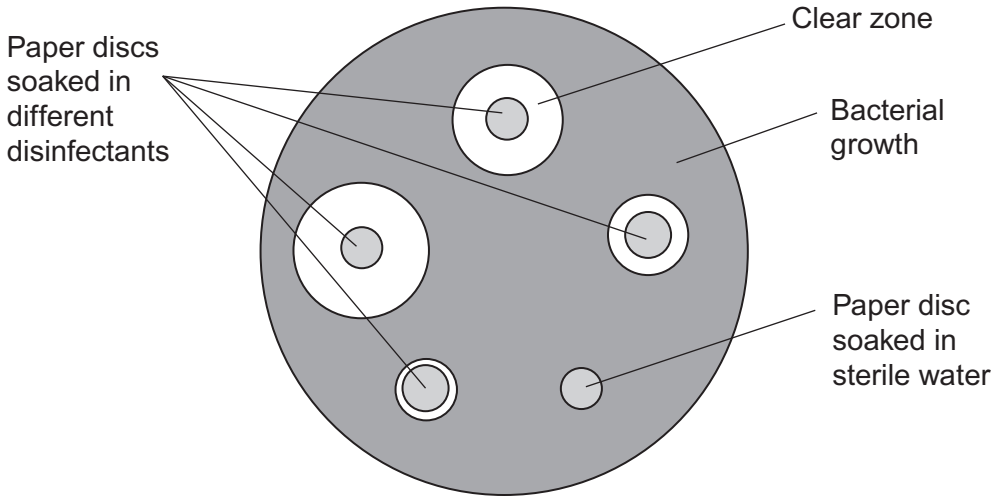
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Pseudomonas aeruginosa is a bacterium that can cause infections in hospital patients suffering from burns. Disinfectants are substances used to kill bacteria on non-living objects, such as medical equipment. Doctors in one hospital investigated how effective four disinfectants were at killing *P. aeruginosa*.

The doctors:

- took samples from many patients in the hospital
- isolated *P. aeruginosa* from those samples
- suspended the *P. aeruginosa* in a solution
- spread many samples of this solution on nutrient jelly in many Petri dishes.

The doctors then placed five small paper discs on the jelly in each dish. Each disc had been soaked in a different disinfectant or sterile water. The doctors left the plates for 24 hours to allow bacteria to grow and divide. The diagram shows a typical Petri dish after 24 hours.



5 (b) The doctors used samples of this bacterium taken from many patients in the hospital. Explain why this was important.

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(1 mark)

Do not write outside the box

After 24 hours, the doctors measured the diameter of any clear zones around each paper disc. They then calculated the mean diameter of the clear zone for each disinfectant. The table shows their results.

Disinfectant	Mean diameter of clear zone / mm (± standard deviation)
Chlorhexidine	22.8 ± 3.9
Cetrimide-C	9.1 ± 2.6
Hypochlorite	26.9 ± 5.2
Micro 10	6.6 ± 1.5

5 (c) Do these data support the conclusion that hypochlorite was the most effective at killing this bacterium? Explain your answer.

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(3 marks)

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5 (d) Doctors in a different hospital repeated this investigation. They found that hypochlorite had little effect on samples of *P. aeruginosa* they obtained. Suggest how this different result may have arisen.

