8.4 The control of gene expression (A-Level Only) - Gene technologies 1 – Questions

Q1.

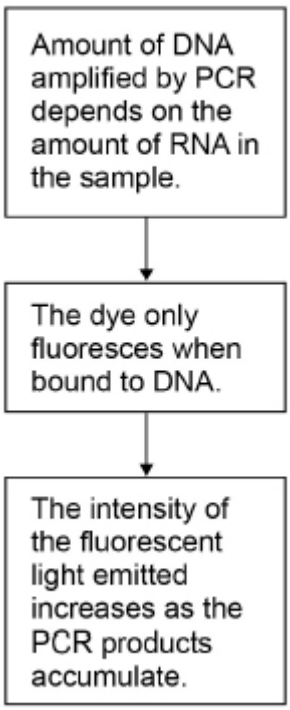
One way to detect and measure accurately the amount of RNA in a tissue sample is by RT-PCR (reverse transcriptase-polymerase chain reaction).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principle behind this method is shown in **Figure 1**.

Figure 1



(a) Explain the role of reverse transcriptase in RT-PCR.

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(1)

(b) Explain the role of DNA polymerase in RT-PCR.

(1)

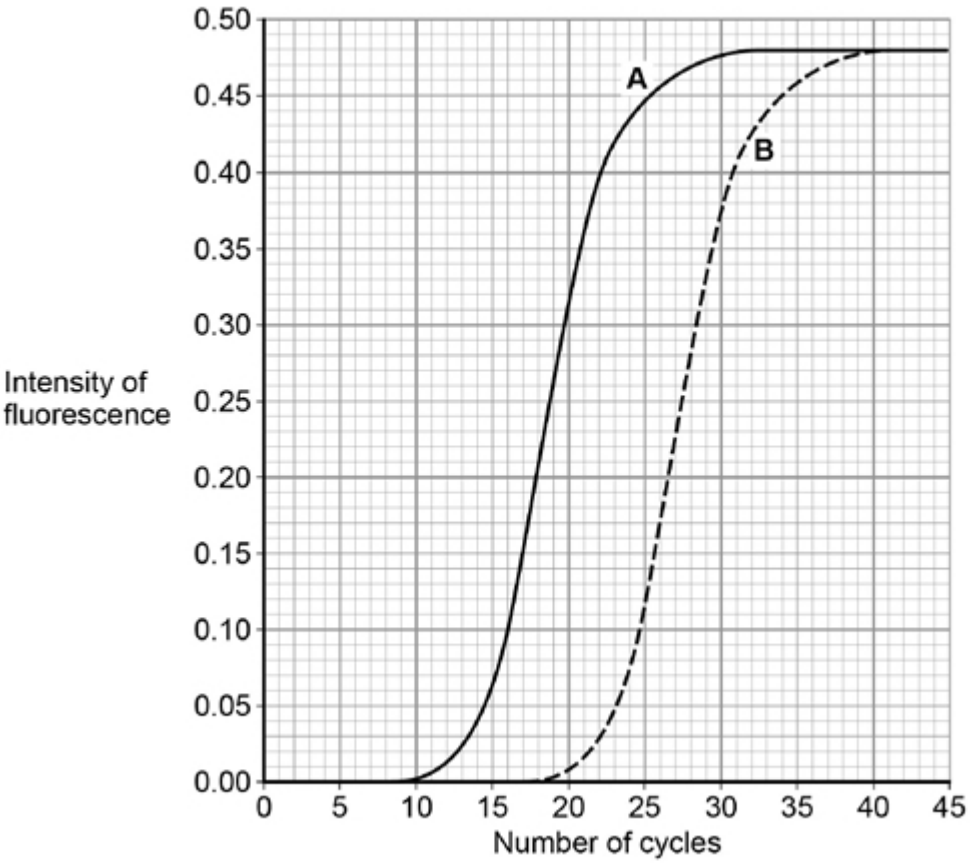
(c) Any DNA in the sample is hydrolysed by enzymes before the sample is added to the reaction mixture.

Explain why.

(2)

(d) **Figure 2** shows the results from using RT-PCR to detect RNA in two different samples, **A** and **B**.

Figure 2



A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (**C**).

The amount of RNA in a sample can be measured as: $\frac{1}{C}$

Use this information to calculate the ratio for RNA content in sample **A** : RNA content in sample **B**.

Answer _____

(2)

(e) Suggest **one** reason why DNA replication stops in the polymerase chain reaction.

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(1)

(f) Scientists have used the RT-PCR method to detect the presence of different RNA viruses in patients suffering from respiratory diseases.

The scientists produced a variety of primers for this procedure.

Explain why.

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(2)

(Total 9 marks)

Q2.

People suffering from pituitary dwarfism do not make enough human growth hormone (HGH). They can be treated using injections of HGH.

A geneticist wants to transform the bacterium, *Escherichia coli*, to make HGH by adding the gene coding for HGH.

The geneticist could obtain the *HGH* gene using any one of three methods.

1. Use restriction enzymes to cut out a fragment of DNA containing the *HGH* gene from a human genome.
2. Convert mRNA for HGH into cDNA using reverse transcriptase.
3. Create the *HGH* gene using a 'gene machine'.

(a) The geneticist decided **not** to use restriction enzymes to cut out a fragment of DNA containing the *HGH* gene from a human genome. She made this decision because only methods 2 and 3 would produce DNA that *E. coli* could use to make HGH.

Explain why only methods 2 and 3 would produce DNA that *E. coli* could use to make HGH.

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(2)

(b) The geneticist concluded it would be faster to create the *HGH* gene using a gene machine than by using reverse transcriptase to convert mRNA for HGH into cDNA.

Suggest why the geneticist reached this conclusion.

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(1)

(c) After obtaining copies of the *HGH* gene, the geneticist will attempt to insert them into plasmid vectors.

Describe how the geneticist would attempt to insert copies of the *HGH* gene into these plasmids.

(3)

(d) The geneticist plans to use the plasmids containing the *HGH* gene to try to transform cells of *E. coli*. She knows that some *E. coli* might not take up the plasmid.

To enable her to identify which bacteria have taken up the plasmid with the *HGH* gene, the plasmids she intends to use contain a gene that codes for a green fluorescent protein (GFP). Bacteria that contain this plasmid glow green under UV light.

Suggest **one** advantage of using this gene for GFP to identify bacteria that have taken up plasmids.

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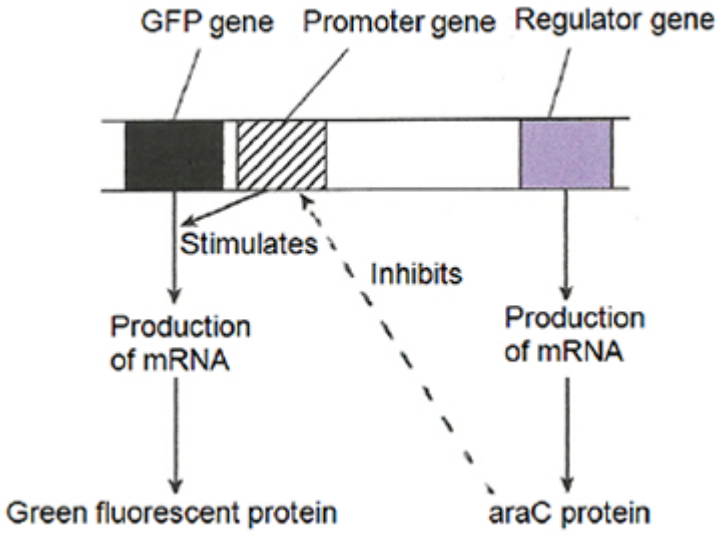
(1)

The diagram below shows part of the plasmid containing the gene that codes for GFP. It also shows the roles of two genes that control the GFP gene.



(e) Arabinose is a sugar that can bind to the araC protein.

Use information in the diagram to suggest why the geneticist must include arabinose in the agar on which she hopes to grow *E. coli* containing the transgenic plasmids.

