



22116012

**BIOLOGY**
STANDARD LEVEL
PAPER 3

Thursday 19 May 2011 (morning)

1 hour

Candidate session number

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Examination code

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INSTRUCTIONS TO CANDIDATES

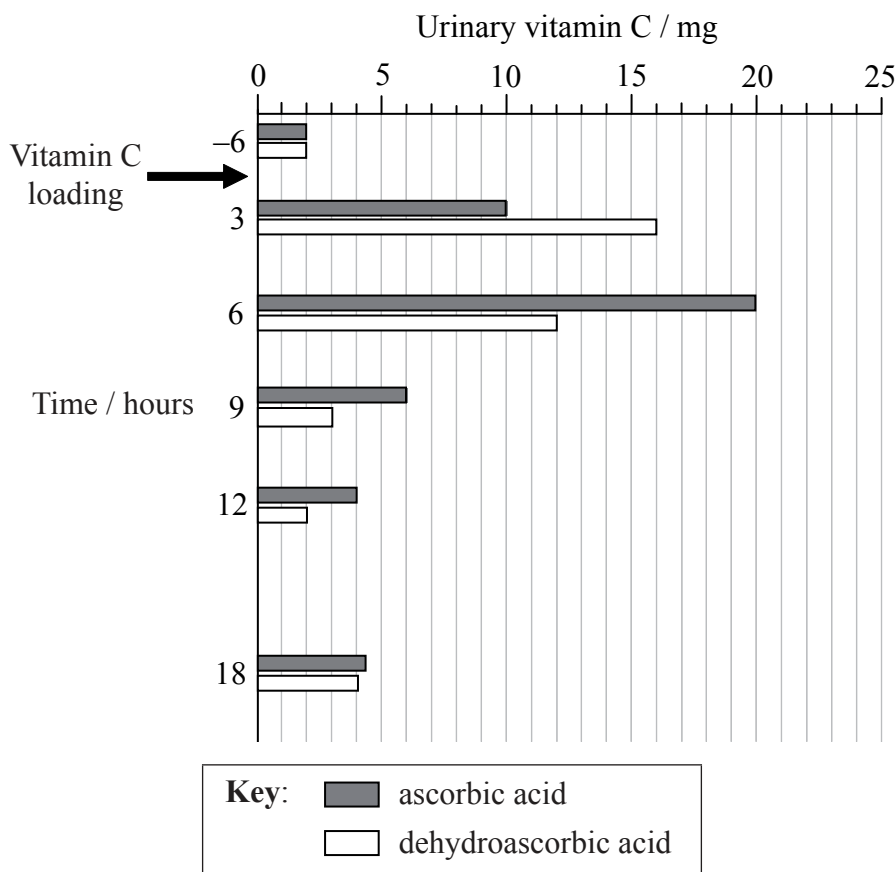
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.



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Option A — Human nutrition and health

A1. Vitamin C is an important component of a healthy diet. Because it is water-soluble it cannot be effectively stored and excess vitamin C is released in the urine. In order to investigate the ability of the body to retain different chemical forms of vitamin C, 17 healthy, female university students, between the ages of 18 and 22, were placed on a low vitamin C diet (<5 mg per day) for three days. The test subjects were divided into two groups and were given an oral vitamin C loading of either ascorbic acid (176 mg) or dehydroascorbic acid (174 mg). Levels of vitamin C in the urine were measured six hours before and at regular intervals over a 24 hour period following vitamin C loading. The negative value indicates time before vitamin C loading.



Masaru TSUJIMURA, Shizu HIGASA, Kazuhiro NAKAYAMA, Yoshiko YANAGISAWA, Sadahiko IWAMOTO and Yasuo KAGAWA. 2008. 'Vitamin C Activity of Dehydroascorbic Acid in Humans — Association between Changes in the Blood Vitamin C Concentration or Urinary Excretion after Oral Loading'. *J. Nutr. Sci. Vitaminol.*, 54: 315-320, 1 table.

(a) State the urinary vitamin C content for each of the two study groups six hours before vitamin C loading. [1]

Ascorbic acid:

Dehydroascorbic acid:

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(Question A1 continued)

- (b) Calculate the percentage increase in urine levels of vitamin C for the ascorbic acid study group during the first three hours after vitamin C loading. [1]

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- (c) Compare the trends in vitamin C release for the two test groups during the first twelve hours after vitamin C loading. [2]

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- (d) Large individual differences in the urine level of ascorbic acid and dehydroascorbic acid were recorded between test subjects after 24 hours. Suggest **one** possible reason for these large individual differences. [1]

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(Question A1 continued)

- (e) Scurvy is a disease that is due to vitamin C deficiency. Evaluate the importance of this investigation for finding ways to combat vitamin C deficiency. [2]

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A2. (a) Body mass index (BMI) can be calculated from the mass (in kg) and height (in m) of an individual. The status of an individual can then be determined from a scale such as the one shown below.

