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.

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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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..... [1]

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

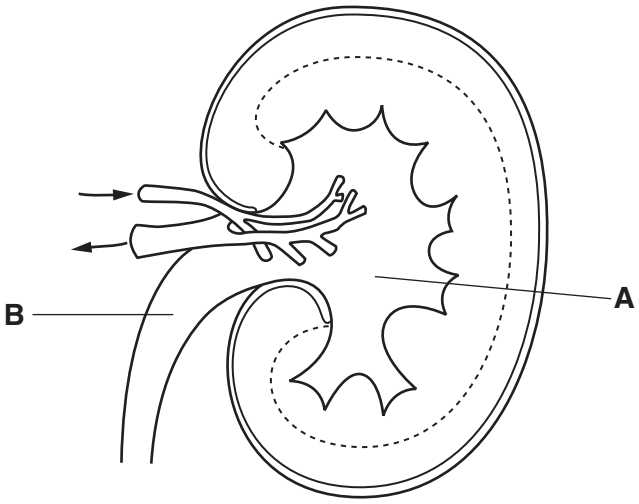


Fig. 1.1

(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]

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(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

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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]

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[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.

..... [1]

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

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..... [1]

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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**.

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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.

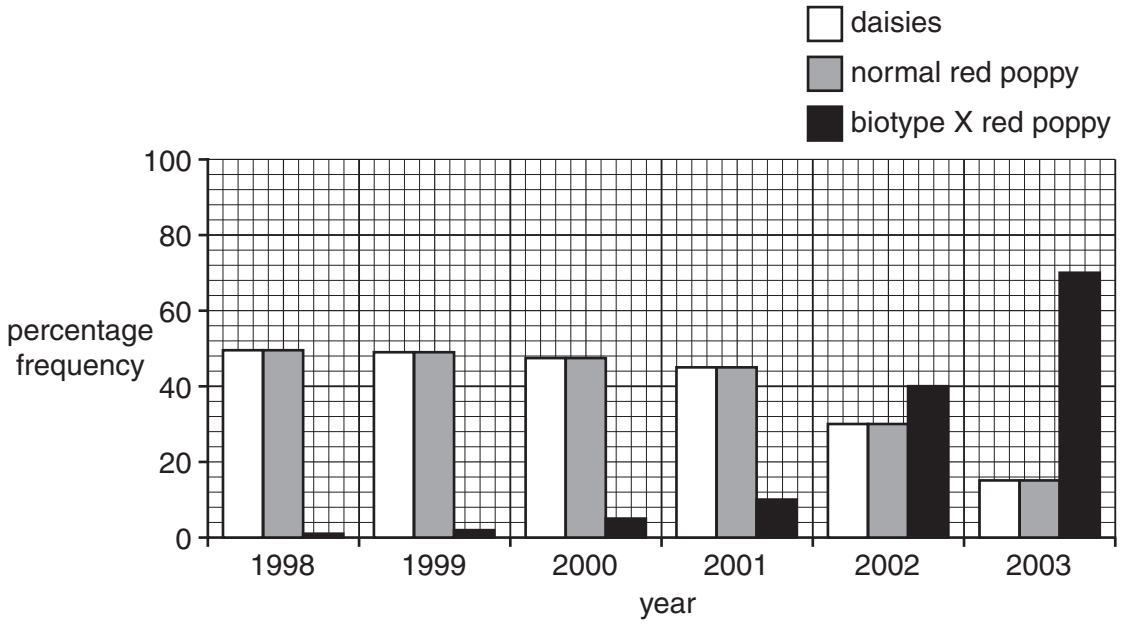


Fig. 5.1

(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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..... [3]

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

..... [1]

(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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..... [2]

(ii) *myosin* .....

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..... [4]

(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.

