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BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate session number

Monday 12 May 2014 (morning)

1 hour

Examination code

2	2	1	4	–	6	0	1	2

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[36 marks]*.

Option	Questions
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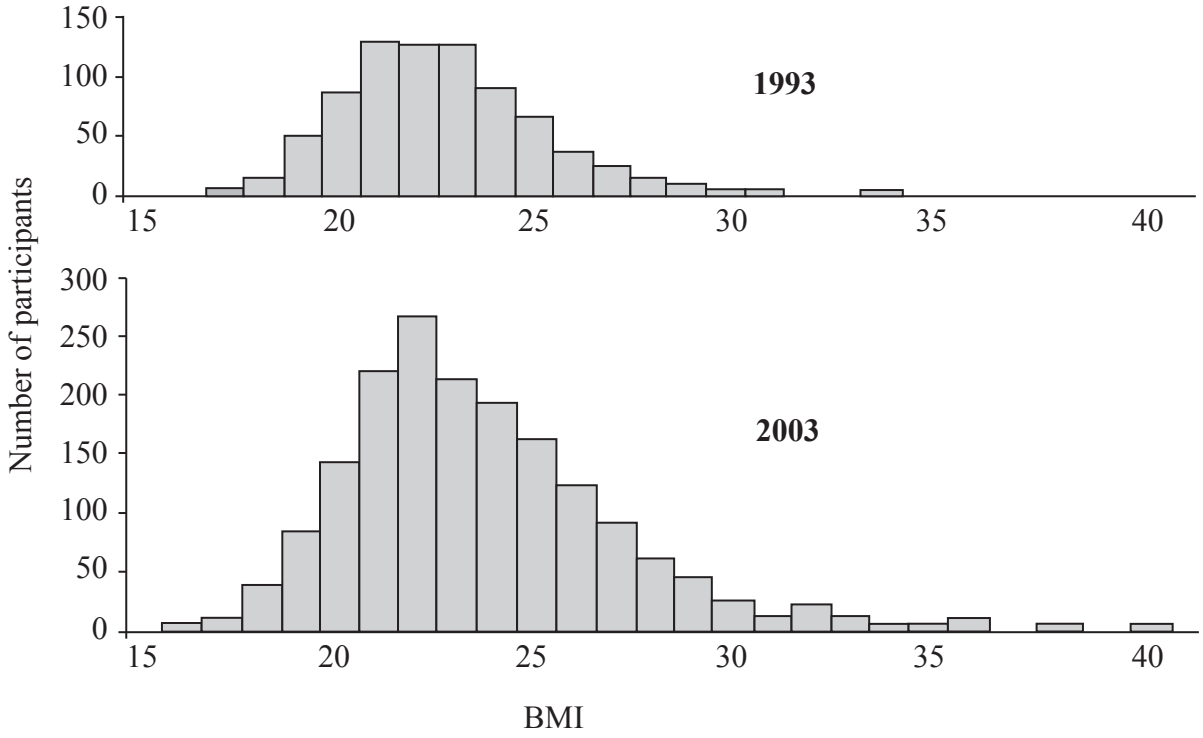
Option A — Human Nutrition and Health

1. Obesity has increased in many developed countries over the past decades. The data shown are from a study of obesity in a city in Switzerland over the time period 1993 to 2003. The study groups were composed of healthy male and female adults between the ages of 20 and 74.



[Source: Kyle, U. G., Kossovsky, M. P., Genton, L. and Pichard, C., 'Overweight and obesity in a Swiss city: 10-year trends' *Public Health Nutrition*, 10 (9), 2007 ©The Nutrition Society, published by Cambridge University Press, reproduced with permission.]

(a) Identify the highest and lowest BMI in the 1993 sample. *[1]*

Highest: . . . . . .

Lowest: . . . . . .

(Option A continues on the following page)

(Option A, question 1 continued)

(b) Outline the changes in the levels of obesity between 1993 and 2003. *[3]*

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(c) Discuss possible reasons for the differences between the two sets of data. *[3]*

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(Option A continues on the following page)

(Option A continued)

2. (a) Distinguish between vitamins and minerals. *[1]*

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(b) List **two** sources of vitamin D in human diets. *[2]*

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(c) Discuss the factors involved in deciding the amount of vitamin C an adult human should consume per day. *[3]*

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(Option A continues on the following page)

(Option A continued)

3. (a) Outline the importance of fibre in a balanced diet. *[2]*

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(b) Discuss whether consumers should choose foods with low food mileage. *[3]*

