Q1.

(a) The *KRAS* gene codes for a protein called K-Ras. The protein relays signals from outside a cell to a cell's nucleus, stimulating cell division. An alteration in the *KRAS* gene produces an oncogene which can cause a tumour to develop.

Suggest and explain how an alteration in the *KRAS* gene can cause a tumour to develop.

(3)

(b) Alterations in the *KRAS* gene can cause colorectal cancer (CRC). Scientists investigated the survival time of the following three groups of CRC patients who had type II diabetes.

Group **A** – received no drug to treat type II diabetes
Group **B** – received the drug metformin to treat type II diabetes
Group **C** – received a combination of drugs (including metformin) to treat type II diabetes

The scientists used a statistical test to compare the survival time of these patients with CRC patients with no history of type II diabetes.

The table below shows some of the results obtained by the scientists.

Group	Mean survival time of CRC patients / months	Probability value (P)
No history of type II diabetes	32.2	–
A	21.3	0.007
B	49.7	0.022
C	38.3	0.636

Using the information provided, what can you conclude about the effects of type II diabetes and the different drug treatments on the survival time of CRC patients?

(5)

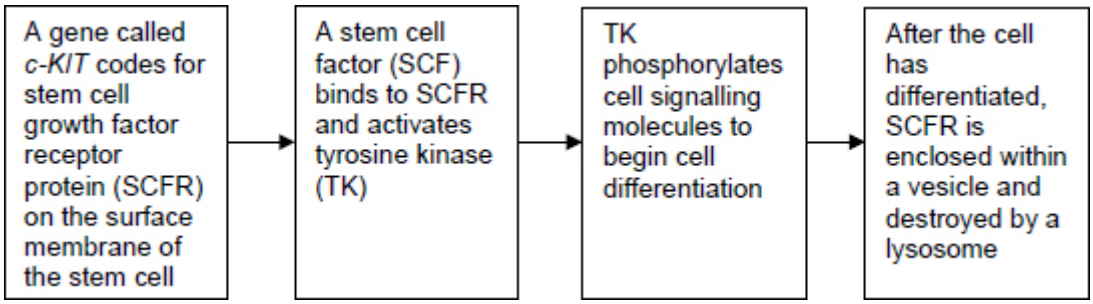
(Total 8 marks)

Q2.

Following a body injury, bone marrow stem cells move to the site of damage and undergo cell differentiation.

Figure 1 shows how this differentiation occurs.

Figure 1



(a) Suggest how SCFR is destroyed by a lysosome.

_____

_____

_____

_____

_____

_____

(2)

After a heart attack, cardiomyocytes (cardiac muscle cells) die, and become infarcted tissue. Infarcted tissue cannot contract.

Stem cells in bone marrow **cannot** move to the infarcted tissue and differentiate into cardiomyocytes.
Scientists used laboratory rats to investigate if bone marrow stem cell transplants could be used to repair infarcted tissue resulting from a heart attack.

They split the rats into three groups.

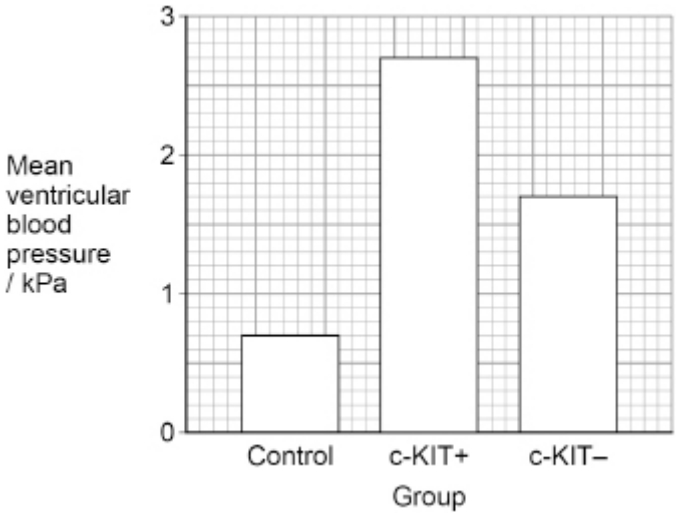
- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT+** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT–** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

After 9 days, the scientists measured the mean ventricular blood pressure of each of the three groups.

Figure 2 shows their results.

The differences between the groups were all statistically significant.

Figure 2



(b) Using all of the information, suggest explanations for the results for the **Control** group and the **c-KIT–** group shown in **Figure 2**.

Control _____

_____

_____

_____

_____

_____

_____

c-KIT– _____

_____

_____

_____

_____

_____

_____

(4)

(c) Nine days after transplantation, the **c-KIT+** group showed that 68% of infarcted tissue was made up of new cardiomyocytes. The control group had **no** new cardiomyocytes.

Assuming that mean ventricular blood pressure is directly proportional to the number of cardiomyocytes, calculate the percentage of infarcted tissue that was made up of new cardiomyocytes in the **c-KIT–** group.

Answer _____ %

(2)

All new cardiomyocytes produced:

- Connexin-43, a channel protein that allows electrical impulses to pass between cardiomyocytes
- GATA-4, a transcriptional factor that stimulates the expression of genes for actin and myosin.

(d) Suggest how production of Connexin-43 and GATA-4 could give the result seen in the **c-KIT+** group in **Figure 2**.

Do **not** include details of transcription or translation in your answer.

Connexin-43 _____

_____

_____

_____

_____

GATA-4 _____

_____

_____

_____

_____

(2)

(Total 10 marks)

Q3.

Read the following passage.

BRCA1 and *BRCA2* are human genes that code for tumour suppressor proteins. Mutations in *BRCA1* and *BRCA2* can cause cancer. Specific inherited mutations in these genes increase the risk of female breast cancers and ovarian cancers and have been associated with increased risks of several other types of cancer. Genetic testing, using DNA from saliva, can screen for all known harmful mutations in both genes.

ER-positive breast cancers have receptors for the hormone oestrogen. These cancers develop as a result of increased oestrogen concentrations in the blood. Effective treatment of ER-positive breast cancers often involves the use of drugs which have a similar structure to oestrogen.

Blood tests can be used to test for cancers. Men with prostate cancer have a high concentration of prostate-specific antigen (PSA) in their blood. Urinary infections and a naturally enlarged prostate can also increase concentrations of PSA.

Recent research has indicated that several cancers result from epigenetic abnormalities. Treatment with drugs might be able to reverse the epigenetic changes that cause cancers.

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

(a) *BRCA1* and *BRCA2* are human genes that code for tumour suppressor proteins. Mutations in *BRCA1* and *BRCA2* can cause cancer (lines 1–2). Explain how.

(3)

(b) Genetic testing, using DNA from saliva, can screen for all known harmful mutations in both genes (lines 5–6). Describe how this DNA could be screened for all known harmful mutations in both genes.

(4)

(c) Effective treatment of ER-positive breast cancers often involves the use of drugs which have a similar structure to oestrogen (lines 9–10).

Suggest and explain how these drugs are an effective treatment of ER-positive breast cancers.

(3)

(d) Blood tests can be used to test for cancers (line 11). However, the results of blood tests may **not** be conclusive when testing for prostate cancer. Explain why.

(2)

(e) Treatment with drugs might be able to reverse the epigenetic changes that cause cancers (lines 16–17). Suggest and explain how.

(3)

(Total 15 marks)