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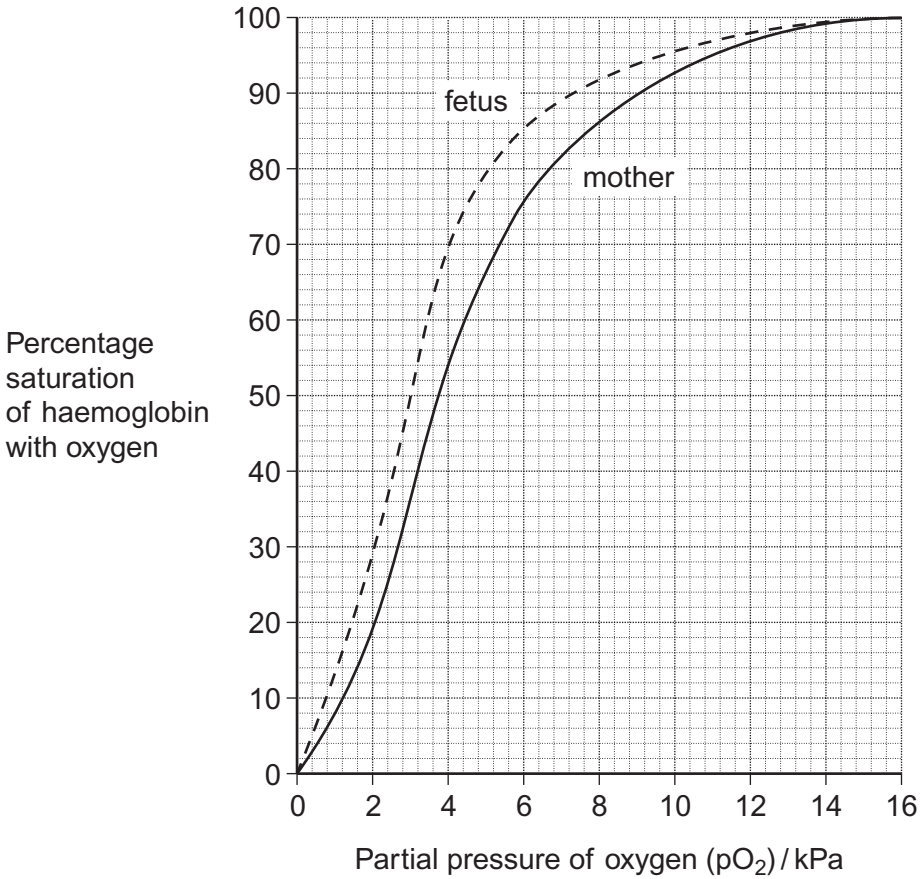
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6 (a) The table shows three statements about some biological molecules. Complete the table with a tick in each box if the statement is true for haemoglobin, cellulose or starch.

Statement	Haemoglobin	Cellulose	Starch
Has a quaternary structure			
Formed by condensation reactions			
Contains nitrogen			

(3 marks)

The graph shows oxygen dissociation curves for the haemoglobin of a mother and her fetus.



Do not write outside the box

6 (b) What is the difference in percentage saturation between the haemoglobin of the mother and her fetus at a partial pressure of oxygen (pO_2) of 4 kPa?

(1 mark)

6 (c) The oxygen dissociation curve of the fetus is to the left of that for its mother. Explain the advantage of this for the fetus.

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(2 marks)

6 (d) After birth, fetal haemoglobin is replaced with adult haemoglobin. Use the graph to suggest the advantage of this to the baby.

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(2 marks)

6 (e) Hereditary persistence of fetal haemoglobin (HPFH) is a condition in which production of fetal haemoglobin continues into adulthood. Adult haemoglobin is also produced.

People with HPFH do not usually show symptoms. Suggest why.

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(1 mark)

9

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7 The Amish are a group of people who live in America. This group was founded by 30 Swiss people, who moved to America many years ago. The Amish do not usually marry people from outside their own group.

One of the 30 Swiss founders had a genetic disorder called Ellis-van Creveld syndrome. People with this disorder have heart defects, are short and have extra fingers and toes. Ellis-van Creveld syndrome is caused by a faulty allele.

In America today, about 1 in 200 Amish people are born with Ellis-van Creveld syndrome. This disorder is very rare in people in America who are not Amish.

7 (a) Use the information provided and your knowledge of the founder effect to explain why Ellis-van Creveld syndrome occurs at a higher frequency in the Amish population than in people in America who are not Amish.

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(3 marks)

(Extra space) .....

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7 (b) In America today, there are approximately 1250 Amish people who have Ellis-van Creveld syndrome. Use the information provided to calculate the current Amish population of America.

Amish population .....

(1 mark)

7 (c) The faulty allele that causes Ellis-van Creveld syndrome is the result of a mutation of a gene called *EVC*. This mutation leads to the production of a protein that has one amino acid missing.

7 (c) (i) Suggest how a mutation can lead to the production of a protein that has one amino acid missing.