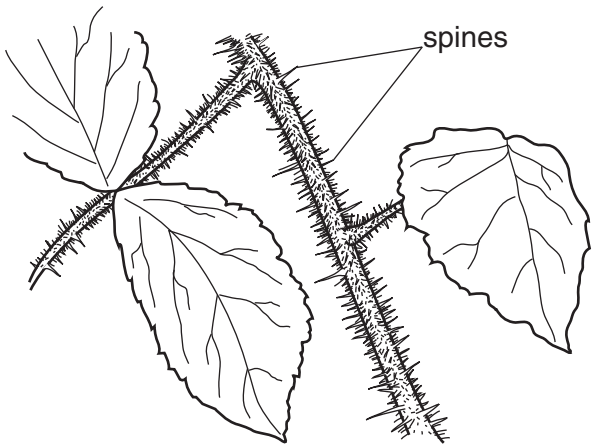


Fig. 7.1

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]

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(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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..... [2]

[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

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(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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..... [2]

[Total: 11]

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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]

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BIOLOGY **9700/42**

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

2 hours

Candidates answer on the Question Paper.

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This document consists of **22** printed pages and **2** lined pages.

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CAMBRIDGE International Examinations

Section A

Answer **all** the questions.

1 **(a)** Fig. 1.1 represents the link reaction.

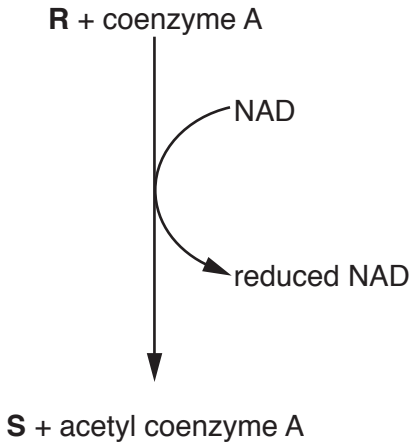


Fig. 1.1

With reference to Fig. 1.1:

(i) name substances **R** and **S**

R .....

S ..... [2]

(ii) explain what happens to the reduced NAD.

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..... [2]

(b) The pH of the blood of an athlete decreases during a race and returns to its normal level after the race. The decrease in the pH of the blood is caused by the presence of waste products that have been excreted by cells during respiration.

Name the waste products that are excreted **and** describe what occurs to these products to help return the pH of the blood back to a normal level.

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..... [5]

[Total: 9]

2 Chloroplasts belong to a group of organelles called plastids. Although different types of plastid have different structures and functions, one type of plastid can change into another type of plastid in response to environmental or developmental signals.

- Example 1: plants grown in the dark have plastids called etioplasts which lack chlorophyll. If these plants are exposed to light, the etioplasts quickly change into chloroplasts.

- Example 2: chloroplasts in surface tissues of tomato fruits change into plastids called chromoplasts as the fruits ripen. Thylakoid membranes break down and chlorophyll synthesis stops. Chromoplasts synthesise and accumulate red lycopene and orange β-carotene pigments.

(a) For each of these examples, explain the effect on the rate of photosynthesis of one type of plastid changing into another type of plastid.

Example 1 .....

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Example 2 .....

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..... [2]

(b) Outline the method you would use to separate and identify the pigments in an extract of tomato chromoplasts.

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..... [4]

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(c) Cyanobacteria are prokaryotic organisms. Plastids are thought to have evolved from cyanobacteria that became incorporated into larger cells. Experiments show that free-living cyanobacteria can adapt to environmental signals in the same way as plastids.

Fig. 2.1 shows the absorption spectra of cyanobacteria grown under two different lighting conditions. One group was grown under fluorescent light and the other group was grown under red light.

The range of light wavelengths absorbed by each group of cyanobacteria was then measured under identical lighting conditions.

