Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9431237737

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **October/November 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 Fig. 1.1 is a transverse section through a leaf from the maize plant, *Zea mays*.

Maize is a **C4** plant.

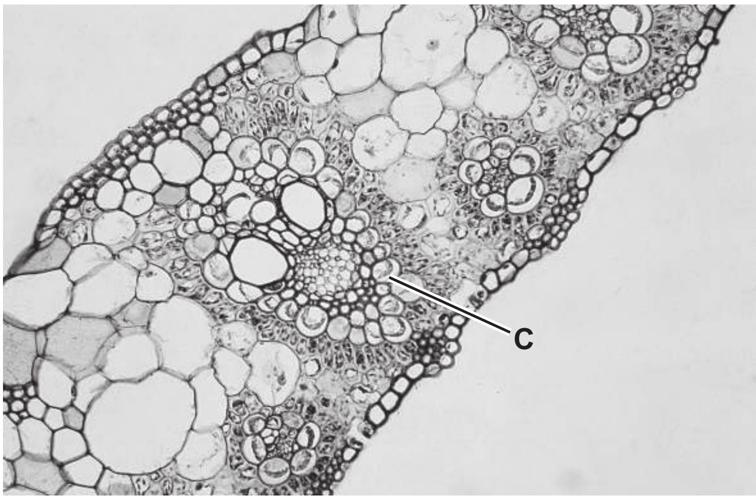

Fig. 1.1

(a) On Fig. 1.1, use label lines and letters to show:

A – a cell in the epidermal layer

B – a cell that contains PEP carboxylase.

[2]

(b) **(i)** Identify the cell type labelled **C** in Fig. 1.1.

C .... [1]

(ii) Explain how the leaf anatomy shown in Fig. 1.1 adapts the C4 plant to maintain a high rate of photosynthesis at high temperatures.

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.... [4]

(c) Fig. 1.2 shows the results of an experiment comparing the rate of carbon dioxide uptake in a C3 plant (*Chenopodium album*) and a C4 plant (*Amaranthus retroflexus*) in high and low carbon dioxide (CO_2) conditions.

The rate of CO_2 uptake is used to measure the rate of photosynthesis.

