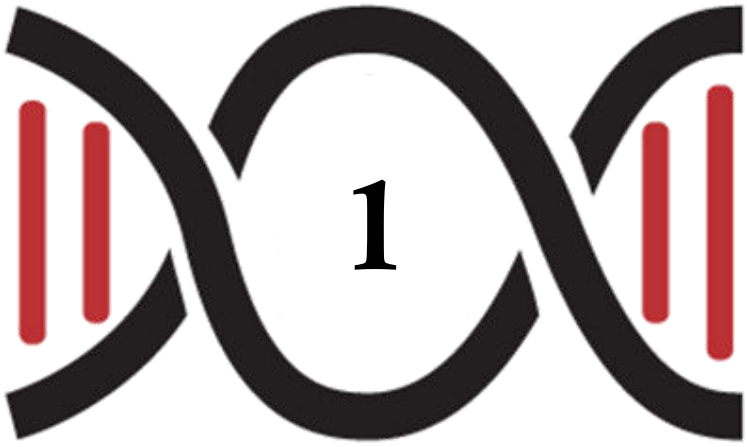
LONDON SCIENCE COLLEGE

AQA A2 BIOLOGY

TOPIC 8

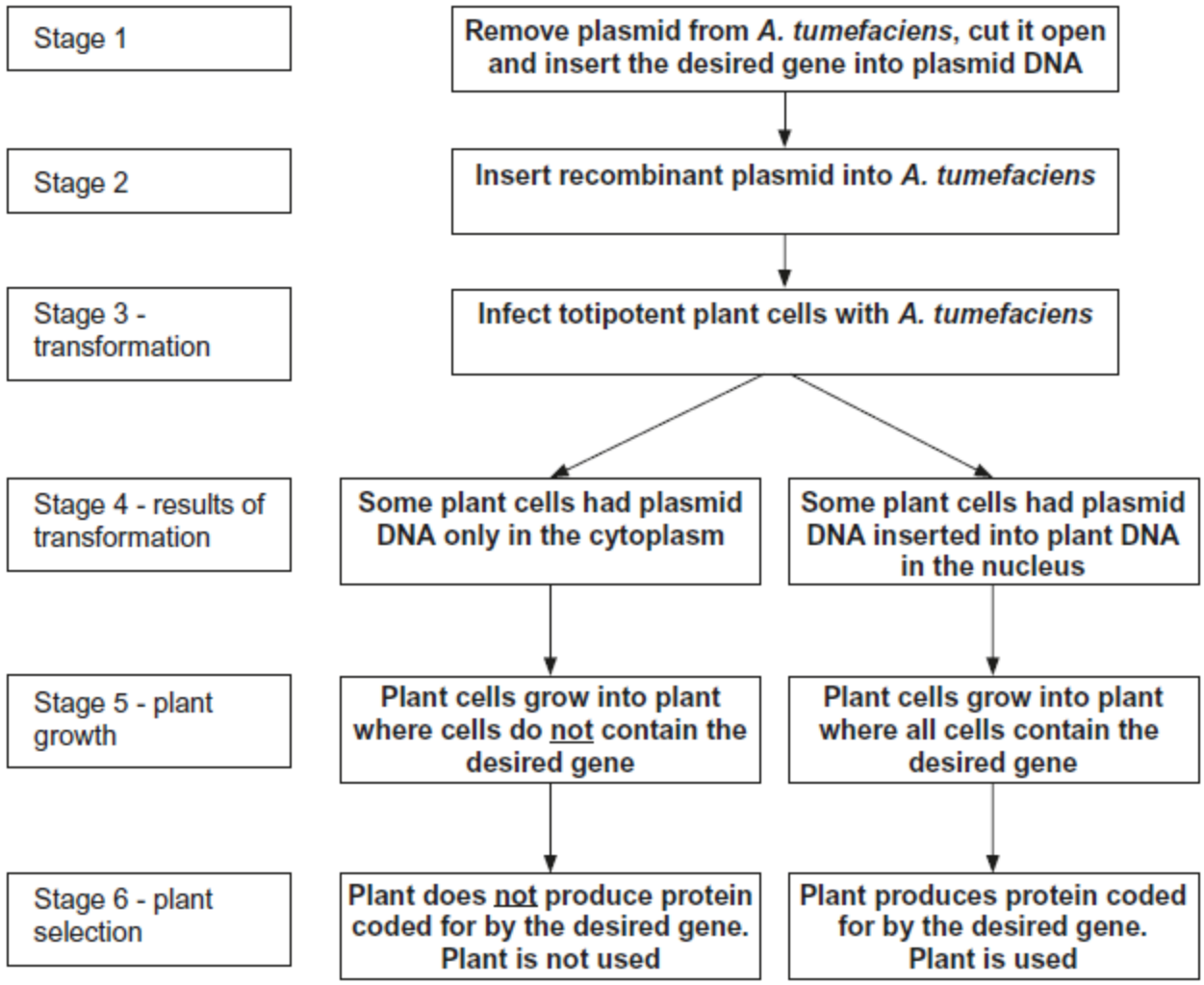
CONTROL OF GENE EXPRESSION



1 *Agrobacterium tumefaciens* is a bacterium that is often used in recombinant DNA technology to produce transformed plants that benefit humans.

A. tumefaciens contains a plasmid which can be used as a vector to transfer a desired gene into plant cells. These plant cells may then develop into plants which produce the protein coded for by the desired gene.

The diagram outlines this process.



(a) (i) In stage 1, an enzyme is used to cut open the plasmid.
Name the type of enzyme used to cut open the plasmid.

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(1)

(ii) In stage 1, another enzyme is used to insert the desired gene into the plasmid DNA.
Name the type of enzyme used to insert the gene into the plasmid.