(2)

(Total 9 marks)

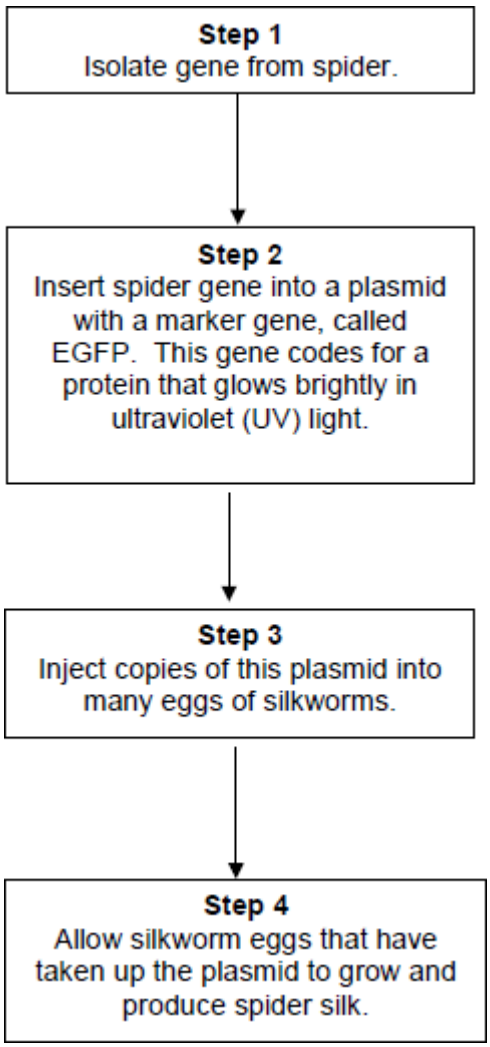
Q3.

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.

(2)

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

(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.

1. _____

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2. _____

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(2)

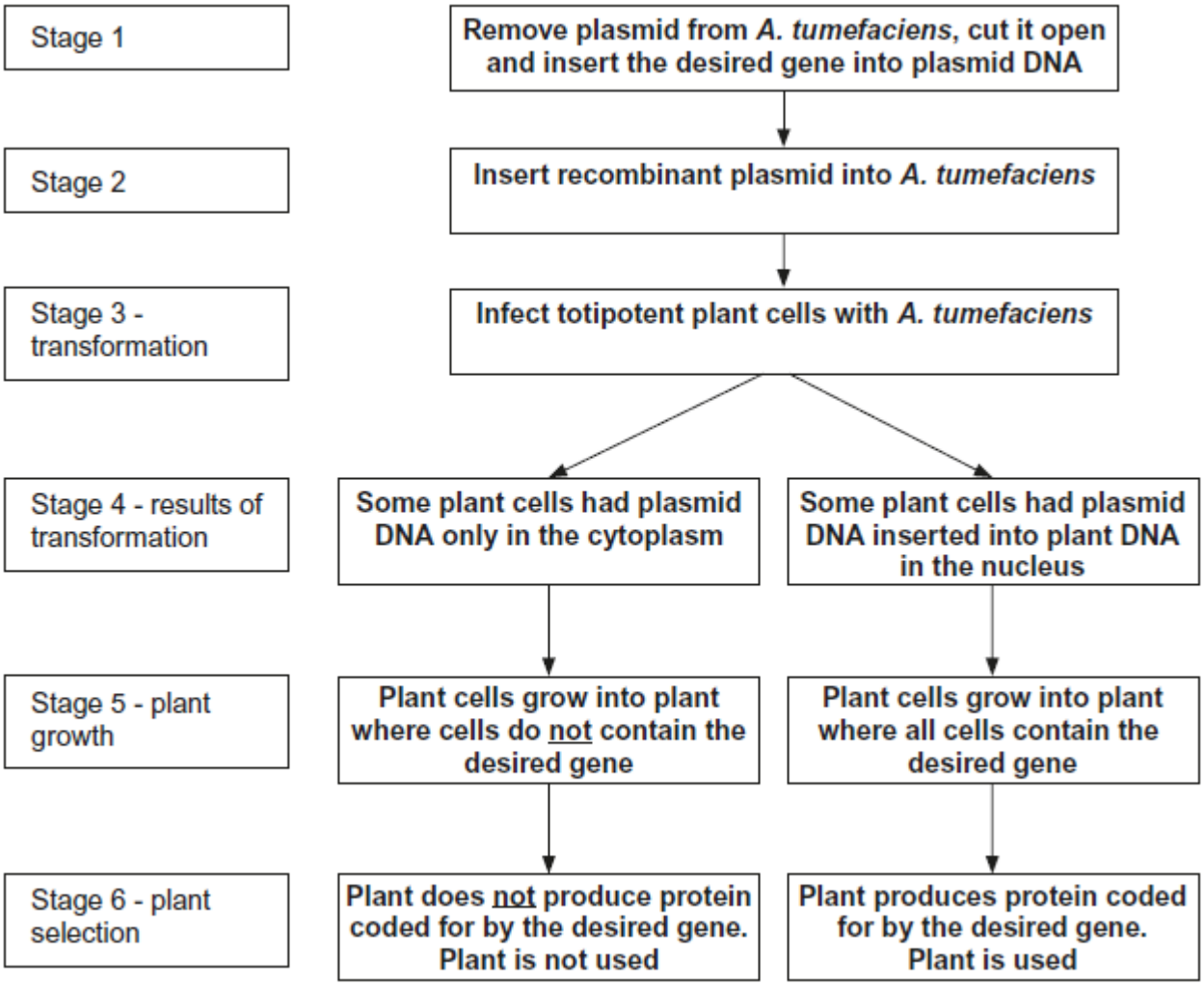
(Total 7 marks)

Q4.

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.

_____

(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.

_____

(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)

Q5.

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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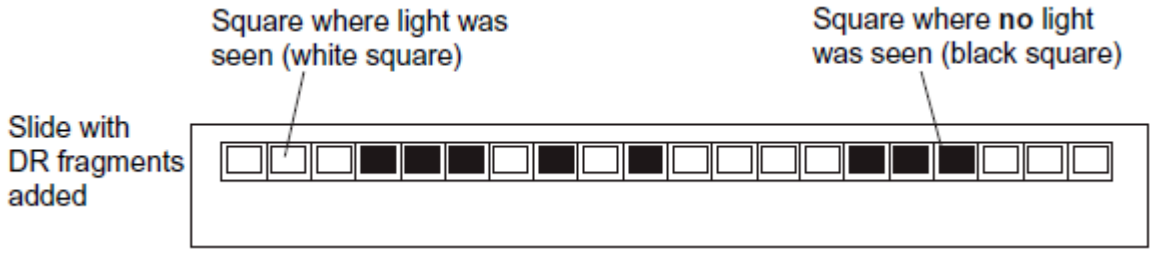
(1)

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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(3)

(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)

Q6.

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)

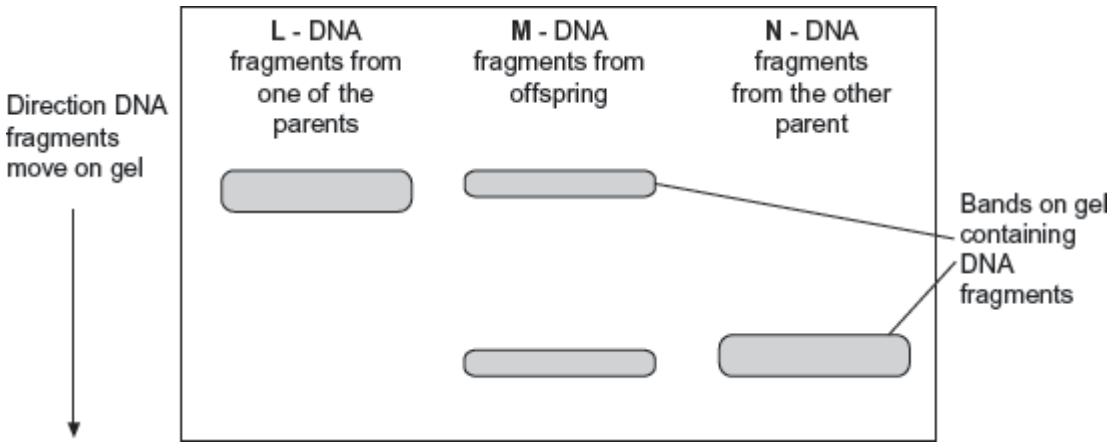
The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- 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.

