



National  
Qualifications

**X807/77/02**

**Biology**  
**Section 1 — Questions**

Duration — 3 hours

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Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X807/77/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



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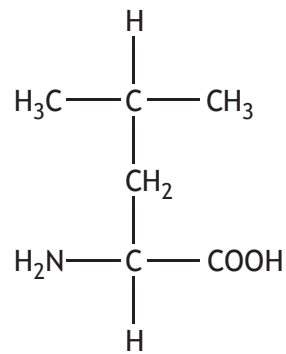
SECTION 1 — 20 marks

Attempt ALL questions

1. Which row in the table describes features of a positive modulator binding to an enzyme?

	Binding	Affinity for substrate
A	allosteric site	increases
B	active site	increases
C	allosteric site	decreases
D	active site	decreases

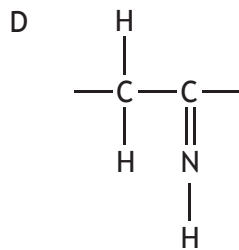
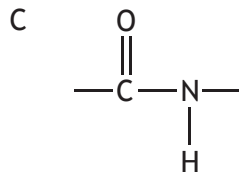
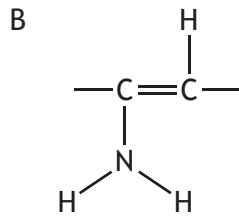
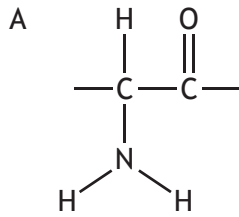
2. The diagram shows the structure of the amino acid leucine.



To which class of amino acids does leucine belong?

- A Polar
- B Hydrophobic
- C Acidic
- D Basic

3. Which of the following diagrams illustrates a peptide bond?

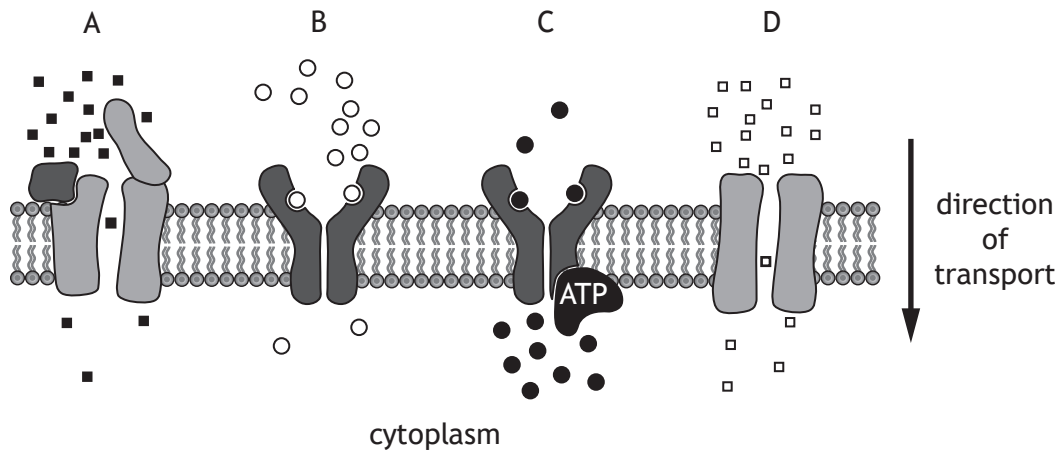


4. Which of the following is an advantage of an *in vitro* experiment?

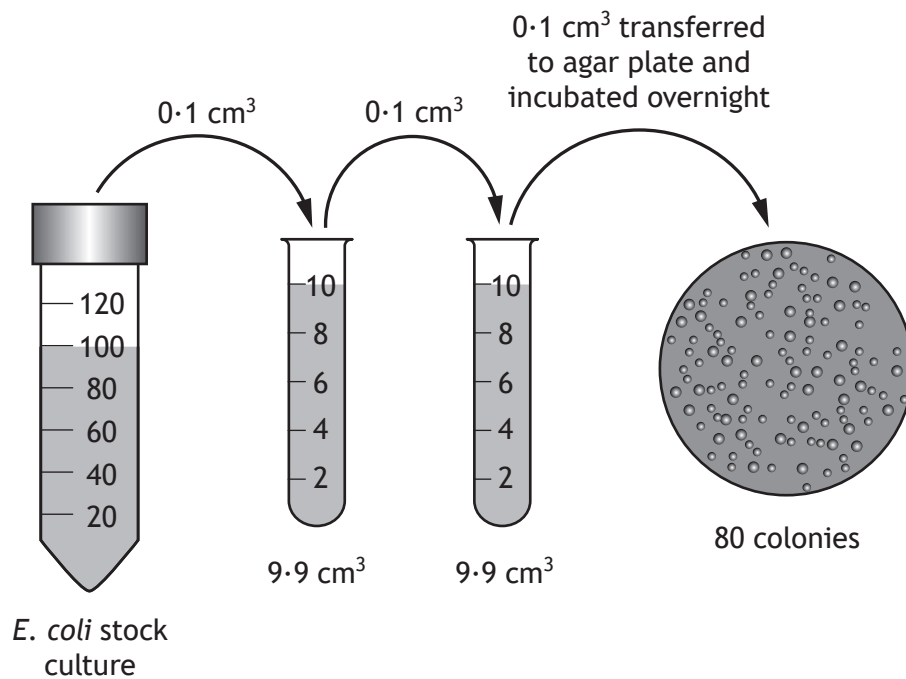
- A The environment is closely controlled
- B The effect on whole organisms can be monitored
- C The organism is in its natural surroundings
- D The environment is affected by confounding variables

[Turn over

5. The diagram shows the transport of four substances into a cell.  
Which substance is transported by facilitated diffusion via a transporter protein?



6. The figure shows how a biologist used serial dilution followed by plating to estimate the number of cells in a 100 cm<sup>3</sup> stock culture of *E. coli*.



How many *E. coli* cells were present in the original stock culture?

