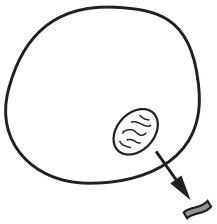
**40** The diagrams show the stages in the production of human insulin.

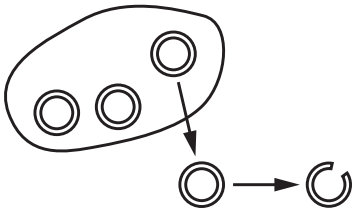
Which stage uses the enzyme DNA ligase?

**A**



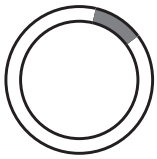
The gene for insulin is identified and removed from a human cell.

**B**



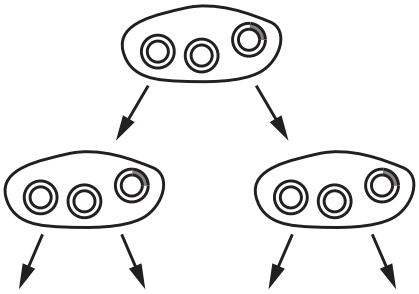
A plasmid is removed from a bacterium and cut open.

**C**



The gene for insulin is inserted into the plasmid.

**D**



The plasmid is inserted into a bacterium that reproduces, and insulin is produced.



**40** Human insulin can be produced in large quantities by genetically modified bacteria.

Four of the steps in the processes of genetic modification and insulin production are listed.

1 Insulin is removed from the bacterial culture.

2 An enzyme is used to cut out the insulin gene from a human chromosome.

3 The insulin gene is placed into the plasmid of a bacterium.

4 Bacteria with the insulin gene reproduce very rapidly.

What is the order of these steps?

**A** $1 \rightarrow 2 \rightarrow 3 \rightarrow 4$

**B** $2 \rightarrow 3 \rightarrow 4 \rightarrow 1$

**C** $3 \rightarrow 2 \rightarrow 4 \rightarrow 1$

**D** $4 \rightarrow 1 \rightarrow 2 \rightarrow 3$

**40** Some of the processes involved in the production of insulin by genetic modification are listed.

1 cutting of bacterial plasmid DNA with restriction enzymes

2 expression in bacteria of the human gene to make insulin

3 insertion of recombinant plasmids into bacteria

4 multiplication of bacteria containing recombinant plasmids

In which order do these processes occur?

**A** $1 \rightarrow 3 \rightarrow 4 \rightarrow 2$

**B** $2 \rightarrow 1 \rightarrow 3 \rightarrow 4$

**C** $3 \rightarrow 1 \rightarrow 2 \rightarrow 4$

**D** $4 \rightarrow 1 \rightarrow 3 \rightarrow 2$



**40** Some processes involved in the production of human insulin by genetic modification are listed.

1 insertion of the human insulin gene DNA into a cut bacterial plasmid

2 bacteria containing recombinant plasmids multiply and make human insulin

3 human insulin gene DNA is isolated using restriction enzymes

4 recombinant plasmids are inserted into bacteria

What is the sequence of these processes in genetic modification?

**A** $1 \rightarrow 3 \rightarrow 2 \rightarrow 4$

**B** $1 \rightarrow 4 \rightarrow 3 \rightarrow 2$

**C** $3 \rightarrow 1 \rightarrow 4 \rightarrow 2$

**D** $3 \rightarrow 2 \rightarrow 1 \rightarrow 4$

**3** Scientists developed genetically modified (GM) maize.

Fig. 3.1 shows the mass of GM maize grown in one country from 2000 to 2015.

