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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

Tuesday 11 November 2014 (morning)

1 hour 15 minutes

Examination code

8 8 1 4 – 6 0 0 3

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 *[40 marks]*.

Option	Questions
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Option E — Neurobiology and behaviour	4 – 6
Option F — Microbes and biotechnology	7 – 9
Option G — Ecology and conservation	10 – 12
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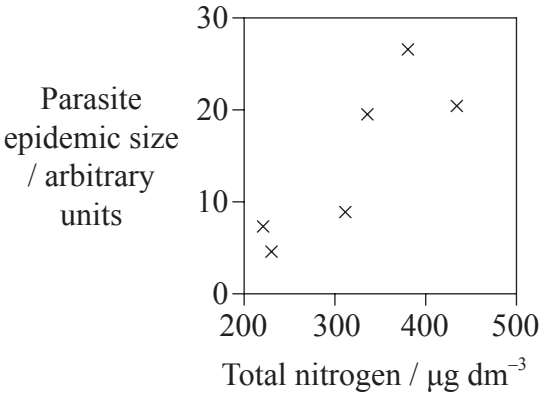
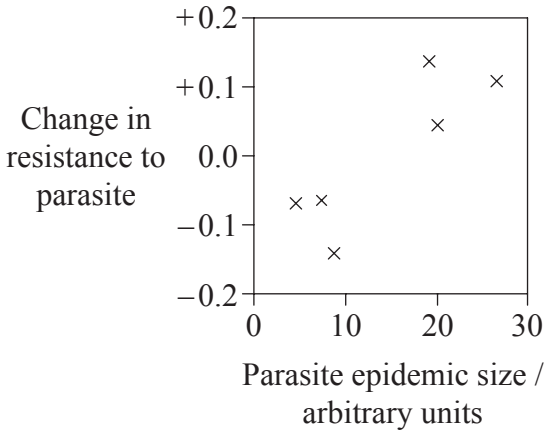
Option D — Evolution

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

. . . . . .

(Option D continues on the following page)

(Option D, question 1 continued)

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

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(c) 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*.

(d) 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)

(Option D continued)

2. (a) State **two** uncertainties in the fossil record that present problems for their use in studying evolution. *[2]*

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(b) Define the *half-life* of a radioisotope. *[1]*

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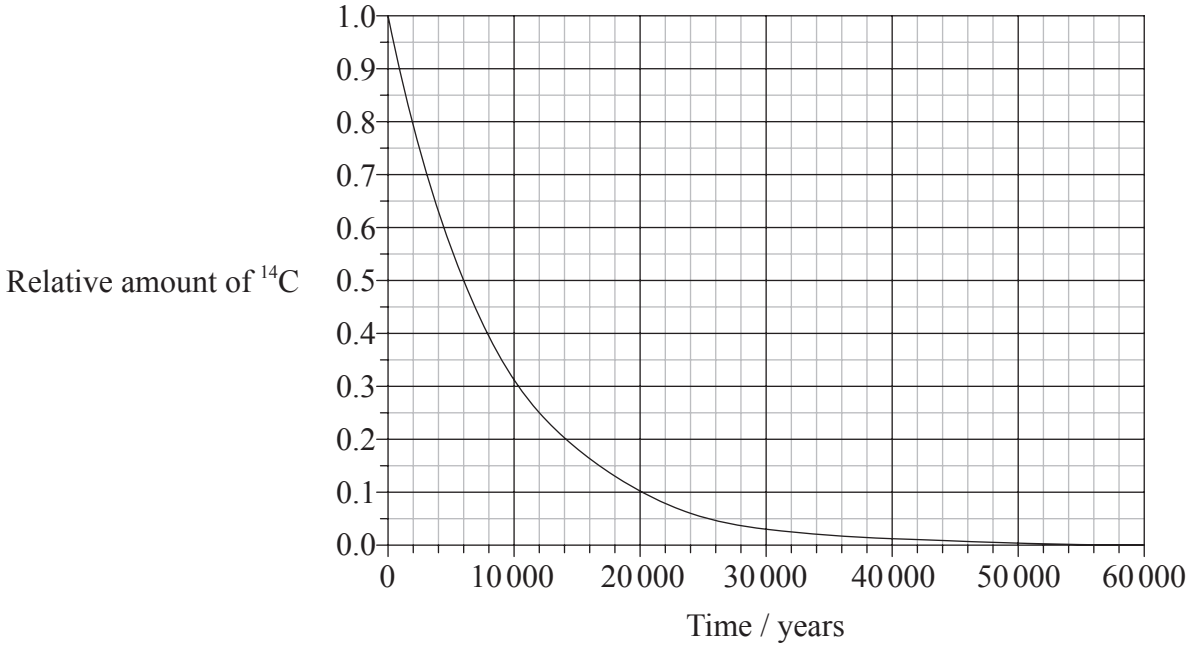
(Option D continues on the following page)

