Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0412132494

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2017**

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 **20** printed pages and **4** lined pages.

CAMBRIDGE International Examinations

Section A

Answer **all** the questions.

1 **(a)** The mammalian kidney is an organ involved in homeostasis.

Explain what is meant by the term *homeostasis.*

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(b) Fig. 1.1 shows a section through a kidney.

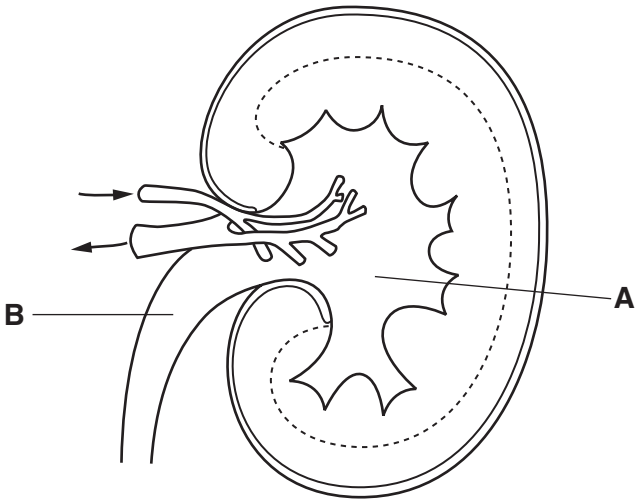

Fig. 1.1

(i) With reference to Fig. 1.1, name structures **A** and **B**.

A .....

B ..... [2]

(ii) On Fig. 1.1, use label lines and letters to label where:

U – ultrafiltration occurs

L – the loop of Henle is found

C – blood urea concentration is low.

[3]

(c) Describe the roles of the hypothalamus and the posterior pituitary in osmoregulation.

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[Total: 11]

2 Corals grow in shallow seawater. Corals consist of colonies of small animals called polyps. These polyps have photosynthetic protoctists called algae inside their cells, which is advantageous both to the coral polyps and to the algae.

The algae that live within the cells of the polyps can also live independently as free-living algae.

(a) The rate of photosynthesis of algae that live within the cells of coral polyps is higher than that of free-living algae.

Suggest **and** explain how living inside the cells of coral polyps increases the rate of photosynthesis in these algae compared to free-living algae.

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(b) The relative abundance of five different chloroplast pigments in the algae of corals was determined. The results are shown in Table 2.1.

Table 2.1

chloroplast pigment	percentage of total
chlorophyll a	39
peridinin	39
chlorophyll c2	13
dinoxanthin	7
β-carotene	2

Outline the method you would use to separate and identify the pigments present in an extract of these algae.

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(c) Table 2.2 shows the light wavelengths at which each algal chloroplast pigment shows its two largest peaks of light absorption.

Table 2.2

chloroplast pigment	peak 1 wavelength /nm	peak 2 wavelength /nm
chlorophyll a	430	662
peridinin	456	485
chlorophyll c2	450	396
dinoxanthin	442	471
β-carotene	454	480

Corals kept in tanks are often illuminated by lamps radiating mostly violet and blue light with wavelengths in the range of 400–490 nm.

With reference to Table 2.1 and Table 2.2, suggest why lamps radiating mostly violet and blue light are expected to increase coral growth.

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[Total: 9]

[Turn over

3 Oil seed rape (canola), *Brassica napus*, has been genetically modified to be resistant to herbicides containing glufosinate ammonium. The genetically modified (GM) oil seed rape contains the *bar* gene, obtained from a soil bacterium. This gene codes for an enzyme that converts glufosinate ammonium into a non-toxic compound.

(a) Outline the advantages to farmers of growing glufosinate-resistant oil seed rape.

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(b) The *bar* gene was introduced into the oil seed rape using plasmids. The plasmids also contained a promoter taken from thale cress, *Arabidopsis thaliana*.

(i) Outline the structure of a plasmid.

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(ii) Explain how the properties of plasmids make them suitable for use during genetic modification programmes.

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(iii) Describe the role of a promoter in gene expression.