BMI / kg m ⁻²	Status
< 18.5	Underweight
18.5–24.9	Normal weight
25.0–29.9	Overweight
≥ 30.0	Obese

(i) Calculate the BMI for an individual whose mass is 74.0 kg and who has a height of 1.80 m. [1]

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(ii) On the basis of the BMI calculated in (a)(i), identify the status of this individual. [1]

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(This question continues on the following page)



(Question A2 continued)

(b) Outline factors that can lead to an individual becoming obese.

[3]

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A3. (a) State **two** advantages of breastfeeding over bottle-feeding. [2]

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(b) State **one** symptom of type II diabetes. [1]

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

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Turn over

Option B — Physiology of exercise

B1. Physiological data were collected for a sample of 12 obese subjects across a range of exercise machines. The average age of the subjects was 47 years and the average mass was 101.6 kg. The subjects completed 15-minute trials on each machine at a self-selected, moderate intensity. Mean values and, in some cases, standard deviations, are shown for the collected data.

Variable	Weight-bearing machines		Non weight-bearing machines	
	Treadmill	Body Trec	Stationary Cycle	Airdyne
VO ₂ / cm ³ kg ⁻¹ min ⁻¹	13.5	16.4	10.8	12.5
Heart rate / bpm	110	128	109	118
O ₂ supply / cm ³ beat ⁻¹	12.3	12.9	10.1	10.9
Ventilation rate / dm ³ min ⁻¹	30.8 × 8	39.7 × 10	29.7 × 14	31.2 × 9
Energy expenditure / kJ min ⁻¹	27.5 × 8.8	33.4 × 8.4	22.2 × 8.6	26.3 × 8.4
Blood lactate / mM	2.82 × 1.33	3.97 × 1.77	3.35 × 1.19	3.67 × 1.63

Jong-Kyung KIM, Hosung NHO and Mitchell H. WHALEY. 2008. 'Inter-Modal Comparisons of Acute Energy Expenditure during Perceptually Based Exercise in Obese Adults'. *J. Nutr. Sci. Vitaminol.*, 54: 39-45.

(a) Calculate the average O₂ supply in cm³ beat⁻¹ for the weight-bearing machines. [1]

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(b) Suggest **one** reason for the higher VO₂ recorded for weight-bearing machines, compared to non weight-bearing machines. [1]

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(Question B1 continued)

(c) Analyse the energy expenditure for the four exercise machines.

[2]

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(d) Based on these data, discuss the advantages and disadvantages of the body trec for obese subjects undergoing moderate exercise.

[3]

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B2. The term *fitness* can be defined as “the physical condition of the body that allows it to perform exercise of a particular type”. Becoming fit requires training a range of muscles and improving the performance of the cardiovascular and pulmonary systems.

(a) State **two** changes in the performance of the cardiovascular system that could occur after a training programme. [2]

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(b) Intense exercise during training can lead to a condition called oxygen debt. Outline how oxygen debt is repaid. [2]

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(c) Warming up and down routines are often used by athletes as a way of avoiding injuries during training. Outline the importance of warm-up exercises for avoiding injuries. [2]

