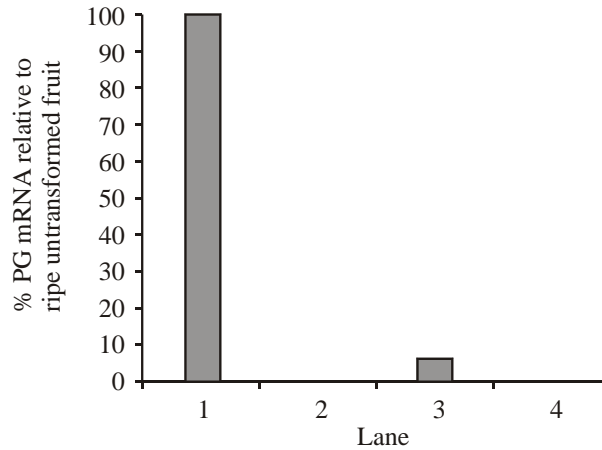
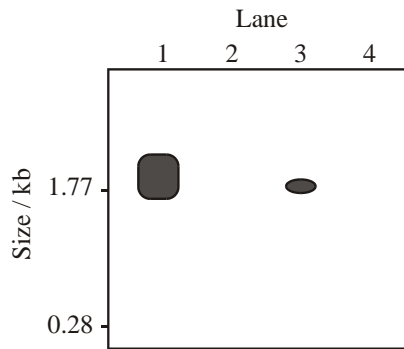


1. Polygalacturonase (PG) plays an important role in fruit softening by making the pectin of the cell wall more soluble. It is synthesized only when the fruit is ripe. In order to slow down the ripening of tomatoes (*Lycopersicon esculentum*), antisense RNA technology was used. Messenger RNA from untransformed and transformed fruit was hybridized to a radioactively labelled probe specific to the PG sense strand. The results of a gel electrophoresis of mRNA are given below. (The size of the mRNA strands is expressed in kilobases, kb.) The histogram shows these results expressed as the percentage of PG mRNA in ripe untransformed fruit.

- Lane 1: Ripe untransformed fruit
- Lane 2: Unripe untransformed fruit
- Lane 3: Ripe transformed fruit
- Lane 4: Unripe transformed fruit



- (a) State the percentage of PG mRNA in ripe transformed fruit.

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(1)

- (b) Compare the results obtained for ripe and unripe fruit.

.....

(2)

- (c) Using the information provided, explain how the antisense technology affects transformed fruit.

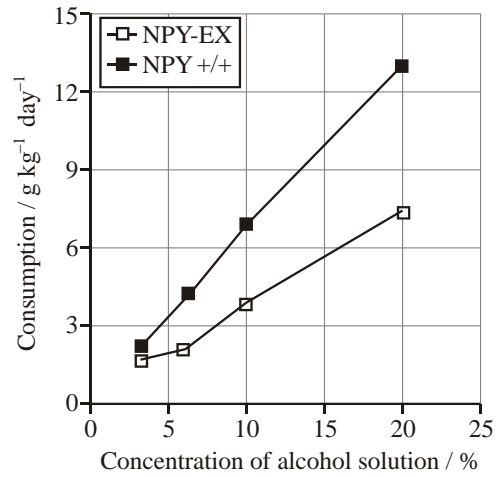
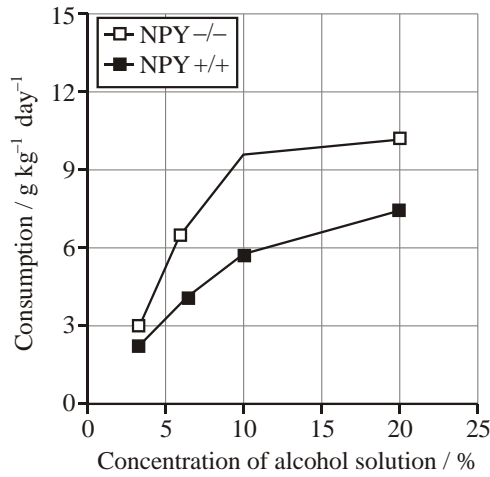
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(3)

2. Rats were bred for several generations to prefer alcohol (ethanol) consumption. When tested, it was discovered that the brains of these rats possessed lower quantities of the chemical neuropeptide Y (NPY). To test the hypothesis that lower quantities of NPY leads to a preference for alcohol, rats were genetically engineered to be NPY deficient (genotype NPY $-/-$), or to produce an excess of NPY (NPY-EX). In separate experiments, the two groups were compared to normal rats (in terms of their alcohol preference) possessing the genotype NPY $+/+$. The groups were offered solutions of increasing alcohol concentration. The quantity of each solution consumed per day was measured.

Figure 1

Figure 2



(a) Calculate the difference in consumption of the 6% alcohol solution between the

(i) NPY -/- and NPY +/+ rats (figure 1);

.....

(1)

(ii) NPY-EX and NPY+/+ rats (figure 2).

.....

(1)

(b) Compare the alcohol consumption of the NPY -/- rats with the NPY-EX rats.

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(3)

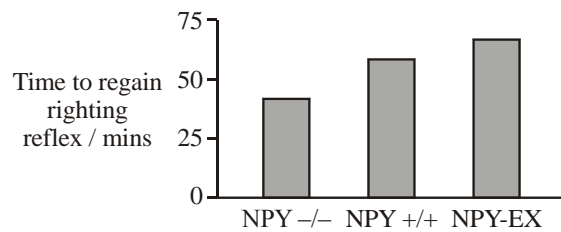
(c) Identify the relationship between NPY levels and alcohol consumption.

.....

