AQA, OCR, Edexcel

A Level

A Level Biology

DNA Technology Questions

Name:

M M E

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Total Marks:

Q1.(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)

Q2. (a) (i) Some human DNA was cut into separate pieces using a restriction enzyme which produced a staggered cut. A scientist wanted to insert these pieces of DNA into plasmids and used the same restriction enzyme to cut the plasmids. Explain why the pieces of human DNA would be able to join to the cut DNA of the plasmids.

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..... **(2)**

(ii) Which other enzyme must the scientist have added to the mixture to form recombinant plasmids?

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..... **(1)**

(b) A plasmid may be used as a vector. Explain what is meant by a *vector*.

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.....(**2**)

(c) Molecular biologists often use plasmids which contain antibiotic resistance genes.

Explain the reason for this.

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(2)
(Total 7 marks)

Q3. Scientists found a correlation between prostate cancer and exposure to cadmium ions.

The scientists investigated the effects of cadmium ions on cells from a human prostate gland. They grew a culture of these cells in liquid growth medium and removed samples at intervals.

For each sample they measured

- how much DNA was not methylated,
- the activity of the enzyme methyltransferase.

Methyltransferase is an enzyme that adds methyl groups to some of the bases in DNA. The addition of a methyl group is called methylation.

(a) The scientists set up another culture as a control.

Describe how the scientists would have set up a control experiment for this investigation.

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(2)

(b) **Figures 1** and **2** show the scientists' results.

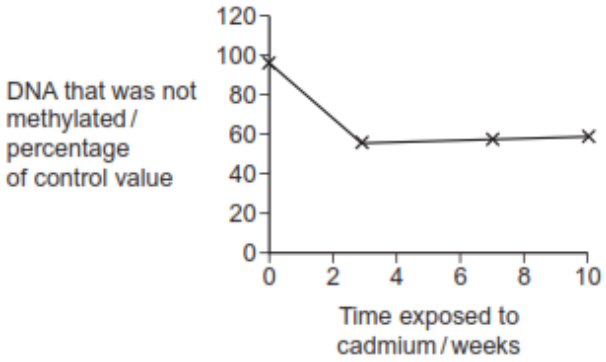

Figure 1

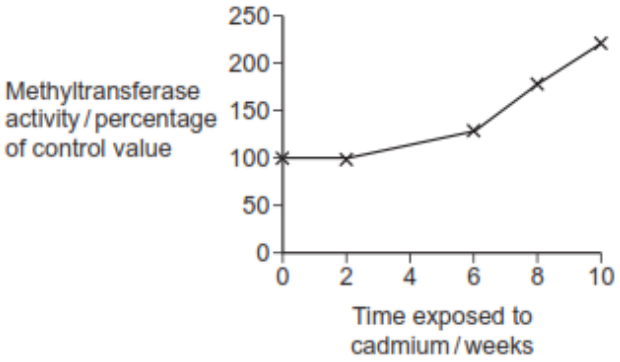

Figure 2

(i) The scientists expressed their results as percentages of the control values. Suggest why.

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.....**(1)**

(ii) Use information from **Figure 1** to describe how exposure to cadmium ions affected the methylation of DNA.

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.....**(1)**

(iii) Use information from **Figure 2** to suggest what caused the change to the DNA shown in **Figure 1**.

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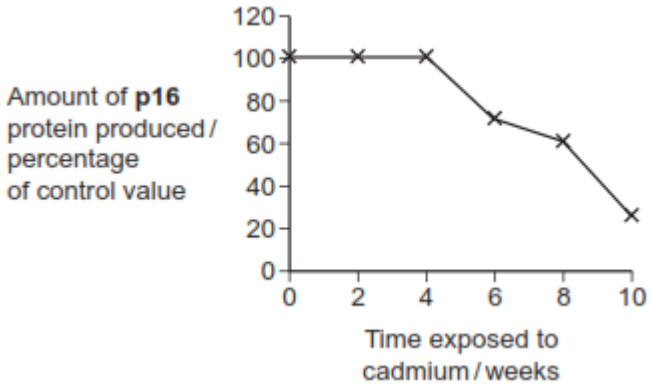
..... **(1)**

(c) Prostate gland cells contain a tumour suppressor gene called **p16**.
During the investigation, the scientists also measured the amount of **p16** protein produced.

Figure 3 shows their results.

Figure 3



The scientists found that the promoter DNA of the **p16** gene had become methylated. The promoter is the sequence of bases where the enzyme RNA-polymerase binds to a DNA molecule.

Explain how methylation of the promoter sequence of the **p16** gene could cause the changes shown in **Figure 3**.

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(d) Each week of the investigation, the scientists took samples of the cadmium-treated prostate cells from the laboratory cultures. They injected these cells into mice and monitored the mice for the growth of tumours.

It was only the samples taken in the tenth week that caused tumours to begin to grow in the mice.

Use information from **Figures 1, 2** and **3** to suggest why.