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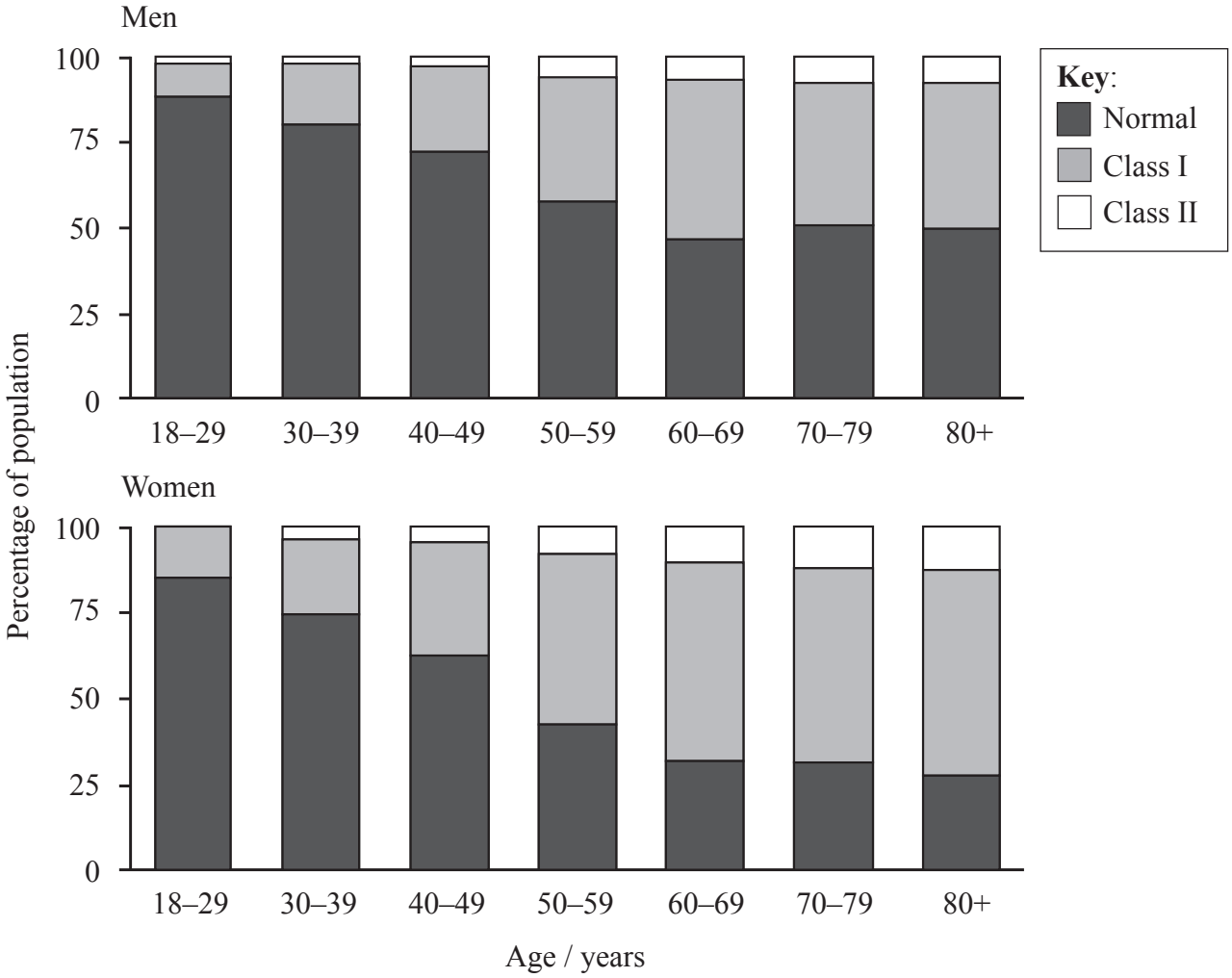
End of Option A

Option B — Physiology of exercise

4. Skeletal muscle mass reaches a peak in early adulthood and then begins to decline. This may lead to injuries and disability in later life because physical strength, stamina and balance depend to some extent on skeletal muscle mass. In a large scale study, individuals were classified as having normal muscle mass (normal), low muscle mass compared to young adults (class I) or very low muscle mass (class II).



[Source: Adapted from I. Janssen *et al.* (2002), 'Low Relative Skeletal Muscle Mass (Sarcopenia) in Older Persons Is Associated with Functional Impairment and Physical Disability', *Journal of the American Geriatrics Society*, 50, pp. 889–896. © John Wiley and Sons. Used with permission.]

(Option B continues on the following page)

(Option B, question 4 continued)

(a) Identify the youngest age categories for men and women in which less than 50% of the population has normal muscle mass. *[1]*

Men: . . . . . .

Women: . . . . . .

(b) Compare the pattern of muscle mass loss for men and women. *[2]*

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(c) Suggest **two** possible reasons for severe skeletal muscle loss in older individuals. *[2]*

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(d) Outline the benefits of exercise to individuals with severe skeletal muscle loss. *[2]*

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(Option B continues on the following page)

(Option B continued)

5. (a) Define the term *tidal volume.* *[1]*

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(b) Explain the need for increased tidal volume during exercise. *[2]*

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(c) Compare the distribution of blood flow during exercise and at rest for a normal healthy individual. *[2]*

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(Option B continues on the following page)

(Option B continued)

6. (a) Outline how oxygen debt is repaid. *[3]*

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(b) (i) Define *fitness*. *[1]*

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(ii) Discuss speed as a way of measuring fitness. *[2]*

