Genetic engineering

4.6.2.4 · Inheritance, variation and evolution · revision notes

Genetic engineering modifies an organism's genome by introducing a gene from another organism to give a desired characteristic, for example bacteria that make human insulin and GM crops. Everyone needs the uses, benefits, risks and objections; Higher tier students must also describe the main steps.

Key facts

- Genetic engineering = introducing a gene from another organism to give a desired characteristic
- GM crops: resistant to insects, herbicides or disease; bigger fruits; increased yields
- Grade 7+ only Steps: enzymes isolate the gene → gene inserted into a vector (plasmid or virus) → vector inserts the gene into the required cells
- Bacteria engineered to make human insulin (to treat diabetes)
- Concerns: effects on wild flowers and insects; effects of eating GM crops on health not fully explored
- Grade 7+ only Genes are transferred at an early stage of development

Notes

What genetic engineering is

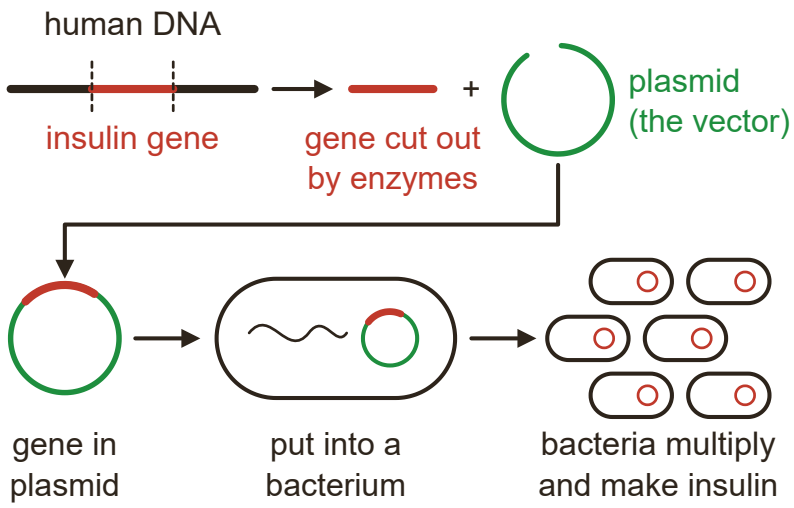
- **Genetic engineering** is modifying the **genome** of an organism by introducing a **gene from another organism** to give a desired characteristic.
- Genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to the cells of other organisms.
- **Bacterial cells** have been genetically engineered to produce useful substances such as **human insulin** to treat diabetes.
- **Plant crops** have been genetically engineered to be resistant to diseases or to produce bigger, better fruits.
- Crops that have had their genes modified in this way are called **genetically modified (GM) crops**. They include crops resistant to **insect attack** or to **herbicides**. GM crops generally show **increased yields**.
- Medical research is exploring the possibility of genetic modification to overcome some **inherited disorders**.

Benefits, risks and objections

- Benefits: bigger yields from the same land; less of the crop lost to pests or disease; medicines such as insulin made in large amounts; possible future treatments for inherited disorders.
- Herbicide-resistant crops: the herbicide kills the weeds but not the crop, so the crop has less competition for light, water and mineral ions, photosynthesises more and gives a higher yield.
- Concerns about GM crops include their effect on populations of **wild flowers and insects**.
- For example, spraying herbicide on herbicide-resistant crops also kills wild flowers, so insects have less food and biodiversity falls.
- Some people feel the effects of **eating GM crops on human health** have not been fully explored.
- Other objections: genes could spread from GM crops to wild plants (e.g. producing herbicide-resistant weeds), and some people think it is wrong to change an organism's genes.

The main steps Grade 7+ only

- **Enzymes** are used to **isolate** (cut out) the required gene.
- The gene is inserted into a **vector**, usually a bacterial **plasmid** or a **virus**. Enzymes are also used to cut open the plasmid and join the gene into it.
- The vector is used to insert the gene into the required cells.
- Genes are transferred to the cells of animals, plants or microorganisms at an **early stage in their development**, so that they develop with the desired characteristics.
- For insulin: the human insulin gene is inserted into a plasmid, the plasmid is put into a bacterium, and the bacteria multiply and produce human insulin.



