

The control of gene expression – A2 Biology

1. No.4

0 4

In cats, males are XY and females are XX. A gene on the X chromosome controls fur colour in cats. The allele **G** codes for ginger fur and the allele **B** codes for black fur. These alleles are codominant. Heterozygous females have ginger and black patches of fur and their phenotype is described as tortoiseshell female.

The two alleles, **F** and **f** of a different gene, which is **not** sex-linked, interact with the gene controlling fur colour. The allele **F** is dominant and stops the formation of pigment in the fur, resulting in white fur. The allele **f** is recessive and has no effect on fur colour.

0 4 . 1

Name the type of interaction between the two genes affecting fur colour.

[1 mark]

epistasis

0 4 . 2

What phenotype would a cat with the following genotype have?

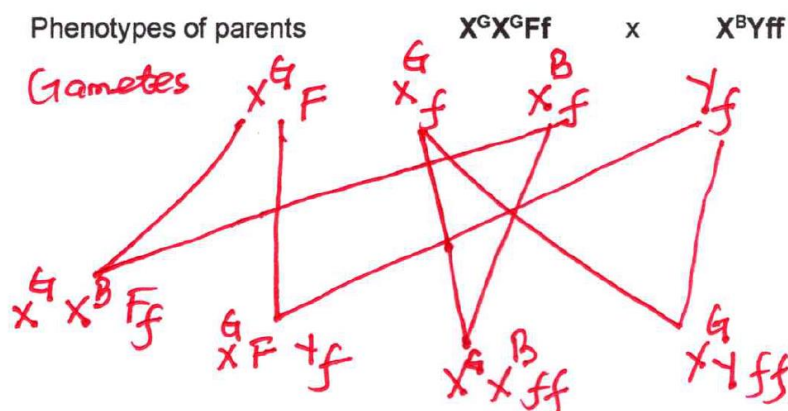
[1 mark]

$X^G X^{Bf}$ *Tortoiseshell female*

0 4 . 3

Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

[3 marks]



Genotypes of offspring *$X^G X^{Bf} Ff$: $X^G X^{Bf} ff$: $X^g X^{Bf} Ff$: $X^g X^{Bf} ff$*

Phenotypes of offspring *3 white female : Tortoiseshell female : white male : Ginger male*

Ratio of offspring phenotypes *1 : 1 : 1 : 1*

0 4 . 4

In a population, 36% of cats had the **F** allele and had white fur.Use the Hardy–Weinberg equation to calculate the frequency of the **f** allele in this population.

Show your working.

36% of cats have F allele and white fur. [2 marks]
 This shows frequency of the homozygous dominant genotype FF
 $p^2 = 0.36$
 $p = \text{frequency of F allele}$

$$p = \pm \sqrt{0.36} = \pm 0.6$$

$$p + q = 1$$

$$q = 1 - 0.6 = 0.4$$

Answer 0.4

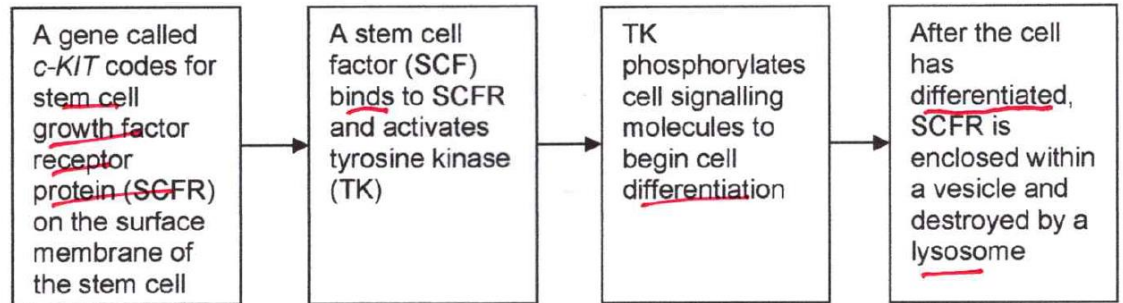
2. No.4

0 4

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

Figure 5 shows how this differentiation occurs.

Figure 5



0 4 . 1

Suggest how SCFR is destroyed by a lysosome.

[2 marks]

The vesicle fuses with a lysosome so that hydrolytic enzymes at lysosome digests SCFR

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.

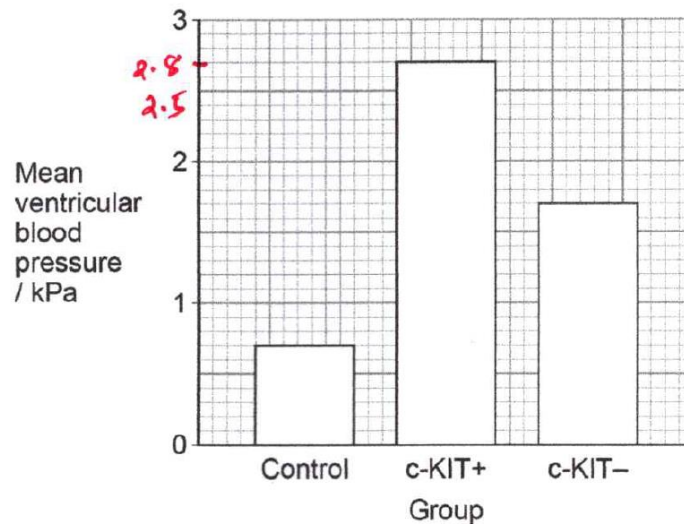
- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT+** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT-** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

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

Figure 6 shows their results.

The differences between the groups were all statistically significant.

Figure 6



0 4 2

Using all of the information, suggest explanations for the results for the **Control** group and the **c-KIT-** group shown in **Figure 6**.

[4 marks]

Control Cardiomyocytes have not been replaced.
This is why contraction of the ventricle is weak.
A small number of Cardiac muscles are still
alive. So, pressure at ventricles remains
low. Pressure is not zero because not all
Cardiac muscles became infarcted.

c-KIT- Mean ventricular pressure is higher
than control because some stem cells must
have been able to differentiate. This shows
that c-KIT is not the only gene responsible
for differentiation. So, SCF must be binding
to something other than SCFR.

0 4 3

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.

[2 marks]

New Cardiomyocytes = 68%

Mean ventricular pressure proportional to the number of cardiomyocytes = $P \propto \text{cardiomyocytes}$

$P_1 = KC$ where $K = \text{constant}$

$P_2 = K \times \frac{68}{100} C = 0.68 KC$

$\frac{68}{100} = 68\%$

% infarcted tissue $\frac{68}{2} = 34\%$

Answer 34 %

New old
68 : 32

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.

0 4 4

Suggest how production of Connexin-43 and GATA-4 could give the result seen in the **c-KIT+** group in **Figure 6** (on page 13).

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

[2 marks]

Connexin-43 It allows impulses to pass to the bottom of the ventricles. It allows diffusion of ions between cardiomyocytes.

GATA-4 It causes more binding of myosin to actin. This leads to formation of more actin-myosin bridges.