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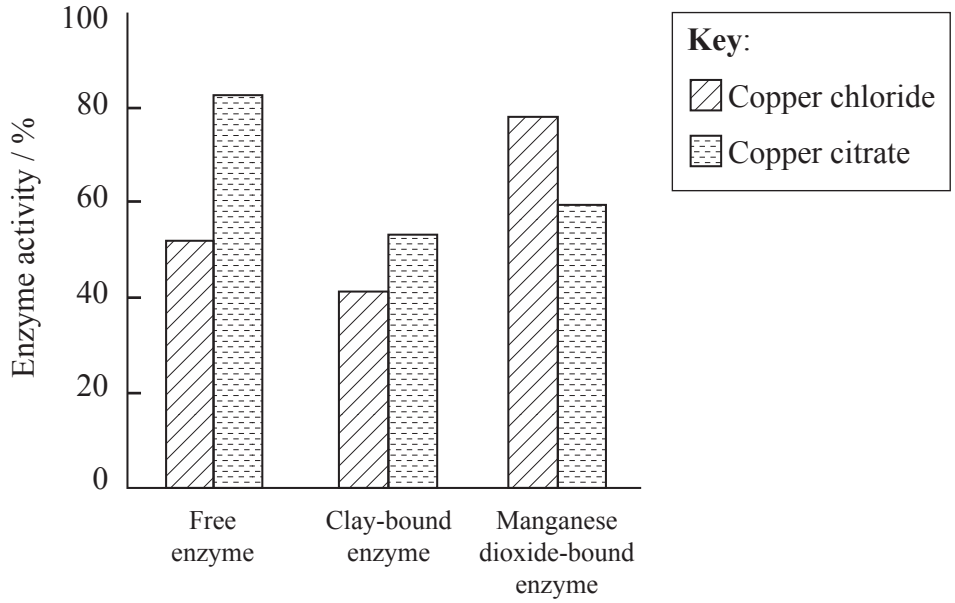
End of Option B

Option C — Cells and energy

7. Heavy metals such as copper are a major source of environmental pollution. They harm cells by acting as enzyme inhibitors. A study of soil pollution examined the effect of copper chloride and copper citrate on the activity of the enzyme acid phosphatase secreted by plant roots onto clay. Enzyme activity was measured using free enzyme in solution as well as clay-bound enzyme. Manganese dioxide-bound enzyme acted as a control. Enzyme activity is expressed as a percentage of the maximum.



[Source: Adapted from Q. Huang and H. Shindo (2000) *Soil Biology & Biochemistry*, 32, pages 188–1892. 'Effects of copper on the activity and kinetics of free and immobilized acid phosphatase', with permission from Elsevier.]

(a) Identify the conditions that cause the greatest inhibition of the activity of the enzyme. *[1]*

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(Option C continues on the following page)

(Option C, question 7 continued)

(b) Outline the effects of copper chloride and copper citrate on the activity of the free enzyme. *[2]*

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(c) Compare the effect of copper chloride on free and bound enzymes. *[2]*

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(d) Explain how a non-competitive inhibitor such as copper causes a reduction in enzyme activity. *[2]*

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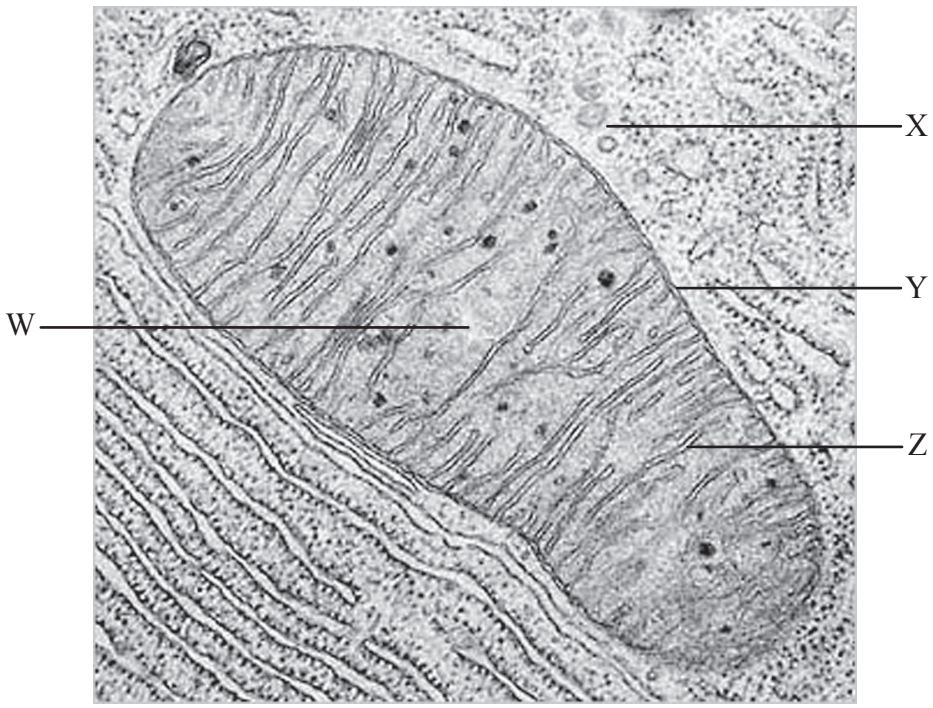
(Option C continues on the following page)

(Option C continued)

8. (a) The image below shows a mitochondrion in an animal cell.



