



88146006

**BIOLOGY**
STANDARD LEVEL
PAPER 3

Candidate session number

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Tuesday 11 November 2014 (morning)

Examination code

1 hour

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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.
- A calculator is required for this paper.
- The maximum mark for this examination paper is [36 marks].

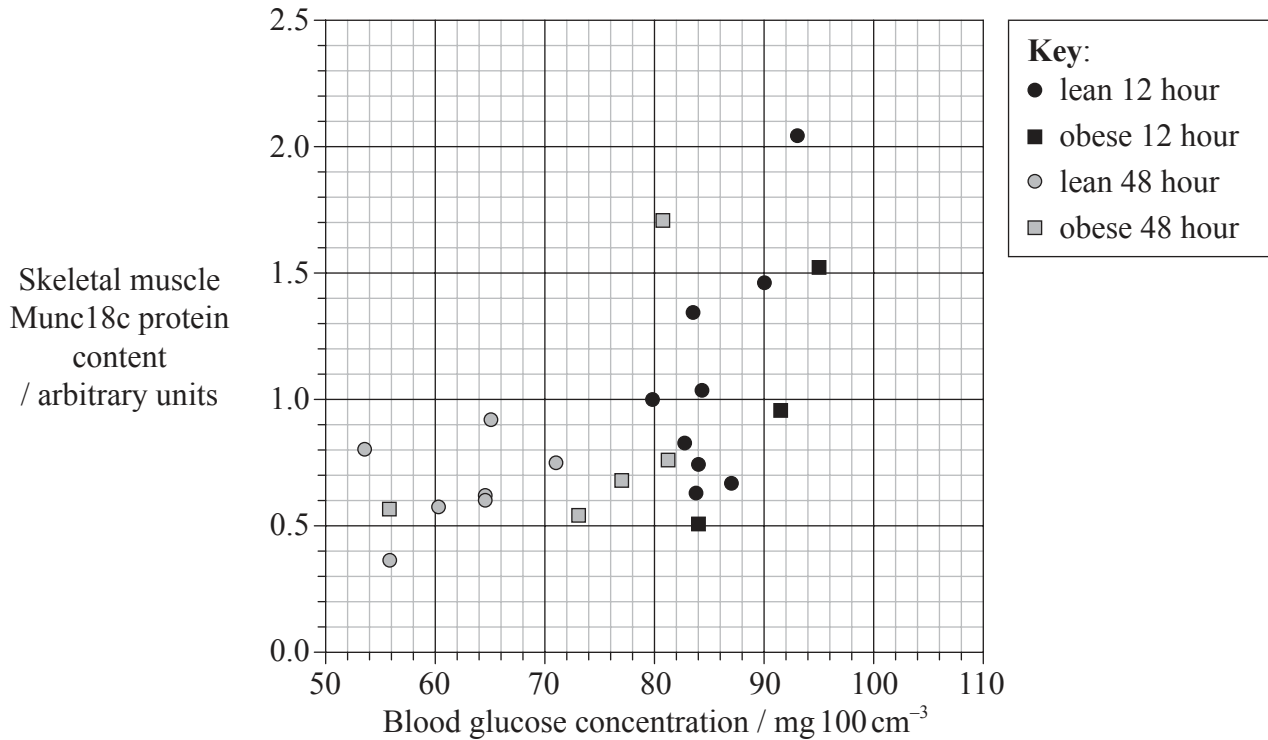
| Option | Questions |
|---------------------------------------|-----------|
| Option A — Human nutrition and health | 1 – 3 |
| Option B — Physiology of exercise | 4 – 6 |
| Option C — Cells and energy | 7 – 9 |
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| Option E — Neurobiology and behaviour | 13 – 15 |
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| Option G — Ecology and conservation | 19 – 21 |



36EP01

Option A — Human nutrition and health

1. Type II diabetes is commonly observed in obese humans. Munc18c is a protein related to insulin-mediated glucose transport in skeletal muscle. A group of lean (BMI <25) and obese (BMI >30) individuals, all non-diabetic, fasted (had no food) for either 12 hours or 48 hours. Blood glucose concentration and skeletal muscle Munc18c protein content were measured at the end of the fasting period in each individual. The results are shown in the graph.



[Source: adapted from B. C. Bergman et al. 'Skeletal muscle munc18c and syntaxin 4 in human obesity' (2008) *Nutrition and Metabolism*, 5 (21).]

- (a) (i) State how body mass index is calculated. [1]

- (ii) Identify the lowest Munc18c protein content in a lean individual after 48 hours of fasting. [1]

..... arbitrary units

(Option A continues on the following page)



36EP02

(Option A, question 1 continued)

- (b) (i) Outline the relationship between blood glucose concentration and Munc18c protein content in obese individuals after 12 hours of fasting. [1]

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- (ii) Compare the overall effects of fasting for 12 hours and 48 hours on the blood glucose concentration. [2]

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- (c) Discuss the hypothesis that obesity is associated with reduced Munc18c protein content. [2]

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(Option A continues on the following page)



36EP03

Turn over

(Option A continued)

2. (a) Describe how the appetite control centre in the brain functions. [2]

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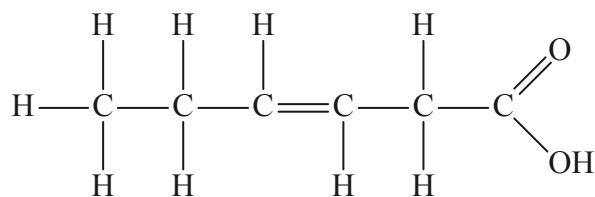
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- (b) Outline the impact of the deficiency of the following components of the human diet. [3]

| Dietary component | Impact of its deficiency in the diet |
|-------------------|--------------------------------------|
| Protein | |
| Vitamin C | |
| Iodine | |

- (c) State the type of fatty acid shown. [1]



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(Option A continues on the following page)



(Option A continued)

3. Food miles are included in the calculation of the total energy input used to produce foods and transport them to the consumer.