- A  $8.0 \times 10^4$
- B  $8.0 \times 10^6$
- C  $8.0 \times 10^7$
- D  $8.0 \times 10^8$

7. The statements describe the sequence of events that follows the absorption of a photon of light by rhodopsin in the rod cell of a mammal.

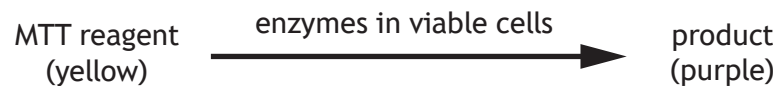
1. Cyclic GMP is hydrolysed
2. Ion channels in the membrane of the rod cell close
3. The G-protein transducin is activated
4. The enzyme phosphodiesterase is activated

The order in which these events occur is

- A 1, 3, 4, 2
- B 3, 4, 1, 2
- C 4, 3, 2, 1
- D 3, 1, 2, 4.

8. The toxicity of potential new drugs can be assessed by measuring the viability of mammalian cells cultured in the presence of the drug.

Cell viability can be measured using an MTT assay, which involves a colour change as shown.



The intensity of colour of the purple product can be measured using a colorimeter and used to calculate the percentage of viable cells.

An MTT assay was used in an experiment to test cell viability in the presence of a drug.

Four culture dishes, each containing mammalian cells in growth media, were set up.

MTT and the drug were added to the dishes as indicated in the table.

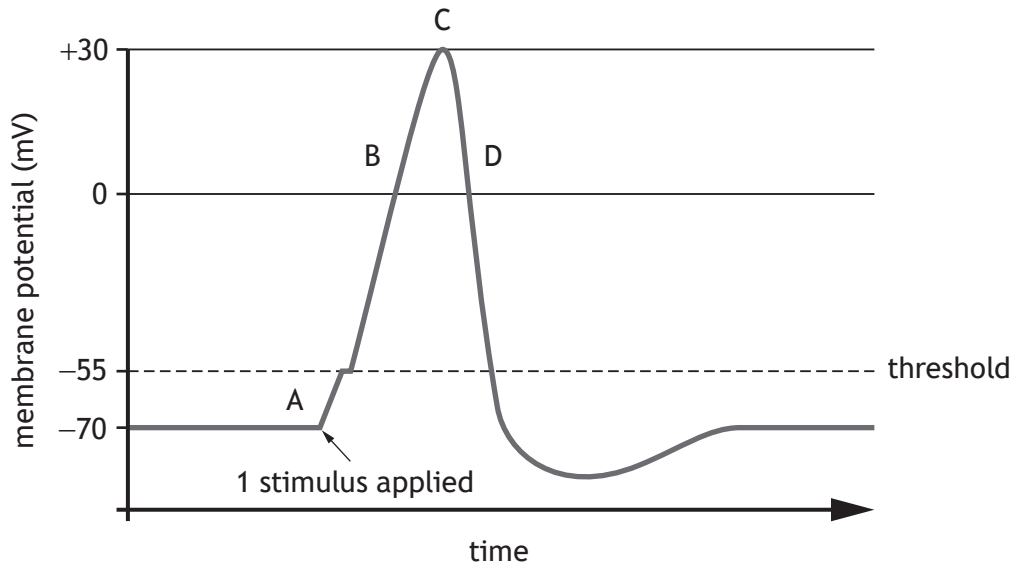
Which dish would act as a positive control for the MTT assay?

Dish	Drug present	MTT present
A	✓	X
B	X	✓
C	✓	✓
D	X	X

[Turn over

9. The diagram shows the changes in membrane potential during the transmission of a nerve impulse.

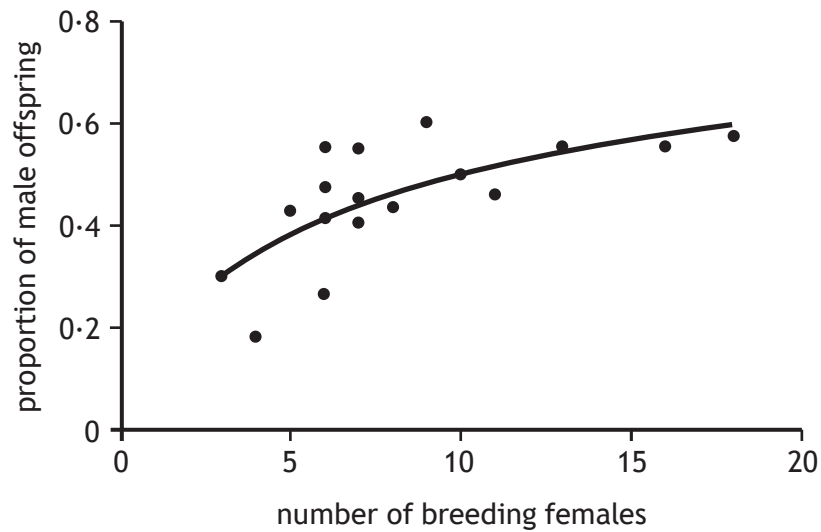
Which letter represents the time when the voltage-gated potassium ion channels are open?



10. Which row in the table identifies the mechanism of apoptosis induced as a result of p53 activation?

	Origin of cell death signal		Trigger for cell death	
	External	Internal	Natural killer cell attachment	DNA damage
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

11. The scatterplot shows how the proportion of male offspring produced each year may depend on the number of breeding females present in a population of small mammals in a given area.



Which of the following predictions is consistent with the data shown?

