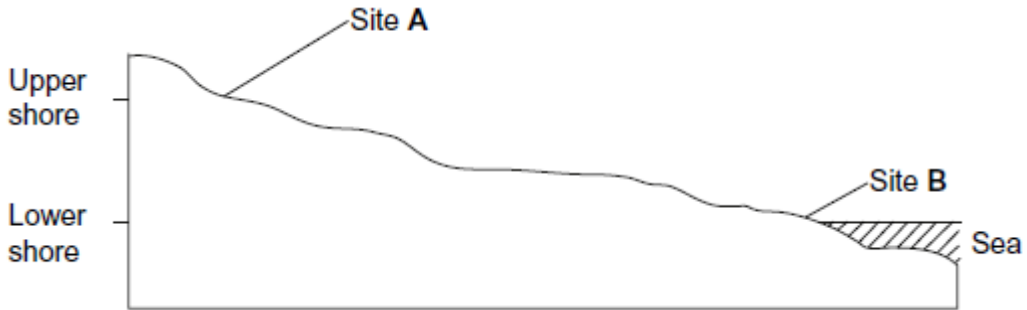


Q1. Algae are photosynthesising organisms. Some grow on rocky shores. Scientists investigated the abundance of different species of algae at two sites, **A** and **B**, on a rocky shore. Site **A** was on the upper shore and site **B** was on the lower shore. The diagram shows the location of sites **A** and **B** on the rocky shore.

Table 1 shows some of the results the scientists obtained.



	Site A Upper shore	Site B Lower shore
Species of algae with percentage cover more than 1%	<i>Gigartina leptorhynchos</i> <i>Gigartina canaliculata</i> <i>Gelidium coulteri</i> <i>Rhodoglossum affine</i>	<i>Gigartina spinosa</i> <i>Rhodoglossum affine</i> <i>Laurencia pacifica</i> <i>Gastroclonium coulteri</i> <i>Centroceros clavulatum</i> <i>Gigartina canaliculata</i> <i>Corallina vancouveriensis</i>

(a) The scientists recorded data from 40 large rocks at each site.

Describe **one** method that the scientists could have used to ensure that the large rocks were chosen without bias.

(2)

(b) The scientists used percentage cover rather than frequency to record the abundance of algae present

Suggest why.

(1)

- (c) Apart from availability of water, describe and explain how **two** abiotic factors may have caused differences in the species of algae growing at sites **A** and **B**.

Factor 1 _____

Explanation _____

Factor 2 _____

Explanation _____

_____ (2)

- (d) Use the information provided in **Table 1** to explain why the diversity of consumers will be greater at site **B**.

_____ (2)

- (e) The scientists also investigated the algae eaten by two consumers found on the rocky shore, the sea slug and the shore crab. The scientists carried out their investigation in a laboratory.

- They put each consumer into a separate tank through which aerated seawater flowed slowly.
- Each tank contained 5 grams of one species of alga.
- After 50 hours, they measured the mass of the alga remaining in each tank.
- They repeated this procedure several times using a different sea slug and a different shore crab each time.

The scientists then calculated the mean mass of each species of alga eaten by the consumers. They used a statistical test to determine the P value.

Table 2 shows some of the results they obtained.

Table 2

Species of alga	Mean mass eaten / g		P value
	Sea slug	Shore crab	
<i>Laurencia pacifica</i>	4.42	0.22	<0.01
<i>Egregia leavigata</i>	0.12	0.08	>0.05
<i>Microcystis pyrifera</i>	0.19	0.14	>0.05
<i>Cystoseira osmondacea</i>	0.17	0.04	<0.05

- (i) The consumers were starved for 5 days before the investigation.

Explain why.

(2)

- (ii) The data in **Table 2** for the mean mass of alga eaten were adjusted for loss of mass by the alga due to respiration.

Suggest how the scientists were able to determine the loss of mass due to respiration of a sample of alga.

(3)

- (iii) Suggest what conclusions the scientists could have made from this investigation when using the probability values in **Table 2**.

(3)

(Total 15 marks)

Q2.

Oestrogen is a substance produced by the enzyme aromatase. In females, the main source of oestrogen is the ovaries but aromatase is produced by many other organs in the body, including the lungs. Oestrogen can stimulate the development of some lung tumours. In these tumours, binding of oestrogen to cell-surface receptors stimulates cell division.

Scientists investigated whether two drugs could prevent lung tumours in female mice. First, they removed the ovaries from these mice. They then injected the mice with a tumour-causing chemical found in tobacco twice a day for 4 weeks. The mice were then randomly allocated to one of four groups. Each group contained 10 mice.

- Group **Q** was given a placebo. This placebo did not contain either drug.

- Group **R** was given the drug anastrozole. This inhibits the enzyme aromatase.
- Group **S** was given the drug fulvestrant. This binds to oestrogen receptors.
- Group **T** was given both anastrozole and fulvestrant.

The mice were given these drugs each week during weeks 5–15 of the investigation.

- (a) The scientists removed the ovaries from the mice for the investigation. They also gave the mice injections of the substrate of aromatase each day.

Explain why these steps were necessary.

(2)

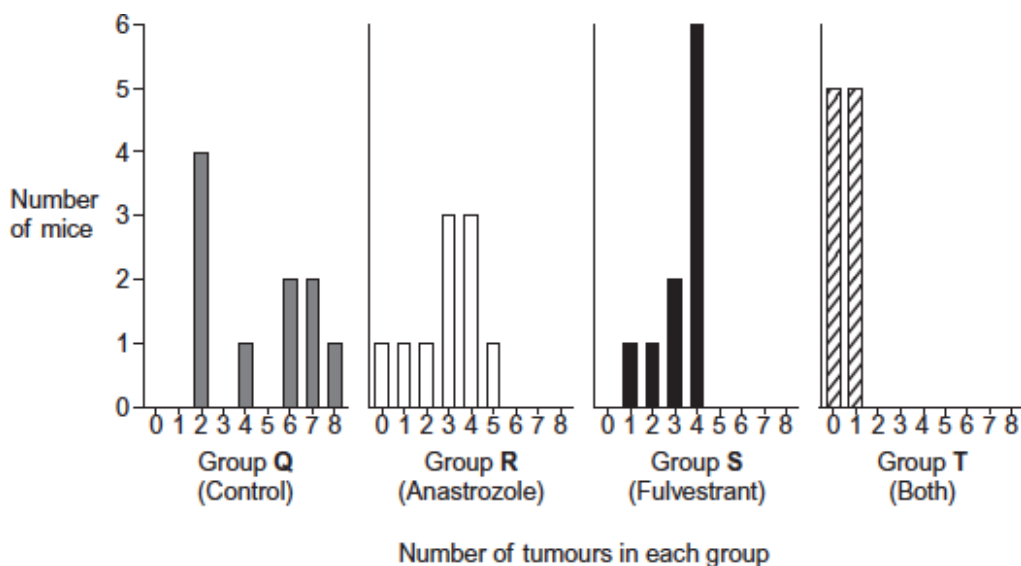
- (b) The scientists predicted that fulvestrant would be more effective when given with anastrozole than when given alone.

Use the information provided to suggest why they predicted this.

(2)

At week 15, the lungs of the mice were removed and examined. The scientists then determined the number of tumours present and the mean tumour area for each group. **Figure 1** and **Figure 2** show the scientists' results.

Figure 1



- (e) The scientists repeated the investigation but this time they did not give the drugs until week 9.

Suggest why they gave the drugs at week 9, rather than at week 5.

(2)

- (f) Another group of scientists is currently using these drugs in human trials. However, the control group is **not** being given a placebo.

Suggest why a placebo is **not** being given and what is being given to this group instead.

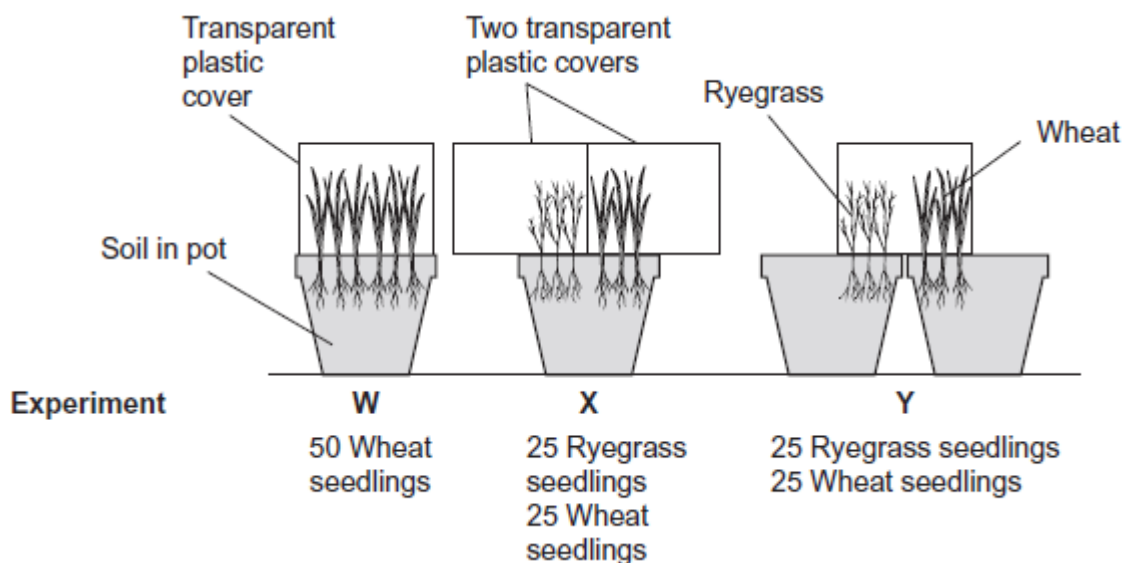
(2)

(Total 15 marks)

Q3.

Wheat is an important cereal crop. Ryegrass is a weed in wheat fields. Wheat and ryegrass belong to the grass family.

Scientists investigated competition between wheat and ryegrass seedlings. They set up three experiments **W**, **X**, and **Y** as shown in the diagram.



The table shows the mean dry mass of the wheat seedlings as a percentage of their dry mass when grown alone.

	Experiment		
	W	X	Y
Mean dry mass of wheat seedlings as a percentage of their dry mass when grown alone	100	76	46

- (a) Experiment **W** was a control experiment. Explain the purpose of the control experiment in this investigation.

(2)

- (b) What can you conclude from this investigation about competition between wheat and ryegrass? Use the data in the table to support your answer.

(4)

- (c) Explain how a decrease in temperature could affect the outcome of this investigation.

(2)

(Total 8 marks)

Q4. Taxol is a drug used to treat cancer. Research scientists investigated the effect of injecting taxol on the growth of tumours in mice. Some of the results are shown in **Figure 1**.

Figure 1

Number of days of treatment	Mean volume of tumour / mm ³	
	Control group	Group injected with taxol in saline
1	1	1
10	7	2
20	21	11
30	43	20
40	114	48
50	372	87

(a) Suggest how the scientists should have treated the control group.

(2)

(b) Suggest and explain **two** factors which should be considered when deciding the number of mice to be used in this investigation.

1. _____

2. _____

(2)

(c) The scientists measured the volume of the tumours. Explain the advantage of using volume rather than length to measure the growth of tumours.

(1)

- (d) The scientists concluded that taxol was effective in reducing the growth rate of the tumours over the 50 days of treatment. Use suitable calculations to support this conclusion.

(2)

- (e) In cells, taxol disrupts spindle activity. Use this information to explain the results in the group that has been treated with taxol.

(3)

- (f) The research scientists then investigated the effect of a drug called OGF on the growth of tumours in mice. OGF and taxol were injected into different mice as separate treatments or as a combined treatment. **Figure 2** and **Figure 3** show the results from this second investigation.