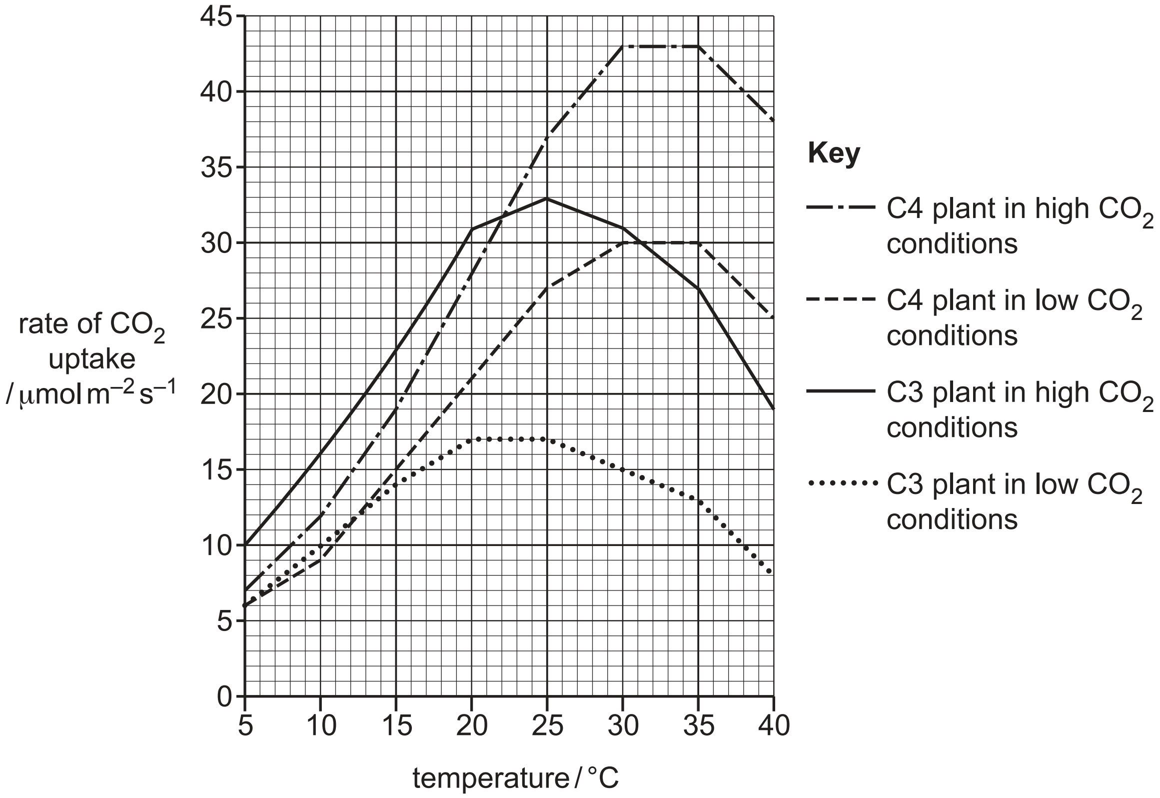

Fig. 1.2

(i) Using Fig. 1.2, compare the rates of photosynthesis in **high** CO_2 conditions in the C3 and C4 plants.

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.... [4]

(ii) Using Fig. 1.2, compare the rates of photosynthesis in low and high CO_2 conditions in the C4 plant between 30 °C and 35 °C **and** suggest an explanation for this difference.

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.... [2]

[Total: 13]

2 Domestic goats are small, herbivorous animals that provide milk for human use. Goats' milk is an important source of food for people living in rural China. Xinong Saanen and Guanzhong are the names of two varieties (breeds) of goat common in China.

In these breeds, there is genetic variation at nucleotide position 5752 of a gene coding for a growth factor. At this position there is either a cytosine (C) or a guanine (G) nucleotide. Some individuals are homozygous for the allele containing C at this position (**CC**), some are homozygous for the allele containing G at this position (**GG**) and some are heterozygous (**CG**).

Table 2.1 compares the mean milk yield of the first milk-producing period (first lactation) and the next milk-producing period (second lactation) for Xinong Saanen goats of each genotype.

Table 2.1

genotype at position 5752	**mean milk yield / kg**	
	first lactation	**second lactation**
CC	679	940
CG	622	858
GG	616	834

(a) **(i)** Variation in a phenotypic characteristic such as milk yield is caused by a combination of genetic and environmental factors.

Goats also show variation in milk yield between the first lactation and second lactation.

Suggest, with reasons, whether the variation in milk yield between the first lactation and second lactation, as shown in Table 2.1, is genetic or environmental.

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.... [3]

(ii) The variation at position 5752 of the gene coding for a growth factor is due to a substitution mutation from **G** to **C**.

With reference to Table 2.1, describe the importance of the substitution from **G** to **C**.

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.... [3]

(b) In a population of 268 Xinong Saanen goats:

- the frequency of the **C** allele (q) is 0.30
- the frequency of the **G** allele (p) is 0.70.

The Hardy-Weinberg principle can be used to predict the number of goats with **CC**, **CG** and **GG** genotypes in the population, using the equation:

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

For example, the number of goats with genotype **GG** can be predicted to be 131.

(i) Use the Hardy-Weinberg principle to predict the number of goats with genotypes **CC** and **CG** in this population of Xinong Saanen goats.

number of goats with genotype **CC** ....

number of goats with genotype **CG** ....

[2]

Table 2.2 shows the **actual** number of goats with each genotype in a population of Xinong Saanen goats and in a population of Guanzhong goats.

Table 2.2

population	total number of goats	number of goats of each genotype			allele frequency	
		CC	CG	GG	*p*	*q*
Xinong Saanen	268	22	116	130	0.70	0.30
Guanzhong	440	47	69	324	0.81	0.19

(ii) A close match between your predicted figures in **(b)(i)** and the actual numbers in Table 2.2 would mean that the Xinong Saanen population is in Hardy-Weinberg equilibrium.

State the name of a statistical test that could be used to find out whether or not the Xinong Saanen population is in Hardy-Weinberg equilibrium.

.... [1]

(iii) The **predicted** numbers of goats with each genotype in the Guanzhong population according to the Hardy-Weinberg principle are:

- **CC** = 16
- **CG** = 135
- **GG** = 289.

These figures are significantly different from the actual figures in Table 2.2.

With reference to Table 2.2, describe the evidence that shows that the Guanzhong population is **not** in Hardy-Weinberg equilibrium **and** suggest reasons for this.

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.... [3]

(c) Goats can be genetically modified to produce human proteins in their milk.

In 2009, an anti-clotting protein produced in this way was approved for use as a drug in people who lack the protein.

