Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0863149993

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **October/November 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **24** printed pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** questions.

1 The Visayan warty pig, *Sus cebifrons*, is found on two islands in the Philippines.

Fig. 1.1 shows a female Visayan warty pig with her young.



Fig. 1.1

(a) The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species.

The Visayan warty pig is categorised as critically endangered on the IUCN Red List, which means that it is nearly extinct in the wild.

There are now only approximately 200 Visayan warty pigs in the Philippines.

Visayan warty pigs live in areas of dense forest that may be close to human habitation.

(i) Suggest **two** reasons why the Visayan warty pig is critically endangered.

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..... [2]

(ii) Describe the role of zoos in the protection of the Visayan warty pig.

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..... [3]

(b) Sometimes the Visayan warty pigs will breed with domestic pigs, *Sus domesticus*.

Suggest the consequences of this interspecific breeding.

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..... [3]

(c) Table 1.1 shows part of the classification of the Visayan warty pig.

Complete Table 1.1.

Table 1.1

taxonomic group	name
domain	.....
kingdom	animalia
phylum	chordata
.....	mammalia
order	artiodactyla
family	suidae

[2]

[Total: 10]

2 **(a)** Researchers have found evidence of natural selection in humans.

- Originally, in human populations it was only babies and children that needed to digest the milk sugar, lactose. The gene coding for the enzyme lactase (*LCT* gene) was switched off before adulthood.
- Today, in many populations, some adult individuals have lactose intolerance, which means they cannot digest lactose. Lactose intolerance leads to side-effects such as abdominal pain after eating food containing lactose.
- A mutation has been identified that keeps the *LCT* gene switched on. An adult who has this mutation is able to digest lactose. This is called lactose persistence.
- Lactose persistence increased in populations in Europe several thousand years ago.
- The increase in lactose persistence in Europe coincided with an increase in farming of cows for milk.

(i) Natural selection has caused this increase in lactose persistence.

State the type of selection that has caused this increase.

..... [1]

(ii) Explain why there was selection for lactose persistence in humans several thousand years ago.

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..... [3]

(b) Lactose intolerance and lactose persistence were investigated in a test population in Europe. The mutation which causes lactose persistence is in a regulatory gene (**T**/**t**).

- People with lactose intolerance have the genotype **tt**.
- People with lactose persistence have the genotypes **TT** and **Tt**.

- 166 people were tested for their genotype.
- 58 people were found to have lactose intolerance.

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(i) The Hardy–Weinberg principle can be used to calculate allele, genotype and phenotype frequencies in populations.

The Hardy–Weinberg equations are shown in Fig. 2.1:

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

Fig. 2.1

Calculate the frequency of allele **T**.

Show your working.

frequency of allele **T** = ... [3]

(ii) When the calculated phenotype frequencies were compared to those in the general population in Europe, it was found that the percentage of people with lactose intolerance in this test population was much higher than in the general population.

Suggest **two** reasons why the percentage of people with lactose intolerance was much higher in the test population than in the general population.

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.....

.....

..... [2]

(c) In eukaryotes, gene expression is controlled by transcription factors, coded for by regulatory genes.

(i) Outline ways in which transcription factors carry out their role.

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.....

.....

..... [2]

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(ii) It is estimated that 2% of human DNA consists of genes coding for proteins (structural genes). Of the remaining 98%, some of the DNA consists of regulatory genes and control sequences that together control gene expression.

State **one** type of control sequence found in human DNA.

..... [1]

(iii) A study of human evolution identified the location of mutations that result in a change in human phenotype. The study found most examples of mutations had occurred in regulatory genes, not structural genes.

Suggest **and** explain why most changes in human phenotype are due to mutations in regulatory genes.

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.....

.....

..... [2]

[Total: 14]

3 Mammals such as sheep, *Ovis aries*, and goats, *Capra hircus*, are important agricultural animals that are sometimes kept together in mixed flocks. Very occasionally, live offspring are born from a mating between a male sheep and a female goat.

In sheep 2n = 54 and in goats 2n = 60.

