1. Nov/2022/Paper_41/No.6

Selective breeding has been used to improve the characteristics of crop plants, including maize and rice.

(a) Outline how vigorous, uniform varieties of maize were developed by selective breeding.

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(b) IR8 is a variety of rice plant that was developed in the 1960s.

IR8 was developed by breeding together two different varieties of rice:

- PETA, which produces a high yield
- DGWG, which is a dwarf variety.

Fig. 6.1 is a diagram showing the three varieties of rice.

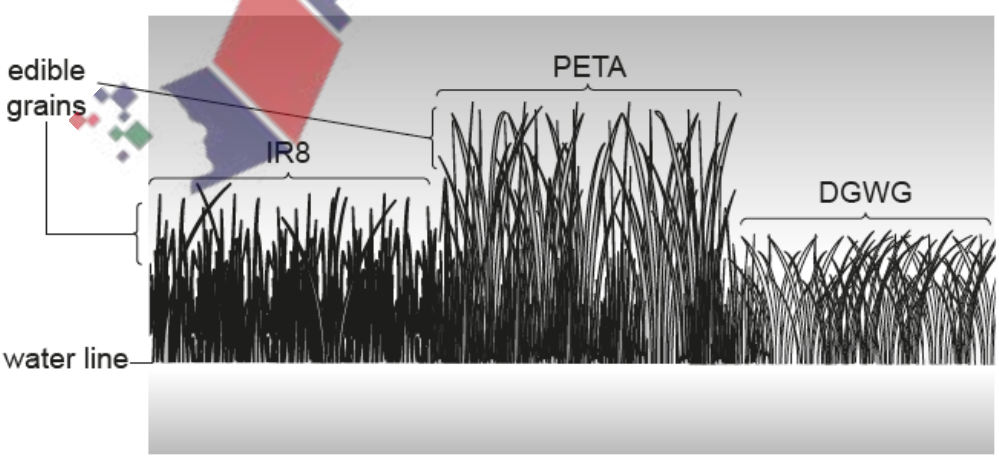

Fig. 6.1

(i) Suggest why IR8 is an improvement on the PETA variety of rice.

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(ii) In 2009, scientists produced a new variety of rice, IR64-Sub1, by breeding together:

- FR13A, a variety which has a low yield but has an allele for flood tolerance
- IR64, a variety which produces a high yield.

The scientists sequenced the DNA of these three rice varieties.

Suggest the benefit of sequencing the DNA of IR64-Sub1.

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(iii) After a few generations of breeding, the scientists crossed IR64-Sub1 with IR64.

Explain why the scientists crossed IR64-Sub1 with IR64.

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(c) Thale cress, *Arabidopsis thaliana*, is another plant that has dwarf varieties.

Scientists treated three varieties of *A. thaliana* with gibberellin:

- the wild type (normal, non-dwarf variety)
- dwarf variety **A**
- dwarf variety **B**.

Fig. 6.2 shows the responses of the three varieties to treatment with gibberellin.

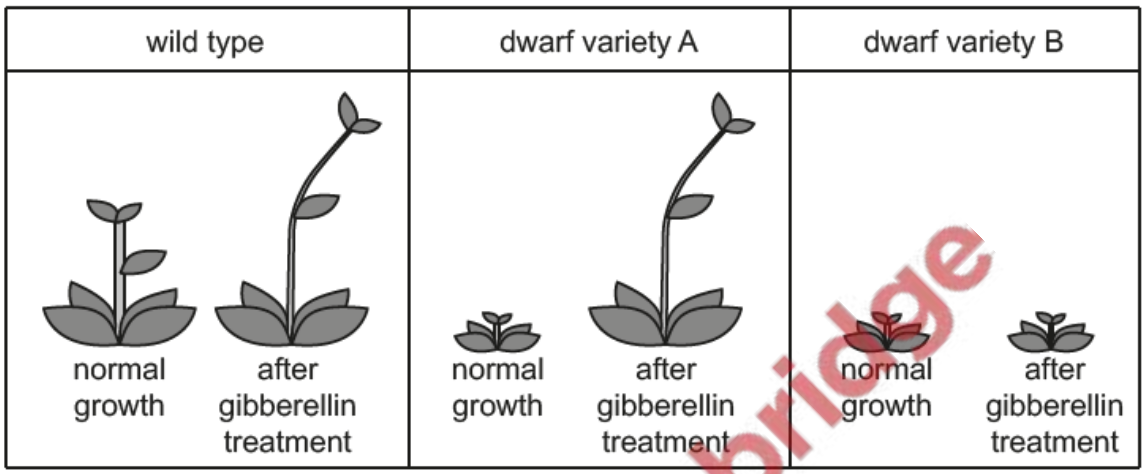

Fig. 6.2

(i) With reference to Fig. 6.2, suggest explanations for the different responses to gibberellin shown by dwarf variety **A** and dwarf variety **B**.

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(ii) BZR1 is a transcription factor that helps to regulate growth and development in *A. thaliana*.

Outline the features of a transcription factor such as BZR1.

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[Total: 13]

2. Nov/2022/Paper_42/No.4

Haemophilia is a blood clotting disorder in humans caused by a mutant allele on the X chromosome.

Table 4.1 compares two forms of haemophilia: haemophilia A and haemophilia B.

Table 4.1

	haemophilia A	**haemophilia B**
gene	*F8*	*F9*
clotting factor protein	factor VIII	factor IX
proportion of males born with haemophilia	1 in 5000	1 in 30 000
length of functional gene (exons only)/kilobase pairs	7.0	1.6

(a) Genetic engineering is used to make recombinant human proteins to treat people with haemophilia A and haemophilia B.

