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SUBJECT: **Biology**  
 PAPER NUMBER: I  
 DATE: 11<sup>th</sup> September 2020  
 TIME: 9:00 a.m. to 12:05 p.m.

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### 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.

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#### For examiners' use only:

Question	1	2	3	4	5	6	7	8	9	10	Total
Score											
Maximum	7	12	6	13	11	8	8	14	11	10	<b>100</b>

1. This question concerns the control of gene expression in prokaryotes.

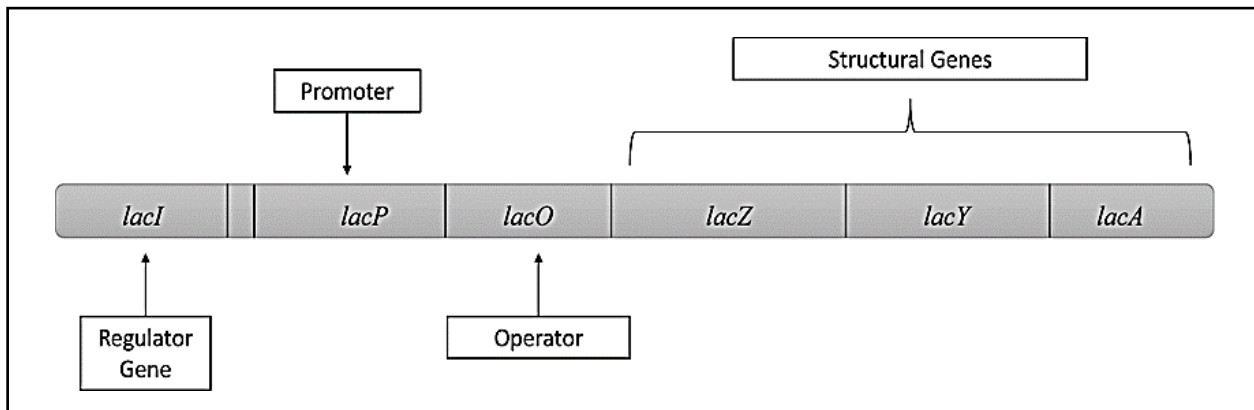


Figure 1: A basic diagram showing the operon and its regulatory elements.  
(Source: <https://www.researchgate.net>)

a. Figure 1 shows a schematic representation of the Lac operon. Define operon.

\_\_\_\_\_  
\_\_\_\_\_  
(2)

b. Briefly describe the function of:

i. the promoter region;

\_\_\_\_\_  
\_\_\_\_\_  
(1)

ii. the operator region;

\_\_\_\_\_  
\_\_\_\_\_  
(1)

iii. the **THREE** structural genes lacZ, lacY and lacA.

lacZ: \_\_\_\_\_(1)

lacY: \_\_\_\_\_(1)

lacA: \_\_\_\_\_(1)

**(Total: 7 marks)**

2. This question concerns photosynthesis.

a. Where, specifically, would the light-dependent reaction and the light-independent reaction of photosynthesis occur?

Light-dependent reaction: \_\_\_\_\_ (1)

Light-independent reaction: \_\_\_\_\_ (1)

b. Complete the following table by indicating whether the following processes take place during the light-dependent reaction of photosynthesis (LDR) or the light-independent reaction of photosynthesis (LIR). You may use the abbreviations to fill in the table.

Table 1: Processes that occur during the LDR or LIR of photosynthesis.

Process	Light-dependent reaction or Light-independent reaction
Photolysis of water molecules	
Oxygen is released	
Production of glucose	
Calvin cycle	
ATP produced	
ATP broken down	
Carbon dioxide fixation	
Regeneration of Ribulose biphosphate (RuBP)	

(4)

c. In eukaryotic cells, chlorophyll and the other reactants involved in photosynthesis are contained within chloroplasts. Suggest **ONE** benefit of this arrangement.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (2)

**Question continues on next page**

- d. The graph depicted in Figure 2 shows how the levels of glycerate-3-phosphate and triose phosphate inside a chloroplast change when a plant is moved from light to darkness.

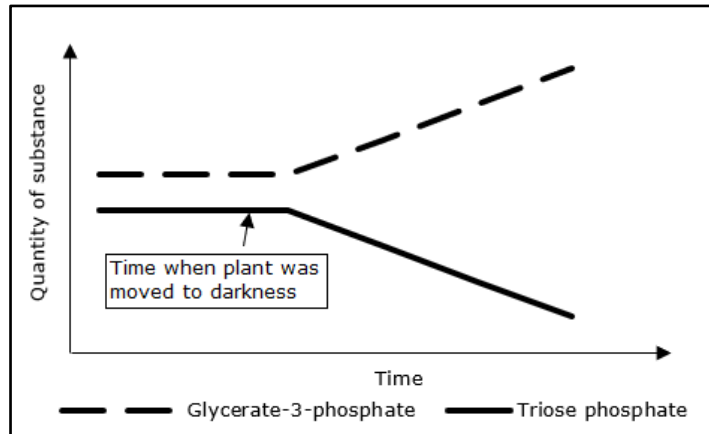


Figure 2: Graph showing the quantity of substance (glycerate-3-phosphate and triose phosphate) against time. (Adapted from Johnstone, 2001)

Explain in detail the changes in the concentration of glycerate-3-phosphate and triose phosphate shown in the graph.

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(4)

**(Total: 12 marks)**

3. This question is about homeostasis.

The human body is characterised by a wide variety of hormones which in turn regulate a number of bodily functions and processes. Most hormones are regulated by feedback mechanisms, which can be positive or negative. Two examples of hormones with different feedback mechanisms are antidiuretic hormone (ADH) and oxytocin. ADH and oxytocin are both related to the pituitary gland.

- a. Explain how ADH and oxytocin are different from one another with respect to their feedback mechanisms.

