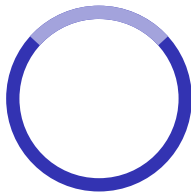


Biotechnology & Genetic Modification

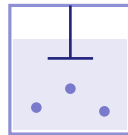
IGCSE Biology ■ Topic 21

IGCSE Biology



What we will cover

- 1 Why bacteria are useful
- 2 Yeast: biofuels & bread
- 3 Enzymes in industry
- 4 Fermenters
- 5 Genetic modification
- 6 GM examples



stirred, warm, sterile

fermenters

1

Biotechnology

Why bacteria are useful

reproduce
very fast

make complex
molecules

contain
plasmids 质粒

Biotechnology 生物技术 uses living things (or their **enzymes** 酶) to make useful products.



Biotechnology uses living systems for products

Why bacteria are the tool of choice

they reproduce fast

a population doubles in minutes, so a useful gene is copied millions of times cheaply

simple requirements

they grow on inexpensive nutrients in a **fermenter** 发酵罐

plasmids 质粒

small **rings of DNA** that are easy to remove, cut and put back – the vehicle for the new gene

few ethical 伦理 concerns

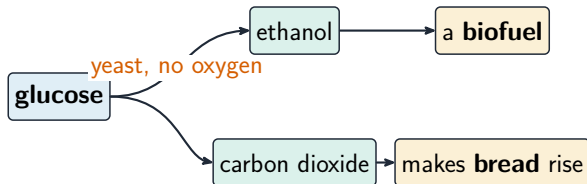
(Supplement) growing bacteria raises far fewer objections than modifying animals

they lack a nucleus

so the plasmid is directly accessible

Plasmids are the whole reason bacteria are used. They are the only easily removable, easily reinserted piece of DNA a cell offers.

Yeast: biofuels and bread



- the ethanol can be used as a **biofuel** 生物燃料.
- in bread-making, the carbon dioxide makes the dough rise.

Enzymes in industry

- **pectinase** 果胶酶 – more, clearer fruit juice
- proteases & lipases – wash out stains
- **lactase** 乳糖酶 – lactose-free milk

pectinase $\longrightarrow$ more fruit juice

protease + lipase $\longrightarrow$ wash out stains

lactase $\longrightarrow$ lactose-free milk

Three industrial enzymes

pectinase 果胶酶

breaks down cell walls to **release more juice** from fruit – more juice, and clearer

biological washing powder 生物洗衣粉

contains protease and lipase, which digest protein and fat stains at **low** temperatures

lactase 乳糖酶

(Supplement) breaks down **lactose 乳糖** to make **lactose-free milk**, for people who cannot digest it

the shared advantage

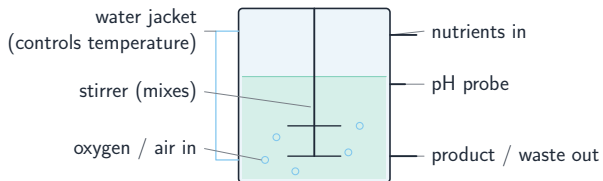
enzymes work at low temperature and pressure, so they save energy

the shared limitation

they are proteins, so they **denature** if the process runs too hot or at the wrong pH

Each enzyme is chosen for the **one bond** it breaks. Naming the substrate and the product is what the question is actually asking.

Fermenters



A **fermenter** 发酵罐 grows microbes to make **insulin** 胰岛素, **penicillin** 青霉素 & **mycoprotein** 真菌蛋白.

Control the temperature, pH, oxygen, nutrients & waste removal.

