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Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Level

BIOLOGY **9700/06**

Paper 6 Options

October/November 2005

1 hour

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre Number, Candidate Number and Name in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** the questions set on **one** of the options.
At the end of the examination, **enter the number of the option you have answered in the grid below**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
The options are:
1 – Mammalian Physiology (page 2)
2 – Microbiology and Biotechnology (page 11)
3 – Growth, Development and Reproduction (page 20)
4 – Applications of Genetics (page 27)

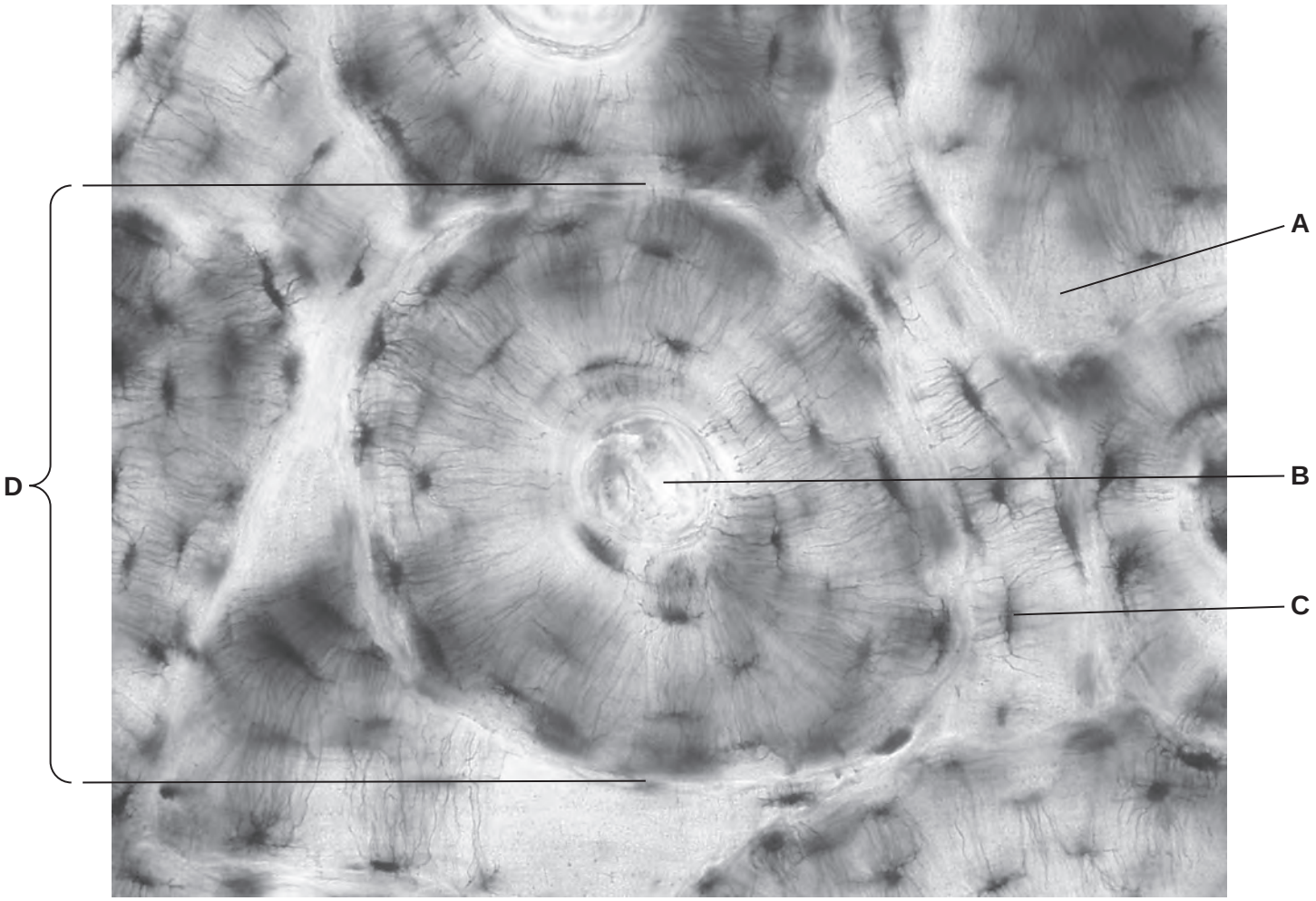
OPTION ANSWERED	
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1	
2	
3	
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TOTAL	

This document consists of **32** printed pages and **4** blank pages.

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OPTION 1 – MAMMALIAN PHYSIOLOGY

1 **(a)** Fig. 1.1 is a photomicrograph of compact bone.



× 1000

Fig. 1.1

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Name **A** to **D**.

A .....

B .....

C .....

D .....[2]

(b) State where in a limb bone you would find bone tissue like that in Fig. 1.1.

.....[1]

(c) The ends of limb bones are covered with a layer of cartilage.

(i) State two ways in which the structure of cartilage differs from that of bone.

1. .....

.....

2. .....

.....[2]

(ii) Explain **one** advantage of the ends of limb bones being covered with a layer of cartilage rather than bone.

.....

.....

.....[2]

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(d) Throughout life, cells called osteoclasts break down bone tissue, while osteoblasts create new bone tissue. As a person ages, the activity of osteoblasts often decreases, which can result in a loss of bone mass and strength. If bone mass falls to a critical level, the condition is known as osteoporosis.

In women, oestrogen helps to promote healthy bone tissue. An investigation was carried out to see if a synthetic oestrogen, called estren, could affect bone strength in mice.

Four groups of female mice were anaesthetised and operated on:

- Group **E** had their ovaries left in place.
- Group **F** had their ovaries removed, but were given no further treatment.
- Group **G** had their ovaries removed and then were treated with oestrogen.
- Group **H** had their ovaries removed and then were treated with the same concentration of estren.

After some weeks, some features of their bones were measured. The results are shown in Table 1.1.

Table 1.1

feature of bone	group **E**	group **F**	group **G**	group **H**
mean number of osteoblasts per unit area of bone surface	14.4	20.3	3.6	10.9
mean number of osteoclasts per unit area of bone surface	2.3	3.4	0.9	1.8
mean strength of femur / newtons	24	18	21	22
mean strength of lumbar vertebra / newtons	66	55	60	64

With reference to Table 1.1,

(i) explain why the group **E** mice were included in this experiment;

.....

.....[1]

(ii) describe the effect of removal of the ovaries on bone strength in the femur and lumbar vertebra, when there was no other treatment;

.....

.....

.....

.....[2]

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(iii) suggest reasons for the effect you have described in **(ii)**;

.....

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.....

.....[2]

(iv) compare the effects of oestrogen and estren on these bones.

.....

.....

.....

.....

.....

.....[3]

[Total: 15]

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2 An investigation was carried out into the effect of eating two different sources of carbohydrate on the concentration of glucose and the concentration of insulin in the blood plasma. The carbohydrate sources used were glucose and rice. The carbohydrate in rice is mainly in the form of starch.

Volunteers were fed either 50 g of glucose or the quantity of rice known to contain 50 g of carbohydrate. The concentration of glucose and insulin in their blood plasma was then measured at intervals for 3 hours. The results are shown in Figs. 2.1 and 2.2.

