Role of biotechnology

4.7.5.4 · Ecology · revision notes

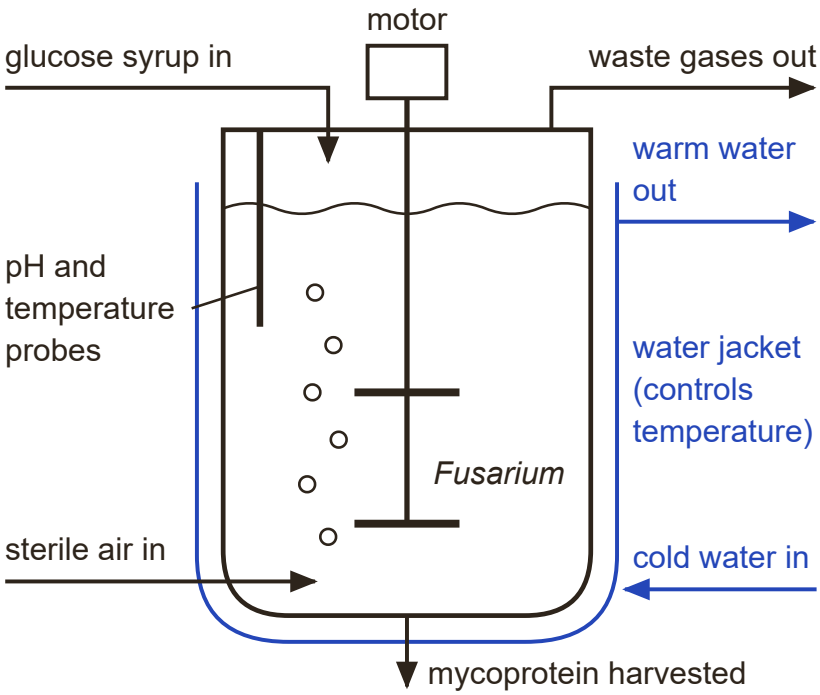
How modern biotechnology helps to feed a growing population: culturing microorganisms such as the fungus *Fusarium* to make mycoprotein, genetically modified bacteria that make human insulin, and GM crops such as golden rice. Expect 'describe' and 'explain' questions and evaluations of GM crops. This subtopic is in GCSE Biology only, not Combined Science.

Key facts

- Mycoprotein: protein-rich food from the fungus *Fusarium*, suitable for vegetarians
- GM bacteria produce human insulin to treat diabetes
- Golden rice: GM rice containing beta-carotene, which the body uses to make vitamin A
- *Fusarium* is grown on glucose syrup in aerobic conditions; the biomass is harvested and purified
- GM crops: more food, or food with improved nutritional value
- Concerns about GM crops: wild flowers and insects; long-term effects on health

Growing microorganisms for food

- Biotechnology now lets us grow microorganisms in huge quantities as food.
- The fungus ***Fusarium*** is used to produce **mycoprotein**, a protein-rich food suitable for vegetarians.
- *Fusarium* is grown on **glucose syrup** in **aerobic conditions** (air is supplied) in large vessels called fermenters. The biomass is then harvested and purified.
- Conditions such as temperature and pH are controlled, and the fermenter is kept sterile so that other microorganisms do not contaminate the product or compete with the *Fusarium* for glucose and oxygen.



A fermenter for growing *Fusarium*. Air supplies oxygen for aerobic respiration; everything going in is sterile.

- Microorganisms grow very quickly and can be grown all year round in any climate, using little land.

GM bacteria and insulin

- Bacteria that have been genetically modified make **human insulin**, which is harvested, purified and used to treat people with diabetes.
- The human insulin gene is inserted into bacteria using a plasmid. The bacteria are grown in fermenters, where they make the insulin.

GM crops

- GM crops could increase the amount of food grown, or make food more nutritious.
- **Golden rice** has been genetically modified to produce beta-carotene in the grain. The body uses beta-carotene to make vitamin A, so golden rice could reduce vitamin A deficiency, which can cause blindness, where rice is the main food.
- Other GM crops are resistant to insect pests or herbicides, or give higher yields.
- Some people worry that GM crops could harm populations of wild flowers and insects, and that the long-term effects on health of eating GM food are not yet fully known.

