Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Wednesday 11 May 2022 (afternoon)

Candidate session number

2 hours 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[72 marks]**.

2222 – 6014

20 pages

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Increases in the frequency and severity of drought are part of climate change in many areas of the world. Drought represents one of the major threats to food security as it can drastically decrease crop yield.

Water stress occurs when the demand for water exceeds its availability. A water stress index of 0.0 indicates non-water-stressed plants with normal transpiration and 1.0 is maximum water stress with much less transpiration.

(a) Define transpiration. [1]

. . . . . .
. . . . . .

A study was carried out on sorghum (*Sorghum bicolor*), an important cereal crop. The sorghum plants were grown for 15 weeks after the date of planting. Flowering occurred in week 9. There were 3 treatment groups in the study:

- Control: plants were watered throughout the study
- Pre-flowering drought: no water until week 9, followed by normal watering
- Post-flowering drought: normal amounts of water until week 9, but none after.

Removed for copyright reasons

(This question continues on the following page)

(Question 1 continued)

(b) (i) Compare the changes in water stress of the pre- and post-flowering drought plants over the period shown on the graph. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Using the data, evaluate the hypothesis that sorghum plants are more vulnerable to drought after flowering. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

It was known that plant growth under certain drought conditions is intimately linked to microbial communities in the root and in the soil around the root. The scientists took samples from both the root and soil, identified the bacterial phyla present and classified them into two groups: Gram-positive and Gram-negative bacteria.

The graph shows the abundance in the root of the three most common Gram-positive phyla, a, b and c, and the three most common Gram-negative phyla, d, e and f, found at week 8 (before flowering), under control conditions and pre-flowering drought conditions.

Removed for copyright reasons

(c) Distinguish between pre-flowering drought plants and control plants in terms of the effect of water availability on the relative abundance of Gram-positive and Gram-negative bacteria in the root. [1]

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

The relative abundance of Gram-positive and Gram-negative bacteria in pre-flowering drought conditions was compared over time inside the root and in the soil around the root.

Removed for copyright reasons

[Source: adapted from Xu, L., *et al.*, 2018. *PNAS*, 115(18), Supporting information appendix. REFERENCE REDACTED.]

(d) (i) Compare and contrast the relative abundance of Gram-negative bacteria in the soil and the roots of pre-flowering drought plants. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Suggest a reason for the changes in relative abundance of bacteria in the soil around the root between week 8 and week 9. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

Scientists inoculated the roots of the sorghum plants with one of two different species of Gram-positive bacteria. One set of plants was grown under drought conditions and the control with normal water. They compared the fresh mass of the roots of these two groups of plants.

Removed for copyright reasons

[Source: adapted from Xu, L., *et al*., 2018. *PNAS*, 115(18), Supporting information appendix. REFERENCE REDACTED.]

(e) (i) Deduce the effect of drought on the fresh mass of the roots that have not been inoculated (X). [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) Compare and contrast the effect of the inoculations with Gram-positive I (Y) and Gram-positive II (Z) on the fresh mass of control and drought roots. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(iii) Suggest a reason for the observed effects of the inoculations in sorghum plants under drought conditions. [1]

. . . . . .

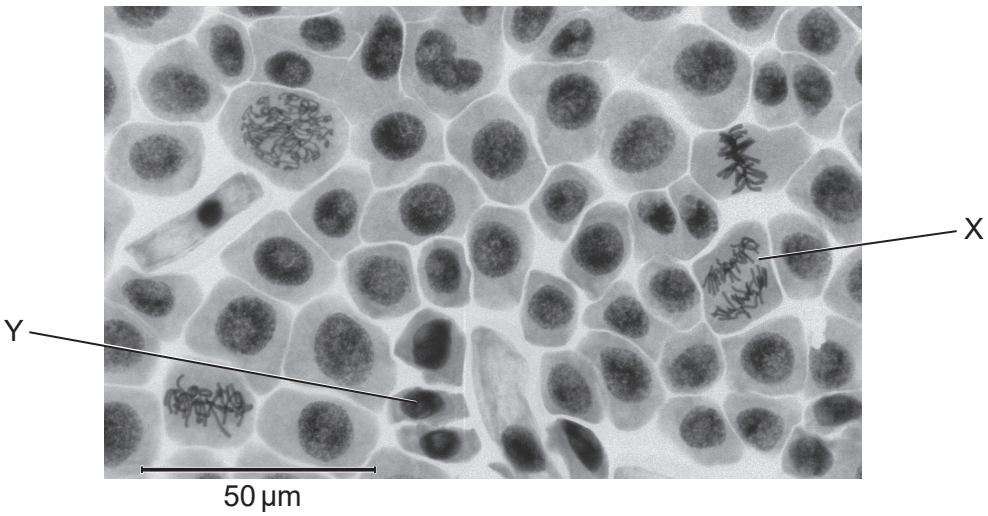
. . . . . .

