

1. (a) (i) A gene controlling coat colour in cats is sex linked. The two alleles of this gene are black and orange. When both are present the coat colour is called tortoiseshell.

Define the following terms:

gene.....
.....

allele

[2]

(ii) Explain why there are no male tortoiseshell cats.

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[2]

Two pure breeding strains of snapdragon, a garden plant, were obtained. One strain had red flowers and the other had white flowers. The two strains were crossed yielding F_1 plants all with pink flowers. The F_1 were then interbred to produce F_2 plants with the following colours:

red	62
pink	131
white	67

The following hypothesis was proposed:

Flower colour is controlled by a single gene with two codominant alleles.

- (b) Complete the genetic diagram to explain this cross. Use the following symbols to represent the alleles:

C^r = red, C^w = white

Parental phenotypes: red flowers x white flowers
 Parental genotypes:
 Gametes:

F_1 genotypes:

F_1 phenotypes:

Gametes:

F_2 genotypes:

F_2 phenotypes:

Expected F_2 phenotypic ratio:.....

(c) A chi-squared (χ^2) test is carried out on the experimental data to determine whether the hypothesis is supported.

(i) Complete the table below by calculating the expected numbers.

F ₂ phenotype	observed numbers	expected numbers
red	62	
pink	131	
white	67	
total	260	260

[3]

The χ^2 statistic is calculated in the following way:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} \quad \sum = \text{“sum of ...”}$$

(ii) Calculate the value of χ^2 for the above data. Show your working.

χ^2 value =

[2]

(iii) The critical value of χ^2 for this type of investigation with two degrees of freedom is 5.991.

Explain whether your answer to **(b) (ii)** supports the hypothesis.

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[1]

[Total 16 marks]

2. Phenotype is influenced by genetic and environmental factors.

Describe **one** example of how the **environment** influences phenotype.

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[Total 2 marks]

3. The bacterium *Escherichia coli* (*E. coli*) uses glucose as a respiratory substrate. In the absence of glucose, *E. coli* can use lactose. The use of a different substrate is determined by the interaction between genes and the environment.

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[Total 5 marks]

4. Cystic fibrosis (CF) in humans is caused by mutations of a gene coding for transmembrane protein (CFTR) which acts as an ion pump. A large number of different mutations of the gene have been found. Explain what is meant by a gene mutation.

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[Total 2 marks]

5. CFTR regulates the transport of chloride ions (Cl^-) across the plasma (cell surface) membrane. Tissues that express the normal CFTR allele secrete alkaline fluids, whereas the secretions of tissues expressing some mutant alleles are acidic.

The transport of Cl^- by epithelial cells expressing the normal CFTR allele was compared with that by epithelial cells expressing one of 10 different mutant CFTR alleles. The results are shown in the table below.

In the table, normal digestive functioning of the pancreas associated with a particular allele is indicated with a tick (✓) and the absence of normal functioning by a cross (✗).

CFTR allele	percentage of Cl ⁻ transported in comparison with normal allele	normal digestive functioning in pancreas
normal	100	✓
mutation 1	6	✗
mutation 2	4	✗
mutation 3	0	✗
mutation 4	3	✗
mutation 5	1	✗
mutation 6	33	✓
mutation 7	41	✓
mutation 8	46	✓
mutation 9	37	✓
mutation 10	44	✓

With reference to the information given in the table, explain why some mutant CFTR alleles allow normal digestive functioning of the pancreas and others do not.

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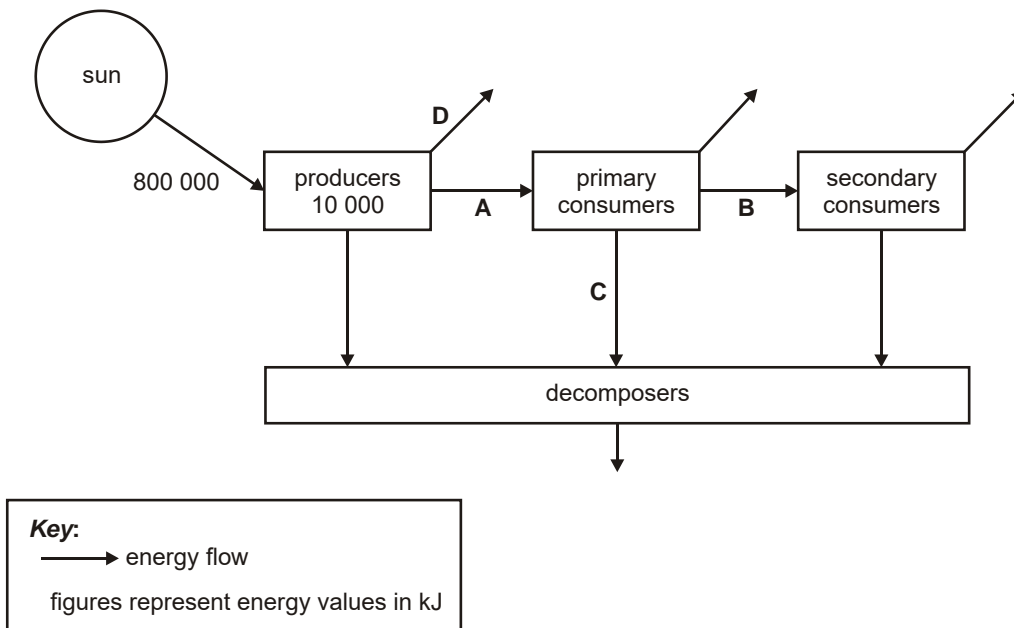
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[Total 3 marks]

6. The figure below represents the transfer of energy through a woodland ecosystem.



- (a) Of the 800 000 kJ of energy which reaches the producers, only 10 000 kJ of energy is converted to growth in the producers.
- (i) Calculate the percentage of the energy reaching the producers that is converted to growth in the producers. Show your working.

Answer = %

[2]

- (ii) Explain what happens to the energy reaching the producers that is **not** converted to growth.

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[2]

(iii) Name **one** decomposer.

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[1]

(iv) State two ways in which energy is transferred from primary consumers to decomposers at **C**.

1

2

[2]

(b) Suggest why the percentage energy transfer between producers and primary consumers at **A** is less than that between the primary consumers and secondary consumers at **B**.

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[3]

[Total 10 marks]

7. One product manufactured using microorganisms is insulin. The process involves genetically engineering bacteria to synthesise human insulin.

(i) Describe how the isolated human insulin gene is inserted into a bacteria plasmid.

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[4]

(ii) Suggest **two** ways in which the bacteria which take up the modified plasmids can be identified.

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[2]

[Total 6 marks]

mutation 9	3 ✓ 8 Suggest one reason why it is considered
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	preferable to use genetically engineered sources of human insulin rather than insulin obtained from pigs.
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[Total 1 mark]

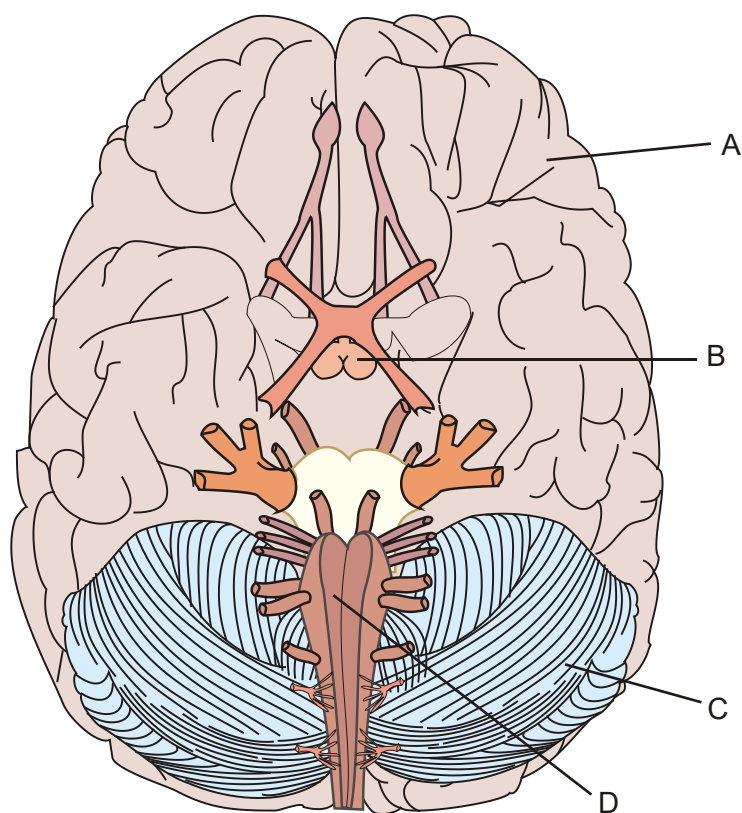
9. A product manufactured using microorganisms is single cell protein (SCP).
Describe how a protein would be synthesised in the cell of a single celled fungus.



In your answer, you should make clear the sequence of the steps in the process.

[Total 10 marks]

10. Below is a drawing of the brain that shows the origin of the cranial nerves.



- (a) State the direction from which the brain has been drawn.

.....

[1]

(b) (i) Name the structures **A**, **B**, **C** and **D** shown on the diagram.

A

B

C

D

[4]

(ii) State **two** roles of structure **D**.

1

2

[2]

(c) The hypothalamus constantly monitors and regulates the concentration of hormones in the blood. Outline how the hypothalamus regulates the concentration of hormones in the blood.

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[2]

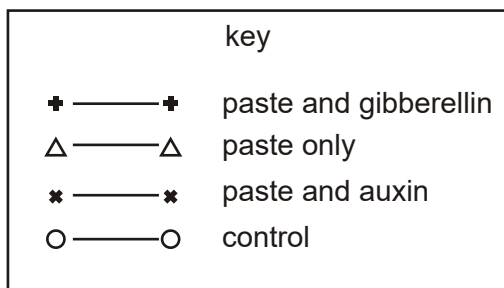
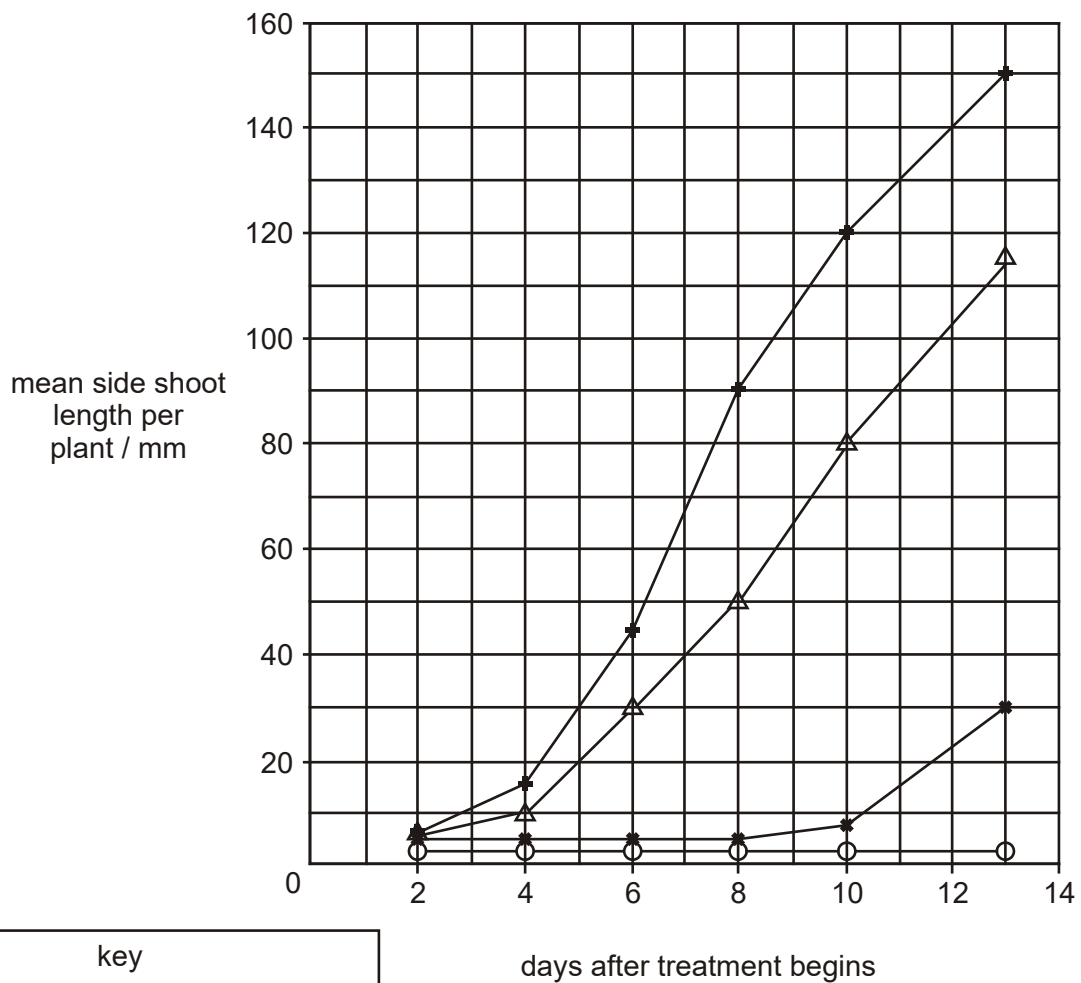
[Total 9 marks]

11. An investigation was carried out into the effects of two plant growth substances, gibberellins and auxins, on apical dominance. The terminal (apical) buds of a number of pea plants were removed and discarded. The tops of each of the remaining shoots were given one of the following treatments:

- Coated with a paste containing gibberellin.
- Coated with a paste containing auxin (IAA).
- Coated with a paste without any plant growth substance.

In addition, a control group of plants did not have their terminal buds removed and were not coated with paste.

The growth of the side shoots was measured at regular time intervals and a mean value calculated. The results are shown in the figure below.



(a) Explain why the side shoots grow when the terminal buds are removed.

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[3]

(b) Side shoots show greater growth when paste containing gibberellin is applied than when paste without any plant growth substance is applied.

Calculate the percentage increase in growth due to gibberellin in 8 day old seedlings compared to seedlings with paste only. Show your working.

Answer =%

[2]

(c) Using data from the figure above describe **and** explain the effect of auxin (IAA) on the growth of side shoots.

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[3]

[Total 8 marks]

12. Immobilised enzymes can be used in bioreactors that attach to space suits. The bioreactors recover water from the astronauts' urine. The bioreactors use immobilised urease enzyme which catalyses the hydrolysis of urea, forming carbon dioxide and ammonia. These products react to form ions, which are then removed by the bioreactor.

(i) State the meaning of the term immobilised enzyme *and describe how immobilisation can be achieved.*

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[3]

(ii) Suggest three practical advantages of using an immobilised urease bioreactor in a spaceship.

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[3]

[Total 6 marks]

13. An investigation was carried out to compare lipase in soluble and immobilised forms. Palm oil was hydrolysed to produce fatty acids and glycerol.

- The two forms of lipase showed optimal activity at the same pH and temperature (pH 7.5 and 35°C).
- At that pH and temperature, 100% of the oil was hydrolysed in two minutes.
- If the temperature was increased to 45°C, the immobilised enzyme hydrolysed 100% of the oil but the soluble enzyme hydrolysed only 80% of the oil in two minutes.

(i) Define the term *hydrolysis*.

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[1]

(ii) Explain, **using the information in the passage**, the advantages of using an immobilised enzyme to hydrolyse palm oil.

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[4]

[Total 5 marks]

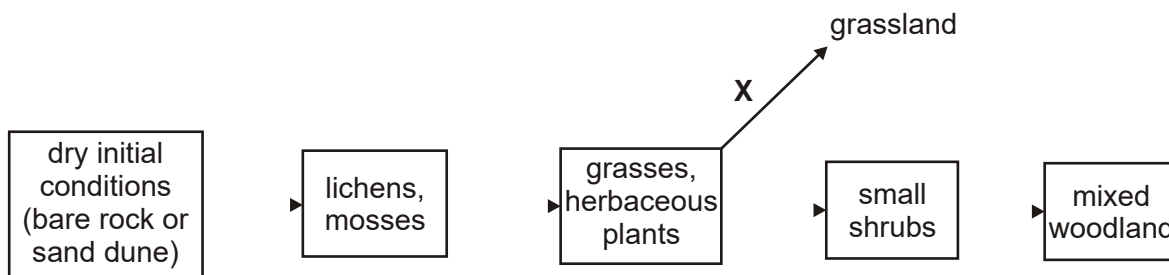
14. (a) Explain the meaning of the term *primary succession*.

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[2]

The figure below shows a primary succession in a temperate climate.

X represents an example of deflected succession.



(b) Explain the role of pioneer plants in succession on a bare rock or sand dune.

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[3]

(c) Suggest two ways in which deflected succession at **X** could be caused.

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[2]

(d) Explain how biomass changes during a **primary** succession.

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[2]

[Total 9 marks]

15. Using timber production in a temperate country as an example, explain how ecosystems can be managed in a sustainable way.



In your answer, you should make clear how the management is sustainable.

[Total 7 marks]

16. Complete the following passage by inserting the most suitable terms in the blank spaces.

Living organisms are interacting constantly with each other and with the environment.

Each individual organism is a member of a group, the,

which consists of all the individuals of a species in an area. This area is known as the

..... . All the organisms of the different species in an area form a group

called the All the species and the non-living components

interacting within an environment are collectively known as the

Photosynthetic organisms such as green plants form the first feeding or

..... level in the food chain and are known as

because they can manufacture their own food. Animals are dependent upon the

photosynthetic organisms to obtain energy and are known as

[Total 7 marks]

17. • DNA is found in the nucleus of a cell.
- During interphase DNA replicates.
- DNA is involved in the transcription stage of protein synthesis.

The following statements, **A** to **H**, refer to events that may take place during:

- ◆ DNA replication **only**
- ◆ transcription **only**
- ◆ **both** DNA replication **and** transcription
- ◆ **neither** DNA replication **nor** transcription.

Complete the table by marking the appropriate boxes with a tick (✓) if the event takes place or a cross (✗) if it does not take place.

		DNA replication	transcription
A	Nucleotides line up along an exposed DNA strand.		
B	The whole of the double helix 'unzips'.		
C	Uracil pairs with adenine.		
D	A tRNA triplet pairs with an exposed codon.		
E	Both DNA polynucleotide chains act as templates.		
F	Adjacent nucleotides bond, forming a sugar-phosphate backbone.		
G	The original DNA molecule is unchanged after the process.		
H	Adenine pairs with thymine.		

[Total 8 marks]

- 18.** Over the last few years there has been much public concern over the diet of people in the UK and its effects upon their weight and health.

Body Mass Index is a calculation used by doctors to indicate whether a person is underweight or overweight.

- (a) State the medical term used to describe a person whose Body Mass Index is greater than 30.

.....

[1]

The table below shows the daily intake of certain components in three diets, **A**, **B** and **C** for men in the UK.

- Diet A** • a normal balanced diet for a typical man
- Diet B** • a weight-reducing low fat diet
 • restricted to avoid fats
 • includes any fruit, vegetables and proteins
 • energy intake is monitored carefully
- Diet C** • a weight-reducing low carbohydrate diet
 • restricted to avoid carbohydrates
 • excludes fruit as these contain sugars
 • includes any non-starchy vegetables, proteins and fats
 • energy intake is not counted and may exceed 10 000 kJ on some days

	Diet A normal balanced diet	Diet B weight-reducing low fat diet	Diet C weight-reducing low carbohydrate diet
energy / kJ	9720	6000	8000
fats / g	87	34	124
carbohydrates / g	275	200	20
proteins / g	88	76	165
combined minerals / g	12	12	18

- (b) In any unbalanced diet it is possible that there may be a deficiency of certain nutrients.

Suggest **one** nutrient that may be deficient in diet **B** and **one** in diet **C**.

Diet B

Diet C

(c) (i) Explain which diet, **B** or **C**, is likely to cause more rapid weight loss.

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[2]

(ii) State the relationship between energy intake and energy use that would allow a person to lose weight.

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[1]

(d) Doctors suggested that diet **C** may not be very healthy in the long term, as it contains unlimited amounts of fats and no fruit.

Suggest what potential health problems, **other than continued weight loss**, might result in a person who kept to a low carbohydrate diet, similar to diet **C**.

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[3]

[Total 9 marks]

19. In woodlands that are managed, a conflict exists between the economic yield and the maintenance of biodiversity.

Below is a photograph of an area of coppice and standard woodland.



- (i) Describe the process of coppicing **and** explain how it is used in the sustainable management of a woodland.

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[3]

(ii) State **two** ways in which managing woodland as a mix of standard and coppiced trees can be of **economic** benefit to the owner.

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3

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[2]

[Total 5 marks]

20. Explain how the fungal decomposition of deadwood is of benefit to the living trees within a woodland.

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[Total 4 marks]

21. Reproduction in seahorses, *Hippocampus*, is unusual as it is the male rather than the female that becomes pregnant. The male has a brood pouch located on its tail. The larger the male the larger the pouch. The female transfers unfertilised eggs into the pouch. The larger the female the more eggs are produced that can be transferred to the brood pouch. The male releases sperm onto the eggs and they are fertilised. The male carries the developing brood for a period of several weeks until he finally gives birth.

Research into seahorse populations has revealed the following.

- They are monogamous. A male and female remain together for the whole mating season.
- Within a population, mates are selected by size. Large females mate with large males and small females mate with small males.
- Few intermediate sized individuals are produced and they have a low survival rate.

Two different species of seahorse are found in the coastal regions shown in the figure below. The ranges of these two seahorse species overlap in many areas of these waters.



Key



Hippocampus erectus ○

Actual size: 12 cm



Hippocampus zosterae △

Actual size: 2 cm

The two seahorse silhouettes are not drawn to scale.

© A G Jones, Male pregnancy and the formation of seahorse species © Institute of Biology, 2004

- (a) (i) Name the type of speciation that occurs when there is no geographical barrier to gene flow.

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- (ii) Explain how the figure above supports the hypothesis that the type of speciation named in (i) has occurred in seahorses.

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[2]

The type of natural selection that can produce the type of speciation that has occurred in seahorses is known as disruptive selection. This is where the extreme phenotypes are more likely to survive and reproduce than the intermediate phenotypes.

- (b) Explain how disruptive selection occurs in seahorse populations.

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[3]

- (c) In terms of reproductive potential, explain why it is beneficial for large females to mate with large, rather than small, males.

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[2]

[Total 8 marks]

22.

During interphase preceding meiosis, each chromosome replicates itself and becomes two chromatids joined at the centromere. These identical chromatids are known as sister chromatids. During the first division of meiosis, pairing of homologous chromosomes takes place. The structure formed is called a bivalent. When paired in this way non-sister chromatids from the two chromosomes exchange segments of genetic material by breaking and rejoining.

- (i) State the name given to the exchange of segments of chromatids by breaking and rejoining.

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[1]

- (ii) Name the stage of the first division of meiosis when this exchange of segments occurs.

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[1]

- (iii) Describe the genetic difference between sister and non-sister chromatids.

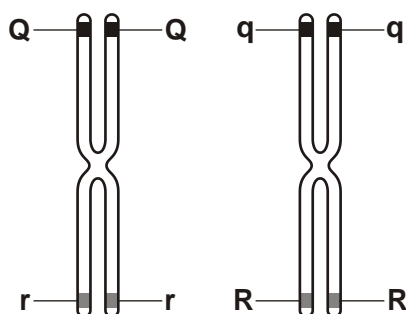
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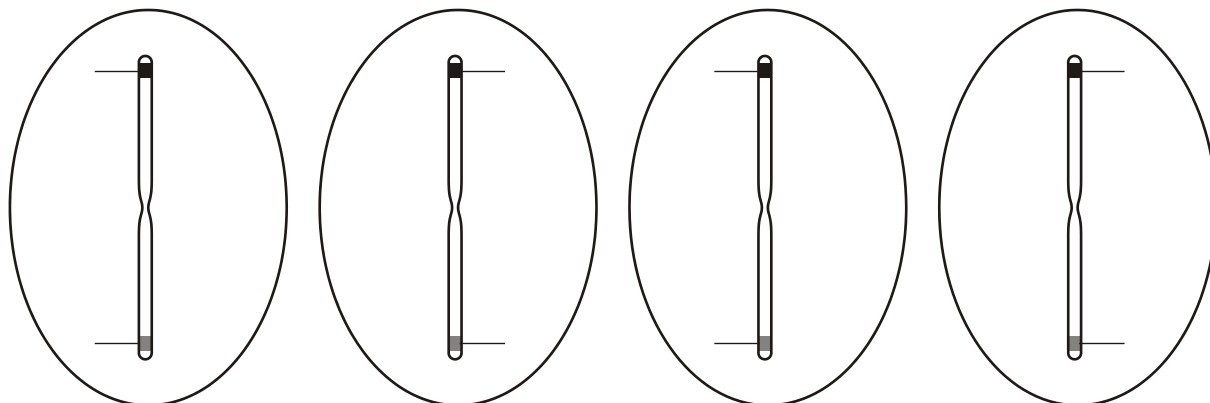
[1]

[Total 3 marks]

- 23. The following figure represents a pair of homologous chromosomes at the beginning of the first division of meiosis. The loci of two genes are shown, and both genes have two alleles.



Complete the diagram below to show the four possible gametes formed at the end of meiosis. Use the same letters as in the figure above.



[Total: 2 marks]

24. A student carried out a genetic investigation with fruit flies, *Drosophila melanogaster*. Two characteristics were observed, body colour and wing shape. The student had the following information:

- the characteristics were controlled by separate genes carried on separate chromosomes
- grey body colour was dominant to black body colour
- normal wing shape was dominant to bent wing shape.

The student carried out a cross between a fly **heterozygous** for both grey body colour and normal wing shape and a fly with a black body and bent wing. The numbers and phenotypes of the offspring were as follows:

grey body and normal wing	83
black body and normal wing	85
grey body and bent wing	78
black body and bent wing	74

- (i) Complete the genetic diagram to explain this cross. Use the following symbols to represent the alleles:

A = grey body colour, a = black body colour
B = normal wing shape, b = bent wing shape

Parental phenotypes: grey body / normal wing x black body / bent wing

Parental genotypes:

Gametes:

Offspring genotypes:

Offspring phenotypes:

.....

Phenotypic ratio:

[5]

The student concluded that the results showed that independent assortment had taken place.

To determine whether this conclusion is justified a chi-squared test (χ^2) can be carried out on the experimental data.

- (ii) Complete the table below by calculating the expected numbers.

offspring	observed numbers	expected numbers
grey body / normal wing	83	
black body / normal wing	85	
grey body / bent wing	78	
black body / bent wing	74	
total	320	320

[1]

- (iii) The χ^2 value is calculated in the following way:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} \quad \text{where} \quad \Sigma \square = \text{'sum of ...'}$$

Calculate the χ^2 value for the above data. Show your working.

χ^2 value =

[2]

- (iv) The critical value of χ^2 for this type of investigation with three degrees of freedom is 7.82.

Explain whether your answer to (c) (iii) supports the student's conclusion.

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[1]

[Total 9 marks]

- 25.** An experiment was carried out to investigate the effect of gibberellins on stem elongation in both wild type and dwarf varieties of *Brassica campestris*. Plants from both varieties were germinated and grown under controlled laboratory conditions. Stem measurements were taken on day 12 after planting, and then on five more occasions, as indicated in the table below. Stems were measured from the point at which they join the seed to the apical meristem. The plants were divided into four groups as follows:

- wild type variety treated with a gibberellin solution
- dwarf variety treated with gibberellin solution
- wild type variety treated with water (control)
- dwarf variety treated with water (control).

The stem lengths were measured and the mean values are shown in the table.

age of plants / days	mean length of stem / mm			
	plants treated with gibberellin		plants treated with water	
	wild type	dwarf	wild type	dwarf
12	25.58	1.27	30.04	0.78
13	52.19	2.50	53.42	1.21
15	65.33	4.46	72.49	2.69
18	96.87	10.63	93.97	4.15
20	97.19	21.55	100.81	6.79
23	104.71	35.44	108.78	8.48

From Russell and Sunday <http://www.sfu.ca/~msr/Papers/BISC/brassica.html>

(a) (i) Suggest how the dwarf variety may have arisen.

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.....

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[2]

(ii) State **two** environmental factors that would need to be controlled during this experiment.

1

2

[2]

(b) With reference to the table, describe the effect of the gibberellin solution on stem elongation in both the wild type and dwarf varieties.

wild type

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dwarf

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[5]

- (c) Explain the different effects of the gibberellin solution on stem elongation in these two varieties.

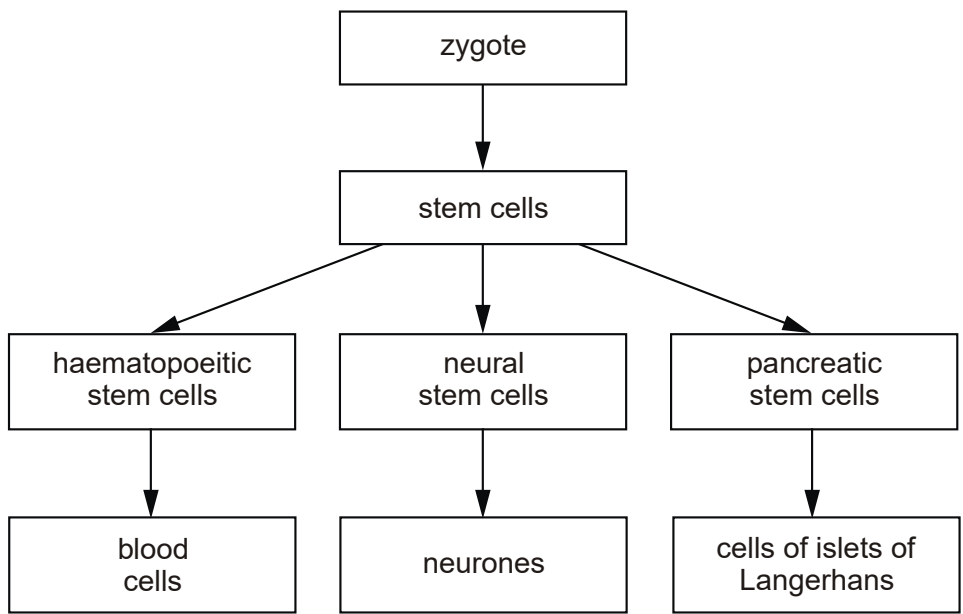
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[2]

[Total: 11 marks]

26. A human zygote divides to produce stem cells. Stem cells have the ability to develop into any cell type, in a similar way to meristematic cells in plants.

The figure below shows development of three cell types from human stem cells.



There are many potential medical uses of stem cells from human embryos. One potential use is to make cells of the islets of Langerhans for transplantation, as a treatment for diabetes mellitus.

(i) Suggest **one** ethical objection to the use of stem cells from human embryos.

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[1]

(ii) Suggest **two** other medical conditions which could be treated using the embryonic stem cells shown in the figure.

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2

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[2]

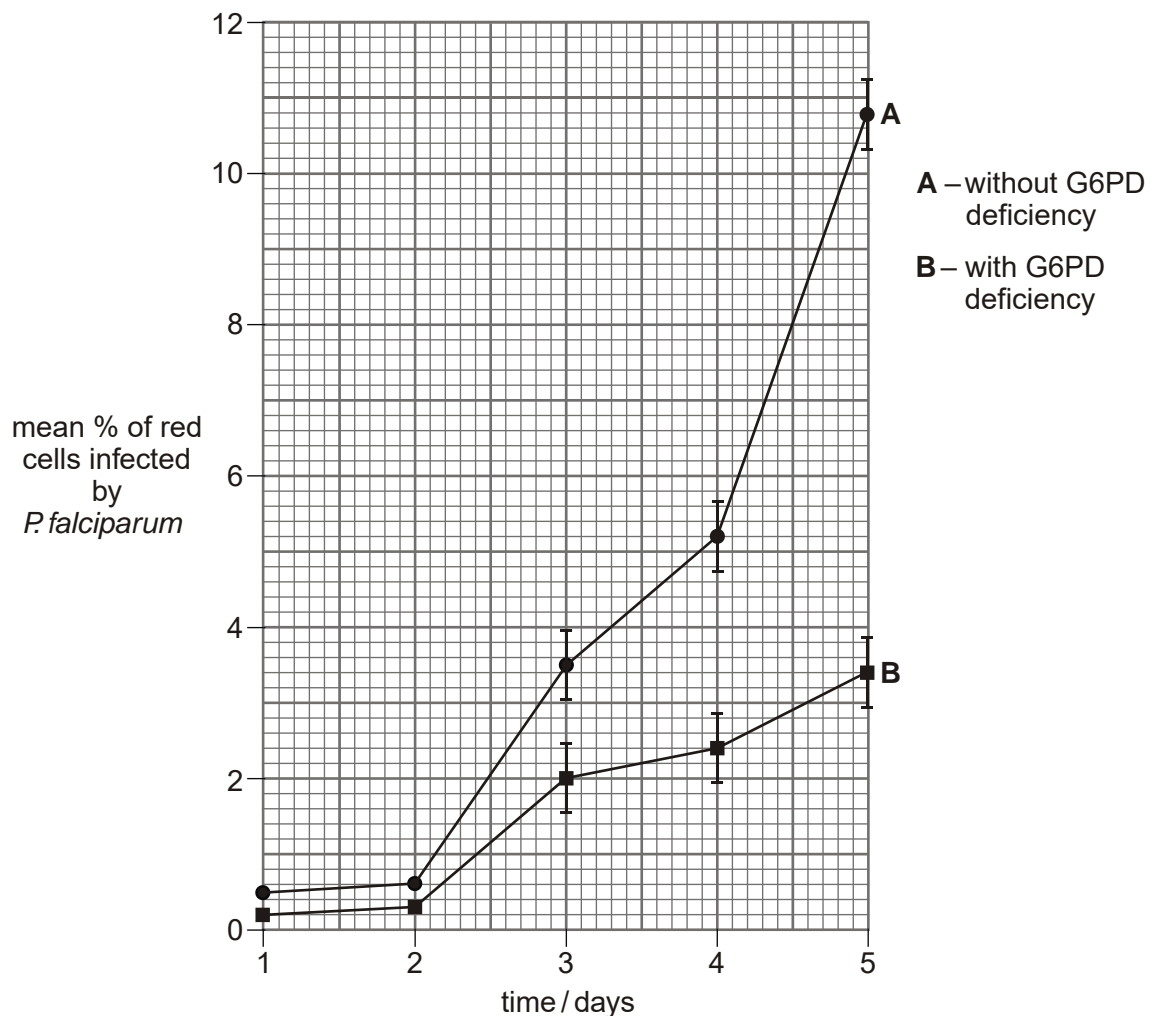
[Total 3 marks]

27. The information below refers to the deficiency of the enzyme, glucose-6-phosphate dehydrogenase (G6PD) in humans:

- a deficiency of G6PD is an inherited condition
- G6PD is necessary for the production of ribose
- ribose is a nutrient needed by *Plasmodium falciparum*
- individuals with G6PD deficiency may be resistant to the parasite *P. falciparum*
- G6PD deficiency is more common in areas where malaria occurs regularly.

In an experiment, red blood cells were collected from individuals deficient in G6PD and from individuals without this deficiency. The cells were collected in a solution containing an anticoagulant, as well as solutes used to maintain a suitable water potential. The red blood cells were used as a growth medium for *P. falciparum*.

The percentage of red blood cells infected by *P. falciparum* was determined over a five day period and the mean calculated. The results obtained are shown in the figure below.



Using the information in the figure above,

- (i) suggest why error bars have been included;

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[2]

- (ii) describe **and** explain the results obtained between day 1 and day 2;

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[2]

- (iii) describe **and** explain the differences between the results for **A** and **B** between days 2 and 5.

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[4]

[Total 8 marks]

28. Explain why G6PD deficiency is more common in areas where malaria occurs regularly.

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[Total: 3 marks]

29. (a) White Leghorn domesticated chickens carry a dominant allele, **I**, that inhibits feather pigmentation. Birds homozygous for the recessive allele, **i**, have pigmented plumage, provided that they carry the dominant allele, **C**, of a gene for melanin production.

Name the interaction between alleles **I** and **C**.

.....

[1]

(b) Allele **i** codes for a protein that is essential for normal production of melanin. In comparison with **i**, allele **I** has a 9 base pair insertion in its DNA.

Explain how such an insertion could alter the expression of the gene.

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[4]

(c) Red Junglefowl are the wild ancestors of domesticated chickens.

Homozygous White Leghorns were crossed with homozygous Red Junglefowl and the **F₁** offspring, all of which were white, interbred to give an **F₂** generation. The **F₂** generation included both white and pigmented birds.

(i) State the genotypes at the **I/i** and **C/c** loci of the parental and **F₁** generations.

parental phenotypes: White Leghorn × Red Junglefowl

parental genotypes:

F₁ genotype:

[2]

(ii) State the ratio of phenotypes expected in the **F₂** generation.

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[1]

[Total 8 marks]

30. Explain why breeders of domesticated chickens consider it important to maintain a population of Red Junglefowl.

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[Total 4 marks]

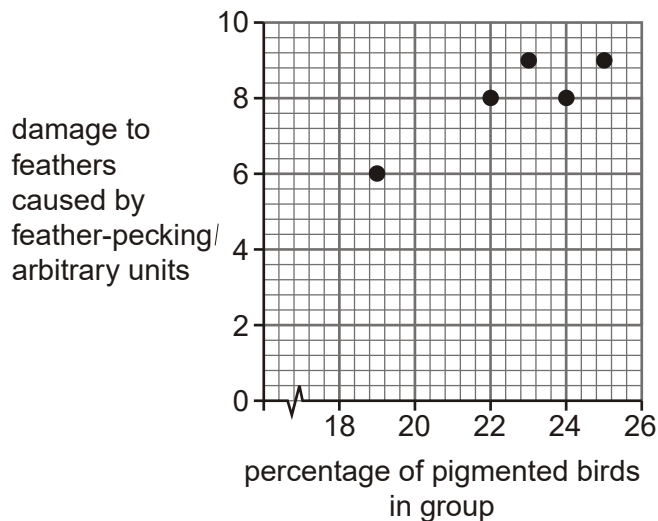
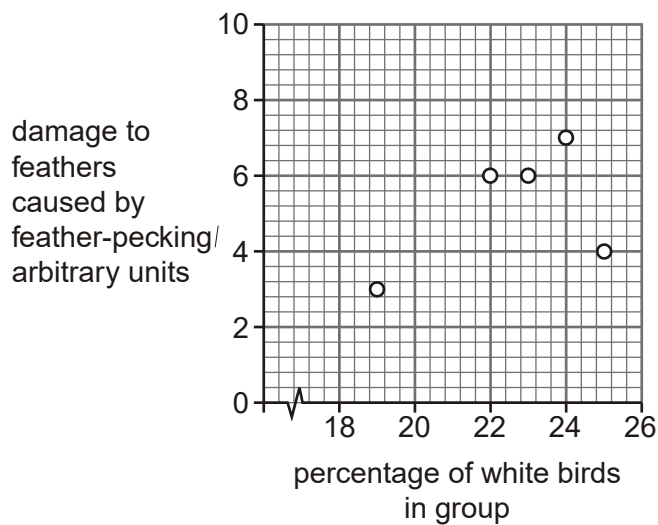
31. Red Junglefowl are the wild ancestors of domesticated chickens.