(1)

An experiment was carried out to test the hypothesis that an increase in preference for alcohol might be related to a decrease in sensitivity to its effects. Rats were injected with a sample of alcohol and then assessed for the length of time it took for them to regain the righting reflex. (The righting reflex refers to the ability of the rat to return to its feet after being placed on its back.)

Figure 3



(d) Deduce the relationship between NPY levels and the time required to regain the righting reflex.

.....

3. Potatoes with more starch have a lower percentage water content. This has an advantage in the transport, cooking and processing of potatoes.

In a strain of *Escherichia coli* scientists found an enzyme which increases the production of starch. Using biotechnology, the gene for this enzyme was transferred to potatoes, increasing their starch content (transgenic potatoes). The gene was transferred to three potato varieties to create three transgenic lines. The table shows the mean amount of starch and sugar contained in three lines of transgenic potatoes and normal potatoes (control), after storage for four months at 4°C.

Potato	Line	Carbohydrate / % of fresh weight	
		Sugar	Starch
Transgenic	I	0.60	11.07
	II	1.56	11.61
	III	1.46	12.74
	Mean	1.21	11.81
Control	I	5.14	5.88
	II	5.61	3.70
	III	4.32	6.35
	Mean	5.02	5.31

- (a) State which line of transgenic potato has the greatest amount of starch.

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(1)

- (b) (i) Compare the levels of carbohydrate between the transgenic lines and the control potatoes.

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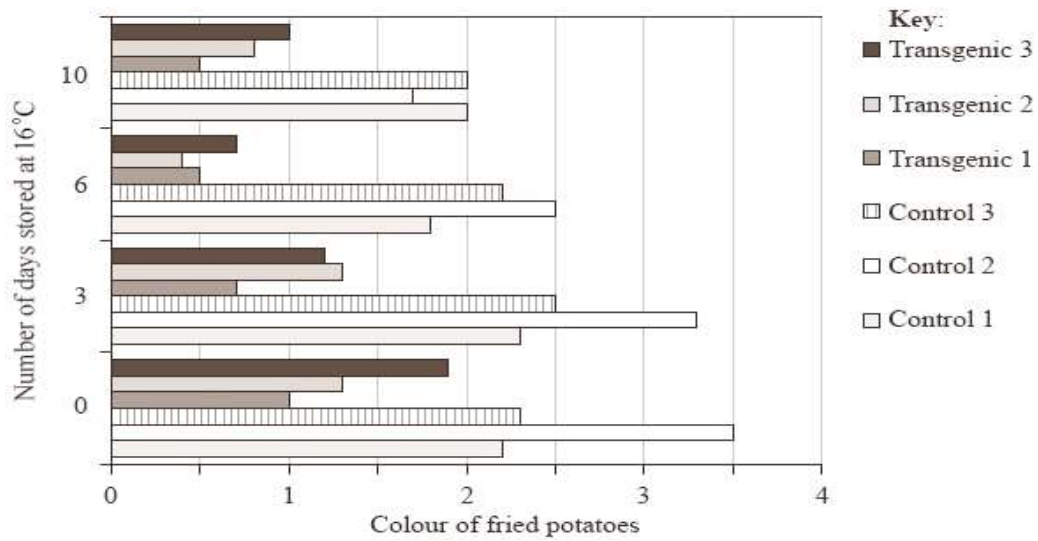
(2)

- (ii) Suggest reasons for these differences.

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(2)

Potato tubers were harvested from the field and stored in high humidity at 4°C for three months. After this period, the tubers were stored at 16°C, and samples were removed after 0, 3, 6 or 10 days, cut into strips, and fried. The colour of the fried potatoes was then measured and values reported using a 0–4 rating (light to dark), where a score of 2 or lower indicates acceptable colour. The results are shown in the table.

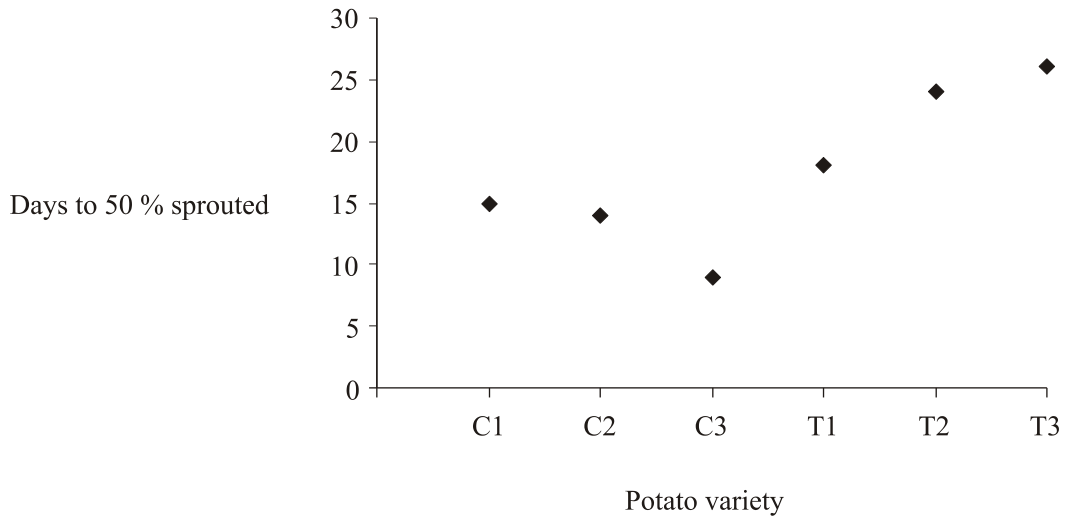


(c) Evaluate the effect of transferring the *E. coli* gene on the suitability of the potatoes for frying.

.....