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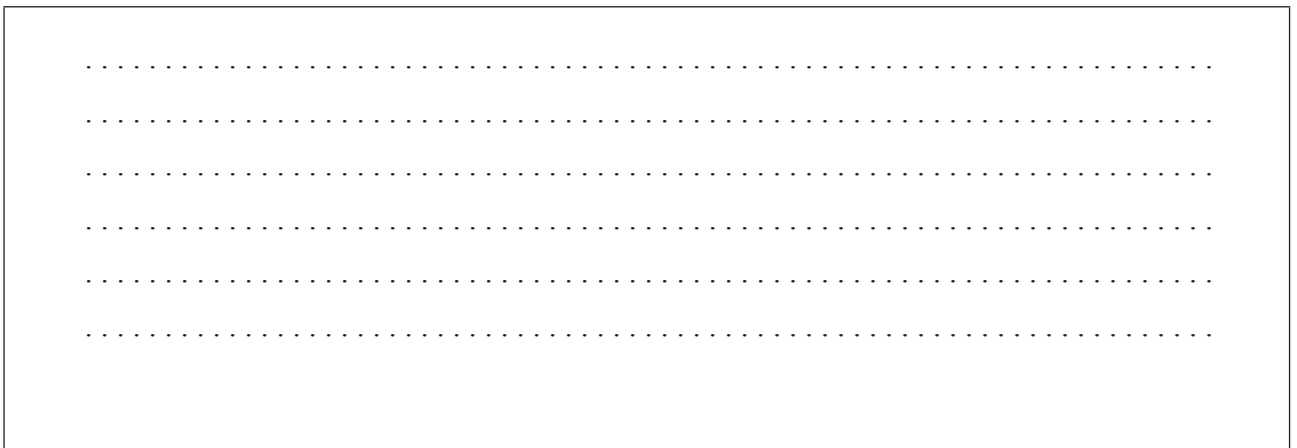
B3. (a) Draw a labelled diagram of a sarcomere.

[3]



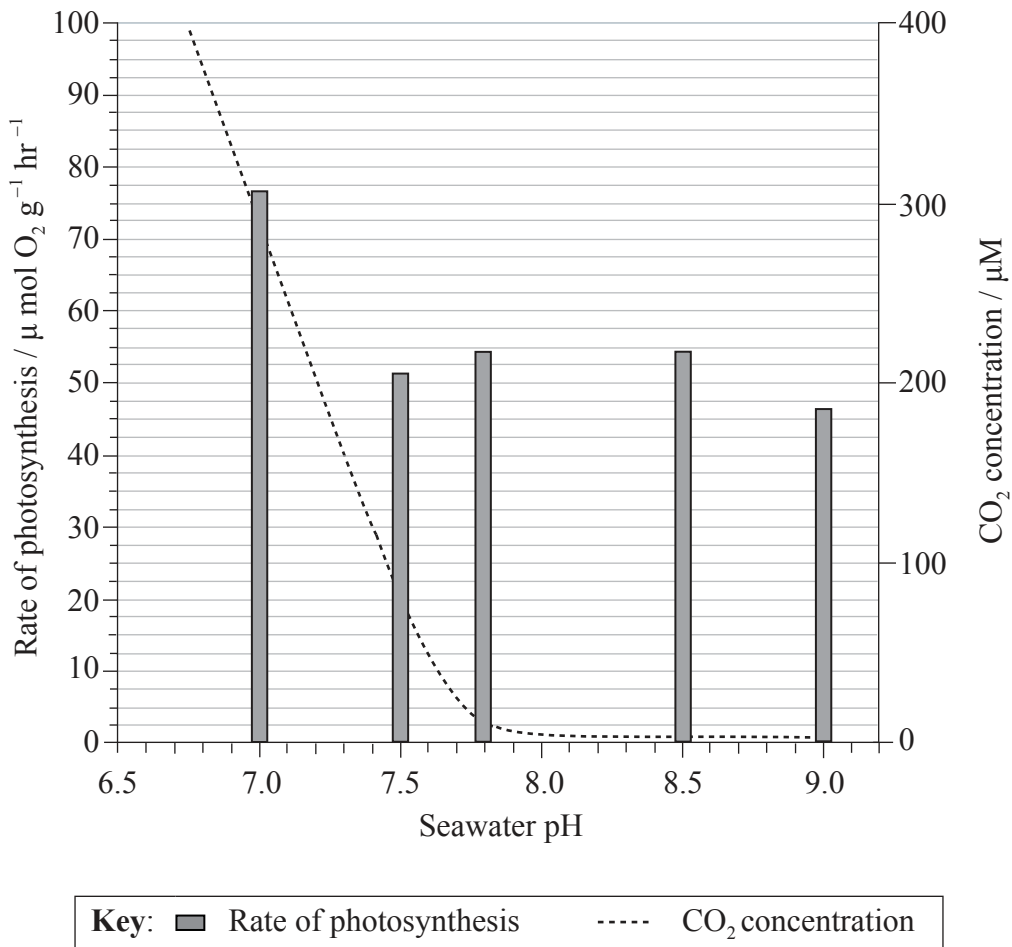
(b) Explain the role of calcium ions in muscle contraction.

