Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

4894483374

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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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Section A

Answer **all** questions.

1 The Sumatran orangutan, *Pongo abelii*, is found only on the island of Sumatra, Indonesia.

Fig. 1.1 shows a Sumatran orangutan.



Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species. The Sumatran orangutan is categorised as critically endangered on the IUCN Red List.

The Sumatran orangutan spends most of its time in trees and is very sensitive to habitat destruction.

Table 1.1 shows the area of natural forest of Sumatra and the numbers of orangutans in 1985 and 2016.

Table 1.1

	1985	**2016**
area of natural forest / million hectares	25.3	12.4
number of orangutans	25 000	7300

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(i) With reference to Table 1.1, state the relationship between area of natural forest and number of orangutans.

.....

.....[1]

(ii) Calculate the mean annual decrease in orangutan numbers between 1985 and 2016.

Show your working.

Give your answer to the nearest whole number.

mean annual decrease = ...[2]

(iii) Use your answer from **(a)(ii)** to estimate the number of years after 2016 that it will take for the Sumatran orangutan to become extinct in the wild, if conservation work is unsuccessful.

..... years [1]

(b) Suggest **two** reasons for the decrease in numbers of Sumatran orangutans, other than habitat loss.

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.....[2]

(c) Outline the role zoos can take in the protection of the Sumatran orangutan.

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.....[3]

[Total: 9]

2 Scientists have found very little evolutionary change in populations of two Australian songbirds, the zebra finch, *Taeniopygia guttata castanotis*, and the budgerigar, *Melopsittacus undulatus*.

(a) Describe the process of evolution by natural selection.

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.....[4]

(b) The number of eggs a bird lays in its nest is called the clutch size.

The variation in clutch size was investigated in the zebra finch over several years.

The data are shown in Fig. 2.1.

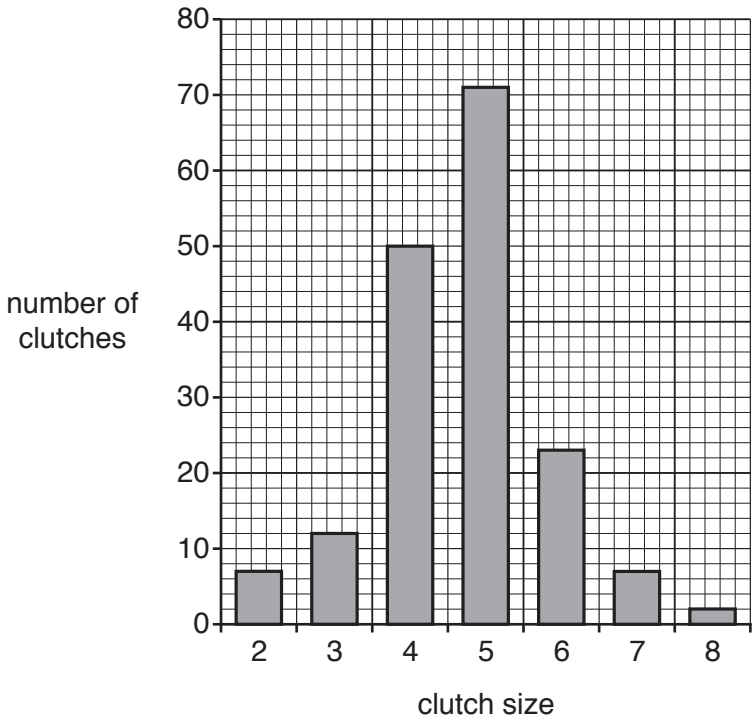


Fig. 2.1

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(i) Describe the pattern shown by the data in Fig. 2.1.

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.....[2]

(ii) The data in this investigation were collected over 60 years ago.

The same investigation, carried out today, would produce the same pattern of results.

Explain how the selection factors acting on zebra finches would maintain the same pattern of results.

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.....[4]

(c) The Hardy–Weinberg principle is used to calculate allele, genotype and phenotype frequencies in populations.

- A breeder of birds keeps a population of 86 budgerigars in one enclosed area.
- Two distinct phenotypes are present, blue feathers and green feathers.
- Feather colour is controlled by one gene:
  - **G** is the allele for green feathers
  - **g** is the allele for blue feathers.
- Only 17 of the budgerigars have blue feathers.

(i) The Hardy–Weinberg equations are shown in Fig. 2.2.

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

Fig. 2.2

Calculate the number of heterozygous individuals in the population.

Show your working.

number = ...[3]

(ii) The Hardy–Weinberg principle cannot be applied to all populations.

State **two** conditions when the Hardy–Weinberg principle **cannot** be applied.

1 .....

.....

2 .....

.....[2]

[Total: 15]

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3 **(a)** The *lac* operon is a section of DNA present in the genome of the bacterium *Escherichia coli*. The structural genes of the operon are only fully expressed when *E. coli* is exposed to high lactose concentrations.

(i) Fig. 3.1 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

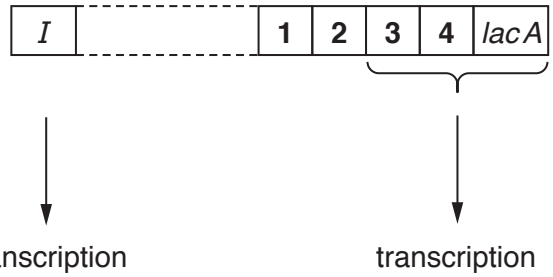


Fig. 3.1

Name sections **1**, **2**, **3** and **4** shown in Fig. 3.1.

1 .....

2 .....

3 .....

4 .....

[2]

(ii) Certain enzymes need to be present inside *E. coli* for it to be able to take up and use lactose. When the genes of the *lac* operon are expressed, the enzymes β-galactosidase and lactose permease are produced in large quantities.

Outline the functions of β-galactosidase and lactose permease.

β-galactosidase .....

.....

.....

lactose permease .....

.....

.....

[2]

(b) (i) Gene *I* is located a short distance away from the *lac* operon.

The product of gene *I*, a repressor protein, is a constitutive protein.

State what is meant by the term *constitutive protein*.

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.....[1]

(ii) Explain why the structural genes of the *lac* operon are **not** expressed when lactose is absent.

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.....[3]

(iii) A strain of *E. coli* has been produced with a mutation in gene *I*. Expression of this gene results in a non-functional repressor protein.

Suggest a negative effect that this mutation will have on this strain of *E. coli*.

.....

.....[1]

[Total: 9]

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4 Domestic goats, *Capra hircus*, show a wide range of coat patterns and colours. One gene involved in coat colour and pattern has multiple alleles. Four of these alleles are:

- **A**, the allele for white, is dominant to all others
- $\mathbf{A^b}$, the allele for badgerface (stripes on face) and $\mathbf{A^g}$, the allele for grey, are codominant
- **a**, the allele for black, is recessive to all others.

(a) State **all** the possible genotypes of:

a grey badgerface goat .....

a white goat. .....

[2]

(b) A cross between a black goat and a white goat produced a white goat. This white offspring was crossed with a grey goat. The genotype of the grey goat was not known.

Use genetic diagrams to show **all** the possible offspring genotypes and phenotypes that could result from the cross between the white offspring and the grey goat.

[4]

(c) When goat skin cells produce black melanin pigment these events occur:

- Melanocyte stimulating hormone (MSH) is secreted into the bloodstream.
- MSH binds to the melanocortin 1 receptor on the cell surface membranes of skin cells.
- This causes a rise in cyclic AMP within the cell.
- The enzyme tyrosinase is activated and begins melanin production.

The white allele **A** codes for a protein that binds irreversibly to the melanocortin 1 receptor. No rise in cyclic AMP occurs, even when MSH is present in the blood.

Explain the appearance of goats with genotype **aa**.