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(1)

(b) In stage 4, some plant cells had plasmid DNA only in their cytoplasm. In other plant cells, the plasmid DNA had become inserted into plant DNA in the nucleus.

In stage 5, only cells with plasmid DNA inserted into the plant DNA in the nucleus grew into plants where all the cells contained the desired gene.

Explain why some of the plants in stage 5 contained the desired gene in all of their cells and others did not.

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(3)

(c) The **desired gene** in the diagram was from an insect. In stage 6, the plant containing this gene was able to use it to synthesise an insect protein.

The plant is able to synthesise the insect protein. Explain why this is possible.

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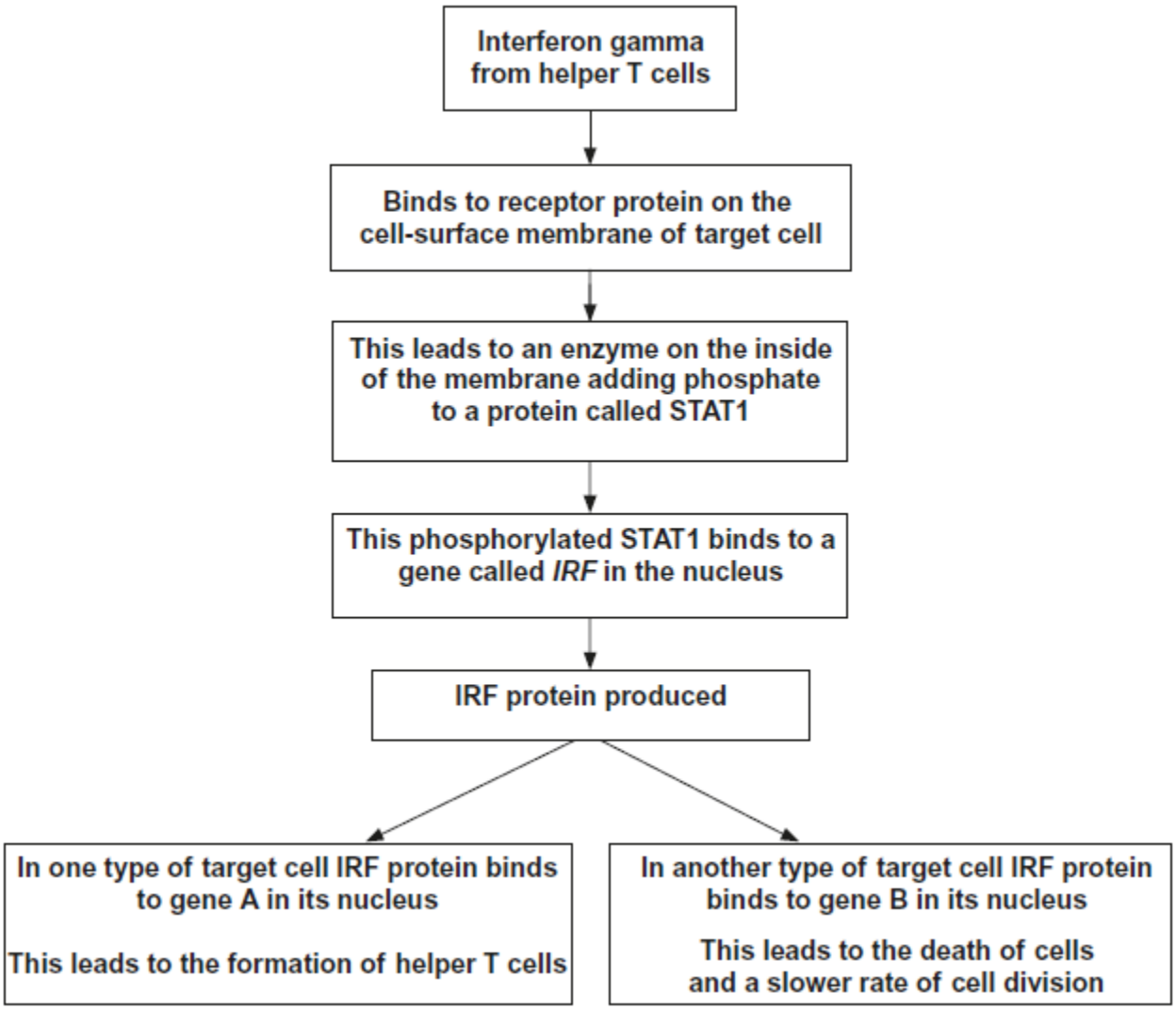
(3)
(Total 8 marks)

