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Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 3

Thursday 7 May 2015 (afternoon)

Candidate session number

1 hour

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]**.

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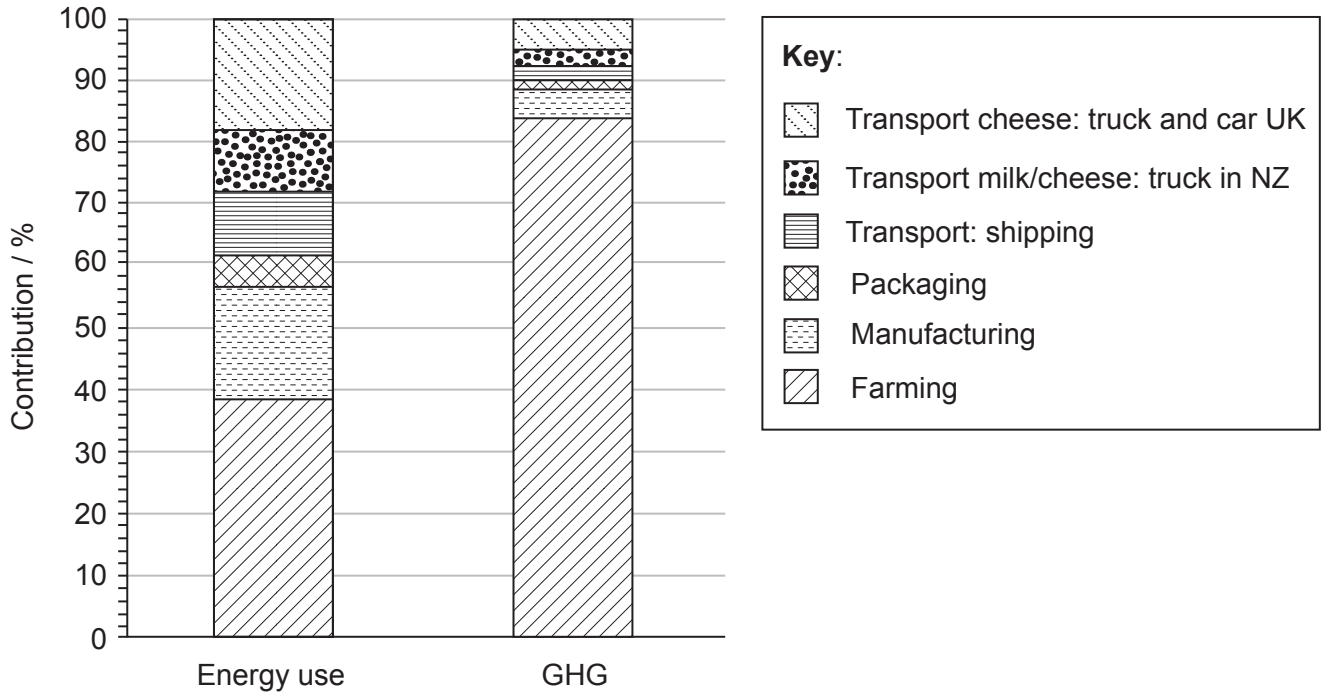
Option A — Human nutrition and health

1. A study was carried out to evaluate the significance of food miles for cheese made from cows' milk produced in New Zealand (NZ) and sold and consumed in the UK. The cheese is transported by ship from New Zealand to the UK, a distance of over 20 000 km. Energy use and greenhouse gas (GHG) emissions were evaluated for each stage of production and transport. The percent contribution of each stage to the total energy use and total GHG emissions are shown below.



[Source: S Ledgard *et al.*, (2007), *Proceedings of the New Zealand Grassland Association,* **69**, pages 223–228. Reprinted with permission]

(a) Identify the stage which contributes most to both energy use and GHG emissions. [1]

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(Option A continues on the following page)

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(Option A, question 1 continued)

(b) Distinguish between the contribution of transport to energy use and GHG emissions in the production of New Zealand cheese. [2]

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(c) Estimate the percentage of energy use and GHG contributed by shipping. [1]

Energy . . . . . % GHG . . . . . %

(d) Using your knowledge of food miles and the information in the data, discuss whether consumers in the UK might choose New Zealand cheese. [3]

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(Option A continued)

2. (a) Water and minerals are essential in the human diet. List **two** other types of nutrient in a human diet. [1]

1: . . . . . .

2: . . . . . .