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(c) The pollen of oil seed rape is transferred from one flower to another by insects. After pollination, fertilisation and seed formation can occur. One of the potential problems of growing glufosinate–resistant oil seed rape is that pollen from these plants could be transferred to the flowers of wild relatives, such as wild radish, *Raphanus raphanistrum*. This could result in genetic changes in these wild species.

An experiment was carried out to investigate whether glufosinate–resistant hybrids between GM oil seed rape and wild radish plants are likely to compete successfully with non-hybrid or non-resistant plants in the natural environment.

- Type 1 hybrids were produced by transferring pollen from wild radish (diploid number 18) to glufosinate–resistant oil seed rape (diploid number 38).
- Type 2 hybrids were produced by transferring pollen from glufosinate–resistant oil seed rape to wild radish.

- Each hybrid was then crossed with wild radish over several generations.
- The resulting offspring were then grown in field trials, together with normal wild radish.
- The height of the plants and number of seeds each produced were measured. Then the plants were tested for the *bar* gene.

Table 3.1 shows the results.

Table 3.1

type of plant	number of seeds per plant	mean height / cm	presence of *bar* gene
offspring from type 1 hybrid and wild radish	265	22.3	absent
	99	28.3	present
offspring from type 2 hybrid and wild radish	3958	88.7	absent
	2047	95.0	present
wild radishes	3515	76.5	absent

(i) Predict the diploid number of chromosomes in a hybrid between oil seed rape and wild radish.

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(ii) Suggest how the researchers could have determined whether or not the *bar* gene was present in the plants.

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(iii) Many varieties of GM oil seed rape are male sterile, meaning that they do not produce pollen.

With reference to Table 3.1, suggest the advantages to the environment of growing male sterile varieties of GM oil seed rape, rather than GM varieties that produce pollen.

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[Total: 14]

4 **(a)** ATP is used or produced at different stages in the respiration of glucose in aerobic conditions.

Complete the table to show whether ATP is used or produced at each stage of respiration.

Write either **YES** or **NO** in each box.

stage of respiration	ATP used	ATP produced
glycolysis		
link reaction		
Krebs cycle		
oxidative phosphorylation		

[2]

(b) An experiment was carried out to investigate the effect of epicatechin on mitochondrial respiration in mice. Epicatechin is a naturally occurring compound in cocoa beans and so is present in chocolate.

Two groups of mice, group **A** and group **B**, were used in this experiment.

- Group **A** was given water containing epicatechin, twice a day for 15 days.
- Group **B** was given water without epicatechin, twice a day for 15 days.

After 15 days, the structure of mitochondria from striated muscle cells in both groups of mice was examined.

The surface area of the inner membrane of the mitochondria was divided by the surface area of the outer membrane to obtain a ratio for each mouse.

Table 4.1 shows the mean ratios for the two groups of mice.

Table 4.1

group	mean ratio
A	2.0 **:** 1
B	1.7 **:** 1

The mice in group **A** were able to exercise longer than the mice in group **B**.

With reference to Table 4.1, explain why the mice in group **A** were able to exercise for longer than the mice in group **B**.

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[Total: 7]

5 The red poppy, *Papaver rhoeas*, and several species of daisy of the family Compositae often co-exist as weeds of wheat fields.

Fig. 5.1 shows changes in the percentage frequency of red poppies and daisies in an area of wheat fields over a six year period from 1998 to 2003. From 1985, the herbicide metsulfuron-methyl was used to control weeds in this area of wheat fields. This practice continued throughout the six year period.

1998 showed the first occurrence of a red poppy known as biotype X. This red poppy had a specific mutation not present in normal red poppies.

