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BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate session number

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Thursday 17 November 2011 (morning)

1 hour

Examination code

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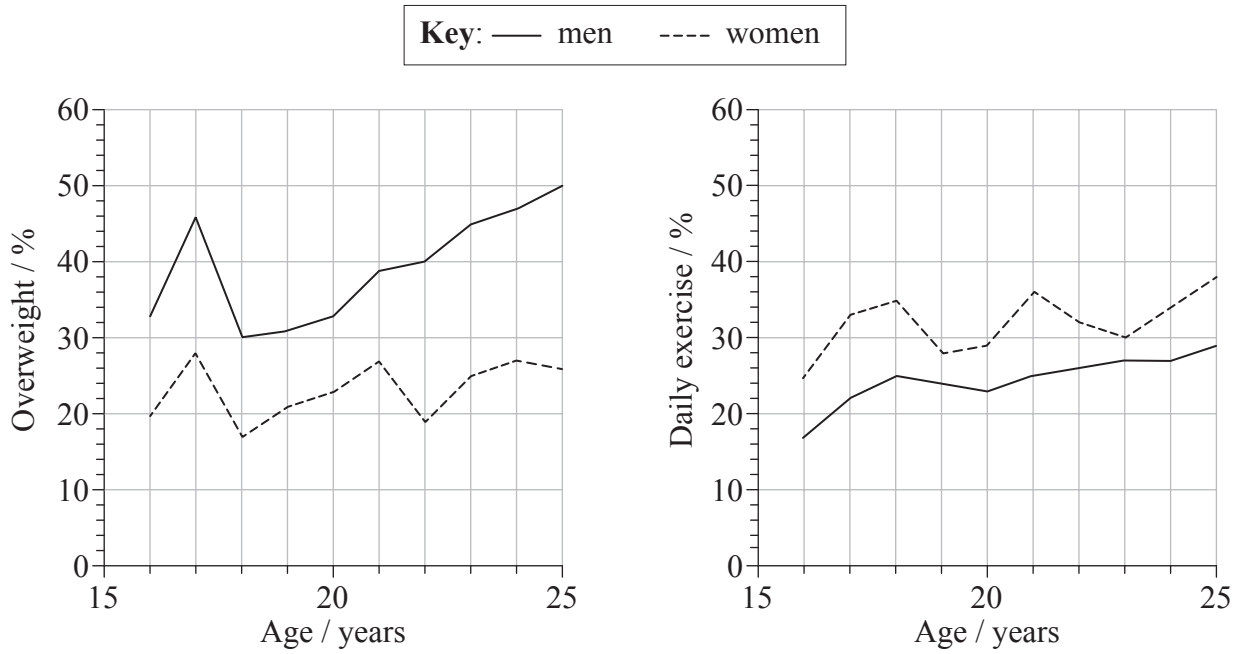
INSTRUCTIONS TO CANDIDATES

- 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.

Option A — Human nutrition and health

A1. Within a cross-sectional study "Fit for Life" in Germany, the body mass index (BMI) of volunteers aged between 16 and 25 years was investigated. Volunteers were also interviewed about their daily exercise habits. The graphs below show the percentage of men and women who were overweight, and the percentage who exercised daily.



[Source: adapted from D Leyk, *et al.*, (2008), *Deutsches Ärzteblatt International*, **105**(46), pages 793–800]

(a) Measure the difference between the percentage of overweight men and the percentage of overweight women at age 20. *[1]*

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(b) State the range of the body mass index (BMI) that corresponds to overweight status. *[1]*

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(This question continues on the following page)

(Question A1 continued)

(c) Compare the percentage of men and women who exercised daily. *[2]*

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(d) Evaluate the hypothesis that being overweight is due to lack of exercise. *[3]*

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A2. The following nutrients are listed on a packet of dry roasted peanuts.

