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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

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3703133241

BIOLOGY **9700/41**

Paper 4 Structured Questions A2 Core **October/November 2009**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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Section A
Answer **all** questions.

Section B
Answer **one** question.
Circle the number of the Section B question you have answered in the grid below.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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8	
Section B	
9 or 10	
Total	

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Section A

Answer **all** the questions.

1 **(a)** The squirrel monkey, *Saimiri sciureus*, of Costa Rica has become an endangered species.

Fig. 1.1 shows a squirrel monkey.



Fig. 1.1

Explain what is meant by the term *endangered species*.

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.....[2]

(b) Discuss possible ways in which the squirrel monkey could be protected.

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.....[4]

[Total: 6]

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2 **(a)** *Asellus aquaticus* is a small freshwater crustacean.

200 *A. aquaticus* were released into a pond where there had previously been none. The pond was favourable for their growth and reproduction.

Describe **and** explain the expected changes in the population size of *A. aquaticus* over the following few months.

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.....[5]

(b) In order for natural selection to occur a population must show phenotypic variation.

Explain why variation is important in natural selection.

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.....[2]

[Total: 7]

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[Turn over

3 Proteases that work in alkaline conditions are made in large quantities for use in the detergent industry. The microorganism that is generally used for this is the bacterium *Bacillus subtilis*.

An investigation was carried out to compare three potential production methods:

- using free cells of *B. subtilis*
- using *B. subtilis* cells immobilised in cubes of agar
- using *B. subtilis* cells immobilised in beads of sodium alginate.

To immobilise the cells in agar, the agar was dissolved and cooled. A suspension of *B. subtilis* was then added. The agar-bacterium mixture was poured into sterile dishes and allowed to solidify. It was then cut into cubes with sides of 2 mm.

(a) (i) Explain why the agar was cooled before the suspension of *B. subtilis* was added.

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..... [1]

(ii) Describe how cells of *B. subtilis* could be immobilised in beads of alginate.

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(b) A liquid medium containing glucose, a nitrogen source and various mineral ions was made up, and 50 cm^3 placed into each of three flasks.

Samples of a culture of free cells of *B. subtilis*, agar cubes containing immobilised *B. subtilis* and alginate beads containing *B. subtilis* were placed in the three flasks. Each flask contained the same number of bacteria. All the flasks were incubated at 37 °C for 48 hours.

Samples of the liquid medium in each flask were taken at six hourly intervals and the concentration of protease measured.

The results are shown in Fig. 3.1.

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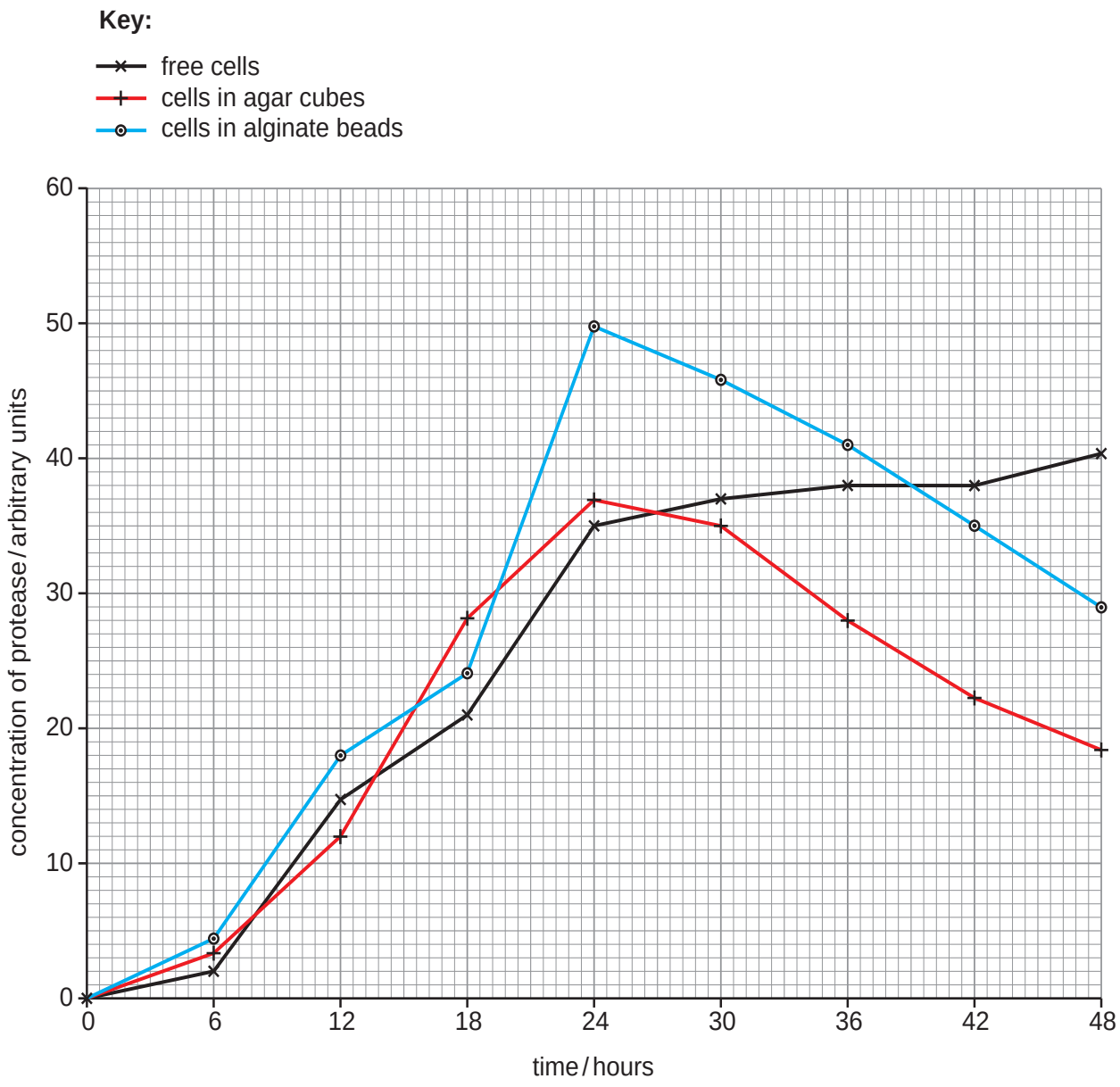


Fig. 3.1

(i) With reference to Fig. 3.1, compare the results for the free cells of *B. subtilis* and cells immobilised in alginate beads.