(Option D, question 2 continued)

The cave of Lascaux in central France represents one of the best preserved examples of Paleolithic cave art. Charcoal used in the paintings was dated using the carbon-14 method.

(c) (i) Using the graph, estimate the age of a charcoal sample that contained the relative amount of carbon-14 (^{14}C) of 0.13. *[1]*



. . . . . .

(ii) Deduce the reason for carbon dating not being accurate for specimens older than 50 000 years. *[1]*

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(Option D continues on the following page)

(Option D, question 2 continued)

(d) Distinguish between genetic evolution and cultural evolution. *[2]*

Genetic evolution	Cultural evolution

(Option D continues on the following page)

(Option D continued)

3. Discuss the use of cladograms in classification and research into the evolutionary origins of living organisms. *[6]*

End of Option D

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will not be marked.

Option E — Neurobiology and behaviour

4. Honey bees (*Apis mellifera*) live in colonies where some workers exhibit scouting behaviour. The scouts communicate information on new food sources to the non-scouting workers of the colony.

(a) Outline how the scouts communicate the location of new food sources to the non-scouts. *[2]*

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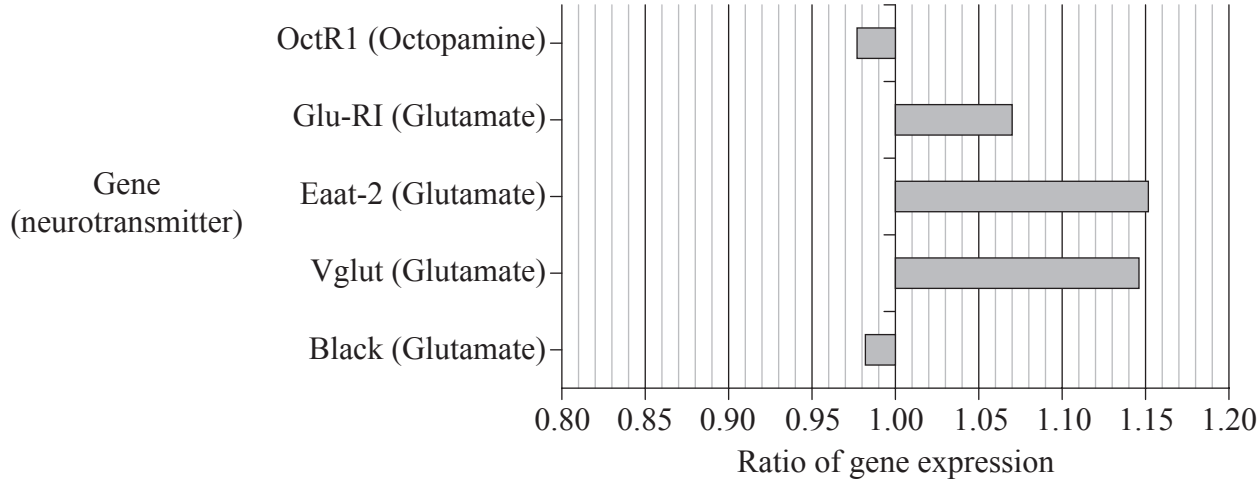
(Option E continues on the following page)

(Option E, question 4 continued)

Biologists compared food scouts to non-scouts to see if the gene expression for neurotransmitter signalling differs in their brain cells. Several genes for neurotransmitters were investigated by the scientists, including one gene for octopamine and four genes for glutamate.

$$\text{Ratio of gene expression} = \frac{\text{the gene expression in the scouts}}{\text{the gene expression in the non-scouts}}$$

The ratio of gene expression was calculated and the results are shown on the graph.