Figure 2

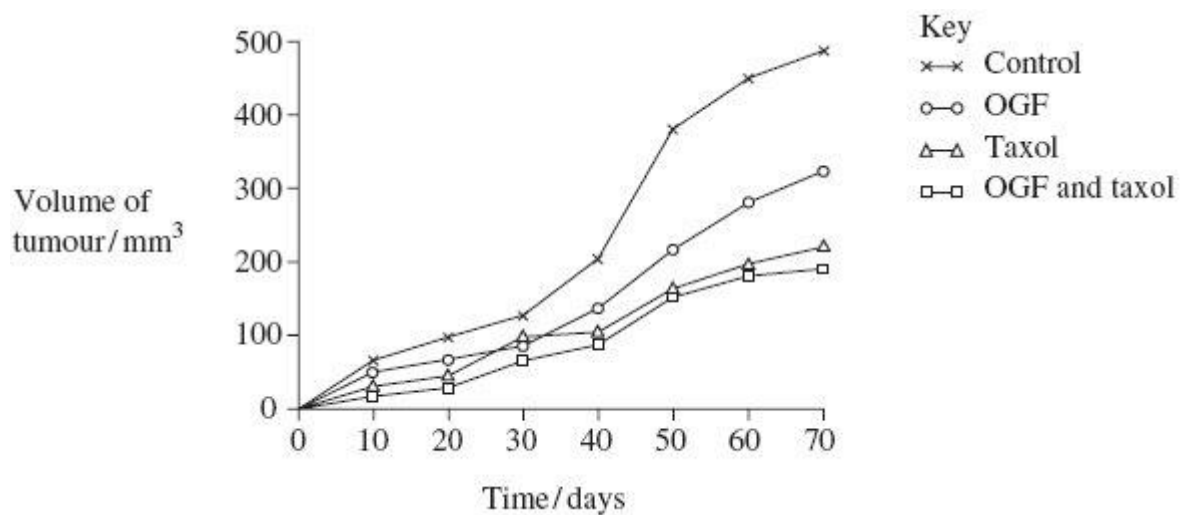


Figure 3

Treatment	Mean volume of tumour following 70 days treatment /mm ³ (\pm standard deviation)
OGF	322 (\pm 28.3)
Taxol	207 (\pm 22.5)
OGF and taxol	190 (\pm 25.7)
Control	488 (\pm 32.4)

- (i) What information does standard deviation give about the volume of the tumours in this investigation?

(1)

- (ii) Use **Figure 2** and **Figure 3** to evaluate the effectiveness of the two drugs when they are used separately and as a combined treatment.

(4)

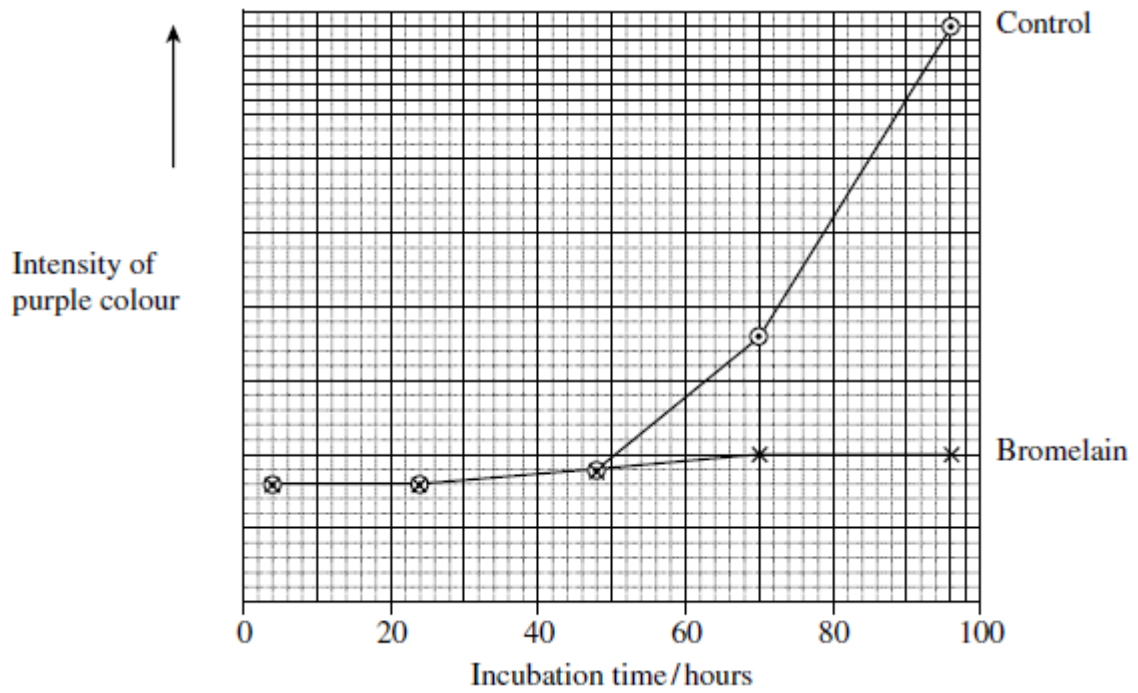
(Total 15 marks)

Q5.

Scientists investigated the effect of bromelain on cancer cells. They took cells from skin cancers in mice and added them to a liquid growth medium in two dishes.

Four hours later they added a solution of bromelain to one of the dishes. They left the other dish as a control. They also added a substance to both dishes that is turned purple by respiring cells.

Both dishes were placed in an incubator. The scientists measured the intensity of the purple colour at intervals over a period of 100 hours.



(a) The scientists put the same number of skin tumour cells in each dish at the start of this investigation. Explain why it was important to put the same number of cells in each dish.

(1)

(b) The scientists concluded that bromelain did not kill cancer cells but stopped them dividing. Does the graph support this conclusion? Explain your answer.

(2)

(c) An article in a newspaper claimed that these data show that bromelain can be used to treat cancer.

Give **three** reasons why we should be careful about accepting this claim.

1. _____

2. _____

3. _____

(3)

(d) The rate of cell division is important in investigations into cancer. Suggest why.

(2)

(e) Scientists have investigated the effects of bromelain on cancer growth in humans. Suggest why they gave bromelain in addition to, rather than instead of, the usual treatment.

(2)

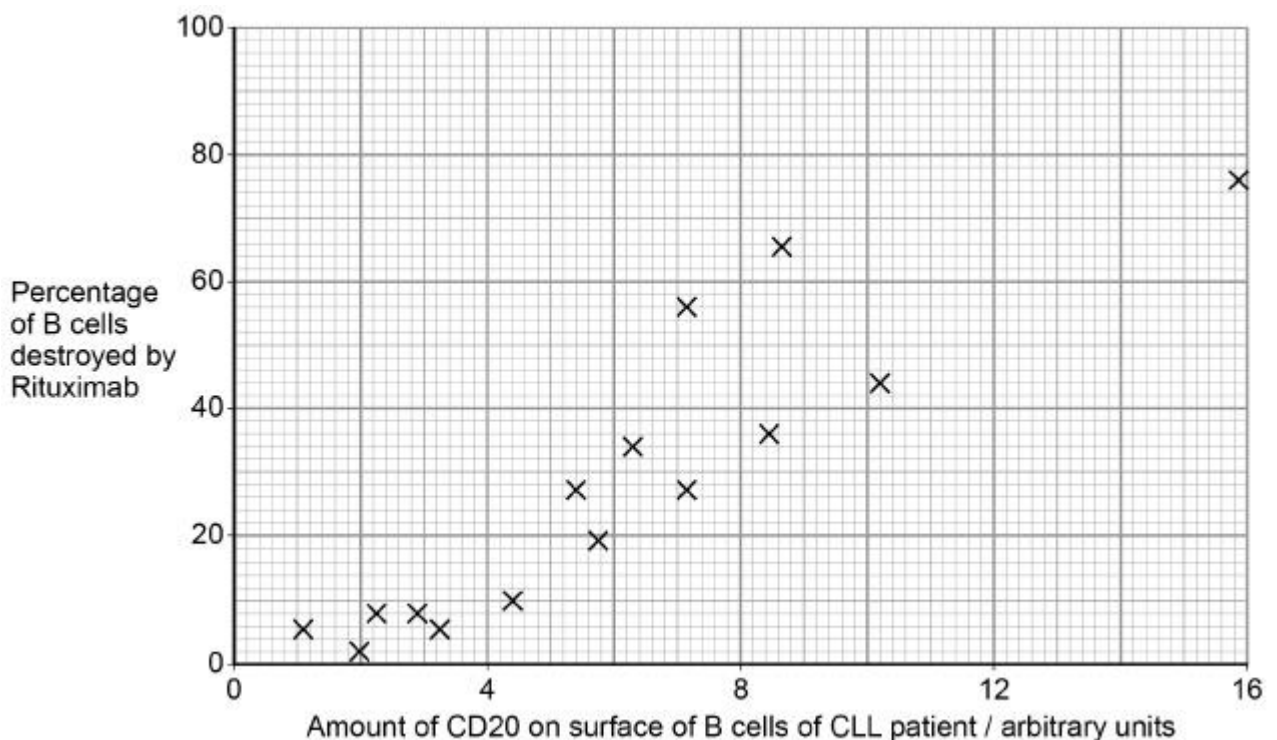
(Total 10 marks)

Q6.

Chronic lymphocytic leukaemia (CLL) is a cancer that affects some B cells of a person's immune system. Rituximab is a drug used to treat CLL. It binds to a protein called CD20 on the surface of B cells. If enough Rituximab binds to a B cell, it can kill the cell. Rituximab kills **both** healthy **and** cancerous B cells. The body then produces new B cells.

The amount of CD20 on the surface of B cells varies from one person to another. Doctors investigated the relationship between the amount of CD20 on the B cells of a patient and the percentage of B cells destroyed by Rituximab.

The graph shows the doctors' results. Each cross is the result for one patient.



- (a) What statistical test could the scientists have used to determine whether there was a significant relationship between the amount of CD20 on the surface of B cells and the percentage of B cells destroyed by Rituximab?
Give a reason for your answer.

Name of test _____

Reason _____

_____ (1)

- (b) From these data, what can you conclude about the effectiveness of Rituximab in treating patients with CLL?

Do **not** include considerations of statistical analyses in your answer.

_____ (3)

Approximately 11 percent of people with CLL also have mutations of a gene called *NOTCH1*. This leads to production of a non-functional transcription factor associated with CD20 production.

The doctors determined the median percentage of B cells destroyed by Rituximab in people with CLL who had the *NOTCH1* mutation and those who did not.

The doctors' results are shown in the table.

	Median percentage of B cell destroyed by Rituximab
In people with CLL who had the <i>NOTCH1</i> mutation	4
In people with CLL who did not have <i>NOTCH1</i> mutation	22

- (c) Human blood contains (approximately) 1.0×10^9 B cells per dm^3 . Use the median values in the table to calculate the difference between the number of B cells per dm^3 in the blood of people treated with Rituximab with the *NOTCH1* mutation and people without the *NOTCH1* mutation.

Express your answer in standard form. Show your working.

_____ cells per dm^3

(2)

- (d) Use all of the information to suggest how the mutation of *NOTCH1* led to the difference in the percentage of B cells destroyed by Rituximab.

(3)

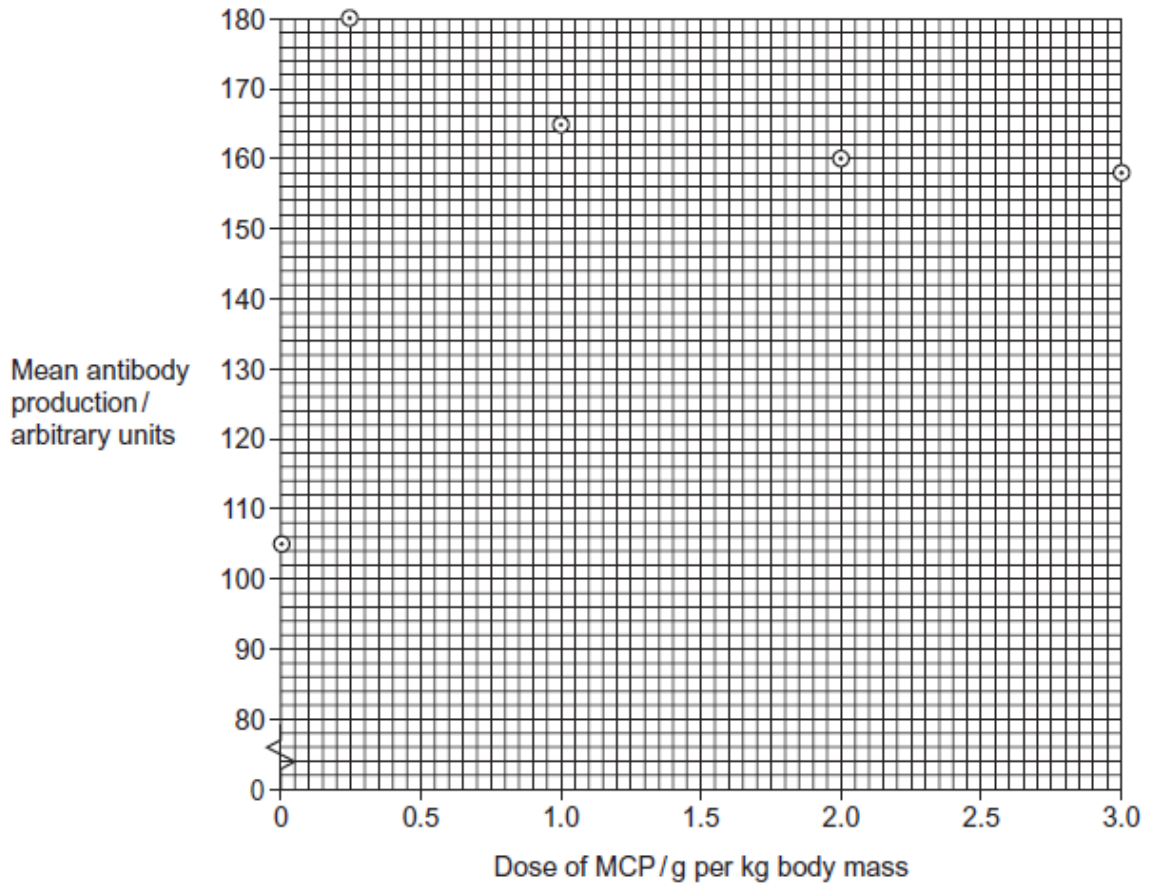
(Total 9 marks)

Q7.