- A The sex ratio in litters will not be affected by the density of breeding females
  - B When breeding female density is low, producing male offspring will increase fitness
  - C When breeding female density is high, the proportion of male offspring will be reduced
  - D Only at intermediate density of breeding females will the sex ratio be in line with the expected ratio if female breeding density had no effect
12. The allele (T) for the ability to taste the bitter chemical phenylthiocarbamide (PTC), is dominant over the allele (t) for the inability to taste the chemical.
- 400 biology students were tested and 64 were found to be non-tasters.
- The percentage of heterozygous students is
- A 16%
  - B 27%
  - C 32%
  - D 48%

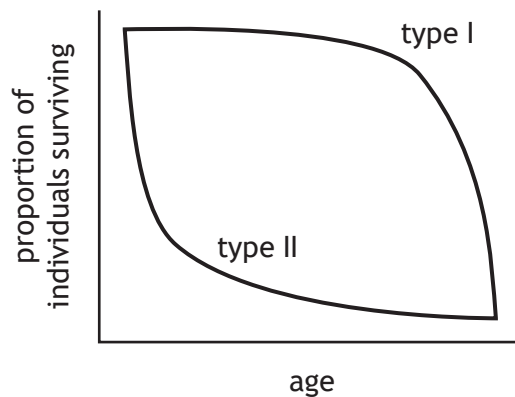
[Turn over

13. The problem solving capability of squirrels was investigated. The time taken to solve a food extraction problem was measured for a sample of grey squirrels and a sample of red squirrels. Mean values were calculated and compared for the two species.
- Which row in the table represents the variables involved in this investigation?

	Independent variable	Dependent variable
A	continuous	continuous
B	continuous	discrete
C	discrete	continuous
D	discrete	discrete

14. In animal behaviour studies, which of the following units could be used in measurements of latency?
- A Metres
  - B Metres per second
  - C Seconds
  - D Seconds per metre

15. The survivorship curves show the probability of individuals in two types of species living to different ages.



Which row in the table shows the likely survivorship and environment of a K-selected species?

	Survivorship	Environment
A	type I	stable
B	type I	unstable
C	type II	stable
D	type II	unstable



16. The red-necked phalarope, *Phalaropus lobatus*, is a rare wading bird that breeds in parts of the British Isles during summer.

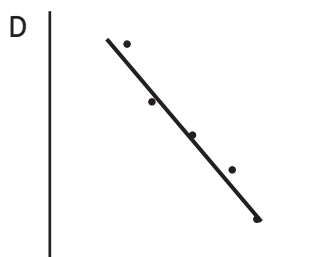
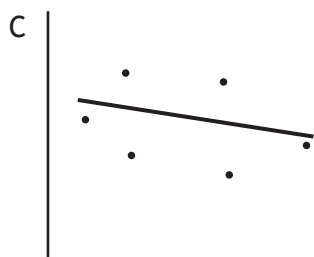
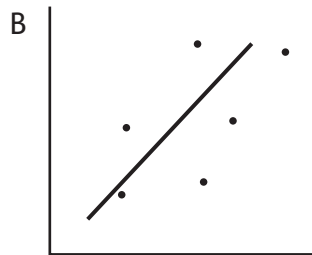
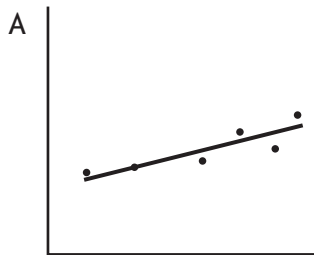
The females are larger than males and are more brightly coloured. When breeding, the females compete for males and take the lead in courtship. When egg-laying is complete, the female may search for another male. Male birds incubate the eggs and carry out all other parental tasks but each male breeds with only one female in a breeding season.

Which of the following are features of the red-necked phalarope's reproductive behaviour?

- A Polygamy and polygyny
  - B Polygamy and polyandry
  - C Monogamy and polygyny
  - D Monogamy and polyandry
17. Aggressive ants that live in the hollow thorns of tropical *Acacia* trees feed on the nectar and lipid-rich bodies that the tree produces.

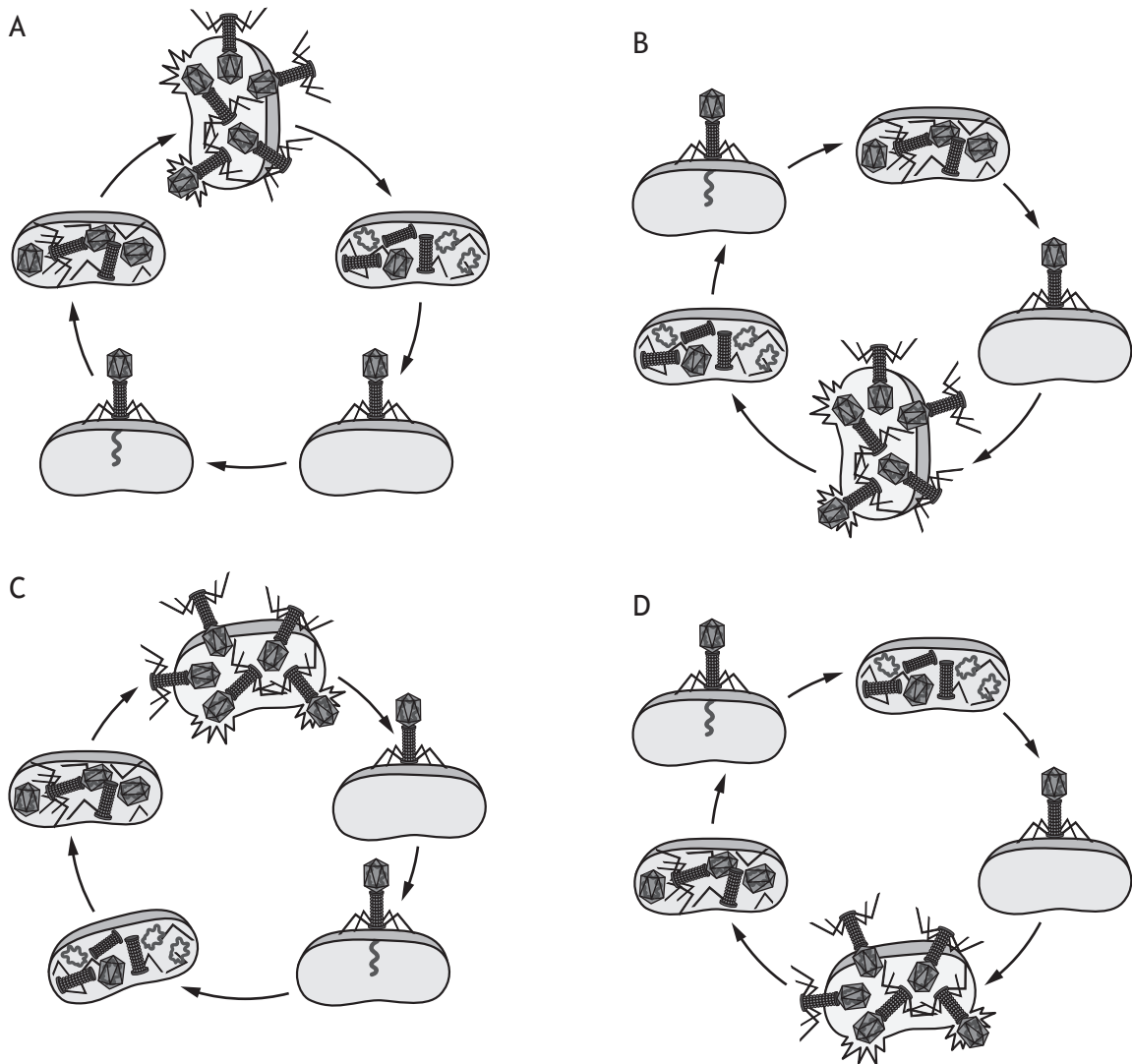
Which of the following experiments best tests the hypothesis that these ants defend the plant by killing or chasing away leaf-feeding insects?

