M09/4/BIOLO/HP3/ENG/TZ2/XX

22096015

BIOLOGY
HIGHER LEVEL
PAPER 3

Thursday 7 May 2009 (morning)

1 hour 15 minutes

Candidate session number

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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 in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.

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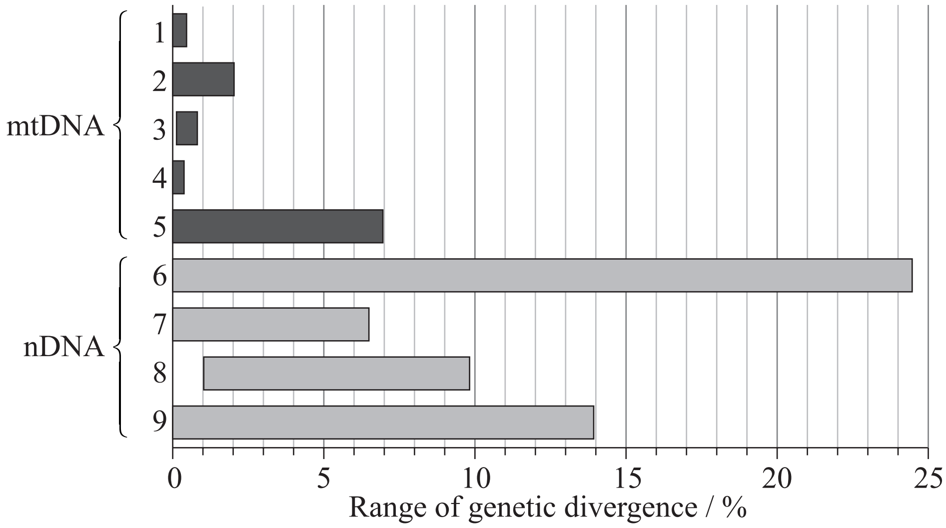
Option D — Evolution

D1. The rate of nucleotide substitution is used as an indication of evolutionary change. A study was carried out on mitochondrial DNA and nuclear DNA of different species of *Acropora*, a Pacific Ocean coral.

The dark grey bars represent the range of genetic sequence divergence between the species for specific mitochondrial DNA sequences (mtDNA) and the light grey bars represent specific nuclear DNA sequences (nDNA).



[Source: T. L. Shearer, M. J. H. van Oppen, S. L. Romano, G. Worheide, "Slow mitochondrial DNA sequence evolution in the Anthozoa (Cnidaria)", *Molecular Ecology*, Volume 11, Issue 12, pp. 2475–2487. Copyright Wiley-Blackwell. Reprinted with permission.]

(a) Measure the percentage of maximum genetic divergence for the mtDNA2 sequence. *[1]*

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(b) Calculate the maximum difference in genetic divergence between the mtDNA5 sequence and nDNA6 sequence. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(c) Compare the variations in the range of genetic divergence of the mtDNA and nDNA sequences. *[3]*

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(d) Discuss the significance of this data in terms of possible evolutionary changes in these genes. *[3]*

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D2. (a) State **one** difference between cultural evolution and genetic evolution. *[1]*

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(b) Outline the pace of evolution as implied in the theory of punctuated equilibrium. *[2]*

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D3. (a) Using examples, distinguish between analogous characteristics and homologous characteristics. *[4]*

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(b) Albinism, a lack of pigmentation in skin and hair, is caused by a recessive allele. Albinism occurs in North America in approximately one in 20 000 persons. Explain how the Hardy-Weinberg equation is applied in this example. *[5]*

