Q1.

Myelodysplastic syndromes (MDS) are a group of malignant cancers. In MDS, the bone marrow does not produce healthy blood cells.

Haematopoietic stem cell transplantation (HSCT) is one treatment for MDS. In HSCT, the patient receives stem cells from the bone marrow of a person who does not have MDS. Before the treatment starts, the patient's faulty bone marrow is destroyed.

(a) For some patients, HSCT is an effective treatment for MDS.

Explain how.

(3)

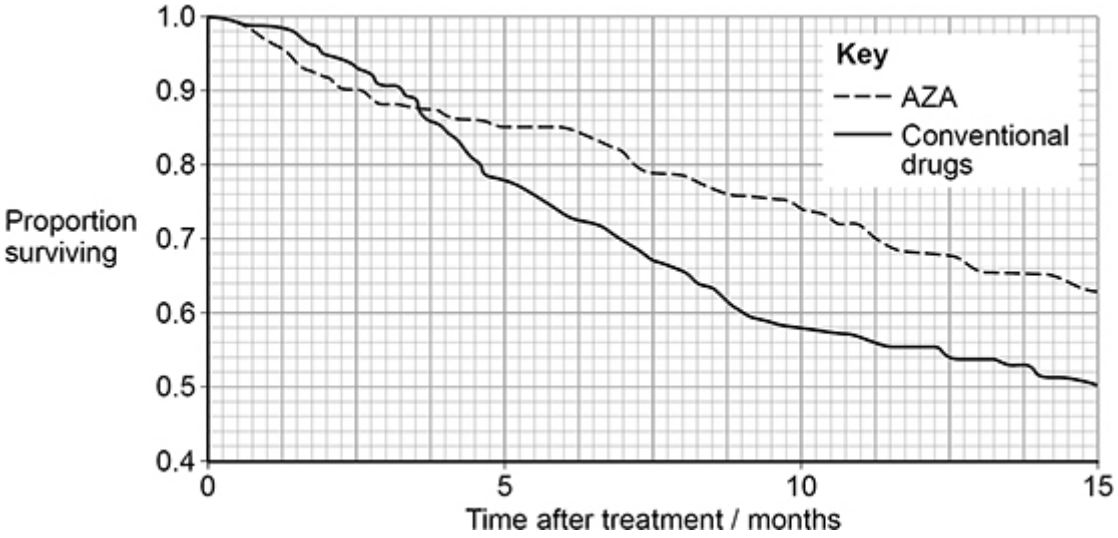
(b) MDS can develop from epigenetic changes to tumour suppressor genes. In some patients, the drug AZA has reduced the effects of MDS. AZA is an inhibitor of DNA methyltransferases. These enzymes add methyl groups to cytosine bases.

Suggest and explain how AZA can reduce the effects of MDS in some patients.

(3)

Scientists investigated the effectiveness of AZA in patients with MDS. A total of 360 patients were randomised in the ratio of 1:1 to receive AZA or conventional drugs (control).

The figure below shows the scientists' results.



(c) The control patients were treated with conventional drugs.

Give **two** reasons why.

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2 _____

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(2)

(d) Use the figure above and the information provided to calculate the difference in the number of patients surviving at 10 months after treatment with AZA compared with conventional drugs.

Answer _____

(2)

(Total 10 marks)

Q2.

Alport syndrome (AS) is an inherited disorder that affects kidney glomeruli of both men and women. Affected individuals have proteinuria (high quantities of protein in their urine).

Scientists investigated the use of transplanted stem cells to treat AS in mice.

The scientists set up four experimental groups.

Group **A** – 40 wild type* mice
Group **B** – 40 AS mice
Group **C** – 40 AS mice that received stem cells from AS mice
Group **D** – 40 AS mice that received stem cells from wild type mice

*Wild type mice are mice **not** affected by AS.

After 20 weeks, the scientists measured the quantity of protein in the urine using a scale from 0 (lowest quantity) to +++++ (highest quantity).