State **one** ethical advantage and **one** ethical problem of producing medicinal drugs from the milk of genetically modified goats.

advantage ....

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problem ....

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[2]

[Total: 14]

3 DNA barcoding is used in species identification.

To create a DNA barcode, a specific region of DNA is sequenced so that it can be compared to an online database of reference DNA. One region of DNA that is commonly used is 648 base pairs long within a mitochondrial gene, coding for the enzyme cytochrome c oxidase I.

(a) The solitary sandpiper, *Tringa solitaria*, is a migratory bird.

DNA barcoding has shown that approximately 2.5 million years ago *T. solitaria* evolved into two subspecies, *Tringa solitaria solitaria* and *Tringa solitaria cinnamomea*.

A subspecies is a genetically distinct population of a species that has some phenotypic differences but is not yet reproductively isolated.

T. s. solitaria breed in eastern North America whereas *T. s. cinnamomea* breed in western North America.

Suggest **and** explain how the two subspecies *T. s. solitaria* and *T. s. cinnamomea* could have evolved from the original *T. solitaria* population.

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.... [4]

(b) Fig. 3.1 shows an American oystercatcher, *Haematopus palliatus*.

Fig. 3.1

The black oystercatcher, *Haematopus bachmani*, has all black feathers.

DNA barcoding analysis suggests that the American oystercatcher and the black oystercatcher are **not** separate species.

Suggest how DNA barcoding evidence could indicate that the American oystercatcher and black oystercatcher are **not** separate species.

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.... [2]

(c) Customs officers at airports can use a hand-held DNA barcoding device to identify biological specimens entering or leaving a country.

Suggest how this helps protect endangered species.

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.... [2]

[Total: 8]

4 There are a number of mutations affecting the production of fetal haemoglobin, HbF, and normal adult haemoglobin, HbA.

- The Hb^A allele codes for the normal β-globin polypeptide of haemoglobin.
- The Hb^S allele, caused by a base substitution mutation, codes for an abnormal β-globin polypeptide.
- The base substitution results in the amino acid glutamine, which has a polar R group, to be replaced by valine, which has a non-polar R group, in the polypeptide.

The abnormal haemoglobin molecules (HbS) form fibres in low partial pressures of oxygen (pO_2). The fibres cause red blood cells to become sickle shaped and the cells can block blood capillaries.

Individuals with adult haemoglobin molecules that are all abnormal (HbS) have sickle cell anaemia. This is a painful chronic condition that can be life-threatening.

(a) Explain why this mutation causes the HbS to form fibres.

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.... [2]

(b) Fetal haemoglobin, HbF, is produced by the fetus until just before birth, when adult haemoglobin begins to be made.

By the age of six months, adult haemoglobin has replaced most of the HbF. This change occurs when the genes coding for HbF are switched off and the genes coding for adult haemoglobin are switched on.

- A base substitution, British-198, causes fetal haemoglobin to continue to be produced.
- Normally by the age of six months, the concentration of HbF reduces to less than 1% of total haemoglobin.
- With the British-198 mutation, the concentration of HbF may be as high as 20% of total haemoglobin in an adult.
- HbF has a higher affinity for oxygen at low pO_2 than adult haemoglobin.

Individuals who have both sickle cell anaemia and British-198 mutation have reduced symptoms of sickle cell anaemia.

(i) Suggest why having the British-198 mutation reduces the symptoms of sickle cell anaemia.

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.... [2]

(ii) In adults with the British-198 mutation, the gene coding for a fetal haemoglobin polypeptide remains switched on. This is due to the presence of a protein that controls gene expression.

State the term that is used to describe a protein that controls gene expression.

.... [1]

(c) Gel electrophoresis can be carried out to test individuals for the different versions of haemoglobin: HbA, HbS and HbF.

- A buffer with alkaline pH is used to make all haemoglobin molecules negatively charged.
- HbS molecules have an additional positive charge compared to HbA.

(i) Describe **and** explain how gel electrophoresis is used to diagnose sickle cell anaemia.

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.... [4]

(ii) Four individuals had their haemoglobin analysed by gel electrophoresis. One of the individuals was heterozygous for the Hb^A and Hb^S alleles and had a condition known as sickle cell trait (SCT).

Some of the results are shown in Fig. 4.1. In Fig. 4.1, lane 1 and lane 5 are complete.