Per 25 g serving (approximately 28 peanuts)	
Carbohydrates:	4.6 g
Fibre:	2.4 g
Protein:	7.3 g
Saturated fat:	1.9 g
Monounsaturated fat:	6.9 g
Polyunsaturated fat:	4.4 g

(a) (i) State which listed nutrient does not supply energy. *[1]*

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(ii) Deduce, with a reason, which listed nutrient provides the most energy per 25 g serving. *[2]*

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(b) Outline the differences in molecular structure between the types of fat found in the peanuts. *[3]*

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A3. (a) Outline the main dietary sources of energy in **two** different ethnic groups. *[2]*

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(b) Explain the benefits of supplementing common foods with vitamins and minerals. *[3]*

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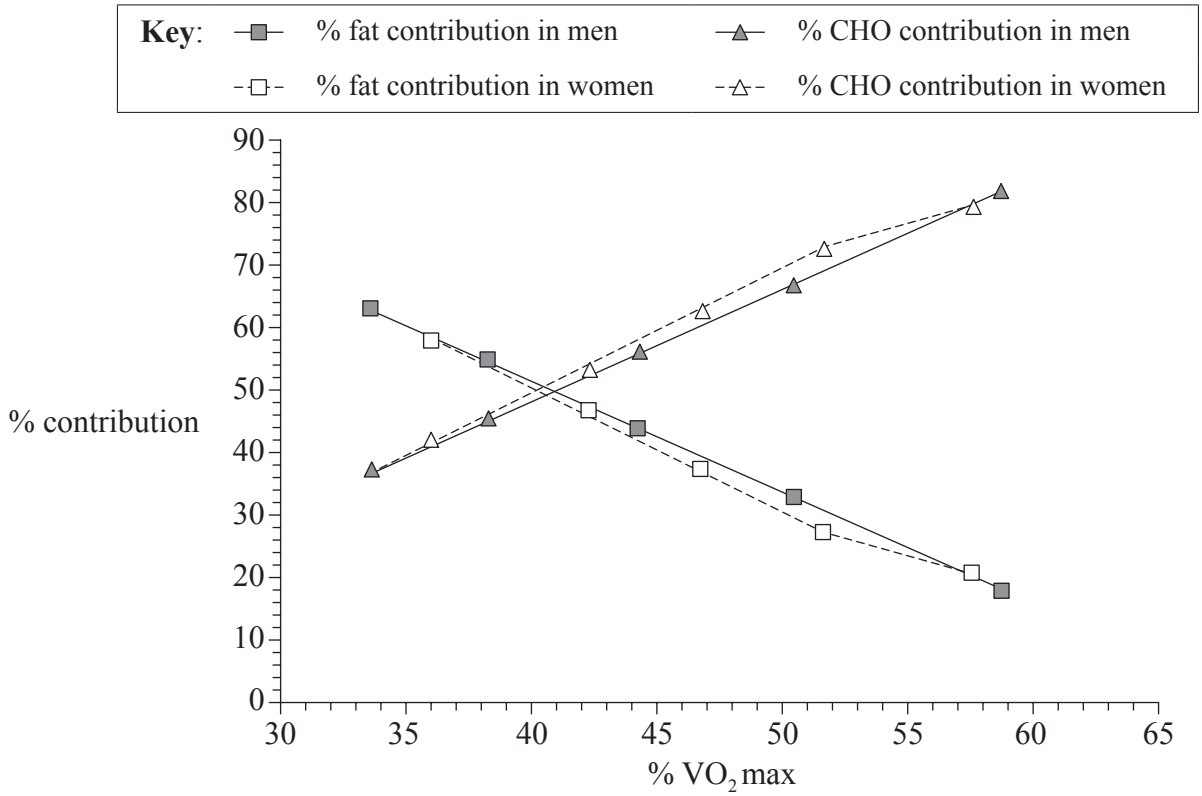
Option B — Physiology of exercise

B1. A treadmill test was taken by 46 men and women who were inactive and overweight. During the test, the percentage of fat and carbohydrate (CHO) used for energy was measured at increasing levels of exercise intensity. The intensity of exercise was assessed by measuring VO_2 and showing it as a percentage of VO_2 max.



Reprinted from *JSSM*, 7, Bogdanis, Vangelakoudi and Maridaki "Peak fat oxidation rate during walking in sedentary overweight men and women." pp. 525–531. Copyright (2008), Figure 3. With permission from the JOURNAL OF SPORTS SCIENCE AND MEDICINE.

