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Baccalauréat International
Bachillerato Internacional

BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate session number

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Friday 18 May 2012 (morning)

1 hour

Examination code

2	2	1	2	–	6	0	1	8

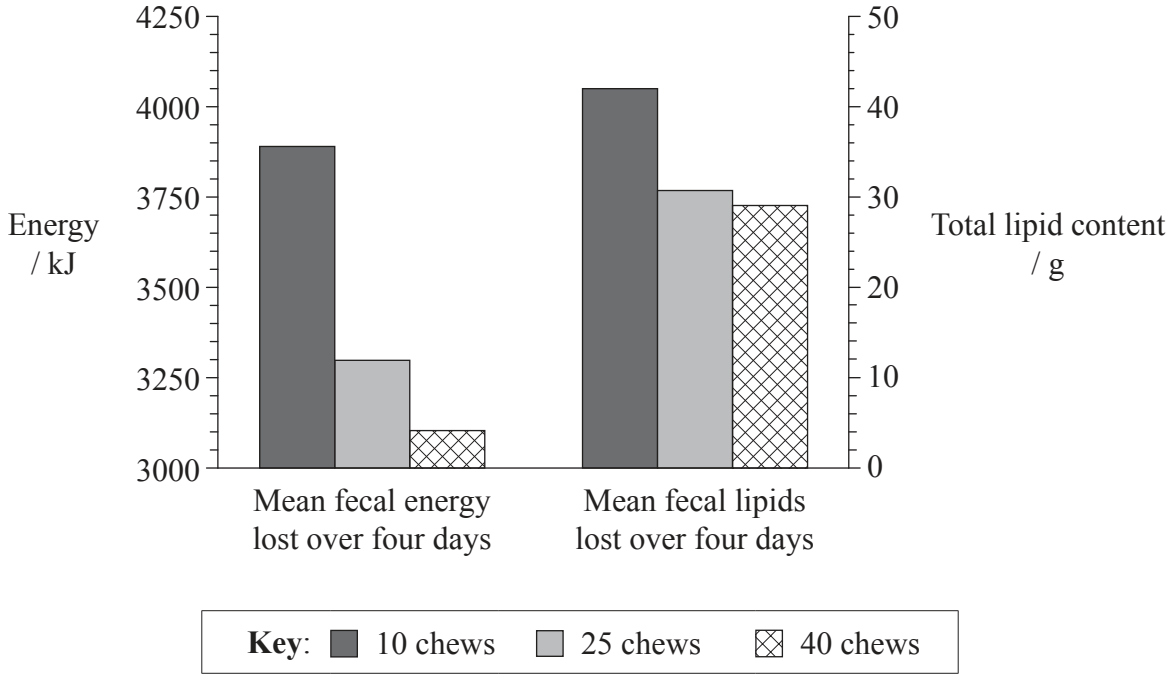
INSTRUCTIONS TO CANDIDATES

- 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]*.

31 pages

Option A — Human nutrition and health

A1. Nuts are nutritionally important because they are energy rich and their lipids may reduce the risk of cardiovascular disease. Despite these advantages, some people avoid eating nuts because they fear gaining weight from them. The role of mastication (chewing) of nuts was explored in relation to the absorption of lipids by the body and to the sense of fullness after eating nuts. Energy and total lipid content in the fecal matter (feces) of 13 people were measured over a four-day period. After not eating for eight hours, participants were initially given 55 g of raw whole almonds (in 5 g portions) to be chewed 10, 25 or 40 times before swallowing. For the remainder of the four-day period, participants were fed three controlled meals each day without any nuts.



[Acknowledgment: Cassady, B.A., Hollis, J.H., Fulford, A.D., Considine, R.V. and Mattes, R.D. 'Mastication of almonds: effects of lipid bioaccessibility, appetite, and hormone response.' *American Journal of Clinical Nutrition*, 2009; 89 (3): 794–800, ©American Society for Nutrition.]

(a) The amount of energy lost in fecal matter after 10 chews is 3890 kJ. State the amount of lipids lost in fecal matter after 10 chews, giving the units. *[1]*

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(This question continues on the following page)

(Question A1 continued)

(b) Using the data, analyse the effects of mastication on loss of energy in fecal matter. *[2]*

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(c) Deduce how mastication affects the absorption of lipids by the body. *[1]*

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(d) Evaluate the importance of the given information for individuals concerned with weight control. *[3]*

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A2. (a) List **two** possible variants in the molecular structure of unsaturated fatty acids. *[2]*

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(b) State **one** reason to include fibre in the diet. *[1]*

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(c) Describe the health consequences of a diet rich in proteins. *[3]*

