22106009

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

BIOLOGY
HIGHER LEVEL
PAPER 3

Tuesday 18 May 2010 (morning)

1 hour 15 minutes

Candidate session number

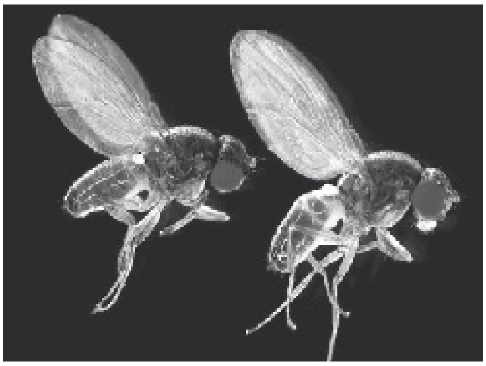
0	0							

INSTRUCTIONS TO CANDIDATES

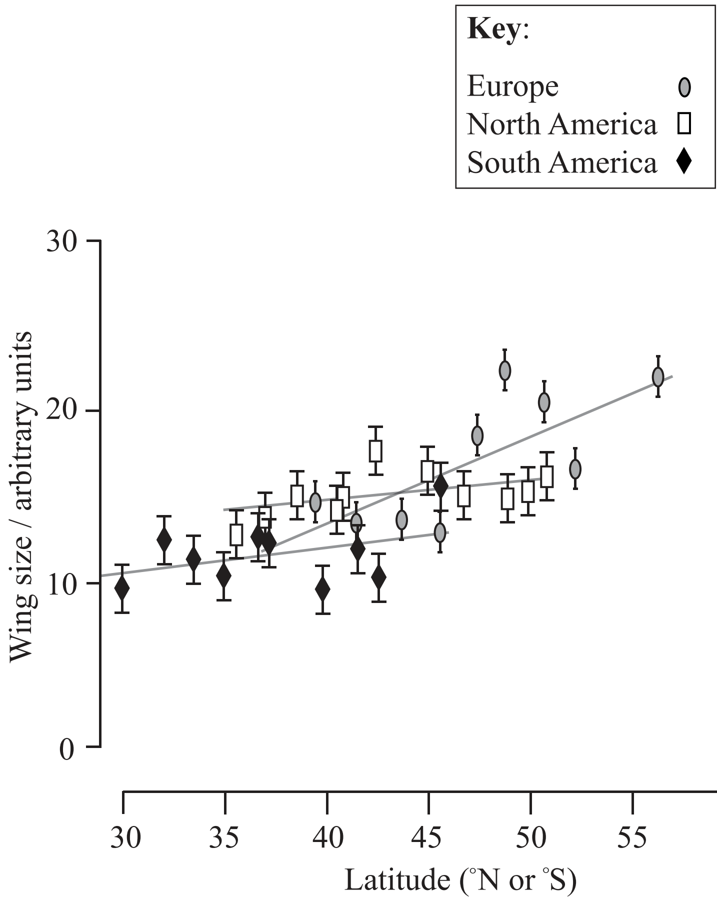
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them 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.

Option D — Evolution

D1. *Drosophila subobscura* (shown in photograph below) is a species of fruit fly native to Europe. The sample on the left is from Spain, latitude 39°, and the one on the right is from Denmark, latitude 56°. The species was introduced into both South America and North America approximately 20 years ago. The graph below shows the wing size in arbitrary units of *D. subobscura* at different latitudes in the three locations.



[Photograph by G W Gilchrist]



[Source: G W Gilchrist, *et al*., "A time series of evolution in action: a latitudinal cline in wing size in South American Drosophila subobscura" (2004), *Evolution*, **58** (4), pages 768–780. Used with the permission of Wiley-Blackwell.]

(a) Identify the relationship between wing size and latitude shown by *D. subobscura* in Europe. *[1]*

. . . .

(This question continues on the following page)

(Question D1 continued)

(b) (i) Compare the data for wing size of *D. subobscura* in North and South America with wing size in Europe. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

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

. . . .

. . . .

(c) Predict, with a reason, what might happen to *D. subobscura* in the future as a result of its introduction to new areas. *[2]*

. . . .

. . . .

. . . .

. . . .

D2. (a) Outline the properties of RNA that may have allowed it to play a role in the origin of life. *[2]*

. . . .

. . . .

. . . .

. . . .

(b) Outline the evidence provided by DNA for the common ancestry of living organisms. *[2]*

. . . .

. . . .