Scientists tested a claim that modified citrus pectin (MCP) increased the production of antibodies by the immune system.

- They divided a large number of mice into five groups.
- They gave the mice in each group a different amount of MCP in their food.
- The scientists then stimulated antibody production in the mice. They did this by injecting them with a solution containing sheep red blood cells.

The results are shown in the graph.



(a) The data obtained in this investigation have been plotted on a graph. How would you join the points? Give a reason for your answer.

(1)

(b) Use the graph to describe the effect of MCP on mean antibody production.

(2)

- (c) Calculate the percentage increase in antibody production from when there was no MCP in the diet to when the dose is 1.0 g per kg.

Answer _____%

(2)

- (d) The dose of MCP given to the mice was calculated in g per kg body mass. Explain why the dose was calculated per unit mass.

(1)

- (e) Explain how antibodies were produced when the mice were injected with sheep red blood cells.

(3)

- (f) A newspaper suggested that these data show that taking MCP will give people increased resistance to disease. With reference to the data give **two** reasons why this conclusion may **not** be valid.

1. _____

2. _____

(2)

(Total 11 marks)

Q8.

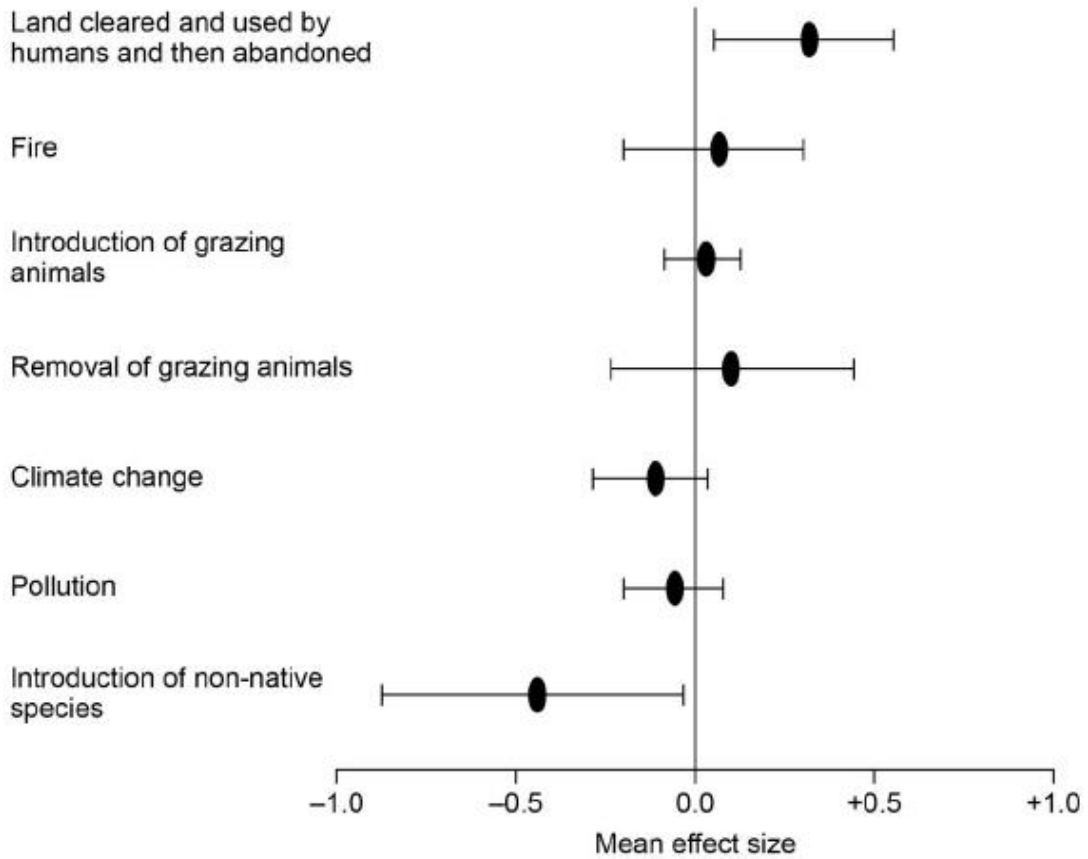
Scientists investigated changes in plant biodiversity in different communities after changes caused by humans. They collected data from many published investigations that recorded changes in species richness of plants over a large number of years.

The scientists used data from each investigation to calculate the effect size.

The effect size is a measure of change in species diversity with time. A positive value shows an increase in species richness with time.

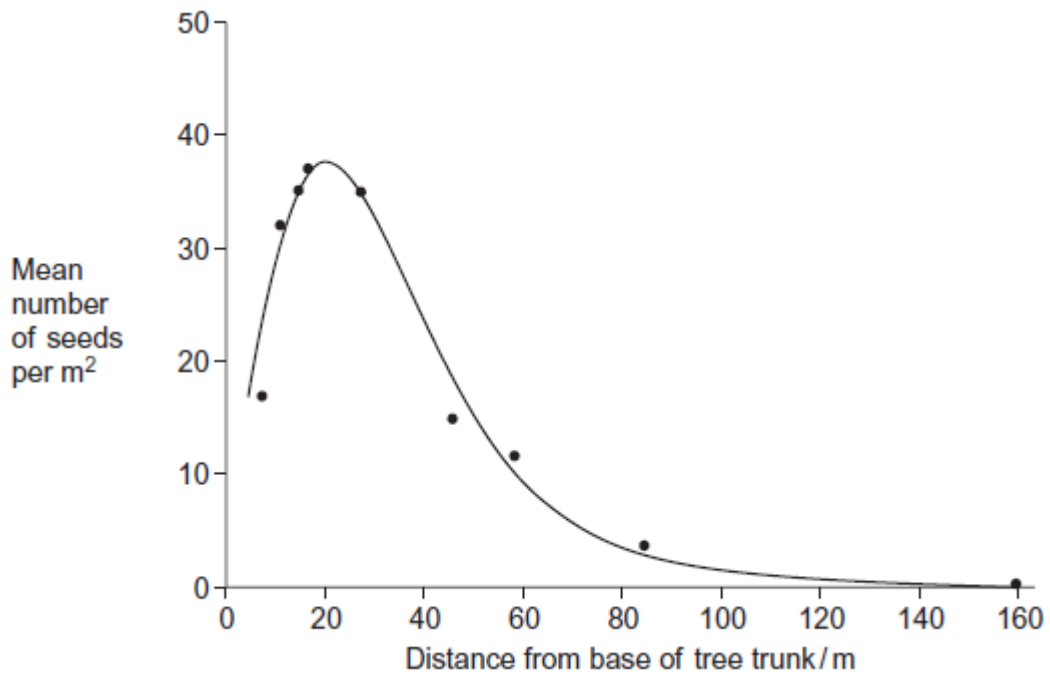
The graph below shows the scientists results in the form in which they were published. The horizontal bars represent ± 2 standard deviations, which includes 95.4% of the data.

Human activity that changes community

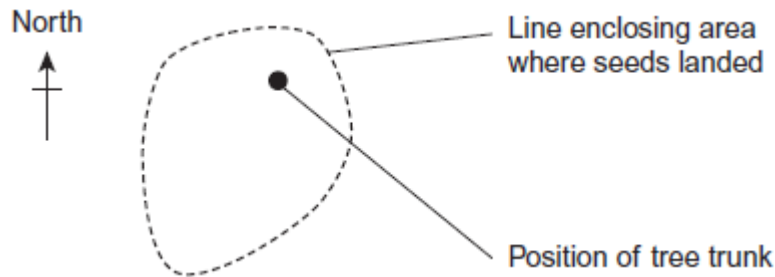


(a) What can you conclude from these data about the effects of human activities on biodiversity?

(3)



The seeds of this tree are dispersed by wind. The diagram shows the pattern of seed dispersal from this tree.



- (a) Describe how the ecologists could have used quadrats and a transect to obtain the data from which the graph was drawn.

(2)

- (b) Look at the diagram showing the pattern of seed dispersal from this tree.

- (i) Suggest an explanation for the shape of the line enclosing the area where the seeds landed.

(2)

- (ii) The line enclosing the area where the seeds landed would be different for trees of this species that were of a different height. Suggest why.

(2)

- (c) In an ecological succession, trees that are pioneer species often have smaller seeds than those that are part of a climax community.

- (i) The species of tree in this investigation is adapted to colonising areas that have been cleared of vegetation. Use information given above to explain how.

(2)

- (ii) The seeds produced by this species of tree did **not** grow successfully in a climax community. Suggest why.

(2)

(Total 10 marks)

Q10.

Herbicides are substances that kill weeds. Three farmers wanted to know which herbicide to use to control weeds in fields of barley. They chose eleven fields of barley and used a different herbicide in each field. Four weeks later they collected, counted and weighed the weeds in each field. Their results are shown in **Figure 1** and **Figure 2**.

Figure 1

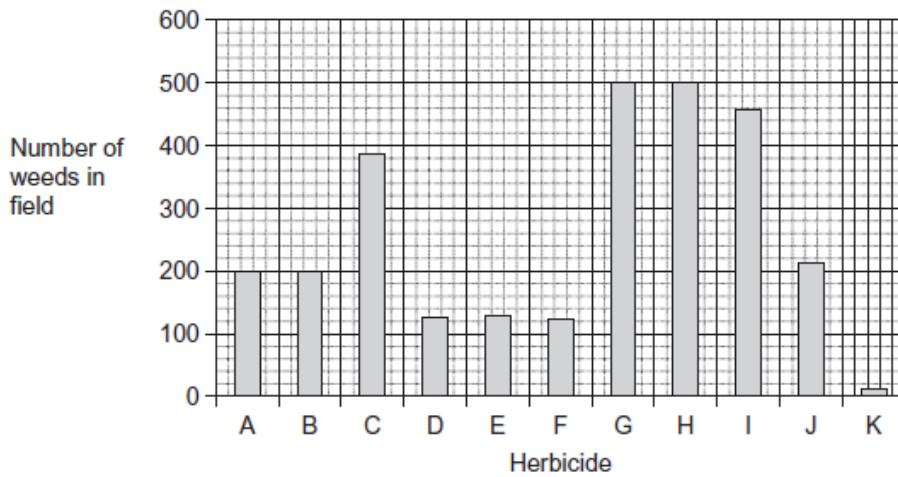
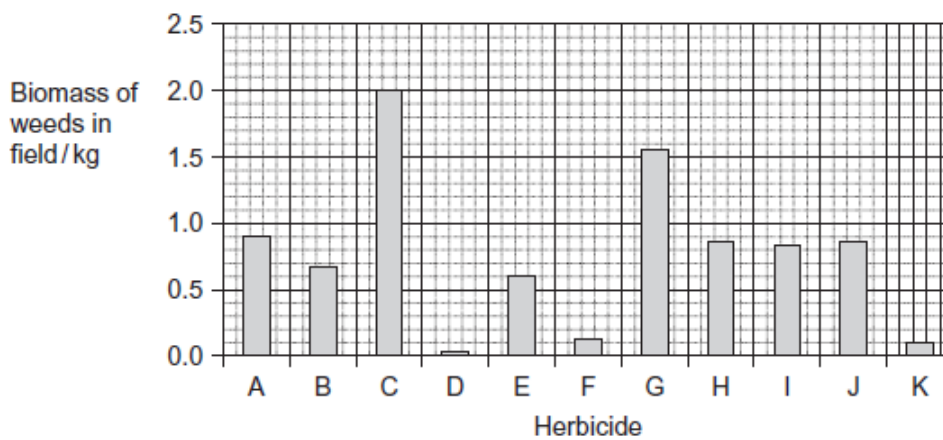


Figure 2



- (a) Describe the difference in biomass of **each** of the weed plants in fields treated with herbicides **G** and **H**. Explain how you arrived at your answer.