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A3. (a) Outline **two** benefits of breastfeeding. *[2]*

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(b) Discuss the ethical arguments concerning the eating of animal products. *[3]*

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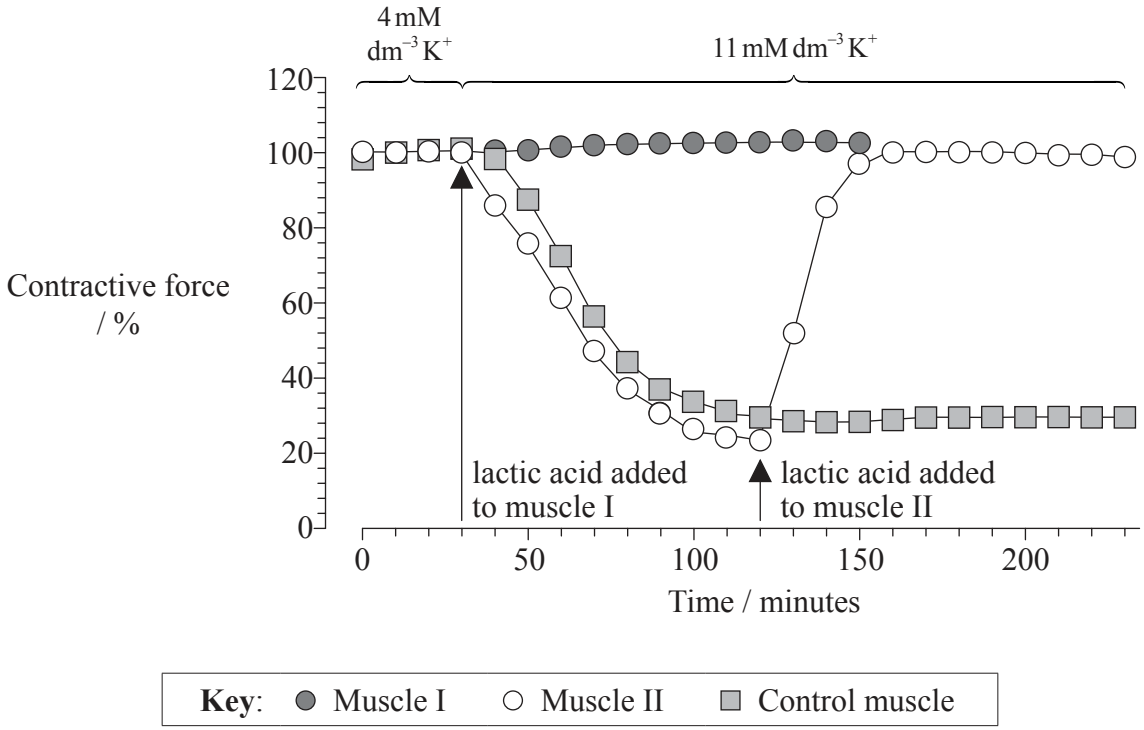
Option B — Physiology of exercise

B1. During strenuous exercise, contracting muscles release lactic acid and K^+. The muscle fatigue that results has usually been explained by the increase of lactic acid. An investigation was conducted using three sets of rat leg muscles to understand how lactic acid and K^+ affect their contractive forces. Contractive force was measured as a percentage of the force with $4\,mM\,dm^{-3}\,K^+$ and no lactic acid.



(a) Outline the effect of increasing K^+ concentration from $4\,mM\,dm^{-3}$ to $11\,mM\,dm^{-3}$ on the control muscle. *[1]*

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(This question continues on the following page)

(Question B1 continued)

(b) State the length of time muscle II is exposed to K^+ concentration of 11 mM dm^{-3} before lactic acid is added, giving the units. *[1]*

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(c) Measure the increase in contractive force of muscle when lactic acid is added to muscle II, giving the units. *[1]*

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(d) State the purpose of a control in this investigation. *[1]*

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(e) Using the data in the graph, evaluate the effect of lactic acid accumulation on muscles during strenuous exercise. *[3]*

