

1 Read the information.

Insects can be both useful and harmful to crop plants.
Insects such as bees pollinate the flowers of some crop plants. Pollination is needed for successful sexual reproduction of crop plants.
Some insects eat crops and other insects eat the insects that eat crops.

Corn borers are insects that eat maize plants.
A toxin produced by the bacterium *Bacillus thuringiensis* kills insects.
Scientists grow *Bacillus thuringiensis* in large containers. The toxin is collected from the containers and is sprayed over maize crops to kill corn borers.

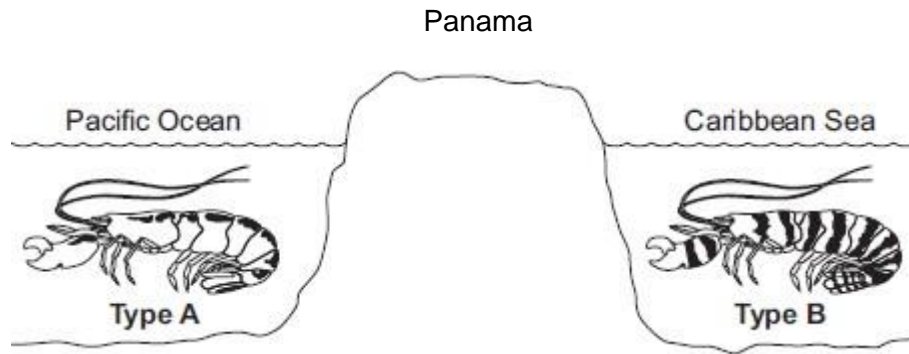
A company has developed genetically modified (GM) maize plants. GM maize plants contain a gene from *Bacillus thuringiensis*. This gene changes the GM maize plants so that they produce the toxin.

- (a) Describe how scientists can transfer the gene from *Bacillus thuringiensis* to maize plants.

(3)

(b) The illustration below shows two types of pistol shrimp.

The shrimps live in shallow, tropical seas on opposite sides of Panama.



Not to scale

Scientists put one **Type A** shrimp and one **Type B** shrimp together in a tank of seawater. The two types of shrimp snapped their claws aggressively at each other. They did not mate.

The scientists said that this was evidence for the **Type A** and **Type B** shrimps being classified as two different species.

(i) Give **one** reason why the scientists' opinion may be correct.

(1)

(ii) Suggest **two** reasons why the scientists' opinion may **not** be correct.

1.

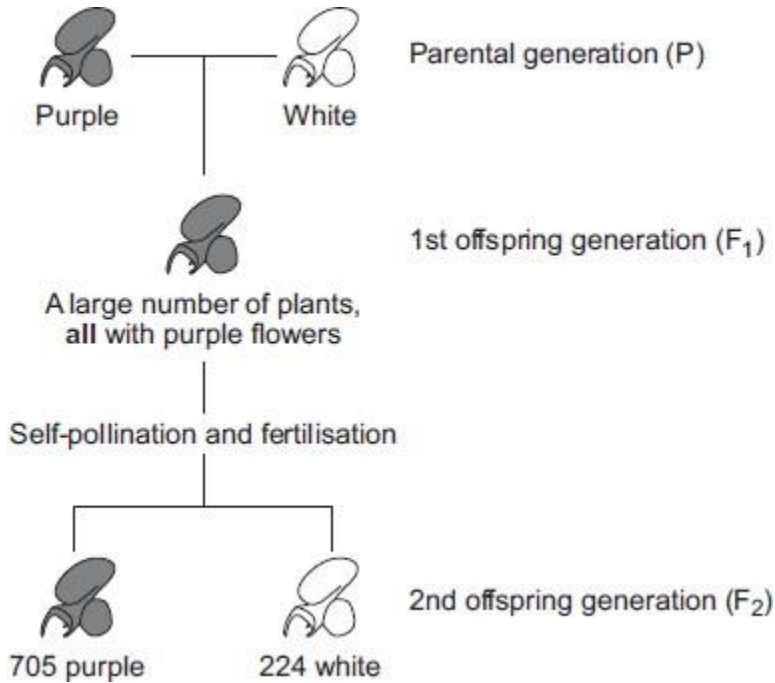
2.

(2)

(c) Panama is a narrow strip of land which today joins North America and South America. It was formed by land moving up from beneath the sea. Panama has separated the Pacific Ocean and the Caribbean Sea for the past 3 million years.

3 In 1866, Gregor Mendel published the results of his investigations into inheritance in garden pea plants.

The diagram below shows the results Mendel obtained in one investigation with purple-flowered and white-flowered pea plants.



