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General Certificate of Education Advanced Level

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4940590719

BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **May/June 2012**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

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Answer **all** questions in Section A and **one** question from Section B.
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8	
Section B	
9 or 10	
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Section A

For Examiner's Use

Answer **all** the questions.

1 The greenish warbler, *Phylloscopus trochiloides*, is a species of small bird that originated in northern India, on the southern edge of the Himalayan mountain range.

Fig. 1.1 shows a greenish warbler.



Fig. 1.1

Thousands of years ago, populations of the greenish warbler spread around the western and eastern edges of the Himalayan mountain range to establish themselves in north-eastern Europe and Siberia.

- A gradual change in characteristics occurred in these populations, leading to different forms of the greenish warbler.
- One example of gradual change is in the song of the male warbler, which is very distinctive and is used in mating behaviour.
- When greenish warblers from north-eastern Europe meet those from Siberia no mating takes place.
- The greenish warblers from north-eastern Europe and Siberia are now considered to be two separate species.

Fig. 1.2 shows the spread of the greenish warbler.

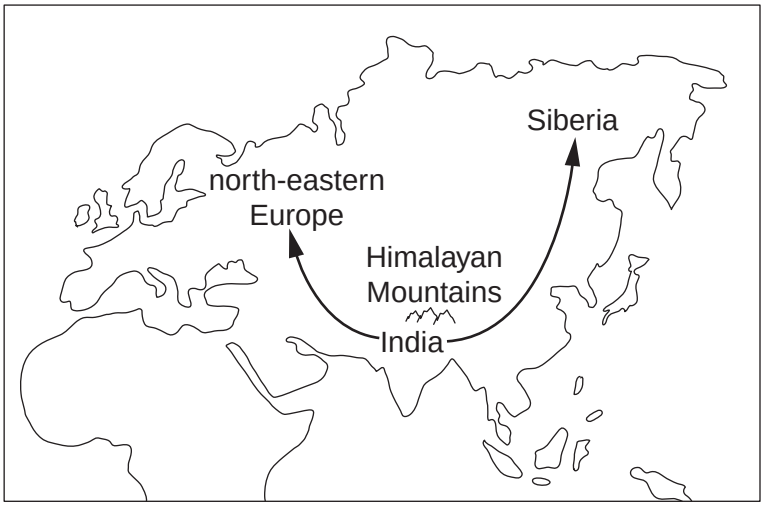


Fig. 1.2

(a) Explain what is meant by the term *species.*

For Examiner's Use

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.....[2]

(b) State the likely isolating mechanism taking place in populations of the greenish warbler.

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(c) Explain how the process of speciation occurred in the greenish warbler populations.

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.....[5]

[Total: 8]

2 Some of the steps in the production of monoclonal antibodies are shown in Fig. 2.1.

For Examiner's Use

step 1
A mouse is injected with an antigen, A.

↓

step 2
The mouse is left for a few weeks to allow an immune response to occur.

↓

step 3
Plasma cells (effector B lymphocytes) are extracted from the mouse's spleen.

↓

step 4
Hybridoma cells are formed.

↓

step 5
Each hybridoma cell is isolated and allowed to grow and divide.

↓

step 6
The hybridoma cells producing anti-A antibodies are identified and cultured on a large scale.

Fig. 2.1

(a) With reference to Fig. 2.1, explain:

(i) what happens during an immune response (**step 2**)

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(ii) what is meant by a hybridoma cell (**step 4**)

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..... [1]

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(iii) why hybridoma cells need to be formed (**step 4**)

For Examiner's Use

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.....[2]

(iv) how hybridoma cells producing anti-A antibody can be identified.

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.....[1]

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(b) Rheumatoid arthritis (RA) is an autoimmune disease in which T lymphocytes attack the cartilage of joints by secreting a protein, TNFα. When RA is untreated, joint damage increases considerably.

For Examiner's Use

The monoclonal antibody, infliximab, is used to treat RA. Infliximab specifically binds to TNFα.

A trial was set up to compare the effectiveness of infliximab and a standard treatment for RA, the anti-inflammatory drug, MTX.

Five groups of people with RA received the following treatments for one year:

- group **P** – MTX only
- group **Q** – MTX plus low dosage of infliximab at intervals of eight weeks
- group **R** – MTX plus low dosage of infliximab at intervals of four weeks
- group **S** – MTX plus high dosage of infliximab at intervals of eight weeks
- group **T** – MTX plus high dosage of infliximab at intervals of four weeks.

At the end of the year's treatment, the proportion of people in each group with increased joint damage was determined.

The results are shown in Fig. 2.2.

The number of people in each group is shown in brackets.

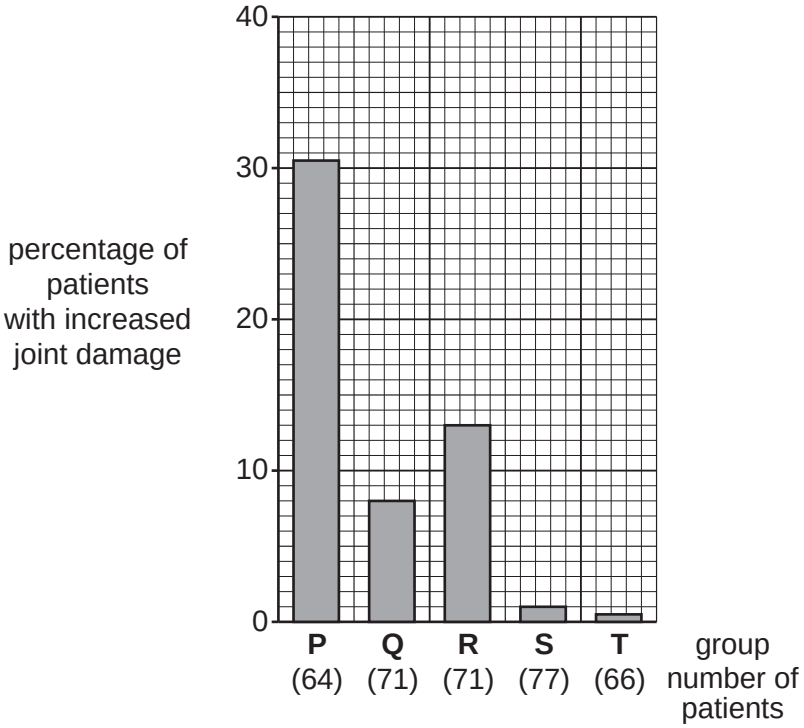


Fig. 2.2

With reference to Fig. 2.2:

For Examiner's Use

(i) describe the effect of infliximab treatment on these people

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(ii) suggest why the results in groups **Q** and **R** do not follow the general trend.

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(c) Explain the advantages of the use of monoclonal antibodies, compared with conventional methods, in the **diagnosis** of disease.

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[Total: 15]

For Examiner's Use

3 Variable number tandem repeats (VNTRs) are repetitive, non-coding sections of DNA. A particular VNTR is located at the same locus in different individuals, but the number of repeats in that VNTR varies between individuals.

(a) Explain how, in the process of genetic fingerprinting, gel electrophoresis is able to distinguish between the VNTRs that occur at the same loci of different individuals.

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..... [3]

(b) Gel electrophoresis is also used in genetic screening.

The mutation of the β-globin gene which gives rise to sickle cell anaemia removes a recognition site of a restriction enzyme, **R**, as shown in Fig. 3.1. **R** cuts DNA at the sites indicated by arrows (↓). The lengths of the resulting fragments are shown in kilobases (kb).

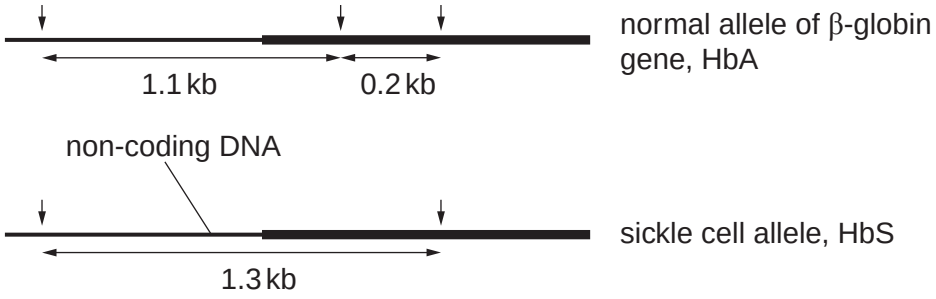


Fig. 3.1

Fig. 3.2 shows an electrophoresis gel with a stained band of DNA from an individual who was homozygous for the normal allele for β-globin, HbA HbA. This band is the 1.1 kb fragment shown in Fig. 3.1. The 0.2 kb fragment is **not** shown.

Complete Fig. 3.2 by drawing the stained DNA that would result from an individual who is heterozygous for the sickle cell allele, HbA HbS.

Put your answer on to Fig. 3.2. [2]

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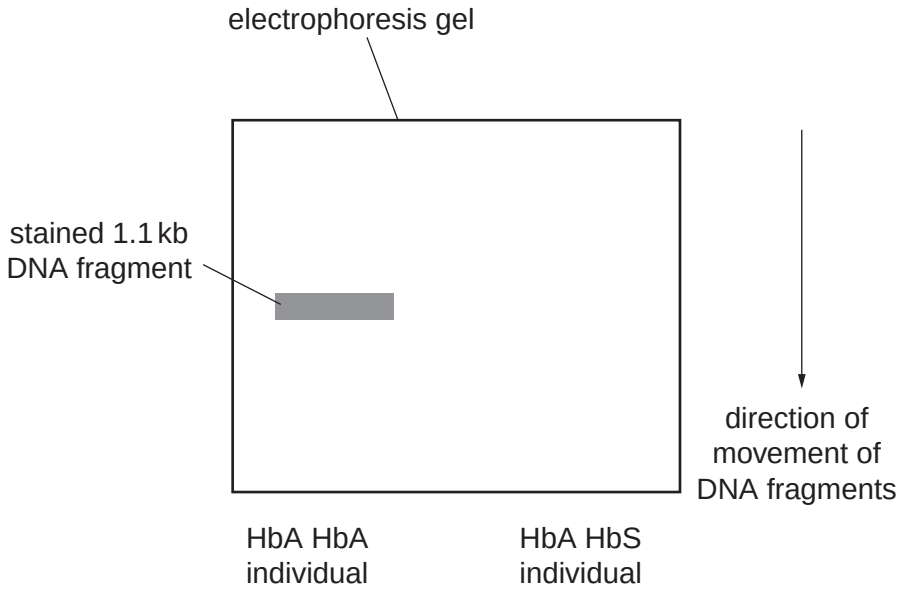


Fig. 3.2

(c) Describe the different circumstances in which this genetic screening for the sickle cell allele, HbS, might be used.