Homozygous White Leghorns were crossed with homozygous Red Junglefowl and the F_1 offspring, all of which were white, interbred to give an F_2 generation. The F_2 generation included both white and pigmented birds.

The F_2 birds were divided into ten groups, each with slightly different percentages of white and pigmented birds. Each bird was examined at intervals to assess any damage to its feathers caused by feather-pecking by other birds in the group.

The results of the investigation are shown in the figure below.

key to phenotypes of birds: ○ white ● pigmented



Describe the effect on feather-pecking of changes in the percentage of each phenotype in a group.

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[Total 3 marks]

- 32.** About 10% of the coffee consumed in the world has been processed to remove caffeine. The decaffeination process also removes some of the flavouring compounds so, since 1987, researchers at the coffee gene bank in Brazil have been trying to produce suitable varieties of caffeine-free coffee plants.

The most commonly cultivated species of coffee plant, *Coffea arabica*, has a narrow genetic diversity. It is a tetraploid with 44 chromosomes ($4n = 44$) and almost always self-pollinates.

All attempts to start a selective breeding programme to transfer the caffeine-free property of a diploid wild species of coffee from Madagascar ($2n = 22$) to *C. arabica* have failed.

- (i) Explain briefly why selective breeding is carried out.

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[2]

(ii) Explain why *C. arabica* has a narrow genetic diversity.

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[2]

(iii) Suggest why attempts at interbreeding *C. arabica* with the wild species from Madagascar have failed.

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[2]

[Total 6 marks]

33. In 2004, researchers at the coffee gene bank in Brazil found three plants of *C. arabica* from Ethiopia with a very low caffeine content thanks to a mutation in the gene for caffeine synthase. It is hoped that the three plants may be cultivated to produce a commercial variety. This process might be speeded up by the use of cloning using tissue culture.

Outline the main steps involved in cloning plants using tissue culture.

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[Total 5 marks]

34. Plants from a different species of coffee plant, *C. canephora*, have been genetically engineered to have a low caffeine content by suppressing the activity of caffeine synthase.

Describe **one** advantage and **one** disadvantage of producing coffee plants with inactive caffeine synthase by genetic engineering rather than by selective breeding.

advantage

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[2]

disadvantage

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[2]

[Total 4 marks]

35. Self-incompatibility in *P. rhoeas* is controlled by a locus, **S**, coding for proteins in the pollen and stigmas of the flowers. The locus has a large number of alleles and even small populations have a large number of different genotypes.

Pollen is rejected when its haploid genotype is the same as either of the two alleles of the diploid stigma of the recipient plant. Pollen with a different allele is compatible.

- (i) Complete the table to show whether pollen is accepted (✓) or rejected (✗) by each stigma.

genotype of haploid pollen	genotype of diploid stigma	pollen accepted (✓) or rejected (✗)
S₁	S₁S₂	
S₂	S₁S₂	
S₁	S₂S₃	
S₂	S₂S₃	

[4]

(ii) State, **with a reason**, whether the variation shown is continuous or discontinuous variation.

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[2]

[Total 6 marks]

36. Recombinant DNA technology, using restriction enzymes, enables bacteria such as *Escherichia coli* to produce human proteins.

(i) Explain what is meant by a *restriction enzyme*.

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[3]

(ii) Outline the formation of recombinant DNA.

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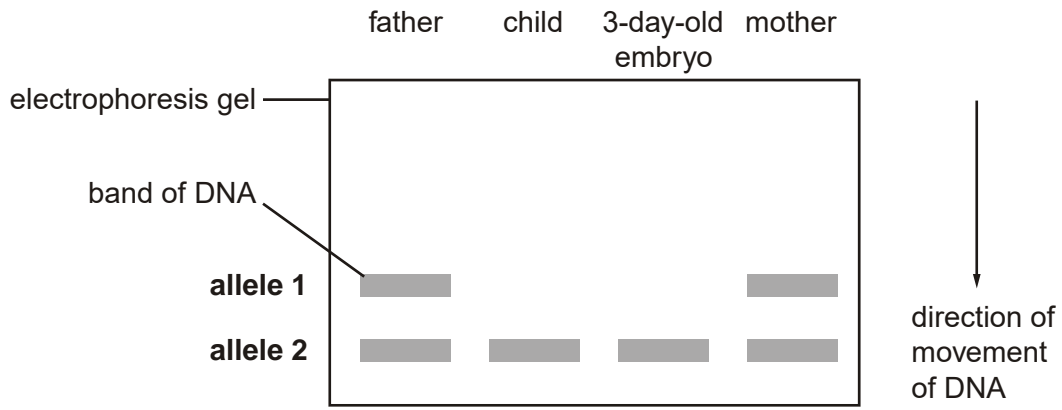
[4]

[Total 7 marks]

37. A couple who already had a child affected by Cystic fibrosis (CF) underwent pre-implantation genetic diagnosis.

In this process, a single cell, taken from one of several three-day-old embryos created by *in vitro* fertilisation (IVF), can be tested for CF.

The resulting DNA banding pattern produced by electrophoresis is shown in the figure below.



(a) Using the information above,

(i) explain why the three-day-old embryo will develop CF;

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.....

[2]

(ii) explain why the position of **allele 2** on the electrophoresis gel indicates that it contains a deletion in comparison with **allele 1**.

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[3]

(b) State the probability of another of the couple's three-day-old embryos having CF.

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[1]

[Total 6 marks]

38. Some drinking water is extracted from the ground. Groundwater is tested for a range of substances including nitrate ions.

Explain why the presence of nitrate ions in ground water is a cause for concern.

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[Total 4 marks]

39. In this question, one mark is available for the quality of the use and organisation of scientific terms.

The caterpillar of the Large Elephant Hawk Moth feeds on willowherb. Describe in detail how you could investigate the distribution and abundance of willowherb in a nature reserve.

[7]

Quality of Written Communication [1]

[Total 8 marks]

40. Hedgerows and other semi-natural habitats can act as 'wildlife corridors' in the fragmented landscape of arable farmland. Hedgerows also provide refuges for beneficial invertebrates including natural predators of pest species.

Suggest what is meant by the term 'wildlife corridor'.

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[Total 2 marks]

41. The use of natural predators is a form of biological pest control. Some farmers rely only on biological pest control.

Describe **two** disadvantages of biological pest control.

1
.....
2
.....

[Total: 2 marks]

42. Suggest **two** advantages, **other than predation of pests**, of maintaining invertebrate populations in arable land.

1
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2
.....

[Total: 2 marks]

43. Farmers who only use biological pest control on their crops can often market their produce as organic. Describe **three** advantages of organic farming.

1

.....

2

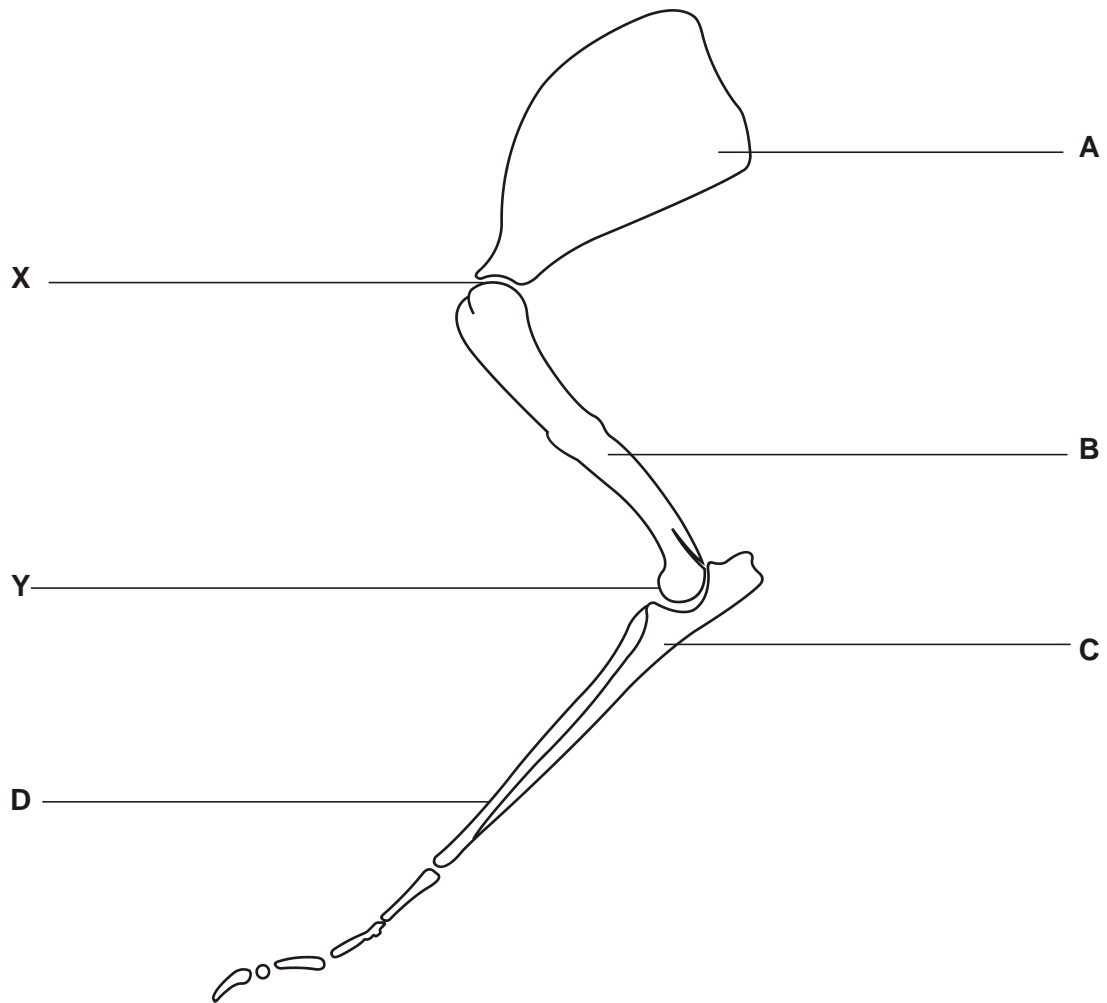
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3

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[Total: 3 marks]

44. The figure below shows the major bones of the front leg of a cheetah.



(i) Name bones **A** to **D**.

A

B

C

D

(ii) Joints **X** and **Y** are synovial joints. Describe the roles played by ligaments and cartilage in this type of joint.

ligaments

.....

.....

.....

cartilage

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.....

.....

[4]

(iii) The muscles that move the lower part of the front leg at joint **Y** are antagonistic. Describe how antagonistic muscles are used to move the lower arm of a human.

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[3]

[Total 9 marks]

45. Calcium ions are necessary for the contraction of rabbit's striated muscle.

Describe the role played by calcium ions in the contraction of striated muscle.

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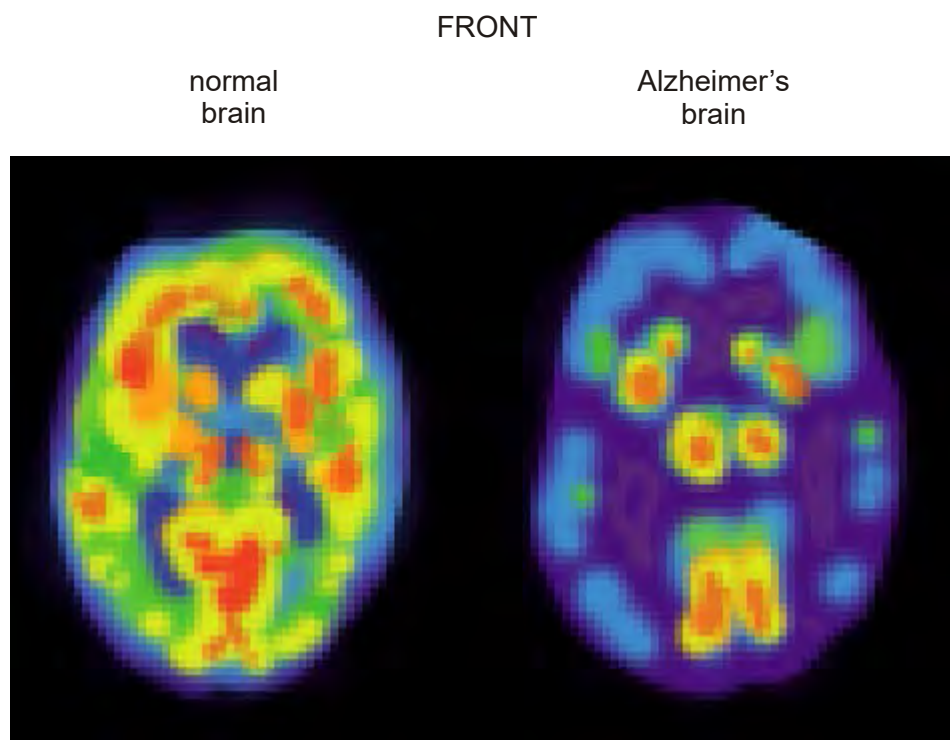
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[Total: 3 marks]

46. A positron emission tomography (PET) scan can be used to investigate the activity of the brain. PET scans can help to diagnose conditions such as Alzheimer's disease. A radioactive isotope is attached to molecules similar to glucose and injected into the blood supplying the brain. The molecules with the radioactive isotope are taken up by healthy cells, but are not metabolised. Instead they emit positrons, which can be detected by the PET scanner.

The figure below shows PET scans of a normal brain and the brain of a person with Alzheimer's disease.

- Red and yellow indicate high emissions of positrons.
- Blue and black indicate low emissions of positrons.



With reference to the figure and the information above, explain the differences between the two PET scans.

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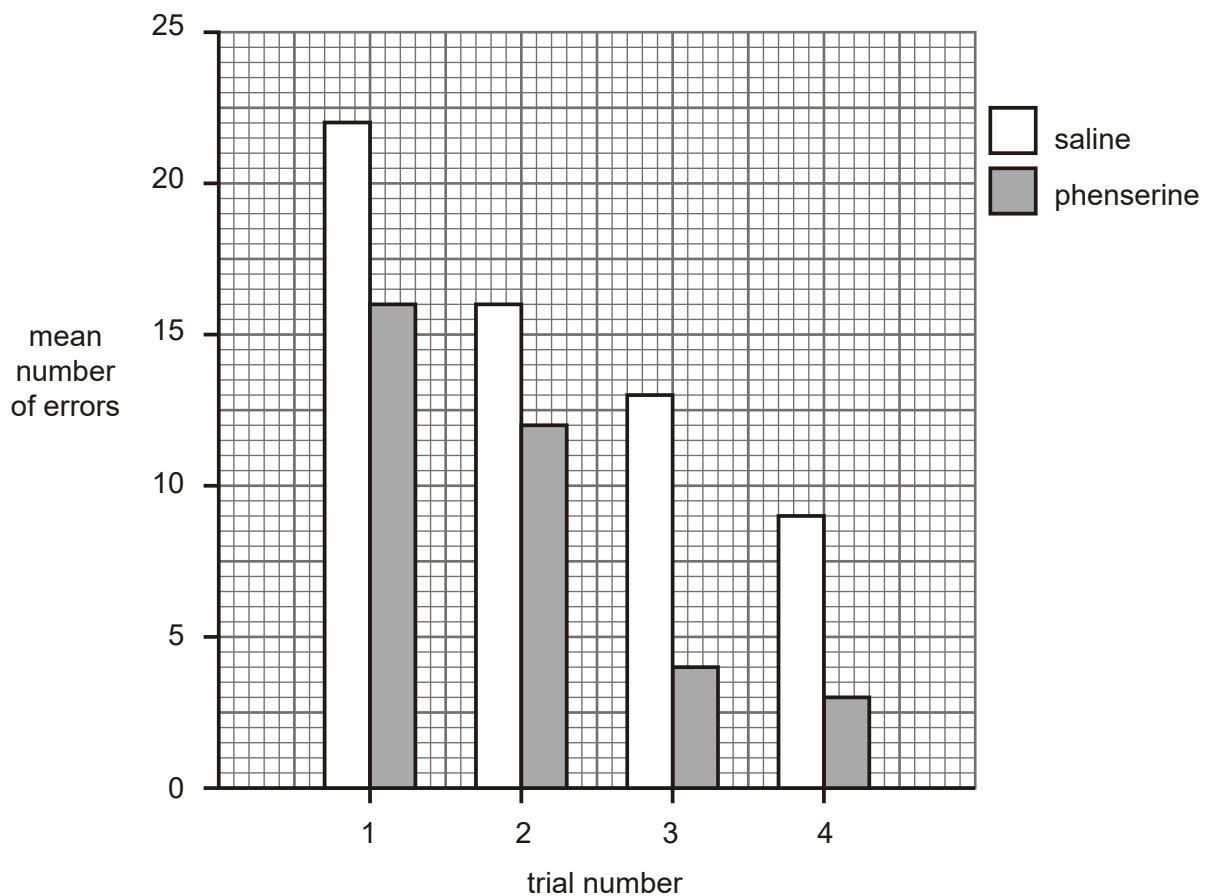
[Total: 3 marks]

47. One form of treatment for people with Alzheimer's disease is to use drugs that act on acetylcholinesterase.

A study using one of these drugs, phenserine, was carried out on elderly rats.

- Ten rats were given injections of saline and another ten were given injections of phenserine.
- Each rat was placed in a maze and the entrance was shut.
- Each rat was allowed to find its way to the exit.
- The number of errors made was recorded.
- The experiment was repeated a further three times with each rat.

The results of the experiment are shown in the following figure.



- (i) Explain why some rats were given an injection of saline.

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.....

(ii) Describe the results shown in the figure above.

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[2]

(iii) Explain briefly the type of learning taking place.

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[3]

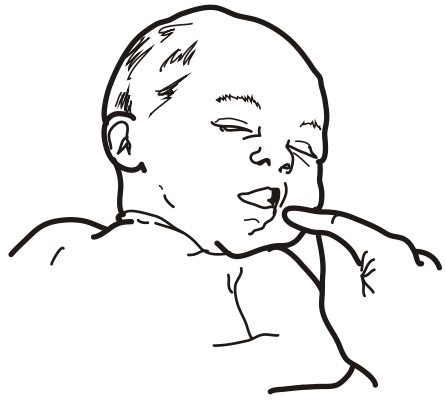
(iv) Suggest how phenserine may work in the brain.

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[3]

[Total 9 marks]

48. If the cheek of a newborn baby is brushed with a finger, as shown in the figure below, the baby will turn its head towards the finger.



Describe the type of behaviour shown by the baby and suggest an advantage of this response.

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[Total 4 marks]

49. All organisms can be classified according to where they get their energy and the element carbon. The table below shows the four forms of nutrition (photoautotrophic, photoheterotrophic, chemoautotrophic, chemoheterotrophic) that are possible. A number of different bacteria (kingdom Prokaryotes) are shown in the table to identify their forms of nutrition.

		CARBON SOURCE	
		carbon dioxide (autotrophic)	organic carbon (heterotrophic)
ENERGY SOURCE	light (phototrophic)	photoautotrophic cyanobacteria	photoheterotrophic purple non-sulphur bacteria
	chemical reactions (chemotrophic)	chemoautotrophic nitrifying bacteria	chemoheterotrophic saprophytic bacteria

- (a) Complete the table with the names of two **other** kingdoms. **Write your answers on the dotted lines in the shaded boxes.**

[2]

- (b) Explain why organisms need to obtain energy and carbon.

energy

.....

.....

.....

.....

.....

carbon

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.....

[4]

- (c) Nitrifying bacteria are chemoautotrophs. Some nitrifying bacteria gain energy from converting nitrite ions (NO_2^-) to nitrate ions (NO_3^-).

Explain how the activity of these bacteria affects the growth of plants in an ecosystem.

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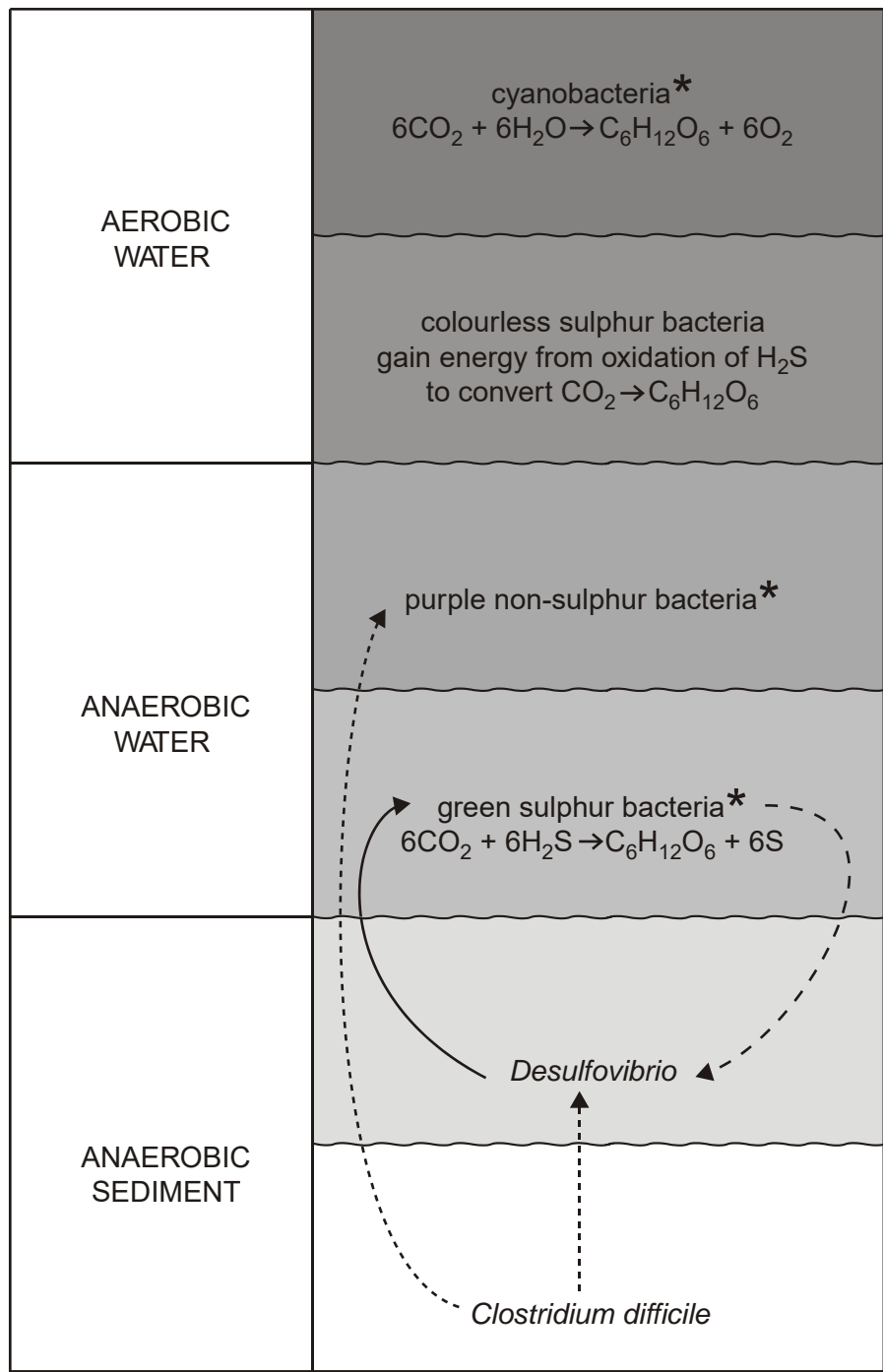
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[2]

Bacteria are metabolically very diverse and show all four forms of nutrition identified in the table above. This diversity can be shown in a simple piece of apparatus called a Winogradsky column.

A glass tube, 30 cm tall and 5 cm in diameter, is set up with the lower third containing river mud, some shredded newspaper as a source of cellulose, and the minerals sodium sulphate and calcium carbonate. The top two-thirds of the column is filled with river water and the tube is sealed and placed under a bright light source. After three months different types of bacteria establish themselves in zones.

Fig. 1 shows some chemical changes occurring in a Winogradsky column containing six types of bacteria.



Arrows show flow of:

-▶ organic acids
- ▶ hydrogen sulphide
- - - -▶ sulphur

Bacteria marked * depend on light for their metabolism.

Fig. 1

Fig. 2 gives more details of the metabolic activities of the six types of bacteria.

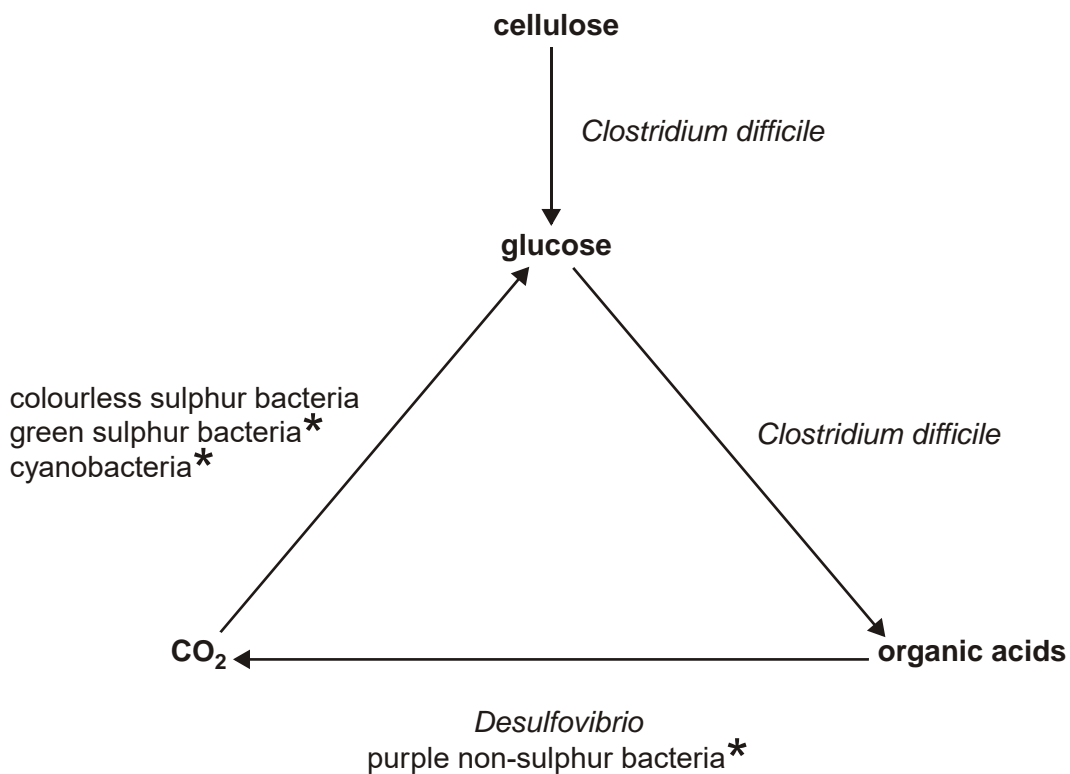


Fig. 2

(d) Use the information given in Figs. 1 and 2, and in the table to identify the forms of nutrition of

(i) *Clostridium* and *Desulfovibrio*

[1]

(ii) green sulphur bacteria

[1]

(e) (i) Name the element that is being recycled in Fig. 2.

.....

[1]

(ii) Use Fig. 1 to describe how **two** named types of bacteria recycle sulphur in the Winogradsky column.

.....
.....
.....
.....

[2]

(f) Unusual communities of animals are found deep in the ocean in warm, sulphur-rich water.

Use the information given in Figs. 1 and 2 to suggest which type of bacteria is the **producer** at the base of food chains in these communities.

.....

[1]

(g) Gas gangrene is a condition caused by the bacterium *Clostridium perfringens*.

Suggest why gas gangrene only occurs in severely damaged tissue where blood supply is restricted.

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.....

[2]

[Total: 16 marks]

50. (a) Part of the **DNA** base sequence coding for a protein is shown below.

A T G G C C T A A G T G

(i) State the corresponding base sequence of **mRNA**.

.....

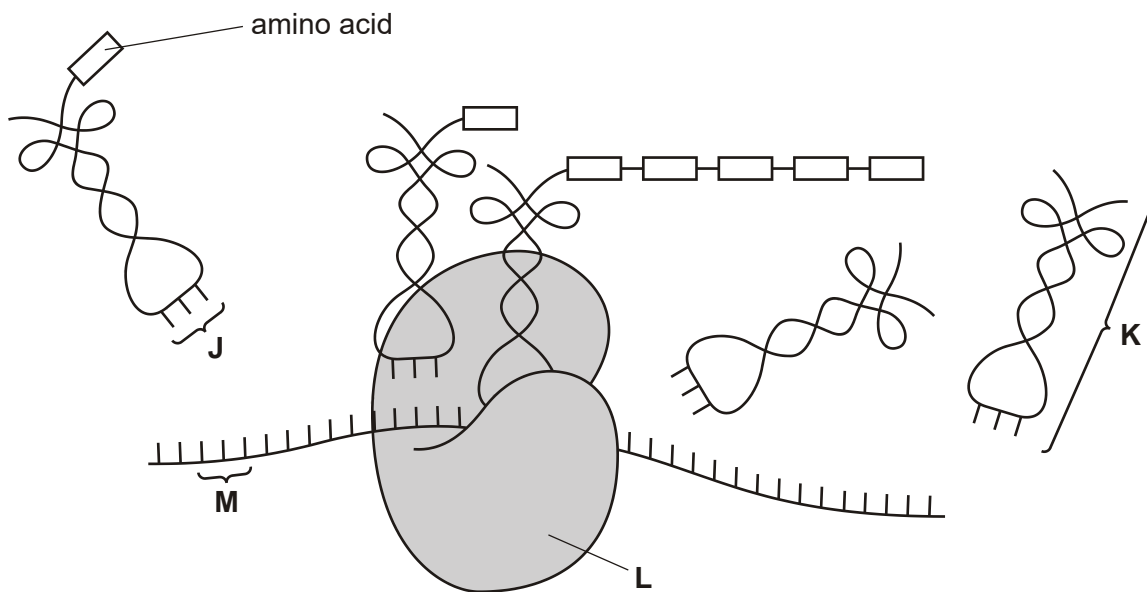
[2]

(ii) Name the process by which the DNA code is transferred to mRNA.

.....

[1]

(b) The figure below is a diagram that shows the stage in protein synthesis when amino acids are joined in the correct sequence to make the primary structure of the protein.



(i) Name **J** to **M**.

The group of bases at **J**

K

.....

L

The group of bases at **M**

[4]

(ii) Using the information in the diagram to help you, explain how amino acids become arranged into the correct sequence in the primary structure of the protein.

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[4]

(c) Mistletoe is a parasitic plant that produces lectin 1, a ribosome-inactivating protein. Lectin 1 inhibits protein synthesis in the cells of the host plant.

Suggest how lectin 1 could inhibit protein synthesis.

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.....

[2]

[Total 13 marks]

51. In this question, one mark is available for the quality of the use and organisation of scientific terms.

People who have one form of diabetes are unable to make insulin. In order to control blood sugar concentration, these people need to receive insulin. Originally, insulin was obtained from animals, such as pigs. Now, bacteria are transformed by genetic engineering to make proteins, such as insulin. This is the source of the majority of insulin now used by diabetics.

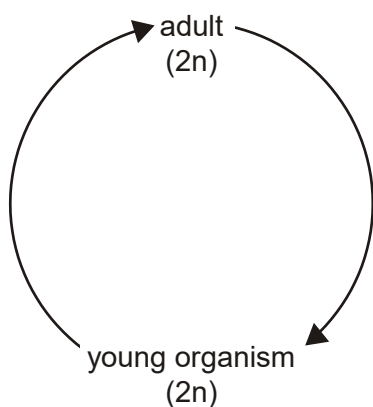
Describe how genetic engineering has been used to produce human insulin **and** the advantages of obtaining insulin in this way.

[8]

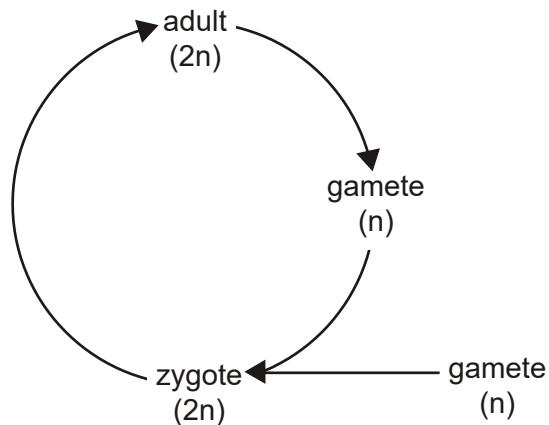
Quality of Written Communication [1]

[Total 9 marks]

52. The diagram below shows the life cycles of two organisms, **A** and **B**.



organism A



organism B

- (i) Name the type of reproduction taking place in the life cycle of organism **A**.

.....

[1]

- (ii) Explain why it is important that the gametes in the life cycle of organism **B** contain the haploid number of chromosomes.

.....

.....

.....

.....

[2]

[Total 3 marks]

- 53.** (a) Plants rely on the cycling of nitrogen to supply them with nitrogen in a form that they can absorb.

Select, from the list, the most suitable word or term that matches the statements (i) to (iv) below.

active transport

nitrogen fixation

denitrification

Nitrobacter

denitrifying bacterium

Nitrosomonas

diffusion

osmosis

endocytosis

Rhizobium

nitrification

- (i) The conversion of nitrate ions into nitrogen gas.

.....

[1]

- (ii) A bacterium that fixes nitrogen.

.....

[1]

(iii) A method by which nitrate ions pass into root hair cells.

.....

[1]

(iv) The conversion of ammonium ions into nitrite ions.

.....

[1]

(b) Before the widespread use of artificial fertilisers, farmers used a variety of methods to improve the fertility of the soil and so improve the yield of their crops. Two of the methods in common use were:

- **Ploughing-in**
In which legumes, such as beans, alfalfa or clover, were grown in a field and then harvested. The roots were then ploughed back into the soil rather than being dug up or burnt.
- **Crop rotation**
In which different crops were grown in a field in each year for three years. In the fourth year, the 'fallow' year, the field was not used for crops. In the following year the crop cycle was started again.

Explain how ploughing-in and crop rotation are able to improve the fertility of the soil.

Ploughing-in

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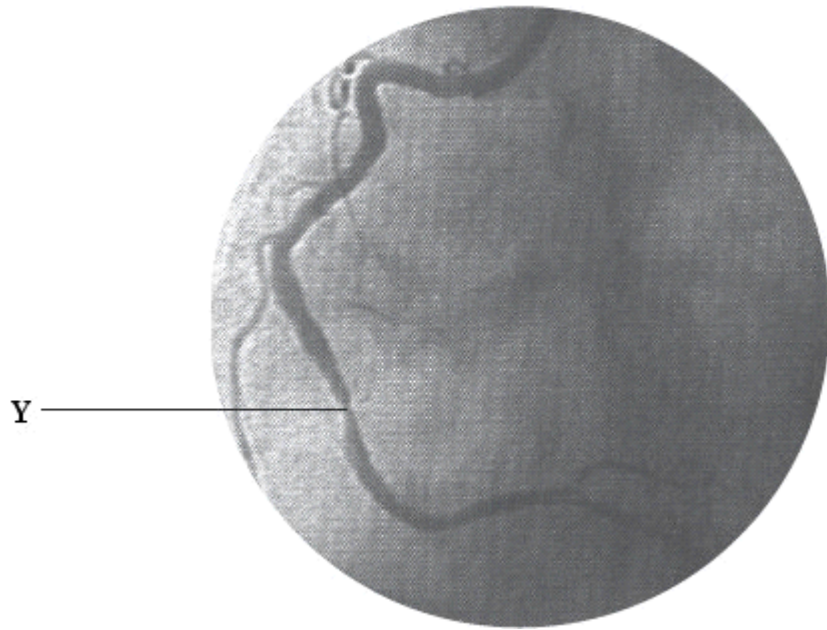
Crop rotation

.....
.....
.....
.....

[4]

[Total 8 marks]

54. The diagram below shows an artery lying on the surface of living heart muscle as seen by an instrument called an endoscope. The lumen of the artery has become narrowed at the point labelled Y.



The Forum on Ischaemic Heart Disease.
Reproduced by kind permission of Dr Graham Jackson,
Cardiology Unit, Guy's and St Thomas' Hospital.

(i) Describe the effects that this narrowing of the artery is likely to have on the **heart muscle**.

.....

.....

.....

.....

.....

.....

(ii) State **two** symptoms that might be shown by a person whose artery has been narrowed in this way.

1

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2

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[2]

[Total 5 marks]

55. Primary succession is the simplest type of succession, beginning with a bare surface such as rock or sand. The first organisms to colonise the area form the pioneer community.

Describe **two** effects of the pioneer community on the habitat.

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[Total 2 marks]

56. Chalk grassland communities are found in areas of southern England such as the South Downs. Woodland rather than grassland is the climax community for this habitat. Grazing by sheep and rabbits maintains the grassland.

(i) Define the term *climax community*.

.....

.....

[1]

- (ii) Suggest how grazing by sheep and rabbits could prevent a woodland climax community from developing.

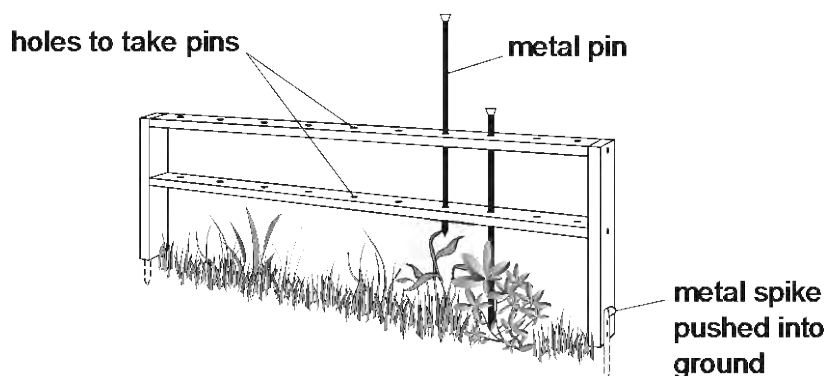
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[1]

[Total 2 marks]

57. A common plant found in chalk grassland communities is bird's foot trefoil. A group of students used a point quadrat to determine the percentage cover of bird's foot trefoil in an area of chalk grassland. They placed the point quadrat at one position on the grassland and lowered the metal pins, as shown in the figure below. They recorded the first hit on each species made with each pin. This was repeated at nine other randomly selected locations within the area of grassland. Their results are shown in the following table.



quadrat number	1	2	3	4	5	6	7	8	9	10
number of hits on bird's foot trefoil	3	8	7	8	9	3	2	1	2	1
number of hits on other species	16	21	20	13	16	21	24	16	20	28

An estimate of percentage cover for a species can be made by calculating the number of hits as a percentage of the total hits.

