Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0012840285

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **February/March 2020**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Section A: answer **all** questions.
- Section B: answer **one** question.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **28** pages. Blank pages are indicated.

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Section A

Answer **all** questions.

1 **(a)** Fig. 1.1 represents part of the wall of a proximal convoluted tubule (pct) in a kidney nephron.

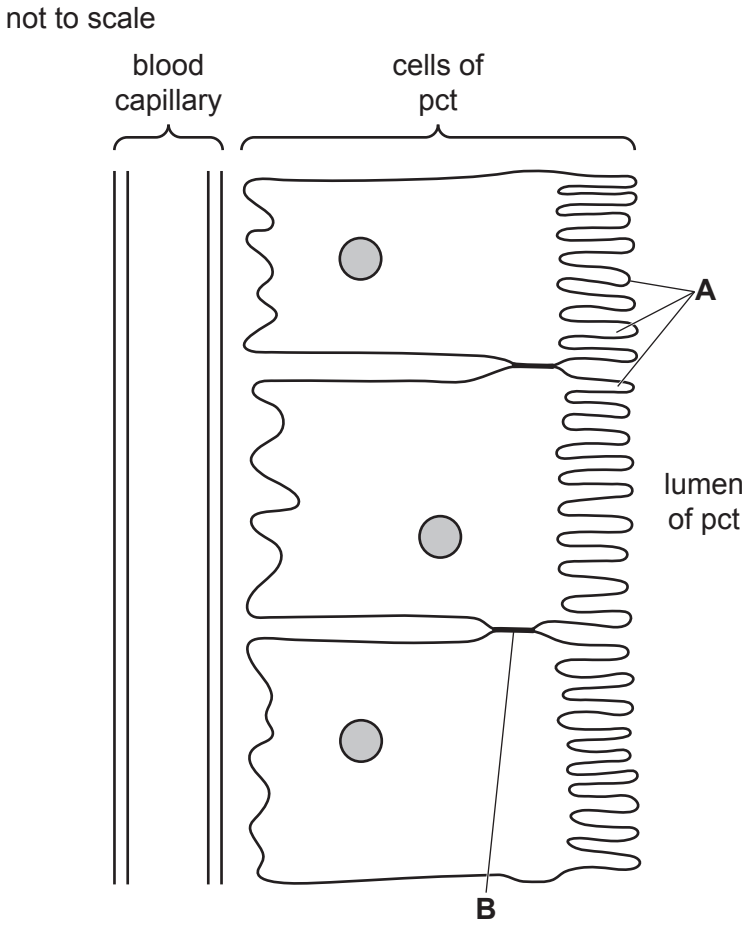


Fig. 1.1

(i) Name the features of the wall of a pct that are labelled **A** and **B** in Fig. 1.1.

A .....

B .....

[2]

(ii) On Fig. 1.1:

- use the letter **C** with a label line to show where co-transport of glucose with sodium ions occurs
- use the letter **D** with a label line to show where active transport of sodium ions occurs.

[2]

(b) Table 1.1 shows the quantities, per day, of some of the substances that are:

- removed from the blood by ultrafiltration
- reabsorbed into the blood by the pct
- excreted in the urine.

Table 1.1

substance	**quantity removed by ultrafiltration and units**		**percentage reabsorbed into blood from pct**	**quantity excreted in urine and units**	
urea	56.0	g	46.4	30.0	g
water	180.0	dm^3	99.2	1.4	dm^3
sodium ions	25200.0	arbitrary units	99.4	.....	arbitrary units
glucose	800.0	nmol	100.0	0.0	nmol

Complete Table 1.1 by calculating the quantity of sodium ions excreted in the urine.

Write your answer in the table to one decimal place.

Show your working in the space below.

[2]

(c) A person who has type 1 diabetes mellitus cannot produce enough insulin. This results in some glucose being excreted in the urine.

The urine can be tested for glucose using a dip stick.

Name the **two** enzymes present on the dip stick **and** outline the reaction catalysed by each enzyme.

enzyme .....

reaction .....

.....

enzyme .....

reaction .....

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[2]

[Total: 8]

2 Severe combined immunodeficiency (SCID) is a group of life-threatening diseases. SCID is caused by mutations that prevent the normal function of the immune system. Infants born with SCID are at very high risk of infectious diseases.