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(ii) Suggest why lower concentrations of protease were produced by *B. subtilis* immobilised in agar cubes than *B. subtilis* immobilised in alginate beads.

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.....[2]

(c) Two new cultures of immobilised *B. subtilis* were set up as described in **(b)**.
However, this time a repeat batch fermentation method was used, in which the liquid medium was replaced every 24 hours. This was continued until the cubes or beads had begun to disintegrate.

The results are shown in Table 3.1.

Table 3.1

	number of batches before cubes or beads disintegrated	total fermentation time / hours	total protease produced / arbitrary units	mean productivity of protease / arbitrary units per hour
agar cubes	6	144	1792	12.44
alginate beads	9	216	3264	15.11

With reference to Table 3.1

(i) calculate the percentage increase in the total protease produced when the bacteria were immobilised in alginate rather than agar.

Show your working.

.....[2]

(ii) explain why using bacteria immobilised in alginate rather than agar would be a more cost-effective production of protease.

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.....[3]

[Total: 15]

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4 Modern varieties of wheat have developed from numerous hybridisation events between different species of wild grasses. Fig. 4.1 shows some of the possible steps that are believed to have been involved in the development of bread wheat, *Triticum aestivum*.

The letters **A**, **B** and **C** represent three different sets of seven chromosomes.

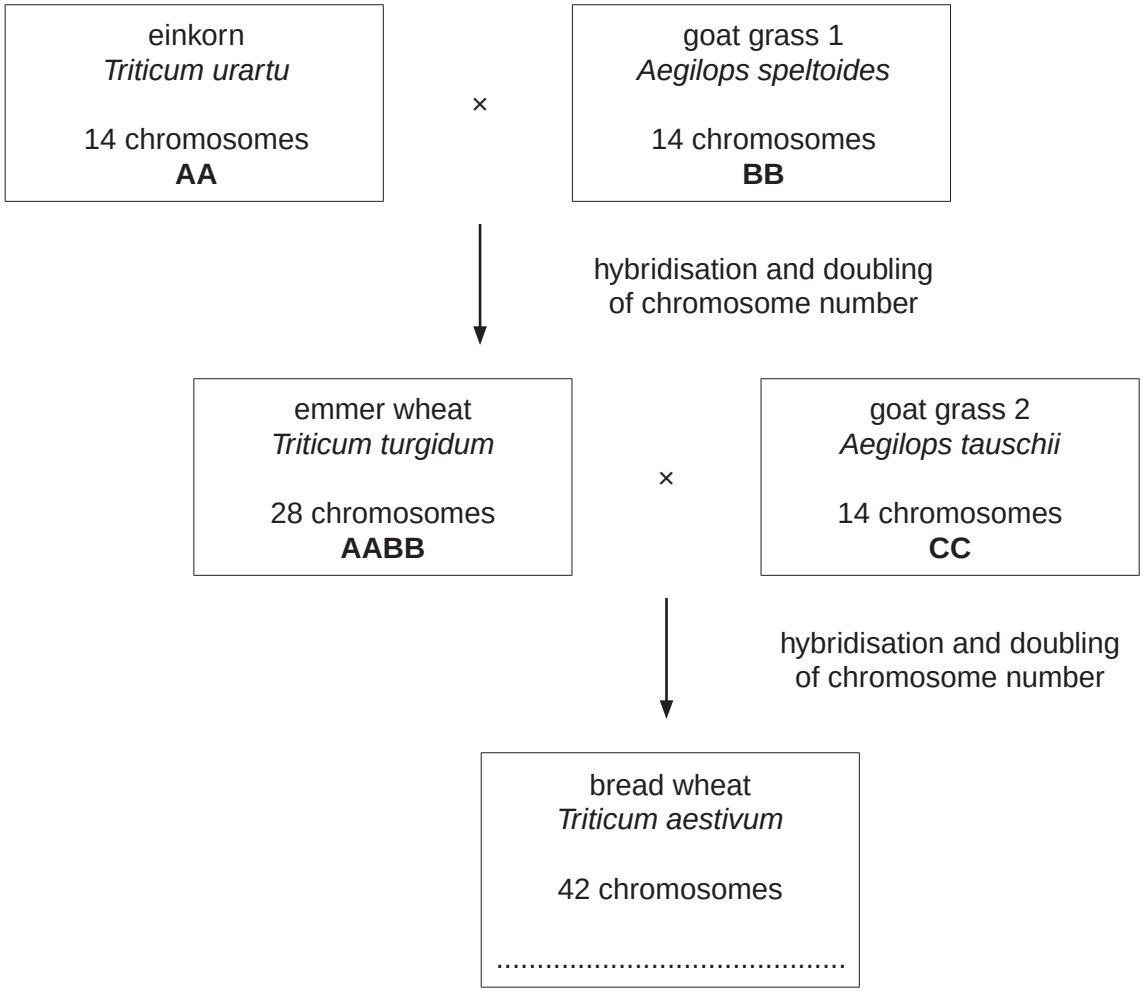


Fig. 4.1

(a) Complete Fig. 4.1 by writing letters to represent the sets of chromosomes in bread wheat.

Write your answer on Fig. 4.1. [1]

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(b) Explain why hybridisation between emmer wheat and goat grass 2 would have produced a sterile hybrid, if doubling of chromosome number had **not** occurred.