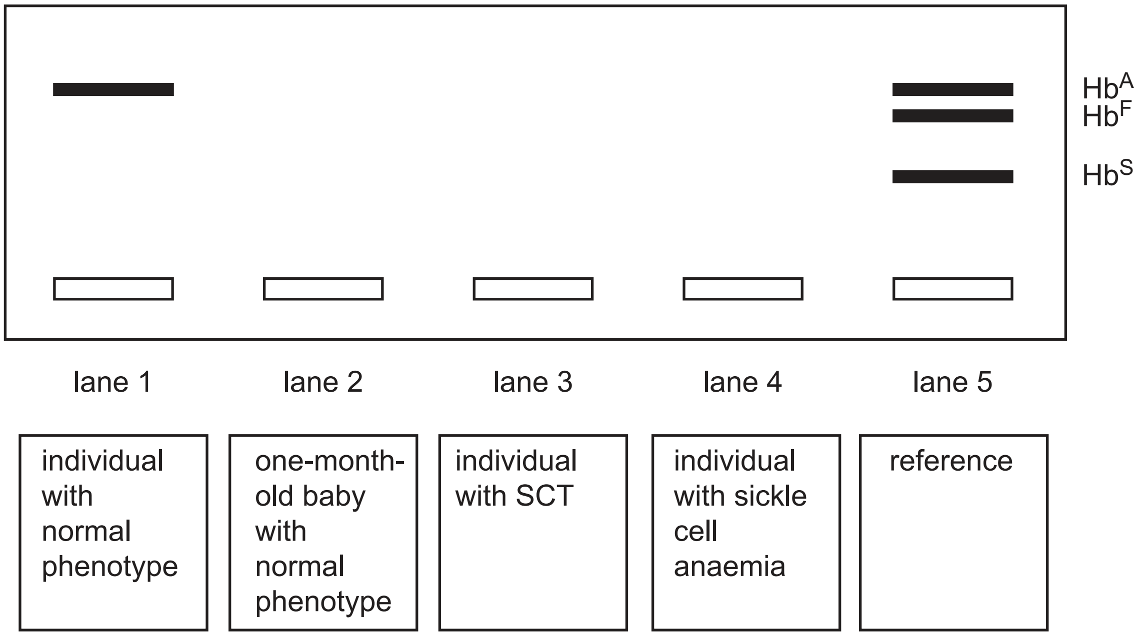

Fig. 4.1

Predict the results for the individuals analysed, by adding bands to lanes 2, 3 and 4 on Fig. 4.1. [2]

[Total: 11]

5 Fig. 5.1 shows a cat displaying the recessive phenotype for two unlinked genes.

- **H/h** controls hair length. The allele for short hair is dominant to the allele for long hair.
- **R/r** controls coat pattern. The allele for 'full colour', with pigment on all parts of the body, is dominant to the allele for 'pointed', where the pigment is restricted to the ears, face, paws and tail.

Fig. 5.1

(a) Draw a genetic diagram to predict the offspring genotypes and phenotypes when the cat in Fig. 5.1 is crossed with a cat that is heterozygous for the hair length gene and heterozygous for the coat pattern gene.

parent phenotypes:

parent genotypes:

gametes:

F1 genotypes:

F1 phenotypes:

[5]

(b) Scientists isolated two sections of DNA thought to correspond with the allele for full colour (**R**) and the allele for pointed (**r**).

Sequencing these two DNA sections showed that the DNA sequence for full colour, **R**, had a restriction site for the restriction enzyme *Hpa*II. This restriction site did **not** occur in the DNA sequence **r** because of a single nucleotide substitution.

The scientists then carried out an analysis of three generations of cats. Each cat was assessed for three features:

- coat pattern, full colour or pointed
- the presence or absence of the *Hpa*II restriction site
- the pair of alleles present at a variable marker locus thought to lie close to the **R/r** locus. The marker locus (gene) has seven different alleles designated as 1, 2, 3, 4, 5, 6 and 7.

Fig. 5.2 shows the relationships of these cats and the results of the assessment.