2 Interferon gamma is a substance secreted by some types of white blood cells, including helper T cells. It regulates the production of a number of proteins by target cells. Which protein is produced depends on the type of target cell.

The diagram shows how interferon gamma regulates three genes.



(a) Use information in the diagram to suggest how the binding of interferon gamma to its receptor protein leads to the production of phosphorylated STAT1.

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(2)

(b) Name the **two** transcription factors in the diagram.

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(2)

(c) The regulation of the formation of helper T cells by interferon gamma is an example of positive feedback.

Explain why it is an example of positive feedback.

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(d) The *IRF* gene can be a tumour suppressor gene.

Use the information in the diagram to explain how the *IRF* gene acts as a tumour suppressor gene.

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(Total 9 marks)

3 *Mycobacterium tuberculosis* causes tuberculosis. The DNA of *M. tuberculosis* contains a direct repeat (DR) region. The DR region consists of 43 different, non-coding base sequences called spacers. Each spacer is found in a specific place in the DR region.
In different strains of *M. tuberculosis*, some of these spacers have been lost.

(a) (i) The DR region consists of non-coding base sequences.

What is meant by a non-coding base sequence?

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(1)

(ii) Name the process by which the base sequence of a spacer is lost from a DR region.

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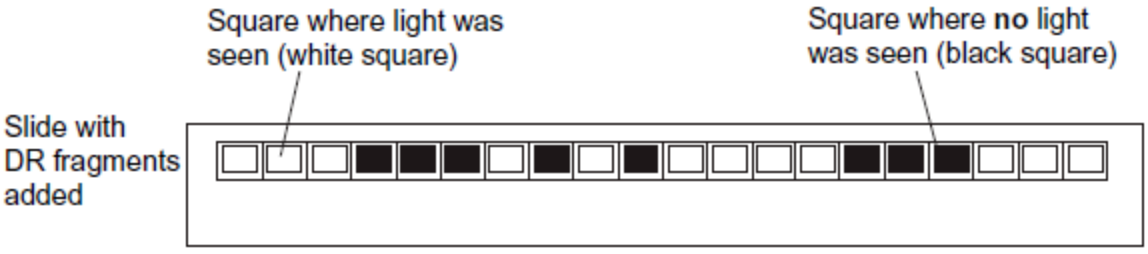
(1)

Scientists investigated the DR regions of different strains of *M. tuberculosis*. They produced a DNA probe for each of the 43 spacer sequences. Each probe was:

- labelled with a fluorescent marker that gave off light if the probe attached to its complementary spacer
- attached to a particular square on a slide.

They obtained samples of the DR region from each strain. These were cut into small single-stranded DNA fragments. The fragments from each strain were added to a slide with the DNA probes attached. The diagram below shows their results for one strain of *M. tuberculosis* with 20 of the probes.



(b) The scientists cloned the DR region DNA *in vitro* before testing for the presence of spacers.

Give the name of the method they used to clone the DNA *in vitro*.

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(1)

(c) Explain how the use of DNA probes produced the results in the diagram.