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..... **(4)**

Q4. 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

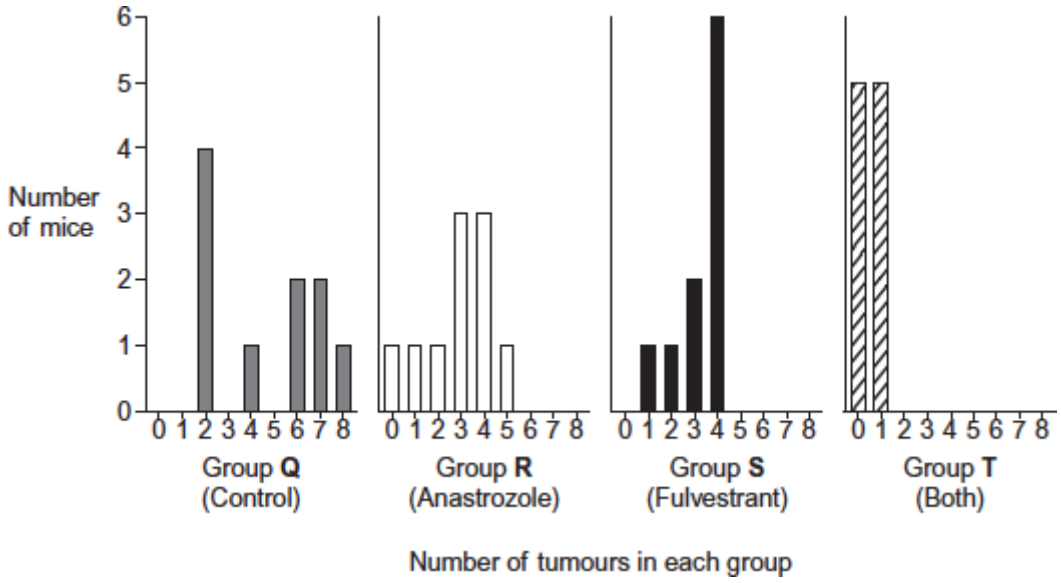
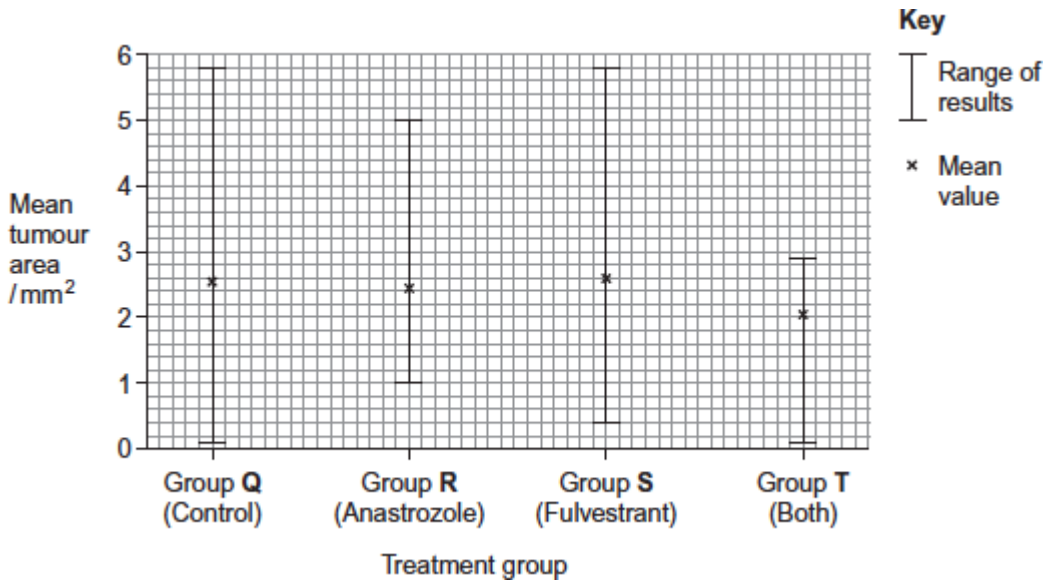


Figure 2



(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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.....**(2)**

(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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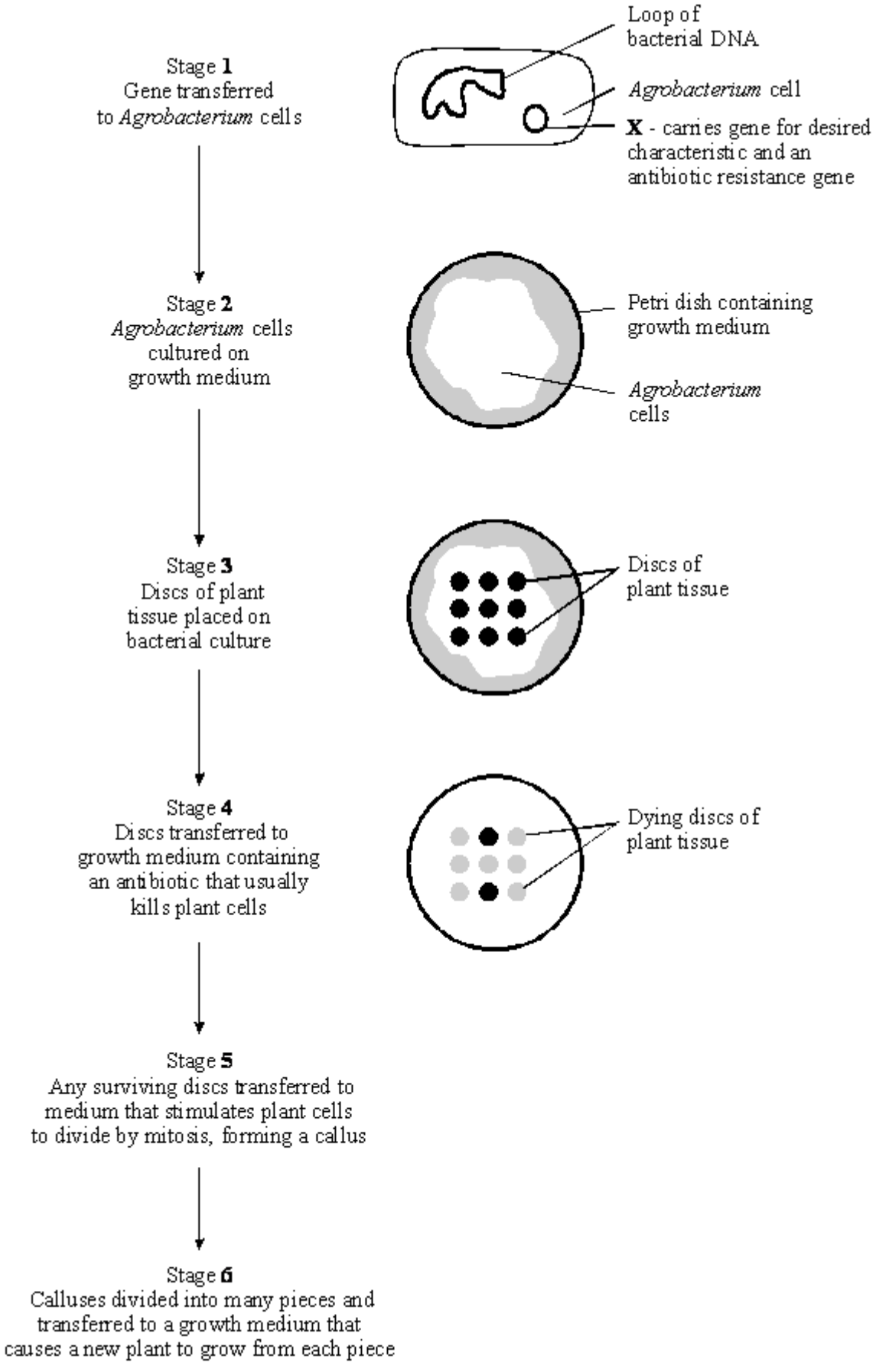
(2)
(Total 15 marks)

Q5. (a) *Agrobacterium* is a bacterium used in genetic engineering of plants. The diagram shows stages in the transfer of a gene into a plant.



