21 Biotechnology and genetic modification

21.1 Biotechnology and genetic modification

Core

1 State that bacteria are useful in biotechnology and genetic modification due to their rapid reproduction rate and their ability to make complex molecules

Supplement

2 Discuss why bacteria are useful in biotechnology and genetic modification, limited to:
   (a) few ethical concerns over their manipulation and growth
   (b) the presence of plasmids

21.2 Biotechnology

Core

1 Describe the role of anaerobic respiration in yeast during the production of ethanol for biofuels
2 Describe the role of anaerobic respiration in yeast during bread-making
3 Describe the use of pectinase in fruit juice production
4 Investigate and describe the use of biological washing powders that contain enzymes

Supplement

5 Explain the use of lactase to produce lactose-free milk
6 Describe how fermenters can be used for the large-scale production of useful products by bacteria and fungi, including insulin, penicillin and mycoprotein
7 Describe and explain the conditions that need to be controlled in a fermenter, including: temperature, pH, oxygen, nutrient supply and waste products

21.3 Genetic modification

Core

1 Describe genetic modification as changing the genetic material of an organism by removing, changing or inserting individual genes

Supplement

3 Outline the process of genetic modification using bacterial production of a human protein as an example, limited to:
   (a) isolation of the DNA making up a human gene using restriction enzymes, forming sticky ends
   (b) cutting of bacterial plasmid DNA with the same restriction enzymes, forming complementary sticky ends
   (c) insertion of human DNA into bacterial plasmid DNA using DNA ligase to form a recombinant plasmid
   (d) insertion of recombinant plasmids into bacteria (specific details are **not** required)
   (e) multiplication of bacteria containing recombinant plasmids
   (f) expression in bacteria of the human gene to make the human protein

2 Outline examples of genetic modification:
   (a) the insertion of human genes into bacteria to produce human proteins
   (b) the insertion of genes into crop plants to confer resistance to herbicides
   (c) the insertion of genes into crop plants to confer resistance to insect pests
   (d) the insertion of genes into crop plants to improve nutritional qualities

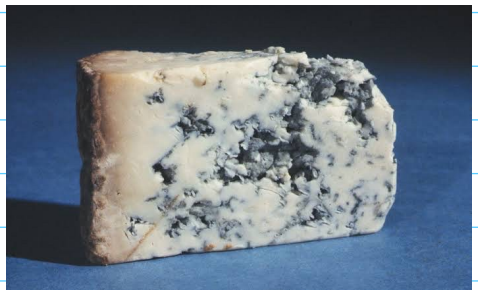
4 Discuss the advantages and disadvantages of genetically modifying crops, including soya, maize and rice

Biotechnology: A branch of biology in which we make life easy for humans.

Fungi

- Antibiotics → Penicillin
- Enzymes √√
- Bread & alcohol → Biofuels, sanitisers — Yeast
  Glucose → Alcohol + carbondioxide
- Cheese
- Mycoprotein (meat substitute)

Mushrooms



Blue cheese

Mycoprotein

Bacteria

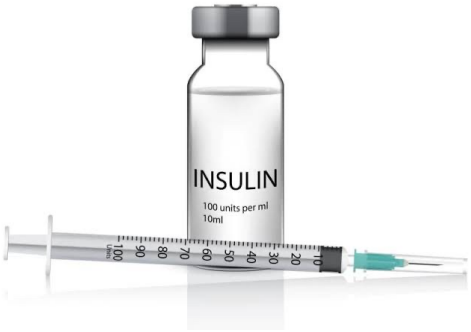
- Cheese → Mozrella
  → cheddar
- Enzymes
- Yogurt → Probiotics
- Genetic modification

Enzymes

- Meat tenderiser → Protease
- Lactose free milk → lactase
- Juice industry (pectinase & cellulase)
- Detergents (lipase, protease)
- Medical science (PCR, ELISA, forensics)
- Genetic modification

Genetic modification: A technique to modify DNA of an organism to get our desired characteristics in that organism.