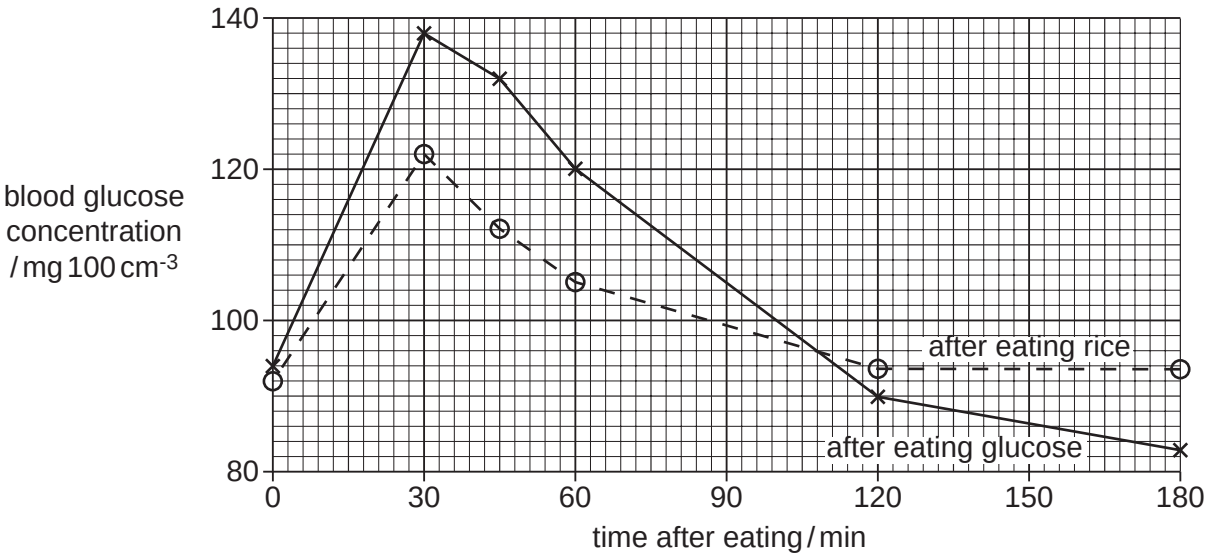


Fig. 2.1

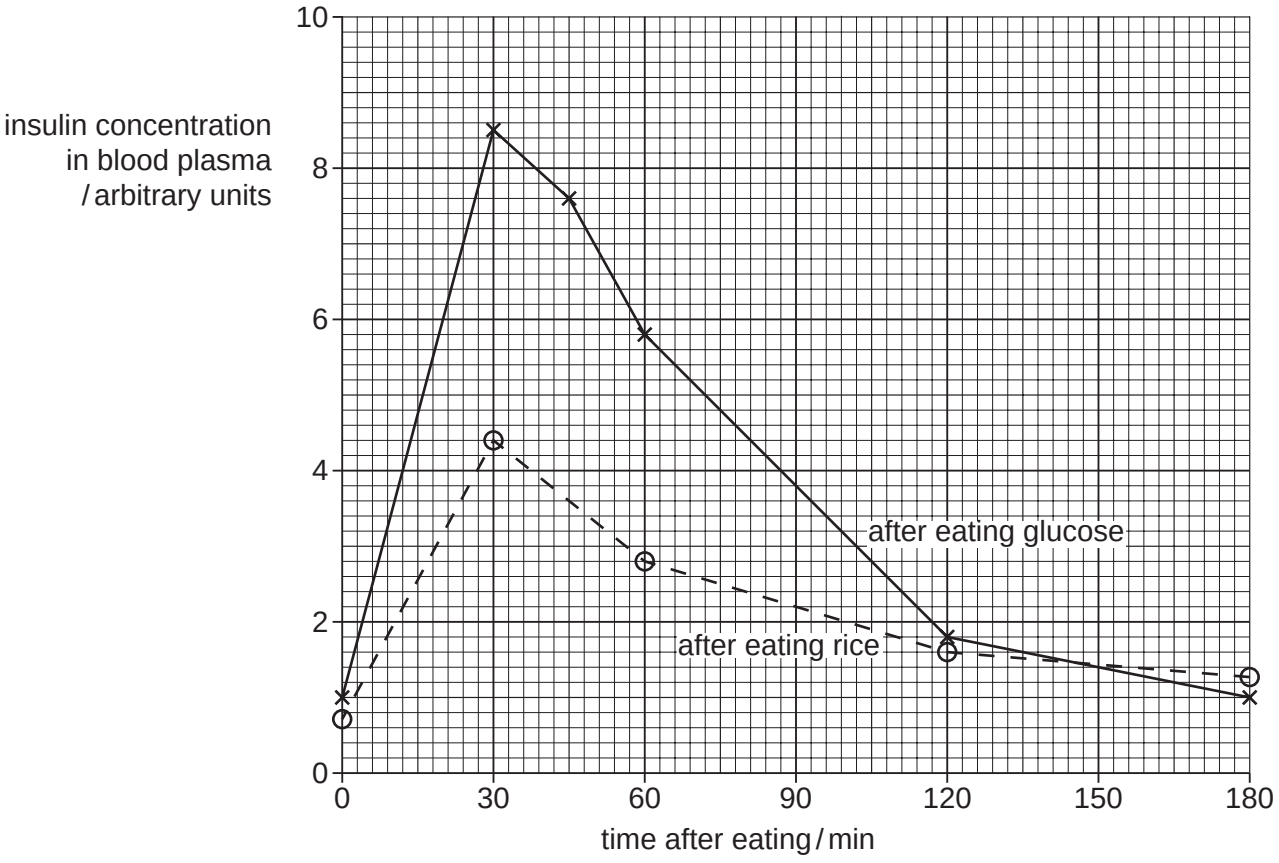


Fig. 2.2

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(a) With reference to **Fig. 2.1**,

(i) calculate the percentage difference between the maximum concentrations of glucose in the blood after eating rice and after eating glucose.
Show your working;

answer .....%. [2]

(ii) give an explanation for the difference you have calculated in **(i)**.

.....

.....

.....

.....[2]

(b) With reference to **Fig. 2.2**, explain the differences between the concentration of insulin in the blood after eating glucose and eating rice.

.....

.....

.....

.....

.....

.....[3]

(c) By 180 minutes after eating the glucose or rice, the concentration of glucose in the blood had fallen considerably.
Describe the role of the liver in bringing about the reduction in blood glucose concentration.

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.....

.....

.....[3]

[Total: 10]

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3 Fig. 3.1 shows the structure of the human brain.

