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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

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Thursday 19 May 2011 (morning)

1 hour 15 minutes

Examination code

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INSTRUCTIONS TO CANDIDATES

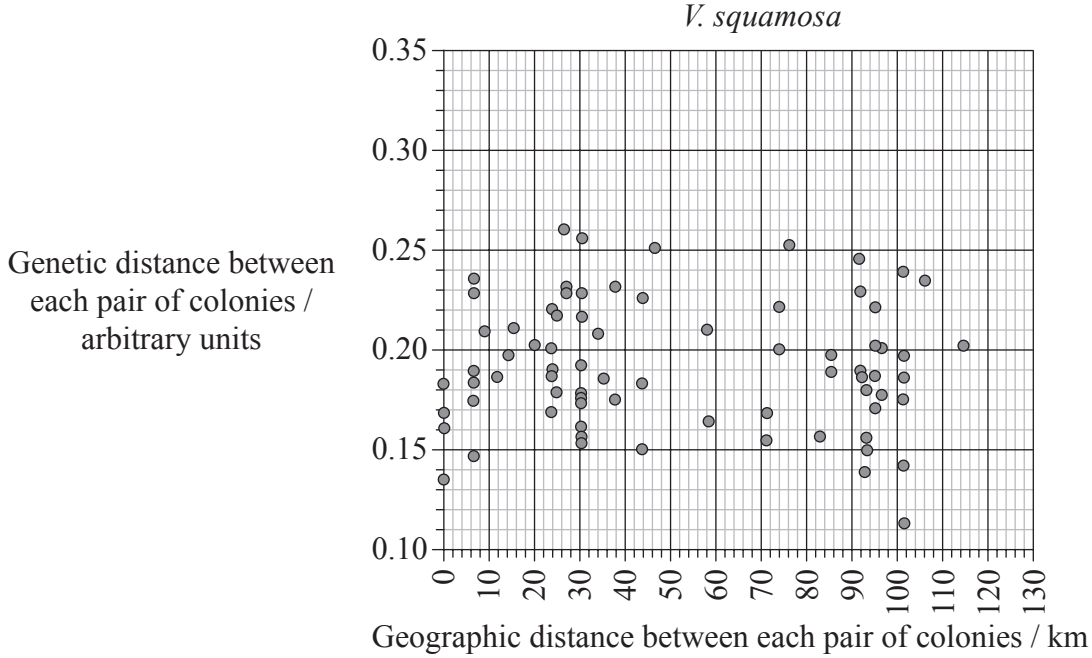
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.

