Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

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2626613177

BIOLOGY **9700/41**

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.

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Section A

Answer **all** questions.

1 The Bali starling, *Leucopsar rothschildi*, is found on the island of Bali, Indonesia.

Fig. 1.1 shows a Bali starling.



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 Bali starling is categorised as critically endangered on the IUCN Red List, which means that it is nearly extinct in the wild.

The Bali starling is protected by Indonesian law and trapping of the birds for sale as pets is illegal. In 2001 there were only six Bali starlings in the wild and about 1000 in captivity.

(i) Suggest reasons, other than the trapping of the birds for sale as pets, for the very low numbers of Bali starlings in the wild.

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..... [3]

(ii) Describe the roles zoos can take in the protection of the Bali starling.

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(b) Explain the consequences on genetic biodiversity of having a wild population of just six birds.

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..... [4]

[Total: 9]

2 In the fruit fly, *Drosophila melanogaster*, two different genes control body colour and eye colour.

- **G**/**g** are alleles of the body colour gene.
- **G** results in grey body, **g** results in black body.

- **R**/**r** are alleles of the eye colour gene.
- **R** results in red eyes, **r** results in brown eyes.

Each gene is autosomal.

A dihybrid cross was carried out using a fly with a grey body and red eyes crossed with a fly with a black body and brown eyes. Both parents were homozygous for both genes. The offspring from the F1 generation were crossed to obtain the F2 offspring.

(a) A statistical test showed that the results of the cross were significantly different from those expected.

State the name of the statistical test used **and** state the expected phenotypic ratio for the F2 generation.

statistical test .....

expected ratio .....

[2]

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(b) A test cross can be carried out in order to identify flies from an F2 generation that are heterozygous for both genes.

Draw a genetic diagram to show how a test cross between a heterozygous grey-bodied, red-eyed F2 fly and a fly with a black body and brown eyes can produce four different offspring phenotypes.

Use the symbols **G**/**g** and **R**/**r**.

[4]

(c) The results of the test cross in **(b)** are shown in Table 2.1. These results are significantly different from the expected results.

Table 2.1

phenotypes of offspring of test cross	number of individuals
grey body, red eyes	123
grey body, brown eyes	7
black body, red eyes	6
black body, brown eyes	132

Describe how these results are different from the expected results **and** explain why they are different.

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..... [5]

[Total: 11]

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3 **(a)** Meiosis is one process that contributes to genetic variation.

(i) State **precisely** the stage of meiosis where single chromosomes line up on the equator.

..... [1]

(ii) Outline the events taking place during anaphase I of meiosis.

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..... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

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..... [2]

Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50% of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 3.1.

Table 3.1

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

(b) (i) Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

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..... [2]

(ii) Explain why this example of genetic variation is important for natural selection in water hemp populations.

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..... [2]

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(iii) Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

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..... [1]

(c) The null hypothesis states there is no significant difference between the mean times for 50% of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for ***t*** at the $p = 0.05$ significance level is 2.23.

(i) Use the formula in Fig. 3.1 to calculate the value of ***t***.

Show your working.

$$t = \frac{\left|\overline{x}_1 - \overline{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\overline{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

Fig. 3.1

t = ... [2]

(ii) Use your calculated value of ***t*** to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

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.....[2]

[Total: 14]

4 The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.

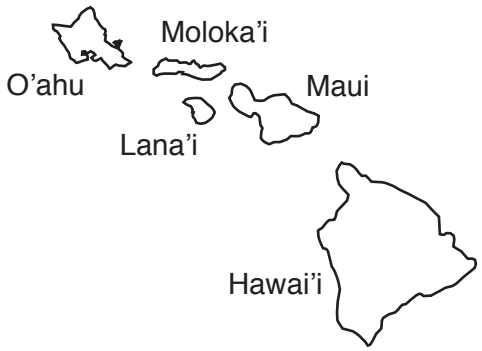


Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalã. This is because they formed at different times from two separate volcanoes.

Table 4.1

island	**area / km^2**	**age of island / million years**	**total number of *Mecyclothorax* species**	**species density / number of species per km^2**
Hawai'i	10433	0.4	30	0.003
Lãna'i	364	1.3	3	0.008
Maui (West)	443	1.3	27	0.061
Maui (Haleakalã)	1440	1.1	116	0.081
Moloka'i	673	1.9 – 1.8	43	0.064
O'ahu	1545	3.7 – 2.6	20	.....

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Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

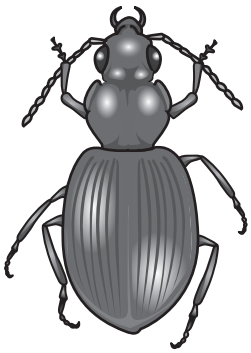


Fig. 4.2

(a) (i) Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

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..... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

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..... [2]

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[Turn over

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalã, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalã developed.

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.....[4]

[Total: 9]

5 **(a)** Leber's congenital amaurosis (LCA) is an autosomal recessive eye disease. LCA results in eye disorders, including severe loss of vision, at birth. LCA has been successfully treated by gene therapy, using a virus instead of a plasmid as the vector.

Adeno-associated virus (AAV) vectors containing the therapeutic allele were injected directly into the retina, the layer at the back of the eye containing the photoreceptor cells. People who had been blind from a young age were able to see again.

There is a risk associated with the injection method used to deliver the vectors, as it might cause the retina to detach, damaging vision. This method of delivery was first used for LCA before being trialled on other retinal diseases that gradually reduce the vision of people as they get older.

(i) Suggest the main steps involved in creating recombinant DNA for this example of gene therapy.

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..... [4]

(ii) Explain why the fact that LCA is an autosomal recessive genetic disease makes it suitable for treatment with gene therapy.