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.....[2]

[Total: 8]

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5 **(a)** Pigs are farm animals used for livestock in some parts of the world. The first genetically modified (transgenic) pigs were produced in 1985. Foreign DNA was injected directly into the nuclei of zygotes. The foreign DNA was made up of two components:

- the gene coding for human growth hormone
- a section of mouse DNA that, in the presence of metal ions, allows transcription to begin.

(i) The human growth hormone synthesised by the transgenic pigs had the effect of making the pigs grow faster, larger and heavier than non-genetically modified pigs.

Suggest reasons for this difference.

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.....[2]

(ii) Suggest **and** explain why the mouse DNA was included in the foreign DNA.

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.....[3]

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[Turn over

Only 1% of the attempts successfully produced transgenic pigs. These pigs showed higher body mass and a greater muscle to fat ratio than normal pigs. Monitoring of the pigs' behaviour revealed that they rested more than normal pigs, suffered from stomach ulcers and were unwilling to mate.

(b) (i) Discuss whether these transgenic pigs have long term economic value.

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.....[3]

(ii) Comment on the ethics of producing transgenic pigs showing the features described.

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.....[2]

(c) In 2015 pigs were produced that had part of their genome altered by a new technique. The technique involved:

- an RNA sequence designed to bind to a specific targeted pig gene
- a gene-editing enzyme that is able to cut out sections of DNA.

The technique was used on pig zygotes that had been created by IVF. All the zygotes treated grew into piglets and these all showed large deletions in the targeted gene.

This gene coded for a specific cell surface membrane protein. The piglets did not express the protein and this gave them resistance to infection by a virus that causes a serious disease in pigs.

(i) Describe **two** advantages of the gene-editing technique compared to the traditional genetic modification technique used to make transgenic pigs in 1985.

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.....[2]

(ii) A scientist stated that this new technique is a form of selective breeding, so is not genetic engineering.

Discuss whether this statement is true **and** whether public groups who oppose transgenic animals will be more or less likely to accept the new technique.

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.....[3]

[Total: 15]

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[Turn over

6 **(a)** Fig. 6.1 shows a transmission electron micrograph of a section through a mitochondrion.

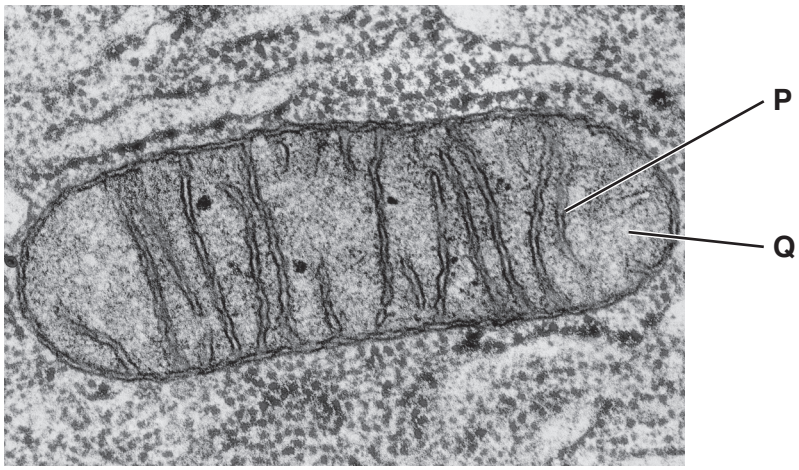


Fig. 6.1

Table 6.1 shows some structures and compounds involved in aerobic respiration.

Use letter **P** or letter **Q** from Fig. 6.1 to complete Table 6.1 to show the location of the structures and where the compounds are used.

Table 6.1

compound or structure	location
ATP synthase	.....
acetyl CoA	.....
phospholipid bilayer	.....
oxaloacetate	.....

[3]

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(b) The number of mitochondria differs from cell to cell. Cells also vary in size and volume.

Table 6.2 shows the mean number of mitochondria per cell, the mean cell volume and the mean number of mitochondria per μm^3 of three types of mammalian cells.

Table 6.2

cell type	mean number of mitochondria per cell	mean cell volume / μm^3	mean number of mitochondria per μm^3
fat cell	100	600 000	0.17×10^{-3}
heart cell	2000	45 000	44.44×10^{-3}
liver cell	2000	125 000	.....

(i) Calculate the mean number of mitochondria per μm^3 for the liver cell.

Write your answer in Table 6.2. [1]

(ii) Suggest reasons for the difference in mean number of mitochondria per μm^3 between the fat cell and the heart cell.

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.....[2]

(iii) Suggest why it is difficult to compare the ability of the three types of cell to respire aerobically, based **only** on the mean number of mitochondria per cell.

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.....[1]

[Total: 7]

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7 **(a)** Fig. 7.1 outlines the process of non-cyclic photophosphorylation in the chloroplast of a leaf mesophyll cell.

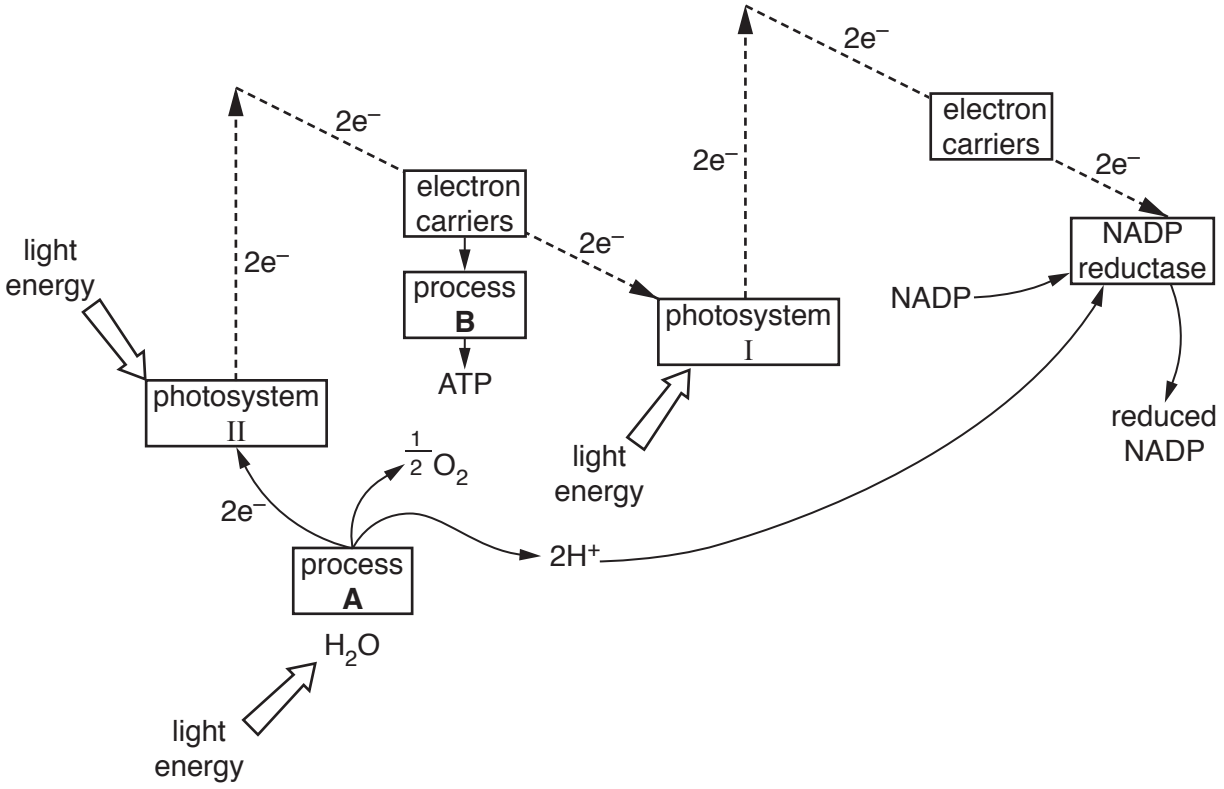


Fig. 7.1

(i) State precisely where non-cyclic photophosphorylation occurs in the chloroplast.