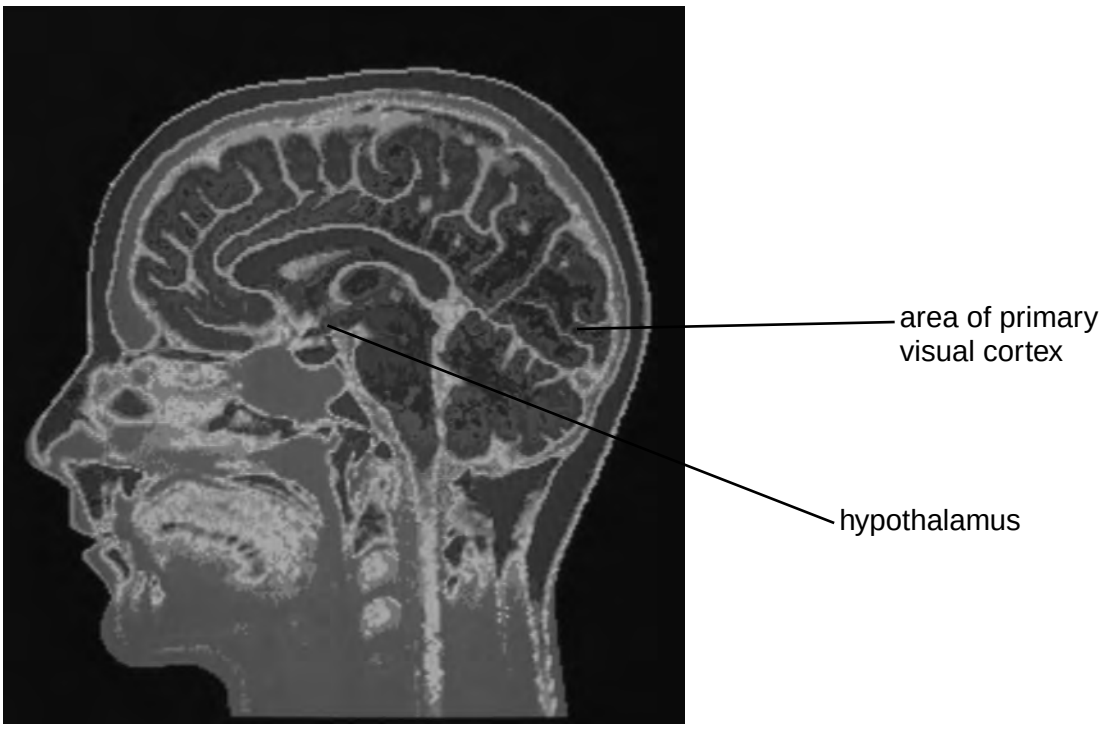


Fig. 3.1

(a) Outline the functions of the hypothalamus.

.....

.....

.....

.....

.....[3]

(b) Visual information from the eyes is processed in several areas of the brain, including the primary visual cortex.

(i) Name the part of the brain in which the primary visual cortex is found.

.....[1]

(ii) Describe how information from the retina is **transmitted** to the primary visual cortex.

.....

.....

.....

.....[3]

[Total: 7]

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4 One of the roles of the liver is to break down drugs, including alcohol. The regular drinking of excessive quantities of alcohol can permanently damage the liver.

Fig. 4.1 summarises the metabolism of alcohol by liver cells.

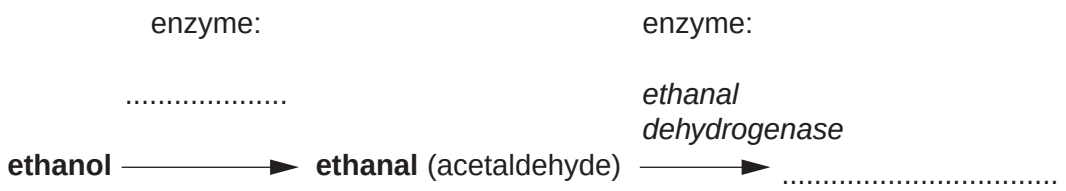


Fig. 4.1

(a) Complete Fig. 4.1 by writing the names of:

- the enzyme responsible for converting ethanol to ethanal
- the final product of this pathway. [2]

(b) State where ethanal is metabolised in the liver cell.

.....[1]

(c) In both of the steps shown in Fig. 4.1, NAD is converted to reduced NAD. This means that, in someone who drinks a large quantity of alcohol, much of the NAD in the liver cells is converted to reduced NAD. Explain how this could result in the suppression of the Krebs cycle in these cells.

.....

.....

.....[2]

(d) Explain how the long-term consumption of excessive amounts of alcohol can lead to the condition known as fatty liver.

.....

.....

.....

.....

.....[3]

[Total: 8]

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OPTION 2 – MICROBIOLOGY AND BIOTECHNOLOGY

1 **(a)** Fig. 1.1 shows a pilot plant to grow a microorganism that produces a useful product.

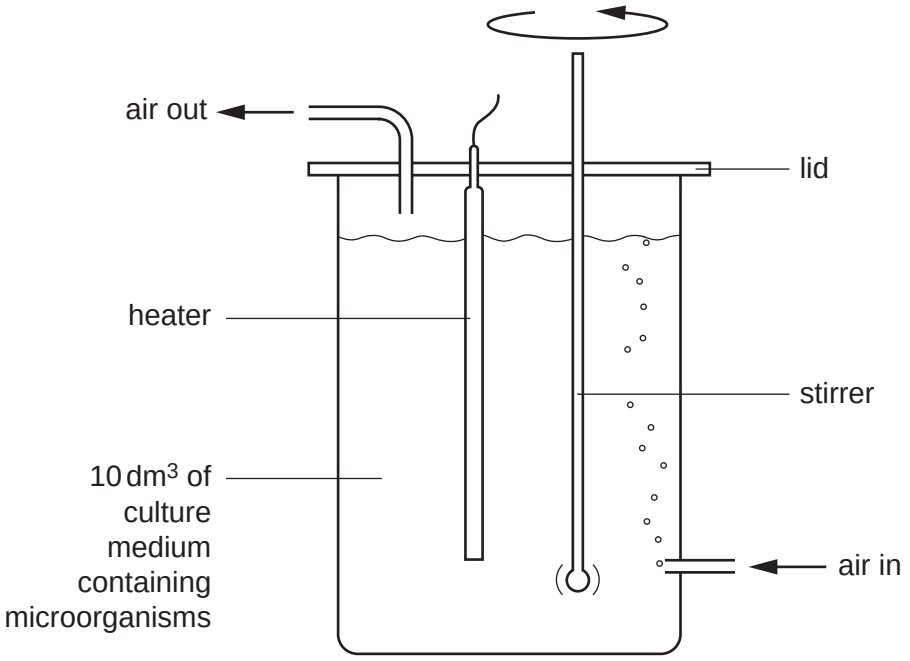


Fig. 1.1

To use on an industrial scale, the fermenter shown in Fig. 1.1 will have to be made much larger.

(i) State **and** explain two **other** alterations that could be made when scaling up this process.

1. .....

.....

.....

2. .....

.....

.....[4]

(ii) To ensure the optimum rate of growth of microorganisms inside the fermenter, various environmental factors must be monitored.

State **one** environmental factor **and** explain why it must be monitored.

.....

.....

.....[2]

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[Turn over

(b) A sample of the culture was taken from the pilot plant and used to make a range of dilutions: 10^{-5}, 10^{-6} and 10^{-7}. 0.1 cm^3 of each dilution was added to each of three separate agar plates. The plates were incubated and the number of colonies that grew was counted. The results are shown in Table 1.1.

Table 1.1

dilution	number of colonies		
	plate1	plate 2	plate 3
10^{-5}	121	192	146
10^{-6}	27	32	28
10^{-7}	7	0	2

(i) With reference to Table 1.1, calculate the mean number of microorganisms in the 10^{-6} dilution. Show your working.

answer .....[1]

(ii) Using your answer from **(i)**, estimate how many microorganisms per cm^3 were present in the original sample taken from the pilot plant. Show your working.

answer ..... per cm^3 [2]

(iii) Explain why the 10^{-6} dilution is the most suitable to use for this calculation.

.....

.....

.....[2]

(c) To monitor the growth of the microorganisms over a period of time, samples would be taken from the pilot plant at regular time intervals.

State **one** method, other than dilution plating, that could be used to measure this growth **and** a disadvantage of your chosen method.