(2)

- (b) The farmers decided that **K** would be the best herbicide to use. Explain why herbicide **K** would give a higher crop yield.

(2)

- (c) The farmers carried out their investigation during the summer. Suggest **one** advantage and **one** disadvantage of carrying out this investigation during the summer.

Advantage _____

Disadvantage _____

_____ (2)

- (d) One of the farmers told a local newspaper reporter of their findings. The newspaper published an article with the following headline: "Local farmers show scientists the way to bigger crop yields." Was this headline justified? Explain your answer.

_____ (5)

(Total 11 marks)

Q11.

Parasites are organisms that live on or in host organisms. The populations of many organisms may be reduced by the effects of parasites.

Feather mites are small parasites found on the wing feathers of many birds. The mites feed on the oil that the birds produce. This oil keeps the feathers in good condition. Birds unable to oil their feathers properly use more energy in maintaining their body temperature. This results in less energy being available for other processes. Scientists investigated the relationship between the numbers of feather mites and the breeding success of one species of bird, the great tit.

- (a) Use the information above to suggest how feather mites could affect breeding in great tits.

_____ (2)

(b) The scientists located a large number of great tit nests. They sampled these at random.

For each nest they recorded

- the total number of eggs laid
- the number of chicks that hatched from the eggs
- the number of chicks that survived to leave the nest
- the total number of feather mites on the two parent birds.

(i) Explain why the scientists sampled the nests at random.

(2)

(ii) The scientists calculated the percentage of each pair's eggs from which chicks survived to leave the nest. They called this 'breeding success per pair'. The table shows some of the data that the scientists obtained.

Total number of feather mites on both parent birds	Breeding success per pair
0	86
2	100
5	64
10	82
14	70
15	85
170	42

Do these data support the hypothesis that the presence of feather mites reduces the ability of great tits to reproduce successfully? Give reasons for your answer.

(3)

(c) The scientists calculated a correlation coefficient for these data.

(i) State a null hypothesis that would be appropriate for this investigation.

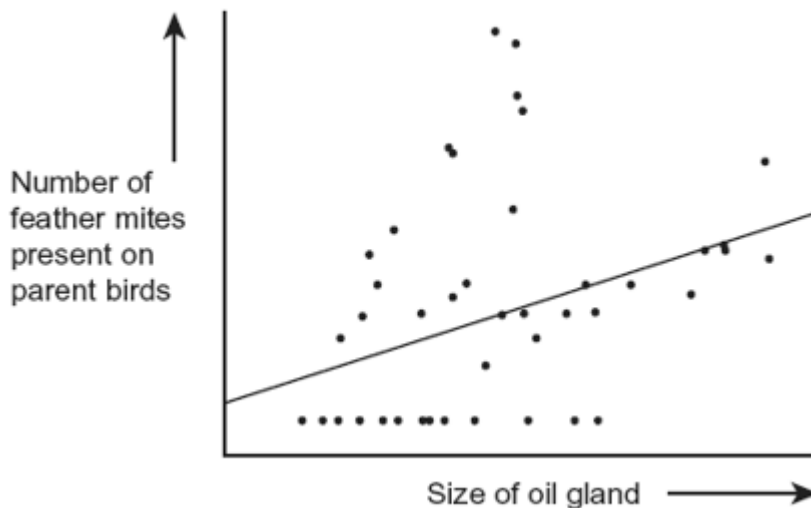
(1)

(ii) The correlation coefficient that they obtained had a negative value. What does a negative value indicate about these data?

(1)

(d) The oil that a great tit puts on its feathers is made in an oil gland at the base of the tail. The bird uses its beak to spread the oil over its feathers. This is called preening. Preening takes place in early morning and evening and empties the oil gland each time. After preening, the oil gland is considerably smaller.

At the same time that the scientists recorded the number of feather mites on each great tit, they also measured the size of the oil gland. The graph shows their results and includes the scientist's line of best fit.



(i) Describe the relationship between the number of feather mites present on each great tit and the size of the oil gland.

(2)

- (ii) Explain how measuring the oil gland at the same time as counting the feather mites may have affected the reliability of the data.

(2)

- (e) Feather mites eat pathogenic bacteria and fungi as well as oil. Explain how this may affect the breeding success of the birds.

(2)
(Total 15 marks)

Q12.

Agricultural scientists divided a field into a number of different plots. They planted soya bean seeds in these plots at different sowing densities. The diagram shows how these plots were arranged. The numbers show the sowing densities in seeds per m². The plots containing seeds sown at a density of 250 seeds per m² have been shaded.

250	500	1000	15	25	50	100
15	25	50	100	250	500	1000
25	50	100	250	500	1000	15
50	100	250	500	1000	15	25
1000	15	25	50	100	250	500
500	1000	15	25	50	100	250
100	250	500	1000	15	25	50

The scientists recorded the number of soya bean plants growing in each plot at different times after the start of the investigation. Their results are shown in the table.

Number of seeds planted per m ²	Mean number of plants surviving per m ² after			
	22 days	39 days	61 days	93 days
15	15	15	15	15
25	24	24	24	23
50	47	46	46	41
100	98	96	96	87
250	246	242	204	196
500	492	486	313	124
1000	987	788	276	95

(a) (i) In terms of rows and columns, describe how the plots containing seeds sown at a density of 250 m² were arranged.

_____ (1)

(ii) Explain the advantage of arranging the plots in this way.

 _____ (2)

(b) The scientists would have treated the plots in the same way. Suggest **two** ways in which the scientists would have treated the plots to ensure that confounding variables would **not** affect the results.

1. _____

2. _____
 _____ (2)

(c) (i) Describe the results of this investigation.

 _____ (3)

(ii) Explain the results when 1000 seeds were planted per m².

(2)
(Total 10 marks)

Q13. During the last 50 years, there have been changes in the climate of the UK. One of the main changes is temperature. The data in the following resources all relate to southern England.

Figure 1 shows the mean temperatures for January and February combined.

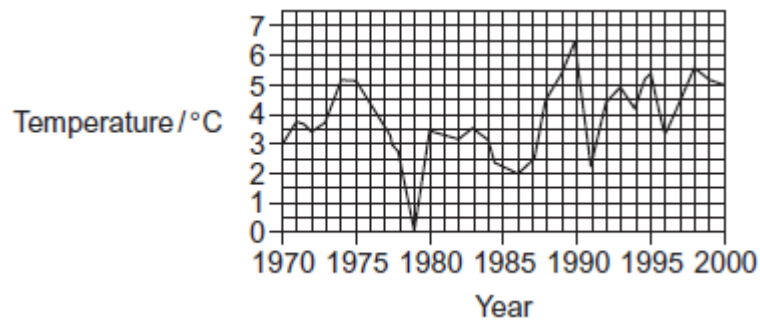
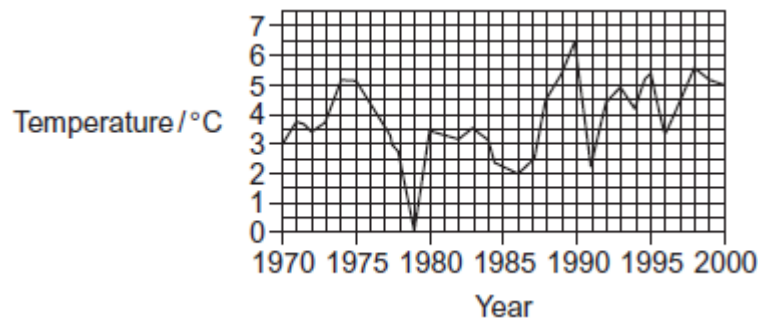
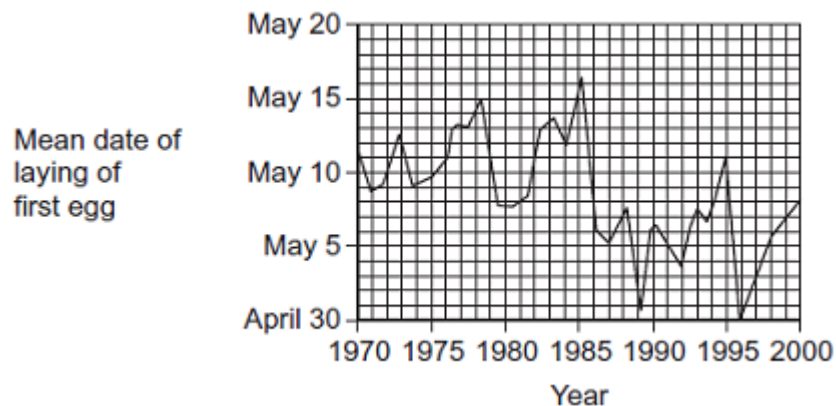


Figure 2 shows the mean temperatures for March.



Birds, such as chaffinches, have been recorded as breeding earlier. Chaffinches build nests. When the nest is complete, the female lays eggs until she has produced a full clutch of 4 to 6 eggs. After the eggs hatch, the parent birds feed the young on insects.

Figure 3 shows the mean date on which chaffinches laid their first egg.



The data from which this graph was drawn were collected by volunteers. They used standard record cards. The volunteers used one record card for each nest they found. Each card was used to record

- the geographical location
- the habitat in which the nest site was situated
- the date of each visit to the nest by the volunteer
- the number of eggs present in the nest at each visit.

Visits were made to the nests at least once every 5 days.

- (a) Do the data in **Figure 1** and **Figure 2** support the idea that there has been a rise in the mean temperatures in southern England between 1970 and 2000? Explain your answer.

(2)

- (b) Describe briefly how you would use a statistical test to find whether there is a significant correlation between mean March temperature and the date when chaffinches laid their first egg.

(3)

- (c) In chaffinches, the date of laying the first egg is determined by a number of factors. These include day length and temperature. What is the advantage to the bird of egg-laying being determined by

- (i) daylength

(2)

(ii) temperature?

(2)

(d) Scientists found that there was a correlation between mean annual temperature and the date when chaffinches laid the first egg. Can you conclude that higher temperatures cause earlier laying of the first egg? Explain your answer.

(2)

(e) How does the way in which the data were collected affect the conclusions which can be drawn from **Figure 3**?

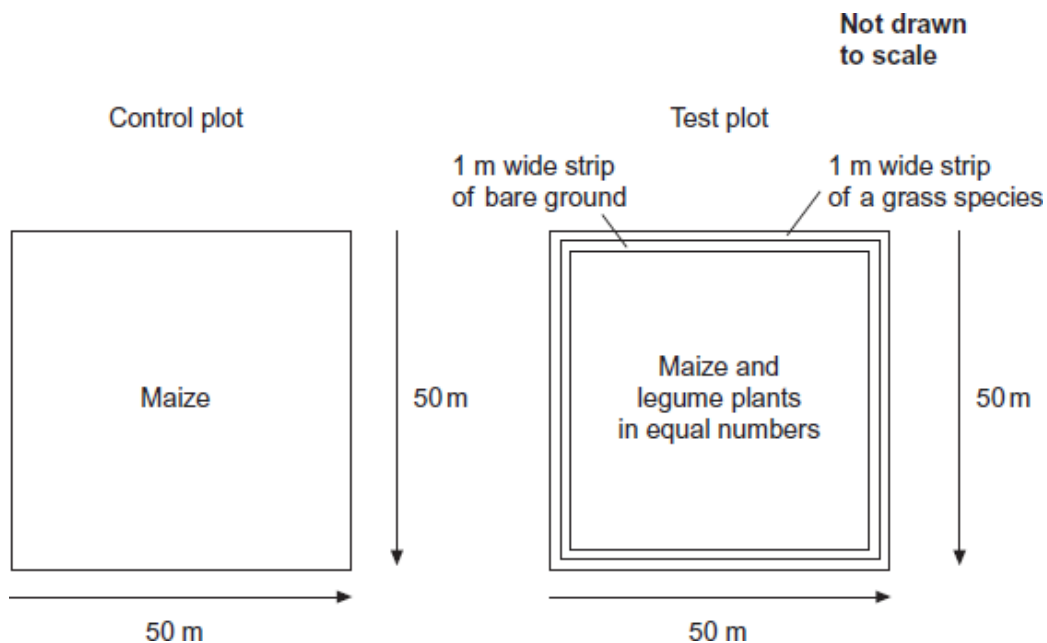
(2)

(Total 13 marks)

Q14.