(2)

An important part of storage management is to delay sprouting of potatoes. A second sample of potatoes was harvested from the field and stored at high humidity for three months at 4°C. Storage temperature was then raised to 16°C and a sample of potatoes were examined daily and scored for the number of sprouts longer than 0.5 cm. The number of days it took for 50% to sprout is indicated in the graph for control varieties (C1, C2 and C3) and three transgenic varieties (T1, T2 and T3) of potatoes.



(d) Deduce how the *E. coli* gene affects the storage of potatoes.

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(2)

(e) Discuss **three** possible harmful effects of genetically modified potatoes.

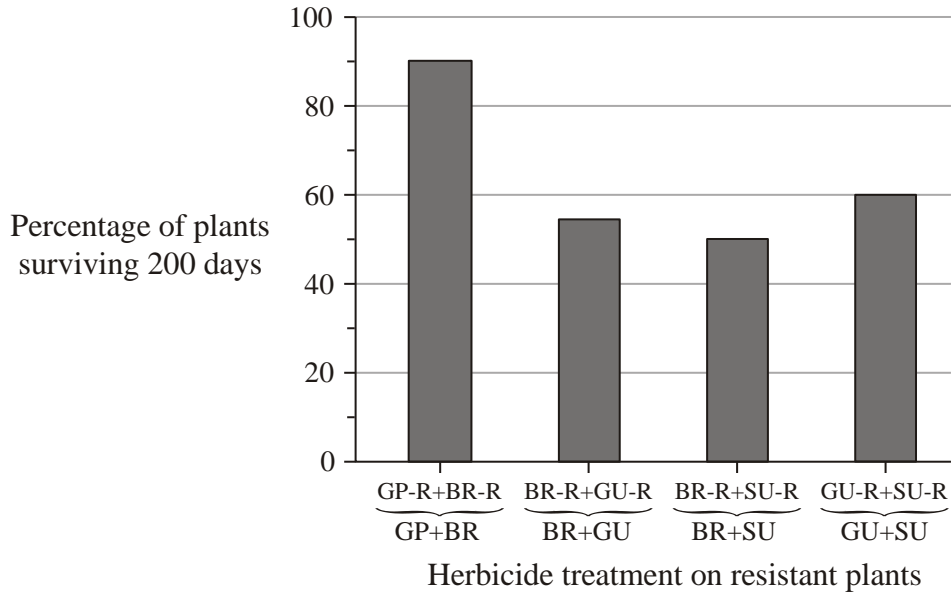
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(3)

4. Weeds growing with crop plants can reduce yields because they compete for nutrients, water and sunlight. Synthetic chemical herbicides are often used to control these weeds. Herbicides are classified by the kinds of plants they kill and their mechanism of action. Broad-spectrum herbicides kill many different kinds of plants, but often kill the crop plant as well. Genetic engineering can create resistance to specific broad-spectrum herbicides which may solve the problem in crop plants.

Different genes from bacterial sources known to protect against the effects of individual herbicides were engineered into corn plants (*Zea mays*). The resistance of normal and genetically engineered corn plants was measured and compared by calculating the percentage of plants that survived for 200 days with regular herbicide treatments.

Graph 1 Exposure of Normal and Resistant Plants to Different Herbicides



	<i>Herbicide</i>	<i>Resistant Genes</i>
GP	Glyphosate	GP-R
BR	Bromozyml	BR-R
GU	Glufosinate	GU-R
SU	Sulfonylurea	SU-R

(a) (i) Calculate the difference between the survival of engineered plants and normal plants treated with Glyphosate (GP).

.....

(1)

(ii) Identify the engineered plant which shows the greatest difference in resistance to herbicide treatment.

.....

(1)

(iii) Suggest a reason for the difference in survival of the normal plants treated with Glyphosate (GP) and Bromozyml (BR).

.....

(1)

(b) (i) Define the term *genetically modified crop*.

.....

(1)

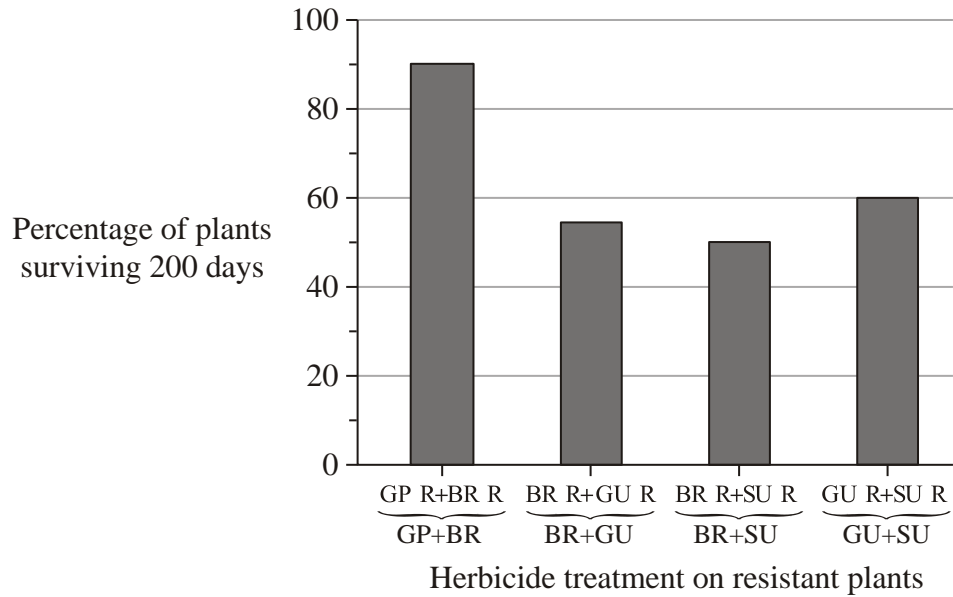
(ii) State an example of a genetically modified plant other than corn.

