

Selective breeding and genetic modification

Revision notes · How selective breeding improves plants and animals, and how genetic engineering uses enzymes and vectors to make insulin and GM crops.

For Pearson Edexcel International GCSE Biology 4BI1 and Science (Double Award) 4SD0. **Biology only** is not in the Double Award and is only examined on Paper 2.

Selective breeding and genetic modification Spec 5.10–5.16

Selective breeding of plants and animals Spec 5.10, 5.11

Selective breeding is when humans choose which organisms to breed so that the desired characteristics are passed on to the next generation. It has been used for thousands of years to develop plants and animals with useful features.

1. Decide which characteristic is wanted, for example high milk yield or disease resistance.
2. Choose parents that show the characteristic most strongly and breed them together.
3. From the offspring, select those with the characteristic and breed them together.
4. Repeat over many **generations** until the desired characteristic is strongly shown.

Examples of selective breeding

Organism type	Characteristics selected for
Food plants (crops)	Disease resistance, larger fruit or grains, better taste, higher yield
Domesticated animals	More milk, more meat, more eggs, a gentle nature, wool quality

Impact of selective breeding

- Food plants and animals give **higher yields**, so more food can be produced from the same land.
- Crops can be bred to resist disease, so less is lost.
- Breeding from only a few individuals reduces **genetic variation** in the population. If a new disease or a change in the environment appears, all individuals may be affected.
- Closely related individuals are bred together (inbreeding), which can make harmful inherited conditions more common in domesticated animals.

Exam tip: Always say that selection is repeated over many generations. Mark schemes award a mark for this.

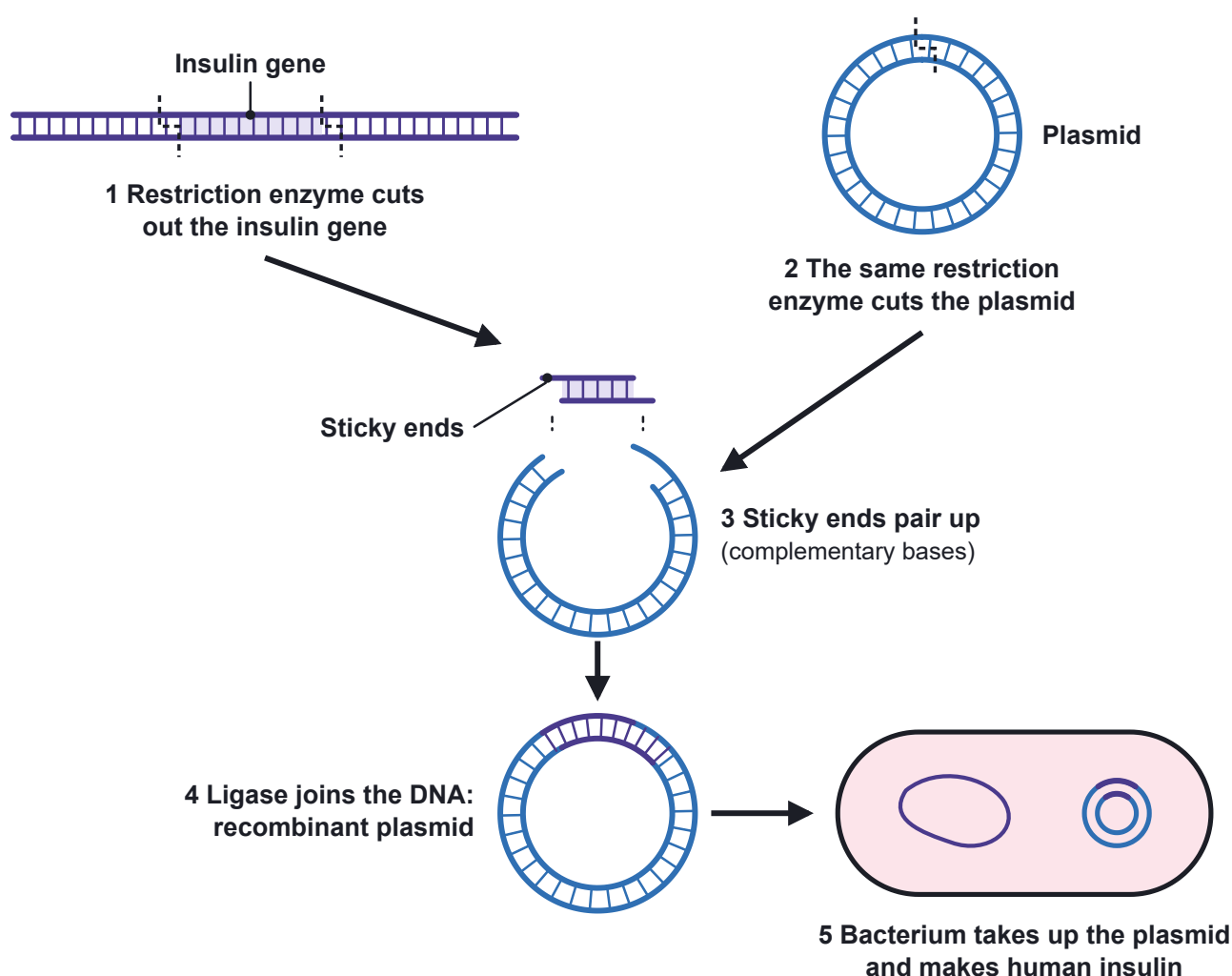
Restriction enzymes, ligase and vectors Spec 5.12, 5.13, 5.16