(a) (i) Calculate the diploid chromosome number of the hybrid offspring of a sheep and a goat.

..... [1]

(ii) Outline why the classification of sheep and goats suggests that hybridisation between them should **not** be likely to occur.

.....

..... [1]

(b) Normal (wild-type) goats have a gold and black coat colour pattern, known as bezoar, and are also horned (have horns). Domestic goats may have a white coat and may be hornless (do not have horns).

These variations are coded for by two unlinked genes:

- white coat colour, coded for by the dominant allele of the gene **A/a**
- hornless, coded by the dominant allele of the gene **H/h**.

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A cross between a white hornless goat and a bezoar horned goat produced offspring of four different phenotypes.

Draw a genetic diagram to show the genotypes of the two parents, their gametes and the offspring, and the phenotypes of the offspring.

[4]

(c) Horns on agricultural animals such as goats and cattle can be dangerous to the farmer and to other animals. Horns are often prevented from growing in 5-day-old animals by a stressful procedure called disbudding.

Genetic modification can cause a deletion in the allele **h** coding for horns in cattle embryos, so that the allele no longer codes for a functional protein and the embryos grow into cattle that are hornless.

(i) State an **ethical** advantage of this example of genetic modification.

.....

..... [1]

(ii) Suggest why genetic modification that causes a deletion in the horned allele, in established breeds of dairy cattle, is preferable to selective breeding for hornless animals.

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..... [1]

[Total: 8]

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[Turn over

4 **(a)** Fig. 4.1 shows a transmission electron micrograph of a section through striated muscle.

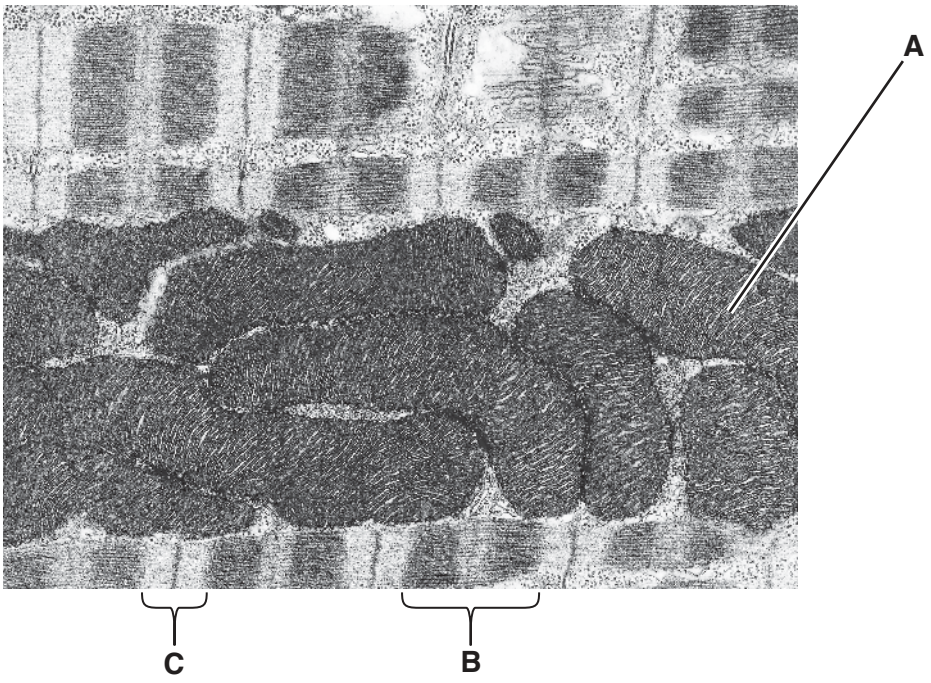


Fig. 4.1

Complete Table 4.1, using the letters **A**, **B** or **C**, to show the location of proteins associated with striated muscle structure.

You may use each letter once, more than once, or not at all.

Table 4.1

protein	location
myosin and actin	.....
actin alone	.....
ATP synthase	.....
ATPase	.....