- (a) Using the results in the table above, calculate the percentage cover for bird's foot trefoil. Show your working and express your answer to the nearest 0.1%.

Answer =%

[2]

- (b) A footpath runs through the area of grassland and one student observed that very few bird's foot trefoil plants were found on the trampled areas.

Explain how the students could use a transect to determine whether there is a link between trampling and the abundance of bird's foot trefoil on this footpath.

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[5]

[Total 7 marks]

58. Coat colour in rabbits is determined by a single gene which has four separate alleles. The gene is **not** sex linked.

- The allele for agouti colour, C^A , is dominant to all the other alleles.
- The allele for albino, C^a , is recessive to all the other alleles.
- The allele for chinchilla, C^{Ch} , is dominant to the Himalayan allele, C^H .

State all the possible genotypes for the following phenotypes:

chinchilla

agouti

[Total 2 marks]

59. In the wild, rabbits have a high reproductive rate. However the population size remains fairly stable.

Explain how this stability is maintained **and** how the gene pool of the rabbit population may be affected.

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[Total 5 marks]

60. Plants must respond to changes in both their external and internal environments. Communication in plants is achieved by using a number of plant growth regulators.

List **three** stimuli that plants respond to.

1

2

3

[Total 3 marks]

61. In this question, one mark is available for the quality of the use and organisation of scientific terms.

Micropropagation (tissue culture) is one method used for the artificial propagation of new plants. Small amounts of tissue are obtained from plants and used to produce clones.

The information below is about some of the steps in the process.

- Tissue from apical or lateral buds is used.
- The surface of the tissue is cleaned using a sterilising agent.
- The growth medium contains cytokinins.
- The growth medium contains magnesium ions, nitrate ions and sucrose.
- When shoots form they are transferred to a medium containing auxins.

Explain the importance of each of the above steps.

[6]

Quality of Written Communication [1]

[Total 7 marks]

62. (a) Explain the meaning of the terms *linkage* and *crossing over*.

linkage

.....

crossing over

.....

.....

[3]

- (b) In an investigation into the genes on chromosome 2 of the tomato genome, pollen from a pure-bred plant with green leaves and smooth-surfaced fruit was transferred to flowers of a plant with mottled green and yellow leaves and hairy (so-called 'peach') fruit. All the F₁ generation had green leaves and smooth fruit.

Describe briefly how a plant breeder ensures that the offspring produced are **only** from the desired cross.

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[3]

- (c) Four different test crosses, **A** to **D**, were then made between F₁ plants and pure-bred plants with mottled leaves and 'peach' fruit. The phenotypes of 50 offspring of each of the crosses were recorded and are shown in the table below.

cross	phenotypes of offspring of test crosses			
	green leaves and smooth fruit	green leaves and 'peach' fruit	mottled leaves and smooth fruit	mottled leaves and 'peach' fruit
A	23	4	3	20
B	21	3	3	23
C	16	4	5	25
D	22	6	4	18
total	82	17	15	86

- (i) Suggest **one** reason why, in the table above, the numbers of plants with green leaves and smooth fruit is not the same in each of the crosses **A** to **D**.

.....

.....

.....

[1]

- (ii) The percentage cross over value is calculated as

$$\frac{\text{number of recombinant offspring}}{\text{total number of offspring}} \times 100$$

Using the information in the table above, calculate the percentage cross over value between the loci for leaf colour and fruit surface texture. Show your working.

Answer = %

[2]

- (iii) Use annotated diagrams of tomato chromosome 2 to explain the results of the test crosses shown in the table.

Use the symbols **A/a** for the leaf colour alleles and **B/b** for the fruit surface texture alleles.

[6]

[Total: 15 marks]

63. (i) Outline the principle of selective breeding.

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[2]

(ii) Explain the use of progeny testing in selective breeding.

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[4]

[Total 6 marks]

64. In this question, one mark is available for the quality of spelling, punctuation and grammar.

In 1959, a breeding colony of 100 female and 30 male Siberian foxes was established in Russia. For the next 45 years, they were selectively bred for **one** trait only: that of lack of aggression to humans (tameness).

By the end of 2004, the behaviour and appearance of the selectively bred foxes differed from wild foxes in the following ways:

- their fur had white patches
- their muzzles were shorter
- some had floppy ears and curly tails
- they whimpered to attract human attention, wagged their tails and licked the human's hand.

Describe how selective breeding of animals is carried out **and** explain how selectively breeding for **one** trait may result in many differences between selectively bred and wild animals.

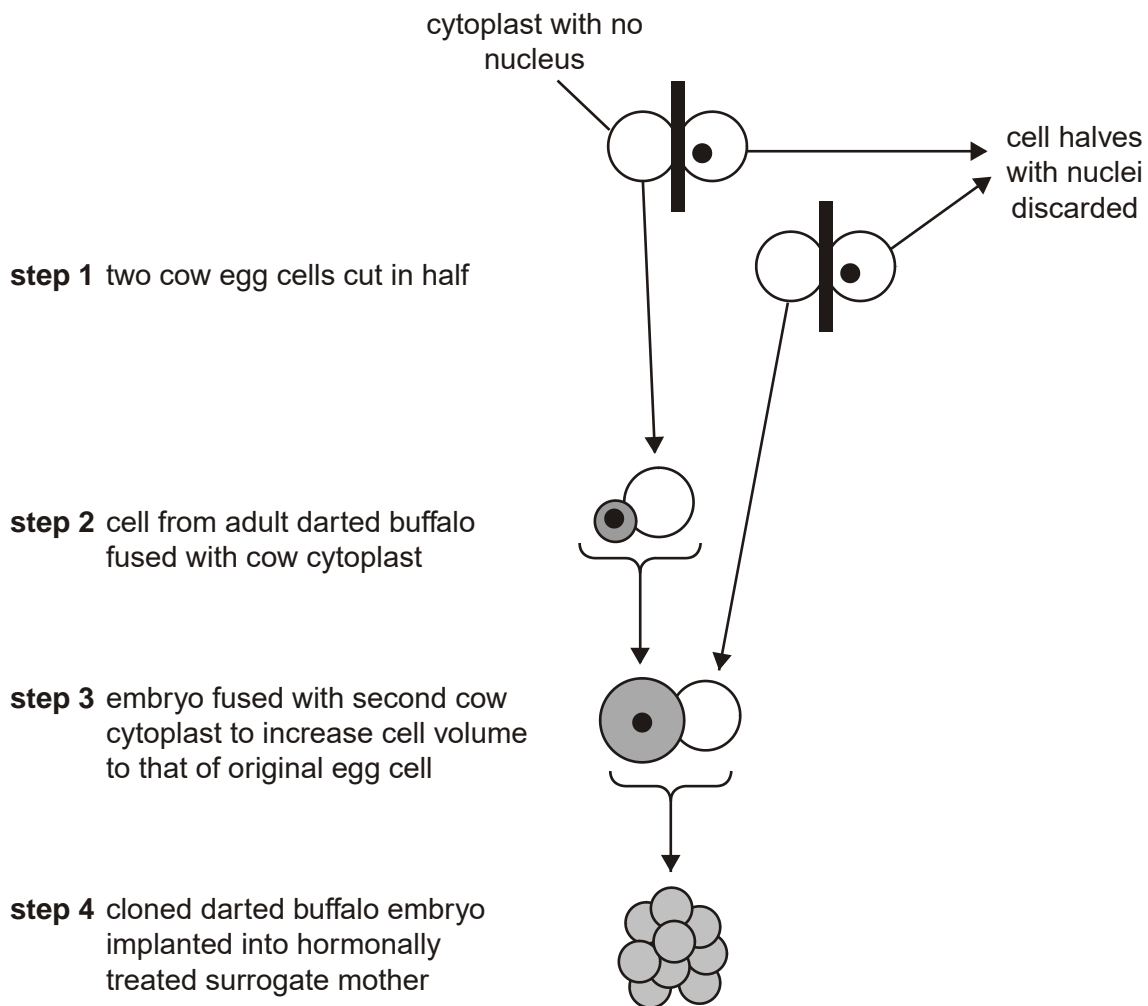
[8]

Quality of Written Communication [1]

[Total 9 marks]

65. (a) The Endangered Wildlife Trust in South Africa uses a cloning technique to help conserve endangered species of mammal such as the darter buffalo.

A cell from an adult darter buffalo was fused with egg cells from domesticated cows, using the procedure outlined in the following figure.



With reference to the figure, explain

- (i) how a supply of cow egg cells is obtained for **step 1**;

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.....

(ii) why the cloned darted buffalo embryo produced in **steps 2 and 3** does **not** have exactly the same DNA as the adult darted buffalo from which a cell was taken;

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.....

[2]

(iii) why it is necessary to treat the surrogate mother with hormones in **step 4**.

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.....
.....

[3]

(b) Explain how a procedure such as that shown in the figure above can help save an endangered species of mammal.

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[4]

(c) State **three** ways of setting up a gene bank for the darted buffalo.

- 1
- 2
- 3.....

[3]

[Total: 15 marks]

66. The DNA target sites of four restriction enzymes are shown in the table below. The points at which the strands of DNA are cut are shown by arrows and lines.

restriction enzyme	target site
Sau3AI	$\begin{array}{c} \downarrow \text{G-A-T-C-} \\ \text{-C-T-A-G} \uparrow \end{array}$
BamHI	$\begin{array}{c} \text{-G} \downarrow \text{G-A-T-C-C-} \\ \text{-C-C-T-A-G} \uparrow \text{G-} \end{array}$
Hinfi	$\begin{array}{c} \text{-G} \downarrow \text{A-N-T-C-} \\ \text{-C-T-N-A} \uparrow \text{G-} \end{array}$ <p>'N/N' may be any complementary base pair</p>

With reference to the information above,

(i) describe the characteristics of a restriction enzyme's target site;

-
-
-

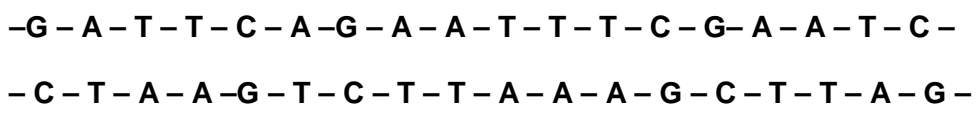
[2]

(ii) explain whether or not a piece of DNA cut by **Sau3AI** could join with one cut by **BamHI**;

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.....

[3]

(iii) show on the figure below the result of exposing this piece of DNA to **Hinfl**.



[1]

[Total 6 marks]

67. In this question, one mark is available for the quality of use and organisation of scientific terms.

Describe the roles of restriction enzymes and other enzymes in genetic engineering.

[8]

Quality of Written Communication [1]

[Total 9 marks]

68. (a) The malarial parasite, *Plasmodium*, and its vector, the mosquito, are both eukaryotes.

The treatment and control of malaria is difficult because *Plasmodium* rapidly develops resistance to most anti-malarial drugs as do mosquitoes to insecticides. Also, vaccine production has proved to be very difficult. The B-cell responses induced by experimental vaccines are not yet very effective.

Explain

- (i) the genetic basis of resistance in eukaryotes;

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[5]

- (ii) why producing an effective vaccine against *Plasmodium* has proved to be so difficult.

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[3]

- (b) A gene has been identified in several species of *Plasmodium* which codes for a small transmembrane protein.

A mutant form of *P. berghei* exists in which this protein is **not** produced. *P. berghei* infects mice. The mutants:

- develop normally in a mosquito and infect the salivary glands in numbers comparable to wild type parasites
- infect mouse liver cells but do not multiply
- do not infect red blood cells.

- (i) Describe **one** mutation of this gene that could have occurred in *P. berghei* so that the encoded protein is **not** produced.

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[2]

- (ii) Suggest **one** reason why mutant *P. berghei* **do not** infect red blood cells.

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[2]

- (c) It has been suggested that *Plasmodium* with this mutation could be used as a 'whole organism' vaccine against malaria.

Mice were inoculated with different numbers of mutant *Plasmodium* and then given one or two 'booster' inoculations. Their protection against infection by wild-type *Plasmodium* was compared with that of mice that had not been inoculated. The results of the investigation are shown in the table below.

number of mutant <i>Plasmodium</i>			percentage of mice resistant to infection by wild-type <i>Plasmodium</i>
in initial inoculation	in first booster inoculation	in second booster inoculation	
50 000	25 000	25 000	100
10 000	10 000	10 000	100
10 000	10 000	0	70
0	0	0	0

With reference to the information in the table and in (b), comment on the use of this mutant *Plasmodium* as a 'whole organism' vaccine.

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[3]

[Total: 15 marks]

69. In an experimental gene therapy for insulin-dependent diabetes, the insulin gene was combined with a glucose-sensitive promoter and inserted into liver cells of diabetic rats. The mean concentration of insulin was then measured at three different concentrations of blood glucose. The results are shown below.

concentration of blood glucose / mg dm^{-3}	mean concentration of insulin / ng cm^{-3}
100	0.3
300	5.0
500	7.0

With reference to the table above, explain the role of the glucose-sensitive promoter in this gene therapy.

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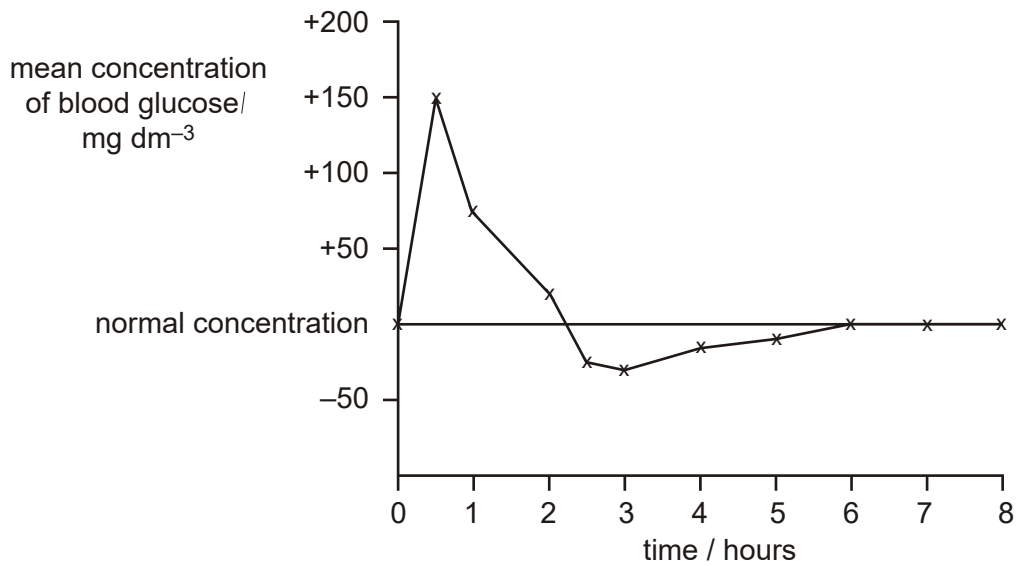
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[Total: 3 marks]

70. Treated rats were given a glucose meal and the concentration of blood glucose measured immediately and at intervals for eight hours. The results of this investigation are shown in the figure below.



With reference to the figure, discuss the possible **benefits** and **problems** of using this gene therapy in the treatment of diabetes in humans, rather than taking insulin.

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[Total 4 marks]

71. The numbers of musk deer have halved in ten years. In parts of China the populations have reached very low numbers. These populations are also widely separated.

Outline the possible consequences of this separation on the populations of musk deer.

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[Total 4 marks]

72. A study was carried out in south-east Scotland on the release of nitrous oxide (N_2O) from agricultural land. Nitrous oxide is produced by the action of bacteria in the soil.

In the study, six plots of grassland, **A** to **F**, were treated in different ways. Plots **B** to **F** were treated with substances containing nitrogen. The quantities applied to each plot contained the same mass of nitrogen, although in different compounds. The table below shows the results obtained for the various treatments.

plot	treatment	N_2O produced / kg ha^{-1}
A	nothing added	57
B	inorganic fertiliser	531
C	urea	190
D	sewage sludge	13 537
E	cattle manure	319
F	poultry manure	6 612

Describe **three** variables in this experiment that the researchers would have taken into account to ensure that the results were valid.

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2

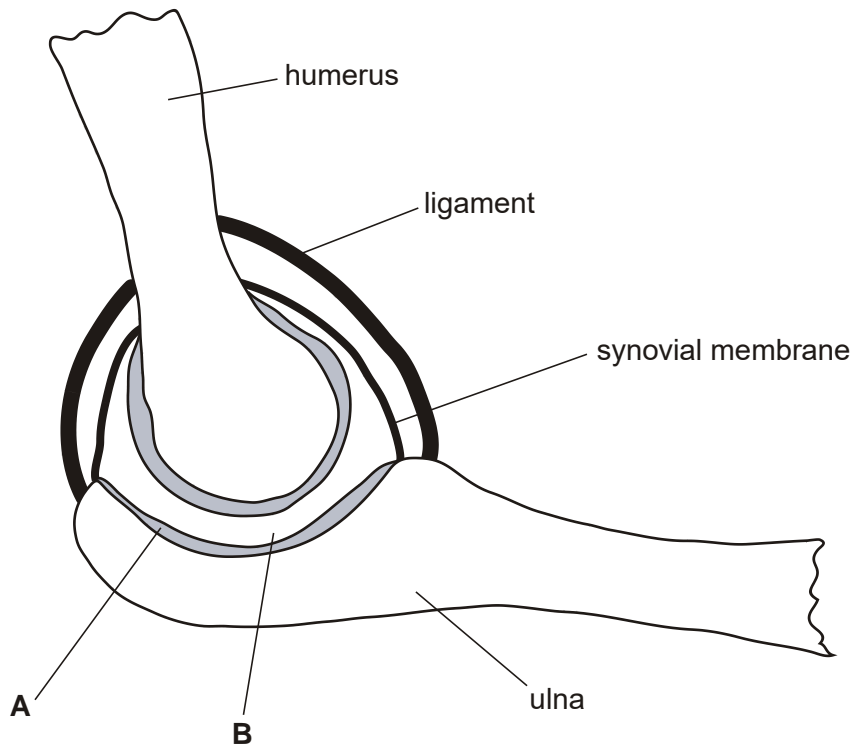
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[Total 3 marks]

73. The figure below shows a section through a human elbow joint.



(i) Name **A** and **B**.

A

B

[2]

(ii) Describe the roles of **A** and **B** in the movement of the elbow joint.

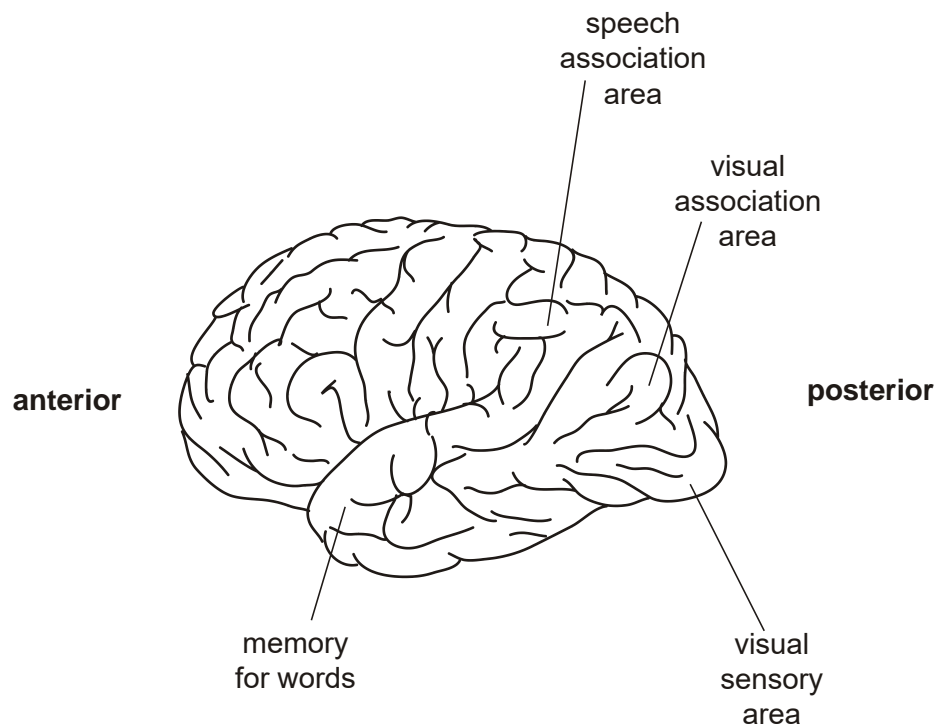
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[3]

[Total 5 marks]

74. In this question, one mark is available for the quality of spelling, punctuation and grammar.

The figure below shows the left side of the cerebrum of a human.



A person is reading a book. Outline the events that take place in the nervous system from the time an image of a word is formed on the retina to the time that word is recognised by the brain.

You may refer to the figure in your answer.

[6]

Quality of Written Communication [1]

[Total 7 marks]

75. The cerebellum and medulla oblongata are regions of the brain. The cerebellum is concerned with the control and coordination of movement and posture.

Suggest why the cerebellum of a chimpanzee is **relatively** larger than the cerebellum of a cow.

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[Total: 2 marks]

76. Classical conditioning concerns learning by association and was discovered by the Russian scientist Ivan Pavlov, using dogs.

A study was carried out on a group of people to test classical conditioning.

- Each person was given a slight electric shock on the hand, which caused the arm to be jerked back.
- The procedure was carried out again but this time a red light was shone just before the electric shock was applied.
- This was repeated many times.
- Eventually, when presented with a red light, most people withdrew their arms even though a shock was not applied.

For **this** study state precisely:

- (i) the conditioned stimulus
- (ii) the conditioned response

[Total: 2 marks]

77. Operant conditioning was initially investigated by the scientist B.F. Skinner, using rats.

Explain briefly how a rat can learn to press a lever in its cage.

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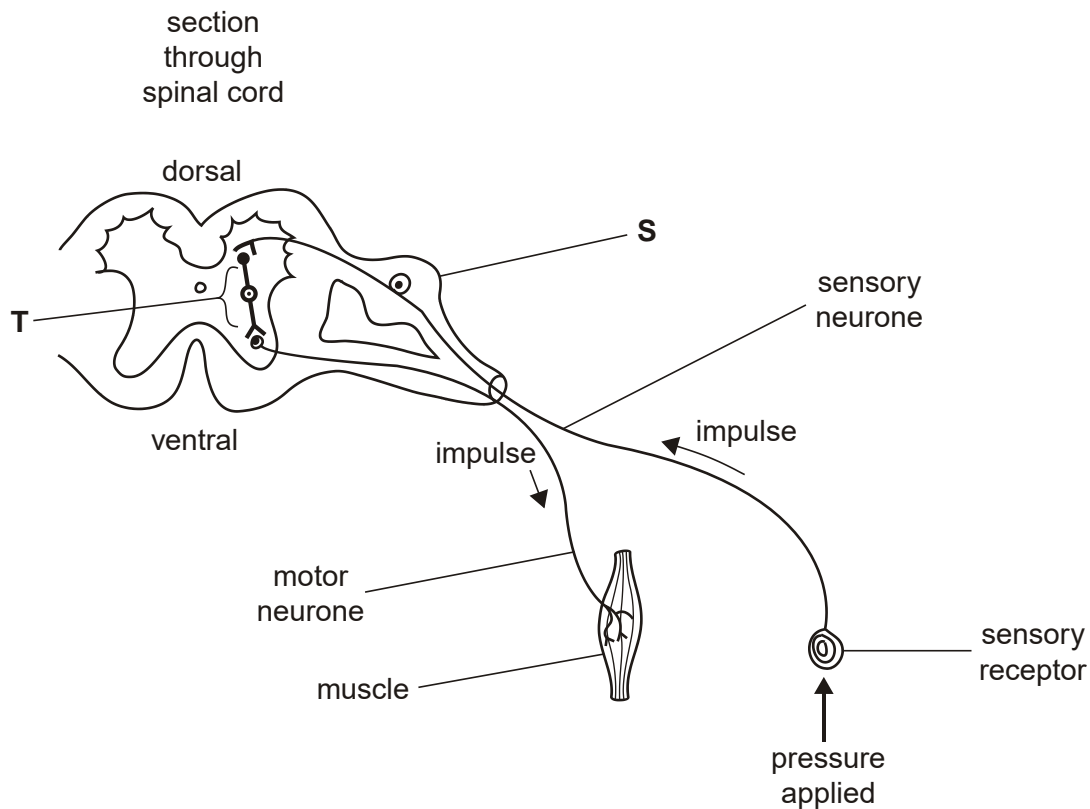
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[Total: 3 marks]

78. The figure below shows a simplified diagram of a mammalian reflex arc.



(i) Name **S** and **T**.

S

T

[2]

(ii) Explain why the withdrawal of a hand, which has been subjected to pressure, is an example of a reflex action.

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[3]

- (iii) In this reflex, when pressure is applied to the receptor, impulses are generated in the sensory neurone.

Outline what happens in the membrane of the sensory receptor in response to pressure.

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[3]

- (iv) Explain why, in the reflex arc shown in the figure above, impulses can only travel in the direction shown.

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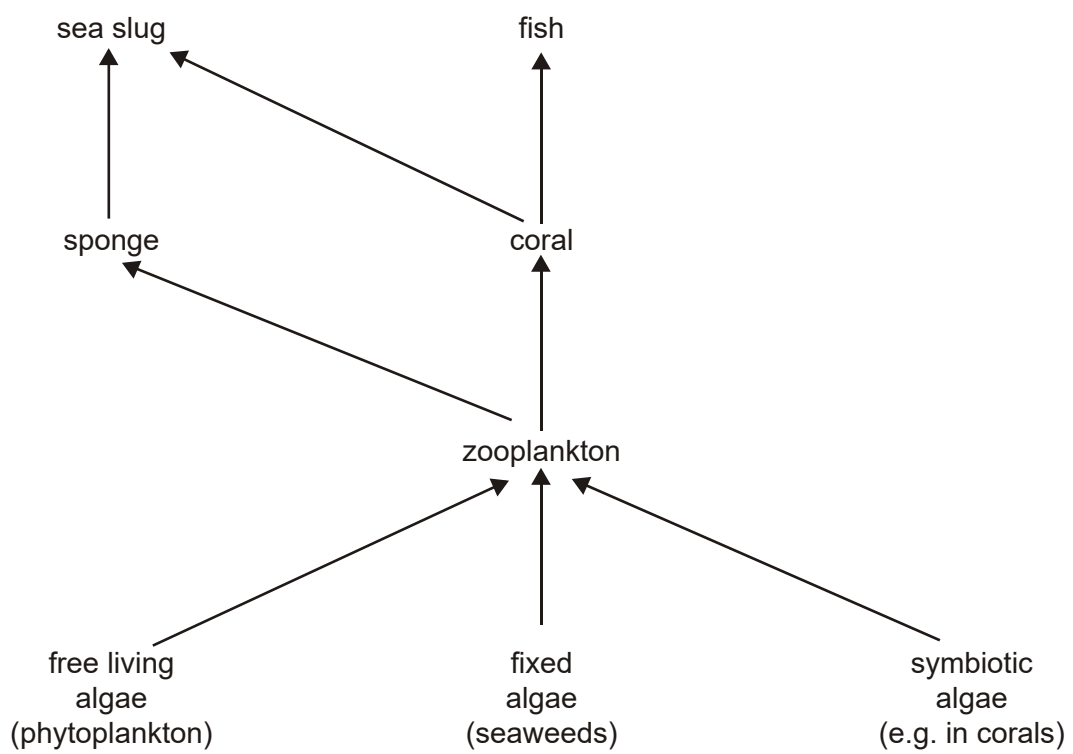
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[2]

[Total: 10 marks]

79. Coral reefs occupy 0.2% of the world's oceans but provide habitat and breeding grounds for 25% of the world's fish species. The figure below shows a food web for a coral reef community.



Reefs are under threat from a variety of sources. One of these is the water that drains from agricultural land that is rich in fertilisers. Another is the discharge of untreated sewage into the sea.

Explain how these forms of pollution could alter the ecological balance of a coral reef.

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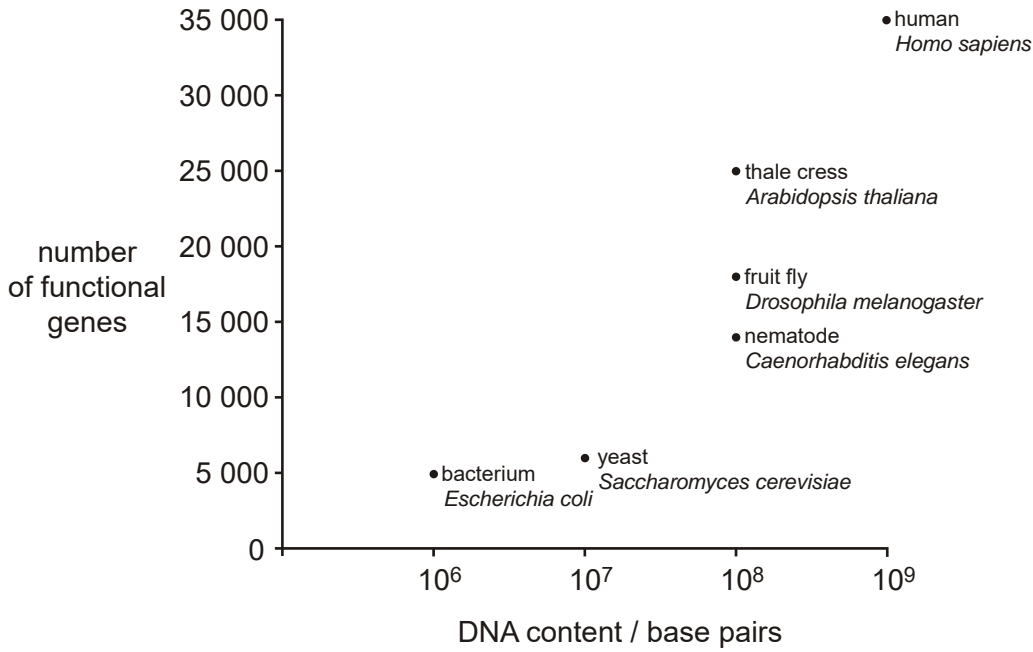
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[Total 4 marks]

80. Recent data shows that organisms vary widely in the size of their genomes. The figure below shows the number of functional genes plotted against the total length of DNA in six organisms. The length of DNA is measured in numbers of base pairs.



Adapted from Teresa Attwood, Bioinformatics: What use is it?, Biological Sciences Review, April 2003. Reproduced by kind permission of Philip Allan Publishers Ltd.

The figure shows that the human genome contains only about seven times as many functional genes as the bacterium *Escherichia coli*, but consists of about a thousand times as much DNA.

Suggest why humans have so much extra DNA despite having only seven times as many functional genes as the bacterium *E. coli*.

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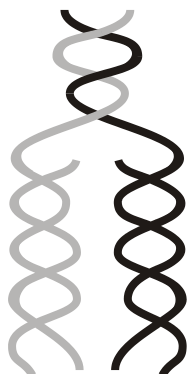
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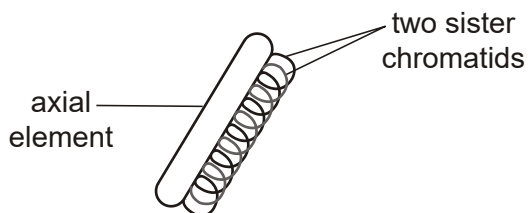
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[Total 2 marks]

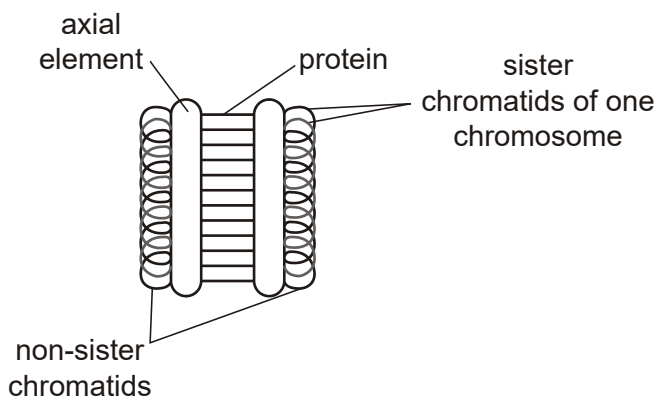
81. The following figure shows events leading to the formation of homologous pairs in meiosis.



- DNA **replicates** during interphase forming two sister chromatids.



- Both sister chromatids attach to a protein rod called the axial element.



- The axial elements of homologous chromosomes come together in the formation of a homologous pair (bivalent).

(i) Explain why the DNA in two sister chromatids is identical.

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(ii) Explain why the DNA in two sister chromatids in metaphase may no longer be identical.

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[2]

(iii) Suggest why axial elements are necessary in meiosis.

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[2]

[Total 6 marks]

82. Liver cells damaged by hepatitis infection switch on a gene called Fas, which causes them to self-destruct. Pioneering research has produced a strikingly successful treatment for hepatitis in mice. The Fas gene was silenced by the technique of RNA interference.

RNA molecules, 21 to 23 nucleotides long, were injected into mice with hepatitis. The sequence of this 'small interfering RNA' (siRNA) matched part of the Fas gene. Once in the liver cell the two strands of the siRNA were separated so that one strand could bind to the mRNA transcript of the Fas gene. This caused the mRNA to be destroyed by enzymes, therefore preventing the gene product from being made.

This therapy prevented liver cell death and considerably increased the survival of mice with hepatitis.

(a) (i) Describe a way in which the **function** of mRNA differs from that of DNA.

.....
.....

[2]

(ii) Describe **two** ways in which the **structure** of siRNA differs from mRNA.

1

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2

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[2]

(b) Describe how one strand of the siRNA can bind to the mRNA of the Fas gene.

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[3]

[Total: 7 marks]

83. The technique of RNA interference has been used to slow replication of HIV (Human Immunodeficiency Virus) *in vitro*. siRNA sequences that match the RNA genome of HIV can be used to trigger destruction of this RNA, preventing HIV from multiplying.

Another approach is to use RNA interference to silence genes for cell surface receptors, such as the CD4 and CCR5 molecules on human white blood cells. If these genes do not produce their protein antigens, HIV cannot bind to and infect the white blood cells.

The table below summarises some information about the two cell surface receptors used by HIV to bind to and infect white blood cells.

	cell surface receptor	
	CD4	CCR5
type of cell with this receptor	T lymphocyte white blood cells which divide by mitosis	macrophage cells which are long-lived and do not undergo mitosis
function of receptor	important roles in the immune system	limited, since 1% of people lack this receptor and show some resistance to HIV

Experiments have been carried out where,

- siRNAs matching the CD4 mRNA were introduced into test tube populations of T lymphocytes;
- siRNAs matching the CCR5 mRNA were introduced into test tube populations of macrophages.

In both cases HIV was present but the presence of the siRNAs reduced its replication.

- (i) Use the table to suggest with reasons which of the two test tube experiments showed most reduction of HIV replication.

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(ii) Explain which receptor would be the best target for RNA interference if the approach was used as a therapy for humans infected with HIV.

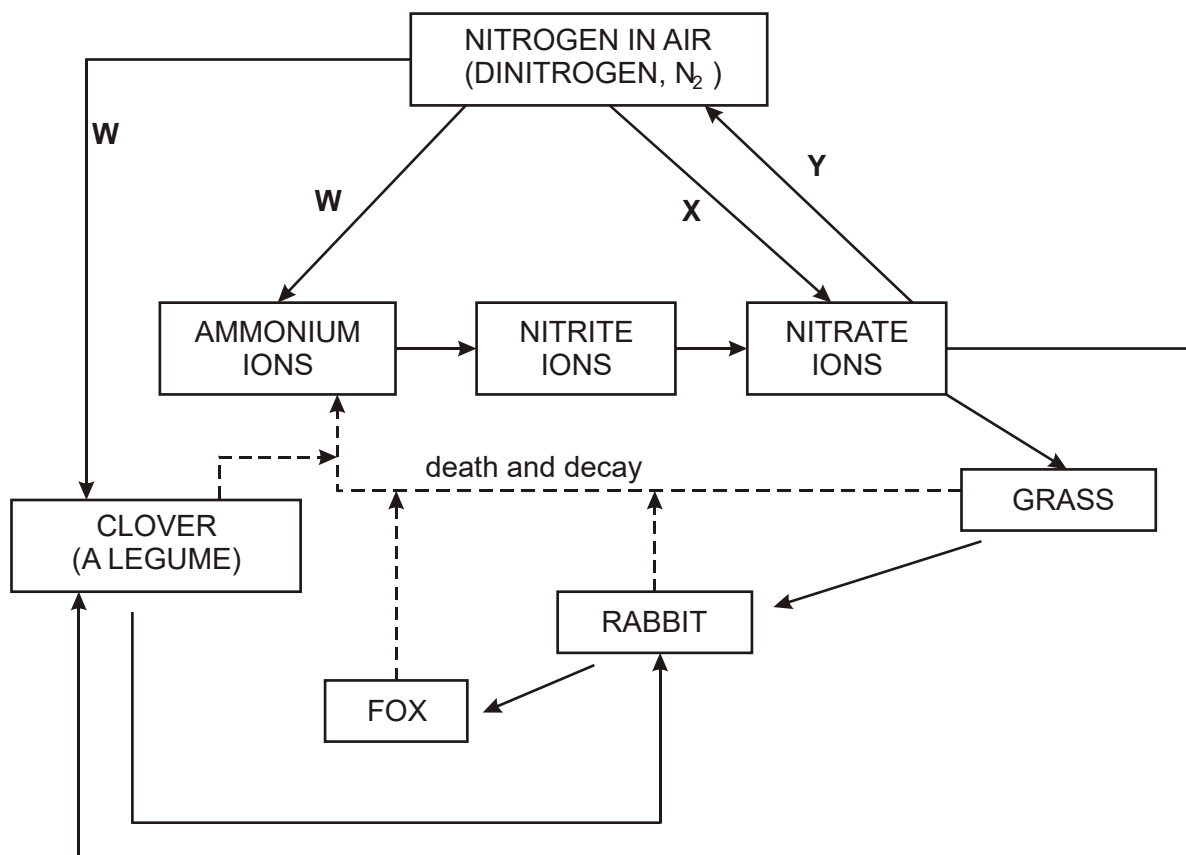
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[1]

[Total: 3 marks]

84. The diagram below shows part of the nitrogen cycle.



(a) Using **only** the information in the diagram, state **one** example of each of the following:

(i) secondary consumer;

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[1]

(ii) producer.