(i) Name structure **X** in stage **1**.

.....**(1)**

(ii) In stage **2**, explain why the bacteria are cultured before the plant tissue is added.

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.....**(1)**

(iii) In stage **4**, explain why the growth medium contains antibiotic.

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.....**(2)**

(iv) Suggest why stages **5** and **6** are necessary for the commercial production of genetically engineered plants.

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.....**(2)**

(b) (i) A toxin that kills insects can be sprayed directly onto the leaves of crop plants. A gene has now been transferred into crop plants that makes their leaves produce this toxin.

Explain **one** advantage to farmers of growing the genetically engineered crop plants, rather than spraying leaves with the toxin.

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.....**(1)**

(ii) Suggest **one** reason why some people are concerned that the toxin gene might get transferred to wild plants that are related to the crop plants.

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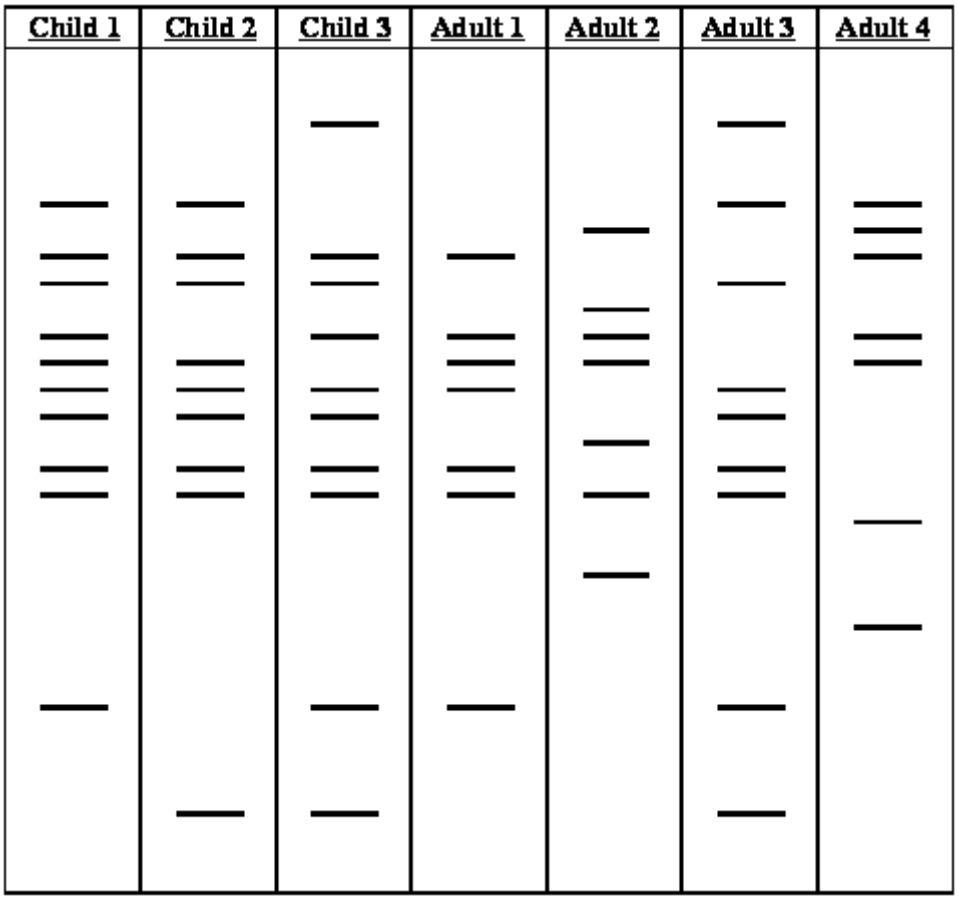
(1)
(Total 8 marks)

Q6. Read the following passage.

In 1991, nine skeletons were found in Russia. They were believed to be those of Tsar Nicholas II, his family and staff who were killed in 1917 during the Russian revolution. Very small amounts of DNA were isolated from these skeletons. This DNA was used in the polymerase chain reaction (PCR). Genetic fingerprinting was then carried out on this DNA to identify the skeletons.

The chart shows some of the results obtained from the genetic fingerprinting of seven of the skeletons, three children and four adults.



Use information from the passage and your own knowledge to answer the following questions.

(a) Explain why the polymerase chain reaction was used in this investigation.

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.....**(2)**

(b) In the polymerase chain reaction, DNA is heated to 95 °C and nucleotides, enzymes and DNA primers are added to the mixture.

(i) Explain why the DNA is heated to 95 °C.

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(1)

(ii) What are DNA *primers*?

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.....**(1)**

(iii) Why are DNA primers added during the polymerase chain reaction?

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.....**(1)**

(iv) What is the advantage of the enzyme used in the polymerase chain reaction being thermostable?

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(c) Describe how genetic fingerprinting is carried out.

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(d) All three children on the chart had the same parents. One of the parents was **Adult 1**.

Which of the other three adults on the chart was the other parent? Give the reason for your answer.

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(2)
(Total 15 marks)

Q7. (a) What is meant by a gene?

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.....**(2)**

The polymerase chain reaction (PCR) can be used to obtain many copies of a particular gene.

(b) Explain how the strands of DNA are separated during the PCR.

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.....**(2)**

(c) In a particular PCR, two different primers are added to the DNA.

(i) Why are primers required?

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.....**(1)**

(ii) Suggest why two different primers are required.

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.....**(1)**

(d) Starting with a single molecule of DNA, the polymerase chain reaction was allowed to go through three complete cycles. How many molecules of DNA would be produced?

Answer .....

(1)
(Total 7 marks)

Q8. Read the following passage.