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(4)

- b. The pituitary gland, specifically the anterior lobe, produces and secretes tropic hormones. Define tropic hormones and identify **ONE** example of such a hormone.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (2)

**(Total: 6 marks)**

4. This question is about genetics.

Figure 3 shows a pedigree chart for Huntington’s disease. Huntington’s disease is an autosomal dominant disorder and it involves the progressive degeneration of the brain. Symptoms include uncontrolled movements, emotional problems, and loss of thinking ability.

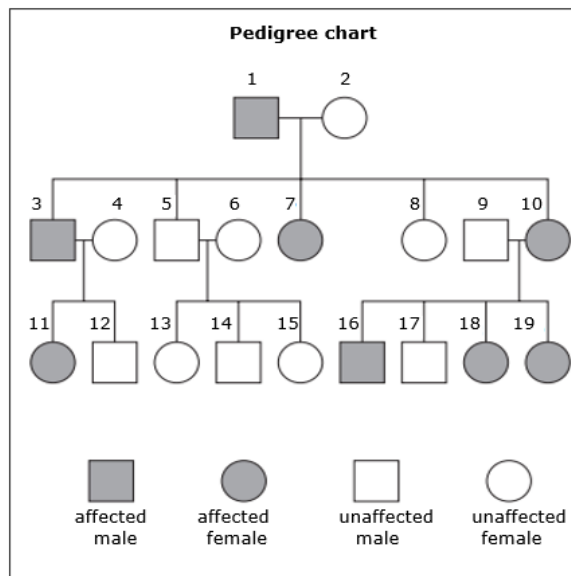


Figure 3: Pedigree chart for Huntington's disease.  
(Source: <https://www.nzqa.govt.nz/>)

- a. Using H to represent the dominant allele and h to represent the recessive allele, give the **TWO** possible genotypes for an individual who has Huntington’s disease.

\_\_\_\_\_ (2)

- b. Using examples from the pedigree chart (Figure 3), demonstrate how Huntington’s disease is an autosomal dominant disorder.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_ (3)

**Question continues on next page**

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c. In this case, a mutation caused a fatal disease. However, mutations may also be beneficial. Explain how mutations may be beneficial.

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(2)

d. In each of the following, you are presented with short DNA sequences. In each pair, there is one normal sequence and one mutated sequence. Identify the type of mutation that the normal sequence undergoes to form the mutated sequence.

i. Normal sequence - CTCGCATCCGTTAAGC  
Mutated sequence - CTCGCATCCCGTTAAGC

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(1)

ii. Normal sequence - CTCGCATCCGTTAAGC  
Mutated sequence - CTCGCATCCGTTAGC

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(1)

iii. Normal sequence - CTCGCATCCGTTAAGC  
Mutated sequence - CTCGCATCCGTTAGGC

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(1)

iv. Normal sequence - CTCGCATCCGTTAAGC  
Mutated sequence - CTCGCATCCGTTGAA

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(1)

e. Which of the mutation types, given as an answer to part d, lead to frameshifts?

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(2)

**(Total: 13 marks)**

5. This question is about environmental biology.

a. Figure 4 depicts two graphs; graph A shows when *Paramecium aurelia* and *Paramecium caudatum* are cultured separately from one another and graph B shows when the two species are cultured together in laboratory conditions.

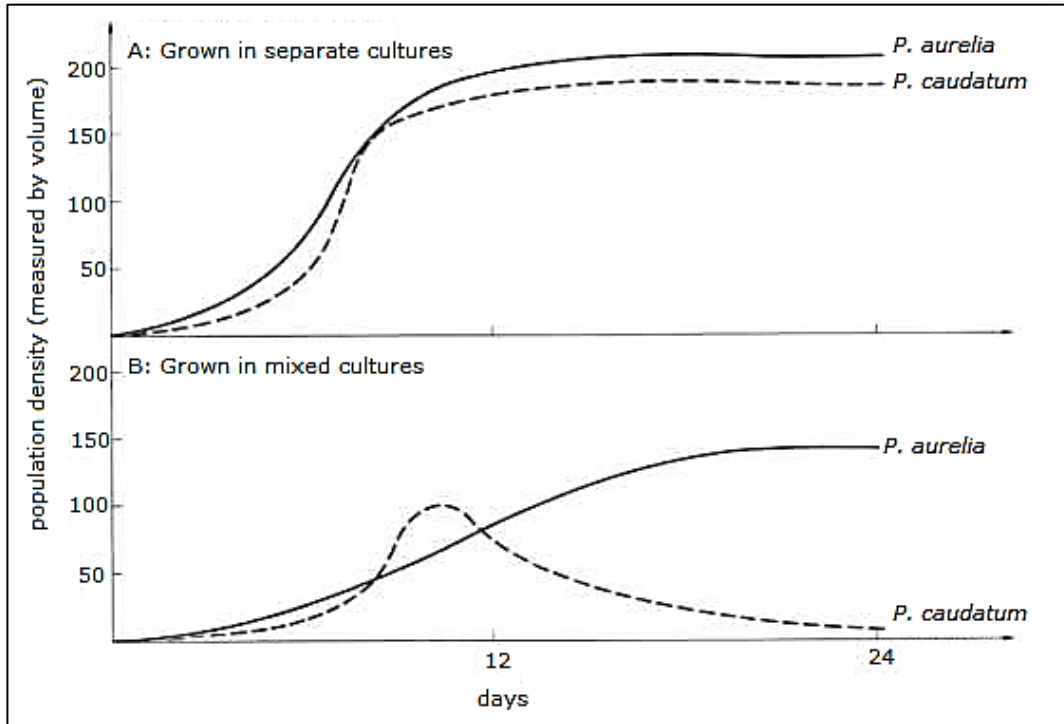


Figure 4: The growth of *P. aurelia* and *P. caudatum* in two different scenarios.  
(Adapted from <http://lungtp.com>)

i. Identify and explain the interspecific interaction between the two species of *Paramecium* in graph B (Figure 4).

