Biology
Higher level
Paper 3

Thursday 5 May 2016 (morning)

Instructions to candidates
• Write your session number in the boxes above.
• Do not open this examination paper until instructed to do so.
• Section A: answer all questions.
• Section B: answer all of the questions from one 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 [45 marks].

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Answer all questions. Write your answers in the boxes provided.

1. Increasing carbon dioxide concentration in the atmosphere leads to acidification of the ocean. This in turn reduces the amount of dissolved calcium carbonate. A study was undertaken to investigate the effect of increasing the concentration of atmospheric carbon dioxide on the calcification rate of marine organisms. Calcification is the uptake of calcium into the bodies and shells of marine organisms. The study was undertaken inside Biosphere-2, a large-scale closed mesocosm. The graph shows the results of the data collection.

![Graph showing relationship between pCO₂ and calcification rate.](source)

(a) State the relationship between atmospheric carbon dioxide and calcification rates.  

(b) Suggest one advantage of using a mesocosm in this experiment.  

(This question continues on the following page)
(Question 1 continued)

(c) Outline one way in which reef-building corals are affected by increasing atmospheric carbon dioxide. [2]
2. The image shows a severed aphid stylet embedded in plant tissue.

(a) Identify the tissue labelled II. [1]

(b) Outline one piece of evidence that the tissue labelled I is phloem tissue. [1]

(This question continues on the following page)
(Question 2 continued)

(c) Explain how aphid stylets can be used to study the movement of solutes in plant tissues. [3]
3. Achieving successful rooting of cuttings is difficult in some shrub species. An experiment was undertaken to determine whether juvenile shoots (J) of shrubs root more successfully than mature shoots (M).

![Graph showing rooting success percentages for different shrub species.]

**Rooting success (%)**

- Arbutus unedo
- Laurus nobilis
- Myrtus communis
- Olea europaea
- Phillyrea latifolia
- Pistacia lentiscus
- Viburnum tinus

**Key:** ○ mature shoots (M) ● juvenile shoots (J)

[Source: "Effects of rejuvenation on cutting propagation of Mediterranean shrub species" by G. Pignatti and S. Crobeddu, *Forest@*, vol. 2, pp. 290-295 (Sep 2005): Figure 3. Used with permission.]

(a) Distinguish between the rooting success of the juvenile shoots and the mature shoots. [1]

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(This question continues on the following page)
(Question 3 continued)

(b) Suggest **one** reason for the difference in the rooting success in the juvenile shoots and the mature shoots. [1]

(c) Outline **one** variable that would need to be controlled in this experiment. [1]

(d) Auxin is a hormone that can be applied to improve the percentage success of rooting in those study plants with poor rooting success. **Explain the effects of auxin on plant cells.** [3]
Section B

Answer all of the questions from one of the options. Write your answers in the boxes provided.

Option A — Neurobiology and behaviour

4. Synaptic density is the number of synapses per unit volume. The graph shows the synaptic density for a 28-week-old fetus, and from birth to age 70.

[Graph showing synaptic density from 28-week fetus to age 70 with data points at various ages and synaptic density values.]


(a) (i) Determine the age when synaptic density is highest. [1]

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(ii) Explain how synaptic density decreases after the age determined in (a)(i). [3]

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(Option A continues on the following page)
(Option A, question 4 continued)

(b) Label the diagram of the reflex arc with the names of the neurons indicated. \[2\]

(c) Draw an arrow on the diagram of the reflex arc to show the direction of impulses. \[1\]
5. The scatter graph shows the relationship between brain mass and body mass for a number of animals. Some representative animals are indicated while the dotted line represents the range of values seen for a much larger group of animals.

(a) State the relationship between body mass and brain mass. [1]

(b) Identify the animal with the lowest brain mass. [1]
(Option A, question 5 continued)

(c) Discuss the evidence provided by the scatter graph for the hypothesis that humans have the largest relative brain mass to body mass ratio.

[3]

(Option A continues on the following page)
6. The graphs compare the changes in membrane potential that result from a combination of stimuli. Graph A shows two excitatory post-synaptic potentials (E₁ and E₂) acting on a neuron. Graph B shows one excitatory (E₁) and one inhibitory (I₁) post-synaptic potential, both acting on a neuron.

![Graph A and Graph B](image)

With respect to the graphs, explain what is meant by summation. [3]

[Source: © International Baccalaureate Organization 2016]
(Option A continued)

7. (a) With respect to Pavlov’s experiments with dogs, distinguish between the conditioned and unconditioned stimulus. [3]

(b) The bird known as the blackcap (*Sylvia atricapilla*) traditionally migrates from its summer breeding grounds in Central Europe to Spain and Portugal for the winter. State two adaptive advantages of bird migration. [2]

(c) Outline one way in which synchronized oestrus in female lions increases the chances of survival and reproduction of offspring. [2]

(Option A continues on the following page)
(Option A, question 7 continued)

(d) Outline one way in which neurons can be altered by memory and learning. [2]

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(Option A continues on the following page)
(Option A continued)

8. Explain how colour in the environment is detected by the eyes and relayed to the brain in humans. [6]
Option B — Biotechnology and bioinformatics

9. Succinate is industrially produced by continuous fermentation. It is used as a raw material in the production of flavour enhancers, drugs and industrial chemicals. One method of increasing the production of succinate is to genetically modify *E. coli* to express high levels of formate dehydrogenase (FDH1). This results in the production of higher concentrations of NADH. The engineered pathway is shown as a bold dotted line in the image.