(iv) Suggest an advantage of using bacterial inoculation, as shown in this study, over traditional selective breeding to obtain crops that are more resistant to drought. [1]

. . . . . .

. . . . . .

2. (a) The onion (*Allium cepa*) root cells shown in the micrograph are in different stages of mitosis.



(i) Identify, with a reason, the stage shown at X. [2]

. . . . . .

. . . . . .

. . . . . .

(ii) Calculate the length of the entire cell labelled Y, showing your working. [1]

. . . . . .

(iii) State the role of cyclins in the cell cycle. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 2 continued)

(b) (i) Distinguish between the structure of chromosomes in prokaryotes and eukaryotes. [2]

. . . . . .

. . . . . .

. . . . . .

(ii) Explain Cairns's technique to measure the length of the DNA molecule. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. A group of students used quadrat sampling and the chi-squared test to find out whether the distributions of two plant species were associated with each other or not. These two species were found in the ground vegetation in a woodland ecosystem.

Ground ivy
(*Glechoma hederacea*)

Wood speedwell
(*Veronica montana*)

The numbers of quadrats with one, both or neither species present were counted and recorded. The observed frequencies from 150 quadrats are shown in the following contingency table.

		Ground ivy (*G. hederacea*)		
		present	absent	total rows
Wood speedwell (*V. montana*)	present	25	45	70
	absent	30	50	80
	total columns	55	95	150

(a) State the alternative hypothesis for this study. [1]

. . . . . .

. . . . . .

(b) To calculate chi-squared, expected values must first be calculated. Assuming that there is no association between the two species, calculate the expected number of quadrats in which both species would be present, showing your working. [1]

. . . . . .

(This question continues on the following page)

(Question 3 continued)

(c) State the number of degrees of freedom for this test to determine the critical value of chi-squared. [1]

. . . . . .

(d) When the data in the table were used to calculate chi-squared, the calculated value was 0.056. The critical value is 3.84. Explain the conclusion that can be drawn from the calculated and critical values for chi-squared. [1]

. . . . . .

. . . . . .

4. Melatonin helps to control circadian rhythms in the body. The graph shows the mean levels of melatonin in the body in day and night workers over 24 hours.

Removed for copyright reasons

(a) State where melatonin is produced in the body. [1]

. . . . . .

(b) Describe **one** difference between melatonin levels of day and night workers. [1]

. . . . . .