.....

[1]

(b) (i) Name the process **W**.

.....

[1]

(ii) State a way in which nitrogen in air can be converted directly into nitrate ions, as indicated by arrow **X**.

.....

[1]

(iii) State the type of bacteria that carry out process **Y**.

.....

[1]

- (iv) The bacterium *Rhizobium* also has a role in the cycle shown in the diagram.

Explain the importance of *Rhizobium* in the nitrogen cycle.

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[2]

[Total 7 marks]

85. Read the following passage and then answer the questions that follow.

Human Factor VIII is a glycoprotein found in blood plasma. It is involved in blood clotting.

5 This glycoprotein contains 2332 amino acids linked into a single chain. This chain is folded and coiled into a secondary structure and then further folded. The chain forms six individual regions, each with its own function.

An artificial source of Factor VIII, created using genetic engineering, is now used to treat patients with haemophilia, a medical condition in which the blood clots more slowly than normal. The Factor VIII gene is first removed from the genome of human cells. It is then inserted into the genome of hamster cells.

10 Cancer cells or cells taken from an ovary are usually used to produce Factor VIII as these grow very well in industrial tanks. The Factor VIII that is produced is then removed from the tanks and purified before use in treating patients.

(i) State the type of enzyme used to remove the gene for Factor VIII from the rest of the human genome (lines 8 and 9).

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[1]

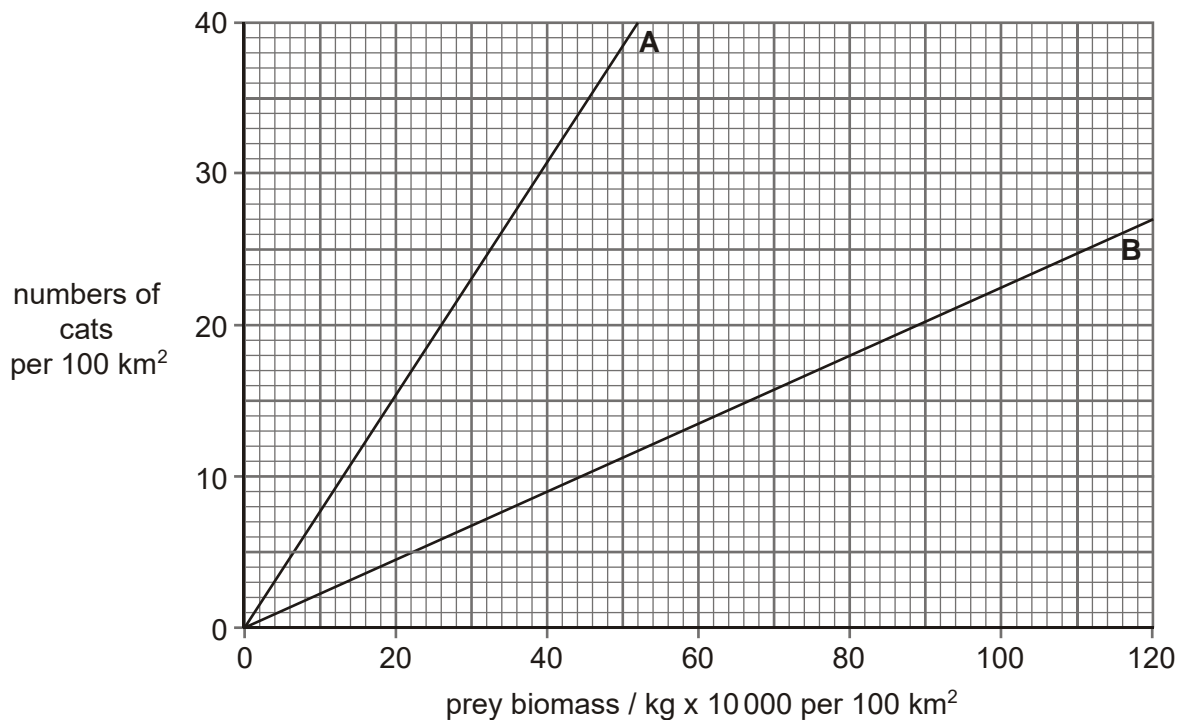
(ii) Name the enzyme used to insert the gene for Factor VIII into the genome of hamster cells (line 9).

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[1]

[Total 2 marks]

86. Tigers prey mainly upon large mammals. One of the threats to the survival of the tiger is a reduction in numbers of prey. The figure below shows the relationship between the numbers of two cat species, **A** and **B**, and the prey biomass.





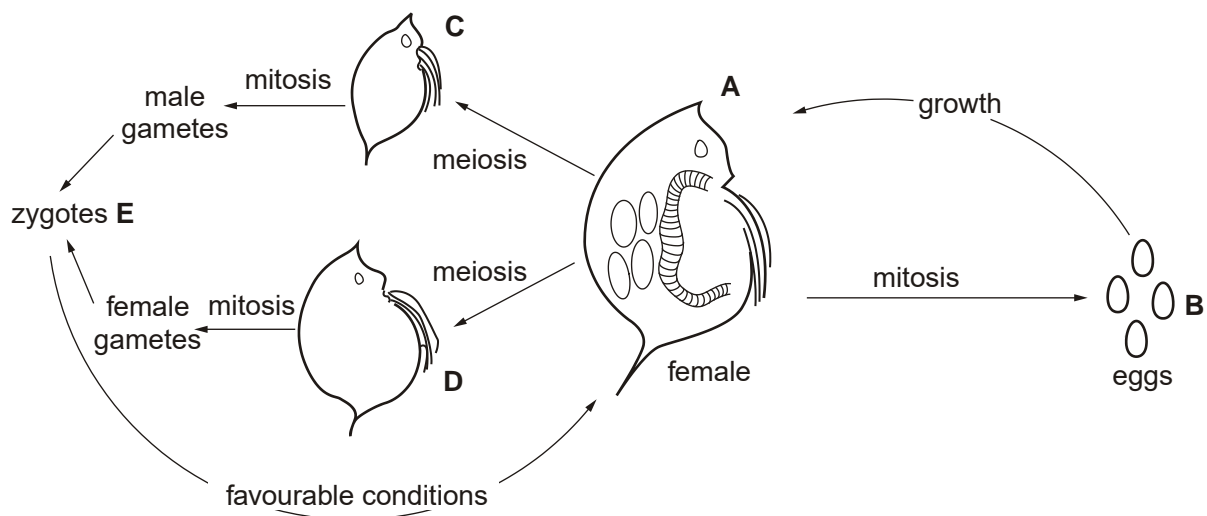
animals drawn to scale

Use the figure to determine the number of **(i)** leopards and **(ii)** tigers per 100 km^2 that can be expected to be supported by a biomass of $300\,000 \text{ kg}$ of prey per 100 km^2 .

- (i) leopards per 100 km^2
(ii) tigers per 100 km^2

[Total 2 marks]

87. The figure below shows several stages in the life cycle of the water flea, *Daphnia*.



- In favourable conditions, all the individuals in a population are females, **A**.
- These females produce eggs, **B**, by **mitosis** which develop into further females.
- In unfavourable conditions, eggs are produced by **meiosis** and develop without fertilisation into either males, **C**, or females, **D**.
- Gametes are produced by **mitosis** from **C** and **D**.
- The resultant zygotes, **E**, develop a protective case which enables them to survive unfavourable conditions.
- When favourable conditions return, these zygotes develop into young females.

(i) State which of the stages, **A** to **E**, contain individuals with the diploid number of chromosomes.

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(ii) Explain why the females in stage **A** show greater variation than the females in stage **D**.

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[2]

(iii) Explain why gametes are produced by mitosis from males **C** and females **D**.

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[2]

[Total 5 marks]

88. In this question, one mark is available for the quality of use and organisation of scientific terms.

Describe the behaviour of chromosomes during **meiosis** which results in genetic variation among *Daphnia* populations.

[7]

Quality of Written Communication [1]

[Total 8 marks]

89. The human ABO blood groups are A, B, AB and O. They are determined by a single gene with multiple alleles. I^A and I^B alleles are codominant, but both these alleles are dominant to the I^O allele.

In a maternity ward, the identities of four babies became accidentally mixed up. The ABO blood groups of the babies were discovered to be O, A, B and AB. The ABO blood groups of the four sets of parents were determined and are shown in the table below.

Complete the table to match each baby to its parents by indicating:

- the parental genotypes, using the symbols I^A , I^B and I^O ;
- the blood group of the baby which belongs to each set of parents.

parental blood groups	parental genotypes	baby blood group
O and O		
AB and O		
A and O		
AB and A		

[Total 4 marks]

90. In both plants and animals, chemical messengers help to transfer information from one part of the organism to another to achieve coordination.

The table below lists some of these chemicals together with their functions.

Complete the table.

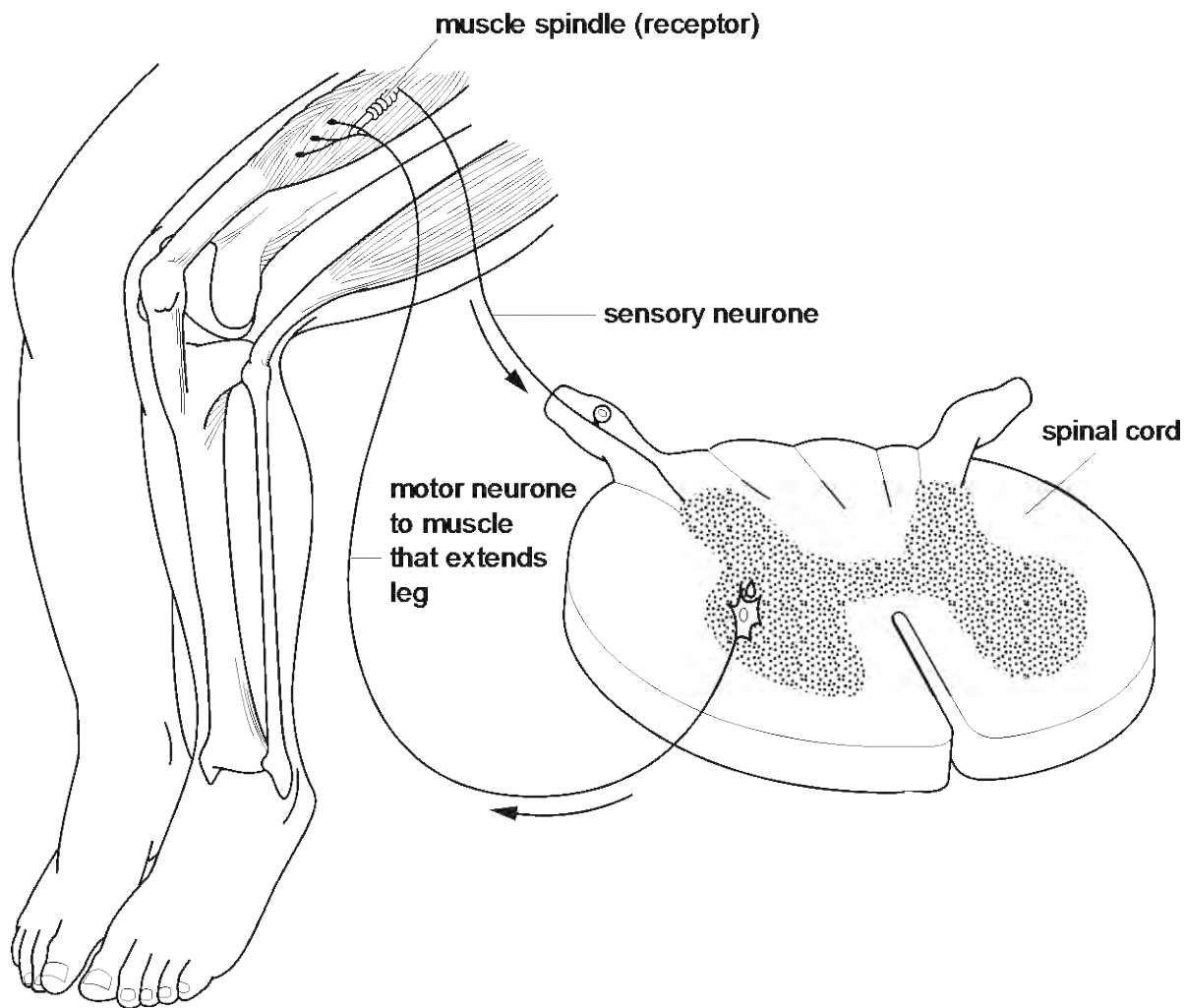
name of chemical messenger	function
.....	controls water permeability of collecting ducts in kidney
insulin
glucagon
.....	stimulates stomatal closure during water stress
.....	controls apical dominance

[Total 5 marks]

91. In this question, one mark is available for the quality of spelling, punctuation and grammar.

Mammals also rely on nerves to transfer information in the form of electrical impulses.

Using the information shown in the figure below, outline how impulses are transmitted from receptor to effector.



[8]

Quality of Written Communication [1]

[Total 9 marks]

92. (a) A great deal of tropical rainforest has been destroyed as trees are cut down to make way for agriculture and also for the wood that they yield. Replanting the rain forests might take 100 years so scientists are using other techniques to speed the process.

They are able to take cuttings from rainforest trees and then to clone them. The clones are from trees best suited to restore the rainforest and are attractive to foresters because of their rapid growth. Cloned trees are planted and grow far more quickly than saplings grown from seed.

(i) Explain the meaning of the term *clone*.

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[2]

(ii) State **two** advantages of using clones instead of saplings grown from seed.

1

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2

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[2]

(iii) Each cutting is given a coating of auxin on its cut surface before it is planted in a rooting medium. This encourages the rooting process.

State **two other** commercial uses of auxin.

1

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2

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[2]

- (iv) Auxin stimulates the growing roots to develop root hairs. These are projections from specialised epidermal cells.

Explain in detail why it is important for the cuttings to develop root hairs.

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[4]

- (b) Micropropagation has been used to produce clones of some pine trees. New plants are grown by culturing tissues from trees with high productivity. The tissues from the trees are grown in artificial conditions in a culture medium.

List **three** constituents of the culture medium.

1

2

3

[3]

- (c) One disadvantage of micropropagation is that it can be more expensive than traditional methods.

Suggest **three** factors which may contribute to this extra cost.

1

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2

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3

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[3]

- (d) Name **one** technique for producing clones of trees, other than taking cuttings, or micropropagation.

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[1]

[Total 17 marks]

93. Two species of monkeyflower, *Mimulus*, have pink anthocyanin pigment in their flower petals.

In both species, two alleles of a gene, **A/a**, control the activity of another gene responsible for the production of a second pigment, a carotenoid. The dominant allele, **A**, prevents carotenoid production so that the flowers show only their pink anthocyanin pigment.

Flowers containing both anthocyanin and carotenoid pigments are red in colour.

- (a) (i) Describe the interaction between gene **A/a** and the gene responsible for carotenoid production.

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[3]

- (ii) Explain why flower colour in *Mimulus* is an example of **discontinuous** variation.

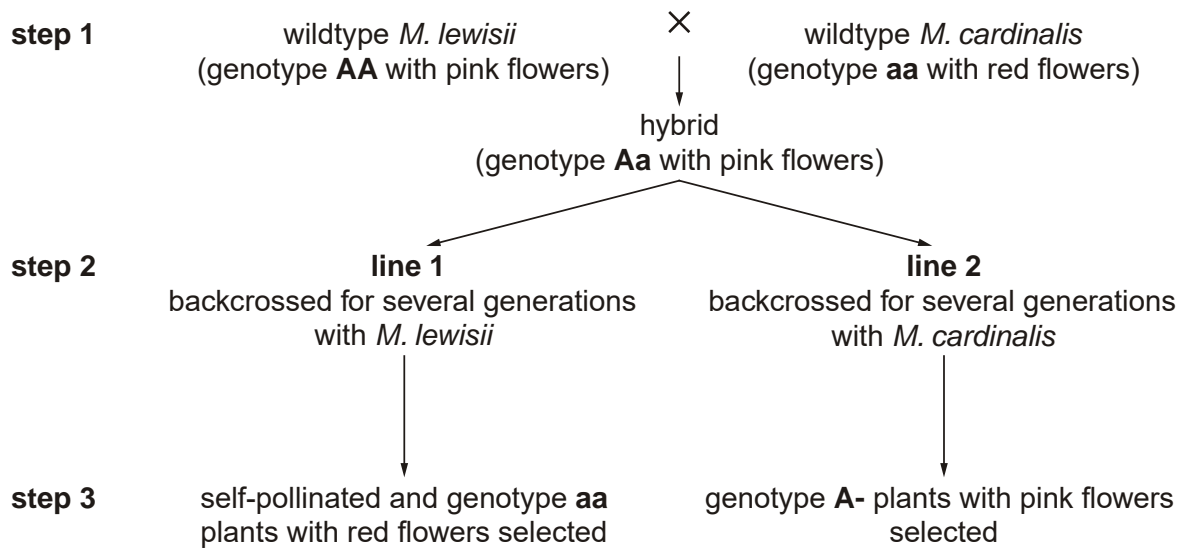
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[3]

(b) Wild type *M. lewisii* have the genotype **AA** and have pink flowers that are pollinated by bumblebees.

Wild type *M. cardinalis* have the genotype **aa** and have red flowers that are pollinated by hummingbirds.

The two species were interbred to investigate the role of gene **A/a** in attracting pollinators to the flowers. Alleles **A** and **a** were exchanged between the two species in the selective breeding programme shown in the figure below.



(i) State **two** practical precautions that the plant breeder could take to be sure that the plants produced in **step 1** were hybrids.

- 1
-
- 2
-

(ii) Explain why, in **step 2**, the hybrids were backcrossed for several generations to one or other of the parent species.

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[2]

(iii) State why the plants in **line 1** were self-pollinated in **step 3**.

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[1]

- (c) The number and type of pollinators visiting different coloured flowers were then recorded. The results are shown in the table below.

plant species	genotype	flower colour	number of pollinator visits per hour	
			bumblebee	hummingbird
wild type <i>M. lewisii</i>	AA	pink	15	0
selectively bred <i>M. lewisii</i>	aa	red	3	2
wild type <i>M. cardinalis</i>	aa	red	0	190
selectively bred <i>M. cardinalis</i>	Aa	pink	11	170

Comment on the effect on pollinators of selectively breeding allele **a** into *M. lewisii* and allele **A** into *M. cardinalis*.

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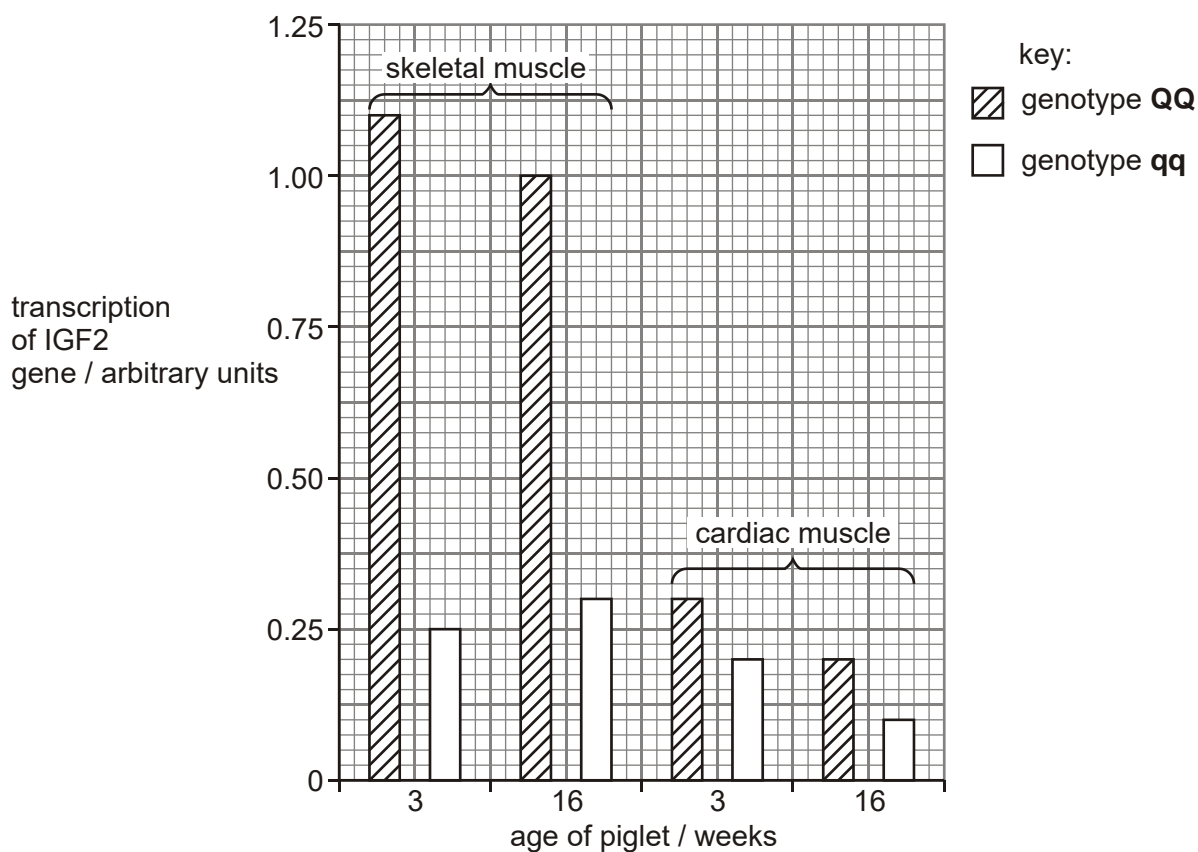
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[4]

[Total 15 marks]

94. A gene, **Q/q**, affecting muscle mass and fat deposition in pigs has been identified in crosses between domesticated pigs and wild boars. Most European domesticated pigs carry the dominant allele, **Q**, but wild boar populations are homozygous recessive. The **Q/q** gene codes for a protein growth factor, IGF2.

The transcription of the gene in skeletal and cardiac muscle was measured in piglets with **QQ** and **qq** genotypes at three and sixteen weeks after birth. The results are shown in the figure below.



Using the information above, compare the transcription of the IGF2 gene in piglets with **QQ** and **qq** genotypes.

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[Total 4 marks]

95. (a) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Britain's only native species of carp, the crucian carp, is very hardy and can live in conditions that would be fatal for most freshwater fish. It can survive in water temperatures from 1 °C to 38 °C and can live in water with a very low oxygen concentration and a low pH.

The crucian carp can interbreed with two other species of carp:

- common carp, a non-native species which was introduced into Britain to increase the stock of fish for freshwater fishing;
- goldfish, which are often illegally released into the wild.

(i) Explain briefly what is meant by a *restriction enzyme*.

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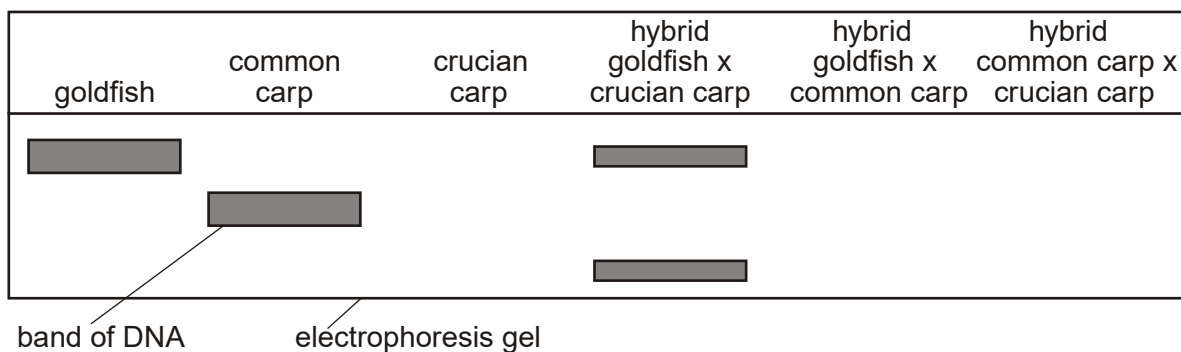
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[3]

(ii) The figure below shows an electrophoresis gel on which bands of DNA produced by genetic fingerprinting have been revealed by staining. **Only** the bands produced from goldfish, common carp and hybrid goldfish × crucian carp are shown.



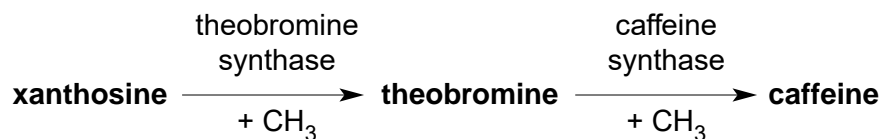
Draw onto the figure the bands expected from:

- crucian carp;
- hybrid goldfish × common carp;
- hybrid common carp × crucian carp.

[3]

[Total 15 marks]

96. The synthesis of caffeine in coffee plants involves enzymes which add methyl groups (CH_3) to convert xanthosine to caffeine:



In an attempt to produce caffeine-free coffee, cells of a coffee plant, *Coffea canephora*, were grown in tissue culture and genetically modified to suppress expression of the gene for theobromine synthase.

DNA was constructed to code either for short or for long lengths of RNA with the **complementary** base sequences to parts of the messenger RNA (mRNA) produced by the gene for theobromine synthase.

- (a) Explain how lengths of RNA that are complementary to mRNA may suppress the expression of a gene.

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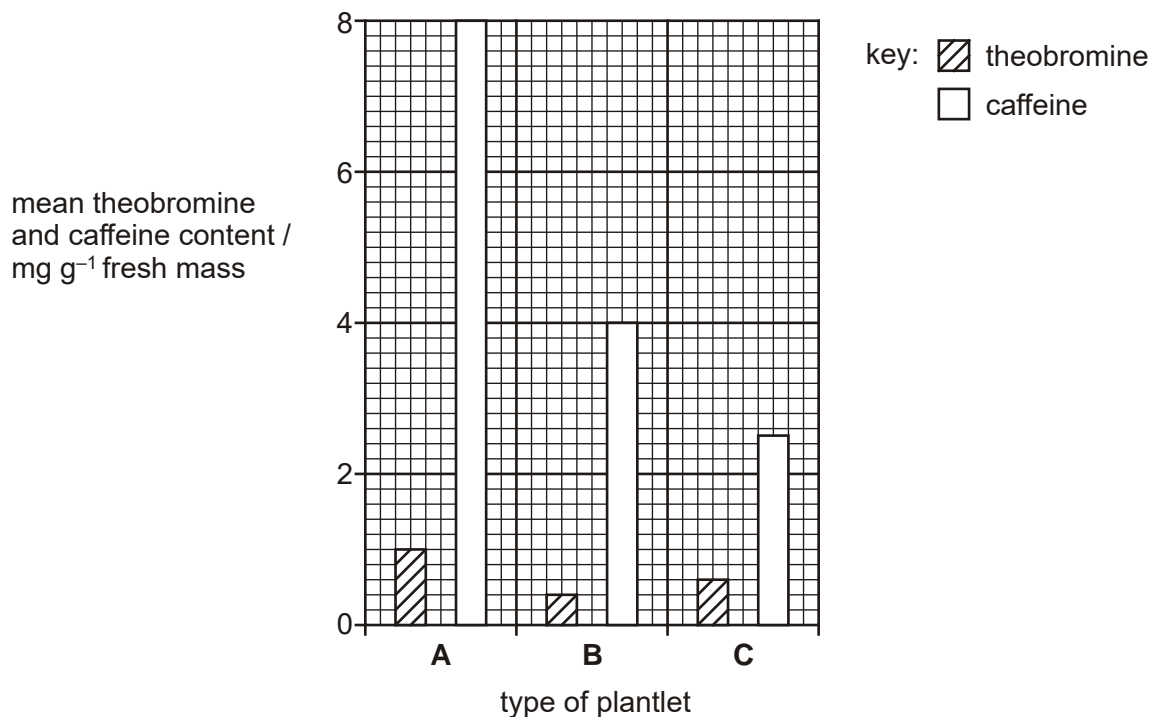
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(b) Three types of cell were then cloned in tissue culture into plantlets:

- A** - unmodified (control) cells
- B** - genetically modified cells with the DNA code for short lengths of RNA complementary to mRNA for theobromine synthase
- C** - genetically modified cells with the DNA code for long lengths of RNA complementary to mRNA for theobromine synthase.

Samples of each of the three types of plantlet were analysed to measure their theobromine and caffeine content. The results of the analysis are shown below.



(i) Describe the results shown in the figure above.

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(ii) Suggest an explanation for the difference in the results of the two experimental treatments, **B** and **C**.

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[1]

(iii) Describe briefly how plants are cloned by tissue culture.

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[4]

(iv) Explain the advantages of using cloned plants in experiments such as this.

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[3]

[Total 15 marks]

97. (a) An infection by the bacterium, *Pseudomonas aeruginosa*, may be in the form of separate bacterial cells or of a 'biofilm'. A biofilm is a layer of bacteria growing on a surface, attached to one another by polymers of glucose. Infections in the form of biofilms are difficult to control by antibiotics.

Suggest why infections in the form of biofilms are more difficult to control by antibiotics than those caused by separate bacterial cells.

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[4]

- (b) The sensitivity of two strains of *P. aeruginosa* to three commonly used antibiotics (**A**, **B** and **C**) was measured when the bacteria were grown in suspension and in biofilms. The results are shown in the table below.

		lowest concentration of antibiotic needed to kill bacteria / $\mu\text{g cm}^{-3}$		
		A	B	C
strain 1	bacteria in suspension	8	40	4
strain 1	bacteria in biofilm	400	500	50
strain 2	bacteria in suspension	8	40	4
strain 2	bacteria in biofilm	25	60	6

Compare the sensitivity of bacterial **strains 1** and **2** to the three antibiotics when grown in suspension and in biofilms.

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[4]

- (c) A gene has been identified in *P. aeruginosa* which is expressed **only** when cells grow in biofilms. The gene codes for an enzyme which is needed for the synthesis of polymers of glucose, called glucans, which are secreted by the bacteria. Strains 1 and 2 have different alleles of this gene.

Explain how the difference in sensitivity to antibiotics of strains 1 and 2 could have arisen.

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[4]

(d) Describe briefly how resistance to an antibiotic may be transferred naturally from *P. aeruginosa* to a different species of bacterium.

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[3]

[Total 15 marks]

98. In 1971, an international treaty was signed to protect over 1800 wetland sites. Known as the Convention on Wetlands, it was designed to provide a framework for dynamic conservation of the wetlands and their resources which are diverse and complex habitats.

Explain what is meant by *dynamic conservation*.

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.....

[Total 2 marks]

99. Penicillin is an antibiotic that is used to treat bacterial diseases caused by Gram-positive bacteria. It can be produced commercially in large fermenters by a fed-batch culture method.

(i) Explain why a continuous culture method would **not** be suitable for the manufacture of penicillin.

.....
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.....

[2]

(ii) Suggest why limited amounts of glucose are added at regular intervals to the culture medium during the fed-batch process.

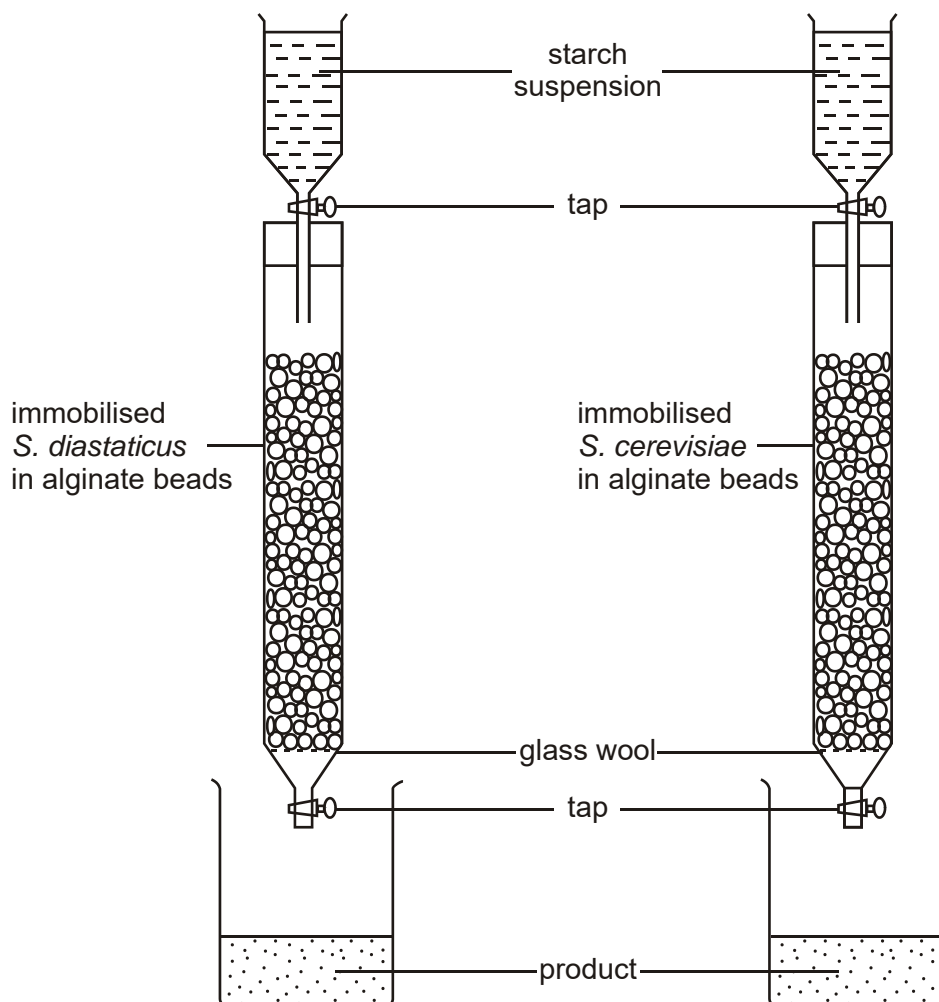
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[2]

[Total 4 marks]

100. Yeast cells can be entrapped in alginate beads using the same methods as used for immobilising enzymes. A student performed an investigation to compare the glucoamylase activity of *S. diastaticus* with that of the genetically modified *S. cerevisiae*.

The figure below is a diagram of the experiment.



- (i) List **three** factors that would need to be controlled in this experiment in order to make valid comparisons.

1

2

3

- (ii) Describe **one** method of measuring the concentration of reducing sugars in the products.

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[2]

- (iii) The student expressed concerns that live yeast cells may be present in the product and that these cells would affect the results of the experiment.

Explain whether or not you agree with these concerns.

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[2]

[Total 7 marks]

101. Ten lambs, nine months old, were placed in an enclosure. A scientist entered the enclosure carrying an umbrella which was opened and closed repeatedly in front of the lambs. The lambs' reaction was to back away nervously from the umbrella. It was noticed that as the activity continued, the behaviour of the lambs changed until they ignored the umbrella.

- (i) State the type of learning behaviour displayed by the lambs at the end of the experiment.

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[1]

(ii) Suggest **two** advantages to the lambs of this change in their behaviour.

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[2]

[Total 3 marks]

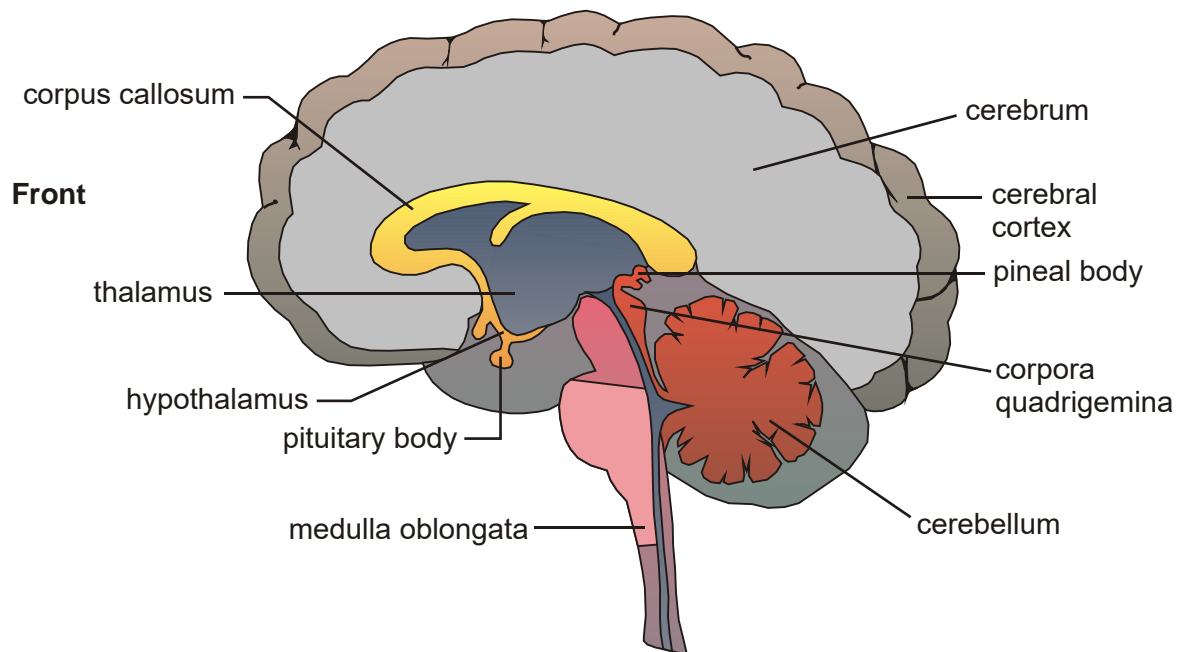
102. Reflex actions are unlearned responses to a stimulus.

Describe **one** advantage of reflex actions compared to learned responses in a mammal.

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.....

[Total 1 mark]

103. The figure below shows a vertical section through the human brain.



(i) Name the structure shown above that links the two cerebral hemispheres.

.....

[1]

(ii) The table below shows the functions of some areas of the brain.

Complete the table using the labels in the figure above.

area of brain	example of function
.....	co-ordination of posture
.....	control of heart rate
.....	control of temperature regulation
.....	control of speech

[4]

[Total 5 marks]

104. Alzheimer’s disease is a complex, degenerative disease that affects the brain. The risk of developing this disease increases with age, particularly over the age of 65. Symptoms include a gradual loss of memory, disorientation, difficulty with learning, loss of language skills and a decline in the ability to perform routine tasks. The areas of the brain that control memory and thinking skills are affected first.