[2]



Option C — Cells and energy

C1. The rate of photosynthesis in the marine seagrass, *Zostera marina*, was investigated under a range of pH conditions. After a period of darkness, the plants were illuminated at a constant light intensity at 15 °C and the rate of photosynthesis was measured. *Zostera marina* can use both dissolved carbon dioxide (CO₂) and hydrogen carbonate ions for photosynthesis. The rate of photosynthesis is plotted on the y-axis on the left. In addition, the concentration of carbon dioxide was measured for each pH investigated and is plotted on the y-axis on the right.



[Source: H Carr and L Axelsson, (2008), *Plant Physiology*, **147**, pages 879–885]

Plant physiology by AMERICAN SOCIETY OF PLANT PHYSIOLOGISTS. Copyright 2008 Reproduced with permission of AMERICAN SOCIETY OF PLANT BIOLOGISTS in the format CD ROM via Copyright Clearance Center.

(a) State the carbon dioxide concentration at pH 7.2.

[1]

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(Question C1 continued)

- (b) Calculate the percentage decrease in the rate of photosynthesis from pH 7 to pH 7.5. [1]

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- (c) Outline the relationship between pH and the rate of photosynthesis. [2]

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- (d) Suggest how *Zostera marina* can perform photosynthesis even at very low carbon dioxide concentrations. [1]

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- (e) Based on the information and data provided, discuss the role of **one** limiting factor, other than carbon dioxide, and suggest how this would affect the rate of photosynthesis. [2]

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C2. (a) State **one** example of a fibrous protein and **one** example of a globular protein. [1]

Fibrous protein:
Globular protein:

(b) Compare the structure of fibrous and globular proteins. [2]

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(c) Amino acid polarity is an important factor in determining the functions of proteins. Explain the importance of polar and non-polar amino acids in membrane proteins. [3]

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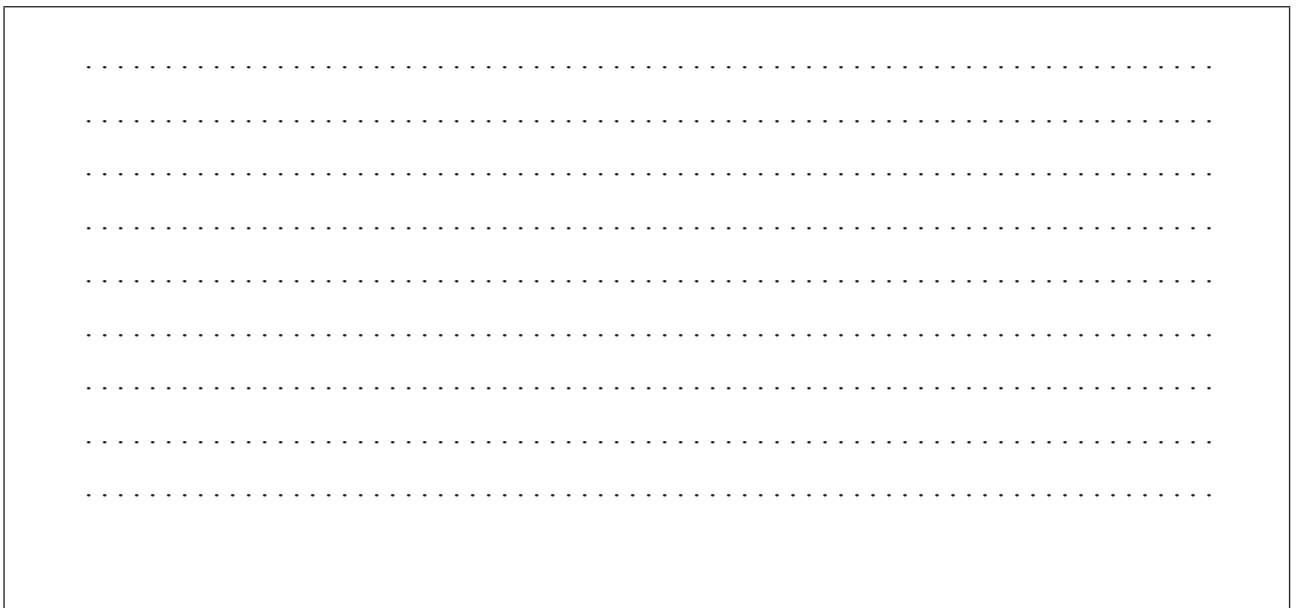
C3. (a) Draw a labelled diagram of a mitochondrion.

[3]



(b) Explain how the structure of a mitochondrion is adapted for its function.