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..... [2]

(iii) Suggest why the retinal injection method of gene therapy was used for LCA before it was trialled on other retinal diseases that gradually reduce the vision of people as they get older.

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.....[2]

(b) Scientists tried to create an improved virus vector for gene therapy.

step 1 – The scientists used a special form of the polymerase chain reaction (PCR). This form of PCR causes mutations in the DNA sequence of AAV by base substitution.

step 2 – The viruses containing different base substitutions were tested. This was done by using the different viruses to deliver a new gene, the gene for green fluorescent protein (GFP), into the photoreceptor cells of mice, using the retinal injection method.

step 3 – The best virus, known as 7m8, caused the photoreceptor cells in the retina of the mouse to fluoresce brightly, even when the recombinant virus was injected into the fluid inside the eye instead of into the retina itself.

step 4 – The 7m8 virus was used to cure a mouse with LCA by injecting this virus containing the therapeutic allele into the fluid inside the eye of the mouse.

(i) Suggest how errors occurring during PCR can cause base substitution mutations in the DNA sequence of AAV.

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..... [3]

(ii) Explain why the photoreceptor cells of the mouse fluoresced in step 3.

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..... [2]

(iii) Predict the impact of the 7m8 AAV on treatment for age-related retinal diseases.

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.....[1]

[Total: 14]

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6 **(a)** Fig. 6.1 outlines some of the steps of glycolysis.

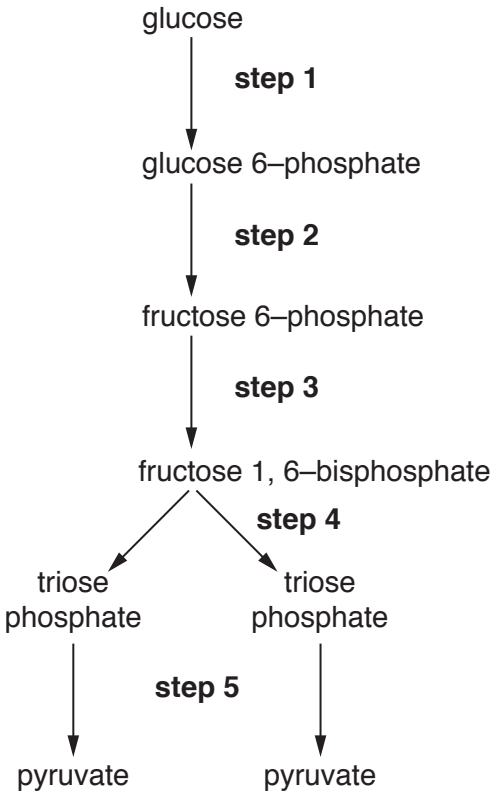


Fig. 6.1

(i) State the precise location of glycolysis in the cell.

..... [1]

(ii) With reference to Fig. 6.1:

state the steps where phosphorylation occurs

.....

state the step where oxidation occurs

.....

name the type of reaction by which ATP is made during **step 5**.

.....
[3]

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[Turn over

(b) Some cancer cells have different metabolic requirements from normal cells. These cancer cells obtain most of their ATP from glycolysis, even if oxygen is available.

State how the glucose and oxygen requirements of these cancer cells differ from normal cells.

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..... [2]

[Total: 6]

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7 **(a)** Fig. 7.1 is a transmission electron micrograph of a chloroplast.

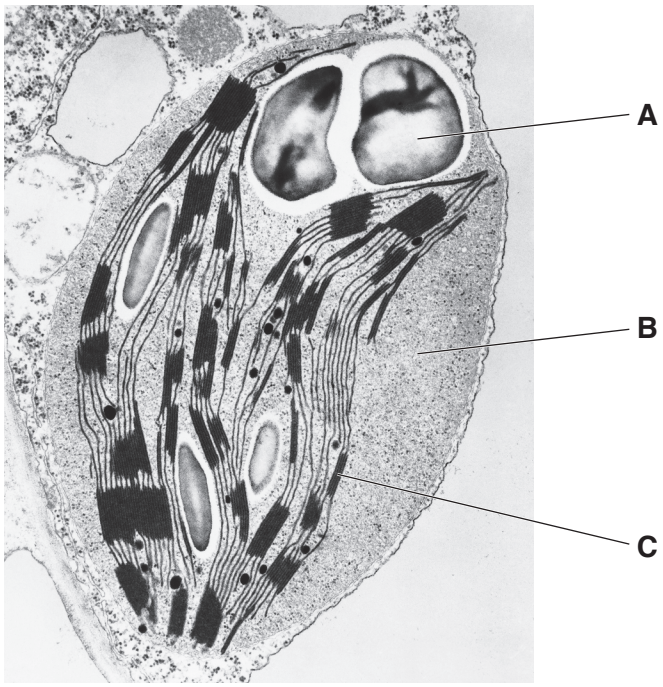


Fig. 7.1

Many compounds and structures involved in photosynthesis are located in a chloroplast.

Using the labels **A**, **B** or **C**, complete Table 7.1 to show the location of four of these compounds or structures.

You may use each of the letters **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound or structure	location
ATP synthase	……..
rubisco	……..
starch grain	……..
phospholipid bilayer	……..

[3]

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[Turn over

(b) *Elodea canadensis* is an aquatic plant that lives submerged in freshwater.

Equal-sized plants of *E. canadensis* were exposed to different wavelengths of light for the same period of time. As each plant photosynthesised, the number of bubbles of oxygen leaving the plant was counted.

For each wavelength, the rate of oxygen production was calculated.

The results are shown in Fig. 7.2.