The daily per capita total energy input to the US food system was calculated to be

- 23.1 kJ for fats, sugars, snacks and baked goods
- 12.6 kJ for meat and eggs
- 8.0 kJ for fruit and vegetables
- 3.4 kJ for whole grain cereals.

(a) State **two** problems caused by long distance food transport. [1]

1.

2.

(b) Discuss the impact on the environment and human health caused by the consumption of foods with high and low total energy input. [4]

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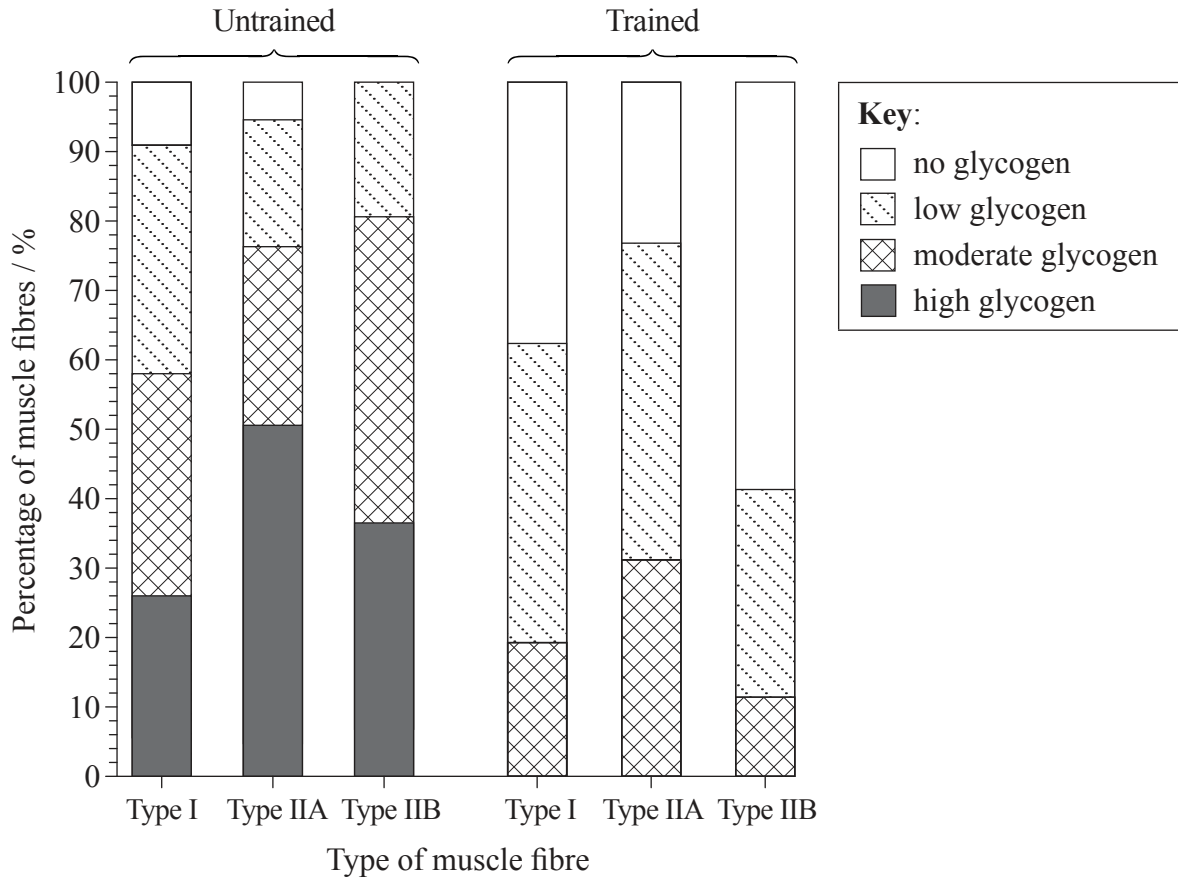
End of Option A



Turn over

Option B — Physiology of exercise

4. In a study to investigate the effect of training on muscles, seven healthy males were subjected to training using the right leg only. They then exercised using both legs and the glycogen content was measured in both the untrained (left leg) and trained (right leg) muscle.



[Source: Sven Asp, Jens R. Dugaard, Søren Kristiansen, Bente Kiens and Erik A. Richter (1998) Exercise metabolism in human skeletal muscle exposed to prior eccentric exercise. *Journal of Physiology*, 509(1), pp. 305–313. doi: 10.1111/j.1469-7793.1998.305bo.x http://onlinelibrary.wiley.com/doi/10.1111/j.1469-7793.1998.305bo.x/abstract. Used with permission.]

