



No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without written permission from the IB.

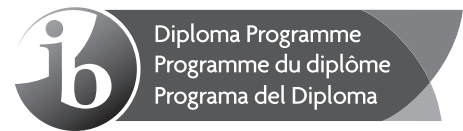
Additionally, the license tied with this product prohibits commercial use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, is not permitted and is subject to the IB's prior written consent via a license. More information on how to request a license can be obtained from <http://www.ibo.org/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite de l'IB.

De plus, la licence associée à ce produit interdit toute utilisation commerciale de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, n'est pas autorisée et est soumise au consentement écrit préalable de l'IB par l'intermédiaire d'une licence. Pour plus d'informations sur la procédure à suivre pour demander une licence, rendez-vous à l'adresse <http://www.ibo.org/fr/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.

No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin que medie la autorización escrita del IB.

Además, la licencia vinculada a este producto prohíbe el uso con fines comerciales de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales— no está permitido y estará sujeto al otorgamiento previo de una licencia escrita por parte del IB. En este enlace encontrará más información sobre cómo solicitar una licencia: <http://www.ibo.org/es/contact-the-ib/media-inquiries/for-publishers/guidance-for-third-party-publishers-and-providers/how-to-apply-for-a-license>.



Biology
Higher level
Paper 2

Thursday 9 May 2019 (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]**.



Please **do not** write on this page.

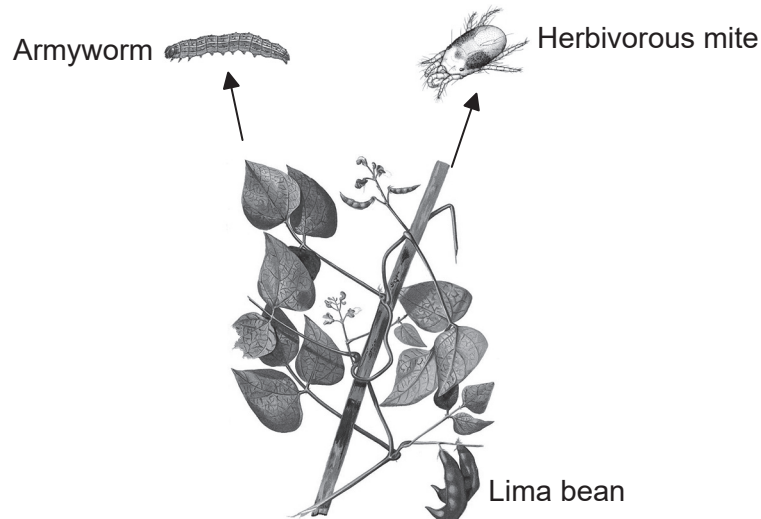
Answers written on this page
will not be marked.



Section A

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

1. Organisms often release chemicals when attacked as part of their defence system. Scientists studied lima bean plants (*Phaseolus lunatus*) infested with either an armyworm, *Spodoptera exigua*, or a herbivorous mite, *Tetranychus urticae*. Both organisms feed on lima bean leaves, causing the leaves to release chemicals.



[Source: https://commons.wikimedia.org/wiki/File:Phaseolus_lunatus_Blanco2.369.png]

The study was conducted to see which defence chemicals were produced by lima bean leaves when infested by armyworms or herbivorous mites. The scientists identified a mixture of compounds (C) released by the plant when attacked. Two of the chemicals in this mixture were identified (C1 and C2).