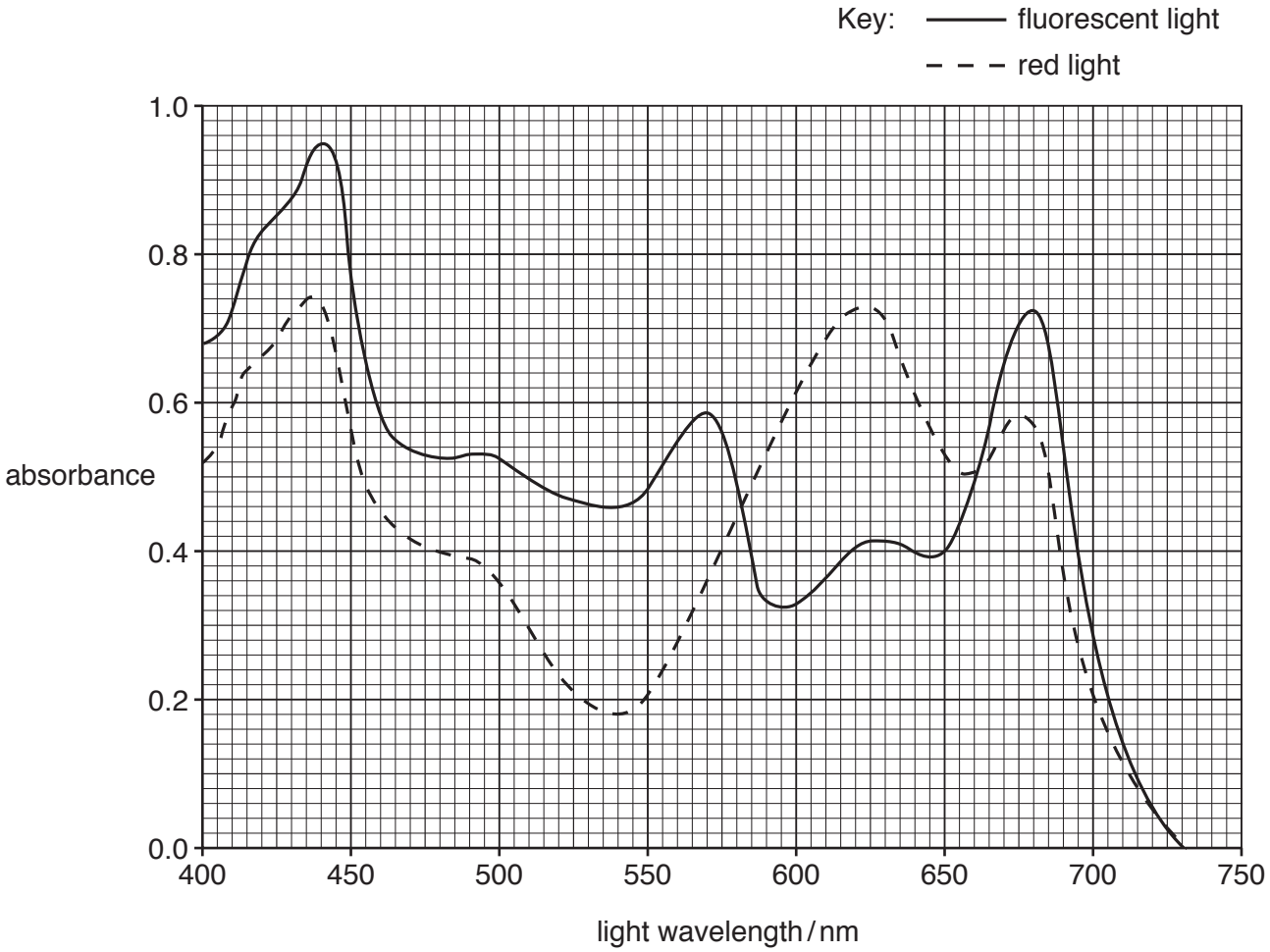


Fig. 2.1

With reference to Fig. 2.1 and the information given on pages 4 and 5, explain the effect of different lighting conditions on the absorption spectra of the two groups of cyanobacteria.

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..... [3]

[Total: 9]