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(3)

ii. List **TWO** resources that might be affecting this type of interaction.

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(2)

**Question continues on next page**

iii. What type of population growth curve is demonstrated by the two species when grown in isolation? Justify your answer.

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(2)

b. Figure 5 shows three examples of pyramids of numbers in three different ecosystems.

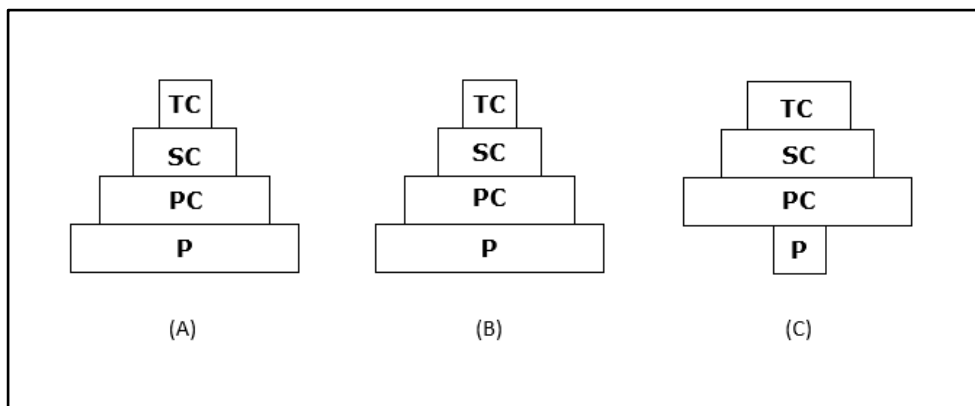


Figure 5: Pyramids of numbers in (A) grassland ecosystem, (B) pond ecosystem and (C) forest ecosystem. P: producers; PC: primary consumers; SC: secondary consumers; TC: tertiary consumers. (Source: <http://www.yourarticlelibrary.com>)

i. How do the pyramids of numbers differ from the other ecological pyramids?

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(2)

ii. Why is the pyramid of numbers for the forest ecosystem different from the other two pyramids?

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(2)

**(Total: 11 marks)**



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6. This question is about locomotion and support.

Earthworms are adapted for life underground. Their streamlined shape allows them to burrow through soil.

a. What type of skeleton do earthworms have?

\_\_\_\_\_ (1)

b. How is the skeleton in an earthworm different from other skeletal systems?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

c. How does the type of skeleton found in an earthworm provide support?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (2)

d. How is locomotion carried out in an earthworm?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

**(Total: 8 marks)**

***Questions continue on next page***

7. This question is about the nervous system.

a. Figure 6 shows a cross-section of the brain. Fill in Table 2 beneath the figure by identifying structures A-F and briefly mention the main function of each structure.

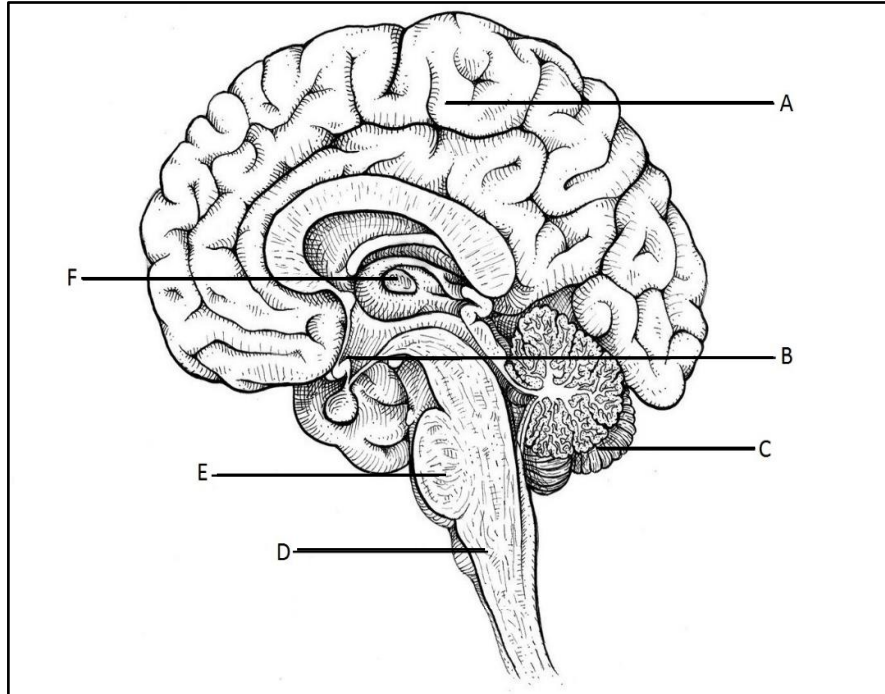


Figure 6: The brain  
 (Source: <https://images.squarespace-cdn.com>)

Table 2: Different components of the brain.

	<b>Structure</b>	<b>Main function</b>
<b>A</b>		
<b>B</b>		
<b>C</b>		
<b>D</b>		
<b>E</b>		
<b>F</b>		

(6)

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b. Does a reflex action involve the brain? Give a reason for your answer.

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(2)

**(Total: 8 marks)**

8. This question is about the Hardy-Weinberg equilibrium.

The Hardy-Weinberg equilibrium is an important component in the analysis of population genetic data. If evolution is not occurring, then the frequency of alleles, genotypes and phenotypes between generations of sexually reproducing organisms should remain in equilibrium. Genotype frequencies, most of the time, may differ from phenotype frequencies.

a. Give **TWO** reasons why in biological populations, it is almost impossible to maintain the Hardy-Weinberg equilibrium.

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(2)

b. Distinguish between allele frequency and genotype frequency.

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(2)

c. Why is it important for the equilibrium to be applied to fertile, sexually reproducing populations?

