Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

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4650011341

BIOLOGY **9700/42**

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 **21** printed pages, **1** blank page and **2** lined pages.

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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(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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(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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[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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(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]

(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.

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(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.

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[Turn over

(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.

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[Total: 10]

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

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(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.

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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**'.

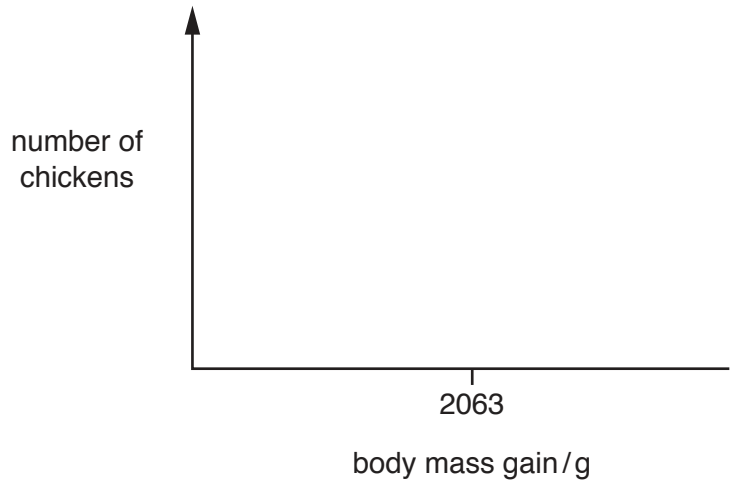

Fig. 3.1

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

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

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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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[Total: 14]

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

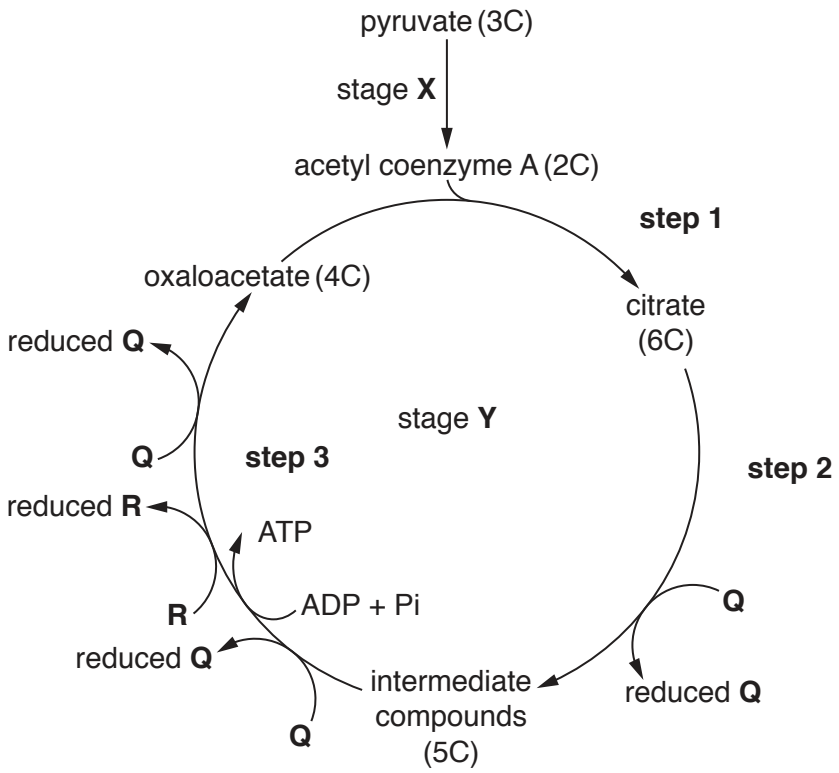

Fig. 6.1

(a) With reference to Fig. 6.1:

name stage **X**

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state the precise location of stage **Y**

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

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

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

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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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[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.

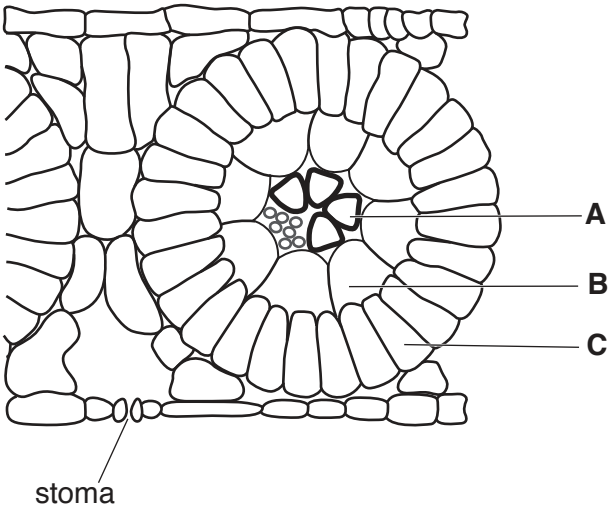

Fig. 7.1

(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**.

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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*.