One feature of SCID is that T-lymphocytes do not develop normally.

In the development of normal T-lymphocytes, the production of circular pieces of DNA called T-lymphocyte receptor excision circles (TRECs) is an important event.

It is possible to use the polymerase chain reaction (PCR) to detect TRECs in DNA extracted from a sample of blood. The results of this reaction can be used to identify children with SCID.

(a) (i) Describe the role of the primers in the PCR used for the detection of TRECs.

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..... [3]

(ii) Suggest **and** explain how the results of PCR for the detection of TRECs can be used to identify children with SCID.

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..... [2]

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(b) Before 2010, children in the United States of America (USA) were tested for SCID either:

- if someone in their **family history** had SCID, or
- if they developed several **infections** in a short space of time.

From 2010, the USA started to introduce a **screening programme** for SCID, in which children were tested soon after birth. By 2016, the screening programme was used for nearly all children in the USA.

Fig. 2.1 shows the percentage contribution of each of these three approaches to the identification of children with SCID from 2010 to 2016 in the USA.

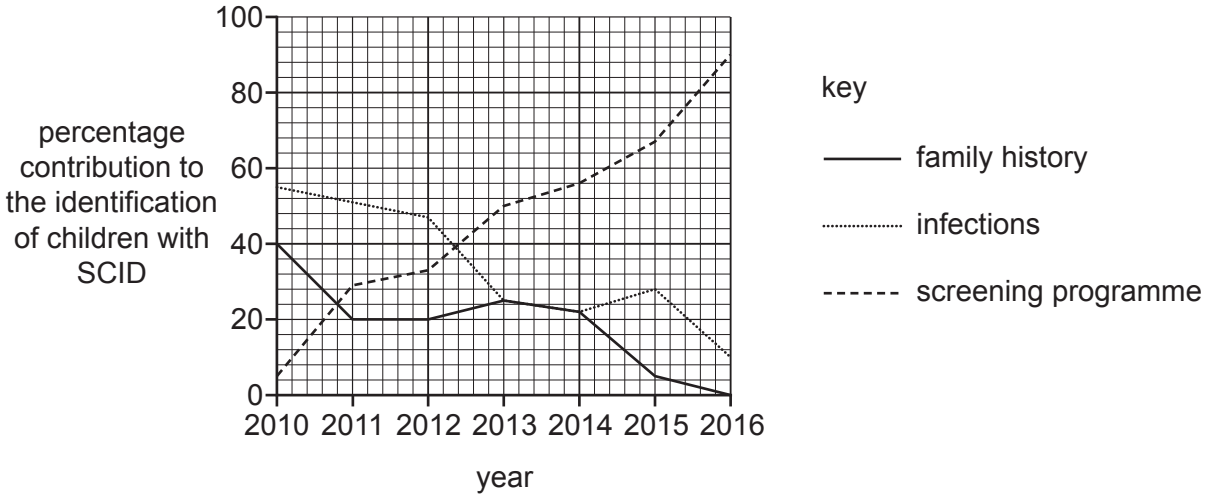


Fig. 2.1

(i) With reference to Fig. 2.1, describe how the contribution of the three approaches to the identification of children with SCID changed from 2010 to 2016.

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..... [3]

(ii) Suggest the advantages of screening all children for SCID soon after birth.

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..... [2]

(c) One form of SCID is caused by a mutation that results in a deficiency of the enzyme adenosine deaminase (ADA).

Children with ADA-deficient SCID can be treated with gene therapy using a virus. After successful gene therapy, the children are able to produce ADA for themselves.

Suggest how children with ADA-deficient SCID can be treated with gene therapy using a virus.

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..... [3]

(d) Outline the challenges of using a virus for gene therapy.

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..... [3]

[Total: 16]

Question 3 starts on page 8

3 Flowers of the common morning-glory plant, *Ipomoea purpurea*, can have several different phenotypes. An example of these flowers is shown in Fig. 3.1.



Fig. 3.1

Flower colour in *I. purpurea* is controlled by **two** genes on **different** chromosomes.

Gene **R**/**r**, which codes for a protein involved in pigment production, has 2 alleles:

- the dominant allele, **R**, allows pigment production
- the recessive allele, **r**, prevents pigment production of any colour, resulting in white flowers.