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(2)

d. Why may genotype frequencies differ from phenotype frequencies?

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(2)

**Question continues on next page**

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e. Colour in *Pyrrhura molinae* (green cheek parakeets) is controlled by two alleles, with the red-sided being a product of a homozygous recessive genotype. A large population of this species is composed of both 396 red-sided and 554 yellow-sided individuals. Assuming that this population is in Hardy-Weinberg equilibrium, calculate, by showing your working, the following:

i. The allele frequency of each allele.

Answer: \_\_\_\_\_(3)

ii. The expected genotype frequencies.

Answer: \_\_\_\_\_(2)

iii. The number of heterozygous individuals within this population.

Answer: \_\_\_\_\_(1)

**(Total: 14 marks)**

9. This question concerns analytical techniques used in gene technology.

Gel electrophoresis is a particular form of chromatography used to separate different fragments of DNA. After PCR, DNA fragment samples are treated with restriction enzymes prior to being separated via an electric current.

a. Why is it important for DNA samples to be treated with restriction enzymes?

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(2)

b. When an electric current is applied, DNA fragments migrate towards the positive electrode. Explain why this happens.

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(2)

c. One of the applications of gel electrophoresis is the identification of genetic diseases. The following figure (Figure 7) shows the result of DNA samples that exhibit abnormalities.

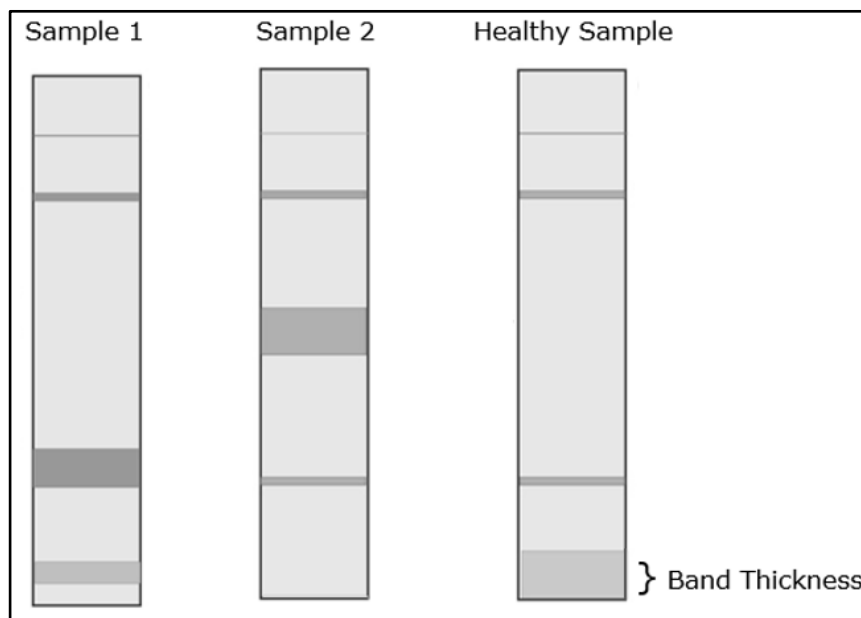


Figure 7: Gel electrophoresis products.  
(Adapted from <http://www.labpedia.net>)

**Question continues on next page**

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i. What does the thickness of each band represent?

\_\_\_\_\_ (1)

ii. Do both samples exhibit the same abnormalities? Give a reason for your answer.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

d. Briefly outline how a researcher may isolate a desired band for further research.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ (3)

**(Total: 11 marks)**

10. This question is about reproduction in plants.

a. State whether the following statements are TRUE or FALSE. Give an explanation for your answers.

i. Flowering plants reproduce asexually in times of stress and sexually in times of stability.

True/False: \_\_\_\_\_

Explanation: \_\_\_\_\_

\_\_\_\_\_ (2)

ii. Self-fertilisation is never beneficial as it does not promote genetic diversity.

True/False: \_\_\_\_\_

Explanation: \_\_\_\_\_

\_\_\_\_\_ (2)

DO NOT WRITE ABOVE THIS LINE

iii. Anemophily is more suited to open areas such as grasslands rather than the opposite.

True/False: \_\_\_\_\_

Explanation: \_\_\_\_\_

\_\_\_\_\_ (2)

b. The graph (Figure 8) below represents the climate events of a temperate deciduous forest that occur throughout the year. Temperate deciduous forests exhibit four (4) distinct seasons:

- Winter: December - February;
- Spring: March - May;
- Summer: June - August;
- Autumn: September - November.