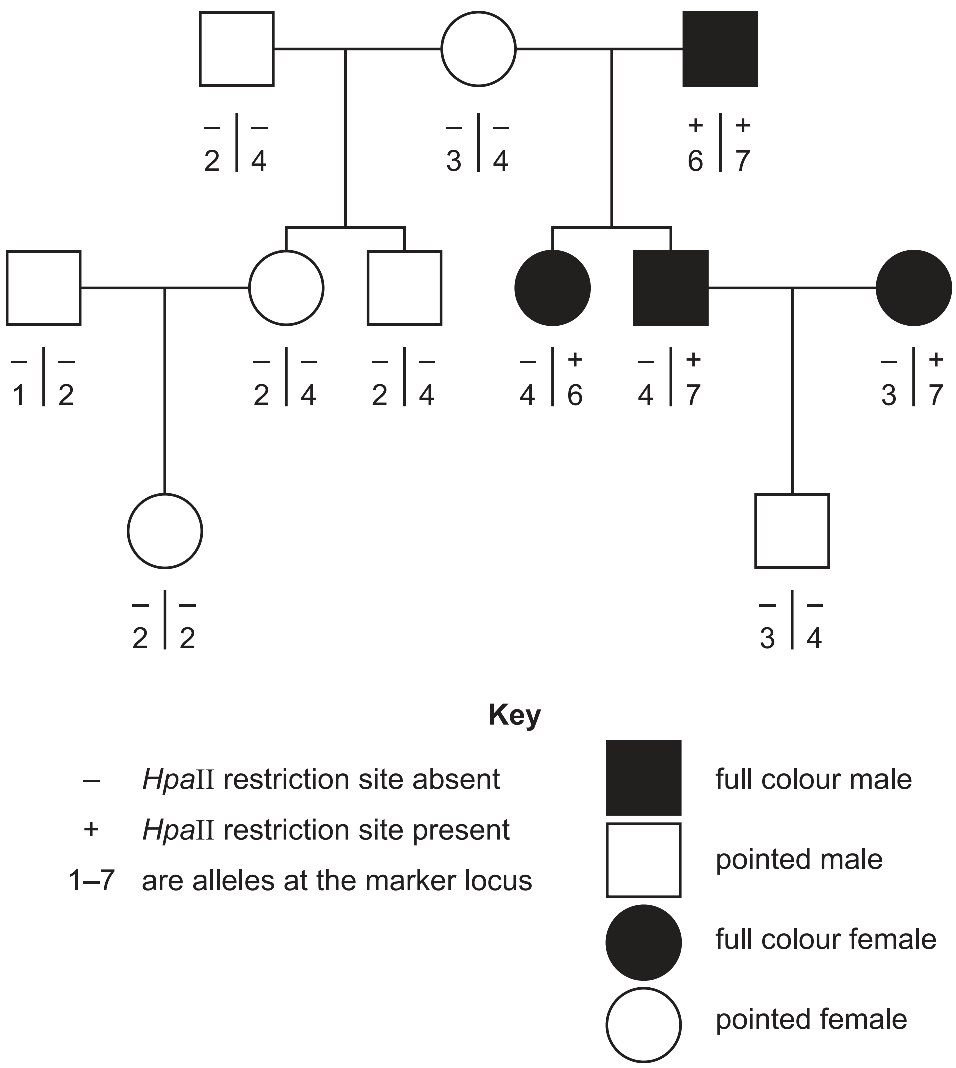

Fig. 5.2

Identify evidence from Fig. 5.2 to support these statements:

(i) the pointed phenotype is due to a recessive allele

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.... [1]

(ii) the **R/r** gene is located on an autosome

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.... [2]

(iii) the marker locus and **R/r** are closely linked.

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.... [2]

[Total: 10]

6 **(a)** **(i)** Identify the precise location in a cholinergic synapse that is described in each of the statements.

A region that contains many mitochondria.

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A region where exocytosis of ACh occurs.

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A region that contains voltage-gated channel proteins.

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A region that contains ligand-gated channel proteins.

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[4]

(ii) Outline the roles of synapses in the nervous system.

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.... [2]

(b) Some insecticides contain compounds called organophosphates. Organophosphates can act as enzyme inhibitors in neuromuscular junctions.

People who use organophosphates and do not follow safety guidelines are at risk of organophosphate poisoning, which affects muscle function.

Suggest how organophosphates could affect muscle function in humans.

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.... [4]

(c) Outline the role of the sarcoplasmic reticulum in the contraction of striated muscle.

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.... [2]

[Total: 12]

7 **(a)** Structures and compounds involved in respiration in anaerobic conditions include:

A – pyruvate

B – reduced NAD

C – ethanol

D – carbon dioxide

E – cytoplasm

F – NAD

G – ethanal

H – lactate

I – oxygen

J – mitochondrion

Complete Table 7.1 by matching each description with **one** letter chosen from **A** to **J** to show the correct structure or compound.

