Diploma Programme
Programme du diplôme
Programa del Diploma

Biology
Standard level
Paper 2

Wednesday 20 November 2019 (afternoon)

Candidate session number

1 hour 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 one question.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

8819–6005

Section A

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

1. Cultivated rice, *Oryza sativa*, is one of the most important human foods. The two main sub-species of cultivated rice are *O. sativa indica* and *O. sativa japonica*. *O. rufipogon* is a wild species from which they probably evolved.

(a) State the reason that *O. sativa* and *O. rufipogon* are classified as different species. [1]

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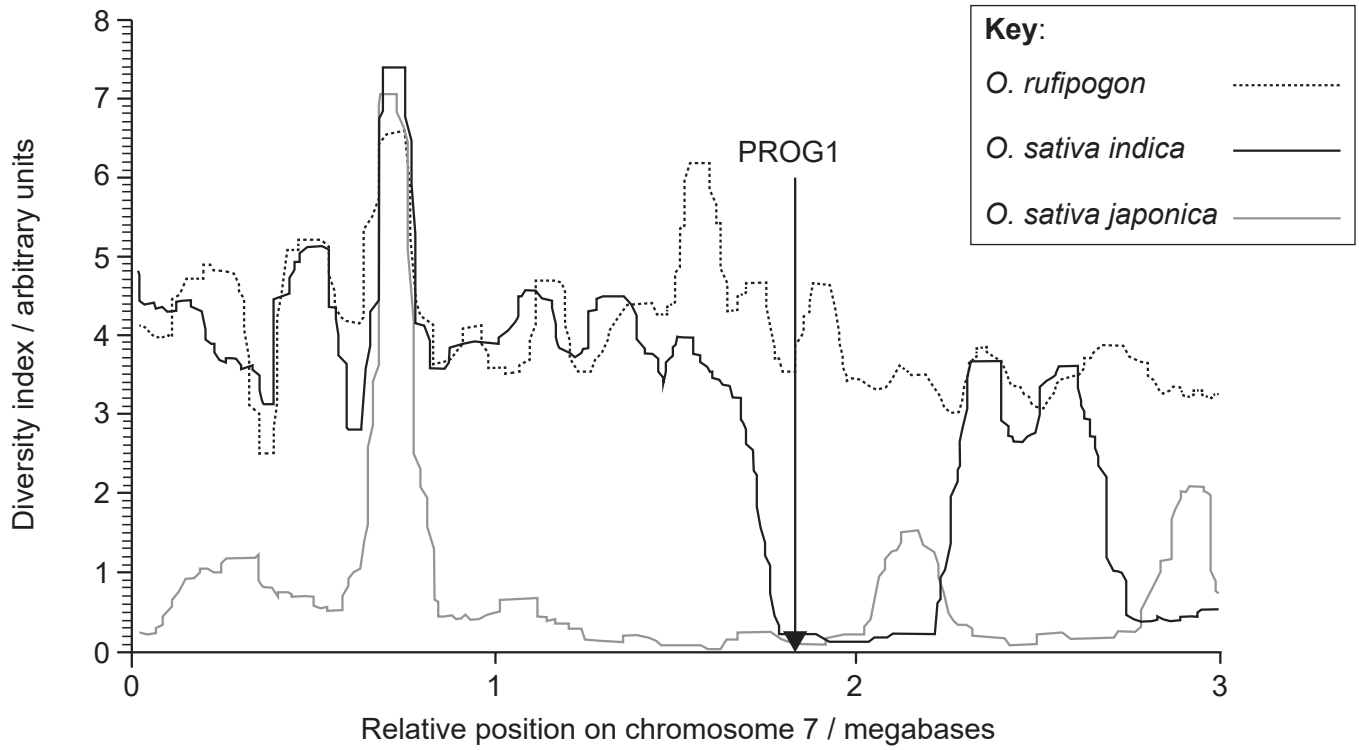
To investigate whether the sub-species of cultivated rice evolved independently from the wild species, scientists analysed their chromosomes to find areas with similar DNA base sequences. Wild species tend to have many different alleles of genes present on each chromosome, but during the development of a crop plant by artificial selection from a wild species, this diversity drops considerably, increasing the base sequence similarity.
The number of different alleles of the genes on a chromosome can be represented by a diversity index. The following graph of part of chromosome 7 shows the diversity index of *O. rufipogon* and two varieties of cultivated rice, *O. sativa indica* and *O. sativa japonica*.
The gene PROG1 allows the plant to stand upright, which is typical of cultivated rice.
Its position is indicated by the vertical arrow on the graph.



[Source: He Z, Zhai W, Wen H, Tang T, Wang Y, Lu X, *et al.* (2011) Two Evolutionary Histories in the Genome of Rice: the Roles of Domestication Genes. *PLoS Genet* **7**(6): e1002100. https://doi.org/10.1371/journal.pgen.1002100]

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(Question 1 continued)

(b) Determine which type of rice has the lowest overall diversity index. [1]

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(c) Compare and contrast the trends for *O. rufipogon* and *O. sativa indica*. [2]

