

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD
UNIVERSITY OF MALTA, MSIDA
MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017

SUBJECT: BIOLOGY
PAPER NUMBER: I
DATE: 4th September 2017
TIME: 9.00 a.m. to 12.05 p.m.

Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
 - Answer **ALL** questions. Write all your answers in the spaces provided in this booklet.
 - 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.
-

For examiners' use only:

Question	1	2	3	4	5	6	7	8	9	10	Total
Score											
Maximum	10	10	11	10	12	10	10	7	10	10	100

DO NOT WRITE ABOVE THIS LINE

1. This question is about water and other biochemicals.
- a. Water is often called the “Universal Solvent”. Figure 1 shows what happens when table salt (NaCl) is mixed with water.

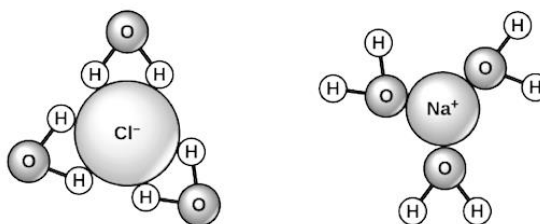


Figure 1: Hydration shells around chloride (left) and sodium ions (right)
 Source: http://cnx.org/contents/GFy_h8cu@9.87:pPjfgsd4@9/Water

- (i) Why do water molecules surround the ions in the way as seen in Figure 1 above?

(2)

- (ii) For a fish living in a lake, the good solvent properties of water enable it to obtain oxygen from its surroundings. In the table below, list **TWO** other properties that help make water an ideal habitat for this fish, giving reasons for each answer.

Property of water	How this property makes water an ideal habitat for fish living in a lake

(4)

- b. Chitosan, seen in Figure 2, is a polymer that is made by treating the shells of shrimps and other crustaceans with an alkaline substance. Its properties allow it to rapidly clot blood and it is therefore used in military bandages since it can stop severe bleeding in under two minutes.

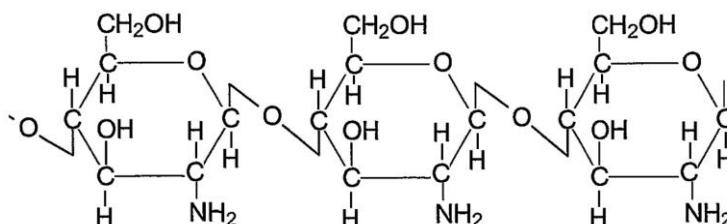


Figure 2: Structural formula of chitosan
 Source: <https://www.google.com/patents/EP1409582A1?cl=en>

(i) In the space below, draw the structural formula of the monomer of chitosan.

(1)

(ii) Give **ONE** similarity between the structure of chitosan and that of cellulose.

_____ (1)

(iii) Relate the structure of cellulose to its function.

_____ (2)

(Total: 10 marks)

2. This question is about heterotrophic nutrition.

a. List the **THREE** types of cells found in zymogen glands (also known as chief glands).

_____ (3)

b. An enzyme that digests protein can be found in the stomach.

(i) Name this enzyme: _____ (1)

(ii) Name the cells that secrete (the inactive form of) this enzyme:

_____ (1)

Question continues on next page

(iii) Why is it necessary that this enzyme is secreted in an inactive state?

(2)

c. In which part of the alimentary canal does the absorption of the end-products of digestion occur?

(1)

d. Why is active transport employed in the absorption of monosaccharides, dipeptides and amino acids into the blood capillaries?

(2)

(Total: 10 marks)

3. This question is about the circulatory system.

The heart is made up of cardiac muscle cells. Figure 3 highlights the structures within the human heart that are concerned with myogenic contractions. The numbers on the heart indicate the cumulative time, in milliseconds, from the initiation of an action potential in structure A.

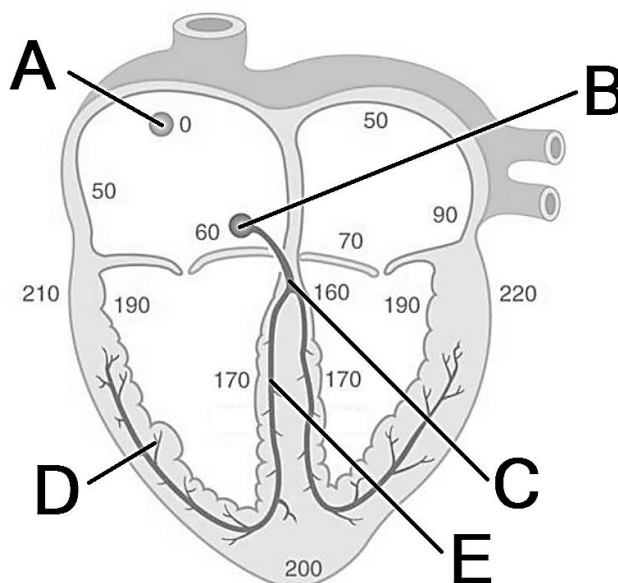


Figure 3: Mammalian heart showing the structures involved in myogenic contractions
Source: <https://www.memorangapp.com/flashcards/84778/Physiology+L16+Cardiac+Electrophysiology/>

DO NOT WRITE ABOVE THIS LINE

a. Identify parts A to D.