[Source: From Z. S. Liang et al. (2012) 'Molecular Determinants of Scouting Behavior in Honey Bees.' *Science*, **335** (6073), pp. 1225–1227. DOI: 10.1126/science.1213962 'Molecular Determinants of Scouting Behavior in Honey Bees.' Used 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.]

(b) State what the ratio of 1.00 means. *[1]*

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(c) State which gene shows the highest expression in the scouts compared to the non-scouts. *[1]*

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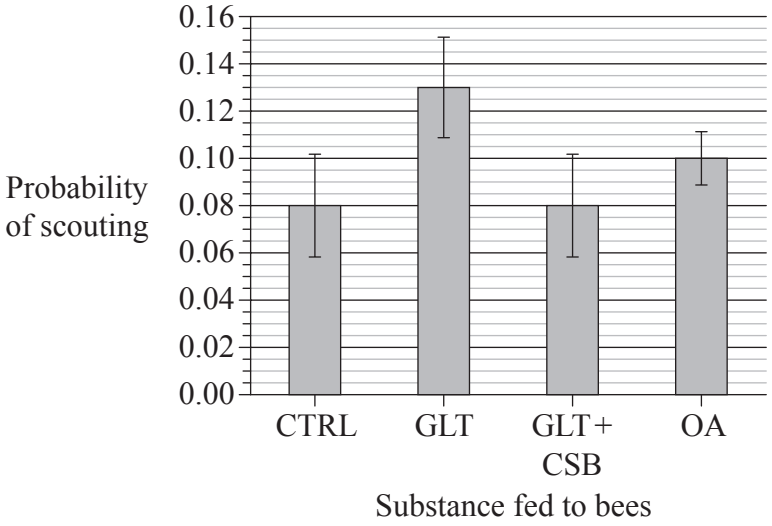
(Option E continues on the following page)

(Option E, question 4 continued)

The biologists then fed non-scout bees various substances to see if they would promote scouting behaviour. The graph shows the effect of these substances.



Key:
CTRL = control
GLT = glutamate
CSB = Chicago Sky Blue (glutamate blocker)
OA = octopamine

[Source: From Z. S. Liang et al. (2012) *Science*, **335**, pp. 1225–1227. DOI: 10.1126/science.1213962 Reprinted with permission from AAAS, www.aaas.org. 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.]

(d) Calculate the increase in the probability of scouting behaviour of non-scouts fed with GLT (glutamate) and OA (octopamine). *[2]*

GLT: . . . . . .
. . . . . .

OA: . . . . . .
. . . . . .

(e) Explain how natural selection could have affected the evolution of scouting behaviour in honey bees. *[3]*

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(Option E continues on the following page)

(Option E continued)

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

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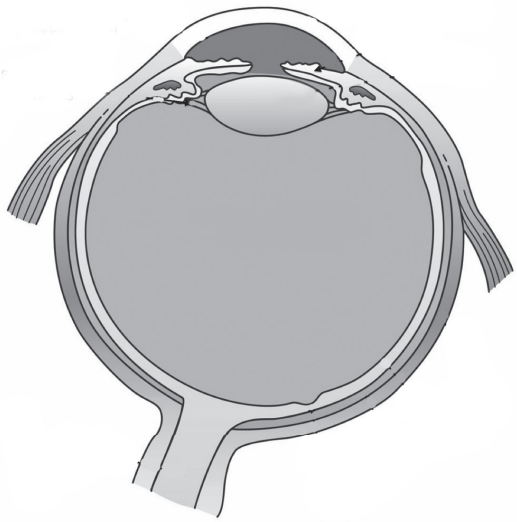
(b) Label the blind spot and the aqueous humour on the diagram of the eye. *[1]*



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

(c) Outline how endorphins act as pain killers. *[1]*

. . . . . .
. . . . . .