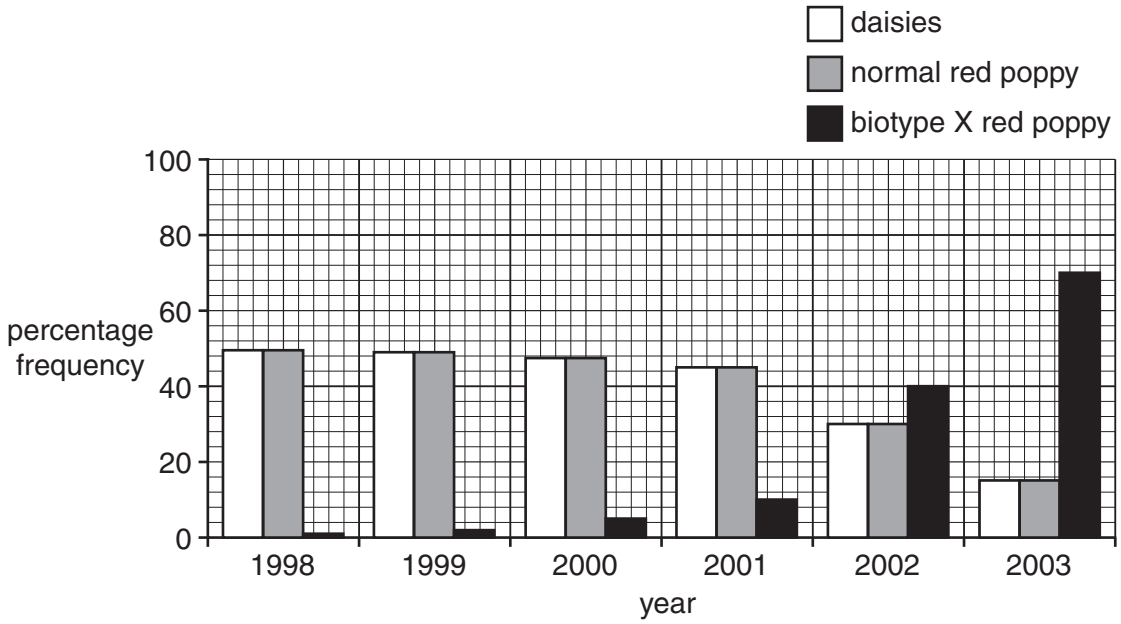

Fig. 5.1

(a) Describe how the percentage frequencies of daisies and red poppies changed over the six year period.

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(b) Metsulfuron-methyl acts by inhibiting an enzyme called acetolactate synthetase, which is needed for the daisies and red poppies to synthesise three amino acids essential for growth. The specific mutation carried by the red poppies of biotype X occurred within the gene coding for this enzyme. The mutation changed amino acid 197 of acetolactate synthetase from proline to leucine.

(i) Suggest the effect of this mutation on the structure and activity of the acetolactate synthetase enzyme of biotype X red poppies.

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(ii) Suggest the effect of this mutation on the biotype X red poppies in the presence of metsulfuron-methyl.

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(iii) With reference to Fig. 5.1, predict **and** explain the effect of biotype X red poppies on the relative proportions of weeds and wheat in the area of wheat fields in 2003 compared to 1998.

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(c) Suggest how stopping the use of the herbicide metsulfuron-methyl and replacing it with a herbicide that inhibits a different target enzyme in weeds would affect the abundance of red poppies of biotype X.

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[Total: 14]

6 **(a)** Describe how tropomyosin and myosin are each involved in the sliding filament model of muscle contraction.

(i) *tropomyosin* .....

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(ii) *myosin* .....

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(b) Striated muscle is made up of many specialised muscle cells known as muscle fibres or myocytes.

There are two different types of muscle fibre in striated muscle:

- fast twitch muscle fibres that contract quickly, but rapidly fatigue (get tired)
- slow twitch muscle fibres that contract slowly and continue to contract for a long time.

Table 6.1 shows some features of fast twitch and slow twitch muscle fibres.

Table 6.1

feature	fast twitch fibre	slow twitch fibre
respiration	mainly anaerobic	mainly aerobic
glycogen concentration	high	low
capillaries	few	many

Use the information in Table 6.1 to suggest **and** explain **one** advantage of:

(i) the high glycogen concentration in fast twitch fibres

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(ii) many capillaries supplying slow twitch fibres.

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[Total: 10]

7 (a) The stems of raspberry plants have spines.

Fig. 7.1 shows part of a raspberry plant.