- A Remove leaf-feeding insects and measure subsequent ant density
  - B Remove lipid-rich bodies and measure subsequent ant density
  - C Remove leaf-feeding insects and measure subsequent plant growth
  - D Remove ants and measure subsequent leaf damage
18. Which graph shows a strong, positive correlation?



[Turn over for next question

19. Which sequence represents the order of stages in the life cycle of a virus?



20. Herd immunity threshold is the

- A density of infected hosts required for the occurrence of an epidemic
- B density of resistant hosts in the population required to prevent an epidemic
- C density of resistant parasites in the host population required to cause an epidemic
- D density of parasites within individual hosts of the population required for an epidemic.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET]

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National Qualifications

Mark

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**X807/77/01**

**Biology**  
**Section 1 — Answer grid**  
**and Section 2**

Duration — 3 hours



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Fill in these boxes and read what is printed below.

Full name of centre

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Town

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Forename(s)

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Date of birth

Day

Month

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Total marks — 100

**SECTION 1 — 20 marks**

Attempt ALL questions.

Instructions for the completion of Section 1 are given on *page 02*.

**SECTION 2 — 80 marks**

Attempt ALL questions.

**A supplementary sheet for question 1 is enclosed inside the front cover of this question paper.**

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.



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SECTION 2 — 80 marks  
 Attempt ALL questions  
 Question 12 contains a choice

1. Read through the supplementary sheet for question 1 before attempting this question.

(a) Refer to Figure 1.

Describe **two** differences between the patterns of pulses in the ‘long chirp’ and ‘short chirp’ sections of the song.

2

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(b) Refer to Figure 2.

Explain why, for male crickets, 60% would be the optimum percentage of long chirp to produce from those tested.

2

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(c) Males are likely to produce less cricket song when their immune systems are challenged by parasite infection.

(i) Explain why parasitised males produce less song.

1

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(ii) Suggest how females may benefit from this behaviour.

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## 1. (continued)

- (d) The crickets and the female parasitoid flies show convergent evolution of hearing apparatus.

Explain what is meant by convergent evolution.

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- (e) Refer to Figure 3.

- (i) Give one general conclusion about the responses shown by flatwing males compared to normal males.

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- (ii) Considering these results and the researchers' hypothesis, explain the rapid evolution of the cricket population on Kauai.

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[Turn over



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2. In lions the colour of the mane is an important indicator of reproductive success. Only male lions have manes, and the growth and depth of colour of their mane is influenced by testosterone levels.



- (a) During testosterone signalling, testosterone enters the cell and binds to its receptor in the cytosol to form a hormone-receptor complex.

- (i) What property of the testosterone molecule allows it to pass directly through the membrane?

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- (ii) Describe how this hormone-receptor complex produces a cellular response.

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- (iii) Testosterone influences both mane colour and length. These traits are controlled by different genes.

Explain how a single signalling molecule such as testosterone is able to influence the expression of multiple genes.

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## 2. (continued)

- (b) Hormones such as insulin do not enter the cell and yet influence multiple cellular pathways in a cell.

Describe how insulin is able to activate intracellular signalling pathways.

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\* X 8 0 7 7 7 0 1 0 9 \*

3. The study of specific proteins often requires purification of the protein from the entire mixture of proteins present in tissue or cells. The table gives data from steps in the purification of an enzyme.

Step	Total protein (milligrams)	Total enzyme activity (units)	Specific activity of enzyme (units per milligram)	Yield of enzyme (%)
Tissue extract	15 000	150 000	10	100
Purification stage 1	4500	121 500		81
Purification stage 2	150	75 000	500	50
Purification stage 3	7	63 000	9000	

(a) Complete the table by inserting the following values.

- (i) The specific activity of the enzyme after purification stage 1.

1

*Space for calculation*

- (ii) The yield of enzyme after purification stage 3.

1

*Space for calculation*





## 3. (continued)

(b) SDS polyacrylamide gel electrophoresis (SDS-PAGE) was used to estimate the number of proteins present after each step.

(i) Describe how SDS-PAGE is used to separate proteins.

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(ii) SDS-PAGE following purification stage 3 showed the presence of three different proteins.

These were transferred onto a solid medium, and an antibody linked to a reporter enzyme was used to identify the enzyme being purified.

Name the technique described.

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4. Glucose transport into cells is an essential process within all multicellular organisms. This happens via transport proteins embedded in the plasma membrane and is either a passive or an active process.