(Option E continues on the following page)

(Option E continued)

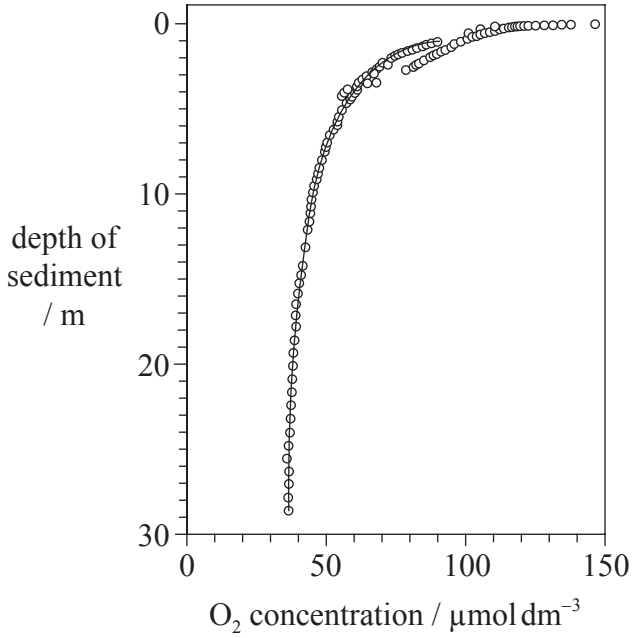
6. Design an experiment on a **named** invertebrate to investigate kinesis **or** taxis. *[6]*

End of Option E

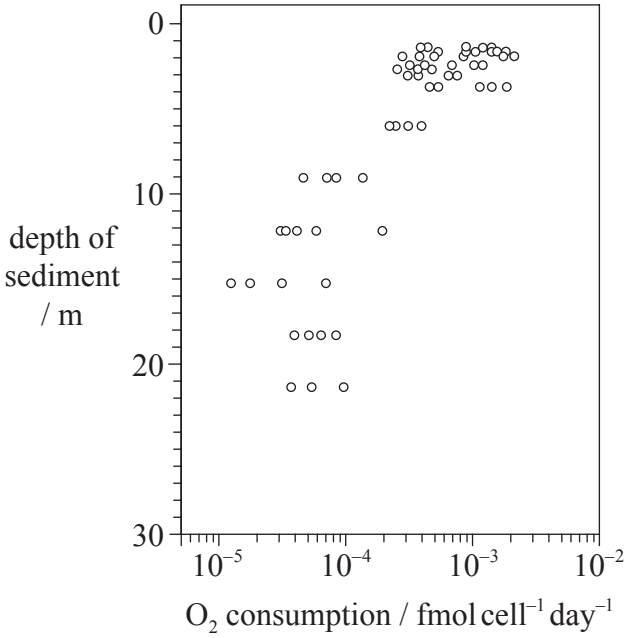
Option F — Microbes and biotechnology

7. Marine sediments form at the bottom of oceans. These sediments contain organic material from the surface waters. Scientists analysed samples drilled from the floor of the north Pacific Ocean, representing 86 million years of sedimentation. Graph A shows the data for oxygen concentrations in 28 metres of sediment and graph B shows the oxygen consumption per cell in 22 metres of sediment measured in femtomoles (fmol = 10^{-15} mol).

Graph A



Graph B



[Source:From Hans Røy, Jens Kallmeyer, Rishi Ram Adhikari, Robert Pockalny, Bo Barker Jørgensen and Steven D'Hondt (2012) Aerobic Microbial Respiration in 86-Million-Year-Old Deep-Sea Red Clay. *Science*, **336**, pp. 922–925, DOI: 10.1126/science.1219424. 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) Estimate the lowest oxygen concentration in these sediments. *[1]*

. . . . . µmol dm^{-3}

(Option F continues on the following page)

(Option F, question 7 continued)

(b) Compare the trends in the oxygen consumption per cell and the oxygen concentration in the sediments. *[2]*

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(c) (i) State the microbial activity that could influence the oxygen concentration. *[1]*

. . . . . .