DNA tests were used to confirm the identity of deposed Iraqi leader Saddam Hussein, after his capture in December 2003. DNA tests were carried out to prove the suspect was not one of the many alleged "look alikes" of the former leader.

Firstly, the DNA was extracted from the mouth of the captured man using a swab. Great care was taken to check that the swab did not become contaminated with any other DNA. DNA extracted from the swab was then subjected to a standard technique called the polymerase chain reaction (PCR), which takes a couple of hours. Lastly, the sample was "typed" to give the genetic fingerprint. This was produced within 24 hours of Saddam Hussein's capture. Tests for use in criminal cases often take much longer because samples are very small or contaminated.

It appears that Hussein's genetic fingerprint was already stored away for comparison. This was obtained from personal items such as his toothbrush. DNA from the toothbrush would have been subjected to PCR before a DNA fingerprint could have been obtained.

Use information from the passage and your own knowledge to answer the questions.

(a) Describe how the technique of genetic fingerprinting is carried out and explain how it can be used to identify a person, such as Saddam Hussein.

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(6)

(b) Explain how DNA could be present on a toothbrush (line 12).

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(2)

(c) (i) Explain why the polymerase chain reaction was used on the sample of DNA from the toothbrush (lines 12-13).

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(2)

(ii) Explain **one** way in which the polymerase chain reaction differs from DNA replication in a cell.

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(2)

(d) Tests for use in criminal cases often take much longer because samples are very small or contaminated (lines 8-10). Explain why it takes longer to obtain a genetic fingerprint if the sample is

(i) very small;

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(1)

(ii) contaminated.

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(2)
(Total 15 marks)

Q9. DNA probes may be used to identify the presence of specific genes associated with human diseases. The flow chart summarises the way in which they are used.

Stage 1 DNA is cut into fragments

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Stage 2 Electrophoresis separates the DNA fragments

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Stage 3 Radioactive DNA probes are used to locate specific DNA fragments

(a) Name the enzyme used in **Stage 1**.

.....**(1)**

(b) Explain how electrophoresis separates the fragments of DNA in **Stage 2**.

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.....**(2)**

(c) (i) What is a *DNA probe*?

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.....**(2)**

(ii) Explain why *radioactive* DNA probes are used to locate specific DNA fragments.

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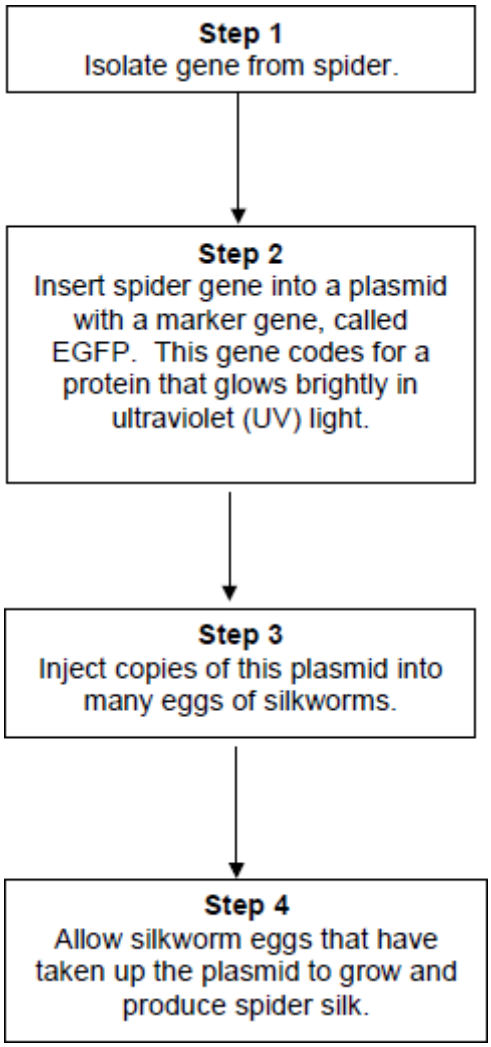
(2)
(Total 7 marks)

Q10. 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?

.....**(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 .....

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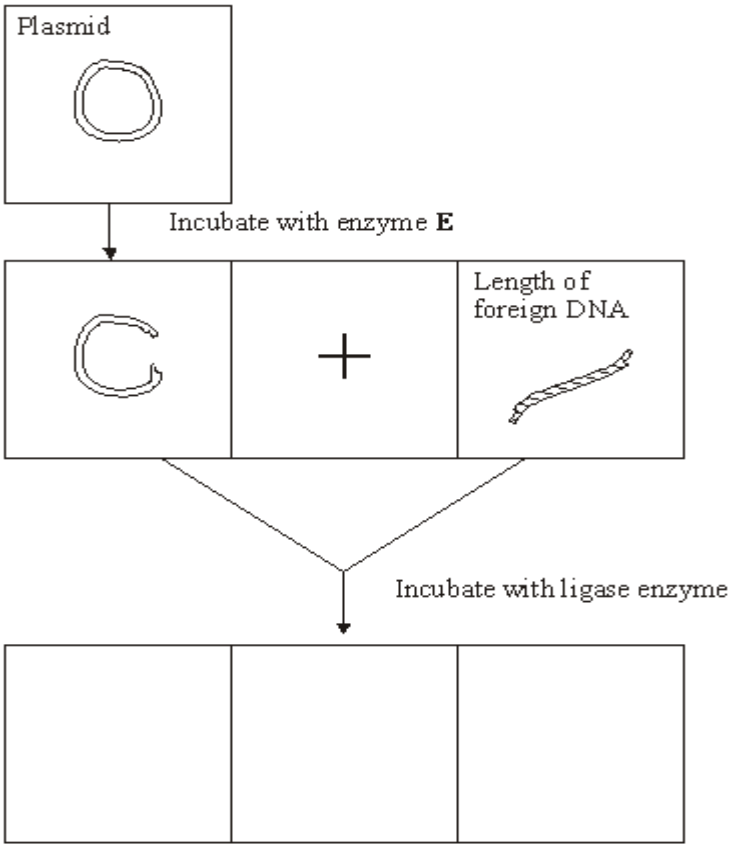
(2)
(Total 7 marks)

Q11. Plasmids can be used as vectors to insert lengths of foreign DNA into bacteria. The diagram shows how this is achieved.



(a) Name enzyme **E**.