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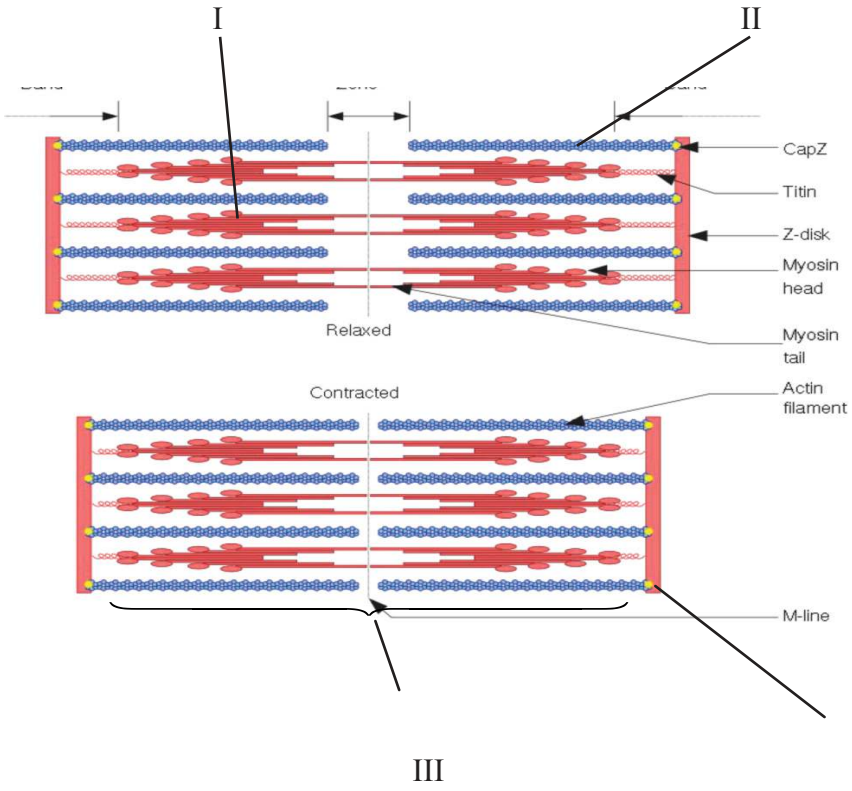
B2. (a) The following is a diagram of a sarcomere.



[Acknowledgment: http://upload.wikimedia.org/wikipedia/commons/6/6e/Sarcomere.svg]

Label parts I, II, III and IV. *[2]*

I. . . . . .

II. . . . . .

III. . . . . .

IV. . . . . .

(b) Outline reasons for increases in tidal volume and ventilation rate during exercise. *[2]*

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(c) Explain how muscle contraction causes changes in cardiac output during exercise. *[2]*

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B3. (a) Evaluate the effectiveness of dietary supplements containing creatine phosphate in enhancing performance. *[4]*

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(b) Distinguish between a sprain and a torn muscle. *[1]*

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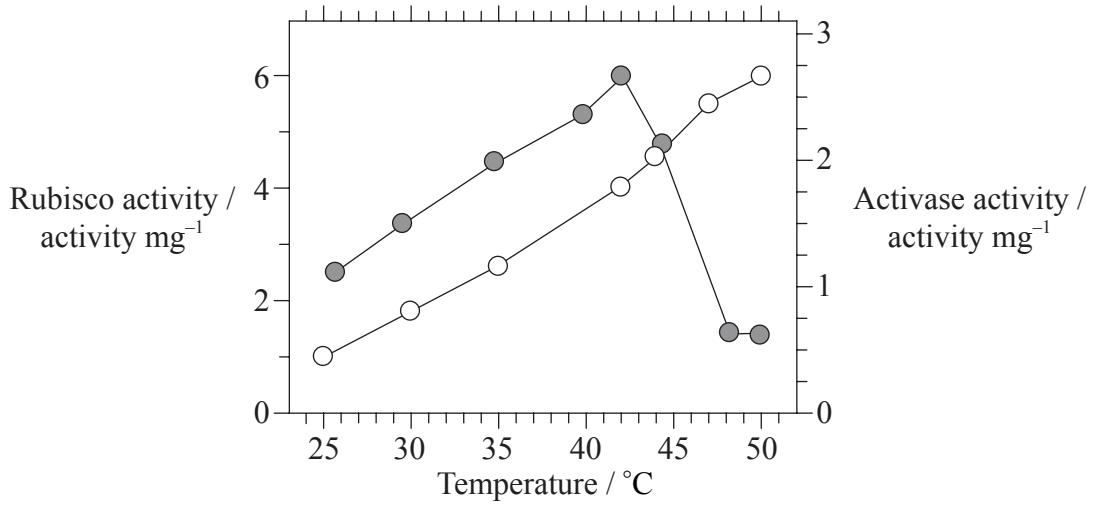
Option C — Cells and energy

C1. A key reaction in photosynthesis occurs when ribulose bisphosphate carboxylase (Rubisco) catalyses the fixation of carbon dioxide to ribulose bisphosphate (RuBP). To be effective, Rubisco must be activated by another enzyme called activase. The activities of Rubisco and activase (each isolated from tobacco leaves) were independently investigated in a laboratory, under conditions of increasing temperature.



