MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD
UNIVERSITY OF MALTA, MSIDA

MATRICULATION CERTIFICATE EXAMINATION
ADVANCED LEVEL
SPECIMEN PAPER (2011-2013)

SUBJECT: BIOLOGY
PAPER NUMBER: SPECIMEN PAPER II (2011-2013)

Directions to Candidates

• Answer the question in Section A, any TWO questions from Section B and ONE question from Section C. Write all the answers in the separate booklet provided.

• If more than two questions from section B are attempted, only the first two answers shall be taken into consideration.

• If more than one question from section C is attempted, only the first answer shall be taken into consideration.

• The mark allocation is indicated at the end of each question. Marks allocated to parts of questions are also indicated.

• You are reminded of the necessity for good English and orderly presentation in your answers.

• In calculations you are advised to show all the steps in your working, giving your answer at each stage.

• The use of electronic calculators is permitted.
SECTION A (Answer the question in this section).

1. Read the extract below carefully and afterward, from the information given and from your knowledge of biology, answer the questions that follow. The numerals in the left-hand margin are line numbers.

Aquaporins In Cell Surface Membranes
A cell surface membrane consists of two main types of molecule: phospholipids and proteins. The properties of the phospholipids result in them forming a bilayer in which the proteins are interspersed. An important function of the membrane is to act as a barrier controlling the entry of substances into the cell. Certain types of molecule can gain entry through the phospholipid layer. Many, however, only dissolve in water and are unable to gain access by this route. They rely on proteins to pass through the membrane. Water is a small molecule and, because of this, some water is able to pass through the phospholipid layer. Some cells, however, have water permeabilities that are many times the level that would be expected if movement only took place through the phospholipid layer. This can now be explained.

In 1988, a group of scientists trying to isolate an antigen from the cell surface membrane of red blood cells discovered another protein present in considerable amounts. They were able to determine the full DNA sequence for this protein and, from this information, were able to predict the exact sequence of its 275 amino acids. Knowing the amino acid sequence meant that the team could make some predictions about its function. One interesting feature of the molecule was that there were six regions which contained large numbers of hydrophobic amino acids. It was thought that these hydrophobic amino acids formed structures within the phospholipid bilayer creating a pore through the membrane. Perhaps this molecule could act as some sort of water channel?

Experimental evidence confirming the role of this protein, now known as aquaporin-1 (AQPI), was obtained three years later. Egg cells from a frog were injected with a solution containing the mRNA which coded for AQP1. These cells, together with others which acted as controls, were transferred from the saline solution in which they were incubating, to a more dilute solution. The cells which had been injected with AQP1 mRNA swelled rapidly.

Since this early work, we have discovered many more aquaporins. They are particularly important in regulating water balance. The cells in the hypothalamus which act as osmoreceptors contain aquaporins in their membranes. These are the cells that respond when a person becomes dehydrated, and trigger the release of ADH from the pituitary gland. When the ADH reaches the kidney, it exerts its effect by instructing the cells of the collecting duct to produce more aquaporin.
Using information in the passage, and your own knowledge, answer the following questions.

(a) Explain how the properties of phospholipid molecules result in them forming a bilayer (line 3). (3 marks)

(b) Oxygen, carbon dioxide, fatty acids and cholesterol enter a cell through the phospholipid bilayer. Give two properties of molecules such as these that allow them to pass through the cell surface membrane in this way. (2 marks)

(c) (i) What is the minimum number of phosphate groups in the double helix of the DNA which codes for the protein referred to in line 14? Explain how you arrived at your answer. (3 marks)

(ii) Although it is possible to predict the exact sequence of amino acids in a protein from its DNA sequence, it is not possible to predict the exact sequence of DNA bases that codes for a particular amino acid sequence. Explain why. (2 marks)

(d) (i) Suggest what causes the molecules of some amino acids to be hydrophobic while others are not. (2 marks)

(ii) Suggest why it is thought that the hydrophobic amino acids form structures within the phospholipid bilayer (line 19). (2 marks)

(e) (i) Suggest how the egg cells which acted as a control (line 25) should have been treated. (2 marks)

(ii) Explain why it was necessary to have this control in this investigation. (2 marks)

(f) Explain why the cells treated with the mRNA for AQPI swelled rapidly (line 26). (3 marks)

(g) (i) Water is able to enter cells through the phospholipid bilayer. What is the advantage of the osmoreceptors in the hypothalamus possessing aquaporins? (2 marks)

(ii) Explain the link between the role of ADH, the collecting duct and aquaporins. (2 marks)

[Total: twenty-five marks]
SECTION B
(Answer any TWO questions from this section; your answers should take the form of essays. Each question carries twenty five marks)

2. Give an overview of electron transport chains and ATP production.

3. Compare and contrast the structure and function of xylem and phloem in plants.

4. Describe the role of countercurrent flows in biological systems.

5. "Arthropods are considered to be the most successful animals on Earth”. Discuss.

SECTION C
(Answer ONE question from this section).

6. Use your knowledge of biology to explain the evolutionary significance of the following:

   6.1 Crossing two pink-flowered snapdragons together is not a certain method of obtaining pink-flowers in a subsequent generation of plants.

   6.2 Haemophilia and colour blindness are more frequent in males than in females.

   6.3 When two purple-flowered, long pollen sweet pea plants were crossed together, 75% of the next generation of plants was purple-flowered, long pollen, and 25% were red-flowered, short pollen varieties.

   6.4 A heterozygous woman with blood group A and a heterozygous male with blood group B could have 4 children, all with a different blood group.

   6.5 In poultry the F2 phenotypic ratios resulting from crossing a pure-breeding pea-comb hen with a pure-breeding rose-comb cock are 9 walnut-comb: 3 pea-comb: 3 rose-comb : 1 single-comb

   (5 marks each)

   [Total: twenty-five marks]
7. Use your knowledge of biology to explain the following statements.

7.1 A single closed circulatory system would be an inefficient method of blood circulation in mammals.

7.2 Predators generally hunt lizards in the early morning.

7.3 Internal fertilisation is an adaptation to life on land.

7.4 Several insect-pollinated plants release volatile organic compounds at the time of flowering.

7.5 Positive feedback mechanisms are rare in nature.

(5 marks each)

[Total: twenty-five marks]