Stem borers are insect pests that feed on maize plants. Scientists investigated the effect of **push-pull** stimuli on the control of these pests.

For this investigation, the scientists divided a large field into plots measuring 50 m × 50 m. They then designated each plot as a control plot or a test plot. The following figure shows what they planted in each type of plot.



The legumes planted with the maize drive stemborers away.
 The grass species attracts stemborers.
 The table below shows the scientists' results.

Plots	Mean percentage damage to maize plants	Mean maize grain yield / tonnes per hectare (\pm standard deviation)	Mean production costs per farmer / \$ per hectare (\pm standard deviation)	Mean total income for farmer / \$ per hectare (\pm standard deviation)
Control	29.6	1.5 (± 0.2)	250 (± 0.7)	329 (± 5.9)
Test	6.7	3.7 (± 0.3)	278 (± 1.1)	679 (± 10.2)

(a) In the test plot of land, identify the push stimulus and the pull stimulus.

Push stimulus _____

Pull stimulus _____ (1)

(b) When measuring the mean percentage damage to maize plants, 60 plants from each test plot were selected at random and examined.
 Describe how the maize plants could be selected at random.

_____ (3)

(c) In the test plot, bare ground was left between the maize and the grass species.

Suggest an explanation why.

(2)

- (d) The legume plants have nodules containing nitrogen-fixing bacteria on their roots. Explain how nitrogen-fixing bacteria could increase the growth of the maize.

(2)

- (e) A year after this investigation, the government of one country decided that their farmers should use these **push-pull** stimuli. How do these data support this decision?

(3)

(Total 11 marks)

Q15.

Ecologists developed a method for estimating the biomass of trees in a plantation. The plantation consisted of trees of the same species.

They collected samples of wood from trees. For each sample they:

- determined the density of the freshly cut wood
- dried the wood in an oven at 103 °C for 24 hours
- determined the volume of the dried wood sample
- determined the density of the dried wood.

The table below shows data about one wood sample.

Volume of freshly cut wood sample / dm ³	Density of freshly cut wood / g per dm ³	Volume of dried wood sample / dm ³	Density of dried wood sample / g per dm ³
1.345	993.0	1.125	769.0

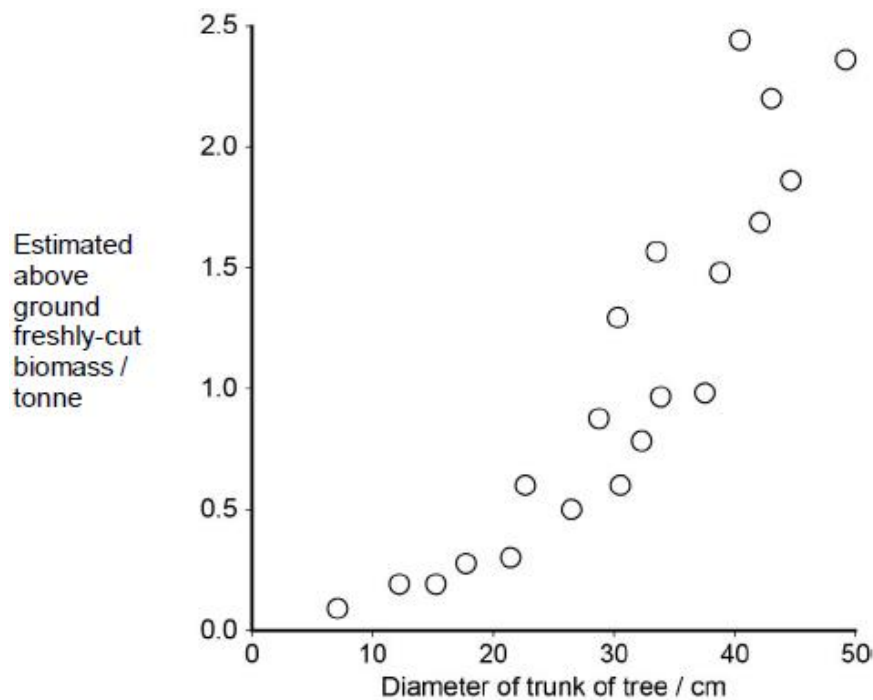
- (a) The loss of mass of the wood sample was due to loss of water. Water has a density of 1 g per cm³. Use the data in the table to calculate the percentage of water in the freshly cut wood sample. Show your working.

Percentage of water = _____(2)

- (b) The ecologists dried the samples in an oven at 103 °C for 24 hours. Describe how the ecologists could have determined whether or not this drying removed all the water from a sample of wood.

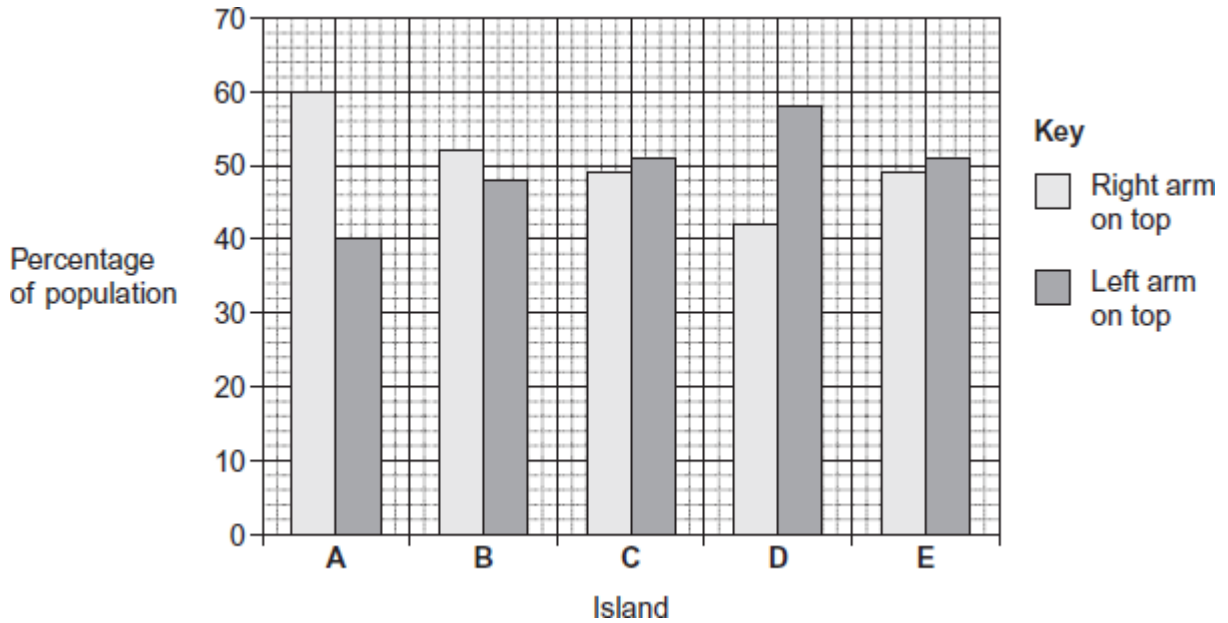
(2)

- (c) Ecologists then investigated the relationship between the diameter of the trunk of the trees and their biomass. The graph below shows their results. Each point is the result for **one** tree.



What does the graph show about the relationship between the diameter of the trunk of the

Figure 1



On one of the islands she recorded the arm-folding characteristics of parents and their children. These results are shown in **Figure 2**.

Figure 2

Arm-folding of parents	Arm-folding of the children / %	
	Right arm on top, R	Left arm on top, L
R and R	41	59
R and L	45	55
L and L	44	56

The geneticist concluded that arm-folding is not determined by a single gene with a dominant allele and a recessive allele.

(a) The geneticist investigated arm-folding on five small islands.

(i) Use information from **Figure 1** to describe the results she obtained.

(2)

(ii) Suggest advantages of using island populations in this investigation.

(1)

The pea plants were divided into four groups, **A**, **B**, **C** and **D**.

- **Group A** – heat-treated mycorrhizal fungus added, nitrate fertiliser
- **Group B** – mycorrhizal fungus added, nitrate fertiliser
- **Group C** – heat-treated mycorrhizal fungus added, ammonium fertiliser
- **Group D** – mycorrhizal fungus added, ammonium fertiliser

The heat-treated fungus had been heated to 120 °C for 1 hour.

- (c) Explain how groups **A** and **C** act as controls.

(2)

After 6 weeks, the scientists removed the plants from the soil and cut the roots from the shoots. They dried the plant material in an oven at 90 °C for 3 days. They then determined the mean dry masses of the roots and shoots of each group of pea plants.

- (d) Suggest what the scientists should have done during the drying process to be sure that all of the water had been removed from the plant samples.

(2)

The scientists' results are shown in the table below.

Treatment	Mean dry mass / g per plant (standard deviation)	
	Root	Shoot
A – heat-treated fungus and nitrate fertiliser	0.40 (±0.05)	1.01 (±0.12)
B – fungus and nitrate fertiliser	1.61 (±0.28)	9.81 (±0.33)
C – heat-treated fungus and ammonium fertiliser	0.34 (±0.03)	0.96 (±0.26)
D – fungus and ammonium fertiliser	0.96 (±0.18)	4.01 (±0.47)

- (e) What conclusions can be drawn from the data in the table about the following?

The effects of the fungus on growth of the pea plants.

The effects of nitrate fertiliser and ammonium fertiliser on growth of the pea plants.

(4)

The scientists determined the dry mass of the roots and shoots separately. The reason for this was they were interested in the ratio of shoot to root growth of pea plants. It is the shoot of the pea plant that is harvested for commercial purposes.

- (f) Explain why determination of dry mass was an appropriate method to use in this investigation.

(2)

- (g) Which treatment gave the best result in commercial terms? Justify your answer.

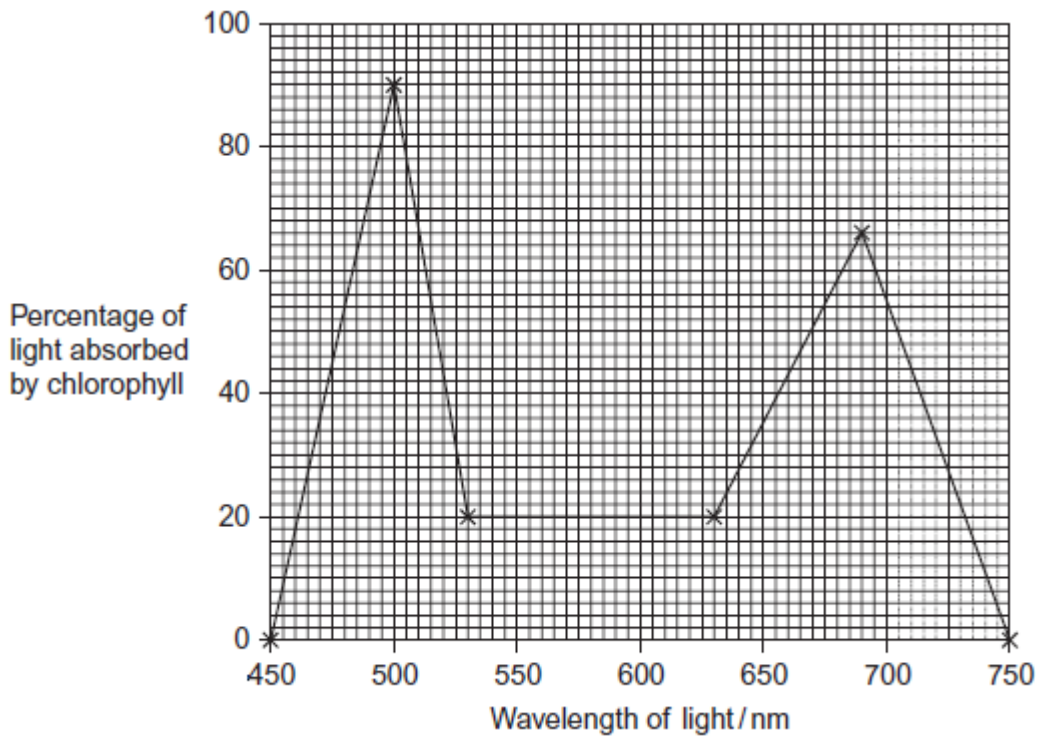
(2)

(Total 15 marks)

Q18.