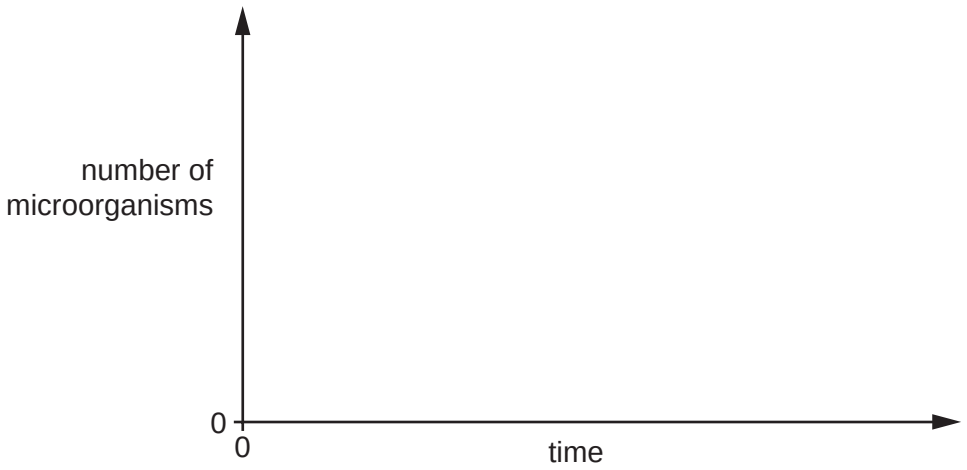
method .....

disadvantage .....

.....[2]

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(d) Sketch a graph on the axes below to show the expected changes in numbers of microorganisms from the start of the fermentation in the pilot plant.



[2]

[Total: 15]

2 Considerable quantities of sweeteners (glucose syrups) used in the confectionery industry are derived from starch. The conversion of starch to sugars is brought about by enzymes.

The first stage in the process (known as liquefaction) is carried out at very high temperatures (about 95 °C) and a pH of around 6.0 to 6.5.

In order that enzymes used in the second stage will work efficiently, it is necessary to reduce the pH to 4.5 and the temperature to 60 °C.

Recent advances in enzyme technology have resulted in the isolation of an enzyme from various thermophilic bacteria. This enzyme is called pullulanase and is effective in breaking down certain bonds in starch molecules.

The effects of temperature and pH on pullulanase activity are shown in Figs. 1.1 and 1.2.

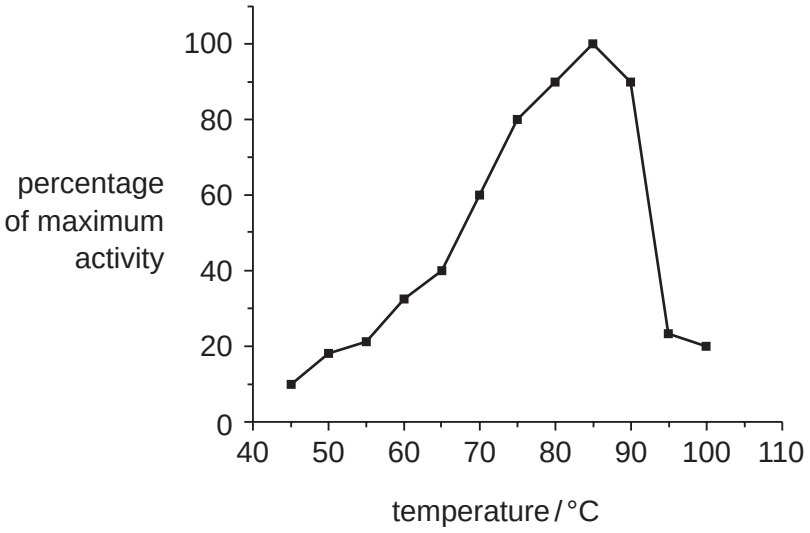


Fig. 1.1

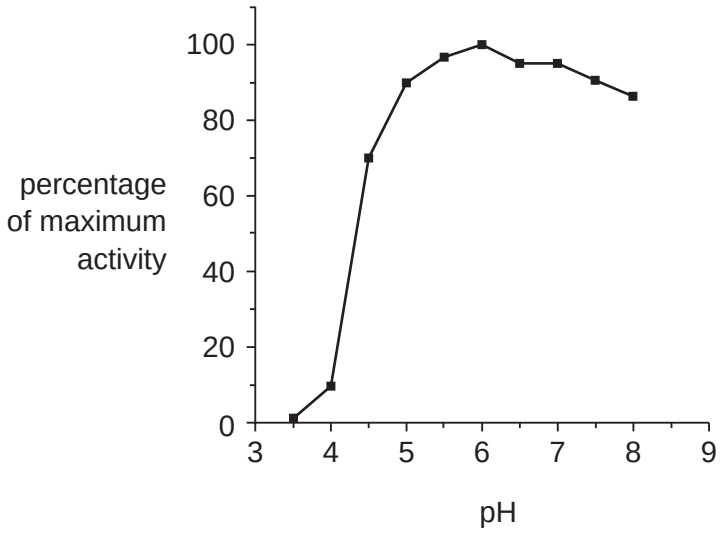


Fig. 1.2

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(a) State what is meant by thermophilic.

.....

.....[1]

(b) With reference to Fig. 1.1 and Fig. 1.2, explain why it may be better to use pullulanase to convert starch to sugars, rather than enzymes that are used at present.

.....

.....

.....

.....

.....[2]

(c) Outline the advantages of using immobilised enzymes in this process.

.....

.....

.....

.....[2]

(d) Glucose syrups are generally produced using batch processing, though it is possible to use continuous processing.
List **three** differences between batch and continuous processing in the following table.

difference	batch	continuous
1		
2		
3		

[3]

[Total: 8]

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3 **(a)** Fig. 3.1 is a drawing showing asexual reproduction in *Aspergillus*, a fungus related to *Penicillium*.

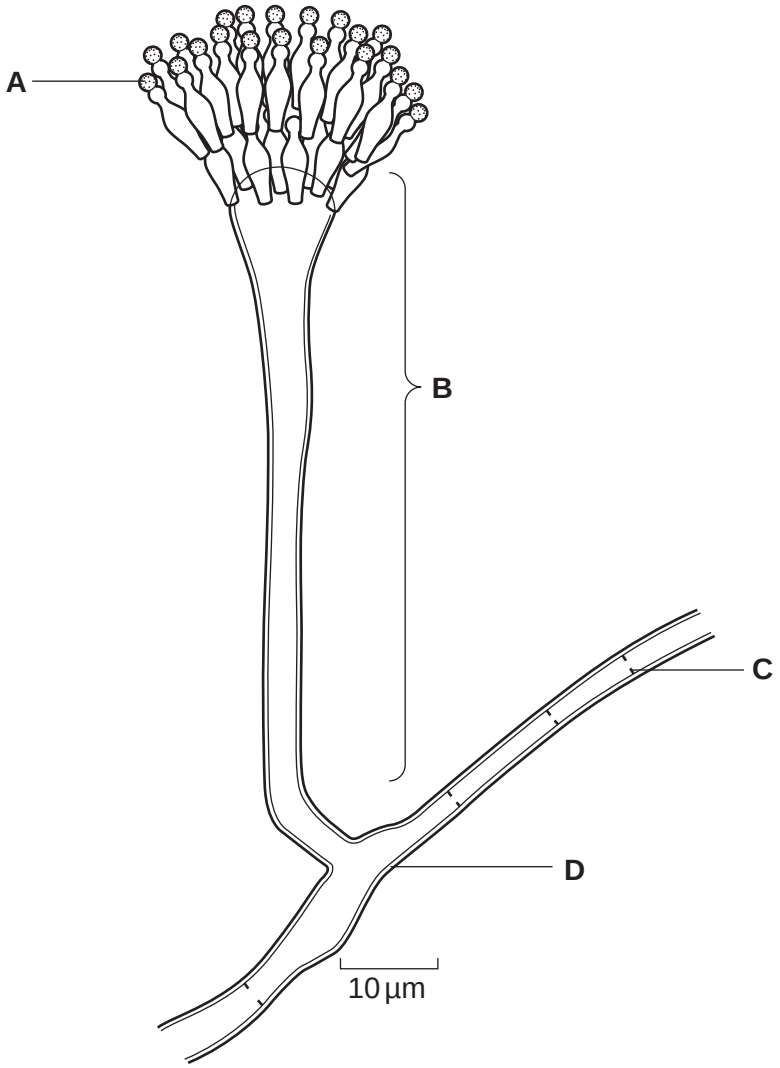


Fig. 3.1

Name **A** to **D**.