Example



→

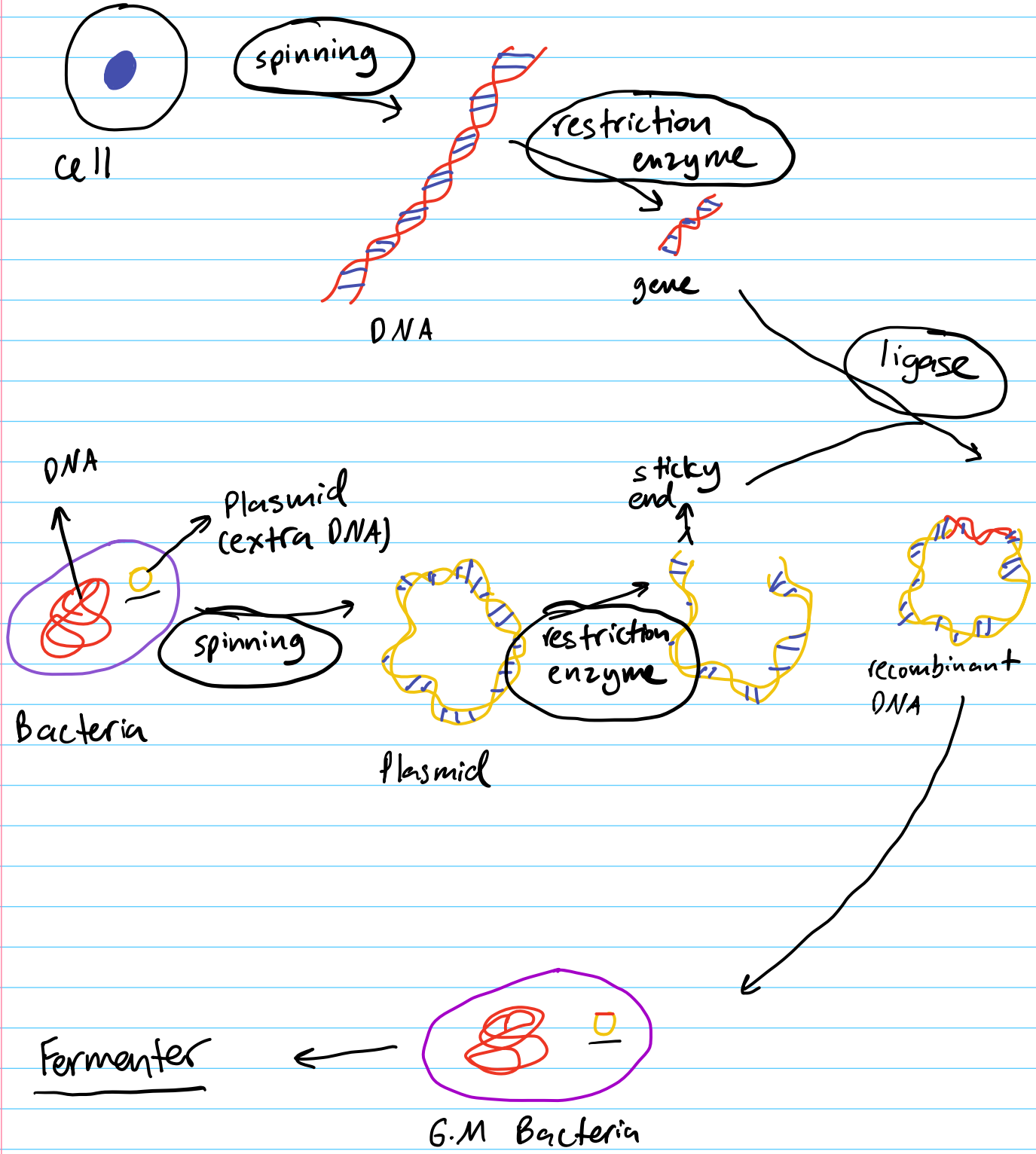
Benefits of GMOs

- Nutritional value of foods could be improved (e.g. by introducing proteins, vitamins or vaccines)
- Crops can be produced that lack known allergens
- Crops can grow in arid conditions for better yield (e.g. by introducing drought resistant genes)
- GM crops can produce herbicides to kill pests
- Improve food supply / agriculture in poor countries (GM crops can be engineered for improved yields)
- GM crops may have longer shelf lives (less spoil)
- Reduces economic costs and carbon footprint – less need for land clearing and pesticide usage

