

**Biology**  
**Higher level**  
**Paper 3**

Thursday 7 May 2015 (afternoon)

Candidate session number

1 hour 15 minutes

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**Instructions to candidates**

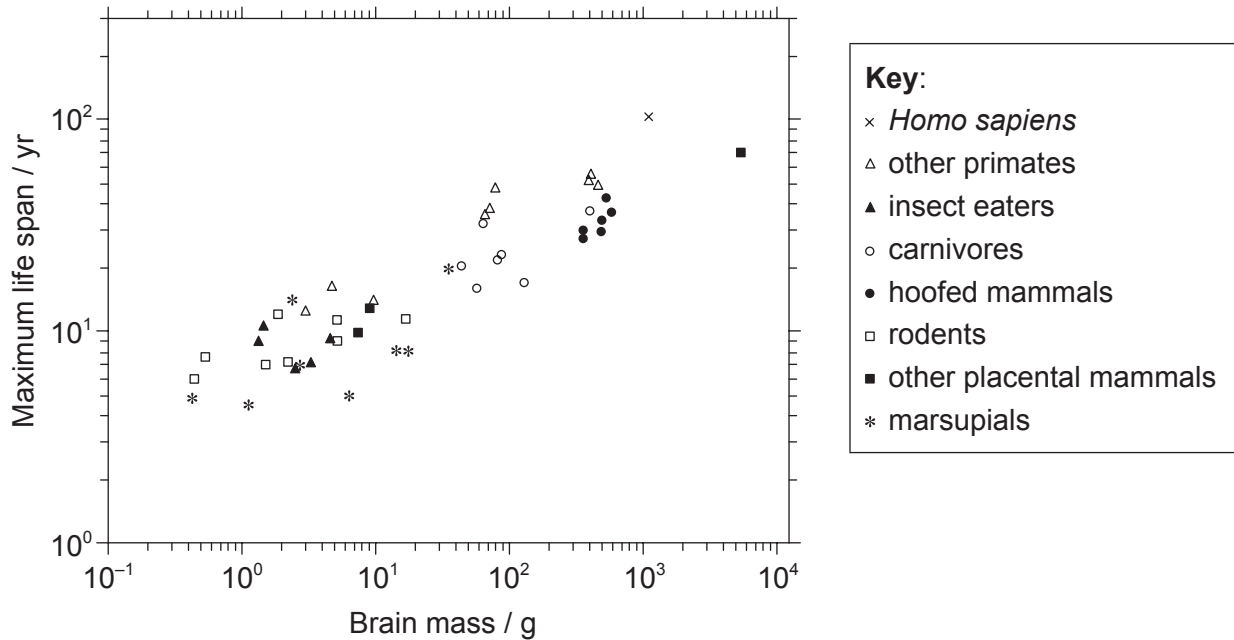
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[40 marks]**.

Option	Questions
Option D — Evolution	1 – 3
Option E — Neurobiology and behaviour	4 – 6
Option F — Microbes and biotechnology	7 – 9
Option G — Ecology and conservation	10 – 12
Option H — Further human physiology	13 – 15



### Option D — Evolution

1. The evolution of increased body size in mammals has been accompanied by an increase in life span. Another variable that could affect life span is brain size. Data was analysed from 47 mammalian species.



[Source: Hofman, M. A. (1993), Encephalization and the evolution of longevity in mammals. *Journal of Evolutionary Biology*, 6: 209–227. doi: 10.1046/j.1420-9101.1993.6020209.x]

- (a) State the relationship between brain mass and maximum life span.

