IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N03/410/H(3)

BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate number

Monday 17 November 2003 (morning)

1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box 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 candidate 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. The mechanisms of speciation in ferns have been studied in temperate and tropical habitats. One group of three species from the genus *Polypodium* lives in rocky areas in temperate forests in North America. Members of this group have similar morphology (form and structure). Another group of four species from the genus *Pleopeltis* live at different altitudes in tropical mountains in Mexico and Central America. Members of this group are morphologically distinct.

Data from the different species within each group was compared in order to study the mechanisms of speciation.

Genetic identity was determined by comparing the similarities of certain proteins and genes in each species. Values between 0 and 1 were assigned to pairs of species to indicate the degree of similarity in genetic identity. A value of 1 would mean that all the genetic factors studied were identical between the species being compared.

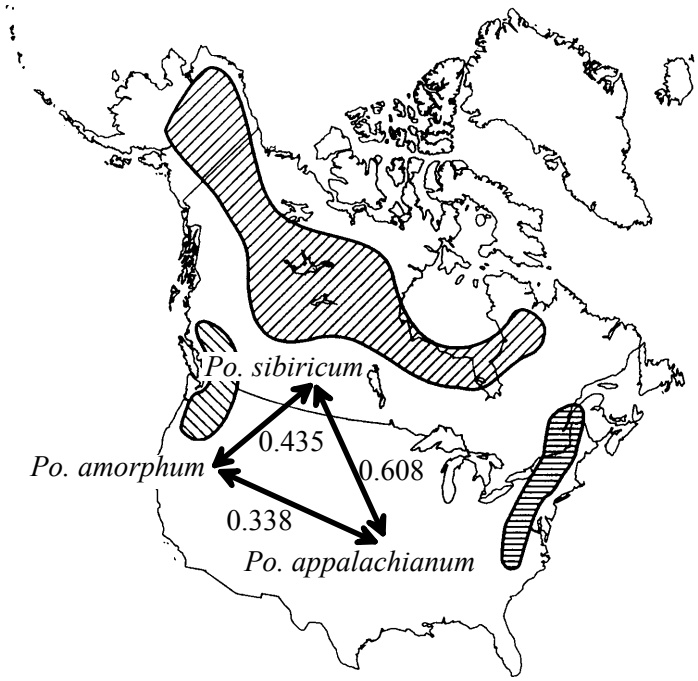

Fig. 1:
The approximate distribution in North America of the three species of *Polypodium (Po.)* and a summary of genetic identity.

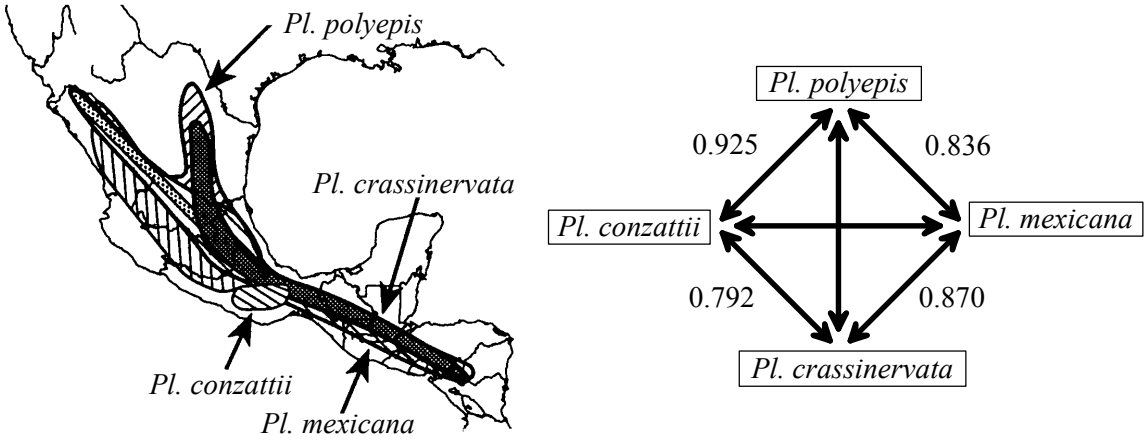

Fig. 2: The approximate distribution in Central America and Mexico of the four species of *Pleopeltis (Pl.)* and a summary of genetic identity.

