Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Higher level
Paper 2

Wednesday 19 May 2021 (morning)

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]**.

2221 – 6008

21 pages

Section A

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

1. Mitosis in cancerous tissues is uncontrolled and the number of cells undergoing mitosis increases exponentially. Rapidly dividing cells in root tips can be used as a model for studying the effects of anticancer drugs. Aqueous extracts of the fruit of avocado (*Persea americana*) and the leaves of crepe jasmine (*Tabernaemontana divaricata*) have been shown to be toxic to some human cancer cell lines. Root tips of the broad bean (*Vicia faba*) were exposed to these aqueous plant extracts over a range of concentrations.

The mitotic index is the percentage of cells examined undergoing mitosis. The table shows the numbers of broad bean root cells examined and the mitotic indices over a range of plant extract concentrations.

	Avocado (*P. americana*)		**Crepe jasmine (*T. divaricata*)**	
Extract concentration / ppm	**Number of cells examined**	**Mitotic index / %**	**Number of cells examined**	**Mitotic index / %**
Control	3017	8.30	3017	8.30
100	3516	8.08	3000	8.00
1250	3450	7.68	3076	6.83
2500	4322	6.94	3089	6.31
5000	4200	4.29	3014	4.90
10 000	4023	3.11	3020	4.00
20 000	3697	2.11	3009	3.72

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(a) (i) Calculate the number of cells undergoing mitosis using 100 ppm of crepe jasmine extract. [1]

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(ii) Describe the effect of avocado extract on mitotic index. [1]

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(Question 1 continued)

(b) Compare and contrast the effect of increasing extract concentration on the mitotic indices for the two plant extracts. [3]

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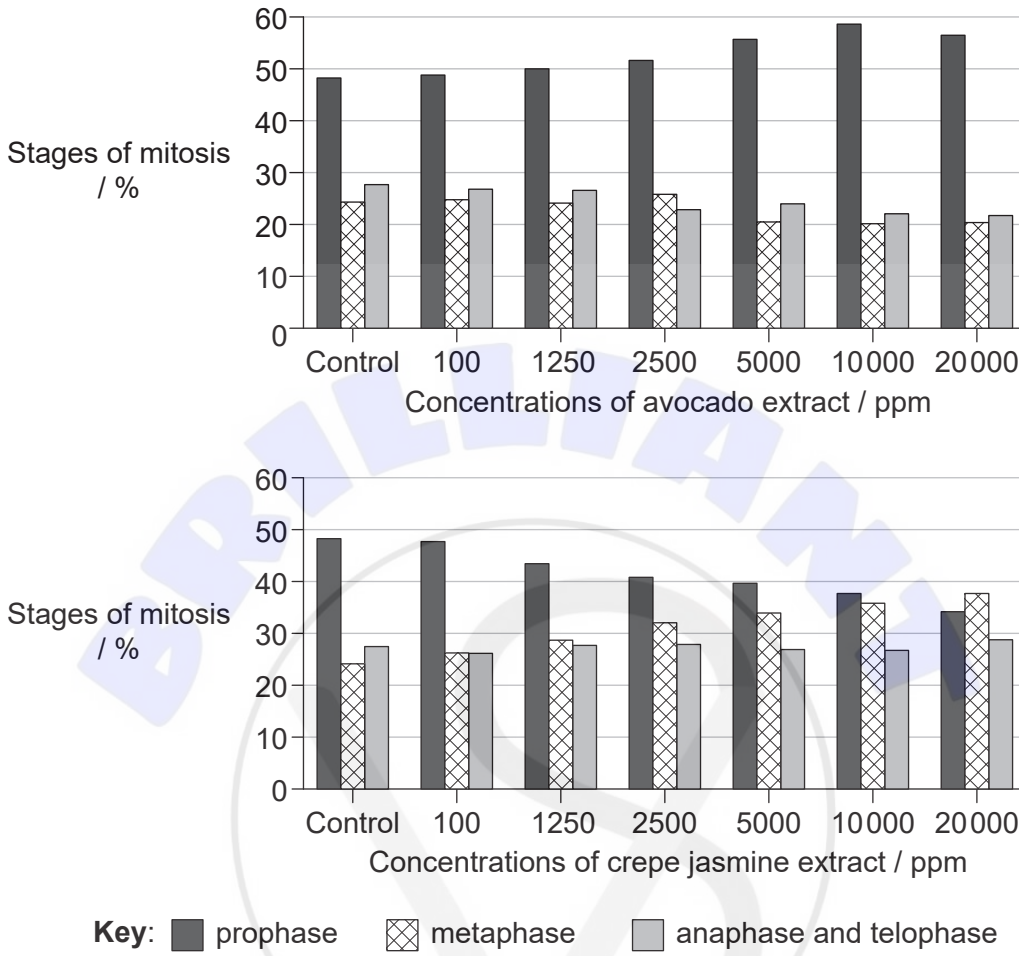
(Question 1 continued)

The percentage of cells in different stages of mitosis in the root tips was also recorded.