[1]

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(Option D continues on the following page)



**(Option D, question 1 continued)**

(b) Identify the group with the widest range of brain mass. [1]

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(c) Compare the brain mass and life span of primates and marsupials. [3]

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(d) Discuss how a larger brain size and longer life span might have contributed to the evolution of these species. [2]

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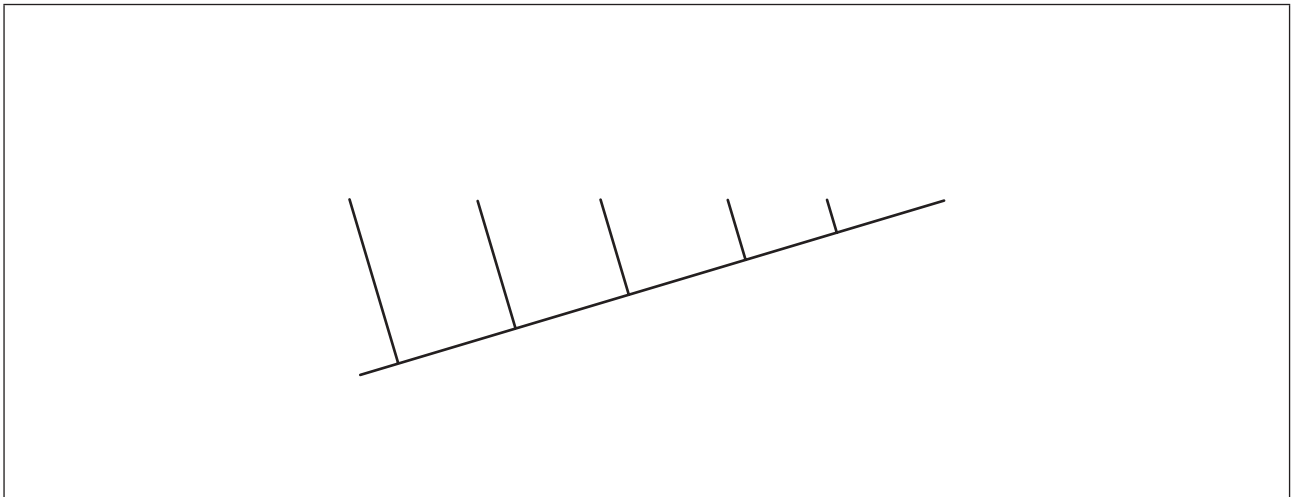
(Option D continued)

2. (a) The table shows certain characteristics present (+) or absent (-) in six organisms.

	Segmented	Jaws	Hair	Placenta	Multicellular	Limbs
Amoeba	-	-	-	-	-	-
Cat	+	+	+	+	+	+
Earthworm	+	-	-	-	+	-
Kangaroo	+	+	+	-	+	+
Lizard	+	+	-	-	+	+
Sponge	-	-	-	-	+	-

Using the data, label the cladogram with the names of the organisms.

[3]



- (b) Compare allopatric speciation and sympatric speciation.

[2]

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(Option D continues on the following page)



**(Option D, question 2 continued)**

- (c) A species is often defined as a group of similar individuals that interbreed in nature and produce fertile offspring. Discuss some problems with the use of this definition. [2]

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



(Option D continued)