(2)

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

[Extra space]

(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.

(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.

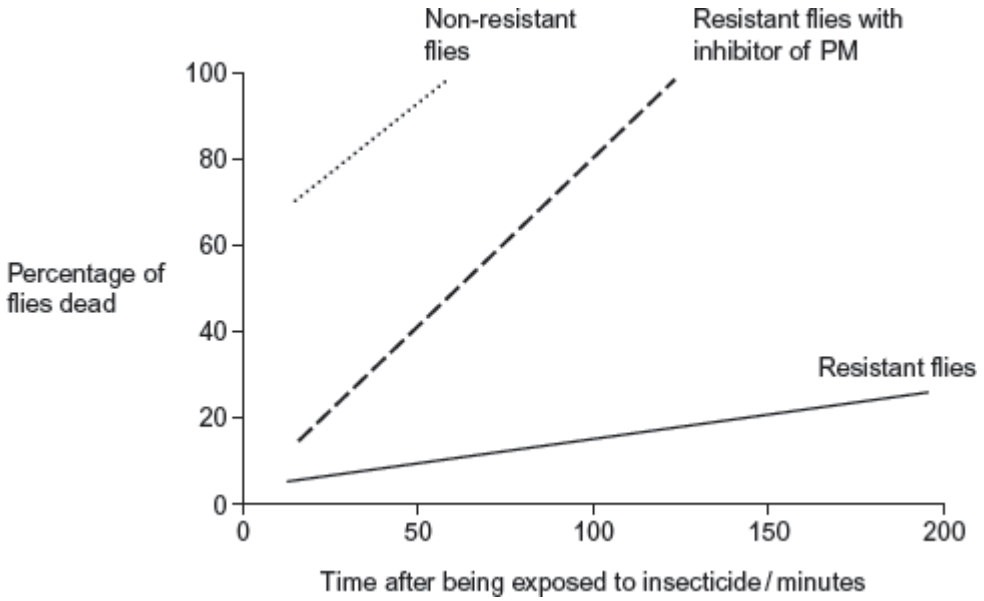
The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- 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.

(2)

(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.

[Extra space]

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(4)

(Total 15 marks)

Q7.

Scientists wanted to measure how much mRNA was transcribed from allele **A** of a gene in a sample of cells. This gene exists in two forms, **A** and **a**.

The scientists isolated mRNA from the cells. They added an enzyme to mRNA to produce cDNA.

(a) Name the type of enzyme used to produce the cDNA.

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(1)

The scientists used the polymerase chain reaction (PCR) to produce copies of the cDNA. They added a DNA probe for allele **A** to the cDNA copies. This DNA probe had a dye attached to it. This dye glows with a green light **only** when the DNA probe is attached to its target cDNA.

(b) Explain why this DNA probe will only detect allele **A**.

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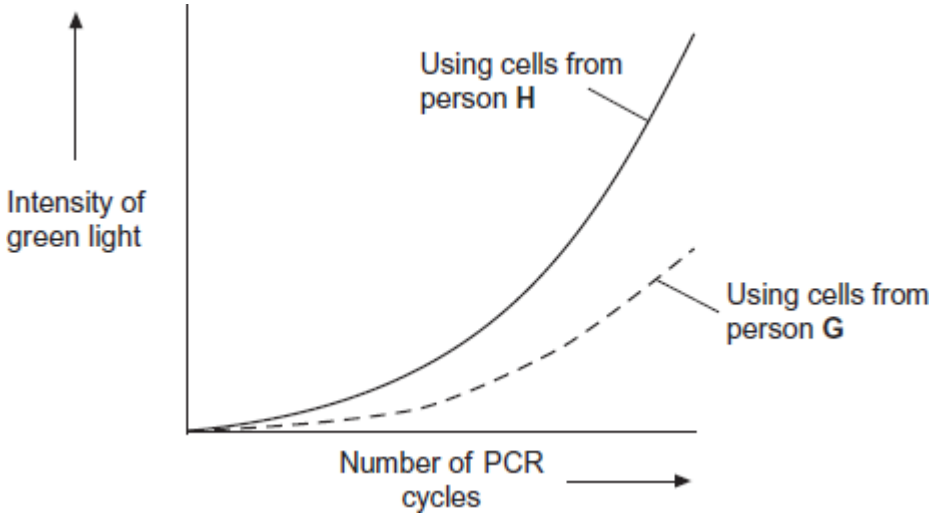
(2)

(c) The scientists used this method with cells from two people, **H** and **G**.
One person was homozygous, **AA**, and the other was heterozygous, **Aa**.
The scientists used the PCR and the DNA probe specific for allele **A** on the cDNA from both people.

The figure shows the scientists' results.



(i) Explain the curve for person **H**.

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(Extra space) _____

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(3)

(ii) Which person, **H** or **G**, was heterozygous, **Aa**? Explain your answer.

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(2)

(Total 8 marks)

Q8.

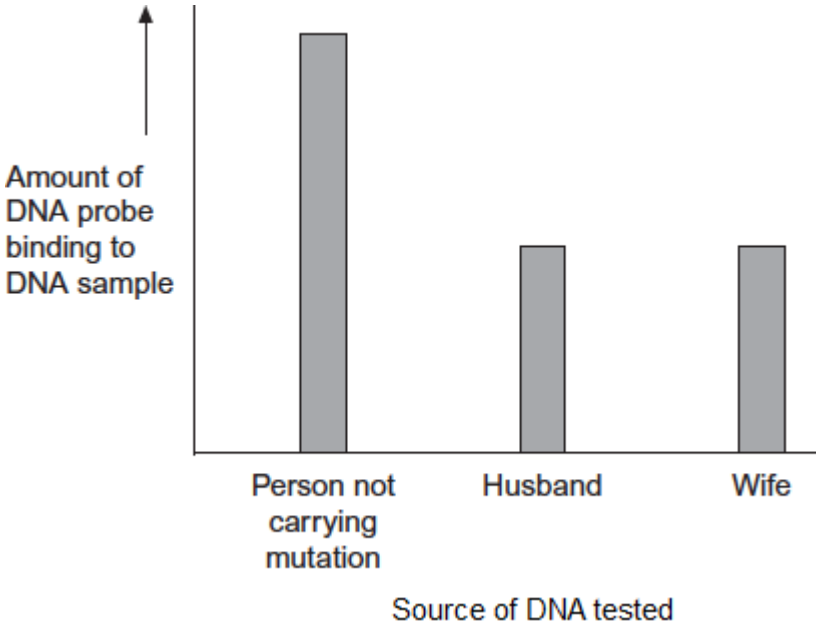
A husband and wife wanted to know whether they were carriers of the mutated form of a gene. This mutation is a deletion that causes a serious inherited genetic disorder in people who are homozygous.

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.

(Extra space)

(3)

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

(Extra space)

(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?

(2)

(Total 8 marks)

Q9.