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(1)

The graph below represents data from experiments in which plants were genetically engineered with more than one resistance gene.

Graph 2 Exposure of resistant plants to combinations of herbicides



(c) (i) Using both graphs, compare the data for BR-R with the data for SU-R, and for BR-R + SU-R in the same plant.

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(2)

(ii) Suggest a possible reason for these results.

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(1)

(d) Evaluate the effects on survival when combining two herbicide resistance genes in the same plant.

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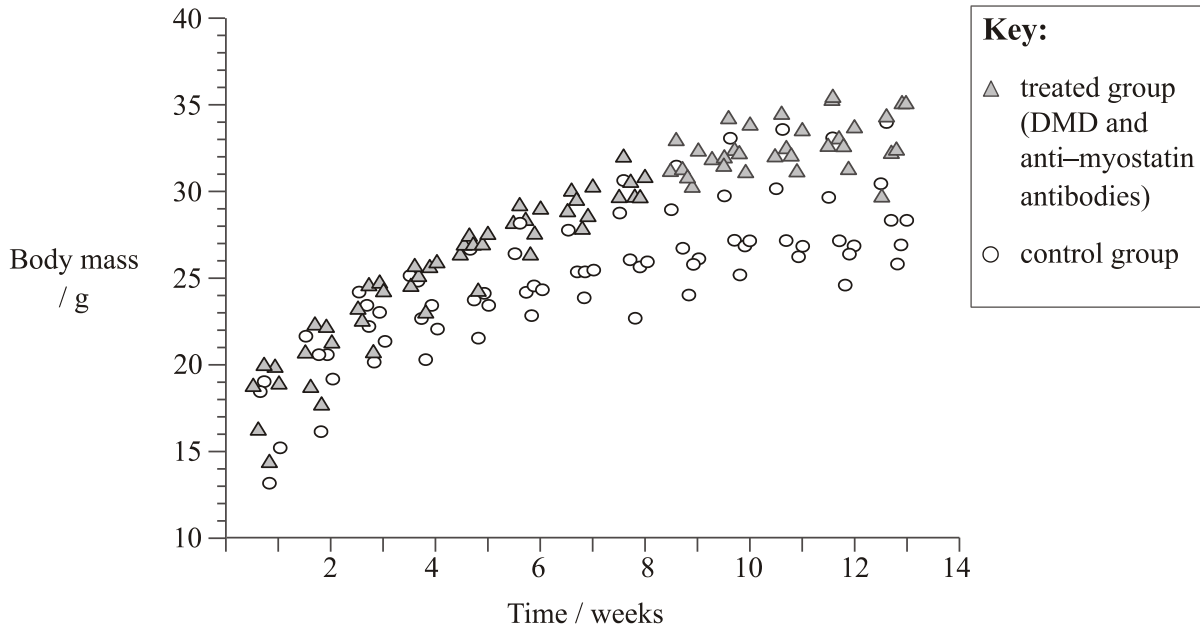
(3)

5. In humans, Duchenne Muscular Dystrophy (DMD) is a lethal X-linked recessive disorder caused by mutations in the dystrophin gene. Affected individuals show a decline in muscle mass over time along with a decline in muscle strength.

One promising area of research in the treatment of DMD involves inhibiting the activity of myostatin, a naturally occurring protein that regulates muscle growth by limiting the development of new muscle cells.

Researchers investigating the disorder in mice predicted that inhibition of myostatin would increase muscle mass. Over a period of three months one group of DMD mice (treated) were given injections of anti-myostatin antibody that inhibited myostatin. A second group of DMD mice were untreated (control).

Figure 1 below shows the differences in body mass during the test period for both groups.



- (a) Outline the relationship between body mass and time in the treated group of mice.

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(2)

- (b) Compare the changes in body mass in the two groups of mice over the test period.

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(3)

- (c) Predict the results that the researchers would have expected if the experiment was continued beyond 13 weeks in

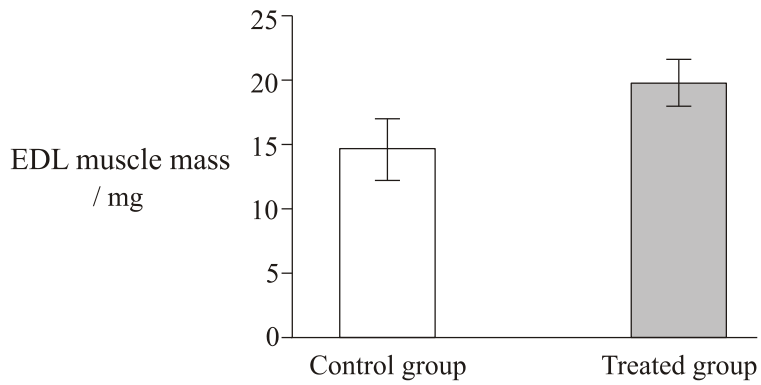
(i) the treated group.....

(1)

(ii) the control group.....

(1)

Figure 2 below shows the change in mass over the course of the experiment on a particular muscle called the EDL muscle in samples of the treated and control groups of mice.



(d) Calculate the percentage increase in the average mass of the EDL muscle between the treated group and the control group.