(a) Define *VO_2 max*. *[1]*

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(This question continues on the following page)

(Question B1 continued)

(b) State the percentage contribution of the different sources of energy at 36% VO_2 max in women. *[1]*

Fat: . . . . . .

CHO: . . . . . .

(c) Using the data in the graph, describe the relationship between the intensity of exercise and the source of energy. *[3]*

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(d) Fat can only be used in aerobic respiration. Suggest reasons for the change in the percentage contribution of fats to energy supply during exercise as the intensity of exercise increases. *[2]*

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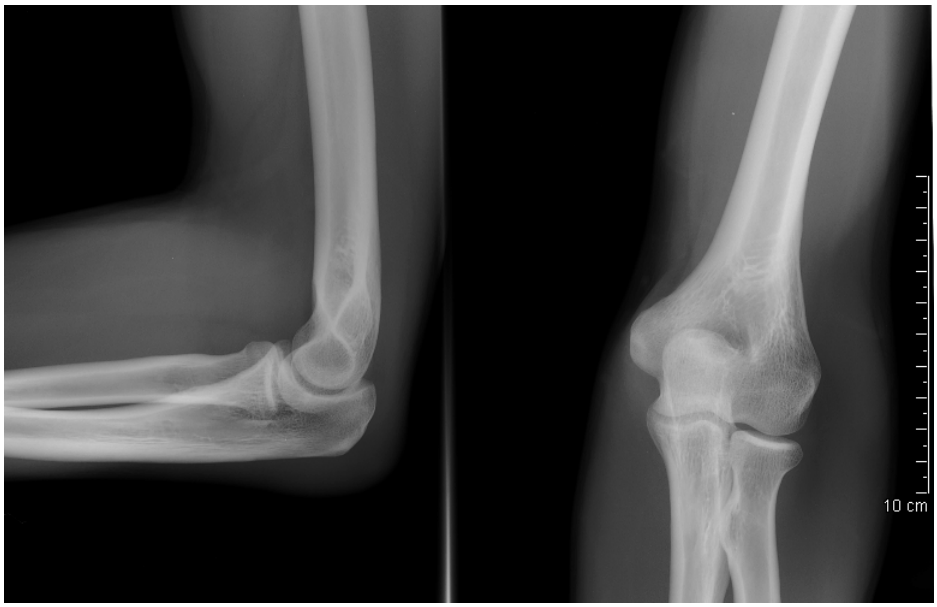
B2. (a) The X-ray below shows the human elbow joint. Label I and II. *[1]*



[Source: http://en.wikipedia.org/wiki/File:Coude_fp.PNG]

(b) Describe a sprain injury. *[2]*

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(c) Compare the movements of the hip joint and the knee joint. *[2]*

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B3. (a) Define *fitness*. *[1]*

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(b) Explain the need for changes in tidal volume and ventilation rate during exercise. *[2]*

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(c) Evaluate the use of erythropoietin to improve performance in sports. *[3]*

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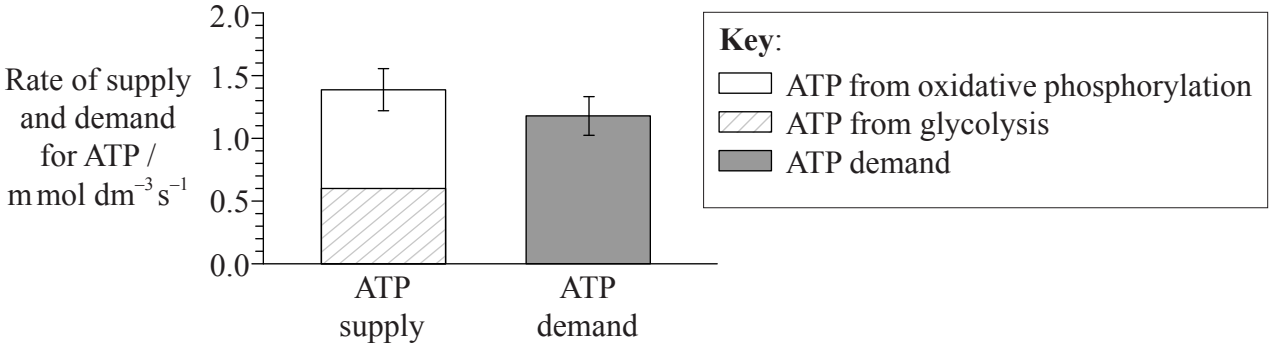
Option C — Cells and energy

C1. The table below shows the results of continuous stimulation of the tailshaker muscle of eight western diamond rattlesnakes (*Crotalus atrox*).