State the functions of acetylcholine and acetylcholinesterase in synapses in the brain.

acetylcholine

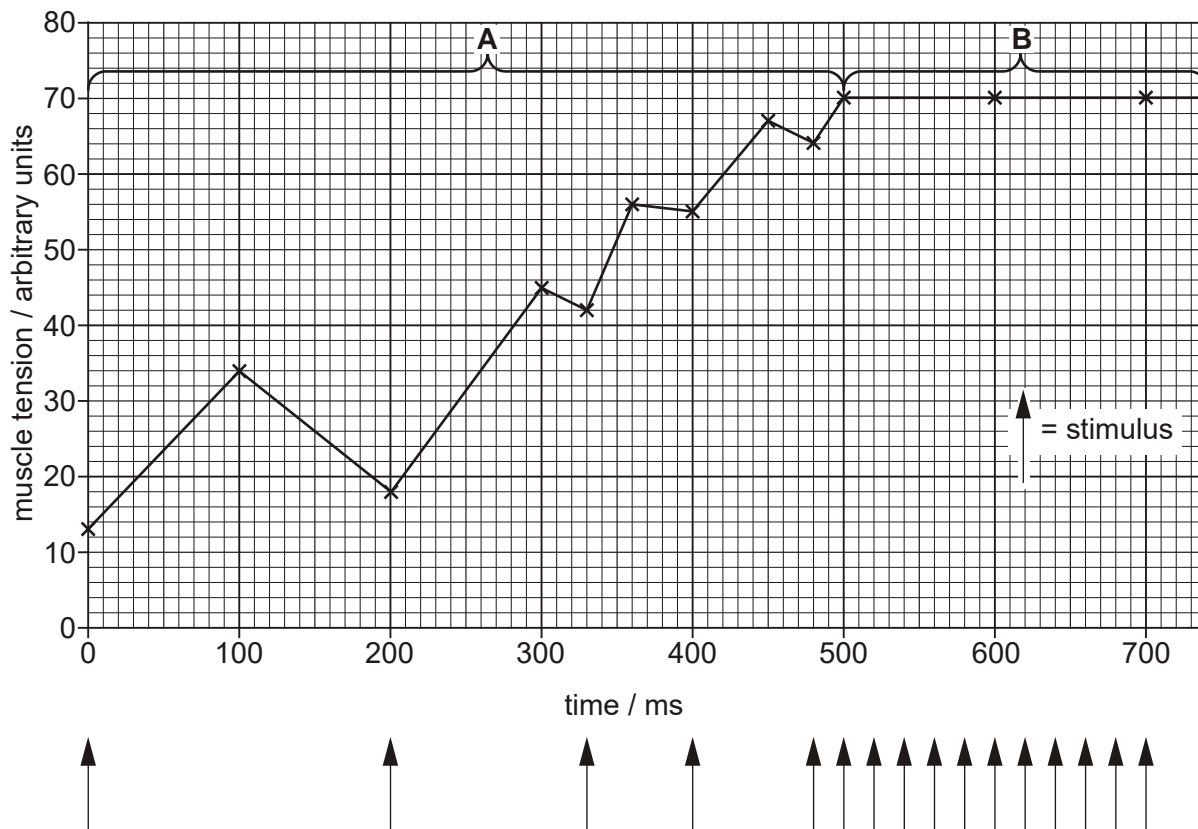
.....

acetylcholinesterase

.....

[Total 2 marks]

105. In an investigation, striated muscle tissue from a mammal was electrically stimulated over a period of 700 milliseconds (ms). The tension generated by the muscle was measured during the investigation and the results are shown in the figure below.



From *Nuffield Advanced Science Biology*. Study Guide 1, adapted from graph p. 349, published by Longman, 1985 (ISBN 0-582-35431-5)

(i) Describe the relationship between muscle stimulation and muscle tension in region **A** on the figure.

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- (ii) Region **B** on the figure above shows the tension of the muscle with repeated stimulation. Some toxins, such as those released by the tetanus bacterium, also cause the effect shown in region **B**.

Suggest why these toxins may be fatal.

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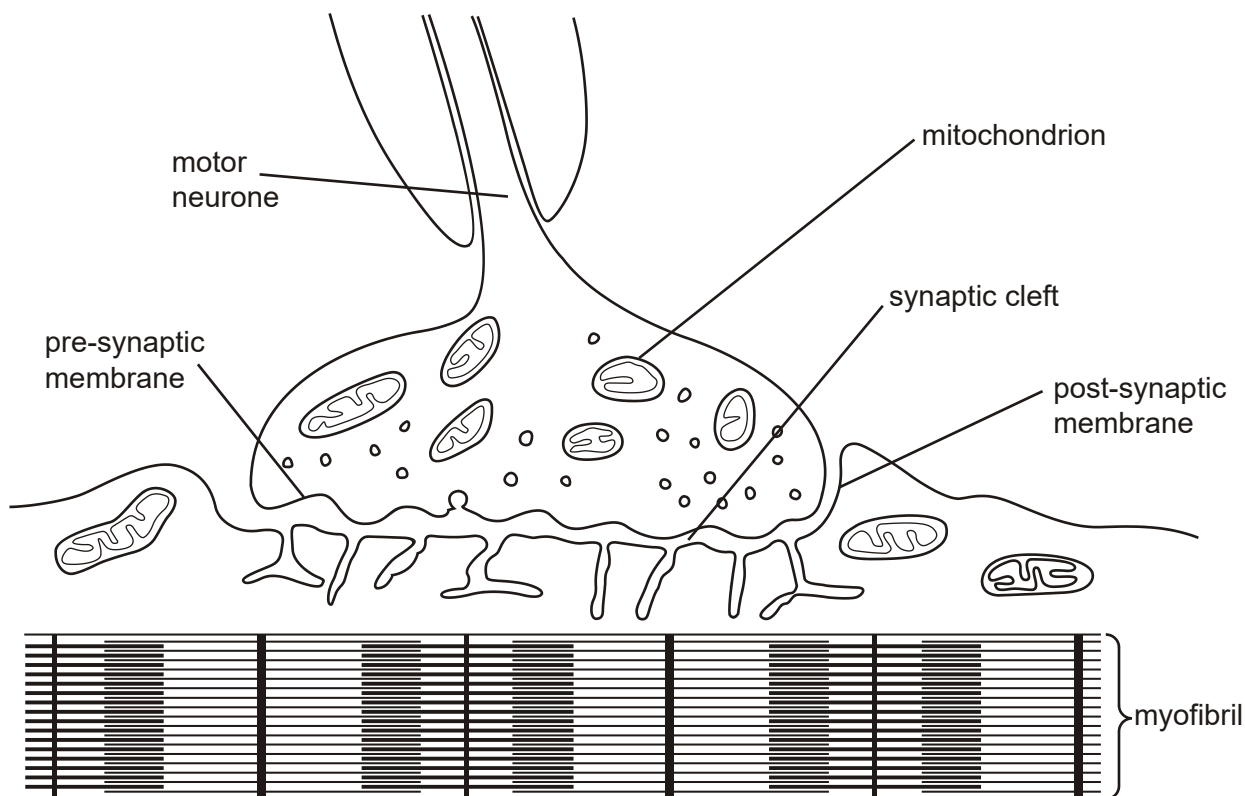
.....

[3]

[Total 5 marks]

106. In this question, one mark is available for the quality of use and organisation of scientific terms.

The following figure shows a neuromuscular junction.



The figure above shows that mitochondria are present on **both** sides of the synaptic cleft. Explain why mitochondria are essential for the transmission of impulses across the cleft and for muscular contraction.

transmission of impulses across the cleft

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muscular contraction

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[8]
Quality of Written Communication [1]
[Total 9 marks]

107. Grasslands which have been left undisturbed for several years often have ant mounds. Ants make burrows in the soil and bring fine crumbs of soil to the surface, where it accumulates as a mound. Each mound is about 50 cm across and about 20 cm high.

Plants grow on the mounds. Ants of the type that make mounds in grassland do not feed on plants.

A student noticed that a plant called wild thyme, *Thymus drucei*, seemed to be more common on ant mounds than it was on other parts of the same grassland, not occupied by ants.

In order to test the hypothesis that wild thyme was indeed more common on ant mounds, the student examined all the mounds in an area of grassland about 100 m by 100 m, noting whether or not wild thyme was present.

After surveying all 47 ant mounds in the grassland, the student threw a bunch of keys, 47 times, to obtain random points on the grassland, equal in number to the ant mounds.

Each time the keys were thrown, the point where they landed was used to place a 1 m² quadrat frame. The presence or absence of wild thyme in the quadrat was noted.

The data obtained are shown in the table below.

	number of ant mounds or quadrats with:	
	at least one wild thyme plant present	no wild thyme plants present
ant mound	36	11
1 m ² quadrat	24	23

- (i) What evidence is there in the table to support the hypothesis that wild thyme is more common on ant mounds?

.....

.....

.....

(ii) Describe **two** ways in which the survey methods could have been improved. Give a reason for each of the changes you have suggested.

1

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2

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.....

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[4]

[Total 5 marks]

108. A research team was investigating the properties of a newly-discovered enzyme, the product of which was a valuable drug.

This enzyme had been extracted from cells of a marine worm, found in the North Atlantic, where the temperature is always close to 5 °C. All the proteins of such animals are adapted to function at low temperatures.

Three water baths were set up at 15, 20 and 25 °C. Into each bath was placed a tube containing 1 cm³ of the enzyme solution and a tube containing 10 cm³ of concentrated substrate solution. On reaching the required temperature, the enzyme and substrate were quickly mixed and kept in the water bath.

There was a **large excess of the substrate**, so that substrate concentration was **not** a limiting factor.

Samples were taken from each tube at regular intervals and the concentration of the drug in these samples was determined. The results are shown in Fig. 1.

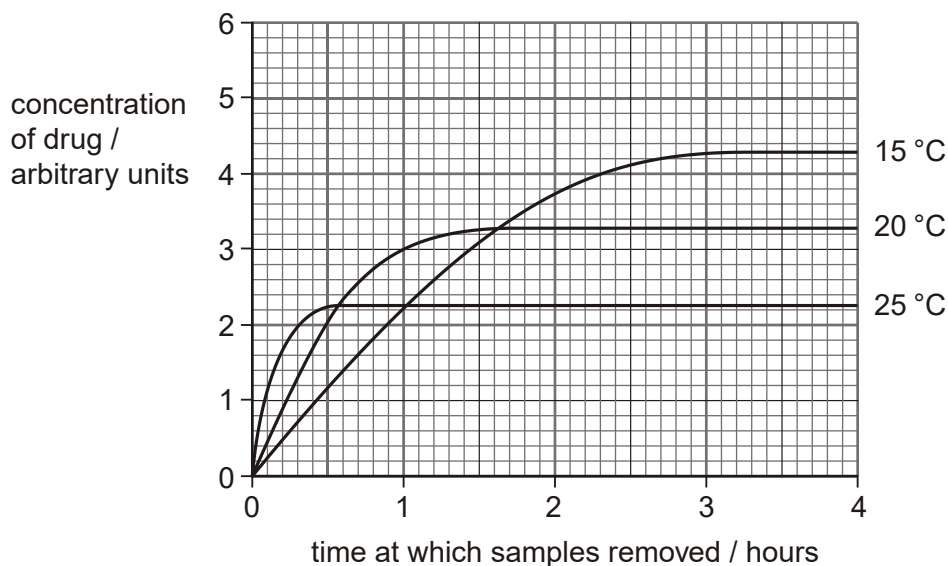


Fig. 1

- (a) Using Fig. 1,
- (i) describe what happened to the concentration of the drug in the tube at 15 °C;

.....

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(ii) explain why the concentration of the drug changed in the way you have described.

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[2]

(b) State **one** factor, **not mentioned in the account of the investigation**, which would have been kept constant in all the tubes for the results to be valid.

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[1]

(c) Predict **and** explain the effect of carrying out the same procedure at 5 °C.

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[3]

Fig. 2 represents part of the primary and tertiary structure of the newly-discovered enzyme, including its active site. The amino acids are represented by circles, which are numbered to show their position in the primary structure.

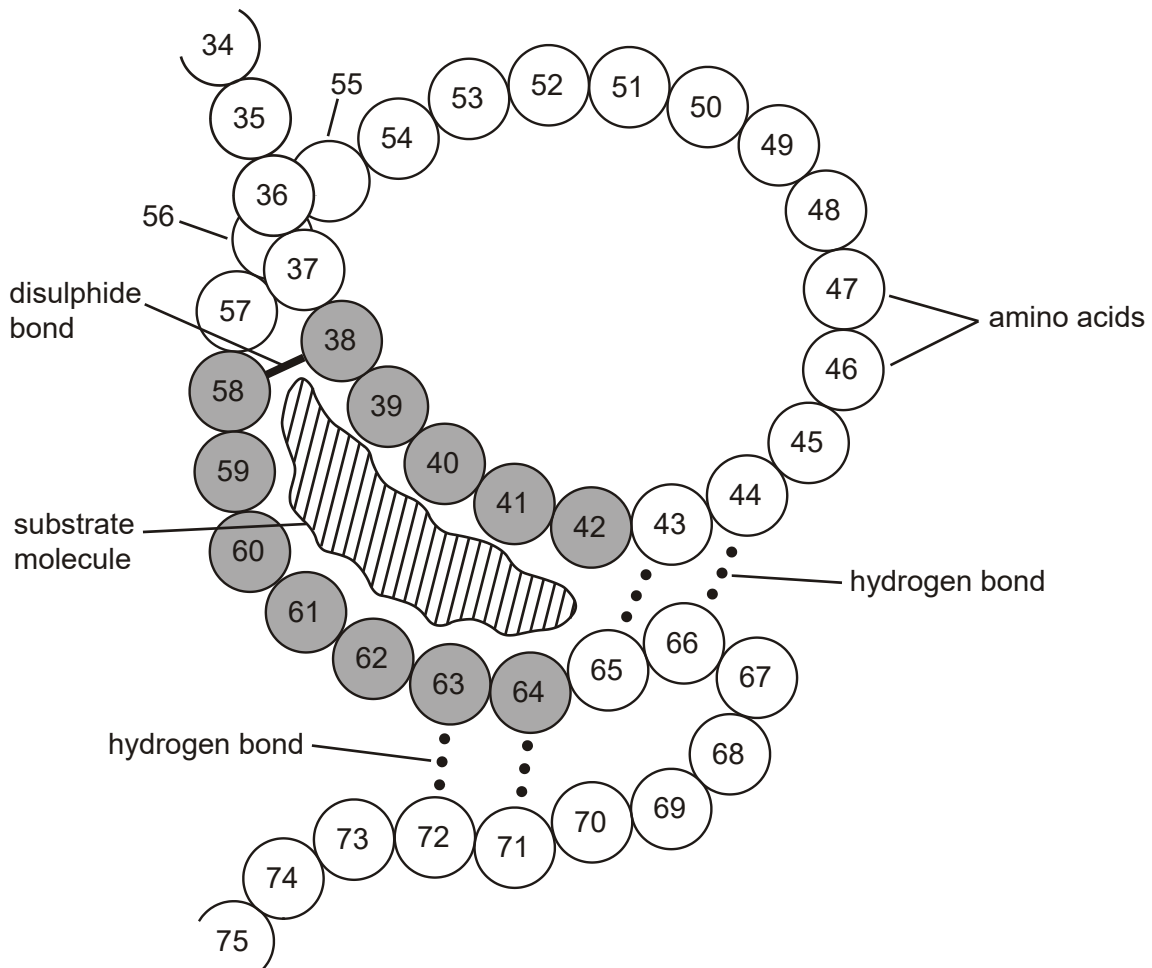


Fig. 2

(d) The research team wanted to change the structure of the enzyme so that it would function at higher temperatures to produce greater yields of the drug. They used a technique called **site directed mutagenesis**. In this technique:

- single changes to the amino acid sequence of the enzyme are planned
- the gene coding for the enzyme produced by the worm is isolated
- specific changes to the gene are made, in order to achieve the planned changes to the amino acid sequence
- the modified gene is introduced into a bacterium
- the offspring of the bacterium produce the changed enzyme molecules

(i) Suggest why it would be important that this procedure did **not** change any of the amino acids shaded grey in Fig. 2.

.....
.....

[1]

(ii) The amino acids numbered 44 and 66 have side chains that link by hydrogen bonding.

Suggest why the research team might plan to replace these two amino acids with the amino acid cysteine, which forms disulphide bonds.

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[2]

(e) Explain why the technique of site directed mutagenesis involves changing nucleotide sequences.

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[2]

[Total 13 marks]

109. The outer surface of a plasma (cell surface) membrane incorporates glycoproteins of many different types.

In some types of cell, some of these glycoproteins have a carbohydrate component that is a polysaccharide. This consists of a long unbranched chain of repeating sugar units, as shown in Fig. 1.

The polysaccharide component extends into the tissue fluid surrounding the cells and in some tissues links the cells together, forming part of the mechanical support for the tissue.

Fig. 1 also shows the chemical structure of one of the component sugar units of the polysaccharide.

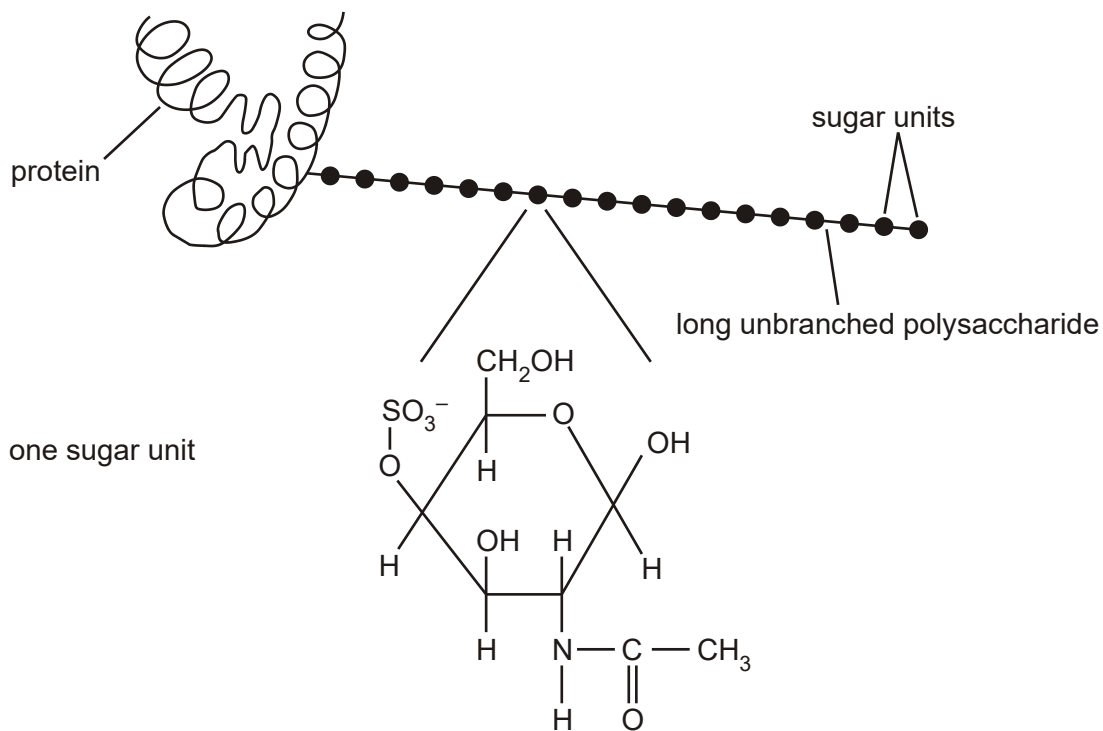


Fig. 1

(a) State **two** ways in which the structure of the polysaccharide shown in Fig. 1 differs from the structure of a molecule of cellulose.

1

.....

2

.....

- (b) During endocytosis, vesicles are formed from the plasma (cell surface) membrane and pass into the cytoplasm.

Any glycoprotein that enters the cell as part of the vesicle is broken down by enzymes in the lysosomes.

In an inherited disease called Hunter's syndrome, one of the enzymes needed to hydrolyse the polysaccharide chains shown in Fig. 1 is absent. Polysaccharides remain in the lysosomes until the cells eventually die.

Many body tissues are affected by Hunter's syndrome. The different tissues are not all affected to the same extent. Suggest an explanation for this observation.

.....
.....

[1]

- (c) Cells from an individual with Hunter's syndrome appear different to normal cells when viewed with an electron microscope.

Suggest **one** way in which they would appear different.

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.....

[1]

Fig. 2 shows part of a family tree where some of the individuals have developed Hunter's syndrome.

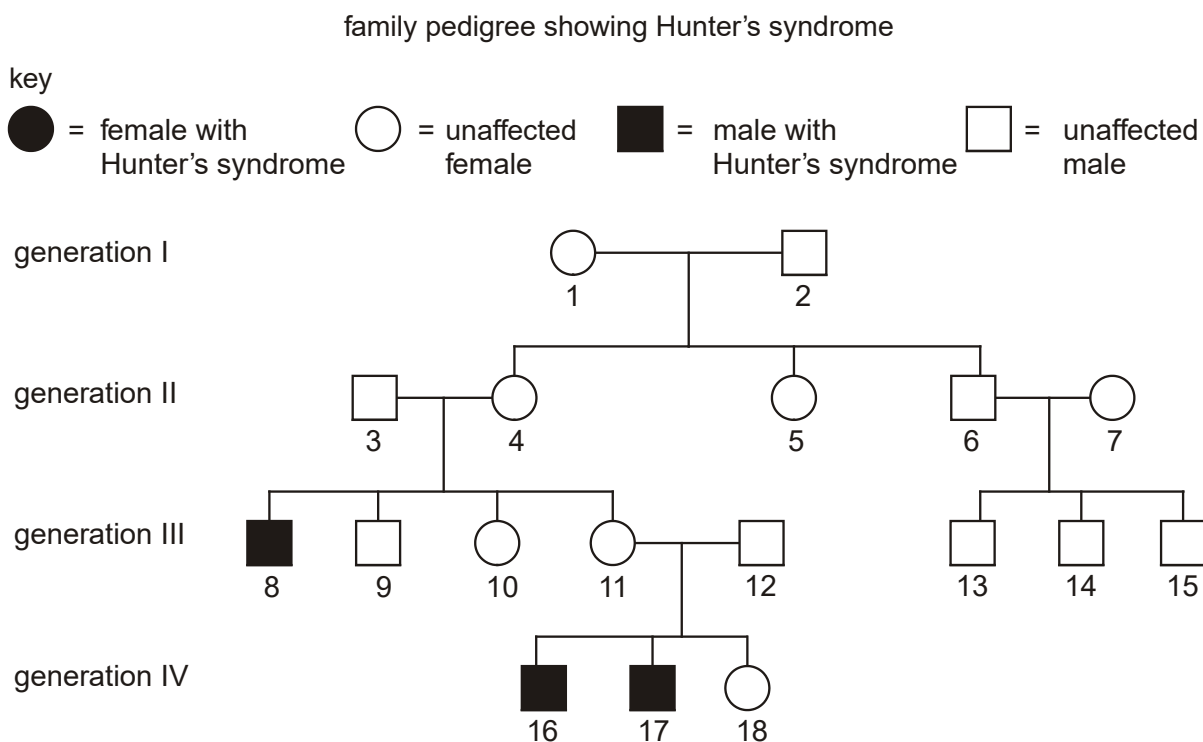


Fig. 2

(d) By referring to numbered individuals **and** the relationships shown in Fig. 2, explain why

(i) the allele that determines Hunter's syndrome must be recessive;

.....

.....

.....

[1]

(ii) the gene concerned may be sex linked.

.....

.....

.....

[2]

(e) Sex linkage is not conclusively shown by the family tree shown in Fig. 2.

Suggest why.

.....
.....

[1]

(f) There are no drugs to treat Hunter's syndrome.

Suggest why a drug to treat people with Hunter's syndrome would be very difficult to develop.

.....
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[2]

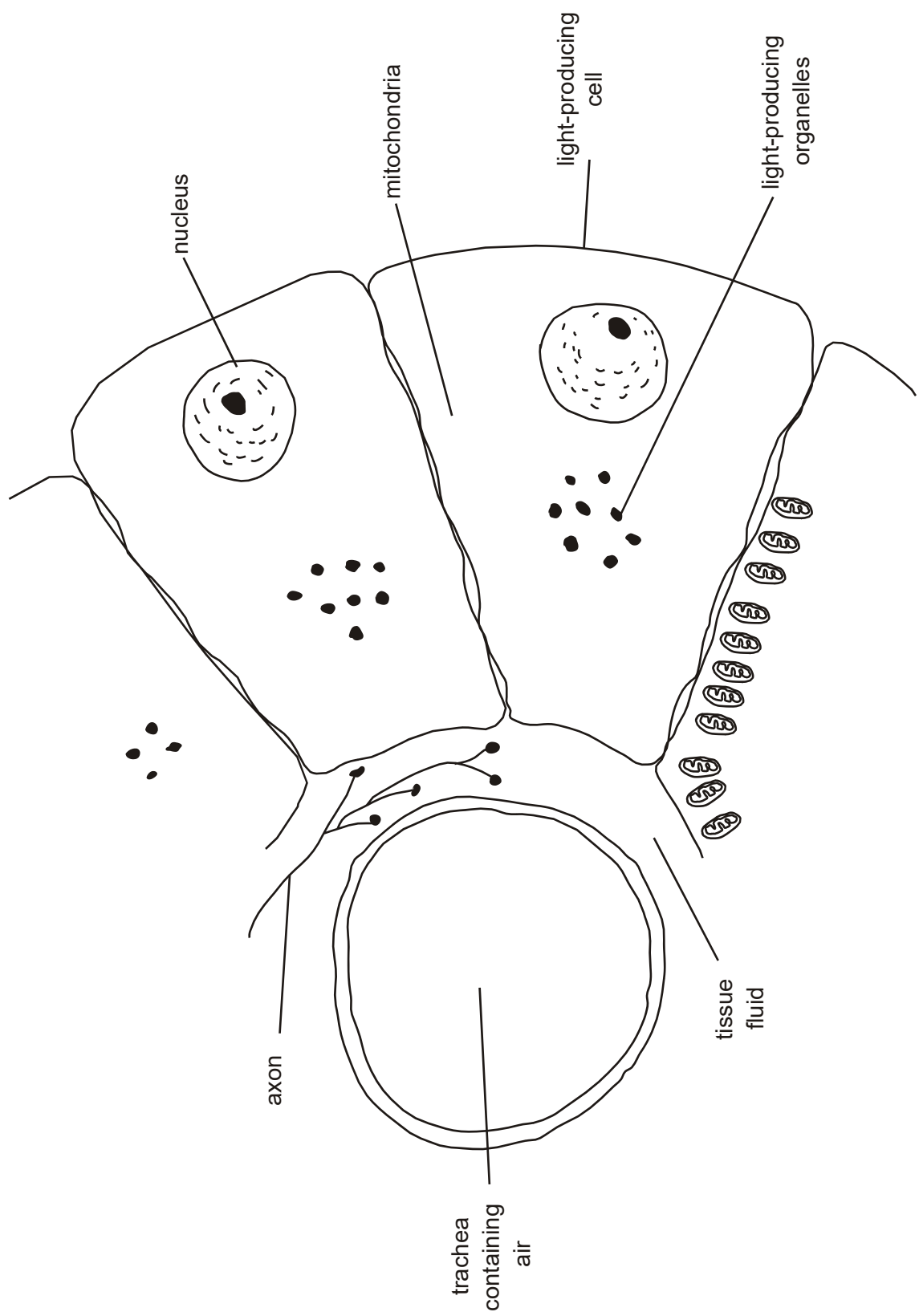
[Total 10 marks]

110. Read the passage below and answer the questions that follow, which relate to this passage.

How fireflies light up

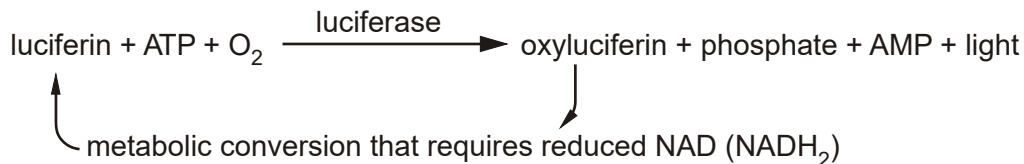
Fireflies are insects which have organs producing flashes of light. Fireflies are active at night and the light flashes are an important part of their sexual behaviour.

Within their light-producing organs are tubes, filled with air, called tracheae. These tracheae supply oxygen to light-producing cells. The figure below shows the arrangement of light-producing cells around a trachea.



Light is produced by organelles situated well away from the surfaces of the cells nearest the trachea.

The reaction that produces light requires **both** oxygen **and** ATP.



When the organ is not producing any light, the numerous mitochondria use oxygen very fast. These mitochondria lie between the tracheae and the light-producing organelles, just under the cell membrane, so that no oxygen is available for the oxidation of luciferin.

A flash of light is produced when nerve impulses stimulate the walls of the tracheae and the cytoplasm of the light-producing cells, to produce nitrous oxide. Nitrous oxide diffuses rapidly through the cells. It enters mitochondria and inhibits oxidative phosphorylation, so the oxygen concentration increases in the cytoplasm of the light-producing cells.

Nitrous oxide is very unstable and breaks down quickly, so its effects are temporary.

An extract of crushed fireflies was found to be an extremely sensitive test for the presence of ATP in foods, such as milk and meat. The more bacteria there are in the food, the more light is produced, provided the mixture of food and firefly extract is well oxygenated.

Fortunately for fireflies, luciferin can be synthesised artificially and luciferase has been produced by gene technology, using methods similar to those for producing human insulin.

- (a) Different species of firefly often live in the same habitat. The frequency with which a firefly flashes its light organ on and off, is a characteristic of a species.

Suggest an advantage, for fireflies, of flashing at a characteristic frequency.

.....

(b) (i) State the process by which oxygen reaches the light-producing organelles.

.....

[1]

(ii) Explain why the light-producing organelles are located well away from the plasma (cell surface) membrane.

.....

[1]

(c) Suggest why it is important for the effects of nitrous oxide to be temporary.

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[2]

(d) Light-producing cells in fireflies do not divide. State **three** ways in which these cells might use ATP **other** than in the production of light.

- 1
- 2
- 3

[3]

- (e) If a firefly is suddenly crushed, for example by hitting a car windscreen, it produces a prolonged and unusually bright flash of light after which all light production ceases.

Suggest an explanation for these observations.

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.....
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.....

[3]

- (f) A solution containing luciferin, luciferase and oxygen glows when painted onto the surface of meat contaminated by live bacteria, but not if the meat is contaminated by dead bacteria.

Explain this observation.

.....
.....

[1]

- (g) What substance would be extracted and purified from light-producing cells of fireflies in order to produce luciferase by gene technology?

.....

[1]

[Total 13 marks]

111. (a) State what ecologists mean by the following terms:

(i) *habitat*

.....

[1]

(ii) *niche*

.....

[1]

(iii) *ecosystem.*

.....

.....

[1]

(b) Two more terms commonly used by ecologists are *population* and *community*.

State the difference between a *population* and a *community*.

.....

.....

[1]

[Total 4 marks]

112. Fig. 1 shows the transfer of energy through a food chain in a wood.

The figures represent the energy in the levels of the ecosystem in $\text{MJ m}^{-2} \text{y}^{-1}$.

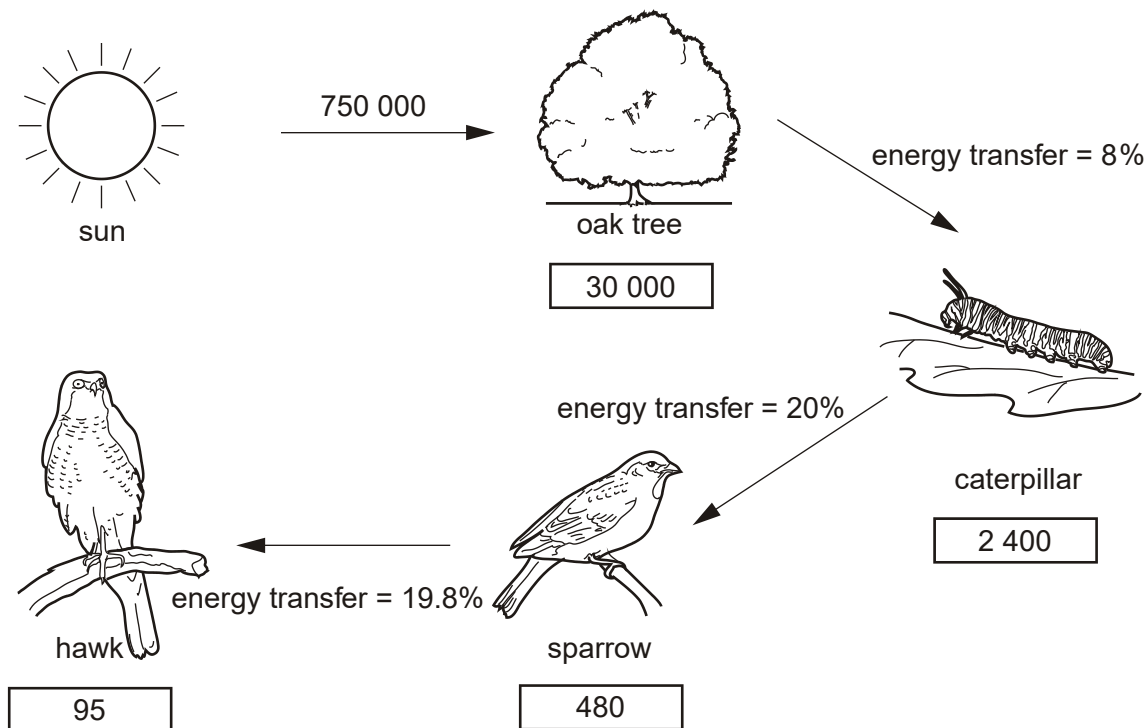


Fig. 1

Fig. 2 shows what happens to the food available to caterpillars in the food chain shown in Fig. 1.

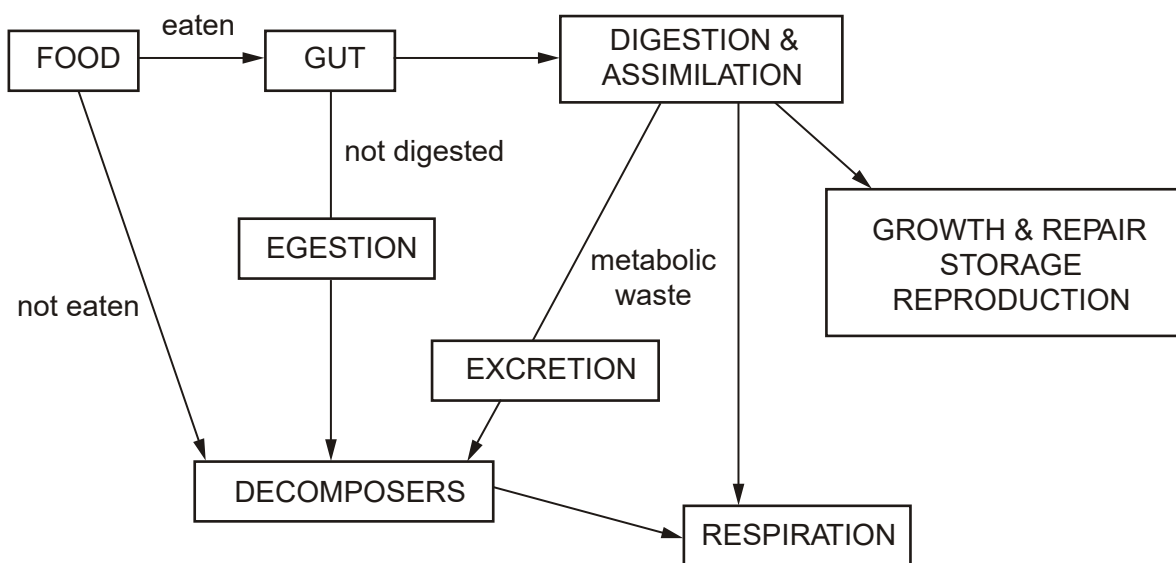


Fig. 2

- (i) Fig. 1 shows that each trophic level has less energy flowing through it than the previous trophic level.

Use the information in Fig. 2 to explain why this is the case.

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[3]

- (ii) Explain the differences in the **percentage** of energy transferred between the trophic levels shown in Fig. 1.

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.....

[2]

[Total 5 marks]

113. The following are different stages in meiosis. Each stage has been given a letter.

anaphase II	metaphase II	anaphase I	prophase I	telophase II	metaphase I
M	N	P	Q	R	S

- (i) Using **only** the letters, arrange these stages in the correct sequence.

.....

.....

[1]

- (ii) State the letter of the stage when each of the following processes occur.

- pairing of chromosomes
- centromeres divide
- crossing over
- bivalents align on equator
- nuclear membrane reforms

[5]

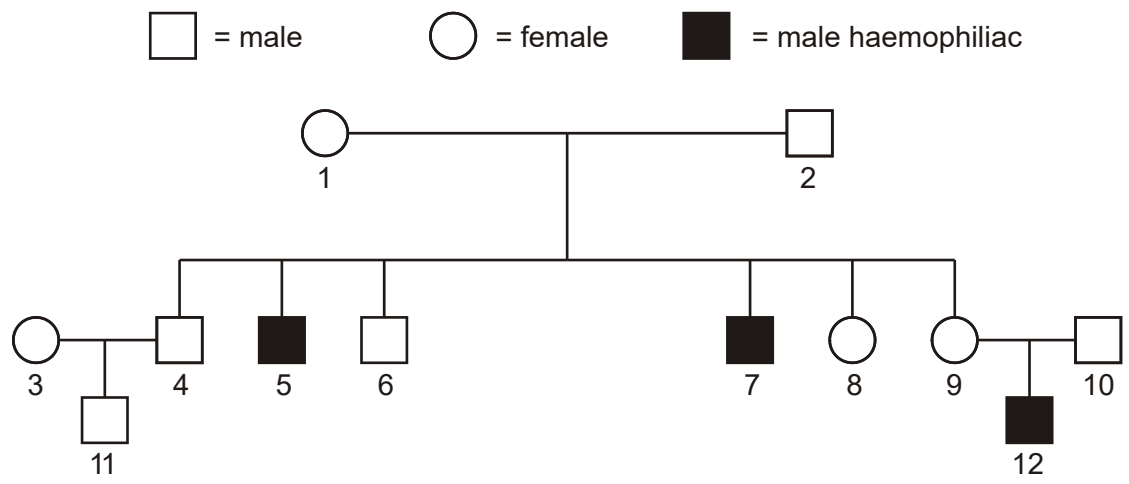
(iii) State **two** processes that occur in a cell during interphase to prepare for a meiotic division.