[Source: C Haufler, E Hooper and J Therrien, (2000), *Plant Species Biology*, **15**, pages 223–236]

(This question continues on the following page)

(Question D1 continued)

(a) Compare the geographic distributions of the two groups. *[1]*

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(b) (i) Identify, giving a reason, which group, *Polypodium* or *Pleopeltis*, is most genetically diverse. *[1]*

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(ii) Identify the **two** species that are most similar genetically. *[1]*

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(c) Suggest how the process of speciation could have occurred in *Polypodium*. *[1]*

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(d) Explain which of the two groups has most probably been genetically isolated for the longest period of time. *[2]*

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D2. (a) Compare the conditions of pre-biotic Earth with the conditions today. *[3]*

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(b) State the theory of panspermia. *[1]*

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D3. (a) Outline **one** example of transient polymorphism and **one** of balanced polymorphism. *[4]*

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(b) Explain how biochemical analysis of different molecules is used to study the evolutionary relationships of different organisms. *[6]*

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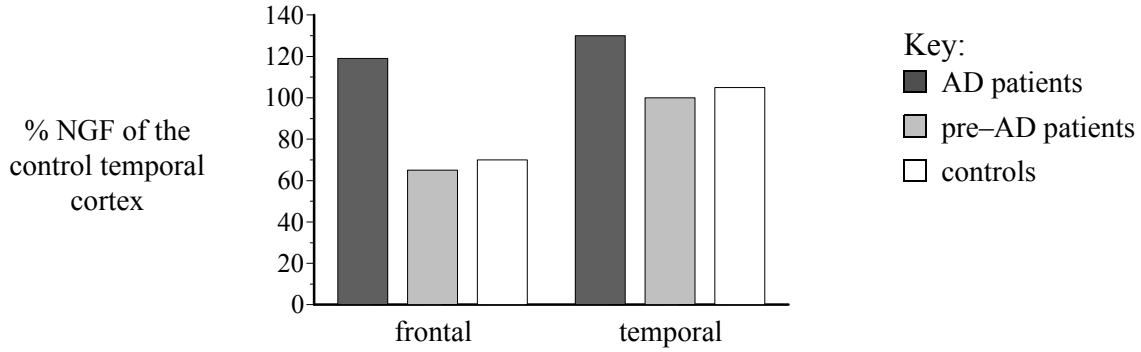
Option E – Neurobiology and Behaviour

E1. Alzheimer's disease (AD) is characterized by increasing dementia (mental and emotional deterioration) in affected persons.

Evidence from the *post-mortem* (after death) analysis of the brains of affected patients has revealed two abnormalities. Affected persons show a change in the concentration of nerve growth factor (NGF) in a region of the brain known as the cortex. The brains of affected patients also have plaques. These are accumulations of insoluble material in and around cells.

A study was carried out to measure the *post-mortem* NGF concentrations in two regions of the cortex, the temporal cortex and the frontal cortex. Three groups of people were compared:

- AD patients
- pre-AD patients with plaques but no dementia
- a control group with no plaques and no dementia.



[Source: R Hellweg *et al*., (1999), *International Journal of Developmental Neuroscience*, **16**, (7/8), pages 787–794]

(a) Compare the data for the two regions of the cortex. *[3]*

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(b) Calculate the increase in percentage NGF in the frontal cortex of AD patients compared to the control group. *[1]*

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(c) Suggest what happens to the quantity of NGF in the cortex as the disease progresses. *[2]*

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E2. (a) Outline Skinner's experiments on operant conditioning. *[2]*

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(b) Explain how kinesis could improve an animal's chances of survival. *[2]*

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E3. (a) Discuss the effects of excitatory psychoactive drugs, giving specific examples. *[5]*

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(Question E3 continued)