A: _____ C: _____

B: _____ D: _____ (2)

b. What is meant by myogenic contractions?

_____ (1)

c. A healthy heart makes two sounds commonly referred to as ‘lub’ and ‘dub’. Describe what causes these sounds.

Lub: _____ (1)

Dub: _____ (1)

d. Mention **TWO** ways by which cardiac muscle cells are adapted to do their job.

_____ (2)

e. In a mammalian heart, the septum prevents blood from the left side of the heart from mixing with blood from the right side. Give **ONE** advantage of this development.

_____ (1)

f. Points B and E are approximately equidistant to point C. However the conduction velocity between point C and E is considerably higher than that between B and C. Suggest a reason for this observation.

_____ (1)

Question continues on next page

DO NOT WRITE ABOVE THIS LINE

- g. The heart shown in Figure 3 has a stroke volume of 90 ml. If the heart rate is 130 beats per minute, calculate its cardiac output.

(2)

(Total: 11 marks)

- 4. This question is about the nervous system.

- a. What is a reflex action?

(2)

- b. Figure 4 below shows a transverse section of the spinal cord of a mammal.

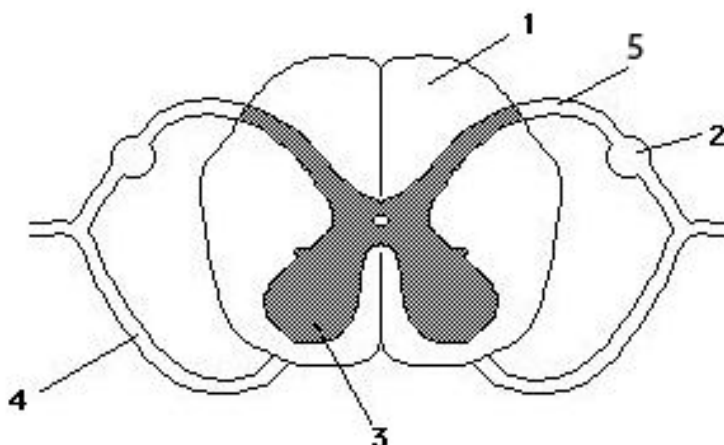


Figure 4: Transverse section through the spinal cord of a mammal

Adapted and modified from:

<http://humanphysiology.academy/Neurosciences%202015/Images/2/spinal%20cross%20section.png>

- (i) Refer to Figure 4 and name parts 1 to 5.

1. _____

2. _____

3. _____

4. _____

5. _____

(2½)

DO NOT WRITE ABOVE THIS LINE

- b. Complete the table below by giving **ONE** basic difference between the events of mitosis and the first division of meiosis at each of the stages named below:

Stage	Mitosis	First division of meiosis
Prophase		
Metaphase		
Anaphase		

(3)

- c. Identify the stage of meiosis whereby the following occur:

(i) Crossing-over;

_____ (1)

(ii) A nuclear envelope forms around each set of chromosomes;

_____ (1)

(iii) Separation of homologous chromosomes;

_____ (1)

(iv) Centromeres divide and chromatids move to the opposite poles of the cells.

_____ (1)

(Total: 12 marks)

6. This question is about water relations.

a. Water potential (Ψ) is described by the following formula:

$$\Psi = \Psi_p + \Psi_s$$

where Ψ is the water potential;

Ψ_p is the pressure potential;

Ψ_s is the solute potential.

(i) Explain the term pressure potential (Ψ_p).

(1)

(ii) How does Ψ_p affect the water potential?

(1)

(iii) Explain the term solute potential (Ψ_s).

(1)

(iv) Discuss the effect of Ψ_s on the water potential.

(1)

Question continues on next page

DO NOT WRITE ABOVE THIS LINE

- b. (i) The solute potential of a flaccid cell is -0.9 mPa. What is the water potential of this cell?

(2)

- (ii) Explain how the water will move if the cell is placed in a sucrose solution which has a water potential of -0.5 mPa.

(2)

- c. Describe the process of mineral ion uptake into roots.

(2)

(Total: 10 marks)

7. This question is about plant reproduction.

a. Plants exhibit alternation of generations in their life cycles. Identify each generation and briefly explain it.

(6)

b. What does a dominant generation mean?

(2)

c. How does the dominant generation change from nonvascular to vascular plants?