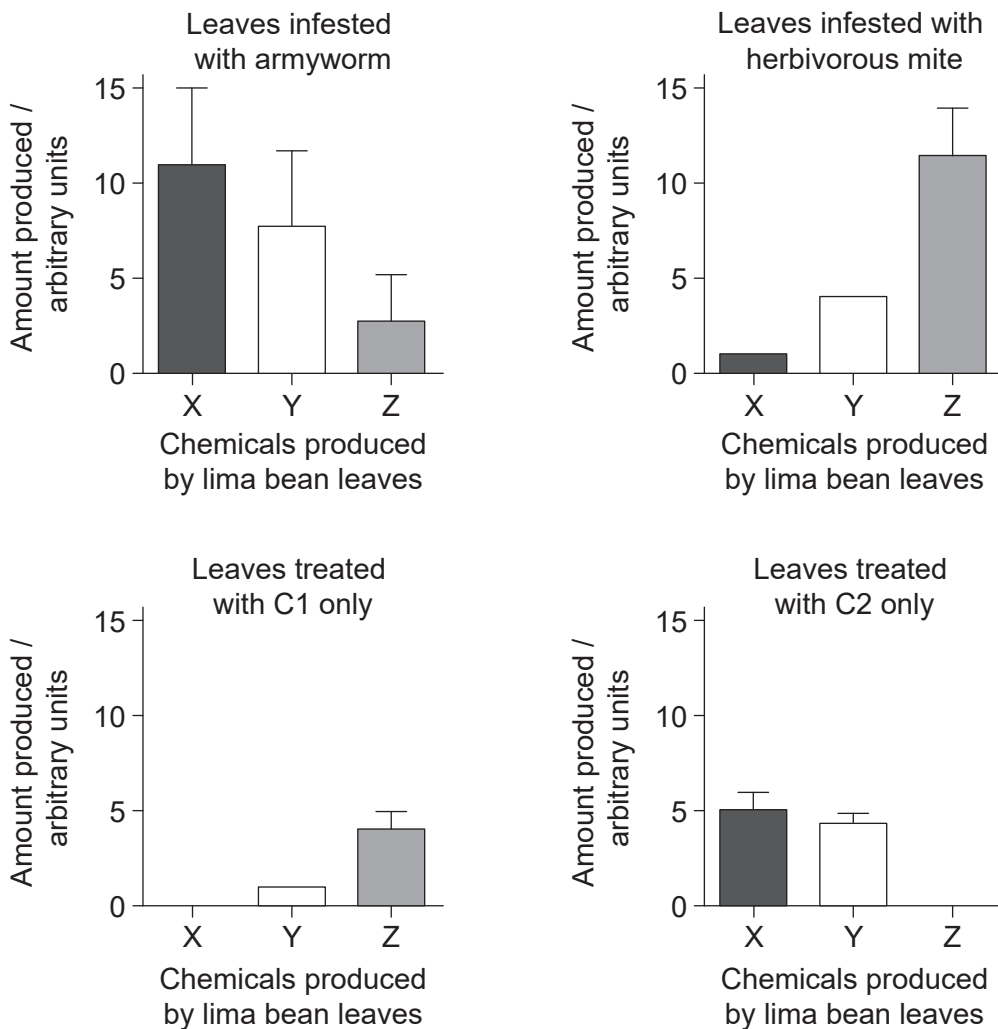
The scientists hypothesized that the defence chemicals in C act as signals to produce other chemicals (X, Y and Z) that are also involved in the defence of the plant.

(This question continues on the following page)



(Question 1 continued)

The graphs show the amounts of chemicals X, Y and Z produced when the plants were infested by either one of the two herbivores or treated with the different chemicals C1 or C2.



[Source: R Ozawa and G Arimura, Involvement of Jasmonate- and Salicylate-Related Signaling Pathways for the Production of Specific Herbivore-Induced Volatiles in Plants, *Plant and Cell Physiology*, 2000, **41**, 4, 391–398, by permission of Oxford University Press]

- (a) Distinguish between the data for the leaves infested with the armyworm and the leaves infested with the herbivorous mite.

[3]

.....

.....

.....

.....

.....

.....

(This question continues on the following page)



(Question 1 continued)

- (b) Compare and contrast the effects of treatment of the leaves using C1 and C2 with the effects of infestation.

[3]

.....

.....

.....

.....

.....

.....

RNA was collected from leaves of the plants after each treatment (armyworm, herbivorous mite and the chemicals C1 and C2). DNA copies of the extracted RNA were made by a process called reverse transcription. Targeted genes in the DNA were then amplified.

- (c) Identify the process that was used to amplify the targeted genes.