- (a) Calculate the percentage of type I muscle fibres containing moderate glycogen in the untrained leg. [1]

..... %

(Option B continues on the following page)



36EP06

(Option B, question 4 continued)

- (b) Distinguish between the results for type I and type IIA muscle fibres in untrained muscles. [2]

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- (c) Describe the impact of training on the glycogen content of the three types of muscle fibres. [3]

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- (d) Based on the data for the trained muscle, deduce with a reason, which type of fibre could be fast muscle fibre. [1]

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(Option B continues on the following page)

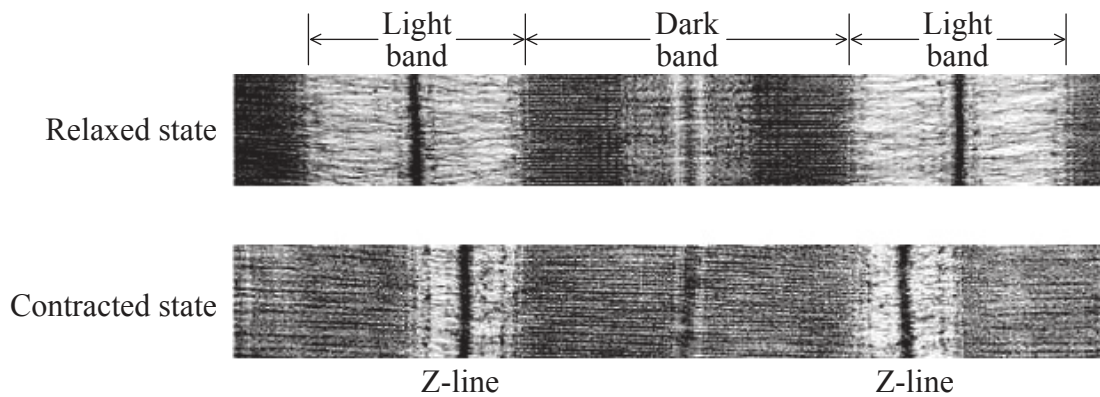


36EP07

Turn over

(Option B continued)

5. (a) The electron-micrograph shows a striated muscle in the relaxed and contracted state.



[Source: <http://www.mrothery.co.uk/images/Imag109.gif>]

(i) State which area has only actin filaments. [1]

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(ii) Analyse the evidence shown on the micrograph that contraction of the muscle is due to the actin and myosin filaments sliding past each other. [2]

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(Option B continues on the following page)



36EP08

(Option B, question 5 continued)

- (b) Distinguish between the movement of the hip joint and the knee joint. [2]

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(Option B continues on the following page)



36EP09

Turn over

(Option B continued)

6. (a) Explain the need for an increase in ventilation rate during exercise. [2]

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- (b) Explain the effects of exercise and of training on cardiac output and heart rate. [4]

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End of Option B



36EP10

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36EP11

Turn over

Option C — Cells and energy

7. Iron (Fe) is the fourth most abundant element in the Earth’s crust but its low bioavailability makes it a limiting nutrient for life. *Chlamydomonas reinhardtii*, a unicellular alga, was grown in light at different concentrations of Fe. The *C. reinhardtii* cells were given either acetate (CH₃CO₂⁻) or carbon dioxide (CO₂) as a carbon source. Measurements were made of cell density (growth) and photosynthetic and respiratory rates with the two carbon sources at different concentrations of Fe.

| Fe / μM | Cells grown with acetate | | | Cells grown with CO ₂ | | |
|---------|---|--|--|---|--|--|
| | Cell density after 10 days of growth / cells cm ⁻³ | Rate of O ₂ production in photosynthesis / arbitrary units per cell | Rate of O ₂ consumption in respiration / arbitrary units per cell | Cell density after 10 days of growth / cells cm ⁻³ | Rate of O ₂ production in photosynthesis / arbitrary units per cell | Rate of O ₂ consumption in respiration / arbitrary units per cell |
| 0.1 | 6 × 10 ⁶ | 3.1 | -2.1 | 2 × 10 ⁶ | 5.2 | -0.8 |
| 0.2 | 1 × 10 ⁷ | 3.4 | -1.9 | 4 × 10 ⁶ | 5.9 | -0.8 |
| 1.0 | 2 × 10 ⁷ | 4.9 | -1.9 | 7 × 10 ⁶ | 6.0 | -0.6 |
| 20 | 2 × 10 ⁷ | 6.7 | -2.5 | 7 × 10 ⁶ | 6.1 | -0.7 |

[Source: Reproduced with permission of Springer from Aimee M. Terauchi, Graham Peers, Marilyn C. Kobayashi, Krishna K. Niyogi and Sabeeha S. Merchant (2010) Trophic status of *Chlamydomonas reinhardtii* influences the impact of iron deficiency on photosynthesis. *Photosynthesis Research*, **105** (1), pp. 39–49; permission conveyed through Copyright Clearance Center.]

(a) Calculate the difference in cell density between cells grown in 0.1 μM and 0.2 μM Fe, with acetate as the carbon source. [1]

..... cells cm⁻³

(Option C continues on the following page)



(Option C, question 7 continued)

- (b) Deduce, with a reason, the concentration below which Fe becomes a limiting factor for cell growth. [1]

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- (c) Describe the impact of Fe concentration on photosynthesis and respiration rates in cells grown with CO₂. [2]

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- (d) Using all of the data, evaluate the impact of iron deficiency on *C. reinhardtii* when grown with acetate and with CO₂. [3]

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(Option C continues on the following page)



36EP13

Turn over

(Option C continued)

8. (a) Define *oxidation*.

[1]

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(b) Distinguish between light-dependent and light-independent reactions in photosynthesis. [2]

| | Light-dependent reactions | Light-independent reactions |
|----------------|----------------------------------|------------------------------------|
| Location | | |
| Major products | | |

(c) Outline the significance of non-polar and polar amino acids in proteins.