(2)

(Total: 10 marks)

Please turn the page

8. This question is about excretion

Consider Figure 5 which depicts the nephron.

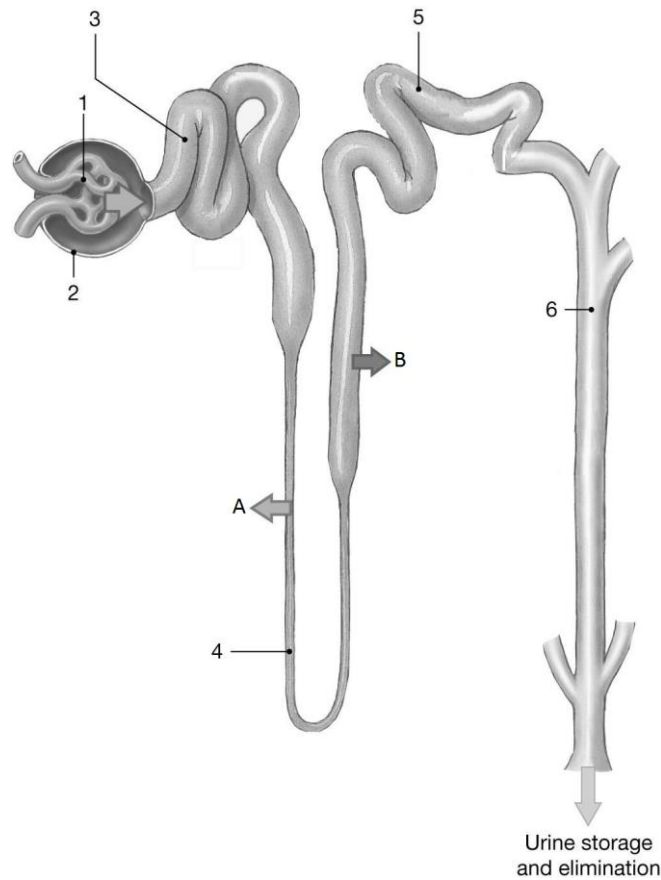


Figure 5: The structure of the Nephron

Adapted from https://classconnection.s3.amazonaws.com/155/flashcards/2376155/jpg/urine_filtration-141F1770DE82F0BE67E.jpg

a. Label structures 1 – 6.

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____
- 6. _____

(3)

DO NOT WRITE ABOVE THIS LINE

-
- b. The nephron allows for the conservation of water. This can be seen in points A and B in Figure 5. What substances move out of points A and B and how do the substances move out from these two points?

(4)

(Total: 7 marks)

9. This question is about respiration.

There are **TWO** mistakes in each of the following statements. Re-write each statement correctly.

- a. Glycolysis is a series of steps where carbon dioxide is broken down to two molecules of pyruvic acid; it takes place entirely in the mitochondria.

(2)

- b. The citric acid cycle plays several roles in catabolic reactions, its central function is the oxidation of acetyl CoA to pyruvate and water.

(2)

Question continues on next page

DO NOT WRITE ABOVE THIS LINE

- c. In the process of lactate fermentation, the organisms accumulate an oxygen surplus which is repaid as soon as possible after activity by slow breathing following the exertion.

(2)

- d. During fat metabolism, each glycerol molecule is reduced by a process called β -oxidation.

(2)

- e. The endosymbiont hypothesis explains how the free energy generated by the electron transport chain is used to produce NADPH.

(2)

(Total: 10 marks)

10. This question is about thermoregulation.

a. Explain how the following structures allow the mammalian skin to maintain a constant body temperature in a hot environment:

(i) blood capillaries;

_____ (1)

(ii) erector pili muscle;

_____ (1)

(iii) sweat glands;

_____ (1)

(iv) thermoreceptors.

_____ (1)

b. Explain how the counter-current heat exchanger found in the limbs of certain mammals and birds can reduce heat loss.

_____ (2)

Question continues on next page

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

MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017

SUBJECT:	BIOLOGY
PAPER NUMBER:	II
DATE:	5 th September 2017
TIME:	9:00a.m. to 12:05 p.m.

Directions to Candidates

- Answer the question in Section A, any **TWO** questions from Section B and **ONE** question from Section C. Write all your 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

This section is obligatory.

1. Read carefully the following extract. Then using the information provided and your knowledge of biology, answer the questions that follow. The numerals in the left-hand margin are the line numbers.

Glowing Plants on Kickstarter: The Ethics of Synthetic Biology

Synthetic biology is a rapidly growing field that applies engineering approaches such as modularity, standardisation, and modelling to build new combinations of biological parts that can accomplish specific tasks. Current applications of synthetic biology range from producing an anti-malarial drug precursor in yeast to building a completely synthetic genome for a cell that can self-replicate.