[1]

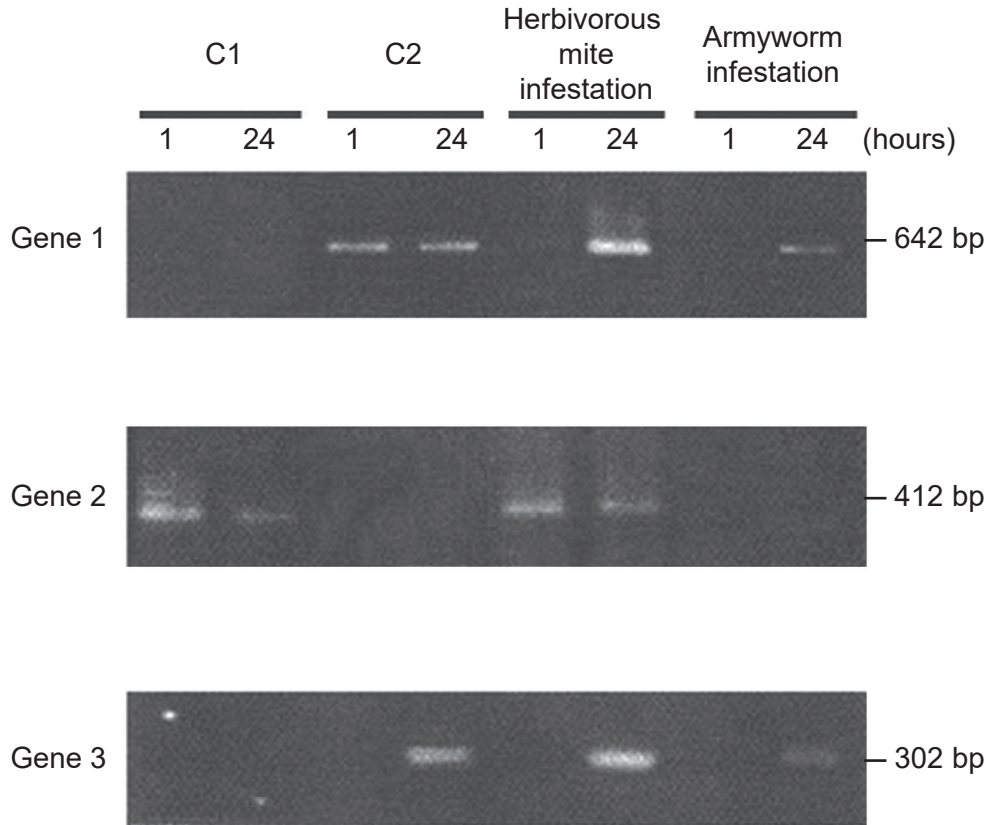
.....

(This question continues on the following page)



(Question 1 continued)

The scientists then used the transcribed DNA of each treatment to study the activation of three genes of the plants' defence system. The DNA was separated by gel electrophoresis. The activation was tested one hour after treatment and again after 24 hours.



[Source: R Ozawa and G Arimura, Involvement of Jasmonate- and Salicylate-Related Signaling Pathways for the Production of Specific Herbivore-Induced Volatiles in Plants, *Plant and Cell Physiology*, 2000, **41**, 4, 391–398, by permission of Oxford University Press]

(d) Deduce, with a reason, which gene is first transcribed when exposed to C2. [1]

.....

(This question continues on the following page)



(Question 1 continued)

- (e) Each gene is activated by one or more of the treatments. From the gel electrophoresis data, discuss the impact of the herbivorous mite infestation on gene activation compared to treatment with C1 and C2. [3]

.....

.....

.....

.....

.....

.....

.....

.....

- (f) Using the gene activation data, deduce, giving **two** reasons, whether the armyworm or the herbivorous mite has infested lima bean plants over a longer period of time. [2]

.....

.....

.....

.....

.....

.....