[2]

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(Option C continues on the following page)



(Option C continued)

9. (a) Outline non-competitive inhibition of enzymes and the role of allosteric sites. [2]

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- (b) Explain the control of metabolic pathways by end-product inhibition. [4]

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End of Option C



36EP15

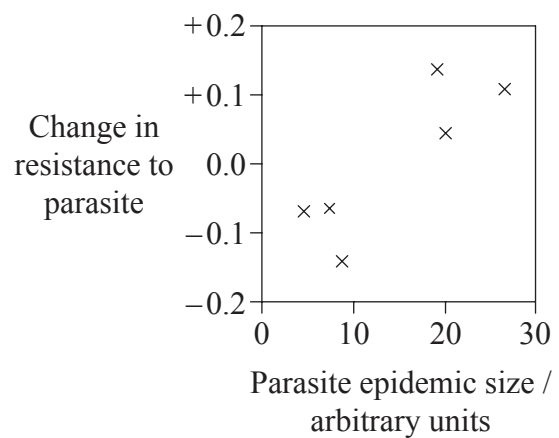
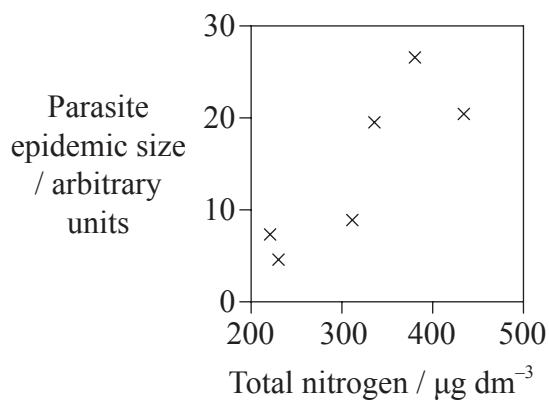
Turn over

Option D — Evolution

10. The yeast *Metschnikowia bicuspidata* is a parasite of a species of zooplankton, *Daphnia dentifera*. Biologists monitored the infections of *D. dentifera* populations in a series of lakes in Indiana (USA). An increase in nitrogen compounds dissolved in the lakes causes the phytoplankton populations to increase. *D. dentifera* feed on phytoplankton.

The graphs show the

- relationship between nitrogen levels dissolved in the water and the size of the parasite epidemic in the *D. dentifera* population.
- relationship between the size of the parasite epidemic in the *D. dentifera* population and the change in the resistance (established by comparing the infection of the *D. dentifera* populations before and after the epidemic).



[Source: From Meghan A. Duffy, Jessica Housley, Rachel M. Penczykowski, David J. Civitello, Christopher A. Klausmeier and Spencer R. Hall (2012) ‘Ecological context influences epidemic size and parasite-driven evolution.’ *Science*, **335**, pp. 1636–1638. DOI: 10.1126/science.1215429. Reprinted with permission from AAAS.

Readers may view, browse, and/or download material for temporary copying purposes only, provided these uses are for noncommercial personal purposes. Except as provided by law, this material may not be further reproduced, distributed, transmitted, modified, adapted, performed, displayed, published, or sold in whole or in part, without prior written permission from the publisher.]

(a) State the value of the change in resistance to the parasite when the parasite epidemic size is 14 arbitrary units. [1]

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(b) State the relationship between total nitrogen and parasite epidemic size. [1]

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(Option D continues on the following page)



36EP16

(Option D, question 10 continued)

- (c) Suggest reasons for the parasite epidemic size increasing with increases in the total nitrogen of the lakes. [2]

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- (d) Outline, according to the theory of natural selection, how increased size of the parasite epidemic in the *D. dentifera* will result in the evolution of increased resistance to the parasite. [2]

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Predatory fish tend to eat infected *D. dentifera* more than uninfected *D. dentifera*.

- (e) Predict the effect of predation by fish on the level of resistance to the parasite in the *D. dentifera* populations. [2]

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(Option D continues on the following page)



36EP17

Turn over

(Option D continued)

11. (a) (i) State **two** possible locations where the synthesis of organic compounds on prebiotic Earth could have originated. [2]

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| 1. |
| 2. |

- (ii) State **one** property of RNA that would have allowed it to play a role in the origin of life. [1]

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- (b) Increase in the brain size of hominids has allowed for cultural evolution. Outline possible relationships between brain size, change in diet and cultural evolution. [2]

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- (c) State **two** different species that may have coexisted at the same time during hominid evolution. [1]

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(Option D continues on the following page)



(Option D continued)

12. Explain how divergent evolution may contribute to speciation.

[4]