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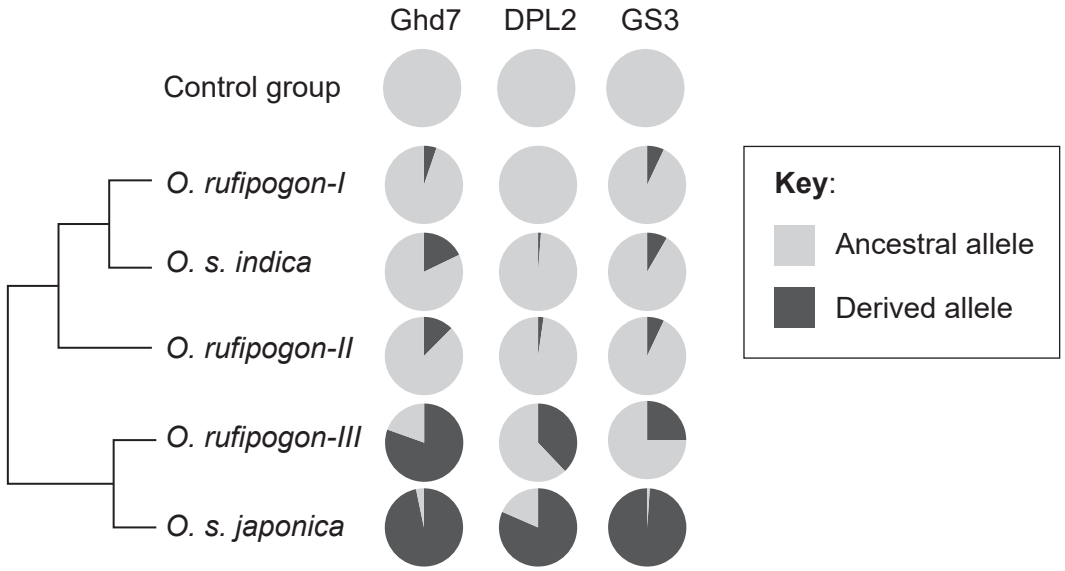
(Question 1 continued)

In another experiment, scientists retrieved genome sequences of the wild rice *O. rufipogon* taken from a wide range of geographical sites (I, II and III) and those of the two sub-species of *O. sativa* from gene banks.

The pie charts, presented along with a cladogram, show the proportion of alleles for three genes which confer specific characteristics to *O. sativa*. Mutations can produce derived alleles that are different from the original ancestral alleles. The control group represents wild rice species other than *O. rufipogon*.



[Source: reprinted by permission from Springer Nature: Nature, Huang, X., Kurata, N., Wei, X. *et al.* A map of rice genome variation reveals the origin of cultivated rice. *Nature* **490**, 497–501 (2012) doi:10.1038/nature11532]

(d) State the proportion of the ancestral allele for the gene GS3 in the *O. rufipogon-III* population. [1]

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(e) Distinguish between the proportion of ancestral and derived alleles for all three genes in *O. sativa indica* and *O. sativa japonica*. [2]

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(Question 1 continued)

(f) State **one** reason for having a control group. [1]

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(g) Using **all** of the data, discuss whether there is evidence that the two sub-species of *O. sativa* might have evolved independently from *O. rufipogon*. [4]

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2. A short base sequence of mRNA and a table of the genetic code are shown below.

Sequence of mRNA

AUGAGCCGAAGGUAGCUG

Table of the genetic code

1st letter	2nd letter: U	2nd letter: C	2nd letter: A	2nd letter: G	3rd letter
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met/START	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

(a) Outline the function of codons. [1]

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(b) (i) Determine the sequence of amino acids that could be translated from the sequence of mRNA. [1]

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(Question 2 continued)

(ii) Determine the DNA base sequence transcribed to form this sequence of mRNA. [1]

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(c) Suggest a hypothesis that accounts for the slightly different meaning of some codons in a very limited number of organisms. [1]

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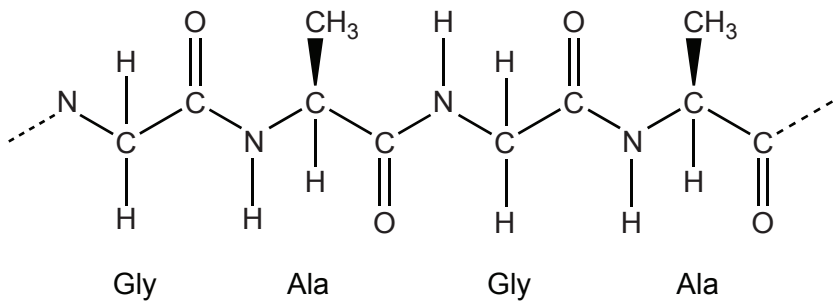
(d) The diagram shows a section of a polypeptide.



(i) Annotate the diagram to show a peptide bond between two amino acids. [1]

(ii) State the type of reaction that removes water while linking amino acids together to form polypeptides. [1]

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(Question 2 continued)

(e) Outline the function of Rubisco and of spider silk in relation to their three-dimensional conformation. [2]

	Function	Conformation
Rubisco		
Spider silk		

3. (a) Outline the cell theory. [2]

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(b) State **two** functions of life. [2]

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(Question 3 continued)

(c) List **three** characteristics of eukaryotic homologous chromosomes. [3]

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(d) Using the following table, compare and contrast anaerobic cell respiration in yeasts and in humans. The first row has been completed as an example. [3]

	Yeasts	**Humans**
Small yield of ATP	yes	yes
Require oxygen		
Produce ethanol and CO_2		
Produce lactate		

4. (a) State the immediate consequence of a species producing more offspring than the environment can support. [1]

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(b) Explain the consequence of overpopulation on the survival and reproduction of better adapted individuals within a population. [3]

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Section B

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

5. (a) Draw a section of the Singer-Nicolson model of an animal cell membrane. [4]

(b) Outline the principles used by scientists to classify organisms. [4]

(c) Explain the movement of energy and inorganic nutrients in an ecosystem. [7]

6. (a) Outline how cuts in the skin are sealed to prevent blood loss. [4]

(b) Outline how two parents could have a child with any of the four ABO blood groups. [4]

(c) Explain how ventilation and lung structure contribute to passive gas exchange. [7]