	O_2 content in arteries / m mol dm^{-3}	Lactate content in arteries / m mol dm^{-3}
At rest	2.4 ± 0.5	2.8 ± 1.2
Rattling	2.8 ± 0.1	4.8 ± 0.8

The graph below shows ATP demand and sources of ATP supply in the tailshaker muscle. Contraction of the tailshaker muscle causes a rattling sound.



Adapted from W. F. Kemper *et al*. "Shaking up glycolysis: sustained, high lactate flux during aerobic rattling". *PNAS*, 98 (2), pp. 723–728. Copyright 2001, National Academy of Sciences, USA.

(a) Using the graph, measure the amount of ATP produced by oxidative phosphorylation, giving the units. *[1]*

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(b) Compare the changes in oxygen and lactate content in the blood when a resting rattlesnake starts rattling. *[2]*

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(Question C1 continued)

(c) Using the data, deduce, with reasons, whether anaerobic respiration provides some or all of the ATP used in rattling. *[3]*

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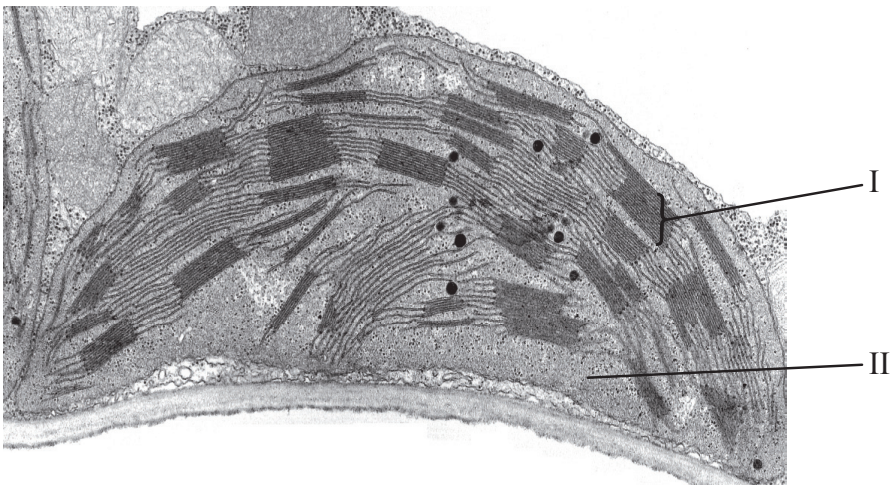
C2. The following is an electron micrograph of a chloroplast.



[Source: http://botit.botany.wisc.edu/images/130/Photosynthesis/Chloroplast_EN.html, used with permission.]

(a) Label I and II. *[1]*

I. . . . . .

II. . . . . .

(This question continues on the following page)

(Question C2 continued)

(b) Explain the relationship between chloroplast structure and its function. *[3]*

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(c) Distinguish between oxidation and reduction. *[2]*

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C3. (a) State the names of **two** examples of fibrous proteins. *[1]*

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(b) Describe the induced-fit model of enzyme activity. *[2]*

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(c) Explain the control of metabolic pathways by end-product inhibition. *[3]*