Figure 1 shows the effect of wavelength on the percentage of light absorbed by the chlorophyll from these seaweeds.

Figure 1



Some scientists investigated the growth of these seaweeds in artificial conditions. They investigated the effect of different lamps on the rate of photosynthesis of the seaweeds.

- Lamp **P** produced light containing all wavelengths of visible light. (450 to 750 nm)
- Lamp **Q** only produced light of wavelength 460 nm.

The scientists measured photosynthesis by recording the rate of oxygen production. Their results are shown in **Figure 2**.

Figure 2

Species	Mean rate of photosynthesis/arbitrary units (\pm standard deviation)	
	Lamp P Light of all wavelengths of visible light	Lamp Q Light of wavelength 460nm
<i>Ulva pertusa</i>	1300.9 (\pm 125.4)	776.6 (\pm 105.6)
<i>Mastocarpus yendoii</i>	318.9 (\pm 69.5)	299.6 (\pm 83.2)

(a) Between 500 and 700 nm, what range of wavelengths of light is absorbed least by chlorophyll?

_____ (1)

(b) The scientists measured the oxygen produced by the light-dependent reaction of photosynthesis. Name **two** other substances produced by the light-dependent reaction.

1. _____

2. _____ (2)

- (c) (i) The scientists measured the rate of photosynthesis of the seaweeds in this investigation in terms of oxygen produced. Suggest the units they should use.

_____ (2)

- (ii) This investigation was carried out in bright light. Explain why reducing the light intensity would affect the amount of oxygen released by the seaweeds.

_____ (3)

- (d) In this investigation, the scientists kept the temperature at 15 °C. A student suggested that repeating the investigation at 20 °C would not affect the amount of oxygen released by the seaweed. Evaluate this suggestion.

_____ (3)

- (e) (i) Did the type of lamp used affect the rate of photosynthesis in *M. yendoi*? Explain the evidence for your answer.

_____ (2)

- (ii) The different lamps resulted in different rates of photosynthesis by *U. pertusa*. Explain why there was a higher rate of photosynthesis when the seaweed was illuminated with lamp **P**.

_____ (3)

Q19.

When coal is mined by open-cast mining, the top layer of soil is first scraped off and stored in a large heap. Once mining has finished, the area can be reclaimed. Soil from this store is then spread back over the surface. Some of the bacteria living in the soil store respire aerobically and some respire anaerobically. **Table 1** shows the numbers of aerobic and anaerobic bacteria found at different depths in a soil store.

Depth / cm	Mean number of bacteria per gram of soil ($\times 10^7$)			
	Aerobic bacteria		Anaerobic bacteria	
	after 1 month	after 6 months	after 1 month	after 6 months
0	12.0	12.1	0.6	0.8
50	10.4	8.6	0.8	1.3
100	10.1	6.1	0.7	4.1
150	10.0	3.2	0.7	7.9
200	11.6	0.8	0.7	8.4
250	11.9	0.7	0.8	8.8
300	11.0	0.8	0.6	9.1

- (a) Some of the soil used to determine bacterial numbers was collected from the surface of the soil store. Describe how you would ensure that this soil was collected at random.

(2)

- (b) (i) Describe how the numbers of aerobic bacteria after 6 months change with depth.

(2)

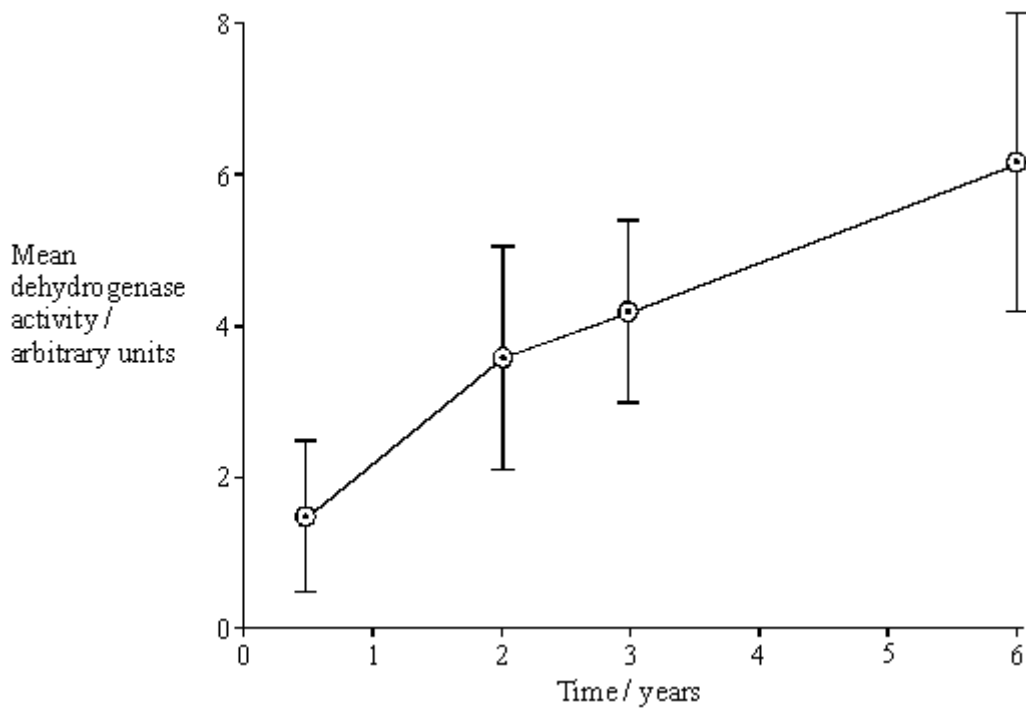
- (ii) Explain the difference in the numbers of aerobic bacteria at a depth of 300 cm between 1 and 6 months.

(2)

- (c) Explain how the changes in bacterial numbers which take place at 150 cm illustrate the process of succession.

(3)

Dehydrogenase is an enzyme involved in aerobic respiration. Dehydrogenase activity in a soil sample can be used as a measure of the activity of aerobic bacteria. The graph shows the mean dehydrogenase activity of soil samples taken from the same depth in a soil store at different times. The bars on the graph represent two standard errors above and below the mean.



- (d) (i) From what depth in the soil store would you expect these soil samples to have been taken? Use information from **Table 1** to explain your answer.

(2)

(ii) How would you expect dehydrogenase activity to vary with depth after 6 months?

Use information from **Table 1** to explain your answer.

(3)

(e) What do the error bars tell you about the difference between the mean dehydrogenase activity at 6 months and 3 years? Explain your answer in terms of probability and chance.

(3)

(f) **Table 2** shows the dehydrogenase activity and the number of aerobic bacteria present in some soil samples.

Dehydrogenase activity / arbitrary units	Number of aerobic bacteria per gram of soil ($\times 10^7$)
13.1	12.0
9.2	8.7
5.5	6.5
3.0	4.6
2.2	2.7
0.4	0.6

Table 2

A sample of soil was found to have dehydrogenase activity of 8.7 arbitrary units.

Explain how you would use the data in **Table 2** to predict the likely number of aerobic bacteria in 1 g of this soil sample.

(3)
(Total 20 marks)

Q20.

Scientists measured the rate of respiration in **three** parts of an ecosystem.

They did this by measuring carbon dioxide released into the air by:

- leaves of plants
- stems and roots of plants
- non-photosynthetic soil organisms.

The table below shows the scientists' results for these three parts of the ecosystem.

Part of ecosystem	Mean rate of carbon dioxide production / $\text{cm}^3 \text{m}^{-2} \text{s}^{-1}$	Percentage of total carbon dioxide production measured by the scientists
Leaves of plants	0.032	25.0
Stems and roots of plants	0.051	
Non- photosynthetic soil organisms	0.045	

- (a) Complete the table to show the percentage of total carbon dioxide production by each part of the ecosystem.

Show your working.

(2)

- (b) A student who looked at the data in the table concluded that plants carry out more respiration than non-photosynthetic organisms in the ecosystem.

Use the information provided to suggest why these data may **not** support the student's conclusion.

(2)

- (c) What measurements would the scientists have made in order to calculate the rate of carbon dioxide production?

(2)

- (d) The scientists calculated the mean rate of carbon dioxide production of the leaves using measurements of carbon dioxide release in the dark.

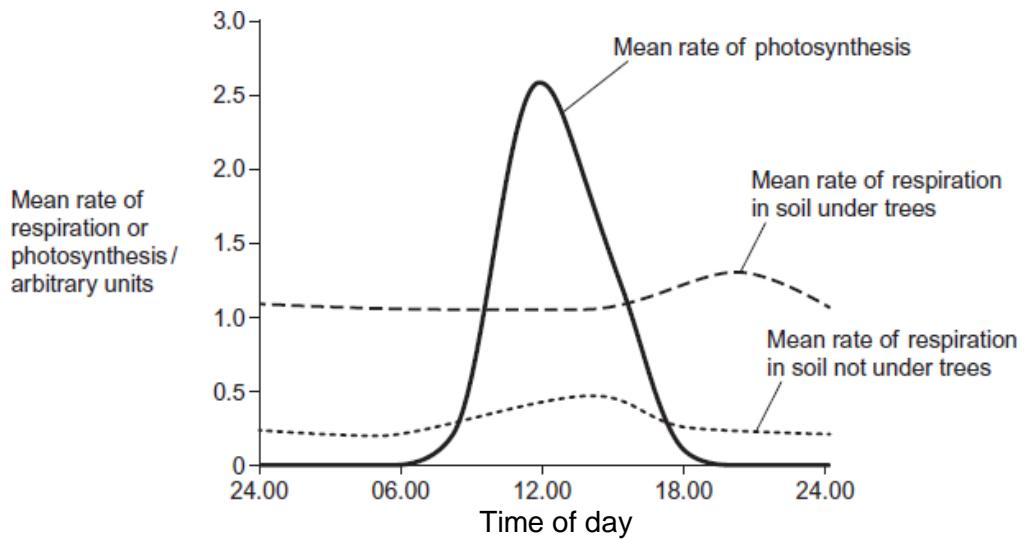
Explain why they did **not** use measurements taken in the light.

(2)

Another group of scientists measured the mean rate of respiration in soil under trees and soil not under trees in the same wood. They also measured the mean rate of photosynthesis in the trees.

They took measurements at different times of day during the summer.

The figure below shows the scientists' results.



(e) (i) Describe **two** ways in which the mean rate of respiration in soil under trees is different from soil not under trees.

1. _____

2. _____

_____ (2)

(ii) Suggest **one** explanation for the differences in the mean rate of respiration in soil under trees and soil not under trees between 06.00 and 12.00.

_____ (2)

(f) The scientists suggested that the rise in the mean rate of photosynthesis was the cause of the rise in the mean rate of respiration in soil under trees.

(i) Suggest how the rise in the mean rate of photosynthesis could lead to the rise in the mean rate of respiration in soil under trees.

_____ (2)

(ii) Suggest why there is a delay between the rise in the mean rate of photosynthesis and the rise in the mean rate of respiration.

_____ (1)

Q21. There are two types of diabetes: type 1 and type 2.

- People with type 1 diabetes do not produce enough insulin.
- People with type 2 diabetes do produce insulin but have cells which do not respond to insulin.

Doctors use a glucose tolerance test to help diagnose people with diabetes. They start each test after a person has not eaten overnight. They measure a person's blood glucose concentration.

The person then drinks a solution containing 75 g of glucose. The doctors measure the person's blood glucose concentration 2 hours later. During the test, the person remains at rest.

Figure 1 shows three diagnoses that can be made from the results of the test.