Gene **T**/**t**, which determines the type of pigment produced, has two alleles:

- the dominant allele, **T**, results in purple flowers
- the recessive allele, **t**, results in red flowers.

(a) (i) Define the term *allele*.

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..... [2]

(ii) Suggest ways in which the expression of allele **R** allows pigment production.

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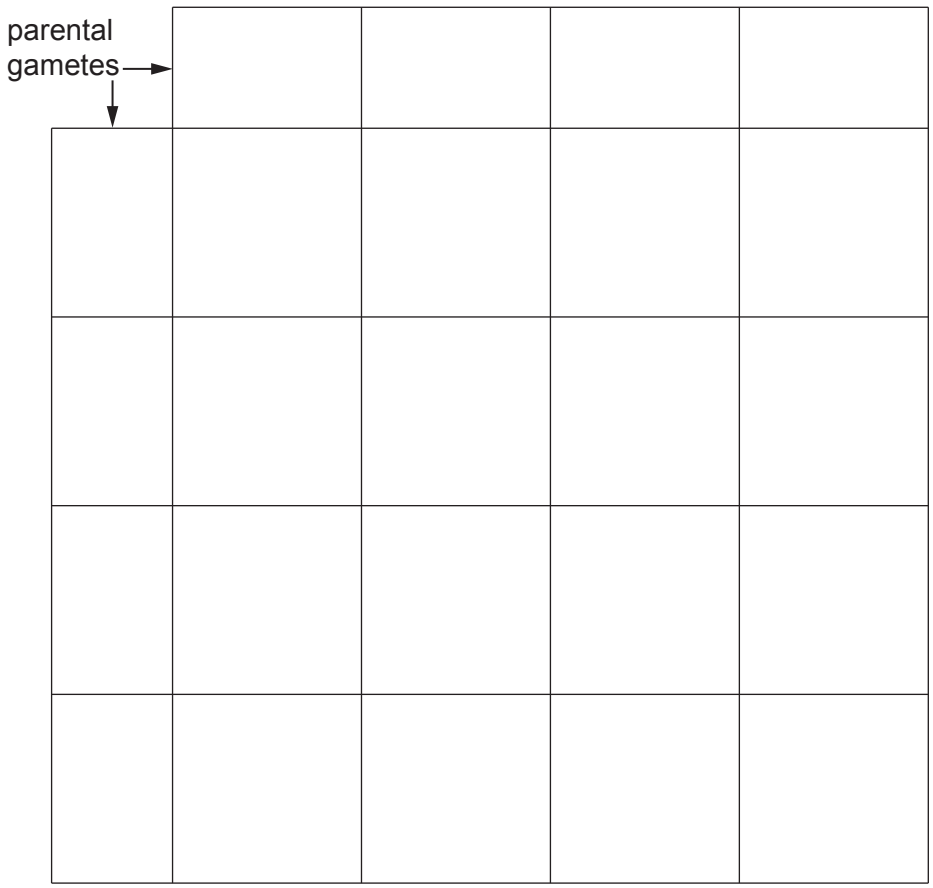
..... [3]

(b) Complete Fig. 3.2 to show the results of a cross between two *I. purpurea* plants that are **heterozygous at both loci**.

parental
genotypes:

parental
gametes:

results of cross:
- show parental gametes in first column and top row
- show offspring genotypes and phenotypes in square boxes



phenotypic
ratios:

Fig. 3.2

[5]

[Total: 10]

4 The rainbow trout, *Oncorhynchus mykiss*, is a fish that is bred in commercial fish farms. Rainbow trout that have a blue-silver colour are sold at a higher price than rainbow trout that have a brown colour.

The number of fish with each of the different colours was recorded in a breeding population in one fish farm.

- population total = 2936
- number of blue-silver fish = 1437
- number of brown fish = 1499

(a) The colour of rainbow trout is controlled by a single autosomal gene with two alleles, one dominant and one recessive. The blue-silver colour occurs when a fish is homozygous for the recessive allele.

The formulae of the Hardy–Weinberg principle state that:

$$p + q = 1$$

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

Use these formulae to calculate the expected number of brown fish that are homozygous, if the Hardy–Weinberg principle applies to this population.