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(d) Doctors can use the method with DNA probes to identify the specific strain of *M. tuberculosis* infecting a patient. This is very important when there is an outbreak of a number of cases of tuberculosis in a city.

Suggest and explain why it is important to be able to identify the specific strain of *M. tuberculosis* infecting a patient.

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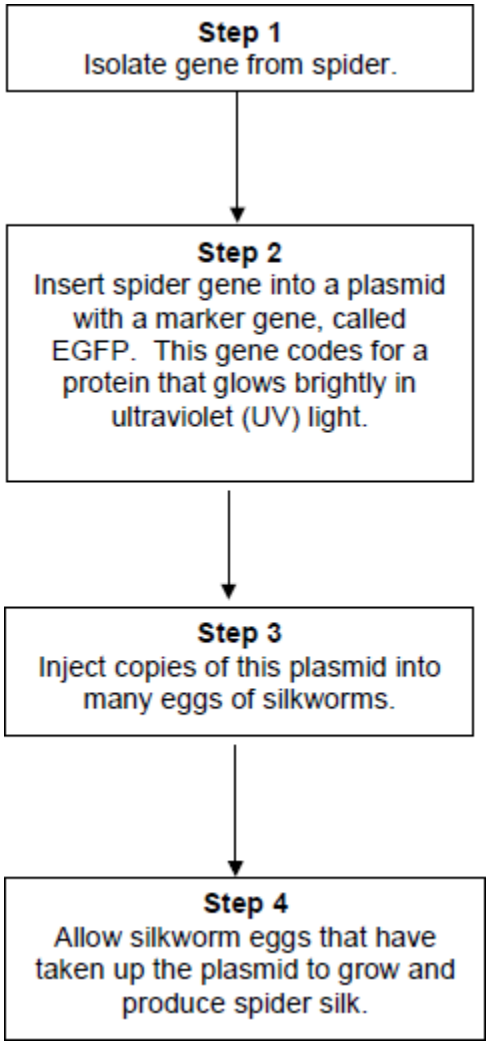
(2)
(Total 8 marks)

4 Silkworms secrete silk fibres, which are harvested and used to manufacture silk fabric.

Scientists have produced genetically modified (GM) silkworms that contain a gene from a spider.

The GM silkworms secrete fibres made of spider web protein (spider silk), which is stronger than normal silk fibre protein.

The method the scientists used is shown in the figure below.



(a) Suggest why the plasmids were injected into the eggs of silkworms, rather than into the silkworms.

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(2)

(b) Suggest why the scientists used a marker gene and why they used the EGFP gene.

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(2)

The scientists ensured the spider gene was expressed only in cells within the silk glands.

(c) What would the scientists have inserted into the plasmid along with the spider gene to ensure that the spider gene was only expressed in the silk glands of the silkworms?

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(1)

(d) Suggest **two** reasons why it was important that the spider gene was expressed only in the silk glands of the silkworms.

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(2)
(Total 7 marks)

5 (a) Explain how the methylation of tumour suppressor genes can lead to cancer.

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(3)

Scientists investigated a possible relationship between the percentage of fat in the diet and the death rate from breast cancer in women from 10 countries.

Their data is shown in the table below.

Percentage of fat in diet of population	Death rate of women from breast cancer per 100 000 women
9.5	1.5
15.0	7.0
20.0	12.0
25.0	9.0
32.0	15.0
35.0	8.0
35.0	20.0
40.5	18.0
43.0	24.0
45.0	26.0

(b) Describe how you would plot a suitable graph of these data. Explain your choice of type of graph.

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(3)

(c) What can you conclude from these data?

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(2)
(Total 8 marks)

6 Metastatic melanoma (MM) is a type of skin cancer. It is caused by a faulty receptor protein in cell-surface membranes. There have been no very effective treatments for this cancer.

Dacarbazine is a drug that has been used to treat MM because it appears to increase survival time for some people with MM.

Doctors investigated the use of a new drug, called ipilimumab, to treat MM. They compared the median survival time (ST) for two groups of patients treated for MM:

- a control group of patients who had been treated with dacarbazine
- a group of patients who had been treated with dacarbazine and ipilimumab.

The ST is how long a patient lives after diagnosis.

The doctors also recorded the percentage of patients showing a significant reduction in tumours with each treatment.

The total number of patients in the investigation was 502.

The table below shows the doctors' results.

Treatment	Median survival time (ST) / months	Percentage of patients showing significant reduction in tumours
Dacarbazine	9.1	10.3
Dacarbazine and ipilimumab	11.2	15.2

(a) The doctors compared median survival times for patients in each group.