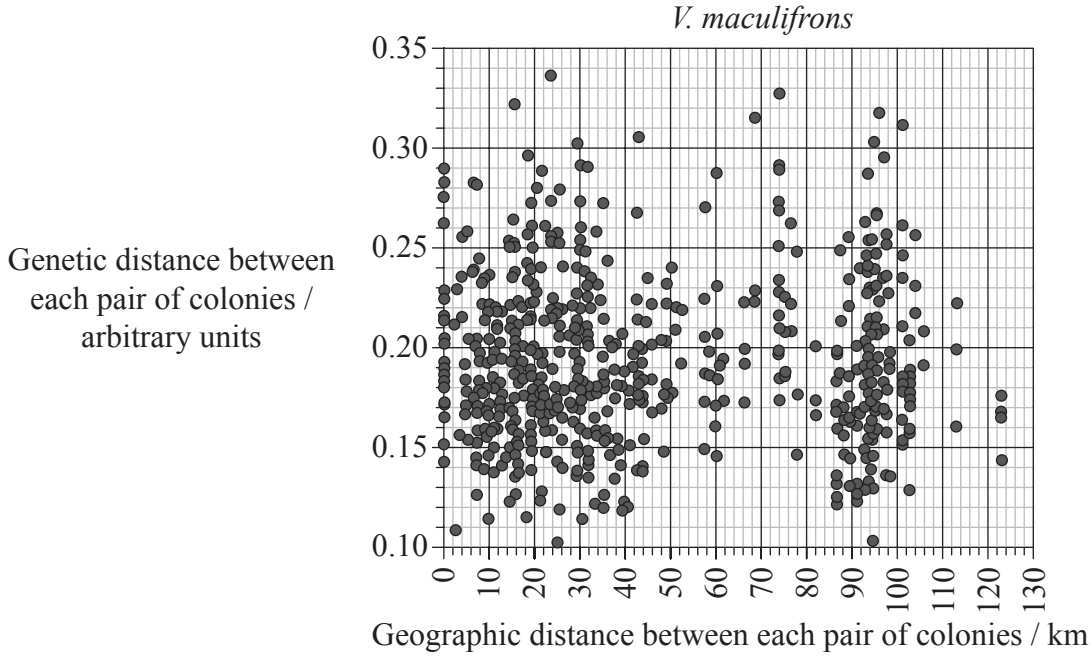
0128

Option D — Evolution

D1. A study was undertaken of the evolution of two species of wasps, one the parasite of the other. The parasite queen, *Vespula squamosa*, kills the host queen, *Vespula maculifrons*, and takes over her role in the colony. Data was compiled for 13 colonies of *V. squamosa* and 37 colonies of *V. maculifrons* to analyse the genetic structure of the two species.

Each point on the graphs represents the genetic distance and geographic distance between a pair of colonies. The genetic distance indicates the number of differences in specific DNA markers between a pair of colonies. The results are shown below.





Source: "Genetic structure and breeding system in a social wasp and its social parasite" by Hoffman EA, Kovacs JL, Goodisman MAD, *BMC Evolutionary Biology* (2008) 8:239. © 2008 Hoffman et al; licensee BioMed Central Ltd

(This question continues on the following page)

(Question D1 continued)

(a) (i) Determine the greatest genetic distance between any pair of colonies of *V. squamosa*. *[1]*

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(ii) Identify the greatest geographic distance between any pair of colonies of *V. maculifrons.* *[1]*

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(b) Describe the relationship between the geographic distance and genetic distance in the two species. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(c) Compare the two species in terms of genetic distance between the pairs of colonies. *[2]*

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(d) Data collected on eight specific alleles in the two species indicated that each species was in Hardy–Weinberg equilibrium. Evaluate all the data regarding possible evolutionary changes within the two species. *[2]*

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D2. (a) (i) Distinguish between transient polymorphism and balanced polymorphism. *[2]*

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(ii) State an example of transient polymorphism. *[1]*

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(b) Describe an example of a barrier between gene pools. *[2]*

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(Question D2 continued)

(c) Outline how variations in DNA can indicate phylogeny. *[2]*

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D3. Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution. *[6]*

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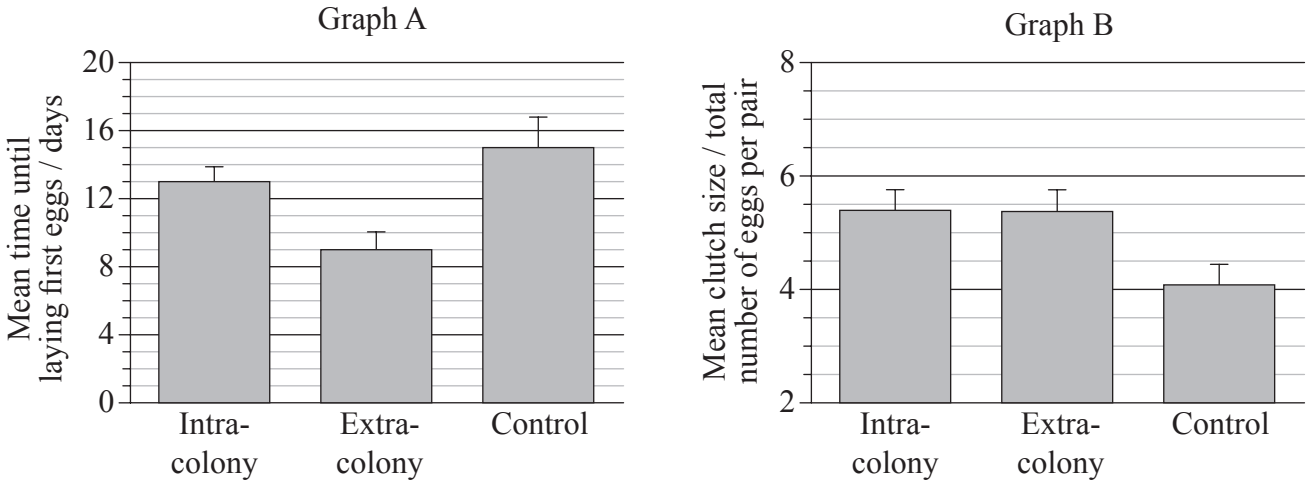
Option E — Neurobiology and behaviour

E1. The effect of social stimulation on the reproductive patterns of egg-laying female Zebra finches (*Taeniopygia guttata*) was studied. The sounds of the same colony (intra-colony) and of a different colony (extra-colony) were recorded and played to different pairs of Zebra finches.