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

Table 7.1

description	**letter**
end product of glycolysis	
cellular location of respiration in anaerobic conditions	
end product of respiration in anaerobic conditions in yeast cells	
compound used to reduce pyruvate	
end product of respiration in anaerobic conditions in muscle cells	
gas released during alcoholic fermentation	

[6]

(b) Respiration in anaerobic conditions in muscle cells during vigorous exercise can create an oxygen debt. Extra oxygen is breathed in after exercise to pay back the oxygen debt.

Explain **two** ways in which the mammalian body uses this **extra** oxygen.

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.... [2]

[Total: 8]

8 Palm oil is a vegetable oil that is used very widely in food products. The oil is extracted from the fruit of the oil palm tree.

(a) Oil palm trees have a higher oil yield than that of other oil-producing plants.

Fig. 8.1 shows the oil yield of four crop plants.

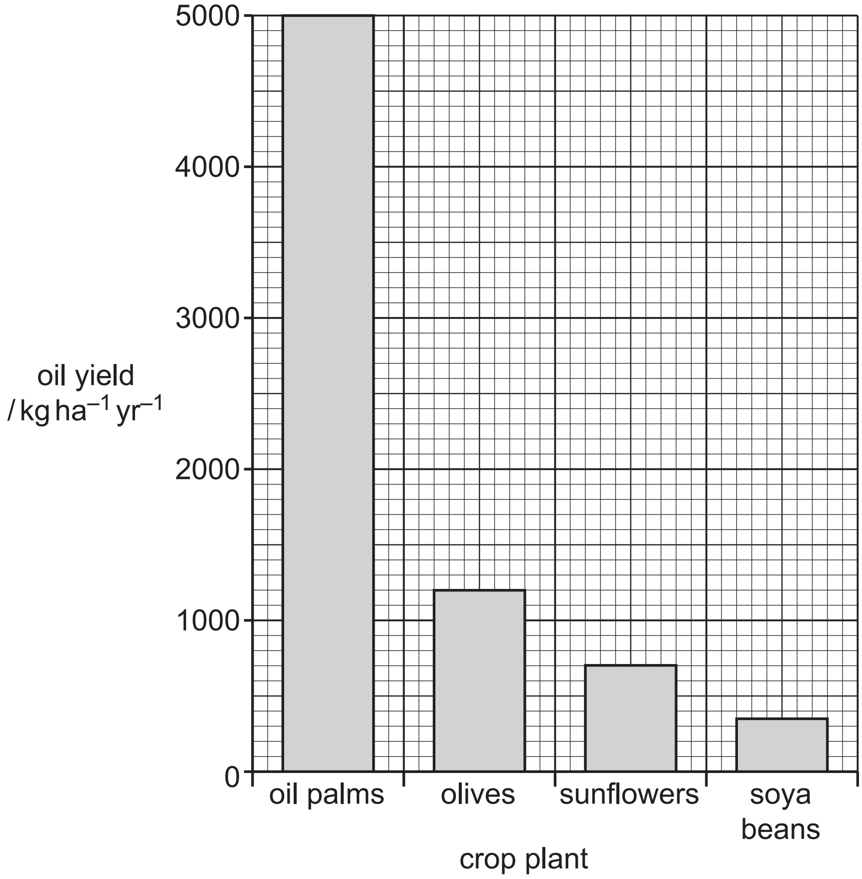

Fig. 8.1

Calculate how many hectares of soya bean plants would be needed to produce the **same** yield of oil as one hectare of oil palm trees.

Show your working and write your answer to **one** decimal place.

answer .... hectares [2]

(b) Oil palm plantations in Malaysia and Indonesia have been created by cutting down rainforests. This reduces biodiversity.

Outline reasons why it is important to maintain biodiversity.

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.... [5]

(c) Palm oil companies are now being asked to produce palm oil in a sustainable way. This means that no more deforestation should take place.

Suggest ways in which individual consumers can encourage manufacturers to use palm oil from sustainable sources.

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.... [2]

[Total: 9]

Section B

Answer **one** question.

9 **(a)** Describe **and** explain the properties of plasmids that allow them to be used in gene cloning. [7]

(b) Explain the roles of restriction endonucleases, ligases and reverse transcriptase in genetic engineering. [8]

[Total: 15]

10 **(a)** Describe how adrenaline can stimulate liver cells to convert glycogen to glucose. [7]

(b) Describe the role of abscisic acid (ABA) in the closure of stomata during times of drought. [8]

[Total: 15]

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