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.....[3]

(c) With reference to Fig. 4.1, suggest why *Triticum urartu* and *Triticum turgidum* are classified as different species.

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.....[2]

(d) *Triticum turgidum* emerged as a new species without being geographically isolated from *Triticum urartu*.

Outline how geographical isolation may result in speciation.

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[Total: 9]

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5 **(a)** Hormones are secreted by endocrine glands.

Explain what is meant by the term *endocrine gland*.

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(b) Fig. 5.1 shows the changes in concentration in the blood of follicle stimulating hormone (FSH) and luteinising hormone (LH) during the first half of the menstrual cycle.

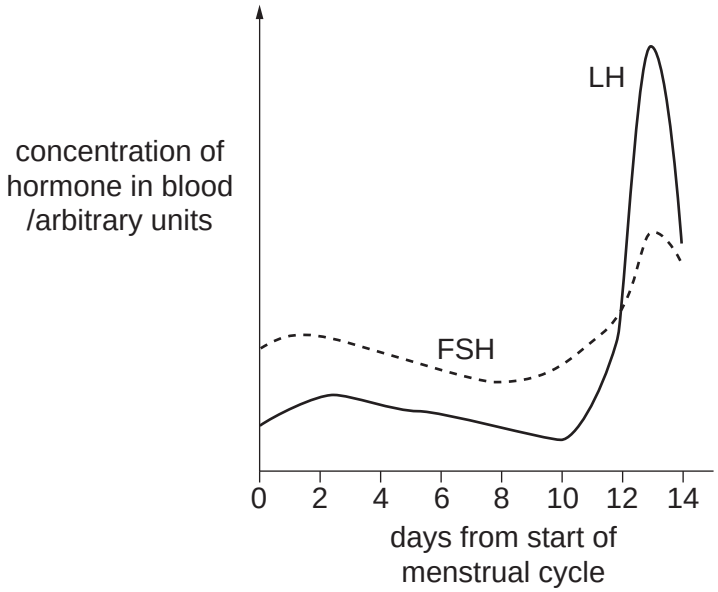


Fig. 5.1

With reference to Fig. 5.1, describe,

(i) the changes that take place in the ovary during this time, as a result of the action of FSH

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.....[2]

(ii) the role of LH.

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.....[1]

(c) In preparation for in-vitro fertilisation (IVF), women are injected with FSH. Explain why treatment with FSH is a necessary preparation for IVF.

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..... [2]

(d) The standard treatment with FSH and clomiphene (clomifene) causes significant side-effects. Clomiphene occupies oestrogen receptors, blocking a negative feedback mechanism.

(i) Explain briefly what is meant by *negative feedback*.

.....

..... [1]

(ii) Outline the feedback mechanism that is blocked by clomiphene.

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..... [1]

(e) Recently a so-called 'mild' treatment has been introduced in the hope of avoiding the side-effects of the standard treatment. This treatment does not use clomiphene. Instead, an antagonist to LH secretion is used.

The days in the first half of the menstrual cycle on which injections of FSH and clomiphene are given in the two treatments are shown by asterisks (*) in Fig. 5.2.

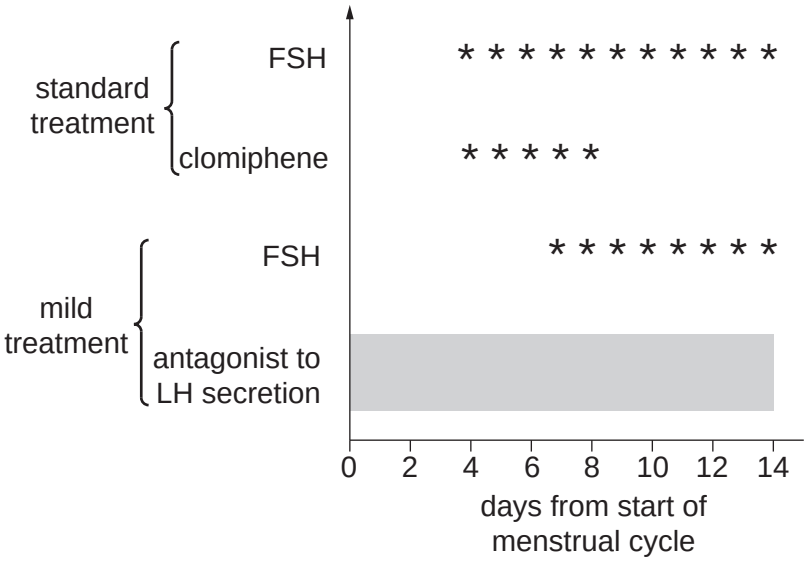


Fig. 5.2

(i) With reference to the concentrations of LH shown in Fig. 5.1, show, using an asterisk on Fig. 5.2 when the antagonist to LH secretion should first be given.

Put your asterisk into the grey area on Fig. 5.2. [1]

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(ii) Suggest why an antagonist to LH secretion forms part of the mild treatment.

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.....[1]

(f) The average dose of FSH given in the mild treatment is 1300 international units (IU), compared with an average dose of 1800 IU in the standard treatment. This could lead to the mild treatment being less effective.

The outcomes of an investigation into the two treatments are shown in Table 5.1.

Table 5.1

	mild treatment	standard treatment
mean number of oocytes harvested per treatment cycle	6.7	8.5
mean number of embryos produced per treatment cycle	2.8	3.8
percentage of pregnancies resulting in live birth	43.4	44.7

With reference to Table 5.1, compare the effectiveness of the two treatments.

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.....[3]

(g) FSH consists of two polypeptide chains which are encoded by genes on different chromosomes. The two genes, together with their promoters, have been inserted into bacteria to produce the hormone used in fertility treatments.

Explain briefly why promoters need to be transferred into the recipient bacteria together with the two genes for the FSH polypeptides.

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.....[2]

[Total: 16]

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6 **(a)** A husband and wife who already have a child with cystic fibrosis (CF) elected to have their second child tested for the condition while still a fetus in very early pregnancy. The results of the test, a DNA banding pattern, were discussed with a genetic counsellor.