[2]

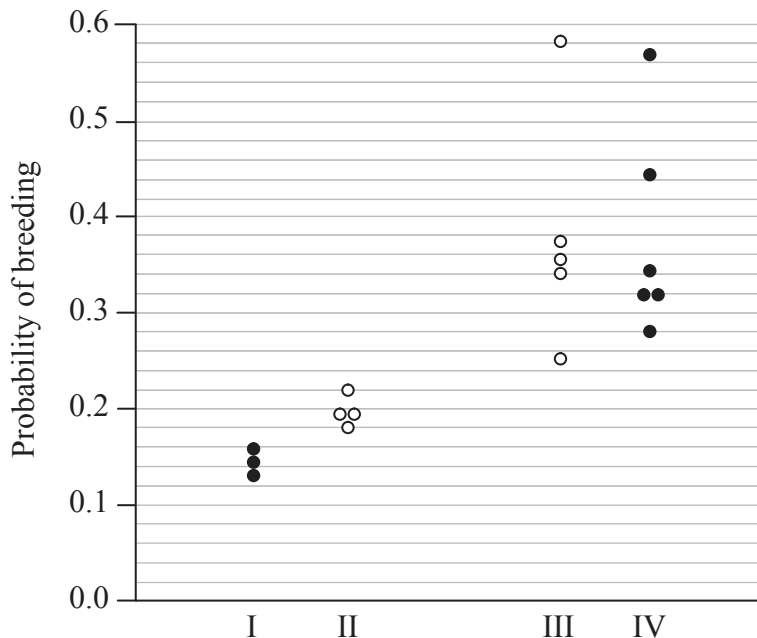


Option D — Evolution

D1. Populations of threespine sticklebacks (*Gasterosteus* sp.), a fish living in small freshwater lakes in British Columbia, Canada, are derived from the marine threespine stickleback (*Gasterosteus aculeatus*). In order to investigate the process of speciation in these populations, three small lakes were studied. Each lake contained two varieties of stickleback: a large, bottom-dwelling variety that fed on invertebrates near the shore and a small, plankton-eating variety that lived in the open water. The probability of breeding between pairs of individuals was measured under laboratory conditions in the following breeding combinations:

- I different varieties (small × large) from the same lake
- II different varieties from different lakes
- III same variety (small × small) and (large × large) from different lakes
- IV same variety from the same lake.

The data are summarized below.



From H. D. Rundle et al. (2000) *Science*, 287, pp. 306–308. Reprinted with permission from AAAS.

- (a) Identify the highest and lowest probabilities of breeding for individuals of the same variety from different lakes. [1]

Highest probability:

Lowest probability:

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(Question D1 continued)

- (b) Identify the breeding combination that results in the lowest probability of breeding. [1]

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- (c) Analyse the probability of breeding between individuals from the same lake. [2]

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- (d) Scientists concluded that speciation is taking place in these populations. Discuss the evidence for speciation provided by the data. [3]

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D2. The spontaneous origin of life on Earth is thought to have involved the non-living synthesis of simple organic molecules.

(a) List **two** other processes needed for the spontaneous origin of life. [2]

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(b) Discuss possible locations where conditions would have allowed the synthesis of organic compounds. [2]

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(c) Outline the role of prokaryotes in the development of an oxygen-rich atmosphere on the Earth. [2]

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D3. Fossils provide important evidence for evolution.

(a) Outline how radioisotopes can be used to date fossils.

[2]