Outline the principles of genetic engineering.

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(b) Scientists are working towards a goal of treating haemophilia by gene therapy. They plan to use a common, harmless virus to introduce the functional gene. The virus has a genome that is 4.7 kilobase pairs long.

(i) With reference to Table 4.1 and the introduction to **(a)**, assess:

- which form of haemophilia, A or B, scientists should try to treat first
- whether they should attempt to treat haemophilia with gene therapy at all.

Explain your reasoning.

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(ii) In gene therapy trials to treat haemophilia, the gene coding for the clotting factor needs to be introduced together with a promoter.

Explain why a promoter has to be introduced as well as the desired gene.

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(iii) Some individuals taking part in gene therapy trials have been naturally exposed to the virus carrying the functional gene, so that their blood already contains antibodies to the virus.

Predict how this will affect the success of the gene therapy treatment.

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(c) Gene editing is a newer technique for modifying DNA. Some scientists are researching the use of gene editing, instead of introducing a functional gene, to treat haemophilia.

State **two** possible advantages of using gene editing as a method of treating haemophilia.

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[Total: 13]

(a) The *lac* operon of prokaryotes contains a group of structural genes that are under the same control and are transcribed together.

Another operon found in prokaryotes is the *trp* operon.

Fig. 6.1 summarises the structure and control of the *trp* operon.

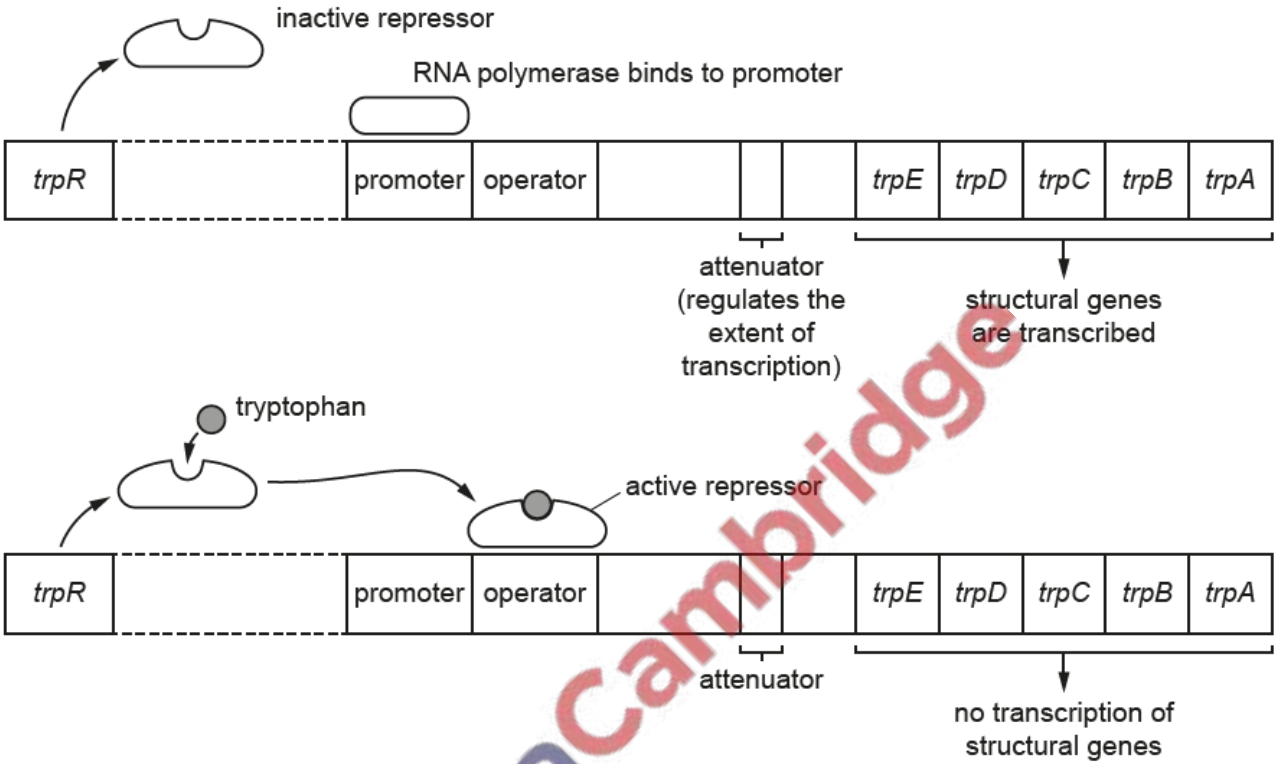

Fig. 6.1

(i) Describe the differences in structure **and** control between the *lac* operon and the *trp* operon.

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(ii) Suggest why structural genes in operons are transcribed together.

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(iii) *trpA* is an example of a structural gene and *trpR* is an example of a regulatory gene.

Describe the differences between the functions of structural genes and regulatory genes.

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(iv) *trpA* codes for the enzyme tryptophan synthase.

Tryptophan synthase catalyses the formation of the amino acid tryptophan.

Explain why tryptophan synthase is an example of a repressible enzyme.

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(b) Control of gene expression in eukaryotes is more complex than in prokaryotes.

In plants, the control of gene expression can involve plant hormones, such as gibberellin, and proteins known as JAZ and MYC.

(i) Describe how gibberellin activates genes in plant cells.

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(ii) Transcription of some plant genes is prevented when JAZ proteins bind to other proteins known as MYC.

When JAZ proteins are broken down, MYC proteins are free to bind to DNA. This allows transcription to begin.

State the term that is used to describe proteins such as MYC proteins.

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[Total: 13]