The results the scientists obtained are shown in below table.

Group	Maximum quantity of protein in urine at 20 weeks	Percentage of mice with this quantity of protein
A	0	100
B	+++++	97.5
C	+++++	100
D	++	68

(c) Using all the information, evaluate the use of stem cells to treat AS in humans.

(4)

(d) The scientists carried out further work to investigate how the transplanted stem cells developed after transplantation.

- The scientists transplanted stem cells from wild type male mice into AS female mice.
- After 20 weeks, they found that the quantity of protein in the urine of these female mice had significantly decreased.
- They examined cells from glomeruli in the female mice. Some of these cells contained a Y chromosome.

Suggest how the transplanted stem cells reduce proteinuria.

(2)

Q3.

Sickle cell disease (SCD) is a group of inherited disorders. People with SCD have sickle-shaped red blood cells. A single base substitution mutation can cause one type of SCD. This mutation causes a change in the structure of the beta polypeptide chains in haemoglobin.

Haematopoietic stem cell transplantation (HSCT) is a long-term treatment for SCD. In HSCT, the patient receives stem cells from the bone marrow of a person who does not have SCD. The donor is often the patient's brother or sister. Before the treatment starts, the patient's faulty bone marrow cells have to be destroyed.

(b) Use this information to explain how HSCT is an effective long-term treatment for SCD.

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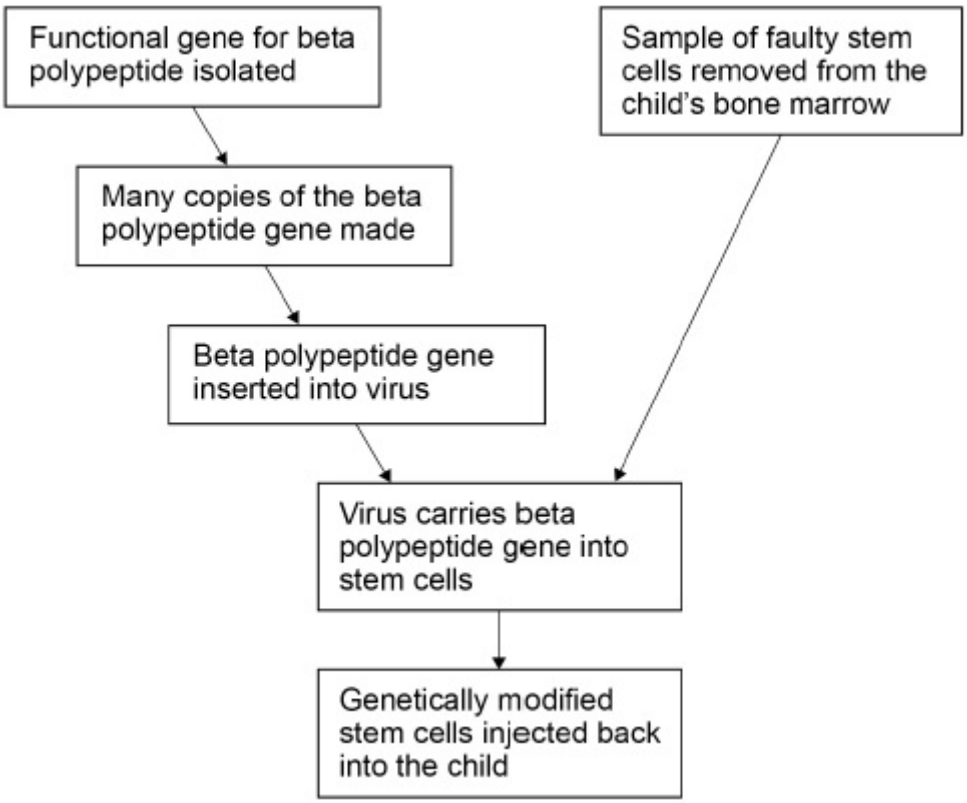
(3)

A new long-term treatment for SCD involves the use of gene therapy.