(b) Outline the benefits of using iodine as a dietary supplement. [2]

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(c) Some ethnic groups rely heavily on fish as their staple energy source. Explain the possible health effects of a protein rich diet of this type. [3]

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(Option A continued)

3. (a) Outline the symptoms of type II diabetes. [2]

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(b) Explain the dietary advice that should be given to a patient who has developed type II diabetes. [3]

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End of Option A

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Option B — Physiology of exercise

4. Erythropoietin (EPO) is a blood protein which regulates red blood cell production in bone marrow and can be used to enhance athletic performance. Measurements of the level of EPO in blood serum are used to detect the misuse of EPO in sport. An investigation was carried out to determine whether training could affect the level of EPO in blood for non-competitive and competitive athletes.

		Competitive athletes		
	Non-competitive athletes	**Swimmers**	**Triathletes**	**Taekwondo athletes**
Mean Age / years	21	18	27	21
Training / mean hours week^{-1}	5	35	16	20
Mean EPO / IU L^{-1}	11.1	15.7	12.6	11.2
EPO standard deviation / IU L^{-1}	4.0	5.2	4.3	3.7

[Source: adapted from A. Abellan, S. Ventura *et al*. (2004) *Recent Advances in Doping Analysis*, **12**, pages 453–457. SPORTVERLAG Strauß. Used with permission.]

(a) Determine the range of EPO values within one standard deviation of the mean for the non-competitive athletes. [1]

From . . . . . IU L^{-1} to . . . . . IU L^{-1}

(b) Compare the mean blood EPO values for non-competitive and competitive athletes. [2]

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(Option B continues on the following page)

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(Option B, question 4 continued)

(c) Evaluate the evidence that training increases blood EPO levels. [3]

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(d) Discuss the use of EPO to improve athletic performance by competitive athletes. [2]

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(Option B continues on the following page)

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(Option B continued)

5. (a) Outline the relationship between VO_2 and the proportion of carbohydrate and fat used in respiration. [2]

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(b) Describe the effects of training on the pulmonary system. [2]

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(Option B continued)

6. (a) State the names and functions of the antagonistic muscles of the human elbow joint. [2]

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(b) Outline how ATP is produced by muscle fibres during intense exercise. [2]

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(c) Explain the role of ATP in muscle contraction. [2]

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End of Option B

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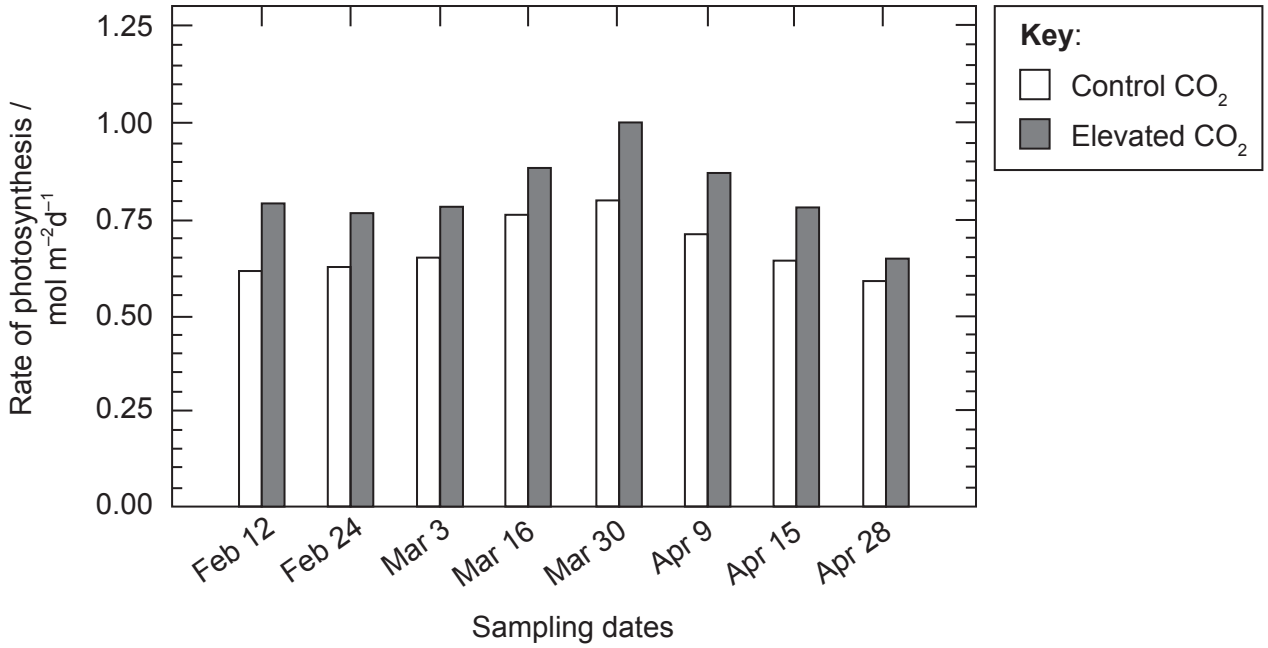
Option C — Cells and energy