(a) (i) Calculate the ratio of purple-flowered plants to white-flowered plants in the F₂ generation.

Ratio of purple : white = _____

(1)

(ii) There was a total of 929 plants in the F₂ generation.

Mendel thought that the production of a large number of offspring plants improved the investigation.

Explain why.

(2)

- (b) (i) Some of the plants in the diagram are homozygous for flower colour and some are heterozygous.

Complete the table to show whether each of the plants is homozygous or heterozygous. For each plant, tick (✓) **one** box.

	Homozygous	Heterozygous
Purple-flowered plant in the P generation		
White-flowered plant in the P generation		
Purple-flowered plant in the F ₁ generation		

(2)

- (ii) Draw a genetic diagram to show how self-pollination of the F₁ purple-flowered plants produced mainly purple-flowered offspring in the F₂ generation together with some white-flowered offspring.

Use the following symbols:

N = allele for purple flower colour

n = allele for white flower colour

(3)

- (c) When Mendel published his work on genetics, other scientists at the time did not realise how important it was.

Suggest **two** reasons why.

1. _____

2. _____

(2)

(Total 10 marks)

4 Glyphosate is a herbicide.

Crop plants have been genetically modified to make them resistant to glyphosate.

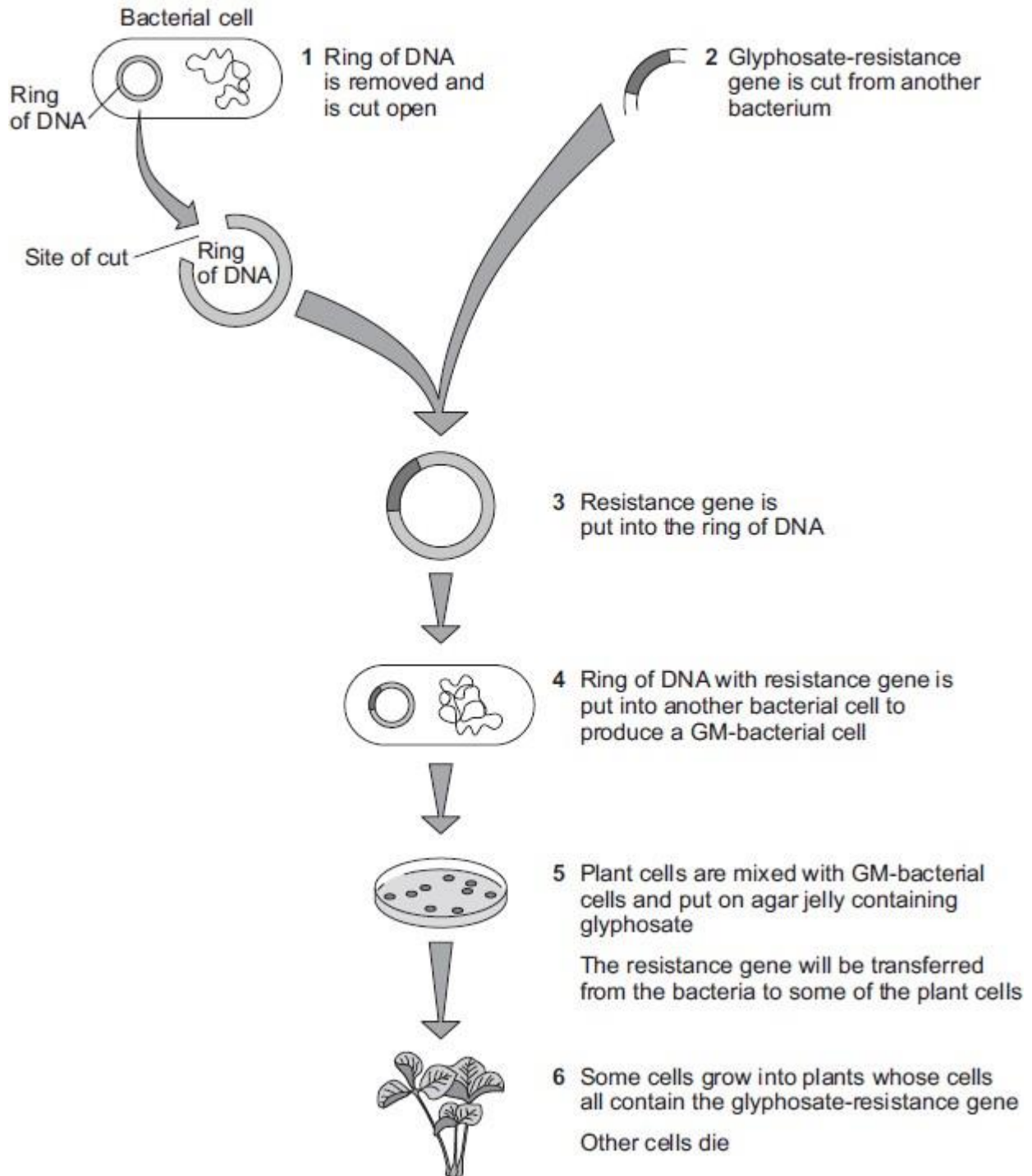
(a) Why is it an advantage to make crop plants resistant to glyphosate?