Show your working.

answer = ...
[3]

(b) Some scientists suggested that the Hardy–Weinberg principle did not apply in this situation because the rainbow trout were being kept in a commercial fish farm.

State **two** conditions that must be met by this commercial fish farm population for the Hardy–Weinberg principle to apply.

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..... [2]

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(c) Describe how selective breeding can be used to increase the proportion of rainbow trout with a blue-silver colour in commercial fish farms.

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..... [4]

(d) The Atlantic salmon, *Salmo salar*, can be genetically modified (GM).

GM Atlantic salmon are bred in commercial fish farms for food production. In 2017, GM Atlantic salmon bred in Canada became the first GM animal to enter the human food chain.

Explain how the genetic modification of the Atlantic salmon can be used to increase food production.

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..... [2]

[Total: 11]

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5 To identify the function of a gene, scientists can insert (add) a copy of the gene into a plasmid to create recombinant DNA. The plasmid is then transferred into a host bacterium to express the gene.

(a) Define recombinant DNA.

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..... [1]

One plasmid used by scientists for this purpose is pIRES2-EGFP.

Fig. 5.1 shows the main features of pIRES2-EGFP.

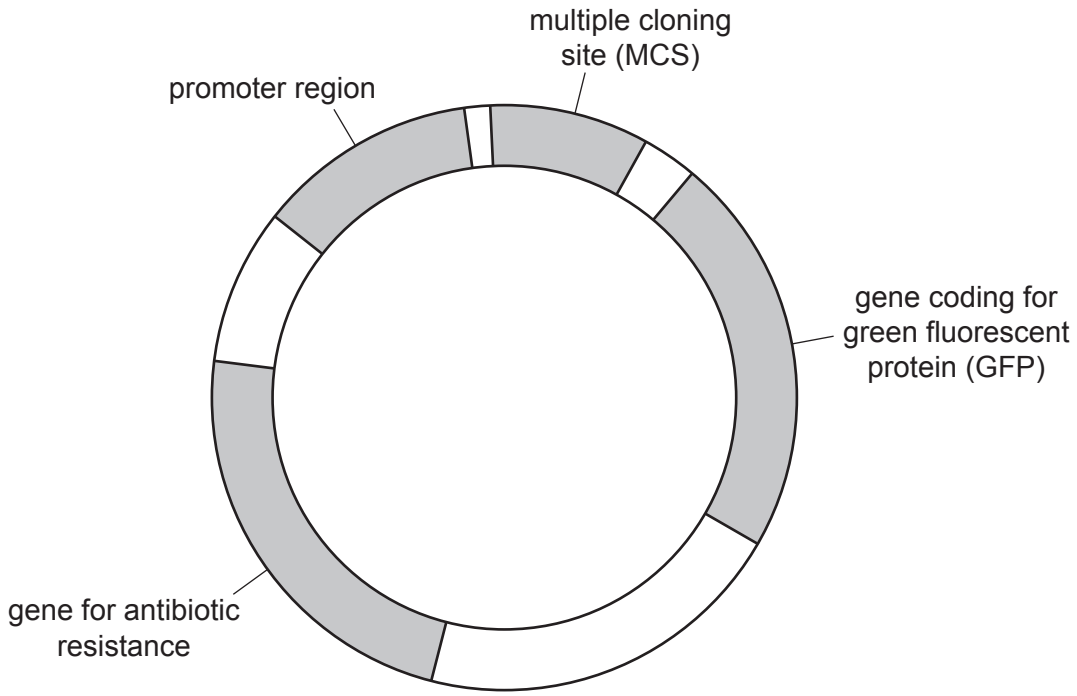


Fig. 5.1

(b) This plasmid includes a gene that codes for a fluorescent protein, GFP.

Explain the purpose of including a gene for a fluorescent protein in the plasmid.

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..... [2]

A gene with unknown function was inserted into the multiple cloning site (MCS) of pIRES2-EGFP. The MCS contains the target nucleotide sequence for a number of different restriction endonucleases.

The nucleotide sequence of the MCS in pIRES2-EGFP is shown in Fig. 5.2.

```
5′ CTCAGATCTCGAGCTCAAGCTTCGAATTCTGCAGTCGACGGTACCGCGGGCCCGGGATCC 3′
   ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
3′ GAGTCTAGAGCTCGAGTTCGAAGCTTAAGACGTCAGCTGCCATGGCGCCCGGGCCCTAGG 5′
```

Fig. 5.2

The nucleotide sequences targeted by six restriction endonucleases and the way in which these enzymes cut DNA are shown in Fig. 5.3.

