Biotechnology and Genetic Modification

The use of yeast and bacteria, fermenters, enzymes in industry, genetic modification and its uses in bacteria and crop plants, and the advantages and risks.

21.2 Biotechnology

Biotechnology is the use of living organisms, or substances from them, to make useful products.

Yeast

Yeast is a single-celled fungus. It respires **anaerobically** when there is no oxygen (fermentation):

$$\text{glucose} \rightarrow \text{ethanol} + \text{carbon dioxide}$$

- **Bread:** yeast ferments the sugar in the dough. The **carbon dioxide** makes bubbles that make the dough **rise**. (The ethanol evaporates during baking.)
- **Ethanol (alcoholic drinks and biofuel):** the **ethanol** made by yeast is used in alcoholic drinks, and as a fuel.

Bacteria

> **Bacteria are useful in biotechnology and genetic modification because they have a rapid reproduction rate and are able to make complex molecules such as proteins.**

Further reasons:

- there are **no ethical concerns** over their manipulation and growth (unlike animals);
- they contain **plasmids**, which can be used to carry new genes (in genetic modification).

Fermenters

A **fermenter** is a large container in which bacteria or fungi are grown on a large scale to make a useful product, such as an antibiotic, a hormone or an enzyme.

The conditions that must be **controlled** to give the best rate of growth and product:

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Condition	Why
temperature	enzymes work best at the optimum temperature (a water jacket cools the vessel, since respiration releases heat)
pH	enzymes work best at the optimum pH
oxygen	needed for aerobic respiration (air is pumped in)
nutrient supply	glucose, nitrogen sources and minerals for growth
waste products	removed, because they could poison the culture or slow growth

A **stirrer** mixes the contents so that the microorganisms get nutrients and oxygen and the temperature is even.

Enzymes in industry

Enzyme	Use
in biological washing powders (proteases, lipases)	digest proteins and fats in stains, so that clothes are cleaned at **lower temperatures**
pectinase	breaks down pectin in fruit cell walls, so more **fruit juice** is released and it is clearer
lactase	breaks down lactose to glucose and galactose, to make **lactose-free milk** for people who are lactose intolerant

21.3 Genetic modification

> **Genetic modification** is **changing the genetic material of an organism** by **removing, changing or inserting individual genes**.

Making human insulin

The **gene that controls the production of human insulin** is cut from human DNA and **inserted into the DNA of bacteria** (using a plasmid). The bacteria are grown in fermenters, and they make **human insulin**, which can be collected and used to treat diabetes. The insulin is cheaper and purer than that taken from animals.

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Genetically modified crop plants

Genes can be inserted into crop plants:

- to give resistance to **herbicides** (so that weeds can be killed without damaging the crop);
- to give resistance to **insect pests** (so less insecticide is needed);
- to provide **additional vitamins** (for example "golden rice", which contains extra vitamin A).

Advantages and risks

Advantages	Risks
a **higher yield**, so more food	the gene may spread to wild plants (for example, herbicide resistance spreading to weeds)
less insecticide used	possible harm to **other organisms** (for example insects that are not pests)
food with **more nutrients**	possible effects on **human health** (allergies), not fully known
crops grow in difficult conditions	**cost**: the seeds are expensive, and farmers may have to buy them each year
bacteria can make useful products such as insulin	loss of biodiversity if only GM crops are grown

> **TRY IT**
>
> Why are bacteria used to make human insulin?

Bacteria **reproduce rapidly**, can **make complex molecules** such as proteins, have **plasmids** that can carry the human gene, and there are **no ethical concerns** about growing them.

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