(ii) State a possible source of food for the microbial community in the sediments. *[1]*

. . . . . .

(d) Suggest reasons for the differences in oxygen consumption between the cells at 2 metres and at 22 metres. *[2]*

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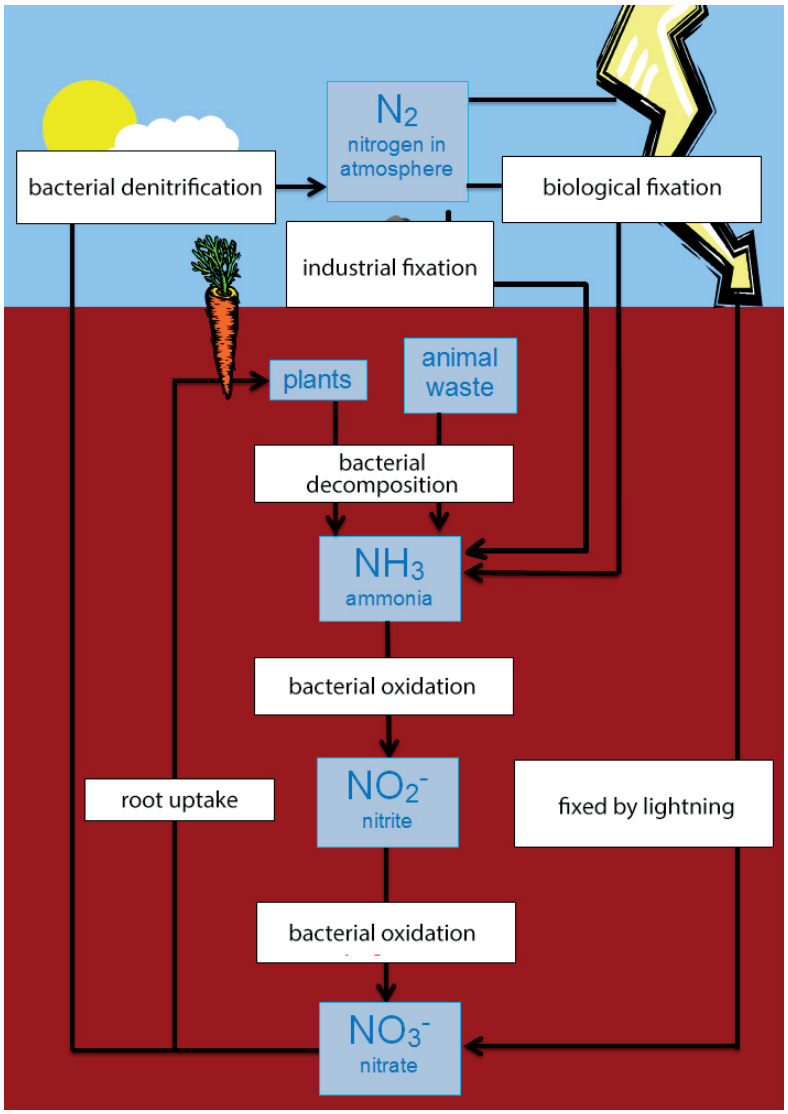
(Option F continues on the following page)

(Option F continued)

8. (a) 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)

(Option F, question 8 continued)

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

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(c) (i) State the role of reverse transcriptase. *[1]*

. . . . . .

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

. . . . . .