The diagram shows some of the stages involved in this treatment in a child with SCD.



(c) Some scientists have concluded that this method of gene therapy will be a more effective long-term treatment for SCD than HSCT. Use all the information provided to evaluate this conclusion.

(3)

Q4.

Read the following passage.

Complete achromatopsia is a form of complete colour blindness. It is caused by having only rods and no functional cone cells. People with complete achromatopsia have difficulty in seeing detail. Complete achromatopsia is caused by an autosomal recessive allele and is usually very rare in populations with only one in 40 000 being affected. However on the Pacific island of Pingelap ten percent of the population are affected.

One form of red-green colour blindness is caused by a sex-linked recessive allele which affects more men than women. People with this red-green colour blindness are unable to distinguish between red and green, and also between other colours. They have green-sensitive cones but the photoreceptive pigment they contain does not function.

Scientists investigated the use of gene therapy to correct red-green colour blindness in monkeys. They injected viruses containing the gene for the green-sensitive pigment directly into the eyes of the monkeys. Although the monkeys maintained two years of colour vision, there is debate on whether this form of gene therapy is worthwhile. No clinical trials of this procedure have been carried out on humans. Current research into the treatment of red-green colour blindness involves the use of induced pluripotent stem cells (iPS cells). The use of iPS cells could have advantages over the use of gene therapy.

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

(e) Current research into the treatment of red-green colour blindness involves the use of induced pluripotent stem cells (iPS cells) (lines 17–19).

Suggest how iPS cells could correct red-green colour blindness.

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(2)

(f) The use of iPS cells could have advantages over the use of gene therapy to correct red-green colour blindness (lines 19–20).

Using the information from the passage, suggest and explain reasons why.

(3)

Q5.

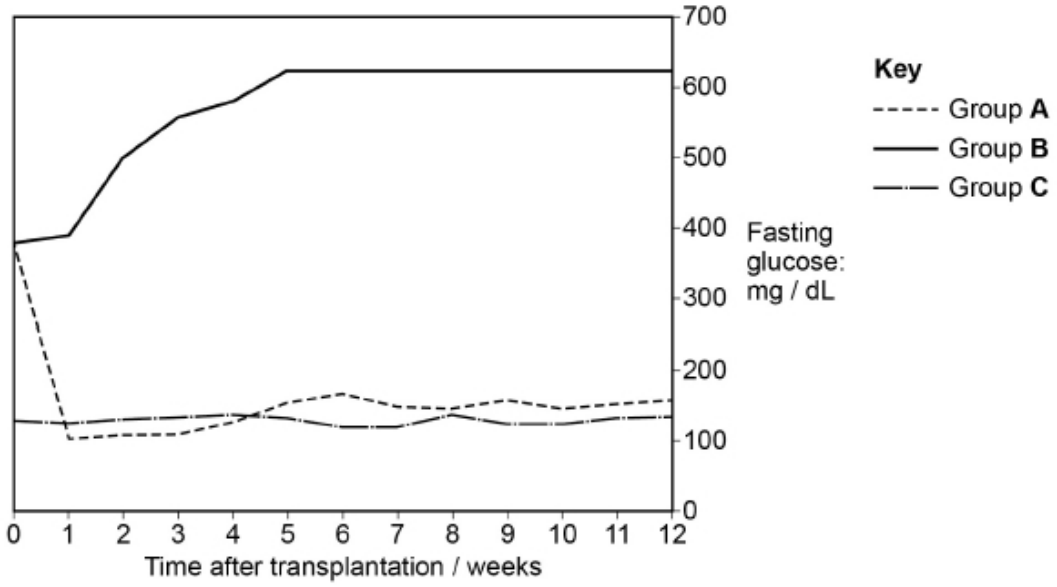
(c) Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells. The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

The scientists set up three experimental groups:

- Group **A** – 30 mice with type I diabetes received pancreatic cell transplants derived from iPS cells.
- Group **B** – 30 mice with type I diabetes were left untreated.
- Group **C** – 30 mice without diabetes were left untreated.