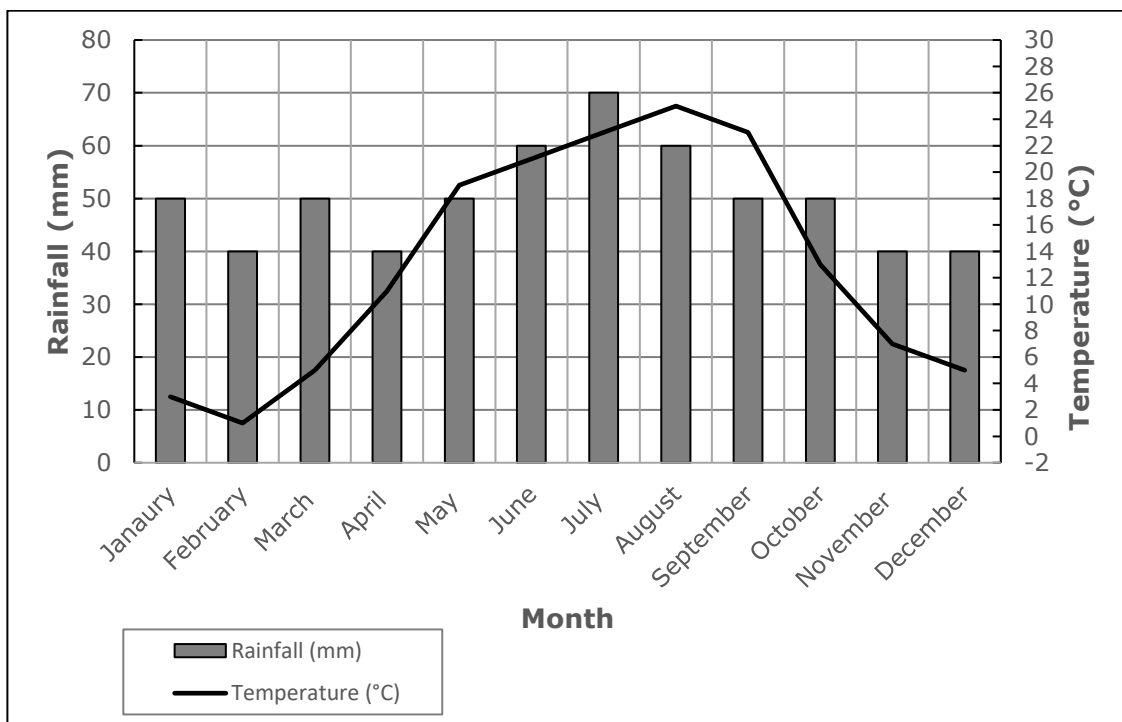


Figure 8: Climate events of Temperate Deciduous Forest  
 (Adapted from <http://bafthetemperatedeciduosforest/climate-temperature>)

**Question continues on next page**

From Figure 8, determine in which season would the following be observed. Give a reason for your answer.

- i. Highest reproductive rate of Bryophytes.

Season: \_\_\_\_\_

Reason: \_\_\_\_\_

\_\_\_\_\_ (2)

- ii. Seed dispersal of small Magnoliophytes that are less than 50 cm in length.

Season: \_\_\_\_\_

Reason: \_\_\_\_\_

\_\_\_\_\_ (2)

**(Total: 10 marks)**





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SUBJECT:	<b>Biology</b>
PAPER NUMBER:	II
DATE:	11 <sup>th</sup> September 2020
TIME:	4:00 p.m. to 7:05 p.m.

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### **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.

**Aliens in the Antarctic**

Antarctica is the least accessible continent on the planet to both flora and fauna. It has remained isolated from the rest of the world, and thus any potential invaders, by the vast expanse and circumpolar current of the Southern Ocean, as well as the strong westerly winds. These create a barrier to the continent, preventing much biological life from arriving by air or sea and colonising the land. Such barriers can significantly affect entire populations, such as reducing the genetic variation, which can hinder the evolution of populations in response to changing environmental variables.

The species that do arrive, via whatever means, are faced with year-round low temperatures, short summers and desolate, infertile soils. Nevertheless, ancient and unique life has persisted in the Antarctic for millions of years, dating back to the final break-up of Gondwana supercontinent around 30 million years ago.

In fact, contrary to popular believe, Antarctica is a diverse continent, with 16 distinct biogeographical regions and many endemic species. These include one insect: the small, flightless, detritivorous midge, *Belgica antarctica*, which occurs on the Antarctic Peninsula and neighbouring islands, and is the largest terrestrial organism on the continent.

The most persistent invader in terrestrial Antarctica to date is also a midge, and one that is already accustomed to a cooler lifestyle. Originating from South Georgia, a subantarctic archipelago in the south Atlantic, *Eretmoptera murphyi* is thought to have been introduced accidentally to Signy Island in the maritime Antarctic during a 1960s transplant experiment that was investigating whether various plant species could survive further south.

The most recent findings suggest that while the midge itself is small, its impacts are not. Indeed, *E. murphyi* is an ecosystem engineer and its introduction to Signy has made it the largest terrestrial animal, and only insect, on the island. The native fauna, which consists of a few species of soil mites, springtails and micro-invertebrates (such as nematodes and tardigrades), while also being detritivores, are outsized and often greatly outnumbered by the midge, which can have densities of 150,000 larvae per square metre in places.

Such populations are able to consume almost an order of magnitude more organic matter than the entire native fauna at the sites where they co-occur. Not only is this affecting the rate of litter turnover, but it is also increasing the nitrate content of the soils. One of our key findings suggests that the nitrogen levels made available by the midge are akin to those seen in association with native seal aggregations. So, this alien midge has brought a function to the terrestrial ecosystem of Signy Island that previously did not exist: *E. murphyi* is effectively doing the job of an earthworm in an ecosystem that has never had such an organism.

This has implications not only for local fauna and flora, particularly the two rare Antarctic flowering plants that would relish greater nitrogen availability, but also other invading species. For example, more fertile soils mean non-native seeds have a greater chance of establishing. Thus, despite

being seemingly innocuous, this invertebrate can have a large impact on these fragile and simple ecosystems.

(Adapted from Bartlett, J., Convey, P., McCarthy, A. and Hayward, S. (2019). *Aliens in the Antarctic*. The Biologist, 66(4), pp.22-25)

- a. The extract focuses on various aspects of biological diversity. What is biological diversity?(1)
  - b. Explain the **THREE** levels of biological diversity. Use examples from the extract to sustain your answer. (6)
  - c. *Eretmoptera murphyi* is increasing the nitrate content in the soil (line 29). Nitrogen is important for any living organism. Explain the importance of nitrogen and why it has to be converted to nitrite and nitrates for it to be biologically available. (3)
  - d. "*E. murphyi* is effectively doing the job of an earthworm in an ecosystem that has never had such an organism" (lines 32-33). How is *E. murphyi* improving the edaphic conditions and how is this beneficial to the surrounding flora and fauna? (3)
  - e. The improvements of the environmental conditions brought about by *E. murphyi* can be related to ecological succession.
    - i. Define ecological succession. (1)
    - ii. Explain the mechanism of succession. (3)
    - iii. Distinguish between primary and secondary succession. (2)
  - f. List and explain **FOUR** abiotic factors that can influence the distribution of organisms. (4)
  - g. Define the term detritivores (line 25). (1)
  - h. Identify and explain **ONE** factor that can govern the population size of *E. murphyi*. (1)
- (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.**

1. Osmoregulation allows animals to maintain a balance between water and minerals despite changes in the external environment. Discuss.
2. Adenosine triphosphate (ATP) is an energy-rich compound which is found in all living cells. Give an outline account of ATP production in living systems.
3. The development of a coelom was a significant evolutionary step in the animal body plan. Discuss.
4. Hydrogen bonding grants different properties to certain basic biomolecules. Elaborate on this statement by making reference to **THREE** different categories of biomolecules that exhibit such bonding.