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[Total: 8]

For Examiner's Use

4 **(a)** Fig. 4.1 shows the structure of a male flower of maize, *Zea mays*.

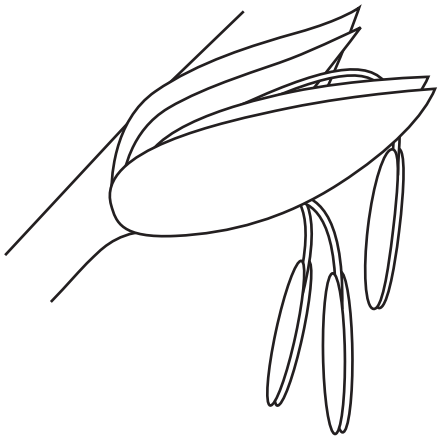


Fig. 4.1

With reference to Fig. 4.1, explain how **two** features of this flower adapt it for wind pollination.

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.....[2]

(b) The corn borer, *Ostrinia nubilalis,* is an insect pest of maize. The larvae are caterpillars that eat the leaves of the maize plants. The adults can fly. Adult corn borers do not feed on maize plants.

Much of the maize that is grown in the USA has been genetically modified to produce *Bt* toxin, which is lethal to insects that feed on the leaves. However, many populations of the corn borer have now evolved resistance to the *Bt* toxin.

Explain how this resistance could have evolved.

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.....[3]

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(c) The recessive allele, **r**, of the gene in corn borers confers resistance to *Bt* toxin. Larvae that are homozygous for the normal, dominant allele **R**, or that are heterozygous, are killed when they feed on *Bt* maize**.**

For Examiner's Use

State the genotype of the corn borers that successfully turn from larvae into adults in the fields where *Bt* maize is grown.

..... [1]

(d) In order to reduce the number of corn borers resistant to *Bt* toxin, farmers in the USA are required to grow up to 50% of their maize as non-*Bt* varieties. The non-*Bt* maize is grown in separate areas, called 'refuges', close to the fields of *Bt* maize. This is called the HDR strategy.

Almost all corn borer larvae feeding on this non-*Bt* maize have the genotypes **RR** or **Rr**. The HDR strategy assumes that, when these become adults, they will interbreed with the adults developing in the *Bt* maize fields.

Explain how the HDR strategy could reduce the proportion of corn borers that are resistant to the *Bt* toxin.

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(e) The HDR strategy works only if a high proportion of the adult corn borers developing in the *Bt* fields mate with adult corn borers from the non-*Bt* refuges. An investigation was carried out to determine the extent to which female corn borers mate with males from their own field, or from outside that field.

- Several hundred male and female adult corn borers were marked and then released into a maize field that contained no corn borers.
- After 36 hours, as many corn borers as possible were recaptured from the field and the number of marked and non-marked male and female corn borers was recorded.
- The percentage of the marked females that had mated with marked males was also recorded.
- This was repeated on four more occasions.

The results are shown in Table 4.1.

Table 4.1

trial	percentage of recaptured males that were marked	percentage of recaptured females that were marked	percentage of marked females that had mated	percentage of marked females that had mated with marked males
1	30	19	96	10
2	43	96	100	38
3	67	83	90	67
4	25	9	67	50
5	18	21	100	35

(i) With reference to the two shaded columns in Table 4.1, explain what the results indicate about the degree of mixing between corn borers from different fields.

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(ii) With reference to Table 4.1, suggest and explain the implications of the results of this investigation for the effectiveness of the HDR strategy.

For Examiner's Use

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[Total: 15]

5 **(a)** In girls, the first menstrual cycle occurs at the onset of puberty.

Outline the role of progesterone in the human menstrual cycle.

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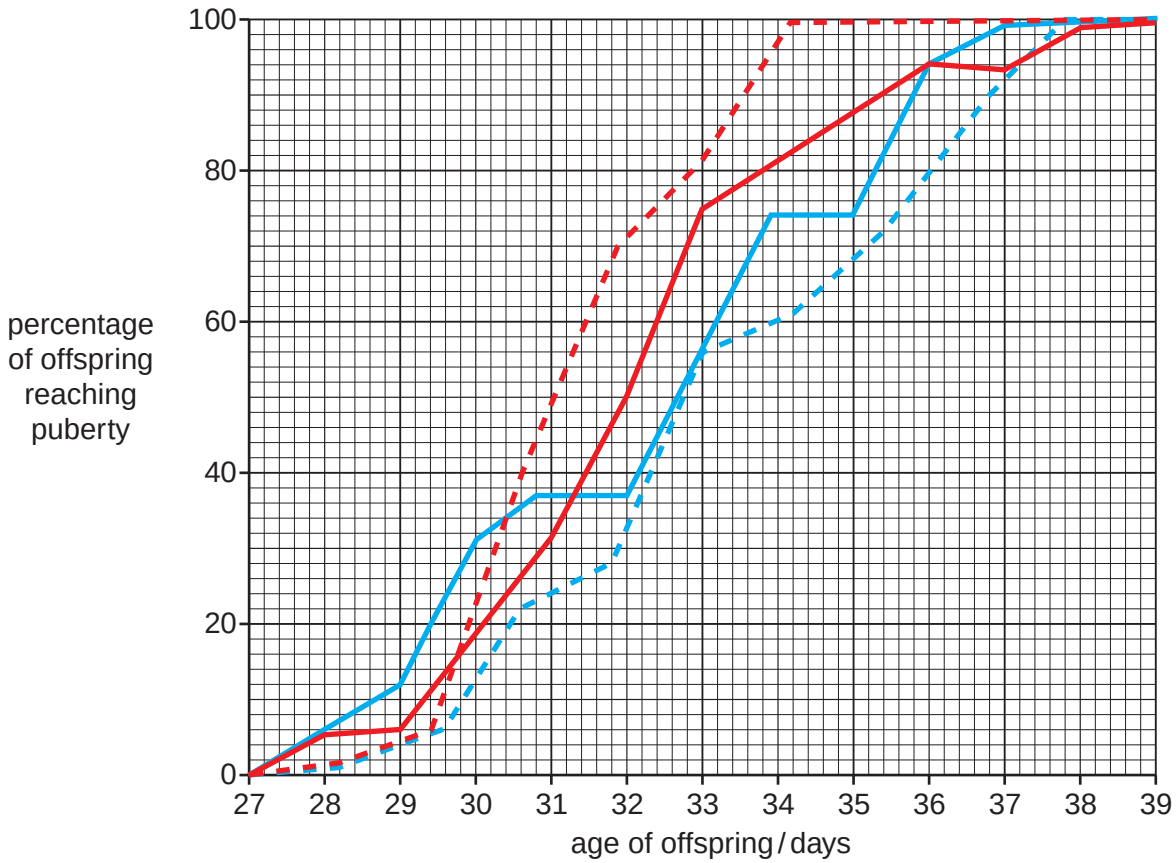
.....[3]

For Examiner's Use

(b) An investigation was carried out into the effect of the diet of pregnant female rats on the mean age of onset of puberty in their female offspring.

Pregnant female rats were fed either a high fat diet or a normal diet. Their offspring were also fed either a high fat diet or a normal diet. The percentage of offspring that had reached puberty was measured at intervals until the offspring were 39 days old.

The results are shown in Fig. 5.1.



Key:

	mother's diet	**offspring's diet**
———	high fat	high fat
- - -	high fat	normal
———	normal	high fat
- - -	normal	normal

Fig. 5.1

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(i) State the age at which 50% of offspring reached puberty when both the mother and her offspring ate a normal diet.

For Examiner's Use

.....[1]

(ii) During the 20th century, the average age of onset of puberty in European girls decreased from about 17 years to about 12 years of age. It has been suggested that a change to a richer diet is largely responsible for this decrease.

With reference to the data in Fig. 5.1, discuss the evidence that changes in diet may be responsible for this decrease in the age of onset of puberty in European girls.

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.....[4]

[Total: 8]

For Examiner's Use

6 **(a)** The plant *Rafflesia arnoldii*, which grows in the jungles of South East Asia, is noted for producing the largest flower of all plants.

- The flower is reddish-brown and can grow up to one metre in diameter.
- The flower gives off a smell similar to rotting flesh to attract flies, which then pollinate it.

Fig. 6.1 shows a flower of *R. arnoldii.*



Fig. 6.1

R. arnoldii is classified as an endangered species.

Suggest why *R. arnoldii* has become an endangered species.

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(b) (i) Explain the meaning of the term *biodiversity.*

For Examiner's Use

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(ii) Suggest reasons for maintaining **plant** biodiversity.

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[Total: 8]

For Examiner's Use

7 The fruit fly, *Drosophila melanogaster*, has many phenotypic variations and has been used in experiments to demonstrate the principles of inheritance.

(a) The majority of fruit flies have red eyes but there is a variant with white eyes.

Fig. 7.1 shows the red-eyed and white-eyed variants of the fruit fly.



Fig. 7.1

The gene for eye colour is located on the X chromosome.

Using suitable symbols, draw a genetic diagram to show the possible offspring of a cross between a heterozygous red-eyed female fruit fly with a white-eyed male fruit fly.

key to symbols:

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parental phenotypes	red-eyed female	white-eyed male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[5]

(b) One of the genes controlling the clotting of blood in humans is also located on the X chromosome. A rare variation of the gene, a recessive allele for haemophilia, can lead to a condition where the blood fails to clot properly.

For Examiner's Use

(i) State why a man who has haemophilia is unable to pass the condition on to his son.

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.....[1]

(ii) Queen Victoria of Great Britain in the 19th century was a carrier of haemophilia, but did not have the condition.

State the term used to describe the genotype of a carrier.

.....[1]

(iii) Neither of Queen Victoria's parents carried the allele for haemophilia.

Suggest how Queen Victoria could have become a carrier.

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.....[1]

[Total: 8]

For Examiner's Use

8 **(a)** Fig. 8.1 shows the effect of temperature on the rate of photosynthesis of a plant at a constant light intensity and a carbon dioxide concentration of 0.03%.