.....[1]

(ii) With reference to Fig. 7.1, name processes **A** and **B**.

A .....

B .....[2]

(iii) State what happens to the oxygen produced by process **A**.

.....

.....[1]

(iv) Name the primary pigment in photosystem I and photosystem II.

.....[1]

(v) Name **two** compounds shown in Fig. 7.1 that are used in the conversion of glycerate-3-phosphate (GP) to triose phosphate (TP) in the Calvin cycle.

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.....[1]

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(b) Outline the uses of triose phosphate in the mesophyll cells of the leaf.

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.....[3]

[Total: 9]

8 **(a)** In mammals, the nervous system and the endocrine system coordinate responses to the changes in internal and external environments.

Complete Table 8.1 to indicate the differences between the nervous system and the endocrine system.

Table 8.1

feature	nervous system	endocrine system
method of communication	.....	.....
method of transmission	.....	.....
transmission speed	.....	.....
duration of effect	.....	.....

[4]

(b) Fig. 8.1 shows the changes in the concentration of hormones in the blood during the menstrual cycle.

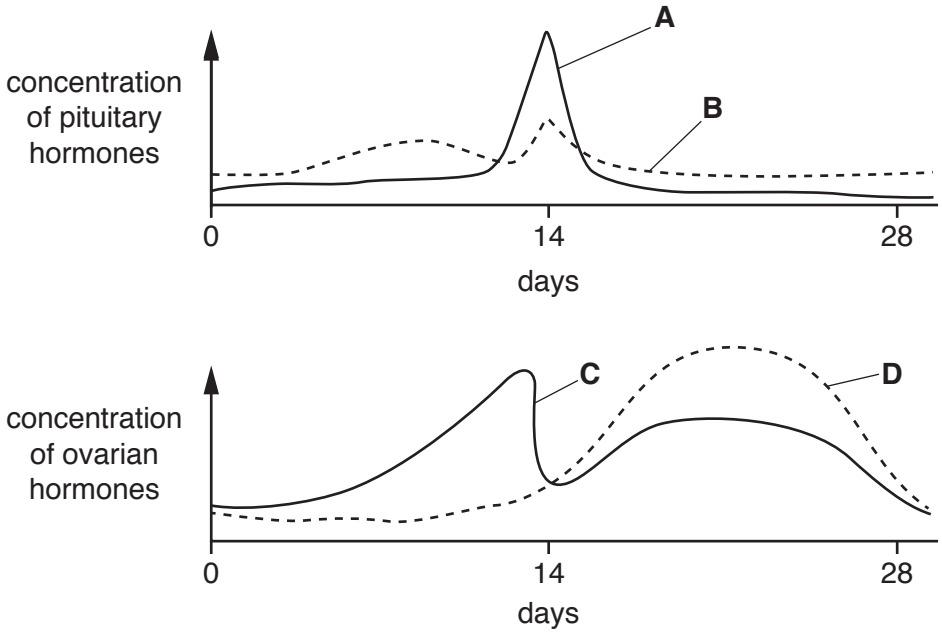


Fig. 8.1

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With reference to Fig. 8.1, match hormones **A**, **B**, **C** or **D** to the correct statements 1 to 4.

Each hormone may be used once, more than once or not at all.

1 made by the corpus luteum .....

2 stimulates the repair of the endometrium .....

3 maintains the endometrium .....

4 stimulates ovulation .....

[4]

(c) Outline the biological basis for contraceptive pills containing oestrogen and progesterone.

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.....[5]

[Total: 13]

Section B

Answer **one** question.

9 **(a)** Describe the features of ATP that make it suitable as the universal energy currency. [6]

(b) Outline respiration in anaerobic conditions in mammalian cells **and** describe how it differs from respiration in anaerobic conditions in yeast cells. [9]

[Total: 15]

10 **(a)** Describe the structure of a sensory neurone. [6]

(b) Describe how a resting potential is set up **and** maintained in a myelinated neurone. [9]

[Total: 15]

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BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **May/June 2018**

2 hours

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This document consists of **21** printed pages, **1** blank page and **2** lined pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** questions.

1 The Sumatran tiger lives on the island of Sumatra, Indonesia.

Fig. 1.1 shows a Sumatran tiger.



Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species.
The Sumatran tiger is categorised as critically endangered on the IUCN Red List. There are approximately 400 Sumatran tigers left in the wild.

Suggest reasons why the Sumatran tiger has become critically endangered.

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.....[3]

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(b) Some zoos in Europe have captive breeding programmes for the Sumatran tiger, which breeds well in captivity. Once cubs have reached maturity they may be moved to other zoos. For example, as part of a coordinated breeding programme carried out in 2013, one tiger born in Chester Zoo in England was moved to France and another tiger born in the same zoo was moved to Germany. This type of coordinated breeding programme is essential for the survival of the Sumatran tiger.

Explain why it is important to the gene pool of Sumatran tigers to move tigers from one zoo to another.

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.....[3]

(c) Some animals do not breed well in captivity.

List the methods of assisted reproduction that may be used with animals that do not breed well in captivity.

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.....[2]

[Total: 8]

2 **(a)** In the sweet pea plant, *Lathyrus odoratus*, one gene codes for flower colour and one gene codes for pollen grain shape.
Flower colour is either purple or red. Pollen grain shape is either long or round.
The inheritance of these genes is an example of **autosomal linkage**.

- The allele **F** for purple flowers is dominant over the allele **f** for red flowers.
- The allele **G** for long pollen grains is dominant over allele **g** for round pollen grains.

Explain the meaning of the term *autosomal linkage*.

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.....[2]

(b) A dihybrid cross was carried out between homozygous dominant and homozygous recessive sweet pea plant parents to produce the F1 generation.

The offspring from the F1 generation were crossed to produce the F2 generation.

(i) Draw a genetic diagram to show a dihybrid cross between two offspring from the F1 generation.

Assume that these genes are closely linked and that there are **no** crossing over events.

[4]

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(ii) The actual results of the dihybrid cross are shown in Table 2.1.

Table 2.1

phenotypes of F2 offspring	number of individuals
purple flowers, long pollen grains	284
purple flowers, round pollen grains	21
red flowers, long pollen grains	21
red flowers, round pollen grains	55

State how the results support the fact that this is an example of autosomal linkage.

.....

.....

.....[1]

(c) (i) In a test cross, an individual of **known** genotype is crossed with an individual that has a dominant phenotype but unknown genotype.

State the genotype of the **known** individual in a test cross.

.....[1]

(ii) A test cross was carried out with sweet pea plants known to be heterozygous for both flower colour and pollen grain shape.

The results of the test cross are shown in Table 2.2.

Table 2.2

phenotypes of offspring of test cross	number of individuals
purple flowers, long pollen grains	215
purple flowers, round pollen grains	30
red flowers, long pollen grains	32
red flowers, round pollen grains	210

The result of a test cross can be used to determine a crossover value (COV).
A crossover value is the percentage of the total number of offspring showing recombination.

The crossover value (COV) can be calculated using the formula shown in Fig. 2.1.

$$\text{COV} = \frac{\text{number of recombinants}}{\text{total number of individuals}} \times 100$$

Fig. 2.1

Calculate the COV from the results shown in Table 2.2.

COV = ...% [1]

(iii) Suggest what information about the relative distance between the linked genes can be gained from crossover values.

.....

.....[1]

[Total: 10]

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3 Within a population, the variation for one characteristic is usually the result of genetic and environmental causes.

(a) Meiosis is one source of genetic variation.

(i) Describe the events that take place during prophase I of meiosis in an animal cell.