3 Fig. 3.1 shows a diagram of two sarcomeres of relaxed striated muscle.

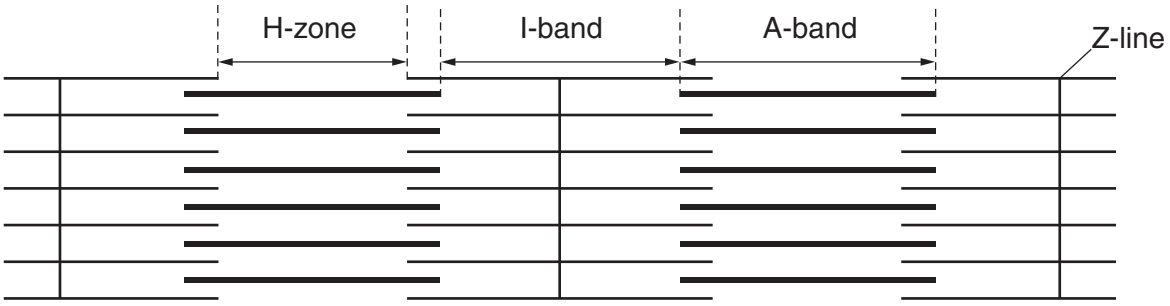


Fig. 3.1

(a) When the striated muscle contracts, state what happens to the length of:

(i) the I-band ..... [1]

(ii) the A-band. ..... [1]

(b) Describe how the response of the sarcoplasmic reticulum to the arrival of an action potential leads to the contraction of striated muscle.

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(c) Glycogen storage disease type V (GSDV) is a metabolic disorder where stored glycogen cannot be broken down to release glucose, resulting in the production of only small quantities of ATP. People with GSDV are unable to exercise normally, as the lack of ATP affects the functioning of striated muscle.

With reference to the sliding filament model of muscular contraction, suggest why a **lack** of ATP affects the functioning of striated muscle.

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[Total: 9]

4 Weeds reduce crop yields by competing with crop plants for space, light, water and minerals. The modes of action of three different types of herbicide are summarised in Table 4.1.

Table 4.1

type of herbicide	mode of action	year of first widespread use
photosystem II inhibitor	prevents photophosphorylation	1960
ALS inhibitor	prevents synthesis of the amino acids isoleucine, leucine and valine	1980
glyphosate	prevents synthesis of the amino acids phenylalanine, tryptophan and tyrosine	1990

Fig. 4.1 shows the cumulative number of species of weeds that have become resistant to these three types of herbicide since 1960.