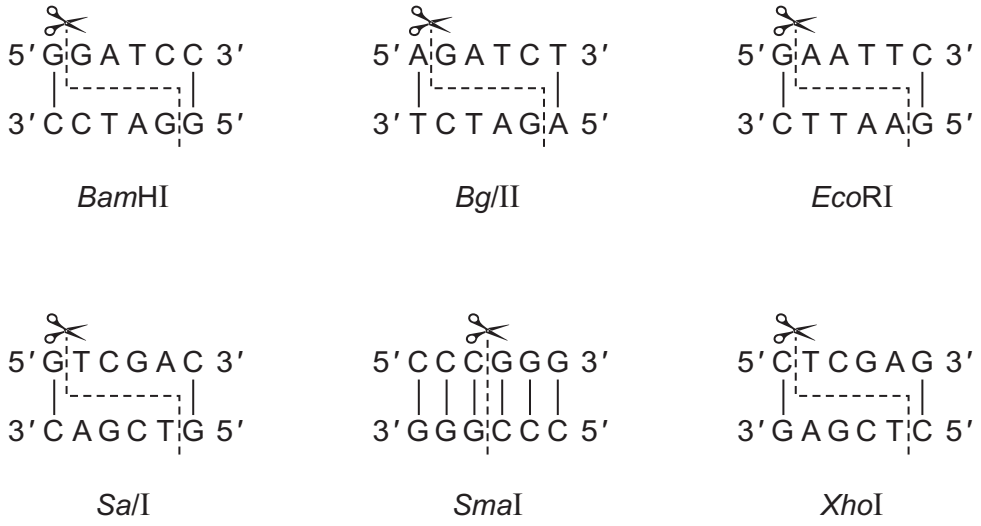


Fig. 5.3

(c) Describe the type of end produced when DNA is cut using the restriction endonuclease *Sma*I.

..... [1]

(d) Scientists used two of the restriction endonucleases shown in Fig. 5.3 to obtain the gene with unknown function for inserting into the MCS of pIRES2-EGFP.

Fig. 5.4 shows the gene obtained after cutting with these two restriction endonucleases, including the nucleotide sequences of the two ends. The DNA START codon, ATG, and DNA STOP codon, TAA, are shaded.

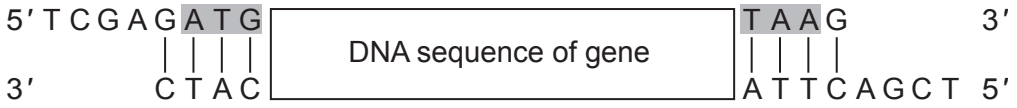


Fig. 5.4

(i) Name the **two** restriction endonucleases in Fig. 5.3 that were used to cut the MCS of pIRES2-EGFP so that the gene shown in Fig. 5.4 could be inserted.

The nucleotide sequence of the MCS in pIRES2-EGFP is shown in Fig. 5.2.

.....

..... [2]

(ii) On Fig. 5.2, draw around the group of nucleotides in the MCS that were removed to insert the gene shown in Fig. 5.4. [2]

(iii) To identify the function of the gene, it is important that the gene can be easily inserted into the plasmid and, once inserted, that it is expressed.

Suggest **one** reason why scientists used different restriction sites at the 5′ end and 3′ end of the gene for inserting the gene into the plasmid.

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..... [1]

(iv) Name the enzyme used to join the cut ends of the gene to the cut ends of the plasmid.

..... [1]

[Total: 10]

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6 **(a)** The sea otter, *Enhydra lutris*, is a marine mammal that lives on the coasts of the North Pacific ocean.

Fig. 6.1 shows a sea otter.



Fig. 6.1

Table 6.1 shows part of the classification of the sea otter.

Table 6.1

taxonomic group	**name**
phylum	Chordata
.....	Mammalia
order	Carnivora
.....	Mustelidae
genus	*Enhydra*
species	*lutris*

Complete Table 6.1 by adding the correct taxonomic groups in the **two** spaces provided. [2]

(b) There were estimated to be about 300 000 sea otters in the year 1700.