The relevant DNA banding pattern produced by electrophoresis is shown in Fig. 6.1.

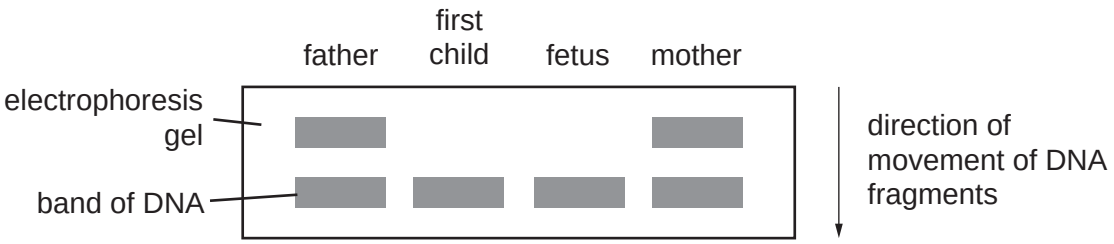


Fig. 6.1

With reference to Fig. 6.1, explain why,

(i) the fetus will develop CF,

.....

.....[1]

(ii) the positions of the bands of DNA of the first child and of the fetus indicate that the mutant allele for CF has a deletion in comparison with the normal allele.

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.....[2]

(b) Explain briefly the need to discuss the result of the test with a genetic counsellor.

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.....[4]

[Total: 7]

7 **(a)** The fruit fly, *Drosophila melanogaster*, feeds on sugars found in damaged fruits. A fly with normal features is called a wild type. It has a striped body and its wings are longer than its abdomen. There are mutant variations such as an ebony coloured body or vestigial wings. These three types of fly are shown in Fig. 7.1.



wild type **ebony body** **vestigial wing**

Fig. 7.1

Wild type features are coded for by dominant alleles, **A** for wild type body and **B** for wild type wings.

Explain what is meant by the terms *allele* and *dominant*.

allele .....

.....

dominant .....

..... [2]

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(b) Two wild type fruit flies were crossed. Each had alleles **A** and **B** and carried alleles for ebony body and vestigial wings.

Draw a genetic diagram to show the possible offspring of this cross.

[6]

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[Turn over

(c) When the two heterozygous fruit flies in **(b)** were crossed, 384 eggs hatched and developed into adult flies.

A chi-squared (χ^2) test was carried out to test the significance of the differences between observed and expected results.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where Σ = sum of
O = observed value
E = expected value

(i) Complete the missing values in Table 7.1.

Table 7.1

	phenotypes of *Drosophila melanogaster*			
	grey body long wing	grey body vestigial wing	ebony body long wing	ebony body vestigial wing
observed number (O)	207	79	68	30
expected ratio	9	3	3	1
expected number (E)	216	72	72	24
O – E	-9	.....	-4	6
$(O - E)^2$	81	.....	16	36
$\frac{(O - E)^2}{E}$	0.38	.....	0.22	1.50

[3]

(ii) Calculate the value for χ^2.

χ^2 = ... [1]

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Table 7.2 relates χ^2 values to probability values.

As four classes of data were counted the number of degrees of freedom was 4 – 1 = 3. Table 7.2 gives values of χ^2 where there are three degrees of freedom.

Table 7.2

probability greater than	*0.50*	*0.20*	*0.10*	*0.05*	*0.01*	*0.001*
values for χ^2	2.37	4.64	6.25	7.82	11.34	16.27

(iii) Using your value for χ^2, and Table 7.2, explain whether or not the observed results were significantly different from the expected results.

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[Total: 14]

8 **(a)** Fig. 8.1 shows the results from two experiments carried out to investigate the effect of light intensity and carbon dioxide concentration on the rate of photosynthesis.

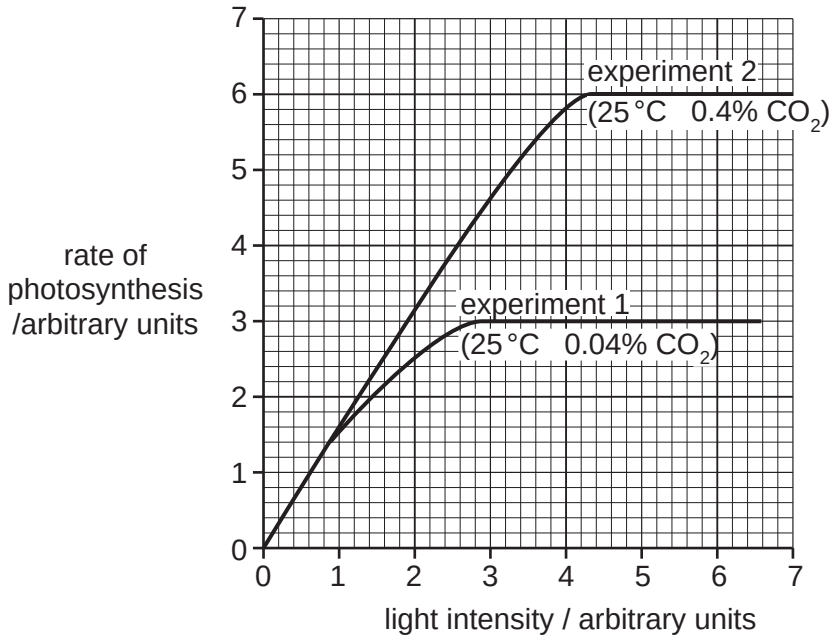


Fig. 8.1

(i) Describe **and** explain the results shown in Fig. 8.1 for **experiment 1**.

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(ii) Describe **and** explain the difference between the results for experiment 1 **and** experiment 2.

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(b) The optimum temperature for many plants living in temperate regions is approximately 25 °C.

Explain why the rate of photosynthesis in these plants decreases at temperatures above 25 °C.