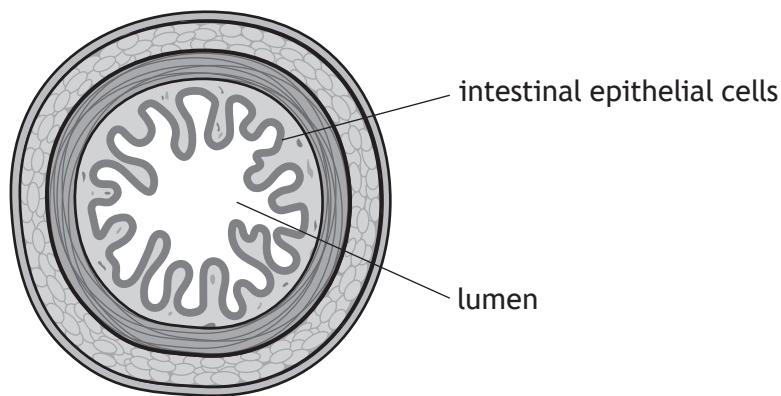
(a) Where there is a higher glucose concentration outside the cell, glucose molecules enter via passive transport. This is the case for fat and muscle cells.

Name the glucose transporter that enables glucose transport in these cells.

1

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(b) The diagram shows a cross-section of the small intestine in a mammal.



(i) In the small intestine the concentration of glucose in the lumen may be lower than the concentration of glucose within the cells lining it. Glucose is therefore transported into the intestinal epithelial cells against its concentration gradient.

Describe the mechanism of glucose symport.

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## 4. (b) (continued)

- (ii) Greenfly are insects that feed on the sugar-rich sap of plants. It has been found that the cells lining the gut of greenfly do not carry out glucose symport. These invertebrates can still successfully transport sugar into the cells lining their gut.

Suggest an explanation for this observation.

2

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[Turn over



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MARKS

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5. Describe the pathway by which proteins translated on the rough endoplasmic reticulum (RER) are modified and then secreted from the cell.

5

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6. In an investigation, samples of normal and tumour cells were examined and their cell cycle phase determined under the microscope.

The results are shown in the table.

Phase	Number of cells in phase	
	Normal cells	Tumour cells
Interphase	920	48
Prophase	79	16
Metaphase	86	30
Anaphase	10	15
Telophase	55	11

- (a) (i) The mitotic index (MI) is the percentage of cells in a sample that are undergoing mitosis.

Calculate the MI for the **tumour** cells.

1

*Space for calculation*

\_\_\_\_\_ %

- (ii) Give a feature of metaphase cells that would allow them to be identified under the microscope.

1

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- (iii) There could be concern over the reliability of the data due to the small sample size, which might result in a non-representative sample.

Give one feature of a representative sample.

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6. (continued)

(b) Further investigation of the tumour cells revealed that they had a mutated version of the gene coding for the retinoblastoma protein, resulting in failure of the G1 checkpoint.

(i) Describe the role of cyclins in cell cycle progression.

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(ii) Explain how the mutation in these tumour cells leads to loss of cell cycle control.

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(iii) Underline one of the alternatives in each pair of brackets to make the following sentences correct.

1

Failure of the G1 checkpoint in these cells will result in them

taking  $\left\{ \begin{array}{l} \text{more} \\ \text{less} \end{array} \right\}$  time to progress through the cell cycle due to

spending  $\left\{ \begin{array}{l} \text{more} \\ \text{less} \end{array} \right\}$  time in cell cycle arrest.

[Turn over



\* X 8 0 7 7 7 0 1 1 7 \*

7. Peregrine falcons, *Falco peregrinus*, are birds of prey. As a result of persecution by humans and the effects of pesticides in the food chain, their numbers decreased to a low-point in the 1960s. Conservation measures have helped the recovery of this species, and their numbers are monitored by surveys.

The table gives data comparing results from a 2014 survey with data collected in 2002.

Area	Number of breeding pairs of peregrine falcons	
	2002	2014
Wales	283	249
Scotland	571	509
England	470	628
Isle of Man	31	23
Northern Ireland	82	96
Total	1437	1505

In 2014 two survey techniques were used to collect information about peregrine falcon numbers: 'random-square' surveys and 'site-based' surveys. For the random-square survey, volunteers randomly selected 5 km × 5 km squares within the peregrine falcons' range. Each square was searched for suitable habitats and the presence of peregrine falcons. More than 2000 squares, representing more than 20% of the land area, were surveyed in this way. The site-based survey involved visiting and counting peregrine falcons at all known nesting sites.

- (a) Suggest why the use of the random-square survey technique would improve the accuracy of the data collected compared to site-based surveying alone.

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- (b) The data show that, overall, peregrine falcon numbers in the UK have increased between 2002 and 2014.

Give one other **general** conclusion that can be drawn from the data.

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**7. (continued)**

(c) Birds of prey remain under threat from illegal human activities, such as interference with their nesting sites.

(i) It has been suggested that the persecution of peregrine falcons may be greater in some areas.

How could the data be used to support this suggestion?

**1**

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(ii) Suggest one way in which individual birds could be monitored.

**1**

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(d) The RSPB organise an annual Big Garden Birdwatch, which is carried out by approximately 500 000 people over three days. Participants are asked to observe their gardens for 1 hour from a fixed location. The numbers and species of birds observed are recorded and submitted to the RSPB for analysis.

(i) State the term used to describe sampling that records all individuals from a fixed location.

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(ii) Suggest one way in which validity may be compromised in this procedure.

