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BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate session number

0	0								

Tuesday 14 May 2013 (morning)

1 hour

Examination code

2	2	1	3	–	6	0	1	2

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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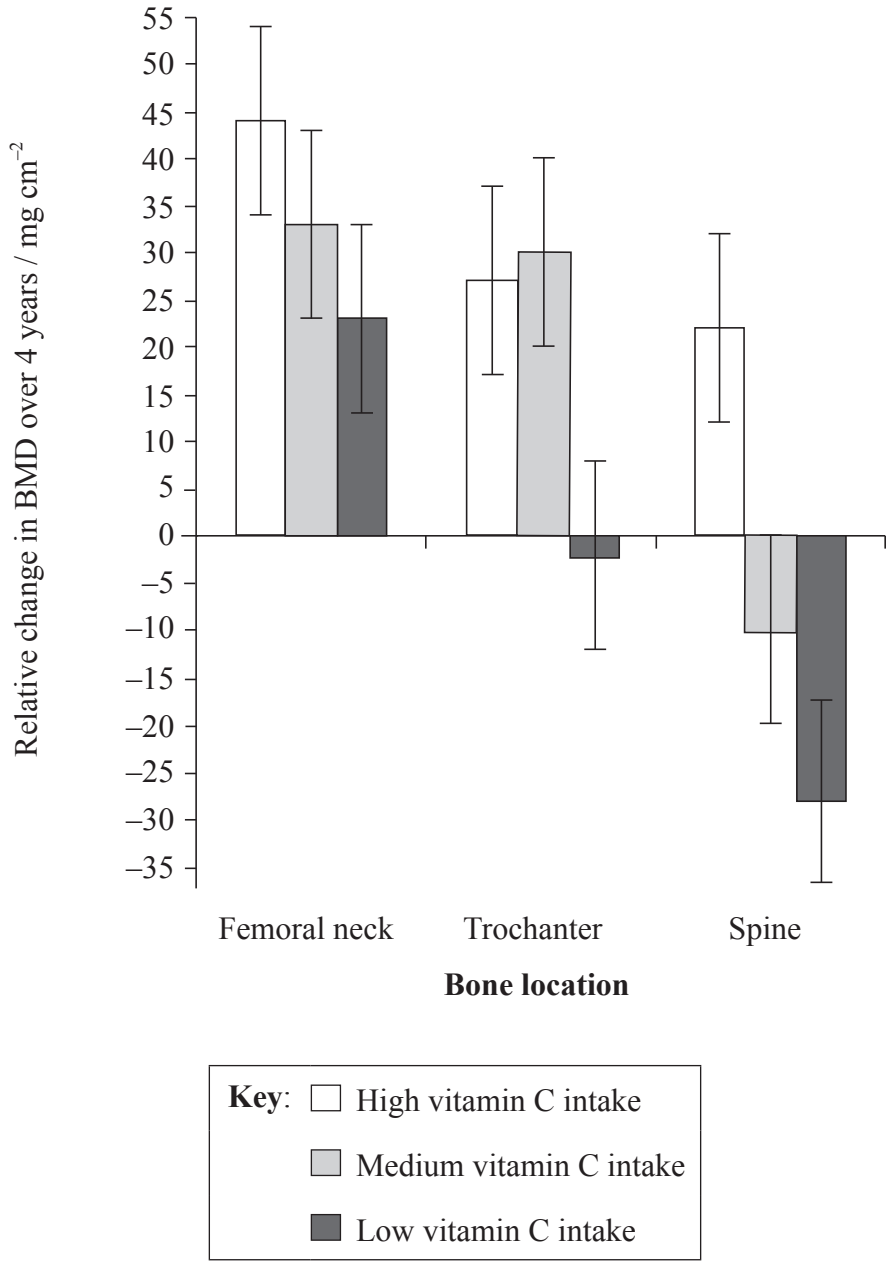
Option A — Human nutrition and health

A1. Elderly people lose bone mineral density (BMD) with age, and this is the source of many health issues, including higher risk of bone fractures. Researchers measured the change in BMD amongst elderly men considering many factors, over a period of four years. The results presented below show the difference between bone density change due solely to vitamin C intake and bone density loss considering a combination of the other factors represented by the baseline (zero). BMD was measured in the spine and at two femur (thigh bone) locations (femoral neck and trochanter) using scanner images. Daily intake of total vitamin C was categorized as high, medium or low.



[Source: Shivani et al. (2008) "High Vitamin C Intake Is Associated with Lower 4-Year Bone Loss in Elderly Men", *Journal of Nutrition*, vol 138 (10), pp. 1931–8: Figure 4. © American Society for Nutrition.]

(This question continues on the following page)

(Question A1 continued)

(a) Outline the effect of vitamin C intake on changes in bone density in the spine. *[1]*

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(b) Compare the changes in bone density of the femoral neck with those of the spine. *[2]*

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(c) Evaluate the evidence provided by the data that the intake of vitamin C supplements may reduce bone density loss in elderly people. *[2]*

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A2. (a) (i) Define the term *nutrient*. *[1]*

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(ii) Define the term *non-essential amino acid.* *[1]*

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(b) The following are from the labels of a bag of all purpose white flour (wheat) and a bag of parboil long grain rice. Amounts shown are per serving.

	Flour	**Rice**
Serving size	30 g	30 g
Fat	0.4 g	0.2 g
Saturated	0.1 g	0 g
Trans fat	0 g	0 g
Cholesterol	0 mg	0 mg
Sodium	0 mg	0 mg
Carbohydrate	22 g	24 g
Fibre	1 g	0 g
Sugars	0 g	0 g
Protein	4 g	2 g

[Source: Flour: Five Roses™, Smucker Foods of Canada Co.;
Rice: NuPak, Shaw Trading Company Limited.]