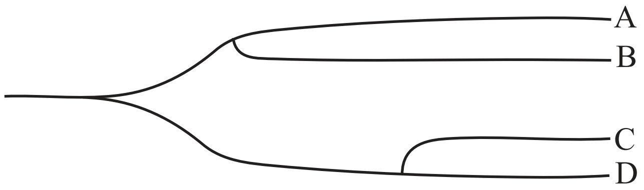
. . . .

. . . .

(This question continues on the following page)

(Question D2 continued)

(c) The cladogram below shows the classification of species A to D. Deduce how similar species A is to species B, C and D. *[2]*



. . . .

. . . .

. . . .

(d) Suggest **two** reasons for using cladograms for the classification of organisms. *[2]*

. . . .

. . . .

. . . .

D3. Discuss, using examples, the importance of cultural and genetic factors in human evolution. *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

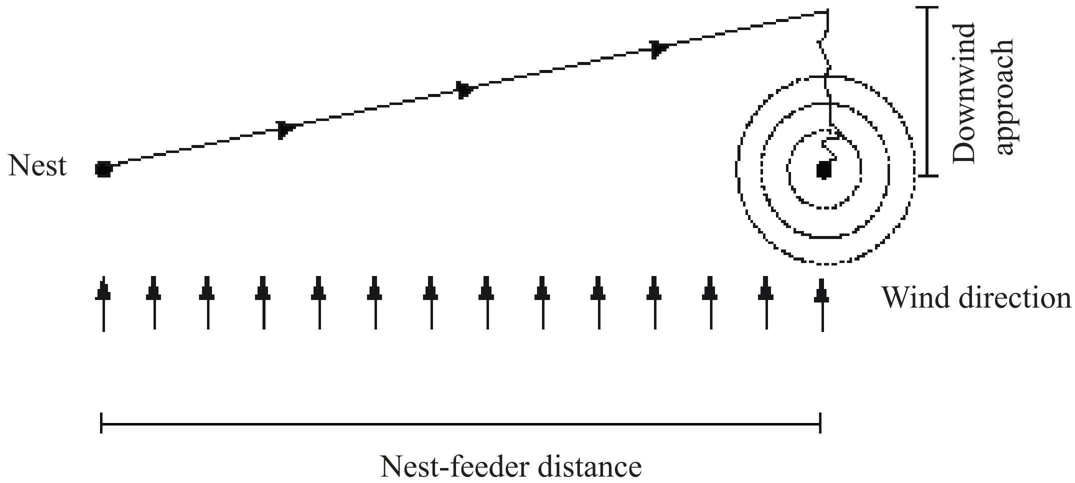
. . . .

. . . .

Blank page

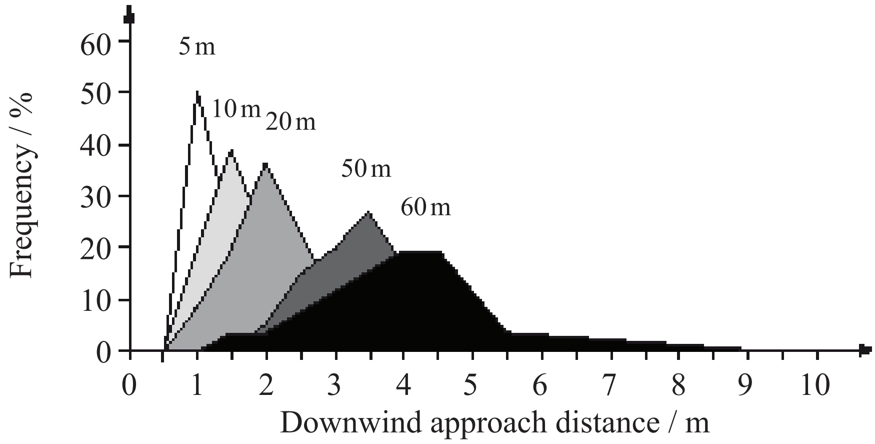
Option E — Neurobiology and behaviour

E1. Desert ants (*Cataglyphis fortis*) use odour to help find their food. When a constant wind is blowing, the ants do not approach food directly. Instead, they walk downwind of the food source and then, when they detect the odour of the food, they follow the odour trail upwind until they reach the food, as shown in the figure below.