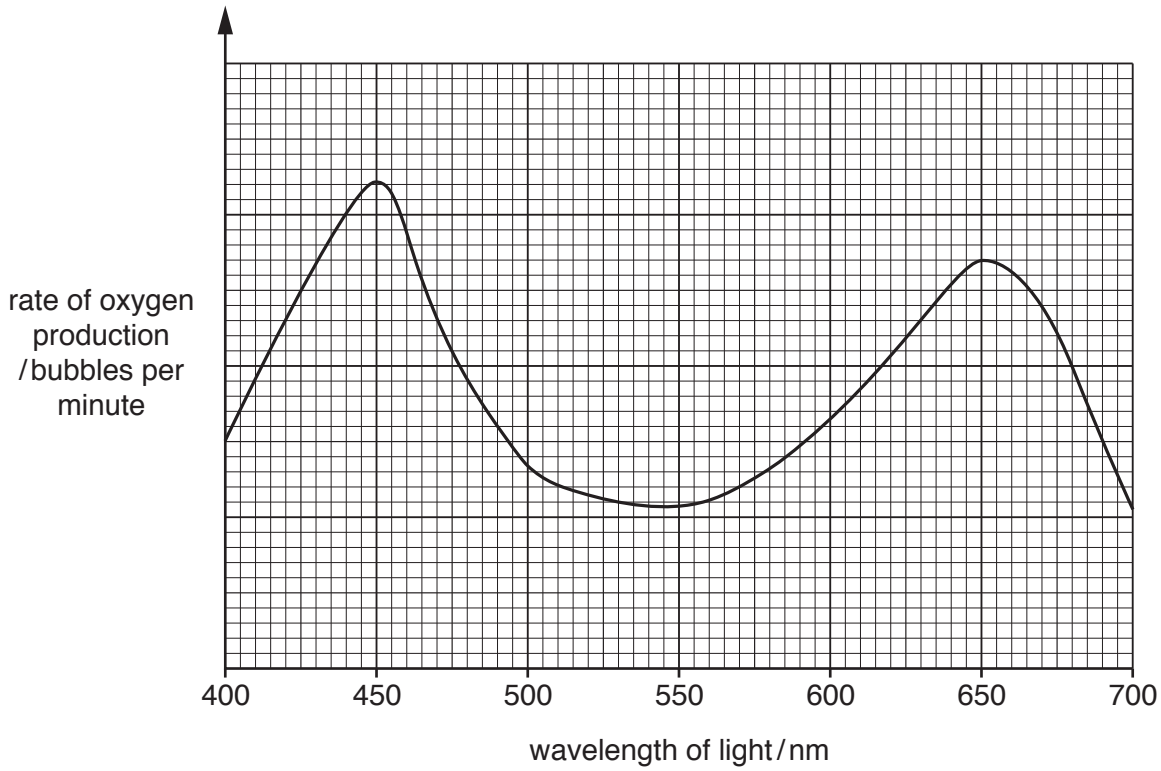


Fig. 7.2

Describe **and** explain the results shown in Fig. 7.2.

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.....[3]

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(c) Chlorophyll b, carotene and xanthophyll are known as accessory pigments. Describe the role of the accessory pigments in photosynthesis.

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..... [2]

[Total: 8]

8 **(a)** Outline the roles of sensory receptor cells in the mammalian nervous system.

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..... [3]

(b) Fig. 8.1 shows the changes in potential difference (p.d.) across the membrane of a receptor cell over a period of time. The membrane was stimulated at time **A** and at time **B** with stimuli of different intensities.

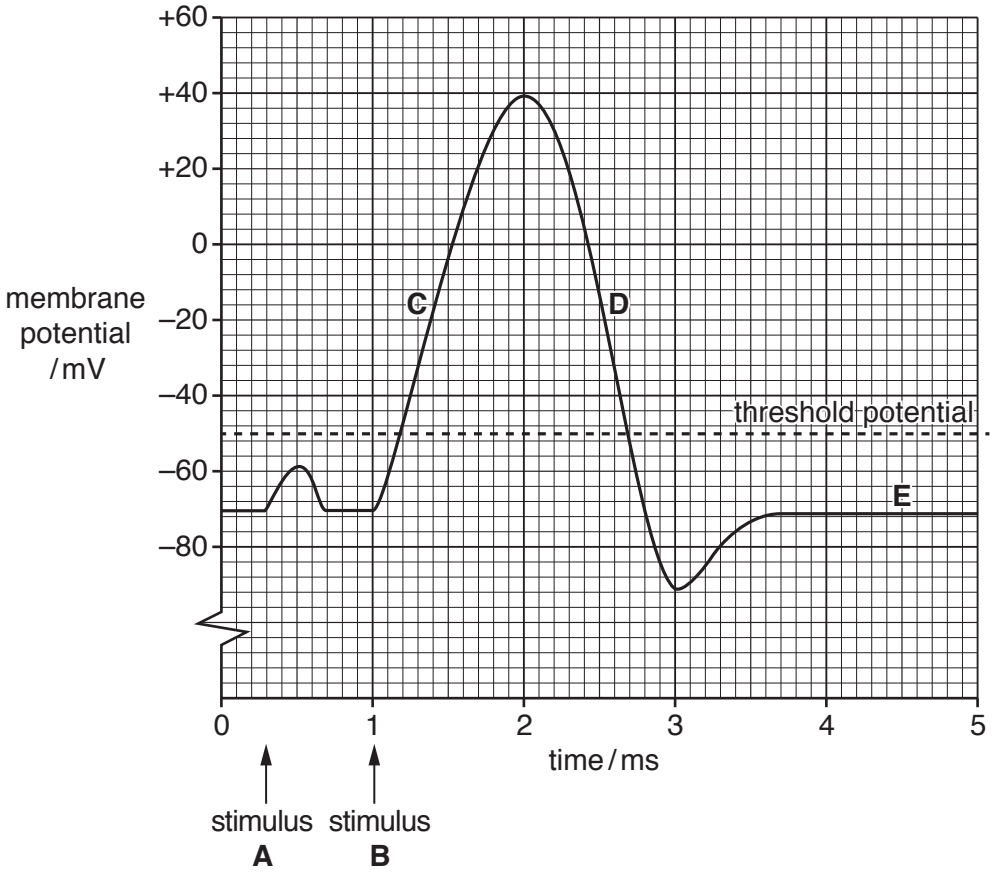


Fig. 8.1

(i) State which of the letters **C**, **D** and **E** on Fig. 8.1 correspond to each of these events. You may use each of the letters **C**, **D** or **E** once, more than once or not at all.