(This question continues on the following page)

(Question A2 continued)

(i) Using your knowledge of the energy content of nutrients, calculate the protein energy value of a serving of rice, showing the units. *[2]*

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(ii) Compare wheat flour and rice as main dietary sources of energy for humans. *[2]*

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(c) Evaluate the benefits of reducing dietary cholesterol in lowering the risk of coronary heart disease. *[2]*

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A3. (a) Outline the control mechanism for appetite in humans. *[2]*

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(b) Explain the possible health consequences of a diet rich in protein. *[3]*

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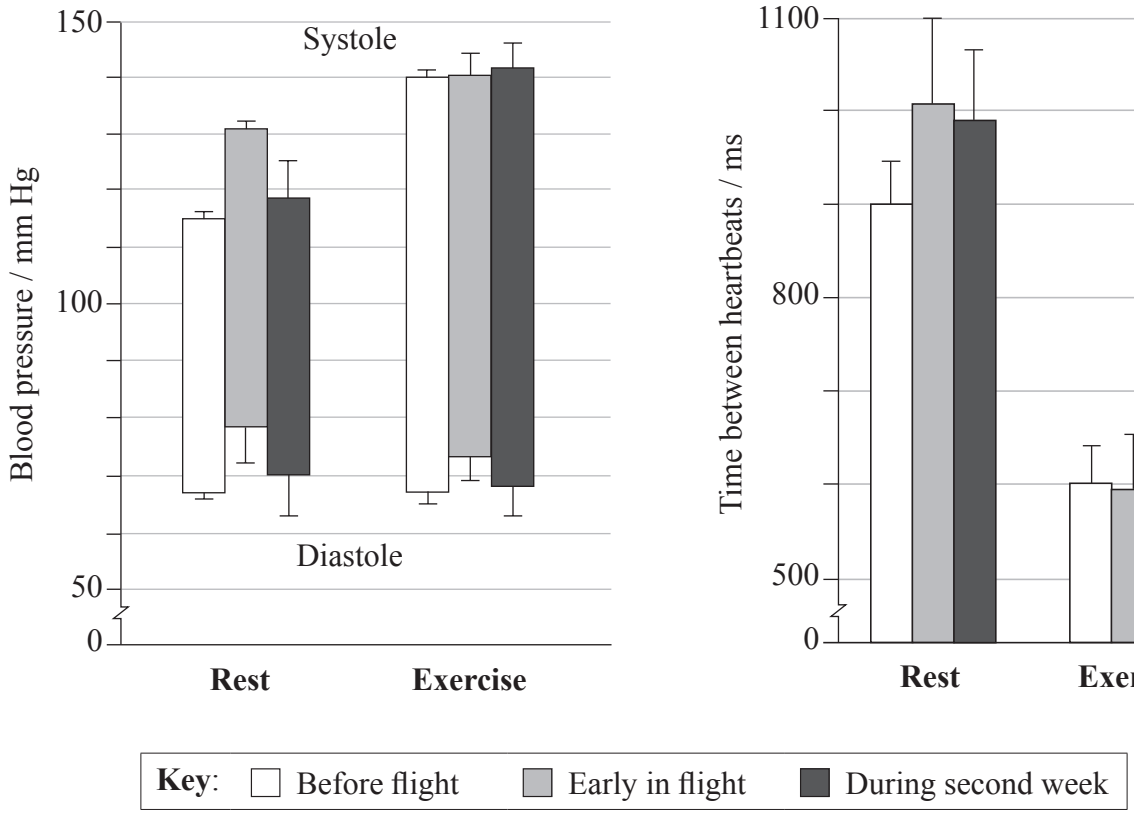
Option B — Physiology of exercise

B1. Scientists investigated astronauts' cardiovascular response to exercise in weightless conditions during a Columbia Space Shuttle mission. They measured the blood pressure and the time between heartbeats, both at rest and during moderate exercise. Blood pressure is expressed by two values corresponding to ventricular contraction (systole) and relaxation (diastole). Measurements were taken before the flight, early in the flight and during the second week in space. The following graphs represent average values for each type of measurement.



[Source: *Journal of Applied Physiology*, M. Di Rienz et al.,105, 2008, pages 1569–1575.]

(a) Calculate the difference in blood pressure at systole between rest and exercise before flight, giving the units. *[1]*

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(This question continues on the following page)

(Question B1 continued)

(b) Outline the response of the astronauts' cardiovascular system to exercise before the flight. *[2]*

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(c) Discuss whether the cardiovascular system has to adjust to weightless conditions in space. *[3]*

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B2. (a) Define the term *fitness*. *[1]*

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(b) (i) State the role of ligaments in human movement. *[1]*

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(ii) Outline what is meant by *torn ligament*. *[1]*

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(c) State how an oxygen debt is created. *[1]*

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(d) Explain the changes in ventilation rate during exercise. *[2]*

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B3. (a) Draw a labelled diagram to show the structure of a sarcomere. *[2]*