7. In a study carried out at the University of Arizona, the effects of increased CO_2 concentration on the rate of photosynthesis in spring wheat, *Triticum aestivum*, were investigated over the course of an entire growing season (from the beginning of February to the end of April). The rate of photosynthesis was measured as the rate of CO_2 uptake from the time of emergence from the seed to maturity. The control plants were grown at a normal air CO_2 concentration while the test plants were grown at an elevated CO_2 concentration.



[Source: R. L. Garcia, S. P. Long, G. W. Wall, C. P. Osborne, B. A. Kimball, G. Y. Nie, P. J. Pinter, R. L. Lamorte and F. Wechsung (1998) 'Photosynthesis and conductance of spring-wheat leaves: field response to continuous free-air atmospheric CO2 enrichment.' *Plant, Cell and Environment*, **21**, pages 659–669.
© Blackwell Science 1998. Used with permission from Wiley.]

(a) Describe the pattern of CO_2 uptake in the control plants. [2]

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(Option C continues on the following page)

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(Option C, question 7 continued)

(b) Outline the effect of increased carbon dioxide concentration on CO_2 uptake. [2]

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(c) Discuss how CO_2 uptake in this investigation may be affected by other limiting factors. [3]

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(Option C continued)

8. (a) Draw a labelled diagram of the structure of a mitochondrion as seen under the electron microscope. [2]

(b) Explain how the structure of a mitochondrion is related to its function. [3]

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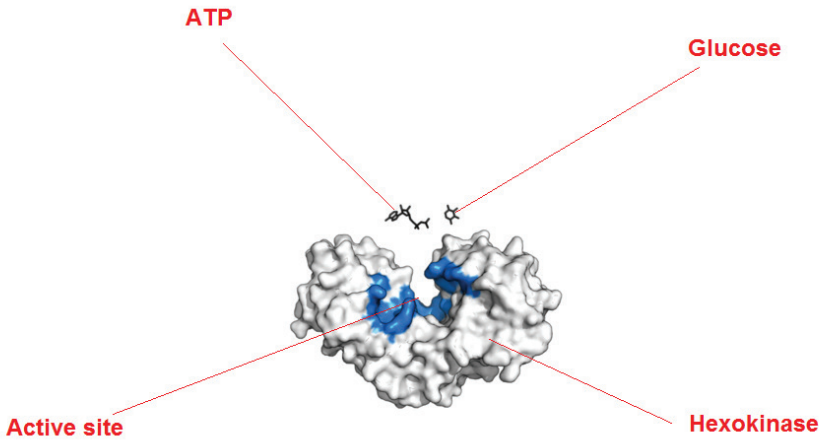
(Option C continued)

9. The enzyme hexokinase catalyses the reaction between glucose and ATP to form Glucose –6– phosphate and ADP.



[Source: https://upload.wikimedia.org/wikipedia/commons/thumb/d/d1/Hexokinase_induced_fit.png/400px-Hexokinase_induced_fit.png]

(a) Hexokinase functions according to the induced fit model. Using this example, describe the induced fit model. [3]

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(Option C, question 9 continued)

(b) The activity of hexokinase is regulated by end product inhibition. Explain how a reaction can be controlled by end product inhibition. [3]