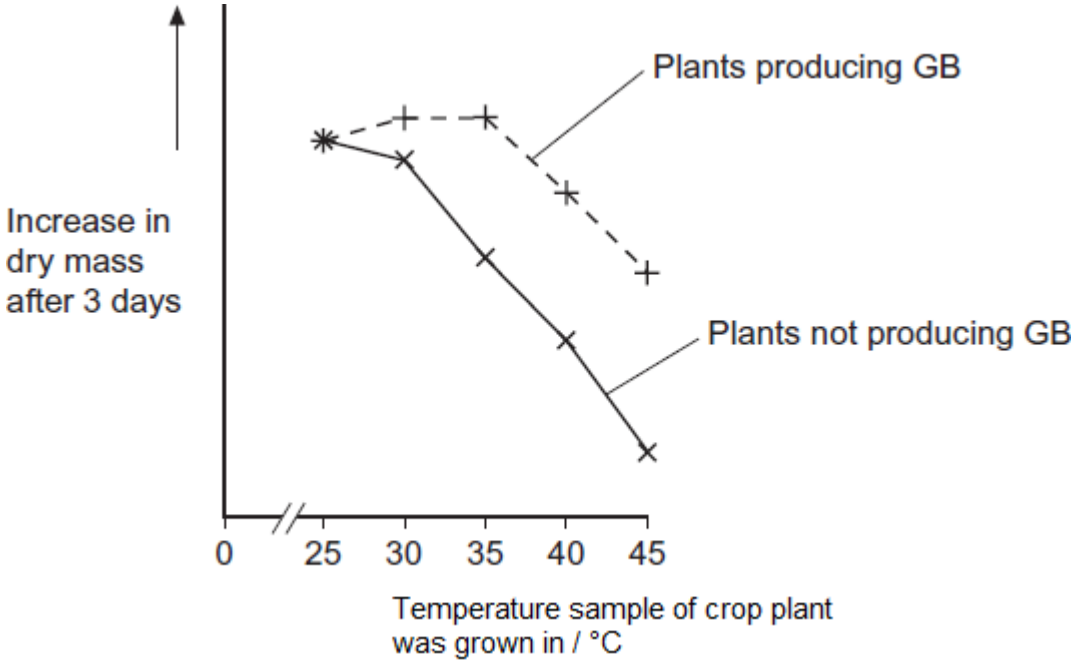
Some species of crop plant produce a substance called glycinebetaine (GB).

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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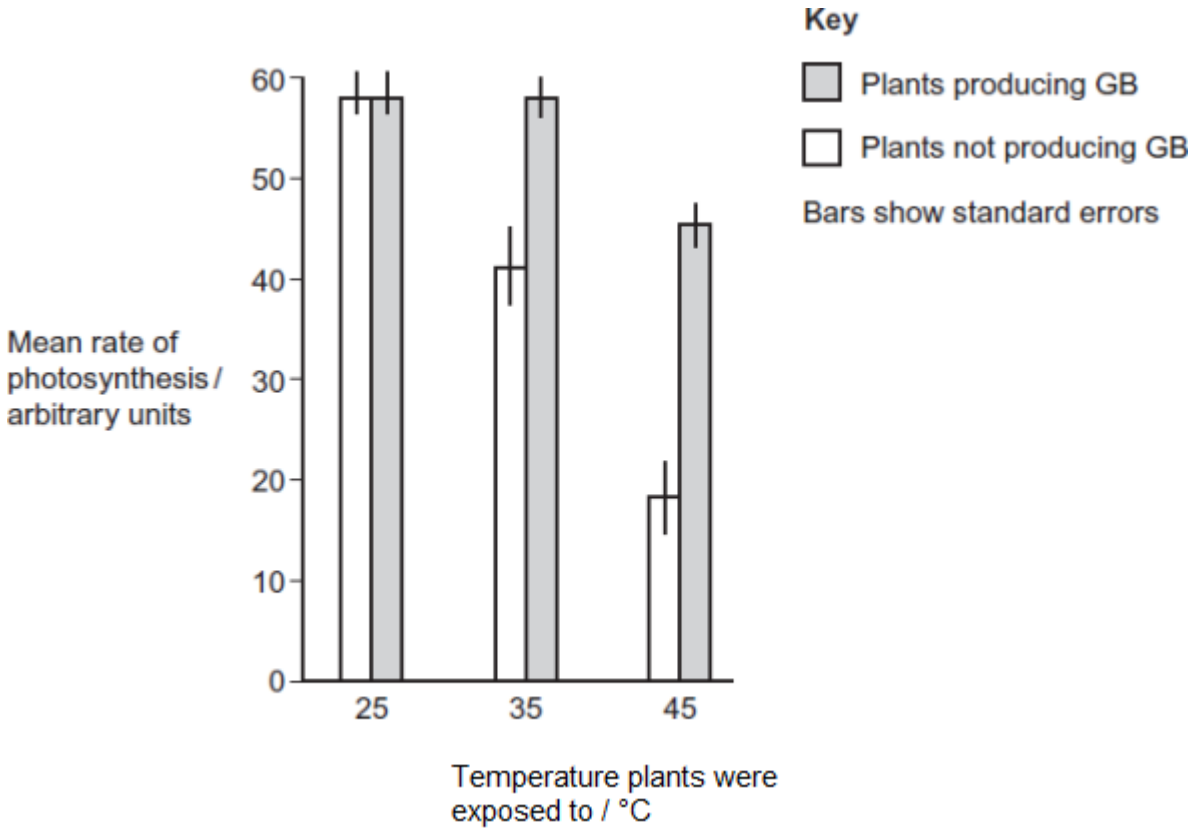
(2)

(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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*(Extra space)*_____

(4)

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.

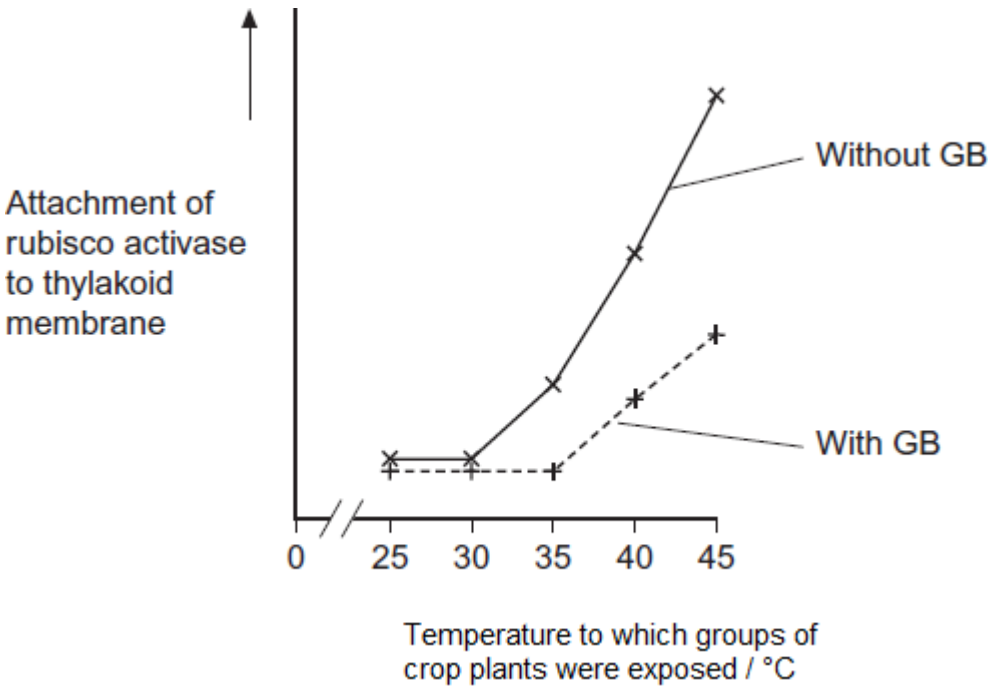
Use your knowledge of protein structure to explain why.

(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.

(Extra space)

(4)

(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.

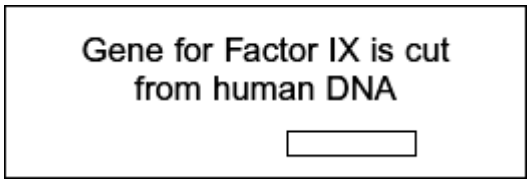
(2)

(Total 15 marks)

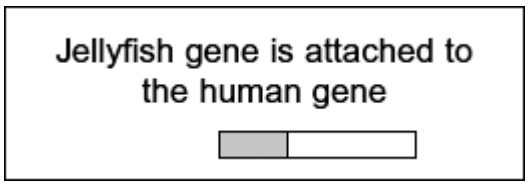
Q10.

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.