(b) Explain the roles of actin and myosin in muscle contraction. *[4]*

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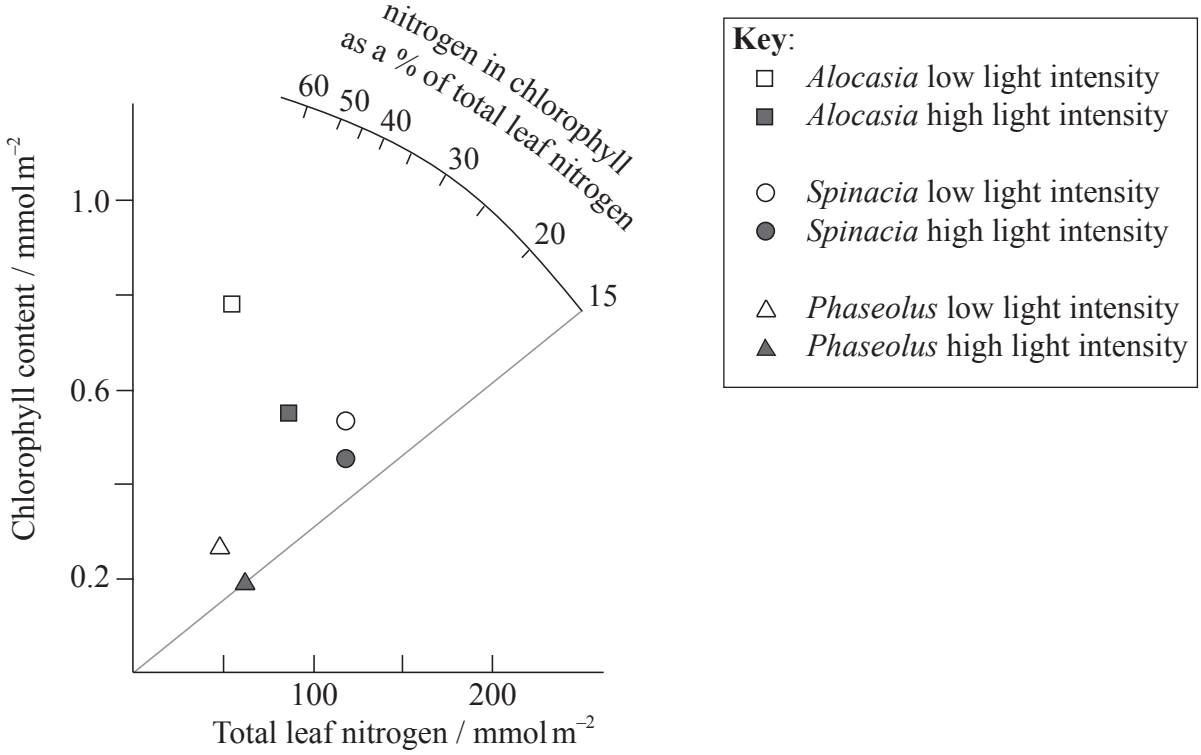
Option C — Cells and energy

C1. The nitrogen content of a leaf is mainly due to the proteins contained in the chloroplasts. These proteins are either in the thylakoids or in the stroma, where most enzymes are found. The quantity of nitrogen from the thylakoids is directly proportional to the amount of chlorophyll; a ratio of approximately 50 mmol nitrogen : 1 mmol chlorophyll would represent 100 % of the leaf nitrogen content. Scientists hypothesized that the higher leaf percentage nitrogen content resulting from a decrease in light intensity is due mainly to an increase in chlorophyll in many plant species, three of which are represented in the following graph.



[Source: With kind permission from Springer Science+Business Media: *Oecologia*, Photosynthesis and nitrogen relationships in leaves of C3 plants, 78, 1989, 9–19, John R. Evans]

(a) State the difference in chlorophyll content for *Phaseolus* between high and low light intensity, giving the units. *[1]*

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(This question continues on the following page)

(Question C1 continued)

(b) State the percentage value of total leaf nitrogen in chlorophyll for *Spinacia* at low light intensity. *[1]*

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(c) Suggest **one** advantage for plants to increase their leaf chlorophyll content per surface area when light intensity is lower. *[1]*

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(d) Evaluate the hypothesis that lower light intensity increases thylakoid nitrogen. *[3]*

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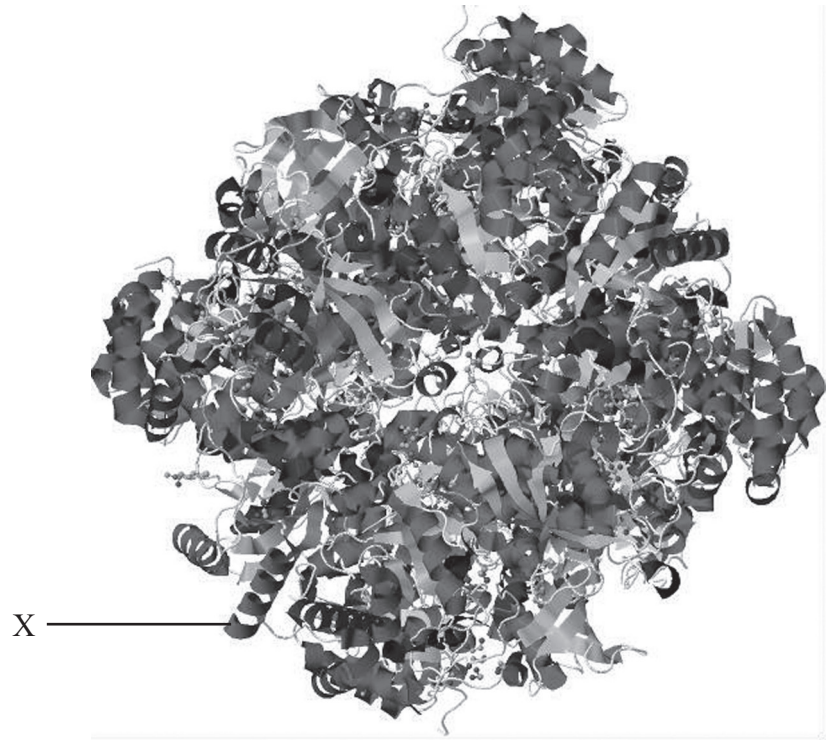
C2. (a) The following image represents a model of ribulose bisphosphate (RuBP) carboxylase (also known as Rubisco) from the green alga *Chlamydomonas*.