How would you find the median survival time for a group of patients?

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(2)

(b) In many trials of new drugs, a control group of patients is given a placebo that does not contain any drug.

The control group in this investigation had been treated with dacarbazine.
Suggest why they had not been given a placebo.

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(1)

(c) A journalist who read this investigation concluded that ipilimumab improved the treatment of MM.

Do the data in the table support this conclusion? Give reasons for your answer.

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(d) MM is caused by a faulty receptor protein in cell-surface membranes.
Cells in MM tumours can be destroyed by the immune system.

Suggest why they can be destroyed by the immune system.

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(3)
(Total 10 marks)

7 Oestrogen is a substance produced by the enzyme aromatase. In females, the main source of oestrogen is the ovaries but aromatase is produced by many other organs in the body, including the lungs. Oestrogen can stimulate the development of some lung tumours. In these tumours, binding of oestrogen to cell-surface receptors stimulates cell division.

Scientists investigated whether two drugs could prevent lung tumours in female mice. First, they removed the ovaries from these mice. They then injected the mice with a tumour-causing chemical found in tobacco twice a day for 4 weeks. The mice were then randomly allocated to one of four groups. Each group contained 10 mice.

- Group **Q** was given a placebo. This placebo did not contain either drug.
- Group **R** was given the drug anastrozole. This inhibits the enzyme aromatase.
- Group **S** was given the drug fulvestrant. This binds to oestrogen receptors.
- Group **T** was given both anastrozole and fulvestrant.

The mice were given these drugs each week during weeks 5−15 of the investigation.

(a) The scientists removed the ovaries from the mice for the investigation. They also gave the mice injections of the substrate of aromatase each day.

Explain why these steps were necessary.

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(2)

(b) The scientists predicted that fulvestrant would be more effective when given with anastrozole than when given alone.

Use the information provided to suggest why they predicted this.

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At week 15, the lungs of the mice were removed and examined. The scientists then determined the number of tumours present and the mean tumour area for each group.

Figure 1 and **Figure 2** show the scientists' results.

Figure 1

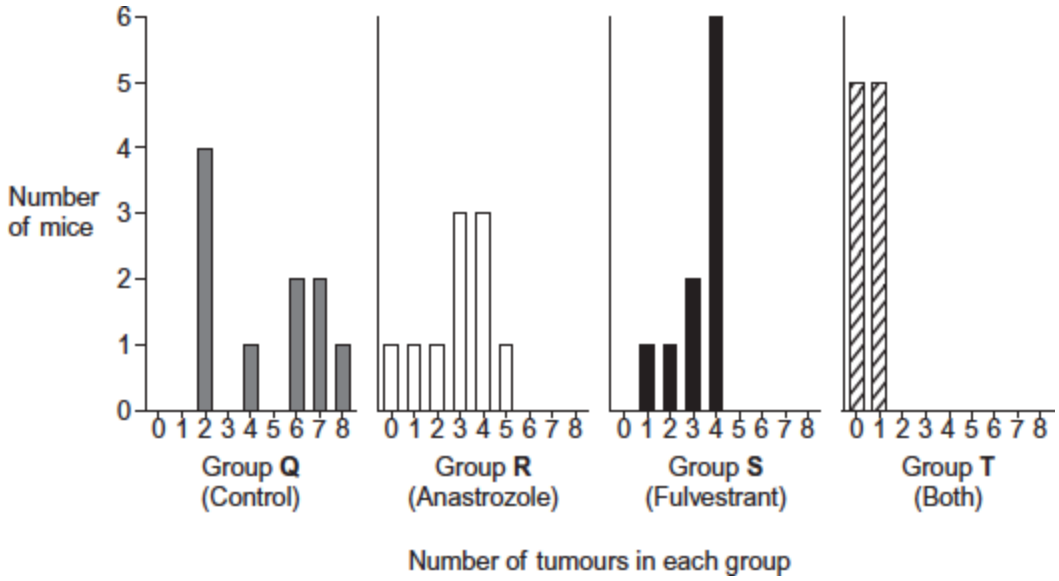
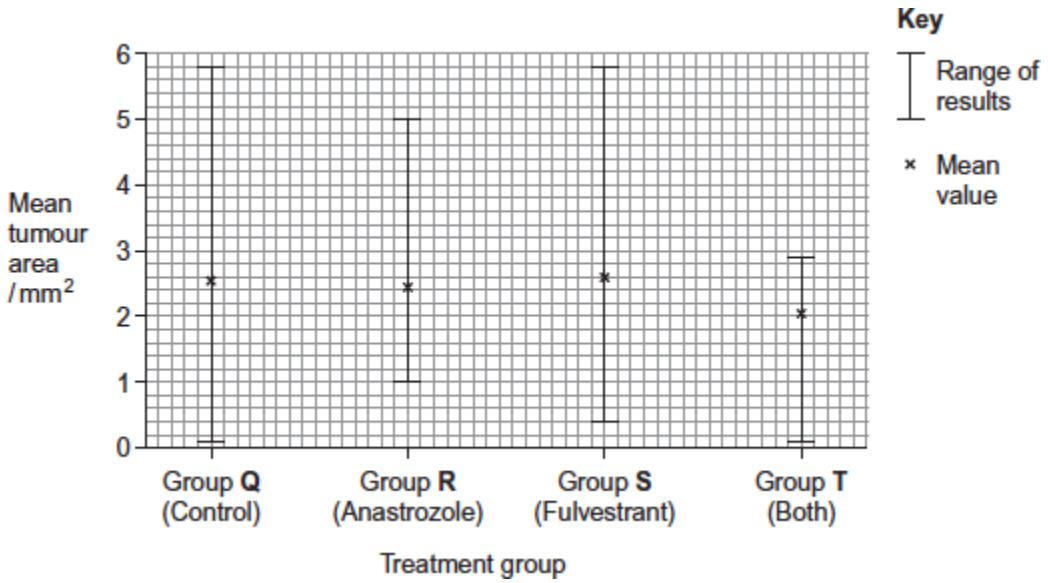