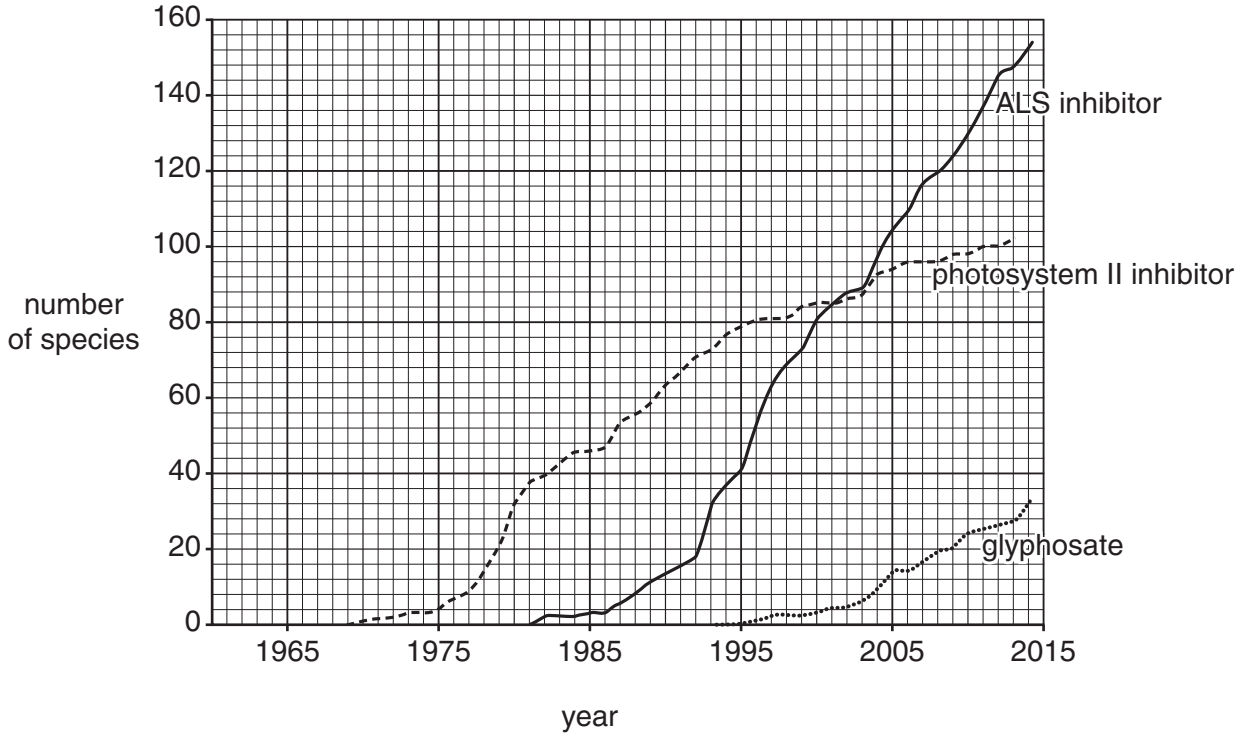


Fig. 4.1

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(a) (i) Describe how the number of weed species resistant to herbicides has changed since 1960.

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(ii) Explain how a weed species becomes resistant to a herbicide.

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(b) ALS inhibitor herbicides work by binding to an enzyme present in chloroplasts called acetolactate synthetase (ALS). ALS is a globular protein consisting of four identical polypeptides each composed of 668 amino acids.

The primary structure of the ALS polypeptide of each weed species resistant to ALS inhibitor herbicides has been sequenced. Amino acid substitutions at positions as far apart as position 122 and position 574 can result in resistance.

(i) The gene that codes for the ALS polypeptide does not contain any non-coding sections (introns). The first amino acid in the final polypeptide is methionine.

State the number of base pairs in the gene that codes for an ALS polypeptide.

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(ii) Explain why resistance to ALS inhibitor herbicide can result from substitutions of amino acids that are **far apart** in the primary sequence.

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(c) Genetic modification is one method used to develop herbicide resistance in crop plants. Other methods include:

method 1: crossing a crop plant with a herbicide-resistant wild plant belonging to the same genus and then applying the herbicide

method 2: causing mutations in the crop plants and then applying the herbicide.

State **two** benefits of using method 1 **and two** benefits of using method 2 to develop herbicide resistance in crop plants.

method 1 .....

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method 2 .....

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..... [4]

[Total: 14]

5 Cancer is a disease in which normal controls over cell division are lost and malignant tumours form. An early diagnosis of many types of cancer can result in successful treatment.

The BRCA2 protein is involved in suppressing the development of tumours. The gene that codes for this protein is on chromosome 13.

Several different dominant alleles of this gene, *BRCA2*, code for faulty versions of the protein. The presence of any one of these faulty alleles leads to an increased chance of developing several types of cancer, including breast cancer. Not everyone with one of these alleles develops cancer. This is because environmental factors, including lifestyle, are also involved.

Fig. 5.1 is a pedigree (family tree) showing the occurrence of cancers in four generations of a family. The presence of a faulty *BRCA2* allele was confirmed in person 15. The other individuals with cancer were not tested for the presence of the allele. Individuals 24–30 are all under twelve years old.