[Source: Image from the RCSB Protein Data Bank: http://www.pdb.org/pdb/explore/jmol.do?structureId=1GK8&bionumber=1]

(i) Identify the level of protein structure of the part labelled X. *[1]*

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(ii) State the role of ribulose bisphosphate (RuBP) carboxylase in the Calvin cycle. *[1]*

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(This question continues on the following page)

(Question C2 continued)

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

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

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C3. (a) Outline the process of glycolysis. *[3]*

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(b) Explain the relationship between the action spectrum and the absorption spectrum of photosynthetic pigments in plants. *[3]*

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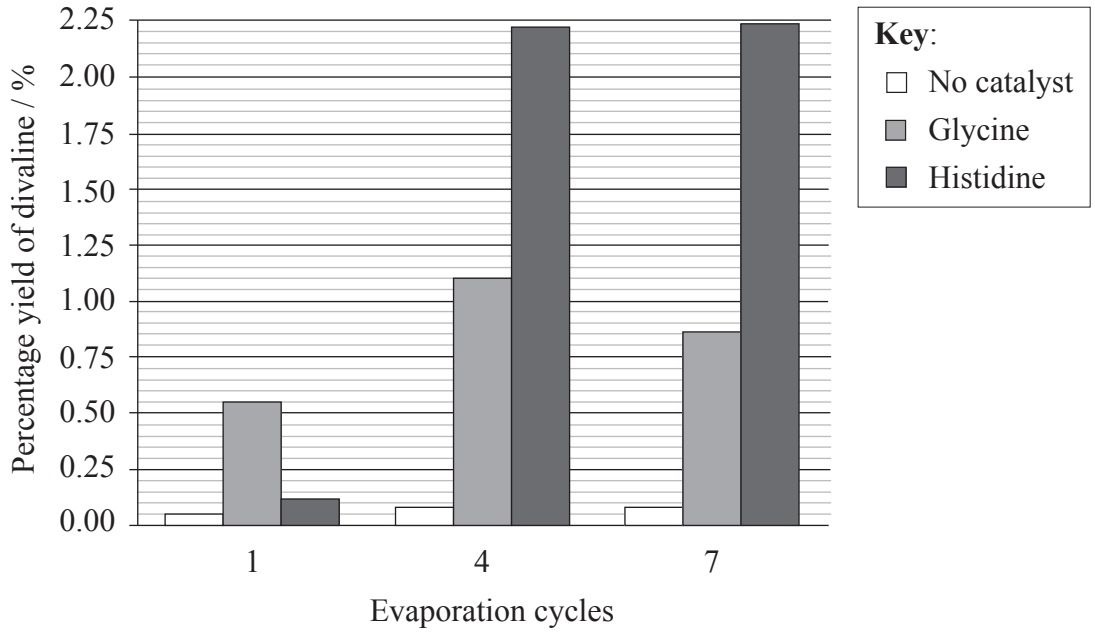
Option D — Evolution

D1. The synthesis of complex organic molecules in sea water is believed to be an important step in the evolution of life on Earth. Researchers investigated if the evaporation of sea water containing amino acids could catalyse the formation of dipeptides such as divaline (valine-valine) under prebiotic Earth conditions. They placed different amino acid combinations in a chamber to simulate the evaporation cycles between high tides in shallow seas. In one investigation the amino acid valine was used as the substrate and percentage yield of divaline was measured after different numbers of evaporation cycles. The experiment was repeated without a catalyst and with either glycine or histidine as catalysts.



[Source: D. Fitz et al. (2007) "Chemical evolution toward the origin of life", *Pure and Applied Chemistry*, 79 (12), pages 2101–2117. Reprinted with permission from IUPAC.]

(a) Outline the effect of repeated evaporation cycles on divaline yields using glycine as a catalyst. *[2]*

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(This question continues on the following page)

(Question D1 continued)

(b) Compare the effectiveness of the two amino acid catalysts used in this experiment. *[3]*

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D2. (a) (i) Define *half-life* of a radioactive molecule. *[1]*

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(ii) Outline the method of dating fossils using ^{40}K. *[2]*

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(b) Outline the contribution of prokaryotes to the creation of an oxygen-rich atmosphere. *[2]*

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(c) Describe the major anatomical features that define humans as primates. *[2]*

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D3. (a) Compare convergent and divergent evolution. *[2]*

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(b) Explain how polyploidy can contribute to speciation. *[4]*