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(2 marks)

7 (c) (ii) Suggest how the production of a protein with one amino acid missing may lead to a genetic disorder such as Ellis-van Creveld syndrome.

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(2 marks)

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8 (a) Explain how water enters xylem from the endodermis in the root and is then transported to the leaves.

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Large insects contract muscles associated with the abdomen to force air in and out of the spiracles. This is known as 'abdominal pumping'. The table shows the mean rate of abdominal pumping of an insect before and during flight.

Stage of flight	Mean rate of abdominal pumping / dm^3 of air kg^{-1} $hour^{-1}$
Before	42
During	186

8 (b) Calculate the percentage increase in the rate of abdominal pumping before and during flight. Show your working.

Answer ..... %

(2 marks)

8 (c) Abdominal pumping increases the efficiency of gas exchange between the tracheoles and muscle tissue of the insect. Explain why.

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(2 marks)

8 (d) Abdominal pumping is an adaptation not found in many small insects. These small insects obtain sufficient oxygen by diffusion.

Explain how their small size enables gas exchange to be efficient without the need for abdominal pumping.

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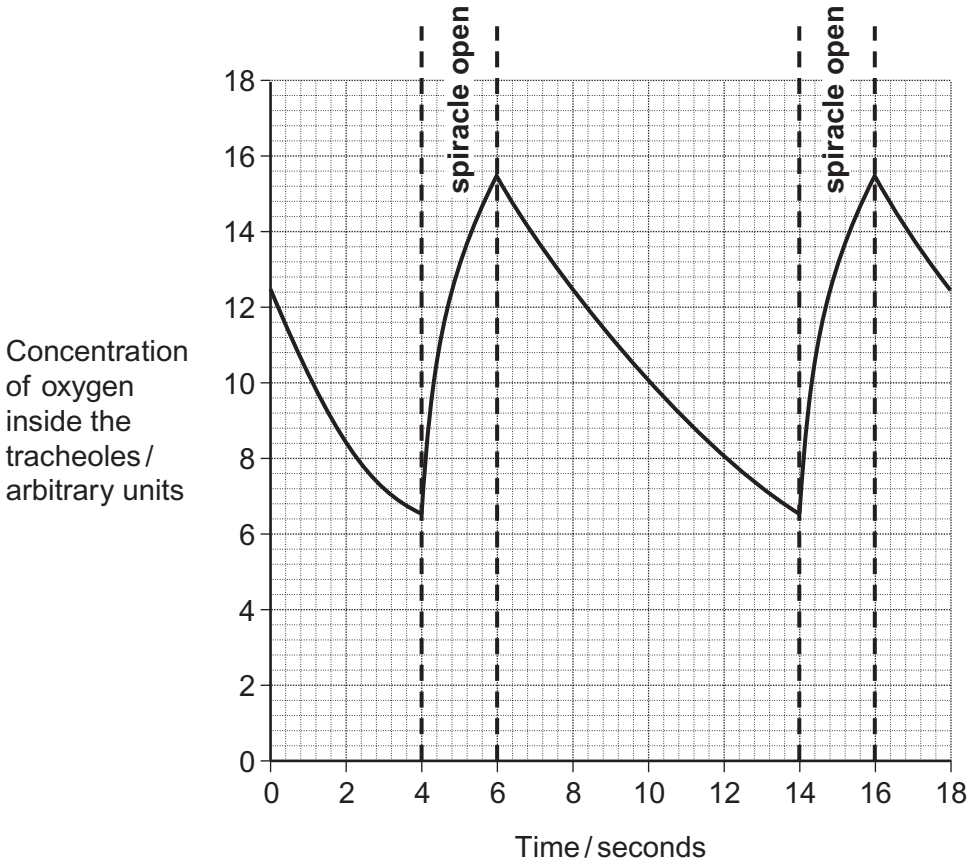
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(1 mark)

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The graph shows the concentration of oxygen inside the tracheoles of an insect when at rest. It also shows when the spiracles are fully open.



8 (e) Use the graph to calculate the frequency of spiracle opening. Show your working.