The Na^+/K^+ pump is operating .....

The voltage-gated Na^+ channels are open .....

The voltage-gated K^+ channels are open .....

[3]

(ii) Explain why stimulus **A** did not result in an action potential being produced whereas stimulus **B** did.

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..... [2]

(iii) Describe the importance of the refractory period in the transmission of action potentials.

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..... [2]

(iv) Describe how action potentials are transmitted along a myelinated axon.

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..... [4]

[Total: 14]

Section B

Answer **one** question.

9 **(a)** Outline the characteristic features of organisms in the domain Bacteria. [8]

(b) Describe the role of botanic gardens in the protection of endangered species. [7]

[Total: 15]

10 **(a)** Describe how the structure of the nephron and its associated blood vessels are adapted to the process of ultrafiltration. [8]

(b) Describe the effects of insulin on its main target tissues **and** explain how this leads to changes in blood glucose concentration. [7]

[Total: 15]

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CANDIDATE NAME

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BIOLOGY **9700/42**

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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.

.....

.....

.....

..... [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.

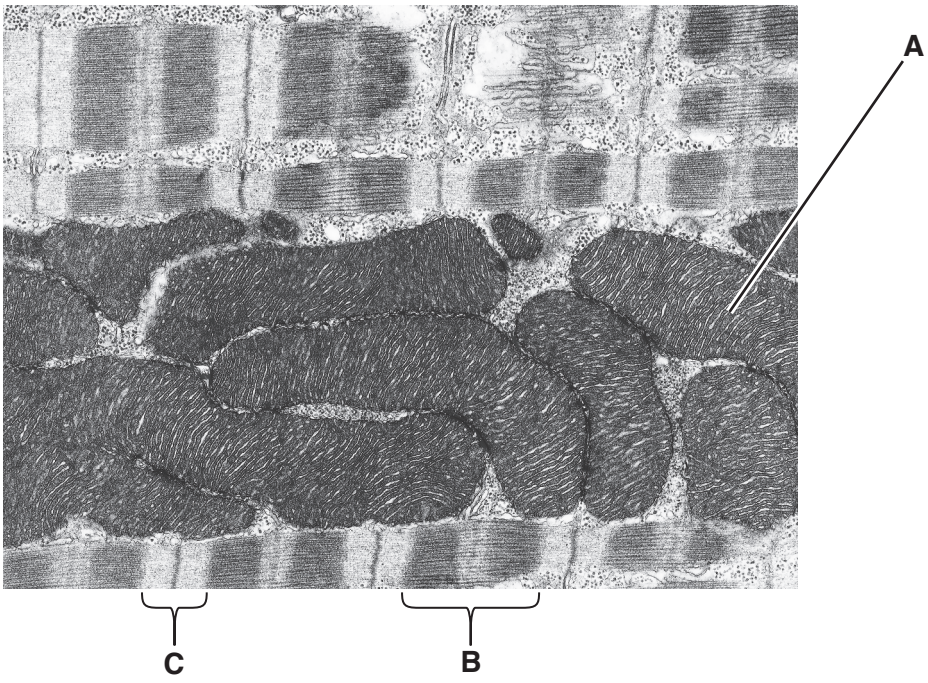


Fig. 4.1

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.

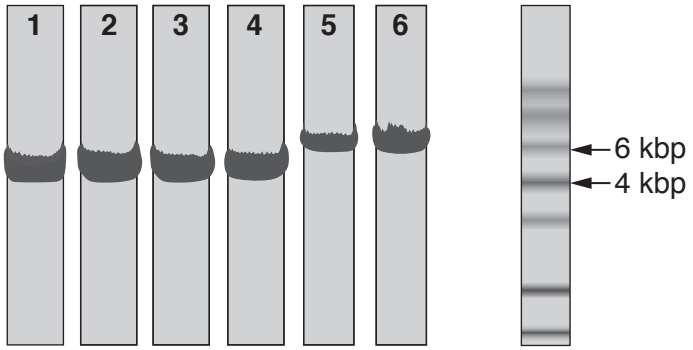


Fig. 5.1

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]

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.

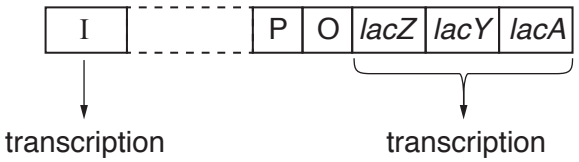


Fig. 6.1

(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.

.....

.....

..... [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*.

.....

.....

.....

.....

..... [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.