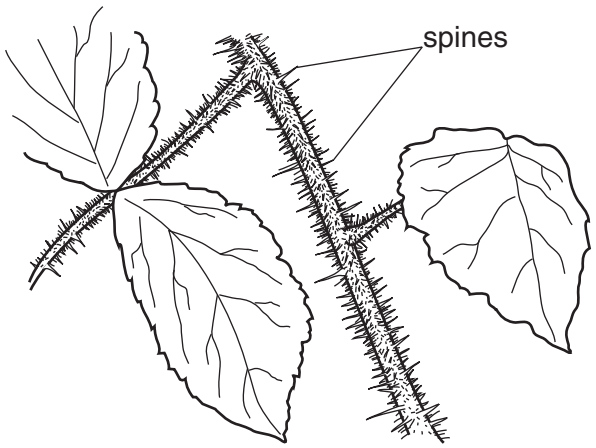

Fig. 7.1

The colour of the spines is controlled by two genes, **A**/**a** and **B**/**b**. The two genes are on different pairs of chromosomes.

- Allele **A** produces a pink anthocyanin pigment in the spines.
- Allele **B** has no effect by itself, but increases the colour produced by allele **A** to give red spines.
- Alleles **a** and **b** have no effect on colour.
- In the absence of anthocyanin, the spines are green.

State the colour of the spines of raspberry plants with the genotypes **Aabb** and **aaBB**.

Aabb .....

aaBB ..... [2]

(b) Plants with the genotype **AaBb** were crossed with plants with the genotype **aabb**. The resulting seeds were sown and the seedlings grown until their stems developed spines.

Use a genetic diagram to show the outcome of this cross, including the ratio of offspring phenotypes.

[5]

(c) Suggest why the ratio you have given in your genetic diagram would be different if the genes **A**/**a** and **B**/**b** were on the same homologous pair of chromosomes.

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[Total: 9]

8 There is considerable variation in the ecosystems that occur in the continent of North America. These include coniferous forest, prairie grassland, scrub and desert. Large areas of land that once contained natural ecosystems are now used for agriculture.

(a) Explain how the variation in ecosystems in North America contributes to biodiversity.

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(b) The diversity of some beetle species that feed on animal dung (faeces) was investigated at two types of grassland site in North America. The first type of grassland site was grazed by cattle and the second type of site was not grazed.

Dung beetles were collected, identified and counted from two areas of the same total size. Some of the results are shown in Table 8.1.

Table 8.1

beetle species	number of dung beetles on grassland grazed by cattle	number of dung beetles on grassland not grazed
Onthophagus pennsylvanicus	4267	6641
Canthon ebenus	2005	774
Canthon pilularius	353	108
Onthophagus hecate	218	85
total	6843	7608

(i) State the null hypothesis for a statistical test comparing the data from the two types of site.

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..... [1]

(ii) State how many genera and how many species of beetle are shown in Table 8.1.

genera ..... species .....
[1]

(iii) Simpson's Index of Diversity for the beetles on the grassland grazed by cattle was calculated as 0.521 using the formula:

$$D = 1 - \left(\sum\left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each species present in the sample
N = the total number of all individuals of all species

Calculate Simpson's Index of Diversity for the beetles on the grassland that was not grazed. Complete Table 8.2 to show your working. Show all working to **three** decimal places. Write your final answer on the dotted line.

Table 8.2

species	**number on grassland not grazed**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Onthophagus pennsylvanicus	6641		
Canthon ebenus	774		
Canthon pilularius	108		
Onthophagus hecate	85		
total	7608		

Simpson's Index of Diversity = ... [3]

(iv) Describe what the results in Table 8.1 **and** both figures for Simpson's Index of Diversity show about the effect of grazing on the diversity of dung beetles.

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[Total: 11]

Section B

Answer **one** question.

9 **(a)** Explain how dip sticks function to test for glucose in a sample of urine. [8]

(b) Outline how a high blood glucose concentration returns to normal in a healthy person. [7]

[Total: 15]

10 **(a)** Describe the structure of a motor neurone. [6]

(b) Describe **and** explain the transmission of an action potential in a myelinated neurone. [9]

[Total: 15]

[Turn over

[Turn over