GRADE 9
CHAPTER # 21

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.

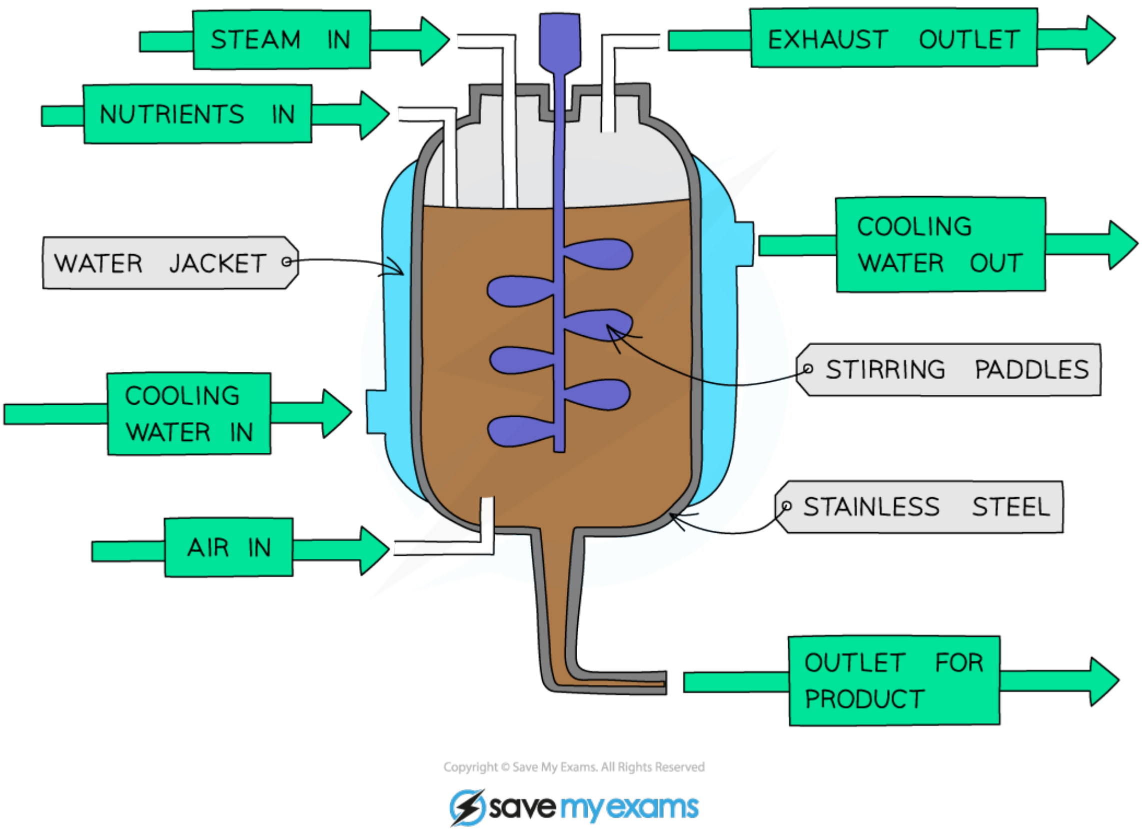
● **Pectinase** is an enzyme used in fruit juice production. Pectinase breaks down pectin, which is found in plant cell walls and is used to hold the cell wall together. Adding pectinase therefore breaks down these walls to release the contents of the cell, which increases the yield of fruit juice.

● **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.

PENICILLIN PRODUCED BY THE FUNGUS PENICILLIUM INHIBITS BACTERIAL GROWTH

- The chemical was isolated and named **penicillin**
- Since the discovery of penicillin, methods have been developed to **produce it on a large scale**, using an **industrial fermenter.**



A DIAGRAM OF AN INDUSTRIAL FERMENTER USED TO PRODUCE LARGE QUANTITIES OF MICROORGANISMS

- The chemical was isolated and named penicillin
- Since the discovery of penicillin, methods have been developed to produce it on a large scale, using an industrial fermenter
- Fermenters are containers used to grow ('culture') microorganisms like bacteria and fungi in large amounts
- These can then be used for many biotechnological processes like producing genetically modified bacteria and the penicillium mould that produces penicillin.
- The advantage of using a fermenter is that conditions can be carefully controlled to produce large quantities of exactly the right type of microorganism