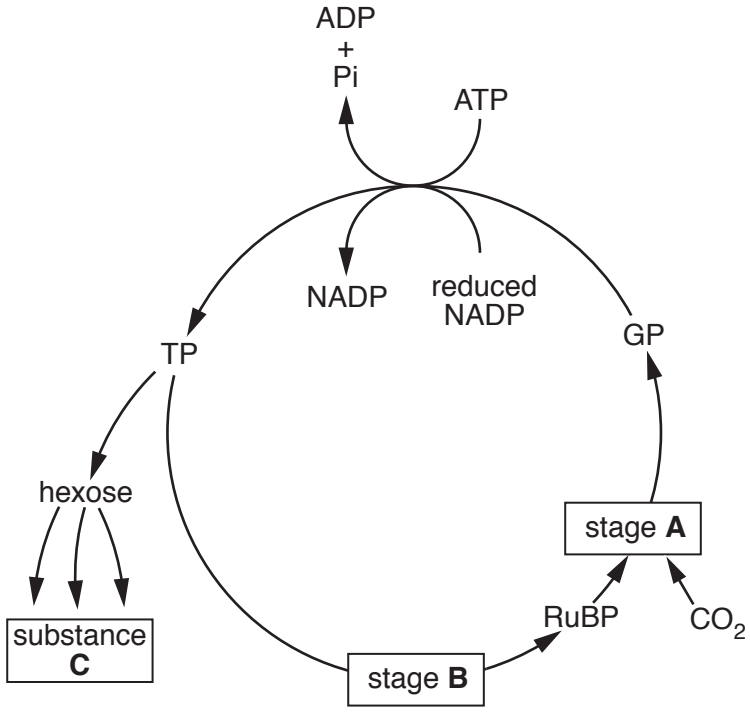


Fig. 7.1

(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.

.....

[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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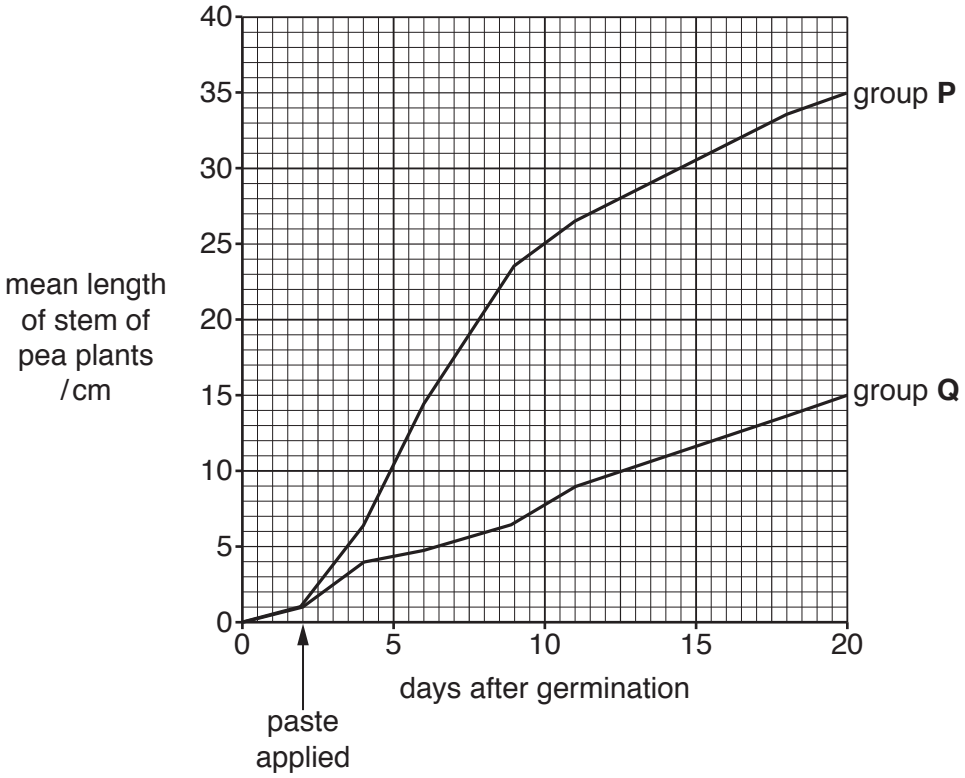


Fig. 8.1

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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[Turn over

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BIOLOGY **9700/43**

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 Bali starling, *Leucopsar rothschildi*, is found on the island of Bali, Indonesia.

Fig. 1.1 shows a Bali starling.



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 Bali starling is categorised as critically endangered on the IUCN Red List, which means that it is nearly extinct in the wild.

The Bali starling is protected by Indonesian law and trapping of the birds for sale as pets is illegal. In 2001 there were only six Bali starlings in the wild and about 1000 in captivity.

(i) Suggest reasons, other than the trapping of the birds for sale as pets, for the very low numbers of Bali starlings in the wild.

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..... [3]

(ii) Describe the roles zoos can take in the protection of the Bali starling.

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..... [2]

(b) Explain the consequences on genetic biodiversity of having a wild population of just six birds.

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..... [4]

[Total: 9]

2 In the fruit fly, *Drosophila melanogaster*, two different genes control body colour and eye colour.

- **G**/**g** are alleles of the body colour gene.
- **G** results in grey body, **g** results in black body.

- **R**/**r** are alleles of the eye colour gene.
- **R** results in red eyes, **r** results in brown eyes.

Each gene is autosomal.

A dihybrid cross was carried out using a fly with a grey body and red eyes crossed with a fly with a black body and brown eyes. Both parents were homozygous for both genes. The offspring from the F1 generation were crossed to obtain the F2 offspring.

(a) A statistical test showed that the results of the cross were significantly different from those expected.

State the name of the statistical test used **and** state the expected phenotypic ratio for the F2 generation.

statistical test .....

expected ratio .....

[2]

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(b) A test cross can be carried out in order to identify flies from an F2 generation that are heterozygous for both genes.

Draw a genetic diagram to show how a test cross between a heterozygous grey-bodied, red-eyed F2 fly and a fly with a black body and brown eyes can produce four different offspring phenotypes.

