

21 Biotechnology & Genetic Modification

21.1 Bacteria

Reasons **bacteria** are used in biotechnology & genetic modification

- Rapid reproduction rate
- Offspring are genetically identical
- Able to make complex molecules
- There are few ethical concerns over their manipulation and growth
- They have **plasmids** (circular loops of DNA used to easily transfer DNA from one cell to another during genetic manipulation)

21.2 Biotechnology

Uses of Biotechnology

- **Biofuels** → **yeast** respires anaerobically to produce **ethanol** for biofuels
 - glucose $C_6H_{12}O_6 \rightarrow$ ethanol $2C_2H_5OH$ + carbon dioxide $2CO_2$
- **Bread** → **yeast** respires anaerobically to produce **carbon dioxide**, which causes bread to rise
- **Fruit Juice** → the enzyme **pectinase** is added to chopped fruit, to break down **pectin** in **cell walls** and release more juice
- **Biological Washing Powders** → contains **enzymes (e.g. proteases, lipases)** to remove stains from organic molecules
 - Quickly breaks down large, insoluble molecules into smaller, soluble molecules (e.g. amino acids, glycerol, fatty acids) that will dissolve in washing water
 - Effective at lower temperatures → less energy (and money) used to wash/clean clothes as washing water does not need to be heated to higher temperatures
 - Can be used on delicate fabrics that would not be suitable for washing at high temperatures
- **Lactose-free milk** → adding the enzyme **lactase** to milk breaks down lactose

Fermenters

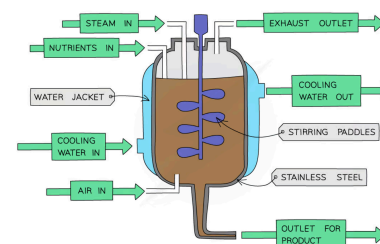
Fermenters are containers used to grow/culture microorganisms (bacteria/fungi) on a large scale

- **Penicillin** (antibiotic) from **penicillium** (fungus)
- **Mycoprotein** (food) from **fungus (Fusarium)**
- **Insulin** (treatment for diabetes) from **bacteria** with **gene** for human insulin

1. The **fungus** is put in a fermenter kept at the optimum pH and temperature (using probes, water jacket, adding acids/alkalis)
2. It is grown in aerobic conditions (provided with oxygen) and provided with sugars (for aerobic respiration)
3. It is stirred using stirring paddles
4. It grows and multiplies exponentially within the fermenter
5. The product is removed & purified from waste/toxins
 - a. **Penicillin** produced is made into pills / packaged

Controlled Conditions in a Fermenter

- **Temperature:** monitored using **probes** and maintained using a **water jacket**
 - Maintain optimum temperature for **enzyme activity** → to prevent **overheating & denaturation**
 - Fungus **releases heat** as it **respires** which would **kill fungus** and result in **no product**
- **pH:** monitored using **probes** and maintained using **acids/alkalis**
 - Maintain optimum pH for **enzymes** → to ensure **maximum enzyme activity** for **maximum yield**
- **Oxygen:** required for **aerobic respiration** to take place
- **Nutrient supply:** needed for use in **respiration** to **release energy** for **growth & reproduction** of the microorganisms
 - **Stirring paddles** are used to ensure temperature, pH, nutrients, and oxygen are distributed evenly
 - **Steam** kills pathogens, **prevents contamination**, but **does not contaminate product**
- **Waste products** are removed
 - **Carbon dioxide** is a waste gas produced during **respiration**
 - Must be removed to **reduce pressure** & buildup is **toxic** to fungus



21.3 Genetic Modification

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

- The DNA of the organism that now contains DNA from another organism as well is known as **recombinant DNA**

Examples of Genetic Modification

- Human genes are inserted into **bacteria** to produce **human proteins**
 - e.g. gene for human insulin is inserted into bacteria which then **produce human insulin** → collected and purified for medical treatment of **diabetes**
- Genes are inserted into **crop plants** to make them **resistant to herbicides** (herbicide will only kill **weeds** without affecting crop)
- Genes are inserted into **crop plants** to make them **resistant to insect pests** (produces poison that kills pests)
- Genes are inserted into **crop plants** to **improve nutritional qualities** (e.g. **golden rice** contains genes that make it produce a chemical which turns into **vitamin A** in the human body)

Advantages & Disadvantages of Genetically Modifying Crops e.g. soya, maize and rice	
+ Crops have <u>disease resistance, herbicide resistance, pest resistance</u> → increases yield & income + Crops have <u>improved nutritional qualities</u> → prevents deficiency diseases in humans + Reduces use of chemicals e.g. herbicides & pesticides is better for the environment	- Cost of GM seeds is higher - Smaller farms cannot compete with larger ones - Increases <u>dependency on chemicals</u> e.g. herbicides that the crops are resistant to - Risk of inserted genes being <u>transferred to weeds</u> which makes them also resistant to herbicide - Pest resistance <u>reduces biodiversity</u> → impacts insects and insect-eating birds

Process of Genetic Modification (e.g. bacterial production of a human protein) ✓

1. **Restriction enzymes** are used to isolate the required **gene**, forming **sticky ends**
2. A **bacterial plasmid** is cut by the same restriction enzyme, forming **complementary sticky ends**
3. The **gene** is inserted into the **bacterial plasmid** using **DNA ligase** to form a **recombinant plasmid**
4. The **recombinant plasmid** is inserted back into **bacteria**
5. The **bacteria** containing recombinant plasmids multiply & all express the **gene** that can produce human protein

