

**BIOLOGY
STANDARD LEVEL
PAPER 3**

Candidate number

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Thursday 8 May 2003 (morning)

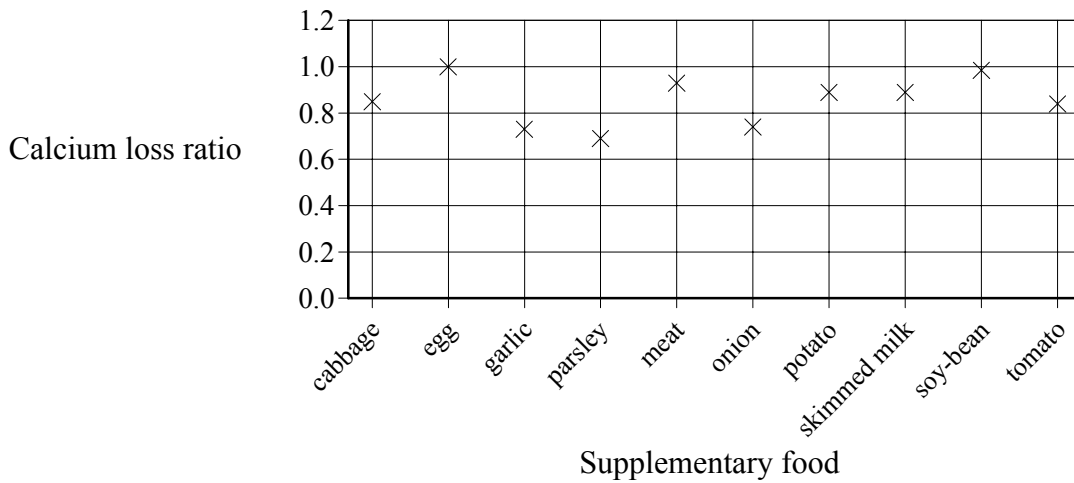
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INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your candidate number on each answer sheet, and attach them to this examination paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

Option A – Diet and human nutrition

A1. Osteoporosis is a major health problem for many post-menopausal women. As the ovaries reduce their secretion of estrogen, calcium is gradually lost from bones, weakening them and increasing the chance of fractures. To test whether diet influences the rate of calcium loss, ovaries were removed from groups of female rats and the rats were then either fed a control diet or the same diet with one gram of a supplementary food per day. The rate at which the rats excreted calcium was measured. The ratio of calcium loss between the control rats and the rats that were given a supplementary food was calculated. $\left(\text{Ratio} = \frac{\text{loss with supplementary food}}{\text{loss in control rats}} \right)$. The results are shown in the graph below.



[Source: Muhlbauer and Li, *Nature*, 1999, **401**, pages 343–344]

(a) (i) Identify which supplementary food was **most** effective in reducing calcium loss. [1]

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(ii) Identify which supplementary food was **least** effective in reducing calcium loss. [1]

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(b) Among the ten foods shown in the graph, seven are plant products (vegetables) and three are animal products. Discuss whether the plant or the animal products were more effective at reducing calcium loss. [3]

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(Question A1 continued)

- (c) Suggest a trial, based on the results shown in the graph, that could be done to try to reduce osteoporosis in humans. [3]

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A2. Carbohydrates are one of the constituents of a balanced diet in humans.

- (a) Carbohydrates can be used as a substrate in cell respiration.
 - (i) State **one** other constituent of human diets that can be used as a respiratory substrate. [1]

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- (ii) Outline **two** uses of carbohydrates in the human body, other than as a respiratory substrate. [2]

1.

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2.

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- (b) Monosaccharides are useful if energy is needed rapidly, but polysaccharides are a better form of carbohydrate if energy is needed over a longer period.

- (i) State **two** foods that are a good source of monosaccharides. [1]

1. 2.

- (ii) State **two** foods that are a good source of polysaccharides. [1]

1. 2.

A3. Eggs contain protein, one of the essential constituents of the human diet. Some humans choose not to eat eggs because of allergies, because they have a high cholesterol content, or for ethical reasons.