- Extensive hunting for their fur resulted in the numbers of sea otters falling to about 1000 by the year 1911, when most hunting was banned.
- The population size then increased to about 125 000 by the year 2012.

All of the sea otters alive today are descended from the 1000 individuals alive in the year 1911.

Outline the **genetic** consequences to a species, such as the sea otter, of having a large population that is descended from a very small number of individuals.

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..... [3]

(c) Seaweeds, such as kelp, are large algae that can grow to be over 30 metres in length. In the ocean along the coasts of California, USA, there are very dense areas of kelp called kelp forests. Kelp forests are very productive and diverse ecosystems.

Fig. 6.2 shows a kelp forest.



Fig. 6.2

The sea otter is a keystone species in kelp forests along the coasts of California. This means that sea otters have a larger than expected effect on other organisms in these kelp forests. The loss of the sea otter would cause major changes to the kelp forest ecosystem and a reduction in biodiversity.

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Fig. 6.3 shows part of a food web in a kelp forest. The arrows show the direction of energy flow.

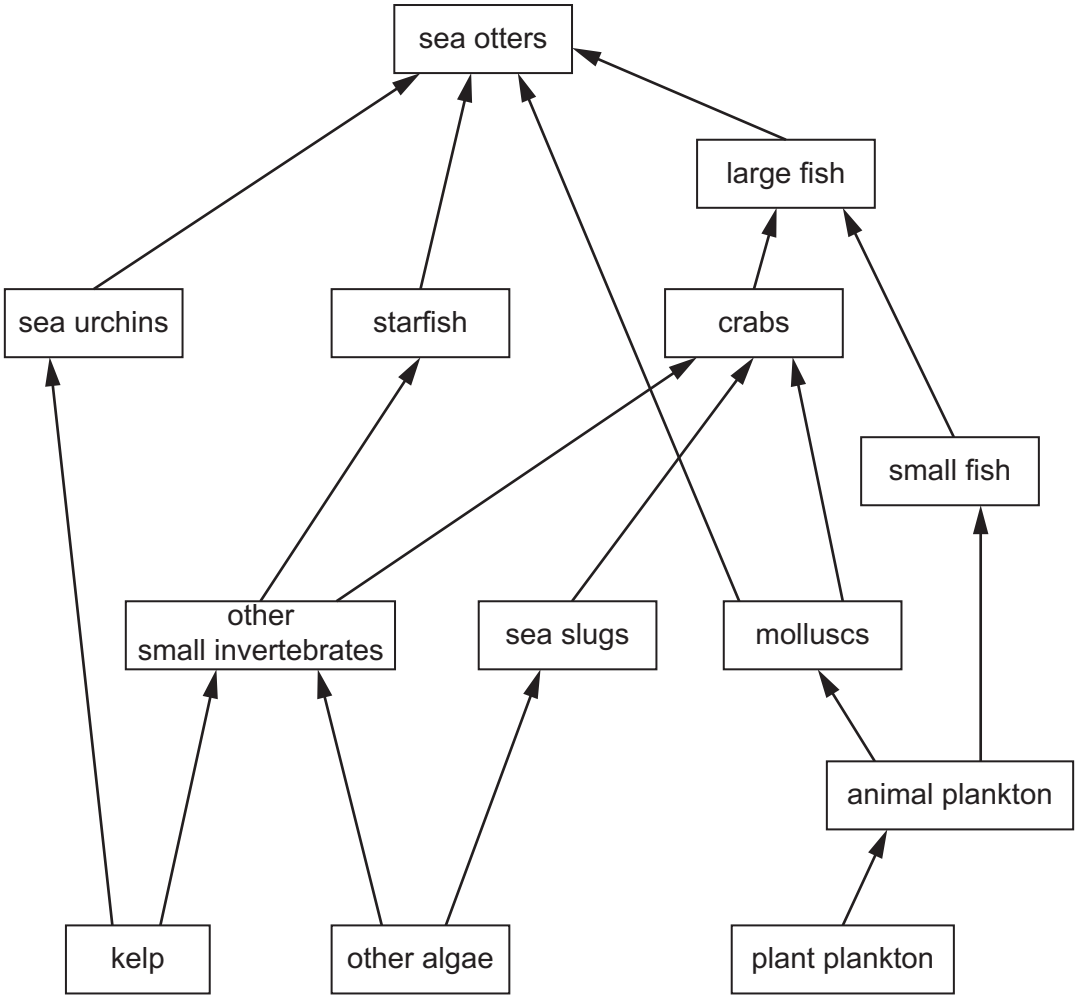


Fig. 6.3

Using Fig. 6.3, suggest **and** explain what would happen to the numbers of sea urchins, animal plankton and crabs if sea otters in this kelp forest became extinct.

sea urchins .....