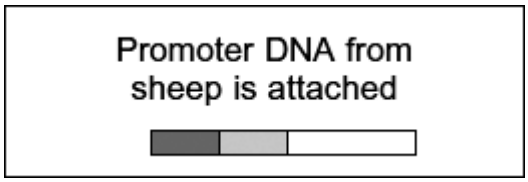
Stage **1**



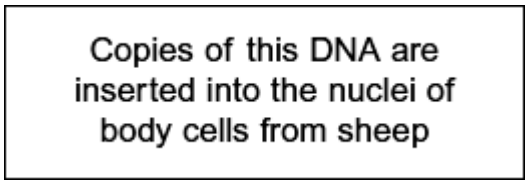
Stage **2**



Stage **3**



Stage **4**



Stage **5**

Each nucleus is transplanted into a sheep egg cell from which the original nucleus has been removed

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**).

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(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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(Extra space)

(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.

(Extra space)

(2)

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

(2)

(Total 9 marks)

Q11.

(a) Adrenaline binds to receptors in the plasma membranes of liver cells. Explain how this causes the blood glucose concentration to increase.

(Extra space)

(2)

(b) Scientists made an artificial gene which codes for insulin. They put the gene into a virus which was then injected into rats with type I diabetes. The virus was harmless to the rats but carried the gene into the cells of the rats.

The treated rats produced insulin for up to 8 months and showed no side-effects. The scientists measured the blood glucose concentrations of the rats at regular intervals. While the rats were producing the insulin, their blood glucose concentrations were normal.

(i) The rats were not fed for at least 6 hours before their blood glucose concentration was measured. Explain why.

(1)

(ii) The rats used in the investigation had type I diabetes. This form of gene therapy may be less effective in treating rats that have type II diabetes. Explain why.

(1)

(iii) Research workers have suggested that treating diabetes in humans by this method of gene therapy would be better than injecting insulin. Evaluate this suggestion.

(Extra space)

(4)

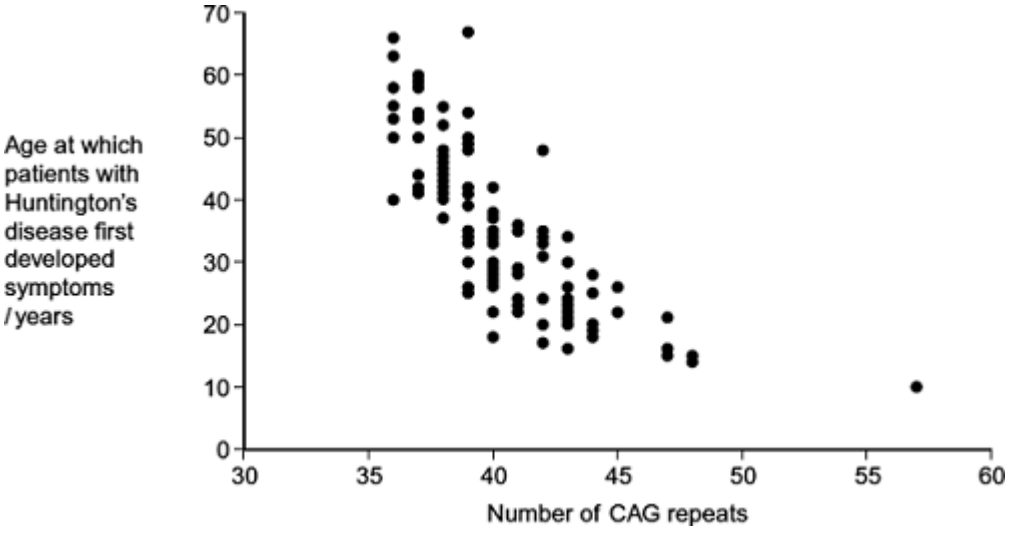
(Total 8 marks)

Q12.

Huntington's disease is a genetic condition that leads to a loss in brain function. The gene involved contains a section of DNA with many repeats of the base sequence CAG. The number of these repeats determines whether or not an allele of this gene will cause Huntington's disease.

- An allele with 40 or more CAG repeats will cause Huntington's disease.
- An allele with 36 – 39 CAG repeats may cause Huntington's disease.
- An allele with fewer than 36 CAG repeats will not cause Huntington's disease.

The graph shows the age at which a sample of patients with Huntington's disease first developed symptoms and the number of CAG repeats in the allele causing Huntington's disease in each patient.



(a) (i) People can be tested to see whether they have an allele for this gene with more than 36 CAG repeats. Some doctors suggest that the results can be used to predict the age at which someone will develop Huntington's disease.

Use information in the graph to evaluate this suggestion.

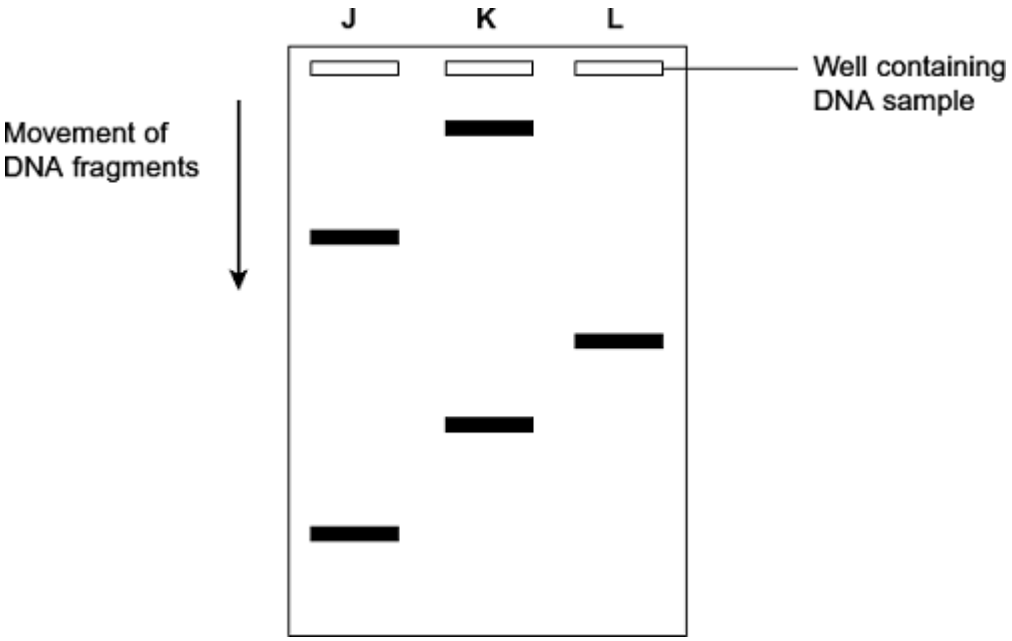
(Extra space)

(3)

(ii) Huntington's disease is always fatal. Despite this, the allele is passed on in human populations. Use information in the graph to suggest why.

(2)

(b) Scientists took DNA samples from three people, **J**, **K** and **L**. They used the polymerase chain reaction (PCR) to produce many copies of the piece of DNA containing the CAG repeats obtained from each person. They separated the DNA fragments by gel electrophoresis. A radioactively labelled probe was then used to detect the fragments. The diagram shows the appearance of part of the gel after an X-ray was taken. The bands show the DNA fragments that contain the CAG repeats.



(i) Only one of these people tested positive for Huntington's disease. Which person was this? Explain your answer.

Person _____

Explanation _____

_____

_____

_____

(2)

(ii) The diagram only shows part of the gel. Suggest how the scientists found the number of CAG repeats in the bands shown on the gel.

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(1)

(iii) Two bands are usually seen for each person tested. Suggest why only one band was seen for Person **L**.