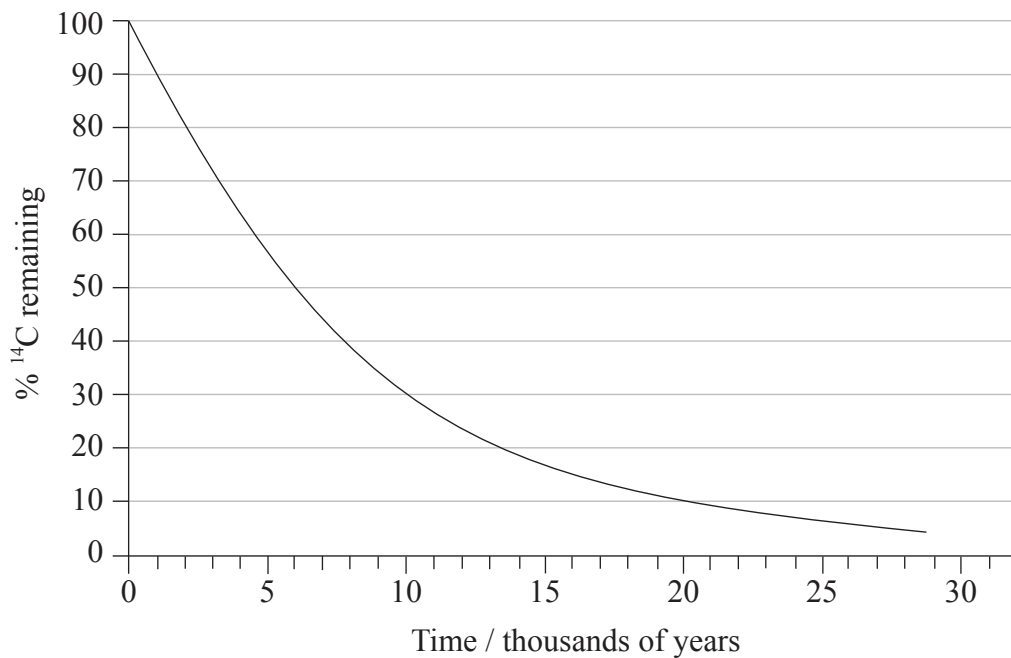
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(b) The half-life of the radioisotope ^{14}C is approximately 5730 years.



Using the decay curve shown above, deduce the age of a fossil that contains 30% of the original amount of ^{14}C .

[1]

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(Question D3 continued)

- (c) Describe **two** major trends that can be seen from fossil remains in the sequence *Ardipithecus ramidus*, *Australopithecus* species and *Homo* species. [2]

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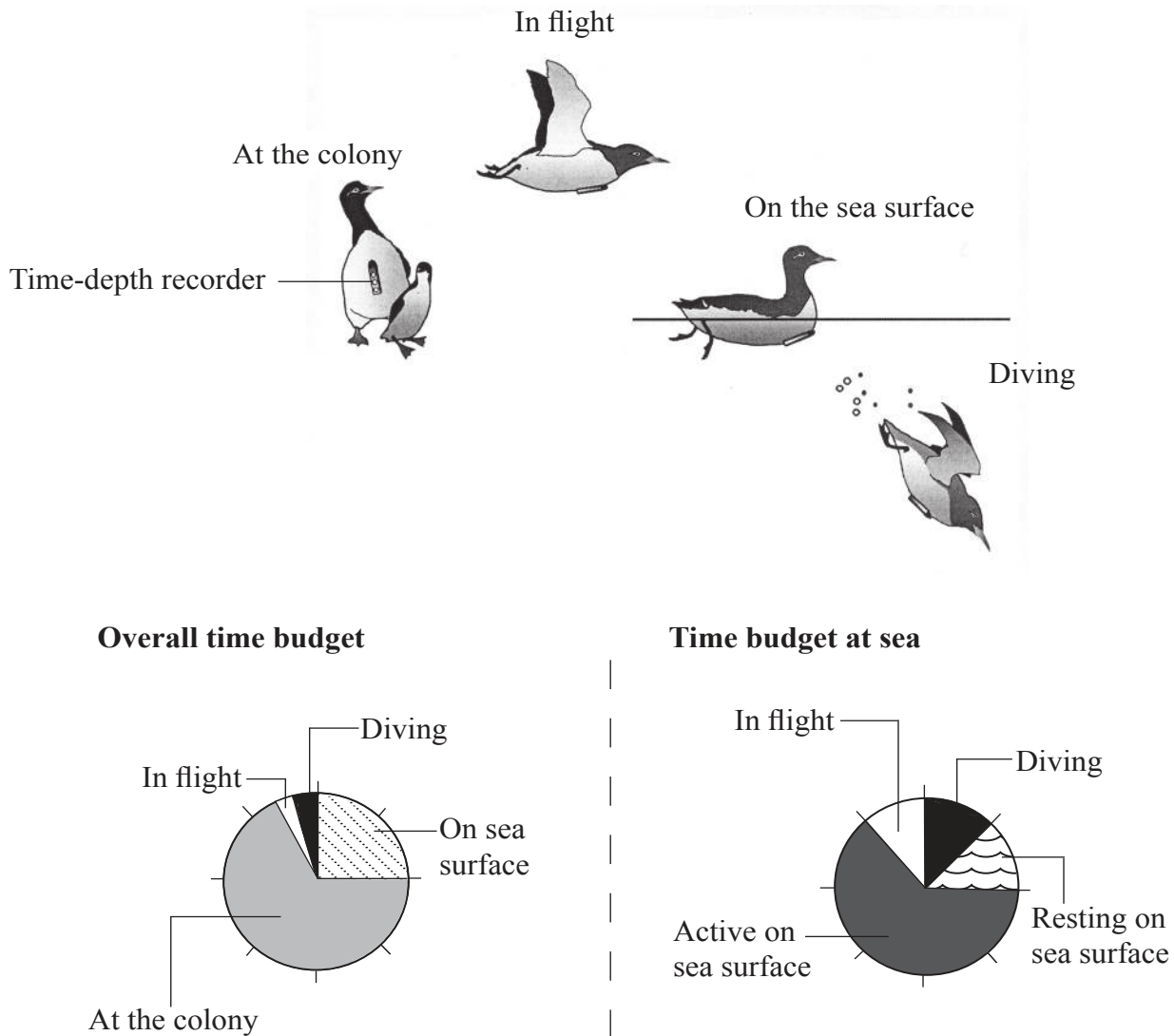