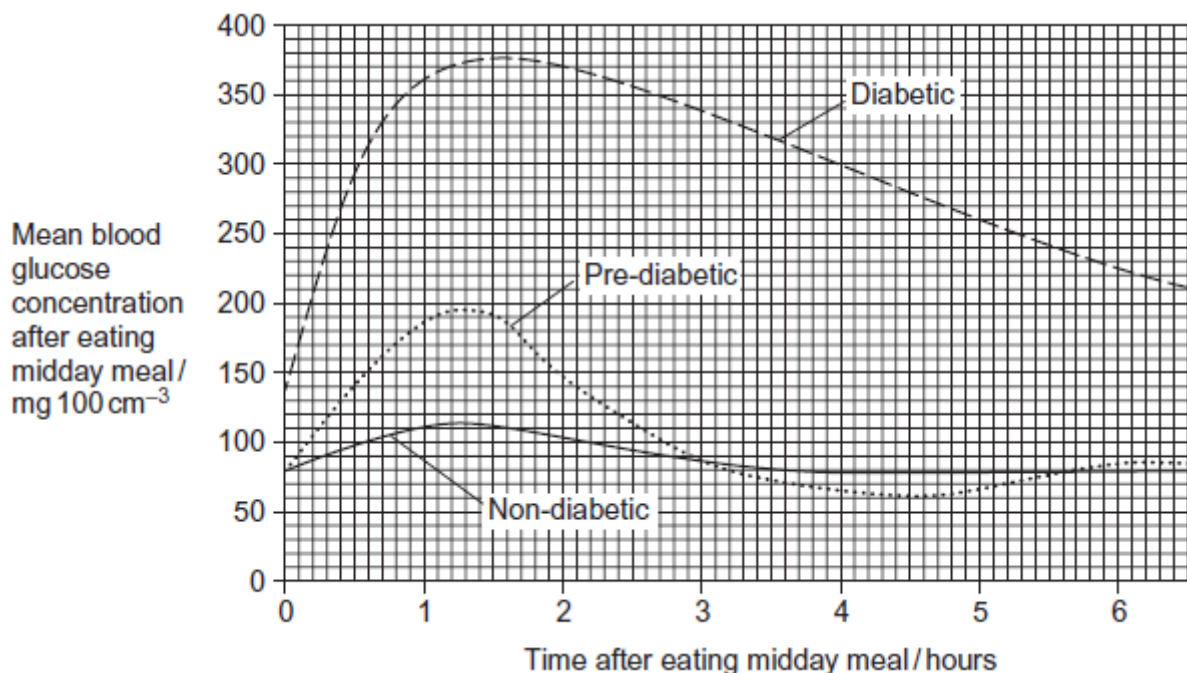
Figure 1 – glucose tolerance test results and diagnoses

Blood glucose concentration after 2 hours / mg 100 cm ⁻³	Diagnosis	Comments
≤ 110	Non-diabetic	Low risk for future diabetes
Between 140 and 200	Pre-diabetic	High risk for future diabetes. Some doctors recommend that the upper value should be lowered to 180 mg 100 cm ⁻³
≥ 200	Diabetic	Confirm by doing a second test

A researcher monitored the mean blood glucose concentration of a non-diabetic, a pre-diabetic and a diabetic after they had each eaten a midday meal.

His results are shown in **Figure 2**.

Figure 2



- (a) People with type 1 diabetes are described as being insulin-dependent. Suggest why they are described as insulin-dependent.

_____ (1)

- (b) Some people with type 2 diabetes have cells which do **not** respond to insulin. Explain how this leads to a reduced ability to regulate blood glucose concentration.

_____ (3)

- (c) During a glucose tolerance test the person remains at rest. Why is it important that the person remains at rest?

_____ (2)

- (d) Use **Figure 2** to calculate how many times the maximum mean blood glucose concentration of the pre-diabetic is greater than the maximum of the non-diabetic person. Show your working.

Answer = _____

(2)

- (e) Give **three** differences between the method used by the researcher to obtain the results in **Figure 2** and the method doctors use to carry out a glucose tolerance test.

1. _____

2. _____

3. _____

_____ (3)

- (f) Some doctors have recommended that the upper value used in the glucose tolerance test should be lowered to $180 \text{ mg } 100 \text{ cm}^{-3}$.
Using information from **Figure 1** and **Figure 2**, suggest why.

(3)
(Total 14 marks)

Q22. Ammonia in soil is oxidised to nitrites and nitrates by species of nitrifying bacteria.

Scientists investigated whether two soils with a different pH contained different communities of nitrifying bacteria. These communities consist of all the nitrifying bacteria of different species in each soil. They took samples of soil from two sites, **A** and **B**.

They measured the pH of the samples and found that

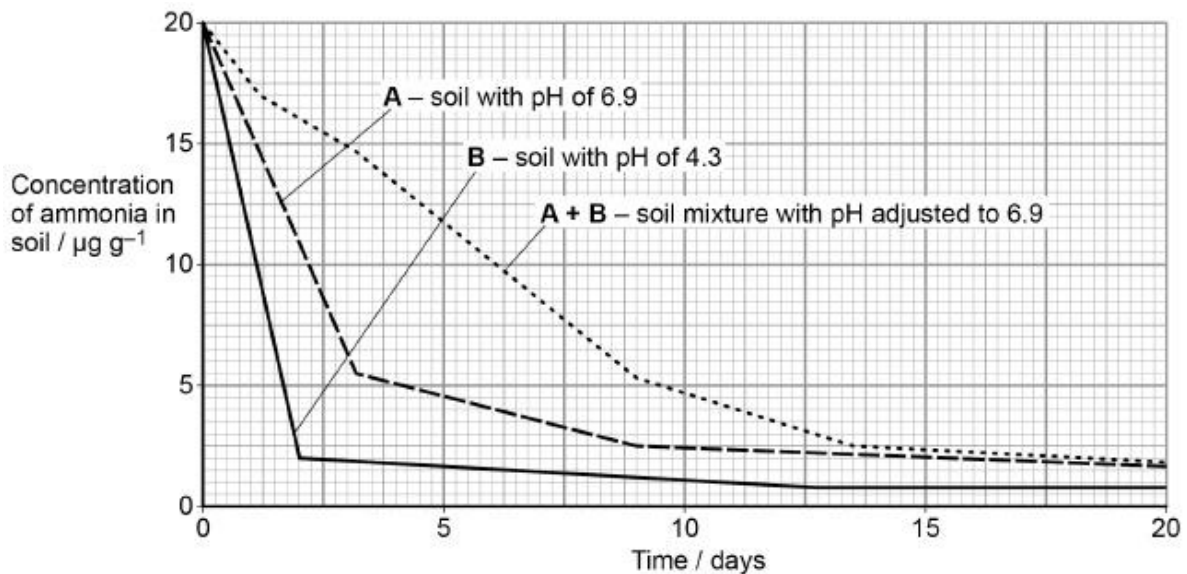
- the soil from site **A** had a pH of 6.9
- the soil from site **B** had a pH of 4.3

The scientists measured the concentration of ammonia in soil samples over 20 days. Each sample contained the same concentration of ammonia at the start and had the same mass. They recorded the concentration of ammonia in

- soil **A** with a pH of 6.9
- soil **B** with a pH of 4.3
- a mixture of equal masses of soils **A** and **B** with its pH adjusted to 6.9

Their results are shown in **Figure 1**.

Figure 1



- (a) The scientists used units of $\mu\text{g g}^{-1}$ for the concentration of ammonia in soil.

Suggest why, in this investigation, the scientists used these units.

μg _____

g^{-1} _____

(2)

- (b) Calculate the difference in the rate of breakdown of ammonia per day between day 0 and day 2 in soil **A** and soil **B**.

Show your working and the units for your answer.

Difference in rate = _____ (2)

- (c) The scientists concluded that the soil mixture experiment showed there were different communities of bacteria in soils A and B.

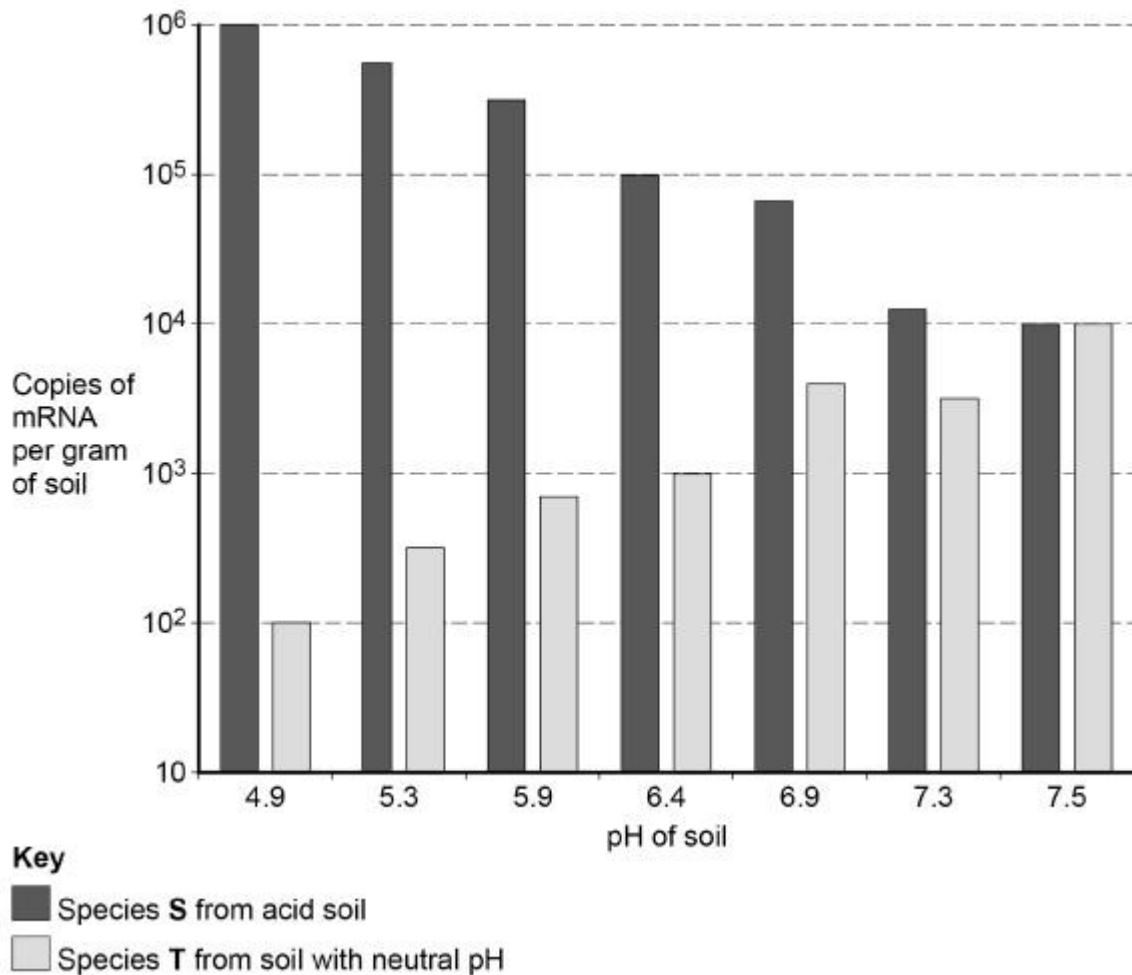
What evidence from **Figure 1** supports their conclusions? Give reasons for your answer.

(3)

The oxidation of ammonia by nitrifying bacteria involves the enzyme ammonia monooxygenase. Each species of nitrifying bacteria has its own specific *amoA* gene that codes for production of ammonia monooxygenase.

In a second investigation, the scientists determined the expression of the *amoA* gene in two species of bacteria, **S** and **T**. Species **S** was from acid soil and species **T** was from soil with a neutral pH.

The scientists grew cultures of each species separately in soils of different pH. They determined the amount of mRNA from the *amoA* gene in each culture. Their results are shown in **Figure 2**.



(d) In which species was the number of copies of mRNA more affected by changes in soil pH from 4.9 to 7.5? Use a calculation to support your answer.

(2)

Q23. Some populations of flies are becoming resistant to insecticides intended to kill them.

Scientists developed a method for finding out whether a fly was carrying a recessive allele, **r**, that gives resistance to an insecticide. The dominant allele, **R**, of this gene does not give resistance.

The scientists:

- crossed flies with genotype **RR** with flies with genotype **rr**
- obtained DNA samples from the parents and offspring
- used the same restriction endonuclease enzymes on each sample, to obtain DNA fragments.

(a) Explain why the scientists used the same restriction endonuclease enzymes on each DNA sample.