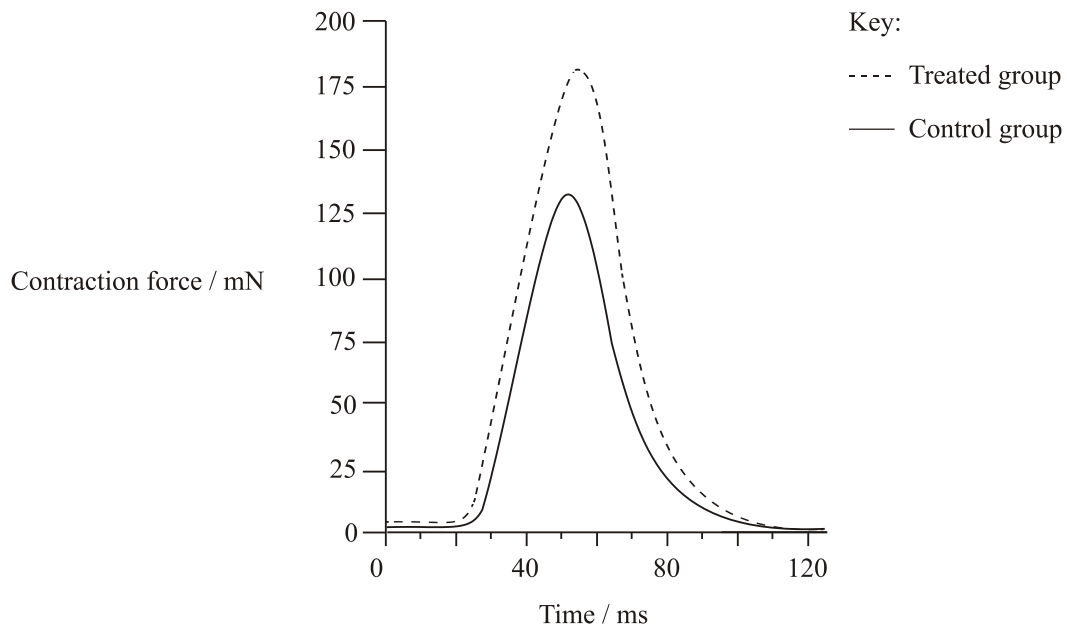
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(2)

Further tests were conducted to see whether myostatin inhibition influenced the muscle function of the mice in the study.

Figure 3 below shows the effect of treatment on muscle strength.



(e) Determine the difference in peak contraction force between the treated group and the control group.

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.....

(1)

(f) Evaluate the effectiveness of myostatin inhibition as a treatment for DMD in humans.

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(3)

- (g) Another proposed treatment for DMD in humans is gene therapy using the dystrophin gene. Outline, **in general**, the process of gene therapy.

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(3)

- (h) Monoclonal antibodies are laboratory-produced identical antibodies that can target specific antigens, such as the myostatin protein. Describe how monoclonal antibodies are produced.

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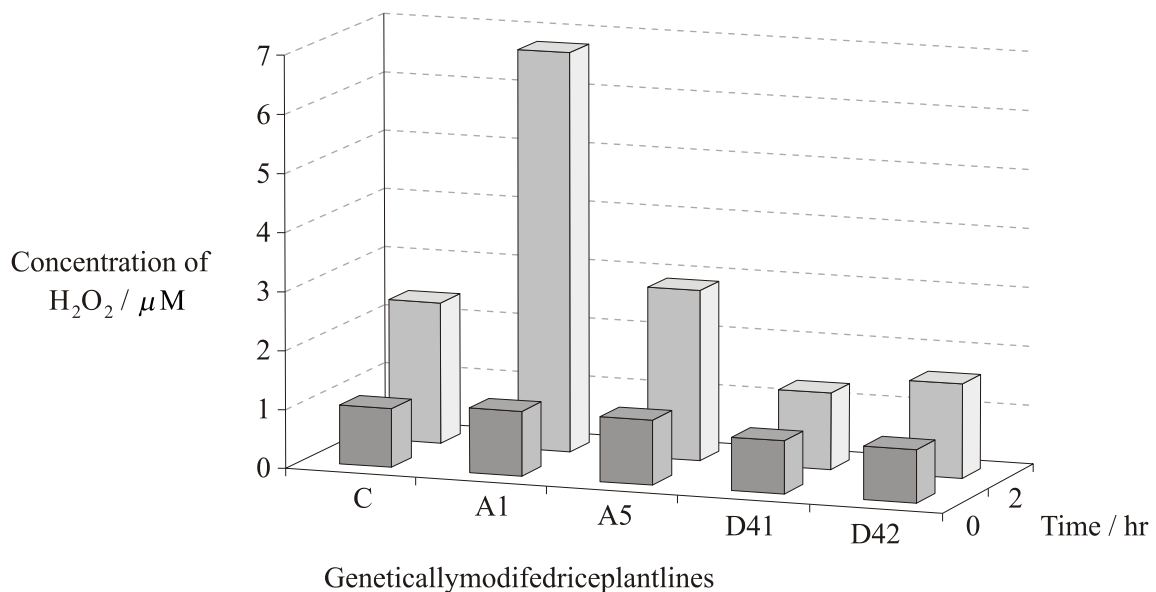
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(3)

6. Plants have developed defence mechanisms against pathogens such as bacteria, fungi, and viruses. Chemicals released by these pathogens can trigger a defence response in infected plant cells. For example, the production of hydrogen peroxide (H_2O_2) which reacts with pathogen membranes and cellular chemicals, eventually kills both the cell and the pathogen.

The OSRac1 gene was isolated and introduced into a number of rice plant (*Oryza spp.*) lines to study its role in disease resistance of plants to Blast fungus. Experiments were carried out to see if the OSRac1 gene was part of the signalling pathway for hydrogen peroxide production. A control and four other genetically modified rice plant lines were exposed to chemicals known to initiate a defence response and the production of hydrogen peroxide. The results are shown in the graph below.