**1**

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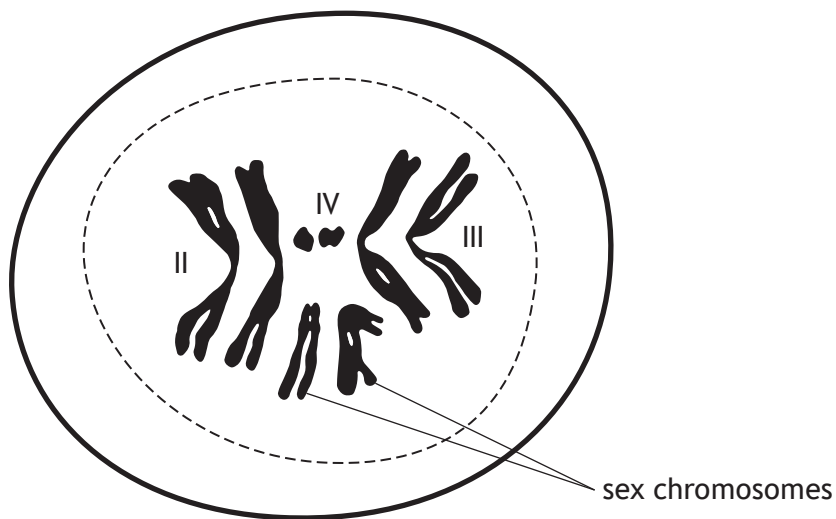
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[Turn over





8. The diagram shows an early stage of meiosis in a cell from a male fruit fly.



(a) Chromosome pairs II, III and IV are homologous and have the same size and shape.

State one other feature shared by homologous chromosomes.

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(b) What is the haploid chromosome number for this species?

1

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(c) Prior to meiosis I the chromosomes replicate to form two chromatids. The following statements describe some of the stages in meiosis I.

- A. Cytokinesis occurs
- B. Pairing of homologous chromosomes
- C. Chromosomes attach to spindle
- D. Chromosomes of each homologous pair separate
- E. Chromosomes condense
- F. Chiasmata formation takes place

Place these stages in the correct sequence in the boxes below.

1



MARKS

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8. (continued)

(d) Describe chiasmata and explain their significance in meiosis.

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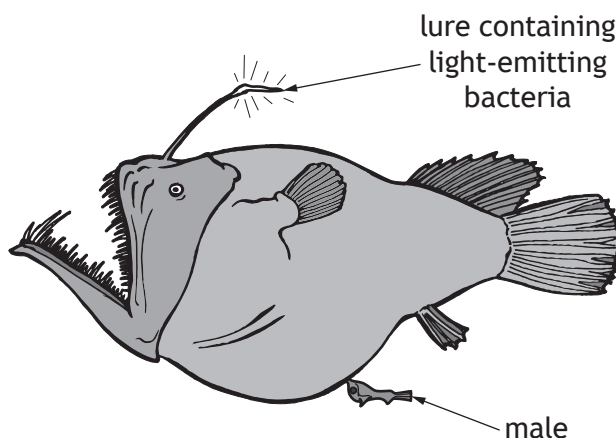
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9. The triplewart seadevil, *Cryptopsaras couesii*, is a deep sea anglerfish. Males are much smaller than females and have a digestive system that has stunted growth. The males lack jaws strong enough to catch prey.

When first captured by scientists, the female fish appeared to have parasites attached to them, which turned out to be very small male fish. Finding a mate is problematic as encounters are rare. When a male does find a female, he bites into her skin and releases an enzyme that digests the skin of his mouth and her body, fusing the pair down to blood vessel level. This attached male is then available to fertilise eggs when the female releases them.



- (a) In many species males are larger and more conspicuous than females.

State the term that describes the size difference in this anglerfish species where the females are larger than the males.

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- (b) (i) Suggest why the male fish in this example might have been considered parasitic.

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- (ii) Give one reason why this relationship is **not** parasitic.

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9. (continued)

(c) Deep sea anglerfish live in total darkness, over 1000 m below sea level. They possess a glowing lure that attracts prey as well as mates. The light from inside the lure is made by light-emitting bacteria that live in extracellular skin grooves of the fish lure. The light-emitting lure bacteria have lost most of the genes associated with making amino acids and breaking down nutrients.

(i) Explain why the relationship between the lure bacteria and the deep sea anglerfish may be described as mutualistic.

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(ii) The light-emitting bacteria have retained genes to make a flagellum for moving in water.

Suggest the benefit to the bacteria of retaining these genes.

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(iii) Changes in the traits of the anglerfish act as selection pressures on the light-emitting bacteria and vice versa.

Name this process.

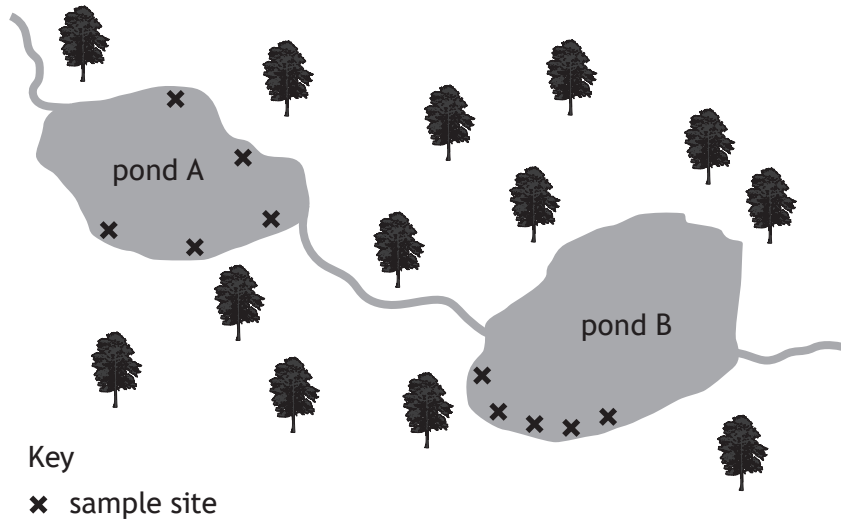
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10. A student investigated the effects of pond water pH on the growth of algal populations. They took five separate 250 cm<sup>3</sup> samples of pond water, from each of two different ponds near to each other in a forest. Water temperature and pH were measured at each sample site. Sample sites were decided by where the student could access the ponds safely.



In the laboratory, the student used a colorimeter to measure the percentage transmission of light through small volumes of the pond water samples.