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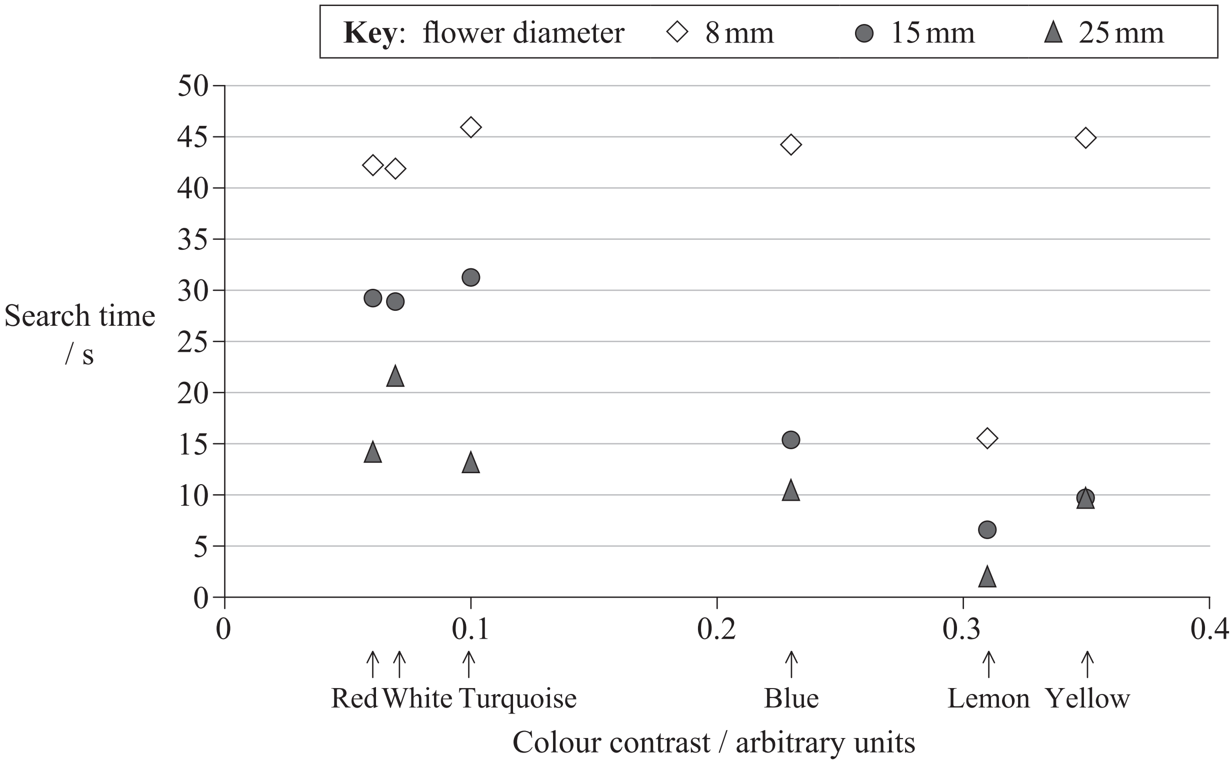
Option E — Neurobiology and behaviour

E1. Scientists studied the flight behaviour of bumblebees (*Bombus terrestris*) searching for artificial flowers of various sizes and colours. The search time is the time taken from leaving the first flower to landing on the second flower. The colour contrast is an arbitrary value which shows the colour contrast of the flowers with their green leaf-like type background. The graph below shows the search time for flowers of different colours and sizes.



[Source: J. Spaethe, J. Tautz and L. Chittka, "Visual constraints in foraging bumblebees: Flower size and color affect search time and flight behavior", Proceedings of the National Academy of Sciences, Volume 98, Issue 7, March 27 2001, pp. 3898–3903: Figure 3a. Copyright 2001 National Academy of Sciences, USA.]

(a) State the time it takes bumblebees to reach a blue flower of 15 mm diameter from another flower. *[1]*

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(b) State the colour of flower the bumblebees find in least time. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(c) Describe the effect of colour contrast on search time for the larger flowers (25 mm diameter). *[1]*

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(d) When searching for smaller flowers, bumblebees changed the strategies used for larger flower detection. Evaluate this hypothesis using the data. *[3]*

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(e) Suggest the type of behavior shown by bumblebees in this experiment and how it can affect their chances of survival. *[1]*

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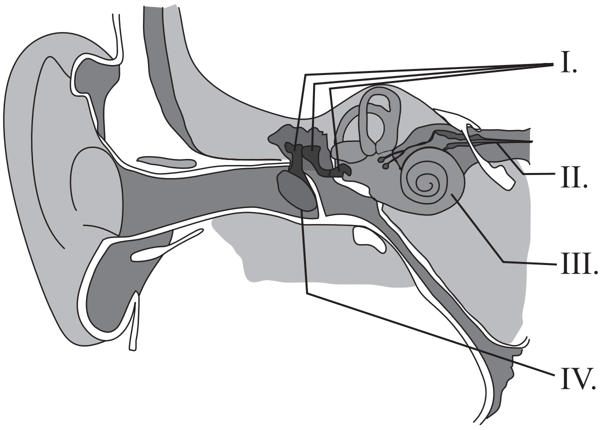
E2. (a) Label the **four** parts of the ear indicated on the drawing below. *[2]*



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IV. . . . .