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Turn over

Option E — Neurobiology and behaviour

E1. Common guillemots (*Uria aalge*) are large sea birds of the auk family. They breed in colonies at high densities but make no nest. Their single egg is incubated on bare rock. Alloparenting behaviour is frequently observed, where non-breeding birds will take care of other chicks. Scientists fitted electronic time-depth recorders onto twelve common guillemots and recorded five different activities during the chick-rearing period: at the colony, in flight, resting or active on the sea surface and diving. The pie charts below include pooled data from all birds showing overall time budget and time budget at sea.



Reproduced with permission from Y. Tremblay *et al.* (2003) *The Journal of Experimental Biology*, 206, pp. 1929–1940
© The Journal of Experimental Biology: jeb@biologists.org..

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(Question E1 continued)

- (a) State which activity takes up least of the overall time budget of the guillemots. [1]

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- (b) Calculate the percentage of the overall time budget the guillemots spend resting on the sea surface. [1]

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- (c) Outline the activity of guillemots at sea. [2]

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- (d) Suggest **two** reasons, other than breeding, why birds spend more time at the colony than any other activity. [2]

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E2. (a) Define the term *reflex*.

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(b) Draw a labelled diagram of a reflex arc for a pain withdrawal reflex.

[3]

(c) Outline Pavlov's experiments into conditioning in dogs.

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E3. (a) Explain the effects of psychoactive drugs on synaptic transmission. [3]

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(b) Suggest an experimental design that could be used to investigate **either** taxis **or** kinesis in an invertebrate. [3]

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Turn over

Option F — Microbes and biotechnology

F1. Soy sauce contains many soluble compounds such as glucose, the amino acid tyrosine and soluble nitrogen compounds including urea, ammonium and nitrates. One of the most important steps in soy sauce production is the growth of *Aspergillus*. The strains of this mould that are used have high protease activity, no toxin production, and give a good taste and aroma to the final product. In factories several strains of mould are used, the most common are the different Japanese strains of *Aspergillus oryzae*. In Thailand, a locally occurring mould, *Aspergillus flavus*, is sometimes used. Several characteristics of the soy sauce produced using *Aspergillus flavus* were compared to those of soy sauce produced using *Aspergillus oryzae*. Acceptability was determined by factory workers based on aroma, colour and taste.

Soy sauce prepared from:	Protease activity / $\mu\text{m min}^{-1} \text{cm}^{-3}$	Tyrosine / g dm^{-3}	Soluble nitrogen / g dm^{-3}	Glucose / g dm^{-3}	Toxicity / aflatoxin bioassay	Acceptability
<i>Aspergillus flavus</i>	103	37.8	10.8	40.7	Not detectable	Acceptable
<i>Aspergillus oryzae</i>	126	28.2	4.9	35.4	Not detectable	Acceptable

[Source: A Bhumiratana, *et al.*, (1980), *Applied and Environmental Microbiology*, **39**, pages 430–435]
Copyright American Society for Microbiology. Reproduced with permission.