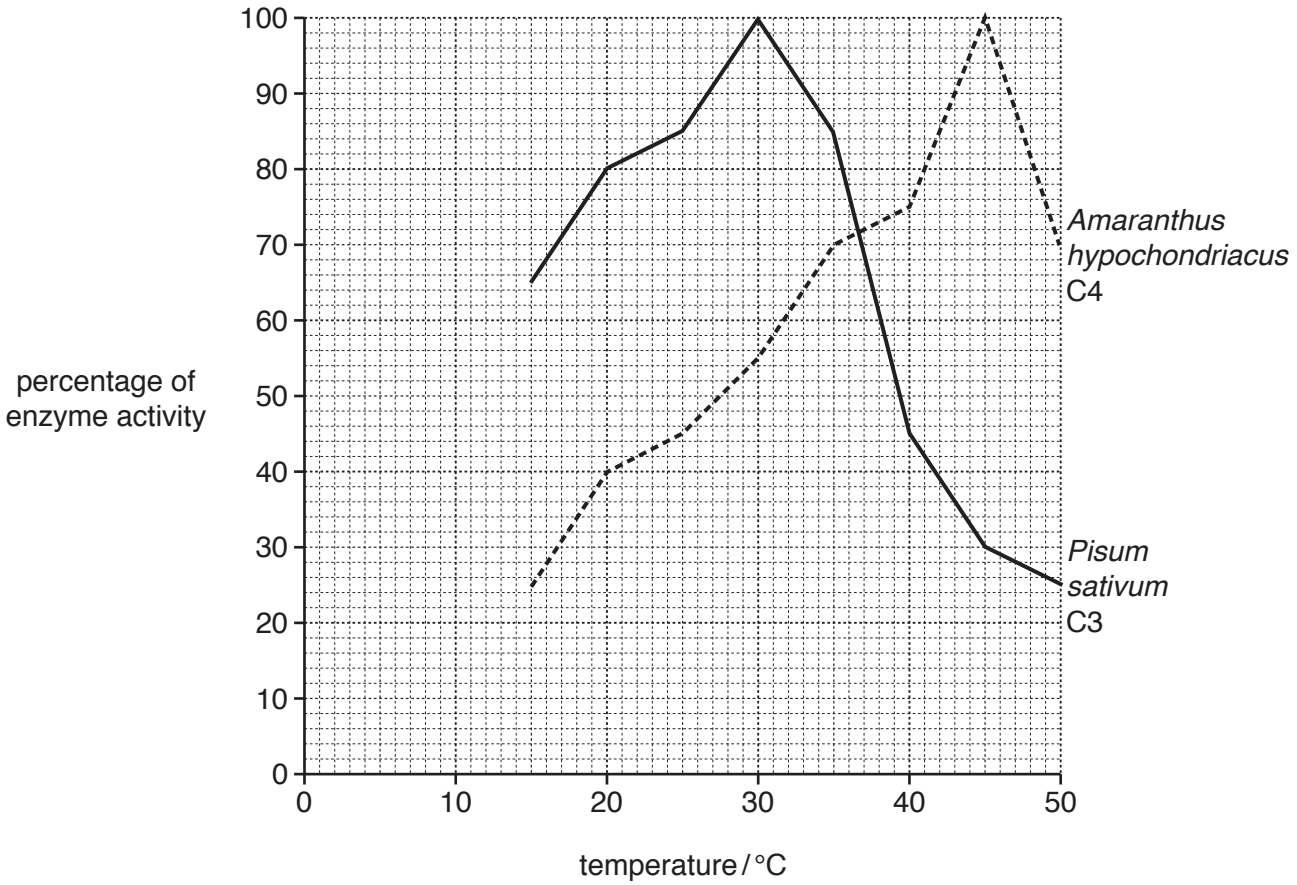

Fig. 7.2

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

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[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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(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.

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

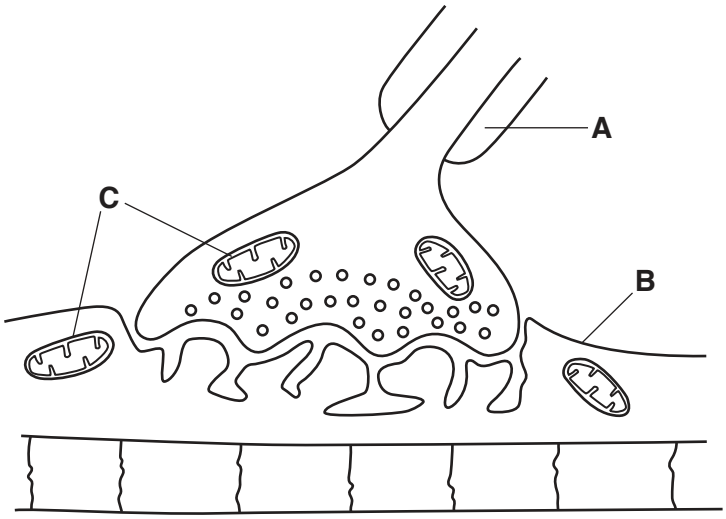

Fig. 8.1

(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.

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

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[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]