Graph A shows the mean time until the laying of the first eggs. Graph B shows the mean clutch size (total number of eggs per pair). The control pairs had no recordings played to them.



J. Waas et al. (2005) Proceedings of the Royal Society, 272, pp. 383–388. Reproduced with permission.

(a) Identify the mean time until the laying of the first eggs in the control group of Zebra finches. *[1]*

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(b) Calculate the percentage decrease between the mean time until the laying of the first eggs in pairs of Zebra finches exposed to intra-colony sounds and in pairs exposed to extra-colony sounds. Show your working. *[2]*

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(This question continues on the following page)

(Question E1 continued)

(c) Evaluate the effect of the recorded colony sounds on the reproductive pattern of laying eggs in Zebra finches. *[3]*

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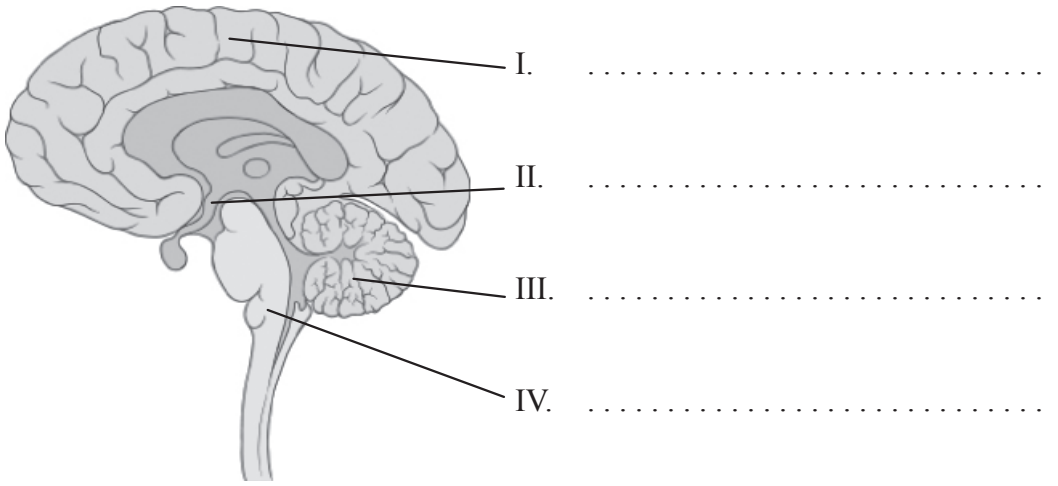
E2. (a) Identify the parts of the brain indicated on the diagram below. *[2]*



Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist

(b) Outline the unconscious control of the heart rate. *[3]*

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(Question E2 continued)

(c) Describe different aspects of the processing of visual stimuli. *[3]*

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E3. Explain the effects of cocaine in terms of its action at synapses in the brain and its social consequences. *[6]*