- 1
- 2

[2]

[Total 8 marks]

114. Haemophilia A is a sex-linked genetic disease which results in the blood failing to clot properly. It is caused by a recessive allele on the X chromosome. The figure below shows the occurrence of haemophilia in one family.



(i) Using the following symbols:

H = dominant allele **h** = recessive allele

state the genotypes of the following individuals. The first one has been completed for you.

individual	genotype
1	X^HX^h
2
5
6
9

[4]

(ii) State the probability of individual 8 being a carrier of haemophilia.

.....

[1]

(iii) Explain why only females can be carriers of haemophilia.

.....

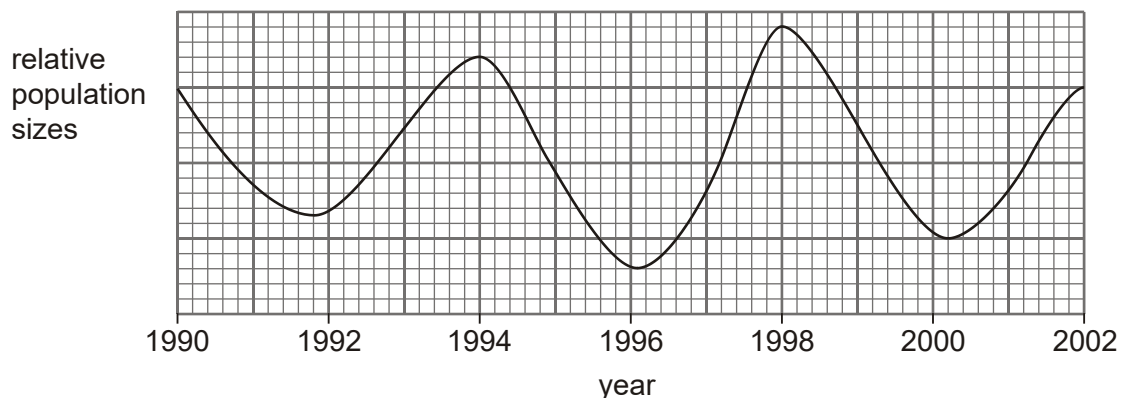
[2]

[Total 7 marks]

115. Lemmings are small mammals that live near the Arctic circle. Their populations show regular patterns of increase and decrease. In 2003, scientists published results based on a long-term project in East Greenland. They made the following observations.

- Population peaks occurred in regular four year cycles.
- Four main predators feed on the lemmings: Arctic owls, Arctic foxes, long-tailed skuas and stoats.
- Stoats feed only on lemmings; the other predators feed on a range of prey species.
- Stoats reproduce more slowly than lemmings.

(a) The figure below shows the changes in the population of lemmings in the East Greenland project area from 1990 to 2002.



(i) Sketch **on the figure** the likely changes in the population size of stoats.

[2]

(ii) Suggest three environmental conditions, **other than climatic**, that are required for a population explosion of lemmings.

- 1
- 2
- 3

[3]

- (b) With reference to the species studied in the East Greenland project, distinguish between interspecific and intraspecific competition.

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.....

[3]

- (c) The carrying capacities for lemmings and for the various predators in this area are all different.

Explain the term *carrying capacity*.

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.....

[2]

[Total 10 marks]

116. The snail, *Cepaea nemoralis*, lives on the ground amongst leaf litter and herbaceous vegetation.

- It exists in three different colours: brown, pink and yellow.
- In some of these snails, there is a shell banding pattern on this background colour. Snails can therefore be divided into banded and unbanded forms.
- The background colour and banding are controlled by alleles at two separate gene loci.

A group of students in central England carried out the following investigation.

- Samples of snails were collected from populations in two different habitats.
- The first habitat was mixed deciduous woodland where the leaf litter was a dark uniform colour.
- The second habitat was grassland, which is more variable in colour but predominantly pale yellow and green.

The main predator of the snail is the song thrush which has excellent colour vision. It therefore acts as a major selection pressure on these populations.

The table below shows the percentage of yellow-shelled snails and unbanded snails found in the samples.

habitat	sample	% of sample yellow	% of sample unbanded
woodland	1	12	88
	2	21	77
	3	12	70
grassland	1	79	21
	2	58	14
	3	83	22

(a) Explain the following terms;

allele

.....

locus

.....

[2]

(b) In this question, one mark is available for the quality of use and organisation of scientific terms.

When the students compared their results with previous investigations in the same habitats, they found that the percentages were very similar.

Using the data in the table above, describe how selection pressures, such as predation by the song thrush, can maintain different allele frequencies in the snail populations in the woodland and grassland habitats.

[8]

Quality of Written Communication [1]

[Total 11 marks]

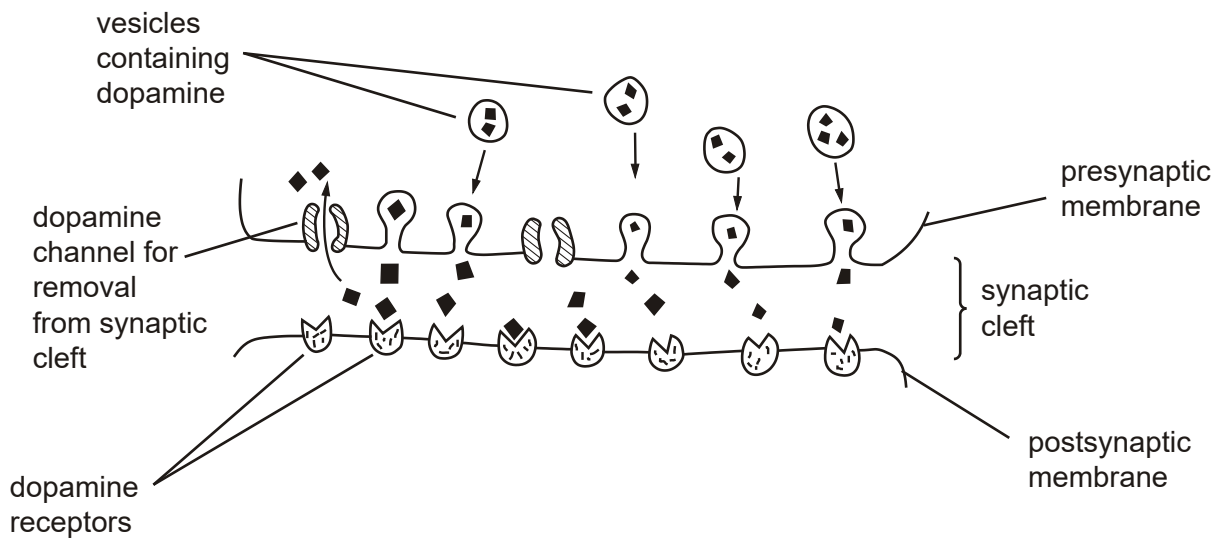
117. Parkinson's disease is a disorder of the nervous system. People with this condition are unable to produce enough of the neurotransmitter substance dopamine. This chemical is required in neurone circuits in the brain that control movement.

(a) Outline **two** roles of synapses in the nervous system.

- 1
-
- 2
-

[2]

The figure below illustrates the events at a synapse where the neurotransmitter is dopamine.



(b) Using **only** the information above, list **three** ways in which the events occurring at this synapse are the same as at a cholinergic synapse.

- 1
- 2
- 3

[3]

- (c) For the proper functioning of neurone circuits, neurotransmitters have to be removed from the receptors in the postsynaptic membrane and from the synaptic cleft. Explain why this is so.

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.....
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.....
.....

[2]

[Total 7 marks]

118. (a) Explain what is meant by *heritability*.

.....
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.....
.....

[2]

- (b) Rice plants may have, in addition to a main stem, a number of side shoots (tillers) growing from ground level. These tillers may also branch. The ability to grow tillers is controlled by a single gene with two alleles, **T/t**. Plants with the genotype **tt** have a single grain-bearing stem and no tillers.

Explain why the heritability of rice tiller growth is likely to be high.

.....
.....
.....
.....

[2]

(c) Allele **T** codes for a protein which regulates transcription. Expression of allele **T** allows stimulation of mitosis in the buds which become tillers.

Allele **t** has a 'stop' triplet within its DNA sequence as well as at its end.

(i) State what is meant by a 'stop' triplet.

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.....

[2]

(ii) Describe the effect of the 'stop' triplet **within** the DNA sequence of allele **t**.

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[3]

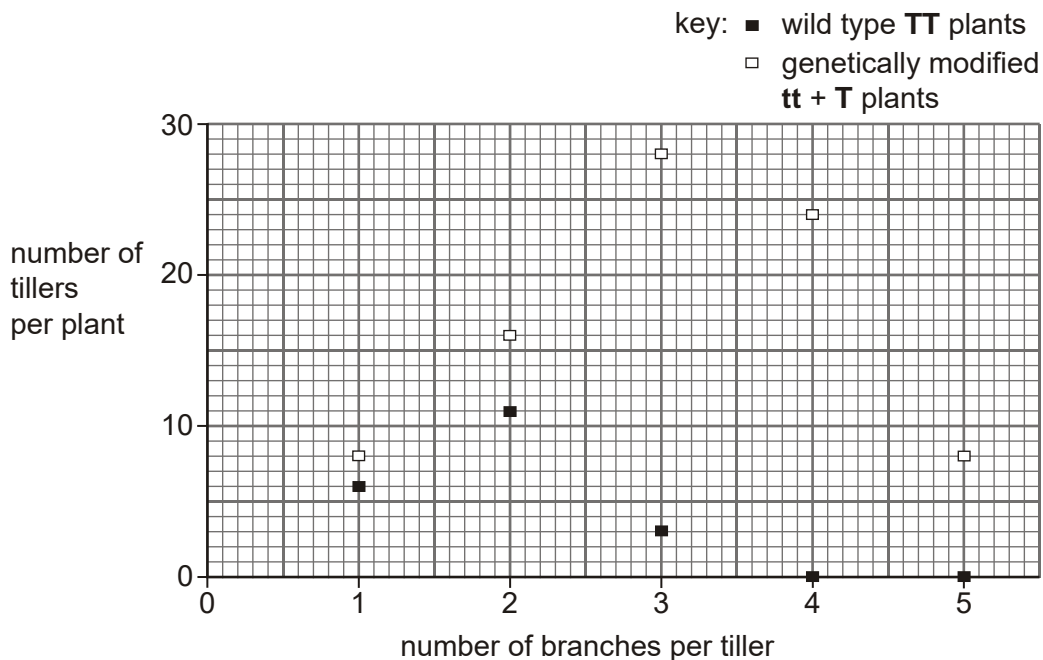
(iii) Suggest how the protein encoded by allele **T** may regulate transcription.

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.....

[2]

- (d) The number of tillers per plant and the number of times each tiller branched were recorded for wild type **TT** plants and for **tt** plants which had been given a copy of allele **T** by genetic engineering.

The results are shown below.



- (i) With reference to the figure above, compare the effect of the two rice genotypes on tiller growth.

.....

.....

.....

.....

- (ii) Suggest why the expression of allele **T** may be changed when it is transferred by genetic engineering into rice plants with the genotype **tt**.

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.....

[2]

[Total 15 marks]

119. In this question, one mark is available for the quality of spelling, punctuation and grammar.

Compare selective breeding with the evolutionary process.

[8]

Quality of Written Communication [1]

[Total 9 marks]

120. Flowering plants have chemical communication systems.

- (i) Outline the nature of chemical communication within flowering plants.

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.....

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[2]

(ii) Explain why plants need such a communication system.

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[2]

[Total 4 marks]

121. Celery plants produce chemical signals when attacked by herbivorous insects. The signals switch on the plants' resistance genes that code for insecticides.

(i) Suggest why celery produces its insecticides only when attacked by insects.

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[2]

(ii) Outline the steps by which resistance to an insecticide may arise and spread in an insect population.

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[5]

[Total 7 marks]

122. When eaten by insects such as the larvae known as earworms, celery plants produce the chemical signal jasmonate (**J**). This stimulates insecticide production. Insecticide begins to build up in the leaves after 24 hours and reaches maximum concentration after 4 to 5 days.

However, earworms become resistant to this insecticide by switching on a gene in the gut lining that codes for an enzyme (**E**) to break it down.

Newly hatched earworms were divided into four groups:

- **not** exposed to **J** but fed on celery leaves containing insecticide
- **not** exposed to **J** but fed on celery leaves with **no** insecticide

- exposed to **J** and fed on celery leaves containing insecticide
- exposed to **J** and fed on celery leaves with **no** insecticide.

The earworms continued to feed on these diets until they pupated.

The percentage mortality of the different groups of earworms and the relative expression of the gene coding for enzyme **E** are shown below. In the table, a tick (✓) indicates the presence of insecticide in the celery leaf diet and a cross (✗) indicates its absence.

group of earworms	presence of insecticide in celery leaf diet	relative expression of gene coding for enzyme E	mortality / %
not exposed to J	✓	1.0	86.7
	✗	0.0	15.6
exposed to J	✓	6.5	48.3
	✗	5.5	6.7

Using the information given, explain the differences in percentage mortality of the different groups of earworms.

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[Total 4 marks]

123. (a) Duchenne muscular dystrophy (DMD) is a genetic disease caused by the absence of the protein dystrophin in muscle fibres. In the absence of dystrophin, muscle fibres gradually die.

A potential gene therapy for DMD involves injecting muscles with a viral vector carrying recombinant DNA (rDNA) for part of the normal allele for dystrophin.

Outline the formation of recombinant DNA.

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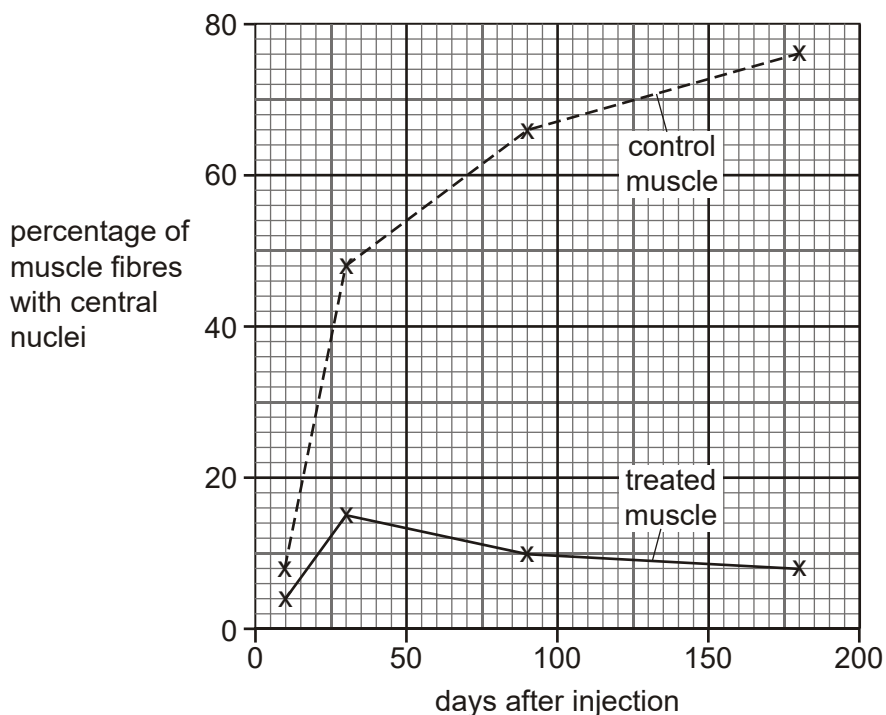
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[3]

- (b) Mice with the symptoms of DMD were given this gene therapy shortly after birth. Each mouse was injected with the viral vector in a muscle of one hind limb. The corresponding muscle of the other hind limb was injected with a buffer solution to provide a control.

The nuclei of muscle fibres that do not produce dystrophin move from the edge of the fibre to the centre. The fibres eventually die.

The percentage of muscle fibres with centrally placed nuclei was measured in fibres from treated and control muscles at different times after injection. The results are shown in the figure below.



Using the information above, describe the results of the experiment.

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- (c) In this question, one mark is available for the quality of use and organisation of scientific terms.

Genetic screening is available for families with a history of DMD.

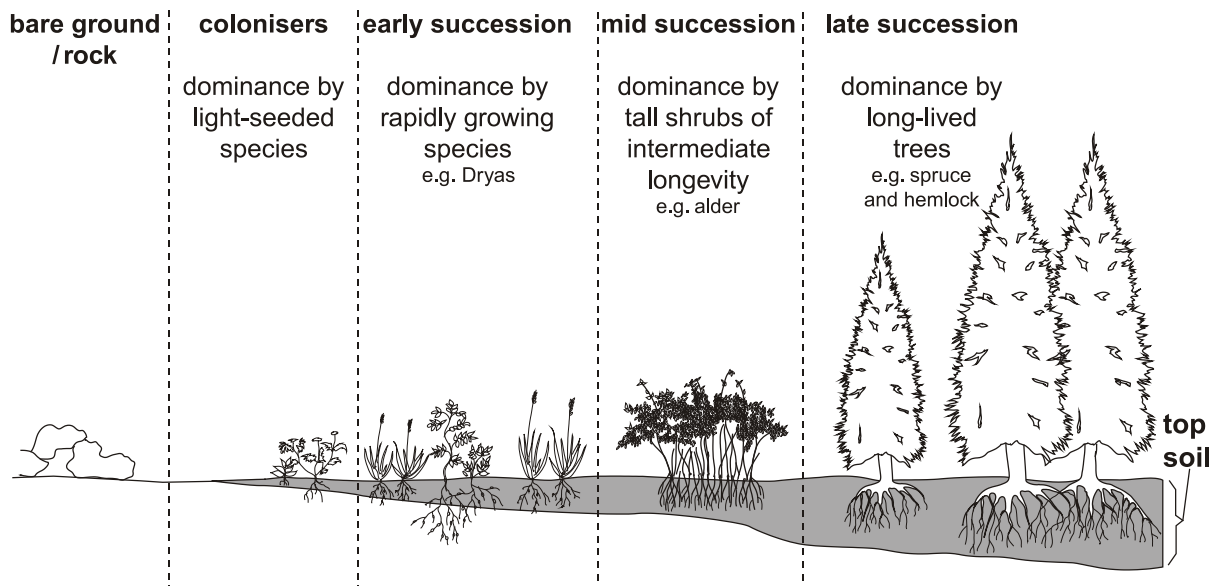
Discuss the advantages and disadvantages of genetic screening.

[8]

Quality of Written Communication [1]

[Total 15 marks]

124. The figure below shows some of the stages that have occurred during succession at Glacier Bay in Alaska.



Using the information in the figure,

(i) explain what is meant by the term *succession* ;

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[4]

(ii) outline **two** changes which occur between mid and late succession;

1

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2

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[2]

(iii) suggest **one** biotic and **one** abiotic change which are **not** indicated in the figure.

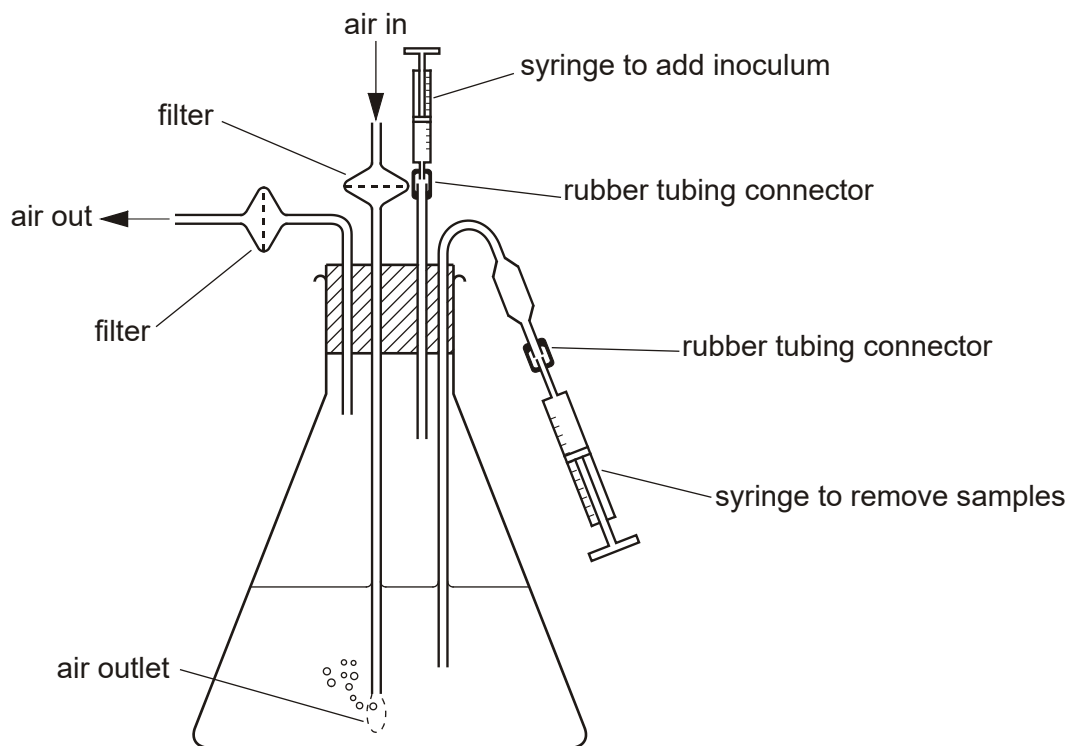
biotic

abiotic

[2]

[Total 8 marks]

125. The figure below shows a laboratory fermenter (bioreactor) used by a student to **batch** culture microorganisms.



Explain how the student could modify the fermenter for **continuous fermentation**.

If you wish, you may add annotations to the figure to help you in your answer.

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[Total 4 marks]

126. State **three** advantages of plant tissue culture.

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[Total 3 marks]

127. In this question, one mark is available for the quality of use and organisation of scientific terms.

Describe the sequence of steps that can be used to produce a protein of medical importance, such as human growth hormone (HGH), on a large scale.

Include in your answer details of how

- a microorganism can be genetically modified to produce such a protein
- large amounts of the protein can then be produced.

[6]

Quality of Written Communication [1]

[Total 7 marks]

128. The mammalian nervous system consists of the central and peripheral nervous systems.

Describe how the central nervous system is protected from **mechanical** damage.

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[Total 3 marks]

129. Fig. 1 shows an apparatus called a double-choice learning box with sound-proofed walls and doors.

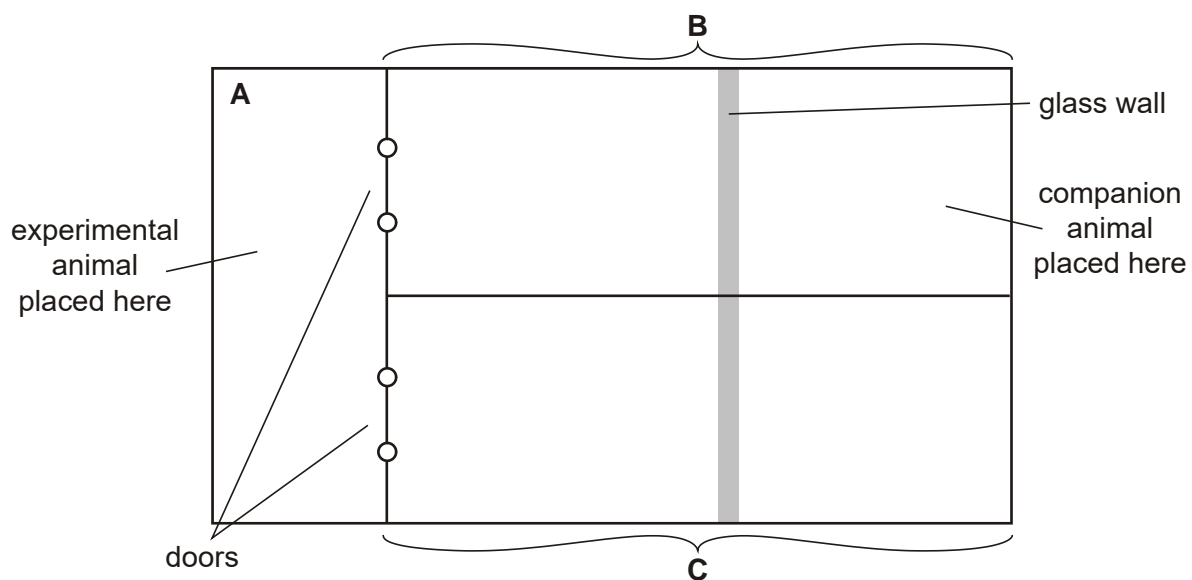


Fig. 1

- Two young mice were kept in separate, identical home cages and were accustomed to being handled.
- One mouse was used as the experimental subject and the other acted as a companion.
- The companion mouse was placed in chamber **B** behind a glass wall.
- Chamber **C** was left empty.
- The experimental mouse was placed in chamber **A** and the stop clock was started.
- The time taken for the experimental mouse to enter chamber **B** or **C** was noted.
- The experimental mouse was allowed to explore chamber **B** or **C** for 10 seconds and was then removed.
- The experiment was repeated a further 14 times with the same two mice.

Fig. 2 shows the results of this experiment.

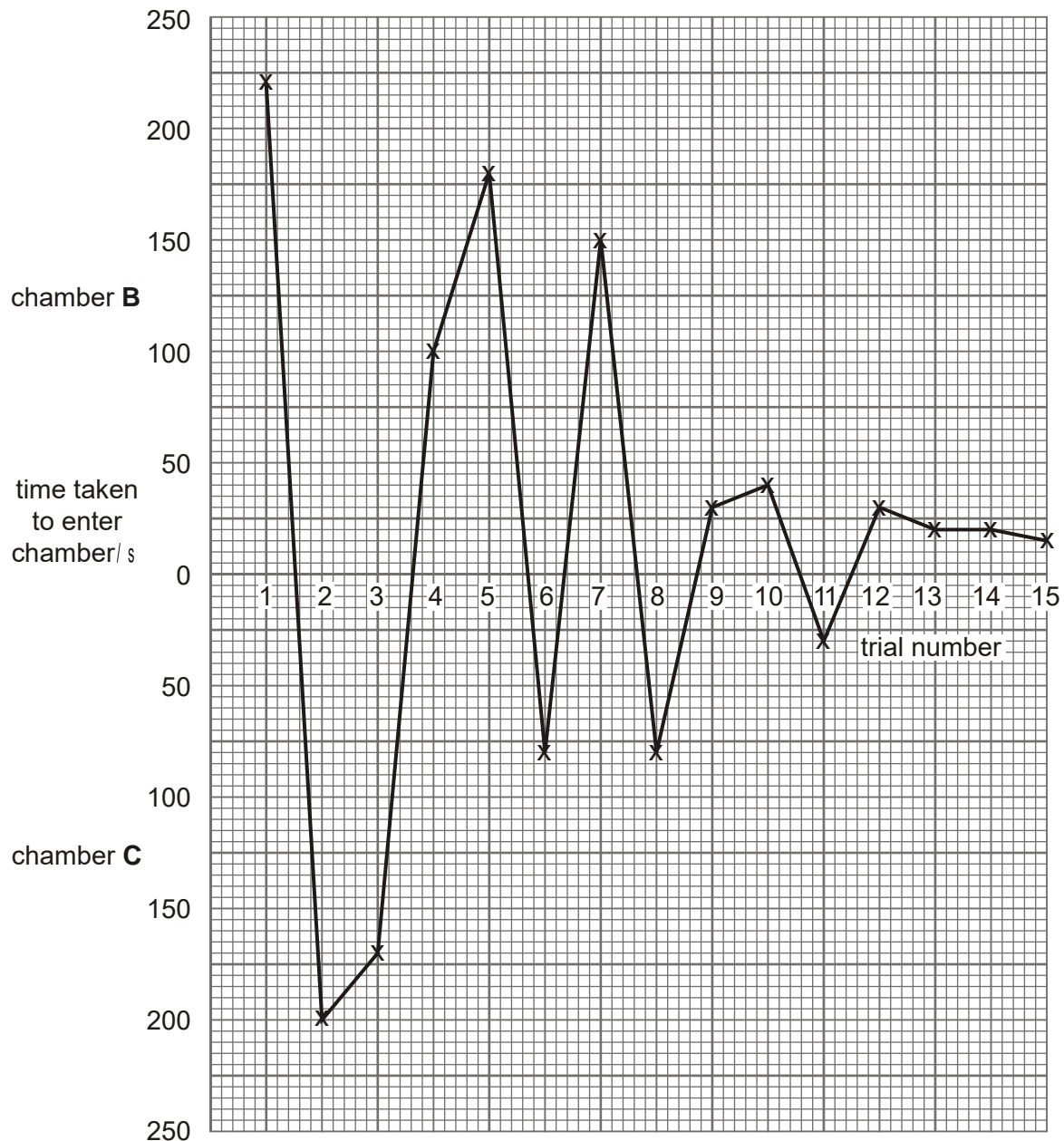


Fig. 2

(i) Using information in Fig. 2, describe the results of this investigation.

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[2]

(ii) Describe how you would carry out a control experiment for this investigation.

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[3]

(iii) Suggest the results you would expect from such a control experiment.

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[1]

- (iv) State what type of learning has taken place in this investigation **and** explain how this type of learning differs from classical conditioning.

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[3]

[Total 9 marks]

130. Read the passage below and answer the questions which follow.

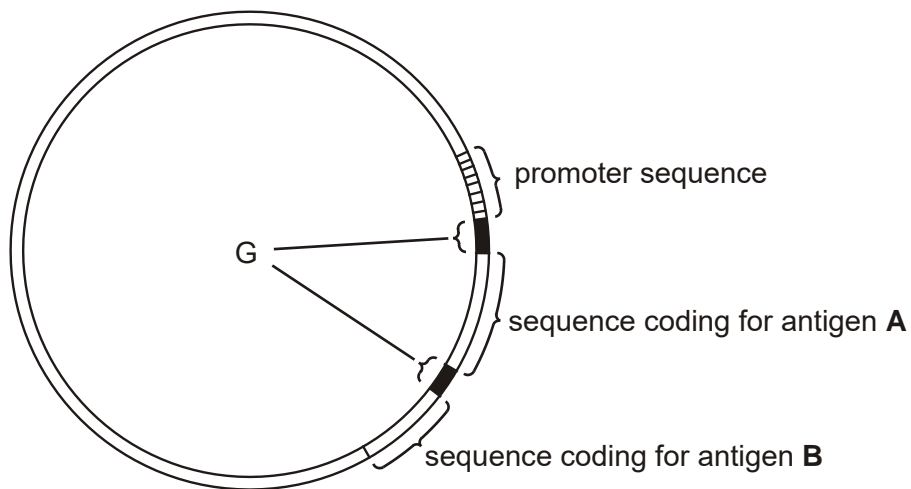
DNA vaccines

Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting proteins were transferred to the plasma membranes (cell surface membranes) of the mouse muscle cells. The proteins were exposed on the muscle plasma membranes together with receptor molecules that allow the immune system to recognise cells as self or non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

The figure below shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.



(a) State **three** ways in which the structure of plasmid DNA differs from the structure of a protein molecule.

- 1
- 2
- 3

[3]

(b) (i) Define the term *antigen*, as used in the passage.

.....

[1]

(ii) Suggest why proteins presented at the cell surface are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids.

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[1]

(c) (i) Explain why a promoter sequence is needed as part of the plasmid if the vaccine is to work.

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[2]

(ii) Suggest why it may be desirable to include nucleotide sequences coding for more than one antigen in a DNA vaccine.

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[2]

- (iii) Sequences of nucleotides, labelled G on the figure, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly synthesised polypeptides to the Golgi apparatus of the muscle cell.

Explain how this makes the vaccine effective.

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[2]

- (d) Suggest **three** reasons why researchers may be more concerned about the potential risks of DNA vaccines as compared with protein-based vaccines.

1

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2

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3

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[3]

[Total 14 marks]

131. Statements about the nitrogen cycle are written below.

1	a genus of bacterium associated with leguminous plants	T
2	conversion of nitrate ions to nitrogen	
3	swelling on the root of a leguminous plant	
4	conversion of ammonium ions to nitrate ions	
5	an animal that eats plants	

Select from the following terms the appropriate letter to match each statement. Write the letter in the box.

The first one has been done for you.

Q	secondary consumer	R	nitrogen fixation
S	primary consumer	T	<i>Rhizobium</i>
U	denitrification	V	nodule
W	niche	X	lightning
Y	decay	Z	nitrification

[Total 4 marks]

132. (a) Cats with either black or white fur are common in Britain; brown fur is rarer. The dominant allele, **B**, of one gene gives black fur and the recessive allele, **b**, brown fur.

Many of the white cats carry a dominant allele, **A**, of a second gene which inhibits pigment production no matter which pigment-producing alleles are present in the genotype. The recessive allele, **a**, has no effect on fur colour.

Genes **A/a** and **B/b** are not linked and neither is on the X chromosome.

(i) State the fur colour of cats with the following genotypes:

- AaBB**
- aaBB**
- Aabb**
- aabb**

[4]

(ii) State the name given to this type of gene interaction.

.....

[1]

(iii) Suggest how one gene may inhibit the action of another.

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[3]

(b) Two white cats produced a litter of kittens with three different coat colours: white, black and brown.

(i) State **one** possible genotype for **each** of the two white parents and explain the reasons for your choice.

You may use the space below for rough work, if needed.

genotypes of parents

explanation

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.....

[5]

(ii) State the ratio of phenotypes this pair of cats would be expected to produce in time, when the fur colour of several litters of kittens could be recorded.

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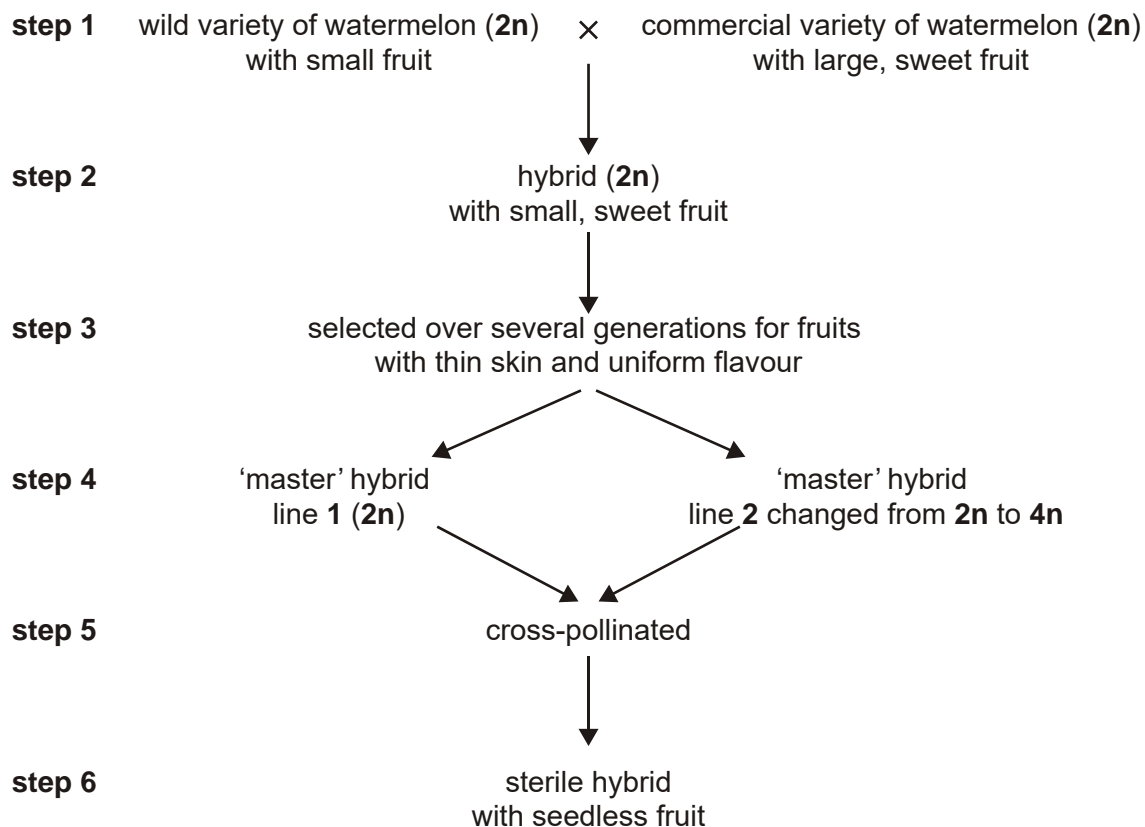
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[2]

[Total 15 marks]

133. A variety of watermelon with small, sweet, seedless fruit has been produced by selective breeding in the USA. The melons, which also have thin skin and a uniform flavour throughout the fruit, first went on sale in 2002. The selective breeding programme followed the sequence shown in the figure below.



(a) With reference to the figure above,

(i) explain why several generations were needed in **step 3**;

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.....

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.....

(ii) suggest how, in **step 4**, 'master' hybrid line **2** was changed from **2n** to **4n**;

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.....

[2]

(iii) describe the process of cross-pollination in **step 5**;

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.....

[2]

(iv) explain why the hybrid produced in **step 6** is sterile and seedless.

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[2]

(b) At first, the supply of seeds for growing sterile watermelons with seedless fruit (**step 6**) was very limited. Cloning plants from tissue culture allowed more of these melons to be grown.

(i) Outline the process of cloning plants from tissue culture.

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[5]

(ii) Explain how using this process could increase the supply of seedless watermelons.

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[2]

[Total 15 marks]

134. Estimates of heritability for various phenotypic traits in Wagyu cattle are shown in the table below.

phenotypic trait	heritability
A 'marbling' of meat with fat	0.49
B growth rate	0.38
C thickness of subcutaneous fat	0.15
D area of 'rib eye' meat	0.02

State which of the Wagyu phenotypic traits shown in Table 3.1 could most easily be improved by selective breeding. Explain your answer.

phenotypic trait

explanation

.....

.....

[Total 3 marks]

135. A number of different crop plants have been genetically engineered to express a gene for an insecticidal toxin (*Bt* toxin) from a bacterium, *Bacillus thuringiensis*, that kills many insect species.

In China, *Bt* cotton has been grown since 1997. A survey at the end of 2001 showed that it was being grown by over two million farmers on fields totalling more than 7000km².

Some further findings of the survey are shown in the table below.

survey finding	percentage of reported cases of insecticide poisoning among cotton farmers	cost of producing 1kg of cotton / US \$
farmers growing non- <i>Bt</i> cotton	22	2.23
farmers growing <i>Bt</i> cotton	5	1.61

Comment on the findings of the survey.