- (a) Calculate the expected percentage increase in protease activity if a manufacturer changes from using *Aspergillus flavus* to *Aspergillus oryzae*. [1]

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(Question F1 continued)

- (b) Distinguish between the soy sauce produced by *Aspergillus flavus* and *Aspergillus oryzae*. [2]

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- (c) Evaluate the use of the strain *Aspergillus flavus* in the production of soy sauce in Thailand. [3]

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F2. (a) State **two** roles of microbes in ecosystems. [1]

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(b) List the diversity in the shapes of Eubacteria. [2]

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(c) Outline the role of saprotrophic bacteria in sewage treatment. [2]

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F3. (a) State the function of reverse transcriptase. [1]

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

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(c) Discuss the risks of gene therapy. [3]

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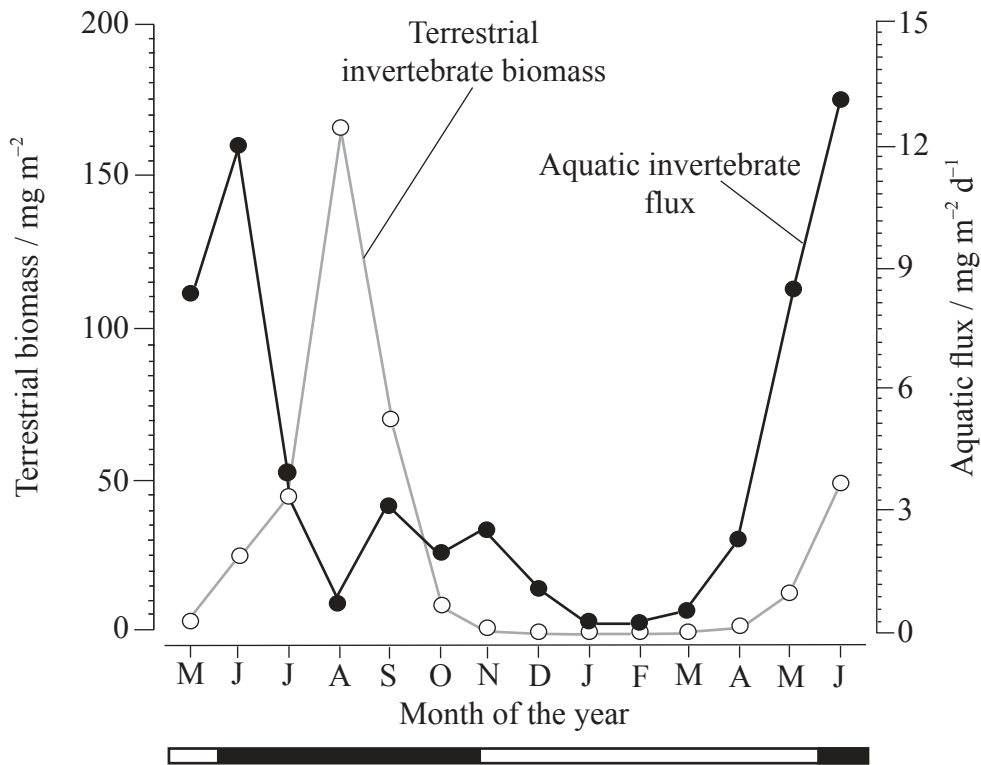
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Option G — Ecology and conservation

G1. The graph below shows the monthly mean values of terrestrial invertebrates from May 1997 to June 1998 in the northern hemisphere. The light line shows the biomass of invertebrates which are prey to forest birds (terrestrial invertebrate biomass). The darker line shows the invertebrates which lived in the stream and have moved to the forest (aquatic invertebrate flux or movement). The black bars on the horizontal line at the bottom show periods when trees have leaves and the white bars show periods of defoliation.



S. Nakano and M. Murakami, 'Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs'. *PNAS*, 98 (1) pp. 166-170. Figure 1C. Copyright (2001) National Academy of Sciences, U.S.A.

(a) State the mean terrestrial invertebrate biomass measured in August. [1]

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(Question G1 continued)

- (b) Describe the trend in the aquatic invertebrate flux. [2]

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- (c) Suggest the relationship between defoliation and the amount of terrestrial invertebrates in the forest. [2]

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- (d) Suggest a possible explanation for the pattern in aquatic invertebrate flux to the forest seen between the months of June and December. [2]

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G2. (a) Define the terms *fundamental niche* and *realized niche*. [2]

Fundamental niche:

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Realized niche:

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(b) Explain why the carnivores in an ecosystem tend to be fewer in number and have a smaller biomass than the herbivores in the same ecosystem. [2]

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(c) Explain why carnivores tend to be more affected by biomagnification than organisms lower down the food chain. [3]

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G3. The introduction of alien species and the release of environmental pollutants are examples of human activities that have an impact on the environment.

(a) Alien species may arrive in an ecosystem due to accidental or deliberate release. State the impact of **one named** example of deliberate release. [2]

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(b) Outline the effect of CFCs on the ozone layer. [2]

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