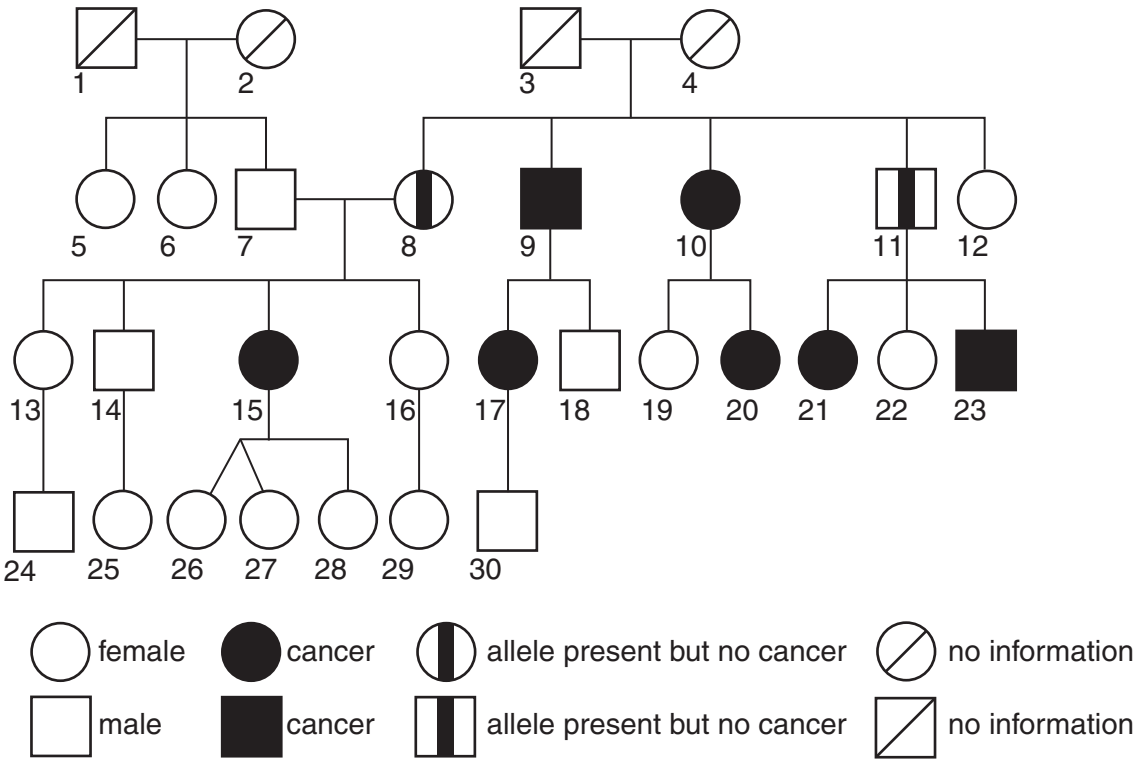


Fig. 5.1

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(a) Discuss the extent to which Fig. 5.1 provides evidence that a faulty *BRCA2* allele increases the risk of a person developing cancer.

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(b) People whose families are suspected of having a faulty *BRCA2* allele may choose to be tested for its presence in their own genome.

A company based in the USA sells a microarray containing DNA probes for 20 different alleles that are associated with an increased risk of cancer, including the faulty *BRCA2* alleles. This microarray can be used in a medical facility or research laboratory to test blood samples for the presence of these alleles.

(i) Explain the meaning of the term *genome*.

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(ii) Suggest a type of cell from a blood sample that is suitable for testing for the presence of this allele **and** explain your choice.

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..... [1]

(iii) Outline how a microarray enables the detection of particular alleles.

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(iv) Suggest **one** advantage and **one** disadvantage of screening for faulty alleles of *BRCA2* before any symptoms occur.

advantage .....

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disadvantage .....

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..... [2]

[Total: 12]

6 **(a)** Fig. 6.1 is a diagram of a Bowman's (renal) capsule of a nephron from a mammalian kidney.

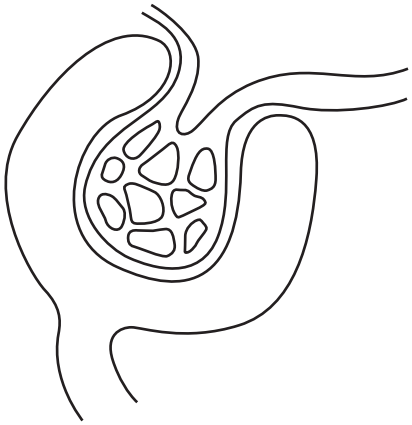


Fig. 6.1

On Fig. 6.1, use label lines and letters to label:

E – the efferent arteriole

G – the glomerulus

P – the region of podocyte cells.

[3]

(b) Describe how the structure of the epithelial cells of the proximal convoluted tubule is adapted to carry out selective reabsorption.

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..... [5]

(c) Complete the following sentences about osmoregulation.

In mammals, the water potential of the blood is constantly monitored by

..... in the hypothalamus of the brain.

When the water potential of the blood decreases, the production of a hormone

called ..... in the cells of the

hypothalamus increases.

This hormone is released into the blood via the .....

This causes the kidneys to retain more water until the water potential of the blood

returns to the set point.

This is an example of a ..... mechanism.