[Source: adapted from http://www.frontiers-in-genetics.org/pictures/mitochondrion_1.jpg]

(i) Identify the letter which shows where glucose is converted to pyruvate. *[1]*

. . . . . .

(ii) Identify the letter which shows the location of the electron transport chain. *[1]*

. . . . . .

(iii) Identify the letter which shows the site of the Krebs cycle. *[1]*

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(Option C continues on the following page)

(Option C, question 8 continued)

(b) Outline the steps in the Krebs cycle. *[3]*

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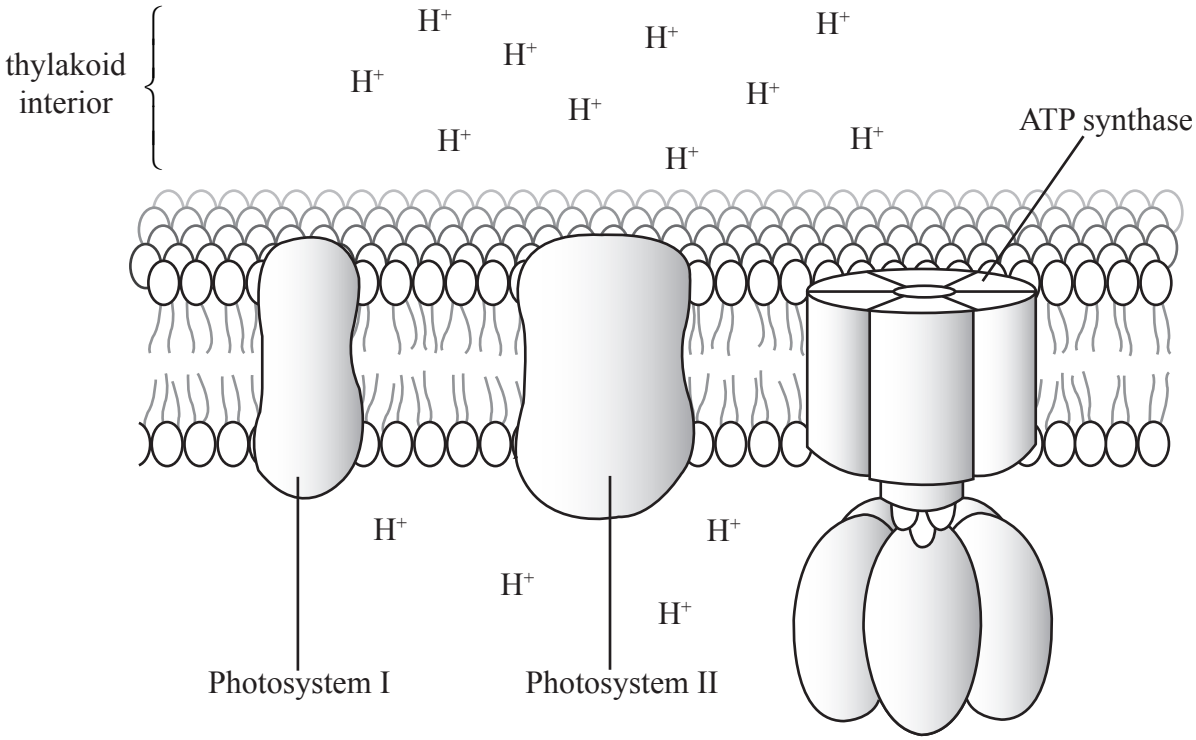
(Option C continues on the following page)

(Option C continued)

9. The diagram below shows a section of a thylakoid membrane and some of the structures involved in the light dependent reactions of photosynthesis.



[Source: Reproduced by permission of the Royal Society of Chemistry for Photosynthesis, Chemistry for Biologists (http://www.rsc.org/Education/Teachers/Resources/cfb/Photosynthesis.htm)]

(a) Explain the high H^+ concentration in the thylakoid interior. *[2]*

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(Option C continues on the following page)

(Option C, question 9 continued)

