

## AICE Biology: Gene and Biotechnology Problem Set

Answer the following AICE practice questions in complete sentences. All attached questions come from AICE Paper 4 (A2 Level topics) and are all essay. This problem set is worth 30 points and is due the day of the test, Friday, December 2.

1

The polymerase chain reaction (PCR) is used to produce large amounts of DNA from a very small original sample. The main stages of a PCR are shown in Fig. 3.1.

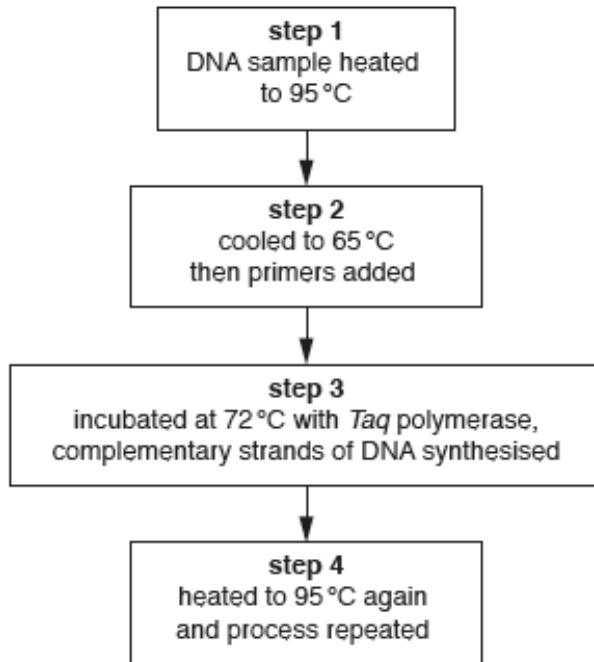


Fig. 3.1

(a) (i) Explain why the DNA sample is heated to 95 °C in **step 1**.

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.....[2]

(ii) Explain why primers are added in **step 2**.

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.....[2]



1 continued...

(i) Explain why there are usually more than 100 copies of mtDNA in a cell, but only two copies of nuclear DNA.

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.....  
..... [2]

(ii) All of the mitochondria in a zygote come from the egg, not the sperm.

List the **letters** of the people in the family tree in Fig. 3.2 who would be expected to have mtDNA identical to the mtDNA of the living relative, G.

.....  
..... [1]

[Total: 9]

2

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.