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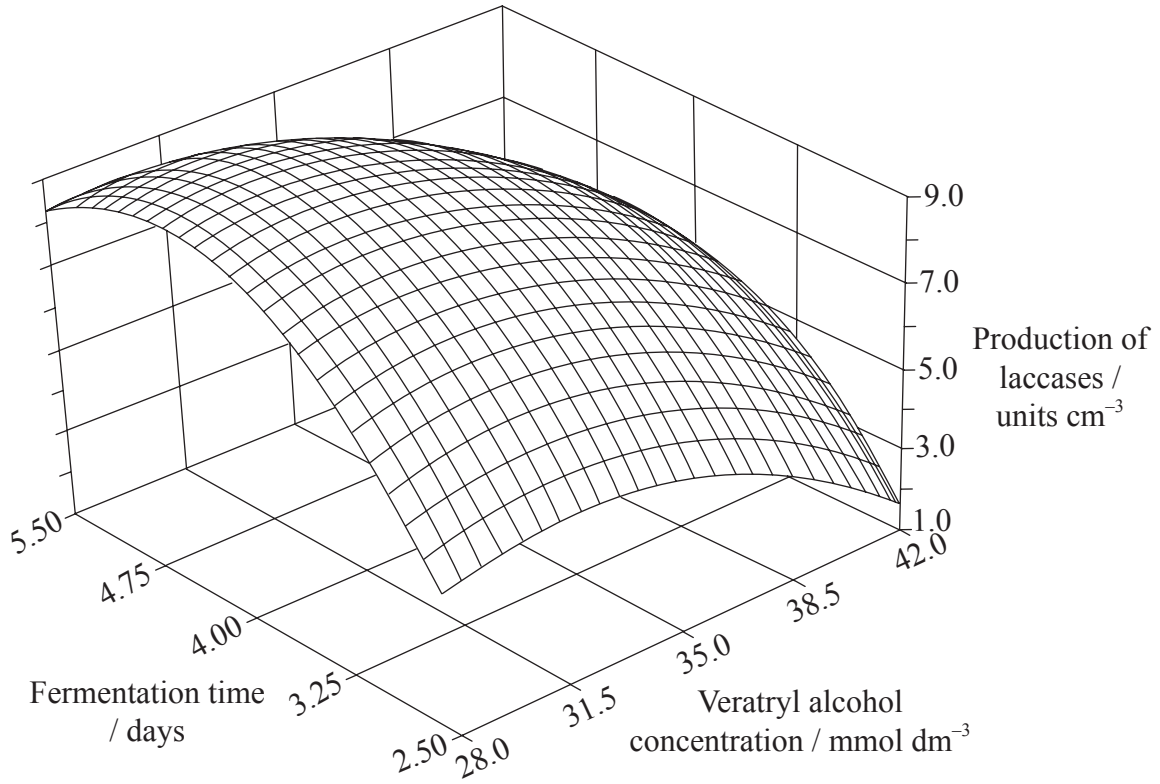
Option F — Microbes and biotechnology

F1. Fungi of the genus *Botryosphaeria* have been found to produce certain oxidizing enzymes, laccases, that are effective in treating contaminated water and soils. Studies were undertaken to test the effects of veratryl alcohol concentrations and fermentation time in order to optimize the industrial production of laccases. Statistical analysis of the data was used to develop the graph below.



(a) (i) Identify the amount of laccases produced when the veratryl alcohol concentration is at its highest level and the fermentation time is at its shortest. *[1]*

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(Question F1 continued)

(ii) Identify the amount of laccases produced when the veratryl alcohol concentration is at its lowest level and the fermentation time is at its longest. *[1]*

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(b) Analyse the overall effects of the veratryl alcohol concentration and fermentation time on the production of laccases. *[3]*

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(c) Suggest **two** other conditions that might affect the production of laccases. *[2]*

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F2. (a) State **two** characteristics that permit the classification of microbes into domains. *[2]*

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(b) Distinguish between chemoautotrophs and chemoheterotrophs in terms of carbon sources. *[2]*

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(c) Outline the transmission and treatment of a **named** example of microbial food poisoning. *[3]*