(b) Discuss how the process of learning can increase chances of survival. *[2]*

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E3. (a) Outline **two named** examples illustrating the adaptive value of rhythmical behaviour patterns. *[4]*

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(b) Discuss how brain lesions and fMRI (functional magnetic resonance imaging) scanning can be used in the identification of the brain part involved in specific functions of animals. *[5]*

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Option F — Microbes and biotechnology

F1. Nitric oxide is an intermediate product which inhibits respiratory electron transport chains during denitrification. A series of experiments were carried out to study the impact of nitric oxide produced by denitrifying bacteria on the growth of non-denitrifying bacteria which do not produce nitric oxide.

Different strains of the denitrifying bacteria *Rhodobacter sphaeroides* (a, b, and c) and *Achronobacter cycloclastes* (Ac) were used to measure the inhibition of the growth of three non-denitrifying bacteria due to the antimicrobial activity of nitric oxide.

DIAGRAM REMOVED FOR COPYRIGHT REASONS

[Source: adapted from P Choi, *et al*., (2006), *Applied and Environmental Microbiology*, March, pages 2200–2205, Figure 3, page 2202 and http://aem.asm.org/cgi/content/abstract/72/3/2200]

(a) (i) Identify the non-denitrifying bacterium that was **most** inhibited by the strain *R. sphaeroides* a. *[1]*

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(ii) Identify the denitrifying bacterium that had the **least** inhibitory effect overall on the non-denitrifying bacterium 2. *[1]*

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(This question continues on the following page)

(Question F1 continued)

The error bars on the graph opposite represent ± 1 standard deviation.

(b) (i) Measure the standard deviation of the inhibition of strain *R. sphaeroides* b on the non-dentrifying bacterium 3. *[1]*

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(ii) State the percentage of the sample that is represented by ± 1 standard deviation. *[1]*

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(c) Compare the results of strain *R. sphaeroides* c and *A. cycloclastes* (Ac) denitrifying bacteria on the inhibition of the growth of the three non-denitrifying bacteria. *[2]*

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(d) Deduce which denitrifying bacterium **least** affects ATP production in non-denitrifying bacteria. *[1]*

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F2. (a) State **one** way nucleic acids can vary in viruses. *[1]*

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(b) Explain, with the use of a specific example, how reverse transcriptase is used in molecular biology. *[3]*

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F3. (a) Outline the symptoms, method of transmission and treatment of **one named** example of food poisoning. *[4]*

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(b) Evaluate **two named** methods of controlling microbial growth. *[5]*

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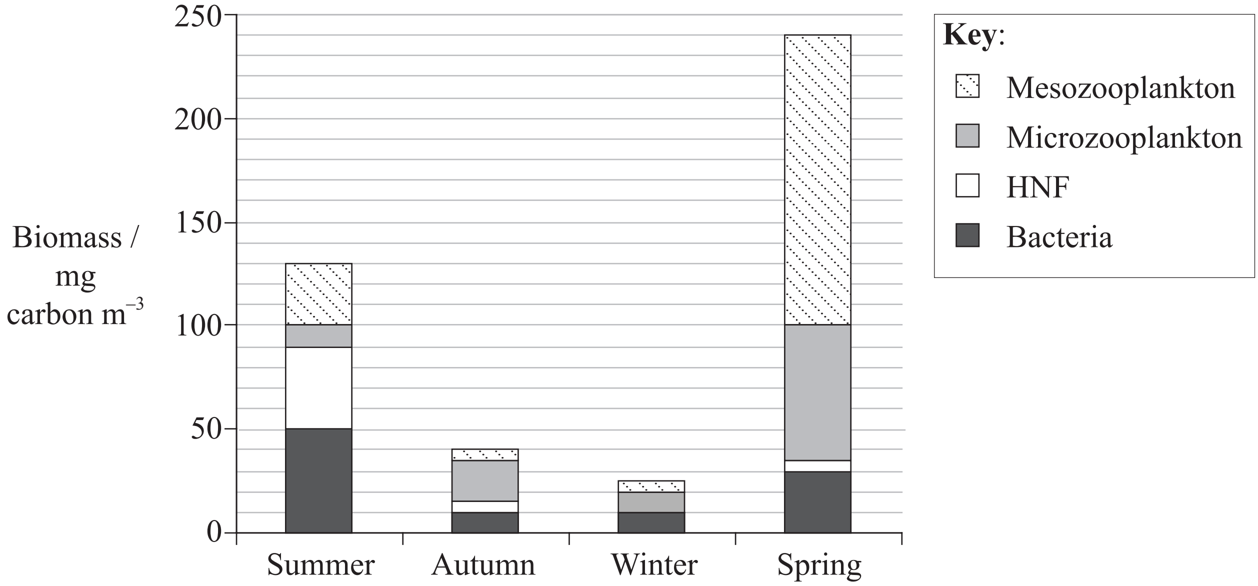
Option G — Ecology and conservation