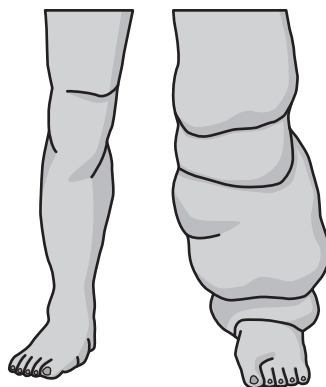
Results from this investigation are shown in the table.

Sample		pH	Temperature (°C)	% Transmission
Pond A	1	6.7	8	25
	2	6.5	8	25
	3	5.6	7	65
	4	7.1	8	22
	5	6.9	7	45
	Mean	6.6	8	36
Pond B	1	5.8	8	15
	2	6.1	7	29
	3	6.2	8	20
	4	5.9	8	69
	5	6.9	7	21
	Mean	6.2	8	



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11. Lymphatic filariasis is a human disease caused by infection with the parasitic nematode worm *Wuchereria bancrofti*. Adult worms live in the lymphatic vessels and disrupt the normal fluid drainage function of this system. Blockage of the lymphatic system can lead to swelling of limbs. Adult worms can live for approximately 6–8 years and, during their lifetime, produce millions of microfilariae (immature larvae) that circulate around the body in the blood.



- (a) What term is used to describe the harm caused by a parasite to its host species?

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- (b) Humans are the definitive host for *Wuchereria bancrofti*. Describe what is meant by a definitive host.

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[Turn over



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## 11. (continued)

Two drugs, Ivermectin and DEC, were compared in a field trial to treat *Wuchereria bancrofti* infections. The trial was double-blind and placebo-controlled. Thirty infected men were randomly assigned one of three treatments: one single dose of Ivermectin; DEC daily for eight days; a placebo. Both drugs quickly reduced microfilaria counts in samples of skin tissue.

The results are shown in Figure 1.

Figure 1

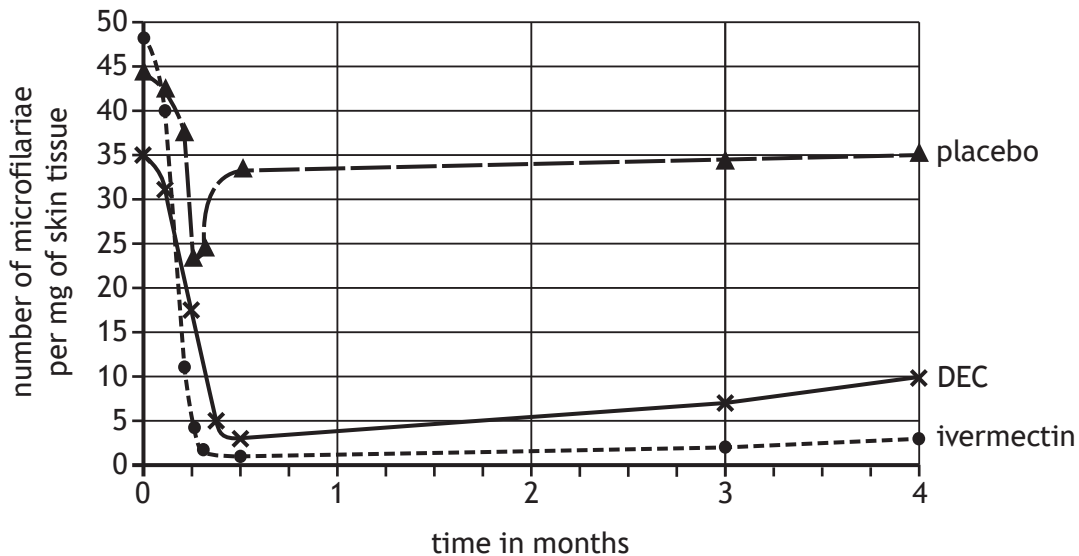


Figure 2 shows the results of an analysis of adult worms in lymph tissue samples taken two months after treatment.

Figure 2

Characteristics of worms		Total number of adult worms found in lymph tissue samples taken two months after treatment		
		Ivermectin	DEC	Placebo
Male	Alive	37	43	59
	Dead	1	1	0
Female	Alive	82	91	101
	Dead	3	4	10



\* X 8 0 7 7 7 0 1 2 8 \*

11. (continued)

(c) Refer to **Figure 1**.

Calculate the total number of microfilariae in the skin of a placebo-treated 75 kg male after 4 months, assuming that his skin is 16% of total body mass.

2

*Space for calculation*

(d) Give one conclusion that can be drawn from the data in **Figure 1** about the effectiveness of the two drugs.

1

(e) Suggest a reason for the apparent difference in data between **Figure 1** and **Figure 2**.

1

(f) Other than independent replication, suggest an improvement to this trial that may increase its validity.

1

[Turn over for next question





12. Attempt **either A or B**. Write your answer in the space below and on *page 31*.

**A** Describe the roles of cells of the immune system in defence against parasitic attack under the following headings.

(i) Non-specific cellular responses 3

(ii) Specific cellular responses 5

**OR**

**B** Discuss the role of sex chromosomes in the development of male and female mammals under the following headings.

(i) Sex determination and sex-linked patterns of inheritance 4

(ii) X-inactivation 4

You may use labelled diagrams where appropriate.





National  
Qualifications

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**X807/77/11**

**Biology  
Supplementary sheet**

Duration — 3 hours

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Supplementary sheet for question 1