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[Total: 11]

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Section B

Answer **one** question.

9 **(a)** Describe the process of glycolysis. [7]

(b) Describe the structure and synthesis of ATP **and** its universal role as the energy currency in all living organisms. [8]

[Total: 15]

10 **(a)** Describe a reflex arc **and** explain why such reflex arcs are important. [7]

(b) Describe the structure of a myelin sheath **and** explain its role in the speed of transmission of a nerve impulse. [8]

[Total: 15]

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vestigial wing © www.exploratorium.edu/exhibits/mutant_flies/short-wings.gif

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2426314116

BIOLOGY **9700/42**

Paper 4 Structured Questions A2 Core **October/November 2009**

2 hours

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Section A

Answer **all** the questions.

1 All living organisms are divided into five kingdoms.

The table below lists some features possessed by living organisms and some processes that they carry out.

Place a tick or a cross in the table to indicate the presence or absence of the feature or process in any or all members of the kingdom.

The first row has been done for you.

feature or process	kingdom				
	Prokaryotae	Protoctista	Fungi	Plantae	Animalia
80s ribosomes	✗	✓	✓	✓	✓
cell walls contain chitin					
circular DNA					
endoplasmic reticulum					
most species unicellular					
autotrophic					
heterotrophic					

[6]

[Total: 6]

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2 **(a)** A recent study of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations.

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes.

As a result of these observations it has been suggested that speciation is taking place.

Fig. 2.1 is a map of Madeira showing the distribution of the six populations.

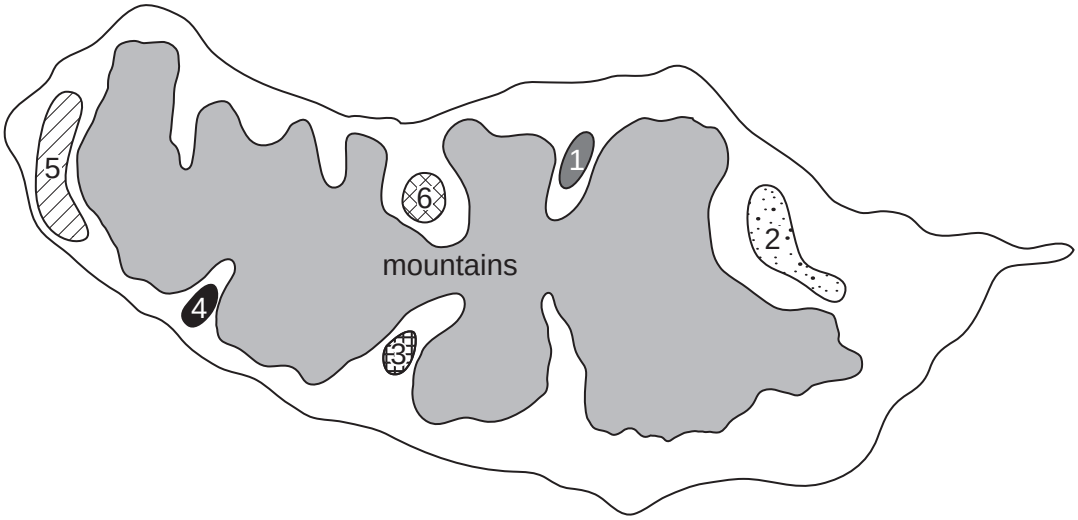


Fig. 2.1

Using the information in Fig. 2.1, state the likely isolating mechanism and the type of speciation taking place.

isolating mechanism .....

type of speciation .....[2]

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(b) Explain how speciation is occurring in the house mouse populations of Madeira.

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[Total: 7]

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3 **(a)** Cell walls of bacteria contain peptidoglycans. Peptidoglycans are long chains of the sugars N-acetylmuranic acid (NAM) and N-acetylglucosamine (NAG) which alternate along the chain. A short peptide chain of three to five amino acids is attached to each NAM and these form cross-links with similar peptide chains from adjacent strands.

Fig. 3.1 shows a diagram representing part of a peptidoglycan structure.

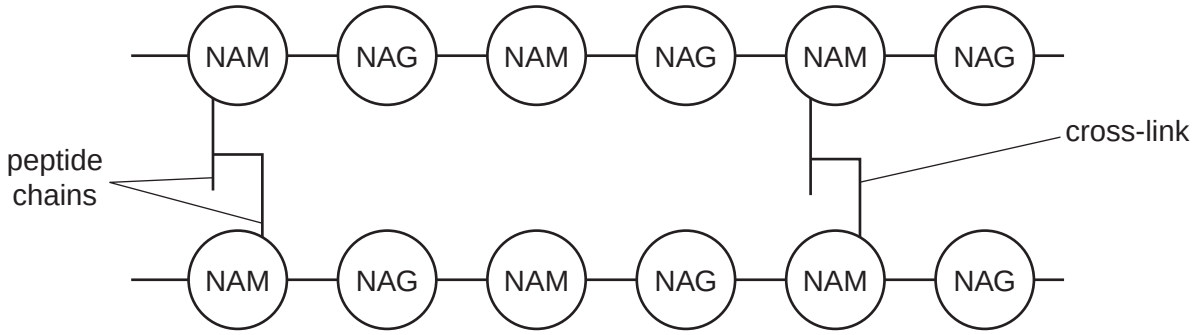


Fig. 3.1

(i) Name the type of reaction that takes place to assemble the peptide chains that form the cross-links.

.....[1]

(ii) Describe the mode of action of antibiotics, such as penicillin, on bacteria.

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(iii) Suggest the name of the type of enzyme that assembles the peptide chains that form the cross-links in peptidoglycans.