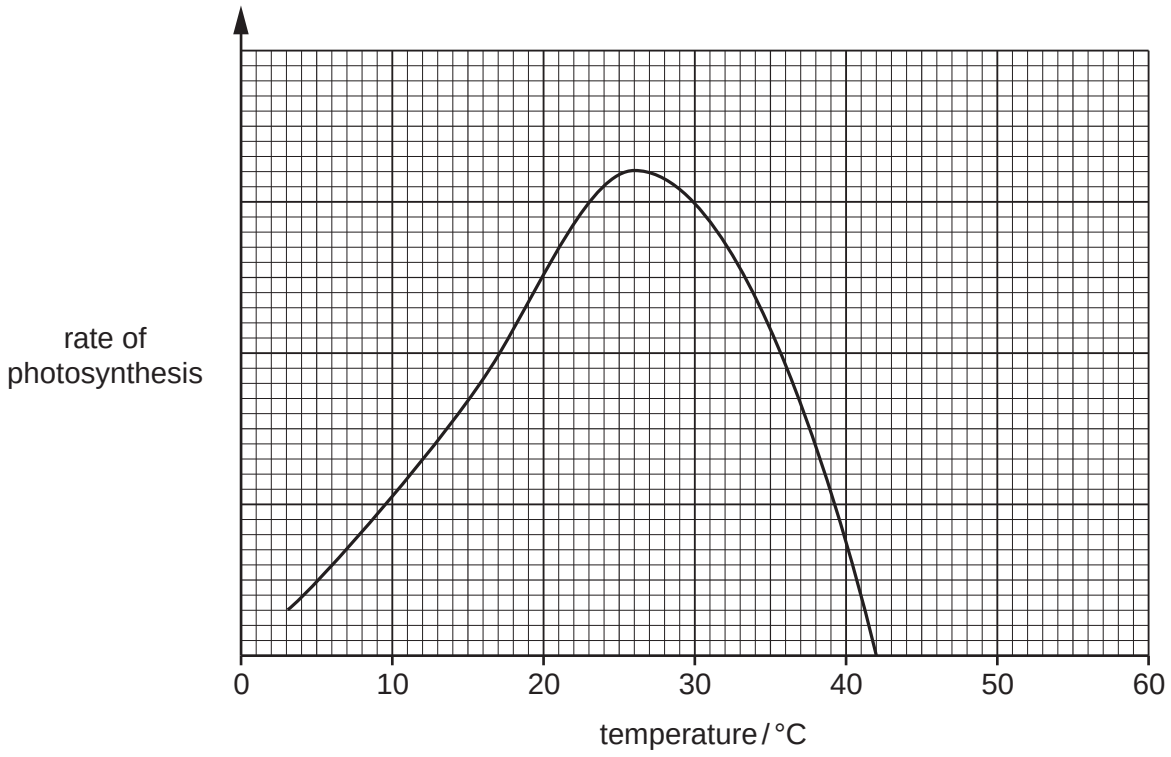


Fig. 8.1

(i) Suggest and explain why the rate of photosynthesis of the plant decreases to zero just above 40 °C.

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(ii) Draw, **on Fig. 8.1**, the likely curve if the same experiment were carried out on a C4 plant, such as sorghum.

For Examiner's Use

Give reasons to explain your curve.

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.....[3]

For Examiner's Use

(b) Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protoctist, *Chlorella*. A cell suspension of *Chlorella* was used.

- The suspension of *Chlorella* was illuminated at a light intensity of 5 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 10, 13 and 15 lux.
- The suspension was maintained at a temperature of 20 °C.

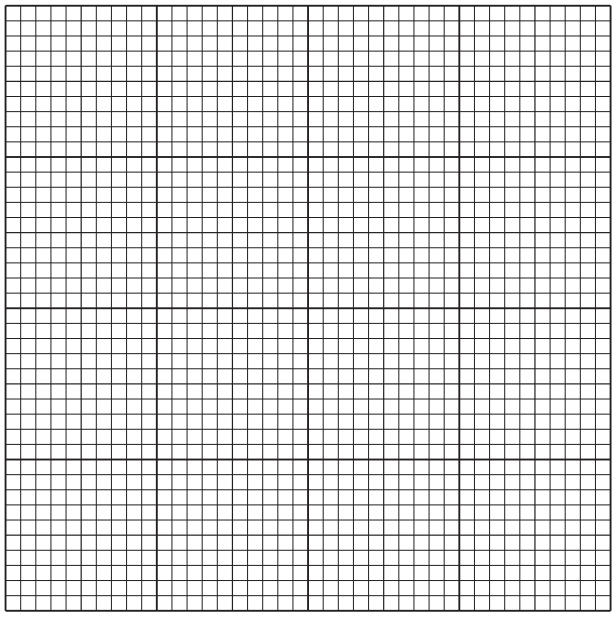
Table 8.1 shows the results of the experiments.

Table 8.1

light intensity / lux	**total CO_2 uptake after 20 seconds / μmol**	**rate of photosynthesis / μmol s^{-1}**
5	36	1.8
10	84	
13	104	
15	120	

(i) Complete Table 8.1. [1]

(ii) Use the data in the table to plot a graph on the grid below to show the effect of light intensity on the rate of photosynthesis.



[3]

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(iii) With reference to photosynthesis, state what is meant by a limiting factor.

For Examiner's Use

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.....[2]

(iv) State the limiting factor in these four experiments.

.....[1]

[Total: 15]

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Describe how ATP is synthesised by oxidative phosphorylation. [8]

(b) Using examples, outline the need for energy in living organisms. [7]

[Total: 15]

10 **(a)** Describe the structure of a kidney, including its associated blood vessels. [6]

(b) Describe the mechanisms involved in reabsorption in the proximal convoluted tubule **and** describe how the epithelial cells of the proximal convoluted tubule are adapted to carry out this process. [9]

[Total: 15]

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Question 1 Fig. 1.1 © Fair Isle Bird Observatory; www.fairislebirdobs.co.uk/Sightings/2006/PAAB/Greenish-Warbler1_19-08-06.jpg; 17/03/2010.
Question 6 Fig. 6.1 © KJELL B. SANDVED / SCIENCE PHOTO LIBRARY.

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BIOLOGY **9700/42**

Paper 4 A2 Structured Questions **May/June 2012**

2 hours

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Section A	
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9 or 10	
Total	

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Section A

Answer **all** the questions.

For Examiner's Use

1 The seahorse, *Hippocampus,* is an unusual small fish. It gives birth to live young and it is the male rather than the female that becomes pregnant.

Fig. 1.1 shows a seahorse.

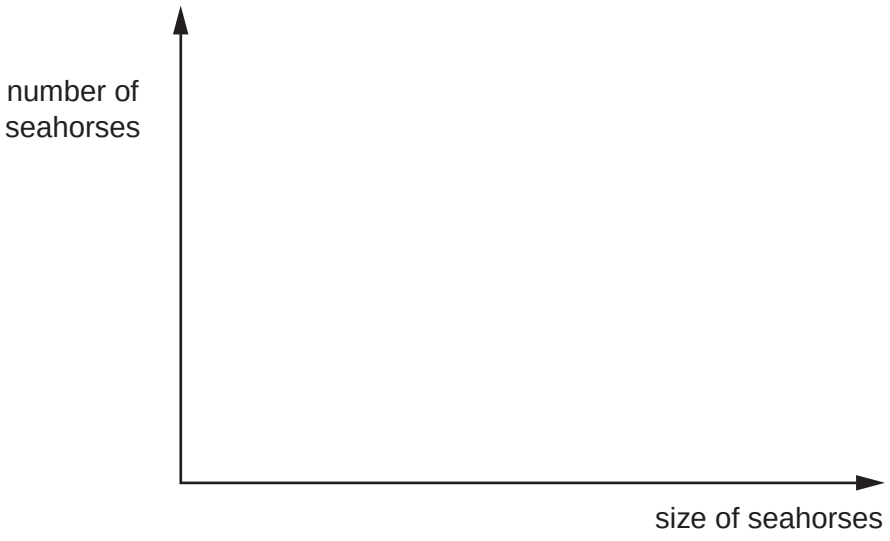


Fig. 1.1

(a) In one species of seahorse, a type of natural selection called disruptive selection occurs. This is where the extreme phenotypes are more likely to survive and reproduce than the intermediate phenotypes.

- Within a population, large females mate with large males and small females mate with small males.
- Few intermediate-sized individuals are produced and they have a low survival rate.

(i) Sketch a graph on the axes below to show the distribution in size of seahorses as a result of disruptive selection.



[2]

(ii) Explain how disruptive selection has been maintained in this species of seahorse.

For Examiner's Use

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(iii) State the term given to the type of selection where variation in a characteristic is maintained in its existing form over time.

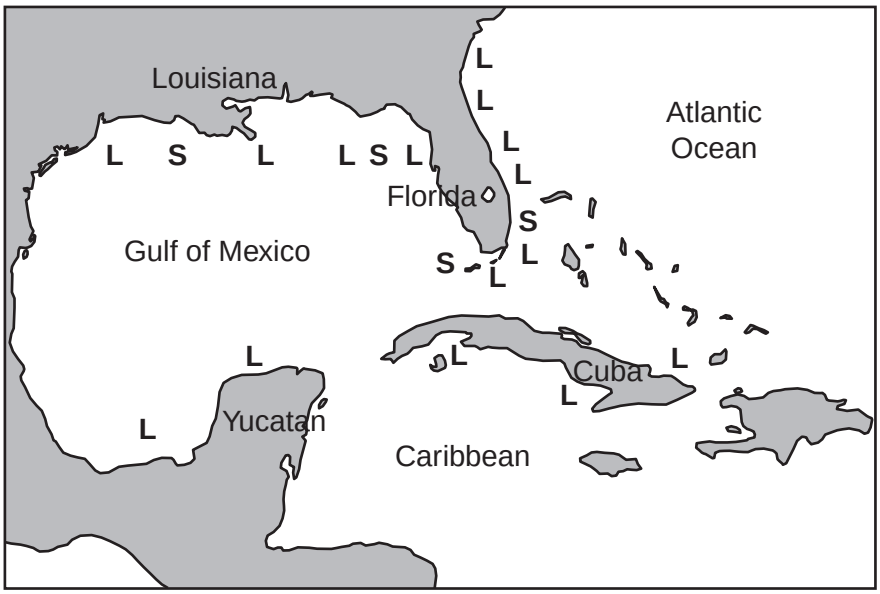
.....[1]

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[Turn over

(b) Two different species of seahorse are found in the coastal waters shown in Fig. 1.2.