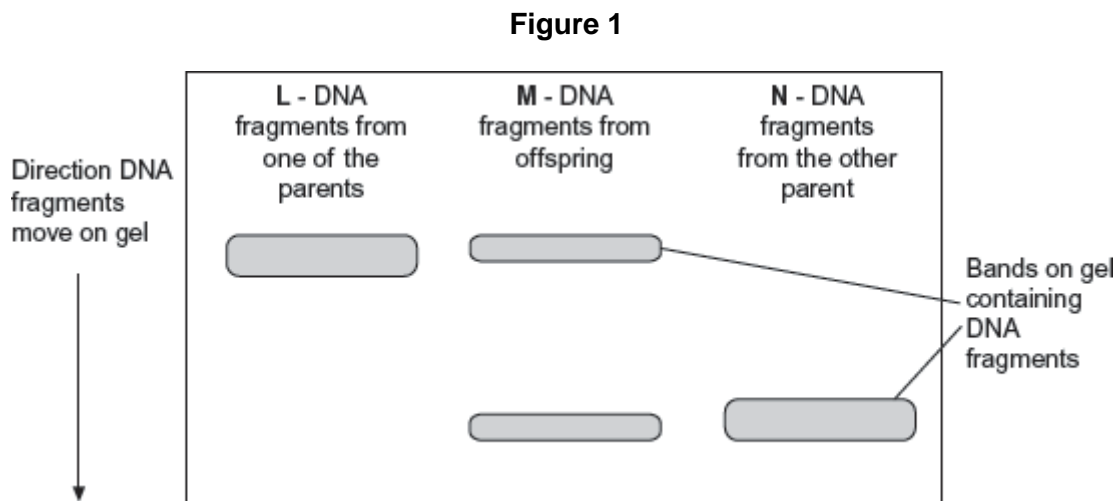
(2)

The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- Primer A3 only binds to a 195 base-pair fragment from allele **r**.
- Primer A4 only binds to a 135 base-pair fragment from allele **R**.

The scientists separated the DNA fragments produced by the PCR on a gel where shorter fragments move further in a given time.

Their results are shown in **Figure 1**.



(b) Explain why primer A3 and primer A4 only bind to specific DNA fragments.

(2)

(c) Use all the information given to explain the results in **Figure 1**.

(3)

(d) The scientists wanted to know on which chromosome the gene with alleles **R** and **r** was located. From the flies with genotype **RR**, they obtained cells that were in mitosis and added a labelled DNA probe specific for allele **R**. They then looked at the cells under an optical microscope.

Explain why they used cells that were in mitosis.

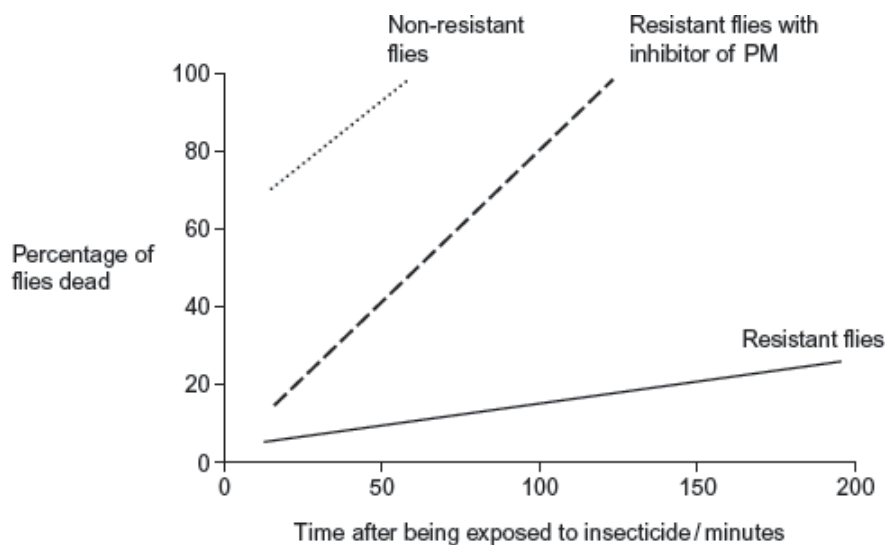
(2)

(e) Another group of scientists thought that pesticide resistance in some flies was related to increased activity of an enzyme called P450 monooxygenase (PM). This enzyme breaks down insecticides.

The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- Non-resistant flies exposed to insecticide.
- Resistant flies exposed to insecticide.
- Resistant flies treated with an inhibitor of PM and then exposed to insecticide.

They then determined the percentage of flies that were dead at different times after being exposed to insecticide. **Figure 2** shows their results.



- (i) Explain why the scientists carried out the control experiment with the non-resistant flies.

(2)

- (ii) The scientists concluded that the resistance of the flies to the insecticide is partly due to increased activity of PM but other factors are also involved.

Explain how these data support this conclusion.

(4)

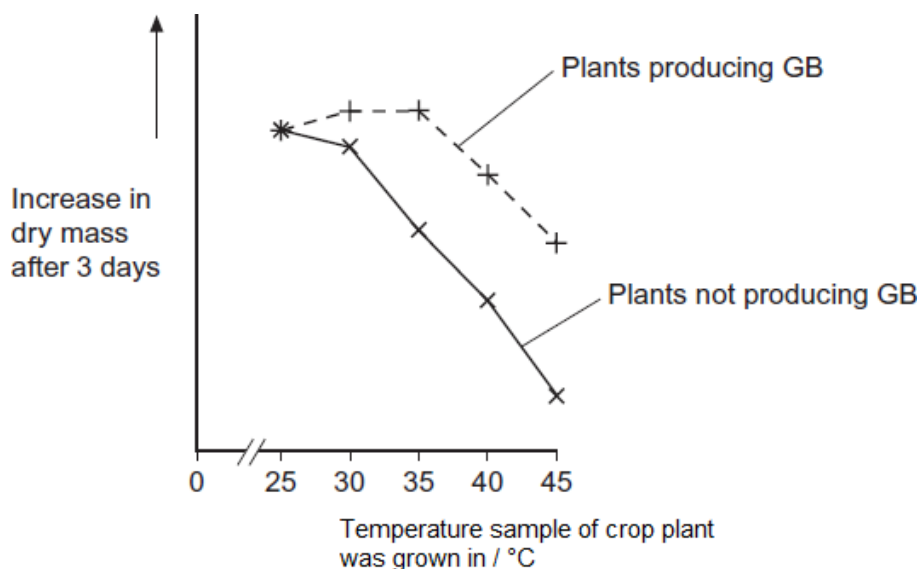
(Total 15 marks)

Q24.

Some species of crop plant produce a substance called glycinebetaine (GB).

Scientists transferred the gene for GB into a species of crop plant that does not normally produce GB. These genetically modified plants then produced GB.

The scientists grew large numbers of the same crop plant with and without the gene at different temperatures. After 3 days, they found the increase in dry mass of the plants. **Figure 1** shows their results.

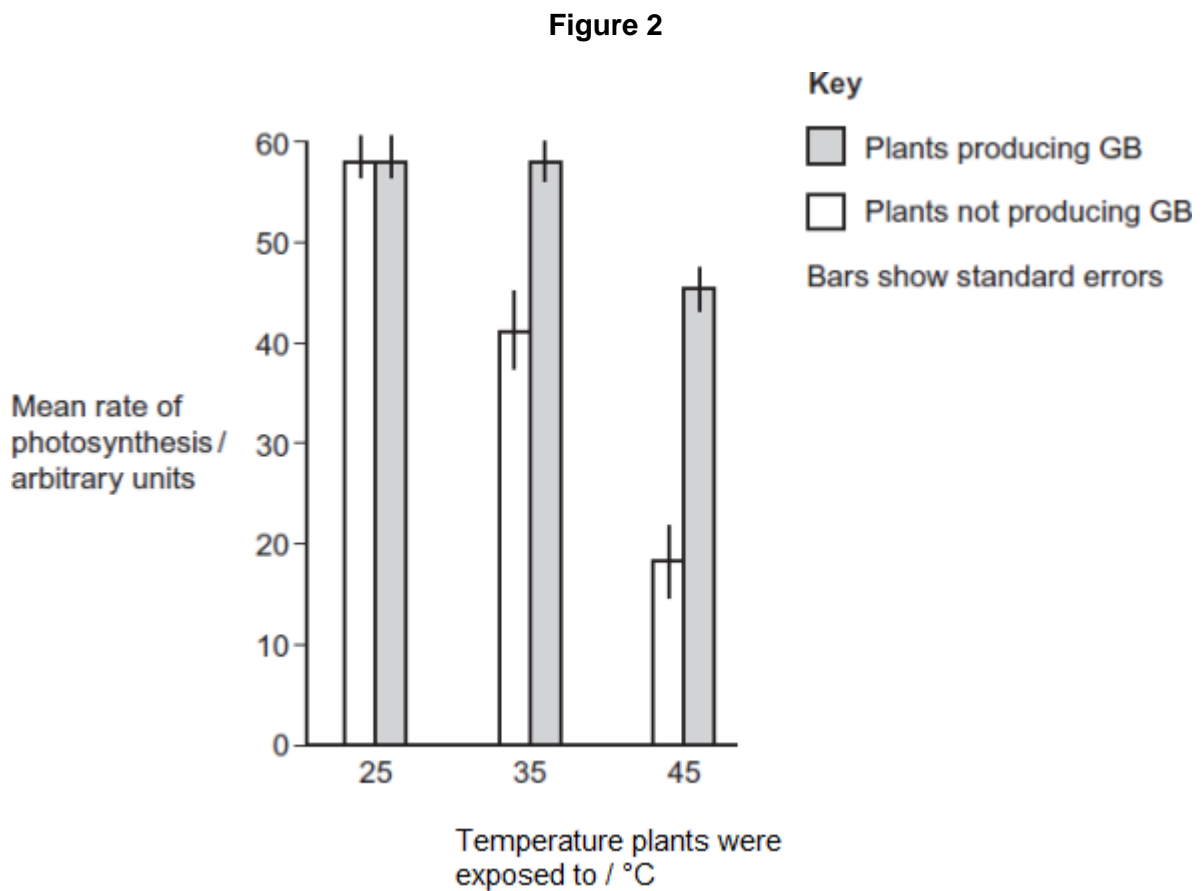


- (a) Describe the effect on growth of transferring the gene for GB into this plant.

(2)

- (b) The scientists measured the rate of photosynthesis in plants that produce GB and plants that do not produce GB at 25°C, 35°C and 45°C.

Figure 2 shows their results.



- (i) The scientists concluded that the production of GB protects photosynthesis from damage by high temperatures.

Use these data to support this conclusion.

(1)

- (ii) Use the data from **Figure 2** for plants that do not produce GB to explain the effect of temperature on changes in dry mass of the plants shown in **Figure 1**.

(4)

Rubisco activase is an enzyme found in chloroplasts. It activates the light-independent reaction of photosynthesis.

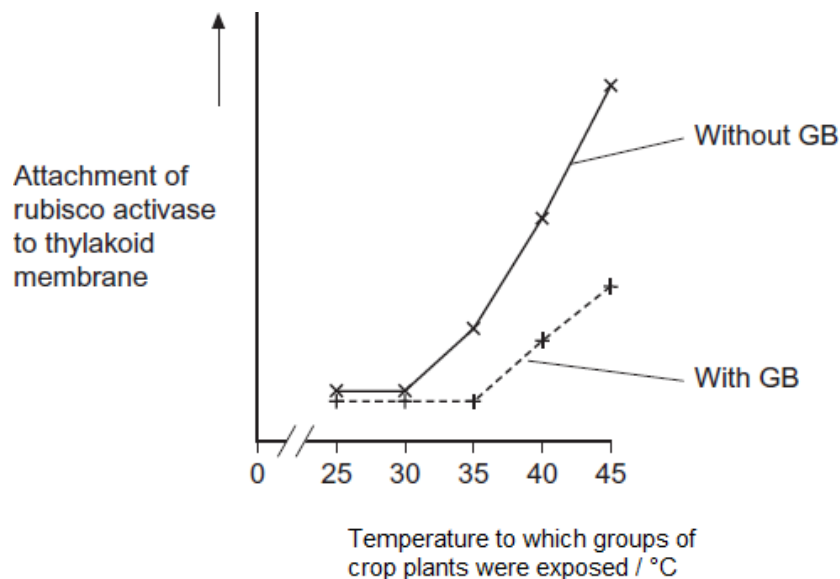
The scientists discovered that, as temperature increased from 25°C to 45°C, rubisco activase began attaching to thylakoid membranes in chloroplasts and this stopped it working.

- (c) Rubisco activase stops working when it attaches to a thylakoid.

Use your knowledge of protein structure to explain why.

(2)

- (d) The scientists investigated the effect of GB on attachment of rubisco activase to thylakoid membranes at different temperatures. **Figure 3** shows their results.



Use information from **Figure 2** and **Figure 3** to suggest how GB protects the crop plant from high temperatures.

(4)

- (e) The scientists' hypothesis at the start of the investigation was that crop plants genetically engineered to produce GB would become more resistant to high environmental temperatures.
The scientists developed this hypothesis on the basis of previous research on crops that are grown in hot climates.

Suggest how the scientists arrived at their hypothesis.

(2)

(Total 15 marks)