Frequency ..... times per minute
(2 marks)

8 (f) The insect opens its spiracles at a lower frequency in very dry conditions.
Suggest **one** advantage of this.

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(1 mark)

Do not write outside the box

8 (g) The ends of tracheoles connect directly with the insect's muscle tissue and are filled with water. When flying, water is absorbed into the muscle tissue. Removal of water from the tracheoles increases the rate of diffusion of oxygen between the tracheoles and muscle tissue. Suggest **one** reason why.

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(1 mark)

15

Turn over for the next question

Do not write outside the box

9 Snakes are predators that lay eggs. Scientists investigated courtship behaviour in male garter snakes in response to:

- the body length of the female
- lipids secreted on the skin of the female.

For each trial, the scientists selected 10 male snakes at random. They placed the snakes into a large cage. The scientists then placed one of the following into the cage with the male snakes:

1. a short female snake
2. a long female snake
3. a piece of filter paper containing lipids from the skins of short females
4. a piece of filter paper containing lipids from the skins of long females.

After 5 minutes, the scientists recorded how many males were showing courtship behaviour. Each trial was repeated several times using different male and female snakes.

9 (a) Apart from the size of the female, suggest **two** factors that should have been kept constant in order to obtain reliable results.

1 .....

2 .....

(2 marks)

9 (b) The male snakes used for each trial were selected at random. Explain why this was important.

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(1 mark)

9 (c) The scientists used different male snakes in each trial. Suggest why.

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(1 mark)

9 (d) What should the scientists have placed in the cage as a control, to show that males were responding to lipids from females?

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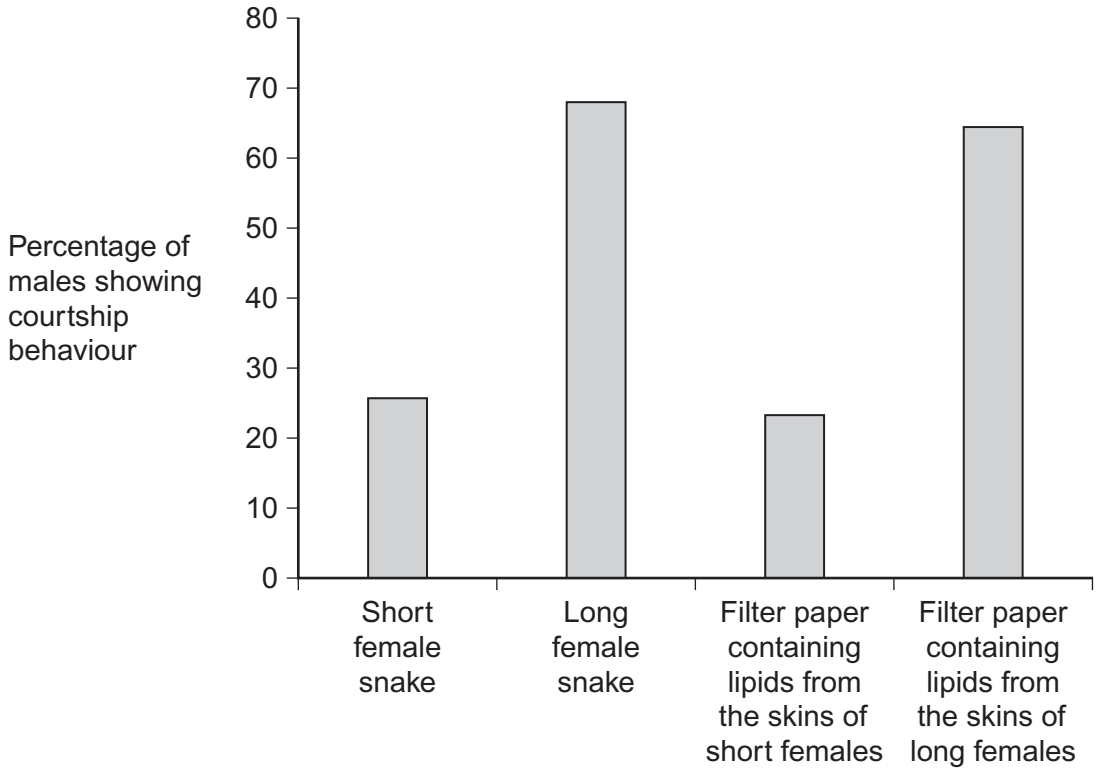
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(1 mark)

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Figure 3 shows the scientists' results.