Making human insulin with genetically engineered bacteria.

How to answer each type of question

Give a benefit and a concern of GM crops

2 to 4 marks | Grade 5

1. Benefits: resistance to insects, herbicides or disease; increased yields; bigger, better fruit.
2. Concerns: effects on wild flowers and insects; effects on human health not fully explored.
3. Link each point to its consequence.

Example. Some crops have been genetically modified to be resistant to insect attack.
Give one advantage and one disadvantage of growing this crop. [2 marks]

Model answer. Advantage: less of the crop is damaged by insects, so the yield increases (1).
Disadvantage: it may reduce populations of insects (and the animals that feed on them) / the effects on human health of eating it have not been fully explored (1).

Describe the steps of genetic engineering

3 to 4 marks | Grade 7

1. Enzymes cut out (isolate) the gene.
2. The gene is inserted into a vector (plasmid or virus).
3. The vector carries the gene into the required cells.
4. Say what happens next, e.g. the bacteria multiply and make the product.

Example. Describe how bacteria can be genetically engineered to produce human insulin. [4 marks]

Model answer. Enzymes are used to isolate / cut out the human insulin gene (1). The gene is inserted into a vector, a bacterial plasmid (1). The plasmid is put into a bacterial cell (1). The bacteria multiply and make human insulin (1).

Evaluate a use of genetic engineering

4 to 6 marks | Grade 8

1. Use the information provided.
2. Give the benefits.
3. Give the risks and objections.
4. Finish with a justified conclusion.

Example. Scientists have produced a variety of rice that is genetically engineered to contain a substance the body uses to make vitamin A. In some countries many children lack vitamin A, which can cause blindness.
Evaluate the use of this genetically engineered rice. [6 marks]

Model answer.

Marked by levels; a top answer covers both sides and reaches a conclusion. For example:
It could prevent vitamin A deficiency and blindness in children (1). Rice is eaten every day by many people in these countries, so it would reach many children (1). It may be cheaper than giving vitamin supplements (1). However, genes could spread from the GM rice to wild plants (1). Some people feel the effects of eating GM crops on human health have not been fully explored (1). Some people object to changing an organism's genes (1). Conclusion: the benefit of preventing blindness is large, so growing the rice is probably justified as long as its safety continues to be tested.

Don’t lose marks

- Confusing genetic engineering with selective breeding or cloning.
- Saying the vector is an enzyme. Enzymes cut out the gene; the vector (plasmid or virus) carries it.
- Saying the gene is added to an adult organism. It is transferred at an early stage of development.
- Giving vague objections such as 'it's unnatural' without explaining a possible effect (on wild flowers, insects or health).
- Writing 'less competition for nutrients' or 'food' for a GM crop. Name light, water or mineral ions.

More tips

Memory tricks

- Steps as 'cut, paste, deliver': enzymes cut out the gene, it is pasted into a vector, and the vector delivers it into the cell.
- Vector = vehicle: a plasmid or a virus that carries the gene in.
- GM crop concerns: wild flowers, insects, human health.

Exam technique

- Use the key words: isolate, enzymes, vector, plasmid, virus.
- In 'evaluate' questions, give both sides and a conclusion supported by the information given.
- Say that the gene comes 'from another organism'.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Define genetic engineering

Modifying an organism's genome by introducing a gene from another organism to give a desired characteristic.

Grade 4

Give examples of genetic engineering

Bacteria that make human insulin; crops resistant to disease, insects or herbicides; bigger, better fruits.

Grade 5

State what GM crops are

Crops whose genes have been modified by genetic engineering; they generally give increased yields.

Grade 5

Give benefits and concerns of GM crops

Higher yields, against concerns about wild flowers, insects and effects on human health.

Grade 7

Describe the main steps of genetic engineering

Enzymes isolate the gene, it is inserted into a vector, and the vector puts the gene into the required cells.

Grade 8

Evaluate genetic engineering in agriculture and medicine

Weigh the benefits against the risks and objections to reach a justified conclusion.

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