(b) Describe how ATP is produced in the thylakoid membrane. *[3]*

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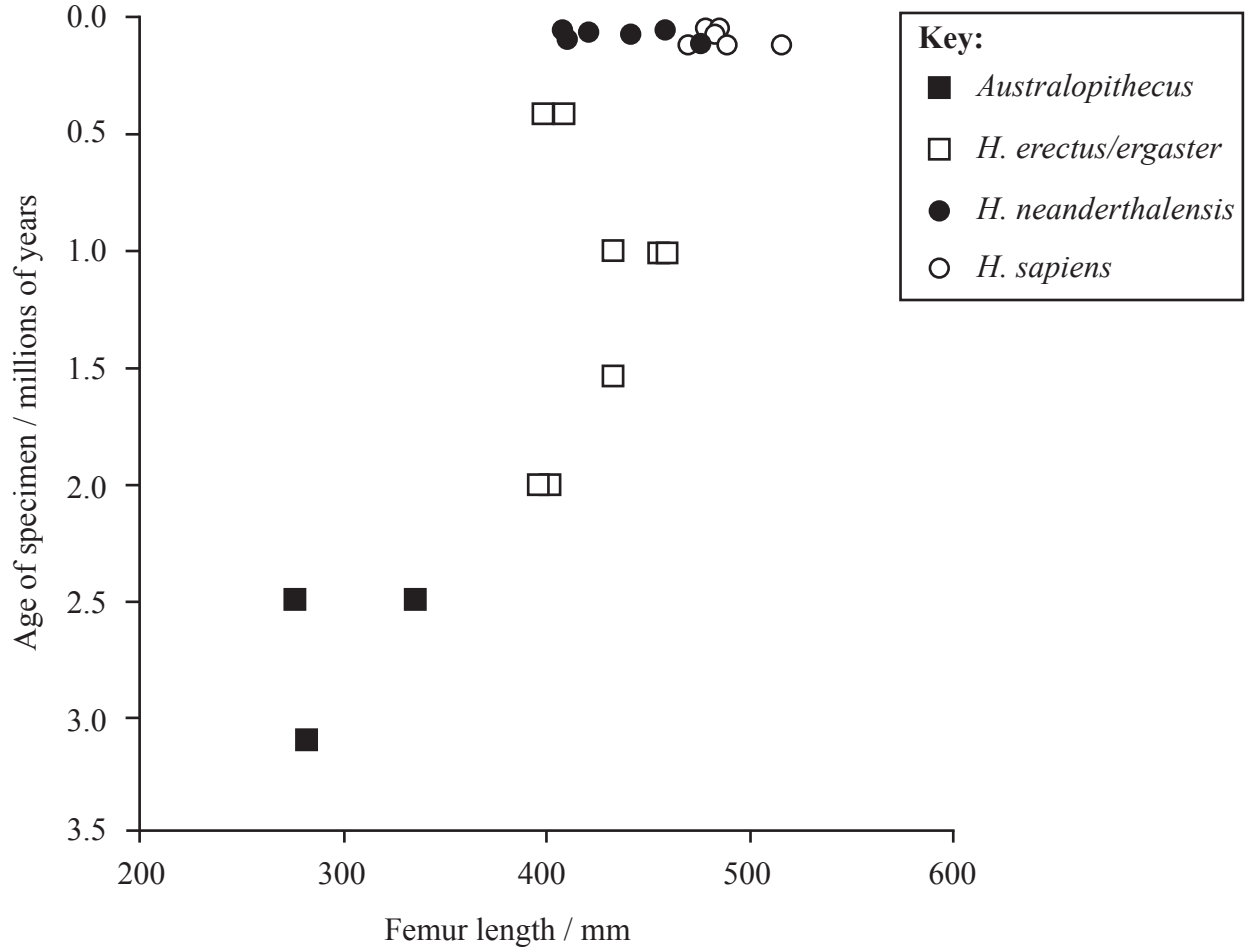
End of Option C

Option D — Evolution

10. The length of the upper leg bone (femur) is an important variable in research into human evolution as it provides information about the energy used in movement. The graph below shows the length of femurs that have been measured or estimated from hominid fossils covering a time period of approximately three and a half million years.



[Source: Adapted from K. Steudel-Numbers and M. Tilkens (2004) *Journal of Human Evolution*, 47, pages 95–109. 'The effect of lower limb length on the energetic cost of locomotion: implications for fossil hominins', with permission from Elsevier.]

(a) Estimate the range of femur lengths and the range of ages of the Australopithecus specimens. *[1]*

Range of femur lengths: . . . . . mm

Range of ages: . . . . . millions of years

(Option D continues on the following page)

(Option D, question 10 continued)

(b) Compare femur lengths in *H. neanderthalensis* and *H. erectus*. *[2]*

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(c) Evaluate the evidence from the data that increasing femur length provides an evolutionary advantage. *[2]*

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(d) Outline **two** reasons why the data may not be reliable. *[2]*

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(Option D continues on the following page)

(Option D continued)

11. (a) Cells may have evolved from simpler structures called protobionts. State the essential feature of a protobiont. *[1]*

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(b) The early Earth's atmosphere did not contain oxygen. State how prokaryotes helped an oxygen rich atmosphere to form. *[1]*

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(c) Discuss how eukaryotes evolved from simpler life forms. *[3]*

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(Option D continues on the following page)

(Option D continued)

12. (a) (i) Define *half-life*. *[1]*

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(ii) Outline the methods used for dating fossils and rocks using ^{40}K. *[2]*

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(b) Discuss the definition of the term *species*. *[3]*