**(Total: 50 marks)**

**SECTION C**

**Answer ONE question from this section.**

1. Use your knowledge of Biology to explain the following statements.
  - a. Floral reproductive methods and morphological adaptations has been heavily influenced by several mutualistic relationships. (5)
  - b. Monoecious plants exhibit processes that promote cross-pollination. (5)
  - c. Natural disasters, such as bushfires, can lead to a reduction in endemic gene diversity and are not usually considered as promoters of natural selection. (5)
  - d. Artificial selection may diminish the natural biological fitness of an organism. (5)
  - e. If left unmonitored, the insertion of the *Bt* gene in crops may lead to a rise in populations of undesired plants and to a certain extent, pests. (5)

**OR**

2. Use your knowledge of Biology to explain the following statements.
  - a. The skin helps regulate body temperature through its intimate association with the sympathetic nervous system. (5)
  - b. The immune system is a host defence system comprising many biological structures and processes within an organism that protects against disease. (5)
  - c. Crossing a pink-flowered carnation with a pink-flowered carnation does not guarantee a subsequent generation of only pink-flowered carnations. (5)
  - d. An open circulatory system is less efficient than a closed circulatory system. (5)
  - e. Progesterone and oestrogen are still needed to be produced even after foetal implantation. (5)

**(Total: 25 marks)**



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SUBJECT:	<b>Biology</b>
PAPER NUMBER:	III
DATE:	14 <sup>th</sup> September 2020
TIME:	9:00 a.m. to 10:35 a.m.

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### 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	18	20	12	<b>50</b>

1. This question is about enzymes.

Lactase tablets are prescribed to people suffering from lactose intolerance, to relief and prevent some of the symptoms following the consumption of dairy products. Lactose intolerance is due to the inability of a person to digest lactose, a reducing sugar found in milk and dairy products. This condition is mainly due to the absence of enzyme lactase in the small intestine. This enzyme is required for the breakdown of lactose into glucose and galactose.

Barfoed's reagent is used in chemical tests aimed at detecting the presence of monosaccharides whilst distinguishing between monosaccharides and reducing disaccharides. When 20 drops Barfoed's reagent are mixed with 10 ml solution of monosaccharides, heated in a water bath for 30 seconds and left to cool, the copper acetate which is present in Barfoed's reagent converts to copper(I) oxide and gives a brick red precipitate. The more monosaccharides present, the darker the precipitate and the faster it will form. Monosaccharides react fast while disaccharides react at a slower rate, enabling one to distinguish between the two.

a. In an experiment, Barfoed's reagent is used to test the enzymatic activity of these lactase tablets on the following milk substrate concentrations:

- 100% milk concentration;
- 50% milk concentration;
- 20% milk concentration;
- 10% milk concentration;
- 2% milk concentration.

i. List **SIX** pieces of apparatus or material/reagents required for this experiment.

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(3)

ii. Explain how a control would be set up to ensure that any formation of precipitate is only due to the activity of the enzyme lactase.

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(2)

iii. Explain how the different milk substrate concentrations are prepared.

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(3)

iv. Give experimental details showing how to determine the rate of enzymatic activity of lactase using the control and milk concentrations prepared as indicated in the answers given to parts (ii) and (iii).

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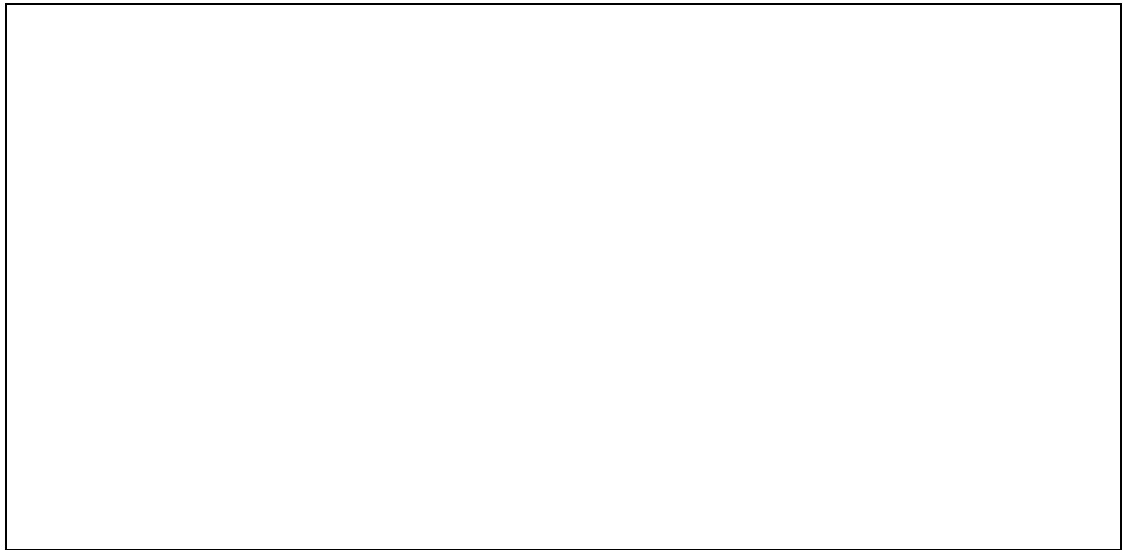
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(3)

**Question continues on next page**

- v. In the space below, sketch a graph of the rate of enzymatic reaction vs substrate concentration showing expected results.