(3)

(b) **Figure 1** shows how scientists produce genetically modified (GM) crop plants.

The scientists use a GM-bacterium that can invade plant cells.

Figure 1



(i) The ring of DNA shown in **Figure 1** acts as a vector for the resistance gene.

What is the scientific name for this ring of DNA?

(ii) At step **1** in **Figure 1**, the ring of DNA is cut open.

How do scientists cut open the ring of DNA?

(1)

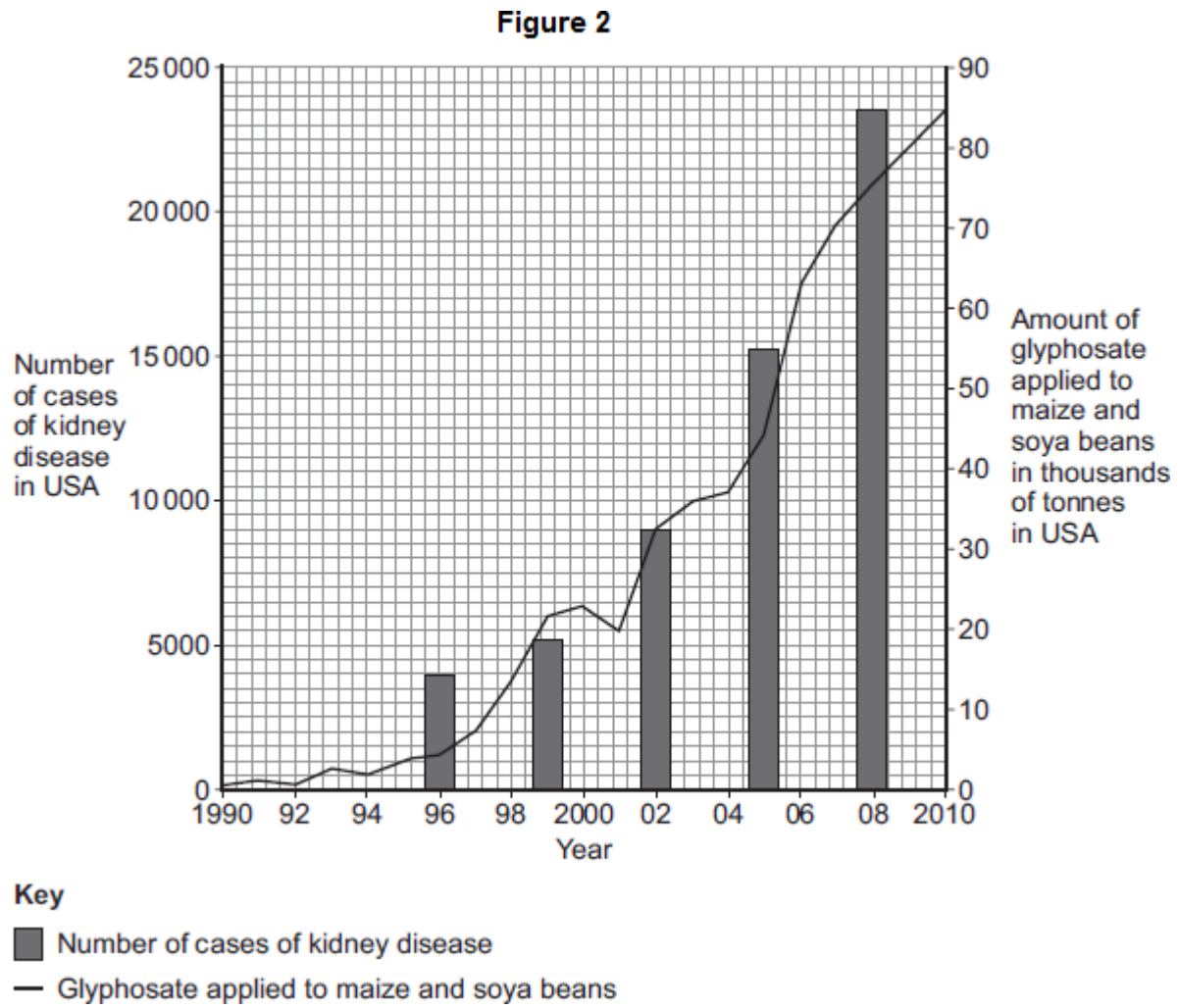
(iii) At step **5** in **Figure 1**, plant cells and GM-bacteria are put on agar containing glyphosate.