Use the symbols **G**/**g** and **R**/**r**.

[4]

(c) The results of the test cross in **(b)** are shown in Table 2.1. These results are significantly different from the expected results.

Table 2.1

phenotypes of offspring of test cross	number of individuals
grey body, red eyes	123
grey body, brown eyes	7
black body, red eyes	6
black body, brown eyes	132

Describe how these results are different from the expected results **and** explain why they are different.

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..... [5]

[Total: 11]

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3 **(a)** Meiosis is one process that contributes to genetic variation.

(i) State **precisely** the stage of meiosis where single chromosomes line up on the equator.

..... [1]

(ii) Outline the events taking place during anaphase I of meiosis.

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..... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

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..... [2]

Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50% of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 3.1.

Table 3.1

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

(b) (i) Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

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..... [2]

(ii) Explain why this example of genetic variation is important for natural selection in water hemp populations.

.....

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..... [2]

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(iii) Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

.....

.....

.....

..... [1]

(c) The null hypothesis states there is no significant difference between the mean times for 50% of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for ***t*** at the $p = 0.05$ significance level is 2.23.

(i) Use the formula in Fig. 3.1 to calculate the value of ***t***.

Show your working.

$$t = \frac{\left|\overline{x}_1 - \overline{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\overline{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

Fig. 3.1

t = ... [2]

(ii) Use your calculated value of ***t*** to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

.....

.....

.....[2]

[Total: 14]

4 The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.

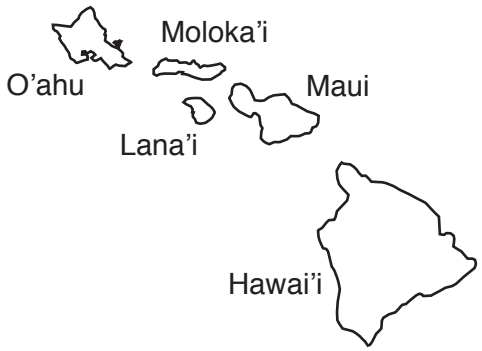


Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalã. This is because they formed at different times from two separate volcanoes.

Table 4.1

island	**area / km^2**	**age of island / million years**	**total number of *Mecyclothorax* species**	**species density / number of species per km^2**
Hawai'i	10 433	0.4	30	0.003
Lãna'i	364	1.3	3	0.008
Maui (West)	443	1.3	27	0.061
Maui (Haleakalã)	1440	1.1	116	0.081
Moloka'i	673	1.9 – 1.8	43	0.064
O'ahu	1545	3.7 – 2.6	20	.....

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Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

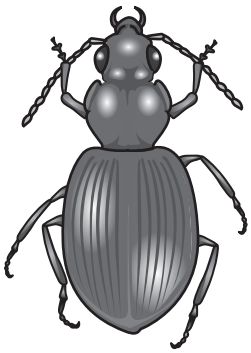


Fig. 4.2

(a) (i) Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

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..... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

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.....

..... [2]

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[Turn over

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalã, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalã developed.

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.....[4]

[Total: 9]

5 **(a)** Leber's congenital amaurosis (LCA) is an autosomal recessive eye disease. LCA results in eye disorders, including severe loss of vision, at birth. LCA has been successfully treated by gene therapy, using a virus instead of a plasmid as the vector.

Adeno-associated virus (AAV) vectors containing the therapeutic allele were injected directly into the retina, the layer at the back of the eye containing the photoreceptor cells. People who had been blind from a young age were able to see again.

There is a risk associated with the injection method used to deliver the vectors, as it might cause the retina to detach, damaging vision. This method of delivery was first used for LCA before being trialled on other retinal diseases that gradually reduce the vision of people as they get older.

(i) Suggest the main steps involved in creating recombinant DNA for this example of gene therapy.

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..... [4]

(ii) Explain why the fact that LCA is an autosomal recessive genetic disease makes it suitable for treatment with gene therapy.

.....

.....

.....

..... [2]

(iii) Suggest why the retinal injection method of gene therapy was used for LCA before it was trialled on other retinal diseases that gradually reduce the vision of people as they get older.

.....

.....

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.....

.....[2]

(b) Scientists tried to create an improved virus vector for gene therapy.

step 1 – The scientists used a special form of the polymerase chain reaction (PCR). This form of PCR causes mutations in the DNA sequence of AAV by base substitution.

step 2 – The viruses containing different base substitutions were tested. This was done by using the different viruses to deliver a new gene, the gene for green fluorescent protein (GFP), into the photoreceptor cells of mice, using the retinal injection method.

step 3 – The best virus, known as 7m8, caused the photoreceptor cells in the retina of the mouse to fluoresce brightly, even when the recombinant virus was injected into the fluid inside the eye instead of into the retina itself.

step 4 – The 7m8 virus was used to cure a mouse with LCA by injecting this virus containing the therapeutic allele into the fluid inside the eye of the mouse.

(i) Suggest how errors occurring during PCR can cause base substitution mutations in the DNA sequence of AAV.

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..... [3]

(ii) Explain why the photoreceptor cells of the mouse fluoresced in step 3.

.....

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.....

..... [2]

(iii) Predict the impact of the 7m8 AAV on treatment for age-related retinal diseases.

.....

.....

.....[1]

[Total: 14]

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6 **(a)** Fig. 6.1 outlines some of the steps of glycolysis.