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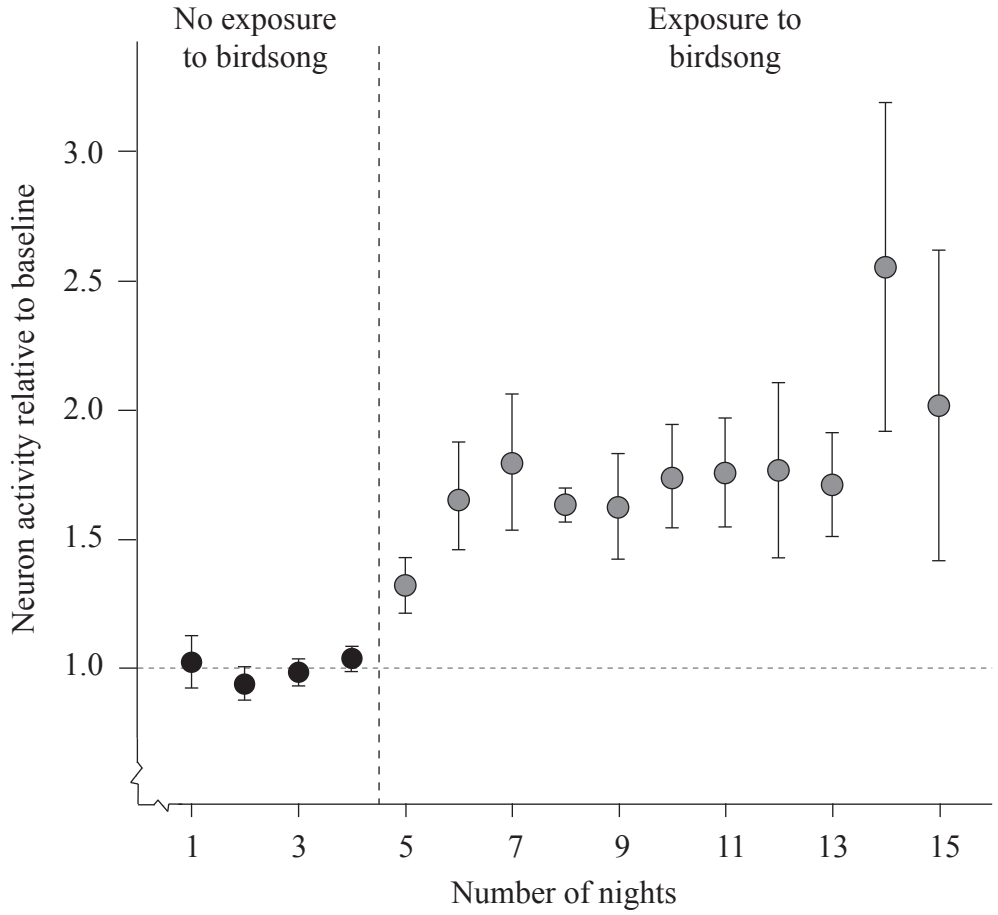
Option E — Neurobiology and behaviour

E1. Scientists investigated if training has an influence on the learning of birdsong. They studied juvenile zebra finches (*Taeniopygia guttata*) that had never been exposed to adult bird songs. They measured neuron activity in an area of the brain involved with song learning. This was done during their sleep, first for four nights when the birds had not heard any birdsong during the previous day, and then for a series of nights after days when they were exposed to recordings of adult zebra finches' songs. In the graph below, the mean neuron activity in the period of no exposure to birdsong was used as a baseline and assigned a value of 1. All other measurements of neuron activity are shown relative to this.



[Source: Reprinted by permission from Macmillan Publishers Ltd, *Nature*, Sylvan S. Shank & Daniel Margoliash, 'Sleep and sensorimotor integration during early vocal learning in a songbird', Vol. 458, pages 73–77, copyright 2009]

(a) State the difference in neuron activity between nights 2 and 7. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(b) Outline the effect of exposure to birdsong on neuron activity. *[2]*

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(c) Suggest **one** reason for the large error bars on days 14 and 15. *[1]*

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(d) Evaluate the hypothesis that listening to other zebra finches is important to develop singing ability amongst juveniles. *[2]*