[4]

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(b) Explain the role of ATP in the contraction of striated muscle.

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..... [5]

[Total: 9]

5 Traditional techniques for genetically modifying organisms use three enzymes:

- restriction endonuclease
- reverse transcriptase
- DNA ligase.

For example, these enzymes have been used to produce genetically modified (transgenic) pigs containing the *GFP* gene coding for green fluorescent protein, originally sourced from jellyfish.

(a) Outline how these three enzymes could be used in genetically engineering a transgenic pig containing the *GFP* gene.

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..... [3]

A new technique that aims to cause a **deletion** in a gene uses an enzyme called Cas9 nuclease. It is injected into zygotes along with an RNA sequence (the guide RNA) that is complementary to a target gene. The Cas9 nuclease causes a deletion in the target gene in the zygotes, preventing the expression of that gene.

The toxicity and efficiency of the new technique was tested on four groups of pig zygotes. These pig zygotes were produced by IVF using:

- ova from a female non-transgenic pig.
- sperm from a male transgenic pig whose somatic (body) cells contained one copy of the *GFP* gene per cell.

The pig zygotes in three groups were injected with different concentrations of Cas9 nuclease and guide RNA **targeted at the *GFP* gene**.

The fourth group of pig zygotes (control group) was **not** injected with Cas9 nuclease and guide RNA.

(b) Explain why the *GFP* gene was chosen for testing the new technique.

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..... [2]

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Some of the zygotes in each group survived and after six days each had developed into a group of cells called a blastocyst.

The blastocysts were counted using a light microscope. A filter was then added to the microscope, so that only blastocysts expressing the green fluorescent protein showed up. These were counted and the results are summarised in Table 5.1.

Table 5.1

concentration of Cas9 nuclease and guide RNA / ng mm^{-3}	number of blastocysts seen under white light	number of blastocysts seen under filter
0 (control)	68	46
10	40	0
20	24	0
50	15	0

(c) (i) Calculate the percentage of zygotes in the control group that were transgenic.

Show your working.

..... % [1]

(ii) Explain whether the percentage you calculated for **(i)** is higher or lower than expected.

.....

.....

..... [1]

(iii) Name a statistical test that would allow you to test the significance of the difference between the percentage you calculated in **(i)** and the expected percentage.

..... [1]

(iv) State the best concentration of Cas9 nuclease and guide RNA to use to cause a deletion in the *GFP* gene **and** give reasons for your choice.

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..... [3]

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(d) Fig. 5.1 shows the results from a second trial of the new technique, analysed by electrophoresis.

- Lanes **1–4** show DNA from four pigs born after Cas9 nuclease was used to cause a deletion in a target gene coding for a cell surface protein.
- Lane **5** shows DNA from their surrogate mother.
- Lane **6** shows DNA from another normal pig for comparison.

The size of the DNA fragments is given in kilobase pairs (kbp) as shown in Fig. 5.1.
1 kbp is 1000 base pairs of DNA.

The target gene measures 6 kbp and codes for a cell surface protein that is essential for the disease virus PRRSV to infect cells in the pig's body.

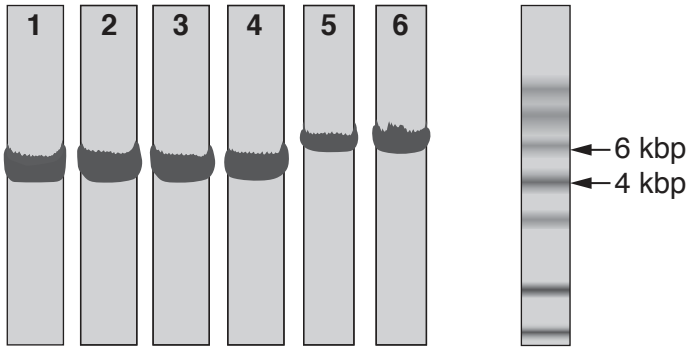


Fig. 5.1

Explain what Fig. 5.1 indicates about the success of the new technique in causing a deletion in a gene in pigs so that they show resistance to PRRSV.