.....[1]

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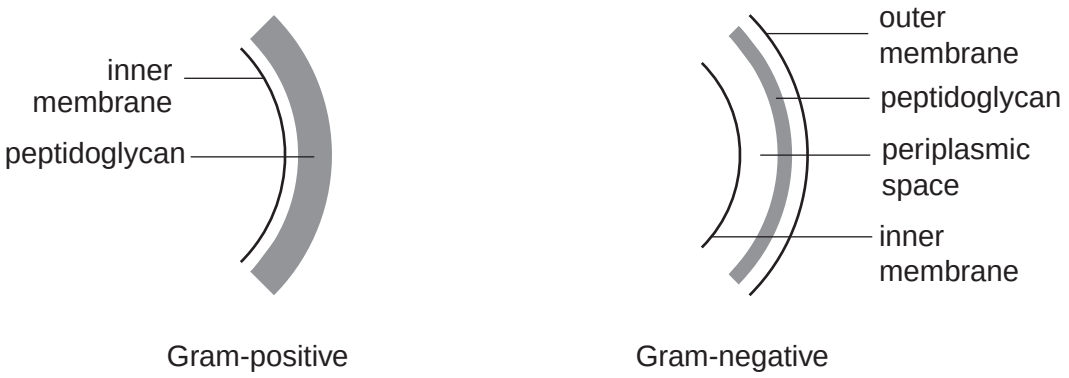
(b) State why antibiotics, such as penicillin, have no effect on viruses.

.....

.....[1]

(c) Bacteria may be Gram-positive or Gram-negative.

Fig. 3.2 shows a diagram of part of the cell walls of both Gram-positive and Gram-negative bacteria.



Gram-positive

Gram-negative

Gram-positive bacteria cell walls have a peptidoglycan content of 50%

Gram-negative bacteria cell walls have a peptidoglycan content of 10 – 20%

Fig. 3.2

Suggest why Gram-positive bacteria are more susceptible to the action of penicillin than Gram-negative bacteria.

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.....[2]

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(d) There is evidence that some bacteria have developed resistance to antibiotics.

One form of pneumonia, a serious lung disease, is caused by the bacterium *Streptococcus pneumoniae*. The Canadian Health Service has carried out a survey to show how the resistance of *S. pneumoniae* to penicillin has changed over the last 20 years.

Fig. 3.3 shows the results of this survey.

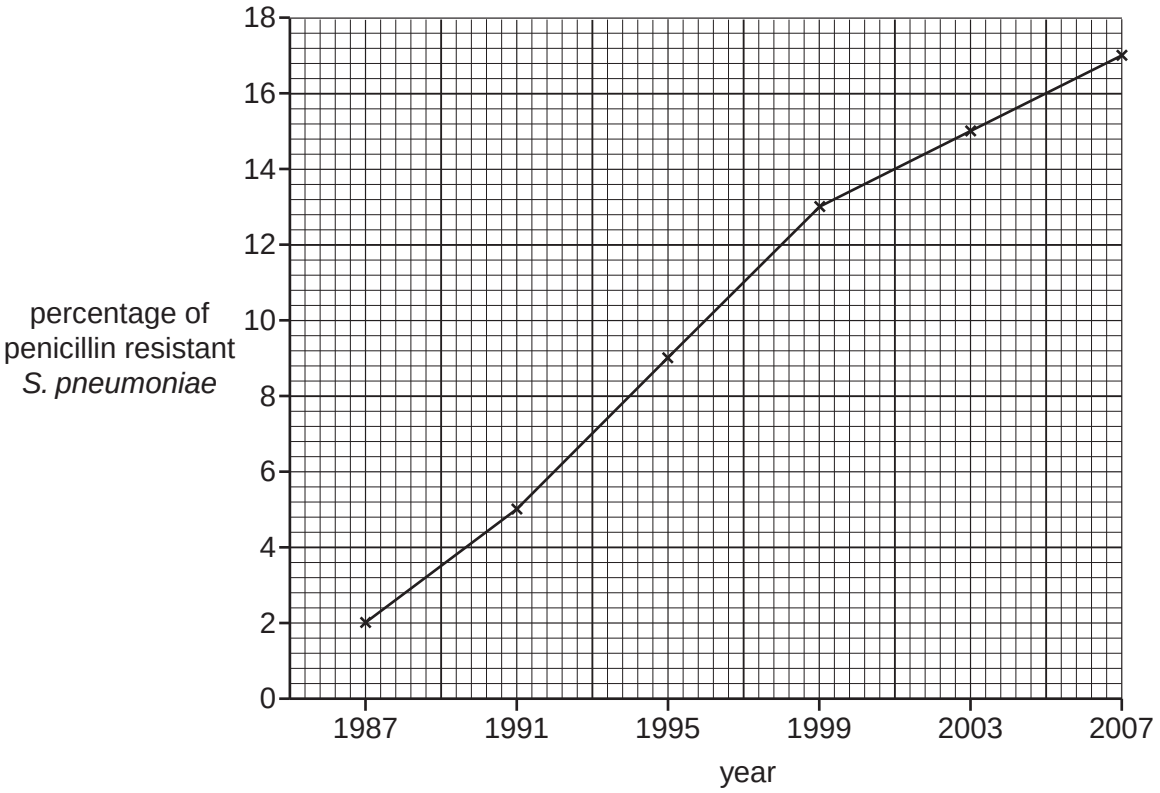


Fig. 3.3

Describe the results shown in Fig. 3.3 **and** explain how some strains of *S. pneumoniae* may have become resistant to penicillin.

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.....[5]

[Total: 14]

4 **(a)** In Queensland, Australia, the effect of the water-holding capacity of soil on the yield of sorghum and wheat was investigated.

- Four test plots were prepared, two with high water-holding capacity (HWC) soil and two with low water-holding capacity (LWC) soil.
- Sorghum seeds were sown on one plot with HWC soil and one plot with LWC soil.
- Wheat seeds were sown on the second plot with HWC soil and the second plot with LWC soil.
- The plots were regularly watered or irrigated throughout the growing season.
- The yield of sorghum and wheat from all four plots was measured at the end of the growing season.

Fig. 4.1 shows the results of this investigation.