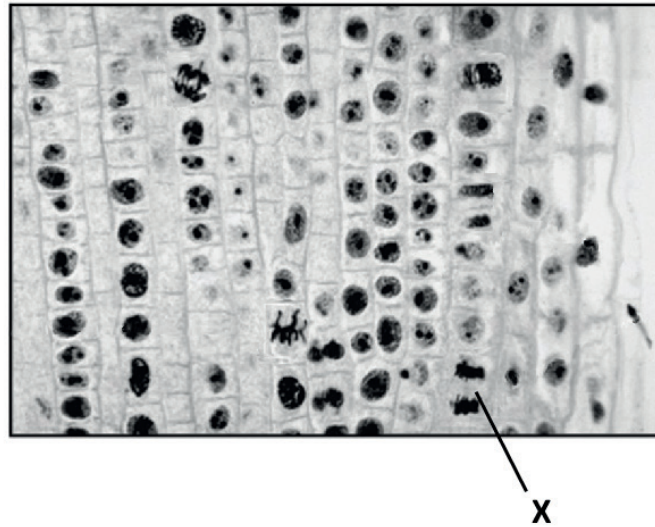


Please **do not** write on this page.

Answers written on this page
will not be marked.



2. (a) (i) Identify the stage of mitosis labelled X in the image, giving a reason. [1]



[Source: Copyright 2002, The Trustees of Indiana University]

.....
.....

- (ii) Outline what is indicated by the mitotic index of tissue taken from a tumour. [2]

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

- (iii) DNA has regions that do not code for proteins. State **two** functions of these regions. [2]

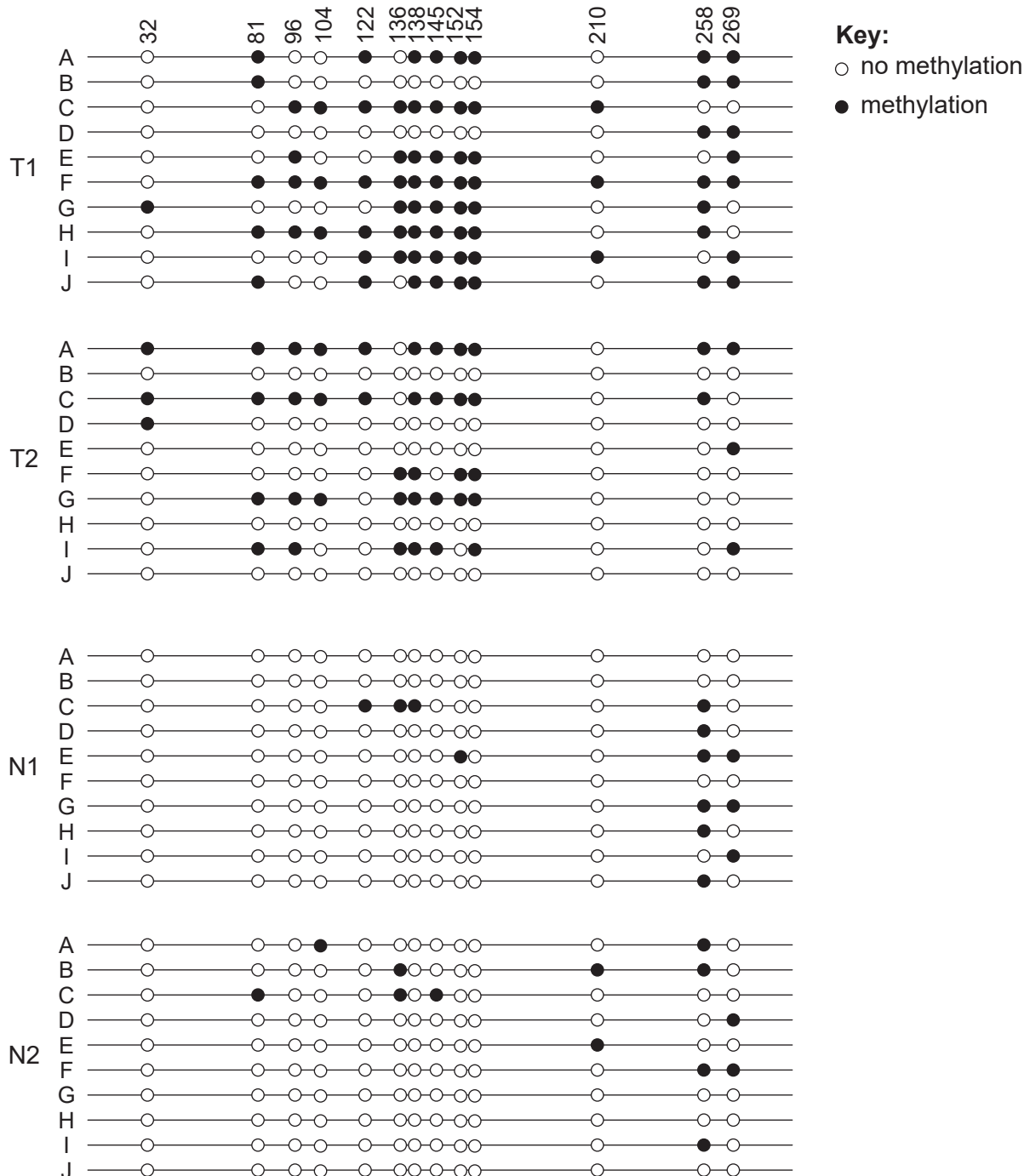
1.
2.