A .....

B .....

C .....

D .....[2]

(b) Many micro-organisms show a tolerance to heavy metals in their environment. The fungus *Aspergillus* has been used in Malaysia to extract cadmium from the effluent produced in the treatment of palm oil. The fungi used to extract the cadmium were found on leaves of plants growing around the refinery.
Aspergillus absorbs the metal into its cells. The cells are extracted from the effluent and burnt. This removes the biomass, allowing the recovery of the cadmium.

Explain how you would attempt to grow, on a solid nutrient medium, colonies of cadmium-tolerant *Aspergillus* isolated from the leaves of plants around the refinery.

.....

.....

.....

.....

.....

.....[4]

(c) Other microorganisms have been isolated which can tolerate and accumulate heavy metals, such as copper and lead.

State two ways in which these microorganisms can be exploited industrially.

1. .....

.....

2. .....

.....[2]

[Total: 8]

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4 Fig. 4.1 shows the percentage of the total US crop area for soybean, corn and cotton that was planted with genetically modified varieties between 1996 and 2001.

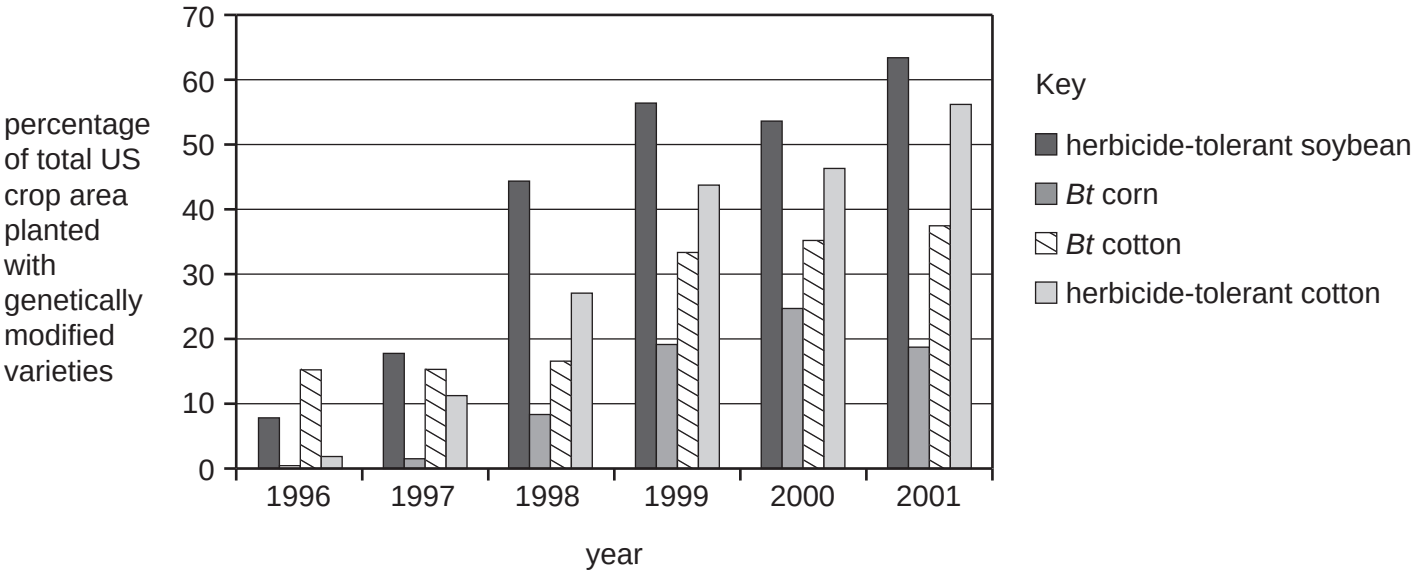


Fig. 4.1

(a) Describe the changes in the percentage of the crop area planted with *Bt* cotton shown in Fig. 4.1.

.....

.....

.....[2]

(b) Describe how the *Bt* gene from *Bacillus thuringiensis* may be inserted into cotton plant cells.

.....

.....

.....

.....[2]

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(c) Insecticide use and yield in India were compared for *Bt* cotton hybrid (**X*Bt***), the same hybrid X but without the *Bt* gene (**X_**), and a different hybrid widely grown in that particular locality (**Y**). This process was repeated at more than 150 locations. Table 4.1 shows the results:

Table 4.1

hybrid	**X*Bt***	**X_**	**Y**
mean number of sprays against insects that eat the cotton	0.6	3.7	3.6
mean number of sprays against sap sucking insects	3.6	3.5	3.5
yield / kg ha^{-1}	1500.0	830.0	800.0

(i) Explain the purpose of including hybrids **X_** and **Y** in the study.

.....

.....

.....[2]

(ii) State three conclusions that can be drawn from the data shown in Table 4.1.

1. .....

.....

2. .....

.....

3. .....

.....[3]

[Total: 9]

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OPTION 3 – GROWTH, DEVELOPMENT AND REPRODUCTION

1 **(a)** Flowering in *Arabidopsis thaliana* is induced by expression of a gene called *FT*. The activity of the *FT* gene can be determined by measuring the production of *FT* mRNA.

Explain why mRNA production provides a measure of the activity of a gene.

.....

.....

.....

.....[3]

(b) *FT* mRNA production was measured at four hour intervals in *Arabidopsis* plants grown for eight days in two different light regimes:

- 8 hours light and 16 hours dark
- 16 hours light and 8 hours dark.

The results during the final 24 hours are shown in Fig. 1.1.

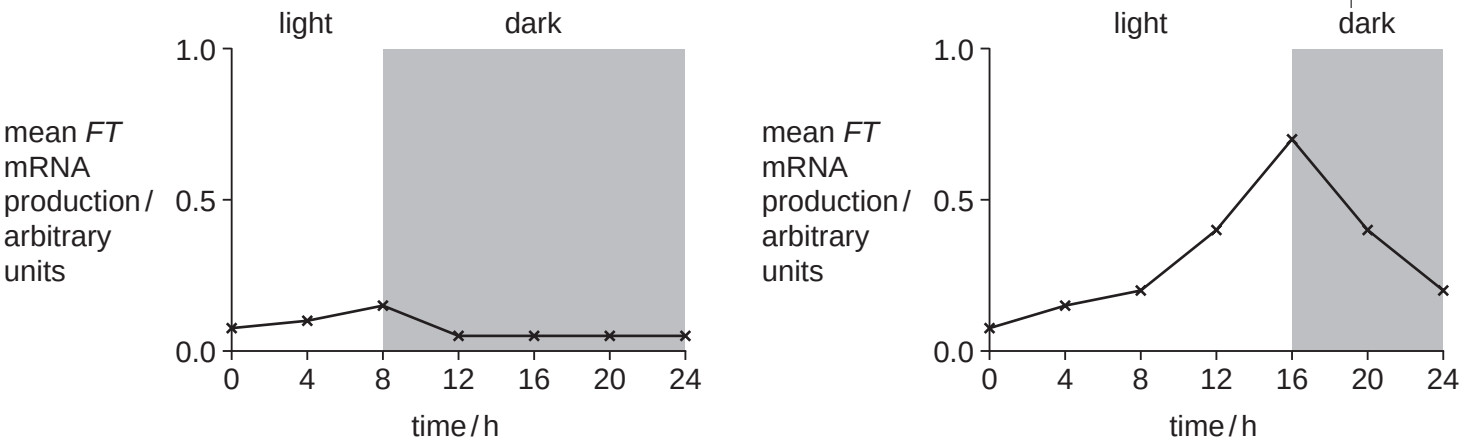


Fig. 1.1

With reference to Fig. 1.1,

(i) describe the activity of the *FT* gene in the two light regimes;

.....