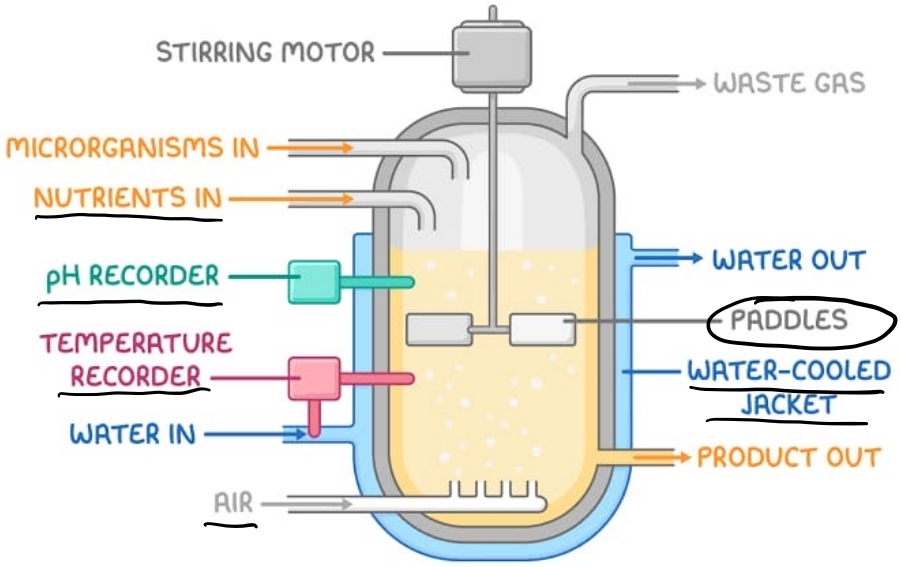
Risks of GMOs

- New traits could cause adverse health reactions (e.g. new proteins may cause allergic responses)
- Removal of traits could have unknown effects
- Crops may limit biodiversity of local environment (increased competition with native species)
- Cross pollination could lead to 'super weeds'
- Patents restrict farmers from accessing GM seeds (biotech companies hold monopolies over crop use)
- Foods with GM components may not be labeled
- Different governments may have conflicting regulatory standards concerning safe usage

The technique (Insulin)



Fermenter : Equipment to grow microbes in controlled environment.



1 **(a)** Define the term *genetic engineering*.

A technique / branch of biology in which we modify genetic material of organisms to get our desired characteristics. [2]

(b) Fig. 6.1 is a flow diagram that shows how insulin can be produced using genetic engineering.