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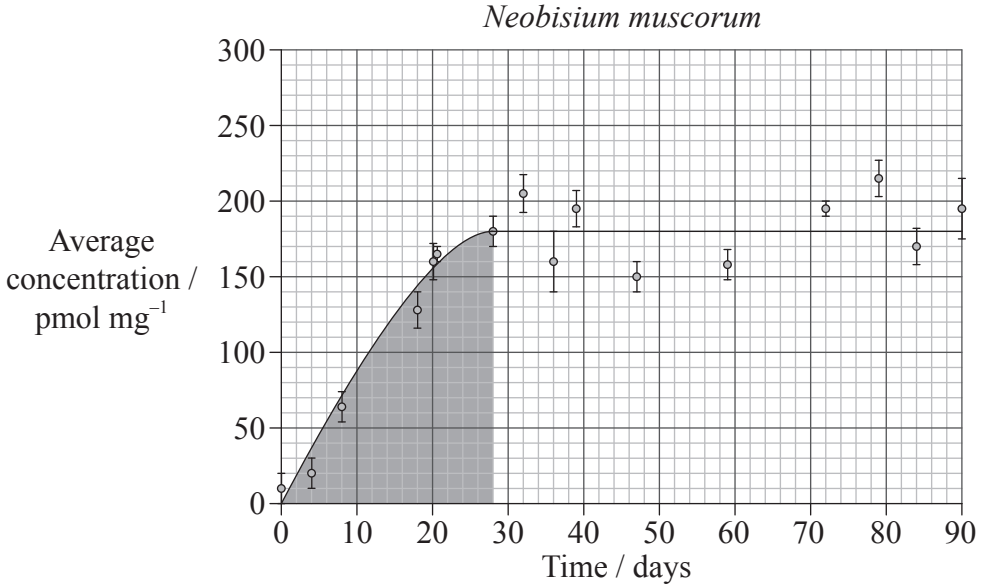
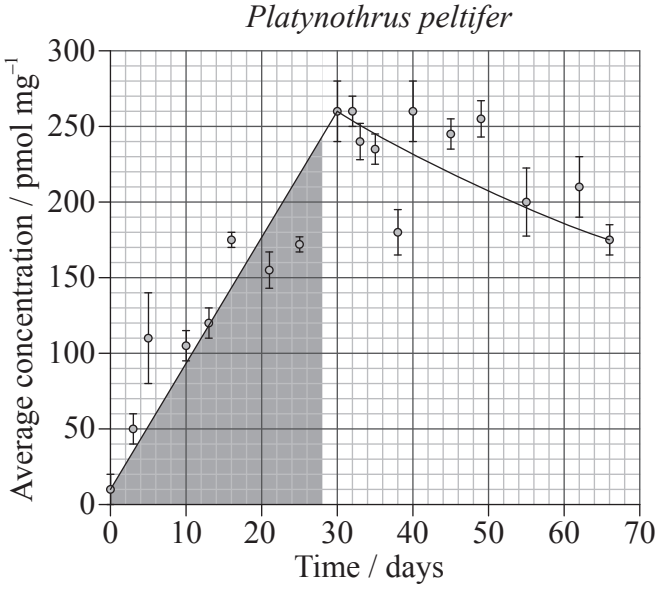
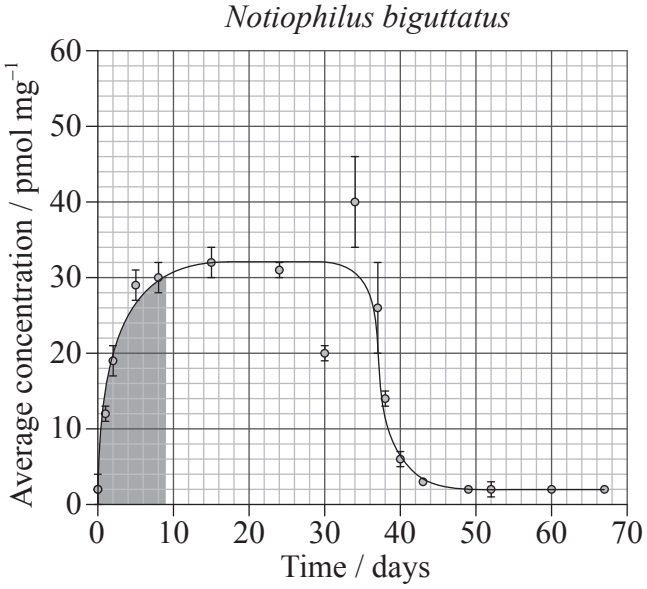
F3. Discuss the cause, epidemiology and problems of control of a **named** pandemic. *[6]*

Option G — Ecology and conservation

G1. Cadmium is a heavy metal that can be toxic to many species. In a study, the concentration of cadmium was examined in the tissues of three soil arthropods, *Neobisium muscorum*, *Platynothrus peltifer* and *Notiophilus biguttatus*. The shaded area of each graph indicates the time that the organisms were exposed to cadmium in their environment, while the unshaded area indicates the time when cadmium was not present in their environment.