(a) Outline the possible health problems that might be caused by eating foods with a high cholesterol content. [2]

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(b) Discuss the ethical issues involved in the production and eating of eggs. [3]

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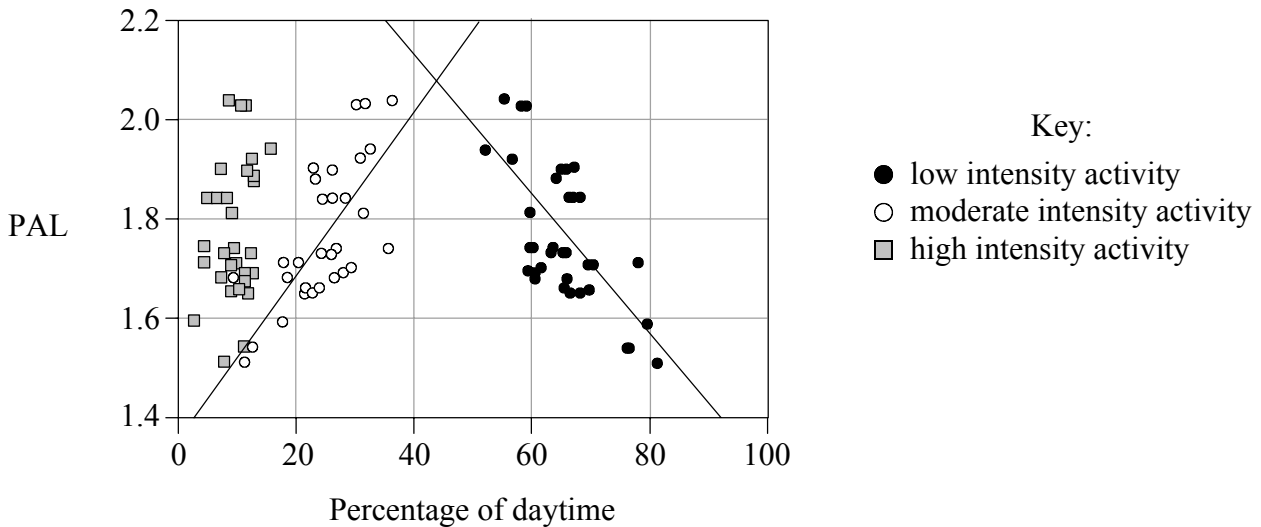
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Option B – Physiology of exercise

B1. In an investigation of amounts of exercise in modern life-styles, sensors were fixed onto thirty adults. The sensors were used to monitor the activity of each of the adults continuously for one week. All of the adults were healthy and none of them were obese (overweight). The intensity of activity that the sensors detected was divided into three categories:

- low intensity – lying, sitting or standing for example
- moderate intensity – walking or cycling for example
- high intensity – vigorous housework, gymnastics or sport for example.

The overall physical activity level of each of the adults was also measured. Physical activity level (PAL) is the factor by which a person’s total energy expenditure exceeds their resting energy expenditure. The scattergram below shows the percentage of daytime spent on low, moderate and high intensity activity, plotted against each adult’s PAL. Three points for each adult have been plotted, one for low, one for moderate and one for high intensity activity, making a total of 100 %.



[Source: Klaas Westerterp, *Nature*, 2001, **410**, page 539]

(a) Using the table below, state the percentage of daytime spent on each category of activity by the adult in the survey with the lowest PAL and the adult with the highest PAL. [2]

	Low intensity	Moderate intensity	High intensity
Lowest PAL			
Highest PAL			

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(Question B1 continued)

(b) The lines on the graph show the trends for two types of activity. State the relationship between PAL and the percentage of daytime spent on

(i) low intensity activity [1]

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(ii) moderate intensity activity [1]

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(iii) high intensity activity. [1]

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(c) Adults who are obese are often encouraged to increase their PAL to help to reduce their body weight. Using the data in the scattergram, discuss changes to the daytime activities of an obese adult that would be effective in increasing his/her PAL. [3]

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B2. The human skeleton consists of many bones, connected by joints.