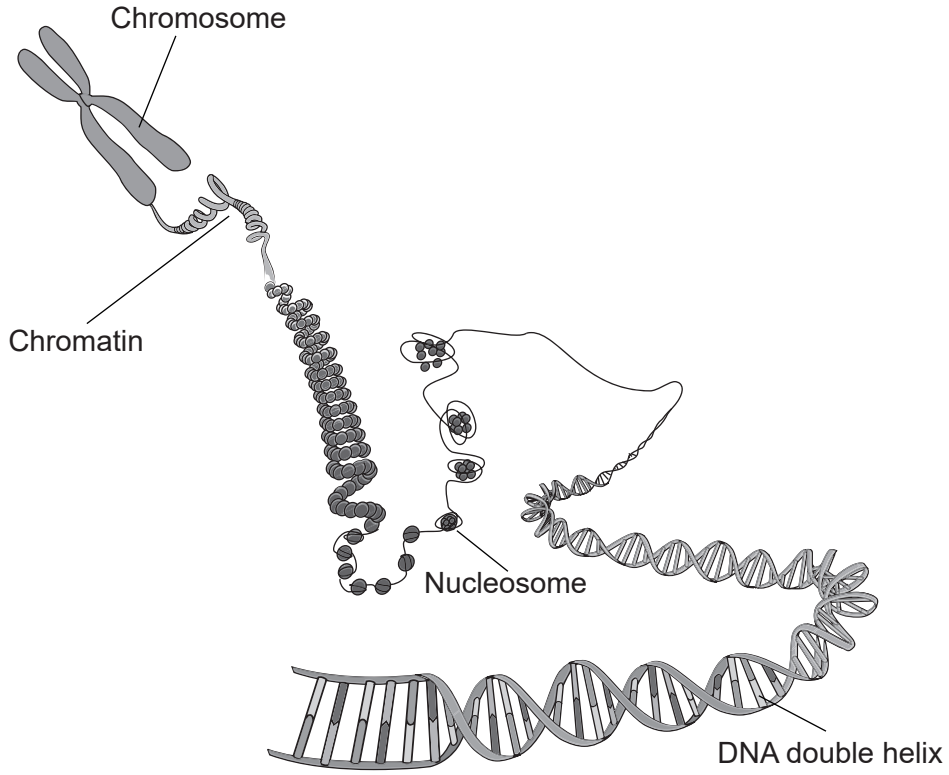
. . . . . .

(c) Deduce, with a reason, what time of day would be a good time to take melatonin if you have travelled over several different time zones and are jet-lagged on your arrival. [1]

. . . . . .

. . . . . .

5. (a) DNA forms chromosomes, but much of eukaryote DNA is non-coding.



(i) Describe the structure of nucleosomes. [1]

. . . . . .
. . . . . .

(ii) Explain how the two strands of the DNA double helix are held together. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(This question continues on the following page)

(Question 5 continued)

(iii) There are multiple tandem repeats of nucleotide segments of DNA found in the non-coding DNA between genes. Outline how tandem repeats are used for DNA profiling. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) People can be analysed genetically for risks of specific diseases before they actually develop. One of these is type I diabetes.

(i) Explain what happens in a person when they develop type I diabetes. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) State how type I diabetes should be treated to avoid harmful health consequences of the condition. [1]

. . . . . .

. . . . . .

Section B

Answer **two** questions. Up to one additional mark is available for the construction of your answers for each question. Answers must be written within the answer boxes provided.

6. (a) Describe how plants transport organic compounds from where they are made to where they are stored. [4]

(b) The processes of photosynthesis and respiration have some factors in common and others differ. Compare and contrast both processes for specific factors. [7]

(c) Humans rely on carbohydrates for much of their energy. Outline the process of digestion and absorption of starch in the human digestive system. [4]

7. (a) Outline, using graphs, the effect of different factors that influence enzyme activity. [5]

(b) Describe the function of **three named** enzymes involved in DNA replication. [3]

(c) Explain how speciation occurs, including the different processes of isolation and selection. [7]

8. (a) Outline **four** different processes, **with examples**, that allow substances to pass through the plasma membrane. [4]

(b) Humans need to balance water and solute concentrations and also excrete nitrogenous wastes. Explain how the different parts of the kidney carry out these processes. [7]

(c) Describe adaptations in mammals living in desert ecosystems to maintain osmolarity in their bodies. [4]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

References:

2. (a) Reischig, J., 2014. Mitosis (261 13) [Pressed; root meristem of onion]. [image online] Available at https://commons.wikimedia.org/wiki/File:Mitosis_(261_13)_Pressed;_root_meristem_of_onion_(cells_in_prophase,_metaphase,_anaphase,_telophase).jpg This file is licensed under the Creative Commons Attribution -ShareAlike 3.0 Unported (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/deed.en [Accessed 3 December 2019].

3. (left) Pixabay.

(right) Topic, J., n.d. Veronica montana 2. [image online] Available at: http://www.freenatureimages.eu/Plants/Flora%20S-Z/Veronica%20montana/#Veronica%2520montana%25202%252C%2520Bosereprijs%252C%2520Saxifraga-Jasenka%2520Topic.jpg [Accessed 3 December 2019].

5. (a) Pixabay.