[Harald Wolf and Rudiger Wehner, "Desert Ants Compensate for Navigation Uncertainty", *Journal of Experimental Biology*, **208** (22), Nov. 2005, pages 4223-4230: Figures 1 and 4. Adapted with permission]

To investigate this behaviour pattern, feeders were established at distances of 5 m to 60 m away from the nest. Each feeder consisted of a Petri dish filled with biscuit crumbs. The graph below shows the distribution of downwind approach distances for each different nest-feeder distance.



[Harald Wolf and Rudiger Wehner, "Desert Ants Compensate for Navigation Uncertainty", *Journal of Experimental Biology*, 208 (22), Nov. 2005, pages 4223-4230: Figures 1 and 4. Adapted with permission]

(This question continues on the following page)

(Question E1 continued)

(a) Outline the relationship between the downwind approach distance and the nest-feeder distance. *[1]*

. . . .

. . . .

(b) Compare the results observed when the feeders were located at 5 m with the feeders at 60 m. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(c) Suggest **one** possible source of uncertainties or errors in these experiments. *[1]*

. . . .

. . . .

(d) Deduce, with a reason, what type of behaviour pattern is shown by the ants in the experiment. *[2]*

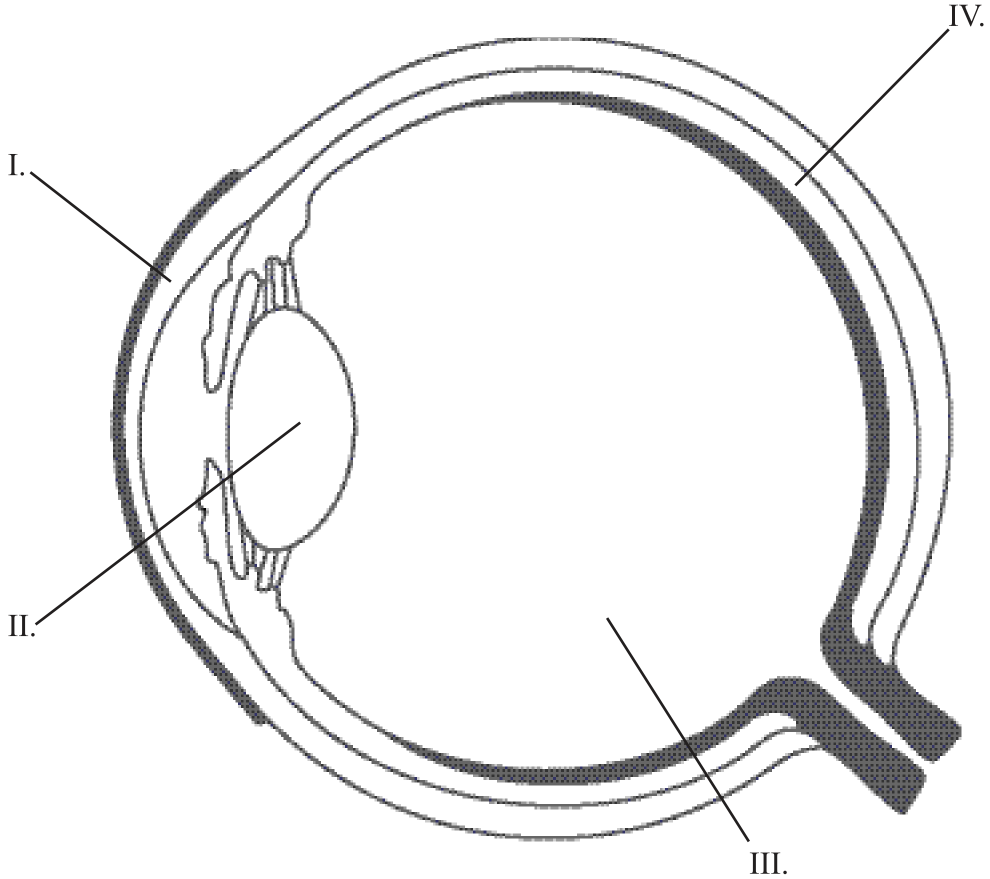
. . . .

. . . .

. . . .

. . . .

E2. (a) The diagram below represents the human eye. State the names of structures I, II, III and IV. *[2]*



I. . . . .

II. . . . .

III. . . . .

IV. . . . .

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

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question E2 continued)

(c) Cocaine is considered an excitatory drug. State **one** other example of an excitatory drug and **one** example of an inhibitory drug. *[2]*

Excitatory drug: . . . .

Inhibitory drug: . . . .