- 5 Synthetic biology goes beyond traditional molecular biology in that it uses Lego-style assembly logic, where many kinds of DNA “building blocks” can be assembled by a few common steps. While recombinant DNA technology (being able to manipulate DNA and combine different pieces to create new or more efficient outcomes) has been around since the 1970s, this streamlining of the assembly process allows scientists to greatly speed up the process of building recombinant pieces of DNA.
10 Thus, recombinant DNA technology is now accessible to many more people and the process of creating new DNA-based products can be much faster and more efficient. This has raised excitement over potential technologies that benefit the environment, human health and industrial applications, but also raises concerns about potential misuse or dangers of the technology.

- 15 In 2013, Genome Compiler Corporation launched The Glowing Plant project, a crowdfunding campaign on Kickstarter. The aim of this project was to produce a plant that produces natural lighting. The Glowing Plant project sought to engineer a small flowering plant, the thale cress *Arabidopsis thaliana* to emit weak, green-blue light by endowing it with genetic circuitry from fireflies. Making plants glow has been possible since the 1980s, when scientists added a gene encoding the firefly enzyme luciferase to a tobacco plant. When sprayed with the chemical substrate luciferin, the plant
20 glowed temporarily. In 2010, another group engineered a tobacco plant by using bacterial genes in order to have its own weak glow. Also in 2010, a team at the University of Cambridge, UK, created a genetic circuit in bacteria that makes both firefly luciferase and luciferin, so that the bacteria glow continuously. The Glowing Plant team planned to tweak the genes in that circuit so that they work in plants. In such projects, techniques such as polymerase chain reaction (PCR), gel electrophoresis and
25 Southern blotting are used.

- If the non-commercial Glowing plant project succeeded, thousands of supporters would receive seeds for a plant that would glow in the dark and the blessings of the project leadership to plant them. Supporters were also promised t-shirts, stickers, and light-bulb vases. Perhaps unsurprisingly, there was a fair bit of demand for glow-in-the-dark plants. The campaign ultimately raised well over seven
30 times its fundraising goal. Although the Glowing Plant project would ultimately push Kickstarter to issue rules banning the use of genetically modified organisms as payment to investors, the questions raised by the project about the future of synthetic biology were not so easily answered.

*Adapted and modified from: http://sciencecases.lib.buffalo.edu/cs/files/glowing_plants.pdf
<http://www.nature.com/news/glowing-plants-spark-debate-1.13131>*

- a. What is recombinant DNA? (line 7) (2)
- b. List **THREE** benefits of using recombinant DNA technology. (3)
- c. One goal of recombinant DNA technology is to clone a particular gene. A gene can be cloned by inserting it into a bacterial cell such as *Escherichia coli*. What will eventually happen once the gene is inserted into the bacterial cell? (2)
- d. State the term used to describe a host cell or organism that contains recombinant DNA? (1)
- e. Name and briefly explain a method of producing multiple copies of a particular gene. (5)
- f. Name and explain a method in which DNA fragments are separated. (4)
- g. Explain why is Southern blotting used. (2)
- h. Give **ONE** example of a Genetically Modified Organism (other than those mentioned in the text) and clearly state its genetically conferred trait. (2)
- i. List **TWO** possible disadvantages related with using Genetically Modified Organisms. (2)
- j. Give **ONE** reason why Kickstarter ended up issuing rules banning the use of Genetically Modified Organisms as payment to investors? (2)

(Total: 25 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. Discuss the ecology of the Maltese Islands giving particular reference to terrestrial habitat types.
3. Vaccinations work because they stimulate the specific branch of the immune system, also known as the adaptive immune system or the third line of defence. Give a detailed account of adaptive defence mechanisms and describe their role in making vaccinations effective.
4. Mutations can be classified into two broad categories – gene mutations (commonly referred to as point mutations) and chromosome mutations. Discuss this statement and describe **TWO** specific disorders for each category.
5. According to the Hardy-Weinberg equilibrium principle, and if certain conditions are met, the genetic structure of a population may not change over time. Discuss.

(Total: 50 marks)

SECTION C

Answer ONE question from this section.

6. Write brief notes on the evolutionary significance of the following:
- a. jointed appendages; (5)
 - b. triploblastic organisation; (5)
 - c. coelomate body plans; (5)
 - d. the pentadactyl tetrapod limb; (5)
 - e. metameric segmentation. (5)
7. Use your knowledge of biology to distinguish between the following pairs:
- a. prokaryotic and eukaryotic cells; (5)
 - b. primary and secondary active transport; (5)
 - c. Bohr effect and Chloride shift; (5)
 - d. substrate level phosphorylation and oxidative phosphorylation; (5)
 - e. C4 and CAM plants. (5)

(Total: 25 marks)

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

**MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017**

SUBJECT:	BIOLOGY
PAPER NUMBER:	III
DATE:	6 th September 2017
TIME:	9:00 a.m. to 10.35 a.m.

Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
 - Answer all questions. Write all your answers in the spaces provided in this booklet.
 - 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.
-


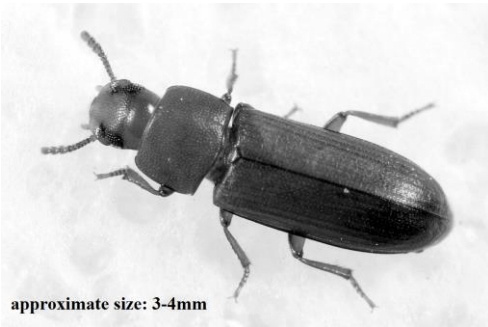
For examiners' use only:

Question	1	2	3	Total
Score				
Maximum	17	12	21	50

1. This question is about classification and biostatistical analysis.

Figure 1 shows a common rough woodlouse (*Porcellio scaber*) and Figure 2 shows a red flour beetle (*Tribolium castaneum*).

- a. Identify the phylum and the class of these organisms. With reference to Figures 1 and 2, list **TWO** visible characteristic features for each of the two.

 <p>approximate size: 15-17mm</p> <p>Figure 1: Common rough woodlouse Source: http://www.lightscapes.info/onewithnature/wp-content/uploads/2014/04/Common-Rough-Woodlouse-Porcellio-scaber-02.jpg</p>	<p>Phylum: _____ (1/2) Class: _____ (1/2)</p> <p>TWO characteristic features:</p> <p>_____</p> <p>_____</p> <p>_____ (2)</p>
 <p>approximate size: 3-4mm</p> <p>Figure 2: Red flour beetle Source: http://www.fugleognatur.dk/images/galleri/98428f7f-4ffa-44e1-a3d1-fcbbfe641d30.jpg</p>	<p>Phylum: _____ (1/2) Class: _____ (1/2)</p> <p>TWO characteristic features:</p> <p>_____</p> <p>_____</p> <p>_____ (2)</p>

- b. A biologist wanted to investigate the response of woodlice and red flour beetle to humidity by studying the rate at which these organisms move when exposed to humid and dry conditions. Animals tend to move faster in unfavourable conditions to increase their chances of entering a more preferred environment.

The investigation was carried out using ten individuals of each organism in total, five in humid conditions and five in dry conditions. Table 1 shows the results of this investigation.

Table 1: Results

Organism	Average Speed (mm/s)									
	Humid Conditions					Dry Conditions				
	1	2	3	4	5	6	7	8	9	10
Woodlouse	0.72	0.89	1.35	0.68	1.68	2.68	3.31	3.91	2.43	2.65
Flour beetle	1.76	2.33	2.05	1.33	2.05	0.21	1.12	1.83	0.71	0.92

- (i) Work out the mean speed of the woodlice in dry conditions.

(1)

- (ii) Work out the mean speed of the red flour beetles in dry conditions.

(1)

Question continues on next page.

(iii) Work out the mean speed of the woodlice in humid conditions.

(1)

(iv) Work out the mean speed of the red flour beetles in humid conditions.

(1)

(v) What can you deduce about the habitats that these two organisms would prefer in terms of humid and/or dry conditions?

(2)

(vi) Which statistical test could the biologist use to study whether the difference in mean speeds exhibited by the two species in dry conditions is statistically significant? Explain your answer.

_____ (2)

(vii) List **THREE** assumptions that should be satisfied for this test to be effective.

_____ (3)

(Total: 17 marks)

Please turn the page

3. This following question is about supporting tissue and locomotion.
- a. Figure 3 is a photomicrograph of a transverse section through a herbaceous stem.