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End of Option C

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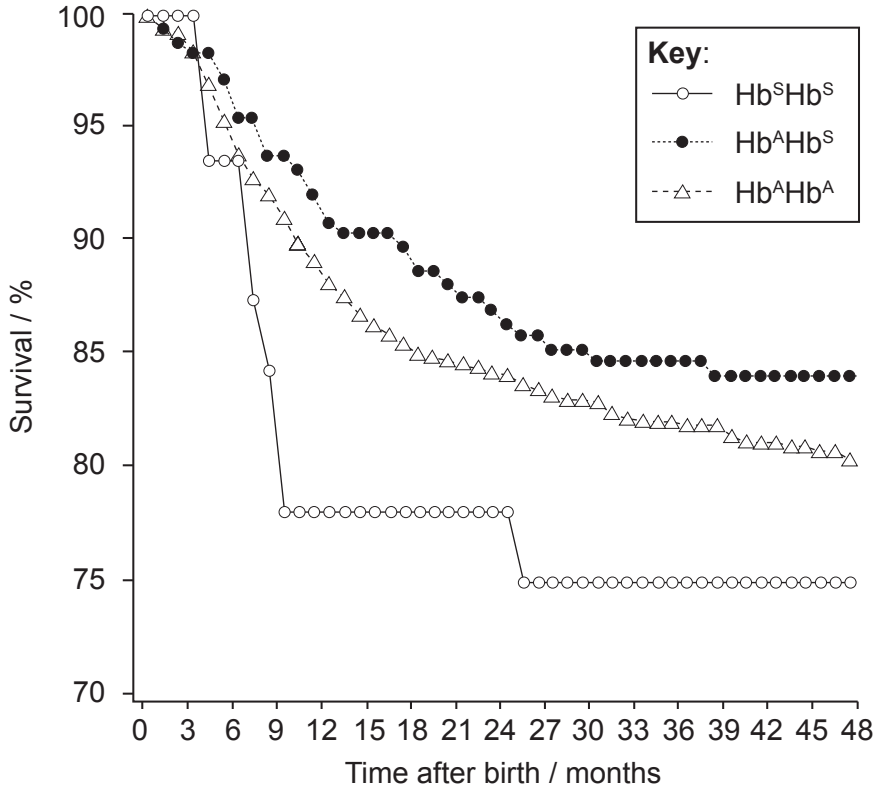
Option D — Evolution

10. The sickle-cell hemoglobin allele (Hb^S) has a high frequency in regions where there is malaria. This is believed to be due to a selective advantage against fatal malaria for the heterozygote (Hb^AHb^S). Individuals who are homozygous for the sickle cell allele (Hb^SHb^S) have sickle cell anemia while heterozygotes have a much less severe form of the disease. Normal individuals without sickle cell anemia are designated Hb^AHb^A.

This study involved 1022 children living in an area of Kenya where malaria is present. The possible protective effect of the sickle cell allele against mortality due to malaria was investigated. The data show the percentage of children surviving after birth over a period of 48 months.



[Source: Reprinted from THE LANCET Vol. 359 No. 9314, Michael Aidoo, Dianne J. Terlouw, Margarette S. Kolczak, Peter D. McElroy, Feiko O. ter Kuile, Simon Kariuki, Bernard L. Nahlen, Altaf A. Lal, Venkatachalam Udhayakumar, "Protective effects of the sickle cell gene against malaria morbidity and mortality", pp. 1311–1312, copyright 2002, with permission from Elsevier.]

(a) Identify the genotype with the highest percentage survival at 3 months and 15 months. [1]

3 months: . . . . . .

15 months: . . . . . .

(Option D continues on the following page)

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(Option D, question 10 continued)

(b) Outline the pattern of survival for individuals homozygous for the sickle cell allele (Hb^SHb^S). [2]

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(c) Compare the patterns of survival for the Hb^AHb^S and Hb^AHb^A genotypes. [2]

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(d) Discuss the evidence from these data for the protective effect of the sickle cell allele. [2]

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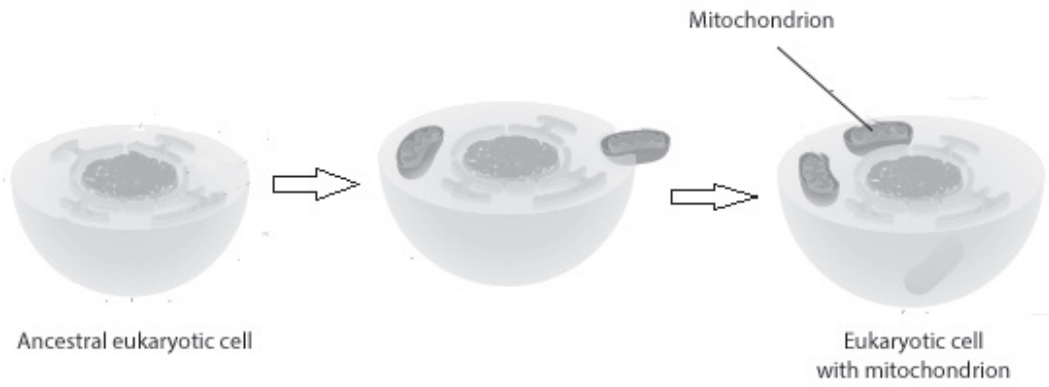
(Option D continued)