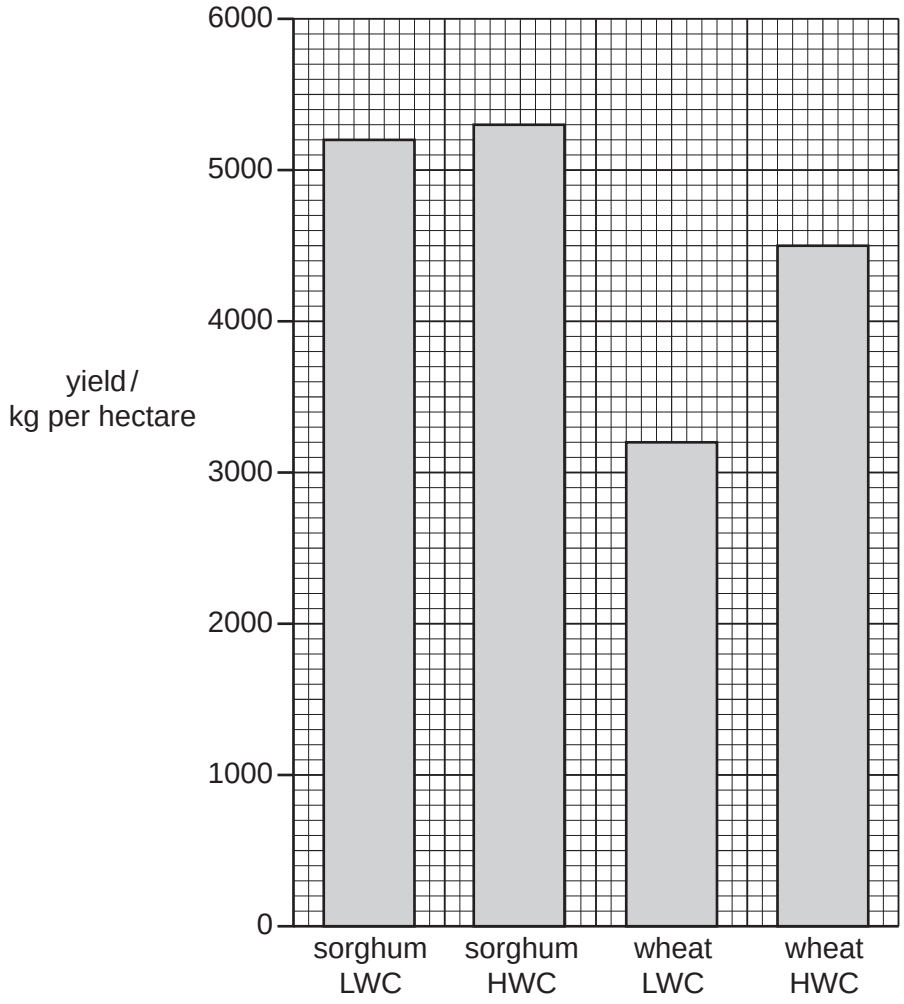


Fig. 4.1

(i) Describe **and** explain the results shown in Fig. 4.1.

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.....[4]

(ii) State two factors, other than water, light and temperature that would have to be controlled during this investigation to ensure that the results were valid.

1 .....

2 .....[2]

(b) Sorghum is able to carry out photosynthesis at high temperatures by preventing photorespiration.

Explain how sorghum is able to prevent photorespiration.

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.....[4]

[Total: 10]

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5 **(a)** Fig. 5.1 shows a section through part of a human testis.

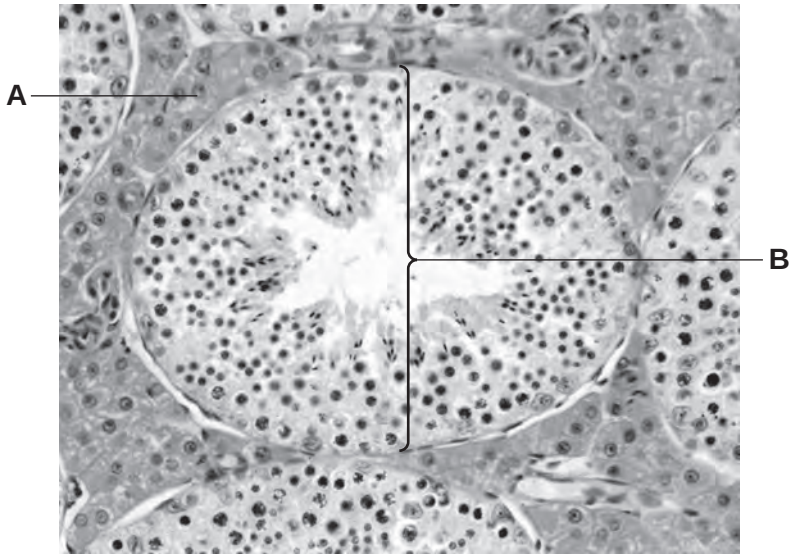


Fig. 5.1

Name structures **A** and **B**.

A ……

B …… [2]

(b) Spermatogenesis, the production of sperm, begins in the testes of a boy around the age of 11 and can continue for the rest of his life.

Fig. 5.2 outlines the sequence of events that occur during spermatogenesis.

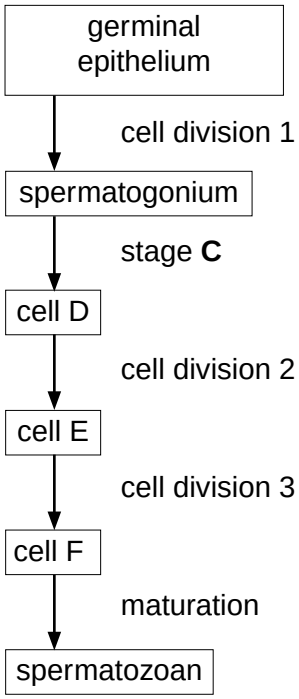


Fig. 5.2

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With reference to Fig. 5.2,

(i) state which cell division is mitotic,

.....[1]

(ii) state which cells are haploid,

.....