Genetic engineering modifies the genome of an organism to introduce desirable characteristics. A gene is usually taken from one species and put into a different species. This is what **transgenic** means: the transfer of genetic material from one species to a different species.

1. The gene for the desired characteristic is cut out of the chromosome of the donor organism using a **restriction enzyme**. Each restriction enzyme cuts DNA at a specific sequence of bases.
2. The cut leaves short, unpaired strands of DNA at each end. These are called **sticky ends**.
3. The **vector** is cut open using the same restriction enzyme, so it has matching sticky ends. A vector is a carrier that takes up the DNA, such as a bacterial plasmid or a virus.

- The gene and the vector are mixed. The sticky ends join by complementary base pairing, and the enzyme **ligase** joins the DNA strands together. This makes recombinant DNA, for example a recombinant plasmid.
- The vector inserts the recombinant DNA into the cells of the target organism. The cells now make the protein coded for by the new gene.

Restriction enzyme	An enzyme that cuts DNA at a specific base sequence.
Ligase	An enzyme that joins pieces of DNA together.
Vector	A plasmid or virus that takes up a piece of DNA and inserts this recombinant DNA into other cells.
Transgenic	Describes an organism with genetic material transferred from one species to a different species.



The same restriction enzyme gives matching sticky ends; ligase joins them to make a recombinant plasmid.

Exam tip: Use the same enzyme to cut both the gene and the vector. That gives matching sticky ends. Ligase then does the joining.