3. Outline how the Hardy-Weinberg equation is derived, including the assumptions for its use. [6]

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**End of Option D**



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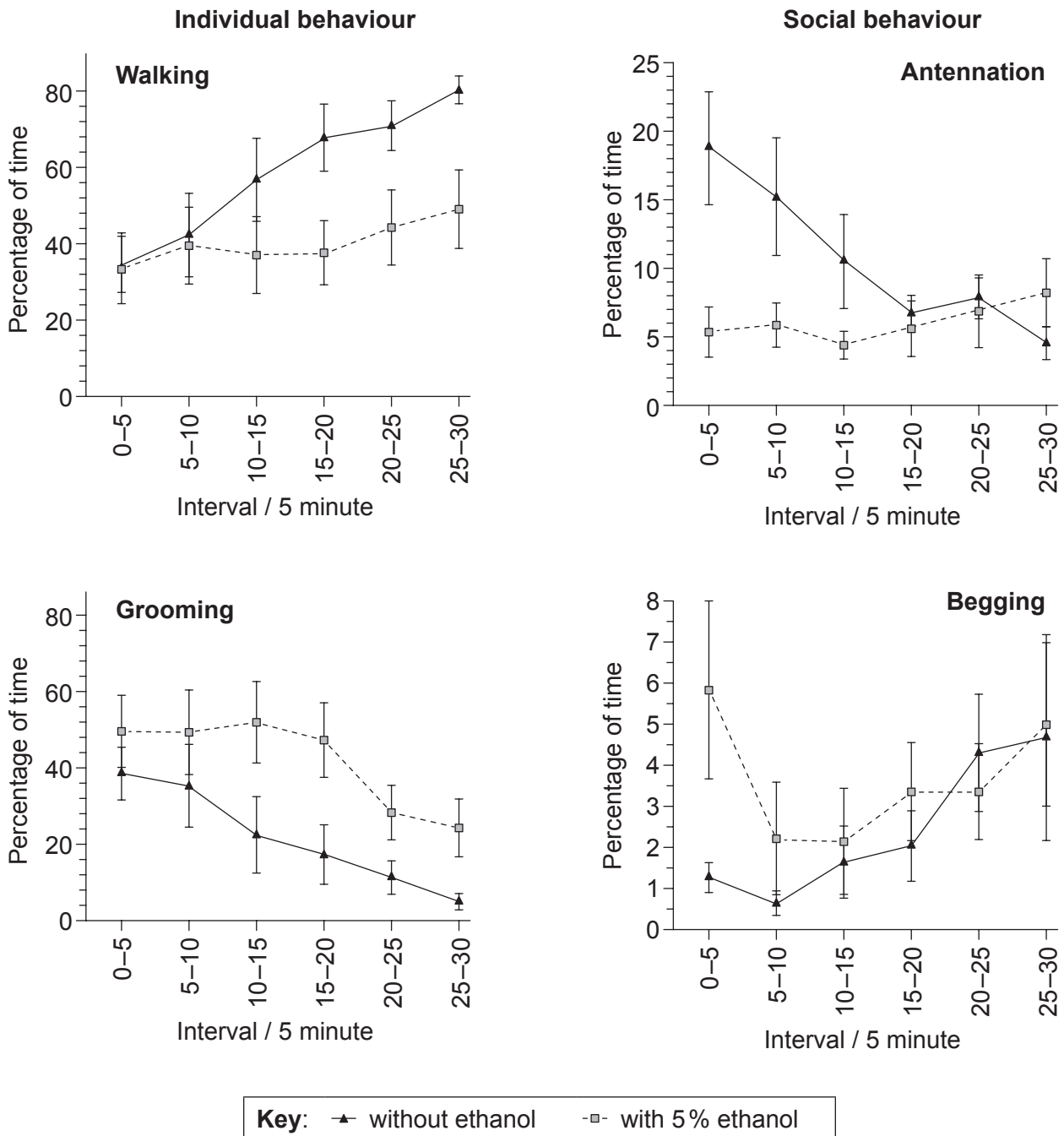
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### Option E — Neurobiology and behaviour

4. Honey bees (*Apis mellifera*) were fed with sucrose solution only or with low doses of ethanol in sucrose solution to examine how a slightly intoxicated state could affect their behaviour.

Individual behaviour involves walking and grooming while social behaviour includes contact of antennae between bees to show recognition (antennation) and asking other bees for food when hungry (begging). The graphs show individual and social behaviour changes observed in successive five minute intervals two hours after honey bees were fed sucrose solution either with or without ethanol.



[Source: Wright GA, Lillis JL, Bray HJ, Mustard JA (2012) Physiological State Influences the Social Interactions of Two Honeybee Nest Mates. *PLoS ONE* 7(3): e32677. doi:10.1371/journal.pone.0032677. Figs 5 (A), (D), (E), (F)]

(Option E continues on the following page)



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**(Option E, question 4 continued)**

- (a) State the percentage of time the honey bees engaged in begging during the first five minute interval. [1]

Bees fed with ethanol:	..... %
Bees fed without ethanol:	..... %

- (b) Describe the trends in antennation for honey bees fed with ethanol and without ethanol. [2]

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- (c) Distinguish between the times spent walking and grooming for honey bees fed with ethanol and without ethanol. [2]

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- (d) Evaluate the hypothesis that ethanol affects the social behaviour of honey bees. [3]

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**(Option E continues on the following page)**



(Option E continued)

5. (a) The bluegill fish eats *Daphnia* (water fleas). Outline how the bluegill fish's foraging behaviour optimizes its food intake. [2]

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- (b) State **one** excitatory and **one** inhibitory psychoactive drug. [2]

Excitatory: .....