[Source: adapted from S. Crafts-Brandner and M. Salvucci (2000) 'Rubisco activase constrains the photosynthetic potential of leaves at high temperature and CO2.' *PNAS*, **97**, pp. 13 430−13 435. Figure 2.]

(a) State the relationship between Rubisco activity and temperature. *[1]*

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(b) Calculate the percentage decrease of activase activity from the optimum temperature to 50 °C. *[1]*

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(This question continues on the following page)

(Question C1 continued)

(c) Determine which enzyme shows overall greater activity from 25 °C to 42 °C. *[1]*

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(d) Explain the change in activase activity at temperatures higher than 42 °C. *[2]*

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(e) In a leaf, both enzymes are present together. Predict, with a reason, how the rate of photosynthesis would change from 35 °C to 50 °C. *[2]*

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C2. (a) Define *quaternary structure* in proteins. *[1]*

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(b) Outline the importance of polar and non-polar amino acids in proteins. *[2]*

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(c) Describe non-competitive inhibition. *[2]*

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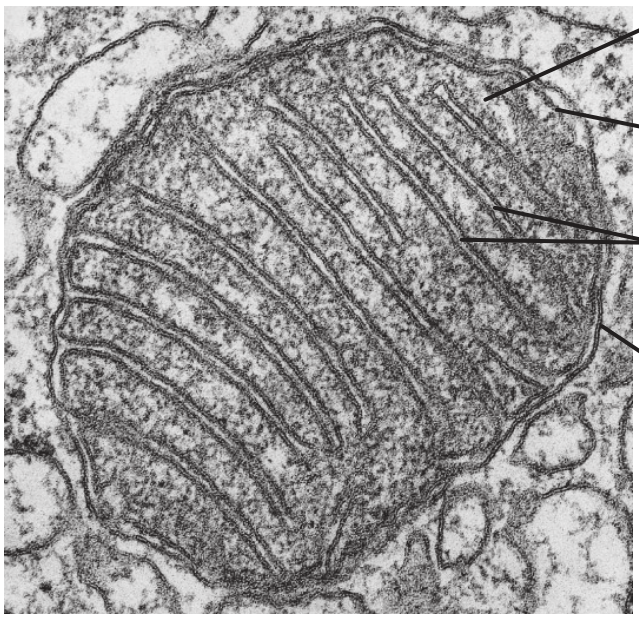
C3. (a) Label the following micrograph of a mitochondrion. *[2]*



(b) Explain how oxidative phosphorylation occurs by means of chemiosmosis. *[4]*

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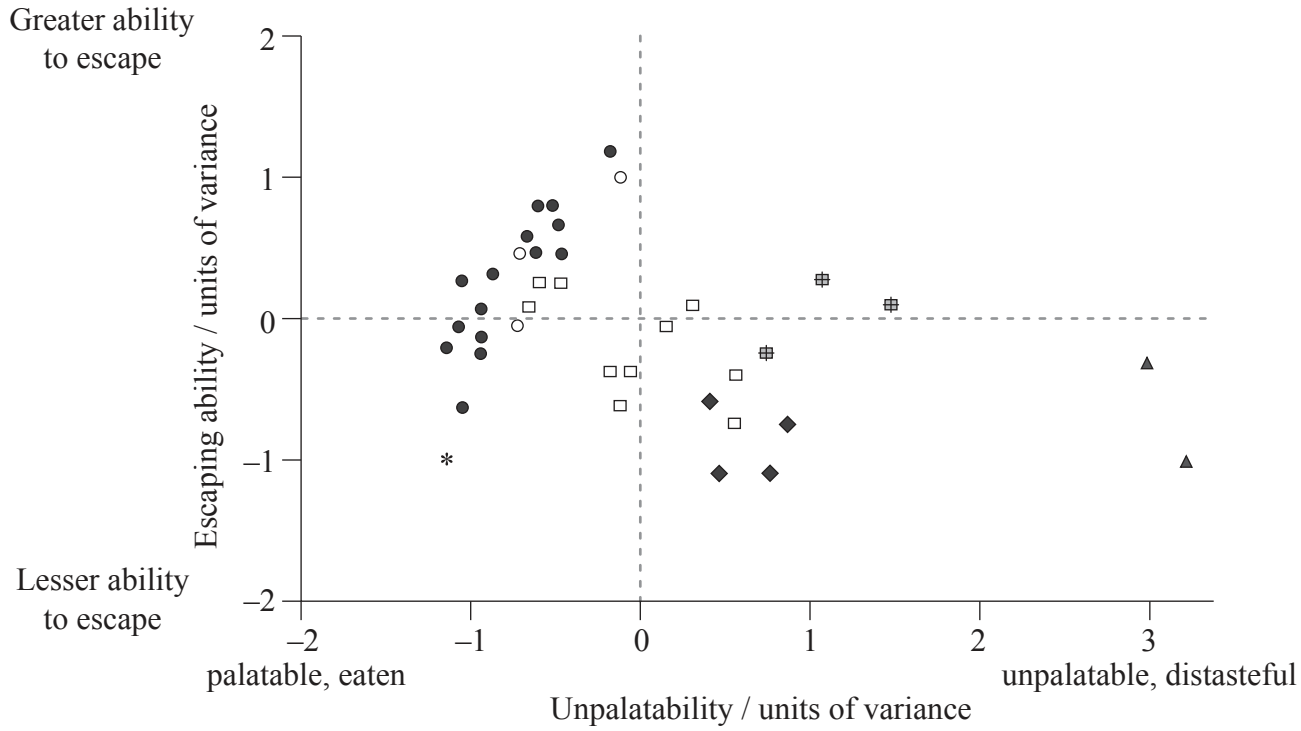
Option D — Evolution