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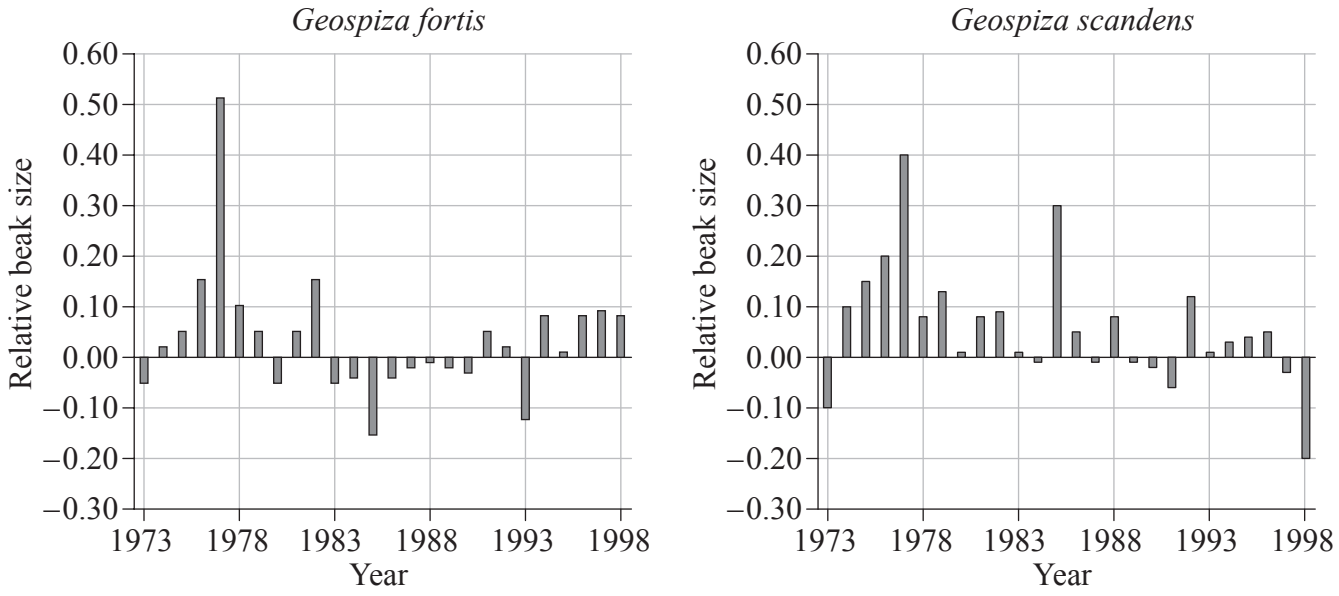
Option D — Evolution

D1. A study of two populations of Darwin's finches, medium ground finch (*Geospiza fortis*) and cactus finch (*Geospiza scandens*), was undertaken between 1973 and 1998 on the Galápagos Islands. The graphs below show the mean beak size in each year from 1973 to 1998 compared with the long-term mean size.



Peter R Grant and Rosemary B Grant, "Unpredictable Evolution in a 30-Year Study of Darwin's Finches", *Science*, Vol. 296 no. 5568, pp. 707–711, 26 April 2002. Reprinted with permission from AAAS.

(a) State the year in which *G. fortis* had the greatest change in relative beak size. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) Compare the trends in relative beak size of *G. fortis* and *G. scandens*. *[3]*

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(c) Outline possible reasons for the trends in relative beak size in finches. *[2]*

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D2. (a) Organic compounds must have been present at the origin of life, but these compounds could not have been synthesized by living organisms. State **two** types of environment where organic compounds might have been synthesized before the first living organisms existed. *[2]*

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(b) Outline how an oxygen-rich atmosphere developed on Earth. *[2]*

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(c) Discuss gradualism and punctuated equilibrium as ideas about the pace of evolution. *[4]*

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D3. (a) Define the term *allele frequency*. *[1]*

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(b) Compare genetic and cultural evolution in humans. *[3]*

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Option E — Neurobiology and behaviour

E1. Many marine invertebrates must swim or move in currents until they find a suitable habitat in which to settle. A laboratory experiment was conducted to determine the swimming response of blue crab (*Callinectes sapidus*) larvae to water flowing at different velocities in a sea water column. The graphs below show the results for water flow velocity at $0\,cm\,s^{-1}$, $3.6\,cm\,s^{-1}$ and $6.3\,cm\,s^{-1}$. Positive values indicate movement in the direction of the current and negative values indicate movement against the current.