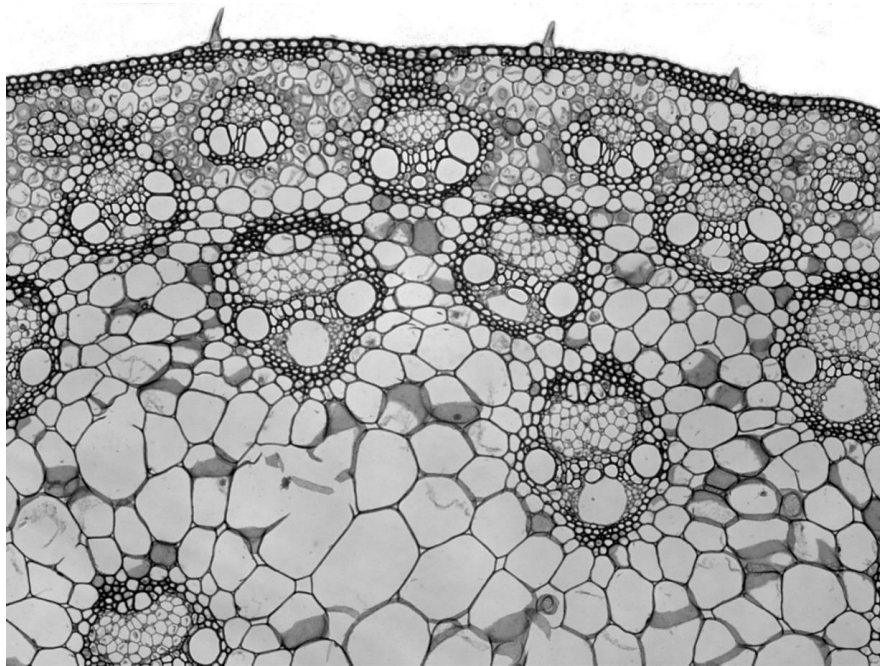


Figure 3: Photomicrograph of a transverse section through a herbaceous stem

Source: <http://emp.byui.edu/wellerg/Roots%20and%20Shoots%20Lab/Images/Zea%20Mays%20Stem%20P.jpg>

- (i) Label the photomicrograph (Figure 3) to identify the **FOUR** supporting plant tissues. (4)
- (ii) Give a brief annotation, related to both the cellular structure and its role in supporting the stem, for **TWO** of the four plant tissues labelled in part (i).

(4)

b. Figure 4 shows a longitudinal section of the upper part of the femur bone.

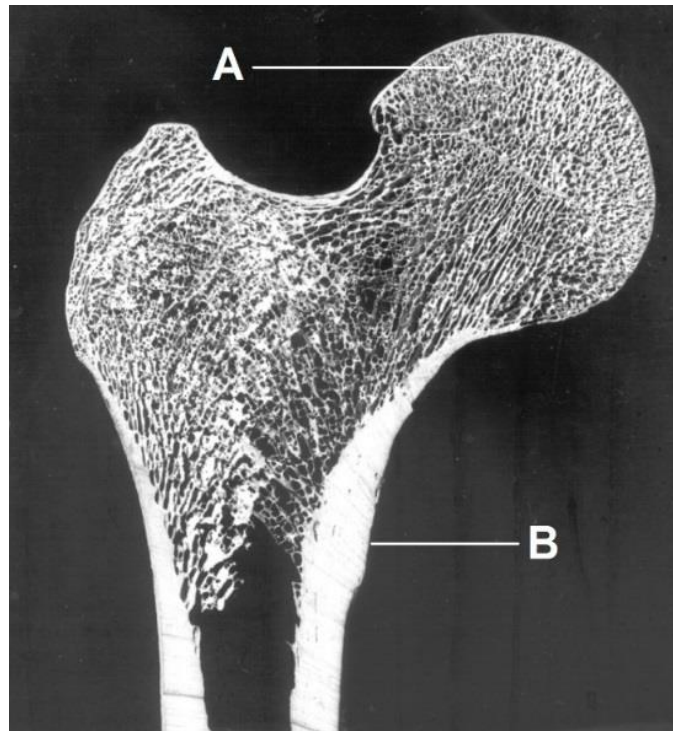


Figure 4 Longitudinal section of the upper part of the femur bone
Source: <https://cristales.fundaciondescubre.es/interactua/fotos/23-F2.large.jpg>

(i) Identify bone types A and B

A: _____ (1)

B: _____ (1)

Question continues on next page.

c. Figure 5 is a transverse section through the human compact bone.