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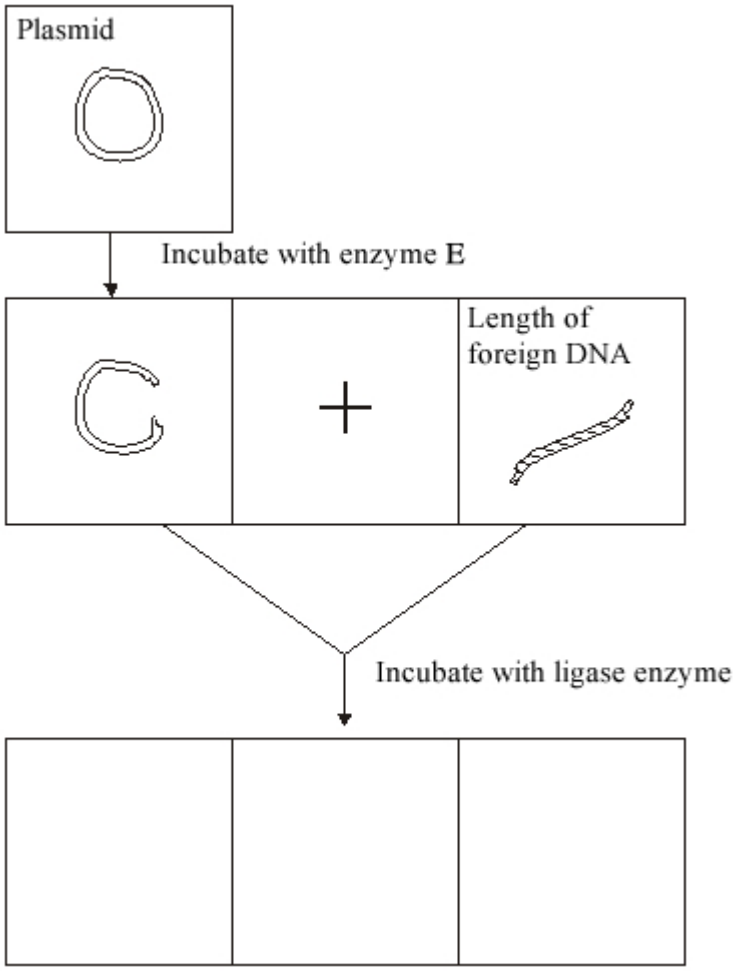
(1)

(Total 9 marks)

Q13.

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)

Q14.

(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.

_____

_____

_____

_____

(2)

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

(i) Why are primers required?

_____

_____

(1)

(ii) Suggest why two different primers are required.

_____

_____

(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)

Q15.

Read the following passage.

The giant panda is one of the rarest animals in the world and is considered to be on the brink of extinction in the wild. Giant pandas have been kept and bred in zoos with the hope that they could be released into the wild. One worry is that small populations, like those in zoos, reduce the genetic variation needed to allow the species to adapt to changing conditions. Unfortunately, pandas find it difficult to reproduce in captivity. Fertilisation of the females is guaranteed only by insemination with semen from several males. With so many potential fathers, the true paternity of the cubs is not clear. It is important to identify the fathers to maintain genetic variation.

Panda faeces can be collected in the wild. The faeces contain DNA from the panda, from the bamboo on which they feed and from bacteria. The DNA is subjected to the polymerase chain reaction (PCR). The primers used attach only to the panda DNA. The resulting DNA is subjected to genetic fingerprinting. This can help us to count the number of individuals in the wild because it allows us to identify individual pandas.

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

(a) Describe how genetic fingerprinting may be carried out on a sample of panda DNA.

_____

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(6)

(b) (i) Explain how genetic fingerprinting allows scientists to identify the father of a particular panda cub.

_____

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_____

_____

(2)

(ii) When pandas are bred in zoos, it is important to ensure only unrelated pandas breed. Suggest how genetic fingerprints might be used to do this.

_____

_____

(1)

(c) (i) Suggest why panda DNA is found in faeces. (line 10)

_____

_____

(1)

(ii) Explain why the PCR is carried out on the DNA from the faeces. (line 12)

_____

_____

(1)

(iii) Explain why the primers used in the PCR will bind to panda DNA, but not to DNA from bacteria or bamboo. (line 12)

_____

_____

_____

_____

(2)

(d) DNA from wild pandas could also be obtained from blood samples. Suggest **two** advantages of using faeces, rather than blood samples, to obtain DNA from pandas.

1. _____

_____

2. _____

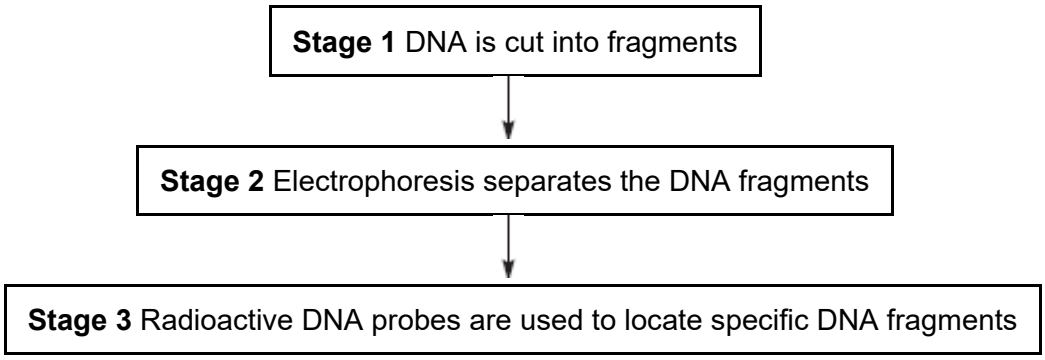
_____

(2)

(Total 15 marks)

Q16.

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.



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

_____

(1)

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(Total 7 marks)

Q17.

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.

Source: adapted from SHAONI BHATTACHARYA, *New Scientist* 15 December, 2003

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.

(6)

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

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(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;

_____

_____

(1)

(ii) contaminated.

_____

_____

_____

_____

(2)

(Total 15 marks)

Q18.

Read the following passage.

Herpes viruses cause cold sores and, in some cases, genital warts. Scientists are well on the way to producing an antibody which will counteract herpes infection. This antibody works by sticking to the virus and blocking its entry into cells. It has proved very effective in animal tests.

5 One drawback with this approach, however, is that antibodies are at present produced using hamster ovary cells. This method is expensive and only produces limited amounts. A new technique is being developed to produce antibodies from plants. It involves introducing the DNA which codes for the required antibody into crop plants such as maize.

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

(a) (i) What is an antibody?

_____

_____

_____

_____

(2)

(ii) Describe how antibodies are produced in the body following a viral infection.

_____

_____

_____

_____

_____

_____

_____

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_____

_____

_____

(6)

(b) Describe how the antibody gene could be isolated from an animal cell and introduced into a crop plant such as maize (lines 7-8).

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) Taking a course of these antibodies from plants to treat a herpes infection would not produce long-term protection against disease. Explain why.

_____

_____

_____

_____

(2)

(d) Explain **one** advantage of using antibodies from plants to treat a disease, rather than antibodies produced in an experimental animal (lines 5-6).

_____

_____

(1)

(Total 15 marks)

Q19.

Scientists are working to produce a genetically modified bacterium to treat patients suffering from a disease of the digestive system. They plan to collect mRNA from human cells. This will be used to produce the DNA of the gene for the protein interleukin. They will then transfer this human gene into the bacterium *Lactococcus*. The scientists intend patients to swallow the genetically modified bacteria. These bacteria will release interleukin inside the digestive system to treat the disease.

(a) (i) Name the type of enzyme which will be used to produce the DNA from the mRNA.

_____

(1)

(ii) It is easier to obtain the interleukin gene from mRNA rather than directly from the DNA removed from human cells. Explain why.

_____

_____

(1)

(b) The scientists propose to put the gene directly into the DNA of *Lactococcus*. Describe the role of the enzyme ligase in this process.

_____

_____

(1)

(Total 3 marks)

Q20.

A gene was broken into fragments using enzyme **Z**. The mixture of fragments produced was then separated by electrophoresis.

(a) What type of enzyme is enzyme **Z**?