Key: C: control
 A1 and A5: rice plants with the OSRac1 gene always turned on
 D41 and D42: rice plants with the OSRac1 gene suppressed

- (a) Identify the concentration of H_2O_2 at time 0 for the control plants.

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(1)

(b) Compare the change in H₂O₂ production in the control and genetically modified plants two hours after the chemical was applied.

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(3)

(c) Evaluate whether the data supports the hypothesis that OSRac1 gene is involved in disease resistance.

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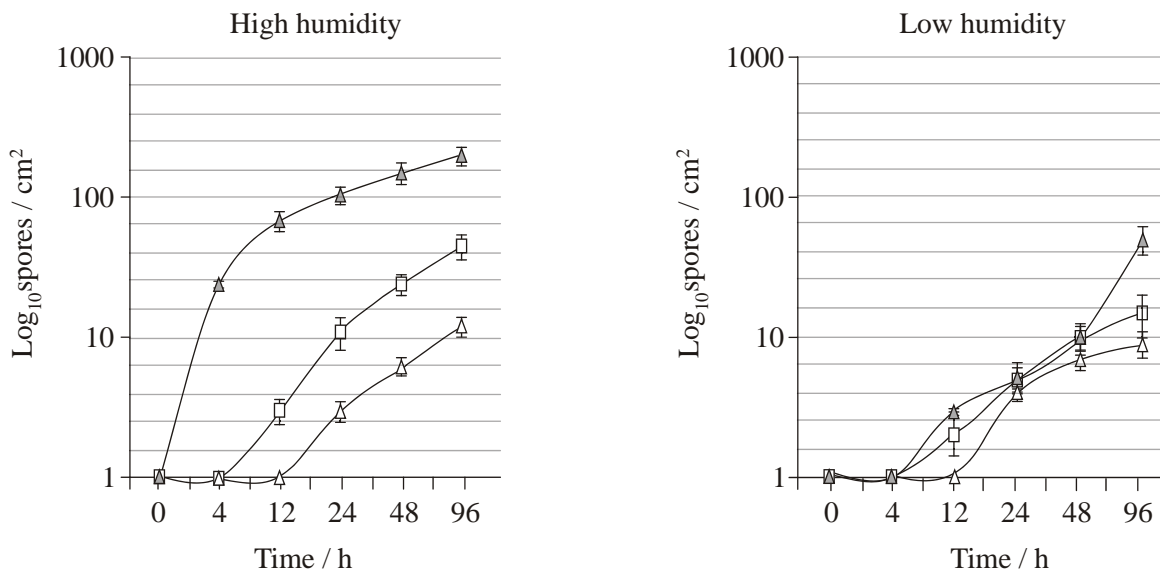
(1)

(d) Suggest **one** possible concern about the use of transgenic plants with the disease resistant gene.

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(1)

7. The mold *Penicillium expansum* causes serious crop loss of apples and pears during storage and packing. The graphs below show the density of *P. expansum* spores on normal skin, damaged skin and lenticels (small air pores allowing gaseous exchange) of apples. The experiments show the results at two humidity levels over a four day period.



Key: Δ density of spore on normal skin
 □ density of spore on damaged skin
 △ density of spore on lenticels

(a) State the time taken for spores on the skin to reach a density of 100 spores/cm² at high humidity.

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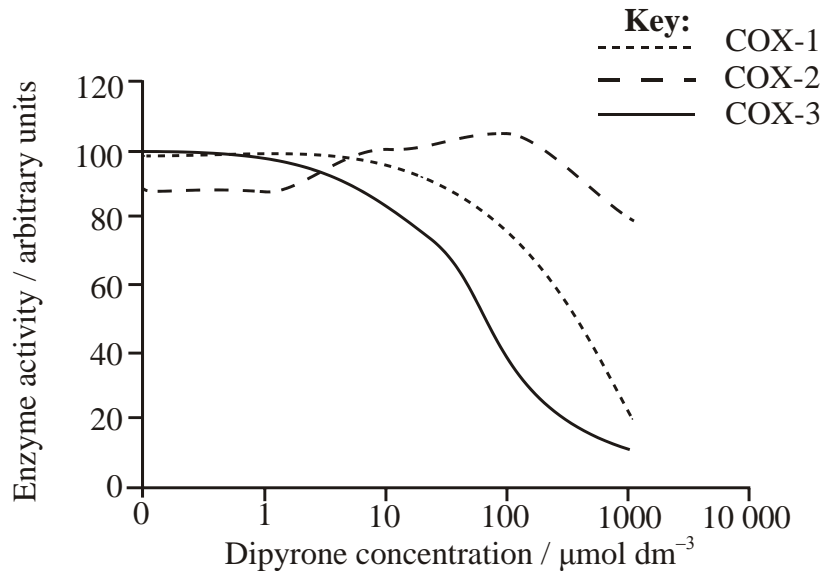
(1)

(b) Compare the density of spores on normal skin with spores on lenticels for apples stored at high humidity.

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(2)

8. Inflammation of human tissues often causes pain. Cyclooxygenases (COX) are a group of enzymes that play a role in causing inflammation. Analgesics are drugs that can reduce pain. The graph below shows how increasing concentrations of the analgesic drug dipyrene, affects the activity of three different cyclooxygenases, COX-1, COX-2 and COX-3.



(a) Outline the relationship between dipyrene concentration and COX-3 activity.

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(2)

(b) Deduce whether dipyrene is an inhibitor of COX-2.

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(2)

(c) Evaluate the potential of dipyrene as an analgesic using the data in the graph.