![Diagram of metabolic pathway involving glucose, formate, NADH, andsuccinate production]

[Source: Ka-Yiu San, E. D. Butcher Professor of Bioengineering, Professor of Chemical Engineering, Rice University.]

(a) Using the diagram, suggest a reason for high concentrations of NADH favouring the production of succinate. [1]

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_manifested into lines_ (Option B continues on the following page)
(Option B, question 9 continued)

(b) Predict one metabolite other than succinate that will be produced in greater amounts if the amount of NADH available is increased. [1]

(c) Outline the process of continuous culture fermentation. [2]

(d) Outline one reason this process, to increase the production of succinate, represents pathway engineering. [1]
10. Annual ryegrass (*Lolium rigidum*) is a weed species that has been successfully controlled by the application of the herbicide glyphosate. The graph shows the number of confirmed cases of glyphosate resistant ryegrass across Australia between 1996–2012.

![Graph showing the number of resistant populations of ryegrass over time in Australia.](source: adapted from www.grdc.com.au)

(a) (i) Outline the pattern of change in resistant populations of ryegrass over time in Australia. [1]

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(ii) Suggest one reason for the pattern. [1]

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(Option B continues on the following page)
(Option B, question 10 continued)

(b) State two environmental benefits from the use of genetically modified glyphosate resistant soybeans. [2]

(c) Explain the role of the *Agrobacterium tumefaciens* Ti plasmid in genetic modification. [3]

(Option B continues on page 21)
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Answers written on this page will not be marked.
11. The dye Reactive Black 5 (RB5) is widely used for dyeing in textile industries. Removal of the dye from factory waste-water is important not only for aesthetic reasons but also because the dye can lead to mutations that may lead to cancer. *Paenibacillus* is a bacterium that can metabolize the dye.

(a) Suggest one way in which organisms such as *Paenibacillus* metabolize toxic substances. [1]

(b) The decontamination system for the removal of the dye uses a surface to which *Paenibacillus* can attach. Suggest one advantage of providing a surface for attachment. [1]

(c) Outline another named example of a microorganism used in bioremediation. [3]
12. International agreement limits the hunting of whales. Only the meat of the Minke, Fin and Humpback whales from Southern Hemisphere populations is allowed to be sold on the domestic market in Japan. Scientists obtained five samples of food that were being sold as “whale meat” in a Japanese market place. They identified the species and probable geographic origin of the meat using genetic analysis. The results were used to construct the cladogram.

![Cladogram]

100% Minke whale (Antarctic)
  Minke whale (Australia)

Minke whale (north Atlantic)
  sample 1

98% Humpback whale (north Atlantic)
  Humpback whale (north Pacific)
  sample 2

>92% sample 3
  Fin whale (Mediterranean)
  Fin whale (Iceland)

92% sample 4
  sample 5
  Hector’s dolphin
  Commerson’s dolphin

[Source: Adapted from C. S. Baker and S. R. Palumbi (1994), Science, 256 (5178), pages 1538–1539. (http://www.soest.hawaii.edu/oceanography/courses_html/OCN331/Baker%26Palumbi.pdf). 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 or classroom 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) Using the data in the cladogram, state the reason for sale of Sample 1 meat being illegal in Japan.

[1]
(Option B, question 12 continued)

(b) Using the data in the cladogram, state the reason for sale of Sample 4 meat being illegal in Japan. [1]

(c) Outline how the polymerase chain reaction (PCR) might have been used in this study. [3]

(d) Explain how sequence alignment software might have been used in this study. [2]

(Option B continues on the following page)
13. Explain how infection by a pathogen can be detected by an ELISA test for antigens. [6]
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Answers written on this page will not be marked.
14. Where high amounts of ammonium ions are present in agricultural areas, gaseous ammonia can be released into the atmosphere. This ammonia can dissolve and be carried across distances and then be deposited through precipitation. In a study of the effects of deposition of ammonium in a forest, soil samples were taken starting at the forest edge next to an open field and moving toward the centre of the forest.

![Graph showing soil ammonia levels](image)


(a) Outline the procedure that was most likely used by the researchers to decide where to take the samples. [2]
(Option C, question 14 continued)

(b) List two sources of the ammonium in the forest soils apart from deposition in rainfall. [2]

(c) Suggest one reason for ammonium levels in the interior of the forest being lower than the soil ammonium close to the edge. [1]
15. The figure shows the distribution of two species of freshwater flatworms, *Planaria gonocephala* and *Planaria montenegrina*, over a range of stream temperatures. Graph A and graph B show the distributions when each species is separate from the other. Graph C shows the distribution when they are found living together.