.....**(1)**

(b) Cut plasmids and lengths of foreign DNA can join. What features of their ends allows them to join?

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.....**(2)**

c) Draw **three** different structures that could be formed by incubating cut plasmids and lengths of foreign DNA with ligase. Use the spaces provided on the diagram.

(3)
(Total 6 marks)

Q12. SCID is a severe inherited disease. People who are affected have no immunity. Doctors carried out a trial using gene therapy to treat children with SCID. The doctors who carried out the trial obtained stem cells from each child's umbilical cord.

(a) Give **two** characteristic features of stem cells.

1 .....

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2 .....

.....**(2)**

The doctors mixed the stem cells with viruses. The viruses had been genetically modified to contain alleles of a gene producing full immunity. The doctors then injected this mixture into the child's bone marrow.

The viruses that the doctors used had RNA as their genetic material. When these viruses infect cells, they pass their RNA and two viral enzymes into the host cells.

(b) One of the viral enzymes makes a DNA copy of the virus RNA. Name this enzyme.

.....**(1)**

The other viral enzyme is called integrase. Integrase inserts the DNA copy anywhere in the DNA of the host cell. It may even insert the DNA copy in one of the host cell's genes.

(c) (i) The insertion of the DNA copy in one of the host cell's genes may cause the cell to make a non-functional protein. Explain how.

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.....**(2)**

(ii) Some of the children in the trial developed cancer. How might the insertion of the DNA have caused cancer?

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.....**(2)**

(d) Five out of the 20 children in the trial developed cancer. Although the cancer was treated successfully, the doctors decided to stop the trial in its early stages. They then reviewed the situation and decided to continue. Do you agree with their decision to continue? Explain your answer.

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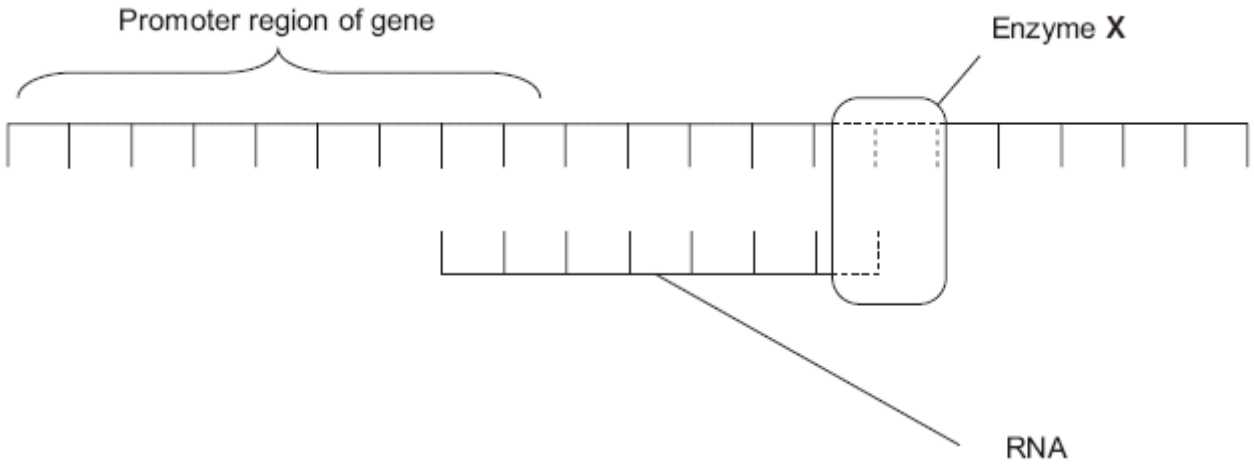
(2)
(Total 9 marks)

Q13.Figure 1 shows part of a gene that is being transcribed.

Figure 1



(a) Name enzyme **X**..... **(1)**

(b) (i) Oestrogen is a hormone that affects transcription. It forms a complex with a receptor in the cytoplasm of target cells. Explain how an activated oestrogen receptor affects the target cell.

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.....**(2)**

(ii) Oestrogen only affects target cells. Explain why oestrogen does not affect other cells in the body.

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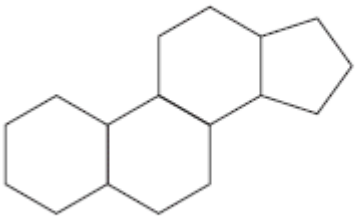
.....**(1)**

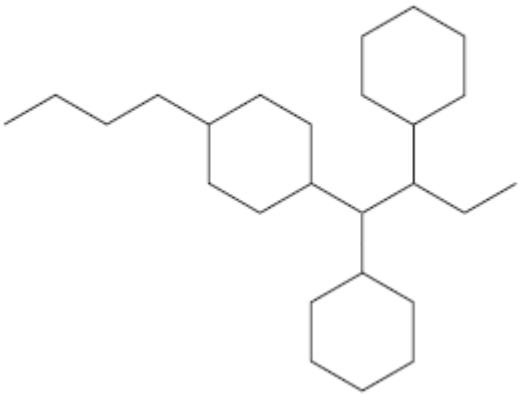
(c) Some breast tumours are stimulated to grow by oestrogen. Tamoxifen is used to treat these breast tumours. In the liver, tamoxifen is converted into an active substance called endoxifen. **Figure 2** shows a molecule of oestrogen and a molecule of endoxifen.

Figure 2

Oestrogen



Endoxifen



Use **Figure 2** to suggest how endoxifen reduces the growth rate of these breast tumours.