JANSSEN, M.P.M., BRUINS, A., DE VRIES, T.H., & VAN STRAALEN, N.M. (1991) Comparison of cadmium kinetics in four soil arthropod species. *Arch. Environ. Contam*. Toxicol., 20: 305-312

(This question continues on the following page)

(Question G1 continued)

(a) Identify the highest average concentration of cadmium found in *P. peltifer*. *[1]*

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(b) Determine, with a reason from the data, which species is unable to eliminate cadmium. *[2]*

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(c) (i) State the species that accumulates the least cadmium. *[1]*

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(ii) Suggest, with observations from the data, a reason why the species stated in (c)(i) accumulates the least cadmium. *[2]*

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(Question G1 continued)

(d) Describe the possible effects of the presence of cadmium in food chains involving these arthropods. *[2]*

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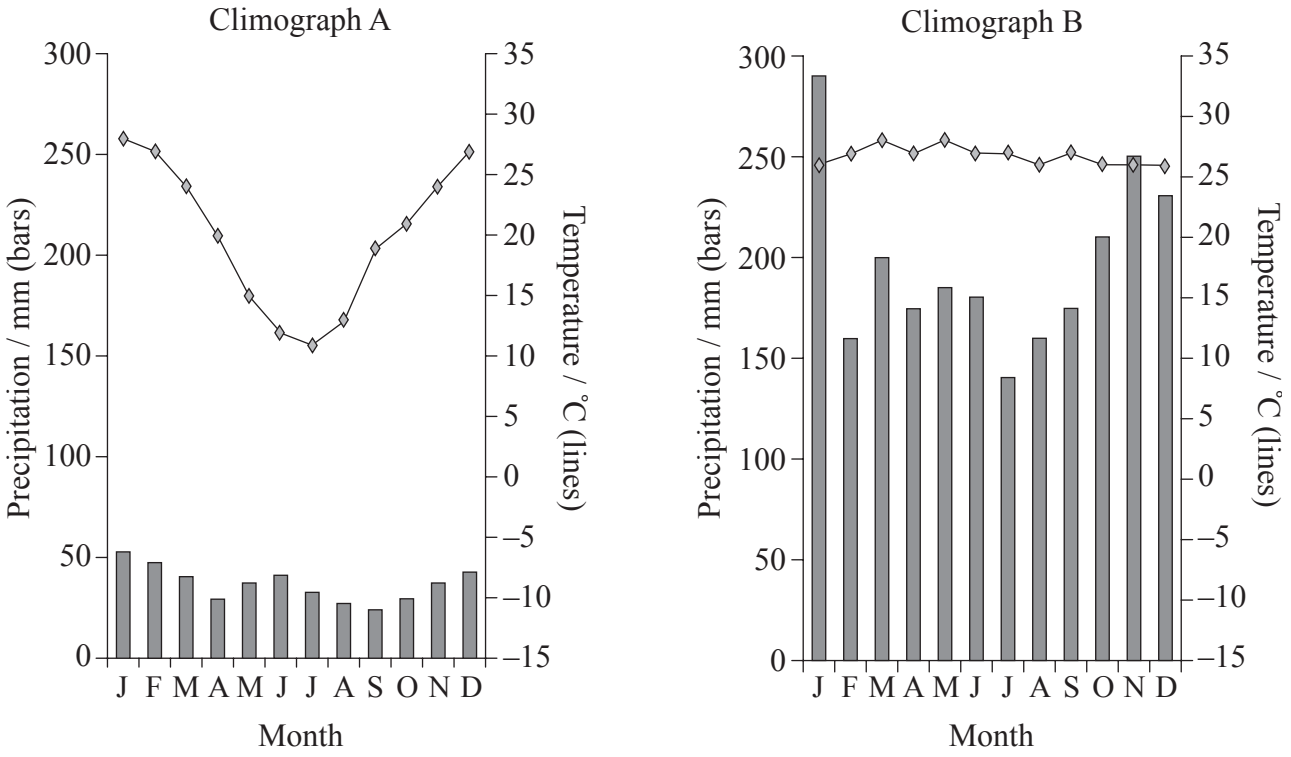
G2. (a) Climograph A below shows a tropical steppe which is a form of grassland.



