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.

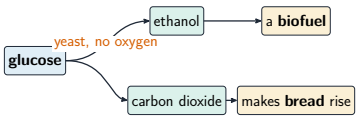
Biotechnology uses living systems for products

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 ⟶ more fruit juice

protease + lipase ⟶ wash out stains

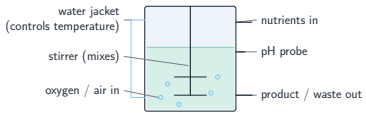
lactase ⟶ lactose-free milk

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.

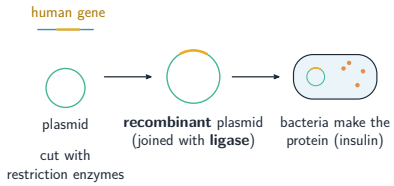
Control the temperature, pH, oxygen, nutrients & waste removal.

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

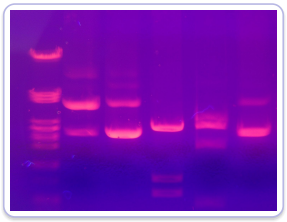


GM examples

- 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.

Genetic modification, continued



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

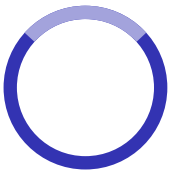
2 Yeast
ethanol (biofuel) & CO_2 (bread)

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