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End of Option D



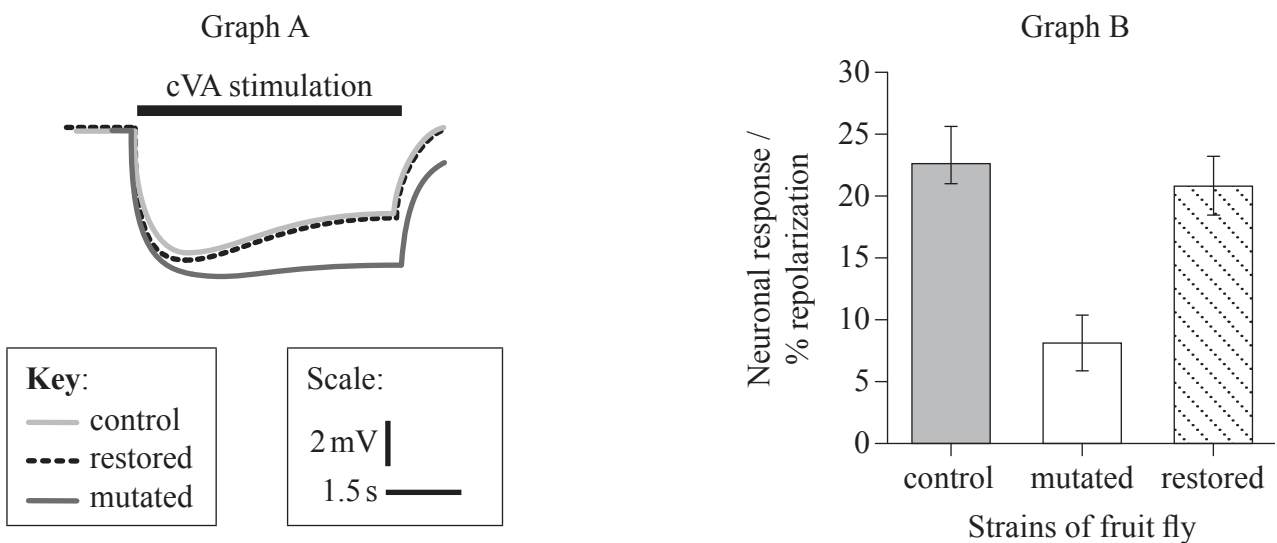
36EP19

Turn over

Option E — Neurobiology and behaviour

13. Male fruit flies, *Drosophila melanogaster*, produce an extracellular enzyme, carboxylesterase, that degrades a pheromone (cVA) made in the male antenna. The role of this enzyme was studied using three different strains of *Drosophila*
- control: a strain with normal carboxylesterase activity
 - mutated: a strain without carboxylesterase activity
 - restored: a mutated strain with restored carboxylesterase activity.

Response to cVA by male antenna olfactory receptors were measured. Graph A shows the average depolarization and repolarization of the three strains when exposed to cVA. Graph B shows the percentage of repolarization of the receptors at the end of the exposure to cVA.



[Source: adapted from T. Cherteremps *et al.* A carboxylesterase, Esterase-6, modulates sensory physiological and behavioral response dynamics to pheromone in *Drosophila*' (2012) *BMC Biology* 2012, 10, p. 56.]

- (a) (i) Using graph A, measure the length of time of the application of cVA. [1]

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(Option E continues on the following page)



(Option E, question 13 continued)

- (ii) Using graph A, compare the responses of the three strains. [2]

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- (b) Using graph B, distinguish between the percentage of repolarization of the three strains. [2]

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- (c) Suggest the role of carboxylesterase in the behaviour of the *Drosophila*. [1]

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In the study, it was observed that the courtship behaviour was strongly reduced in the mutated strain when compared to the control strain.

- (d) Suggest an application of this data in insect pest management. [1]

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(Option E continues on the following page)



36EP21

Turn over

(Option E continued)

14. (a) List the sequence of the components of a reflex arc for a pain withdrawal reflex. [3]

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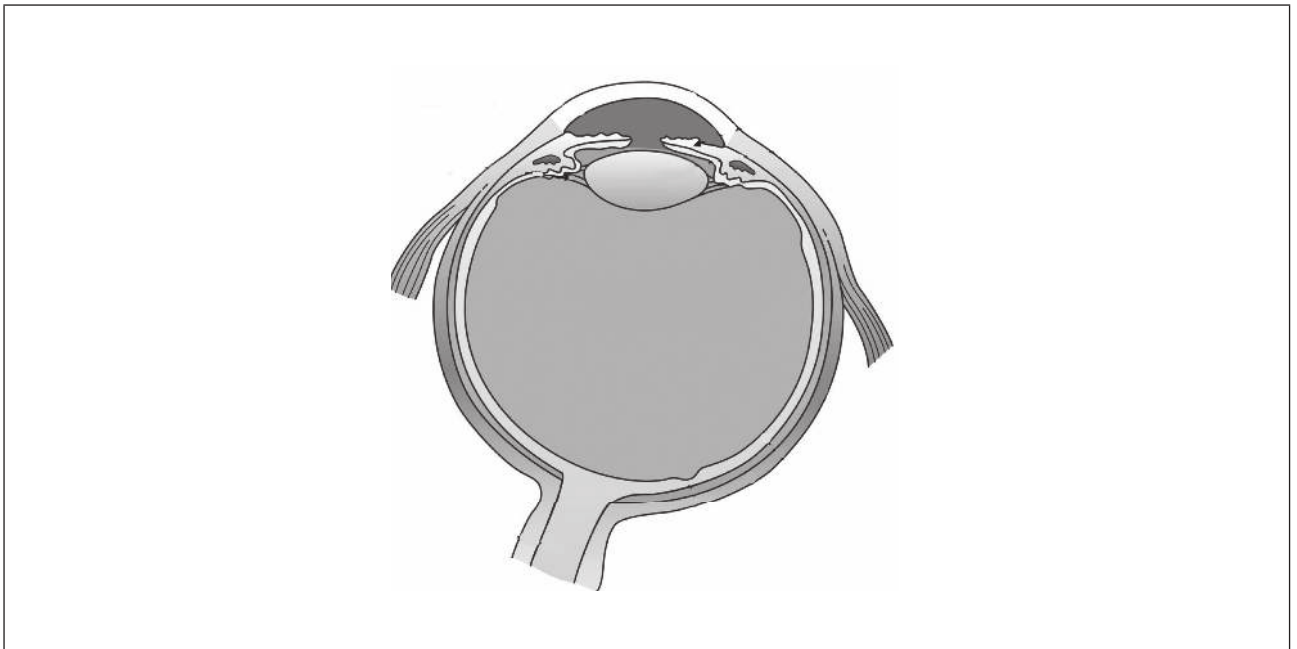
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- (b) Label the blind spot and the aqueous humour on the diagram of the eye. [1]