.....

.....

animal plankton .....

.....

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crabs .....

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.....

[3]

(d) Sea otters may spend up to five minutes under water while searching for food. During this time, respiration in anaerobic conditions takes place.

When a sea otter first returns to the surface of the ocean, its breathing is faster and deeper than normal.

Explain why its breathing is faster and deeper than normal.

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..... [3]

(e) The striated muscle of the sea otter is composed of fibres called myofibrils. Myofibrils are made of units called sarcomeres.

Describe the proteins that are involved in the contraction of a sarcomere.

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..... [4]

[Total: 15]

7 Fig. 7.1 outlines some of the events in the process of photosynthesis in a chloroplast.

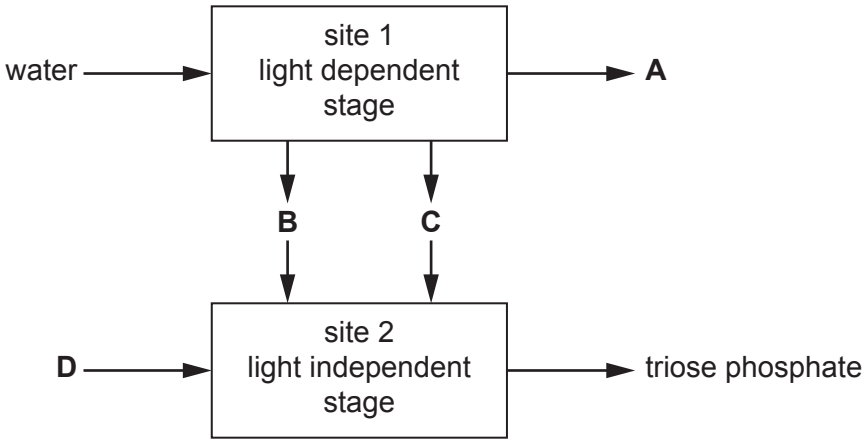


Fig. 7.1

(a) Name the parts of a chloroplast labelled site 1 and site 2 in Fig. 7.1.

site 1 .....

site 2 .....

[2]

(b) Name the substances labelled **A**, **B**, **C** and **D** in Fig. 7.1.

The substances labelled **B** and **C** may be named in either order.

A .....

B .....

C .....

D .....

[3]

(c) Most of the triose phosphate produced in the light independent stage is used to regenerate RuBP so that the Calvin cycle can continue. Some of the triose phosphate is used to make other organic compounds with a range of functions.

State **three** different functions of these other organic compounds in a plant cell and give **one** example of an organic compound for each function.

function .....

.....

compound .....

function .....

.....

compound .....

function .....

.....

compound .....

[3]

[Total: 8]

8 Farmers can use insecticides to remove parasites from their sheep. Some of these insecticides act as inhibitors of the enzyme acetylcholinesterase.

(a) Suggest **and** explain how an inhibitor of acetylcholinesterase could work.

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..... [3]

(b) Acetylcholinesterase inhibitors affect nerve impulse conduction.

Explain the effects of the inhibition of acetylcholinesterase at a synapse.

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..... [3]

(c) Suggest **one** way of reducing the effects of acetylcholinesterase inhibitors.

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..... [1]

[Total: 7]

Section B

Answer **one** question.

9 **(a)** Explain how meiosis and fertilisation can result in genetic variation amongst offspring. [8]

(b) Outline the effects of mutant alleles on the phenotype in albinism and haemophilia. [7]

[Total: 15]

10 **(a)** Describe how random sampling can be used to assess the distribution and abundance of plants in an area. [6]

(b) Describe named examples of threats to the biodiversity of aquatic ecosystems and terrestrial ecosystems. [9]

[Total: 15]

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