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(ii) Explain how independent assortment of homologous chromosomes leads to genetic variation during meiosis I.

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(b) Both genetic and environmental factors contribute to variation in body mass in a bird population.

One cause of variation in body mass in chickens is infection with the gut protoctist *Eimeria*. When fed with the same diet, infected chickens have a lower gain in body mass than healthy chickens in the same population.

(i) Suggest reasons why infected chickens have a lower gain in body mass than healthy chickens.

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.....[2]

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(ii) Suggest **one** environmental factor that affects the growth and reproduction of *Eimeria*.

.....

.....[1]

(c) A study was carried out to investigate the effect of treating infected chickens with extracts from a plant, *Bidens pilosa*.
B. pilosa is used in traditional medicine for the treatment of some infectious diseases.

- Three populations, each containing 25 chickens infected with *Eimeria* were observed.
- The body mass of each chicken was measured at the start of the study.
- Each population was given a different treatment for 56 days:
  - standard diet with no *B. pilosa* extract
  - standard diet with low dose of *B. pilosa* extract
  - standard diet with high dose of *B. pilosa* extract.

- The body mass of each chicken was measured at the end of the study and the gain in body mass over the 56 days was calculated.
- The mean gain in body mass was calculated for each population.

The results are shown in Table 3.1.

Table 3.1

treatment	mean gain in body mass / g
no *B. pilosa*	1773.0 ±23.9
low dose of *B. pilosa*	2093.1 ±34.2
high dose of *B. pilosa*	2033.3 ±29.9

A statistical analysis of the results of the study of these three populations confirmed that there was a significant difference in mean gain in body mass between low dose *B. pilosa* and high dose *B. Pilosa* extract treatments.

(i) Name a statistical test that could be used to analyse the results of this study.

.....[1]

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(ii) Sketch on Fig. 3.1 curves to show the pattern of variation for gain in body mass in chickens treated with low dose *B. pilosa* extract and in chickens treated with high dose *B. pilosa* extract.

Label one curve '**low dose**' and the other curve '**high dose**'.

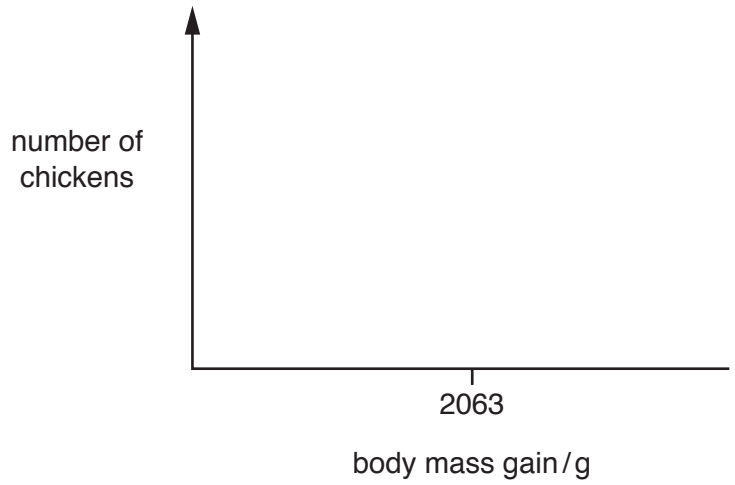


Fig. 3.1

[3]

[Total: 13]

4 Adult *Drosophila* fruit flies feed on yeasts on the surface of ripe fruits. Female flies lay their eggs inside the fruit and the larvae feed inside the fruit before developing into adults.

The tree *Morinda citrifolia* produces fruits called noni fruits. Noni fruits contain a toxin and are avoided by nearly all *Drosophila* species, including *Drosophila yakuba* in mainland Africa.

One population of *D. yakuba* lives on the island of Mayotte off the coast of Africa. The population of *D. yakuba* on Mayotte has specialised to feed on noni fruit. Flies of this population produce enzymes that give them resistance to the toxin in noni fruits. Adults are able to feed on yeasts on the fruit surface and their eggs and larvae can develop and grow inside the fruit.

Scientists have used bioinformatics to estimate that the unique *D. yakuba* population on Mayotte originated in the last 30 000 years.

(a) Describe how a population of *Drosophila* can develop resistance to noni fruit toxin.

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(b) Explain why living on an island increases the likelihood of the noni toxin-resistant population of *D. yakuba* on Mayotte becoming a separate species to the mainland population of *D. yakuba*.

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.....[3]

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(c) Suggest how scientists can use bioinformatics to estimate the length of time that the population of *D. yakuba* has been living on Mayotte.

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.....[3]

[Total: 10]

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5 **(a)** A severe reduction of blood flow to the brain causes cells to die. This is called a stroke. The after-effects of a stroke can range from recovery to permanent brain damage and death.

A new emergency gene therapy treatment for people who are at risk of brain damage from a stroke was tested in mice.

- The human granulocyte colony-stimulating factor, hG-CSF, is a protein that stimulates the production of stem cells in bone marrow.
- mRNA coding for hG-CSF was obtained and used to make cDNA.
- This cDNA was inserted into an adeno-associated virus (AAV) vector and given in eye drops to mice just after they experienced a stroke.

(i) Explain what is meant by *gene therapy*.

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.....[2]

(ii) Describe the roles of reverse transcriptase and DNA polymerase in making cDNA for hG-CSF.

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.....[2]

(iii) The AAV vector used was unable to replicate itself within the target cells.

Suggest why the researchers chose a vector that could not replicate.

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.....[2]

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(b) A study was carried out to investigate the effect of the gene therapy described in **(a)**. Four groups of mice were used.

- Group **A** mice had a stroke. They received eye drops containing AAV vector carrying cDNA for hG-CSF **once** only.
- Group **B** mice had a stroke. They received eye drops containing AAV vector carrying cDNA for hG-CSF **four** times.
- Group **C** mice had a stroke. They received eye drops containing AAV vector carrying the *GFP* gene coding for green fluorescent protein, instead of the cDNA for hG-CSF, **once** only.
- Group **D** mice did not have a stroke. They were not given any eye drops.

(i) Explain why the mice in group **C** were used in the study.

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.....[3]

(ii) Explain why the mice in group **D** were used in the study.

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.....[1]

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(c) Table 5.1 summarises some results from the study and shows:

- the percentage of mice surviving
- the percentage of brain volume occupied by fluid-filled space
- the score on a behavioural test in which normal mice score 0.5 and brain-damaged mice score nearer to 1.0.

Table 5.1

mouse treatment group	percentage of mice surviving	percentage of brain occupied by fluid-filled space	behavioural test score / arbitrary units
A	63	3.6	0.67
B	100	3.0	0.67
C	25	5.2	0.90
D	100	3.0	0.50

Use the results in Table 5.1 to evaluate the benefits of gene therapy treatment, with AAV vector carrying the gene for hG-CSF, for **people** who have a stroke.