(This question continues on the following page)



(Question 2 continued)

- (b) DNA methylation has a critical role in gene regulation by affecting transcription. Samples were taken from two colon cancer tumours (T1 and T2) and two normal colon samples (N1 and N2). A particular gene was implicated as a possible cause of cancer. The promoter of this gene was cloned (A–J). The data show the DNA methylation patterns from these samples. The numbers (32–269) represent different markers in the promoter.



[Source: Philipp Schatz, Dimo Dietrich & Matthias Schuster. Rapid analysis of CpG methylation patterns using RNase T1 cleavage and MALDI-TOF. *Nucleic Acids Research* (2004) **32** (21): e167, doi:10.1093/nar/gnh165. Reproduced by permission of Oxford University Press]

(This question continues on the following page)



20EP10

(Question 2 continued)

- (i) Outline the difference in methylation pattern between tumorous and normal tissue samples. [2]

.....

.....

.....

.....

- (ii) Suggest a way methylation may affect tumour cell genes. [1]

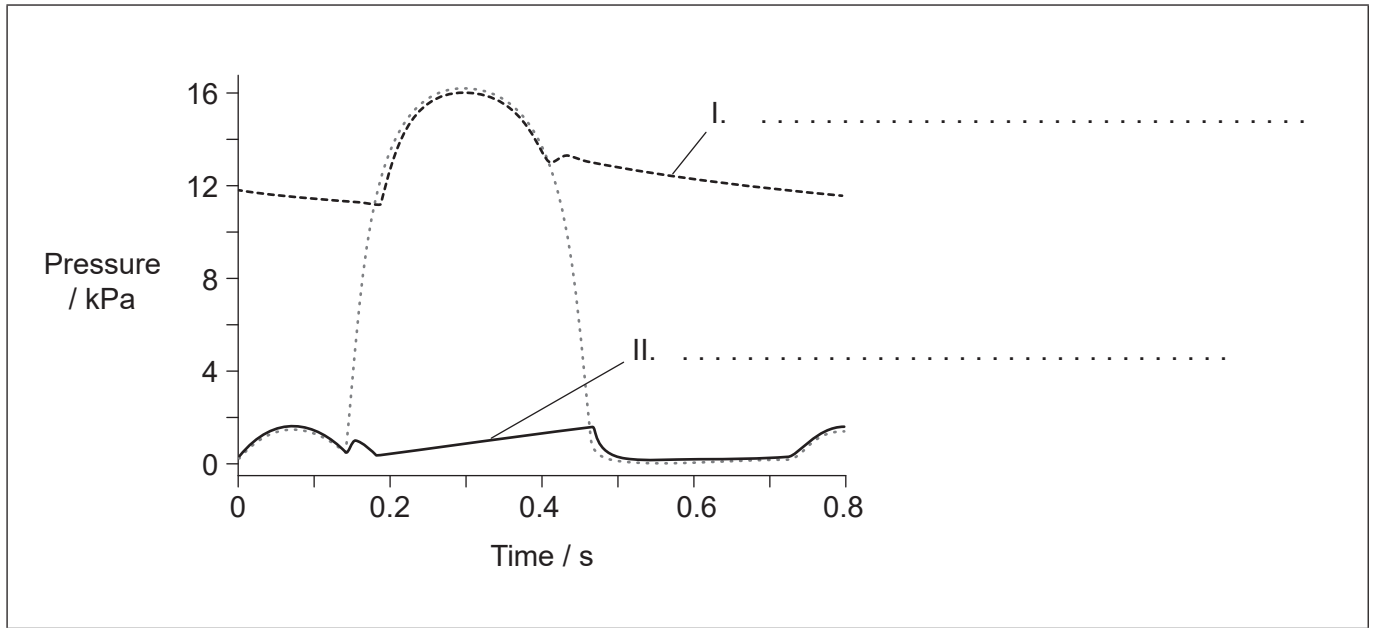
.....