(d) State the characteristics of endotoxins. *[1]*

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(Option F continues on the following page)

(Option F continued)

9. Explain the principles of methane generation from biomass. *[6]*

End of Option F

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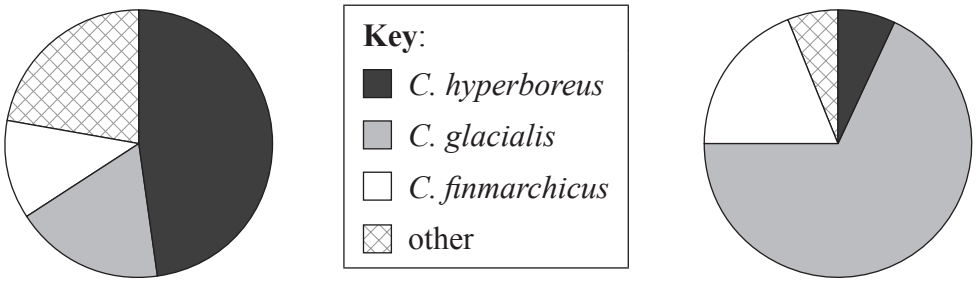
will not be marked.

Option G — Ecology and conservation

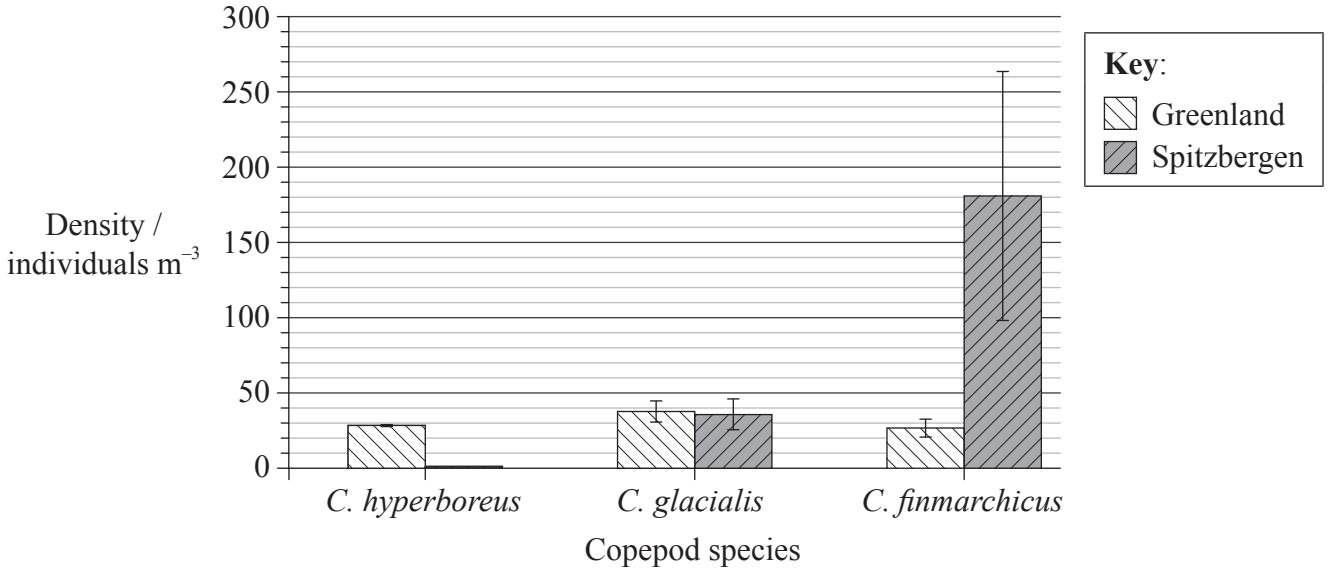
10. The little auk (*Alle alle*) is one of the most abundant predatory birds of the Arctic marine environment. It feeds mainly on copepod zooplankton (*Calanus*) that live in the surface waters of the Arctic seas. The feeding patterns of the little auks were studied at two different sites. One was off the coast of Greenland, subject to a cold water current coming south from the Arctic (0 °C). The other was off the island of Spitzbergen, subject to a warmer water current coming from the Atlantic Ocean (+5 °C).

The pie charts show the composition of the meals brought back from the sea by the parents to their chicks. Of the *Calanus* species eaten *C. hyperboreus* has three times the energy content of *C. glacialis* and 25 times more energy than *C. finmarchicus*.