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.....[4]

[Total: 14]

6 Fig. 6.1 is an outline diagram showing two stages of aerobic respiration.

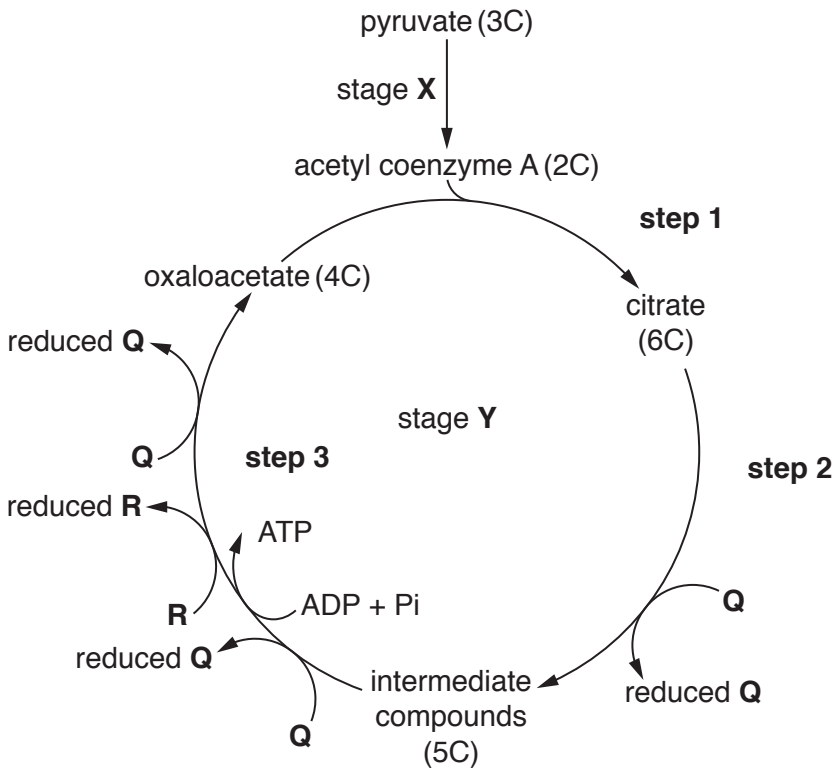


Fig. 6.1

(a) With reference to Fig. 6.1:

name stage **X**

.....

state the precise location of stage **Y**

.....

state the numbered steps in stage **Y** in which decarboxylation occurs

.....

name the type of reaction by which ATP is made during **step 3**

.....

name substances **Q** and **R**.

.....[5]

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(b) Uncontrolled cell division can lead to a cancerous tumour. Many cancer cells break down the amino acid glutamine and convert it to a 5-carbon intermediate compound, which is shown in Fig. 6.1.

Suggest how the breakdown of glutamine can lead to the production of ATP in a cancer cell, other than that directly produced during **step 3**.

.....

.....

.....

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.....[2]

[Total: 7]

7 Fig. 7.1 shows part of a section through the leaf of a C4 plant such as maize. The letters **A**, **B** and **C** show three types of cell found in the leaf.

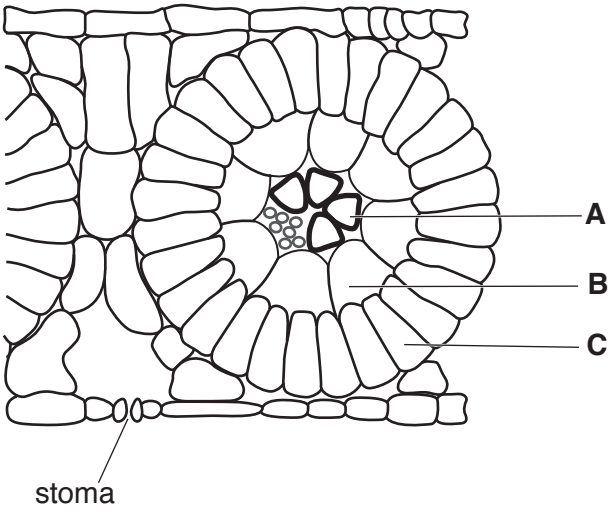


Fig. 7.1

(a) Complete Table 7.1 by using the letters **A**, **B** or **C** from Fig. 7.1 to show the location of several compounds associated with photosynthesis in C4 plants.

You may use **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound	location
PEP carboxylase	.....
RuBP	.....
rubisco	.....

[3]

(b) Explain why the cells in **C** form a tight ring around the cells in **B**.

.....

.....

.....

.....

.....[2]

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(c) Several enzymes have a role in the light independent stage of photosynthesis.

Fig. 7.2 shows the activity of one of these enzymes at different temperatures for a C3 plant, *Pisum sativum*, and a C4 plant, *Amaranthus hypochondriacus*.

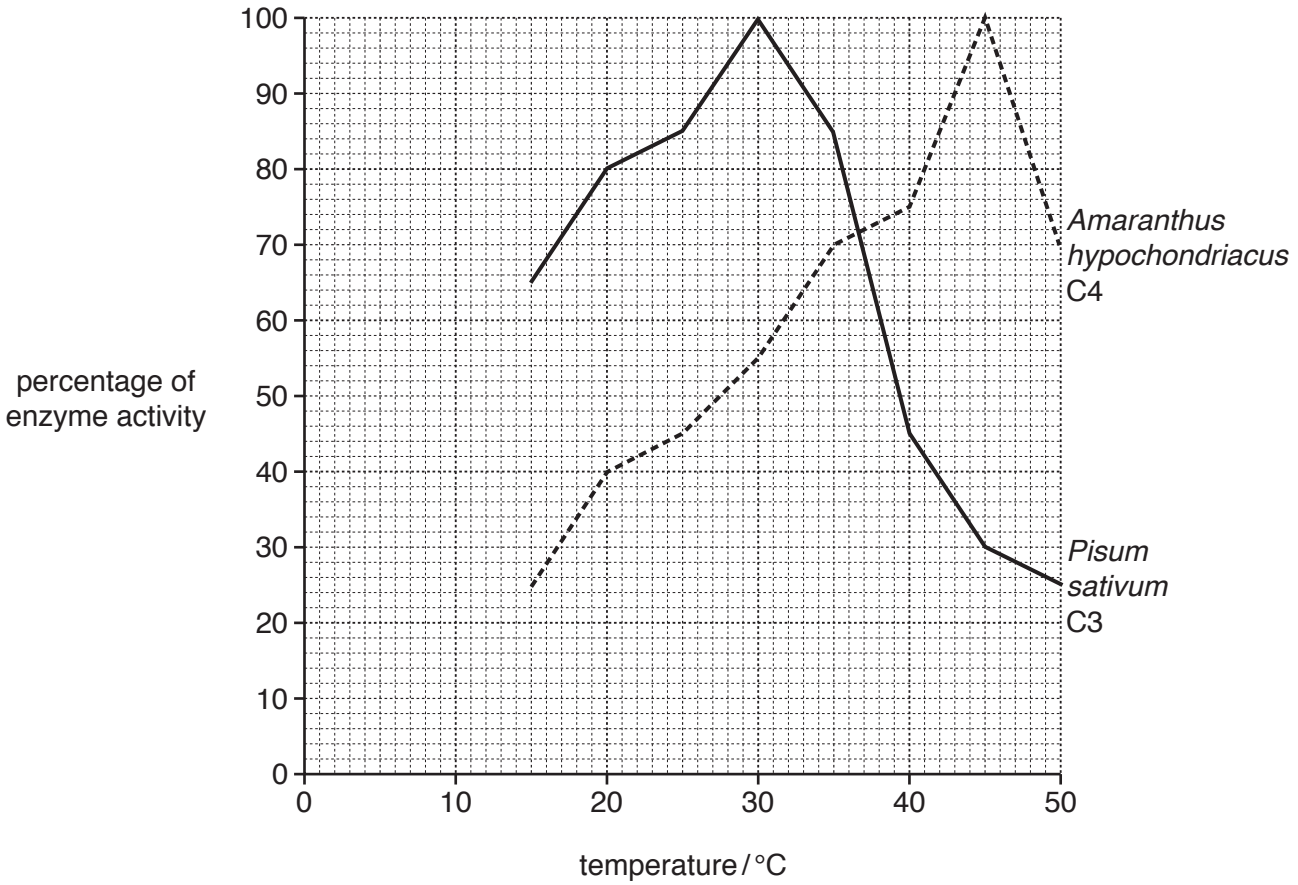


Fig. 7.2

Describe the differences between the two curves **and** suggest explanations for these differences.

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.....

.....

.....

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.....

.....[3]

[Total: 8]

8 **(a)** Describe how an action potential arriving at a presynaptic neurone can result in the release of acetylcholine into the synaptic cleft.