For Examiner's Use



Key: L = large seahorse *H. erectus* **S** = small seahorse *H. zosterae*

Fig. 1.2

Suggest how these two different species of *Hippocampus* could have arisen.

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.....[2]

[Total: 8]

2 The bacterium, *Treponema pallidum*, causes the sexually-transmitted infectious disease, syphilis. If left untreated, the disease can be fatal, but early diagnosis can lead to successful treatment. One of the difficulties of diagnosing this disease in its early stages is the problem of recognising *T. pallidum* among the other species belonging to the genus *Treponema* that live in humans. These other treponemes are harmless.

For Examiner's Use

A mouse was injected with some cells of *T. pallidum*.

(a) Outline the steps that would then be necessary to produce a clone of hybridoma cells secreting an antibody against this bacterium.

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(b) A monoclonal antibody, H9-1, has been developed that is specific to a surface protein on *T. pallidum*, but which is not present on four other species of treponemes found in humans.

Each molecule of H9-1 carries a fluorescent yellow marker.

One of the first visible signs of syphilis is a painless sore.

Suggest how H9-1 is used in the diagnosis of syphilis, using a sample taken from a sore and placed on a microscope slide.

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For Examiner's Use

(c) Before the development of H9-1, two tests for the presence of *T. pallidum* were commonly used:

- dark-field microscopy (in which treponemes could be seen moving against a dark background)
- testing for the presence of anti-treponemal antibodies in the blood plasma.

Suggest why, in the **early** stages of an infection, the presence of *T. pallidum* might not be detected by either of these tests.

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..... [2]

(d) The accuracy of the diagnosis of infection by *T. pallidum* using H9-1 was compared with that using dark-field microscopy and with blood testing. The results are shown in Table 2.1.

A positive test result indicated that *T. pallidum* is present and a negative test result that it is absent.

Table 2.1

test	test results of 30 people later confirmed to have the infection	test results of 31 people later confirmed not to have the infection
H9-1	all positive	all negative
dark-field microscopy	one negative	two positive
blood test	three negative	two positive

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With reference to Table 2.1:

For Examiner's Use

(i) compare the accuracy of diagnosis of the presence of *T. pallidum* using the different tests

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(ii) suggest why blood testing for anti-treponemal antibodies gave two positive results in patients later found not to have the infection.

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(e) Describe briefly **one** use of a monoclonal antibody in the **treatment** of disease.

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[Total: 15]

For Examiner's Use

3 In order to sequence the DNA of a gene, it is first denatured to separate its two strands.

Then, in the presence of a large supply of each of the four nucleotides, the single-stranded DNA is replicated by DNA polymerase.

(a) Explain what determines the sequence of nucleotides in the newly replicated strand of DNA.

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.....[2]

(b) A low concentration of specially prepared nucleotides is also present. Once added to the chain, these nucleotides do **not** allow the chain to continue growing.

Each special nucleotide is labelled with a fluorescent dye, using a different colour for each of the four bases.

Fig. 3.1 shows a replicated DNA chain ending with one of the special nucleotides.

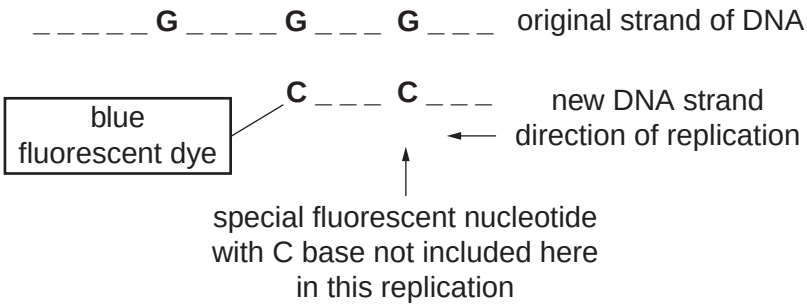


Fig. 3.1

With reference to Fig. 3.1 and to the information given, suggest why a special nucleotide with a C base was **not** included by DNA polymerase at the first site requiring a C nucleotide.

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.....[2]

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(c) This method of sequencing a gene produces as many DNA fragments as there are nucleotides in the gene, each fragment differing in length by one nucleotide.

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Fig. 3.2 shows part of a set of such fragments.

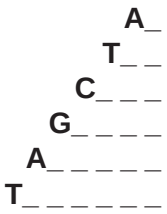


Fig. 3.2

These fragments are loaded onto a sequencing gel, shown in Fig. 3.3, and separated by electrophoresis.

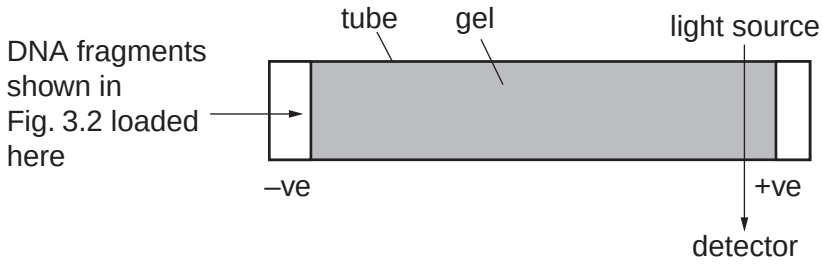


Fig. 3.3

(i) In what order will the fragments shown in Fig. 3.2 reach the light source and detector shown in Fig. 3.3?

.....

..... [1]

(ii) Explain how gel electrophoresis separates these fragments of DNA.

.....

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..... [3]

[Total: 8]

For Examiner's Use

4 Golden Rice™ is a genetically modified form of rice that produces relatively large amounts of β carotene in the endosperm. β carotene is metabolised in the human body to produce vitamin A.

(a) Explain why rice has been genetically modified to produce extra β carotene.

.....

.....

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.....[2]

(b) The first types of Golden Rice™ produced only a very low mass of β carotene per gram of rice. Research continued to try to increase this.

Fig. 4.1 shows the metabolic pathway by which β carotene is synthesised in plants, and the enzymes that catalyse each step of the pathway.

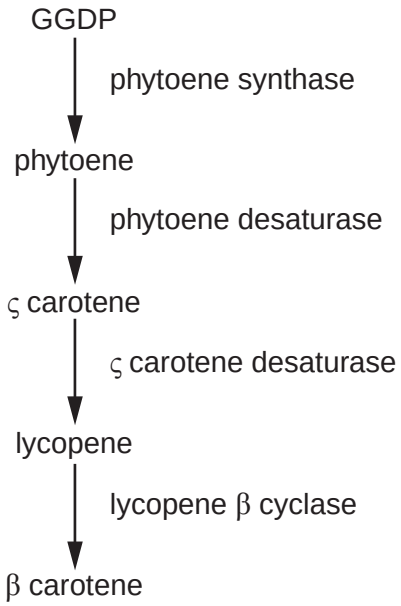


Fig. 4.1

For Examiner's Use

The first types of Golden Rice™ contained a phytoene synthase gene, *psy*, from daffodils and a gene *crtI*, which produced the two desaturase enzymes, from the bacterium *Erwinia uredovora.*

Measurements of the quantities of intermediates in this metabolic pathway in rice endosperm showed that there was always a large amount of GGDP present, and that no phytoene accumulated in the tissues.

Explain how this suggests it was **not** the enzymes produced by the *crtI* gene that were limiting the production of β carotene.

.....

.....

.....

.....[2]

(c) Investigations were carried out to see if *psy* genes taken from species other than daffodils would enable rice endosperm to produce greater quantities of β carotene than the first types of Golden Rice™.

- *Psy* genes were isolated from the DNA of maize, tomatoes, peppers and daffodils. The genes were inserted into different plasmids.
- The promoter *Ubi* 1, and *crtI* genes from *E. uredovora*, were also inserted into all of the plasmids.
- The four types of genetically modified plasmids were then inserted into different cultures of rice cells.
- The quantity of β carotene produced by these rice cells was measured.

The results are shown in Table 4.1.

Table 4.1

source of *psy* gene	**total β carotene content of rice cells / arbitrary units**
maize	14
pepper	4
tomato	6
daffodil	1

(i) Name the type of enzyme that would have been used to cut the *psy* gene out of the DNA of the plant cells.

.....[1]

(ii) Explain why a promoter was inserted into the plasmids.

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.....

.....

.....[2]

(iii) Explain whether or not these results support the hypothesis that the *psy* gene, not the *crtI* gene, was limiting the production of β carotene in genetically modified rice.

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.....[2]

(d) The original choice of a *psy* gene from daffodils was made because daffodils produce large amounts of β carotene in their yellow petals, and because they are monocotyledonous plants, like rice.

Suggest explanations for the much lower production of β carotene in rice containing the *psy* gene from daffodils than in rice containing the *psy* gene from maize.

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.....[2]

(e) Describe the possible disadvantages of growing Golden Rice™.

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.....[3]

[Total: 14]

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Question 5 starts on page 14

For Examiner's Use

5 **(a)** Outline the biological basis of the effect of the contraceptive pill.

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..... [2]

(b) In Uganda, many children are infected with HIV from their mothers. This is called vertical HIV transmission.

Uganda has used two ways of trying to reduce vertical HIV transmission. These methods are

- to increase the use of antiretroviral drugs (ARVs) by HIV-infected pregnant women
- to reduce, through contraception, the numbers of unwanted pregnancies.

Table 5.1 shows the percentage reductions in the number of children born with HIV infections and the number of pregnancies in HIV-infected women, that were brought about as a result of the use of ARVs and contraception in 2007.

Table 5.1 also shows the predicted reductions in 2012 if usage of ARVs and contraception increase as expected.

Table 5.1

	percentage reduction caused			
	by use of ARVs		**by contraception**	
	in 2007	predicted in 2012	in 2007	predicted in 2012
pregnancies in HIV-infected women	0	0	21.7	34.0
births of HIV-infected children	8.1	18.1	21.6	32.9

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(i) It is estimated that if no ARVs had been used in 2007, 27 000 children would have been born with HIV infection.

Calculate the actual number of children born with HIV infection in 2007.

Show your working.

answer .....[2]

(ii) With reference to Table 5.1, explain the difference between the effects of ARVs and contraception on the numbers of pregnancies in HIV-infected women.

.....

.....

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.....[2]

(iii) There is only a limited amount of money to spend on HIV prevention in Uganda.

With reference to Table 5.1, suggest arguments for spending at least as much money on increasing access to contraception as on providing ARVs to HIV-infected pregnant women.