percentage of total  
crop grown that is  
genetically modified

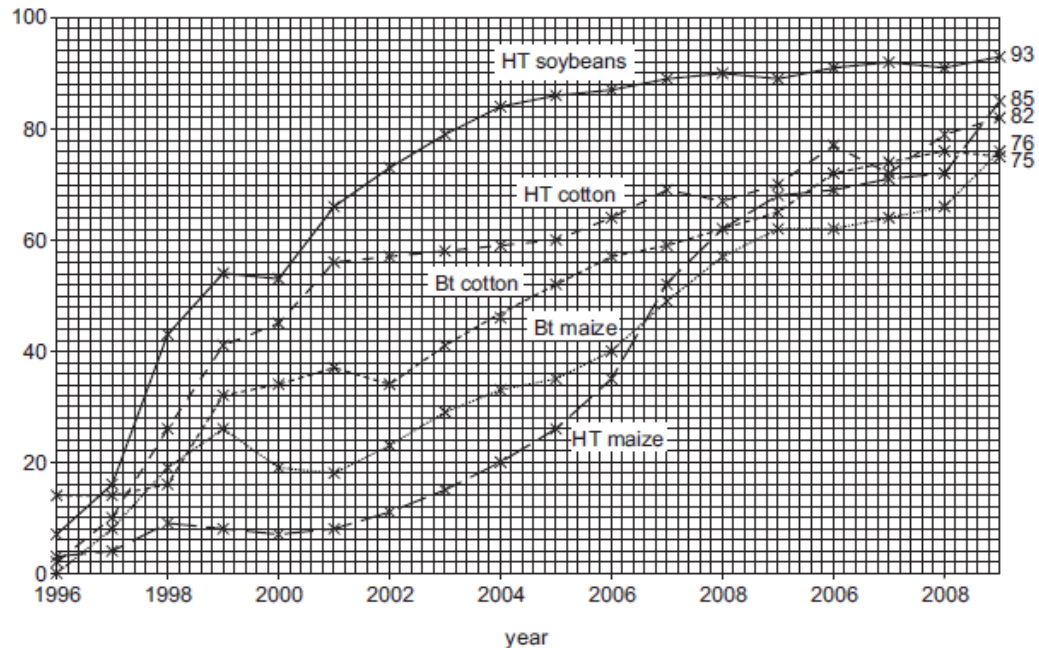


Fig. 8.1

- (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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..... [3]

- (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.

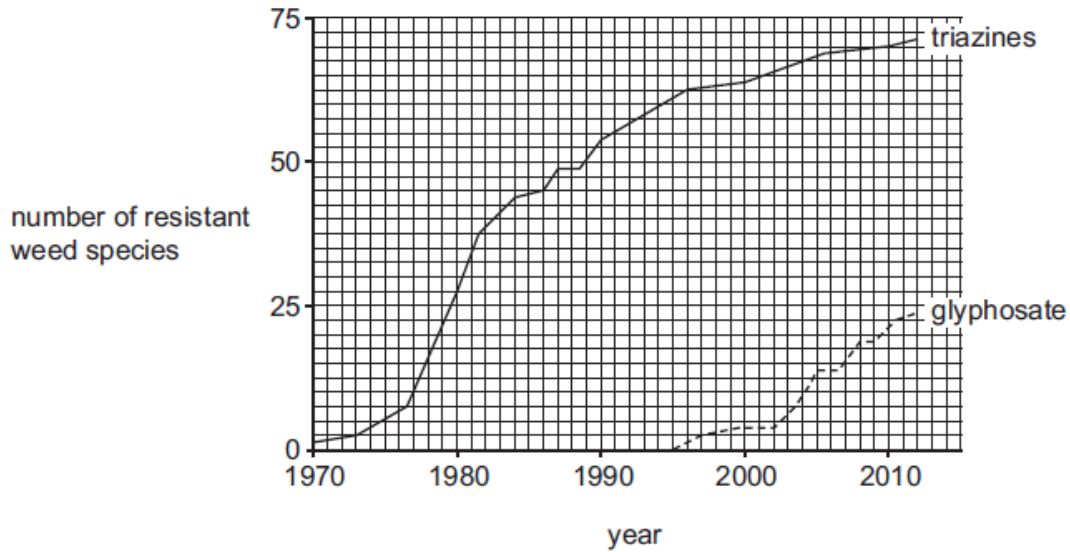


Fig. 8.2

- (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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..... [2]

- (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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..... [1]

2 continued...

- (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]

3 In humans, the gene *RPE65* encodes a protein responsible for regenerating visual pigment in rod and cone cells after they have been exposed to light. A recessive allele of this gene causes impaired vision from birth, progressing to complete blindness in early adulthood. This condition is called LCA.

In 2008, trials were carried out into the possibility and safety of treating LCA using gene therapy.

(a) Suggest and explain why LCA is suitable for treatment using gene therapy.

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..... [3]

(b) Six adults with this condition were used in the study. Genetically modified adenoviruses (a type of virus that can cause respiratory infections) were used as vectors. The vectors were injected beneath the retina of one eye of each of the participants.

Suggest two ways in which the genome of the adenoviruses used as vectors would differ from that of normal adenoviruses.

1. ....  
.....  
2. ....  
..... [2]

(c) Improvements were found in the vision of all the participants, but the small number in the trials made most of these improvements not statistically significant.

Suggest why these trials were designed to include such a small number of participants.

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..... [2]

[Total: 7]

4

Insulin can be produced on a large scale using gene technology and prokaryotes such as *Escherichia coli*.

Table 7.1 summarises the sequence of steps in one method of production of insulin by *E. coli*.

Complete Table 7.1 by adding one statement in each of the empty boxes.