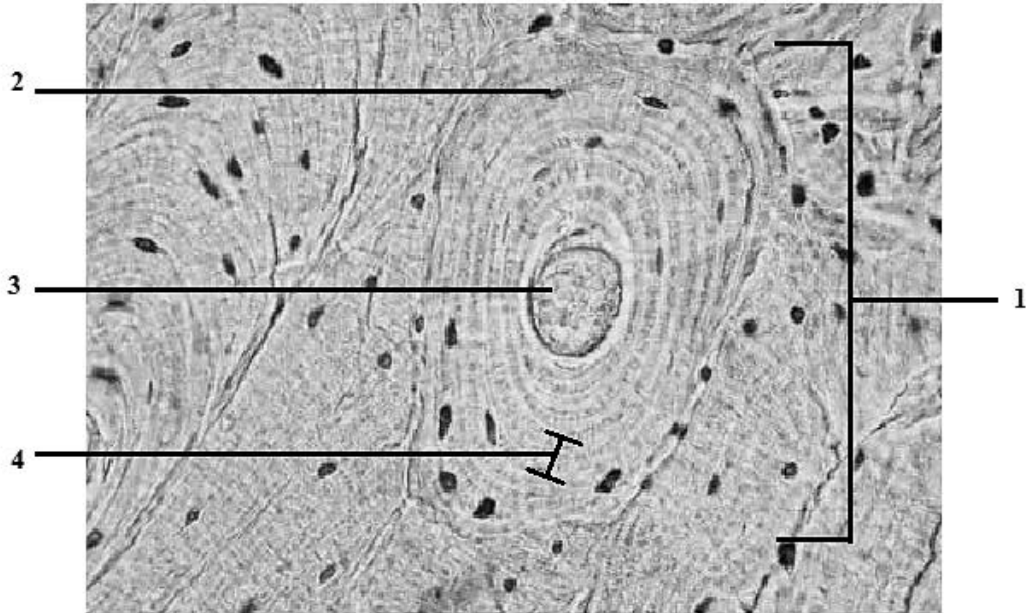


Figure 5: Transverse section through the human compact bone
Source: <http://www.eugraph.com/histology/crtbone/ctboimag/compbo.jpg>

(i) Identify and annotate structures 1 to 4.

1: _____ (1)

2: _____ (1)

3: _____ (1)

4: _____ (1)

d. The photomicrograph in Figure 6 shows a longitudinal section of a skeletal muscle.

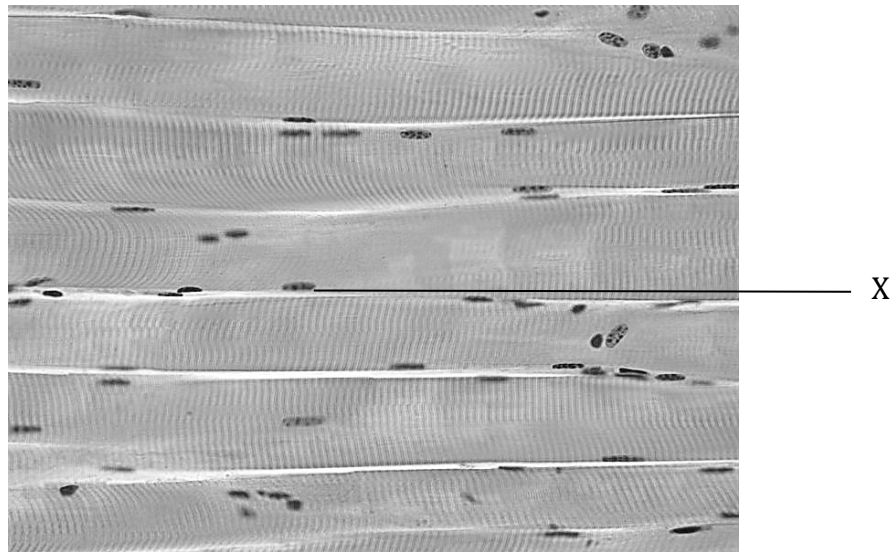


Figure 6: Longitudinal section of a skeletal muscle

Source: <https://osu.pb.unizin.org/vethisto/wp-content/uploads/sites/36/h5p/content/33/images/file-598f0bceb1f13.jpg>

(i) Identify the type of skeletal muscle shown in Figure 6.

_____ (1)

(ii) With reference to Figure 6, describe the shape and arrangement of the muscle fibres in this skeletal muscle.

_____ (2)

(iii) Label the A-bands and I-bands on Figure 6. (2)

(iv) Identify structure X.

_____ (1)

(v) Label the sarcolemma on Figure 6. (1)

(Total: 21 marks)

BLANK PAGE

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

MATRICULATION EXAMINATION
ADVANCED LEVEL
SEPTEMBER 2017

SUBJECT: BIOLOGY
PAPER NUMBER: IV – *Practical*
DATE: 30th August, 2017
TIME: 1 hr 35 min

Directions to Candidates

- Write your index number in the space at the top left-hand corner of this page.
 - Answer all parts of the question. Write all your answers in this booklet. Drawings of biological material and graphical representations of data are to be made on the appropriate pages within this booklet.
 - The marks allotted to parts of question are 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.
-

For examiners' use only:

Question	Total
Score	
Maximum	40

DO NOT WRITE ABOVE THIS LINE

1. Capillary action causes some of the movement of water up plant stems. Capillary action is the movement of water through narrow spaces. You are required to devise and implement an experiment to investigate whether the concentration of sodium chloride (salt) in solution has any effect on capillary action in plant stems.

You are provided with the following material:

- pieces of celery stem;
- coloured water;
- coloured salt solutions of concentrations 0.25 M, 0.5 M and 1.0 M
- other laboratory apparatus as required.

Candidates are advised to use 100 ml of solution.

- a. State the aim of your biological investigation.

(1)

- b. Suggest suitable null and alternative hypotheses for this investigation.

(2)

DO NOT WRITE ABOVE THIS LINE

-
- d. List and justify **TWO** precautions that should be taken before the start of the experiment.

(4)

Carry out the investigation that you devised and record the results in part (e).

