



A-Level Biology

Stem Cells

Question Paper

Time available: 57 minutes

Marks available: 43 marks

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1.

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)

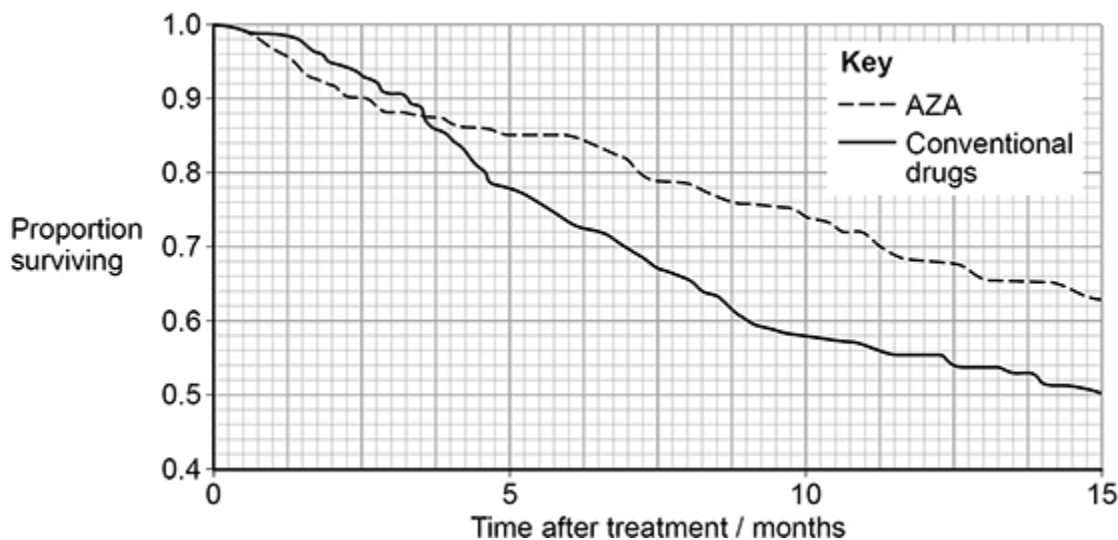
- (b) MDS can develop from epigenetic changes to tumour suppressor genes. In some patients, the drug AZA has reduced the effects of MDS. AZA is an inhibitor of DNA methyltransferases. These enzymes add methyl groups to cytosine bases.

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.

1 _____

2 _____

(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)

2.

- (a) Each year, a few people with type I diabetes are given a pancreas transplant. Pancreas transplants are not used to treat people with type II diabetes.

Give **two** reasons why pancreas transplants are not used for the treatment of type II diabetes.

1. _____

2. _____

(2)

(b) The pancreas produces the hormone insulin.

Put a tick (✓) in the box next to the statement which describes **incorrectly** the action of insulin.

Activates enzymes involved in the conversion of glucose to glycogen.

Controls the uptake of glucose by regulating the inclusion of channel proteins in the surface membranes of target cells.

Attaches to receptors on the surfaces of target cells.

Activates enzymes involved in the conversion of glycerol to glucose.

(1)