(a) When the skeleton is studied, it is often sub-divided into two parts. State the names of the **two** parts. [1]

1. 2.

(b) Elongated bones in the arms and legs are called long bones. Explain how the structure of a long bone gives it strength. [3]

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(c) The structure of joints can permit or prevent movements at a joint. Describe the movements that can occur at the hip joint. [2]

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B3. Muscles are controlled by the spinal cord and by parts of the brain called motor areas.

(a) State the location of the motor areas in the brain. [1]

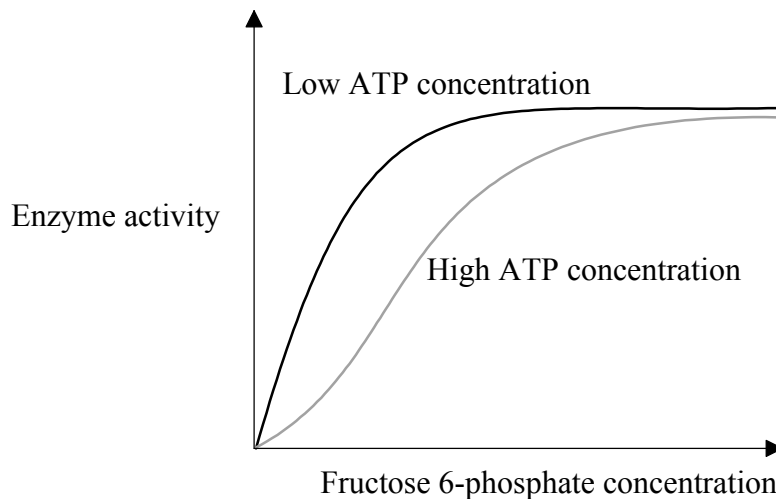
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(b) Explain the role of proprioceptors in the control of muscle contraction. [3]

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Option C – Cells and energy

C1. At the start of glycolysis, glucose is phosphorylated to produce glucose 6-phosphate, which is converted into fructose 6-phosphate. A second phosphorylation reaction is then carried out, in which fructose 6-phosphate is converted into fructose 1,6-bisphosphate. This reaction is catalyzed by the enzyme phosphofructokinase. Biochemists measured the enzyme activity of phosphofructokinase (the rate at which it catalyzed the reaction) at different concentrations of fructose 6-phosphate. The enzyme activity was measured with a low concentration of ATP and a high concentration of ATP in the reaction mixture. The graph below shows the results.



(a) (i) Using **only** the data in the above graph, outline the effect of increasing fructose 6-phosphate concentration on the activity of phosphofructokinase, at a low ATP concentration. [2]

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(ii) Explain how increases in fructose 6-phosphate concentration affect the activity of the enzyme. [2]

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(Question C1 continued)

- (b) (i) Outline the effect of increasing the ATP concentration on the activity of phosphofructokinase. [2]

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- (ii) Suggest an advantage to living organisms of the effect of ATP on phosphofructokinase. [1]

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C2. The complex structure of proteins can be explained in terms of four levels of structure, primary, secondary, tertiary and quaternary.

- (a) Primary structure involves the sequence of amino acids that are bonded together to form a polypeptide. State the name of the linkage that bonds the amino acids together. [1]

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- (b) Beta pleated sheets are an example of secondary structure. State **one** other example. [1]

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- (c) Tertiary structure in globular proteins involves the folding of polypeptides. State **one** type of bond that stabilizes the tertiary structure. [1]

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- (d) Outline the quaternary structure of proteins. [2]

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C3. Explain the reasons for

(a) a large area of thylakoid membrane in the chloroplast. [2]

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(b) low rates of photosynthesis in plants growing beneath trees, where the light has already passed through the trees' leaves. [2]