[Source: http://upload.wikimedia.org/wikipedia/commons/8/8a/Three_Internal_chambers_of_the_Eye.png]

- (c) Outline the innate behaviour of kinesis in invertebrates. [1]

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(Option E continues on the following page)



36EP22

(Option E continued)

15. (a) List **two** inhibitory psychoactive drugs. [2]

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| 1. |
| 2. |

(b) Discuss **two** possible causes of addiction in humans. [4]

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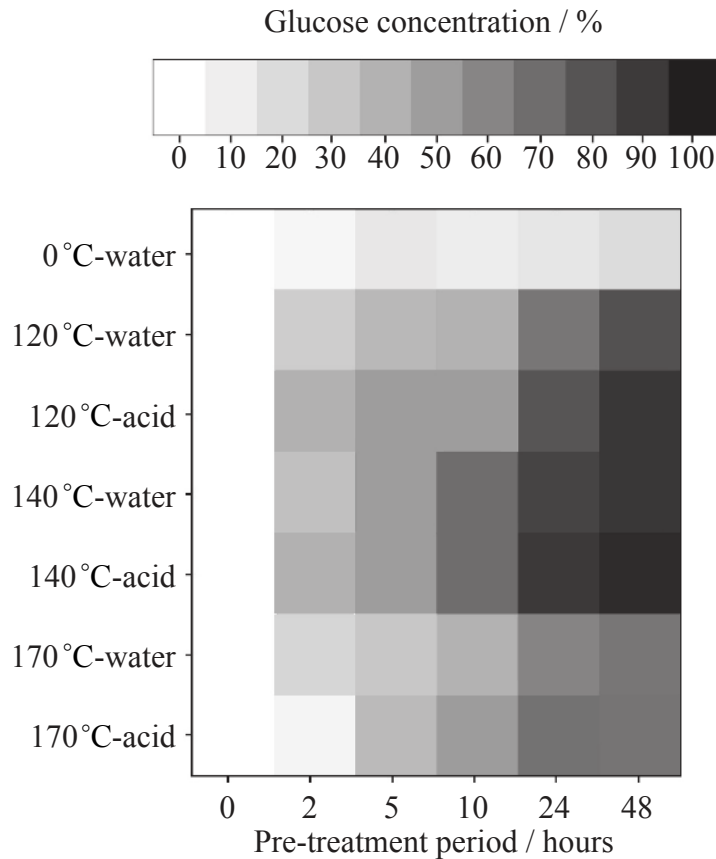


36EP23

Turn over

Option F — Microbes and biotechnology

16. Yeast can break down sugar beet pulp (SBP) to bioethanol through fermentation. However, the SBP requires pre-treatment to break down complex polysaccharides before the yeast can convert them into glucose. Pre-treatments at three different temperatures, with water and with acid, were carried out. The products were sampled over a period of 48 hours to determine which pre-treatments were more efficient.



[Source: adapted from Stefan Kühnel, Henk A. Schols and Harry Gruppen (2011) 'Aiming for the complete utilization of sugar-beet pulp: examination of the effects of mild acid and hydrothermal pretreatment followed by enzymatic digestion.' *Biotechnology for Biofuels*, 4 (14).]

(a) (i) Identify the glucose concentration at 170°C-water at two hours pre-treatment. [1]

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|---------|
| % |
|---------|

(Option F continues on the following page)



36EP24

(Option F, question 16 continued)

(ii) Distinguish between the effects of the water and the acid treatments at 120°C. [1]

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(b) Scientists hypothesized that the best conditions for pre-treatment were acid at 140°C. Evaluate this hypothesis using the data provided. [2]

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(c) Suggest a reason why the use of acid may not be justified in this process. [2]

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(Option F continues on the following page)



36EP25

Turn over

(Option F continued)

17. (a) Outline the characteristics of the following microscopic eukaryotes.

[2]

| Characteristic | <i>Amoeba</i> | <i>Euglena</i> |
|-----------------------|---------------|----------------|
| Mode of nutrition | | |
| Mode of locomotion | | |