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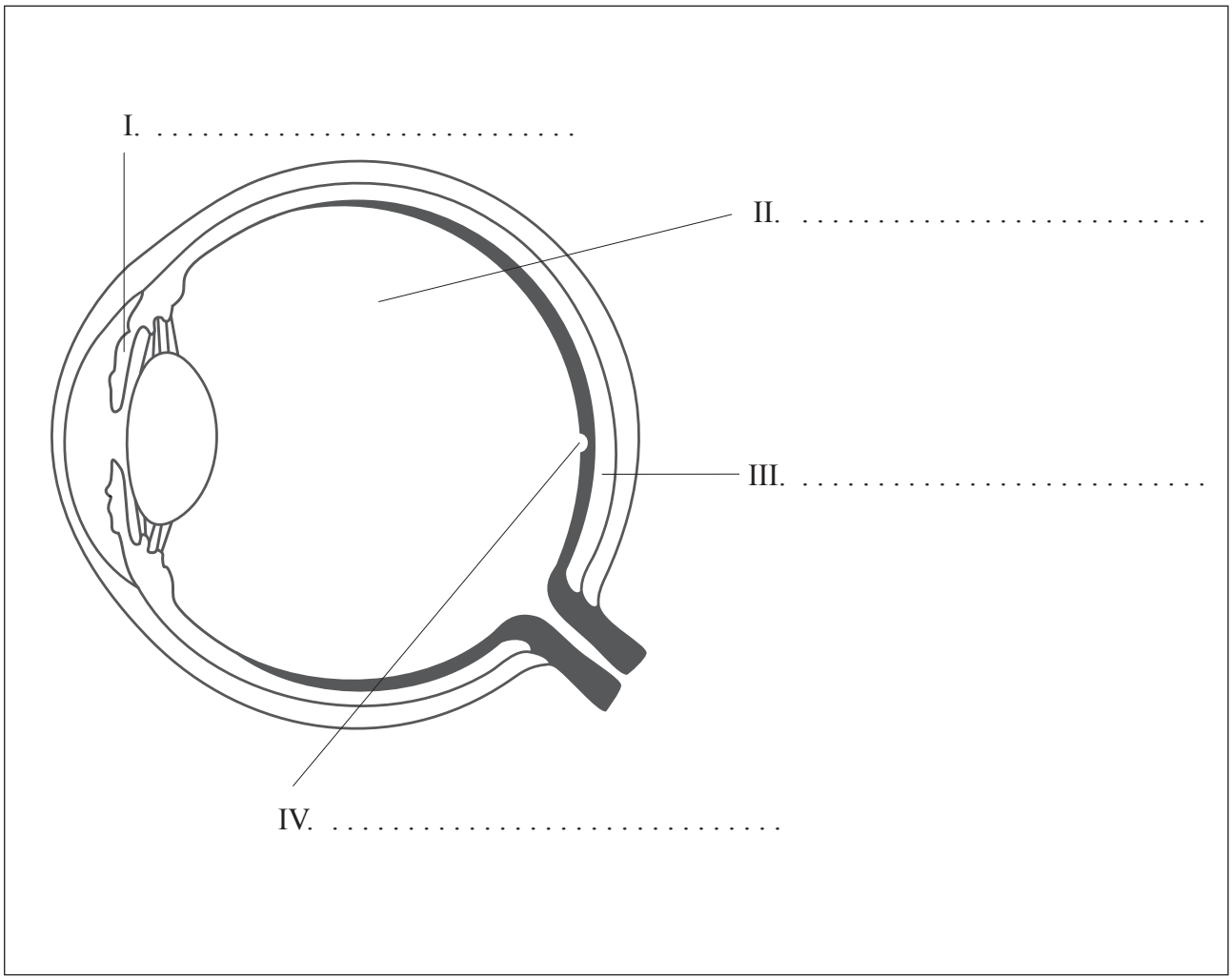
E2. (a) Label the following diagram of the eye. *[2]*



(This question continues on the following page)

(Question E2 continued)

(b) (i) Define the term *stimulus*. *[1]*

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(ii) Define the term *reflex*. *[1]*

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(c) Outline the diversity of stimuli that can be detected by human chemoreceptors. *[2]*

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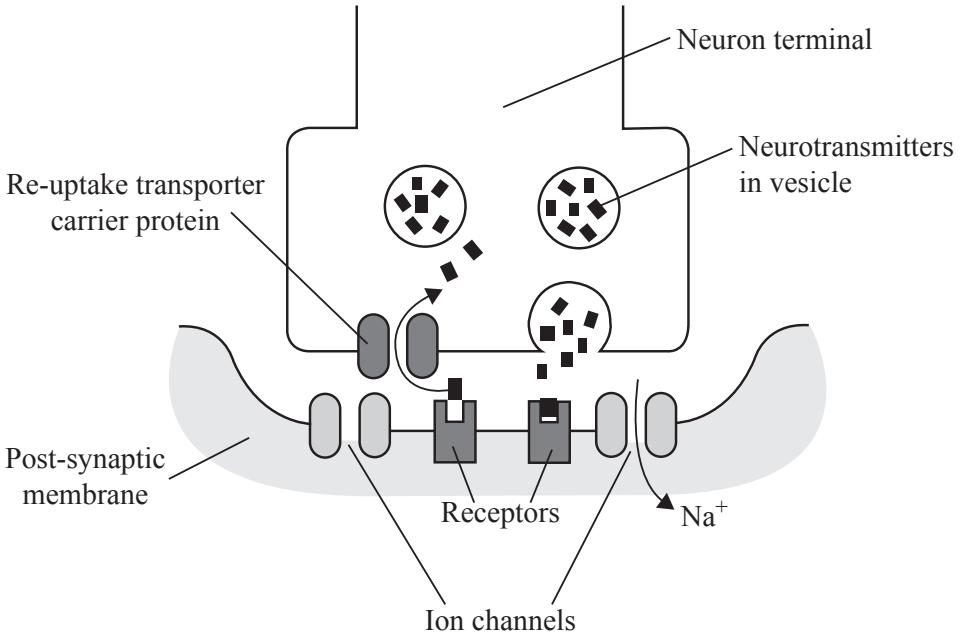
E3. (a) The diagram below shows a synapse where the neurotransmitter is dopamine and some of the processes that take place during nerve transmission.

Explain the effect of cocaine on neurotransmission at a synapse. *[3]*



[Source: Birmingham City University, Faculty of Health http://www.hce.uce.ac.uk/physiology/pharmacology01.htm Reprinted with permission from the Faculty of Health, Birmingham City University, UK.]