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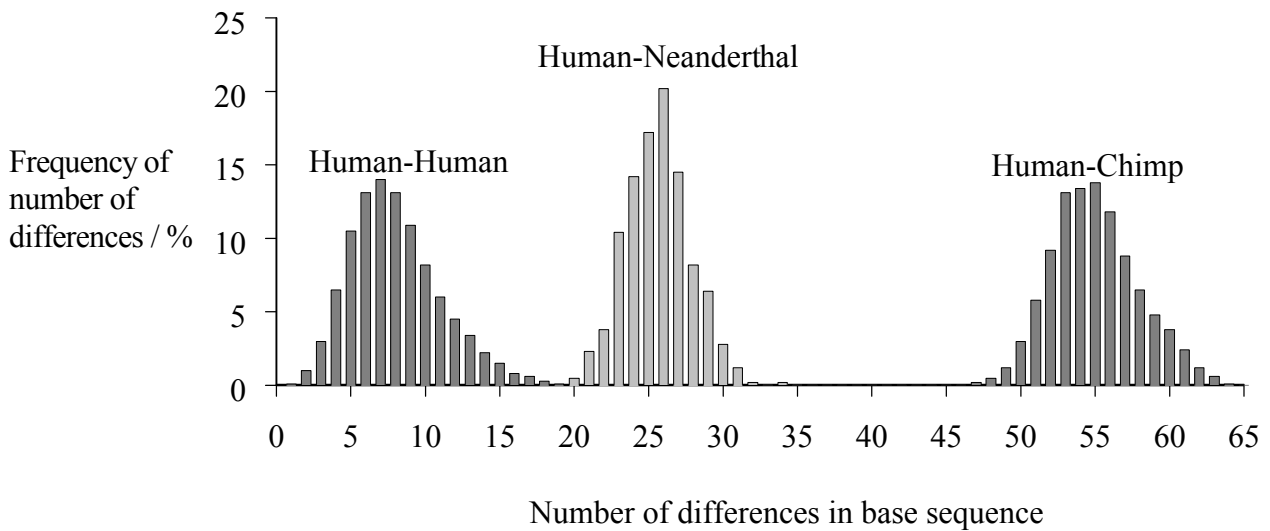
(c) large amounts of RuBP carboxylase in the chloroplast. [2]

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Option D – Evolution

D1. The evolution of groups of living organisms can be studied by comparing the base sequences of their DNA. If a species becomes separated into two groups, differences in base sequence between the two species accumulate gradually over long periods of time. The number of differences can be used as an evolutionary clock.

Samples of DNA were recently obtained from fossil bones of a Neanderthal (*Homo neanderthalensis*). A section of the DNA from the mitochondrion was chosen for study, as it shows a high level of variation in base sequence between different individuals. A section of the Neanderthal mitochondrial DNA was sequenced and compared with sequences from 994 humans and 16 chimpanzees. The bar chart below shows how many base sequence differences were found among humans, between the humans and the Neanderthal and between humans and chimpanzees.



[Source: Krings, *et al.*, Cell, 1997, 90, pages 19–30]

(a) The number of differences in base sequence between pairs of humans varied from 1 to 24. State the number of differences shown by the highest percentage of pairs of humans. [1]

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(b) Humans and Neanderthals are both classified in the genus *Homo* and chimpanzees are classified in the genus *Pan*. Discuss whether this classification is supported by the data in the bar chart. [3]

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(Question D1 continued)

Data suggests that humans and Neanderthals diverged 550000 to 700000 years ago.

- (c) If a sample of mitochondrial DNA was obtained from a fossil bone of *Australopithecus*, predict, with a reason, how many base sequence differences there would be between it and human DNA. [2]

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- D2.** (a) (i) Outline the methods used by Miller and Urey in their experiments into the origin of organic compounds on Earth. [2]

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- (ii) Outline the conclusions that Miller and Urey drew from their experiments. [2]

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(Question D2 continued)

(b) Darwin developed the theory that natural selection is responsible for the origin of species.

(i) Suggest **two** other theories for the origin of species. [2]

1.

2.