(2)

- vi. Interpret the graph sketched as an answer to part (v) in terms of the effect of substrate concentration on the rate of enzymatic activity.

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(3)

- vii. Explain why the use of Benedict's reagent instead of the Barfoed's reagent would **not** have been suitable for this experiment.

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(2)

**(Total: 18 marks)**



2. This question is about leaf modifications and transport in plants.

Figure 1 shows a transverse section through the leaf of *Ammophila arenaria*, also known as Marram Grass.

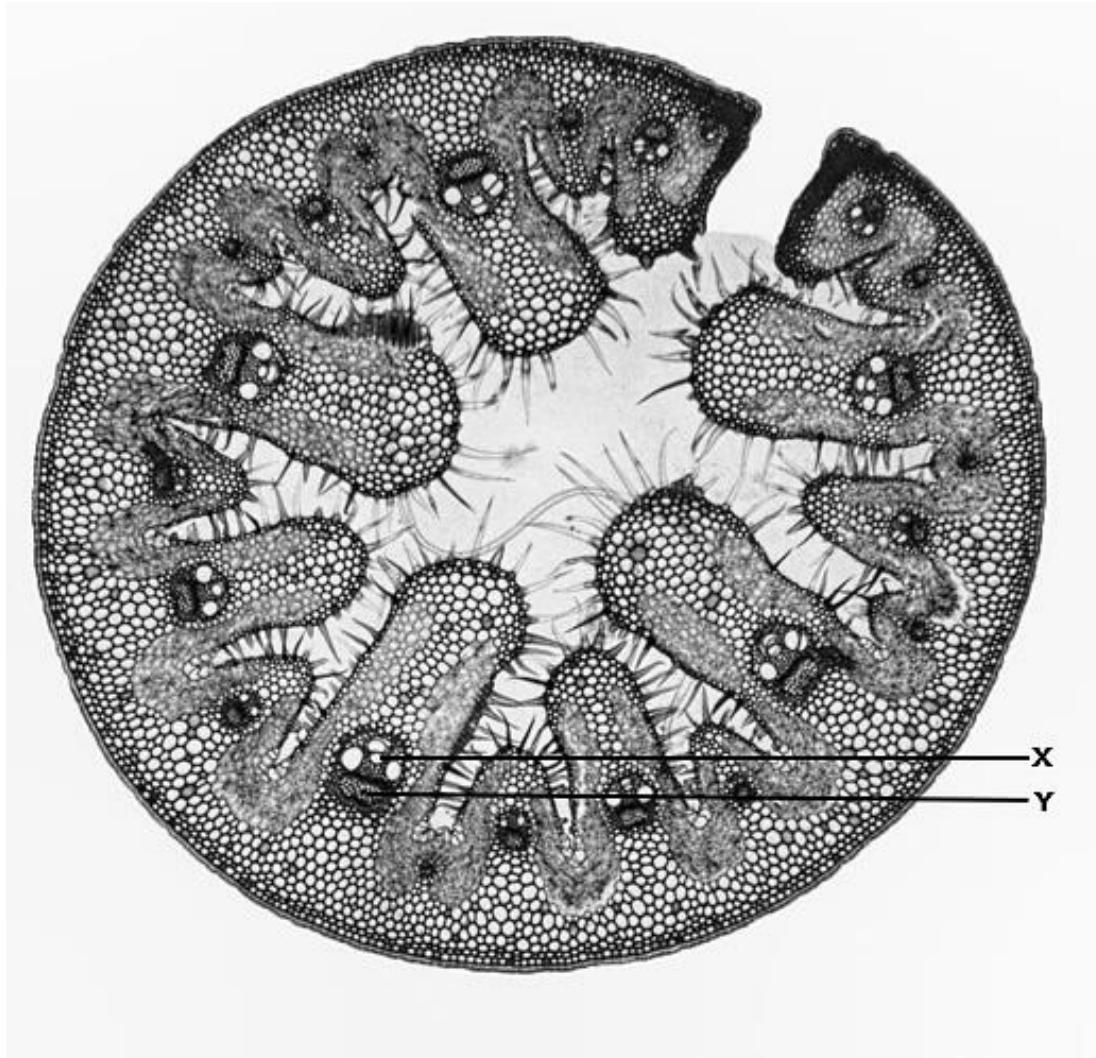


Figure 1: A Transverse Section through the leaf of *Ammophila arenaria* (Magn. X40).  
(Source: <https://www.blipfoto.com>)

a. i. Describe the type of habitat in which *Ammophila arenaria* is normally found.

\_\_\_\_\_  
\_\_\_\_\_  
(1)

ii. What type of plants are adapted to live in the environmental conditions given as an answer to part (i)?

\_\_\_\_\_  
(1)

**Question continues on next page**



- e. Figure 2 shows a longitudinal section through the plant vascular tissue responsible for translocation.