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..... [3]

[Total: 14]

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Question 6 starts on page 14

6 (a) The *lac* operon is a section of DNA present in the genome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 6.1 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

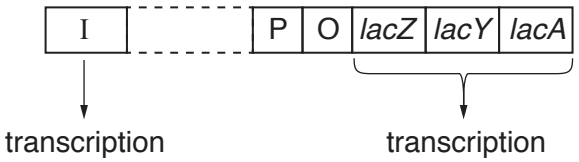


Fig. 6.1

(i) Fig. 6.1 shows how the *lac* operon consists of structural genes and regulatory sequences.

Use Fig. 6.1 to identify two structural genes.

Complete Table 6.1 to name each structural gene and its product.

Table 6.1

structural gene	name of gene product

[2]

(ii) Gene I is transcribed all the time to produce its protein. This is constitutive expression.

Explain why some genes show constitutive expression.

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.....

..... [1]

(iii) Describe the effect of the product of gene I on the functioning of the *lac* operon.

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..... [2]

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(b) If *E. coli* is put into a nutrient medium containing lactose, some new enzymes are synthesised. These are described as inducible enzymes.

(i) Explain what is meant by an *inducible enzyme*.

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..... [2]

(ii) The structural genes of the *lac* operon are **not** expressed when lactose is absent.

Suggest **one** reason why this is beneficial to *E. coli*.

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..... [1]

[Total: 8]

7 **(a)** Fig. 7.1 is an outline diagram of the Calvin cycle.

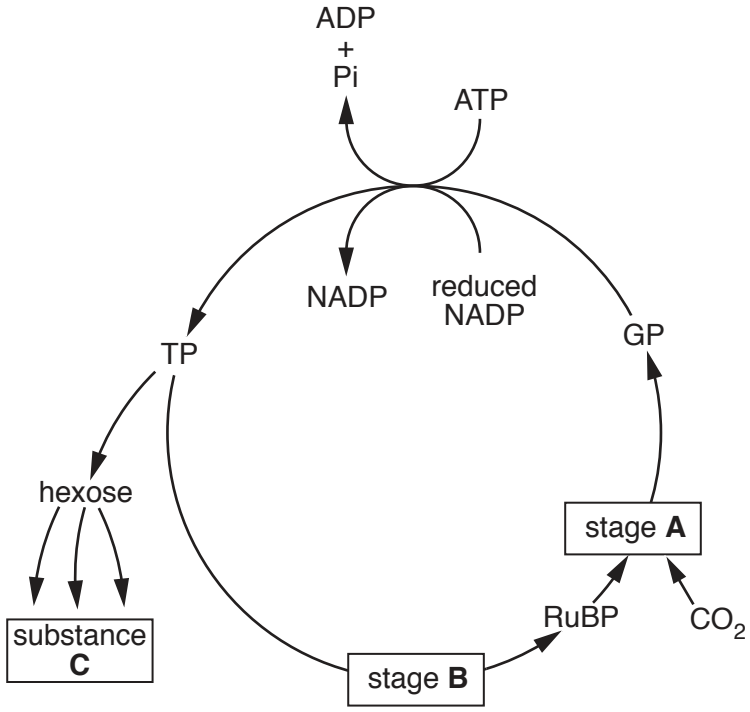


Fig. 7.1

(i) With reference to Fig. 7.1:

name the stage of the Calvin cycle occurring at **A**

.....

name the **enzyme** involved in the stage of the Calvin cycle occurring at **A**

.....

name two examples of substance **C**

1 .....

2 .....

name the biochemical process that produces reduced NADP **and** ATP.

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[5]

(ii) With reference to Fig. 7.1, outline what is occurring at stage **B** of the Calvin cycle.

.....

.....[1]

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(b) Explain why there is a tight ring of mesophyll cells around the bundle sheath cells in the leaves of a C4 plant.

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..... [3]

[Total: 9]

8 Gibberellin is a plant growth hormone that has a role in germination and in stem elongation.

(a) Outline how gibberellin is involved in activating genes for stem elongation.

