CIE Biology GCSE

20: Biotechnology and genetic engineering

Notes

Genetic engineering is the process of **artificially altering genes** in a cell to change the way it works. This could be to make the cell perform a **desired function**, such as making a specific protein, or to make the cell **resistant** to different factors. For example, some strawberries have been genetically modified to become resistant to frost by inserting a gene taken from cold water fish which makes antifreeze proteins.

Genetic engineering and bacteria:

Bacteria are useful to genetic engineering as they **reproduce very rapidly** but still have the **ability to produce complex molecules**. Bacteria contain **plasmids**, which are circular rings of DNA, into which new genes can be **inserted, removed or changed**. There are also **no ethical concerns** about manipulating the DNA of bacteria.

Bacteria can be manipulated to **produce human proteins**, such as insulin:

1. The gene which codes for the desired protein is **located** and **isolated** using **restriction enzymes**. The isolated gene has "**sticky ends**".
2. The plasmid from the bacterial cell is cut with the same restriction enzymes. This leaves complementary sticky ends to the isolated gene.
3. The gene is inserted into the plasmid. The **complementary sticky ends** are joined using the enzyme **DNA ligase**. This forms a **recombinant plasmid**.
4. This plasmid is inserted into the bacteria, which will then produce this protein as the inserted gene is **expressed**.
5. The bacterial cell **reproduces**, making more cells which produce the protein.

Examples of genetic engineering:

- **Insulin production** - people with diabetes must take insulin to regulate their blood-glucose concentration. Insulin was originally harvested from animals, such as pigs, although this had slight differences to human insulin, which made some people allergic to it. Genetic engineering has allowed human insulin to be made in bacteria cells. This produces cheap, human insulin in high quantities.
- **Herbicide and insect resistant plants** - genes can be inserted into plants to make them resistant to herbicides and insects. This means that less crops die, so farmers have a larger crop yield.
- **Vitamin-rich plants** - some plants can be genetically modified to increase the number of vitamins in them. This is beneficial to places where certain vitamins are hard to find to reduce vitamin deficiency. For example, "golden rice" is a type of rice that has been genetically modified to produce beta carotene, which humans use to produce vitamin A. This reduces vitamin A deficiency in some areas.

Disadvantages of genetic engineering:

- **Loss of biodiversity**.
- Potential development of weeds that are **resistant** to herbicides.
- GM crops are more **expensive**.
- GM crops may **contaminate wild species** by crossbreeding.
- Long-term **health impacts not known**.

Biotechnology:

Biotechnology involves using **microorganisms and biological substances** to carry out functions in manufacturing processes:

- **Yeast** is a microorganism which can **respire anaerobically** (without oxygen) to **release carbon dioxide**. This can be used in bread-making to make dough rise as bubbles of carbon dioxide form. **Ethanol** is also released during this reaction, which can be used to make **biofuels** that are used as an **alternative to fossil fuels**.

- **Pectinase** is an **enzyme** used in **fruit juice production**. Pectinase **breaks down pectin**, which is found in **plant cell walls** and is used to hold the cell wall together. Adding pectinase therefore breaks down these walls to release the contents of the cell, which **increases the yield of fruit juice**.

- **Biological washing powders** contain **enzymes** to break down different molecules. Amylases break down starch, lipases break down fats and oils, and proteases break down proteins. Enzymes break these into **smaller products** that are **water soluble**, thus can be washed out easily. As enzymes are **denatured** at high temperatures and extreme pH, a lower washing temperature is needed, and the enzymes may not work in acidic or alkaline water.

- The enzyme **lactase** can be used to make **lactose-free milk**. When lactase is added to milk, it breaks down the lactose into **glucose and galactose**, which can be safely consumed by lactose-intolerant people.

- **Penicillium** is a fungus used to produce **penicillin**, an **antibiotic**. The fungus is placed in a **fermenter** to keep it at the optimum temperature and pH, so the penicillin yield is high. There is also an air inlet so that aerobic respiration can take place, and all other microorganisms are killed to limit contamination and competition.