D1. Butterflies have evolved different methods of defence against bird attacks. The relative escaping ability and unpalatability (distastefulness) of different tropical butterfly families and subfamilies was investigated in the presence of wild kingbirds, *Tyrannus melancholicus*, a natural predator of butterflies. Each symbol on the graph represents a different species within a (sub)family.



[Acknowledgment: 'Palatability and escaping ability in Neotropical butterflies: tests with wild kingbirds (*Tyrannus melancholicus*, Tyrannidae).' *Biological Journal of the Linnean Society*, **59**, pp. 351−365. Carlos E.G. Pinheiro ©1996 Linnean Society. Reproduced with permission of Blackwell Publishing Ltd.]

(a) Identify which (sub)family included the most butterfly species in the study. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) State which butterfly (sub)family contains the species with the greatest escaping ability. *[1]*

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(c) Suggest **one** feature of butterfly wings that might help a butterfly to escape from a predator. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(d) (i) Explain how the ability of a butterfly to escape from predators could increase by natural selection. *[3]*

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(ii) The graph shows that distasteful butterflies tend to have a lower ability to escape from predators than palatable butterflies. Suggest reasons for this trend. *[2]*

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D2. (a) State how comets may have affected the early Earth. *[1]*

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(b) Outline how organic compounds may have been synthesized deep in the oceans. *[2]*

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(c) State the change that occurs in the gene pool of a population when the population evolves. *[1]*

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(d) Outline convergent and divergent evolution. *[2]*

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D3. (a) Define *half-life*. *[1]*

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(b) Discuss uncertainties about human evolution based on the fossil record. *[3]*

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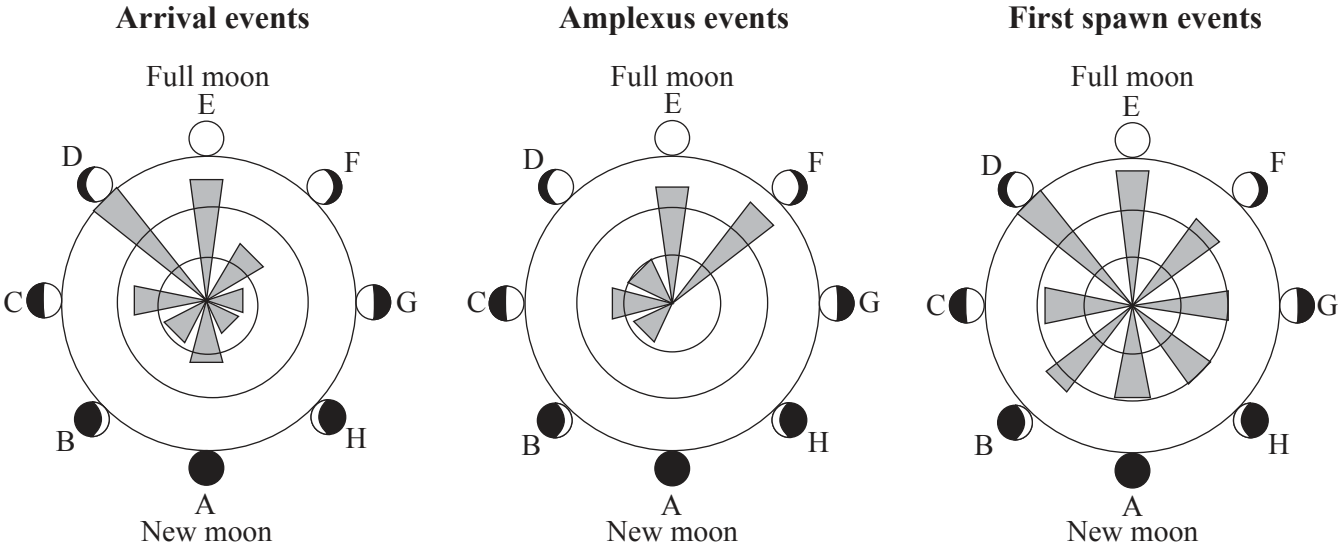
Option E — Neurobiology and behaviour