(b) Compare rod and cone cells in terms of their structure and functions. *[5]*

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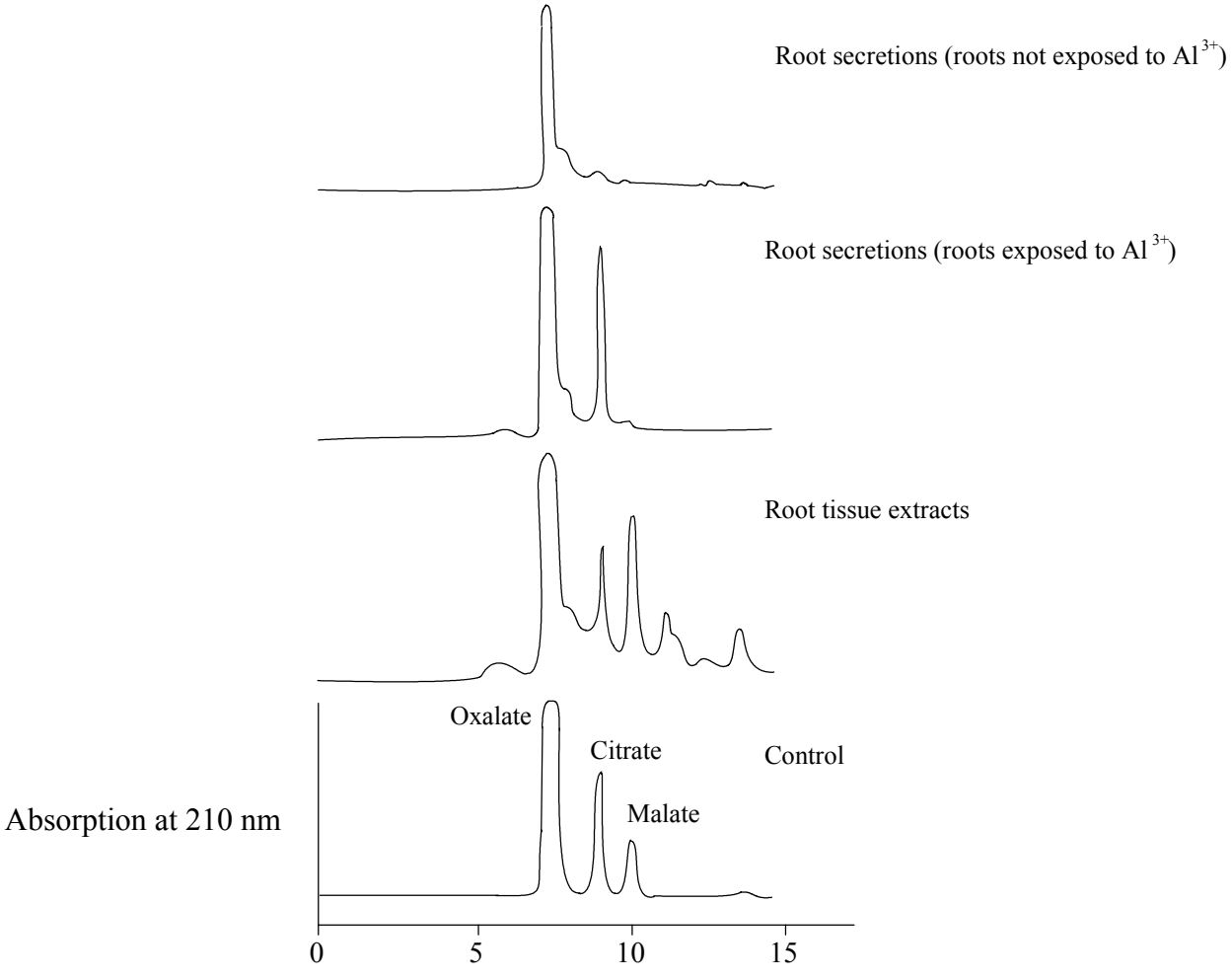
Option F – Applied Plant and Animal Science

F1. The element aluminium (Al) makes up 7 % of the Earth's crust, usually combined as harmless oxides and silicates. However, when the soil becomes acidic, aluminium becomes soluble as Al^{3+}, a toxic ion. The presence of Al^{3+} inhibits root growth which then affects nutrient and water uptake by the roots.

Some plants, such as maize and wheat, have evolved mechanisms to tolerate aluminium stress. Evidence indicates that the roots of such plants secrete organic acids, including oxalate, citrate and malate, all of which are involved in the Krebs cycle. These organic acids form stable, non-toxic complexes with Al^{3+} ions.

In an experiment, *Cassia tora* roots were exposed for 9 hours to solutions with or without Al^{3+} ions. The organic acids in the extracts of root tissue were compared with those secreted into the solution by means of HPLC (high pressure liquid chromatography). The acids were separated by this technique and their presence detected by their absorption of light at 210 nm. Each acid was identified by the time taken for separation to occur.