11. The diagram shows some of the later stages in the origin of eukaryotic cells according to the endosymbiotic theory.



[Source: "Serial endosymbiosis" by Kelvinsong - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Serial_endosymbiosis.svg#/media/File:Serial_endosymbiosis.svg]

(a) Discuss the endosymbiotic theory including the evidence for the process shown in the diagram. [3]

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(b) Ancestral eukaryotic cells may have been preceded by protobionts. State **one** feature of a protobiont. [1]

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(Option D, question 11 continued)

(c) Outline the contribution of prokaryotes to an oxygen rich atmosphere. [2]

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12. (a) Outline the process of adaptive radiation. [2]

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(b) Discuss the correlation between brain size and diet in human evolution. [3]

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End of Option D

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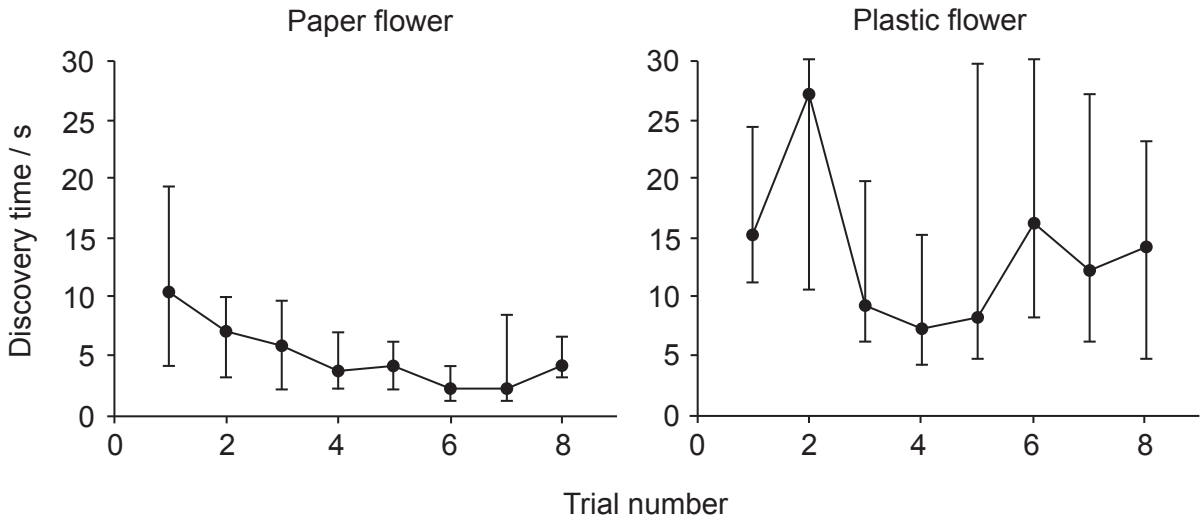
Option E — Neurobiology and behaviour

13. Moths use a variety of sensory processes (including vision, smell and mechanoreception) to locate nectar on flowers. The ability of the nocturnal tobacco hornworm moth, *Manduca sexta*, to find nectar using mechanoreceptors was investigated using artifical flowers. Three-day-old moths that had no experience of natural flowers were used in the investigation. The artificial flowers had nectar placed at the centre and were made of either paper (with a rough surface to stimulate mechanoreception) or plastic (to reduce mechanoreception). The time taken for moths to discover the nectar (discovery time) over a series of eight trials is shown for the artificial flower types. Vertical bars show the variation in the data.



[Source: Joaquín Goyret and Robert A. Raguso, "The role of mechanosensory input in flower handling efficiency and learning by Manduca sexta". *J Exp Biol* 2006 **209**:1585–1593. doi:10.1242/jeb.02169
Reproduced with permission from *The Journal of Experimental Biology*: jeb.biologists.org]

(a) Identify the trial for each flower type that shows the greatest variation. [1]

Paper: . . . . . .

Plastic: . . . . . .