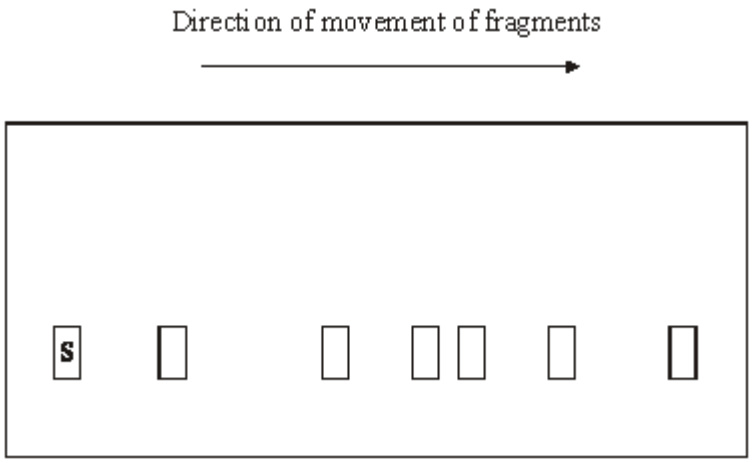
_____

(1)

The table shows the number of base pairs present in the fragments.

Fragment	Number of base pairs ($\times 10^3$)
1	4.65
2	5.72
3	10.71
4	2.39
5	5.35
6	7.53

The diagram shows the electrophoresis gel used. The mixture of fragments was placed at the start point marked **S** and the process started. The boxes indicate the positions reached by the different fragments.



(b) Explain why base pairs are a suitable way of measuring the length of a piece of DNA.

_____

_____

_____

_____

(2)

(c) (i) Write **6** above the appropriate box on the diagram to show the position you would expect fragment **6** to have reached.

(1)

(ii) Explain how you arrived at your answer.

_____

_____

(1)

(d) Enzyme **Z** recognises a particular sequence of bases in the gene. How many times does this sequence appear in the DNA of this gene?

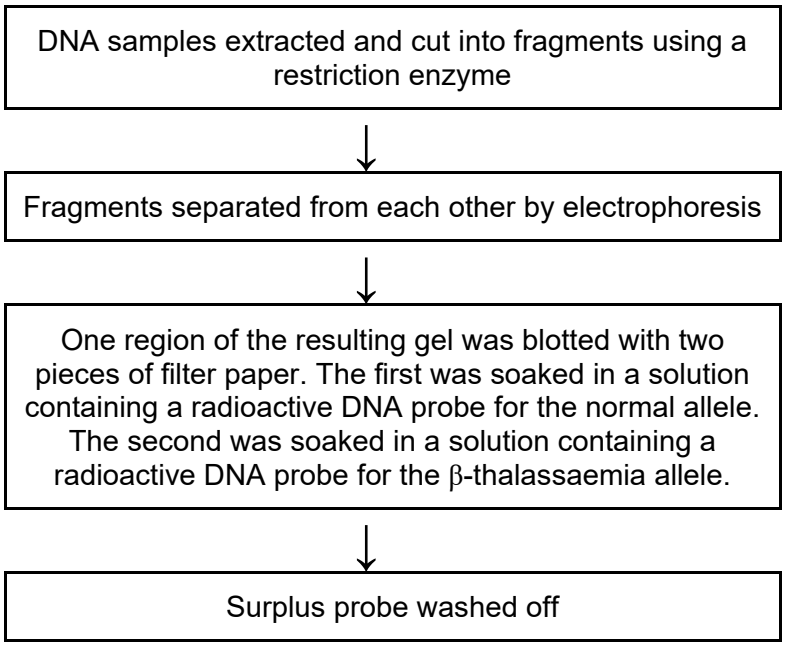
_____

(1)

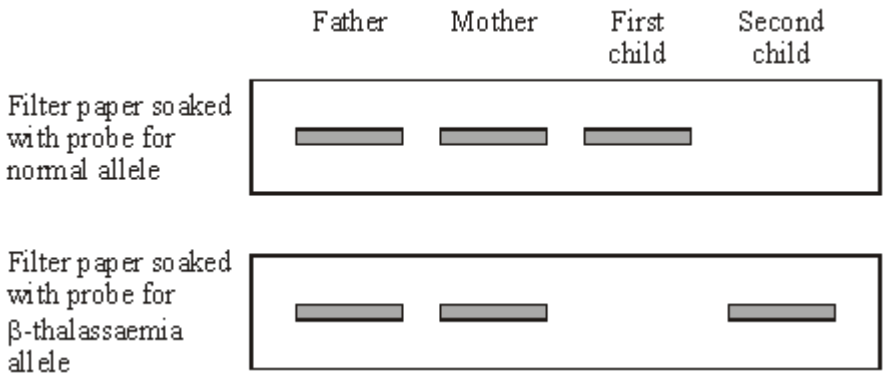
(Total 6 marks)

Q21.

β-thalassaemia is a genetic condition in which abnormal haemoglobin is produced. In one form, the recessive allele for β-thalassaemia, **t**, differs from the normal allele, **T**, by a single base-pair. A radioactive DNA probe was used to investigate the genotypes of four members of one family. The flowchart summarises the technique involved.



The diagram below shows the appearance of the two pieces of filter paper which resulted from the investigation.



(a) What is the probability that the next child that this couple have is a girl who has β-thalassaemia? Explain your answer.

(3)

(b) (i) The fragment of DNA containing the normal allele and the fragment with the β-thalassaemia allele moved the same distance on the gel. Explain why.

(2)

(ii) The allele for β-thalassaemia differs from the normal allele by only one base-pair. Explain why the probe used to identify these alleles consists of a piece of DNA twenty bases in length and not just one base.

(2)

(Total 7 marks)

Q22.

(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.

_____

_____

_____

_____

(2)

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

_____

_____

(1)

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

_____

_____

_____

_____

(2)

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

Explain the reason for this.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q23.

Read the following passage.

Shark-fin soup is an expensive delicacy. To provide the basic ingredient, fishermen catch the sharks, hack the fins off and throw the dead bodies back into the ocean. But sharks are slow to mature and produce only a few offspring at a time, so they are vulnerable to overfishing. Monitoring the shark-fin trade is difficult, as once a fin has been cut off, it can be extremely difficult to work out precisely from which species it was taken.

The DNA from different species of sharks shows some differences in base sequence. This has enabled a new genetic fingerprinting technique to be developed. This technique would allow conservationists and fisheries managers to assess which of the 400 shark species are most threatened by the trade in shark fins.

An identification process has been developed using a range of "primers". These are short pieces of single-stranded DNA that are complementary to a particular sequence of DNA. Each primer is specific to the DNA of one shark species.

The primers are added to DNA taken from a shark's fin and the polymerase chain reaction is carried out. Only two primers, one at each end of a certain piece of DNA, will bind. The piece of DNA between the primers is replicated by the polymerase chain reaction. The primers that bind are specific to a particular species of shark and the length of the DNA fragment replicated differs for each species. When this DNA is run in an electrophoresis gel it produces a single band, enabling the researchers to identify which species of shark is involved.

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

(a) (i) Explain why the DNA for each species of shark shows differences in base sequence (line 6).

(2)

(ii) Each primer is specific to the DNA of one shark species (line 12).

Explain why a particular primer will only bind to the DNA of one species.

(2)

(iii) The length of the replicated DNA fragment is different for each species.

Explain why this is important in identifying the shark species involved.

(3)

(b) In conventional DNA fingerprinting, a series of bands is produced on the electrophoresis gel, resembling the rungs of a ladder. When the DNA in this new genetic fingerprinting technique is run in an electrophoresis gel it produces just one of these 'rungs'.

Explain the reason for the difference in the number of 'rungs' produced.

(2)

(c) Describe the polymerase chain reaction.

(6)

(Total 15 marks)

Q24.

(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.

_____

_____

(2)

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

_____

_____

(1)

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

_____

_____

_____

_____

(2)

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

Explain the reason for this.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q25.

Read the following passage.

Soon a single drop of blood might be enough to reveal, at a very early stage, if a patient has cancer. It could also tell us what type of cancer it is and whether it is treatable. Fragments of DNA from body cells are present in blood plasma. Some of these fragments may be from cancer cells. The fragments can be detected by a new test in which a test strip containing nucleic acid binds to sections of altered DNA.

Other cancer-detecting techniques involve removing a tissue sample from a patient. The tissue sample is used to obtain mRNA. By examining the mRNA, scientists can discover whether cancer is present.