The scientists measured the blood glucose concentration of all the mice on a weekly basis for 12 weeks.

The results the scientists obtained are shown in the graph.



Suggest how transcription factors can **reprogramme** cells to form iPS cells.

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(2)

(d) Using all the information provided, evaluate the use of iPS cells to treat type I diabetes in humans.

(4)

Q6.

Scientists have investigated the use of different types of stem cell to treat damage to the heart after a myocardial infarction. During a myocardial infarction, a number of different cell types in the heart die. This includes cardiomyocytes which are heart-muscle cells.

Embryonic pluripotent stem cells (ESCs) can divide and differentiate into a wide range of different cell types.

(a) Using the information given, suggest **one** reason why ESCs might be suitable to treat damage to the heart.

(1)

(b) ESCs have not yet been used to treat people who have had a myocardial infarction. This is because of concern that the use of ESCs might lead to more harm to the person. One way that ESCs might lead to more harm is by differentiating into the wrong types of cells.

Suggest **one** other way that putting ESCs into a person's heart might lead to more harm to the person.

(2)

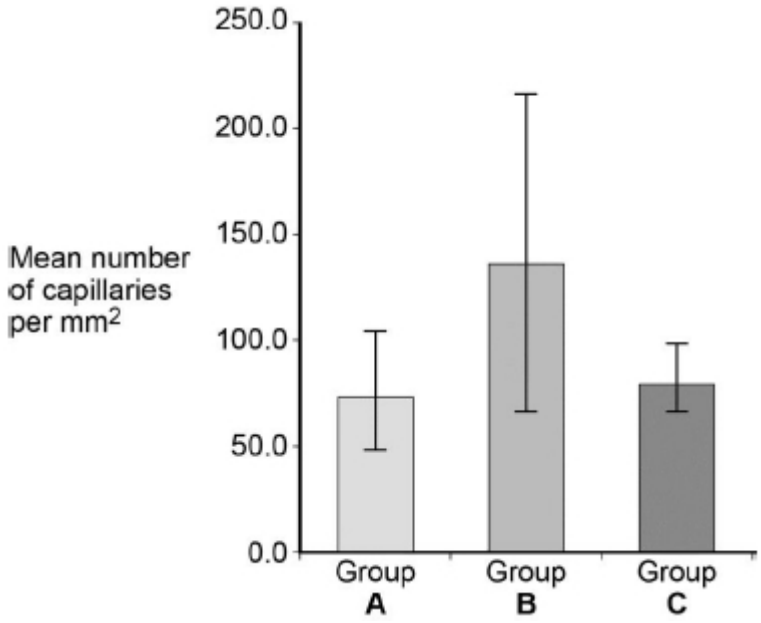
(c) Transplants of cardiomyocytes have been shown to increase the repair of heart tissue damaged by myocardial infarction.

One group of scientists investigated the hypothesis that these transplants work by stimulating growth of new blood vessels into damaged heart tissues. They obtained three groups of mice, **A**, **B** and **C** that had suffered myocardial infarctions.

- **Group A** were operated on but no transplant was given.
- **Group B** were operated on and given transplants containing cardiomyocytes and two other types of heart cell.
- **Group C** were operated on and given transplants containing the two other types of heart cells but no cardiomyocytes.

After a suitable time, the scientists measured the mean number of capillaries per mm^2 in sections taken from areas of the hearts of the mice affected by myocardial infarction.

Their results are shown in the graph below. The bars show ±2 standard deviations, which includes 95.4% of the data.



Group **A** was a control group. Explain **two** ways in which Group **A** acts as a control.

1. _____

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2. _____

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(2)

(d) What can you conclude from these data about the stimulation by cardiomyocytes on growth of new blood vessels into damaged heart tissues?

(3)

(e) Suggest how the growth of new blood vessels into damaged heart tissues could increase the rate of repair of tissues.

(3)