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(c) Outline the effect of avocado extract concentration on the percentage of cells in the different stages of mitosis. [2]

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(Question 1 continued)

(d) Using both the table of mitotic indices and the bar charts, deduce whether these extracts contain chemicals that block mitosis in broad bean root tips. [3]

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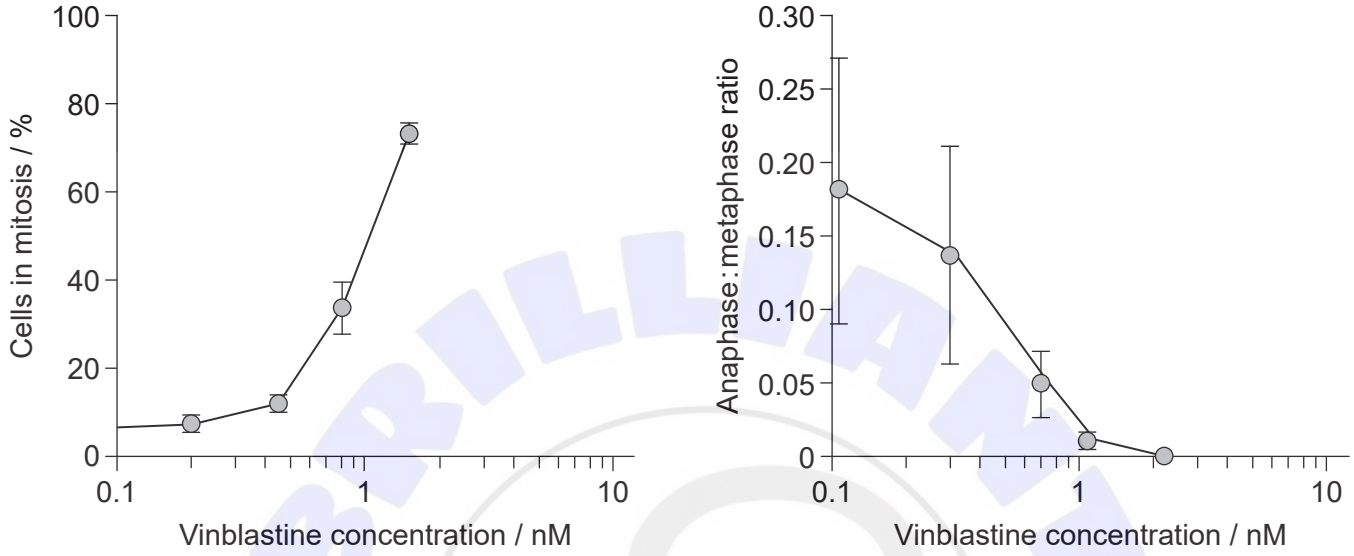
(Question 1 continued)

The mechanism of action of vinblastine, an anticancer drug, was investigated over a range of concentrations. Vinblastine is an alkaloid isolated from the periwinkle plant (*Catharanthus roseus*). The percentage of cells in mitosis and ratio of anaphase to metaphase in cells exposed to this drug *in vitro* for a fixed time were recorded. The data are displayed in two graphs.



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(e) By referring to both graphs, evaluate the hypothesis that vinblastine targets cells in mitosis and prevents them from completing the process. [3]

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(Question 1 continued)

(f) Some anticancer drugs inhibit mitosis by blocking the formation of the spindle. Suggest **one** other way in which vinblastine could block mitosis. [1]