.....

.....

.....

.....[4]

(ii) state, giving a reason, whether *Arabidopsis* is a short-day, long-day or day-neutral plant.

.....

.....[2]

(c) (i) Explain how plants such as *Arabidopsis* detect day length.

.....

.....

.....

.....

.....[4]

(ii) Suggest two advantages to a plant species of flowering according to a particular daylength.

1. .....

.....

2. .....

.....[2]

[Total: 15]

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2 **(a)** Spermatozoa (sperm) of the woodmouse, *Apodemus sylvaticus*, link together after ejaculation by means of hooks on the sperm heads. They then swim as 'sperm trains' of hundreds or thousands of cells.

The average velocity of 'sperm trains' in media with different viscosities was compared with that of single sperm. The range of viscosities used were those found in different parts of the female reproductive tract. The results are shown in Fig. 2.1.

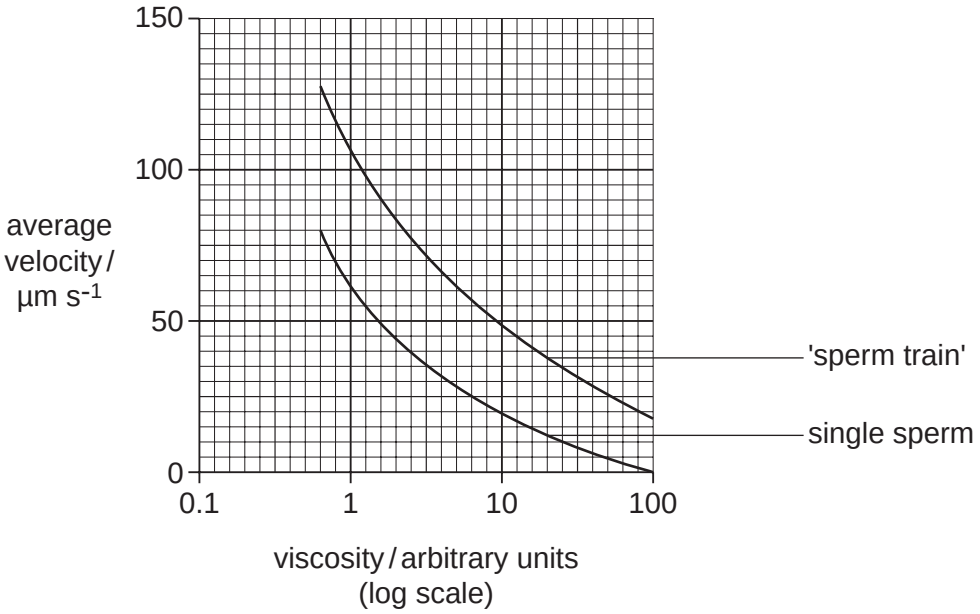


Fig. 2.1

With reference to Fig. 2.1,

(i) compare the average velocities of 'sperm trains' and single sperm;

.....

.....

.....[2]

(ii) explain the advantage of sperm forming 'sperm trains'.

.....

.....

.....

.....[3]

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(b) The proportions of sperm that formed 'sperm trains' and that had undergone the acrosome reaction at different times after ejaculation were found. The results are shown in Fig. 2.2.

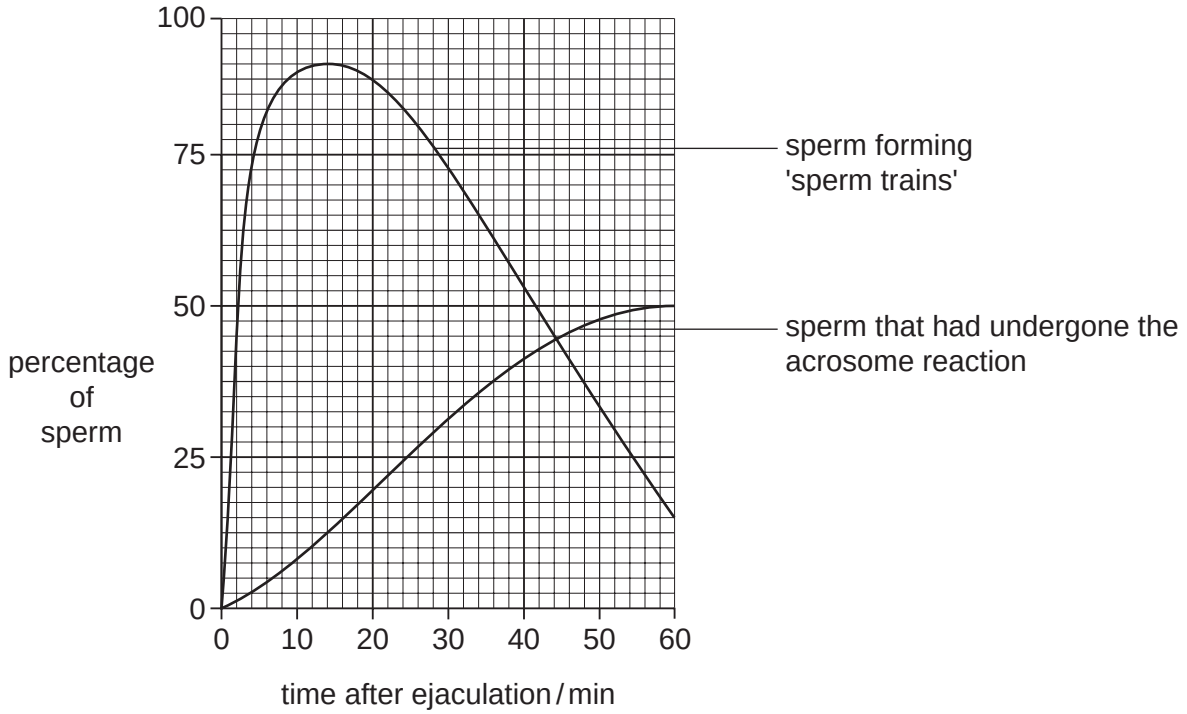


Fig. 2.2

(i) Explain what is meant by the acrosome reaction.

.....

.....

.....

.....

.....[3]

(ii) With reference to Fig. 2.2, suggest how sperm become detached from a 'sperm train'.

.....

.....

.....[1]

(iii) State why it is important that some sperm do **not** undergo a premature acrosome reaction.

.....

.....[1]

[Total: 10]

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3 **(a)** Some flowers show adaptations for wind pollination. List three structural features of the **male parts** of such a flower.

1. .....

.....

2. .....

.....

3. .....

.....[3]

(b) The dead horse arum, *Helicodiceros muscivorus*, grows on small islands off the coasts of Corsica and Sardinia in the Mediterranean. Its flowers produce a smell like a dead animal and are pollinated by female flies that are attracted to rotting flesh in order to lay their eggs. Each arum flower stays open for two days.

The compounds responsible for the flowers' smell have been identified as oligosulphides. These compounds are also produced during protein decomposition in rotting flesh.

The mean numbers of flies visiting a flower at different times during its two day opening period were recorded. At the start of the second day, cotton wool impregnated with oligosulphides was placed in some flowers. The results are shown in Fig. 3.1.