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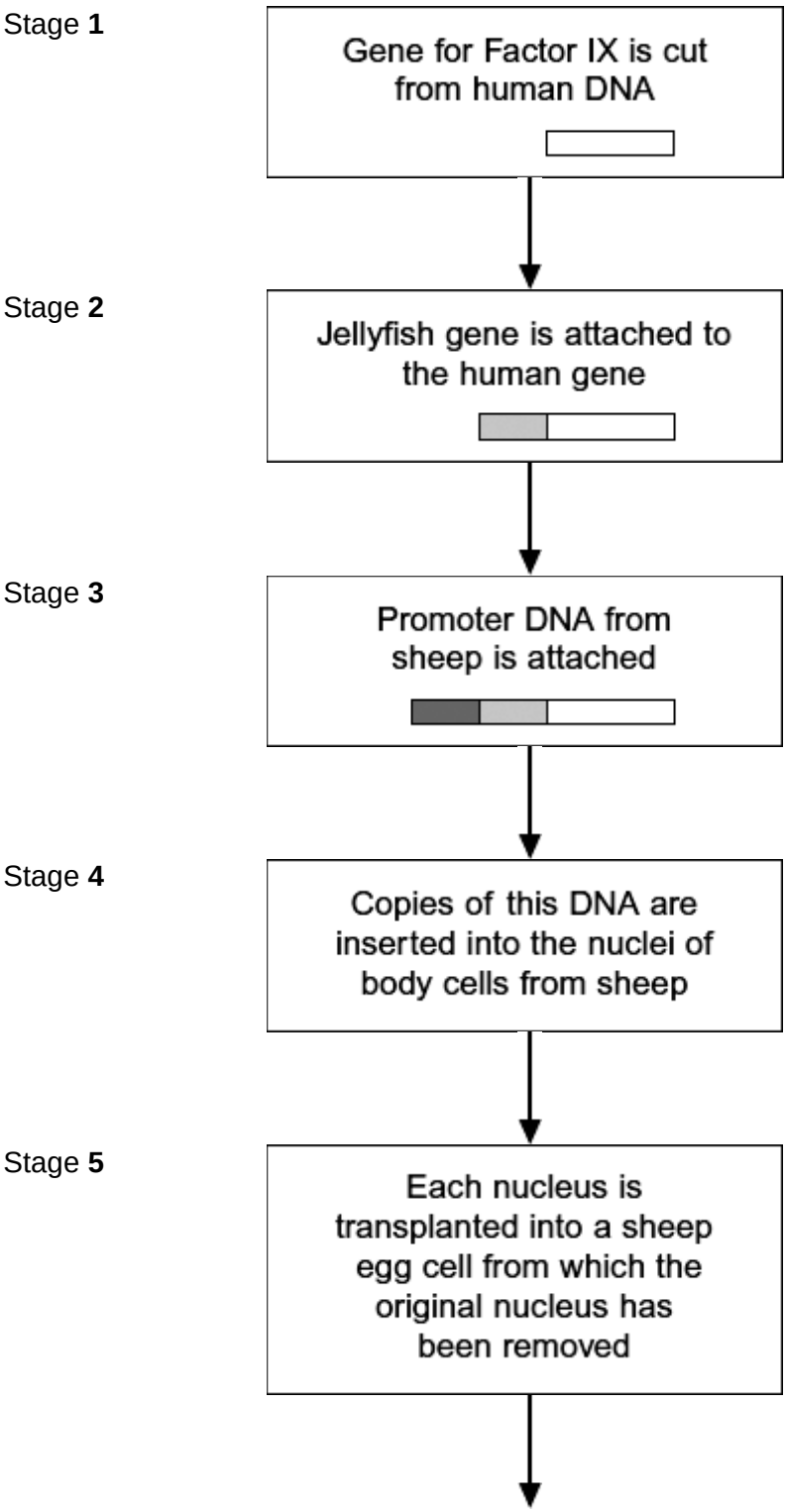
(2)
(Total 6 marks)

Q14. Haemophilia is a genetic condition in which blood fails to clot. Factor IX is a protein used to treat haemophilia. Sheep can be genetically engineered to produce Factor IX in the milk produced by their mammary glands. The diagram shows the stages involved in this process.



Stage **6**

The egg cells divide to form an embryo. Each embryo is implanted into the uterus of a different sheep

(a) Name the type of enzyme that is used to cut the gene for Factor IX from human DNA (Stage **1**) .

.....**(1)**

(b) (i) The jellyfish gene attached to the human Factor IX gene (Stage **2**) codes for a protein that glows green under fluorescent light. Explain the purpose of attaching this gene.

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.....**(2)**

(ii) The promoter DNA from sheep (Stage **3**) causes transcription of genes coding for proteins found in sheep milk.

Suggest the advantage of using this promoter DNA.

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..... **(2)**

(c) Many attempts to produce transgenic animals have failed. Very few live births result from the many embryos that are implanted.

(i) Suggest **one** reason why very few live births result from the many embryos that are implanted.

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(ii) It is important that scientists still report the results from failed attempts to produce transgenic animals. Explain why.

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(2)
(Total 9 marks)

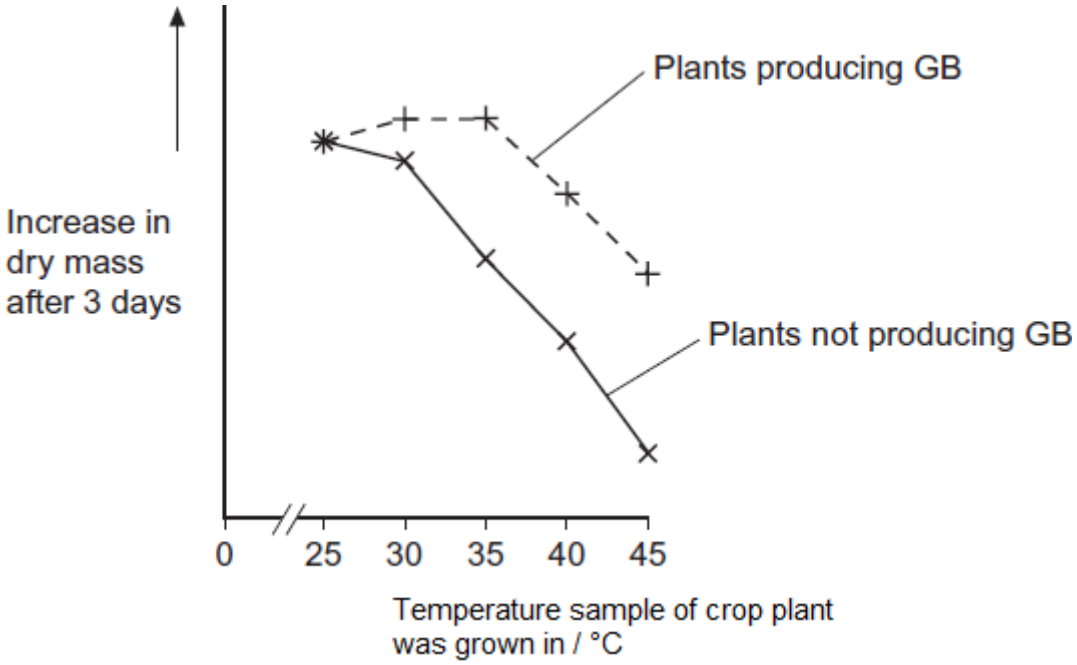
Q15. Some species of crop plant produce a substance called glycinebetaine (GB).