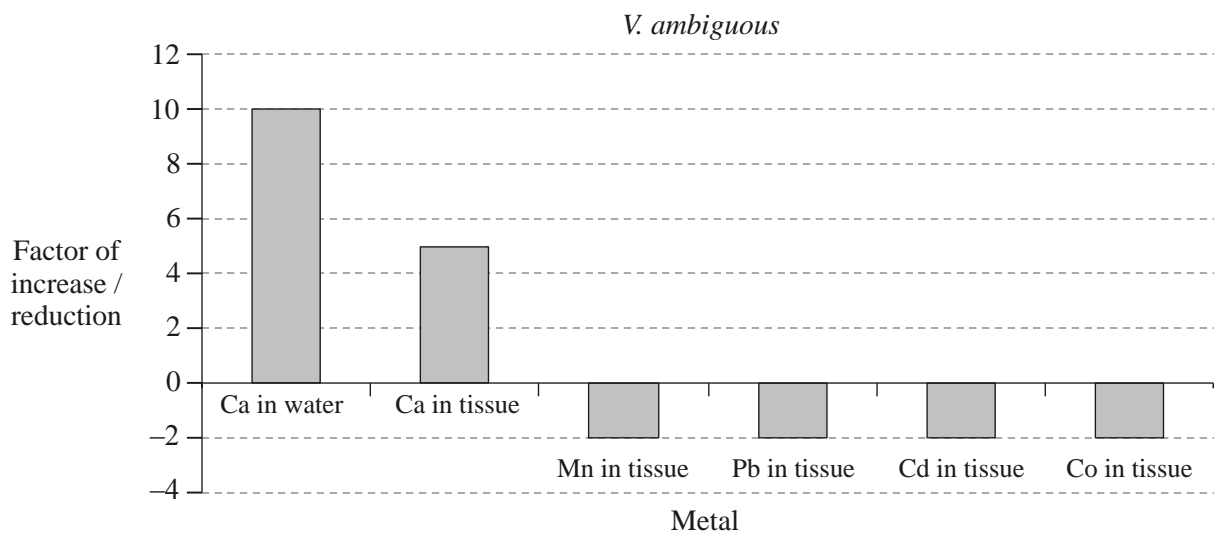
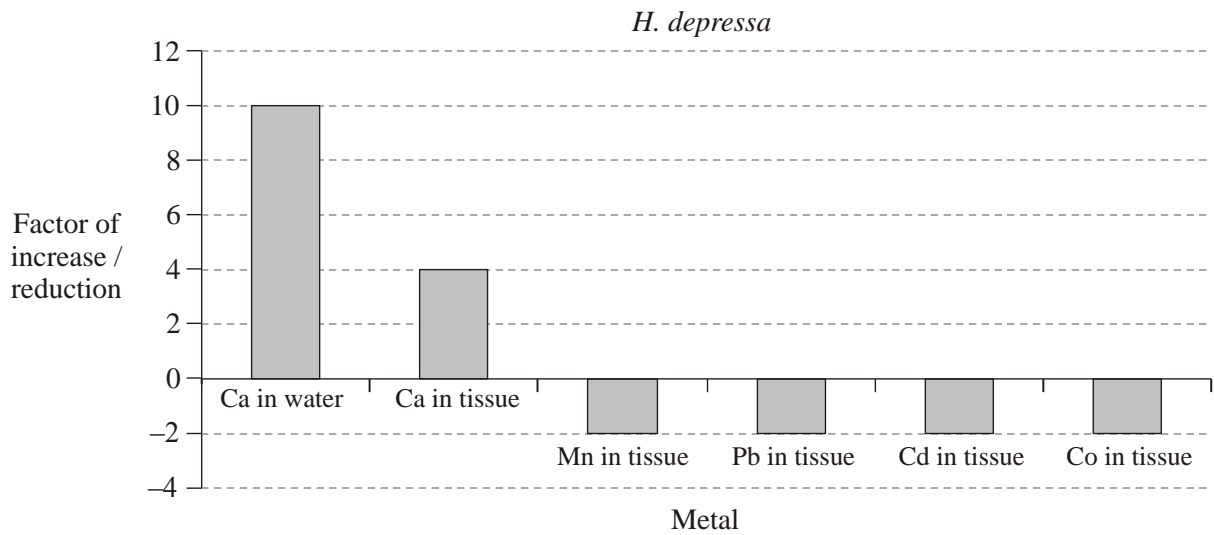
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(2)

9. Scientists have long been concerned about the effect of heavy metals in foods that we eat. Aquatic filter feeders including bivalves, such as mussels and oysters, are especially prone to accumulation of heavy metals.

Calcium is taken into bivalves through protein channels, but other non-essential elements may also be taken in.

To investigate the relationship between the uptake of calcium and other elements, the bivalves *Hyridella depressa* and *Velesunio ambiguous* were placed in solutions containing ten times the normal level of calcium (Ca). The elements manganese (Mn), lead (Pb), cadmium (Cd) and cobalt (Co) were also present in the solutions at normal concentrations. The results are shown below.



(a) (i) Outline the effect of increasing calcium levels in the water on calcium levels in the tissue of the bivalves.

.....

(1)

(ii) Outline the effect of increasing calcium levels in the water on metals other than calcium in the tissue of the bivalves.

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(1)

(b) Suggest reasons for the effects of calcium on the levels of the other metals in the tissues.