(b) Compare the data for plastic and paper flowers. [2]

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(Option E continues on the following page)

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(Option E, question 13 continued)

(c) Outline the evidence from the data that the ability to find nectar using mechanoreceptors is a learned behaviour. [2]

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(d) Discuss how learning to find nectar using mechanoreceptors could lead to improved chances of survival and reproduction for the tobacco hornworm moth. [2]

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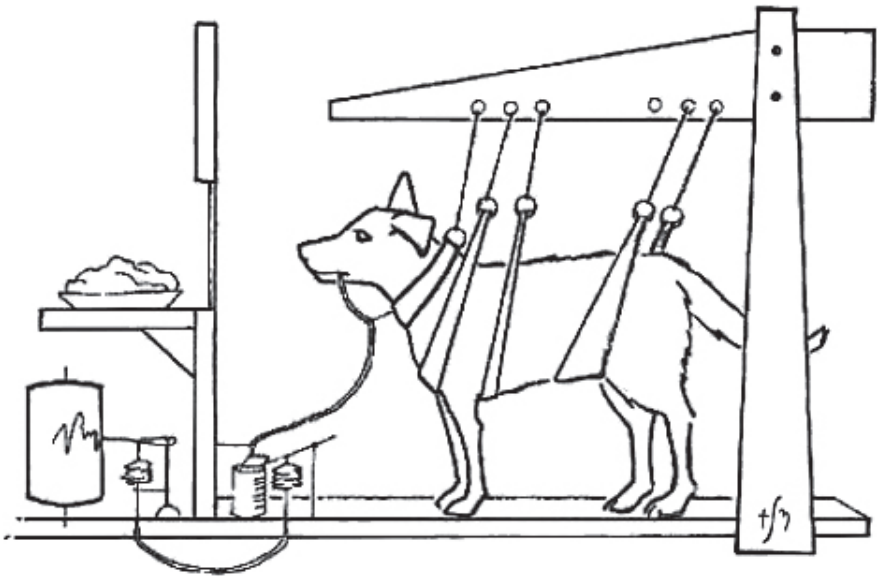
(Option E continued)



[Source: http://animalbehaviour.net/ClassicalConditioning.htm]

14. (a) The diagram above shows the set up similar to that used in Pavlov's experiments on conditioning in dogs. Describe Pavlov's experiments on conditioning in dogs. [3]

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(b) Salivation is normally a simple reflex. Explain the role of sensory, relay and motor neurons in a simple reflex. [2]

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(Option E continued)

15. (a) List **two** examples of excitatory psychoactive drugs. [1]

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(b) Outline the possible effects of excitatory drugs on mood and behaviour. [2]

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(c) Discuss the causes of addiction to cocaine. [3]

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End of Option E

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Option F — Microbes and biotechnology

16. Poultry, cattle and pig farming all produce large amounts of manure. Generating biogas (mainly methane) from this waste is an important way of increasing energy efficiency and reducing pollution from these farms. Separate samples of manure from cattle, poultry and pigs were mixed with water using manure : water ratios of 1:1, 2:1 and 3:1 by mass. The mixtures were stirred and digested for thirty days. The biogas yield per kg of manure for each mixing ratio was measured.

Graph removed for copyright reasons
Please go to this link: http://www.m.elewa.org/JABS/2009/22/22-0ctober-2009.html

(a) Identify the manure type and mixing ratio which produces the highest yield of biogas. [1]

Manure type: . . . . . .

Mixing ratio: . . . . . .

(Option F continues on the following page)

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(Option F, question 16 continued)

(b) Compare the effect of changing the mixing ratio on the yield of biogas from each of the three types of manure. [3]

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(c) Suggest **one** reason for the difference in biogas yield between poultry and cattle manure. [1]

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(d) Biogas is a mixture of combustible gases including methane (CH_4) and hydrogen (H_2). Using the data and your knowledge, outline the conditions needed for the efficient production of biogas from manure. [2]