Condition	Why and how it is controlled
Aseptic precautions	Fermenter is cleaned by steam to kill microorganisms and prevent chemical contamination, which ensures only the desired microorganisms will grow
Nutrients	Nutrients are needed for use in respiration to release energy for growth and to ensure the microorganisms are able to reproduce
Optimum temperature	Temperature is monitored using probes and maintained using the water jacket to ensure an optimum environment for enzymes to increase enzyme activity (enzymes will denature if the temperature is too high or work too slowly if it is too low)
Optimum pH	pH inside the fermenter is monitored using a probe to check it is at the optimum value for the particular microorganism being grown. The pH can be adjusted, if necessary, using acids or alkalis.
Oxygenation	Oxygen is needed for aerobic respiration to take place
Agitation	Stirring paddles ensure that microorganisms, nutrients, oxygen, temperature and pH are evenly distributed throughout the fermenter

GENETIC ENGINEERING

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.

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.

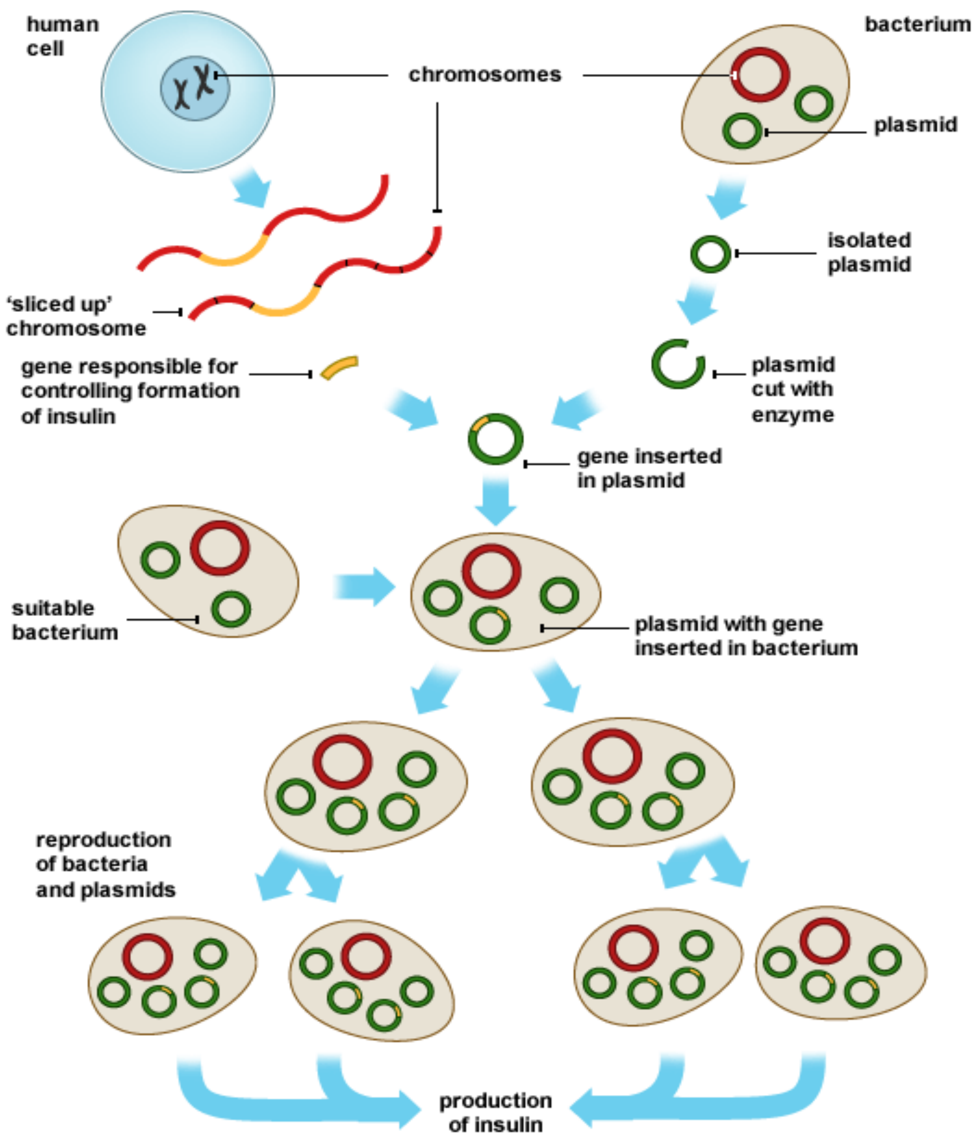
3. The gene is inserted into the plasmid. The **complementary sticky ends** are joined using

   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 prote



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**.