How to answer each type of question

Describe how mycoprotein is produced

3 marks | Grade 4

1. Name the fungus: *Fusarium*.
2. Say it is grown on glucose syrup, with air supplied (aerobic conditions).
3. Say the biomass is harvested and purified.

Example. Describe how mycoprotein is produced.

Model answer. The fungus *Fusarium* is grown in a fermenter on glucose syrup (1). Air / oxygen is supplied, so the conditions are aerobic (1). The fungal biomass is harvested and purified (1).

Explain why conditions are controlled in a fermenter

2 to 4 marks | Grade 5

1. Oxygen: needed for aerobic respiration, which releases energy for rapid growth.
2. Temperature: kept near the optimum for the microorganism's enzymes; too hot denatures them.
3. Sterile conditions: stop other microorganisms contaminating the product or competing for the glucose.

Example. Explain why air is bubbled through the fermenter used to grow *Fusarium*, and why the fermenter is sterilised before use. (4 marks)

Model answer. Air provides oxygen for aerobic respiration (1), which releases the energy the fungus needs to grow and multiply quickly (1). Sterilising kills other microorganisms (1), which could contaminate the product or compete with the *Fusarium* for glucose (1).

Explain how a biotechnology product improves health or food supply

3 marks | Grade 6

1. Say what the organism has been changed to do, or what it produces.
2. Explain the benefit: more food, more protein, better nutrition or a treatment.
3. Link it to the people who benefit.

Example. Explain how golden rice could improve the health of people in countries where rice is the main food.

Model answer. Golden rice is genetically modified to produce beta-carotene (1). The body uses beta-carotene to make vitamin A (1). This reduces vitamin A deficiency and the diseases it causes, such as blindness (1).

Evaluate GM crops

4 to 6 marks | Grade 7

1. Give benefits: higher yields, pest resistance, better nutrition, less land needed.
2. Give concerns: effects on wild flowers and insects, long-term health effects not fully explored.
3. Finish with a justified conclusion.

Example. A country is deciding whether to grow a GM maize that is resistant to insect pests. Evaluate this proposal. (4 marks)

Model answer. Fewer plants are damaged by insects, so yields are higher and more food is produced (1). Less insecticide may be needed (1). However, the GM crop may affect populations of wild flowers and insects, including insects that are not pests (1). Some people worry that the long-term effects on health of eating GM food are not yet fully known (1). A justified conclusion is expected, e.g. grow it if trials show no harm to wildlife.

Don't lose marks

- Calling *Fusarium* a bacterium. It is a fungus.
- Saying *Fusarium* is grown in anaerobic conditions. It needs oxygen (aerobic).
- Saying golden rice contains vitamin A. It contains beta-carotene, which the body uses to make vitamin A.
- Saying the insulin is 'bacterial insulin'. It is human insulin made by genetically modified bacteria.

More tips

Memory tricks

- Mycoprotein recipe: *Fusarium* + glucose syrup + air → harvest → purify.
- Golden rice is golden because of beta-carotene, which the body turns into vitamin A.
- Three GM examples to learn: insulin from bacteria, golden rice, and pest-resistant or higher-yield crops.

Exam technique

- Learn the exact phrases: glucose syrup, aerobic conditions, harvested and purified.
- In 'evaluate' questions on GM crops, give benefits and concerns, and finish with a judgement.
- Link biotechnology back to food security: more food, more protein or better nutrition for a growing population.

What each grade needs

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

Grade 3 — **Name a food made from a fungus**
Mycoprotein, a protein-rich food made from the fungus *Fusarium*.

Grade 4 — **Describe how mycoprotein is produced**
Fusarium is grown on glucose syrup in aerobic conditions, then the biomass is harvested and purified.

Grade 5 — **Describe how GM bacteria produce insulin**

Bacteria given the human insulin gene are grown in large numbers, and the insulin is harvested and purified.

Grade 5

Explain how GM crops can improve food supply

They can give more food or better nutrition, e.g. golden rice makes a substance the body uses to make vitamin A.

Grade 7

Explain advantages of culturing microorganisms for food

They grow quickly, can be grown all year in any climate, and need little land.

Grade 7

Evaluate GM crops as a solution

Weigh more or better food against concerns about wild flowers, insects and long-term effects on health.

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