Human insulin from genetically modified bacteria Spec 5.14

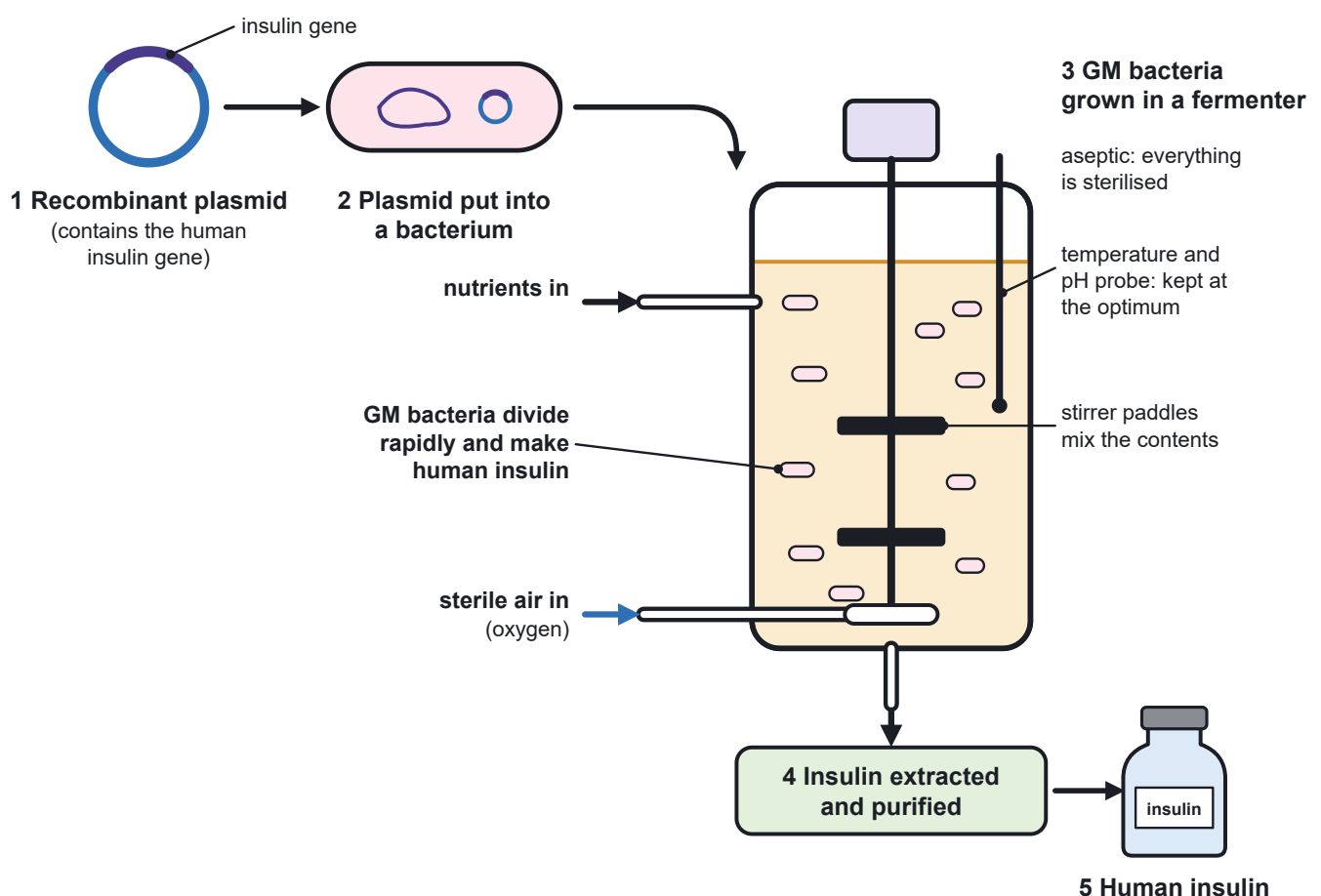
People with type 1 diabetes need insulin. Large amounts of **human insulin** can be made by genetically modified (GM) bacteria grown in a **fermenter**.

- The human gene for insulin is cut out of human DNA using a restriction enzyme.

2. A plasmid is cut with the same restriction enzyme, the gene is inserted and ligase joins the DNA. This makes a recombinant plasmid.
3. The recombinant plasmid is put into bacteria. These GM bacteria now contain the human insulin gene.
4. The bacteria are grown in a fermenter, where they divide rapidly to make huge numbers of bacteria.
5. The bacteria make human insulin. The insulin is then extracted and purified before it is used to treat people with diabetes.

Conditions in the fermenter

- Aseptic precautions, so that other micro-organisms do not contaminate the culture.
- A supply of nutrients for growth.
- An optimum temperature and pH for the bacteria.
- Oxygen supplied, and the contents stirred (agitated) so that nutrients and oxygen are mixed evenly.



GM bacteria grown in a **fermenter** make large amounts of **human insulin**.

Exam tip: Bacteria are used because they reproduce very quickly, so a large amount of insulin is made in a short time.

Genetically modified plants Spec 5.15

Genetically modified plants can be used to improve food production. A gene for a useful characteristic is transferred into a crop plant, so the crop has that characteristic.

A well-known example is the gene from the bacterium *Bacillus thuringiensis* (Bt) put into crop plants. The gene codes for a **toxin** that kills many insect pests. The plants make the toxin themselves and so

have **insect resistance**.

Advantages and disadvantages of GM crops	
Advantages	Disadvantages
Less crop is lost to pests, so yields are higher	Possible risk to human health, which some people worry about
Less insecticide needs to be sprayed, which saves money and reduces damage to other organisms	Genes may spread to wild plants, and the toxin might harm other insects
Crops can be given extra characteristics, such as greater nutritional value or resistance to disease	GM seeds can be expensive
More food can be produced for a growing population	Concerns that it is wrong or unnatural to change the genes of organisms

Exam tip: Structure 'advantages and disadvantages' answers as a balanced argument. Link each point to the crop, the farmer, people or the environment.

Quick check

1. What is selective breeding?
2. Which enzyme cuts DNA at specific sites?
3. Which enzyme joins pieces of DNA together?
4. What does transgenic mean?
5. Where are GM bacteria grown to make large amounts of insulin?

Quick check answers

Selective breeding and genetic modification

- 1 . Humans choosing which organisms to breed so that desired characteristics are passed on to the next generation.
- 2 . A restriction enzyme.
- 3 . Ligase.
- 4 . The transfer of genetic material from one species to a different species.
- 5 . In a fermenter.