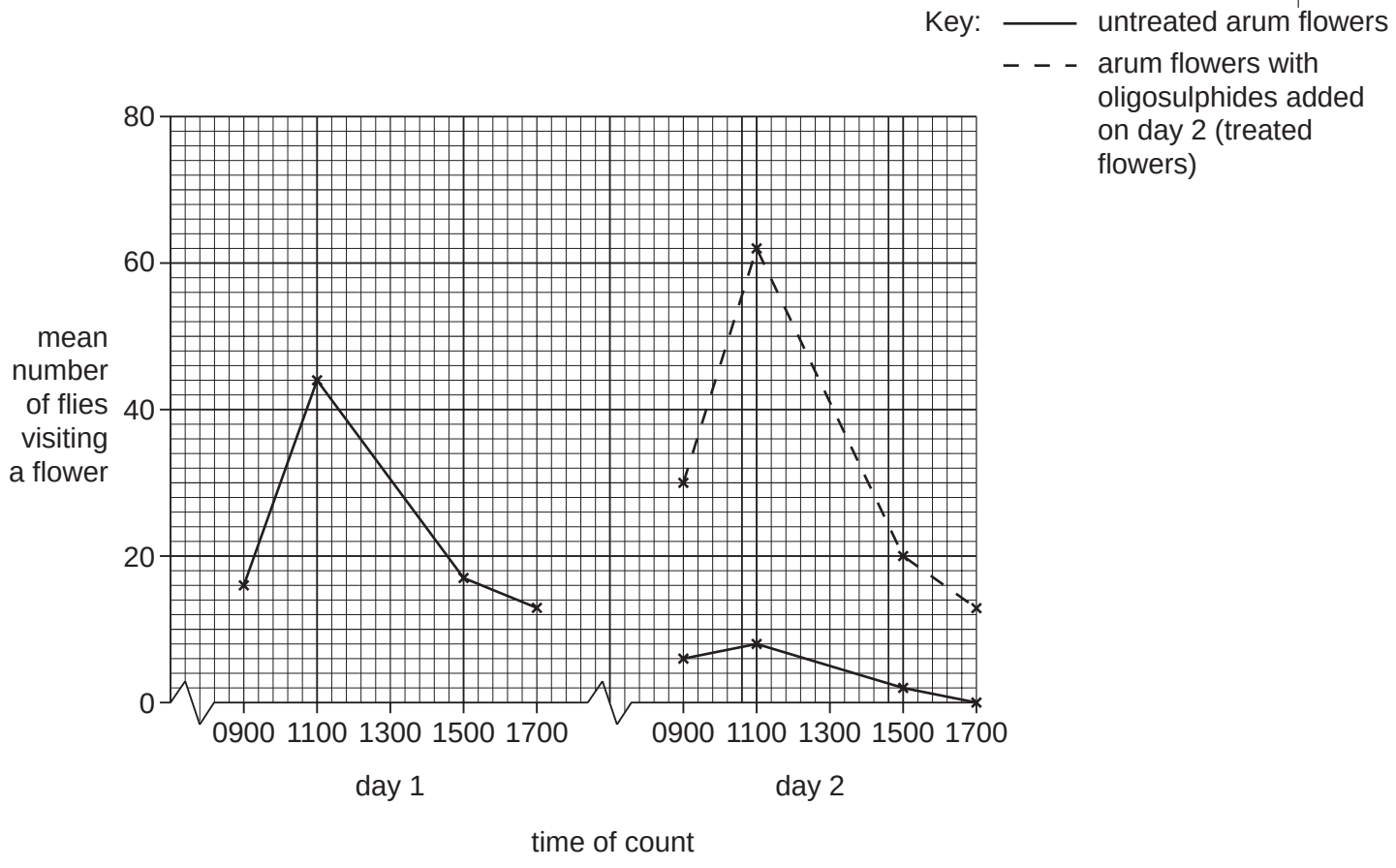


Fig. 3.1

With reference to Fig. 3.1,

(i) describe the pattern of visits by pollinating flies to **untreated** arum flowers;

.....

.....

.....

.....[3]

(ii) calculate the percentage difference between the mean number of flies visiting treated and untreated flowers at 1100 on day 2. Show your working.

answer .....% [2]

[Total: 8]

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[Turn over

4 **(a)** The marbled crayfish, *Procambarus sp.*, is a popular aquarium animal. All the animals are females. They grow rapidly to adult size and produce large numbers of offspring without any fertilisation taking place. Parent and offspring are genetically identical and form a clone.

(i) State two advantages of such reproduction.

1. .....

.....

2. .....

.....[2]

(ii) Explain the evolutionary consequences of such reproduction.

.....

.....

.....

.....[3]

(iii) Suggest why the release of a marbled crayfish into a fresh water ecosystem might have serious environmental consequences.

.....

.....

.....[2]

[Total: 7]

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OPTION 4 – APPLICATIONS OF GENETICS

1 **(a)** Explain why the sinoatrial node is known as the pacemaker of the heart.

.....

.....

.....

.....[3]

(b) All cells of the heart of an early embryo mammal have intrinsic pacemaker ability, but this activity is suppressed in the atria and ventricles as the heart develops.

This lack of activity is caused by the expression of a gene for extra potassium ion channels. In the presence of these channels the cells have a strongly negative resting potential, which prevents the cells from reaching the 'threshold to fire'.

A possible gene therapy for restoring a heart's lost pacemaker activity involves adding a dominant mutant allele of the gene for this ion channel to atrium or ventricle cells.

(i) Explain the theoretical basis of *gene therapy*.

.....

.....

.....

.....

.....[3]

(ii) The normal and mutant alleles of the gene differ in their coding for three adjacent amino acids of the ion channel:

normal ion channel ———— glycine - tyrosine - glycine ————

mutant ion channel ———— alanine - alanine - alanine ————

The ion channel produced by the mutant allele is inactive.

Suggest why the ion channel produced by the mutant allele is inactive.

.....

.....

.....

.....[2]

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[Turn over

(c) This gene therapy was applied to cells from the left ventricles of guinea pigs. The electrical activity of normal ventricle cells and of cells that had received gene therapy is shown in Fig. 1.1. The cells received **no** external stimulation.

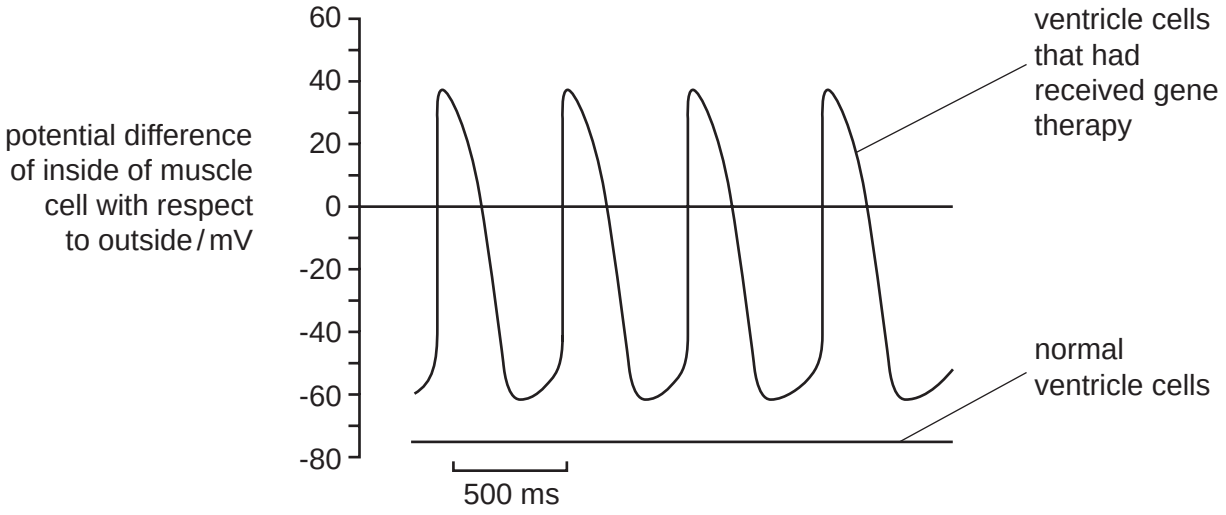


Fig. 1.1

With reference to Fig. 1.1,

(i) compare the electrical activity of normal ventricle cells with cells that had received gene therapy;

.....