Inhibitory: .....

- (c) Describe, using **one** specific example of an animal, how the process of learning can improve its chances of survival and reproduction. [2]

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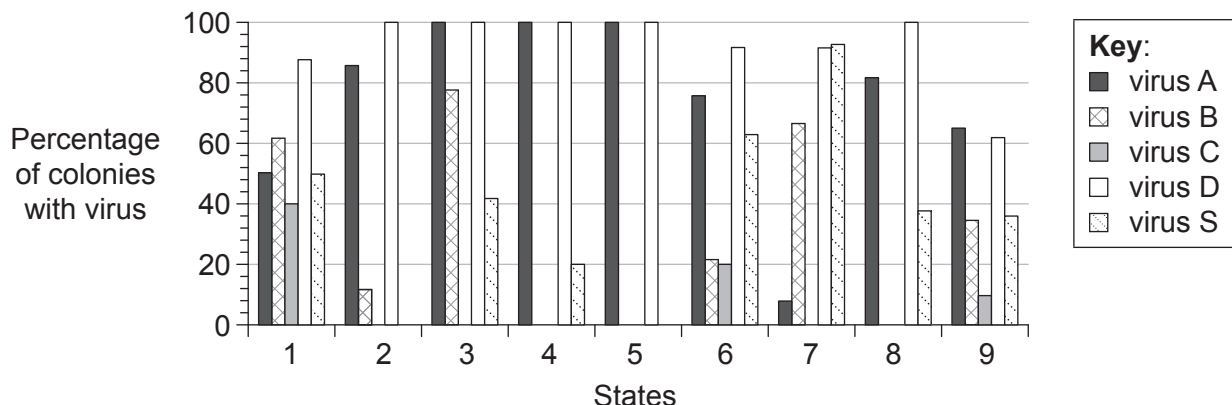
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**Option F — Microbes and biotechnology**

7. Honey bees (*Apis mellifera*) can suffer from lethal diseases caused by different viruses. An epidemiological study was undertaken to identify the presence of five viruses in 90 diseased honey bee colonies in the nine states of Austria.



[Source: Adapted from O. Berényi *et al.* (2006) *Applied Environmental Microbiology*, **72** (4), pages 2414–2420. "Occurrence of Six Honeybee Viruses in Diseased Austrian Apiaries". Doi:10.1128/AEM.72.4.2414-2420.2006. Reproduced with permission from American Society for Microbiology.]

- (a) (i) Identify the state with the greatest percentage of colonies infected with virus S. [1]

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- (ii) Suggest **two** possible reasons for a difference in the distribution of the viruses between the different states of Austria. [2]

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2. ....  
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(Option F continues on the following page)



**(Option F, question 7 continued)**

- (b) Compare the percentage of colonies infected with the different viruses in state 1 and state 4. [2]

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- (c) Analyse the distribution of virus B and virus D across Austria. [2]

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- (d) Suggest, with a reason, the best state for the location of a bee farm. [1]

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**(Option F continues on the following page)**



**(Option F continued)**

8. (a) Outline how a defective gene can be replaced using viral vectors. [2]

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- (b) State a use of species of *Aspergillus* and *Saccharomyces* in food production. [2]

*Aspergillus:*  
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*Saccharomyces:*  
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- (c) Compare chemoautotrophs with photoheterotrophs. [2]