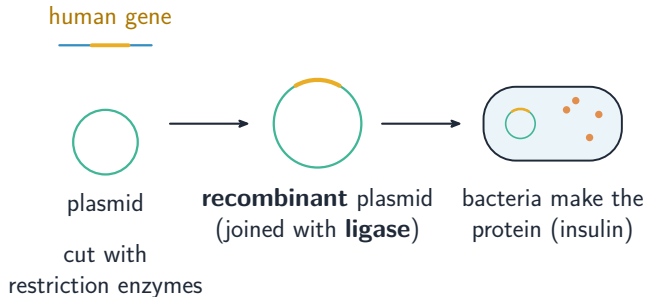
2

Genetic modification

Genetic modification

Genetic modification 基因改造 moves genes between organisms:

- 1 **restriction enzymes** 限制酶 cut (sticky ends)
- 2 **ligase** 连接酶 joins the gene into a plasmid
- 3 bacteria **express** 表达 it → the protein



GM examples

human **insulin** 胰岛素 from bacteria

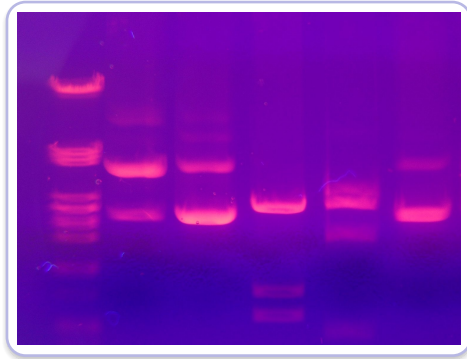
herbicide 除草剂-resistant crops

insect-pest-resistant crops

crops with better nutrition

GM crops can give higher **yields** 产量, but raise worries about health, wild species & cost.

DNA bands on an electrophoresis gel



DNA fragments separated by gel electrophoresis appear as glowing bands

Genetic modification, and what it is used for

genetic modification 基因改造

changing an organism's **genetic material** 遗传物质 by removing, changing or inserting individual genes

the steps

cut the gene out with an enzyme, insert it into a plasmid, put the plasmid into a bacterium, and let the bacterium multiply

insulin

human insulin made by bacteria – pure, plentiful, and free of animal-source objections

crop plants 农作物

genes inserted for herbicide tolerance, insect **resistance** 抗性, or improved food value

the concerns

effects on wild species, the cost of seed to small farmers, and long-term safety

The exam wants the **mechanism** – gene, enzyme, plasmid, bacterium – and then one benefit and one concern. All three parts are marked.

Exam tips

- Bacteria are used because they reproduce fast, make complex molecules, and contain plasmids.
- Yeast (anaerobic respiration) → ethanol (biofuel) and carbon dioxide (bread).
Enzymes: pectinase (fruit juice), proteases and lipases (washing powders), lactase (lactose-free milk).
- Fermenters make insulin, penicillin and mycoprotein; control temperature, pH, oxygen, nutrients and waste.
- Genetic modification: cut a gene with restriction enzymes (sticky ends) → join it into a plasmid with ligase (a recombinant plasmid) → put into bacteria → express the gene to make the protein.
- GM crops can resist herbicides or insect pests, or have better nutrition.

3

Recap

Worked example – making human insulin

Outline how bacteria are made to produce human insulin.

- Cut out the **human insulin gene** with a **restriction enzyme** 限制酶, leaving sticky ends.
- Cut a bacterial **plasmid** with the **same** enzyme, so the ends match.
- Join gene into plasmid with **DNA ligase** ⇒ recombinant plasmid.
- Put it into a bacterium and grow them in a **fermenter**: they read the gene and **make real human insulin**.

Use the **same restriction enzyme** on both, or the sticky ends will not match. The insulin is **identical** to human insulin, so fewer allergic reactions.

Topic 21 – key takeaways

1

Bacteria

fast, complex molecules, plasmids

2

Yeast

ethanol (biofuel) & CO₂ (bread)

3

Fermenter

insulin, penicillin; controlled conditions

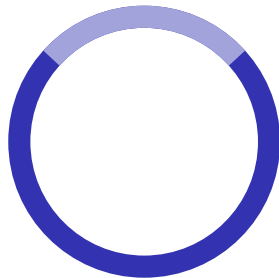
4

GM

cut with restriction enzymes, join with ligase

Check yourself

- 1 Why are bacteria useful in biotechnology?
- 2 What two products does yeast make?
- 3 What enzyme cuts out a gene?
- 4 Name one use of genetic modification.



Answers 1. fast, make complex molecules, have plasmids 2. ethanol & carbon dioxide
3. a restriction enzyme 4. e.g. making insulin