.....[2]

(iii) state what is happening to the cell during stage **C**.

.....[1]

(c) The middle piece of a spermatozoan contains many mitochondria.

Suggest why a spermatozoan needs so many mitochondria.

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.....[2]

(d) Some couples have difficulty in conceiving. This could be due to a problem with either the male or female reproductive systems.

(i) Suggest reasons why a man may be infertile.

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.....[3]

(ii) *In vitro fertilisation* (IVF) is a widely used treatment for infertility.

Explain what is meant by the term *in vitro fertilisation*.

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.....[2]

(iii) At one IVF clinic, over 1000 treatment cycles were monitored. The number of live births was recorded as a percentage of the number of treatment cycles for each age group. The results are shown in Table 5.1.

Table 5.1

age of women/years	percentage of live births per treatment cycle
under 34	27.6
34 to 36	22.3
37 to 39	18.3
40 to 42	10.0
above 42	less than 5.0

The data in Table 5.1 show that there is a decrease in the percentage of live births per treatment cycle with increasing age.

Explain this trend.

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.....[3]

[Total: 16]

6 **(a)** The pancreas acts both as an exocrine and an endocrine gland.

(i) Describe the parts of the pancreas involved in its **endocrine** function.

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.....[3]

(ii) State precisely the group of compounds to which the pancreatic hormone insulin belongs.

.....[1]

(b) People with insulin-dependent (type 1) diabetes require regular injections of insulin. In the past the insulin used came from animal sources such as pigs. Diabetics now use human insulin that has been manufactured using gene technology.

Describe the advantages of treating diabetics with insulin produced by gene technology.

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.....

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.....

.....

.....[3]

[Total: 7]

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7 Pompe disease is a rare neuromuscular disease caused by an autosomal recessive allele. This allele prevents the production of an enzyme called acid alpha-glucosidase (AG), which breaks down glycogen in muscle cells. Glycogen can build up in muscle cells causing damage to the cells. This damage leads to muscle weakness which gets worse with time.

(a) Explain how two parents, both of whom produce normal amounts of AG, can produce a child with Pompe disease.

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.....[3]

(b) One form of treatment is enzyme replacement therapy where AG is given through regular injections.

(i) Suggest how AG may be manufactured.

.....

.....[1]

(ii) Name the hormone that stimulates the breakdown of glycogen in **liver** cells.

.....[1]

(iii) State under what conditions glycogen would need to be broken down in liver or muscle cells.

.....

.....[1]

(c) The MN blood group system is based on the presence of glycoproteins M and N, on the surface membrane of red blood cells, which act as *antigens*.

State what is meant by the term *antigen*.

.....

.....[1]

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(d) The type of MN antigen on the surface membrane of red blood cells is controlled by a single gene with two alleles, $\mathbf{L^M}$ and $\mathbf{L^N}$. The phenotypes of the MN blood group system are MM, MN and NN.

Complete the genetic diagram to show how the MN blood group is inherited.

parental phenotypes MN x MN

parental genotypes ....

gametes .....

offspring genotypes .....

offspring phenotypes ..... [3]

(e) Allele frequencies for $\mathbf{L^M}$ and $\mathbf{L^N}$ vary in different human populations throughout the world.

Table 7.1 shows the $\mathbf{L^M}$ and $\mathbf{L^N}$ allele frequencies from five populations.

Table 7.1

population	allele frequency / %	
	$\mathbf{L^M}$	$\mathbf{L^N}$
Canadian Inuit	91	9
Egyptian	52	48
German	55	45
Chinese	57	43
Nigerian	55	45

Discuss the data shown in Table 7.1.

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.....[3]

[Total: 13]

8 (a) In the majority of plants the leaf is the main photosynthetic organ.

List four ways in which the structure of a dicotyledonous leaf is adapted for gas exchange.

1 .....

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2 .....

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3 .....

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4 .....

..... [4]

In an experiment to investigate the effect of light intensity on the rate of photosynthesis, the following procedure was carried out.

- Discs were cut, using a cork borer, from the photosynthetic tissue of the brown alga, *Fucus serratus*, a common seaweed of rocky shores.
- Ten discs were placed in each of four beakers containing 50 cm^3 of sea water. The discs are denser than sea water and therefore initially sink to the bottom of the beaker.
- Each beaker was illuminated with a bench lamp placed at different distances, *d*, from the beaker.
- With time the discs began to rise to the surface of the water.
- The time, *t*, in minutes, at which the fifth disc from each batch reached the surface was recorded.
- The rate of photosynthesis was determined by calculating 1000 / *t*.

A student's set of results is shown in Table 8.1.

Table 8.1

distance of beaker from lamp, *d* / cm	light intensity $1/d^2$	time for fifth disc to reach the surface *t* / min	rate of photosynthesis 1000 / *t*
5	0.04	23	43.5
10	0.01	36	27.8
15	0.004	52	19.2
20	.....	88	11.4

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(b) Calculate the value for light intensity when the distance between beaker and lamp was 20 cm.

Record the value in the space in Table 8.1.
[1]

(c) Explain why the discs rise to the surface after being illuminated for a length of time.

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.....[3]

(d) Using the data in Table 8.1, describe the relationship between light intensity and the rate of photosynthesis.

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.....[2]

(e) The student found that there was no increase in the rate of photosynthesis when two lamps were placed 5 cm from the beaker.

Suggest why there was no increase in the rate of photosynthesis.

.....

.....

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.....[2]

[Total: 12]

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Section B

Answer **one** question.

9 **(a)** Outline the main features of the Krebs cycle. [9]

(b) Explain the role of NAD in aerobic respiration. [6]

[Total: 15]

10 **(a)** Describe how a nerve impulse crosses a cholinergic synapse. [9]

(b) Explain the roles of synapses in the nervous system. [6]

[Total: 15]

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