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(This question continues on the following page)

(Question E1 continued)

(a) State the maximum net swimming velocity observed, giving the units. *[1]*

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(b) Calculate the percentage of *C. sapidus* larvae that swam against the current when the water flow velocity was $3.6\,cm\,s^{-1}$. *[1]*

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(c) Compare the swimming of the *C. sapidus* larvae at the different water flow velocities. *[2]*

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(d) The hypothesis was made that *C. sapidus* larvae are able to actively move in any direction to find suitable sites in which to settle. Analyse the data to determine if it supports this hypothesis. *[2]*

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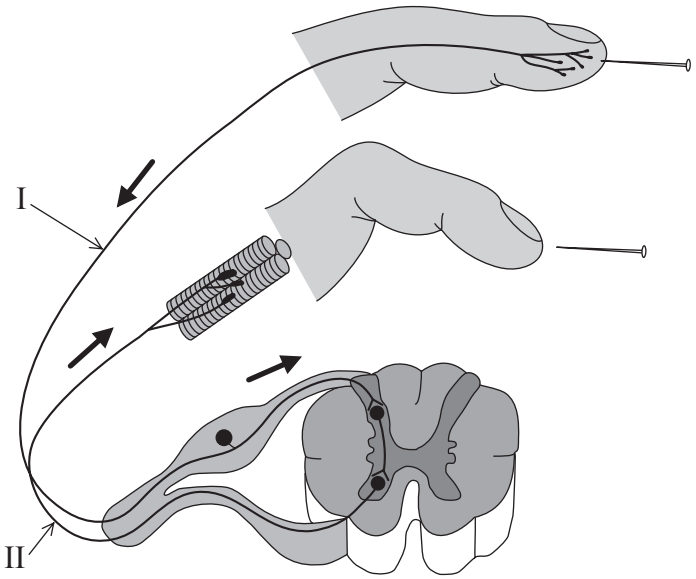
E2. The diagram below shows a reflex arc.



[Source: adapted from www.sciencegeek.net/Biology/review/graphics/Unit8/ReflexArc.jpg]

(a) Label I and II. *[1]*

I. . . . . .

II. . . . . .

(b) Outline how stimuli can be detected by human sensory receptors. *[2]*

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(This question continues on the following page)

(Question E2 continued)

(c) Explain how sound is perceived by the ear. *[4]*

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E3. (a) Distinguish between innate and learned behaviour. *[1]*

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(b) Outline the role of inheritance and learning in the development of birdsong in young birds. *[2]*

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(c) Explain the effects of cocaine on mood and behaviour. *[2]*

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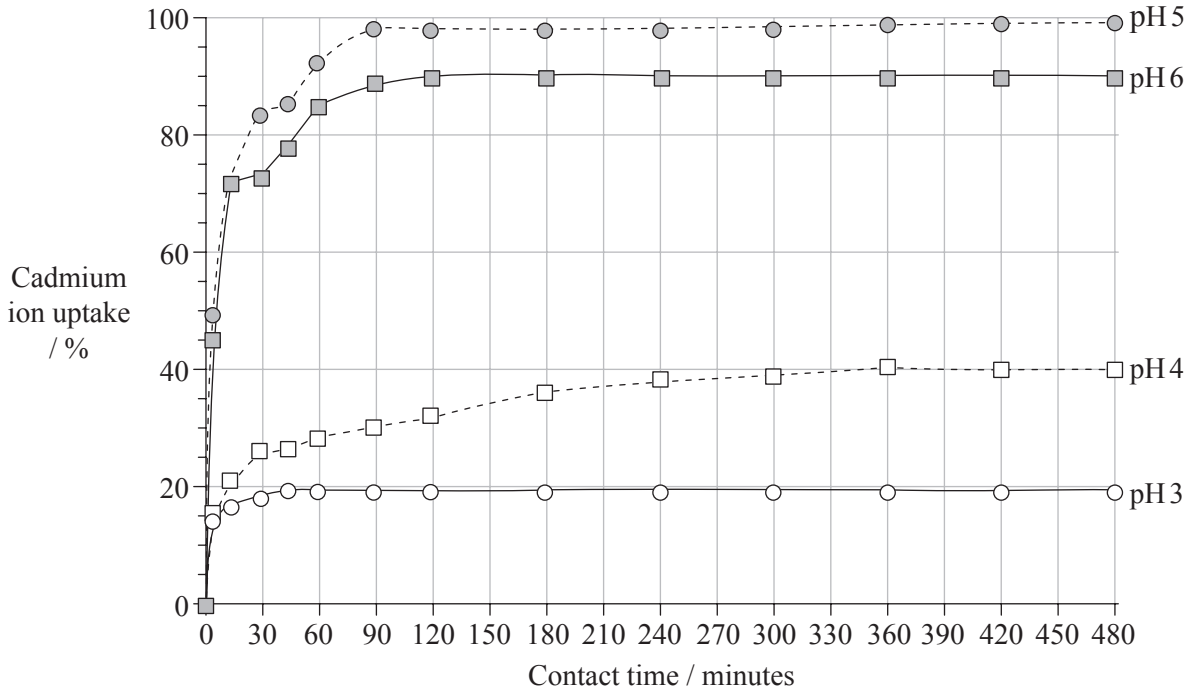
Option F — Microbes and biotechnology