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(2)

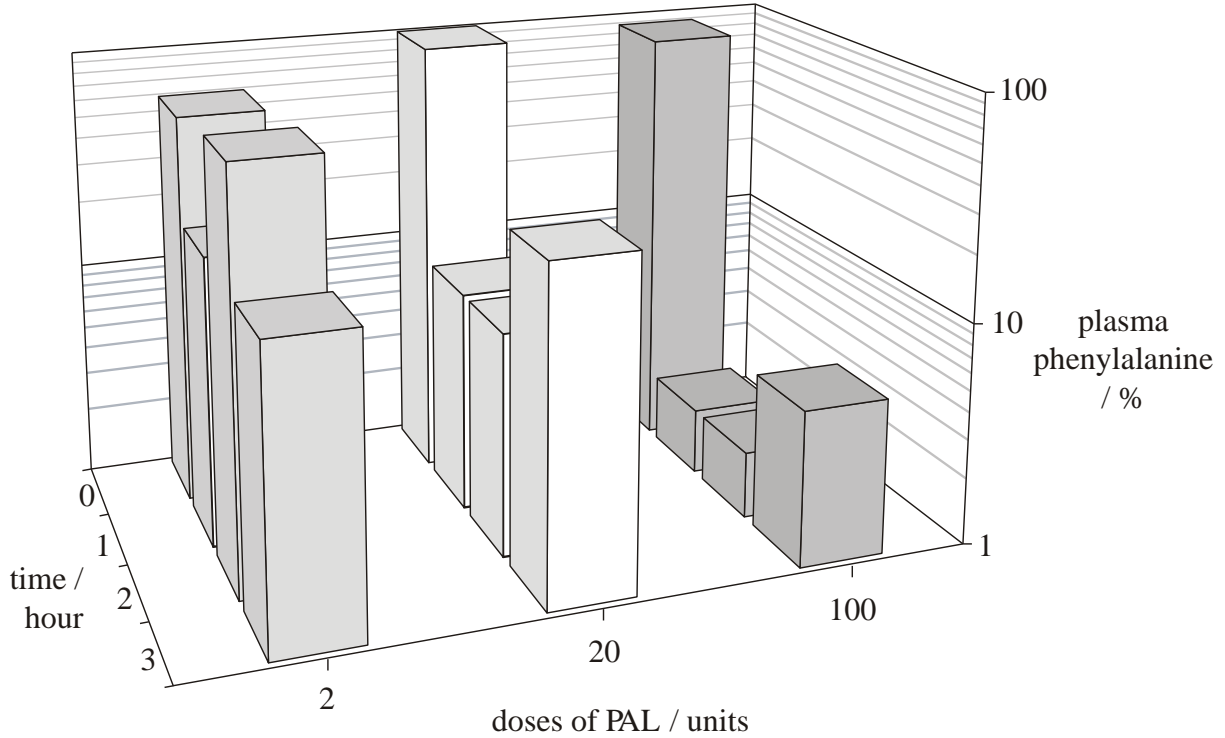
(c) Evaluate the implications of these results for monitoring water quality in regions where bivalves are harvested.

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(3)

10. Phenylketonuria (PKU) is a disease caused by a gene mutation that makes too much phenylalanine which may cause brain damage. The enzyme phenylalanine ammonia lyase (PAL), converts phenylalanine into harmless products. Mice with PKU were injected with PAL. The levels of phenylalanine in blood plasma were measured immediately after the injection (0 hour) and every hour for the next three hours. Different groups of mice with PKU were injected with three different doses of PAL. The results are shown below as a percentage of the levels of phenylalanine before the PAL injection.



(a) Calculate the approximate percentage reduction in phenylalanine at 0 hour when the mice were injected with a dose of two units of PAL.

..... %

(1)

(b) Outline the effect of a dose of twenty units of PAL on phenylalanine levels.

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(2)

(c) Discuss the effectiveness of the different doses of PAL to treat PKU mice.

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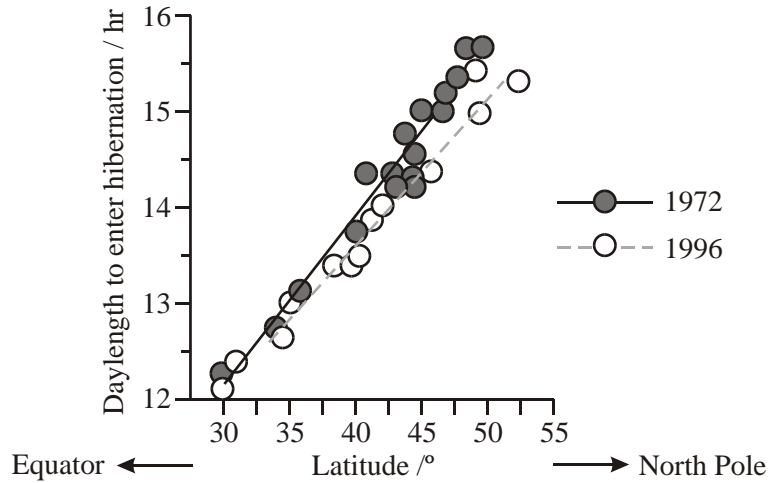
(3)

(d) Outline how the type of mutation that causes PKU differs from Klinefelter’s syndrome.

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(1)

11. The mosquito (*Wyeomyia smithii*) uses daylength as a guide to either continue development of its larvae or to begin hibernation. This response to daylength is genetically controlled. Longer daylengths maintain development whereas shorter daylengths induce hibernation. In the northern regions of the northern hemisphere, even though daylengths are longer, winter arrives earlier than in regions closer to the equator. The following data is from an experiment to determine if *W. smithii* has adapted to later onsets of winter as a consequence of global warming. In 1972 and 1996, larvae were collected at various locations in the United States at latitudes 30–50° North. The larvae were examined to determine what daylength induced hibernation. Each circle on the following graph represents one larval population.



- (a) Outline the relationship between daylength and latitude for the larval populations in 1972.

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(1)

- (b) Compare the data of 1972 with 1996.

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(2)

- (c) Explain how the data illustrates an evolutionary response to a longer growing season due to a later onset of winter.

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(2)