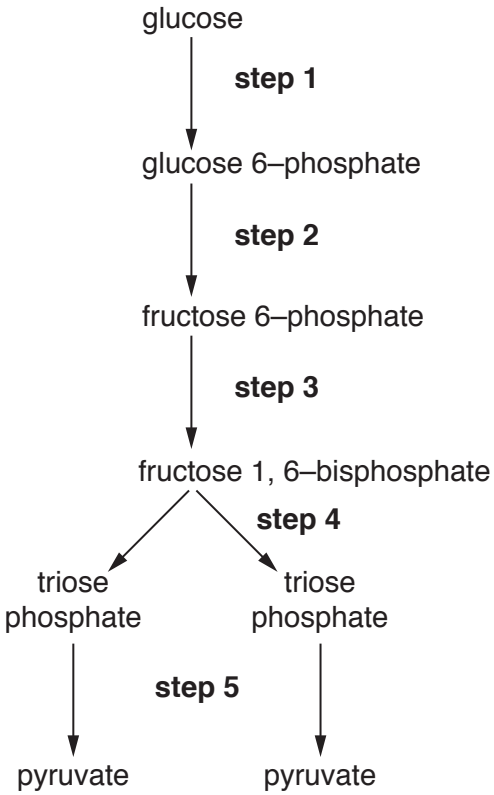


Fig. 6.1

(i) State the precise location of glycolysis in the cell.

..... [1]

(ii) With reference to Fig. 6.1:

state the steps where phosphorylation occurs

.....

state the step where oxidation occurs

.....

name the type of reaction by which ATP is made during **step 5**.

.....
[3]

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(b) Some cancer cells have different metabolic requirements from normal cells. These cancer cells obtain most of their ATP from glycolysis, even if oxygen is available.

State how the glucose and oxygen requirements of these cancer cells differ from normal cells.

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..... [2]

[Total: 6]

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7 **(a)** Fig. 7.1 is a transmission electron micrograph of a chloroplast.

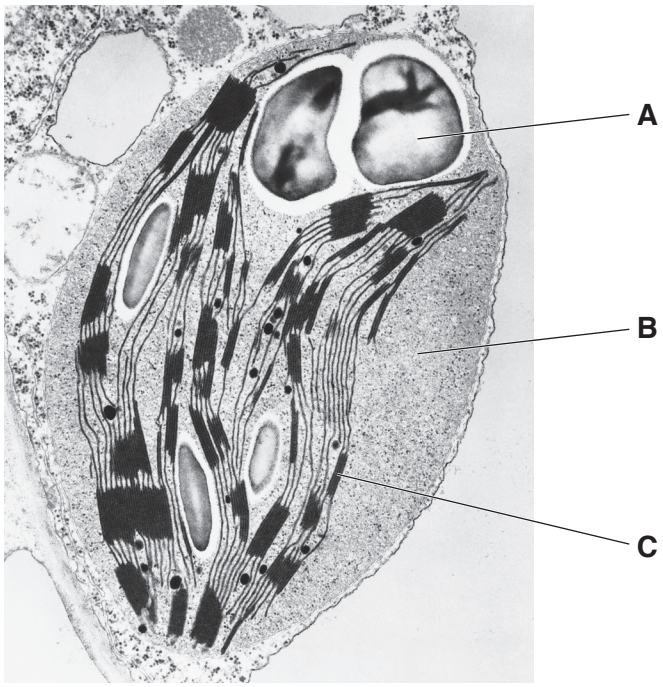


Fig. 7.1

Many compounds and structures involved in photosynthesis are located in a chloroplast.

Using the labels **A**, **B** or **C**, complete Table 7.1 to show the location of four of these compounds or structures.

You may use each of the letters **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound or structure	location
ATP synthase	……..
rubisco	……..
starch grain	……..
phospholipid bilayer	……..

[3]

(b) *Elodea canadensis* is an aquatic plant that lives submerged in freshwater.

Equal-sized plants of *E. canadensis* were exposed to different wavelengths of light for the same period of time. As each plant photosynthesised, the number of bubbles of oxygen leaving the plant was counted.

For each wavelength, the rate of oxygen production was calculated.

The results are shown in Fig. 7.2.