[Source: Nina J. Karnovsky, Zachary W. Brown, Jorg Welcker, Ann M. A. Harding, Wojciech Walkusz, Andre Cavalcanti, Johanna Hardin, Alexander Kitaysky, Geir Gabrielsen and David Grémillet, (2011) 'Inter-colony comparison of diving behavior of an Arctic top predator: implications for warming in the Greenland Sea.' *Marine Ecology Progress Series*, **440**, pp. 229–240.]

The bar chart shows the densities of copepod species in the waters off the coast of Greenland and Spitzbergen.



[Source: Adapted from Nina Karnovsky, Ann Harding, Wojciech Walkusz, Slawomir Kwasniewski, Ilona Goszczko, Josef Wiktor Jr, Heli Routti, Allison Bailey, Laurel McFadden, Zachary Brown, Grégory Beaugrand and David Grémillet, 'Foraging distributions of little auks Alle alle across the Greenland Sea: implications of present and future Arctic climate change'.(2010) *Marine Ecology Progress Series*, **415**, pp. 283–293.]

(Option G continues on the following page)

(Option G, question 10 continued)

(a) Estimate the proportion of *C. hyperboreus* present in the food given to the chicks of the Greenland site. *[1]*

. . . . . %

(b) Distinguish between the diets of the chicks at the two sites. *[2]*

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(c) Calculate the difference in the density of *C. finmarchicus* between the Spitzbergen site and the Greenland site, giving the units. *[1]*

. . . . . .

(d) Suggest, with a reason, why the chicks are fed so much more *C. glacialis* in Spitzbergen than in Greenland. *[1]*

. . . . . .

(Option G continues on the following page)

(Option G, question 10 continued)

(e) Deduce the relationship between the temperature of the water in which the auks feed and the growth rate of their chicks, based on the evidence in the pie charts and bar charts. *[3]*

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(Option G continues on the following page)

(Option G continued)

11. (a) List **two** methods of *ex situ* conservation. *[2]*

1. . . . . .

2. . . . . .

(b) Outline the concept of maximum sustainable yield in the conservation of fish stocks. *[2]*

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(c) State how species diversity usually changes during primary succession. *[2]*

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(Option G continues on the following page)

(Option G continued)

12. Discuss the impacts of alien species on ecosystems using a **named** example. *[6]*

End of Option G

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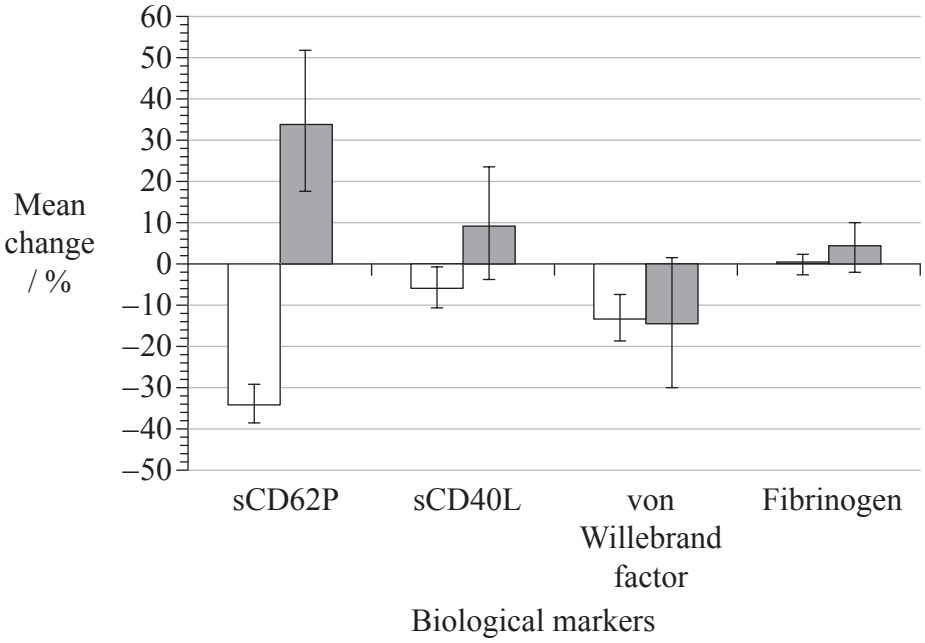
will not be marked.