[Source: J Feng Ma, P R Ryan and E Elhaize, (2001), *Trends in Plant Science*, **6**, pages 273–278]

(This question continues on the following page)

(Question F1 continued)

(a) Identify which acid is secreted from the root in response to the presence of Al^{3+} ions. *[1]*

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(b) Identify the organelle of the root cells where all these organic acids would be found. *[1]*

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(c) Explain why more acids are found in the root tissue extracts than in the root secretions. *[1]*

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Hydrangeas are plants that are grown in gardens in many parts of the world because of their large, colourful flowers. It has been shown that the different colours are due to the ability of the plant to accumulate high concentrations of Al^{3+} in the flowers, changing their colour from pink to blue.

(d) Discuss different methods that a flower grower might use, based on the information from the aluminium research, to produce different colours of *Hydrangea* flowers. *[3]*

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F2. (a) Compare biological issues surrounding organic and non-organic farming methods. *[2]*

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(b) Distinguish between growth regulators and fertilizers. *[2]*

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F3. (a) Outline veterinary techniques that are applied to improve the health and fecundity of animals. *[4]*

(b) Discuss the use of asexual reproduction in the artificial propagation of plants. *[6]*

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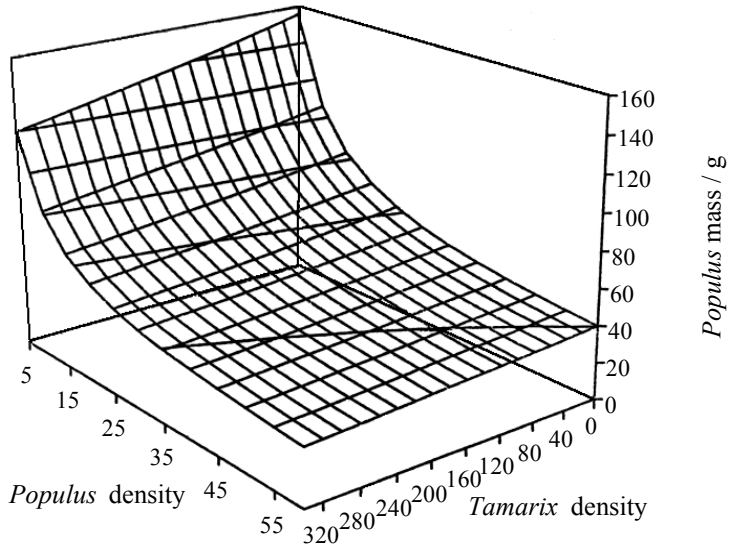
Option G – Ecology and Conservation

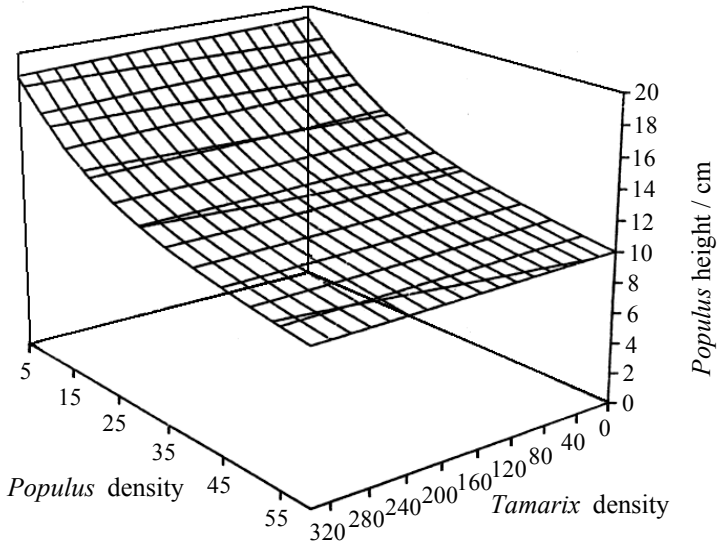
G1. In the south-west of the USA, dams were built across rivers in the early 1900s to stop natural flooding. As a result, a non-native tree *Tamarix ramosissima* (salt cedar) gradually replaced the native *Populus deltoides* (cottonwood) as the dominant woody species. Flooding is being re-established to reverse the invasion of *Tamarix*.

Studies were done to investigate the relative competitive abilities at the seedling stage using different densities of the two species. Seedlings were grown in pots at different densities and mixtures of the two species. A three dimensional model was developed to show the effect of the densities of each species on *Populus* mass (graph A) and height (graph B). Densities represent the number of seedlings per 20-cm-diameter pot.