E1. Each spring, the breeding season for various species of toads begins with a mass arrival of females at ponds and lakes. Males arrive later and actively compete for the females. Amplexus (mating embrace) and spawning (depositing eggs in water) then follow. Many environmental variables affect the timing of breeding. The hypothesis that periodicity in reproductive behaviour reflects periodicity in the lunar cycle was tested over several breeding seasons at sites in Wales (UK) and Italy. The lengths of the shaded bars indicate the relative frequencies of the events.



[Acknowledgment: Reprinted from *Animal Behaviour*, vol. **78** (2), Rachel A. Grant, Elizabeth A. Chadwick and Tim Halliday, 'The lunar cycle: a cue for amphibian reproductive phenology?', pp, 349–357, ©2009, with permission from Elsevier.]

(a) Identify which reproductive event is least influenced by the lunar cycle. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(b) Compare the data for arrival events with amplexus events. *[2]*

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(c) Deduce the relationship between arrival events and amplexus events in moon phases D to F. *[1]*

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(d) Suggest, with a reason, whether the timing of arrival is a learned **or** innate behaviour. *[1]*

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(e) The lunar cycle could affect the timing of breeding. Suggest, with a reason, **one** other environmental variable which could affect the timing. *[2]*

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E2. (a) Define the term *stimulus*. *[1]*

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(b) List the components of a spinal reflex arc in order from stimulus to response. *[2]*

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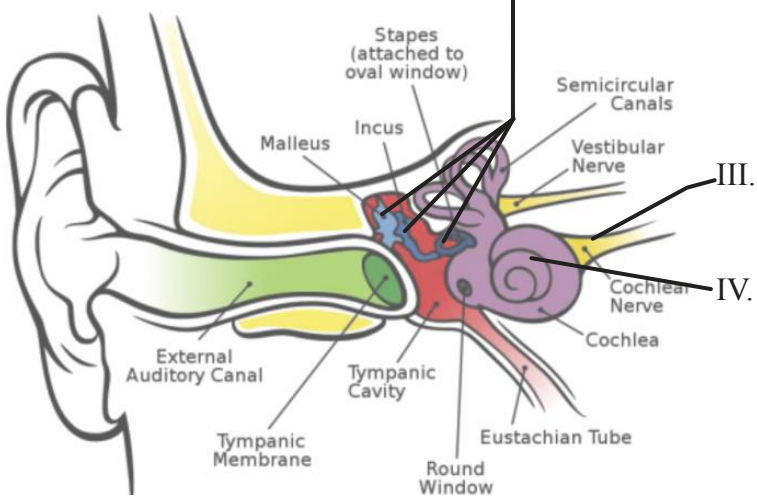
(c) Label the diagram of the ear. *[2]*

I. . . . . II. . . . . .



III. . . . . .

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[Acknowledgment: http://upload.wikimedia.org/wikipedia/commons/d/d2/Anatomy_of_the_Human_Ear.svg]

(This question continues on the following page)

(Question E2 continued)

(d) Explain how the cochlea functions during hearing. *[3]*

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E3. Outline the development of birdsong in young birds. *[3]*