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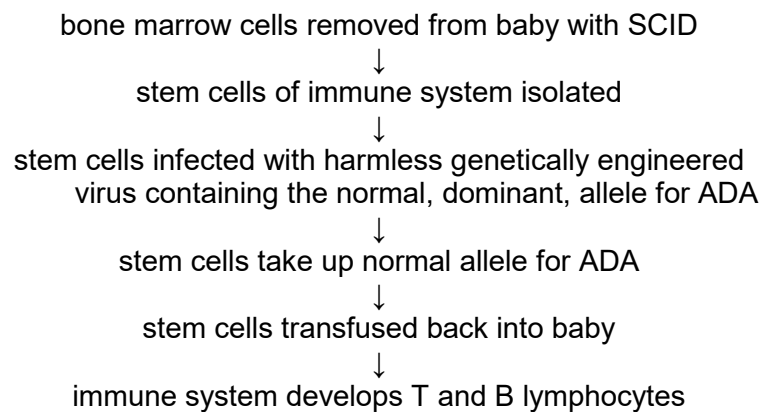
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[Total 4 marks]

- 136.** Babies born with severe combined immune deficiency (SCID) have no defence against common infections and quickly become ill when the protection from maternal antibodies is lost.

SCID is caused by a mutant allele of the gene coding for an enzyme, adenosine deaminase (ADA).

Gene therapy for SCID has been carried out using the procedure shown in the figure below.



- (i) Describe how the DNA of the harmless virus referred to above can be genetically engineered to carry the normal allele of the human gene for ADA.

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[4]

- (ii) Explain why it is easier to perform gene therapy when the normal allele is the dominant allele of the gene concerned.

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[2]

[Total 6 marks]

137. Some manufacturers of paper and timber products claim that their raw materials come from 'sustainable forest resources'.

With reference to paper and timber production, explain what is meant by

(i) *a biological resource;*

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[2]

(ii) *sustainable production.*

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[2]

[Total 4 marks]

138. The cyclamen mite is a pest of strawberry crops in California. Populations of these mites are usually kept under control by a species of predatory mite of the genus *Typhlodromus*.

An experiment was carried out to investigate the effectiveness of predation in controlling cyclamen mites.

Both predator and prey mites were released on a group of strawberry plants in a greenhouse and the numbers of both types of mite were monitored over a period of 12 months. The results are summarised in Fig. 1. A second investigation was carried out on a crop of strawberry plants growing in a field. The plants were sprayed periodically with parathion, an insecticide that reduces the number of predators, but does not affect the cyclamen mite. The effects of this on the numbers of cyclamen mites is summarised in Fig. 2.

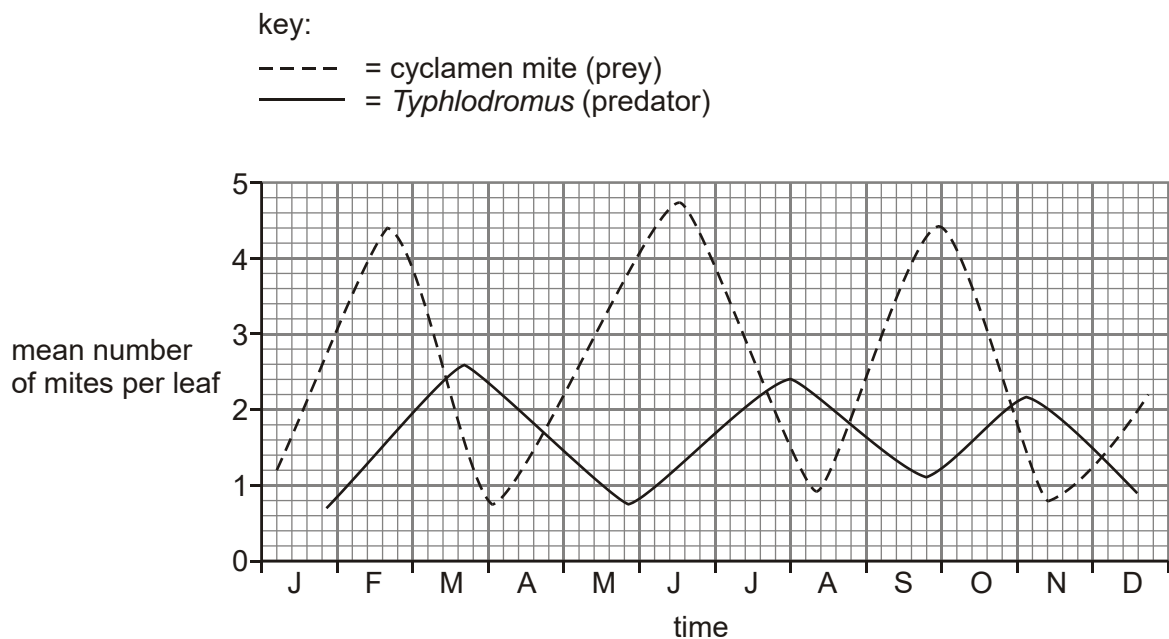


Fig. 1

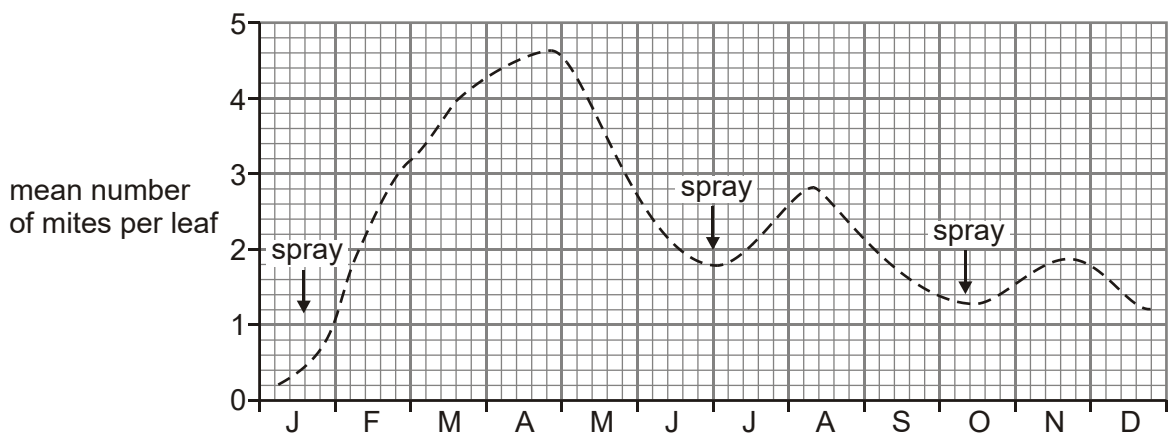


Fig. 2

(a) The results shown in Fig. 1 illustrate many of the features of a typical predator-prey relationship.

Describe and explain these typical features.

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[4]

(b) (i) Sketch a curve on Fig. 2 to show the likely effect of spraying on the population of the predatory mite.

[2]

(ii) Suggest *two* reasons for the gradual decrease in the numbers of cyclamen mites over the year, as shown in Fig. 2.

1

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2

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[2]

(c) Many Californian strawberry growers keep the cyclamen mite under control by ensuring that there are healthy populations of the *Typhlodromus* mite.

(i) State the name given to this type of pest control.

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[1]

(ii) Explain why many would regard the use of predatory mites as preferable to the application of insecticides.

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[5]

(d) Suggest *two* methods of pest control other than the use of predatory mites or insecticides.

1

2

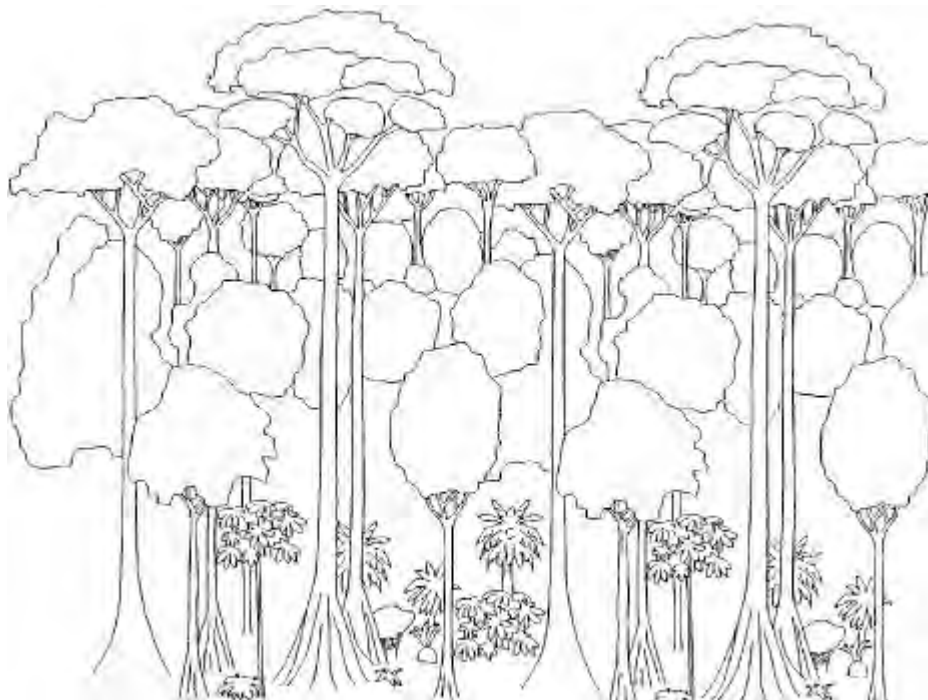
[2]

[Total 16 marks]

139. The climax vegetation in tropical areas with abundant rainfall is rainforest. Although rainforests now cover less than 4% of the land surface of the Earth, they account for more than 20% of the planet's net carbon fixation. By comparison, temperate forests are about half as productive (per unit area), while boreal forests (forests of northern latitudes) and grasslands are only a quarter as productive.

A 13 km² rainforest preserve in Costa Rica has 450 species of trees, more than 1000 other plant species, 400 species of birds, 58 species of bats and 130 species of amphibians and reptiles.

The figure below shows a diagram of a typical area of tropical rainforest.



- (a) List *three* reasons why tropical rainforests have been destroyed, so that they now cover only 4% of the land surface of the Earth.

1

2

3

[3]

- (b) In this question, one mark is available for the quality of use and organisation of scientific terms.

Making use of the information in the passage and the figure, describe the important features of tropical rainforests **and** explain why their disappearance is a cause of considerable concern.

(Allow one line page)

[8]

Quality of Written Communication [1]

(c) Outline the **international** measures that can be taken to try and halt the decline of the tropical rainforests.

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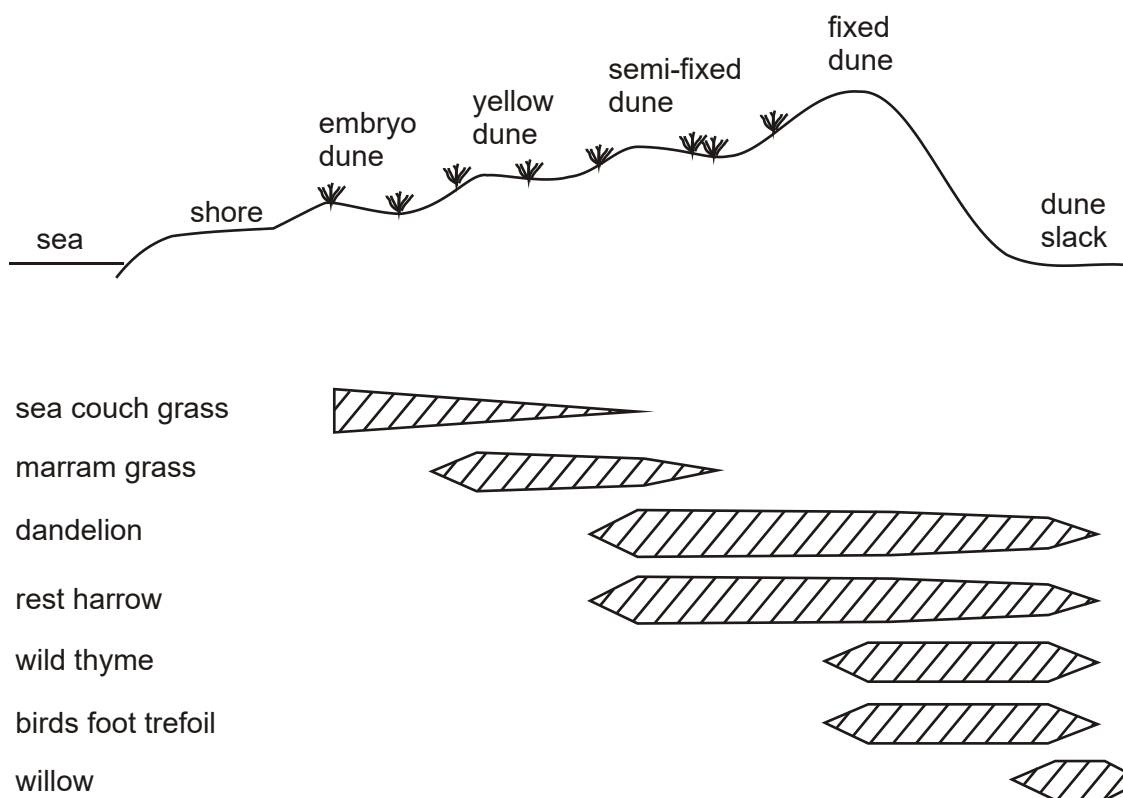
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[3]

[Total 15 marks]

140. The figure below illustrates the profile of a sand dune system, together with kite diagrams of some plant species. This summarises the results of a belt transect carried out over the dunes.



The results of the transect were initially recorded using the ACFOR scale:

A – abundant

C – common

F – frequent

O – occasional

R – rare

- (a) Outline the advantages and disadvantages of using a scale, such as the ACFOR scale.

advantages

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.....

disadvantages

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.....

[3]

- (b) Explain

- (i) how such a transect would have been carried out;

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[4]

- (ii) how the ACFOR readings would have been converted to kite diagrams. You may use the space below for any diagrams to help your answer.

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[3]

- (c) The distribution of plant species in sand dunes will be influenced by a number of abiotic factors, such as temperature.

Explain how to measure, in different parts of the sand dune system, variations in temperature of the sand or soil.

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[2]

- (d) Sand dune systems are a result of the process of succession. The semi-fixed dunes represent an intermediate sere between yellow and fixed dunes.

Explain

- (i) what is meant by a sere;

.....

[1]

- (ii) the process of succession in a system of sand dunes, or in an area you have studied.

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[4]

[Total 17 marks]

141. (a) A number of organic chemicals are produced commercially using microorganisms.

Citric acid is produced by certain fungi and is a secondary metabolite.

- (i) Name **one other** secondary metabolite produced commercially from a fungus.

.....

[1]

(ii) State what is meant by the term *secondary metabolite* .

.....

[1]

(iii) State which method of fermentation would be used to produce a secondary metabolite and explain your answer.

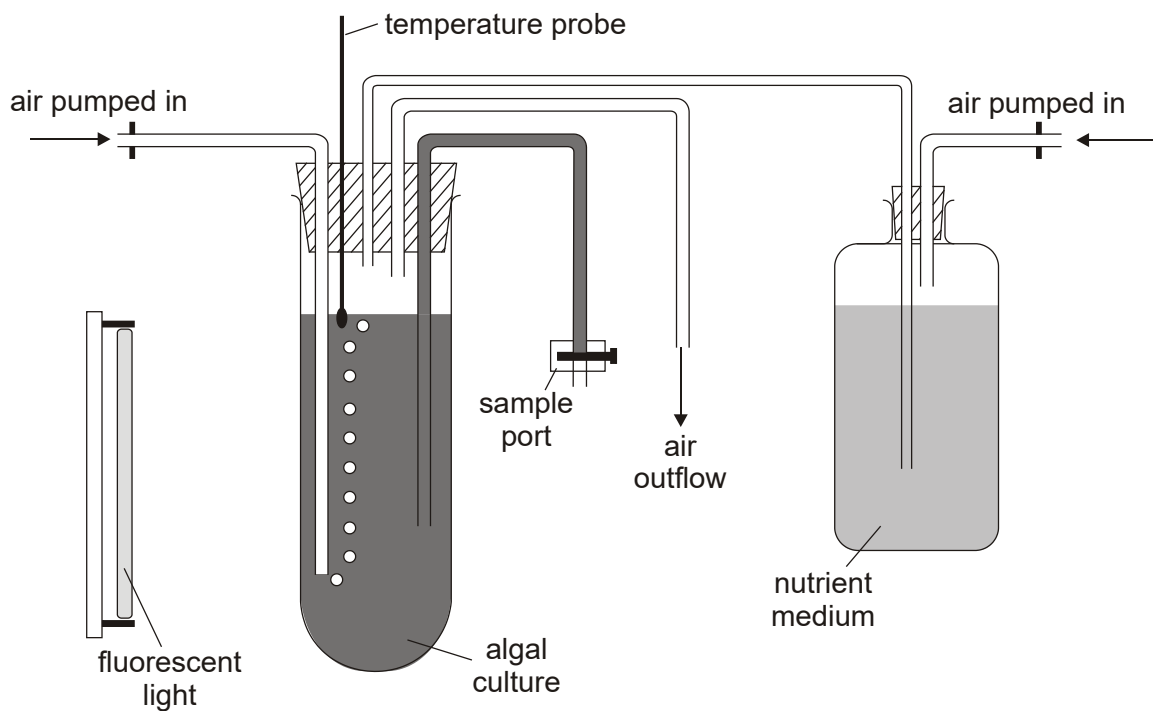
method

explanation

.....

[3]

The figure below shows a 'pilot plant' assembled by a student in a school laboratory.



- (b) The student has undertaken a project to culture an alga called *Chlorella* to feed brine shrimps for use as fish food. If it works, the student hopes to produce a **continuous culture** of algae.

Explain how the apparatus shown in the figure above allows a continuous culture of *Chlorella*.

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[6]

- (c) Describe the major problems of developing this project to enable the large-scale production of *Chlorella*.

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[4]

[Total 15 marks]

- 142. Research is taking place to see if chemicals can be added to toothpaste that block the expression of the genes responsible for the synthesis of the sticky gel and therefore stop plaque forming.

RNA interference is one method used to block the expression of genes.

This uses RNA molecules that are complementary to the messenger RNA of the gene.

- (i) Explain how RNA interference affects the expression of a gene.

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[3]

- (ii) Unfortunately, adding complementary RNA to toothpaste has not proved successful in controlling plaque. Suggest why.

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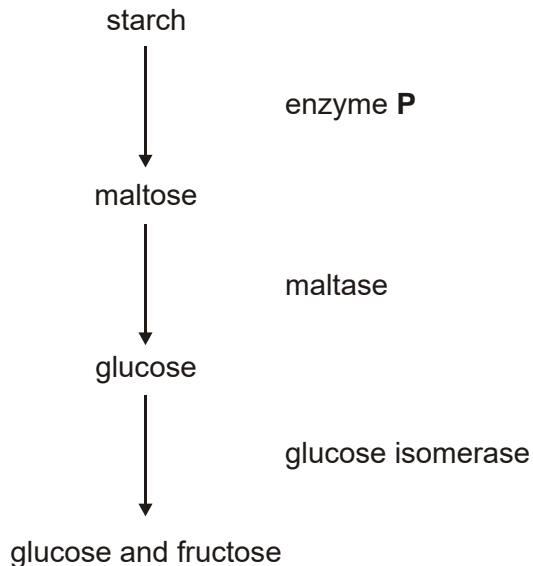
[2]

[Total 5 marks]

- 143.** Immobilised glucose isomerase is used for the production of high-fructose syrups. Starch is used as a source of glucose, which is then treated by glucose isomerase to form a mixture of glucose and fructose.

Fructose is sweeter than glucose and the syrup formed is used in sweets and soft drinks.

The figure below shows the stages in this process.



- (a) (i) Name enzyme **P**.

.....

[1]

(ii) Name the type of bond that is broken when maltose is converted to glucose.

.....

[1]

(iii) Name the form of glucose produced when maltose is broken down.

.....

[1]

(b) The enzyme glucose isomerase is immobilised by being attached to an insoluble material.

(i) State **two** ways in which glucose isomerase could be immobilised.

1

2

[2]

(ii) Explain **two** advantages of using immobilised glucose isomerase rather than the enzyme in solution.

1

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2

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[4]

- (c) Nitrogenase is an enzyme found in some bacteria that converts nitrogen gas into ammonia in a process known as nitrogen fixation. The enzyme is inactivated when exposed to oxygen. Commercial methods of fixing nitrogen are being developed but whole cells rather than the isolated enzyme are immobilised.

Suggest advantages of immobilising the whole cell rather than the enzyme.

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[2]

[Total 11 marks]

144. Reflexes are automatic, stereotyped responses to stimuli that can also be conditioned.

- (a) Explain the meaning of the terms

(i) *automatic*;

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.....

[1]

(ii) *stereotyped*;

.....

.....

[1]

(iii) *conditioned*.

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[1]

(b) Describe **one** example of a reflex response to a **named** stimulus.

stimulus

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response

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.....

[1]

Fig. 1 shows a piece of apparatus called a puzzle box, used by Edward Thorndike to investigate operant conditioning in animals.

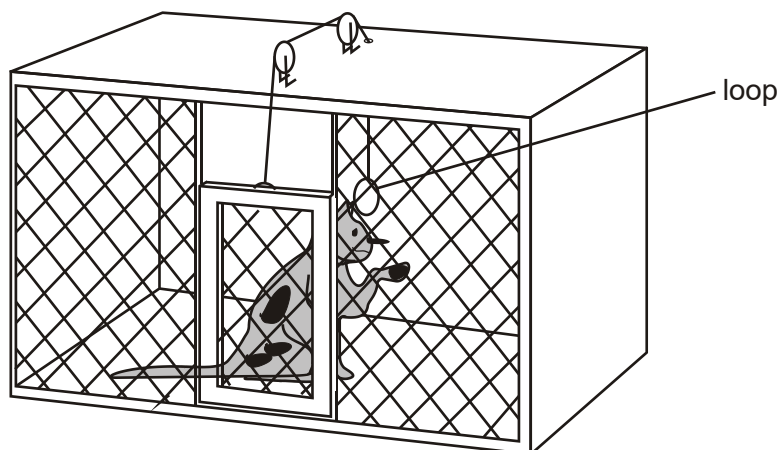


Fig. 1

During an experimental trial, a cat was placed inside the puzzle box. If the cat pulled the loop with its mouth or a paw, the door opened and it could escape. The time taken for the cat to escape was recorded. The experiment was then repeated several times with the same cat.

Fig. 2 shows a graph of the time taken for the cat to escape from the puzzle box during repeated trials.

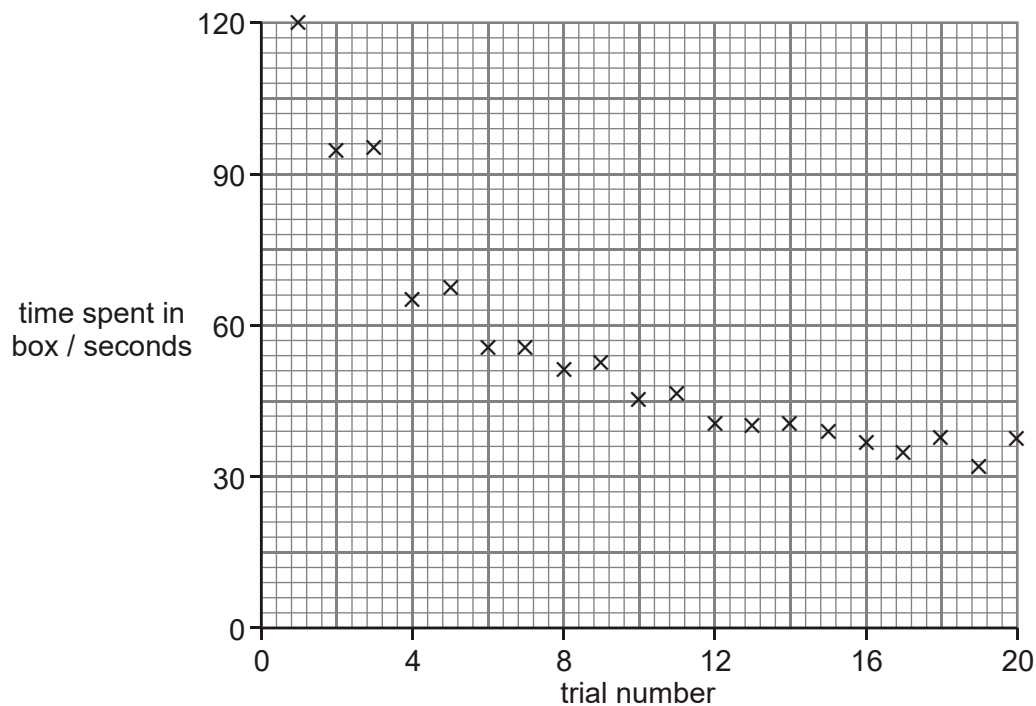


Fig. 2

- (c) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Describe **and** explain the data shown in Fig. 2.

Include in your answer a reason why the type of learning shown by the cat is operant conditioning.

(Allow one line page)

[7]

Quality of Written Communication [1]

(d) State **two** differences between operant conditioning and classical conditioning.

1

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.....

2

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.....

[2]

[Total 14 marks]

145. (a) The cerebellum and medulla oblongata are both parts of the hindbrain. Outline the functions of these two parts of the brain.

cerebellum

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[2]

medulla oblongata

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.....

[2]

- (b) Alzheimer's disease is characterised by several changes in the cerebrum, including 'tangles' inside neurones and 'plaques' between neurones.

State what causes

- (i) tangles;
-
-

- (ii) plaques.
-
-

[2]

Another change in the cerebrum of a person with Alzheimer's disease is a decrease in acetylcholine released by neurones that form memory circuits.

During a clinical trial, people with Alzheimer's disease were treated with a drug that inhibited the enzyme acetylcholinesterase. This improved their short-term memory.

- (c) Suggest how the drug may inhibit acetylcholinesterase.

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[3]

(d) Suggest how the drug improves short-term memory.

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[2]

(e) State **three** precautions that should be taken when designing such clinical trials, to ensure that any effects are due to the drugs being tested.

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[3]

[Total 14 marks]

146. The leaves of tomato plants are usually dark green. A variety known as 'Sunny' has yellow-green leaves when grown under the same conditions as dark green varieties.

A 'Sunny' plant was allowed to self-pollinate and many seeds were collected from its fruit. A class of students germinated some of these seeds in pots, each containing 80 g of compost and 50 cm³ of water. Six seeds were planted in each pot. The pots were placed in an incubator at 26 °C for four days and then on a bench near a window in bright daylight for a further four days, after which the seedlings were examined and the colour of their leaves recorded.

Some of the students' results are shown in Table 1.

Table 1

pot	numbers of seedlings developed after 8 days		
	dark green	yellow-green	yellow
A	3	2	0
B	0	6	0
C	1	4	1
D	1	0	2
E	2	3	1
F	1	4	1

After all the data had been recorded, totals were calculated and are shown in Table 2.

Table 2

	numbers of seedlings developed after 8 days		
	dark green	yellow-green	yellow
totals	28	56	33
ratio			

- (a) Calculate the ratio of dark green : yellow-green : yellow seedlings to the nearest whole number and enter this ratio in the spaces provided in Table 2.

[1]

(b) Explain the results shown in Table 2.

You may include a genetic diagram as part of your explanation. Explain any symbols that you use.

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[5]

(c) The student who had been responsible for pot **B** was concerned that there must have been some error because all six of the seedlings were the same.

Another student said that the totals of the results, shown in Table 2, seemed so 'good' that they must have been 'fiddled', i.e. must have been a scientific fraud.

Comment on the views of these two students.

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[3]

- (d) The seedlings were left to grow in the pots for a further 14 days. The pots remained in bright light and were watered regularly.
- All the yellow seedlings died.
 - The dark green seedlings grew larger than the yellow-green seedlings.

Explain these observations.

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[3]

[Total 12 marks]

147. Read the passage below and answer the questions that follow.

Snake Venoms

Some types of snake kill their prey and defend themselves by means of a poisonous bite.

Fangs (hollow teeth) inject venom from specialised glands into the victim. The venom contains a protein, which is a toxin.

Different species of snake have toxins that act in different ways. Haemolytic toxins are enzymes that hydrolyse phospholipids. They damage tissues, including heart muscle.

Neurotoxins, such as the one produced by green mamba snakes, bind to acetylcholine receptors on the surface membranes of nerve cells or muscle fibres. This leads to muscle paralysis and heart failure.

Some antibodies bind to toxins and inactivate them. These antibodies are known as antitoxins.

The human immune response is far too slow to be effective in making antitoxins against snake venom.

Injecting a very small, non-lethal quantity of venom into a horse produces antitoxin. The horse produces antitoxins that can be extracted from horse blood and used as an emergency treatment for those bitten by the same species of snake.

Each time the horse is injected with venom, it is able to tolerate larger doses and the concentration of the specific antitoxin in its blood is greater.

(a) State how enzymes which hydrolyse phospholipids damage tissues.

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[1]

(b) Suggest how a neurotoxin which binds to acetylcholine receptors on muscle fibres would produce paralysis.

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[2]

(c) Explain why the **human** immune response is too slow to protect a person from a snake bite.

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[2]

(d) Explain why a horse is injected more than once with a small amount of venom when it is being prepared for use as a source of antitoxin.

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[3]

(e) Why would treatment with horse antitoxin produce no long-term protection against snake bites?

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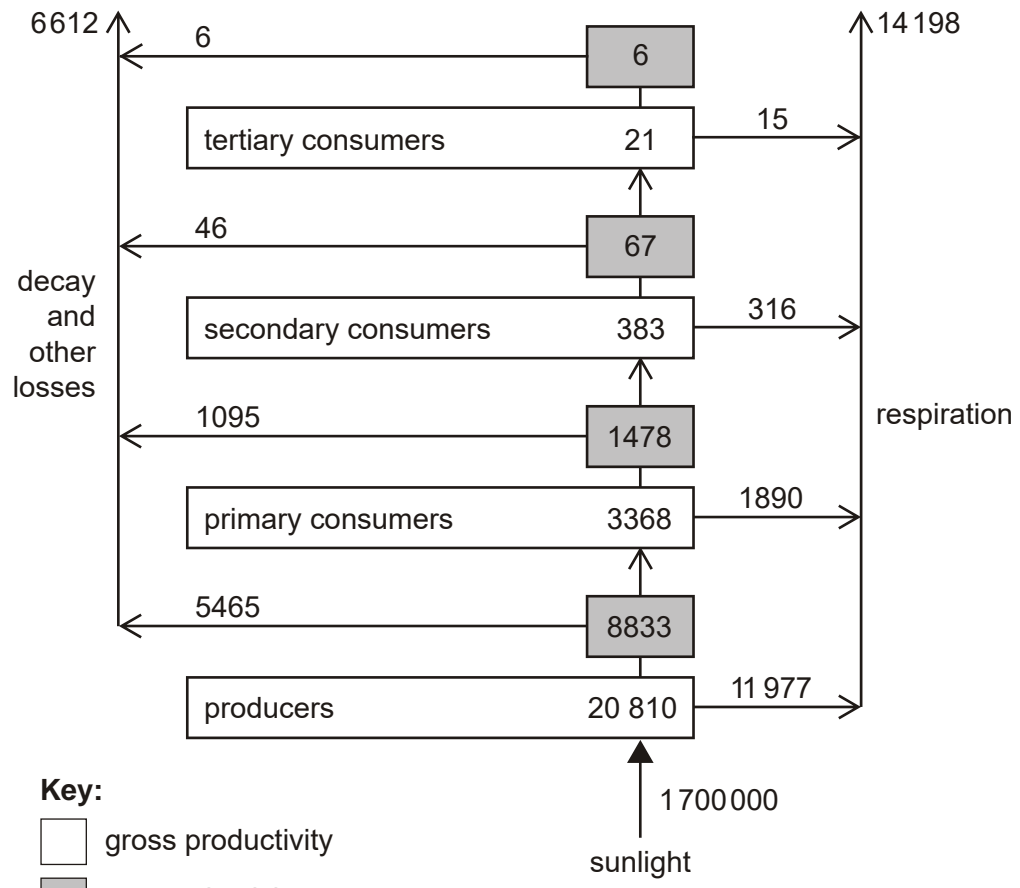
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[2]

[Total 10 marks]

148. In this question, one mark is available for the quality of spelling, punctuation and grammar.

The diagram below represents the energy flow through an ecosystem.



Key:

- gross productivity
- net productivity

all figures given are in kJ m⁻²yr⁻¹

Explain how energy is transferred through food chains and food webs in an ecosystem. You should refer to the efficiency of this transfer in your answer. You will gain credit if you make use of the information in the diagram.

[9]
Quality of Written Communication [1]
[Total 10 marks]

- 149.** Many human proteins, such as growth hormone, are now produced in large quantities by genetically engineered cells. Previously, growth hormone was extracted from animals.

State **two** advantages of producing growth hormone by genetically engineered cells.

1

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2

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[Total 2 marks]

- 150.** Scientists have produced strains of genetically engineered yeast that are capable of producing proteins and adding the branching arrangement of sugars characteristic of human cells. Each strain of yeast produces a different specific protein.

The process involves:

- removing the yeast gene that is responsible for adding the yeast sugars to the protein;
- adding to the yeast a gene from roundworms that builds short chains of mannose sugar units;
- adding two further genes, one from humans and one from a fungus, that add other sugars, such as galactose, to the short chains and make branched chains.

- (i) State the type of enzyme that is used to remove a gene from the rest of an organism's DNA.

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[1]

(ii) Describe how the foreign genes can be inserted into DNA.

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[3]

(iii) Suggest how the gene from roundworms is responsible for the building of short chains of mannose sugar units.

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[2]

[Total 6 marks]

151. Chromosome 22 was the first chromosome to be decoded as part of the human genome project. This chromosome is known to carry genes involved in the functioning of the immune system, congenital heart disease, several cancers and certain mental disorders, such as schizophrenia.

Explain how knowledge of particular genes, such as those found on chromosome 22, may be used in the field of modern medicine.

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[Total 4 marks]

152. It has been suggested that future testing of our DNA will show our susceptibility to certain diseases and could create a genetic underclass.

Explain the arguments **against** extensive genetic screening of the population.

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[Total 4 marks]

153. In guinea pigs, the genes for coat texture and coat colour are found on separate chromosomes. The allele for rough coat is dominant to the allele for smooth coat. The allele for black coat is dominant to the allele for white coat.

A black guinea pig with a rough coat was crossed with a white guinea pig with a rough coat.

The cross was repeated on a number of occasions and the phenotypes of the offspring were as follows:

28 rough and black coats

31 rough and white coats

11 smooth and black coats

10 smooth and white coats

Complete the genetic diagram to explain this cross.

Use the following symbols to represent the alleles:

R = rough r = smooth

B = black b = white

Parental phenotypes: rough and black coat × rough and white coat

Parental genotypes:

Gametes:

Offspring genotypes:

Offspring phenotypes:

Expected phenotypic ratio:

[Total 5 marks]

154. A gene controlling coat colour in cats is **sex linked**. The two alleles of this gene are black and orange. When both the black and orange alleles are present, the coat colour produced is called tortoiseshell.

(i) Define the following terms.

gene
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[2]

allele
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[1]

(ii) Explain why there are no male tortoiseshell cats.

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[2]

[Total 5 marks]

155. The bacterium *Escherichia coli* uses glucose as a respiratory substrate. In the absence of glucose, *E. coli* can use lactose.

Explain how lactose induces the enzyme system involved in its uptake and metabolism.

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[Total 5 marks]

156. Resistance to the poison warfarin is now extremely common in rats. Warfarin inhibits an enzyme in the liver that is necessary for the recycling of vitamin K. This vitamin is involved in the production of substances required for blood clotting. There are two alleles of the gene that code for this enzyme. Resistant rats have the allele R^R ; rats susceptible to warfarin have the genotype $R^S R^S$.

- Rats susceptible to warfarin die of internal bleeding.
- Homozygous resistant rats do not suffer from internal bleeding if their diet provides more than 70 μg of vitamin K per kg body mass per day.
- Heterozygous rats are resistant to warfarin if their diet provides about 10 μg of vitamin K per kg body mass per day.

- (a) A population of rats was studied in an area where warfarin was used. The dietary intake of the rats was about $15\mu\text{g}$ of vitamin K per kg body mass per day.

Complete the table below to indicate whether rats of the three genotypes have a **high** or a **low** chance of surviving to maturity in this population. Explain each of your answers.

genotype	chance of surviving to maturity	explanation
$R^R R^R$		
$R^R R^S$		
$R^S R^S$		

[3]

- (b) (i) State how the allele for warfarin resistance originated.

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[1]

(ii) Explain how the allele spread through the population.

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[5]

(c) State why this is an example of **natural** selection.

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[1]

(d) Explain what is likely to happen to the frequencies of the two alleles (**R^R** and **R^S**) within the rat population over a period of time if warfarin use is discontinued.

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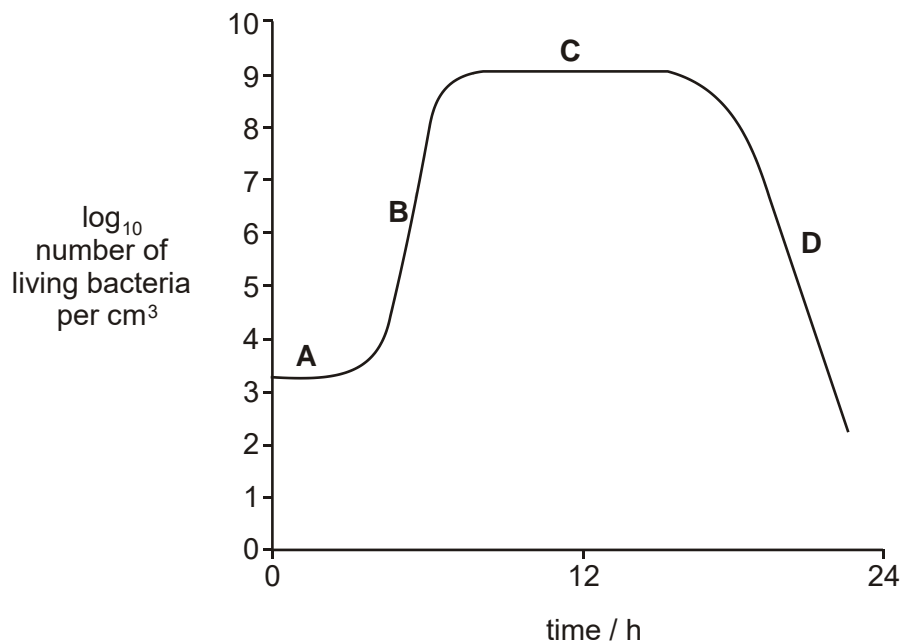
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[2]

[Total 12 marks]

157. The figure below shows a typical bacterial growth curve for a closed system, such as a test tube or conical flask.



From *The Control of Growth and Differentiation in Plants*, p.123, by P. Waring & I. Phillips, published by Pergamon Press Ltd., 1970 (ISBN 0-08-015500-6).