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

(a) Describe how altered DNA may lead to cancer.

(6)

(b) Explain why fragments of DNA from cancer cells may be present in blood plasma (lines 3-4).

(2)

(c) Explain why the nucleic acid on the test strip will only bind to altered DNA (lines 4-5).

(2)

(d) This test strip will allow cancers to be detected at a very early stage. Explain why cancer is more likely to be treated successfully if the disease is detected at a very early stage.

_____

(2)

(e) Explain how examining mRNA (line 7) enables scientists to discover whether cancer is present.

_____

_____

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_____

_____

_____

(3)

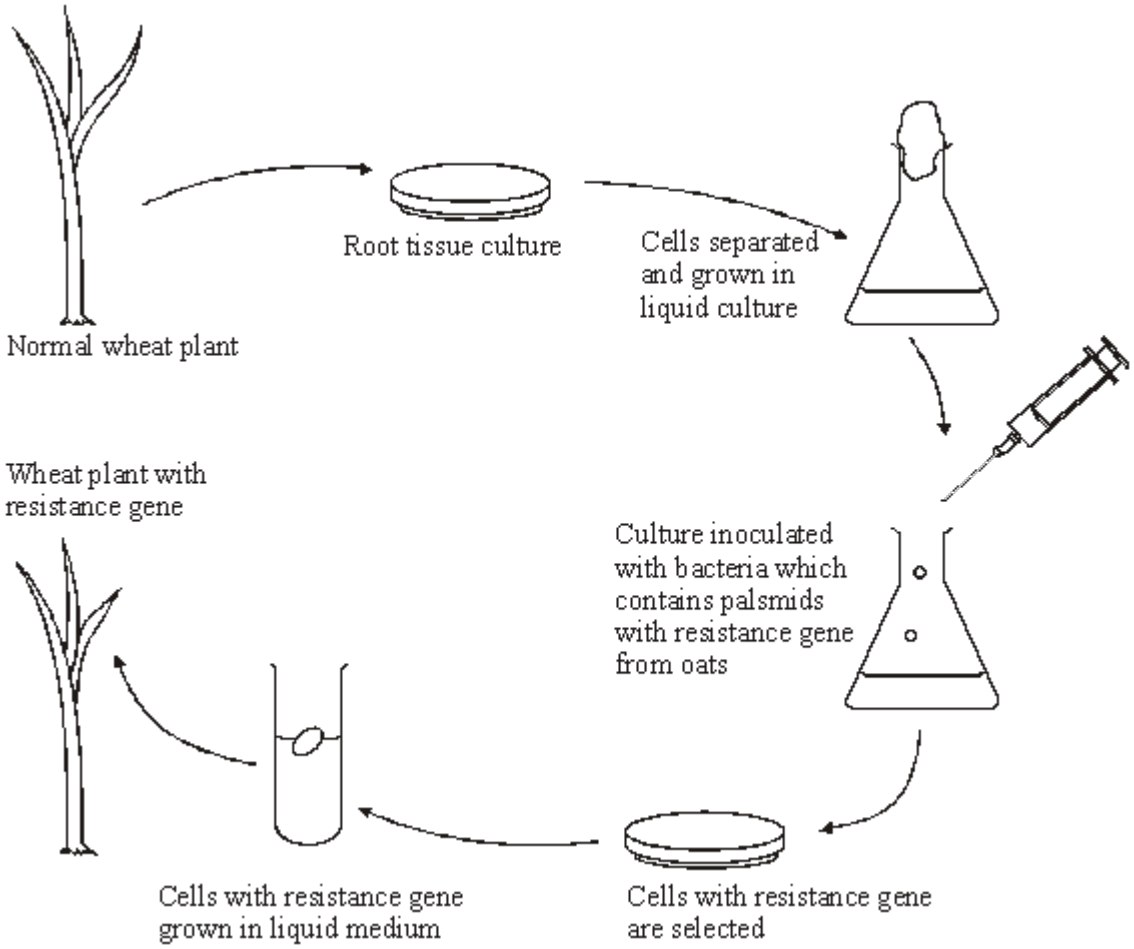
(Total 15 marks)

Q26.

'Take-all' is a disease of wheat caused by a fungus. It can cause serious damage to the crop.

There is no gene for resistance to this fungus in wheat. There is, however, a gene for resistance to this fungus present in oats.

The diagram shows how this gene might be transferred to wheat.



(a) (i) The wheat plant with the resistance gene contains recombinant DNA. What is *recombinant* DNA?

_____

_____

(1)

(ii) The plasmids act as vectors for the resistance gene. What is a *vector*?

_____

_____

(1)

(iii) Suggest how cells with the resistance gene might be selected.

_____

_____

_____

_____

(2)

(b) A laboratory has oat plants containing the resistance gene and a supply of plasmids.

Describe how bacteria may be produced which have the resistance gene in their plasmids.

(6)

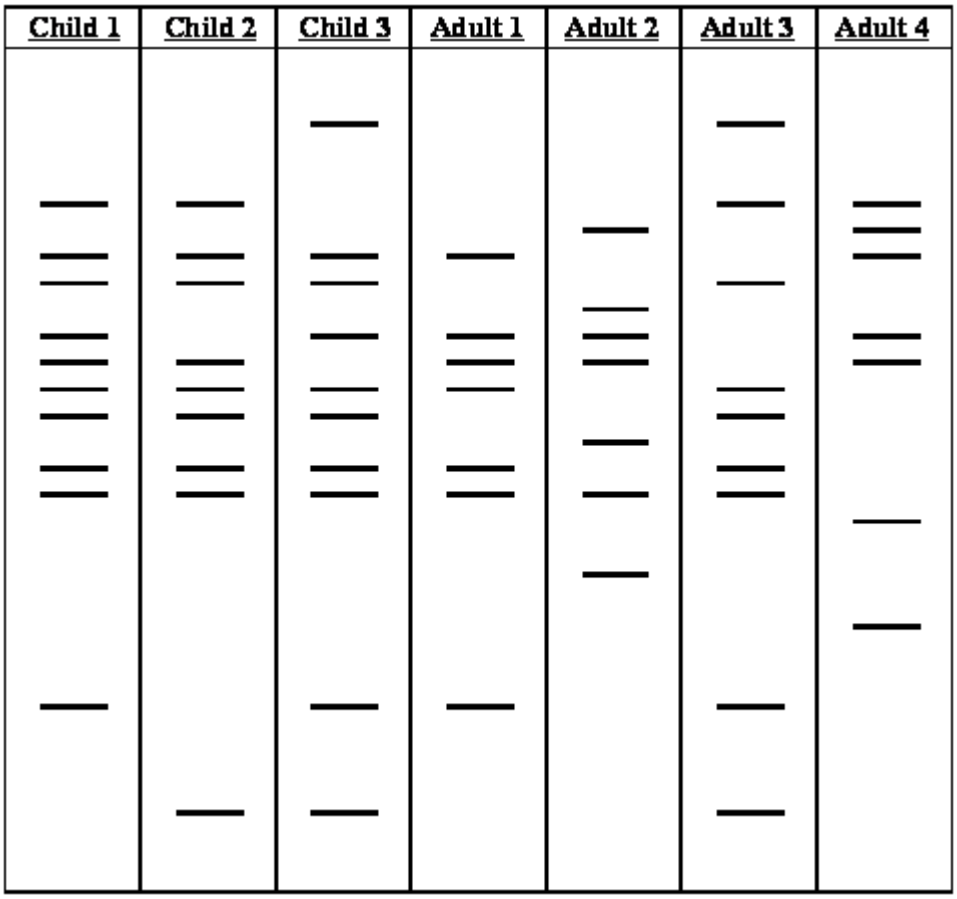
(Total 10 marks)

Q27.

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.

_____

_____

_____

_____

(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.

_____

_____

(1)

(ii) What are DNA *primers*?

_____

_____

(1)

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

(1)

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

(2)

(c) Describe how genetic fingerprinting is carried out.

(6)

(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.

(2)

(Total 15 marks)