Figure 3



9 (e) The scientists concluded that male snakes showed more courtship behaviour towards long female snakes and to lipids from the skins of long females.

Explain **one** other conclusion that can be made from the data.

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(2 marks)

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9 (f) Suggest **two** advantages of male snakes courting with longer females.

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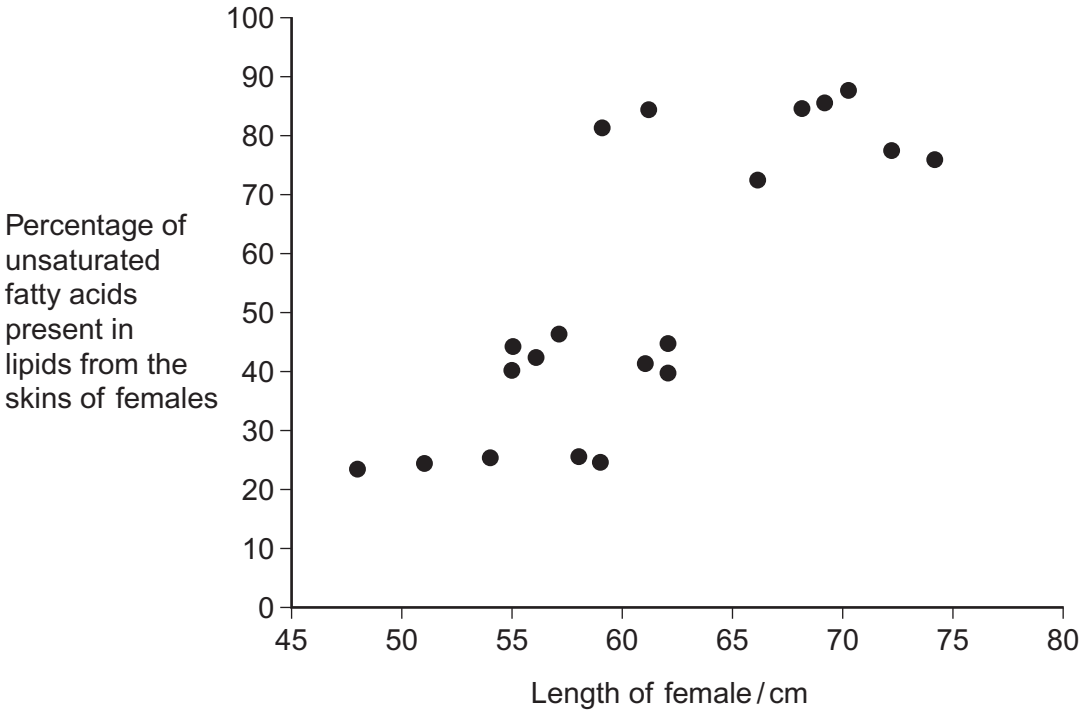
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(2 marks)

The scientists analysed the lipids produced on the skins of females of different lengths. They found the percentage of unsaturated fatty acids present in the lipids. Their results are shown in **Figure 4**.

Figure 4



9 (g) Use **Figure 3** and **Figure 4** to suggest why male garter snakes show greater courtship behaviour to longer female snakes.

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(2 marks)

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9 (h) Describe how **Figure 4** could be used to predict the percentage of unsaturated fatty acids produced by female garter snakes of body length greater than 75 cm.

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(2 marks)

9 (i) Using **Figure 4** to predict the percentage of unsaturated fatty acids produced by female garter snakes of body length greater than 75 cm might not give a true value. Suggest why.

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(1 mark)

9 (j) The females of other species of snake secrete lipids on their skin. These lipids also contain unsaturated fatty acids. Male garter snakes do not show courtship behaviour towards these females. Suggest why.

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(1 mark)

15

END OF QUESTIONS

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