Table 7.1

step	reason for step
obtain copies of gene with sticky ends	the gene codes for the synthesis of insulin
	acts as a vector for the transfer of the gene into the host
use restriction endonuclease enzyme	
mix vector and gene	
	to seal the sugar-phosphate backbone
	to obtain transformed host <i>E. coli</i> cells
screen for, and obtain, successfully transformed cells	
	to obtain large amounts of insulin for extraction and purification

[7]

[Total: 7]





With reference to Fig. 4.1,

- (i) compare the effects on breast cancer cells of the different treatments

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 ..... [3]

- (ii) calculate the percentage increase in the ability to induce cell death of using Herceptin and X-ray treatment compared with using Herceptin only.

Show your working.

..... [2]

- (c) A second experiment investigated the effect of increasing doses of X-rays on the survival of breast cancer cells in the presence and absence of Herceptin. The results are shown in Fig. 4.2.

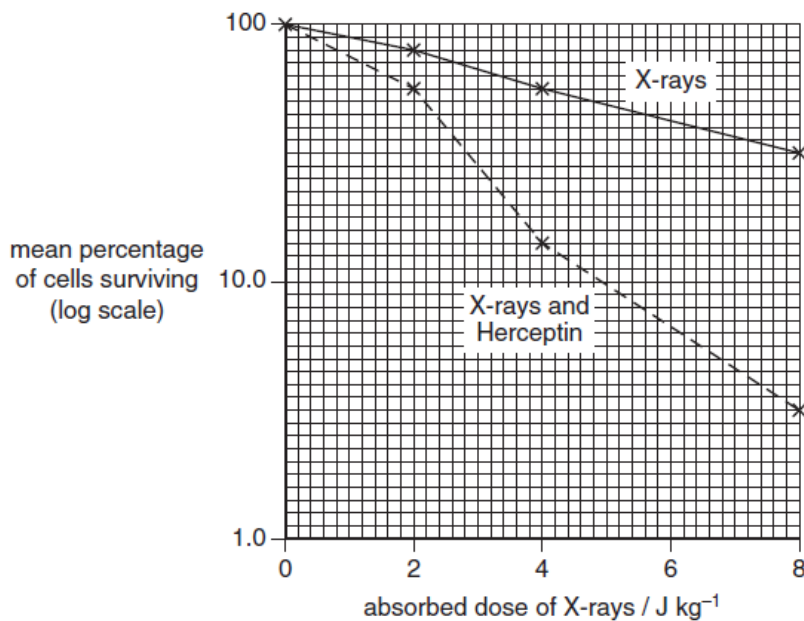


Fig. 4.2

With reference to Fig. 4.2,

- (i) compare the effects of increasing doses of X-rays on cells in the presence and absence of Herceptin

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.....[3]

- (ii) suggest an explanation for the effect of Herceptin.

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.....[2]

[Total: 14]

6 Many attempts have been made to find methods of using gene therapy to treat cystic fibrosis. One approach uses viruses to deliver normal alleles of the CFTR gene into epithelial cells of the airways. Viral delivery systems have two main problems:

- The virus may trigger an immune response which destroys the infected cells.
- Most non-pathogenic viruses are not very good at getting into cells, so very few cells receive the allele.

A team of researchers in the USA developed a new strain (AAV2.5T) of AAV, a non-pathogenic virus. AAV2.5T has an improved ability to bind with epithelial cells of the airways. Genes for the CFTR protein and for an enzyme, luciferase, were added to the DNA of the viruses. Luciferase produces a fluorescent green protein when luciferin is added.

The normal AAV strain and the AAV2.5T strain were added to cultures of epithelial cells from the airways. After adding luciferin, the numbers of cells that had taken up the viral genes was estimated using the intensity of the green fluorescence which developed.

The results are shown in Fig. 5.1.