(ii) Discuss briefly the evidence for **one** of these two other theories. [3]

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D3. Describe the evidence for evolution provided by the geographical distribution of placental, marsupial and monotreme mammals. [3]

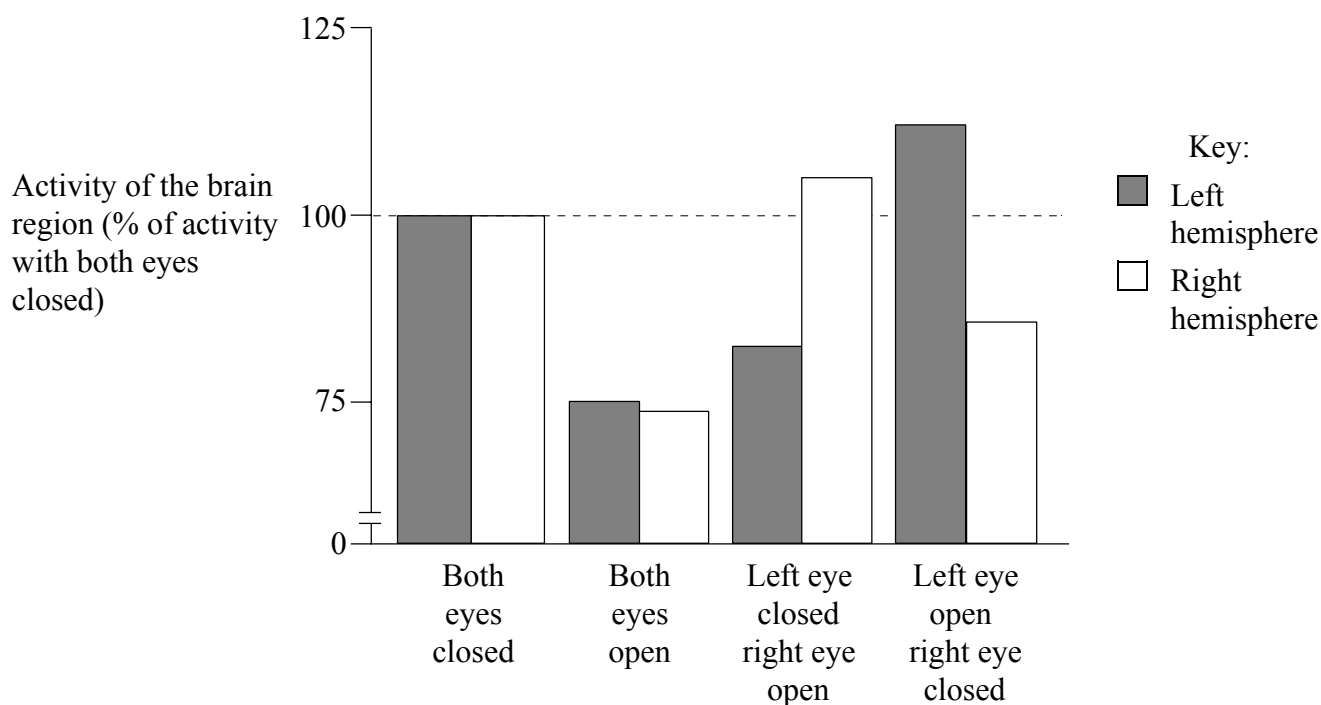
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Option E – Neurobiology and behaviour

E1. When birds are in danger of attack by predators, they sometimes sleep with one eye open and one eye closed. Neurobiologists investigated this behaviour pattern using mallard ducks (*Anas platyrhynchos*). Video recordings were made of groups of four sleeping birds, arranged in a row. The birds at the ends of the row were more vulnerable to predator attacks and kept one eye open 150 % more of the time than the two birds in the centre of the row.

Electroencephalograph (EEG) recordings were made to monitor the brain state of the birds at the ends of the rows. A region of the brain which indicates whether the bird is asleep or awake was monitored in each of the left and right cerebral hemispheres. EEG recordings were made when the birds were sleeping with both eyes closed, when the birds had both eyes open and also when they had one eye open. These results are shown in the bar chart below, as a percentage of the activity of the brain region when the birds were sleeping with both eyes closed.