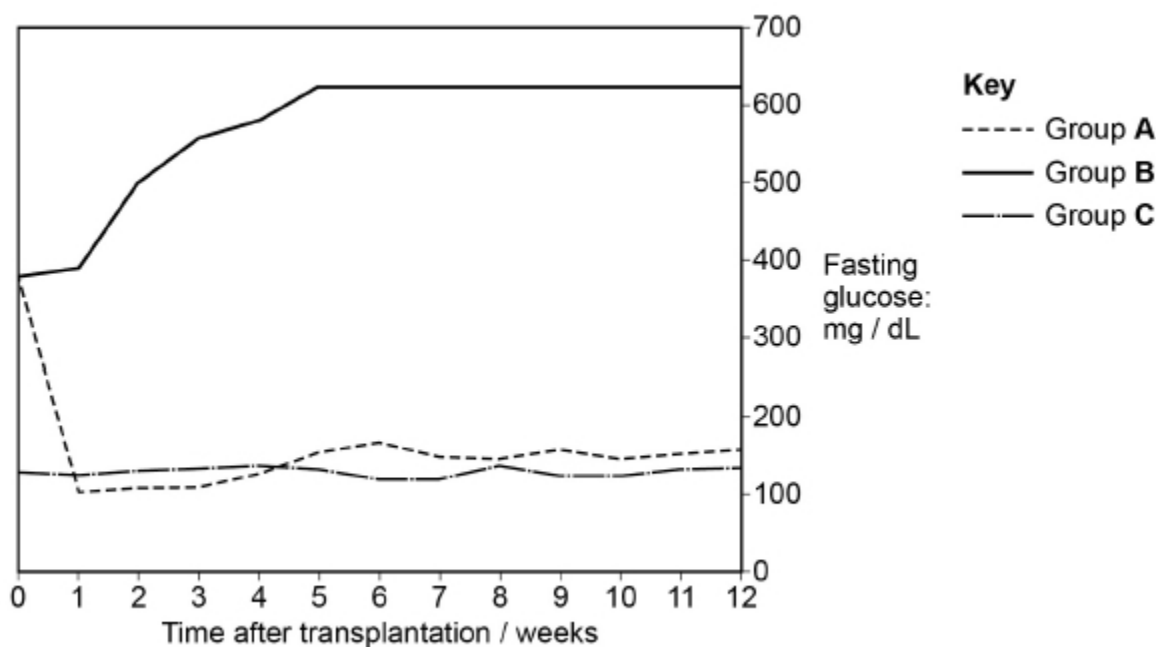
(c) Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells. The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

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.

(2)

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

(4)

(Total 9 marks)

3.

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)

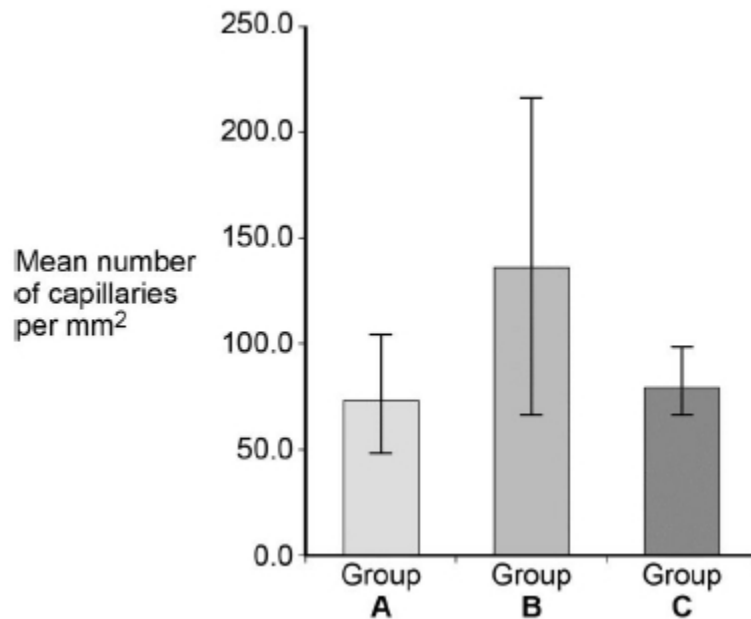
- (c) Transplants of cardiomyocytes have been shown to increase the repair of heart tissue damaged by myocardial infarction.

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 mm² 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. _____

2. _____

(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)

- (f) The scientists used an optical microscope to measure the number of capillaries in thin sections cut from samples of heart muscle.

Describe the method they would have used to find the mean number of capillaries per mm².

(4)

(Total 15 marks)

4.

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. _____

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.

(2)

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

(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.

(2)

(Total 9 marks)