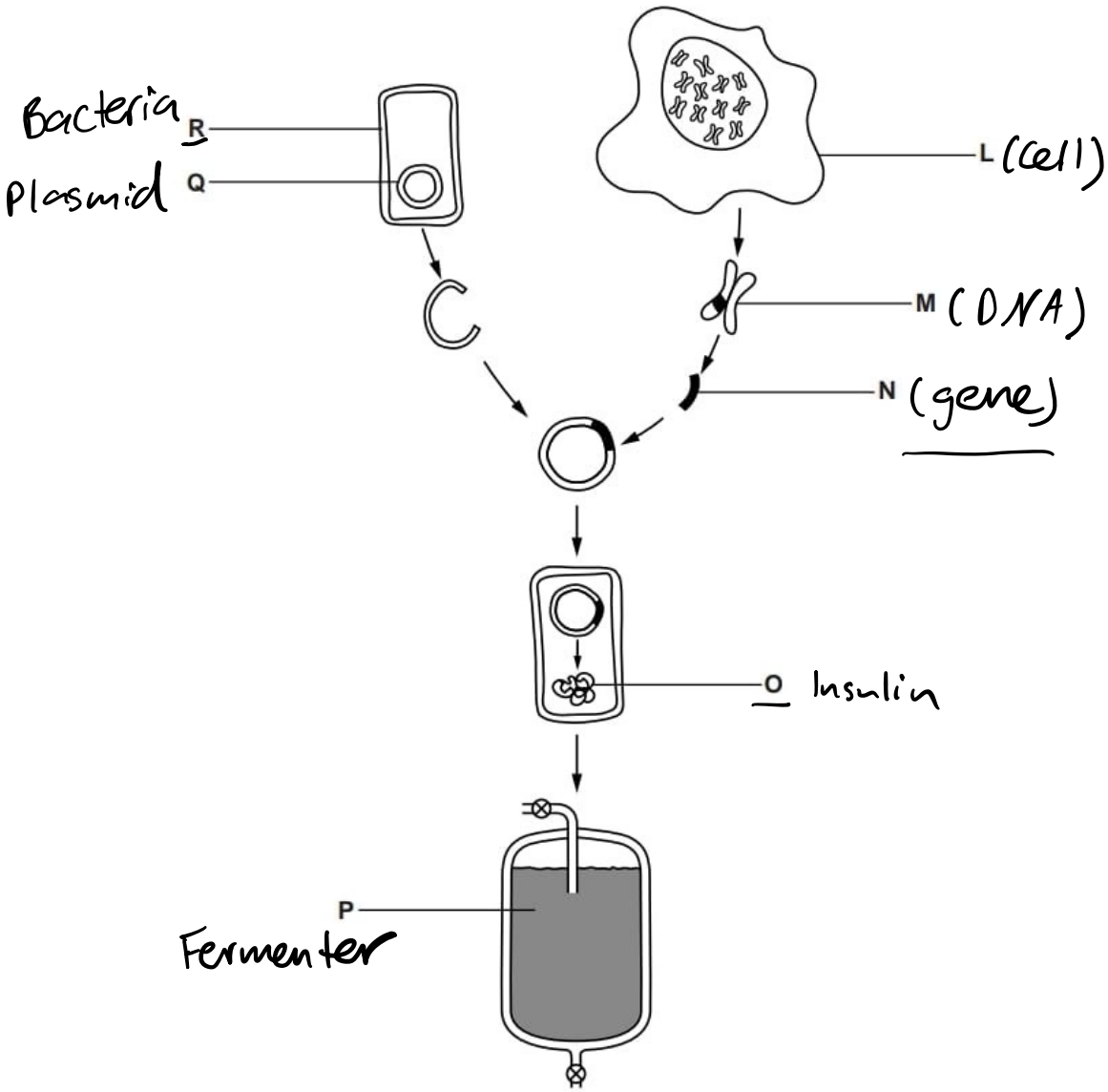


Fig. 6.1

Table 6.1 shows stages in the production of insulin by genetic engineering.

Complete Table 6.1. The first row has been done for you.

Table 6.1

letter from Fig. 6.1	name	description
M	chromosomes	threads of DNA found in the nucleus
N	gene	section of DNA removed from human cell
Q	plasmid	Extra DNA in bacteria
R	Bacteria	type of cell that is genetically engineered
O	Insulin	specific chain of amino acids coded by the section of DNA removed from the human cell
P	fermenter	Equipment to grow bacteria

[5]

(c) The genetically engineered cells in Fig. 6.1 reproduce asexually.

Explain the advantages of asexual reproduction for insulin production by genetic engineering.

- Fast
- Economical / cost effective
- We get our desired product

[3]

[Total: 10]

Insulin produced by genetically engineered bacteria first became available in 1982. Before 1982, insulin had been prepared from dead animal tissues.

Explain the **advantages** of using insulin produced by genetically engineered bacteria rather than insulin from dead animal tissues.

- Quick
- No allergic response
- Cost effective

[3]

Fig. 5.1 shows some of the steps involved in the genetic engineering of bacteria.

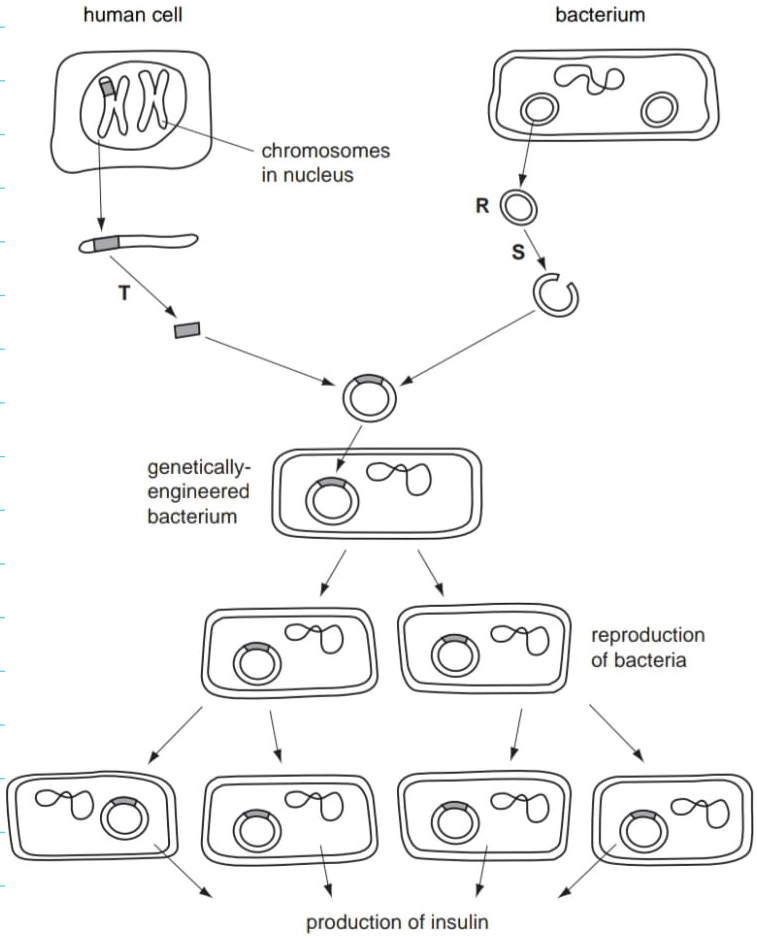


Fig. 5.1

(i) Name structure **R** and state what it is made from.

Plasmid [2]

(ii) State what is added at stages **S** and **T**.

Restriction enzyme [1]