G1. Seasonal changes of heterotrophic plankton biomass were measured in the western arctic Pacific during a one year period. The mesozooplankton, whose size is greater than 330 µm, was formed mainly by copepods. The microzooplankton, ranging from 10 to 200 µm, comprised mainly of ciliates and flagellates. Heterotrophic nanoflagellates (HNF), size range 2 to 10 µm, are organisms that feed on small flagellates and bacteria. The results are shown below.



[Source: A. Shinada, et. al., "Seasonal dynamics of planktonic food chain in the Oyashio region, western subarctic Pacific", *Journal of Plankton Research*, Volume 23, Issue 11, pp. 1237–1248, by permission of Oxford University Press]

(a) State the biomass of HNF found in this region in summer. *[1]*

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(b) Calculate the percentage increase in mesozooplankton from summer to spring. Show your working. *[2]*

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(Question G1 continued)

(c) Suggest how the seasonal changes cause the differences in biomass of heterotrophic plankton. *[3]*

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G2. (a) Outline the major differences in temperature and moisture that are characteristic of **two named** biomes. *[2]*

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(b) Explain, using a **named** example, the cause and consequence of biomagnification. *[3]*

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G3. (a) Outline the use of **two named** *ex situ* conservation measures. *[4]*

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(b) Discuss the environmental conditions that favour *r*-strategies and *K*-strategies. *[5]*

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Option H — Further human physiology

H1. The effects of lack of oxygen (hypoxia) and of altitude were studied in a group of men. The group was measured for weight, amount of hemoglobin in the blood, maximum oxygen uptake and maximum power output during bicycle exercise both at sea level and at 5260 m. The conditions at each location are described in the following table.

Location / altitude	Oxygen conditions
in Copenhagen (0 m at sea level)	breathing normal air (normoxia)
	breathing an air mixture containing low levels of O_2 (hypoxia)
on Mount Chacaltaya, in Bolivia (5260 m above sea level)	breathing a gas mixture with high levels of O_2, allowing normal hemoglobin saturation (normoxia)
	after nine weeks of acclimatization breathing normal mountain air (hypoxia)

The results of the study are shown in the table below.

	Copenhagen altitude = 0 m		Mount Chacaltaya altitude = 5260 m	
	normoxia	hypoxia	normoxia	hypoxia
Hemoglobin / g dl^{-1}	14.3	–	–	18.7
Maximum oxygen uptake / l min^{-1}	4.3	2.7	–	2.8
Maximum oxygen uptake per body mass ml min^{-1} / kg body mass^{-1}	56.0	35.0	–	40.0
Maximum power output / W	339.0	233.0	332.0	245.0
Maximum power output (W) / kg body mass^{-1}	4.6	3.1	4.8	3.6

[Source: G. van Hall, J. A. L. Calbet, H. Søndergaard and B. Saltin, "The re-establishment of the normal blood lactate response to exercise in humans after prolonged acclimatization to altitude", *The Journal of Physiology*, Volume 536, Issue 3, pp. 963–975. Copyright Wiley-Blackwell. Reprinted with permission.]

(a) Identify which conditions of altitude and oxygen levels permit the **least** maximum oxygen uptake per minute. *[1]*

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(This question continues on the following page)

(Question H1 continued)

(b) Calculate the percentage change in maximum oxygen uptake per body mass from conditions of normoxia at 0 m to hypoxia at 5260 m altitude. Show your working. *[2]*

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(c) Analyse the data to determine which conditions permit the **greatest** power output per kilogram of body mass. *[2]*

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(d) Suggest why the amount of hemoglobin changes under the different conditions. *[1]*

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(e) Explain **two** adaptations of the body to high altitude conditions other than hemoglobin increase. *[2]*

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H2. (a) Distinguish between the mode of action of steroid hormones and protein hormones. *[2]*

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(b) State the major role of *Helicobacter pylori* in the development of stomach ulcers. *[1]*

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H3. (a) Outline **two** factors that affect the incidence of coronary heart disease. *[4]*

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(b) Explain the liver damage caused by excessive alcohol consumption. *[5]*

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