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(Question E3 continued)

(b) Explain contralateral processing of visual stimuli. *[3]*

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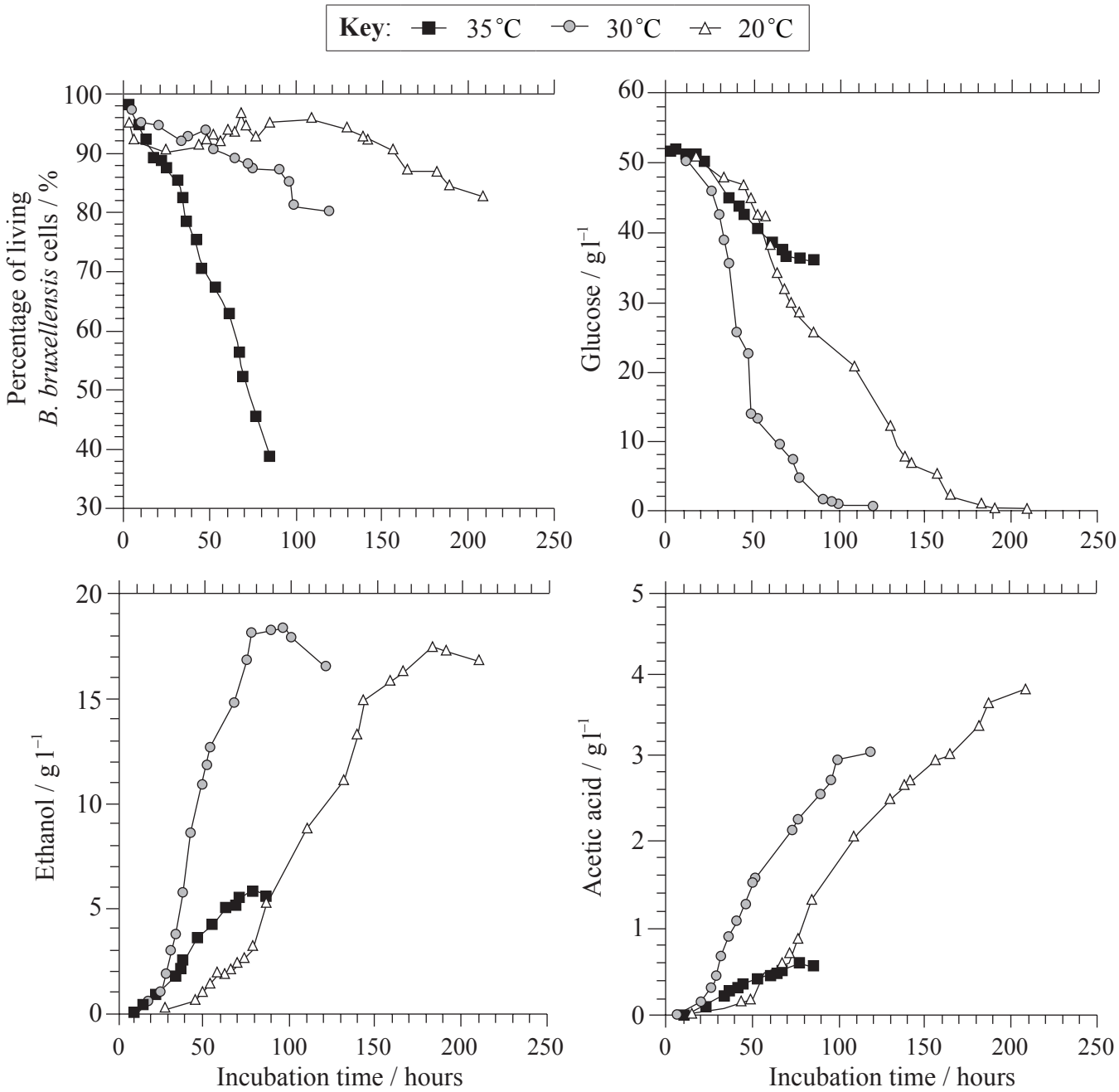
Option F — Microbes and biotechnology

F1. The yeast *Brettanomyces bruxellensis* is a contaminant of wine which when present produces acetic acid, the main component of vinegar. The presence of acetic acid can lead to economic losses as it alters the taste of the wine and inhibits the growth of *Saccharomyces cerevisiae,* thus decreasing the ethanol production. Scientists investigated the effect of changing the temperature in fermentation tanks containing only *Brettanomyces bruxellensis* and a growth medium containing glucose in order to understand the dynamics of this contaminant.



[Source: Cédric Brandam, Claudia Castro-Martínez, Marie-Line Délia, Felipe Ramón-Portugal, Pierre Strehaiano (2008) "Effect of temperature on Brettanomyces bruxellensis: metabolic and kinetic aspects", *Canadian Journal of Microbiology*, vol 54 (1), pp. 11–18 © Canadian Science Publishing or its licensors.]

(This question continues on the following page)

(Question F1 continued)

(a) State the concentration of glucose at 20°C after 110 hours of incubation, giving the units. *[1]*

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(b) State the effect of increasing temperature from 20°C to 30°C on the rate of production of ethanol. *[1]*

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(c) Deduce **one** reason why

(i) there were no more rises in ethanol concentration after 120 hours at 30°C. *[1]*

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(ii) the concentration of ethanol and acetic acid at 35°C does not rise after 80 hours despite the fact that the concentration of glucose is still high. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(d) Discuss the idea of producing wine using a lower temperature range to avoid economic losses due to contamination by yeasts other than *S. cerevisiae*. *[3]*

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F2. (a) Describe how methane can be made from biomass. *[3]*

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(b) Microscopic eukaryotes include *Euglena* and *Paramecium*. Outline the range of cellular structures used for locomotion in these organisms. *[2]*

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F3. (a) Distinguish between Archaea and Eukarya. *[2]*

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(b) Explain the consequences of releasing raw sewage and nitrate fertilizer into rivers. *[4]*