\* X 8 0 7 7 7 1 1 \*

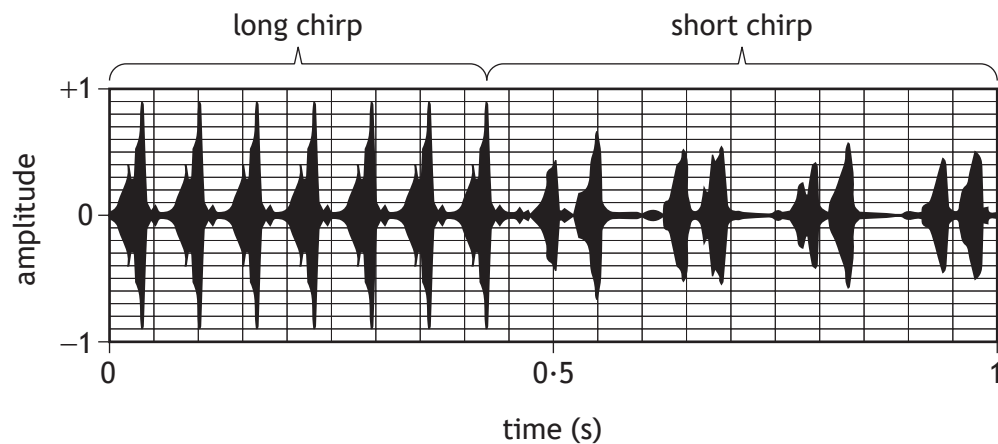


1. One disadvantage of sexual reproduction concerns the problems involved in locating and attracting a suitable mating partner. In many animal species, males use signals of some kind to attract mates. In the Pacific field cricket, *Teleogryllus oceanicus*, normal-wing males produce calling 'songs' to attract females by rubbing together specialised forewing structures.

Cricket calling songs can be recorded and presented visually as patterns of pulses in *sonograms*, where *amplitude* is a measure of the loudness of different parts of the song.

Figure 1 shows a sonogram of one male cricket's song consisting of a 'long chirp' section followed by a 'short chirp' section.

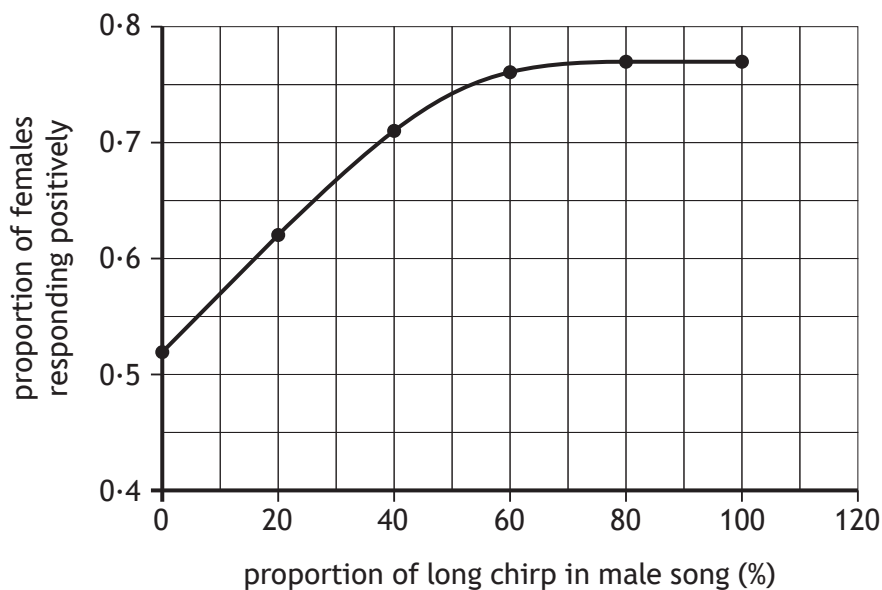
Figure 1



The proportion of song taken up by the long chirp section is important in female choice. Long chirps are more energetically demanding and may provide information to the female about the fitness of the singing male.

Figure 2 shows some results from an experiment investigating the positive responses of female crickets to songs with different proportions of the long chirp component.

Figure 2



1. (continued)

Apart from its energetic cost, sound signalling may make males more vulnerable to predators and parasites who can detect these signals. The female parasitoid fly, *Ormia ochracea*, can locate and parasitise singing male crickets using hearing apparatus that is evolutionarily convergent to that of *Teleogryllus oceanicus* females.

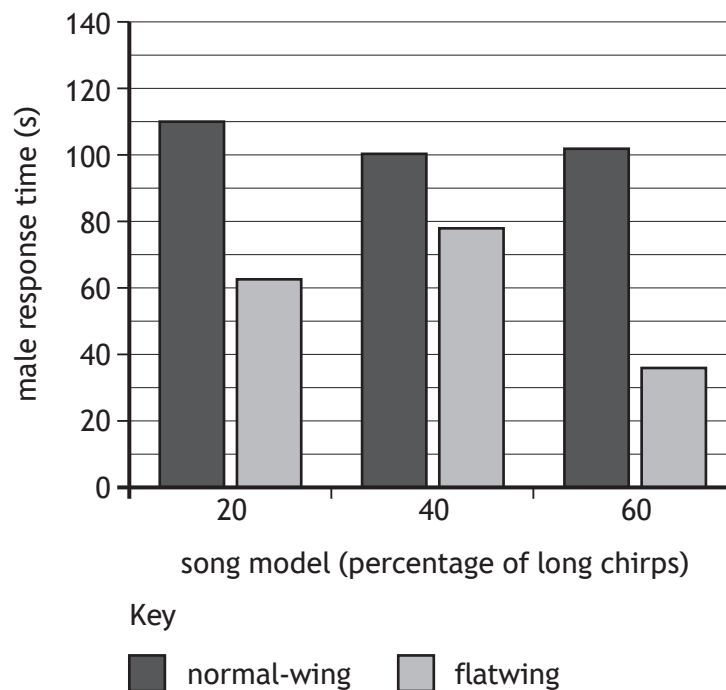
Some males, however, express a 'flatwing' mutation, which makes them unable to produce the song used by normal-wing males. This mutation makes such males silent. In fewer than 20 generations this flatwing trait has spread to more than 90% of males on the Hawaiian island of Kauai, which is also populated by the parasitoid fly.

Research was carried out to investigate the reproduction of flatwing males. It was discovered that these non-signalling males position themselves near signalling males and attempt to intercept and mate with approaching females.

The researchers hypothesised that such satellite flatwing males would be more likely to locate close to males with songs that were more attractive to females. To test this hypothesis they placed normal-wing and flatwing males in experimental chambers. Different song models were played through speakers and the response times of the males to settle near the speakers were measured.

Some of their results are shown in Figure 3.

Figure 3



[END OF SUPPLEMENTARY SHEET]