[4]

[Total: 12]

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7 **(a)** Cats with either black fur or white fur are common in Europe, whereas cats with brown fur are less common.

A gene, coding for an enzyme involved in pigment production, has two alleles.

- The dominant allele, **B**, results in black fur.
- The recessive allele, **b**, results in brown fur.

A second gene can affect fur colour.

- The dominant allele, **A**, prevents pigment production, resulting in a cat with white fur.
- The recessive allele, **a**, has no effect on fur colour.

The two genes are on different pairs of autosomes.

Use a genetic diagram to show how a cross between two cats, heterozygous at both loci, can produce offspring with three different colours: white, black and brown.

State the expected ratio of the different coloured offspring.

[6]

(b) Suggest how the presence of allele **A** prevents pigment production.

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..... [3]

[Total: 9]

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8 An investigation was carried out in a temperate woodland that contained a number of areas with two different types of ground cover vegetation.

- On higher ground where the soil was drier, the dominant ground cover plant was bracken, *Pteridium aquilinum*.
- On lower ground where the soil was wetter, the dominant ground cover plant was bramble, *Rubus fruticosus*.

(a) Describe how the abundance of the two plant species at higher and lower ground sites could be measured.

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..... [4]

(b) Soil from under bracken and under brambles was collected and placed in two funnels. A bright light was placed over each funnel so that small invertebrate animals moved down the funnels and were collected in two collecting vessels.

The main groups of invertebrates present were identified and counted. Some of the results are shown in Table 8.1.

Table 8.1

invertebrate group	number present in soil under bracken	number present in soil under brambles
pseudoscorpion	49	21
wireworm	22	12
gamasid mite	18	7
springtail	10	1
total	99	41

(i) It was not possible to identify the invertebrates as far as genus or species level, and only the wireworm group could be classified as far as the taxonomic level **above** genus.

Name the taxonomic level represented by the wireworm group.

..... [1]

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

.....

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..... [1]

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(iii) Simpson's Index of Diversity for invertebrates from the soil under bracken was calculated as 0.663 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 invertebrates from the soil under brambles. Complete Table 8.2 and use the space provided to show your working. Show all working to **three** decimal places. Write your final answer on the dotted line.

Table 8.2

animal taxon	**number present in soil under brambles**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
pseudoscorpion	21		
wireworm	12		
gamasid mite	7		
springtail	1		
total	41		

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

(iv) Describe what Table 8.1 and the calculated figures for Simpson's Index of Diversity show about the effect of bracken and bramble vegetation cover on the diversity and abundance of soil invertebrates in the woodland.

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..... [2]

[Total: 11]

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[Turn over

Section B

Answer **one** question.

9 **(a)** Explain the mechanism by which guard cells open stomata. [9]

(b) State the changes in the external environment that lead to stomatal opening and closure. Explain why these stomatal responses are necessary. [6]

[Total: 15]

10 **(a)** Compare the endocrine and nervous systems in control and co-ordination in mammals. [8]

(b) Outline the role of a chemoreceptor cell in the human taste bud in detecting stimuli **and** in stimulating the transmission of nerve impulses in sensory neurones. [7]

[Total: 15]

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[Turn over

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BIOLOGY **9700/43**

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.

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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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..... [1]

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

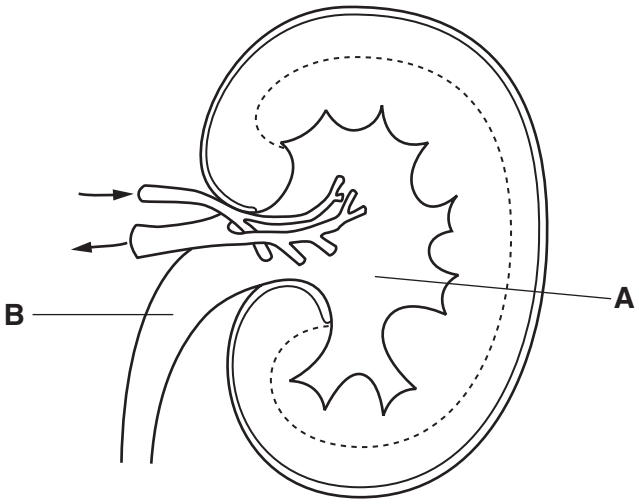


Fig. 1.1

(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]

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

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..... [5]

[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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..... [2]

(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

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

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..... [4]

(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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..... [3]

[Total: 9]

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[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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..... [2]

(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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..... [3]

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

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..... [2]

(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.