Scientists transferred the gene for GB into a species of crop plant that does not normally produce GB. These genetically modified plants then produced GB.

The scientists grew large numbers of the same crop plant with and without the gene at different temperatures. After 3 days, they found the increase in dry mass of the plants.

Figure 1 shows their results.

Figure 1



(a) Describe the effect on growth of transferring the gene for GB into this plant.

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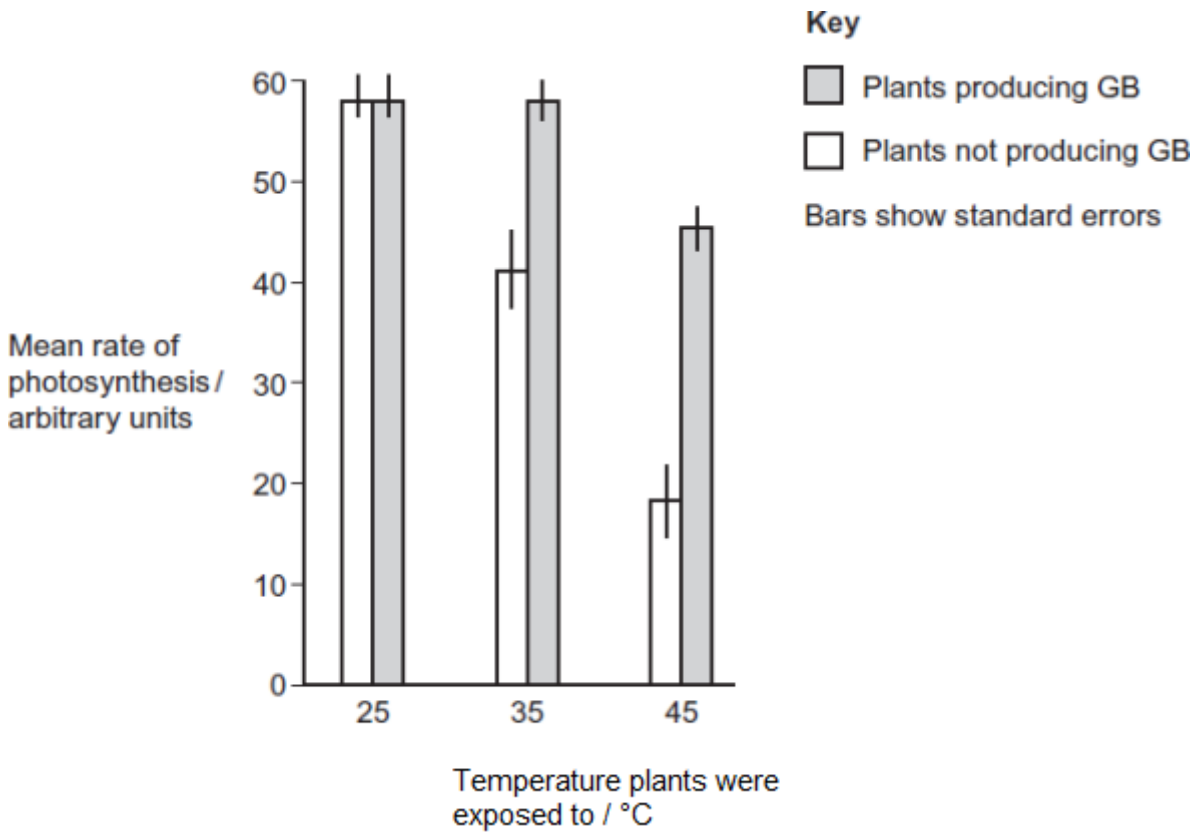
(2)

(b) The scientists measured the rate of photosynthesis in plants that produce GB and plants that do not produce GB at 25°C, 35°C and 45°C.

Figure 2 shows their results.

Figure 2



(i) The scientists concluded that the production of GB protects photosynthesis from damage by high temperatures.

Use these data to support this conclusion.

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(1)

(ii) Use the data from **Figure 2** for plants that do not produce GB to explain the effect of temperature on changes in dry mass of the plants shown in **Figure 1.**

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Rubisco activase is an enzyme found in chloroplasts. It activates the light-independent reaction of photosynthesis. The scientists discovered that, as temperature increased from 25°C to 45°C, rubisco activase began attaching to thylakoid membranes in chloroplasts and this stopped it working.

(c) Rubisco activase stops working when it attaches to a thylakoid.

Use your knowledge of protein structure to explain why.

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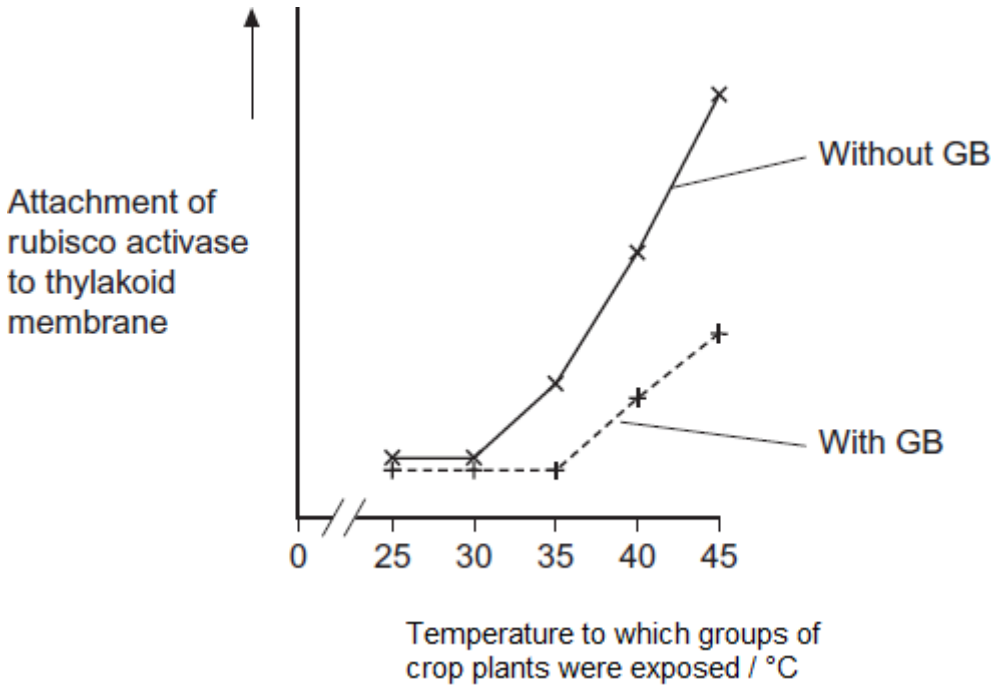
.....**(2)**