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.....[3]

[Total: 9]

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[Turn over

For Examiner's Use

6 **(a)** The Millennium Seed Bank is located in the UK. So far it has successfully stored seeds from 10% of the world's wild plant species.

(i) Suggest the benefits to humans of conserving plant species.

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.....[3]

(ii) In the wild, seeds may be subjected to conditions that can be hostile to successful germination and growth.

Suggest how the seeds should be stored in the seed bank to keep them viable for future use.

.....

.....[1]

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(b) Plant biodiversity varies throughout the world and is dependent on many factors, particularly climate.

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Fig. 6.1 shows the relationship between the number of plant genera and the mean annual rainfall in seven countries.

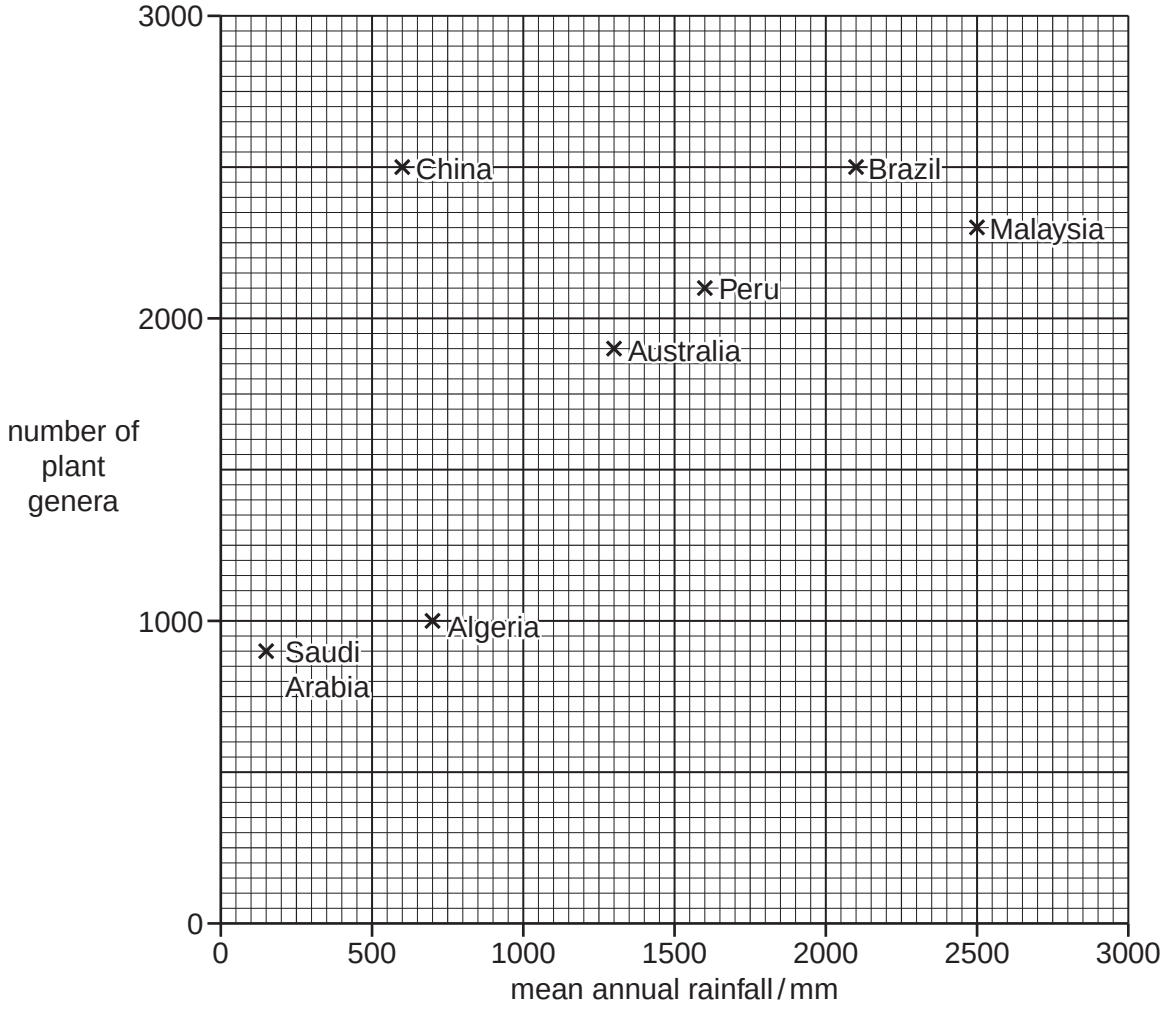


Fig. 6.1

(i) Describe the relationship between the number of plant genera and the mean annual rainfall in these seven countries.

.....

.....

.....

.....[2]

(ii) Suggest what other climatic factors, apart from rainfall, affect plant biodiversity.

.....

.....

.....

.....[2]

[Total: 8]

For Examiner's Use

7 **(a)** Explain what is meant by the term *heterozygous genotype*.

heterozygous .....

.....

genotype .....

.....[2]

(b) The budgerigar, *Melopsittacus undulatus*, is a small type of parrot that is native to Australia.

Fig. 7.1 shows a budgerigar.



Fig. 7.1

A budgerigar can have blue, green, yellow or white feathers.

Two genes, **A**/**a** and **D**/**d**, are involved in the inheritance of feather colour in budgerigars.

- A bird which has at least one dominant allele **A** but is homozygous for **d** has blue feathers.
- A bird which has at least one dominant allele **D** but is homozygous for **a** has yellow feathers.
- A bird with at least one dominant **A** allele **and** one dominant **D** allele has green feathers.
- A bird that is homozygous for **a** and **d** has white feathers.

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(c) Two green-feathered budgerigars, heterozygous at both gene loci, were crossed.

Draw a genetic diagram of this cross to show the probability of producing offspring with yellow feathers.

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[6]

[Total: 8]

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Question 8 starts on page 21

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8 Fig. 8.1 shows a diagram of a stoma, its guard cells and adjacent epidermal cells.

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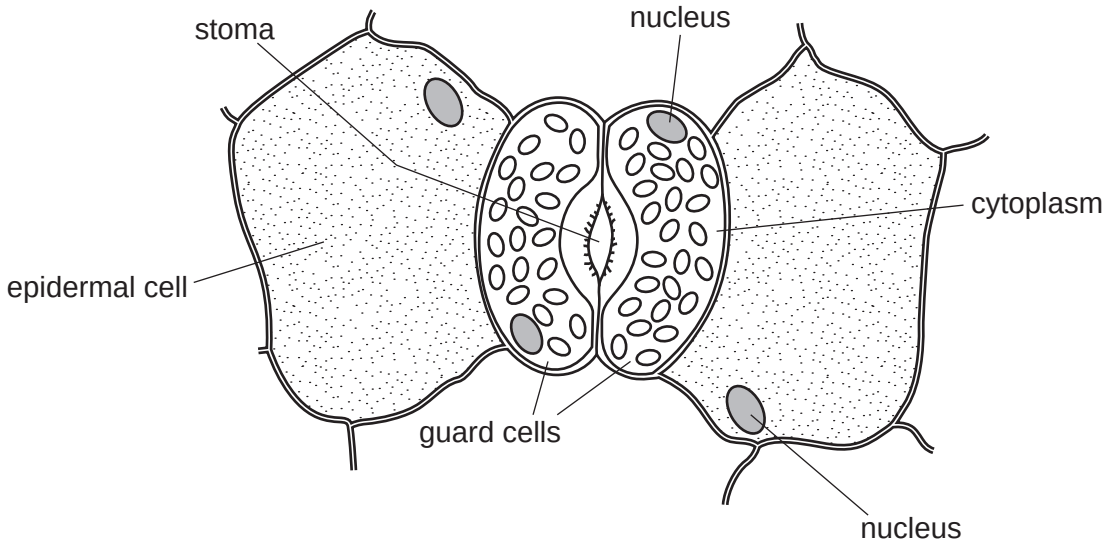


Fig. 8.1

(a) Guard cells have chloroplasts while epidermal cells do not have chloroplasts.

State **one other** difference, visible in Fig. 8.1, between guard cells and epidermal cells.

.....

..... [1]

(b) During stomatal closure:

(i) state precisely where abscisic acid (ABA) binds

..... [1]

(ii) identify the ion that diffuses from the guard cells to epidermal cells

..... [1]

(iii) compare the relative water potential of the guard cells with that of epidermal cells

..... [1]

(iv) describe the change in volume of the guard cells.

..... [1]

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(c) The following experiment was carried out to investigate the effect of light intensity on the rate of photosynthesis of a water plant, *Elodea.*

- *Elodea* was cut into three pieces, each 10 cm long.
- Each piece of *Elodea* was placed in a glass tube, containing 0.5% sodium hydrogencarbonate solution, which was then sealed with a bung.
- Tube **A** was placed 10 cm away from a lamp.
- Tube **B** was placed 5 cm away from a lamp.
- Tube **C** was placed in a dark room.
- An oxygen sensor was used to measure the percentage of oxygen in the solutions at the start of the experiment and again at 5, 10 and 20 minutes.

The results are shown in Fig. 8.2.