Graph A:
Effect of seedling densities on *Populus* mass



Graph B:
Effect of seedling densities on *Populus* height



[Source: A Sher, D Marshall and S Gilbert, (2000), *Conservation Biology*, **14**, pages 1744–1754]

(This question continues on the following page)

(Question G1 continued)

(a) Considering the pots where *Populus* is growing without *Tamarix*, describe the change in mass **and** height of *Populus* with increased density of *Populus* seedlings. *[3]*

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(b) Describe how *Tamarix* density affects *Populus* height. *[1]*

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(c) Suggest **two** factors that could have allowed *Tamarix* to dominate in non-flood conditions. *[2]*

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G2. (a) Distinguish between parasitism and mutualism. *[2]*

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(b) Outline the management of nature reserves. *[2]*

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G3. (a) Outline the consequences of releasing raw sewage into a river. *[4]*

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(b) Discuss the actions taken by farmers/gardeners to increase the nitrogen fertility of the soil. *[6]*

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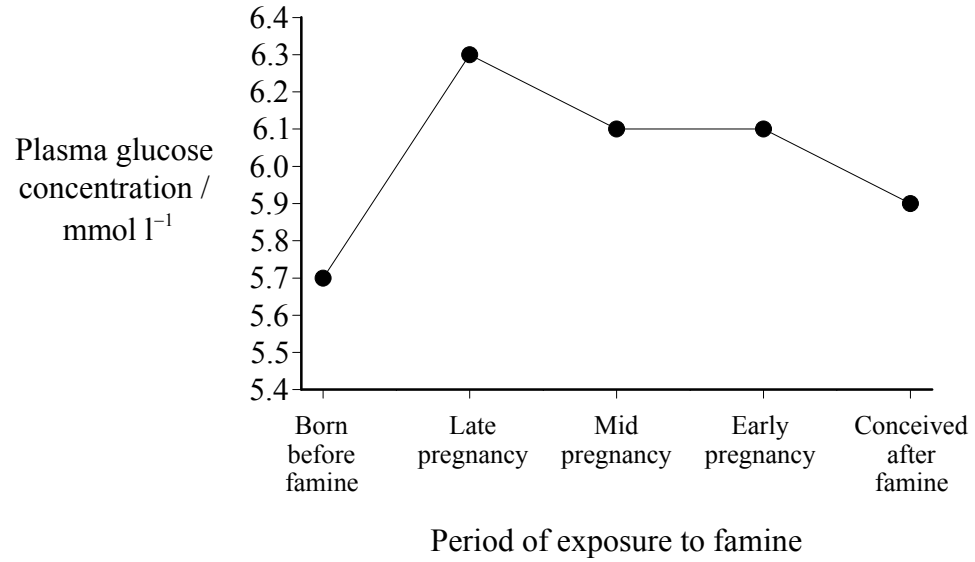
Option H – Further Human Physiology

H1. Poor nutrition of a woman during pregnancy has been associated with a variety of metabolic disorders later in the life of her offspring.

During the Second World War (WWII) the normally well-fed population of Holland suffered famine over a relatively short and precisely defined period. The data available from this period provided examples of fetuses that were affected by famine at specific periods during pregnancy.

Glucose tolerance was analyzed in human adults 50–55 years of age who had suffered fetal famine during WWII (Figure 1). High glucose levels in blood plasma indicate poor glucose tolerance.

Figure 1: Glucose tolerance



[Source: N Metcalfe and P Monaghan, (2001), *Trends in Ecology and Evolution*, **16**, pages 254–260]

(a) (i) Identify the period of exposure to famine that produces the greatest decrease in glucose tolerance. *[1]*

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(ii) Calculate the percentage change in plasma glucose concentration after exposure to famine from early to late pregnancy. *[1]*

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(iii) Suggest a reason why glucose tolerance did not return to normal in people conceived after the famine. *[1]*

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(This question continues on the following page)

(Question H1 continued)

(b) Outline a possible cause of poor glucose tolerance. *[1]*

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(c) Suggest how poor glucose tolerance could be related to the occurrence of coronary heart disease. *[2]*

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H2. (a) Draw a diagram of the hypothalamus **and** the pituitary gland. *[2]*

(b) Outline the role of bile in lipid digestion in a hydrophilic medium. *[2]*

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H3. (a) Describe the mechanisms that control the heartbeat. *[4]*

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(b) Explain why ventilation rate varies with exercise. *[6]*

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