E3. Discuss the concept of brain death and how it can be diagnosed. *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

Option F — Microbes and biotechnology

F1. Release of sewage in marine waters is a common practice but it can cause water contamination with pathogens. A series of experiments were conducted to compare inactivation rates of two different groups of microbes with different sunlight exposures. One group were fecal coliform bacteria and the other were coliphage viruses. Experiments were conducted outdoors using 300-litre mixtures of sewage-seawater in open-top tanks.

A two-day experiment was carried out with untreated sewage added to seawater. Both days were sunny with no clouds. The figure below shows the inactivation of the microbes in seawater as a function of the cumulative amount of sunlight and time. The survival curves of the two microbes are plotted against sunlight exposure (lower x axis) during daylight periods and against time during the overnight period (upper x axis). The y axis gives counts of bacteria and viruses per 100 ml.

GRAPH REMOVED DUE TO COPYRIGHT REASONS.

(This question continues on the following page)

(Question F1 continued)

(a) Identify the time at which fecal coliform bacteria counts fell below 1 unit per 100 ml. *[1]*

. . . .

(b) Deduce, using the data in the graph, the effect of sunlight on

(i) fecal coliform bacteria. *[2]*

. . . .

. . . .

. . . .

. . . .

(ii) coliphage viruses. *[2]*

. . . .

. . . .

. . . .

. . . .

(c) For an accidental sewage spill, suggest, giving a reason, which of the two microbes may be most useful as a fecal indicator two days after the spill. *[1]*

. . . .

. . . .

. . . .

(d) The release of raw sewage in aquatic environments may cause several consequences such as the contamination of drinking water. State another possible consequence. *[1]*

. . . .

. . . .

F2. (a) (i) Define *chemoheterotroph*. *[1]*

. . . .

. . . .

. . . .

(ii) State **one** example of a bacterial chemoheterotroph. *[1]*

. . . .

(b) Many bacteria produce toxins. Distinguish between endotoxins and exotoxins. *[2]*

Endotoxins	**Exotoxins**

(c) Outline, using an example, the mechanism of action of antibiotics. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

F3. Discuss methods used in gene therapy, including the risks involved. *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

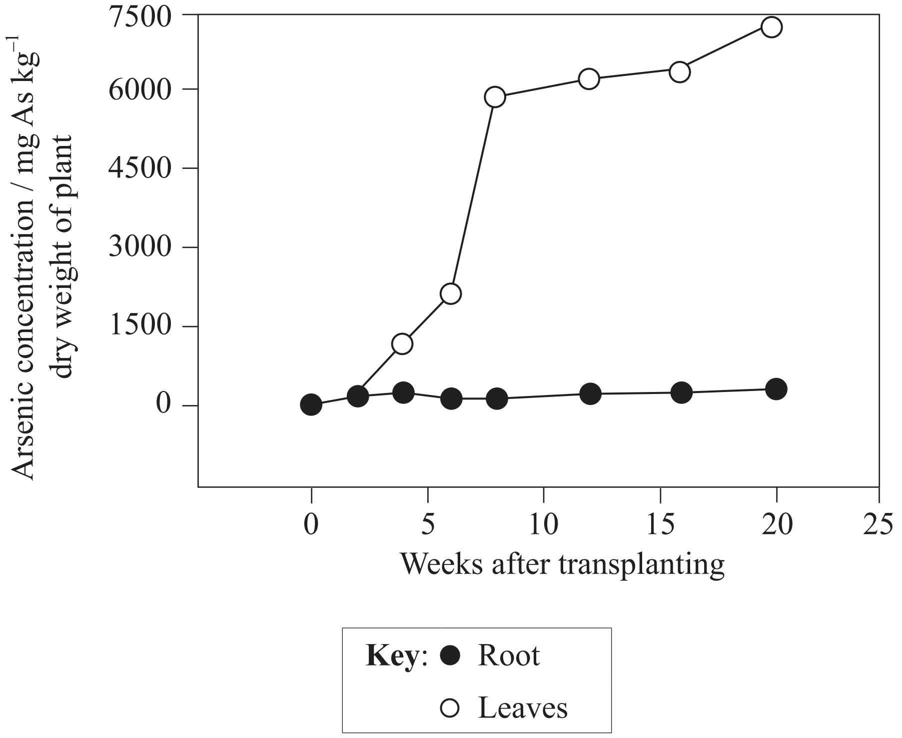
. . . .

. . . .