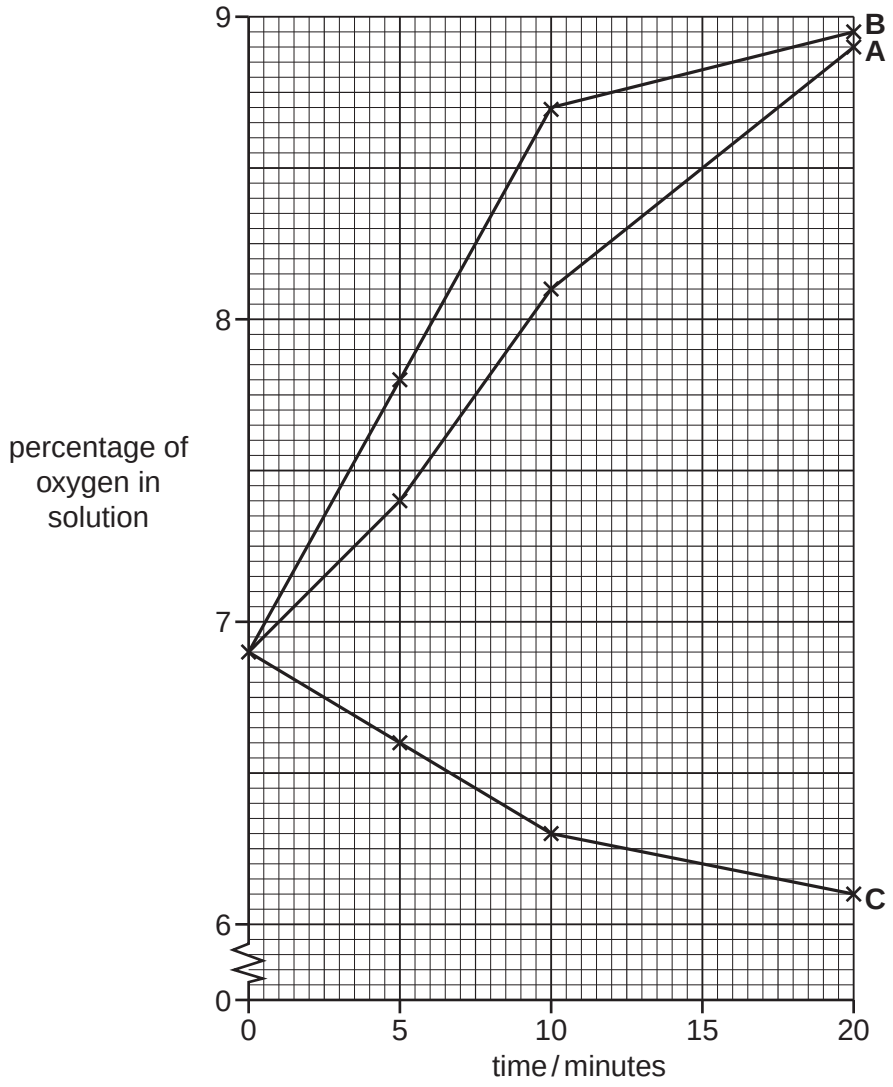


Fig. 8.2

(i) State why sodium hydrogencarbonate solution was used.

For Examiner's Use

.....

.....[1]

(ii) Calculate the mean rate of oxygen production for tube **A** for the 20 minutes of the experiment.

Show your working.

answer .....[2]

(iii) Compare the results for tubes **A** and **B**.

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.....[2]

(iv) Explain the results for tube **C**.

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.....[2]

(v) Suggest what factor, which may have an effect on the rate of photosynthesis, was **not** taken into account in this experiment.

.....[1]

(d) Fig. 8.3 shows the relationship between the light-dependent and light-independent reactions in a chloroplast.

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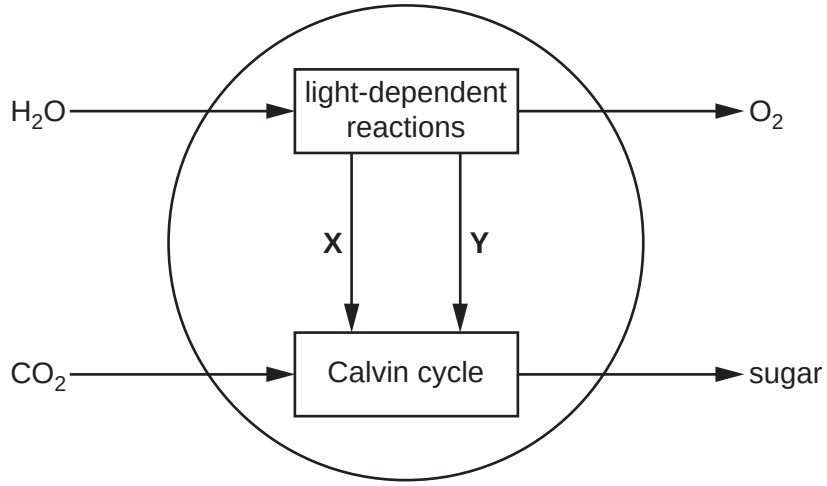


Fig. 8.3

Name the substances **X** and **Y** in Fig. 8.3.

X .....

Y ..... [2]

[Total: 15]

Section B

Answer **one** question.

For Examiner's Use

9 **(a)** Explain the role of ATP in active transport of ions **and** in named anabolic reactions. [7]

(b) Outline the process of anaerobic respiration in both mammal and yeast cells. [8]

[Total: 15]

10 **(a)** Outline, with reference to blood glucose concentration, the principles of homeostasis in mammals. [6]

(b) Describe the roles of the endocrine and nervous systems in control and coordination in mammals. [9]

[Total: 15]

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General Certificate of Education Advanced Level

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BIOLOGY **9700/43**

Paper 4 A2 Structured Questions **May/June 2012**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

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 ink.
You may use a pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions in Section A and **one** question from Section B.
Circle the number of the Section B question you have answered in the grid below.

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.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **24** printed pages and **4** lined pages.

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Section A

For Examiner's Use

Answer **all** the questions.

1 The greenish warbler, *Phylloscopus trochiloides*, is a species of small bird that originated in northern India, on the southern edge of the Himalayan mountain range.

Fig. 1.1 shows a greenish warbler.



Fig. 1.1

Thousands of years ago, populations of the greenish warbler spread around the western and eastern edges of the Himalayan mountain range to establish themselves in north-eastern Europe and Siberia.

- A gradual change in characteristics occurred in these populations, leading to different forms of the greenish warbler.
- One example of gradual change is in the song of the male warbler, which is very distinctive and is used in mating behaviour.
- When greenish warblers from north-eastern Europe meet those from Siberia no mating takes place.
- The greenish warblers from north-eastern Europe and Siberia are now considered to be two separate species.

Fig. 1.2 shows the spread of the greenish warbler.

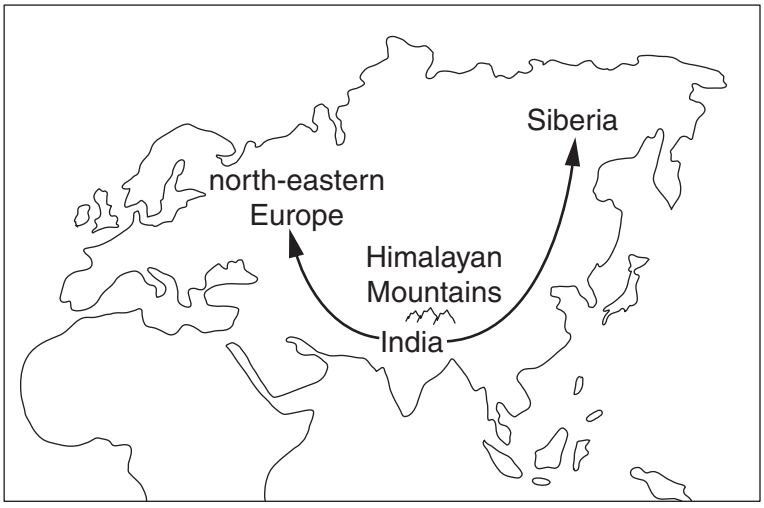


Fig. 1.2

(a) Explain what is meant by the term *species.*

For Examiner's Use

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.....[2]

(b) State the likely isolating mechanism taking place in populations of the greenish warbler.

.....[1]

(c) Explain how the process of speciation occurred in the greenish warbler populations.

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.....[5]

[Total: 8]

2 Some of the steps in the production of monoclonal antibodies are shown in Fig. 2.1.

For Examiner's Use

step 1
A mouse is injected with an antigen, A.

↓

step 2
The mouse is left for a few weeks to allow an immune response to occur.

↓

step 3
Plasma cells (effector B lymphocytes) are extracted from the mouse's spleen.

↓

step 4
Hybridoma cells are formed.

↓

step 5
Each hybridoma cell is isolated and allowed to grow and divide.

↓

step 6
The hybridoma cells producing anti-A antibodies are identified and cultured on a large scale.

Fig. 2.1

(a) With reference to Fig. 2.1, explain:

(i) what happens during an immune response (**step 2**)

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.....[4]

(ii) what is meant by a hybridoma cell (**step 4**)

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.....[1]

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(iii) why hybridoma cells need to be formed (**step 4**)

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.....[2]

(iv) how hybridoma cells producing anti-A antibody can be identified.

.....

.....[1]

(b) Rheumatoid arthritis (RA) is an autoimmune disease in which T lymphocytes attack the cartilage of joints by secreting a protein, TNFα. When RA is untreated, joint damage increases considerably.

For Examiner's Use

The monoclonal antibody, infliximab, is used to treat RA. Infliximab specifically binds to TNFα.

A trial was set up to compare the effectiveness of infliximab and a standard treatment for RA, the anti-inflammatory drug, MTX.

Five groups of people with RA received the following treatments for one year:

- group **P** – MTX only
- group **Q** – MTX plus low dosage of infliximab at intervals of eight weeks
- group **R** – MTX plus low dosage of infliximab at intervals of four weeks
- group **S** – MTX plus high dosage of infliximab at intervals of eight weeks
- group **T** – MTX plus high dosage of infliximab at intervals of four weeks.

At the end of the year's treatment, the proportion of people in each group with increased joint damage was determined.

The results are shown in Fig. 2.2.

The number of people in each group is shown in brackets.

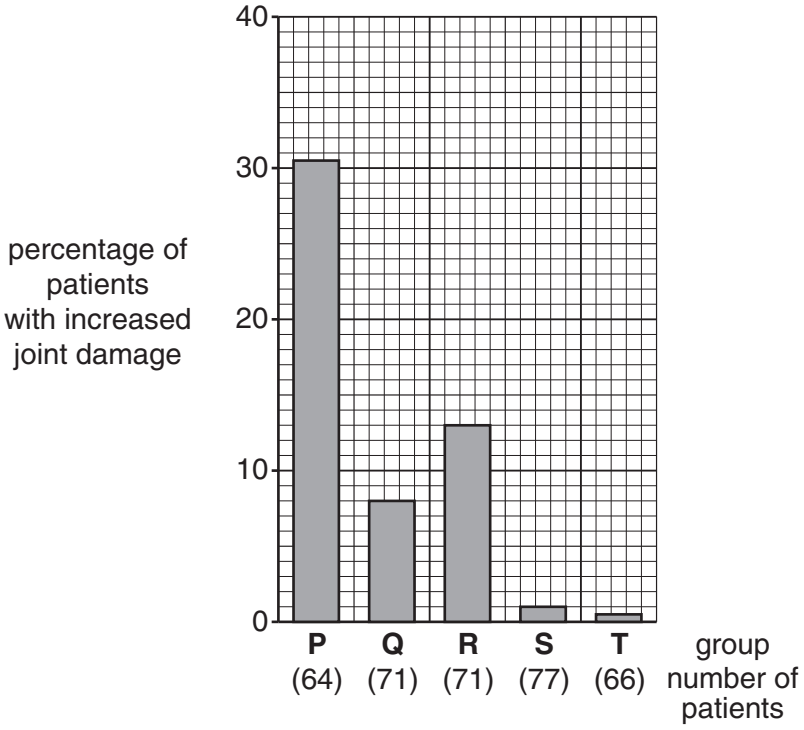


Fig. 2.2

With reference to Fig. 2.2:

For Examiner's Use

(i) describe the effect of infliximab treatment on these people

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.....[3]

(ii) suggest why the results in groups **Q** and **R** do not follow the general trend.