Explain why the scientists add glyphosate to the agar.

(2)

(c) Some people disagree with the use of GM herbicide-resistant crop plants.

Figure 2 shows data published on a website in 2013.



A journalist used the data to claim: 'Scientists show that GM crops cause kidney disease in humans.'

Use information from **Figure 2** to evaluate the evidence for this claim.

(4)
(Total 11 marks)

5

DNA is the genetic material of human cells.

Figure 1 shows the structure of part of a DNA molecule.

Figure 1



(a) (i) Describe where DNA is found in a human cell.

(2)

(ii) When a cell divides by mitosis the new cells are genetically identical.

What causes the cells to be genetically identical?

(1)

(b) Many genes have different forms called alleles.

(i) A person has polydactyly (extra fingers or toes). Polydactyly is caused by a dominant allele.

What is the smallest number of copies of the dominant allele for polydactyly that could be found in a body cell of this person?

(1)

(ii) Another person has cystic fibrosis. Cystic fibrosis (CF) is caused by a recessive allele.

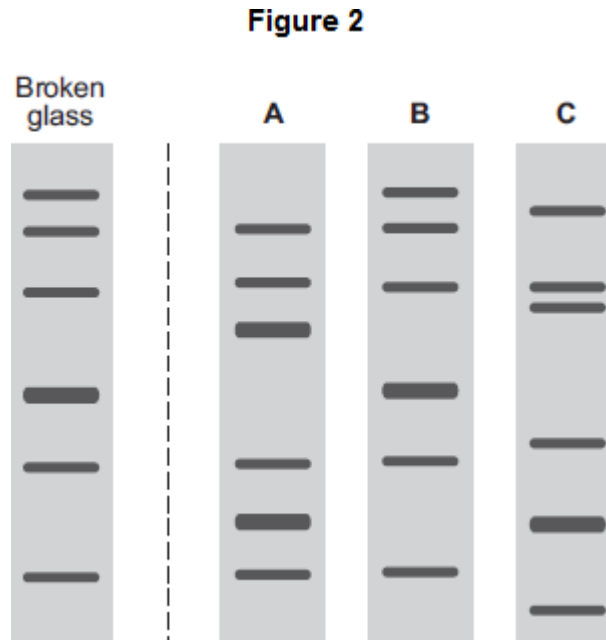
How many copies of the recessive CF allele are there in a body cell of this person?

(1)

- (c) A burglar broke into a house. The burglar cut his hand on some broken glass. Scientists extracted DNA from the blood on the broken glass.

The scientists analysed the DNA from the glass and DNA from three suspects, **A**, **B** and **C**. The scientists used a method called DNA fingerprinting.

Figure 2 shows the scientists' results.



Which suspect, **A**, **B** or **C**, is most likely to have been the burglar?

Tick (✓) **one** box.

A

B

C

(1)
(Total 6 marks)

Mark schemes

1

(a) any **three** from:

- (gene) cut out
- (gene / cut out) from (bacterial) chromosome / DNA
accept (gene / cut out) from (bacterial) plasmid
- ref to enzymes (at any point)
- (gene spliced) into maize chromosome / DNA
- (gene added) at an early stage of development

3

(b) any **four** from:

- justification based on comparison of the relative merits of at least one advantage and one disadvantage
max 3 marks if only advantages or disadvantages given

Advantages:

- less effort for farmer **or** less likely to harm farmer
ignore ref to cost
- (pesticide) always there **or** doesn't wash away
allow examples eg no need to spray
- less insects to eat crop / maize **or** carry disease
allow pesticide doesn't contaminate water courses
- so greater crop production / yield

Disadvantages:

- (toxin) kills other insects
ignore ref to cost
- so (some) crops don't get pollinated / (sexually) reproduce
allow maize not pollinated
- possible harm when eaten by humans / animals
allow may have unpleasant taste
- damage to food chains
allow reduced biodiversity
- gene may spread to other species

4

[7]