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.....[2]

(b) Outline the role played by gibberellin in the germination of wheat seeds.

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.....[4]

(c) The length of stem in pea plants is controlled by a single gene. Pea plants can be either tall or short.

A study was carried out to investigate the effect of applying gibberellin to short pea plants. Two groups of short pea seedlings were used, group **P** and group **Q**.

- Group **P** consisted of 20 seedlings to which a paste containing gibberellin had been applied two days after germination.
- Group **Q** consisted of 20 seedlings to which a paste **without** gibberellin had been applied two days after germination.
- The length of stem of the pea plants was recorded at intervals over 20 days.

The results are shown in Fig. 8.1.

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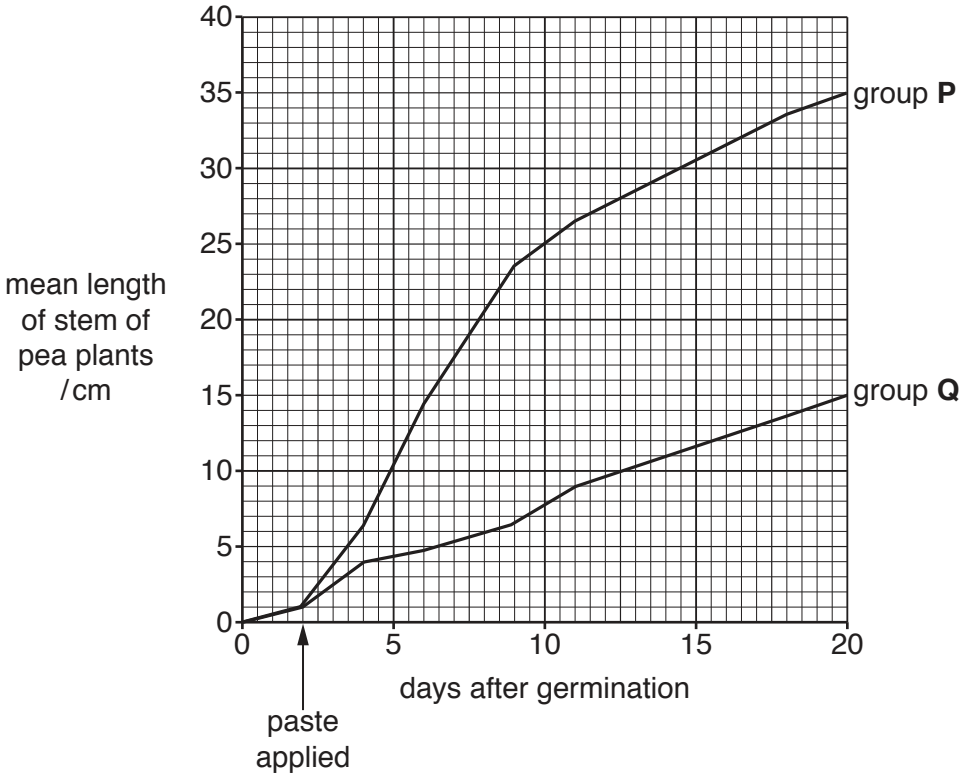


Fig. 8.1

With reference to Fig. 8.1, describe the results of the investigation **and** compare the growth rate of plants in group **P** and group **Q**.

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.....[4]

(d) Explain the role of the gene controlling stem length in pea plants.

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.....[3]

[Total: 13]

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Section B

Answer **one** question.

9 **(a)** Explain why carbohydrates, lipids and proteins have different relative energy values as substrates in respiration in aerobic conditions. [6]

(b) Define the term respiratory quotient (RQ) **and** describe how you would carry out an investigation to determine the RQ of germinating barley seeds. [9]

[Total: 15]

10 **(a)** Describe how a spinal reflex arc functions **and** explain why it is an advantage to a mammal. [9]

(b) Explain the importance of the myelin sheath in determining the speed of nerve impulses. [6]

[Total: 15]

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