Figure 2



(c) The scientists concluded that both drugs should be used together to reduce the risk of lung cancer in women exposed to tobacco products.

Do you agree? Explain your answer.

(5)

(d) The scientists used tumour area as an indicator of tumour size.

Explain why tumour area may **not** be the best indicator of tumour size and suggest a more reliable measurement.

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(2)

(e) The scientists repeated the investigation but this time they did not give the drugs until week 9.

Suggest why they gave the drugs at week 9, rather than at week 5.

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(f) Another group of scientists is currently using these drugs in human trials. However, the control group is **not** being given a placebo.

Suggest why a placebo is **not** being given and what is being given to this group instead.

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(2)
(Total 15 marks)

8 (a) (i) A mutation of a tumour suppressor gene can result in the formation of a tumour.

Explain how.

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(ii) Not all mutations result in a change to the amino acid sequence of the encoded polypeptide.

Explain why.

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(1)

(b) Some cancer cells have a receptor protein in their cell-surface membrane that binds to a hormone called **growth factor**. This stimulates the cancer cells to divide.

Scientists have produced a monoclonal antibody that stops this stimulation.

Use your knowledge of monoclonal antibodies to suggest how this antibody stops the growth of a tumour.

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(3)
(Total 6 marks)

9 Some populations of flies are becoming resistant to insecticides intended to kill them.

Scientists developed a method for finding out whether a fly was carrying a recessive allele, **r**, that gives resistance to an insecticide. The dominant allele, **R**, of this gene does not give resistance.

The scientists:

- crossed flies with genotype **RR** with flies with genotype **rr**
- obtained DNA samples from the parents and offspring
- used the same restriction endonuclease enzymes on each sample, to obtain DNA fragments.

(a) Explain why the scientists used the same restriction endonuclease enzymes on each DNA sample.

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(2)

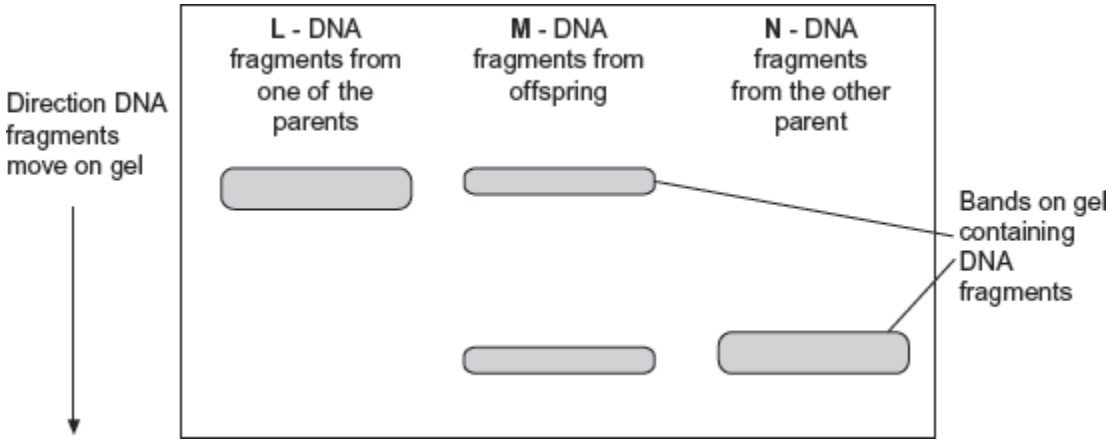
The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- Primer A3 only binds to a 195 base-pair fragment from allele **r**.
- Primer A4 only binds to a 135 base-pair fragment from allele **R**.