[Source: Rattenborg, *et al.*, Nature, 1999, 397, pages 397–398]

(a) State the effect of opening both eyes on activity in the region of the brain that was being monitored.

[1]

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(Question E1 continued)

- (b) (i) Using the data in the bar chart, deduce the effect on the two cerebral hemispheres of opening only the right eye. [2]

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- (ii) Determine which hemisphere is more awake when the right eye is open. [1]

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- (iii) Using the data in the bar chart, deduce how the left and right eyes and left and right hemispheres are connected. [1]

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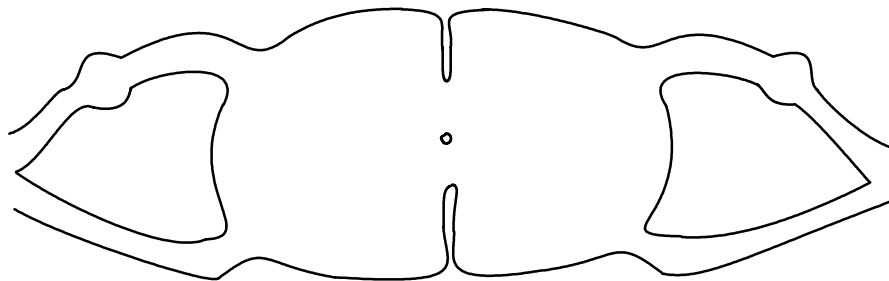
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- (c) Suggest **two** advantages to birds of keeping one eye open during sleep. [2]

1.

2.

E2. The diagram below represents the spinal cord in cross section.



- (a) Draw lines and labels on the diagram to show the areas of grey and white matter in the spinal cord. [2]

- (b) Annotate the diagram to show the location of cell bodies of motor neurones and sensory neurones. [2]

E3. Courtship is an important form of behaviour in many species of bird and mammal.

- (a) Describe the courtship behaviour of **either** one species of bird **or** one species of non-human mammal. [3]

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- (b) Explain the role of natural selection in the development of this courtship behaviour. [3]

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- (c) State **one** type of behaviour, other than courtship, that has developed by natural selection. [1]

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Option F – Applied plant and animal science

F1. Organic farmers sometimes claim that fruit and vegetables grown organically taste better than the same varieties grown using non-organic methods. To test this theory and other claimed advantages of organic farming, crop scientists set up trial plots on which apples were grown using three different production systems:

- organic (no artificial fertilizer or spray chemicals used)
- conventional non-organic (artificial chemical fertilizers and spray chemicals used)
- integrated (organic and non-organic methods combined, to reduce artificial chemical use).

A group of consumers tested the apples for flavour, firmness, sweetness and sourness (acid taste). The acidity of the fruit was also measured by chemical analysis. The table below shows the mean results.

Test	Organic	Conventional non-organic	Integrated
Flavour 1 = dislike extremely 9 = like extremely	6.0 <i>a</i>	5.9 <i>a</i>	6.7 <i>b</i>
Firmness 1 = very soft 9 = very hard	5.5 <i>a</i>	5.3 <i>a</i>	5.1 <i>a</i>
Sweetness 1 = not at all sweet 9 = extremely sweet	5.6 <i>a</i>	5.0 <i>b</i>	5.6 <i>a</i>
Sourness 1 = not at all sour 9 = extremely sour	3.6 <i>a</i>	4.7 <i>b</i>	4.8 <i>b</i>
Measurable acidity / %	0.49 <i>a</i>	0.52 <i>ab</i>	0.54 <i>b</i>

[Source: Reganold, *et al.*, *Nature*, 2001, **410**, pages 926–929]

The letters *a* and *b* after the values in each test indicate whether the differences between the means are significant or not. If the letters in a test are the same, the difference is too small for any conclusions to be drawn. If the letters are different, there is a significant difference.