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.....[4]

(b) Lidocaine is a local anaesthetic drug which blocks voltage-gated Na^+ channels in the postsynaptic membrane of a synapse.

Explain the effect of lidocaine action on the postsynaptic neurone.

.....

.....

.....

.....

.....[2]

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(c) Fig. 8.1 is a diagram of a neuromuscular junction.

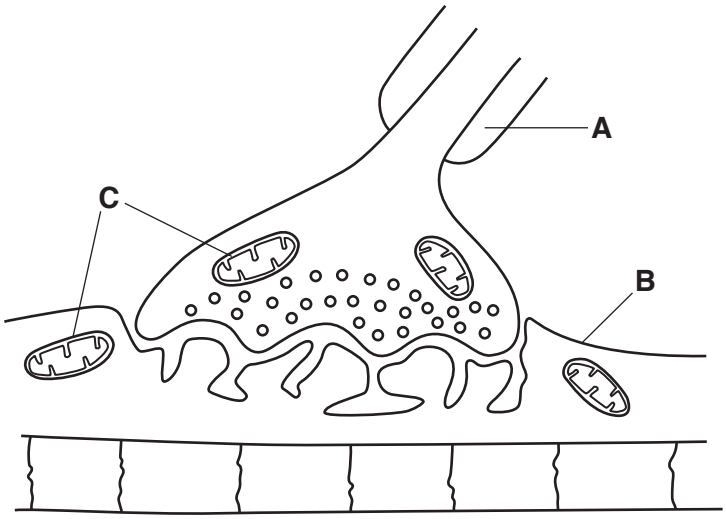


Fig. 8.1

(i) With reference to Fig. 8.1, name structures **A**, **B** and **C**.

A .....

B .....

C ..... [3]

(ii) Outline the importance of structure **A** in the transmission of nerve impulses.

.....

.....

.....

.....

.....[2]

(iii) Explain why the structures labelled **C** are needed in a neuromuscular junction.

.....

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.....[4]

[Total: 15]

Section B

Answer **one** question.

9 **(a)** Outline the characteristic features of organisms in the domain Archaea. [8]

(b) Describe the role of seed banks in the protection of endangered species. [7]

[Total: 15]

10 **(a)** Describe the process of selective reabsorption **and** explain how the cells of the proximal convoluted tubule are adapted to carry out selective reabsorption. [9]

(b) Describe the role of the hypothalamus **and** the role of the posterior pituitary in osmoregulation. [6]

[Total: 15]

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[Turn over

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BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

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.

This document consists of **22** printed pages and **2** lined pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** questions.

1 The Sulawesi macaque, *Macaca nigra*, is found on the large island of Sulawesi in Indonesia. The Sulawesi macaque is also found on other smaller islands close to Sulawesi, such as the island of Bacan.

Fig. 1.1 shows a Sulawesi macaque.



Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species. The Sulawesi macaque is categorised as critically endangered on the IUCN Red List.

Table 1.1 shows the numbers of humans and the numbers of Sulawesi macaques on Sulawesi and Bacan.

Table 1.1

island	area / km^2	number of humans	number of humans per km^2	number of macaques	number of macaques per km^2
Sulawesi	174 600	17 360 000	99.43	5200	.....
Bacan	1900	60 741	31.97	90 000	47.37

(i) Calculate the number of macaques per km^2 for Sulawesi.

Write your answer in Table 1.1. [1]

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(ii) Comment on the data shown in Table 1.1 **and** suggest reasons for the pattern shown.

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.....[3]

(b) Suggest ways of protecting the Sulawesi macaque.

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.....[4]

[Total: 8]

2 **(a)** In the fruit fly, *Drosophila melanogaster*, eye colour and wing shape are controlled by genes.

- **E/e** are alleles of a gene involved in eye colour.
- **E** results in red eyes, **e** results in purple eyes.

- **N/n** are alleles of a gene involved in wing shape.
- **N** results in normal (functional) wings, **n** results in vestigial (short, non-functional) wings.

These genes are **both** autosomal.

A dihybrid cross was carried out between a fly with red eyes and normal wings and a fly with purple eyes and vestigial wings. Both parents were homozygous for both genes. The offspring from the F1 generation were crossed to obtain the F2 offspring.

The results are shown in Table 2.1.

Table 2.1

F2 offspring phenotype	expected number of individuals	expected F2 ratio	observed number of individuals	observed F2 ratio
red eye, normal wing	225	.....	287	22.1
red eye, vestigial wing	.....	3	13	1.0
purple eye, normal wing	75	.....	17	1.3
purple eye, vestigial wing	.....	1	83	6.4

(i) Complete the missing expected number of individuals and the expected F2 ratio in Table 2.1.

[2]

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(ii) A chi-squared test showed that the results for the F2 generation in Table 2.1 were significantly different from those expected.

To investigate this, test crosses were carried out using flies taken from the **F1 generation** and flies that were homozygous recessive for both genes.
The investigator assumed that the genes were **unlinked** and expected a ratio of 1:1:1:1.

Draw a genetic diagram of this test cross. Use the symbols **E/e** and **N/n**.

[4]

(b) The results of the test crosses described in **(a)(ii)** are shown in Table 2.2.

Table 2.2

offspring phenotype	number of individuals
red eye, normal wing	196
red eye, vestigial wing	22
purple eye, normal wing	23
purple eye, vestigial wing	175

(i) Flies with red eye, vestigial wing and flies with purple eye, normal wing phenotypes are described as recombinant.

Name the stage of meiosis when these recombinants are produced **and** state how this occurs.

.....

.....

.....

.....[2]

(ii) Explain why the results in Table 2.2 are different from the expected ratio of 1:1:1:1.

.....

.....

.....

.....[2]

[Total: 10]

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3 **(a)** Meiosis is described as reduction division.

Explain why meiosis is necessary in the life cycle of a sexually reproducing organism.

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.....

.....

.....[3]

(b) Plants need mineral ions to grow and develop. For example, plants need phosphates and a deficiency inhibits cell division and root growth.

Mutations in individuals of some plant populations allow them to survive in mineral-deficient soils.

(i) Name **two** examples of environmental conditions that affect plant phenotype, **other than** mineral deficiency.

For **each** example, describe how it affects the phenotype.

.....

.....

.....

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.....

.....

.....[2]

(ii) Explain why mutations are important in selection.

.....

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.....

.....

.....[2]

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[Turn over

(c) A study compared root growth of thale cress, *Arabidopsis thaliana*, in two different soil types:

- full nutrient
- low phosphate.

Two different populations of thale cress were used:

- thale cress with a functional enzyme **X**
- thale cress, with a non-functional enzyme **X**.

30 seedlings from each population were placed in each type of soil and left to grow for seven days. At the start all seedlings had a root of the same length. After seven days, the length of this root was measured again for each seedling.

The mean final root length and standard deviation was calculated for each population of thale cress.

The mean final root lengths are shown in Fig. 3.1.