The scientists separated the DNA fragments produced by the PCR on a gel where shorter fragments move further in a given time.

Their results are shown in **Figure 1**.

Figure 1



(b) Explain why primer A3 and primer A4 only bind to specific DNA fragments.

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(c) Use all the information given to explain the results in **Figure 1**.

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(3)

(d) The scientists wanted to know on which chromosome the gene with alleles **R** and **r** was located. From the flies with genotype **RR**, they obtained cells that were in mitosis and added a labelled DNA probe specific for allele **R**. They then looked at the cells under an optical microscope.

Explain why they used cells that were in mitosis.

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(2)

(e) Another group of scientists thought that pesticide resistance in some flies was related to increased activity of an enzyme called P450 monooxygenase (PM).
This enzyme breaks down insecticides.

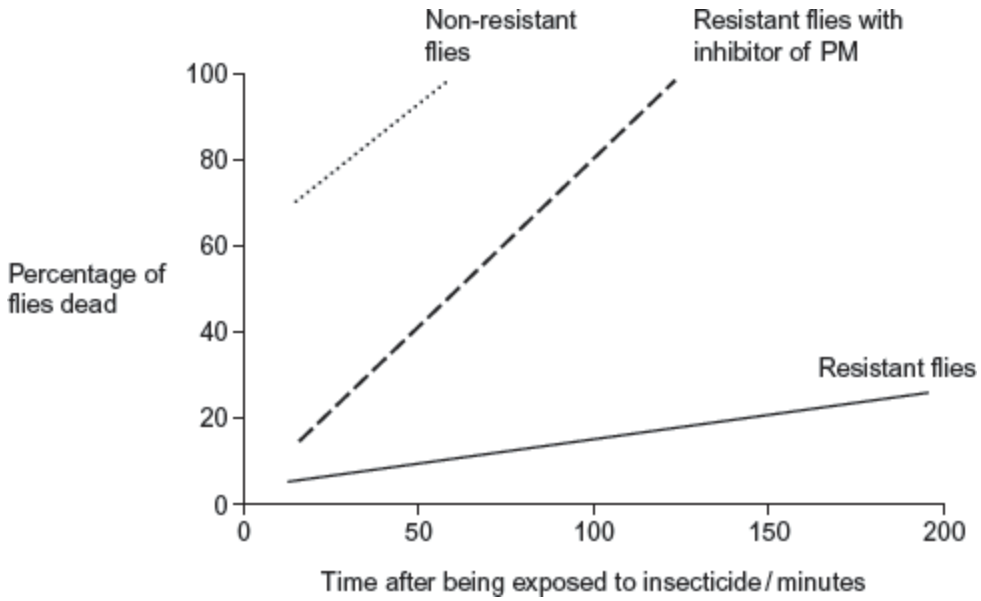
The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- Non-resistant flies exposed to insecticide.
- Resistant flies exposed to insecticide.
- Resistant flies treated with an inhibitor of PM and then exposed to insecticide.

They then determined the percentage of flies that were dead at different times after being exposed to insecticide.

Figure 2 shows their results.

Figure 2



(i) Explain why the scientists carried out the control experiment with the non-resistant flies.

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(ii) The scientists concluded that the resistance of the flies to the insecticide is partly due to increased activity of PM but other factors are also involved.

Explain how these data support this conclusion.

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(4)
(Total 15 marks)

10 (a) Explain how the structure of DNA is related to its functions.

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(6)

Scientists investigated three genes, **C**, **D** and **E**, involved in controlling cell division.
They studied the effect of mutations in these genes on the risk of developing lung cancer.

The scientists analysed genes **C**, **D** and **E** from healthy people and people with lung cancer.