.....

.....



3. (a) The graph shows blood pressure changes on the left side of the heart during one heartbeat. Identify the **two** parts of the circulatory system that produce traces I and II on the graph. [2]



[Source: © International Baccalaureate Organization 2019]

- (b) Outline the actions taken by the body to avoid infection when the skin is cut. [3]

.....

.....

.....

.....

.....

.....

.....

.....

- (c) Hormones are distributed throughout the body by the blood. Outline the roles of **two** reproductive hormones during the menstrual cycle in women. [2]

.....

.....

.....

.....



4. (a) The images show parts of plants belonging to two different phyla.

Plant X



[Source: DanielCD / <https://commons.wikimedia.org/wiki/File:SoriDicksonia.jpg>]

Plant Y



[Source: tbenedict/Pixabay <https://pixabay.com/photos/pine-cones-tree-evergreen-cone-581557/>]

State the phylum of plant X and of plant Y.

[2]

X:
Y:

(b) Some plant families, such as the figwort family, have been reclassified on the basis of evidence from cladistics. Explain the methods that have been used recently to reclassify groups of plants.

[3]

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

(This question continues on the following page)



(Question 4 continued)

- (c) Successful sexual reproduction in flowering plants depends on several essential processes. Outline the role of pollination and seed dispersal. [2]

Pollination:

.....
.....

Seed dispersal:

.....
.....

5. (a) State **two** causes of the decrease of biomass along food chains in terrestrial ecosystems. [2]

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

(This question continues on the following page)



(Question 5 continued)

- (b) The table shows the global carbon budget over two decades; the years 1990 to 1999 and 2000 to 2009.

Carbon	Global carbon budget / $\times 10^{12}$ kg	
	1990 to 1999	2000 to 2009
Atmospheric carbon dioxide	3.0	4.0
Fossil fuel and cement	6.5	8.0
Land use change	1.5	1.0
Carbon storage in land	2.5	2.0
Carbon storage in oceans	2.0	2.5

[Source: © International Baccalaureate Organization 2019]

Using the table, explain causes of the changes in carbon flux over the two decades.

[3]

.....

.....

.....

.....

.....

.....

.....

.....



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) Outline **four** types of membrane transport, including their use of energy. [4]
- (b) Draw the structure of a dipeptide. [3]
- (c) ADH (antidiuretic hormone) is a peptide hormone that is produced in the hypothalamus. Explain its action in the human body. [8]
7. (a) Distinguish between the structures of DNA and RNA. [3]
- (b) Mendel found the same pattern of inheritance in all the crosses that he performed. Outline, with examples, different types of inheritance that produce non-Mendelian ratios. [4]
- (c) Explain the cause of sickle cell anemia and how this disease affects humans. [8]
8. (a) Outline energy flow through a food chain. [4]
- (b) Draw a fully labelled graph of the action spectrum for photosynthesis. [3]
- (c) Explain Calvin's experiment and what was discovered about photosynthesis through his work. [8]



A large rectangular area containing horizontal dotted lines for writing.



A large rectangular area with horizontal dotted lines for writing.



20EP19

Turn over

A large rectangular area with a dotted grid pattern, intended for writing answers.