Deduce, with a justification, the type of biome represented by climograph B. *[3]*

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(Question G2 continued)

(b) Define *indicator species*. *[1]*

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(c) Outline, with a **named** example, biological control of invasive species. *[2]*

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G3. Outline **either** *r*-strategies **or** *K*-strategies. *[6]*

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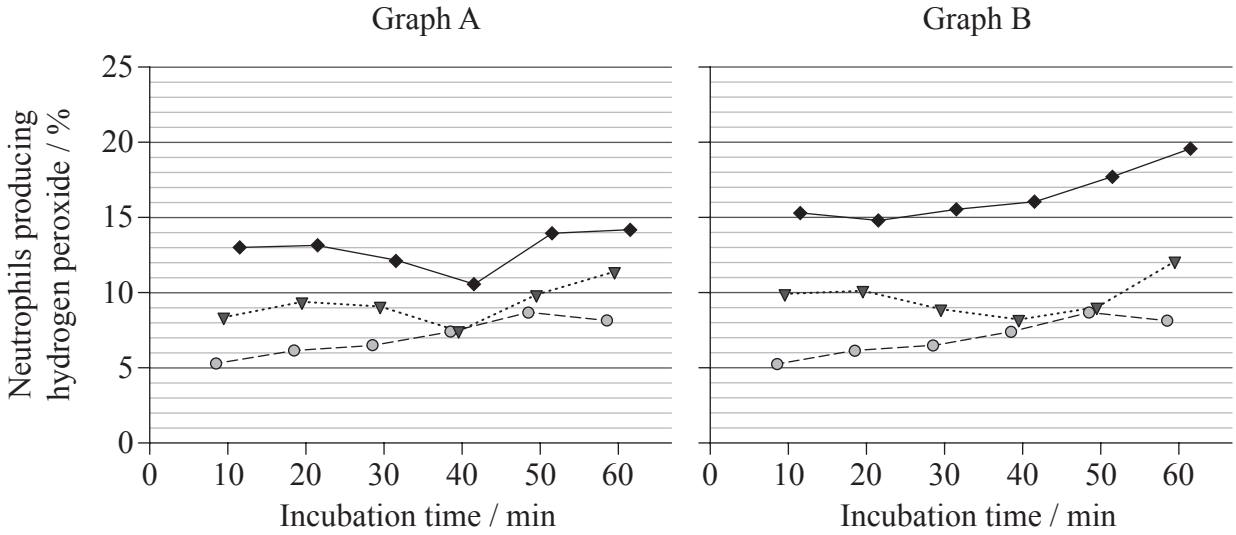
Option H — Further human physiology

H1. Neutrophils are a primary defence against bacterial and fungal infection. This defence involves both phagocytosis and hydrogen peroxide production. If there is an excess production of hydrogen peroxide, tissue damage may occur.

In hospitals, intravenous feeding of patients is often necessary and lipids form an essential part of the solutions used. A study was undertaken to measure the impact of two different types of lipid solutions on the activity of neutrophils in blood samples and on their production of hydrogen peroxide. The two lipid solutions were tested at two different concentrations, $0.06\,mg\,cm^{-3}$ (Graph A) and $0.6\,mg\,cm^{-3}$ (Graph B). The control has no lipid solutions.



Source: "Unsaturated long-chain fatty acids induce the respiratory burst of human neutrophils and monocytes in whole blood" by Björn Jüttner, Janina Kröplin, Sina M Coldewey, Lars Witt, Wilhelm A Osthaus, Christian Weilbach, Dirk Scheinichen, *Nutrition & Metabolism* (2008), 5:19. © 2008 Jüttner et al; licensee BioMed Central Ltd.

(a) Identify the maximum percentage value of neutrophils producing hydrogen peroxide for the LCT-MCT solution at $0.06\,mg\,cm^{-3}$. *[1]*

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(Question H1 continued)

(b) Compare the effects of the two different lipid solutions at the two different concentrations on the percentage of neutrophils producing hydrogen peroxide. *[3]*

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(c) Suggest why the addition of an increasing concentration of lipid into a hydrophilic medium, such as the intravenous feeding solution, may be a problem. *[1]*

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(d) Evaluate the data in terms of decisions for the intravenous feeding of patients. *[3]*

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H2. (a) List the locations of chemosensors that detect changes in CO_2 concentrations in the blood. *[2]*

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(b) State the name of the enzyme in red blood cells that converts CO_2 to a more soluble form. *[1]*

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(c) Explain the oxygen dissociation curve of myoglobin. *[3]*

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H3. Outline the roles of gastric acid and *Helicobacter pylori* in the development of stomach ulcers and stomach cancers. *[6]*

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