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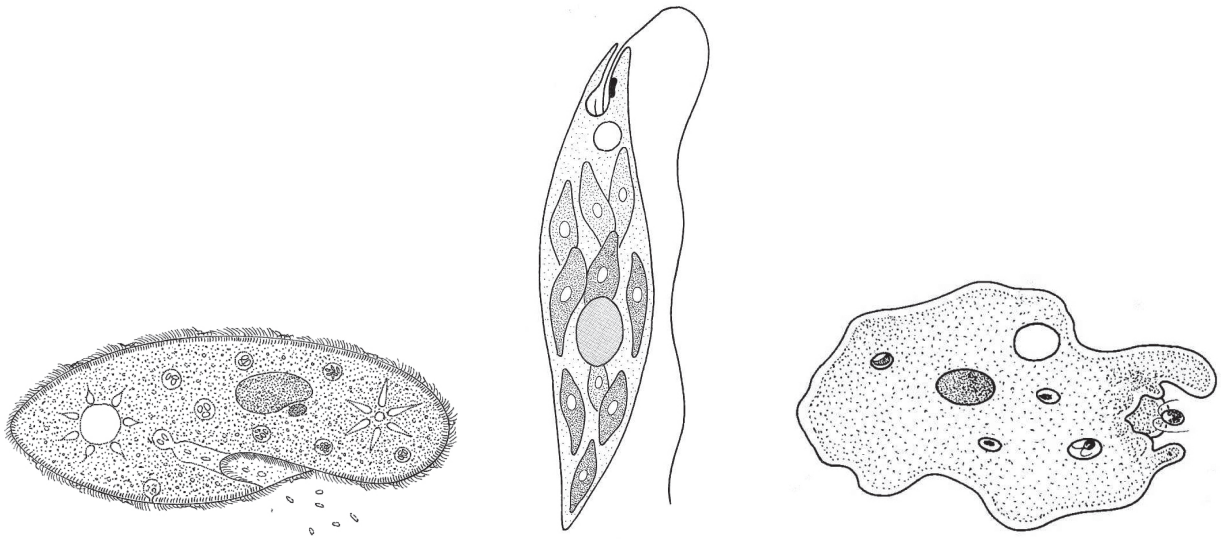
(Option F continued)

17. The images below show three microscopic eukaryotes.



Paramecium *Euglena* *Amoeba*

[Source: http://www.biology-resources.com/ © D. G. Mackean]

(a) Identify the eukaryote which uses cilia for locomotion. [1]

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(b) Outline the diversity of modes of nutrition in these three eukaryotes. [2]

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(Option F, question 17 continued)

(c) *Saccharomyces* is a microscopic eukaryote. Explain the use of *Saccharomyces* in beer production. [3]

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(Option F continued)

18. (a) Reverse transcriptase is an important enzyme in biotechnology. State the function of reverse transcriptase. [1]

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(b) Explain how reverse transcriptase is used in molecular biology. [3]

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(c) Identify **one** risk associated with gene therapy. [1]

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End of Option F

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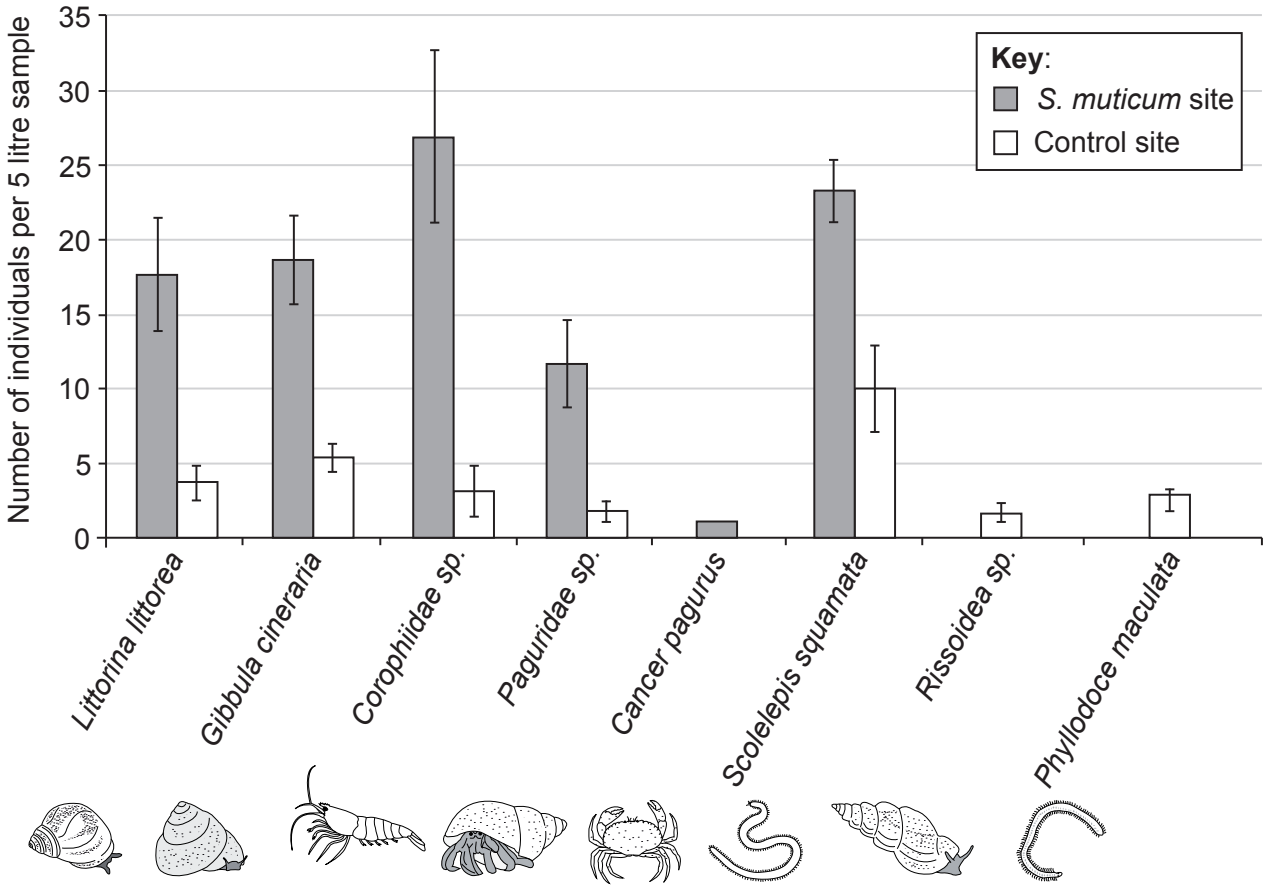
Option G — Ecology and conservation