F1. Removal of toxic heavy metals from industrial waste water is essential in order to control environmental pollution. Industrial waste water near Yanbu City, Saudi Arabia was found to contain 19 species of microorganisms that could tolerate heavy metals. The accumulation of cadmium ions in the most common of these microorganisms, *Aspergillus fumigatus*, was investigated.

The graph below shows the effect of pH on the ability of *A. fumigatus* to absorb cadmium ions from an aqueous solution.



[Source: adapted from S Al-Garni, *et al*., (2009), *African Journal of Biotechnology*, **8** (17), pages 4163–4172]

(a) Describe the cadmium ion uptake by *A. fumigatus* at pH 6. *[2]*

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(This question continues on the following page)

(Question F1 continued)

(b) Calculate the difference in cadmium ion uptake between pH 4 and pH 5 at 60 minutes. *[1]*

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(c) Discuss the use of *A. fumigatus* for the removal of cadmium ions in polluted waters. *[2]*

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(d) The investigation found that both living and dead *A. fumigatus* cells were able to absorb cadmium ions. Suggest an advantage of using dead *A. fumigatus* cells. *[1]*

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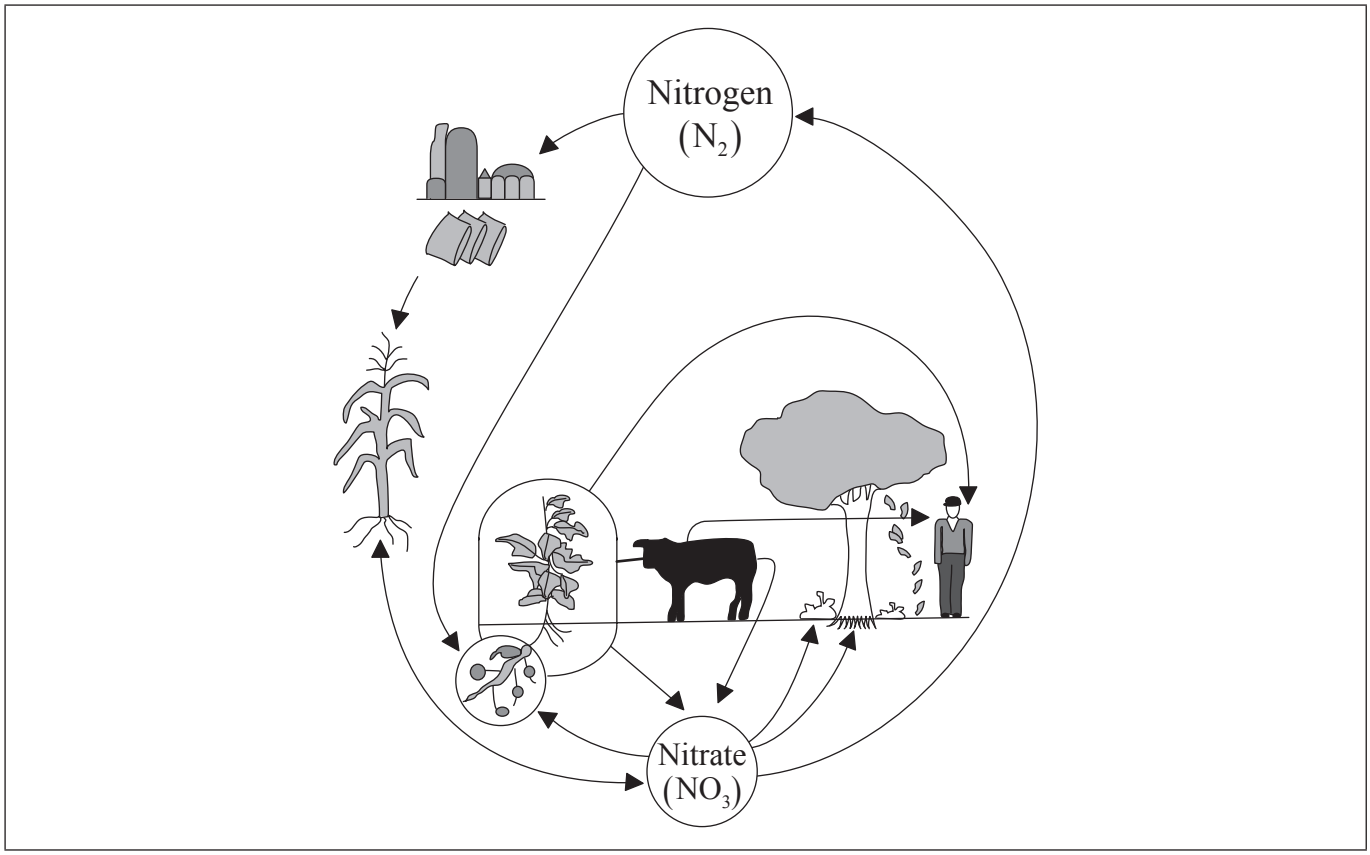
F2. The diagram below shows the nitrogen cycle.