..... [1]

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

.....

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..... [1]

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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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..... [3]

[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**.

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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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..... [5]

[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.

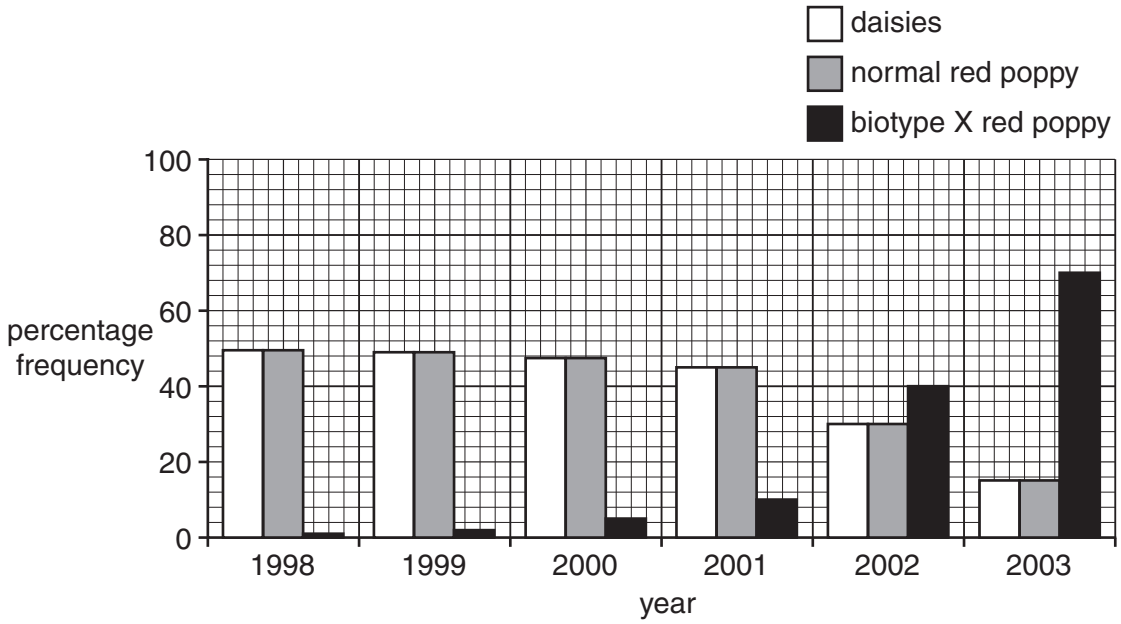


Fig. 5.1

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

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..... [4]

(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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..... [3]

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

..... [1]

(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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..... [3]

(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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..... [3]

[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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..... [2]

(ii) *myosin* .....

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..... [4]

(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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..... [2]

(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.

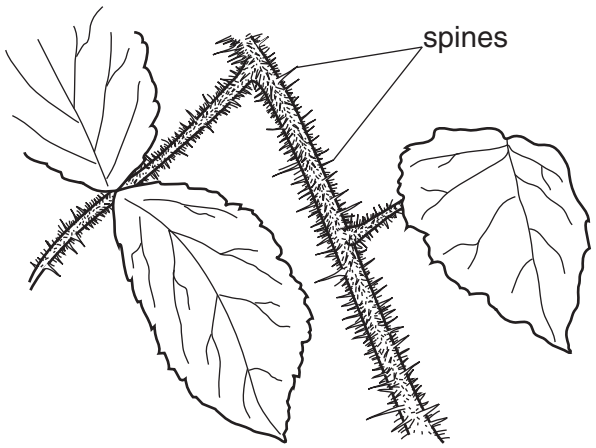


Fig. 7.1

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]

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(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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..... [2]

[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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..... [4]

(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

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

.....

..... [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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..... [2]

[Total: 11]

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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]

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