2

(a) lack of fossils / fossils destroyed

allow lack of evidence

1

(due to soft parts) decaying / geological activity

allow an example – eg vulcanism or earth movements or erosion

allow converse points re skeletons, shells, hard parts

1

(b) (i) **A** and **B** did not mate successfully
'A and B did not mate' insufficient
allow did not produce fertile offspring 1

(ii) any **two** from:

- may not be mating season
- **A** and **B** may not find each other attractive
- this is just a one-off attempt / an anomaly / need repeats
- may be juvenile / immature
- may be the same sex

allow other sensible suggestion eg were put in unfavourable environment or one / both could be infertile 2

(c) 1. (two ancestral populations) separated (by geographical barrier / by land) / were isolated 1

2. genetic variation (in each population) **or** different / new alleles **or** mutations occur 1

3. different environment / conditions
allow abiotic or biotic example 1

4. natural selection occurs **or** some phenotypes survived **or** some genotypes survived 1

5. (favourable) alleles / genes / mutations passed on (in each population) 1

6. eventually two types cannot interbreed successfully
allow eventually cannot produce fertile offspring 1

[11]

3

(a) (i) 3.15 : 1
accept 3.147:1 or 3.1 : 1 or 3 : 1
do not accept 3.14 : 1
Ignore 705:224 1

(ii) any **two** from:

- fertilisation is random **or** ref. to chance combinations (of alleles / genes / chromosomes)
- more likely to get theoretical ratios **or** see (correct) pattern **or** get valid results if large number
allow ref. to more representative / reliable
*do **not** allow more accurate **or** precise*
ignore fair / repeatable
- anomalies have limited effect / anomalies can be identified
accept example of an anomaly

2

(b) (i) in sequence:

Homozygous

Homozygous

Heterozygous

All 3 correct = 2 marks

2 correct = 1 mark

1 or 0 correct = 0 marks

2

(ii) genetic diagram including:

Parental genotypes: **Nn** and **Nn**

allow other characters / symbols only if clearly defined

1

or

Gametes: **N** and **n** + **N** and **n** derivation of offspring genotypes: **NN** **Nn** **Nn**
nn

allow genotypes correctly derived from candidate's P gametes

1

identification: **NN** and **Nn** as purple **and** **nn** as white

allow correct identification of candidate's offspring genotypes but only if some F₂ are purple and some are white

1

(c) any **two** from:

- did not know about chromosomes / genes / DNA
or did not know chromosomes occurred in pairs
ignore genetics
- had pre-conceived theories
eg blending of inherited characters
ignore religious ideas unless qualified
- Mendel's (mathematical) approach was novel concept
allow his work was not understood or no other scientist had similar ideas
- Mendel was not part of academic establishment
allow he was not considered to be a scientist / not well known / he was only a monk
- work published in obscure journal / work lost for many years
- peas gave unusual results of other species
allow he only worked on pea plants
- Mendel's results were not corroborated until later / 1900

2

[10]

4 (a) kills weeds among crops / does not kill crops

1

(kills weeds) so less competition for named factor eg light / water / ions
ignore space

1

crops grow better / higher yield

1

(b) (i) plasmid

1

(ii) use an enzyme
allow correct example

1

(iii) only some cells become GM / take up the plasmid / take up resistance gene
allow idea of transfer of gene / plasmid to some plant cells from bacteria

1

GM cells survive / non-GM cells are killed

1

- (c) Pro:
(positive) correlation between use of glyphosate and number of cases of kidney disease

allow 1 mark for justified conclusion that the claim is not justified

1

+ any **three** from:

Con:

- lack of controls / control group
- correlation does not prove a causal link
- some other factor could be the cause
accept obesity / infection
- no evidence that kidney patients actually consumed GM crops / crops treated with glyphosate / no evidence about amount consumed
or graph shows amount of herbicide not amount of GM crops grown
or graph shows data only for maize and soya / not for other (GM) crops
- data have been manipulated by carefully chosen scales to make it look like they coincide
- data from some years is missing
- no data for the dosage of herbicide used

allow kidney disease has been around for much longer than GM crops / better diagnosis of kidney disease.

3

[11]

5

- (a) (i) in the chromosome(s)

ignore genes / alleles

1

in the nucleus

allow nuclei

allow mitochondria

1

- (ii) the DNA / chromosomes / genes are replicated / copied / multiplied / doubled / duplicated

allow DNA is cloned

ignore same DNA / chromosomes / genes if unqualified

1

- (b) (i) 1 / one

1

- (ii) 2 / two

1

- (c) **B**

1

[6]