(d) The scientists investigated the effect of GB on attachment of rubisco activase to thylakoid membranes at different temperatures.

Figure 3 shows their results.

Figure 3



Use information from **Figure 2** and **Figure 3** to suggest how GB protects the crop plant from high temperatures.

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(e) The scientists' hypothesis at the start of the investigation was that crop plants genetically engineered to produce GB would become more resistant to high environmental temperatures. The scientists developed this hypothesis on the basis of previous research on crops that are grown in hot climates. Suggest how the scientists arrived at their hypothesis.

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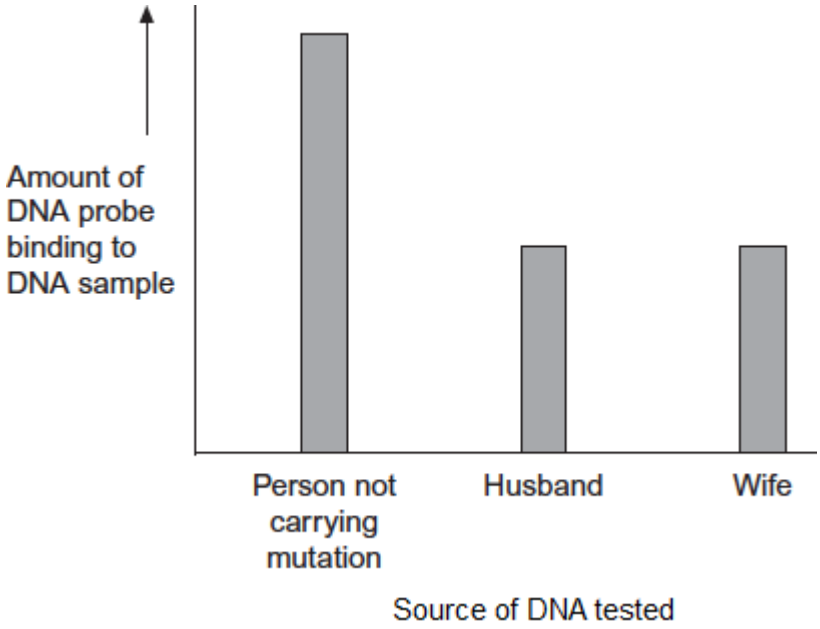
(2)
(Total 15 marks)

Q16. A husband and wife wanted to know whether they were carriers of the mutated form of a gene. This mutation is a deletion that causes a serious inherited genetic disorder in people who are homozygous.

A geneticist took samples of DNA from the husband and the wife. He used a DNA probe to look for the deletion mutation. The DNA probe was specific to a particular base sequence in an exon in the gene. Exons are the coding sequences in a gene.

The geneticist compared the couple's DNA with that of a person known not to carry this mutation.

The chart shows the geneticist's results.



(a) The geneticist told the couple they were both carriers of the mutated gene. Explain how he reached this conclusion.

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(b) The DNA probe the geneticist used was for an exon in the DNA, **not** an intron. Explain why.

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..... **(3)**

(c) To make the DNA probe, the geneticist had to find the base sequence of the normal gene. Once he had copies of the gene, what methods would he use to find the base sequence of the gene?

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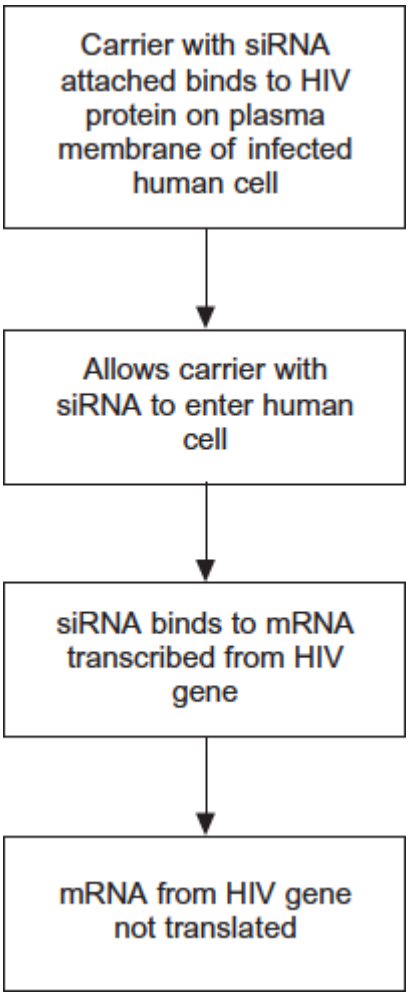
(2)
(Total 8 marks)

Q17. Human immunodeficiency virus (HIV) particles have a specific protein on their surface.This protein binds to a receptor on the plasma membrane of a human cell and allows HIV to enter. This HIV protein is found on the surface of human cells after they have become infected with HIV.

Scientists made siRNA to inhibit expression of a specific HIV gene inside a human cell. They attached this siRNA to a carrier molecule. The flow chart shows what happens when this carrier molecule reaches a human cell infected with HIV.



(a) When siRNA binds to mRNA, name the complementary base pairs holding the siRNA and mRNA together. One of the bases is named for you.

.....with.....

.....**Adenine**.....with.....

(1)

(b) This siRNA would **only** affect gene expression in cells infected with HIV.

Suggest **two** reasons why.

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(4)

(c) The carrier molecule on its own may be able to prevent the infection of cells by HIV.

Explain how.

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(2)
(Total 7 marks)