![Graph A](Image)

![Graph B](Image)

![Graph C](Image)


(a) Using graph A and graph B, compare and contrast the temperature ranges of the two species when they are found separately.

..."
(Option C, question 15 continued)

(b) Explain, with respect to the example of *P. montenegrina*, what is meant by realized niche. [2]

(Option C continues on the following page)
16. The graph is a model showing biomass and respiration levels in a field where farming stops at time zero and the abandoned land develops into forest.

![Graph of Forest succession showing biomass and respiration levels over 100 years.](image)


(a) Describe the change in biomass over the 100 year period. [2]

(b) Outline the evidence from the graph that the area had plentiful rainfall. [2]
(Option C, question 16 continued)

(c) Explain the changes in biomass.  

(d) Explain why biomass continues to increase after the respiration levels plateau.
17. The Laysan Albatross (*Phoebastria immutabilis*) sometimes ingests plastic. A bolus is a pellet made of material that the albatross cannot digest, so brings it back up from its stomach to its mouth and then ejects the indigestible matter. Graph A indicates the mass of indigestible natural material, such as bones and octopus beaks, in the bolus of birds at two different locations. Graph B indicates the mass of plastic in the bolus at both locations.

![Graph A](image1)

![Graph B](image2)


(a) Suggest one reason for the Laysan Albatross ingesting indigestible plastic.

(b) Suggest a reason for the difference in ingested plastic in the diets of the Laysan Albatross in the two locations.
(Option C, question 17 continued)

(c) Outline the origin of microplastic debris in the marine environment. [2]

(d) Using microplastics as an example, outline the concept of biomagnification. [2]
(Option C continued)

18. Evaluate the methods used to estimate populations of marine organisms. [6]
Option D — Human physiology

19. The table summarizes the relative content of essential amino acids in different foods. Cysteine and tyrosine are classified as being "conditionally essential". The quantity of each amino acid in a hen egg is set as 1.0 and all other values are relative to the hen egg standard.

<table>
<thead>
<tr>
<th></th>
<th>Hen egg</th>
<th>Human milk</th>
<th>Cow milk</th>
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</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Leucine</td>
<td>1.0</td>
<td>1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Valine</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Threonine</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Methionine and Cysteine</td>
<td>1.0</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.0</td>
<td>1.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Lysine</td>
<td>1.0</td>
<td>1.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Phenylalanine and Tyrosine</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Histidine</td>
<td>1.0</td>
<td>0.9</td>
<td>1.1</td>
</tr>
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[Source: Data obtained from Robert McGilvery, Biochemistry: A Functional Approach, 1970, W. B. Saunders.]

(a) Outline what is meant by the term essential amino acid. [2]
(Option D, question 19 continued)

(b) Phenylalanine is converted to tyrosine by the enzyme phenylalanine hydroxylase.

\[
\begin{align*}
\text{Phenylalanine} & \xrightarrow{\text{Phenylalanine hydroxylase}} \text{Tyrosine} \\
\end{align*}
\]

(i) Deduce the reason that tyrosine is considered to be a conditionally essential amino acid.

(ii) When infants with the condition phenylketonuria (PKU) are left untreated, they have a build-up of phenylalanine in the blood and high levels of phenylalanine in the urine. State the cause of this condition.

(c) Evaluate human milk as an overall source of essential amino acids.
(Option D, question 19 continued)

(d) Outline the control of milk secretion by oxytocin and prolactin. [3]

(e) The diagram represents a lobule from a mammary gland. The mammary gland is an example of an exocrine gland.

[Source: Luis A Bate, Professor of Physiology and Ethology, University of Prince Edward Island. Used with permission.]

Identify two features of an exocrine gland visible in the diagram. [2]

(Option D continues on the following page)
(Option D continued)

20. The graph shows the length of time that the content of a meal takes to pass through the gut as a function of digestible matter content. The more digestible matter present in the meal, the lower the dietary fibre content.

Mean residence time / h

[Source: © International Baccalaureate Organization 2016]

(a) Estimate the mean residence time of a meal with 50% digestible matter. [1]

(Option D continues on the following page)
(Option D, question 20 continued)

(b) Explain the relationship between percentage of digestible matter and mean residence time. [3]

(Option D continues on the following page)
21. The diagram shows an ECG trace with the QRS complex indicated.

(a) Outline the events of the cardiac cycle that are occurring during this QRS interval. [2]

(b) Heart rate is affected by the hormone epinephrine. The action of epinephrine is mediated by a chemical called a second messenger. Explain the mechanism of action of a second messenger. [3]
(Option D, question 21 continued)

(c) During cardiac arrest, the ventricles of the heart might begin to contract in an uncoordinated fashion. Outline the treatment used for this condition. [1]

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(d) Explain the role of chemoreceptors in the regulation of ventilation rate. [3]

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(Option D continues on the following page)
22. Outline the ways in which the liver regulates the chemical and cellular composition of the blood. [6]
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