19. The brown alga *Sargassum muticum* is a successful invasive species around the world. It grows attached to rocks in the intertidal zone and has large fronds that float in the water. It has recently become established in intertidal communities on the west coast of Scotland. The impact of this invasive species was investigated by measuring the composition of the animal community in the intertidal zone in an affected area. The data were compared to a control site with no invasive *S. muticum* which was located close by.



[Source: D. Harries, S. Harrow *et al*. (2007) *Journal of the Marine Biological Association*, **87**, pages 1057–1067, Figure 2. "The establishment of the invasive alga *Sargassum muticum* on the west coast of Scotland: a preliminary assessment of community effects", reproduced with permission.]

(a) Identify the most abundant animal type at [1]

the *S. muticum* site: . . . . . .

the control site: . . . . . .

(Option G continues on the following page)

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(Option G, question 19 continued)

(b) Describe the impact of invasive *S. muticum* on the shoreline animal community. [3]

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(c) Discuss possible reasons for the differences in the animal communities seen at the two sites. [3]

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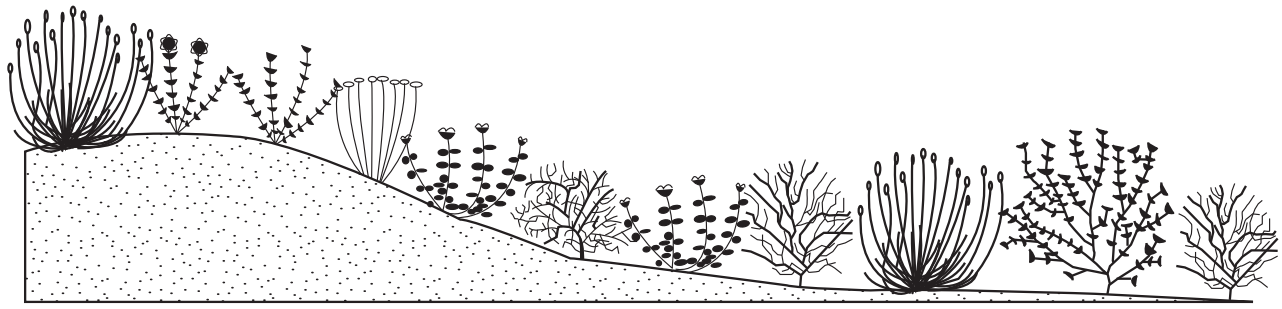
(Option G continued)

20. The diagram below shows changing vegetation along a slope in a terrestrial ecosystem.



[Source: © International Baccalaureate Organization 2015]

(a) Describe how a transect can be used to investigate the distribution of plant species in this ecosystem. [2]

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(b) The vegetation shown here has developed as a result of primary succession. Outline the changes that take place in the abiotic environment during primary succession. [2]

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(Option G, question 20 continued)

(c) Outline the abiotic factors that affect the distribution of plant species in an ecosystem. [2]

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21. (a) Explain the causes and consequences of biomagnification of a named chemical. [3]

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(b) Explain the concept of niche. [2]

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End of Option G

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