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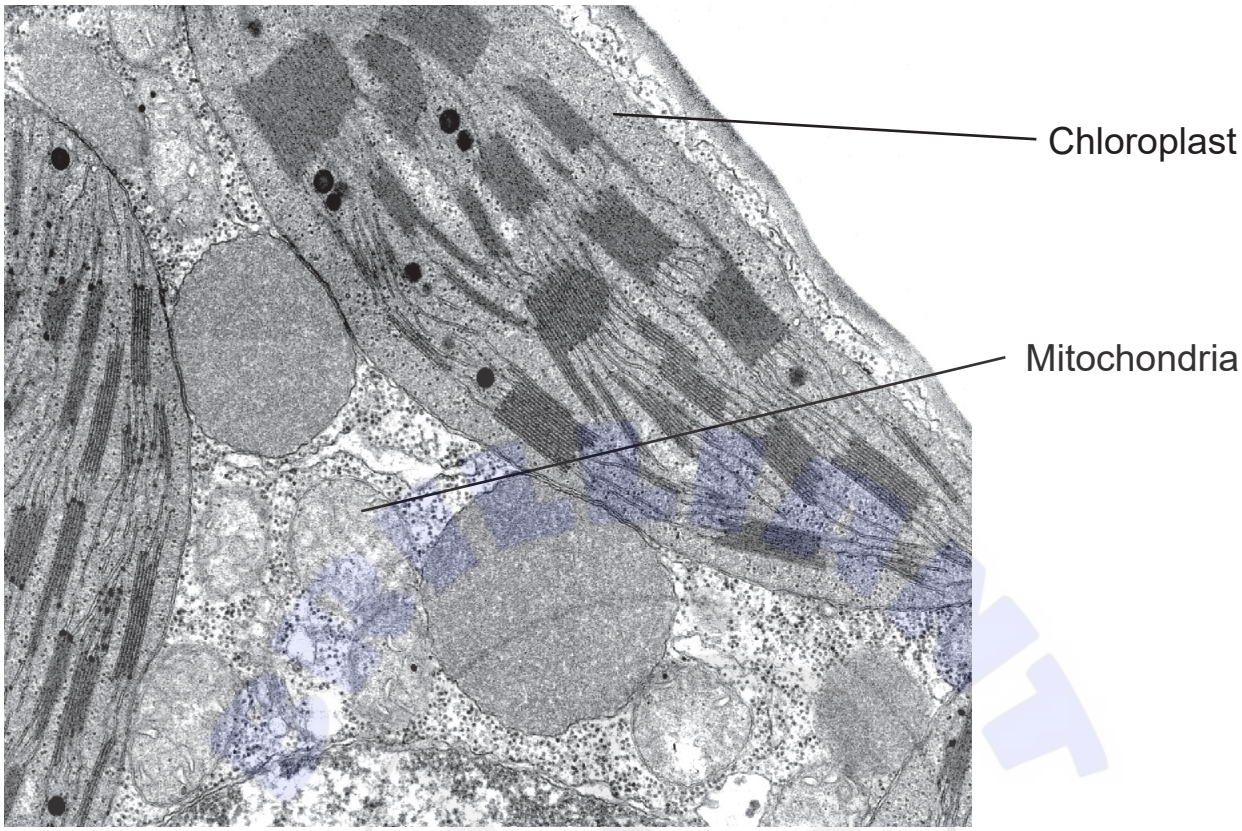
(g) Discuss **one** advantage and **one** disadvantage of using plant tissue to investigate drugs intended to treat cancer in humans. [2]

Advantage: . . . . . .

Disadvantage: . . . . . .

2. The image shows part of a plant cell with a chloroplast in close proximity to mitochondria.



(a) State **two** structural similarities between mitochondria and chloroplasts. [2]

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(b) Compare and contrast mitochondria and chloroplasts in terms of the substrates they use and the products they produce. [2]

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(Question 2 continued)

(c) Outline how the compounds produced by chloroplasts are distributed throughout the plant. [3]

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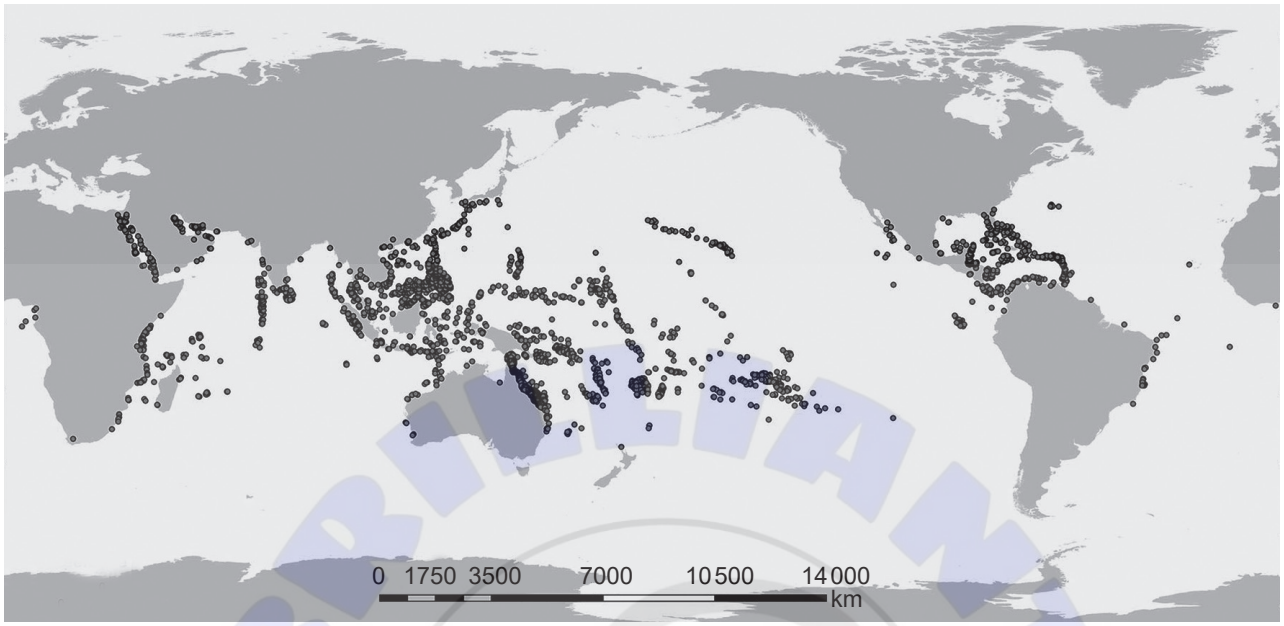
3. The map shows the widespread distribution of coral reef ecosystems (indicated by black dots) in the world's oceans. Death of coral reefs is related to increasing atmospheric carbon dioxide concentrations.