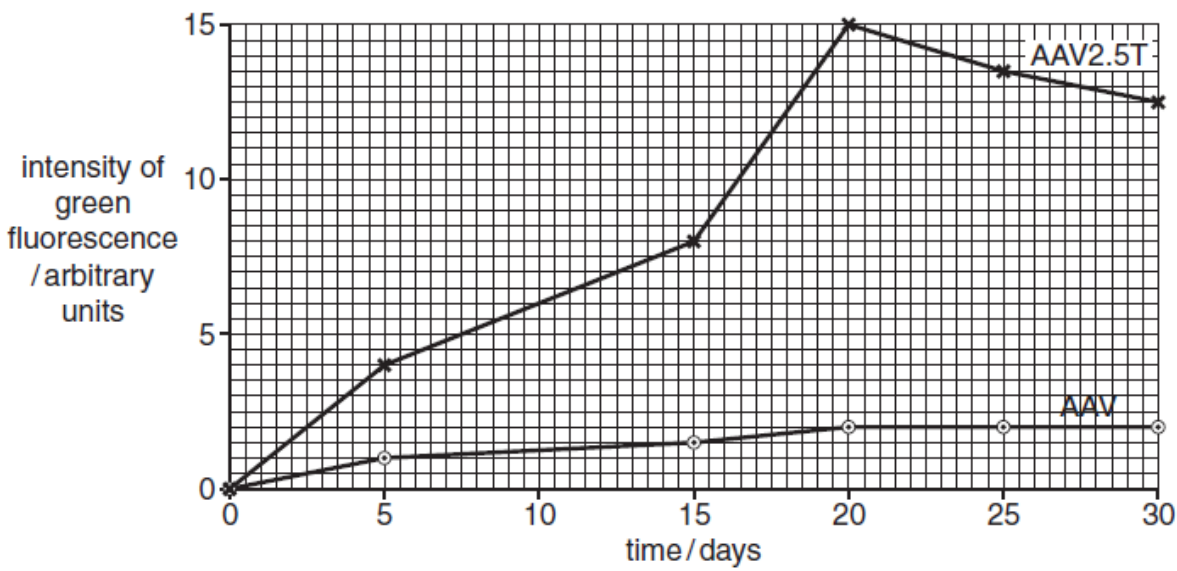


Fig. 5.1

(a) With reference to Fig. 5.1, compare the ability of the two viral strains, AAV and AAV2.5T, to infect epithelial cells from the airways.

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..... [2]

6 continued...

(b) Explain why the researchers added a gene for luciferase to the viral DNA.

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(c) Suggest how delivering normal alleles of the CFTR gene into epithelial cells in the airways could relieve the symptoms of cystic fibrosis.

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..... [4]

[Total: 8]

7

Green fluorescent protein (GFP) is a small protein that emits bright green fluorescence in blue light. It was first isolated from the jellyfish, *Aequorea victoria*.

The gene coding for GFP can be expressed in bacteria, such as *Escherichia coli*, and so it is often used as a marker to show successful uptake of a gene by the bacterium.

(a) (i) Outline how a gene from another species can be inserted into *E. coli*.

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..... [3]

(ii) Explain how a marker gene, such as the gene for GFP, is used to show successful uptake of a gene for a wanted protein.

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..... [3]

7 continued...

(b) Genes for enzymes that produce fluorescent substances are often used as markers in gene technology.

GFP is **not** an enzyme.

Suggest **one** disadvantage of using the gene for GFP to produce easily detectable fluorescence, rather than using a gene for an enzyme that produces a fluorescent substance.

Explain your answer.

*disadvantage* .....

*explanation* .....

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.....[2]

[Total: 8]

**Answer the following extended essay questions on your own paper and attach:**

8 (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]

9 (a) Cystic fibrosis (CF) is a genetic disease caused by an autosomal recessive allele. Gene therapy has been attempted to treat CF since 1993. Outline the basic principles of gene therapy for the treatment of CF. [8]

(b) Describe the role of a genetic counsellor in dealing with genetic diseases in humans and discuss the circumstances in which a couple might be referred to a genetic counsellor. [7]

[Total: 15]

10 (a) Describe the principles of the polymerase chain reaction (PCR). [9]

(b) Explain why plasmids are frequently used in gene technology. [6]

[Total: 15]