- If a person had a normal allele for a gene, they used the symbol N.
- If a person had two mutant alleles for a gene, they used the symbol M.

They used their data to calculate the risk of developing lung cancer for people with different combinations of N and M alleles of the genes. A risk value of 1.00 indicates no increased risk.
The following table shows the scientists' results.

Gene C	Gene D	Gene E	Risk of developing lung cancer
N	N	N	1.00
M	N	N	1.30
N	N	M	1.78
N	M	N	1.45

N = at least one copy of the normal allele is present
M = two copies of the mutant allele are present

(b) What do these data suggest about the relative importance of the mutant alleles of genes **C**, **D** and **E** on **increasing** the risk of developing lung cancer? Explain your answer.

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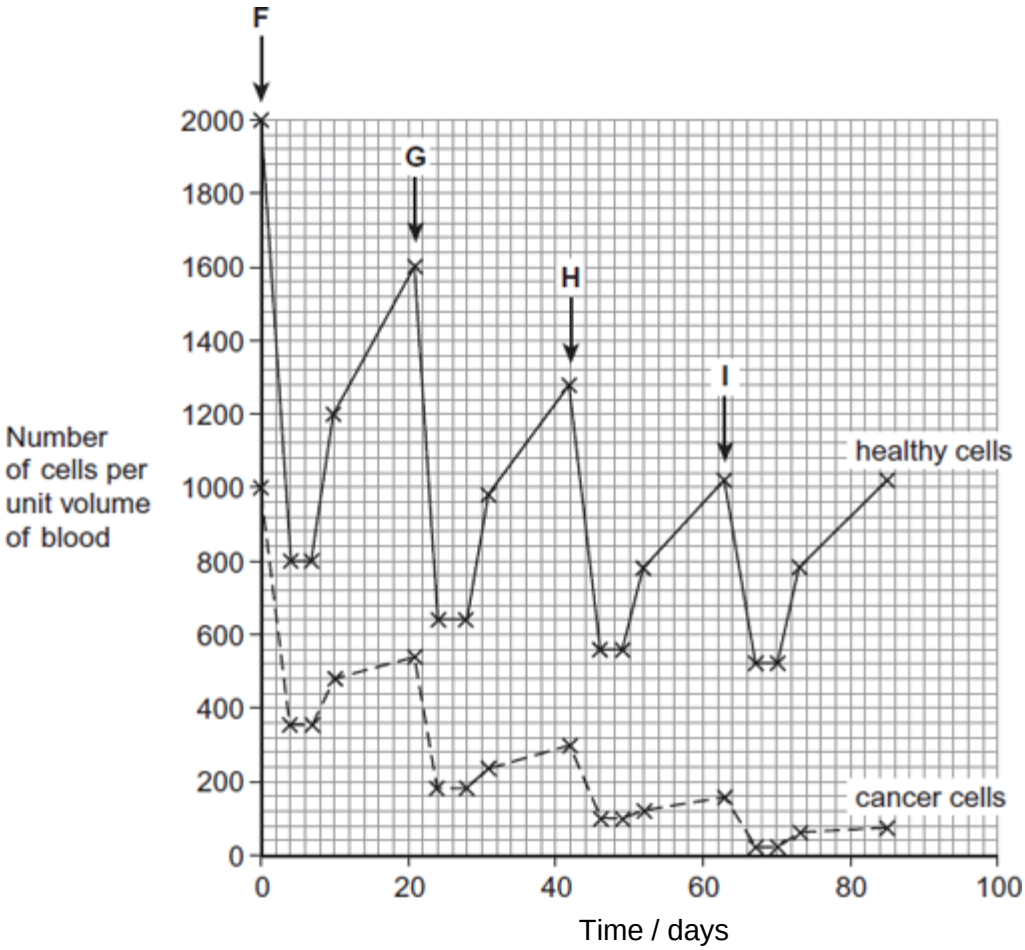
(3)

Chemotherapy is the use of a drug to treat cancer. The drug kills dividing cells.
The figure below shows the number of healthy cells and cancer cells in the blood of a patient receiving chemotherapy. The arrows labelled **F** to **I** show when the drug was given to the patient.



(c) Calculate the rate at which healthy cells were killed between days 42 and 46.

..... cells killed per unit volume of blood per day

(1)

(d) Describe similarities and differences in the response of healthy cells and cancer cells to the drug between times **F** and **G**.

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(e) More cancer cells could be destroyed if the drug was given more frequently.

Suggest why the drug was **not** given more frequently.

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(2)
(Total 15 marks)