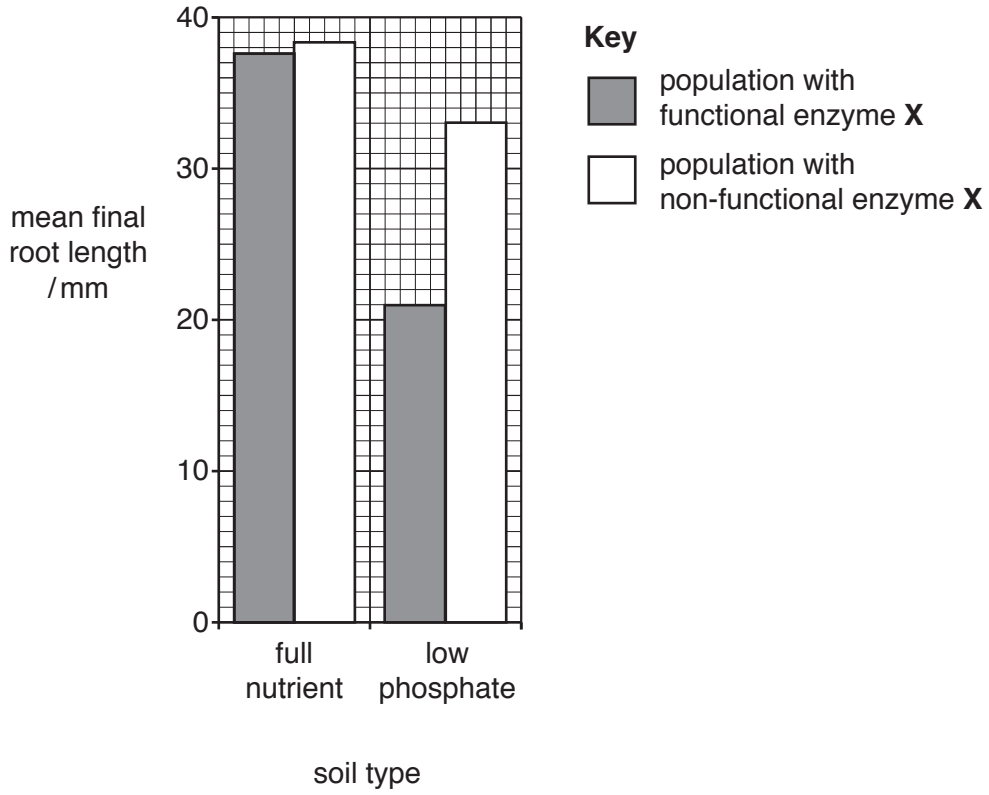


Fig. 3.1

With reference to Fig. 3.1, describe the effect of the low phosphate soil type compared to the full nutrient soil type on root growth, for both populations of thale cress.

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.....[2]

(d) The null hypothesis states there is no significant difference between the mean final root lengths of the two populations of thale cress grown in low phosphate soil type.

A *t*-test can be carried out to compare these two means. The critical value for *t* at the $p = 0.05$ significance level is 2.00.

Table 3.1

population grown in low phosphate soil type	mean final root length / mm	standard deviation
functional enzyme **X**	21	0.5
non-functional enzyme **X**	33	0.8

(i) Fig. 3.2 shows the formula for calculating the value of *t*.

$$t = \frac{|\overline{x}_1 - \overline{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

$\overline{x}$ = mean
s = standard deviation
n = sample size (number of measurements)

Fig. 3.2

Use the formula in Fig. 3.2 to calculate the value of *t*.

Show your working.

t = ...[2]

(ii) Use your calculated value of *t* to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

.....

.....

.....[2]

[Total: 13]

4 **(a)** A study was carried out to investigate natural selection in the plant evening primrose, *Oenothera biennis*.

Physiological changes associated with resistance to grazing by herbivorous insects were measured over 5 years in 16 experimental populations of evening primrose. For 8 of the experimental populations the plants were regularly sprayed with chemical insecticide, and the other 8 experimental populations were not sprayed.

In each of the 5 years some older plants died after producing seeds and some new plants grew from seed.
Observations after the study were:

- sprayed populations:
  - The length of time that the plants produced flowers (flowering period) became longer.
  - Flowering started earlier in each generation.
  - The mean concentration of natural insect-deterring chemicals in the plants was relatively low.

- non-sprayed populations:
  - The flowering period remained the same over the 5 years.
  - The mean concentration of natural insect-deterring chemicals in the plants increased.

Analysis showed that genetic differences were responsible for the differences in flowering time and concentration of natural insect-deterring chemicals in the plants. The researchers concluded that natural selection was acting on both groups of plants.

Explain how natural selection acted in the **non-sprayed** populations to cause the mean concentration of natural insect-deterring chemicals to increase.

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.....[4]

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(b) (i) Identify the type of natural selection that caused an increase in the mean concentration of insect-deterring chemicals in the non-sprayed populations.

.....[1]

(ii) Identify the type of natural selection that caused the flowering period to remain the same in the non-sprayed populations.

.....[1]

(c) The same trends in results were recorded in all of the non-sprayed populations.

Explain how this supports the researchers' conclusion that natural selection caused the trends and **not** genetic drift.

.....

.....

.....

.....

.....[2]

[Total: 8]

5 **(a)** People with Alzheimer's disease (AD) lose their ability to form new memories. One form of Alzheimer's disease, called familial Alzheimer's disease, is caused by an autosomal dominant allele of the *APP* gene.

To study Alzheimer's disease, identical genetically modified mice containing the dominant human *APP* allele have been produced. These mice are known as AD mice and are used as mouse models of Alzheimer's disease.

When these AD mice are trained to swim through a water maze, they perform poorly and cannot learn as well as normal mice.

(i) Suggest what steps will be needed to make identical genetically modified AD mice.

.....

.....

.....

.....

.....

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.....

.....[4]

(ii) Suggest why it is useful to have an animal model of a human disease.

.....

.....

.....[1]

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(b) Researchers wanted to know if changes in gene expression were important in the inability of the AD mice to learn.

Groups of normal mice and AD mice either received training to allow them to learn how to swim a water maze, or they received no training. The mice in the four groups then had mRNA extracted from the memory-forming areas of their brains.

Reverse transcription of the mRNA of individuals in each group was carried out and the resulting cDNA was labelled with fluorescent nucleotides. This was then used for DNA microarray analysis using slides containing DNA sequences from **33 696** mouse genes.

Explain the principles of this type of DNA microarray analysis.

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.....[4]

(c) Table 5.1 summarises the microarray analysis of differences in gene expression for:

- an untrained AD mouse compared to an untrained normal mouse
- a trained AD mouse compared to a trained normal mouse.

Table 5.1

training received	number of genes expressed in AD mouse but not in normal mouse	number of genes expressed in normal mouse but not in AD mouse	total number of genes showing a difference in expression between the normal mouse and AD mouse
no	17	11	28
yes	112	820	932

(i) Calculate the percentage of mouse genes whose expression has been shown to be affected by training.

Show your working.

percentage = ... % [2]

(ii) State what the results in Table 5.1 show about the effect of training and learning on gene expression in brain cells.

.....

.....

.....[1]

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(d) The genes which are expressed in the brains of normal mice undergoing training and learning code for proteins important in synapse and memory formation. A large number of these genes are under the control of one transcription factor, a protein called Crtc1.

To try to improve learning in AD mice, researchers caused over-expression of the *Crtc1* gene in the brains of AD mice, by delivering the gene to mouse brain cells using a virus vector.

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

.....[1]

(ii) Suggest the effects of over-expression in the brain of the *Crtc1* gene on AD mice.

.....

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.....[2]

[Total: 15]

6 **(a)** Fig. 6.1 is a diagram of part of a mitochondrion showing some of the events occurring in oxidative phosphorylation.