Option H — Further human physiology

13. Plasma proteins, sCD62P and sCD40L, are involved in the activation of blood platelets. The von Willebrand factor causes the platelets to stick to blood vessel walls. Fibrinogen is a marker for inflammation of the blood system. All four are biological markers that indicate a risk of thrombosis.

During the 2008 Olympic games held in Beijing, the Chinese authorities temporarily reduced air pollution levels by restricting emissions from motor vehicles and industry. Doctors used this event to test the effects of air pollution on these biological markers. The graph shows the mean percentage changes in the levels of biological markers in volunteers during the study.



Key: Mean percentage change in biological markers

□ (during the games) – (before the games) ■ (after the games) – (during the games)

[Source: ©International Baccalaureate Organization 2015]

(Option H continues on the following page)

(Option H, question 13 continued)

Thromboses, including coronary thrombosis, could be a consequence of a build-up of these biomarkers.

(a) State the role of platelets in thromboses. *[1]*

. . . . . .
. . . . . .

(b) List **two** characteristics that should be considered in selecting the group of volunteers. *[2]*

1. . . . . .

2. . . . . .

(c) State the mean change in sCD62P from before to during the Olympic games. *[1]*

. . . . . %

(d) Compare the effect of the changes in air pollution of sCD62P with sCD40L. *[2]*

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(Option H continues on the following page)

(Option H, question 13 continued)

(e) Evaluate the hypothesis that air quality affects the risk of thrombosis. *[3]*

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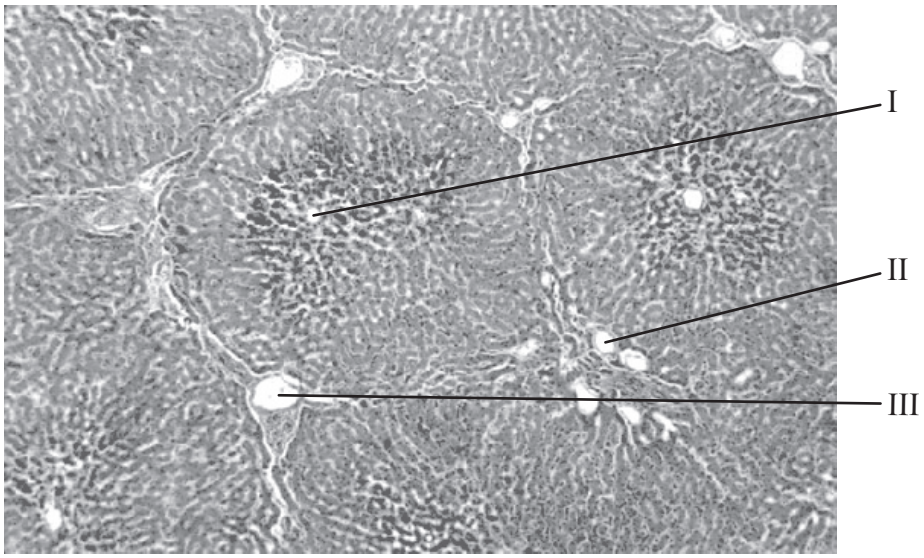
(Option H continues on the following page)

(Option H continued)

14. The image shows a photomicrograph of liver tissue.



[Source: www.meddean.luc.edu/lumen/MedEd/orfpath/images/fig02x.jpg, page last modified 27 June 2012]

(a) Structures I, II and III are branches of the three major blood vessels that serve the liver. Structure I is a branch of the hepatic vein. Identify structures II and III. *[1]*

II. . . . . .

III. . . . . .

(b) Describe the chloride shift in the transport of carbon dioxide in red blood cells of tissue capillaries. *[2]*

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(Option H continues on the following page)

(Option H, question 14 continued)

(c) Outline the mechanisms used by the ileum epithelial cells to absorb specific food molecules. *[2]*

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(Option H continues on the following page)

(Option H continued)

15. Explain the synthesis and activation of pepsin and trypsin. *[6]*

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will not be marked.

End of Option H