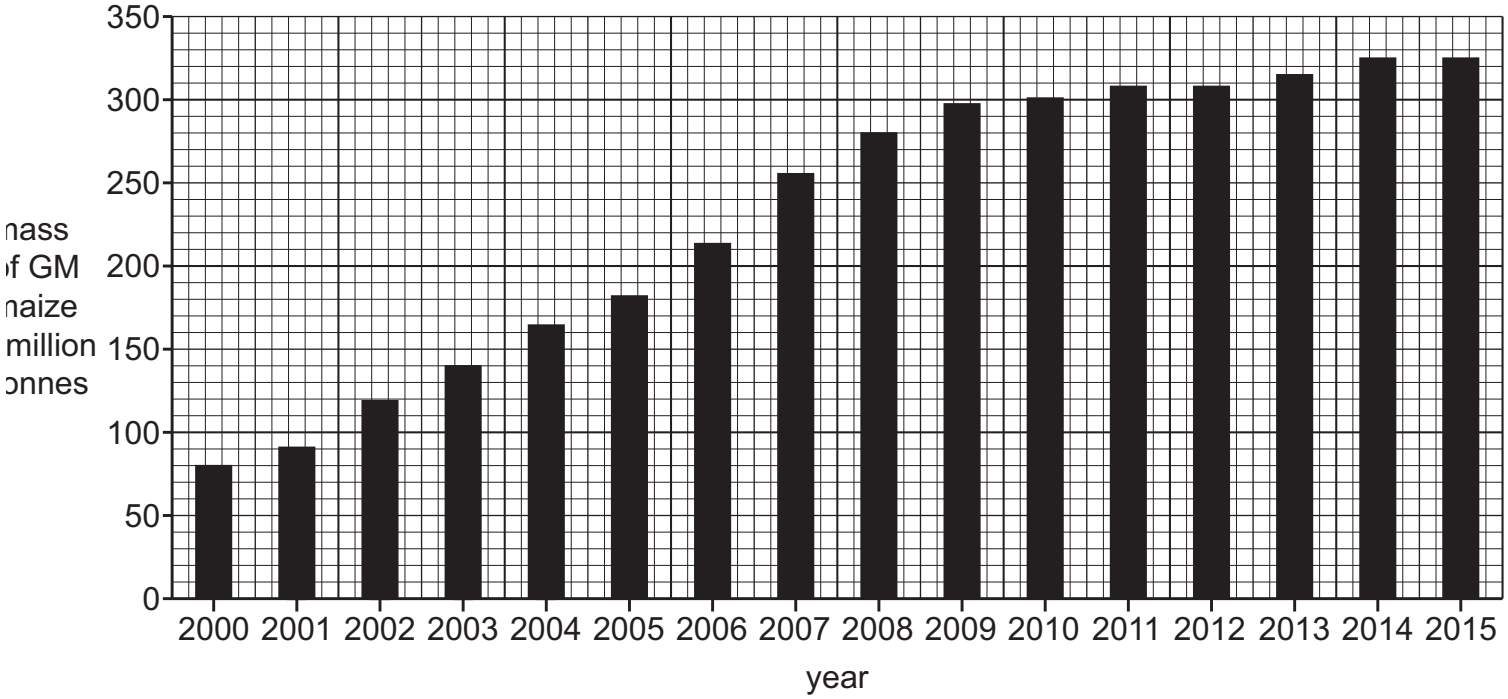



**Fig. 3.1**

**(a)** Calculate the percentage increase in the mass of GM maize grown between 2000 and 2015.

Give your answer to **two** significant figures.

Space for working.

..... % [3]

**(b)** To develop GM maize, a gene for producing a natural insecticide was taken from a bacterium and transferred into maize plant cells.

**(i)** Genes are found at specific positions on a biological molecule.

State the name of this biological molecule.

..... [1]

**(ii)** Scientists who develop GM crop plants breed them for many generations before allowing farmers to grow the crop plants.

Suggest why scientists breed the GM crop plants for many generations.

.....

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.....

..... [2]

**(iii)** Human proteins can also be made using bacteria that have been genetically modified.

Describe how a gene can be transferred from one organism to another using genetic modification.

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..... [6]

**(c)** Some people are worried that GM crops could pollinate wild plants.

**(i)** Suggest how pollination between GM crops and wild plants could be prevented.

.....

.....

..... [1]

**(ii)** State **two** advantages of GM crops **other than** insect resistance.

1 .....

2 .....
[2]

[Total: 15]



**40** The diagram shows a bacterial cell.

Which cell structure makes bacteria useful in genetic modification?