(a) (i) Identify **one** test in which there were no significant differences between the mean results for the three systems. [1]

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(ii) Identify **one** test in which the mean result for the conventional system was significantly different from those for the other two systems. [1]

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(Question F1 continued)

- (b) The acidity of the apples was tested both by chemical analysis and by the group of consumers. Compare the results obtained by these two methods. [2]

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- (c) Evaluate the hypothesis that the taste of apples is better if organic rather than conventional methods are used to grow them. [2]

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- F2.** (a) Suggest **two** reasons for conserving ancient breeds of farm livestock. [2]

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2.
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- (b) Outline the feeding of **either** cattle **or** sheep **or** chickens. [3]

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(Question F2 continued)

(c) Artificial insemination (AI) is sometimes used in livestock production, instead of natural mating. Suggest **two** advantages of artificial insemination. [2]

- 1.
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- 2.
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F3. Light, water and carbon dioxide concentration all affect the productivity of crop plants.

(a) State **two** other factors that affect plant productivity. [2]

- 1.
- 2.

(b) Explain how plant productivity can be increased by growing crops in greenhouses. [3]

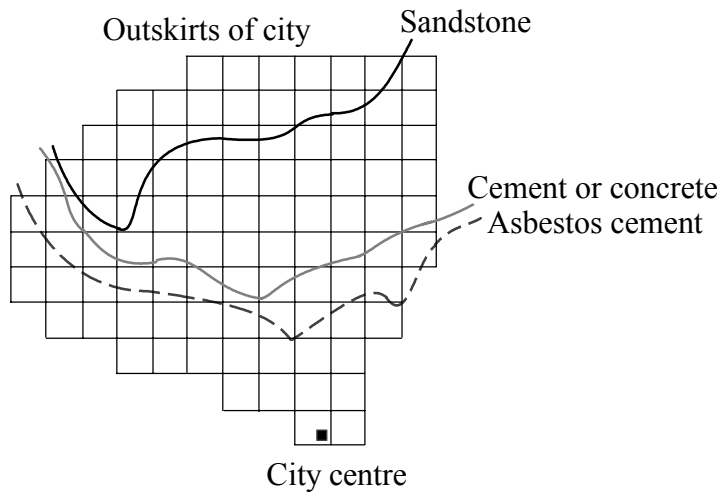
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Option G – Ecology and conservation

G1. *Lecanora muralis* is a species of lichen that grows on walls and roofs in northwest Europe. In 1976 ecologists did a survey of the distribution of *L. muralis* in a sector of Leeds, an industrial city in the north of England. Wind direction in this area is variable and levels of air pollution decrease from the centre of the city outwards. *L. muralis* was found growing on three habitat types:

- sandstone blocks, used to build the tops of walls
- walls constructed using cement or concrete
- roofs made of asbestos cement.

Like many lichens, this species does not tolerate high levels of sulfur dioxide, an acidic gas that is a major component of acid rain. Acid rain can be neutralized by alkaline materials, including cement and concrete. The results of the survey are shown in the map below. *L. muralis* was found north of the lines shown on the map for each of the three types of habitat. The grid lines are 1 km apart.



[Source: Oliver Gilbert, *Lichens*, 2000, Harper Collins, page 56]

(a) (i) Deduce which habitat type allows *L. muralis* to tolerate the highest level of sulfur dioxide pollution. Give a reason for your answer. [2]

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(ii) Suggest a reason for the differences in tolerance between the habitat types. [1]

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(Question G1 continued)

- (b) Explain the value of a survey of this kind, especially if it is repeated at regular intervals. [3]

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- G2.** (a) Distinguish between *in situ* and *ex situ* conservation. [1]

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- (b) List **three** examples of *ex situ* measures that could be used to conserve endangered species. [3]

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- (c) Discuss the international measures needed to conserve endangered species of fish. [3]

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G3. Ecologists sometimes measure the gross production and net production of a species in an ecosystem.

(a) Define the term *gross production*. [1]

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(b) Explain why the gross production of a species in an ecosystem is always higher than the net production. [2]

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(c) Outline the changes in the gross production of an ecosystem during ecological succession. [2]

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