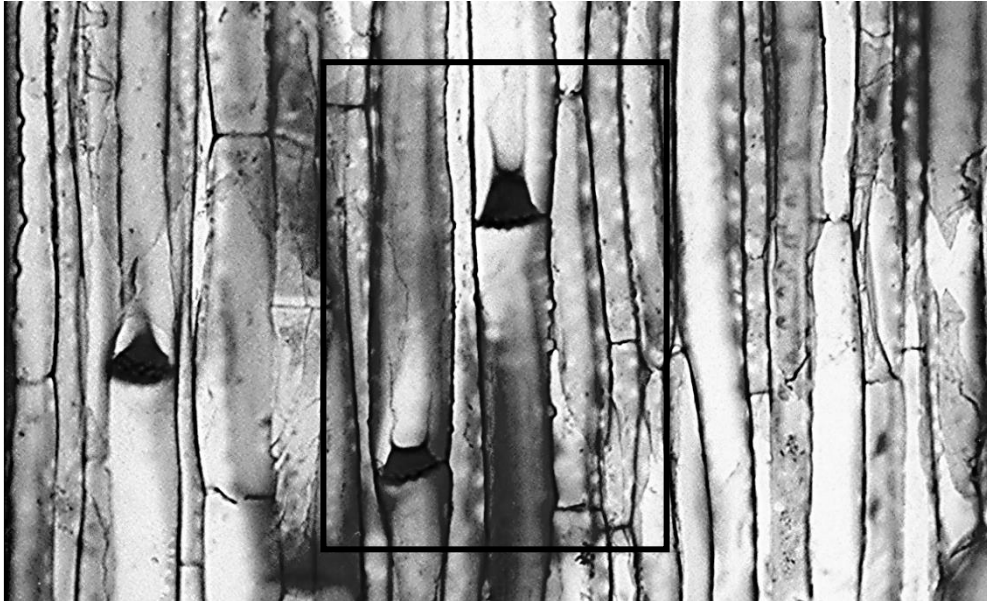
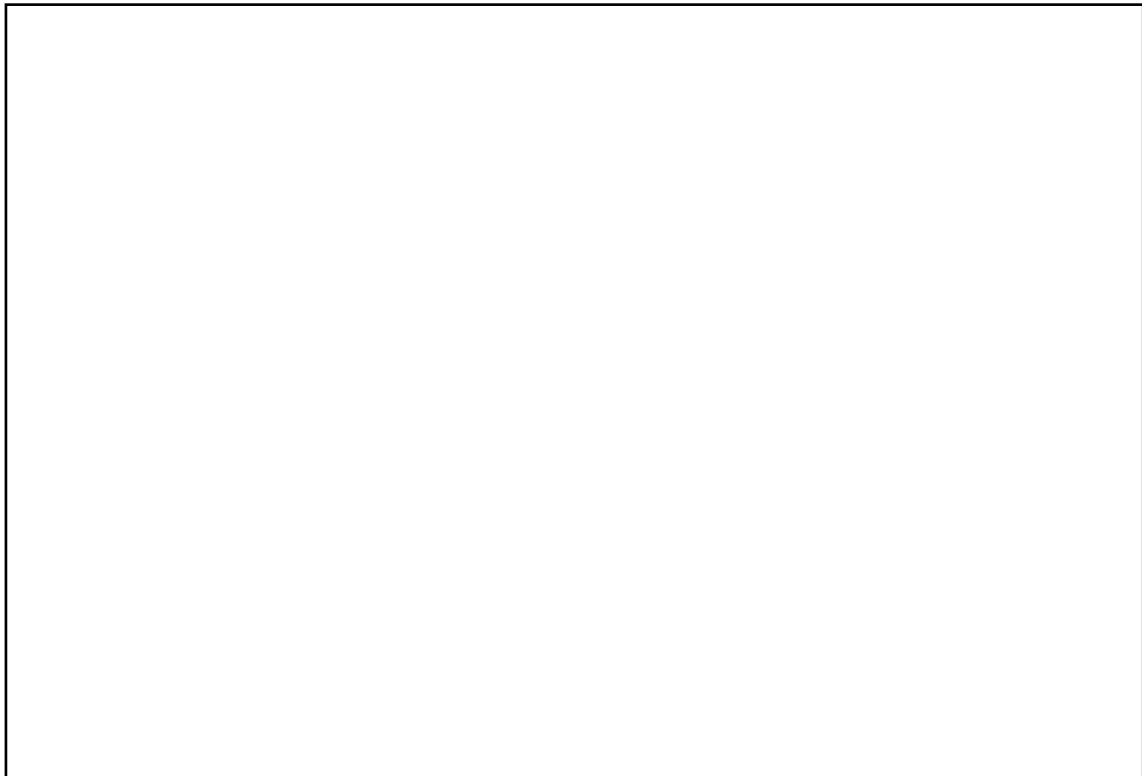


Figure 2: Longitudinal section through the plant vascular tissue responsible for translocation (Magn. x400).  
(Source: <http://metabolism.net>)

- i. Identify the vascular tissue shown in Figure 2.

\_\_\_\_\_ (1)




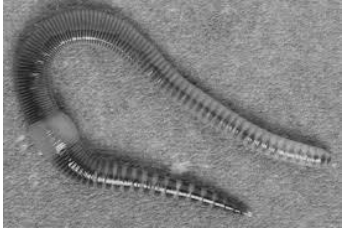
- ii. In the space provided below, draw high power details of the indicated section (in box) shown in Figure 2. Label and annotate the main components of this plant tissue. (7)



**(Total: 20 marks)**

3. This question is about Taxonomy.

a. Identify the phylum and class (where requested) of the organisms shown in Figures 3 to 7.

<p>i.</p>	 <p>Figure 3 (Source: <a href="https://beagleproject.wordpress.com/">https://beagleproject.wordpress.com/</a>)</p>	<p>Phylum: _____</p>
<p>ii.</p>	 <p>Figure 4 (Source: <a href="https://www.warrenphotographic.co.uk">https://www.warrenphotographic.co.uk</a>)</p>	<p>Phylum: _____ Class: _____</p>
<p>iii.</p>	 <p>Figure 5 (Source: <a href="http://www.maltawildplants.com">http://www.maltawildplants.com</a>)</p>	<p>Phylum: _____ Class: _____</p>
<p>iv.</p>	 <p>Figure 6 (Source: <a href="https://encrypted-tbn0.gstatic.com">https://encrypted-tbn0.gstatic.com</a>)</p>	<p>Phylum: _____ Class: _____</p>



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