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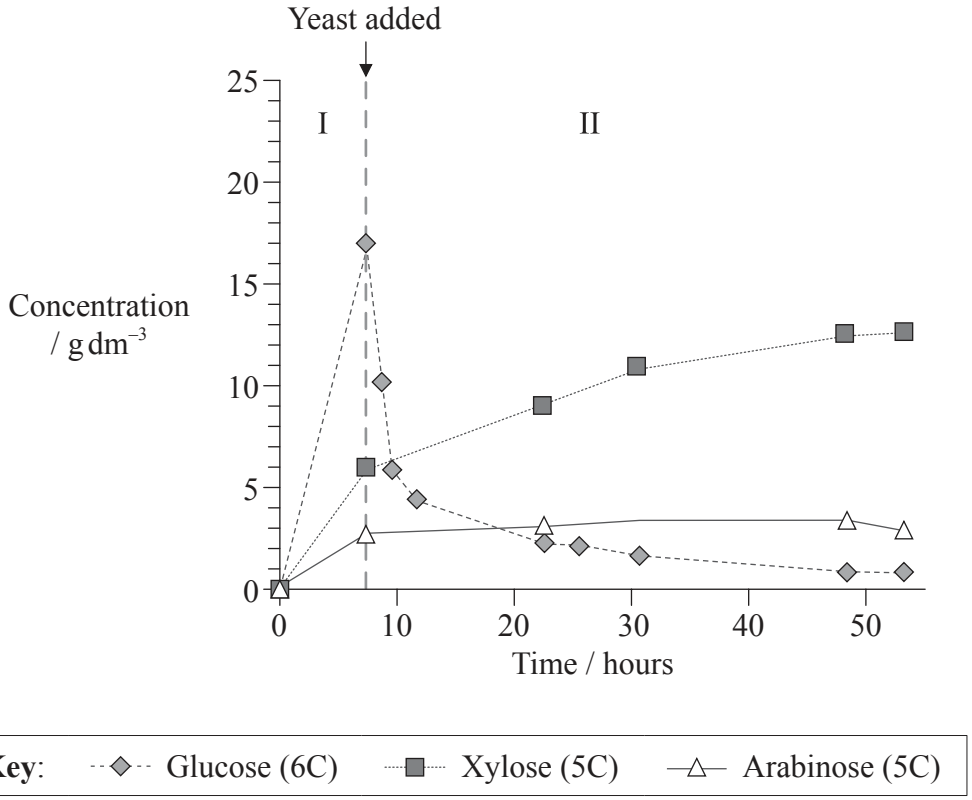
Option F — Microbes and biotechnology

F1. Ethanol is an alternative energy source. Wheat straw can be converted into ethanol in two phases. Hydrolysis of complex polysaccharides in wheat straw (phase I) produces three monosaccharides (glucose, xylose and arabinose). Fermentation by yeast (*Saccharomyces cerevisiae*) then produces ethanol (phase II). The graph shows the changes in concentration of the three monosaccharides in both phases.



[Adapted from: Ronald H.W. Maas, Robert R. Bakker, Arjen R. Boersma, Iemke Bisschops, Jan R. Pels, Ed de Jong, Ruud A. Weusthuis and Hans Reith (2008) 'Pilot-scale conversion of lime-treated wheat straw into bioethanol: quality assessment of bioethanol and valorization of side streams by anaerobic digestion and combustion.' *Biotechnology for Biofuels*, **1**, p. 14, Figure 1 (A). Covered by a Creative Commons licence: http://creativecommons.org/licenses/by/2.0/]

(a) State the maximum concentration of glucose reached during the two phases, giving the units. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(b) Distinguish between the changes in concentration of xylose and arabinose in phase II. *[2]*

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(c) Explain the changes in concentration of glucose and xylose during phase II. *[3]*

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(d) Suggest an advantage of the use of wheat straw as a source of energy. *[1]*

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F2. (a) Explain the reasons for the reclassification of Prokaryotes and Eukaryotes into Eubacteria, Archaea and Eukaryota. *[2]*

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(b) Identify the organisms *Chlorella*, *Euglena*, *Paramecium* and *Saccharomyces* by writing them in the first column of the table in the correct rows. *Amoeba* has been given as an example. *[2]*

Organism	Flagellum	Cilia	Cell wall	Chloroplasts	Pseudopodia
Amoeba					✓
			✓		
			✓	✓	
		✓			
	✓			✓	

(c) (i) State the role of *Rhizobium* in the nitrogen cycle. *[1]*

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(ii) State the role of *Saccharomyces* in the production of wine and beer. *[1]*

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F3. (a) Outline how reverse transcriptase is used in molecular biology. *[2]*

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(b) Explain the principles involved in the generation of methane from biomass. *[3]*