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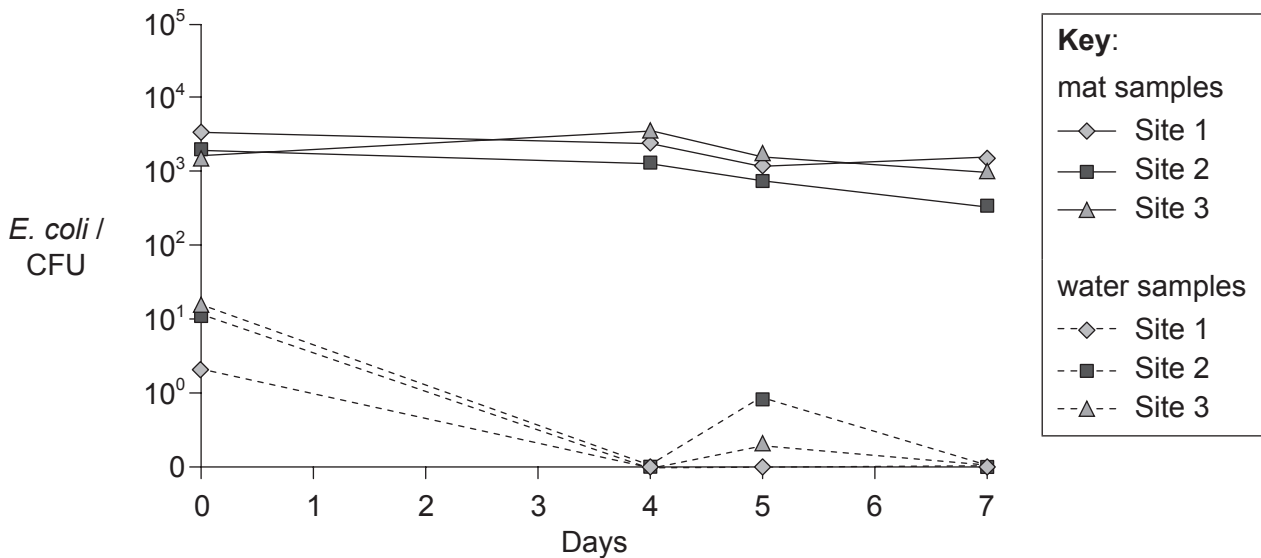
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**Option G — Ecology and conservation**

10. The filamentous green alga (*Cladophora*) forms mats along the shore of certain fresh water lakes. When the mats become stranded on beaches, they produce a bad odour from the action of decomposers. A study was undertaken on the abundance and persistence of fecal indicator bacterium *Escherichia coli* in the mats and in the water at three beach sites on one lake. The number of colonies (colony-forming unit or CFU) that grew from bacteria in a 100 gram sample of mat or water collected on day 0 at the three sites was measured on four days over an eight day period to test the survival of *E. coli*.



[Source: Adapted from O. Olapade *et al.* (2006) *Applied Environmental Microbiology*, **72** (3), pages 1932–1938. ‘Microbial Communities and Fecal Indicator Bacteria Associated with *Cladophora* Mats on Beach Sites along Lake Michigan Shores’. Ola A. Olapade, Morgan M. Depas, Erika T. Jensen, and Sandra L. McLellan. Doi:10.1128/AEM.72.3.1932–1938.2006. Reproduced with permission from American Society for Microbiology.]

(a) Identify the site with the lowest average CFU of *E. coli* in the water samples. [1]

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(b) Distinguish between the trends in the survival of *E. coli* on mat samples and in water samples over time. [2]

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(Option G continues on the following page)





**(Option G, question 10 continued)**

- (c) Scientists formerly related the population of *Cladophora* to changes in phosphorous levels in the lake. However, phosphorous quantities have decreased but *Cladophora* has recently increased along the shore. Suggest **two** reasons, other than phosphorous, for the change in population growth of *Cladophora* in the lake. [2]

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- (d) Discuss the possible ecological relationships between *E. coli* and *Cladophora*. [2]

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**(Option G continues on the following page)**



**(Option G continued)**

11. (a) (i) Calculate the Simpson diversity index from the data given for **one** community, using the formula provided. Show your working. [2]

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

Species	Number ( <i>n</i> )
Caddisfly larva ( <i>Trichoptera</i> )	5
Cranefly larva ( <i>Diptera</i> )	3
Damselfly larva ( <i>Zygoptera</i> )	4
Mayfly larva ( <i>Ephemeroptera</i> )	3
Stonefly larva ( <i>Plecoptera</i> )	5

- (ii) The same area was sampled the previous year and found to have a value for  $D=4.3$ . Analyse the biodiversity of this community. [2]

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**(Option G continues on the following page)**



(Option G, question 11 continued)

(b) Identify the biome represented in the climograph.