- e. Record your raw data in the space provided below. *Marks will be awarded for the structure and the organisation of the results obtained.*

(4)

DO NOT WRITE ABOVE THIS LINE

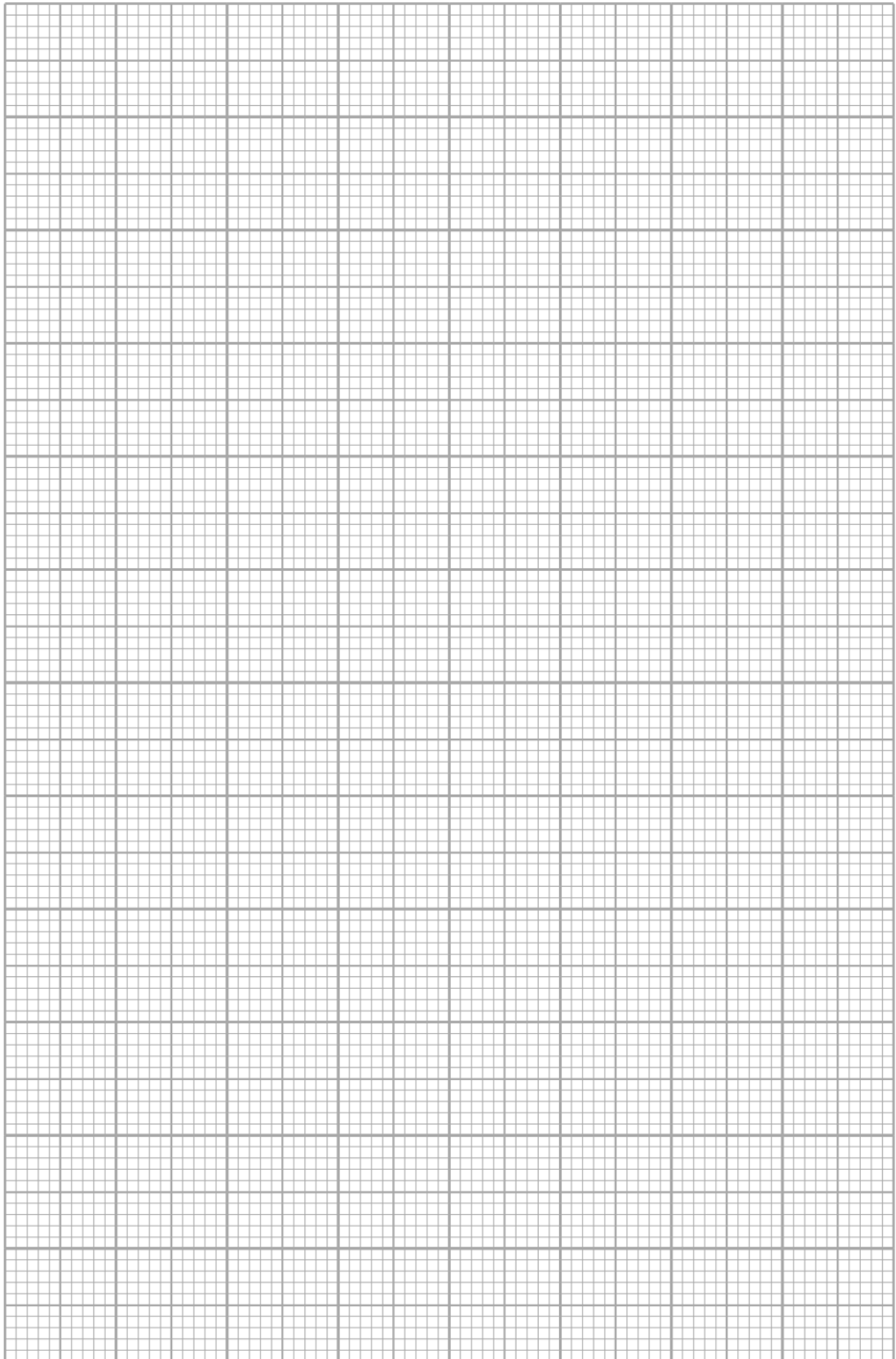
- f. Use the raw data to determine the rate at which the solutions move up the stem. Input your results in the table below: (4)

	Rate (cm min^{-1})
0.00 M NaCl	
0.25 M NaCl	
0.50 M NaCl	
1.00 M NaCl	

- g. Use the graph paper overleaf to draw a graph representing how the rate at which the solutions move up the stem changes with the concentration of sodium chloride. (6)

Question continues on next page.

DO NOT WRITE ABOVE THIS LINE



DO NOT WRITE ABOVE THIS LINE

h. Describe, in brief, any trends in the results you obtained.

(3)

i. Explain how the coloured solution moved up the stem.

(4)

j. List **TWO** possible sources of error in your investigation.

(2)

(Total: 40 marks)

BLANK PAGE