- (a) Complete the table below by writing the appropriate letter from the figure in the spaces provided.

description of stage	letter
cells divide at a constant rate depending upon the composition of the growth medium and the conditions of the incubation	
some cells are dividing and an equal number are dying	
number of living cells is decreasing	
time required for synthesis of inducible enzymes and factors involved in cell division	

[4]

- (b) Generation time (**G**) is defined as the length of time (**t**) from one generation to the next.

The mean generation time is calculated using the following formula:

$$G = \frac{t}{n} \text{ where } t = \text{time and } n = \text{number of generations}$$

- (i) The bacterium *Streptococcus lactis* has been shown to divide 55 times during 24 hours.

Calculate the mean generation time of this bacterium in minutes. Show your working.

Generation time = minutes

[2]

- (ii) The generation time for *Escherichia coli* in a laboratory can be 20 minutes, but in the intestinal tract it can be as much as 24 hours. Suggest **three** reasons for this difference.

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2

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3

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[3]

[Total 9 marks]

158. (a) The colour of the spines on the stems of raspberry plants are controlled by two genes, **A/a** and **B/b**. The genes are on different pairs of chromosomes.

Allele **A** produces a pink anthocyanin pigment in the spines. Allele **B** has no effect by itself, but increases the colour produced by allele **A** to give red spines. Alleles **a** and **b** have no effect on spine colour. In the absence of anthocyanin, the spines are green.

- (i) State the colour of the spines of raspberry plants with the following genotypes:

Aabb

aaBB

[2]

- (ii) Suggest how allele **B** may alter the expression of allele **A**.

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[3]

(b) Plants with the genotypes **AaBb** and **aabb** were cross-pollinated. The resulting seeds were sown and the seedlings grown until their stems developed spines.

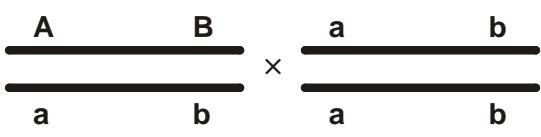
(i) Draw a genetic diagram of this cross to show:

- the phenotypes of the parents
- the gametes
- the genotypes and phenotypes of the offspring
- the ratio of different phenotypes expected in the offspring.

ratio of phenotypes of offspring

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(ii) Explain what differences in the phenotypic ratio would be expected if genes **A/a** and **B/b** were on the same homologous pair of chromosomes, as shown in the figure below.



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[5]
[Total 15 marks]

159. Much of the world's irrigated farmland has become too salty for growing many crops.

Two varieties of tomato plant have been found that are tolerant of salty soil.

- Variety 1 can tolerate high concentrations of NaCl in its tissues but has little ability to prevent the ions from entering the plant. The tomatoes produced are large, but not very tasty.
- Variety 2 cannot tolerate high concentrations of NaCl in its tissues, but is able to prevent excess ions from entering the plant. The tomatoes produced are small, but tasty.

- (a) In this question, one mark is available for the quality of spelling, punctuation and grammar.

Describe a programme for selectively breeding these two varieties to give tomato plants with high salt tolerance and large, tasty tomatoes.

(Allow one line page)

[8]

Quality of Written Communication [1]

- (b) Another variety of tomato plant has been genetically engineered to grow in a concentration of 0.2mol dm^{-3} NaCl by increasing the expression of a gene coding for a protein in the vacuole membrane that pumps excess Na^+ into the vacuoles of the leaf cells.

- (i) Explain how such proteins pump ions into a plant cell vacuole.

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[3]

- (ii) Describe the advantages of producing salt-tolerant tomato plants by genetic engineering rather than by selective breeding.

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[3]

[Total 15 marks]

160. (i) Outline how resistance to an insecticide (pesticide) can arise and spread in a population of mosquitoes.

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[3]

(ii) Explain briefly why efforts to control the spread of malaria are hindered by such insecticide resistance.

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[2]

[Total 5 marks]

161. Malarial parasites infect mosquitoes and are then transmitted to humans. An artificial gene has been synthesised to reduce transmission of malarial parasites by mosquitoes.

Recombinant DNA containing this gene was constructed using enzymes and inserted into mosquitoes.

(i) Explain what is meant by *recombinant* DNA.

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[2]

(ii) Describe briefly the use of enzymes in constructing recombinant DNA.

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[3]

[Total 5 marks]

162. The anti-malarial parasite gene is switched on when the mosquito takes a blood meal.

The protein coded for by the gene inhibits the malarial parasite from passing through the epithelia of both the gut and the salivary gland of the mosquito.

The genetically engineered mosquitoes and unaltered (control) mosquitoes were fed on the same mouse which was infected with malarial parasites.

The mosquitoes' abilities to be infected by and to transmit the parasites were then compared.

The results of the investigation are shown in the table below.

type of mosquito	percentage of mosquitoes in which malarial parasites have passed across the midgut	percentage of mosquitoes with malarial parasites in the salivary glands	percentage of mosquitoes that transmitted malarial parasites to uninfected mice
control	88	76	62
genetically engineered	46	26	10

- (i) Use the data in the table to compare the abilities of control and genetically engineered mosquitoes to act as vectors of the malarial parasite.

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[3]

- (ii) Suggest **one** potential benefit and **one** potential hazard of controlling the spread of malaria by such genetically engineered mosquitoes.

benefit

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hazard

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[2]

[Total 5 marks]

163. David Bellamy, the president of Plantlife, describes peat bogs as ‘the jewel of Britain’s habitats’.

‘You walk with a spring in your step – the peat underfoot is nine-tenths water – to the tireless song of a hovering skylark, on an undulating carpet of green, shot through with red, pink, burnished gold and orange, yellow and white flowers that thrive here. There are hundreds of insect species in the pools and on the plants and an abundance of round-leaved sundew, one of several carnivorous plants that get their nutrients (especially nitrogen compounds) from the insects they trap in their sticky leaves.’

Explain:

(i) why very wet soils are usually nitrogen-deficient **and** how the sundew is at a competitive advantage in such soils;

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[4]

(ii) why, in addition to nitrogen-deficiency, many plants cannot grow successfully in very wet soils.

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[3]

[Total 7 marks]

164. A group of students carried out an investigation into the growth of the Scotch Thistle, *Onopordum acanthium*, in two different sites, **A** and **B**.

At each site, 15 plants were selected and their heights measured and recorded. These are summarised in the table below.

height of plants / mm		
site A	site B	
462	267	
484	295	
396	254	
421	147	
437	116	
365	189	
409	274	
427	196	
439	322	
416	168	
387	244	
488	267	
463	298	
472	321	
399	227	
mean	431	239
standard deviation (s.d.)	37	63

- (a) Describe how the students would have ensured that they measured a **representative** sample of thistles.

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(b) Explain what is meant in the table above by:

(i) *mean*;

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[2]

(ii) *standard deviation*.

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[2]

(c) The figure for s.d. at site **B** is greater than the figure for site **A**. Explain what this means.

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[1]

(d) In order to draw a statistically valid conclusion from their results, the students carried out a *t*-test.

Before calculating a *t* value, they had to state a Null Hypothesis.

(i) State what the Null Hypothesis would be in this investigation.

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[2]

The calculation gave a value for t of 9.64.

The table below shows critical t values at different levels of significance and degrees of freedom.

The number of degrees of freedom for a t -test is two less than the total number of samples.

		level of significance (p)			
		0.10	0.05	0.01	0.001
Degrees of freedom	14	1.76	2.15	2.98	4.14
	16	1.75	2.12	2.92	4.02
	18	1.73	2.10	2.88	3.92
	20	1.73	2.09	2.85	3.85
	22	1.72	2.07	2.82	3.79
	24	1.71	2.06	2.80	3.75
	26	1.71	2.06	2.78	3.71
	28	1.70	2.05	2.76	3.67
	30	1.70	2.04	2.75	3.65

- (ii) Using the table, state the conclusion that would be drawn from the calculation of a t value of 9.64 **and** explain how you reached this conclusion.

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[4]

[Total 15 marks]

165. The table below compares the mean protein yields of two cereal crops, with that of two legume crops.

	crop	mean protein yield / kg ha ⁻¹
cereal	maize	146
	sorghum	91
legume	soybean	509
	groundnut (peanut)	227

Explain how soybean and groundnut produce a significantly higher mean protein yield than either maize or sorghum.

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[Total 4 marks]

166. Enzymes are used in many commercial processes, either in a free, soluble form or immobilised.

Immobilised enzymes are being used in a bioreactor that attaches to spacesuits. The bioreactor was developed during 'Water Recovery Tests'. This immobilised enzyme bioreactor removes the urea from an astronaut's urine. The bioreactor uses immobilized urease enzyme, which catalyses the hydrolysis of urea, forming carbon dioxide and ammonia. These products react to form ions, which are then removed by the bioreactor.

- (i) State the meaning of the term *immobilised enzyme*.

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[1]

(ii) State **two** different methods of immobilising an enzyme.

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- 2
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[2]

(iii) Suggest **three** practical advantages of using an immobilised urease bioreactor in a space ship.

- 1
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- 2
-
- 3
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[3]

[Total 6 marks]

167. Soluble and immobilised lipases were tested for their ability to hydrolyse palm oil. When oil is hydrolysed, it produces fatty acids and glycerol.

The two forms of lipase showed **optimal** activity at the same pH and temperature (pH 7.5 and 35 °C). At that pH and temperature, 100% of the oil was hydrolysed in two minutes.

If the temperature was increased to 45 °C, 100% of the oil was hydrolysed using immobilised lipase but when soluble lipase was used, only 80% was hydrolysed within the two-minute period.

- (i) Define the term *hydrolysis*.

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[2]

- (ii) Using the information from the passage and your knowledge of the products of the reaction, explain the advantages of using an immobilised enzyme to hydrolyse palm oil.

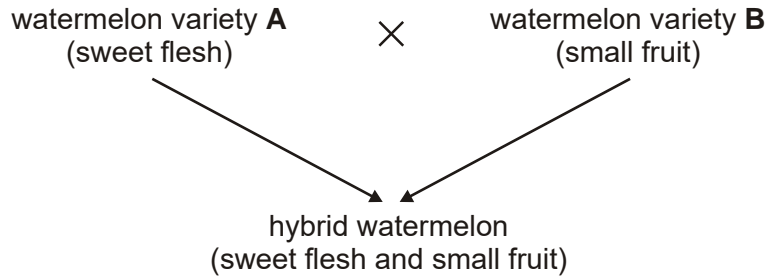
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[4]

[Total 6 marks]

168. Artificial selection has been used for many years to produce plants and animals with characteristics valued by breeders.

A hybrid variety of watermelon has been produced which is small, sweet and seedless. This was achieved by selectively breeding two different varieties of watermelon plant, as shown in the figure below.



The hybrid from this cross is sterile because it is triploid (3n). Tissue culture may be used to clone more of this hybrid variety.

(a) Explain why the hybrid is sterile.

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[2]

(b) Describe how plants that produce watermelons with sweet flesh and small fruits could be obtained by cloning from tissue culture.

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[5]

- (c) Discuss the advantages **and** disadvantages of using the technique of tissue culture for cloning plants.

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[5]

[Total 12 marks]

- 169.** A student investigated the fermentation of two sugars, glucose and maltose, by yeast cells.

Two fermentation tubes were prepared containing equal volumes of a yeast suspension and the respective sugar solutions.

Each fermentation tube was placed inside a test tube, as shown in Fig. 1.

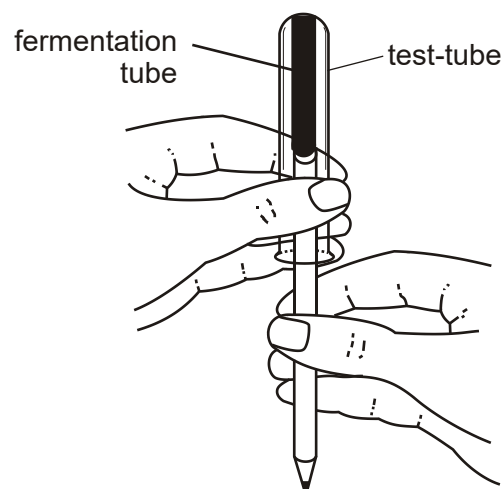


Fig. 1

The test-tubes were turned through 180° and placed in a test-tube rack. The yeast suspensions were left to ferment for 80 minutes. During this time, gas collected as shown in Fig. 2.

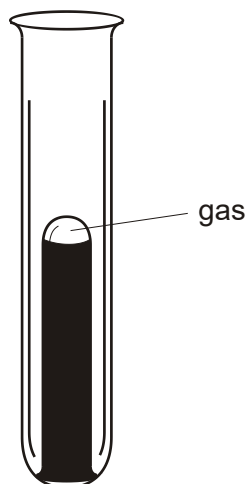


Fig. 2

The student determined the volume of gas collected in each tube at intervals of ten minutes.

The results are shown in Fig. 3.

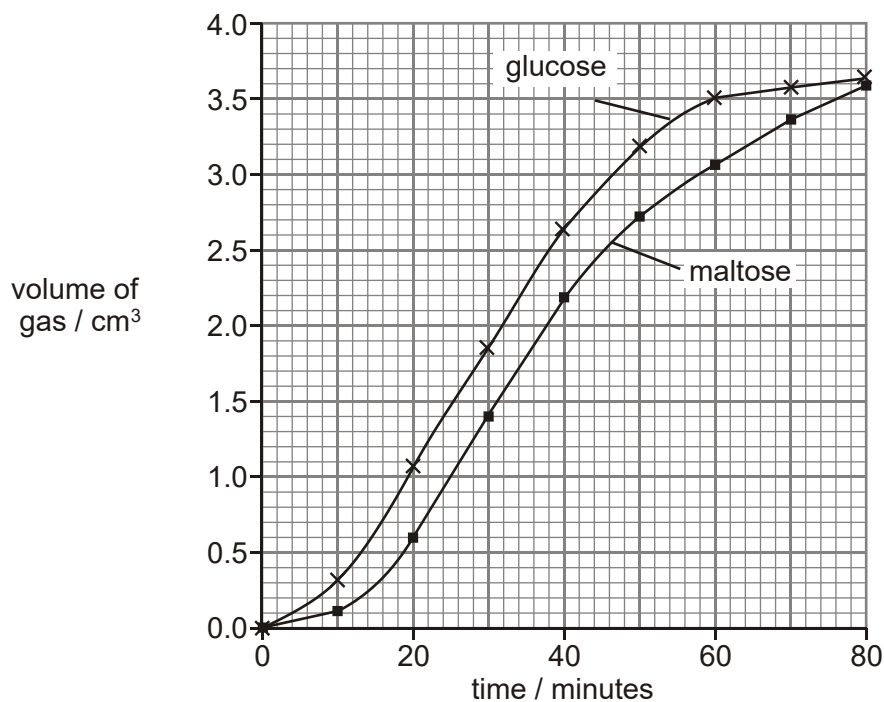


Fig. 3

(a) (i) Suggest **three** variables, **other than type of sugar**, that could affect the results of this investigation.

1

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3

[3]

(ii) Name the gas that is produced by fermentation.

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[1]

(b) (i) Using the data in Fig. 3, describe the results obtained with glucose.

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[4]

(ii) Suggest reasons for the results you have described in (b) (i).

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[4]

(c) Suggest why there is a difference between the results for maltose and the results for glucose.

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[2]

[Total 14 marks]

170. Fig. 1 shows a batch fermenter used to produce penicillin.

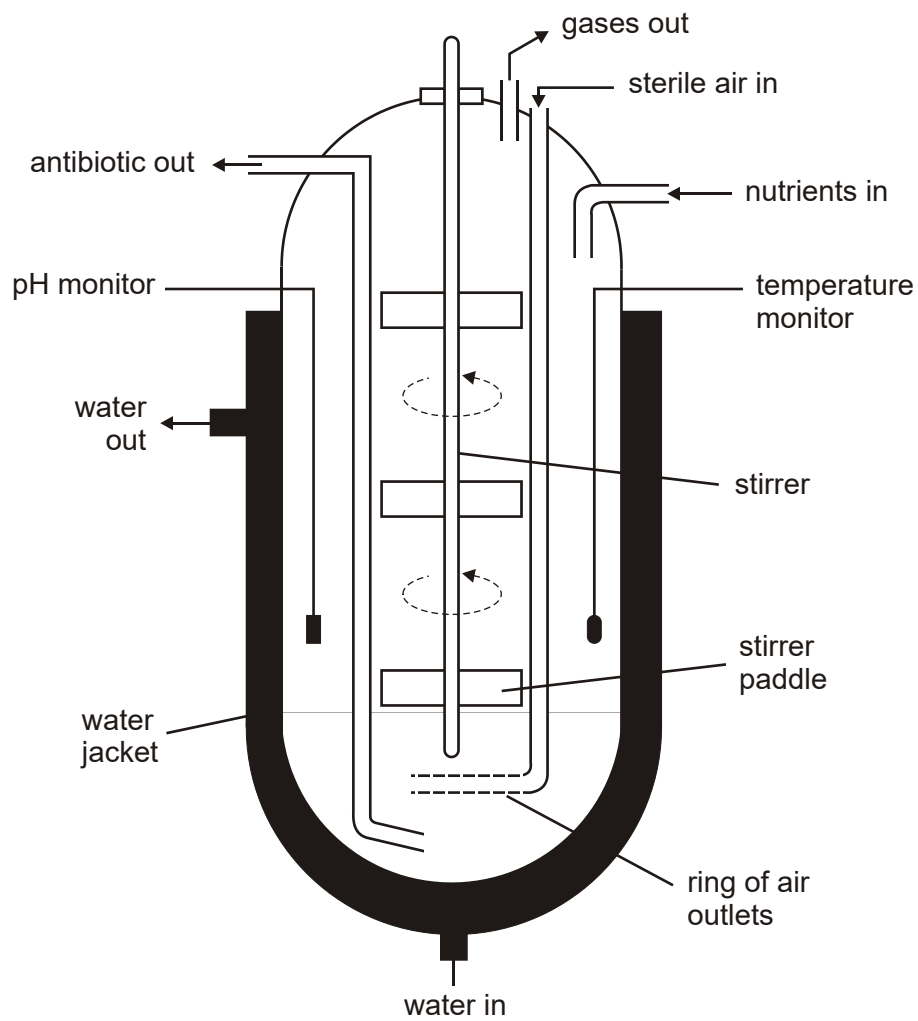


Fig. 1

(a) Explain why sterile air is pumped into the fermenter.

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(b) (i) The fungus that produces penicillin needs a supply of carbon and nitrogen.

Give the form in which these elements are added to the culture.

carbon

nitrogen

[2]

(ii) Explain why it is necessary to pump water into the jacket surrounding the culture.

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[3]

(iii) State why pH is monitored **and** describe how it is controlled.

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[2]

- (c) Fig. 2 is a graph showing the production of penicillin and the growth of the fungus, *Penicillium*, in the fermenter shown in Fig. 1.

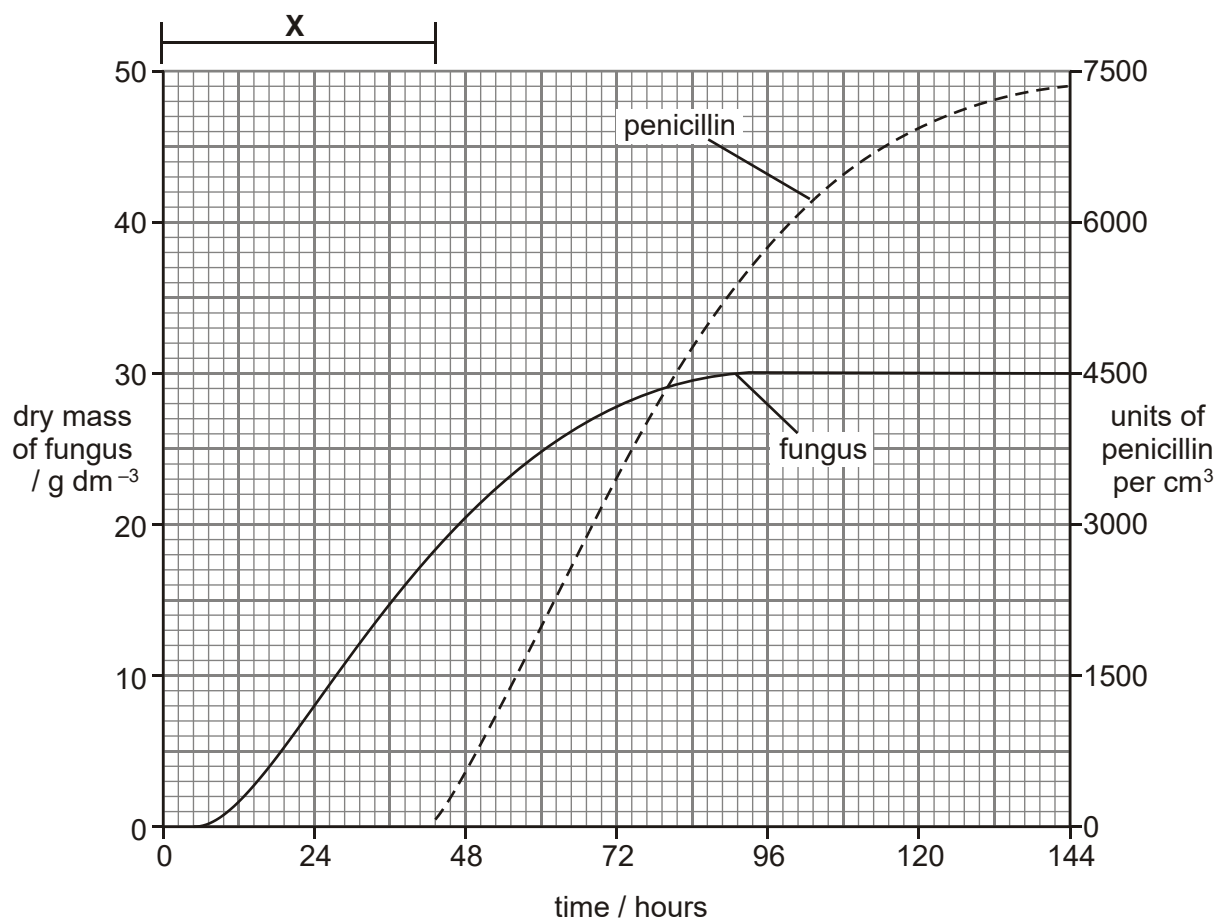


Fig. 2

- (i) Using the data in Fig. 2, state the time when *Penicillium* enters its stationary phase.

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[1]

(ii) Explain why there is no antibiotic produced during phase X.

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[3]

(d) Penicillin is removed from the fermenter for downstream processing.

Describe what happens during downstream processing.

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[3]

- (e) Other medically important products, such as insulin and growth hormone, are produced on a large scale using microorganisms.

Give reasons for using microorganisms in the production of insulin and growth hormone.

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[4]

[Total 20 marks]

171. The human brain is an organ, protected by the skull. The largest part of the human brain is the cerebrum. The surface of the cerebrum is covered by a highly folded region of tissue, called the cerebral cortex. The cerebrum contains regions of mostly myelinated axons, called white matter, and regions of mostly cell bodies and dendrites, called grey matter.

Explain why the cerebral cortex is a tissue, whereas the brain is an organ.

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[Total 3 marks]

172. The following is a list of the functions of the brain. Put a tick (✓) in the box next to the function performed by the cerebrum.

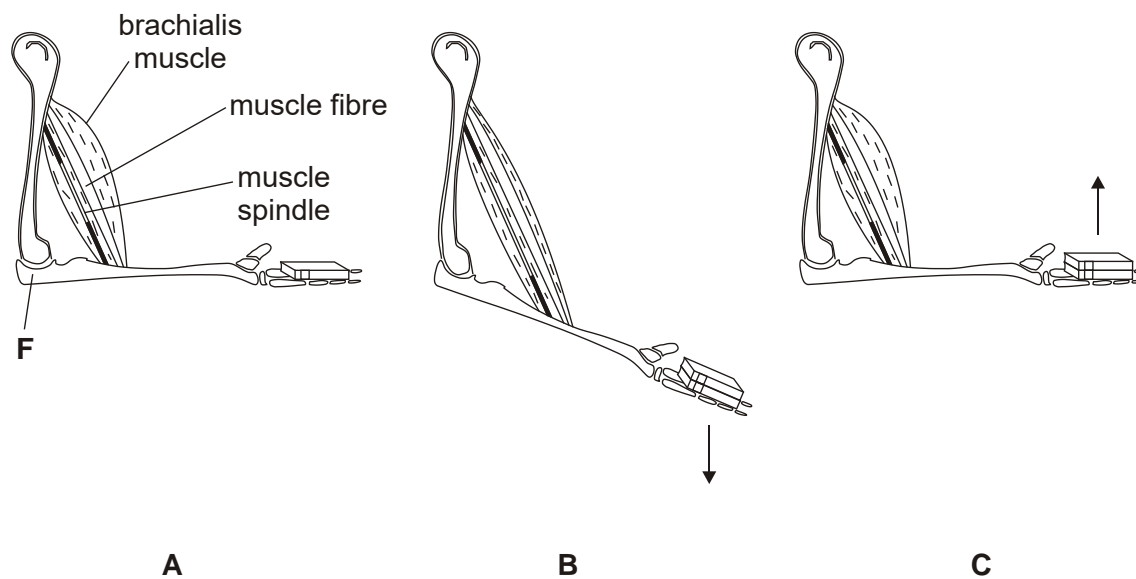
- | | |
|---|--------------------------|
| control of the autonomic nervous system | <input type="checkbox"/> |
| coordination of posture | <input type="checkbox"/> |
| planning a task | <input type="checkbox"/> |
| control of heart rate | <input type="checkbox"/> |

[Total 1 mark]

173. When a book is held in the hand, as shown in Fig.1 **A**, there is a constant load. The muscles of the upper arm contract to produce a force that opposes the load, so maintaining the position of the hand.

Muscle spindles are a type of stretch receptor, which detect changes in the length of muscles.

When a second book is placed in the hand, as shown in Fig.1 **B**, the load increases. This stretches the muscle spindle resulting in an almost immediate increase in the contraction of the muscles of the upper arm, to maintain the position of the hand, as shown in the figure Fig.1 **C**.



Name bone F.

.....

[Total 1 mark]

174. Muscle fibres may become torn and damaged.

Damaged muscle fibres have an increased messenger RNA (mRNA) concentration and a higher rate of oxygen consumption, **at rest**, than undamaged muscle fibres.

Explain these observations:

increased mRNA concentration;

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higher rate of oxygen consumption.

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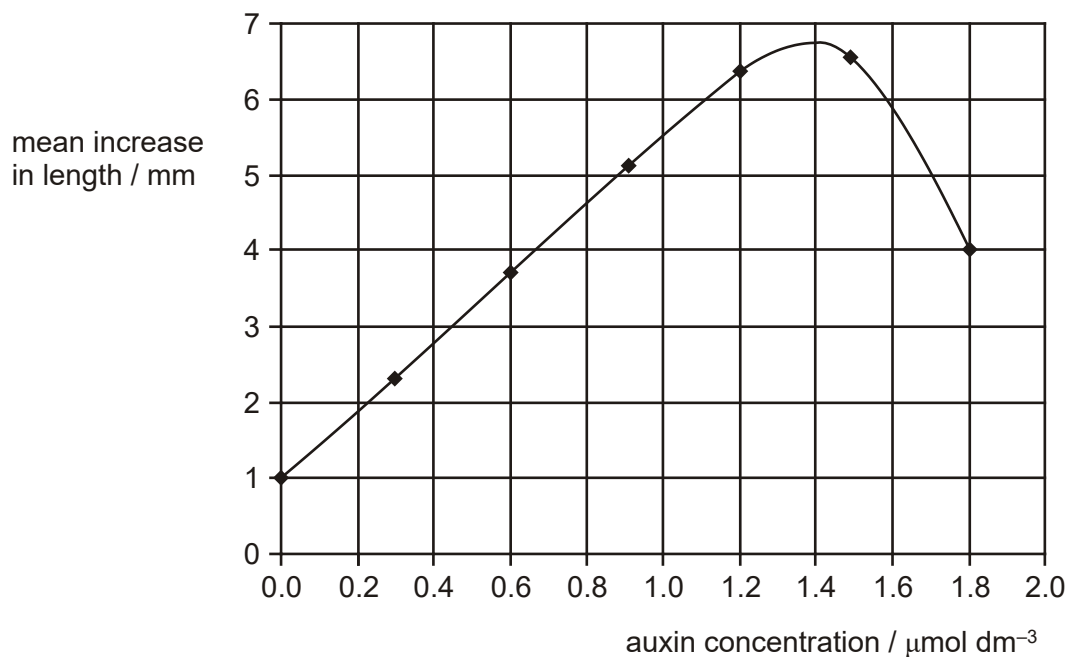
[Total 5 marks]

175. Sections of young, growing stems were cut from just below the terminal buds of several similar plants of the same species. Each section was 5 mm long.

The stem sections were placed in Petri dishes containing different solutions of auxin, with ten sections in each dish.

After 12 hours, the sections were removed from the Petri dishes and measured.

The figure below shows the mean **increase** in length of the sections in each dish, plotted against the concentration of auxin in the solution in the dish.



(a) (i) Using the figure above, describe the relationship between the concentration of auxin in the solutions in the Petri dishes and the mean increase in length of the stem sections.

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(ii) List **three** variables which should have been controlled in the investigation.

1

2

3

[3]

(b) Suggest **two** ways in which auxin might have caused the change in growth of the stems as shown in the figure above.

1

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2

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[2]

(c) State **two** ways in which the control of plant growth by growth substances differs from the control of blood sugar concentration by mammalian hormones.

1

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2

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[2]

[Total 10 marks]

176. Vancouver Island, off the west coast of Canada, was covered by cool temperate rain forest until timber extraction began about one hundred years ago. A large area of this climatic climax community has been cut or burned, though much remains.

When timber is extracted from an area of forest, all trees, including those not required for timber, are usually cut down. The land is then left so that seeds of tree species can germinate and new forest can develop. It takes many decades for a complete canopy of mature trees to develop in an area which has been treated in this way.

Small soil animals of two arthropod orders – **mites** and **springtails** – were studied in several areas of forest on Vancouver Island. Each of the areas was similar in slope and soil type.

The study areas had different stages of tree growth. In each area, mites and springtails were extracted from soil samples and counted. The species of springtail in each sample were identified. The species of mite were not identified.

Some of the data from the investigation are shown in the table below.

stage of tree growth	numbers per 100 g of soil		
	mean number of individuals of all types of mite	mean number of individuals of all types of springtail	mean number of species of springtail
tree seedlings	1375	125	9
young trees	2564	300	13
mature trees	1981	312	11
climax forest, not cut or burned since records began	2890	715	16

State **three** conclusions that you can draw from the data in the table.

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3

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[Total 3 marks]

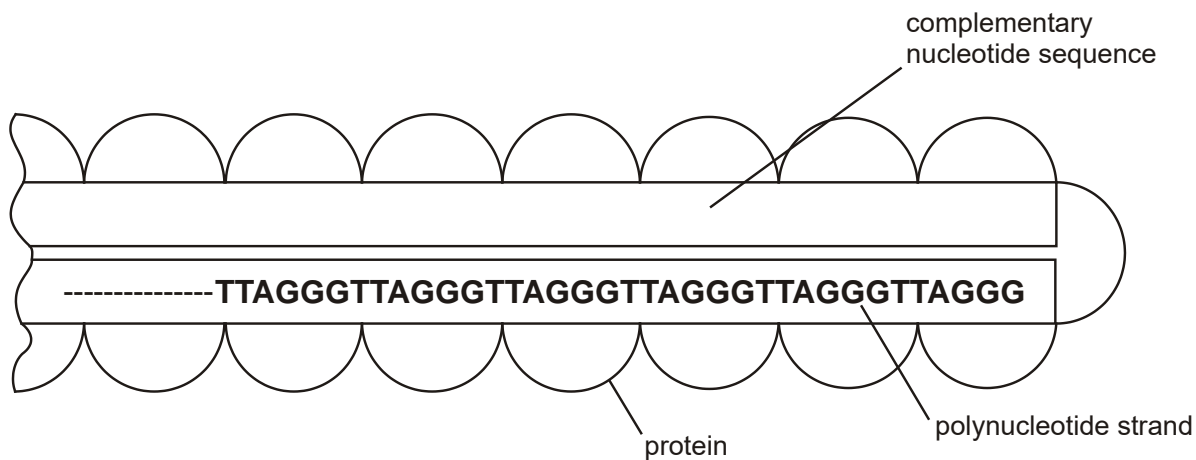
177. Telomeres are the lengths of DNA double helix at the **ends** of all eukaryotic chromosomes.

They have a nucleotide sequence in which the order of the bases in one of the single strands is:

Thymine Thymine Adenine Guanine Guanine Guanine.

This sequence is repeated as many as 2000 times. This repetition is shown in the figure below.

Attached to the DNA of the telomere are protein units that protect the DNA and enable homologous chromosomes to pair during meiosis.



What sequence of bases is **repeated** in the complementary polynucleotide shown in the figure above?

.....

[Total 1 mark]

178. (a) Repeating nucleotide sequences are common in the genomes of eukaryotes, for example in the centromeres and in the regions, called introns, which appear to interrupt the genes. Repeating sequences have been referred to as 'junk DNA'.

Suggest why the term 'junk DNA' is misleading.

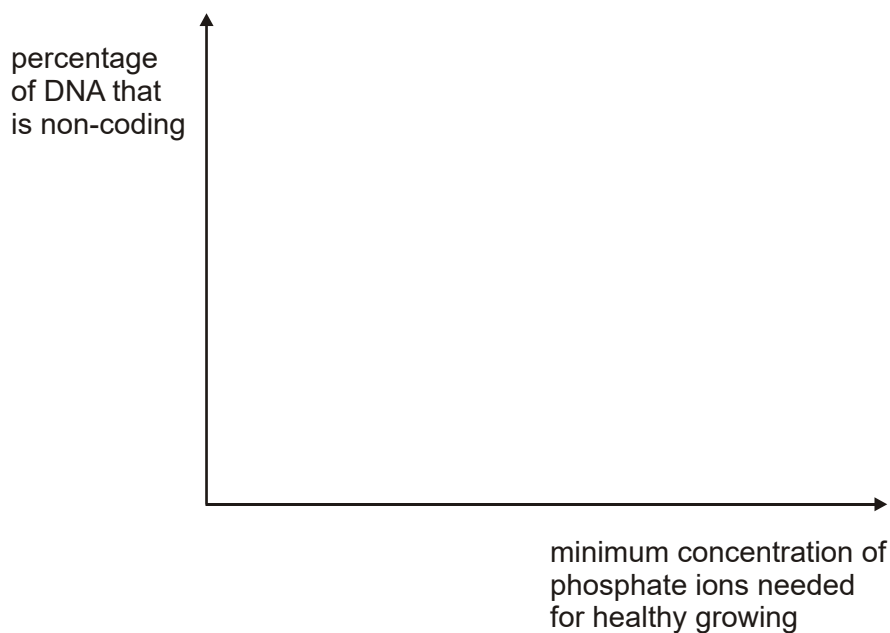
.....

[2]

- (b) Some species of plant are able to grow on soils that contain very little phosphate, while other species, for example stinging nettles, can only grow well in soils that are rich in phosphate. Each nucleotide in a DNA molecule includes a phosphate group.

If much of the non-coding DNA can be correctly regarded as functionless 'junk', there may be a correlation between the percentage of DNA that is non-coding and the minimum concentration of phosphate ions needed for healthy growth.

Draw a straight line graph, using the axes in the figure below, to show the correlation that you would predict.



[1]

- (c) Name a substance **other than DNA** that is found in cells and has one or more phosphate groups as part of its chemical structure.

.....

[1]

[Total 4 marks]

179. An enzyme, such as amylase, has a specific 3-dimensional shape.

Explain how DNA structure determines the specific shape of enzymes.

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[Total 4 marks]

180. Nitrifying and denitrifying bacteria are involved in the nitrogen cycle.

Explain the role in the nitrogen cycle of

(i) nitrifying bacteria;

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.....

(ii) denitrifying bacteria.

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.....

[Total 4 marks]

181. Read the following passage carefully, then answer the questions below.

Rhizobium is a bacterium that is closely associated with the roots of certain plants known as legumes. These plants produce chemicals to attract the bacteria and extra root hairs are produced. The bacteria attach to the surface of the root hairs. Chemical links are formed between a complex
5 polysaccharide on the bacterial surface and lectin, a protein, formed by the plants. The bacteria penetrate the cell walls of the root hairs and enter the cells. The presence of the bacteria stimulates the cells of the root to divide, forming swellings known as nodules.

The bacteria produce an enzyme, nitrogenase, that is the catalyst for the
10 conversion of nitrogen gas to ammonia. The bacteria use carbon compounds manufactured by the plant to respire, making energy available for this conversion. The ammonia is then used to form amino acids. Nitrogenase only functions in low oxygen concentrations. The root cells produce a pigment,
15 leghaemoglobin, that is very similar to haemoglobin. Leghaemoglobin absorbs oxygen, leaving low concentrations in the nodules.

(i) *Rhizobium* is a prokaryotic organism.

State **one** characteristic that is typical of prokaryotes, but not of eukaryotes.

.....

.....

[1]

- (ii) Lectin (line 5) and polysaccharides are compounds that are formed from small molecules joined together by chemical bonds.

Explain how the small molecules are joined together to form these compounds.

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[3]

- (iii) Leghaemoglobin contains the same metal element as haemoglobin.

Name this metal element.

.....

[1]

- (iv) State the names of **two** proteins, **other than lectin**, mentioned in the passage.

1

2

[2]

- (v) Name the process that occurs in *Rhizobium* to convert nitrogen gas into ammonia.

.....

[1]

(vi) It has been suggested that oxygen is an inhibitor of nitrogenase.

Explain **one** way in which oxygen could act as an inhibitor.

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[2]

[Total 10 marks]

182. Genetic engineers have tried to introduce genes for nitrogenase into wheat, which is **not** a legume.

Suggest the possible advantages of developing this wheat.

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[Total 2 marks]

183. State the word or phrase that best describes an organism that obtains its food by eating **only** producers.

.....

[Total 1 mark]