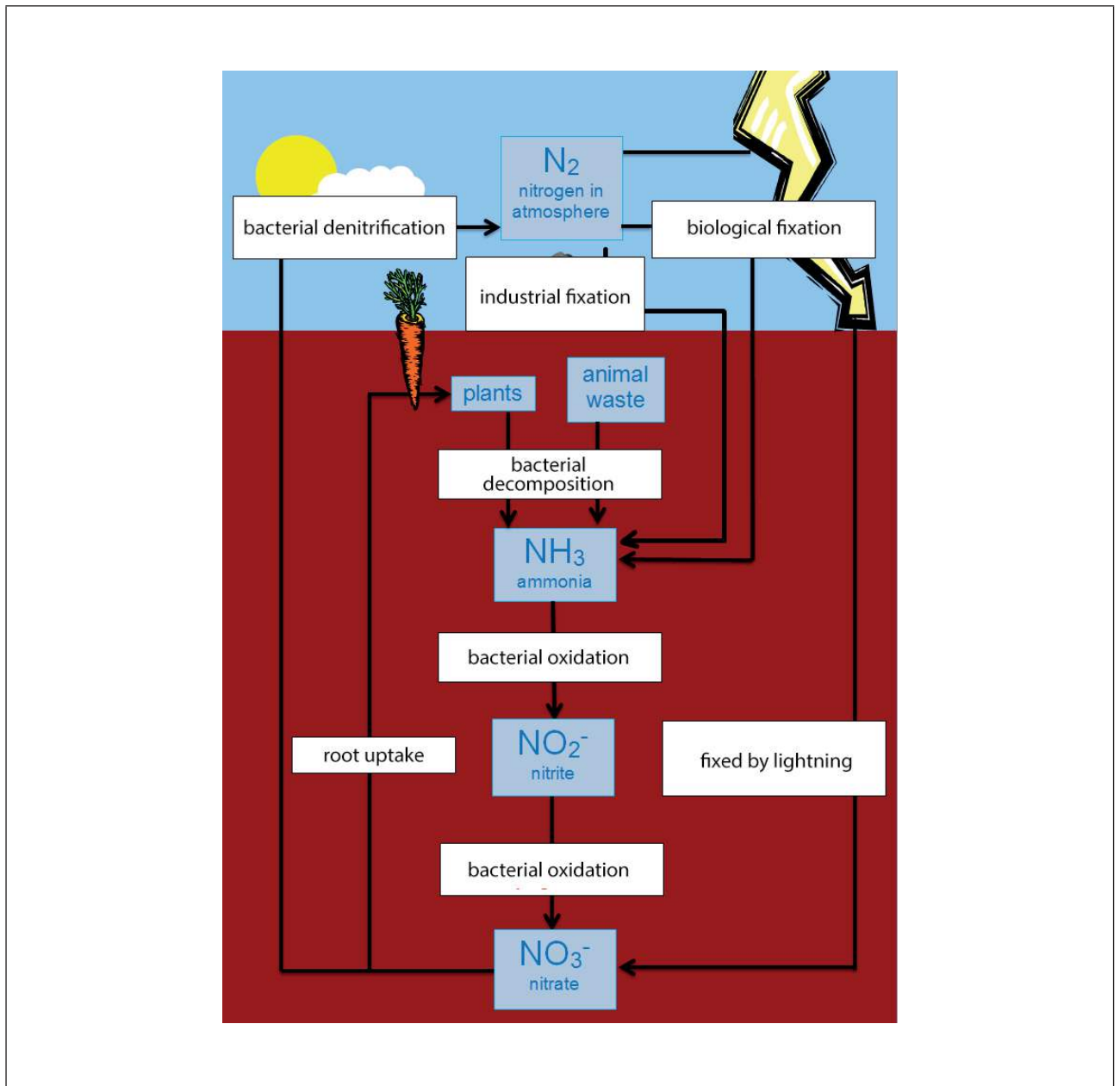
(Option F continues on the following page)



36EP26

(Option F, question 17 continued)

(b) The diagram shows a nitrogen cycle.



[Source: Adapted from http://en.wikipedia.org/wiki/Nitrogen_cycle#mediaviewer/File:The_Nitrogen_Cycle.png by Roseramona]

On the diagram identify the processes where the following bacteria act.

(i) *Rhizobium* X (label with X) [1]

(ii) *Nitrobacter* Y (label with Y) [1]

(Option F continues on the following page)



36EP27

Turn over

(Option F, question 17 continued)

- (c) Outline the use of *Saccharomyces* in the production of beer. [2]

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18. (a) (i) State the role of reverse transcriptase. [1]

.....

- (ii) State a virus that produces reverse transcriptase. [1]

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(Option F continues on the following page)



(Option F, question 18 continued)

(b) Explain the use of reverse transcriptase in molecular biology.

[4]