.....

.....

.....[3]

(ii) explain the differences in activity between the two types of cell;

.....

.....

.....

.....[3]

(iii) suggest how this gene therapy might be used to restore lost pacemaker activity to a heart.

.....

.....

.....[1]

[Total: 15]

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[Turn over

2 **(a)** The carbamate insecticide, Propoxur, inactivates the enzyme acetylcholinesterase (ACh-ase).

State the role of ACh-ase.

.....

.....[1]

(b) Populations of mosquitoes have been found that are resistant to the effects of Propoxur. The alleles of the gene coding for ACh-ase in resistant and susceptible mosquitoes differ by one base and the enzymes differ by one amino acid close to the enzyme's active site.

The activity of ACh-ase from resistant and susceptible mosquitoes was measured at different concentrations of Propoxur. The results are shown in Fig. 2.1.

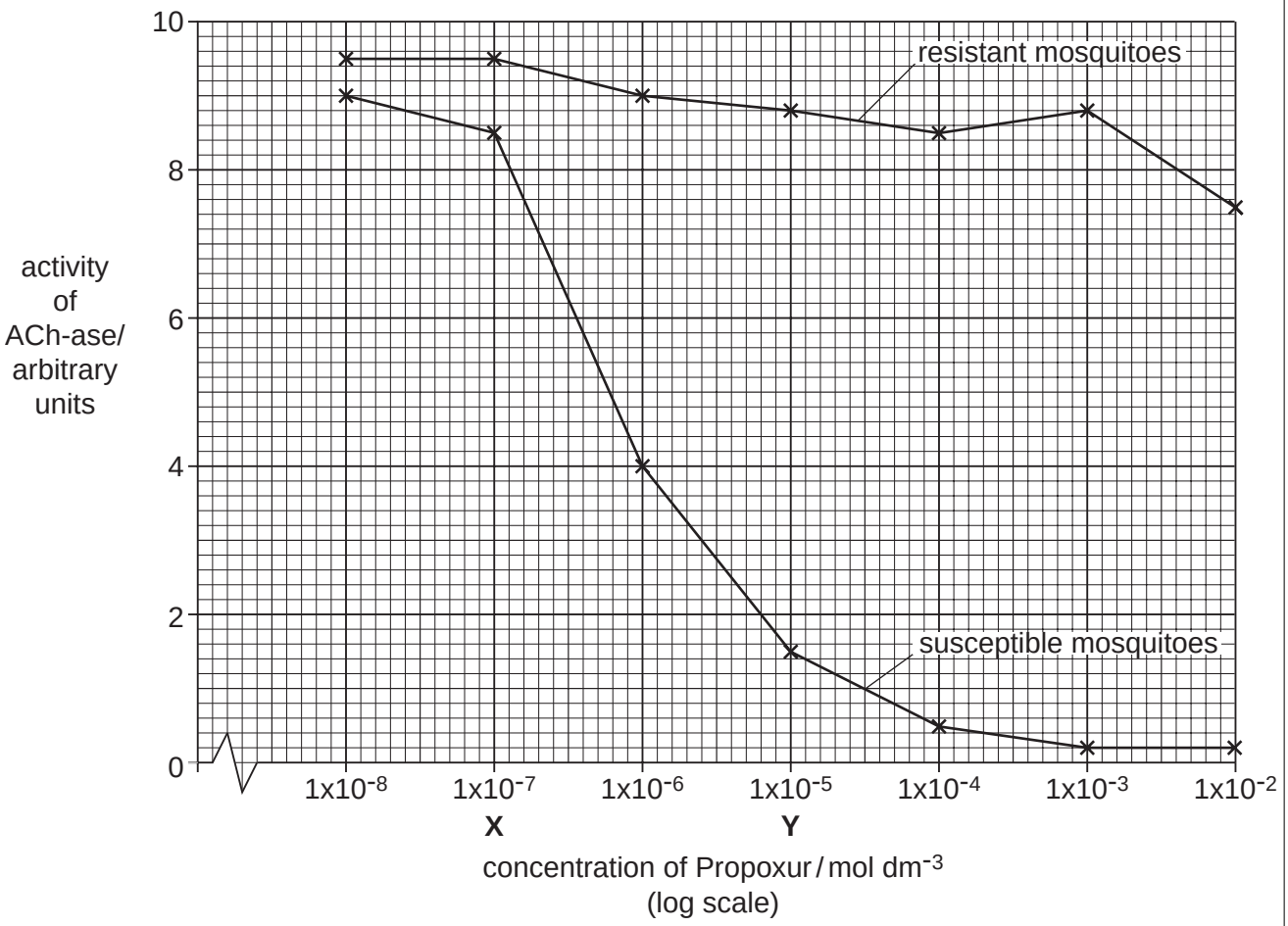


Fig. 2.1

With reference to Fig. 2.1,

(i) compare the effect of different concentrations of Propoxur on ACh-ase from resistant and susceptible mosquitoes;

.....

.....

.....

.....[3]

(ii) calculate the percentage decrease in the activity of ACh-ase from susceptible mosquitoes between Propoxur concentrations **X** and **Y**. Show your working.

answer ..... % [2]

(c) Explain how resistance to Propoxur has arisen **and** spread in some populations of mosquitoes.

.....

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.....

.....

.....[4]

[Total: 10]

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[Turn over

3 **(a)** The Rare Breeds Survival Trust is a charity dedicated to the support of rare breeds of livestock. It maintains a sperm bank, the 'reGENEration bank' for 63 breeds.

(i) Explain the need to maintain rare breeds of livestock.

.....

.....

.....

.....[3]

(ii) Describe how a sperm bank is maintained.

.....

.....

.....

.....[3]

(b) Some breeds have recently reached critically low numbers. For example, in 2003 there were only 21 vaymol cattle and 66 boreray sheep left in the world.

Explain how a sperm bank is used to maintain such breeds.

.....

.....

.....[2]

[Total: 8]

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4 **(a)** Two unlinked genes control the production of yellow flavone pigment in petals of *Dahlia* flowers. The dominant allele, **A**, of one gene produces yellow pigment. No pigment is produced by the recessive allele, **a**.

The dominant allele, **B**, of the second gene inhibits pigment production by **A**. The recessive allele, **b**, has no effect.

When no yellow pigment is produced the petals are white.

This is an example of dominant epistasis.

(i) Explain the term *dominant epistasis*.

.....

.....

.....[2]

(ii) State the colours of the petals of plants with the following genotypes:

AaBb .....

Aabb ..... [1]

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(b) Plants with the genotypes **AABB** and **aabb** were crossed and the resulting F_1 generation test-crossed with **aabb** plants.

Draw a genetic diagram of the **test-cross** to show the genotypes and phenotypes of the parents and offspring.

State the ratio of phenotypes of the offspring.

ratio of phenotypes .....[4]

[Total: 7]

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