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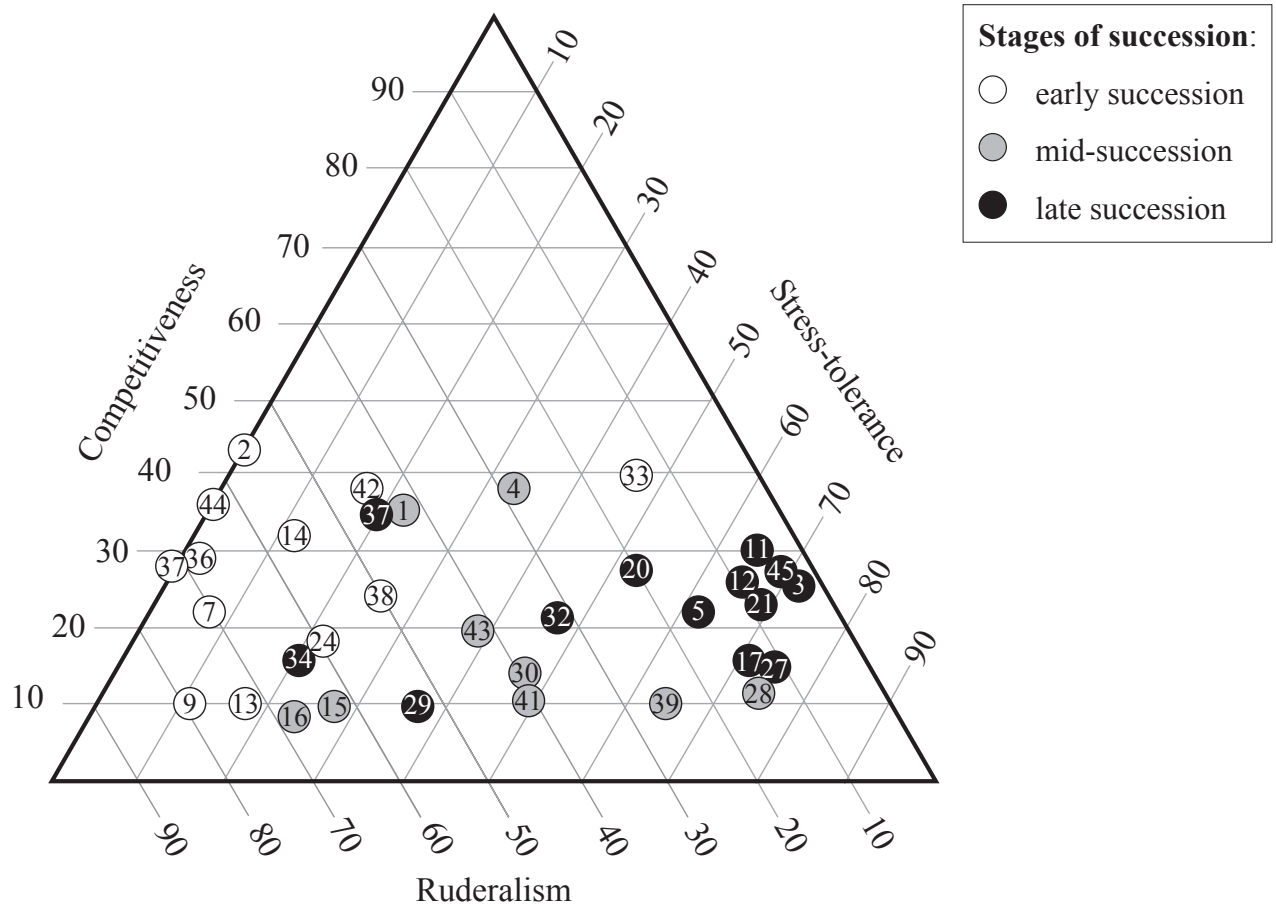
Option G — Ecology and conservation

G1. Scientists studied the characteristics of plant species growing in front of the progressively receding Rutor glacier in Italy. As the ice recedes plants are able to colonize the exposed ground. In a study of primary succession, scientists sampled plants from three areas exposed during different time periods. The data is shown in the following triangle graph.

Each species is represented by a number and positioned according to its degree of competitiveness (the ability to exclude other species), stress-tolerance (the ability to use nutrients efficiently) and ruderalism (the ability to develop rapidly to avoid disturbance).

Stages of succession were classified according to the time the ground had been exposed: early succession (species occurring in ground exposed for less than 68 years), mid-succession (species found in ground exposed between 69 and 181 years) and late-succession (species found in ground exposed for more than 181 years).



[Source: M. Caccianiga et al. (2006) "The functional basis of a primary succession resolved by CSR classification", *OIKOS*, 112, pages 10–20.]

(This question continues on the following page)

(Question G1 continued)

(a) (i) State the most ruderal species. *[1]*

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(ii) Species number 4 has a ruderalism value of 29. State the stress-tolerance value and competitiveness value of this species. *[1]*

Stress-tolerance value: . . . . . .

Competitiveness value: . . . . . .

(b) Analyse the change of species over time. *[3]*

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(c) Pioneer species are often highly ruderal. Suggest **one** reason why pioneer species develop in early succession. *[1]*

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G2. (a) Distinguish between biome and biosphere. *[1]*

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(b) Outline the characteristics of **three named** biomes including temperature, moisture and vegetation. An example has been provided. *[3]*

Biome	Temperature	Moisture	Vegetation
tropical rain forest	***hot, little fluctuation***	***wet***	***evergreen / stratified***

(This question continues on the following page)

(Question G2 continued)

(c) Outline the effect of ultraviolet (UV) radiation on biological productivity. *[2]*

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G3. (a) Discuss the difficulties of classifying organisms into trophic levels. *[2]*

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(b) Explain the cause and consequences of biomagnification, using a **named** example. *[4]*

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