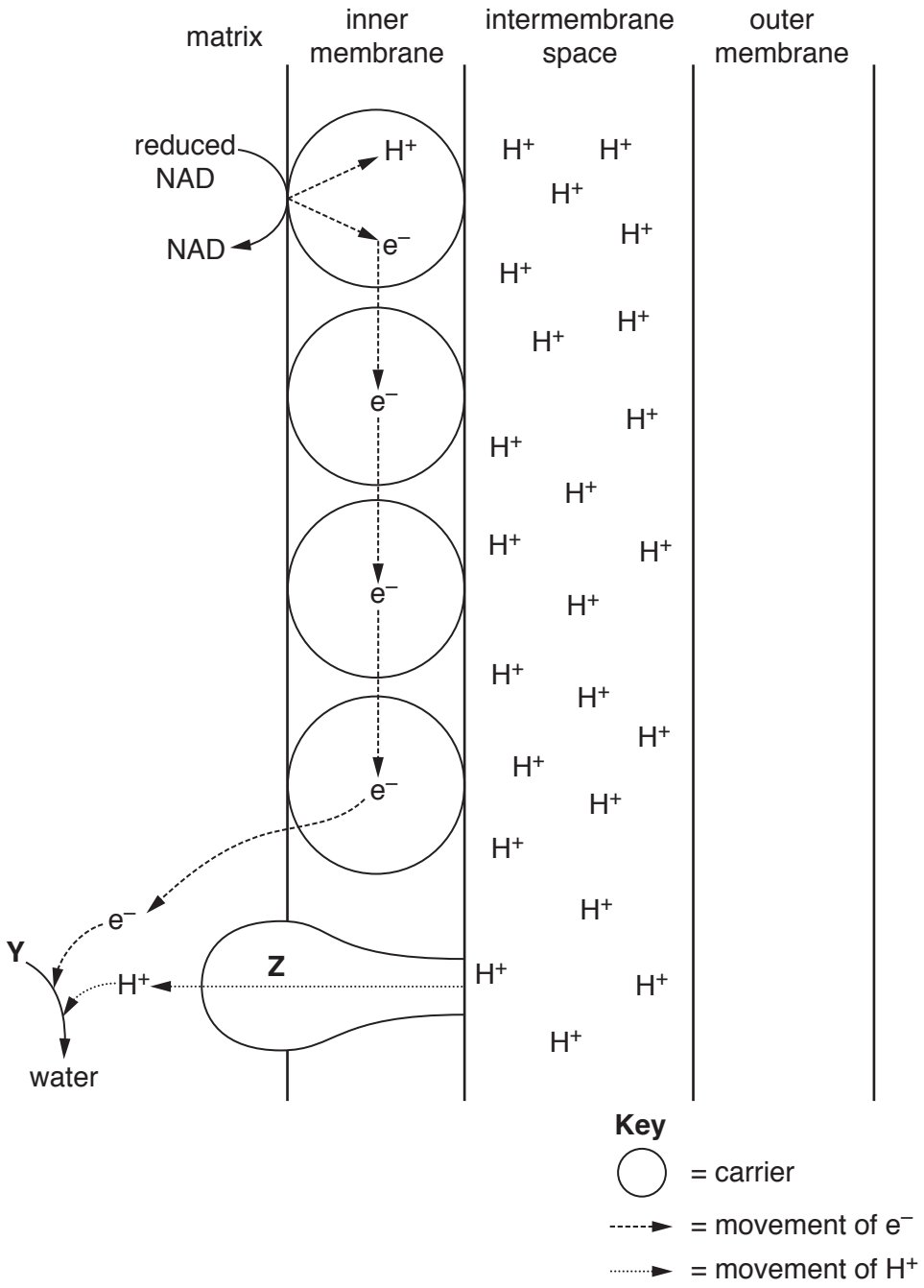


Fig. 6.1

(i) State two sources of the reduced NAD in Fig. 6.1.

.....

.....[2]

(ii) With reference to Fig. 6.1, outline the role of carriers in the inner membrane.

.....

.....

.....

.....

.....[2]

(iii) With reference to Fig. 6.1, name **Y** and **Z**.

Y .....

Z .....[2]

(b) Explain why it is an advantage to the cell for the inner membrane of the mitochondrion to be folded.

.....

.....

.....

.....

.....[2]

[Total: 8]

7 **(a)** Fig. 7.1 is a transmission electron micrograph of part of a chloroplast of a leaf cell from maize.

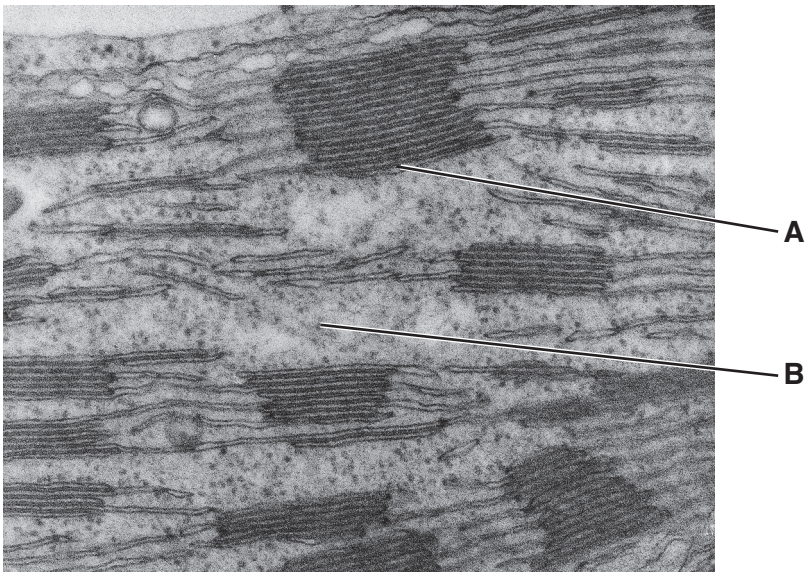


Fig. 7.1

Table 7.1 shows some substrates and products involved in photosynthesis.

Use letter **A** or letter **B** from Fig. 7.1 to complete Table 7.1 to show the location where the substrates or products are used or produced.

Table 7.1

substrate or product	location
oxygen produced	.....
carbon dioxide used	.....
reduced NADP used	.....
ATP produced	.....
hexose produced	.....

[3]

(b) Chloroplasts isolated from leaf palisade cells can still function if they are suspended in a buffer solution. The buffer solution has the same water potential as the chloroplasts.

The dye DCPIP is a hydrogen acceptor that changes colour from blue to colourless when it becomes reduced.

Three test tubes were set up as shown in Table 7.2 and left for 20 minutes to allow any colour change to occur. The results are also shown in Table 7.2.

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Table 7.2

test-tube	contents	conditions	colour change
1	buffer solution + DCPIP	light	no
2	chloroplast suspension + DCPIP	light	yes
3	chloroplast suspension + DCPIP	dark	no

(i) Explain the results for test-tube 2.

.....

.....

.....

.....[2]

(ii) Test-tube 1 is a control tube. Explain why test-tube 1 was included in the investigation.

.....

.....[1]

(iii) Suggest **and** explain what would happen to the chloroplasts if they were suspended in distilled water.

.....

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.....

.....

.....[2]

(c) The rate of photosynthesis in green plants can be limited by factors such as light intensity, temperature and carbon dioxide concentration.

State which factor would have **no** effect on the reducing ability of a chloroplast suspension. Give a reason for your answer.

factor .....

reason .....

.....

.....[2]

[Total: 10]

8 **(a)** Striated muscle is made of many fibres. Each fibre is composed of myofibrils.

The striated appearance of the muscle fibre is due to the arrangement of two types of protein filaments, thick filaments and thin filaments, within the sarcomeres of the myofibril.

Describe the main structural features of thick filaments and thin filaments in the sarcomere.

thick filaments .....

.....

.....

.....

.....

thin filaments .....

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.....[4]

(b) Describe the role of calcium ions in the contraction of striated muscle.

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.....[5]

(c) Muscle cells sometimes have to carry out respiration in anaerobic conditions.

Describe how respiration occurs in anaerobic conditions in a muscle cell **and** state why it is important that this process occurs.

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.....[4]

[Total: 13]

Section B

Answer **one** question.

9 **(a)** Outline the characteristic features of organisms in the domain Eukarya. [8]

(b) Discuss the use of assisted reproduction techniques in the conservation of endangered mammal species. [7]

[Total: 15]

10 **(a)** Describe the effect of a high blood concentration of ADH on the kidney. [8]

(b) Explain how glucagon brings about a rise in blood glucose concentration. [7]

[Total: 15]

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[Turn over

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