[Source: adapted from http://bldg6.arsusda.gov/images/Ncycle.jpg]

(a) Using the letter X, label where the process of denitrification occurs in the nitrogen cycle. *[1]*

(b) Using the table below, state the habitats of the following members of the Archaea. *[3]*

	Habitat
Methanogens	
Thermophiles	
Halophiles	

(This question continues on the following page)

(Question F2 continued)

(c) Explain the use of high sugar concentrations in food preservation. *[2]*

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F3. (a) Distinguish between somatic and germ line therapy. *[1]*

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(b) Outline the use of viral vectors in gene therapy. *[2]*

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(c) Explain how reverse transcriptase is used in molecular biology to produce DNA from RNA. *[3]*

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Option G — Ecology and conservation

G1. The impact on ecosystems of the loss of large herbivore species was studied by looking at plant communities in two similar grassland ecosystems in South Africa (Kruger National Park) and North America (Konza, Kansas). Some sites had large herbivore species present and at other sites they were absent. The main herbivores were Cape buffalo (*Syncerus caffer*) in South Africa and bison (*Bos bison*) in North America. The herbaceous plants identified were grouped as either grass or non-grass.

The table shows plant abundance and diversity in Kruger National Park and Konza, Kansas.

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(a) At Konza, grass abundance was 4.4 units greater in areas where there was a single large herbivore species than in areas where there was no large herbivore species.

(i) Calculate the difference in non-grass abundance between areas with and without a large herbivore species at Konza. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(ii) Identify if the trend shown at Konza is the same at Kruger. *[1]*

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(iii) Suggest a possible reason for the difference in changes of grass and non-grass abundance. *[1]*

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(b) Compare plant species diversity at Kruger and Konza. *[2]*

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(c) Evaluate the data to determine if a single large herbivore species **or** multiple large herbivore species are better for grassland plant community abundance and diversity. *[2]*

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G2. (a) List **two** abiotic factors that affect the distribution of plant species. *[1]*

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2. . . . . .

(b) State **one** example of secondary succession. *[1]*

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(c) Distinguish between fundamental and realized niches. *[2]*

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(d) Discuss the difficulties of classifying organisms into trophic levels. *[2]*

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G3. (a) Outline the effects of chlorofluorocarbons (CFCs) on the ozone layer. *[2]*

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(b) Discuss reasons for the conservation of biodiversity using the Amazon rainforest as an example. *[3]*

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