Option G — Ecology and conservation

G1. The element arsenic (As) is not needed for plant growth and development. The accumulation of arsenic in the Chinese brake fern (*Pteris vittata*) was studied. Young ferns with five or six leaves were transplanted to soil contaminated with arsenic and were grown for 20 weeks in a greenhouse.

The graph below shows the arsenic concentrations in leaves and roots of the Chinese brake fern during the 20 weeks after transplanting. Arsenic concentration is expressed as mg As kg^{-1} dry weight of plant.



[C Tu, *et al*.,"Arsenic Accumulation in the Hyperaccumulator Chinese Brake and its Utilization Potential for Phytoremediation" (2002) Journal of Environmental Quality, **31** (5), pages 1671–1675: Figure 2 (adapted). Reprinted with permission.]

(a) Using the data in the graph, describe the accumulation of arsenic in the Chinese brake fern. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question G1 continued)

The table below shows the total amount of arsenic accumulated by the Chinese brake fern, expressed as a concentration in the plant tissue and as a percentage of the arsenic originally in the soil.

Time / weeks	Arsenic concentration in fern / mg As kg^{-1}	Percentage of original soil arsenic absorbed by fern
0	2	0.00
2	66	0.05
4	221	0.15
6	408	0.28
8	1300	0.88
12	5390	3.68
16	13 800	9.43
20	37 900	25.90

[C Tu, *et al*.,"Arsenic Accumulation in the Hyperaccumulator Chinese Brake and its Utilization Potential for Phytoremediation" (2002) Journal of Environmental Quality, **31** (5), pages 1671–1675: Figure 2 (adapted). Reprinted with permission.]

(b) (i) Assuming the mean rate of arsenic accumulation over the first 20 weeks continued, calculate how long it would take to remove all the arsenic from the soil. *[1]*

. . . .

. . . .

. . . .

(ii) Using the data in the table, discuss the potential of using Chinese brake fern to remove arsenic from contaminated soil. *[2]*

. . . .

. . . .

. . . .

. . . .

. . . .

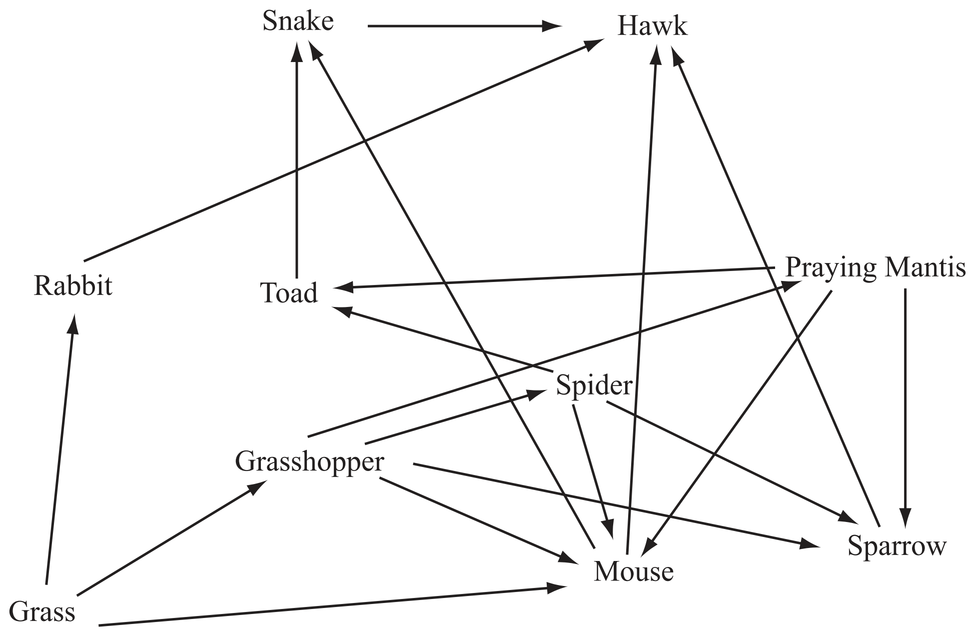
(c) Suggest **one** possible consequence of arsenic accumulation in plants for other organisms in the community. *[1]*

. . . .

. . . .

. . . .

G2. The following figure represents a terrestrial food web.



(a) Identify the trophic level of the toad. *[1]*

. . . .

(b) Outline a method that could be used to estimate the population of rabbits in this environment. *[4]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question G2 continued)

(c) The Simpson diversity index is used to calculate the species richness in an ecosystem.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Define the terms N and n in the formula above. *[2]*

$N =$ . . . .

$n =$ . . . .