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.....[1]

(c) Explain the advantages of the use of monoclonal antibodies, compared with conventional methods, in the **diagnosis** of disease.

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.....[3]

[Total: 15]

For Examiner's Use

3 Variable number tandem repeats (VNTRs) are repetitive, non-coding sections of DNA. A particular VNTR is located at the same locus in different individuals, but the number of repeats in that VNTR varies between individuals.

(a) Explain how, in the process of genetic fingerprinting, gel electrophoresis is able to distinguish between the VNTRs that occur at the same loci of different individuals.

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..... [3]

(b) Gel electrophoresis is also used in genetic screening.

The mutation of the β-globin gene which gives rise to sickle cell anaemia removes a recognition site of a restriction enzyme, **R**, as shown in Fig. 3.1. **R** cuts DNA at the sites indicated by arrows (↓). The lengths of the resulting fragments are shown in kilobases (kb).

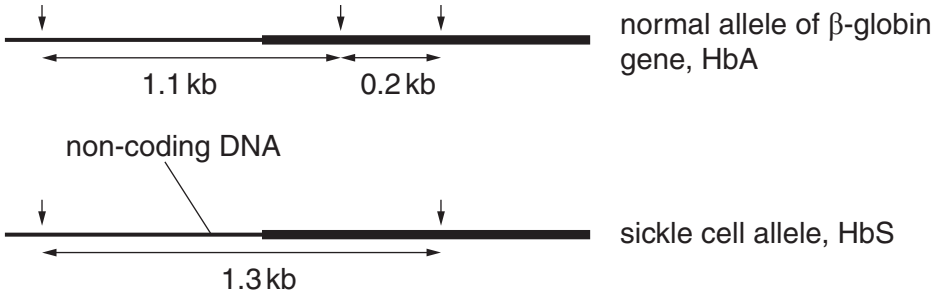


Fig. 3.1

Fig. 3.2 shows an electrophoresis gel with a stained band of DNA from an individual who was homozygous for the normal allele for β-globin, HbA HbA. This band is the 1.1 kb fragment shown in Fig. 3.1. The 0.2 kb fragment is **not** shown.

Complete Fig. 3.2 by drawing the stained DNA that would result from an individual who is heterozygous for the sickle cell allele, HbA HbS.

Put your answer on to Fig. 3.2. [2]

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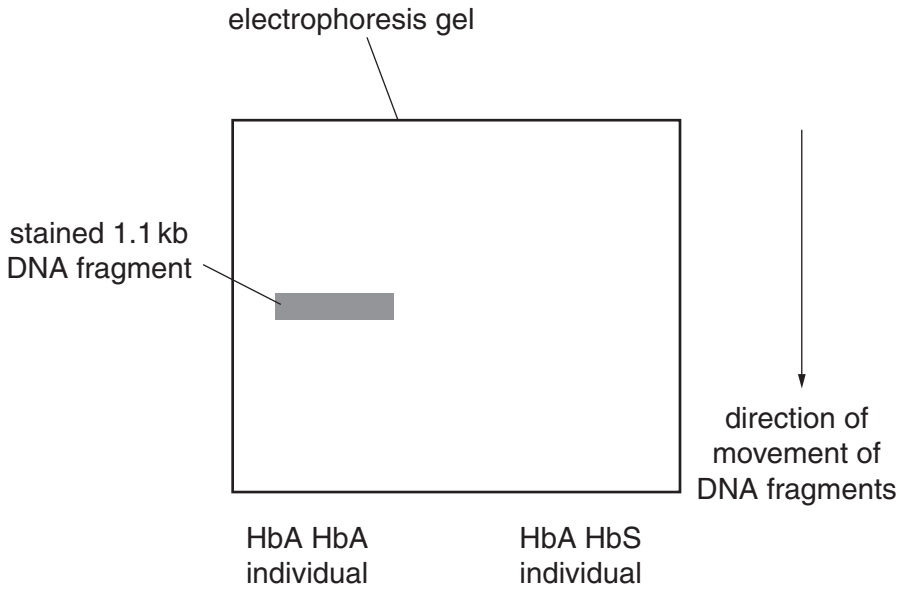


Fig. 3.2

(c) Describe the different circumstances in which this genetic screening for the sickle cell allele, HbS, might be used.

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.....[3]

[Total: 8]

4 **(a)** Fig. 4.1 shows the structure of a male flower of maize, *Zea mays*.

For Examiner's Use

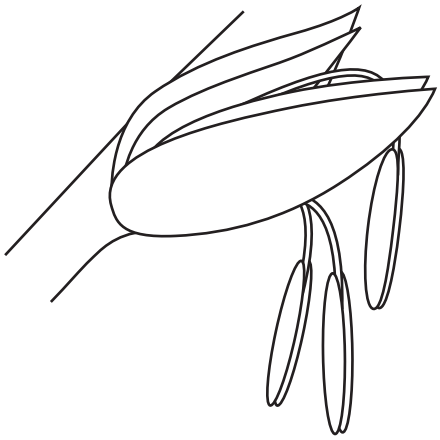


Fig. 4.1

With reference to Fig. 4.1, explain how **two** features of this flower adapt it for wind pollination.

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.....[2]

(b) The corn borer, *Ostrinia nubilalis,* is an insect pest of maize. The larvae are caterpillars that eat the leaves of the maize plants. The adults can fly. Adult corn borers do not feed on maize plants.

Much of the maize that is grown in the USA has been genetically modified to produce *Bt* toxin, which is lethal to insects that feed on the leaves. However, many populations of the corn borer have now evolved resistance to the *Bt* toxin.

Explain how this resistance could have evolved.

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.....[3]

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(c) The recessive allele, **r**, of the gene in corn borers confers resistance to *Bt* toxin. Larvae that are homozygous for the normal, dominant allele **R**, or that are heterozygous, are killed when they feed on *Bt* maize**.**

For Examiner's Use

State the genotype of the corn borers that successfully turn from larvae into adults in the fields where *Bt* maize is grown.

..... [1]

(d) In order to reduce the number of corn borers resistant to *Bt* toxin, farmers in the USA are required to grow up to 50% of their maize as non-*Bt* varieties. The non-*Bt* maize is grown in separate areas, called 'refuges', close to the fields of *Bt* maize. This is called the HDR strategy.

Almost all corn borer larvae feeding on this non-*Bt* maize have the genotypes **RR** or **Rr**. The HDR strategy assumes that, when these become adults, they will interbreed with the adults developing in the *Bt* maize fields.

Explain how the HDR strategy could reduce the proportion of corn borers that are resistant to the *Bt* toxin.

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..... [2]

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[Turn over

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(e) The HDR strategy works only if a high proportion of the adult corn borers developing in the *Bt* fields mate with adult corn borers from the non-*Bt* refuges. An investigation was carried out to determine the extent to which female corn borers mate with males from their own field, or from outside that field.

- Several hundred male and female adult corn borers were marked and then released into a maize field that contained no corn borers.
- After 36 hours, as many corn borers as possible were recaptured from the field and the number of marked and non-marked male and female corn borers was recorded.
- The percentage of the marked females that had mated with marked males was also recorded.
- This was repeated on four more occasions.

The results are shown in Table 4.1.

Table 4.1

trial	percentage of recaptured males that were marked	percentage of recaptured females that were marked	percentage of marked females that had mated	percentage of marked females that had mated with marked males
1	30	19	96	10
2	43	96	100	38
3	67	83	90	67
4	25	9	67	50
5	18	21	100	35

(i) With reference to the two shaded columns in Table 4.1, explain what the results indicate about the degree of mixing between corn borers from different fields.

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.....[3]

(ii) With reference to Table 4.1, suggest and explain the implications of the results of this investigation for the effectiveness of the HDR strategy.

For Examiner's Use

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.....[4]

[Total: 15]

5 **(a)** In girls, the first menstrual cycle occurs at the onset of puberty.

Outline the role of progesterone in the human menstrual cycle.

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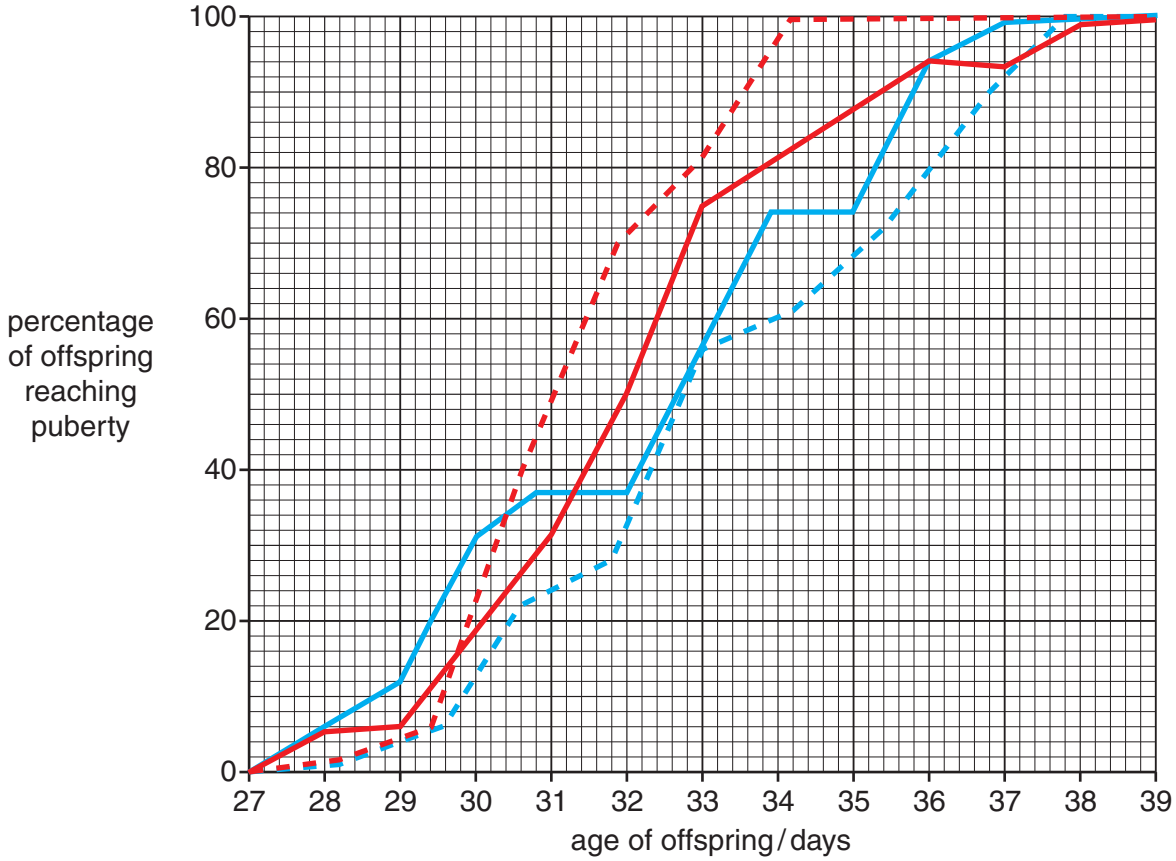
.....[3]

(b) An investigation was carried out into the effect of the diet of pregnant female rats on the mean age of onset of puberty in their female offspring.

For Examiner's Use

Pregnant female rats were fed either a high fat diet or a normal diet. Their offspring were also fed either a high fat diet or a normal diet. The percentage of offspring that had reached puberty was measured at intervals until the offspring were 39 days old.

The results are shown in Fig. 5.1.



Key:

	mother's diet	**offspring's diet**
———	high fat	high fat
- - -	high fat	normal
———	normal	high fat
- - -	normal	normal

Fig. 5.1

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(i) State the age at which 50% of offspring reached puberty when both the mother and her offspring ate a normal diet.

For Examiner's Use

.....[1]

(ii) During the 20th century, the average age of onset of puberty in European girls decreased from about 17 years to about 12 years of age. It has been suggested that a change to a richer diet is largely responsible for this decrease.

With reference to the data in Fig. 5.1, discuss the evidence that changes in diet may be responsible for this decrease in the age of onset of puberty in European girls.

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.....[4]

[Total: 8]

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[Turn over

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6 **(a)** The plant *Rafflesia arnoldii*, which grows in the jungles of South East Asia, is noted for producing the largest flower of all plants.

- The flower is reddish-brown and can grow up to one metre in diameter.
- The flower gives off a smell similar to rotting flesh to attract flies, which then pollinate it.

Fig. 6.1 shows a flower of *R. arnoldii.*



Fig. 6.1

R. arnoldii is classified as an endangered species.

Suggest why *R. arnoldii* has become an endangered species.

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..... [3]

(b) (i) Explain the meaning of the term *biodiversity.*

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.....[1]

(ii) Suggest reasons for maintaining **plant** biodiversity.

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.....[4]

[Total: 8]

For Examiner's Use

7 The fruit fly, *Drosophila melanogaster*, has many phenotypic variations and has been used in experiments to demonstrate the principles of inheritance.

(a) The majority of fruit flies have red eyes but there is a variant with white eyes.

Fig. 7.1 shows the red-eyed and white-eyed variants of the fruit fly.



Fig. 7.1

The gene for eye colour is located on the X chromosome.

Using suitable symbols, draw a genetic diagram to show the possible offspring of a cross between a heterozygous red-eyed female fruit fly with a white-eyed male fruit fly.

key to symbols:

.....

.....

parental phenotypes	red-eyed female	white-eyed male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[5]

(b) One of the genes controlling the clotting of blood in humans is also located on the X chromosome. A rare variation of the gene, a recessive allele for haemophilia, can lead to a condition where the blood fails to clot properly.

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(i) State why a man who has haemophilia is unable to pass the condition on to his son.

.....

.....[1]

(ii) Queen Victoria of Great Britain in the 19th century was a carrier of haemophilia, but did not have the condition.

State the term used to describe the genotype of a carrier.

.....[1]

(iii) Neither of Queen Victoria's parents carried the allele for haemophilia.

Suggest how Queen Victoria could have become a carrier.

.....

.....[1]

[Total: 8]

8 **(a)** Fig. 8.1 shows the effect of temperature on the rate of photosynthesis of a plant at a constant light intensity and a carbon dioxide concentration of 0.03%.

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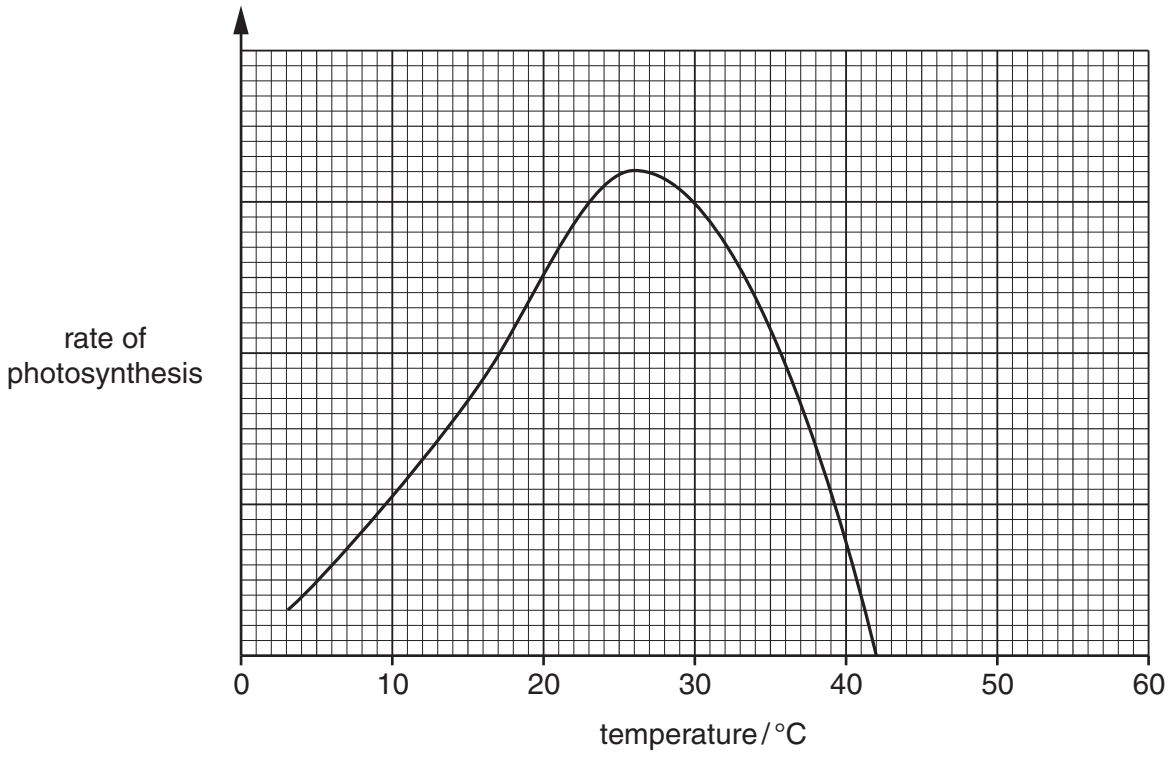


Fig. 8.1

(i) Suggest and explain why the rate of photosynthesis of the plant decreases to zero just above 40 °C.

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..... [5]

(ii) Draw, **on Fig. 8.1**, the likely curve if the same experiment were carried out on a C4 plant, such as sorghum.

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Give reasons to explain your curve.

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.....[3]

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(b) Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protoctist, *Chlorella*. A cell suspension of *Chlorella* was used.

- The suspension of *Chlorella* was illuminated at a light intensity of 5 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 10, 13 and 15 lux.
- The suspension was maintained at a temperature of 20 °C.

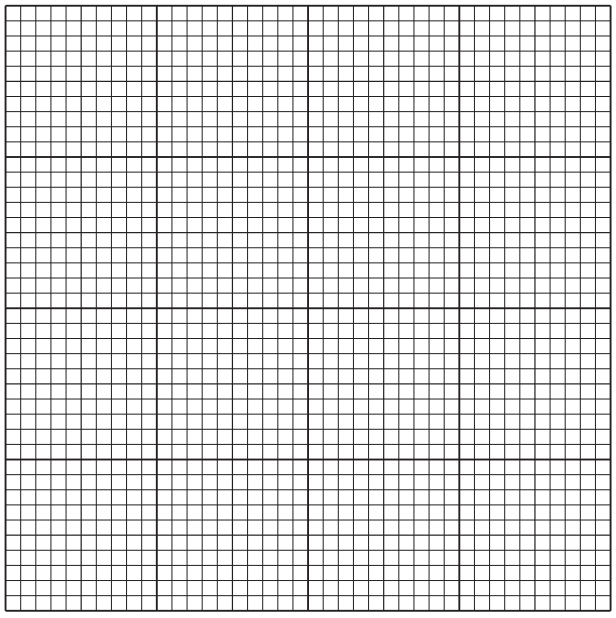
Table 8.1 shows the results of the experiments.

Table 8.1

light intensity / lux	**total CO_2 uptake after 20 seconds / μmol**	**rate of photosynthesis / μmol s^{-1}**
5	36	1.8
10	84	
13	104	
15	120	

(i) Complete Table 8.1. [1]

(ii) Use the data in the table to plot a graph on the grid below to show the effect of light intensity on the rate of photosynthesis.



[3]

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(iii) With reference to photosynthesis, state what is meant by a limiting factor.

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.....[2]

(iv) State the limiting factor in these four experiments.

.....[1]

[Total: 15]

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Section B

Answer **one** question.

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9 **(a)** Describe how ATP is synthesised by oxidative phosphorylation. [8]

(b) Using examples, outline the need for energy in living organisms. [7]

[Total: 15]

10 **(a)** Describe the structure of a kidney, including its associated blood vessels. [6]

(b) Describe the mechanisms involved in reabsorption in the proximal convoluted tubule **and** describe how the epithelial cells of the proximal convoluted tubule are adapted to carry out this process. [9]

[Total: 15]

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Question 6 Fig. 6.1 © KJELL B. SANDVED / SCIENCE PHOTO LIBRARY.

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