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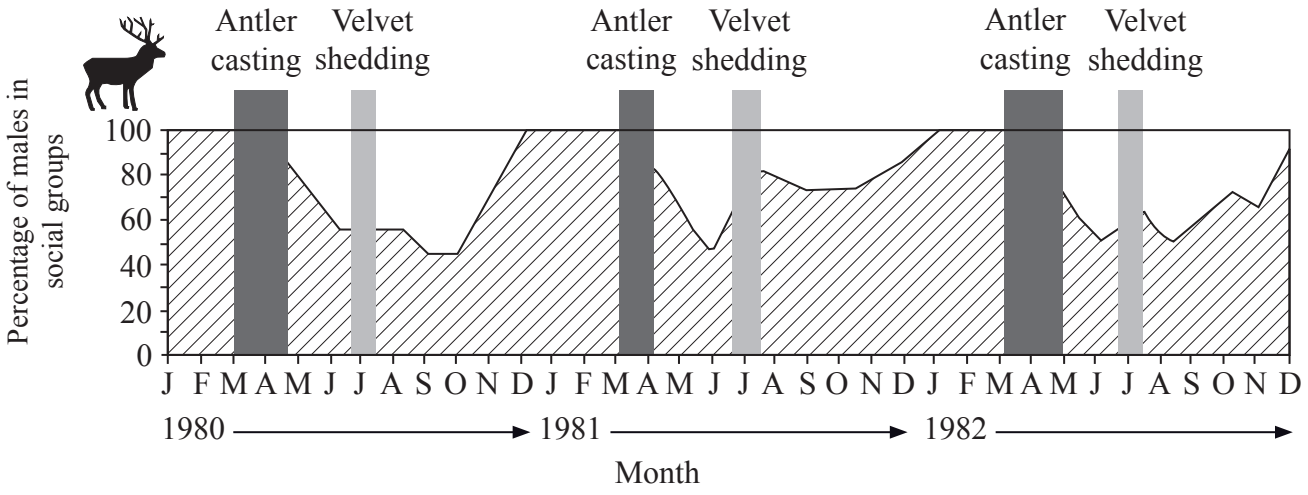
End of Option D

Option E — Neurobiology and behaviour

13. Red deer (*Cervus elaphus*) form social groups which show seasonal variation in the percentage of males and females. Male deer have antlers formed from bone tissue which start growing in May and are cast off once a year. A soft covering called velvet helps to protect the developing antlers and is shed when the antlers are fully grown. The graph shows the seasonal variation in the percentage of males in social groups as well as the timing of antler casting and velvet shedding.



[Source: Reproduced with permission from *Animal Production Science*, 51: 303–310 (L. Bartos and G. A. Bubenik). Copyright CSIRO 2011. Published by CSIRO Publishing, Collingwood, Victoria Australia — http://www.publish.csiro.au/nid/72/paper/AN10195.htm.]

(a) Describe the annual pattern in the composition of the social groups in 1980. *[2]*

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(Option E continues on the following page)

(Option E, question 13 continued)

(b) Analyse the pattern of antler casting and velvet shedding for the three years shown. *[2]*

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(c) Suggest reasons for the change in the percentage of males in the social groups after antler casting in 1980. *[2]*

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(d) Suggest how antler casting may be controlled by an external stimulus. *[1]*

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(Option E continues on the following page)

(Option E continued)

14. (a) Explain how sound is perceived by the ear. *[3]*

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(b) State **two** differences in the way rod and cone cells function. *[2]*

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(Option E continues on the following page)

(Option E continued)

15. (a) State **one** example of an inhibitory psychoactive drug. *[1]*

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(b) Outline the effect of psychoactive drugs on the brain. *[3]*

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(c) Discuss the causes of drug addiction. *[2]*

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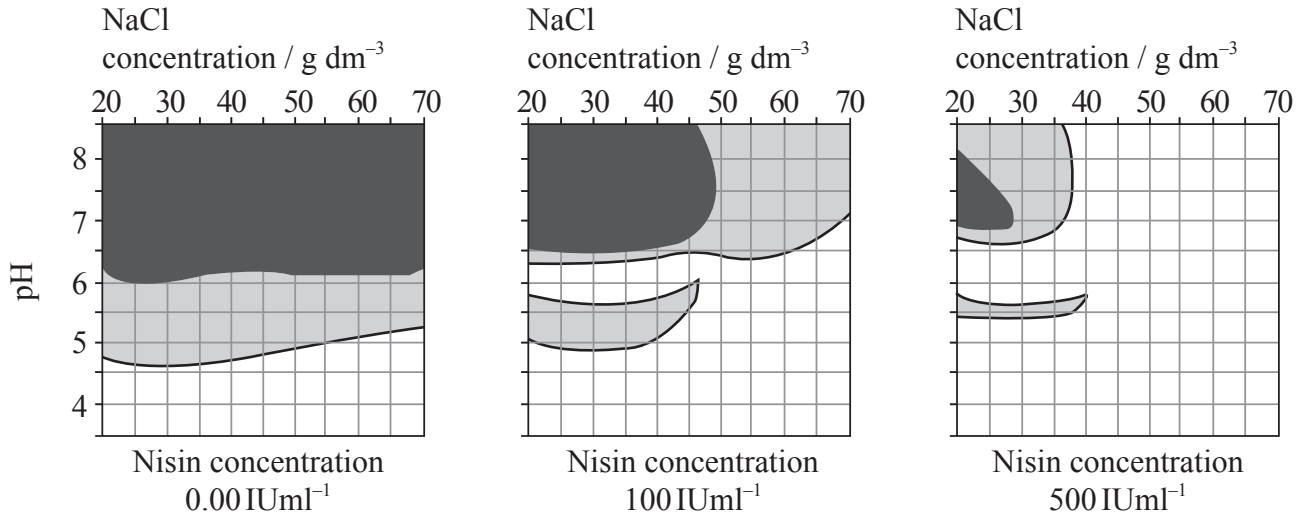
End of Option E

Option F — Microbes and biotechnology

16. Nisin, is a naturally occurring polypeptide, that is used in the food industry to prevent the growth of food-borne pathogens such as *Listeria monocytogenes*. The pathogen was grown at three different nisin concentrations using a range of pH values and NaCl concentrations. Dark shading shows visible growth of bacteria after 48 hours of incubation and light shading shows areas where bacterial growth was inhibited but the bacteria were not killed, clear areas show where bacteria were killed.