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End of Option F

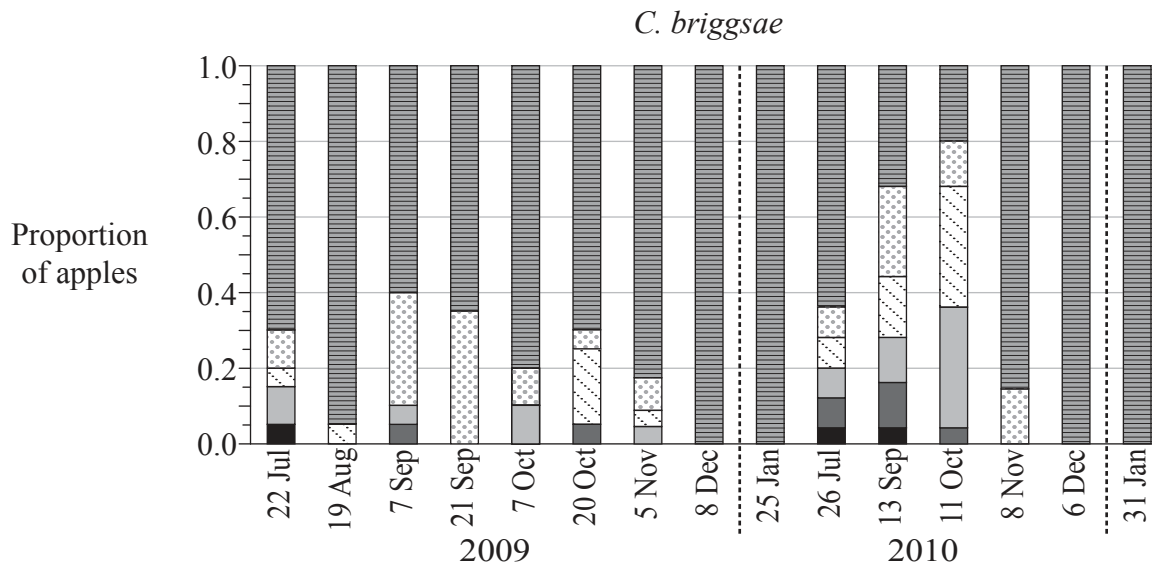
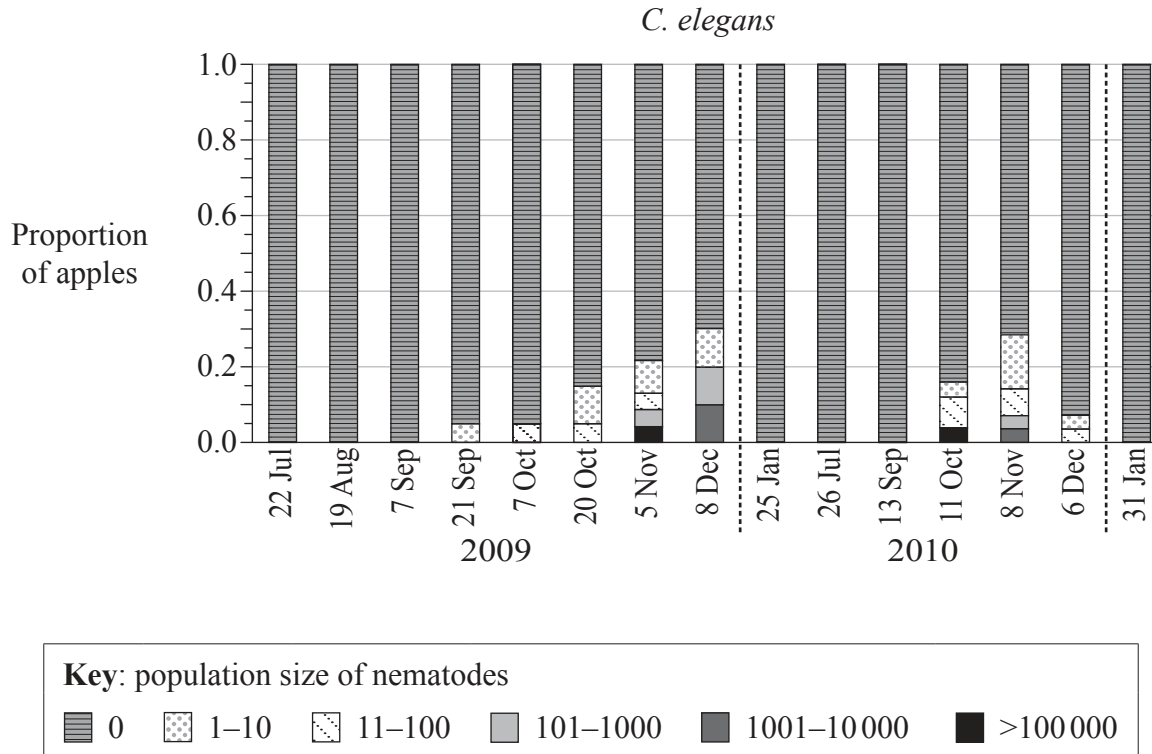


36EP29

Turn over

Option G — Ecology and conservation

19. *Caenorhabditis elegans* and *Caenorhabditis briggsae* are two species of nematode that co-exist in rotting plant material. A study was conducted in France to determine the relative population of each species in samples of apples.



[Source: Marie-Anne Félix and Fabien Duveau (2012) 'Population dynamics and habitat sharing of natural populations of *Caenorhabditis elegans* and *C. briggsae*.' *BMC Biology*, 10: 59.]

(Option G continues on the following page)



36EP30

(Option G, question 19 continued)

- (a) State the proportion of apples infected with 1–10 *C. briggsae* on 7 October 2009. [1]

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- (b) Distinguish between the trends in *C. elegans* and *C. briggsae* during the study. [3]

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The summer months in France are June, July and August. Autumn is September, October and November and winter is December, January and February.

- (c) The seasonal changes in temperature may affect the size of the populations of the two nematodes. Analyse the data to support this hypothesis. [2]

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(Option G continues on the following page)



36EP31

Turn over

(Option G, question 19 continued)

(d) Suggest, with a reason, the type of interaction that may exist between the two nematodes. [1]

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(Option G continues on the following page)



36EP32

(Option G continued)

20. (a) State the characteristics of a

(i) biome.

[1]

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.....

(ii) biosphere.

[1]

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(b) Calculate the gross production of an aquatic ecosystem that has a net primary production of $96 \text{ kJ m}^{-2} \text{ y}^{-1}$ and a respiration rate of $45 \text{ kJ m}^{-2} \text{ y}^{-1}$, giving the units.

[1]

.....

(c) Describe what is meant by the niche concept.

[2]

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(Option G continues on the following page)



36EP33

Turn over

(Option G continued)

21. (a) Outline **one** example of the release of a **named** alien species. [2]

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(b) Discuss the impacts of alien species on ecosystems. [4]

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End of Option G



36EP34

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36EP35

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36EP36