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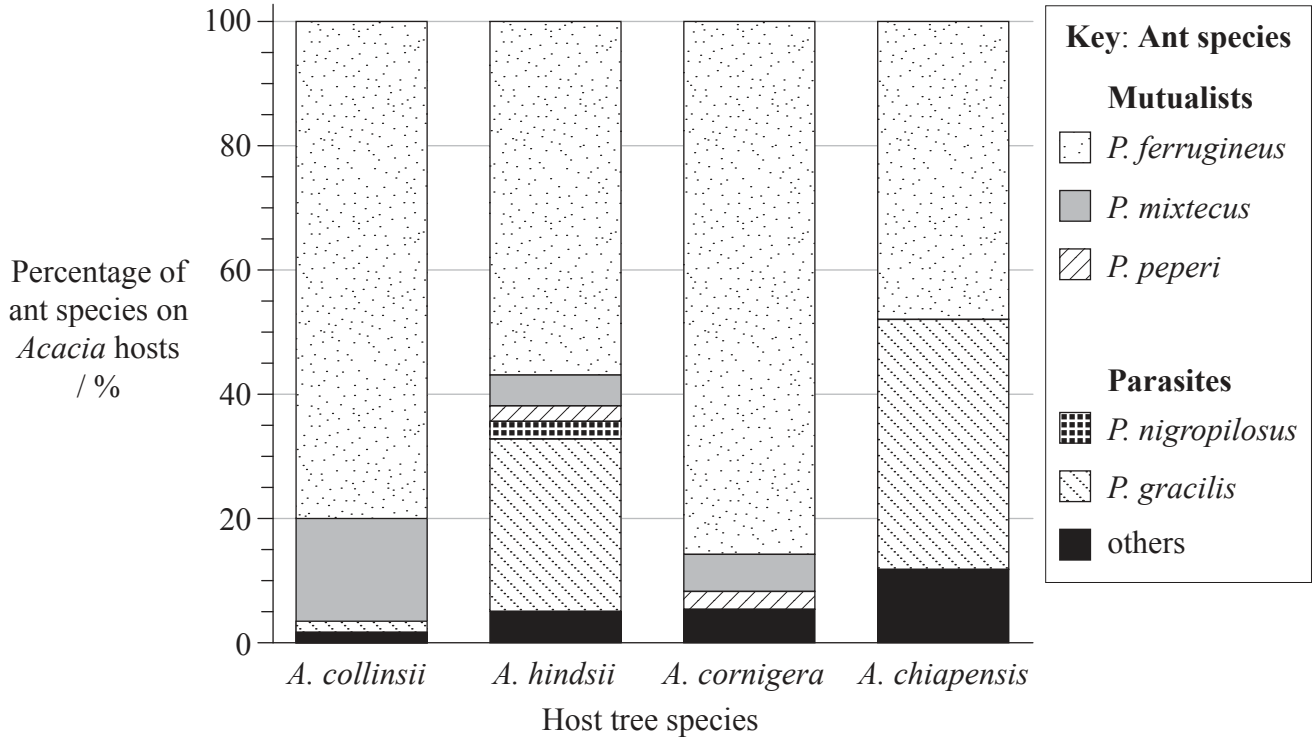
Option G — Ecology and conservation

G1. Mutualisms are interactions between different species that provide benefits for both partners. A study was undertaken of the mutualism between four species of the host tree *Acacia* and six species of the ant *Pseudomyrmex*. Mutualistic ant species were compared to parasitic ant species of the same genus. Both groups of ants live inside the hollow thorns of the *Acacia* and eat the extrafloral nectar produced by the tree. Mutualistic ant species defend the *Acacia* from herbivores, while parasitic ant species do not.



[Source: adapted from: Martin Heil, Marcia González-Teuber, Lars W. Clement, Stefanie Kautz, Manfred Verhaagh and Juan Carlos Silva Buenoa (2009) 'Divergent investment strategies of Acacia myrmecophytes and the coexistence of mutualists and exploiters'. *PNAS*, **106**, pp. 18 091–18 096. Figure 1.]

(a) (i) Identify the species of ant that was most common on **all** four species of *Acacia*. *[1]*

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(ii) Identify the *Acacia* species that had the greatest percentage of parasitic ants on it. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Calculate the percentage of mutualistic species on *A. hindsii*. *[1]*

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(c) Further studies showed the *A. collinsii* and *A. cornigera* have more thorns per centimetre of shoot and produce more extrafloral nectar than the other two species of *Acacia*. Suggest how these adaptations benefit

(i) the mutualistic ants. *[1]*

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(ii) the *Acacia*. *[1]*

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(d) Using the data, deduce the relationships between the mutualistic and parasitic species of *Pseudomyrmex*. *[2]*

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G2. (a) Biotic factors involve the other organisms in the environment of an animal species. List **two** biotic factors that could affect the distribution of an animal species. *[2]*

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2. . . . . .

(b) Research into a river ecosystem produced these approximate values: 25, 300, 6000 and 36 000 $kJ\,m^{-2}\,yr^{-1}$. Using this data, construct a pyramid of energy showing **four named** trophic levels, each with their corresponding energy value. *[2]*

(c) Outline biome and biosphere. *[2]*

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G3. (a) Explain how living organisms can affect the abiotic environment during primary succession. *[3]*

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(b) State **one** example of biological control of an invasive species. *[1]*

Invasive species: . . . . . .
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Biological control: . . . . . .
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(c) Define *biomagnification*. *[1]*

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will not be marked.