[1]

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(c) Discuss *in situ* conservation of endangered species.

[2]

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**Option H — Further human physiology**

13. Scientists studied the relationship of the age of asthma onset and body weight. A study was undertaken of 504 people with asthma in categories of obese, overweight and normal.

Late-onset asthma was defined as beginning at 12 years of age or above. The results are shown in the table.

Late-onset asthma (n=504)						
Categories	Obese (n=245)		Overweight (n=125)		Normal (n=134)	
Demographic and clinical characteristics						
	median	range	median	range	median	range
Age at asthma onset (y)	27	(15–37)	26	(18–35)	22	(19–31)
Median asthma duration (y)	14	(6–24)	11	(6–21)	12	(6–23)

Severity	%	%	%
Mild	23	36	44
Moderate	23	23	18
Severe	54	41	38
Exercise provokes asthma symptoms	82	83	76

[Source: Adapted from F. Holguin *et al.* (2011) *Journal of Allergy and Clinical Immunology*, **127** (6), pages 1486–1493. "Obesity and asthma: An association modified by age of asthma onset". Copyright 2011, with permission from Elsevier.]

(Option H continues on the following page)



**(Option H, question 13 continued)**

- (a) (i) State the median age of asthma onset for an obese person with late-onset asthma. [1]

..... years

- (ii) Outline, using your own knowledge, the effects of asthma on the gas exchange system of the people in this study. [2]

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- (b) Using the data, comment on the statement that exercise provokes asthma symptoms. [1]

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- (c) Analyse the relationship of body weight categories and asthma severity. [2]

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(Option H, question 13 continued)

- (d) Using the data, explain the disadvantages of becoming obese for adults who have late-onset asthma. [2]

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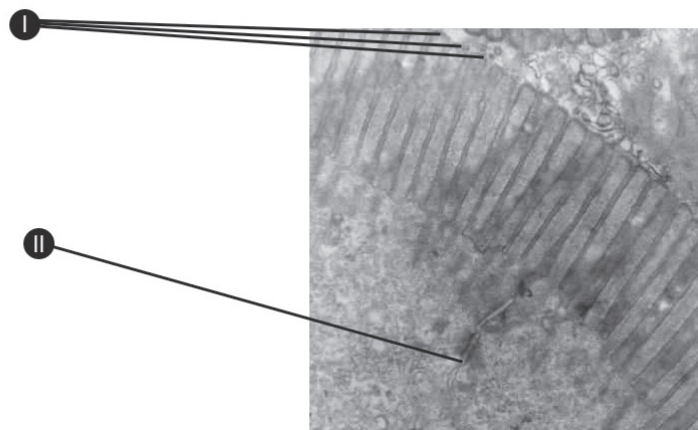
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- 14. (a) The electron micrograph shows the epithelial cells of the villus.



[Source: Courtesy of Dr John McNulty and the Loyola University Medical Center, Chicago  
[http://www.dartmouth.edu/~anatomy/Histo/lab\\_1/epithelium/DMS028/microvilli.jpg](http://www.dartmouth.edu/~anatomy/Histo/lab_1/epithelium/DMS028/microvilli.jpg)]

Identify the parts labelled I and II. [2]

I: .....

II: .....

(Option H continues on the following page)





**(Option H, question 14 continued)**

(b) Compare the composition of gastric juice and pancreatic juice. [2]

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(c) Discuss the impact of smoking on the incidence of coronary heart disease (CHD). [2]

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