[Source: Adapted from L. V. Thomas and J. W. Wimpenny (1996) 'Investigation of the effect of combined variations in temperature, pH, and NaCl concentration on nisin inhibition of Listeria monocytogenes and Staphylococcus aureus.' *Applied and Environmental Microbiology*, 62 (6), pages 2006–2012.]

(a) Describe the effect of pH on *L. monocytogenes* in the absence of nisin (0.00 $IUml^{-1}$) at 20g dm^{-3} NaCl. *[2]*

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(Option F continues on the following page)

(Option F, question 16 continued)

(b) Analyse the effect of increasing nisin concentration on *L. monocytogenes.* *[3]*

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(c) Deduce the highest pH at which all *L. monocytogenes* are killed. *[1]*

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(d) Suggest **one** advantage of using nisin for the preservation of food. *[1]*

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(Option F continues on the following page)

(Option F continued)

17. (a) Outline the diversity of structure in viruses. *[2]*

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(b) Viral vectors can be used to treat some diseases.

(i) State how a viral vector can be used to treat a disease. *[1]*

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. . . . . .

(ii) State an example of a disease which may be treated using a viral vector. *[1]*

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(c) Recombinant DNA is DNA into which a gene from a different source has been inserted. Explain how recombinant DNA can be made starting with mRNA. *[3]*

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(Option F continues on the following page)

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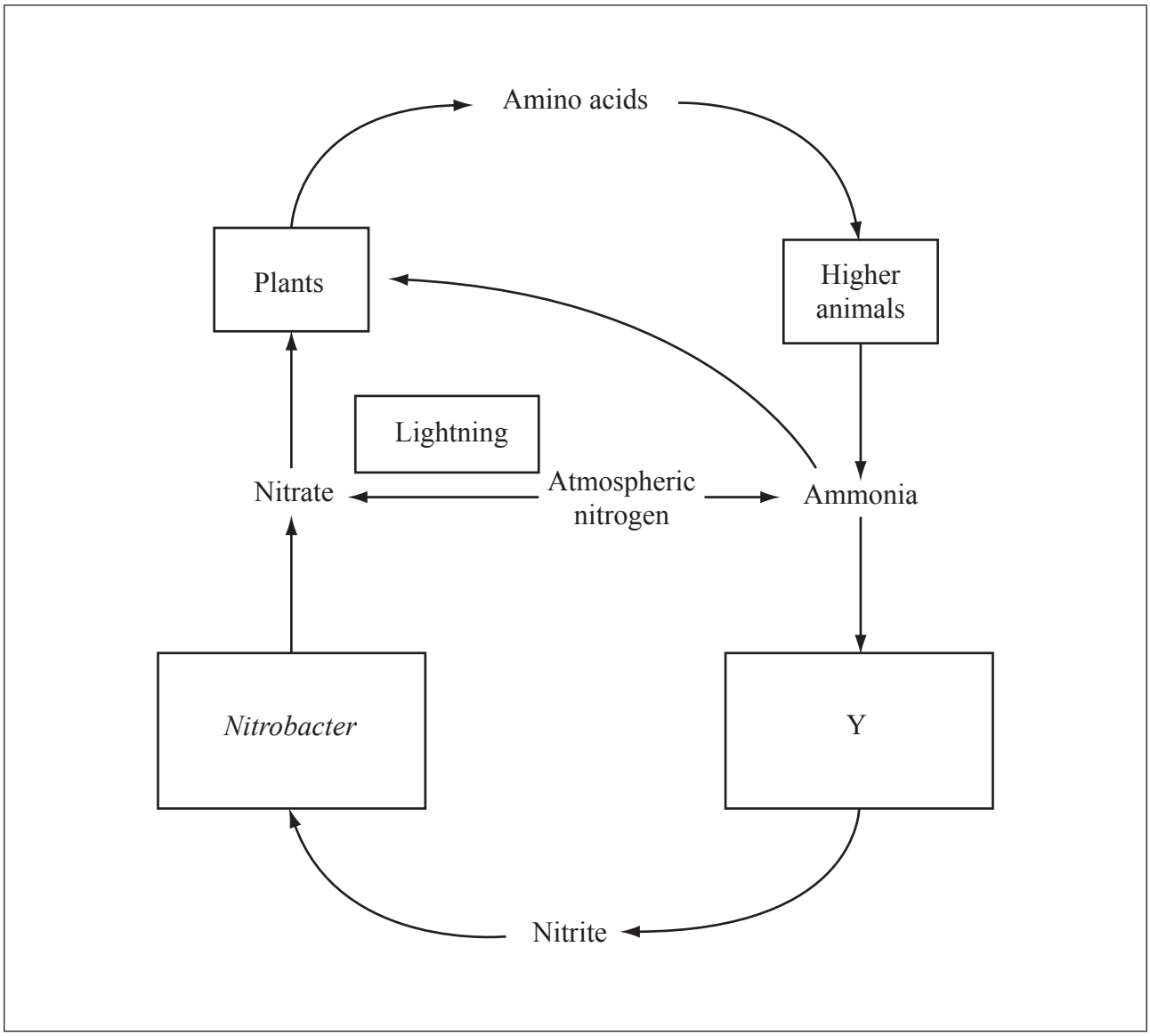
(Option F continued)

18. The diagram below shows a simplified nitrogen cycle. The arrows show some of the important processes in the cycle while the boxes represent important organisms.