G3. Evaluate the use of indicator species in monitoring environmental changes. *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

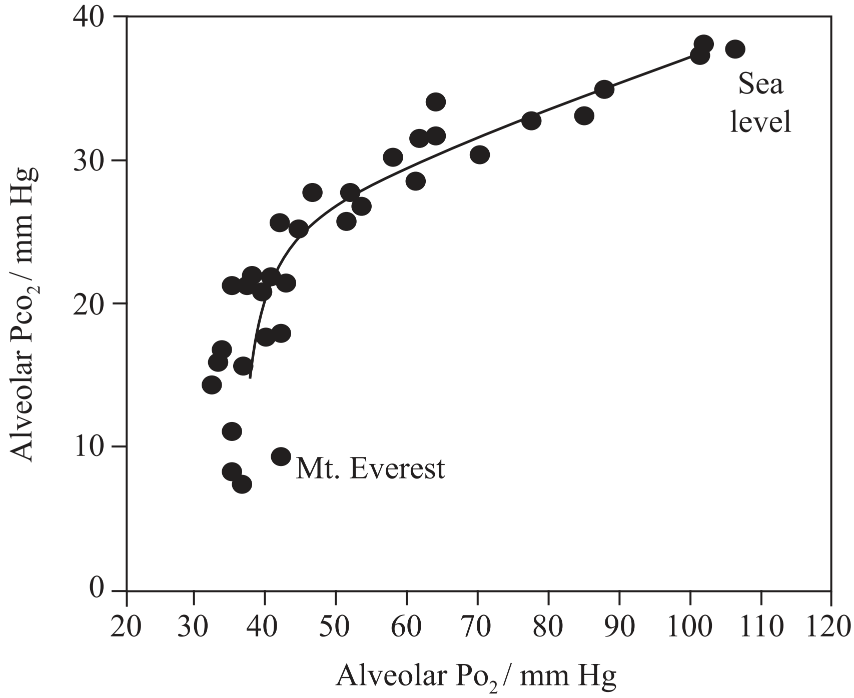
. . . .

. . . .

. . . .

Option H — Further human physiology

H1. The human body suffers significant physiological changes at extreme altitudes. Extensive scientific information has been obtained from medical research expeditions to Mount Everest (8848 m above sea level). The figure below shows the relationship between the partial pressures of oxygen (Po_2) and carbon dioxide (Pco_2) in the alveoli as altitude increases from sea level (at top right) to the summit of Mt. Everest (at bottom left).



[Source: J. B. West, Integrative and Comparative Biology, 46 (1), pp. 25–34, (2006), "Human responses to extreme altitudes" by permission of the Society for Integrative and Comparative Biology]

(a) Outline the changes in the partial pressures of carbon dioxide and oxygen as altitude increases. *[2]*

. . . .

. . . .

. . . .

. . . .

(This question continues on the following page)

(Question H1 continued)

The table below shows the data from the field study on the alveolar gas and arterial blood values for a climber at sea level and on the summit of Mt. Everest.

Altitude / meters	**Inspired Pco_2 / mm Hg**	**Arterial Pco_2 / mm Hg**	**Arterial pH**
Sea level (0)	2.50	40.0	7.40
Summit (8848)	0.83	7.5	>7.70

[Source: J B West, *Integrative and Comparative Biology*, **46** (1), pages 25–34, (2006), "Human responses to extreme altitudes" by permission of the Society for Integrative and Comparative Biology]

(b) Predict, with a reason, how the ventilation rate will change as a climber ascends from sea level to the summit of Mt. Everest. *[2]*

. . . .

. . . .

(c) (i) Calculate the percentage change in the arterial partial pressure of carbon dioxide (Pco_2) at the summit compared with that at sea level. *[1]*

. . . .

. . . .

(ii) Suggest a reason for the low arterial partial pressure of carbon dioxide at the summit. *[1]*

. . . .

. . . .

(d) State **one** adaptation of people who live permanently in high altitude areas. *[1]*

. . . .

. . . .

. . . .

H2. (a) (i) Define *hormones*. *[1]*

. . . .

. . . .

(ii) State **one** type of hormone, giving an example. *[1]*

. . . .

. . . .

(b) Compare gastric juice and pancreatic juice. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

(c) Outline the reason for **one named** substance found in food not being digested and absorbed by humans. *[2]*

. . . .

. . . .

. . . .

H3. Explain the role of the SA (sinoatrial) node in the cardiac cycle. *[6]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .