Q1.

5 Rice, *Oryza sativa*, is a grass that is grown as a cereal crop in many parts of the world. In most rice-growing regimes, the rice fields are flooded with water while the rice is actively growing. Fig. 5.1 shows cultivation of rice.

(a) (i) Describe **one** structural feature of the tissues in the submerged stems and leaves of rice that is an adaptation for growth in water.

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....[2]

(ii) Explain the importance of the adaptation you have described in **(i)**.

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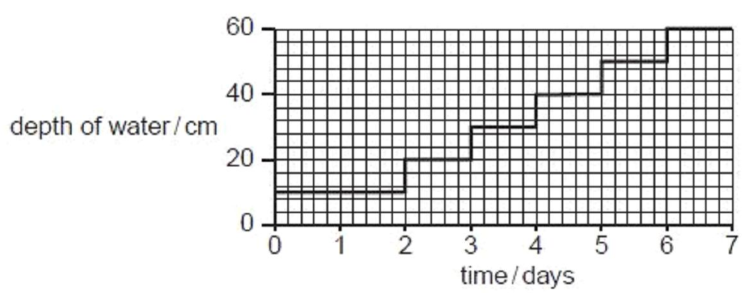
....[2]

(b) An investigation was carried out into the effect of flooding on the growth of the submerged stems of rice plants.

Young rice plants were grown in a container in which the level of water was increased in 10 cm steps, over a period of seven days. The mean length of the submerged internodes (lengths of stem between two leaves) and the concentration of ethene in the rice stems was measured each day. As a control, rice plants were grown in identical conditions but the water level was kept constant throughout the seven days. The results are shown in Fig. 5.2.



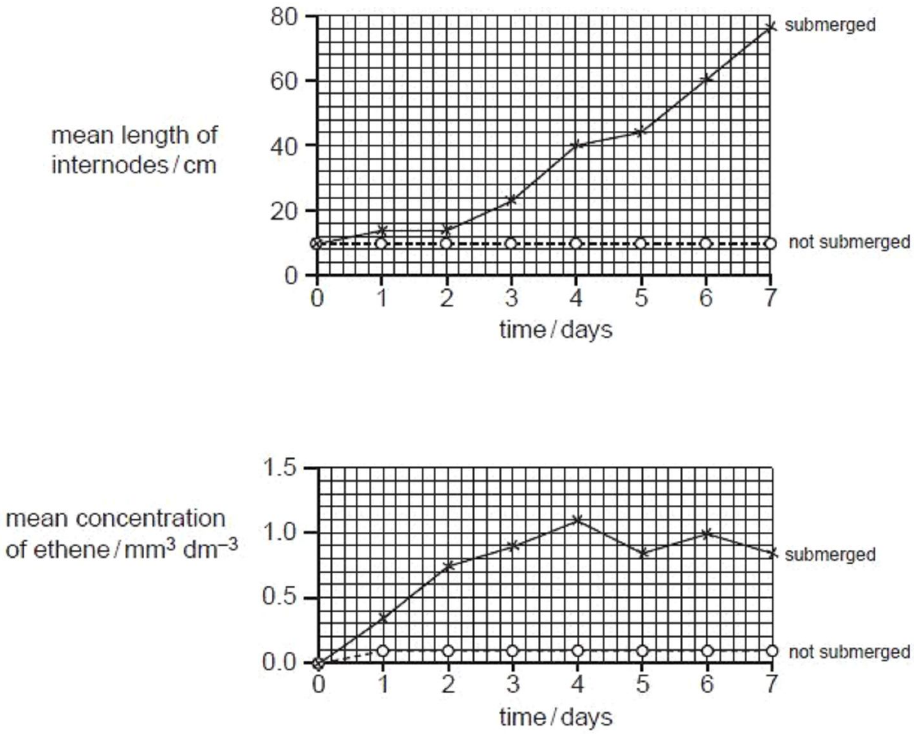

mean length of internodes / cm
80
60
40
20
0
submerged
not submerged
0 1 2 3 4 5 6 7
time / days
mean concentration of ethene / mm3 dm−3
1.5
1.0
0.5
0.0
submerged
not submerged
0 1 2 3 4 5 6 7
time / days

Fig. 5.2

(i) With reference to Fig. 5.2, describe the effect of increasing water level on the length of the submerged internodes.

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....[2]

(ii) Suggest advantages to the rice plants of the effect that you have described in **(i)**.

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....[2]

(iii) With reference to Fig. 5.2, describe the effect of increasing water level on the concentration of ethene in the rice stems.

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....[2]

(c) Application of gibberellin can also affect the growth of rice plants. In a further investigation, various concentrations of gibberellin were applied to submerged rice stems. The stems were placed, for three days in closed containers, in which the air supply either contained pure air or contained ethene. Ethene is a gas that is secreted by plant tissues and acts as a plant growth regulator.

The results are shown in Fig. 5.3.

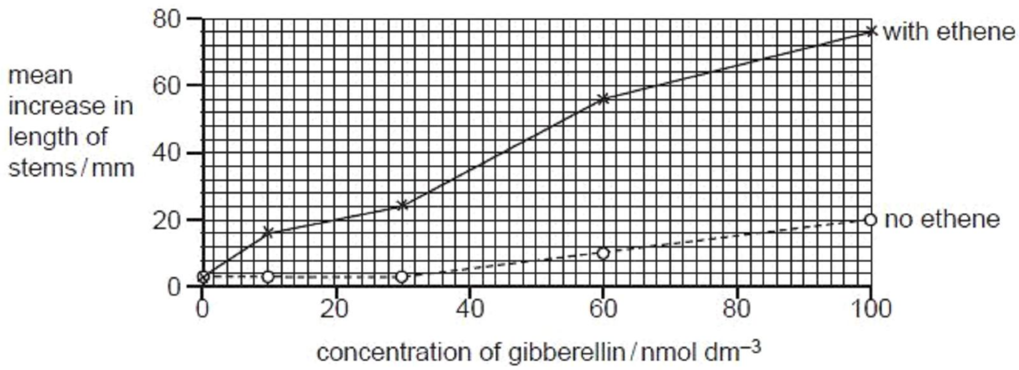

Fig. 5.3

(i) State the meaning of the term *plant growth regulator*.

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....[1]

(ii) Using your knowledge of the effects of gibberellin, and the results shown in Fig. 5.2, suggest an explanation for the results shown in Fig. 5.3.

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[Total: 14]

Q2.

3 **(a)** Fig. 3.1 shows the male and female flowers of maize.

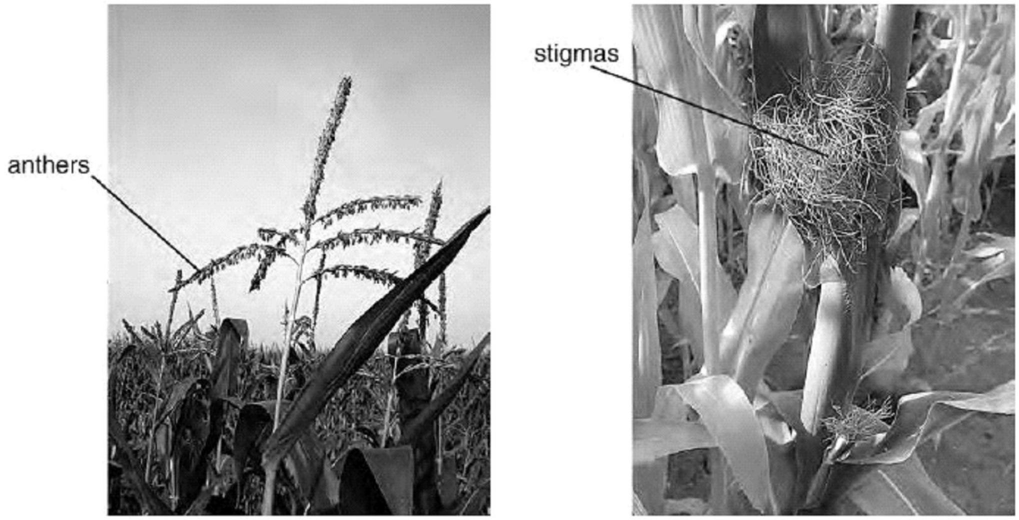

Fig. 3.1

(i) With reference to Fig. 3.1, describe how the flowering habit of maize encourages wind-pollination.

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.... [3]

(ii) In a maize plant, the anthers normally ripen before the stigmas are mature and ready to receive pollen. This encourages cross-pollination.

Explain the potential advantages of cross-pollination to a plant species.

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.... [3]

Q3.

4 **(a)** Fig. 4.1 shows a section through a maize fruit.

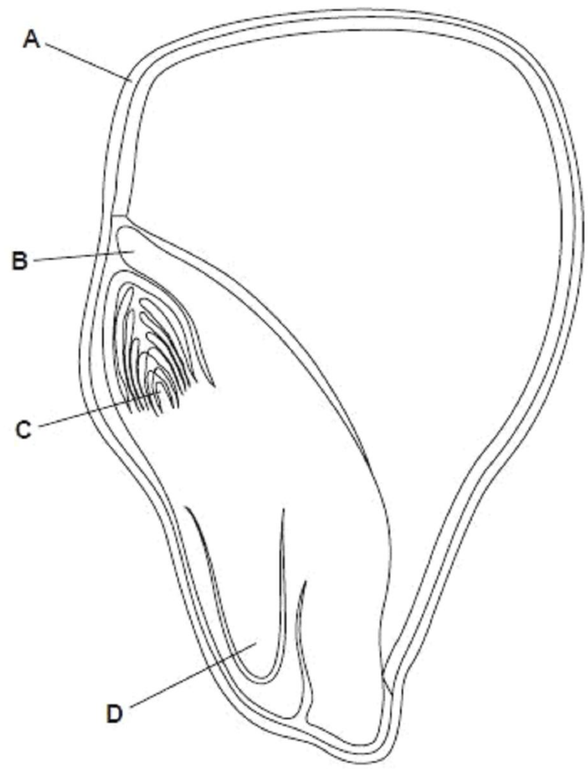

Fig. 4.1

Ex

(i) Name the parts labelled **A** to **D**.

A ....

B ....

C ....

D .... [2]

(ii) Describe the function of the endosperm.

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.... [3]

(b) The corn earworm, is the larva of a moth *Helicoverpa zea*, that is a serious pest of maize. Insecticides containing pyrethrum have long been used to control this insect. These act by irreversibly inhibiting the enzyme acetylcholinesterase, which normally catalyses the hydrolysis of acetylcholine.

(i) Describe how an insecticide could irreversibly inhibit acetycholinesterase.

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.... [2]

(ii) Suggest the effects on synapses of this irreversible inhibition of acetylcholinesterase.

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.... [2]

(c) Some populations of *H. zea* have developed resistance to pyrethrum. This occurs as the result of a point mutation of the acetylcholinesterase gene. Many different such mutations have been identified in different populations.

Explain how a point mutation in the acetylcholinesterase gene could confer resistance to pyrethrum.

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.... [3]

For Examiner's Use

(d)

- A group of corn earworms was collected from a field where the farmer had reported resistance to insecticides containing pyrethrum.
- Another group was collected from a field where the insects showed no resistance (were susceptible).
- Some individuals from these two groups were crossed with each other to form a hybrid group.

Insects from each of the three groups were then exposed to a range of concentrations of pyrethrum. The percentage of the insects that were dead after 24 hours was recorded. The results are shown in Table 4.1.

Table 4.1

dose of insecticide / µg per group	% mortality of insects after 24 hours		
	resistant group	hybrid group	susceptible group
0	0	0	0
0.1	0	0	50
0.5	0	23	63
1.5	7	45	94
2.5	12	50	100
5.0	42	89	100
10.0	80	100	100
30.0	100	100	100

(i) With reference to Table 4.1, compare the effect of the insecticide on the resistant group and on the hybrid group.

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.... [3]

(ii) Assuming that resistance is conferred by a single point mutation in the gene for acetycholinesterase, suggest an explanation for the overall differences between all **three** groups of insects in Table 4.1.

Fo Exami Us

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[Total: 17]

Q4.

4 Fig. 4.1 is a photomicrograph of a transverse section through the leaf of a C4 plant.

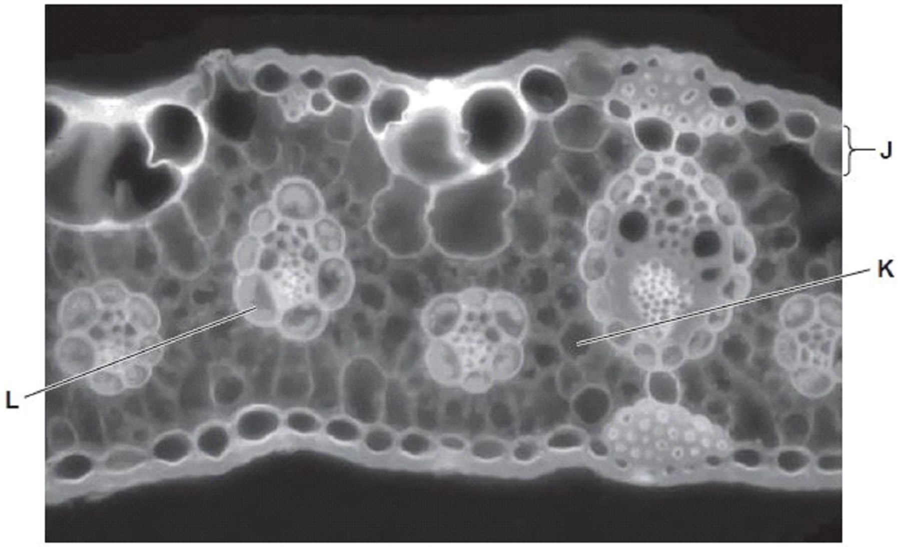

Fig. 4.1

(a) **(i)** Identify structures **J** to **L**.

J ....

K ....

L .... [3]

(ii) Outline how this leaf anatomy adapts the plant for high rates of carbon fixation at high temperatures.

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.... [4]

(b) Sorghum is a C4 plant and *Sorghum bicolor* is a major food crop in dry tropical regions. The leaves of *S. bicolor* are covered with a layer of wax made up of a mixture of esters and free fatty acids, with a melting point of 77–85 °C. Waxes from the leaves of non-tropical plants tend to have melting points lower than this. For example, wax from the bayberry, *Myrica* sp., has a melting point of 45 °C.

Suggest how the wax on sorghum leaves helps the plant to survive in dry, tropical regions.

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.... [2]

(c) An investigation was carried out into the response of sorghum to being kept at a low temperature for a short period of time. Soybean plants, which are better adapted than sorghum for growth in subtropical and temperate climates, were used for comparison.

Plants of sorghum and soybean were kept at 25 °C for several weeks and then at 10 °C for three days. The temperature was then increased to 25 °C again for seven days. Day length, light intensity and carbon dioxide concentration were kept constant throughout.

The uptake of carbon dioxide, as mg CO_2 absorbed per gram of leaf dry mass, was measured

- at 25 °C before cooling
- on each of the three days at 10 °C
- for seven days at 25 °C.

The results are shown in Table 4.1.

Table 4.1

plant	carbon dioxide uptake / mg CO_2 g^{-1}				
	at 25 °C, before cooling	at 10 °C			at 25 °C (mean over days 4 to 10)
		day 1	day 2	day 3	
sorghum	48.2	5.5	2.9	1.2	1.5
soybean	23.2	5.2	3.1	1.6	6.4

(i) Compare the **changes** in carbon dioxide uptake in sorghum and soybean during the three days at 10 °C.

For Examiner's Use

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.... [2]

(ii) During the cooling period, the ultrastructure of the sorghum chloroplasts changed. The membranes of the thylakoids moved closer together, eliminating the spaces between them. The size and number of grana became reduced.

Explain how these changes could be responsible for the low rate of carbon dioxide uptake by sorghum even when returned to a temperature of 25 °C.

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.... [4]

[Total: 15]

Q5.

4 Cereal crops, such as sorghum and rice, are a major source of nutrients all over the world.

For Examiner's Use

(a) Explain why cereal crops are important components of many people's diets.

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.... [3]

(b) Alpha amylase is an enzyme produced in germinating seeds, where it hydrolyses starch. Fig. 4.1 shows the effect of temperature on alpha amylase in germinating seeds of sorghum and rice.

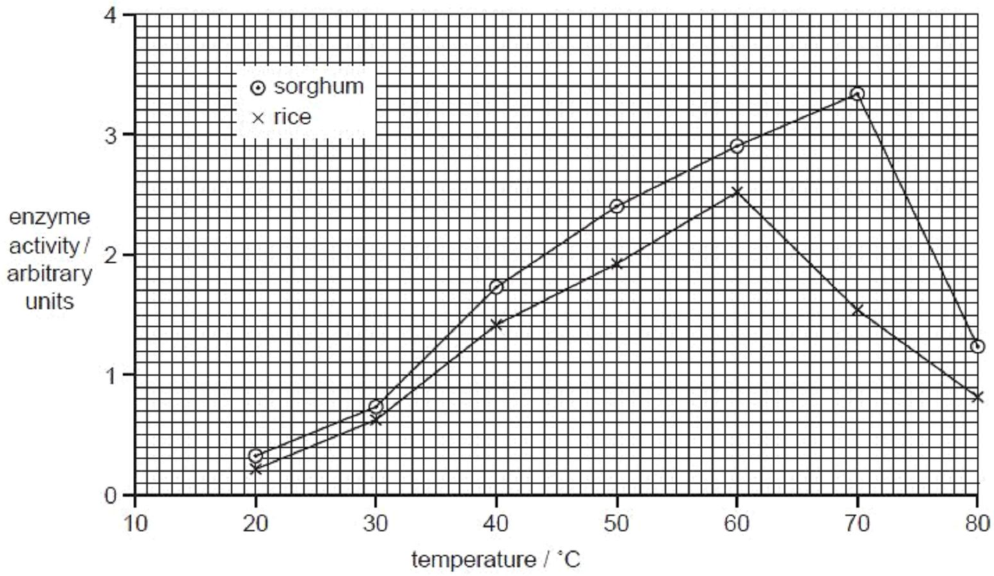

Fig. 4.1

(i) Name the part of the seed that contains starch.

.... [1]

(ii) With reference to Fig. 4.1, compare the effects of temperature on alpha amylase in sorghum and rice.

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.... [3]

(iii) With reference to the types of bonding in proteins, suggest how differences in the tertiary structure of alpha amylase in rice and sorghum could explain the differences in their activities shown in Fig. 4.1.

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.... [3]

(c) Sorghum does not grow well at low temperatures. An investigation was carried out into the response of sorghum to low temperatures at different light intensities.

- Sorghum plants were kept at 25 °C in a light intensity of 215 $W m^{-2}$ for several weeks, and then at 10 °C for three days.
- The temperature was then increased to 25 °C again for seven days.
- The investigation was repeated at light intensities of 170 $W m^{-2}$ and 50 $W m^{-2}$.
- Day length and carbon dioxide concentration were kept constant throughout.

The uptake of carbon dioxide, as mg CO_2 absorbed per gram of leaf dry mass, was measured

- at 25 °C before cooling
- at on each of the three days at 10 °C
- for seven days at 25 °C.

The results are shown in Table 4.1.

Table 4.1

light intensity / $W m^{-2}$	carbon dioxide uptake / mg CO_2 g^{-1}				
	at 25 °C, before cooling	during cooling at 10 °C			at 25 °C (mean over days 4 to 10)
		day 1	day 2	day 3	
215	50.1	3.0	0.4	0.2	0.2
170	48.2	5.5	2.9	1.2	1.5
50	22.4	3.0	1.2	0.7	9.2

With reference to Table 4.1

(i) describe **and** explain the effect of light intensity on the rate of carbon dioxide uptake **before cooling**

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.... [3]

(ii) describe the effect of light intensity on the ability of sorghum plants to survive cooling.

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.... [2]

[Total: 15]

Ex

Q6.

5 Both sorghum and maize are important food crops in dry regions of the world, but sorghum is able to produce higher yields than maize in very dry conditions.

This is partly because sorghum plants have a smaller leaf area than maize, and also because sorghum leaves have rows of motor cells along the midrib of the upper surface of the leaf, allowing the leaves to roll up.

(a) Explain how **these two** features adapt sorghum plants for growth in very dry conditions.

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(b) Sorghum is a staple food in Africa, but the major storage protein that it contains, kaffirin, is not easily digested by protease enzymes. The main cause of this is cross-linking between kaffirin molecules.

The digestibility of the protein in five varieties of sorghum was measured when raw, and after cooking. Digestibility was measured as the percentage of the protein that would be broken down to amino acids during digestion.

The results are shown in Fig. 5.1.

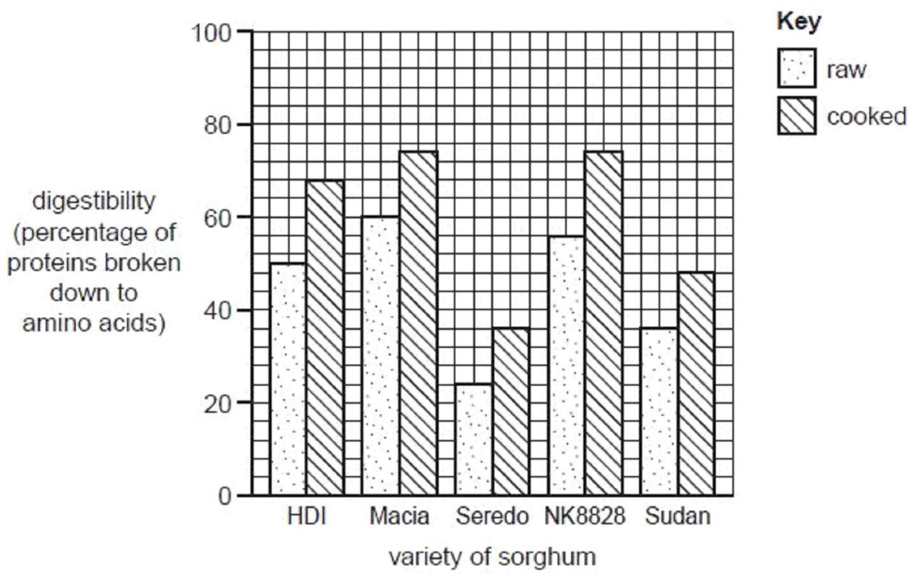

Fig. 5.1

With reference to Fig. 5.1

(i) compare the digestibility of raw and cooked sorghum protein

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.... [2]

(ii) using your knowledge of protein structure and enzyme activity, suggest reasons for the differences you have described in **(i)**.

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.... [3]

[Total: 8]

For Examiner's Use

Q7.

4 Maize, *Zea mays*, is a major cereal food crop. Unlike most crop plants, maize seed is produced by hybridisation between two different inbred parental strains.

For Examiner's Use

(a) (i) Explain why this is done.

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....[3]

(ii) Suggest **one** disadvantage of producing seed in this way.

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....[1]

(b) In the light-independent stage of photosynthesis, the enzyme rubisco catalyses the combination of carbon dioxide with ribulose bisphosphate, RuBP. When the carbon dioxide concentration within the leaf is very low, rubisco tends to combine oxygen, rather than carbon dioxide, with RuBP. This process is called photorespiration. It reduces carbon dioxide assimilation and therefore reduces crop yields.

Photorespiration is most likely to happen in hot, dry conditions.

(i) Suggest **why** photorespiration is most likely to take place in hot, dry conditions.

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....[3]

(ii) Explain how the leaf anatomy of a maize plant reduces photorespiration, even in hot, dry conditions.

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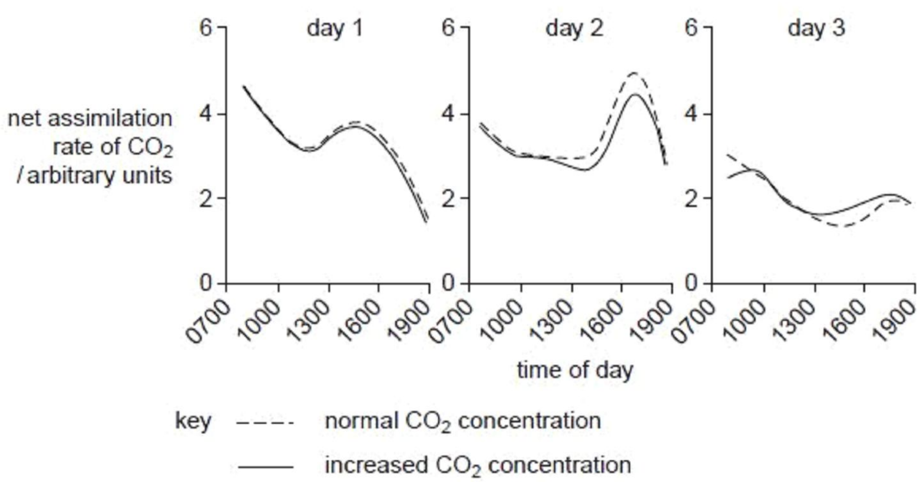
.... [4]

(c) It is expected that the carbon dioxide concentration in the atmosphere will increase in the future, which would be expected to increase rates of photosynthesis in many crop plants.

Investigations were carried out into the effect of increased carbon dioxide concentration on the rate of photosynthesis in maize.

- Maize plants were grown in open-air trials, in the same field and were exposed to the same changes in the weather.
- 50% of the plants were exposed to a normal carbon dioxide concentration.
- 50% of the plants were exposed to an increased carbon dioxide concentration.
- The rate of photosynthesis was measured as the net assimilation rate of carbon dioxide.
- Measurements were made at three-hourly intervals between 0700 hours and 1900 hours on three different days.

The results are shown in Fig. 4.1.



(i) Suggest an explanation for the lack of effect of carbon dioxide concentration on the rate of photosynthesis in maize plants, shown by these results.

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....[2]

(ii) Suggest **one** explanation for the changes in the rate of photosynthesis between 0700 hours and 1900 hours on day 1.

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....[2]

[Total: 15]

Ex

Q8.

For Examiner Use

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

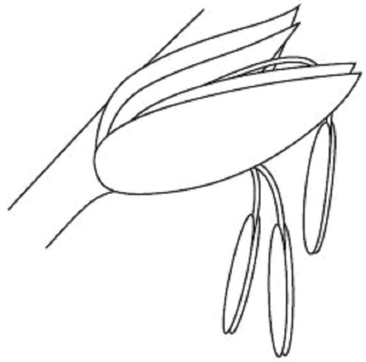

Fig. 4.1

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]

(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.

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]

(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]

For Examiner's Use

(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.

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....[4]

[Total: 15]

Q9.

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.

GGDP
↓ phytoene synthase
phytoene
↓ phytoene desaturase
ς carotene
↓ ς carotene desaturase
lycopene
↓ lycopene β cyclase
β carotene

Fig. 4.1

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*.

F
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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.

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....[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 *crtl* 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]

For Examiner's Use

Q10.

5 Wheat, maize and sorghum are three of the most important cereal crops in the world.

(a) Fig. 5.1 shows the effect of temperature on the rate of photosynthesis of wheat plants.

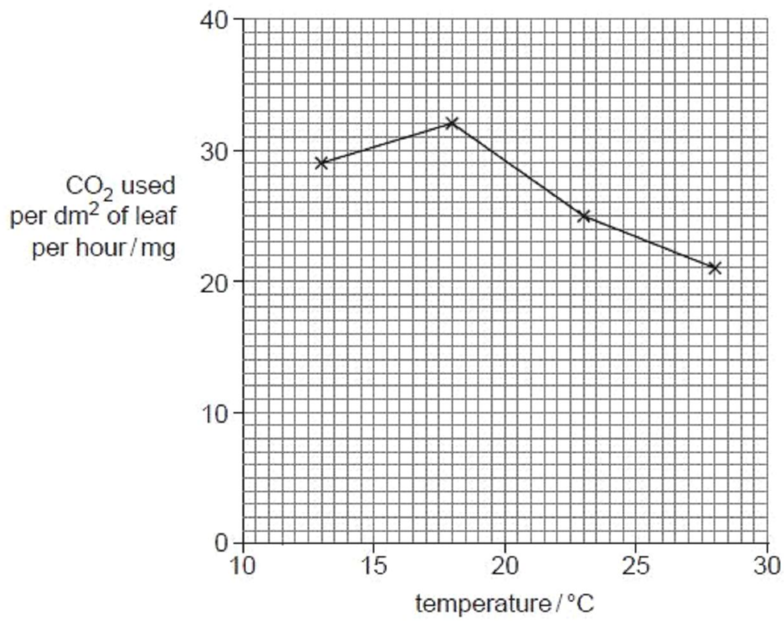

Fig. 5.1

(i) With reference to Fig. 5.1, describe the effect of temperature on the rate of photosynthesis of wheat plants.

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.... [2]

(ii) Suggest why temperature affects the rate of photosynthesis in the way you have described in **(i)**.

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.... [2]

Use

(b) The conditions in which young plants of wheat and maize are grown affects their ability to photosynthesise at high and low temperatures when they are mature.

Young maize and wheat plants were grown to maturity at high and low temperatures. When they were mature, their rate of photosynthesis was measured at different temperatures. The results are shown in Fig. 5.2.

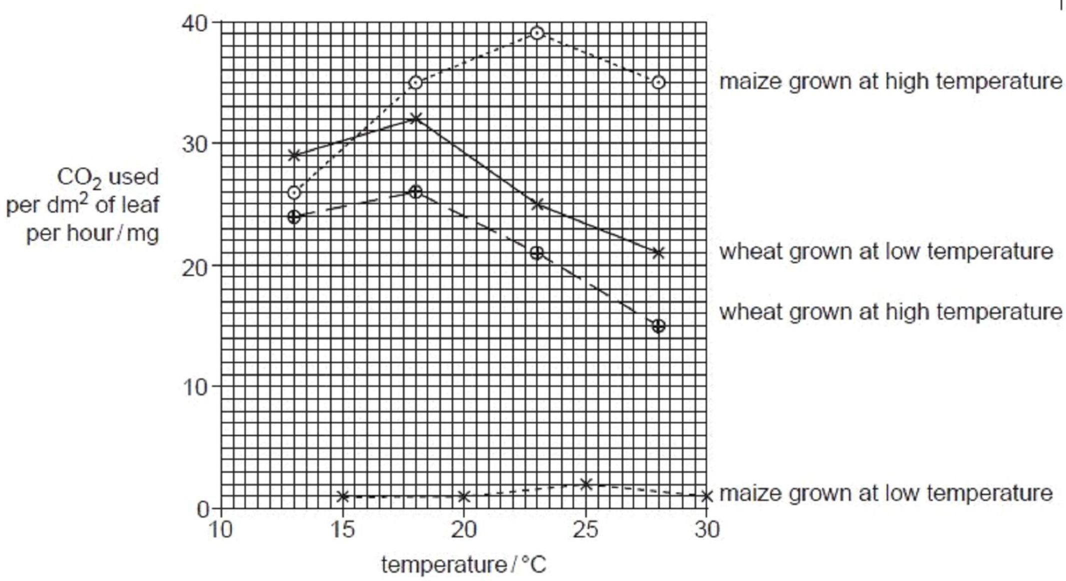

Fig. 5.2

(i) With reference to Fig. 5.2, compare the effect of temperature on the rate of photosynthesis of maize plants and wheat plants that were grown at a high temperature when they were young.

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.... [2]

(ii) Maize is a C4 plant.
Explain how the structure of the leaves of maize plants enables them to photosynthesise more effectively at high temperatures than wheat plants.

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.... [3]

(iii) Low temperatures slow down the formation of the membranes inside chloroplasts in maize leaves, but not in wheat leaves.
Use this information to explain the differences between the results for maize and wheat grown at low temperatures, shown in Fig. 5.2.

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.... [2]

(c) Cereal crops frequently form the staple diet of human populations. Table 5.1 shows the oil and starch content of maize and sorghum grains.

Table 5.1

	percentage of dry mass	
	maize	sorghum
oil	4.7	3.8
starch	62.2	70.1

(i) Name the part of the maize grain in which oil and starch are stored.

.... [1]

(ii) With reference to Table 5.1, compare the energy values of maize and sorghum grains when the oil and starch they contain are used as respiratory substrates.

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.... [3]

[Total: 15]

Q11.

3 Sorghum is a cereal crop that grows well in very dry (arid) conditions.

Exa

(a) Outline **two** structural features of sorghum that adapt it to survive in arid environments.

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....[2]

(b) An investigation was carried out to measure the effect of lack of water on the leaves of sorghum plants.

- Several well-watered sorghum plants were kept in conditions of normal light and temperature.
- Watering was then stopped for 6 days, and resumed on day 7.
- The water potential of the cells in the leaves, the concentrations of abscisic acid in the leaves and stomatal resistance were measured each day.

A high stomatal resistance indicates that most stomata are partially or completely closed.

The results are shown in Fig. 3.1.

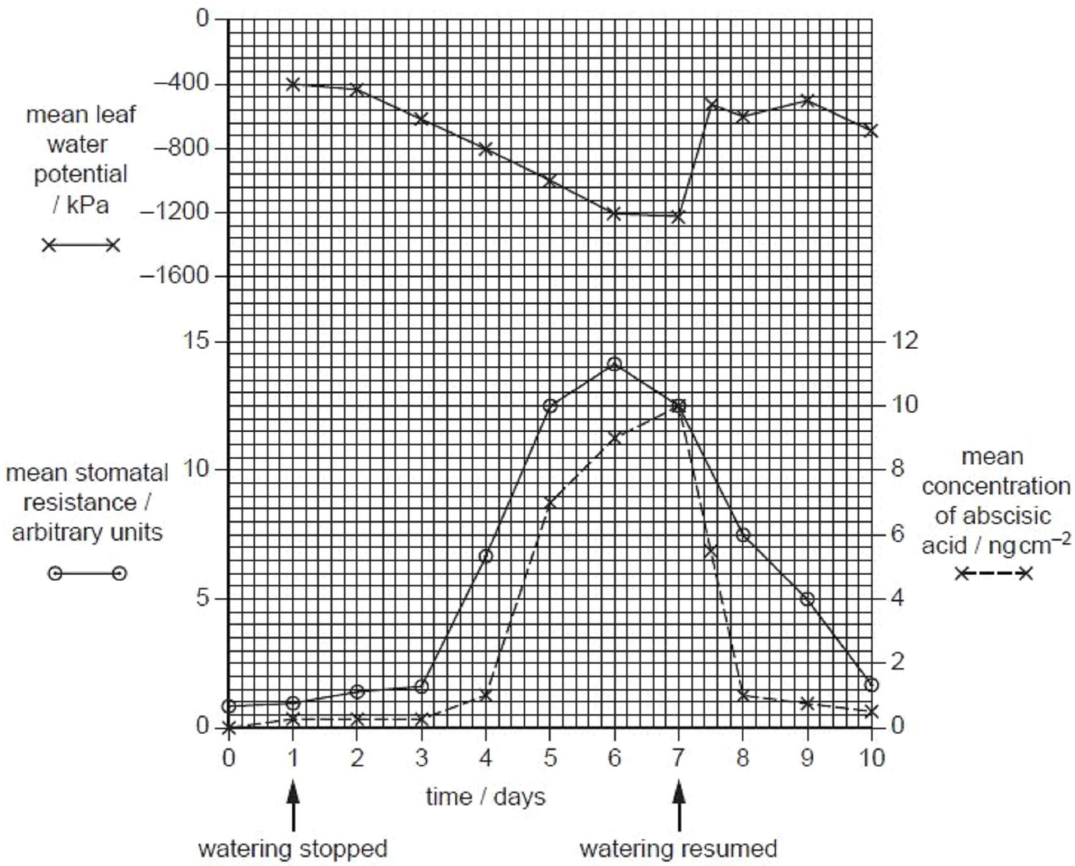

Fig. 3.1

With reference to Fig. 3.1,

(i) describe **and** explain the changes in abscisic acid concentration over the 10 day period

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.... [3]

(ii) explain the changes in stomatal resistance over this period.

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.... [2]

(c) Explain how the changes you have described in **(b)** help sorghum to survive in arid conditions.

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....[2]

[Total: 9]

Q12.

4 Modern varieties of wheat have developed from numerous hybridisation events between different species of wild grasses. Fig. 4.1 shows some of the possible steps that are believed to have been involved in the development of bread wheat, *Triticum aestivum*.

The letters **A**, **B** and **C** represent three different sets of seven chromosomes.

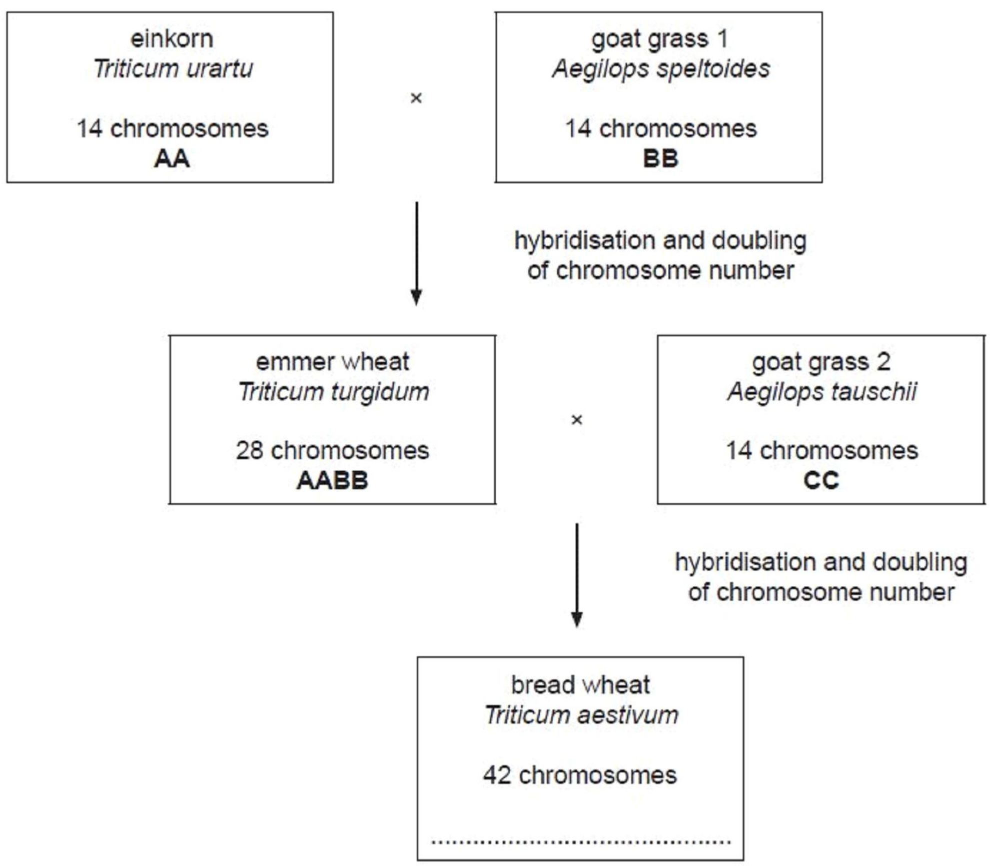

Fig. 4.1

(a) Complete Fig. 4.1 by writing letters to represent the sets of chromosomes in bread wheat.

Write your answer on Fig. 4.1. [1]

(b) Explain why hybridisation between emmer wheat and goat grass 2 would have produced a sterile hybrid, if doubling of chromosome number had **not** occurred.

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.... [3]

(c) With reference to Fig. 4.1, suggest why *Triticum urartu* and *Triticum turgidum* are classified as different species.

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.... [2]

(d) *Triticum turgidum* emerged as a new species without being geographically isolated from *Triticum urartu*.

Outline how geographical isolation may result in speciation.

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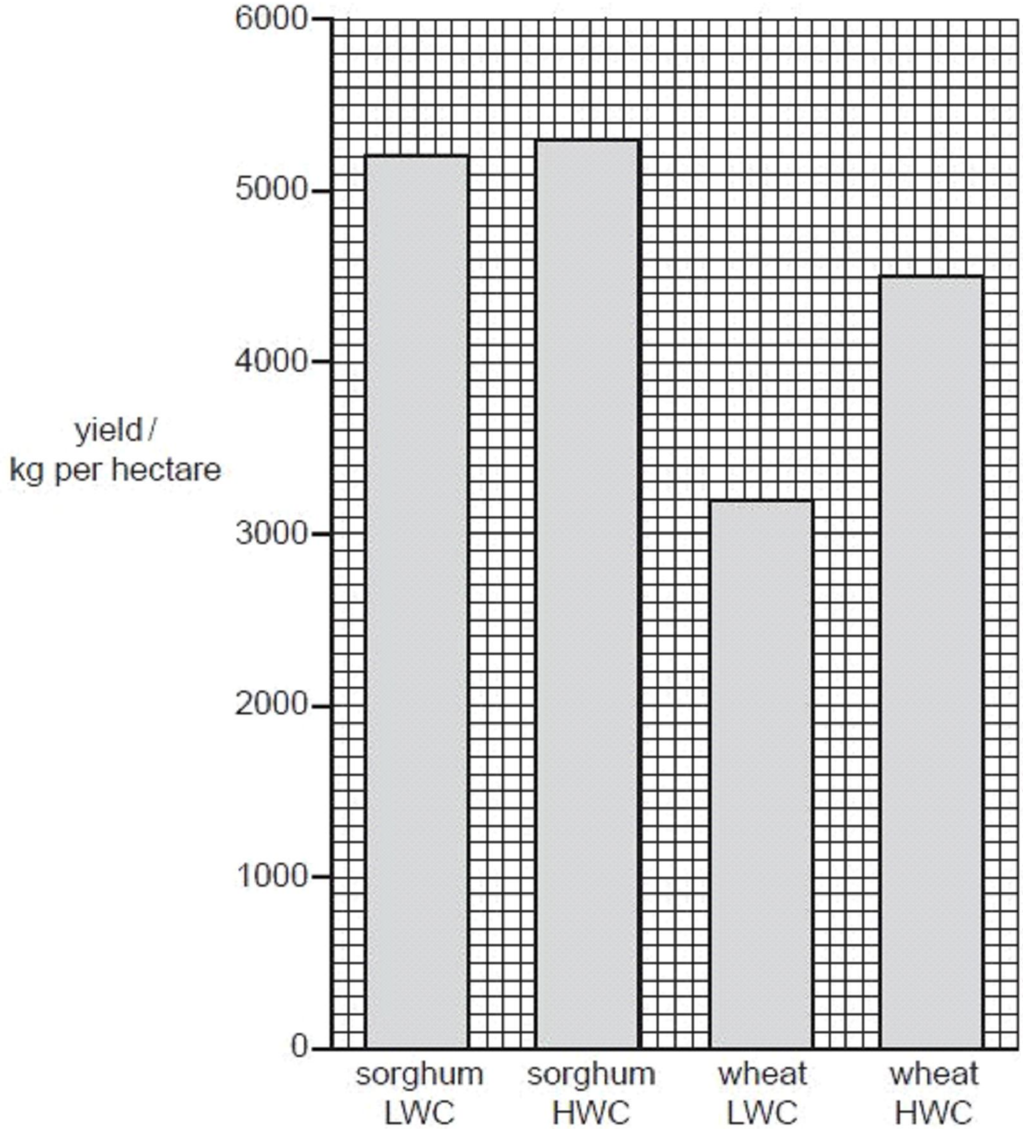
[Total: 9]

Q13.

4 **(a)** In Queensland, Australia, the effect of the water-holding capacity of soil on the yield of sorghum and wheat was investigated.

- Four test plots were prepared, two with high water-holding capacity (HWC) soil and two with low water-holding capacity (LWC) soil.
- Sorghum seeds were sown on one plot with HWC soil and one plot with LWC soil.
- Wheat seeds were sown on the second plot with HWC soil and the second plot with LWC soil.
- The plots were regularly watered or irrigated throughout the growing season.
- The yield of sorghum and wheat from all four plots was measured at the end of the growing season.

Fig. 4.1 shows the results of this investigation.


6000
5000
4000
3000
2000
1000
0
yield / kg per hectare
sorghum LWC
sorghum HWC
wheat LWC
wheat HWC

(i) Describe **and** explain the results shown in Fig. 4.1.

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....[4]

(ii) State two factors, other than water, light and temperature that would have to be controlled during this investigation to ensure that the results were valid.

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2 ....[2]

(b) Sorghum is able to carry out photosynthesis at high temperatures by preventing photorespiration.

Explain how sorghum is able to prevent photorespiration.

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....[4]

[Total: 10]

Q14.

5 Rice, *Oryza sativa*, is a staple food in many parts of the world. Rice is often grown in fields that are flooded with water for part of the growing season.

For Examiner's Use

(a) The roots of young rice plants are highly tolerant of ethanol. Explain how this helps them to survive when the fields are flooded.

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.... [2]

(b) Rice grains have a similar structure to those of maize. The endosperm makes up most of the rice grain. The endosperm is surrounded by an aleurone layer, which contains hydrolytic enzymes. Outside the aleurone layer is the fused pericarp and testa, containing large amounts of cellulose.

(i) Describe the function of the endosperm.

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.... [2]

Brown rice includes the pericarp and testa, whereas in white rice these have been removed during milling, along with most of the aleurone layer.

For Examiner's Use

Table 5.1 shows the nutrient content of samples of white and brown rice.

Table 5.1

	nutrient content per 100g	
	white rice	brown rice
lipid / g	0.8	2.4
dietary fibre / g	0.6	2.8
calcium / mg	8	12
vitamin B_1 / mg	0.07	0.26
protein / g	6.0	7.4
carbohydrate / g	82.0	77.7

(ii) With reference to the structure of rice grains, suggest why brown rice contains more protein than white rice.

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.... [2]

(iii) Explain why brown rice contains less carbohydrate per gram than white rice.

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.... [1]

(iv) Explain why the grains of cereals such as rice are staple foods in many parts of the world.

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.... [2]

[Total: 9]

Q15.

4 Maize, *Zea mays*, is a cereal crop that is adapted for growth at high temperatures. However, it does not cope with drought as well as some other crops, such as sorghum.

Fc Exam Us

An investigation was carried out into the effect of low water availability on the activity of mitochondria taken from maize seedlings.

Young seedlings were uprooted and left in dry air for varying periods of time to reduce the water potential of their tissues.

(a) Explain why this treatment reduced the water potential of the maize seedling tissues.

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.... [2]

(b) After drying in air, mitochondria were extracted from the tissues of the seedlings. The extracted mitochondria were provided with succinate, which is one of the intermediate compounds in the Krebs cycle, and also with ADP and inorganic phosphate. The rate at which the extracted mitochondria took up oxygen was measured. The results are shown in Fig. 4.1.

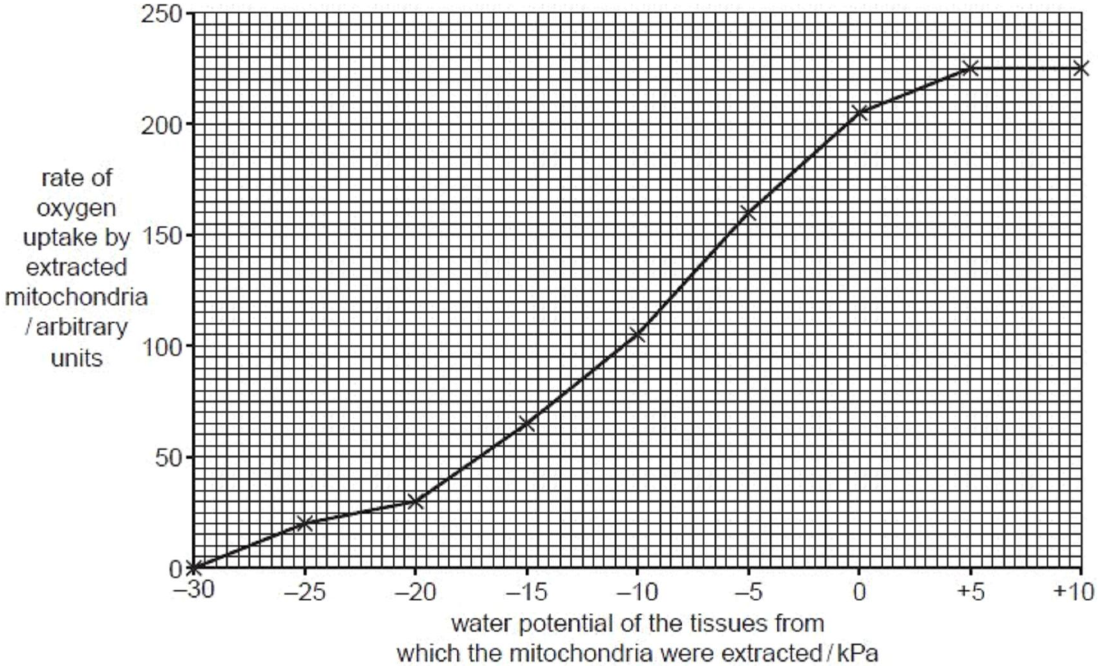

Fig. 4.1

(i) Describe the results shown in Fig. 4.1.

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.... [2]

(ii) The mitochondria take up oxygen. Explain how this oxygen, plus the succinate, ADP and inorganic phosphate, are used by the mitochondria.

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(c) In a further experiment, it was found that mitochondrial membranes lost their normal structure when the water potential was low.

(i) Suggest why membranes in cells lose their normal structure when the water potential is low.

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(ii) Suggest how this could explain the results shown in Fig. 4.1.

Exa

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(d) In tissues where water potential is low, the mitochondria of sorghum are affected in a very similar way to those of maize.

Describe **two** ways in which sorghum plants are adapted to prevent the development of low water potentials in their tissues during drought conditions.

1. ....

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2. ....

.... [2]

[Total: 16]

Q16.

4 Cultivated rice, *Oryza sativa*, is often grown in fields flooded with water.

(a) Explain how rice plants are adapted for growth with the roots submerged in water.

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.... [3]

(b) Some varieties of cultivated rice are able to grow long internodes when they are submerged in water, keeping the leaves and flowers above water level (an internode is a length of stem between leaves). These varieties are known as deepwater rice.

The snorkel genes *SK1* and *SK2*, thought to be responsible for this response, were identified in a variety of deepwater rice, C9285. A non-deepwater variety, T65, did not have these genes.

When submerged, rice plants produce the gaseous plant hormone ethene. This has a very low solubility in water, so it accumulates in the aerenchyma tissue in the rice stems.

Fig. 4.1 shows the concentration of ethene in the aerenchyma of T65 and C9285 when the plants are submerged in water for 18 hours.

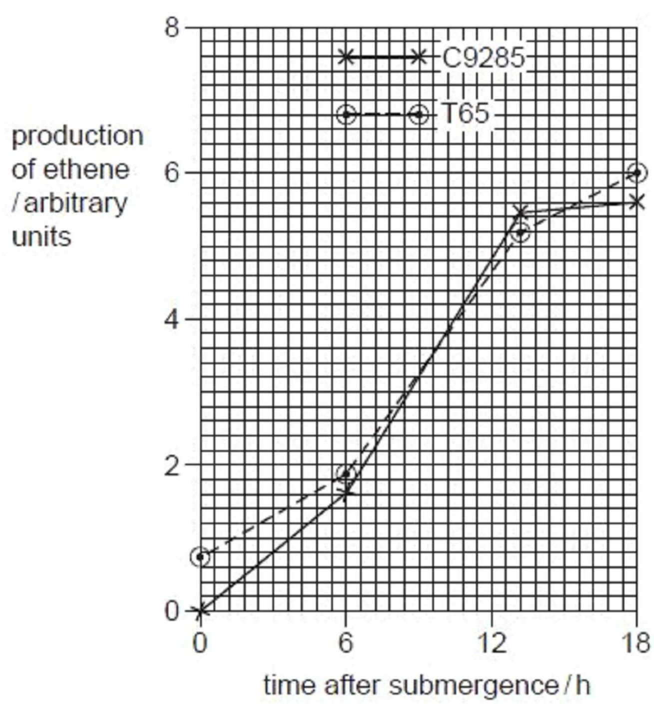

Fig. 4.1

Fig. 4.2 shows the results of exposing T65 and C9285 to different concentrations of ethene in dry conditions.

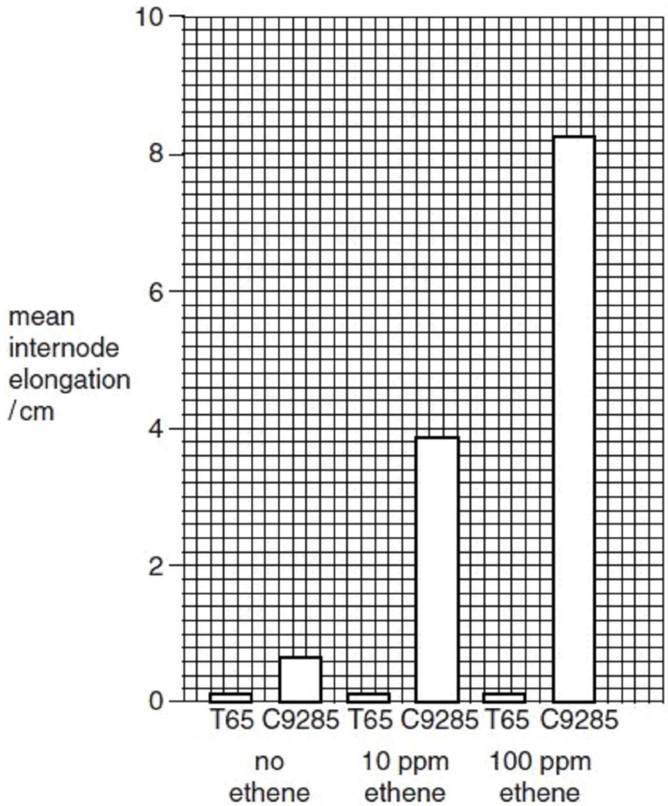

Fig. 4.2

(i) With reference to Fig. 4.1, describe the effect of submergence in water on the production of ethene in rice.

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....[2]

(ii) With reference to Fig. 4.2, compare the effect of ethene on internode elongation in C9285 and T65.

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(c) The snorkel genes were found to be expressed when the plant was exposed to ethene. The expression of these genes results in increased production of gibberellin, GA.

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Fig. 4.3 shows the effect of submergence on GA production in C9285 and in T65.

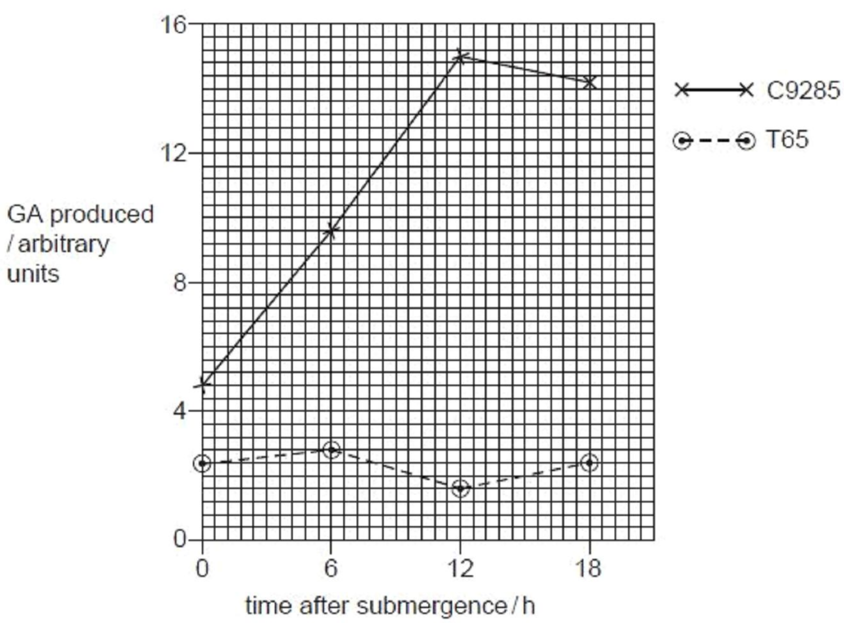

Fig. 4.3

With reference to Fig. 4.3, and your knowledge of the functions of GA, suggest an explanation for the differences in the effects of ethene in C9285 and T65 shown in Fig. 4.2.

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(d) Cultivated rice has been developed from the wild rice species *Oryza rufipogon* and *Oryza nivara*. *O. rufipogon* has a strong deepwater elongation response, but *O. nivara* has only a slight elongation response. Another species, *Oryza glumaepatula*, shows a strong elongation response.

- *O. rufipogon* has both the snorkel genes, *SK1* and *SK2*.
- *O. nivara* has *SK1*, but an addition (insertion) mutation has produced a stop triplet within *SK2*.
- *O. glumaepatula* has *SK2*, but not *SK1*.

(i) Describe what this information indicates about the relative importance of the genes *SK1* and *SK2* in the deepwater elongation response.

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....[2]

(ii) Explain how an addition mutation could produce a stop triplet.

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....[2]

Exa

(iii) Deepwater rice is the main food crop in many parts of the world that undergo flooding in the rainy season. Many varieties of deepwater rice have lower yields than non-deepwater varieties.

Suggest how a deepwater rice variety with high yield could be produced, using artificial selection.

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....[3]

[Total: 17]

Q17.

4 **(a)** Fig. 4.1 shows the male and female flowers of maize.

Fig. 4.1

(i) With reference to Fig. 4.1 suggest how the flowering habit of maize encourages wind pollination.

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....[3]

(ii) In a maize plant, the anthers normally ripen and release pollen before the stigmas are mature and ready to receive pollen. This encourages cross-pollination.

Explain **two** potential advantages of cross-pollination to a plant species.

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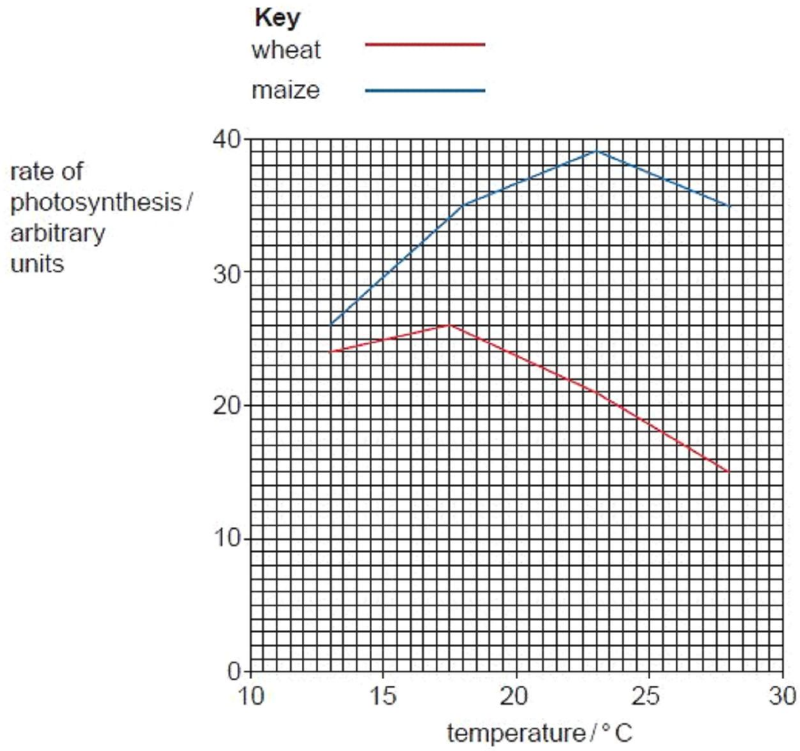
....[2]

(b) The conditions in which wheat and maize are grown affect their ability to photosynthesise.

Fig. 4.2 compares the rate of photosynthesis of wheat and maize at different temperatures.



Exa

With reference to Fig. 4.2:

(i) **compare** the effect of temperature on the rates of photosynthesis of wheat and maize

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.... [2]

(ii) explain the difference between the rates of photosynthesis of wheat and maize at **28 °C**.

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Exa

(c) Cereal grains are a major component of the human diet.

Table 4.1 shows some of the nutrient contents of 100 g samples of grains of wheat, white rice and maize.

Table 4.1

	wheat	**white rice**	**maize**
protein / g	12.3	7.5	8.9
fat / g	2.0	2.8	4.7
carbohydrate / g	75.0	77.0	74.0
fibre / g	2.3	0.9	2.0
calcium / mg	34.0	28.0	7.0
iron / mg	5.4	1.6	2.7
sodium / mg	2.0	6.0	35.0

(i) With reference to Table 4.1 suggest reasons for the difference in protein content between wheat and white rice.

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(ii) State, giving a reason, which type of grain would be beneficial for a person with anaemia.

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[Total: 14]

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Q18.

5 Flowers are the organs of sexual reproduction in plants. Before fertilisation and seed development can take place, pollination must occur. This can be either self-pollination or cross-pollination, and can be carried out by insects or by wind.

For Examiner Use

(a) Explain the meaning of the term *self-pollination*.

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....[2]

(b) Explain why cross-pollination may be more beneficial to a species than self-pollination.

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....[3]

(c) In maize, wind pollination occurs. An investigation was carried out to find out how the length of time that maize pollen is in the air affects its ability to bring about fertilisation in a female flower.

- Pollen grains were removed from maize flowers and left exposed to the air for varying times.
- The pollen grains were then placed onto groups of female flowers.
- The groups of fertilised flowers developed into 'ears', each containing many seeds. The number of seeds per ear was counted.

The results are shown in Fig. 5.1.

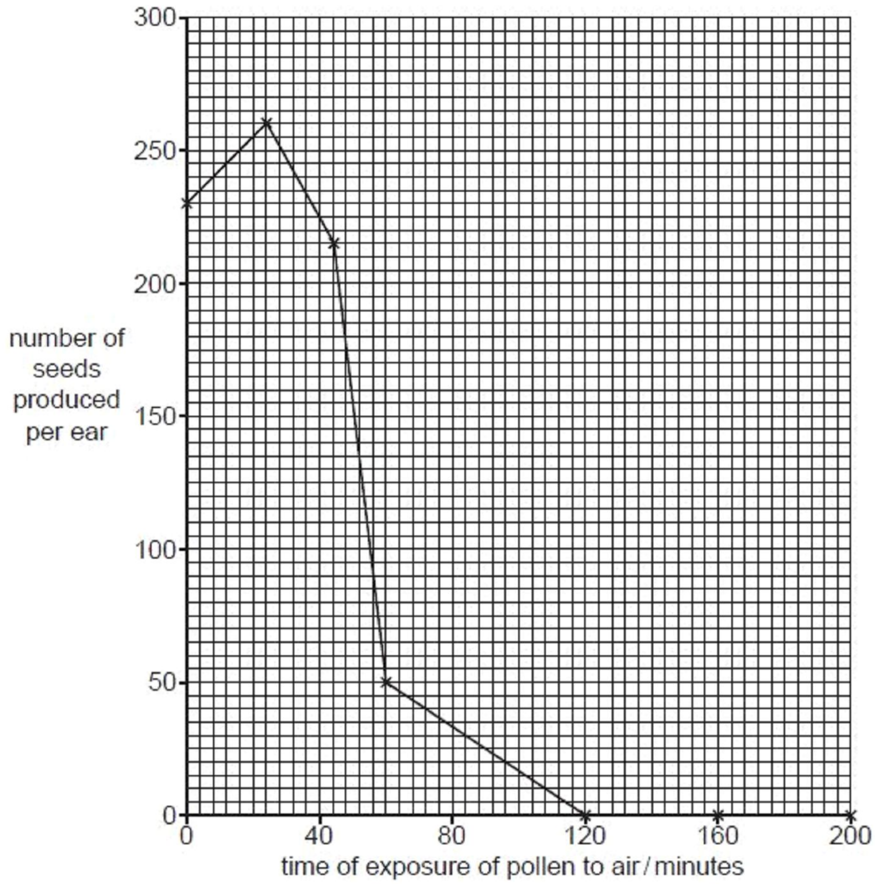

Fig. 5.1

(i) Describe the effect of exposure to the air on maize pollen.

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.... [2]

(ii) A wild relative of maize, called teosinte, grows in Mexico. There are concerns that pollen from genetically-modified maize could pollinate wild teosinte and transfer new genes to it.

Suggest how the results shown in Fig. 5.1 could be used to devise strategies that would reduce the possibility of this happening.

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....[2]

[Total: 9]

Q19.

4 **(a)** Fig. 4.1 shows a light micrograph of a section through a wheat grain.

The structure of a wheat grain is very similar to that of a maize fruit.

Fig. 4.1

On Fig. 4.1, use label lines and letters to label each of the following parts.

A endosperm

B fused testa and pericarp (fruit coat)

C embryo [3]

(b) Wheat grains are ground to make flour, which can be used for making bread.

Whole grain flour is made from the complete wheat grain.

Refined (white) flour is produced from wheat grains from which the embryo, aleurone layer and the fused testa and pericarp have been removed.

Table 4.1 shows the carbohydrate, protein and dietary fibre content of bread made from whole grain flour and white flour.

Table 4.1

	bread made from whole grain flour	**bread made from white flour**
protein / g per 100 g	9.4	7.9
dietary fibre / g per 100 g	7.0	2.5
carbohydrate / g per 100 g	42	46

With reference to the structure of a wheat grain, explain the differences between the composition of the two types of bread shown in Table 4.1.

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Ex

(c) The glycaemic index, GI, of a carbohydrate-containing food is a measure of the effect of its consumption on blood glucose concentration. If two foods containing the same mass of carbohydrate, but different GIs, are consumed, the food with the higher GI will increase blood glucose concentration more rapidly than the food with the lower GI.

Suggest an explanation for each of the following.

(i) Foods containing starch have lower GIs than foods containing glucose.

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.... [1]

(ii) Foods containing starch made up mostly of amylose have lower GIs than foods containing starch made up mostly of amylopectin.

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.... [2]

(d) A diet containing large amounts of foods with a high GI can increase the risk of developing type II diabetes. A study was carried out into the effect of consuming whole cereal grains, refined cereal grains and fruit on the risk of developing type II diabetes.

For Examine Use

- In 1986, questionnaires about diet were completed by 41836 women, all between the ages of 55–69 years old, in Iowa, USA.
- The women were then divided into five groups according to their range of intake of each food type.
- In 1992 the same women were asked whether or not they had developed type II diabetes.
- Their answers were used to calculate the relative risk of developing type II diabetes for each of the five groups.

For each food type, the group with the lowest intake of that food type was allocated a risk of 1.00.

Table 4.2 shows the results of this study.

Table 4.2

food type	range of intake / servings per week	relative risk of developing type II diabetes
whole cereal grains	< 13.0	1.00
	13.0 – 18.5	0.89
	19.0 – 24.5	0.94
	25.0 – 33.0	0.81
	> 33.0	0.68
refined cereal grains	< 6.0	1.00
	6.0 – 9.5	0.96
	10.0 – 13.5	1.00
	14.0 – 22.0	0.98
	> 22.0	0.87
fruit	< 6.25	1.00
	6.5 – 10.0	1.05
	10.1– 13.5	1.00
	13.6 – 19.0	1.08
	> 19.0	1.14

(i) Describe the effect of increased intake of whole cereal grains on the risk of developing type II diabetes.

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(ii) Explain why the results in Table 4.2 **cannot** be used to make a direct comparison of the effects of consuming whole cereal grains and refined cereal grains on the risk of developing type II diabetes.

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Exa

(iii) The results in Table 4.2 suggest that eating large quantities of fruit may slightly increase the risk of developing type II diabetes.

Suggest a reason for this.

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[Total: 16]

Q20.

7 **(a)** Explain the advantages to a plant species of cross-pollination compared to self-pollination.

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(b) Some of the most important food plants for humans depend on insect pollinators, such as the honeybee, *Apis mellifera*.

Fig. 7.1 shows a honeybee.

Fig. 7.1

A study was carried out in 2006 to show how four food crops are pollinated.

Fig. 7.2 shows the results of this study.

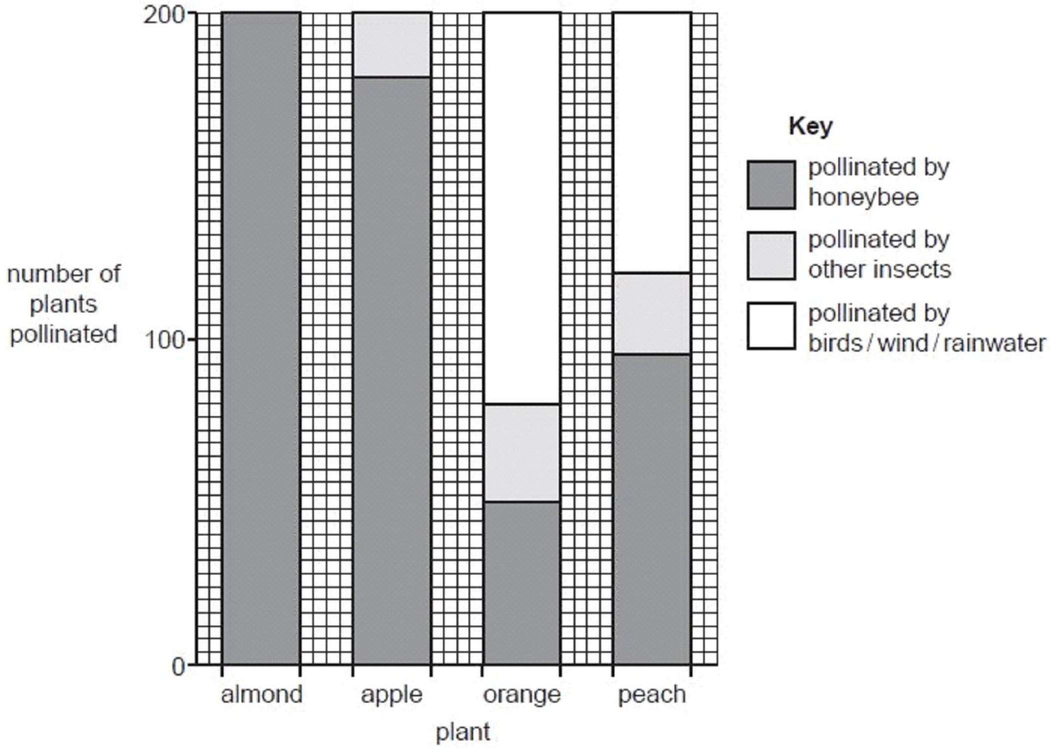

Fig. 7.2

The populations of honeybees in some parts of the world have declined in recent years.

(i) With reference to Fig. 7.2, **explain** which crop will be most affected **and** which crop will be least affected by the decline in honeybees.

most affected ....

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least affected ....

.... [2]

(ii) Suggest reasons why honeybee populations have declined.

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....[3]

[Total: 8]

Q21.

5 **(a)** Maize originated in the Americas, and 55% of the world's maize production is from this part of the world.

Exa

Fig. 5.1 shows the mean yields of maize in the USA between 1860 and 2010.

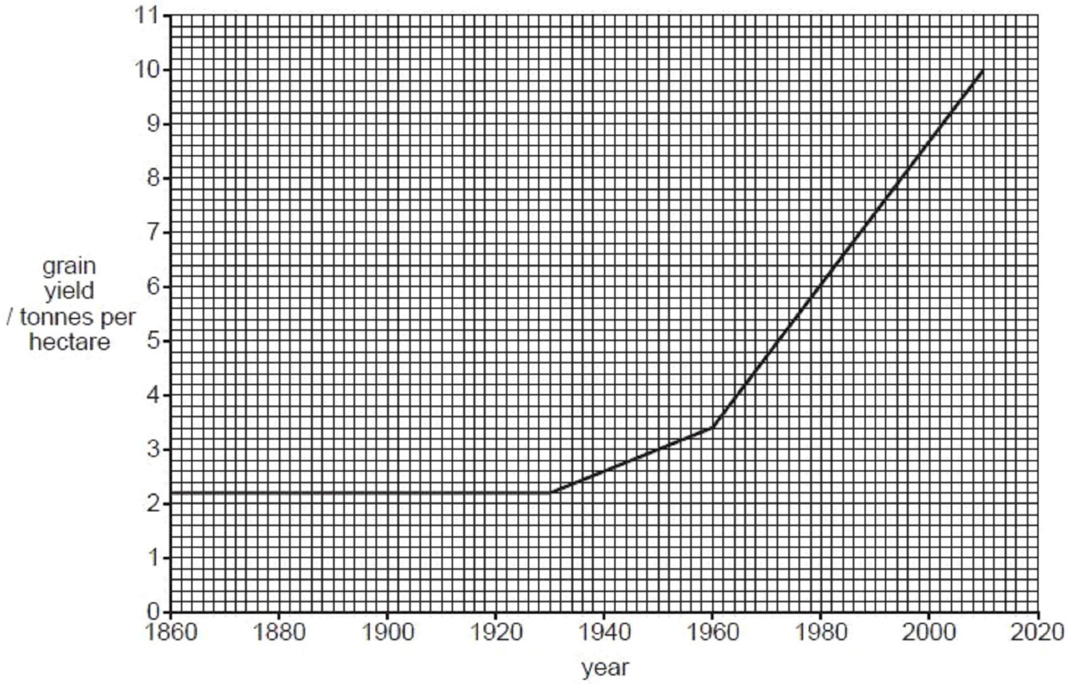

Fig. 5.1

Describe the changes in grain yield between 1860 and 2010.

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(b) The greatest improvement in maize yields came after growers realised that maize hybrids have a much greater yield than inbred lines.

Ex

Between 1860 and the 1930s, maize was allowed to pollinate naturally in the field. From the 1930s onward, maize seed was produced using 'double-cross' hybrids.

To produce a double-cross hybrid:

- two different maize plants, **A** and **B**, are crossed to produce a hybrid, **C**
- two other maize plants, **X** and **Y**, are crossed to produce a hybrid, **Z**
- the hybrid **C** is then crossed with the hybrid **Z**, to produce the double-cross hybrid.

From 1960 onwards, maize seed was produced using 'single-cross' hybrids. This involves crossing one inbred (entirely homozygous) plant with a different inbred plant.

Explain why single-cross hybrids are genetically uniform, but double-cross hybrids are not.

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(c) An experiment was carried out in 1996–1997 to investigate the relative effects of genotype and environment on the yield of maize.

Maize seeds with different 'inbreeding coefficients' were used. The greater the inbreeding coefficient, the greater the degree of homozygosity in the maize plants.

Maize seeds with different inbreeding coefficients were planted in two different areas in 1996, and in the same two areas in 1997.

Fig. 5.2 shows the results.

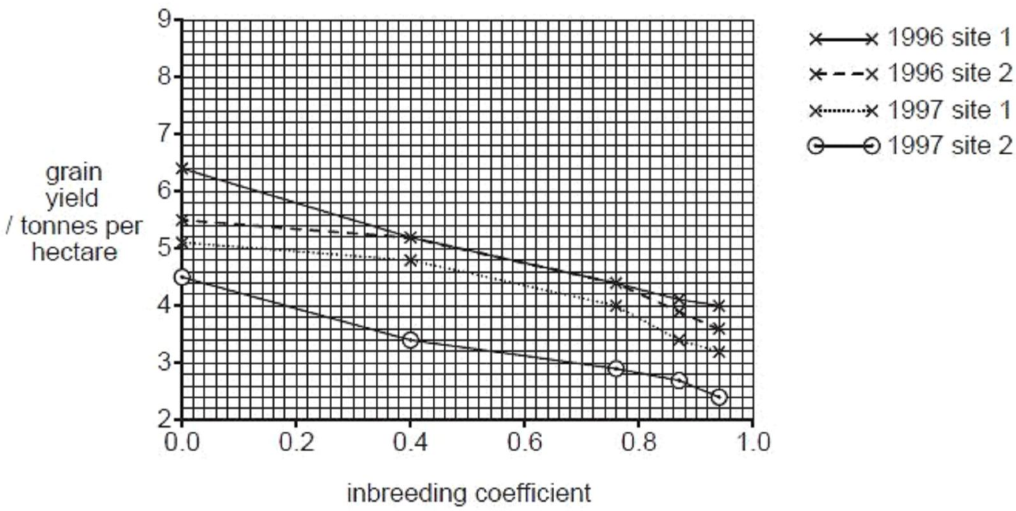

Fig. 5.2

For Examiner's Use

(i) Inbreeding depression is a reduction in vigour that results from inbreeding.

Explain how the results in Fig. 5.2 demonstrate inbreeding depression in maize.

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.... [2]

(ii) Explain how the results in Fig. 5.2 show that the environment affects maize yields.

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.... [2]

[Total: 10]

Q22.

5 Maize was developed from a wild plant called teosinte, which grows from Mexico south to Argentina. It is thought that cultivated maize was derived from teosinte only once.

Fo
Exami
Us

Maize has been found at archaeological sites dated to 5500 years ago.

(a) Fig. 5.1 shows the genetic diversity at ten gene loci in teosinte and in cultivated maize. This was determined by sequencing the DNA base pairs at each locus, and calculating how much each of these base sequences varied. The gene loci are numbered in order of the degree of diversity in teosinte.

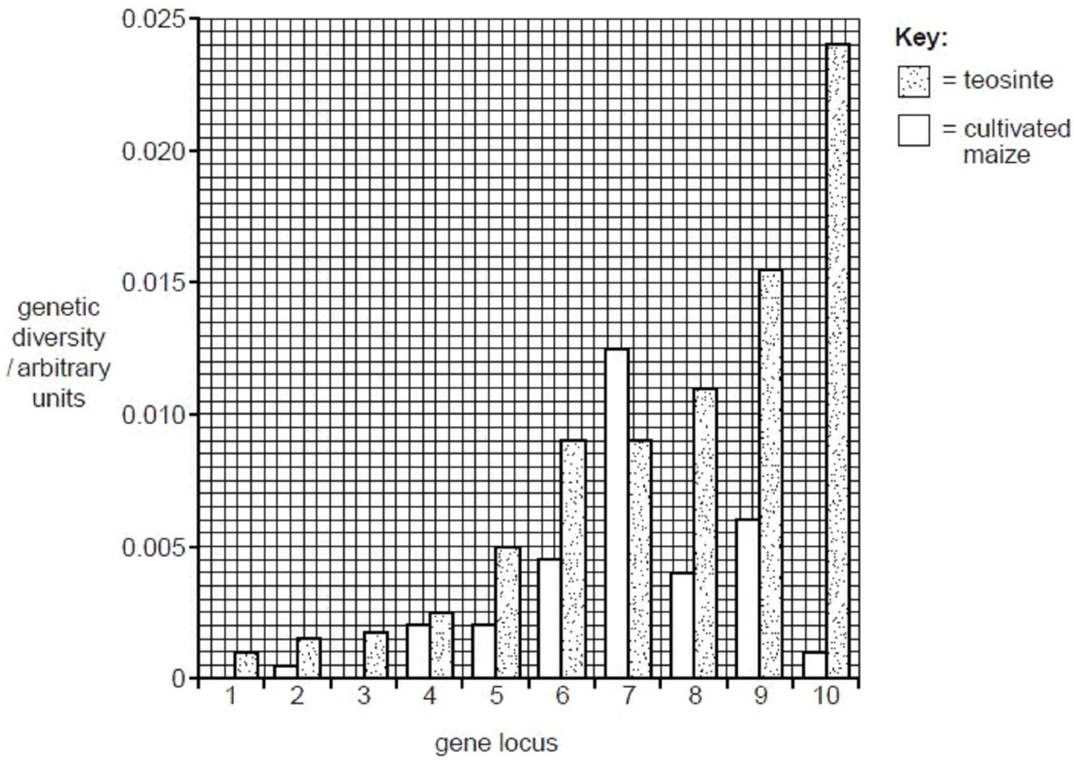

Fig. 5.1

(i) Compare the genetic diversity of teosinte with that of cultivated maize.

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.... [2]

(ii) Suggest reasons for the differences in genetic diversity between teosinte and cultivated maize.

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(iii) Explain how these data support the idea that wild relatives of crop plants, such as maize, should be conserved.

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(b) Most farmers today grow maize from seeds that have been produced by crossing two different homozygous parents.

Explain why this is done.

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[Total: 10]

Q23.

8 Fig. 8.1 shows the proportion of cotton, maize and soybeans grown in the USA that are genetically modified in two different ways:

- HT crops are modified to be resistant to the herbicide glyphosate
- Bt crops are modified to express the Bt toxin which kills insect pests.

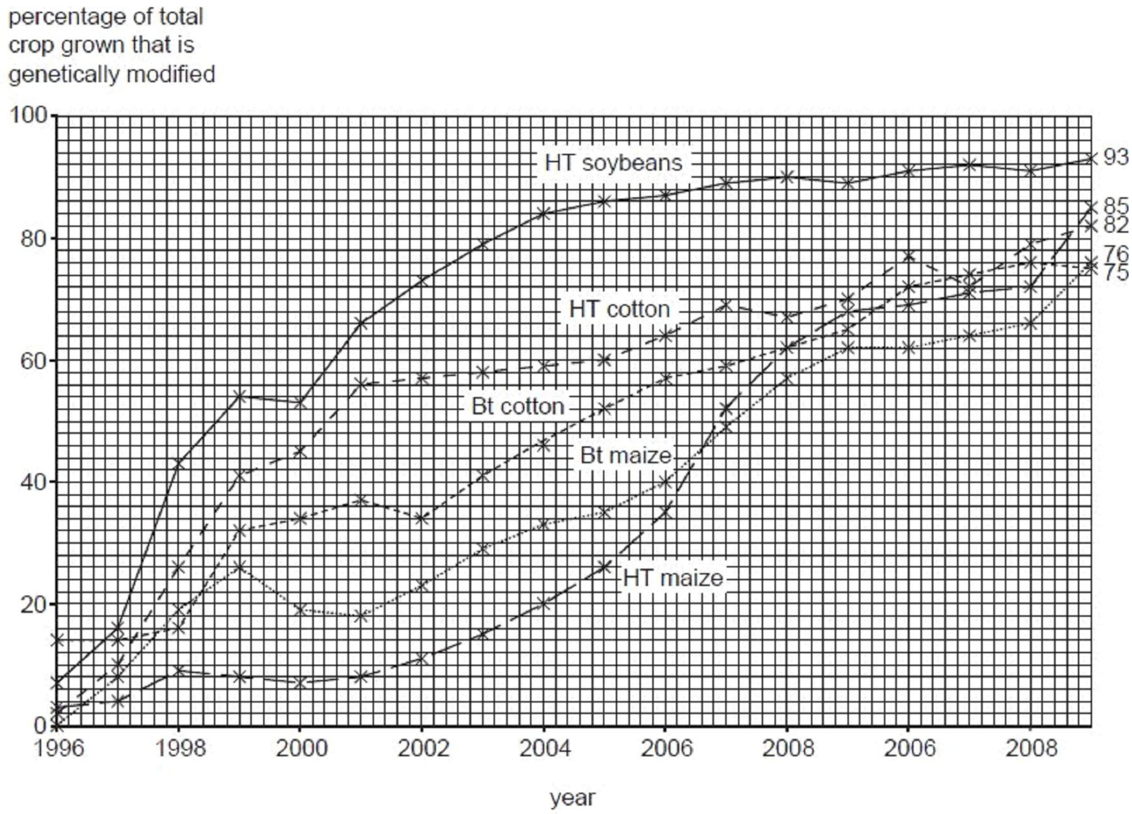

Fig. 8.1

(a) **(i)** With reference to Fig. 8.1, describe the change in the percentage of genetically modified cotton grown in the USA since 1996.

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(ii) Name a vector suitable for genetically modifying plant cells.

.... [1]

(iii) The HT crops received two new genes that gave resistance to glyphosate herbicide and also a marker gene called GUS. The parts of the plant that express the GUS gene turn blue when dipped into a colourless chemical substrate.

Explain why the GUS gene was also transferred to the genetically modified crops.

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.... [2]

(b) Fig. 8.2 shows the increase in the number of weed species resistant to glyphosate herbicide and triazine herbicides since 1970.

Crops have not been genetically modified to resist triazine herbicides.

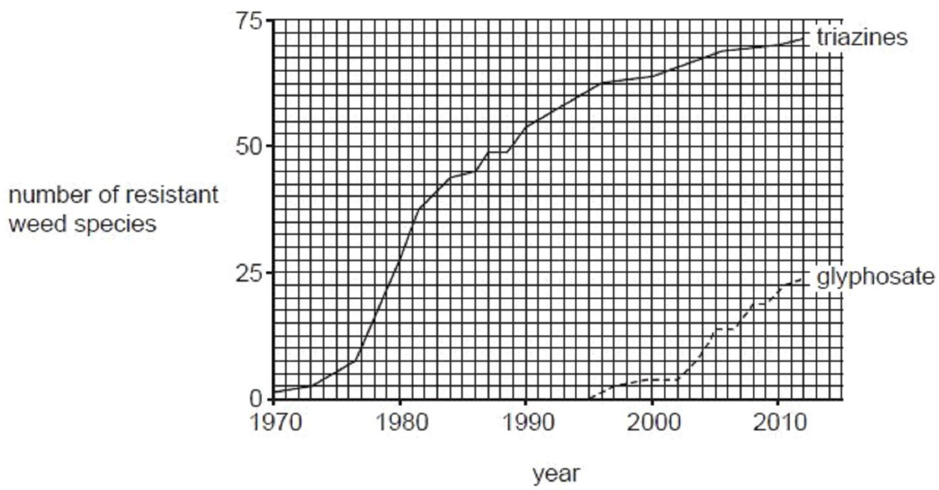

Fig. 8.2

(i) With reference to Fig. 8.1 and Fig. 8.2, justify the statement that the rise in glyphosate-resistant weeds has resulted from the introduction of genetically modified crops.

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(ii) Give **one** piece of evidence from Fig. 8.2 to support the idea that the development of weeds resistant to herbicides is **not** due to horizontal gene transfer from genetically modified crops.

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(iii) Outline how herbicide resistance in weeds arises and spreads without horizontal gene transfer.

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(c) Crops such as maize and cotton are genetically modified to produce Bt toxins to protect them against insect pests. When these GM crops first became available it was predicted that insect pests would develop resistance to these toxins.

The extent of Bt resistance in insect pest species was surveyed in 2005 and in 2011.

The level of resistance in each species was classified according to the highest percentage of resistant individuals recorded in any population anywhere in the world. Three levels of resistance were identified:

- <1%
- 1–6%
- >50%

There were no reports of populations of insect pests having between 6% and 50% of resistant individuals.

The results of the surveys are shown in Table 8.1.

Table 8.1

year	total number of insect pest species surveyed	number of insect pest species susceptible to Bt toxins	number of insect pest species with reported levels of resistance		
			<1%	1–6%	>50%
2005	9	8	0	0	1
2011	13	4	3	1	5

The results in the table show that levels of resistance to Bt toxins have increased between 2005 and 2011.

Suggest **two** other pieces of information that are needed to assess the significance of the results of the surveys.

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.... [2]

[Total: 15]

Q24.

3 (a) Wheat, *Triticum aestivum*, owes its origin to hybridisation involving three different, but related, species of grass, **A**, **B** and **C**.

Each of these species had seven pairs of chromosomes (2n = 14).

The hybridisation process is shown in Fig. 3.1.

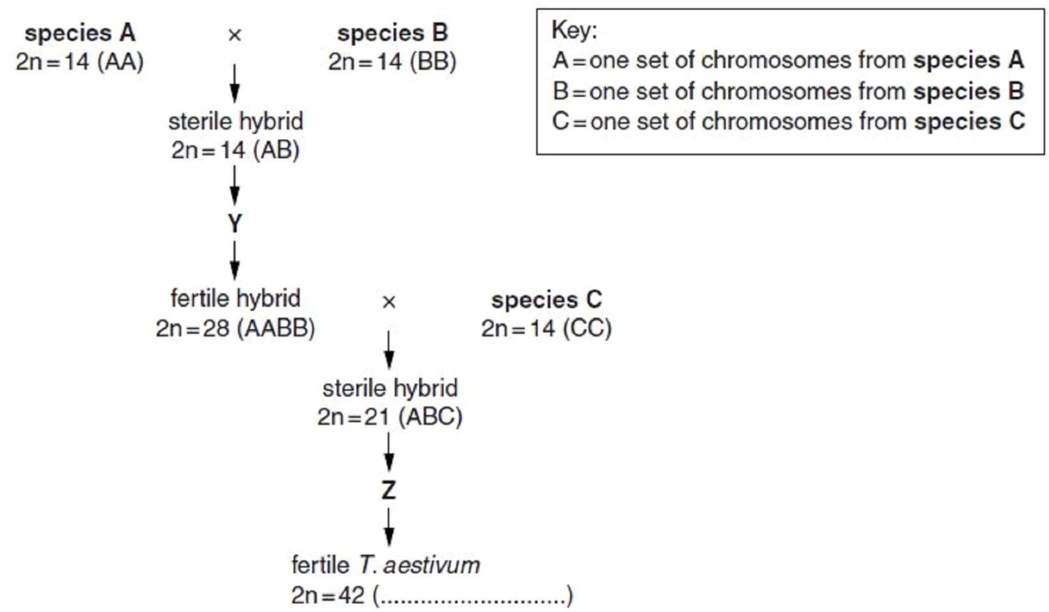

Fig. 3.1

(i) Using the symbols in the key, complete Fig. 3.1 by writing in the chromosome sets of *T. aestivum*. [1]

(ii) At the points labelled **Y** and **Z** in the hybridisation process, a fertile hybrid was produced from a sterile hybrid.

Explain why the hybrid (AB) is sterile **and** what occurred at the point labelled **Y** in Fig. 3.1.

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(b) In 2012, permission was granted for a field trial in the UK of genetically modified *T. aestivum*. The wheat carries a gene, taken from peppermint plants, that results in the wheat leaves releasing a volatile, non-toxic chemical, (E)-β-farnesene (Eβf), into the atmosphere.

Eβf is not only produced by various species of plants. It is also secreted by aphids when they are disturbed by a predator.

Two experiments have been performed into the effect of Eβf on the behaviour of aphids feeding on leaves in closed containers.

Experiment 1
Either 10 cm^3 of air from a syringe that contained plant leaves that secrete Eβf
or 10 cm^3 of air from a syringe with no such leaves
was added to the containers of feeding aphids.

Experiment 2
Either 20 cm^3 of air containing 50ng of Eβf
or 20 cm^3 of air containing no Eβf
was added to the containers of feeding aphids.

In both experiments, the number of aphids that stopped feeding and moved away from the food leaves was counted. The results are shown in Table 3.1.

Table 3.1

	Experiment 1		**Experiment 2**	
air added to containers of feeding aphids	10 cm^3 air that had been in contact with leaves secreting Eβf	10 cm^3 air that had not been in contact with leaves secreting Eβf	20 cm^3 air containing 50ng Eβf	20 cm^3 air containing no Eβf
number of aphids in containers	99	113	132	106
number of aphids that stopped feeding and moved away from the food leaves	54	1	111	0

(i) Discuss the extent to which the results of these experiments support the idea that Eβf is an alarm signal for aphids.

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(ii) Other experiments show that Eβf attracts predators of aphids, such as ladybirds.

Explain how growing genetically modified wheat secreting Eβf could increase the yield of wheat.

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(iii) Suggest why growing this genetically modified wheat might be acceptable to people who object to the growth of genetically modified insect-resistant maize or cotton.

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[Total: 15]

Section-B

`1.

10 (a) Describe the structure of a chloroplast. [7]

(b) Explain how rice is adapted to growing in flooded fields. [8]

[Total:15]

2.

9 (a) Explain the significance of cereal crops in the human diet. [8]

(b) Describe and explain how gibberellins are involved in the germination of wheat or barley seeds. [7]

[Total: 15]

3.

9 (a) Describe how the vitamin A content of rice can be enhanced by genetic modification. [8]

(b) Outline the disadvantages of using plants that have been genetically modified. [7]

[Total: 15]