(a) (i) Identify the process of nitrogen fixation in bacteria by writing a letter X on the arrow that represents it. *[1]*



[Source: © International Baccalaureate Organization 2014]

(ii) Identify the organism represented by the box labelled Y. *[1]*

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(Option F continues on the following page)

(Option F, question 18 continued)

(b) Outline the consequences of releasing raw sewage into rivers. *[2]*

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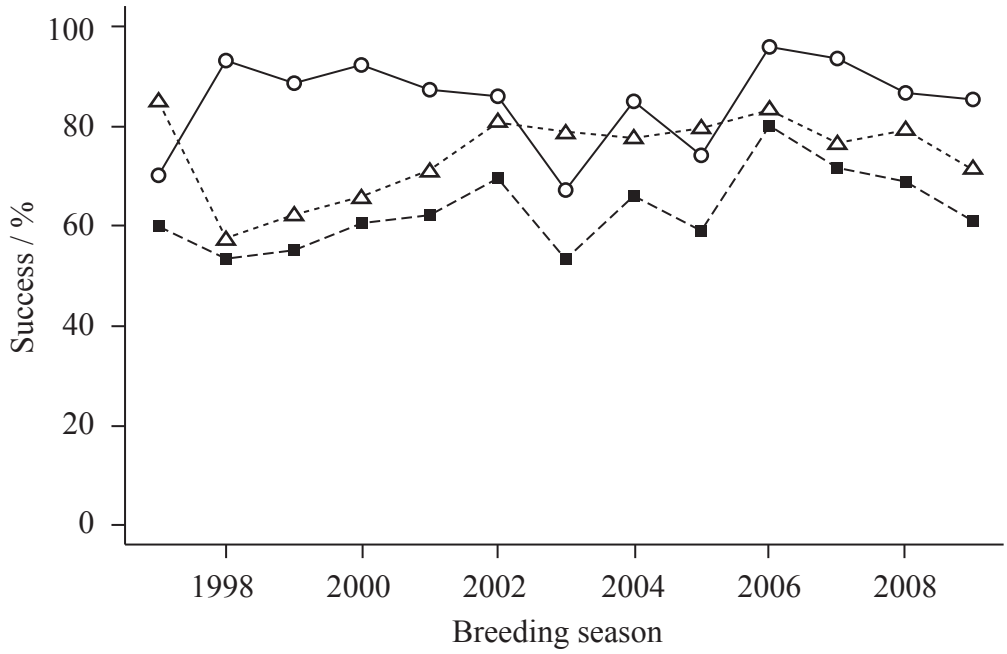
End of Option F

Option G — Ecology and conservation

19. The breeding success of white-flippered penguins (*Eudyptula minor albosignata*) was monitored in New Zealand, between 1997 and 2009. This involved counting the number of eggs laid and calculating the percentage that hatched (successfully emerged from egg) and the percentage of chicks that fledged (became independent of their parents). Successful breeding contributes to the survival of penguin colonies.



Key:

△ Hatching success $\left(\frac{\text{eggs hatched}}{\text{eggs laid}}\right)$

○ Fledging success $\left(\frac{\text{chicks fledged}}{\text{eggs hatched}}\right)$

■ Breeding success $\left(\frac{\text{chicks fledged}}{\text{eggs laid}}\right)$

[Source: W. J. Allen *et al.* (2011) 'Factors affecting breeding success of the Flea Bay white-flippered penguin (Eudyptula minor albosignata) colony', *New Zealand Journal of Ecology*, 35 (3), pp. 199–208. Reprinted with permission.]

(a) Identify the year that has the highest breeding success. *[1]*

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(Option G continues on the following page)

(Option G, question 19 continued)

(b) Describe the trend in hatching success between 1998 and 2006. *[1]*

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(c) Compare breeding and fledging success between 1997 and 2009. *[2]*

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(d) In the year 1998 there is relatively low breeding success. Using all the data, suggest a possible reason for this situation. *[1]*

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(e) In 2003 and 2005 low fledging and breeding success is combined with relatively high hatching success. Suggest **two** possible reasons for this. *[2]*

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(Option G continues on the following page)

(Option G continued)

20. (a) Outline how a transect may be used to collect data in an ecosystem. *[2]*

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(b) Outline **one** method that could be used to estimate the population size of a plant species. *[2]*

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(Option G continues on the following page)

(Option G continued)

21. (a) (i) List **two** factors that affect the distribution of plant species. *[2]*

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(ii) Outline the principle of competitive exclusion. *[2]*

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(b) Explain how living organisms affect the abiotic environment during primary succession. *[3]*

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End of Option G

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