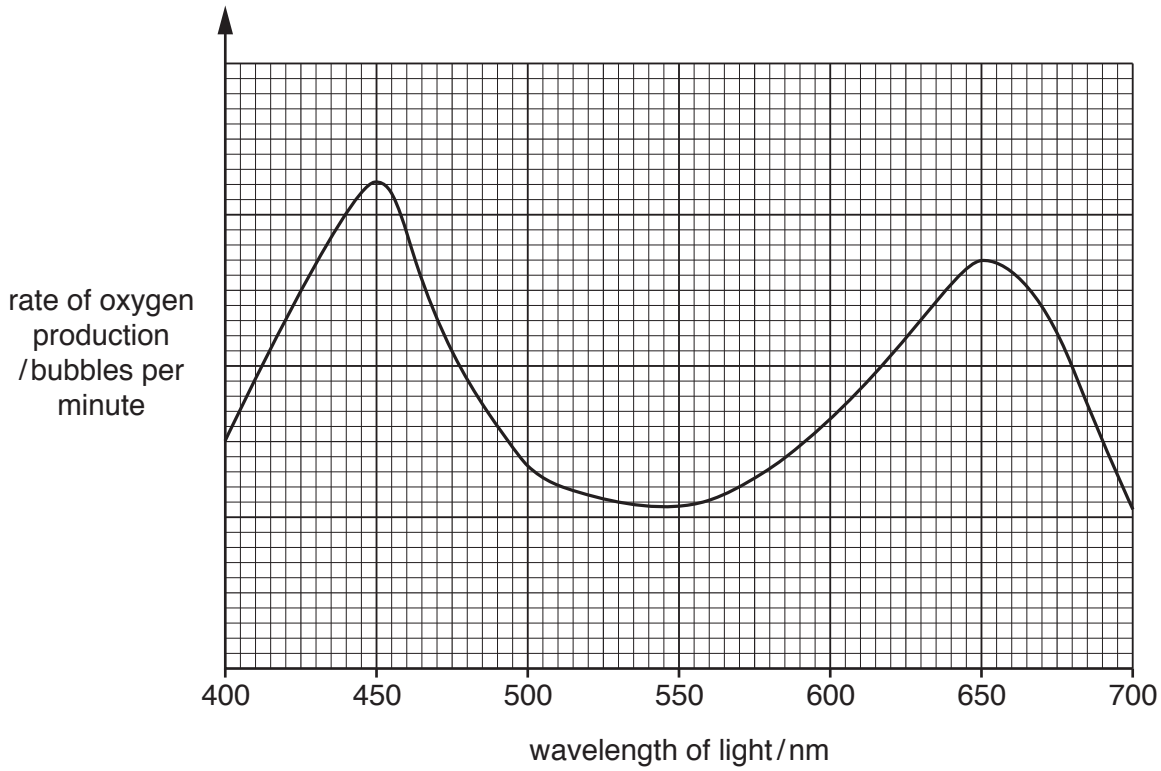


Fig. 7.2

Describe **and** explain the results shown in Fig. 7.2.

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.....[3]

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(c) Chlorophyll b, carotene and xanthophyll are known as accessory pigments. Describe the role of the accessory pigments in photosynthesis.

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..... [2]

[Total: 8]

8 **(a)** Outline the roles of sensory receptor cells in the mammalian nervous system.

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..... [3]

(b) Fig. 8.1 shows the changes in potential difference (p.d.) across the membrane of a receptor cell over a period of time. The membrane was stimulated at time **A** and at time **B** with stimuli of different intensities.

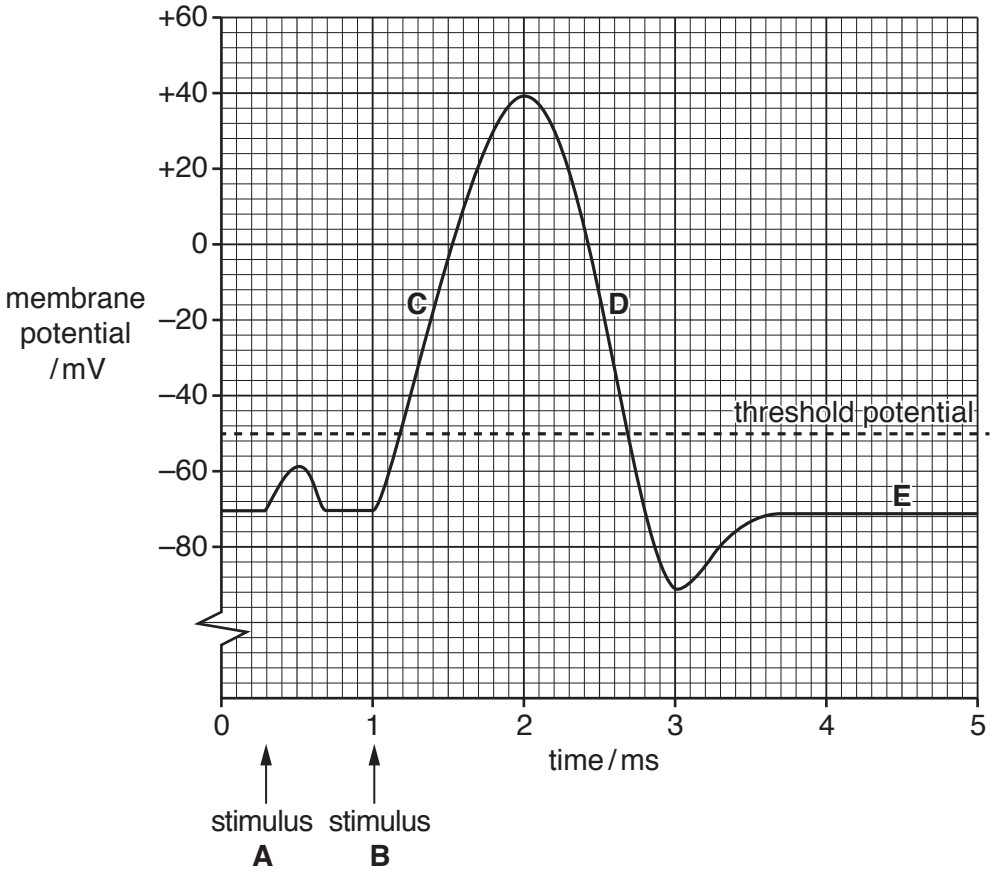


Fig. 8.1

(i) State which of the letters **C**, **D** and **E** on Fig. 8.1 correspond to each of these events. You may use each of the letters **C**, **D** or **E** once, more than once or not at all.

The Na^+/K^+ pump is operating .....

The voltage-gated Na^+ channels are open .....

The voltage-gated K^+ channels are open .....

[3]

(ii) Explain why stimulus **A** did not result in an action potential being produced whereas stimulus **B** did.

.....

.....

.....

..... [2]

(iii) Describe the importance of the refractory period in the transmission of action potentials.

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..... [2]

(iv) Describe how action potentials are transmitted along a myelinated axon.

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..... [4]

[Total: 14]

Section B

Answer **one** question.

9 **(a)** Outline the characteristic features of organisms in the domain Bacteria. [8]

(b) Describe the role of botanic gardens in the protection of endangered species. [7]

[Total: 15]

10 **(a)** Describe how the structure of the nephron and its associated blood vessels are adapted to the process of ultrafiltration. [8]

(b) Describe the effects of insulin on its main target tissues **and** explain how this leads to changes in blood glucose concentration. [7]

[Total: 15]

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[Turn over

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