(a) Explain how increased atmospheric carbon dioxide concentrations can lead to coral death. [2]

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(Question 3 continued)

(b) The image shows part of the food web for a coral reef. Lines show the relationships for energy between organisms in the web.

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(i) Identify the trophic level of the detritivore, based on this food web. [1]

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(ii) Detritus accumulates on coral reefs damaged by ocean acidification. Suggest **two** possible impacts of an increase in detritus on the organisms in this food web. [2]

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4. (a) Plasma cells secrete antibodies against specific antigens. Outline how plasma cells become activated. [3]

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(b) A hybridoma is a cell produced by the fusion of a plasma cell with a tumour cell. Explain the advantages of using hybridoma cells in the production of monoclonal antibodies. [2]

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(c) State **one** use of monoclonal antibodies. [1]

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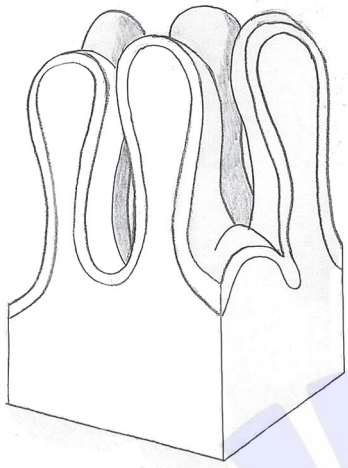
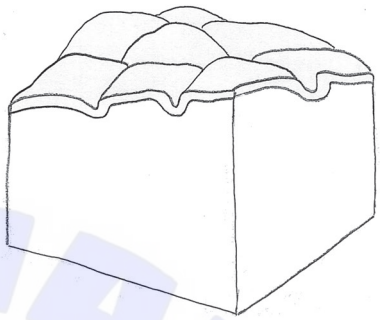
5. Celiac disease is an immune reaction to eating gluten, a protein found in many cereals. The diagram shows the arrangement of normal villi and villi affected by celiac disease in the small intestine.



Normal villi



Villi affected by celiac disease

(a) Outline the functions of the villi in the small intestine. [2]

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(b) Explain the consequences of celiac disease for absorption of digested nutrients. [2]

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(c) Wheat, barley and rye all contain gluten. Outline how a protein such as gluten is digested. [2]

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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. Hormones are produced by one tissue in an organism and have their effect on a target tissue.

(a) Describe the genetic and hormonal control of male sexual characteristics in a human. [3]

(b) Outline how the hormone auxin controls phototropism in plant shoots. [5]

(c) Compare and contrast hormonal and nervous communication. [7]

7. Variation in genetically inherited characteristics is the basis for evolution.

(a) Outline the inheritance of blood types in the ABO blood system in humans. [4]

(b) Explain how genetic variation between the individuals in a species can be generated. [7]

(c) Outline the use of analogous and homologous traits in natural classification. [4]

8. Cellular processes at the molecular level are regulated by enzymes.

(a) Outline the process of DNA profiling. [4]

(b) Outline the role of DNA polymerase III in DNA replication. [4]

(c) Explain the factors that affect the rate of enzyme-controlled reactions in cells. [7]

References:

1. Republished with permission of SPRINGER-VERLAG DORDRECHT, from Do cancer cells in human and meristematic cells in plant exhibit similar responses toward plant extracts with cytotoxic activities?, *Cytotechnology*, Noha S. Khalifa, Hoda S. Barakat, Salwa Elhallouty, Dina Salem, Volume 67, 2015; permission conveyed through Copyright Clearance Center, Inc.

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2. Photo © E. Newcomb.

3. National Oceanic and Atmospheric Administration, 2021. Where Reef Building Corals Found. [map online] Available at: https://oceanservice.noaa.gov/education/tutorial_corals/media/supp_coral05a.html [Accessed 20 May 2021].