

Use of biological resources revision notes

Humans use living organisms to produce food. This topic looks at how crop yields are increased in glasshouses and with fertilisers and pest control, and how yeast and bacteria are grown to make foods such as bread and yoghurt. It then moves on to selective breeding and genetic modification.

For Edexcel International GCSE Science (Double Award) 4SD0.

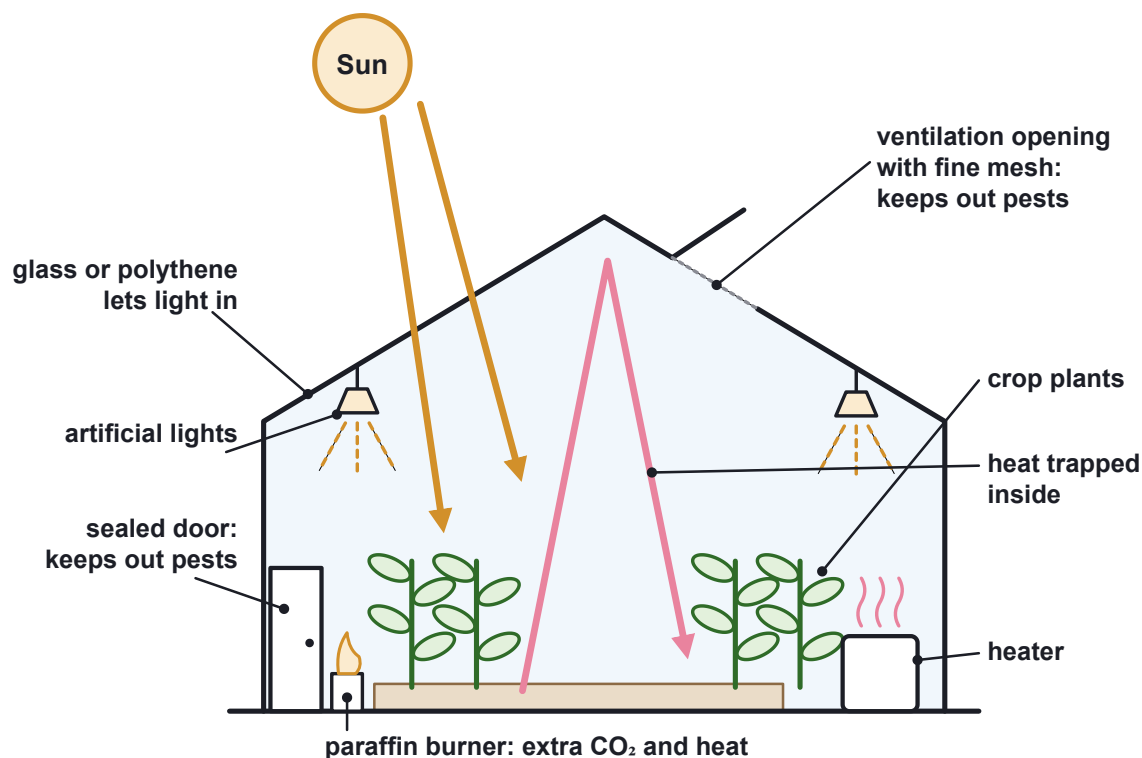
1 Food production: crop plants Spec 5.1-5.4

Glasshouses and polythene tunnels Spec 5.1, 5.2

Farmers can increase the **yield** of some crops, such as tomatoes and cucumbers, by growing them in **glasshouses** or polythene tunnels. These structures let the farmer control the conditions around the plants instead of relying on the weather.

How glasshouses and polythene tunnels help

- They trap heat from the Sun, so the air is warmer than outside. Heaters can be added to keep the temperature at the optimum for the enzymes in photosynthesis.
- Clear glass or polythene lets light in. Artificial lighting can be used to extend the day length so plants photosynthesise for longer.
- Carbon dioxide can be added to the air, for example by burning paraffin, which also releases heat.
- They protect crops from strong wind, heavy rain, frost and many pests, so less of the crop is damaged or lost.
- The growing season can be longer, so crops can be grown at times of year when they would not grow outside.



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A glasshouse lets the farmer control **light, temperature and carbon dioxide**, and keeps out pests.

Effect of carbon dioxide and temperature on yield

Photosynthesis makes the glucose that plants use to grow. Its rate can be limited by light intensity, carbon dioxide concentration or temperature, whichever is in shortest supply.

- **Increased carbon dioxide**: if carbon dioxide is the limiting factor, adding more increases the rate of photosynthesis. The plants make more glucose, grow faster and the yield rises.
- **Increased temperature**: a warmer glasshouse increases the rate of photosynthesis, because the enzymes work faster, up to the optimum temperature. Above the optimum the enzymes are denatured and the rate falls.

Costs and benefits of controlling conditions

Condition controlled	Benefit to the plant	Cost or limit
Higher CO₂	Faster photosynthesis if CO ₂ was limiting, so a higher yield	Cost of the fuel or gas; no extra benefit if another factor is limiting
Higher temperature	Faster photosynthesis and growth, up to the optimum	Heating costs; too hot denatures enzymes
Extra light	More photosynthesis, especially in winter	Cost of electricity

*Exam tip: Say that the factor must be **limiting** for adding more to help. Then link the faster photosynthesis to more glucose and so more growth and a higher yield.*

Fertilisers, pesticides and biological control Spec 5.3, 5.4

Fertilisers

Crops take mineral ions, such as nitrates, from the soil. When a crop is harvested, these ions are removed from the field. **Fertilisers** replace them. They contain mineral ions such as nitrate (for making

proteins), phosphate and potassium.

With more mineral ions available, the plants grow faster and bigger, so the **crop yield** is higher. Without enough of them, growth is poor and the leaves may turn yellow.

Common mistake: Fertilisers are not plant food. Plants make their own food by photosynthesis. Fertilisers supply the mineral ions plants need to make proteins and other substances.

Why pests are controlled

A **pest** is an organism that damages a crop, such as an insect that eats the leaves. Pests reduce the yield, because they eat the plants or spread disease, and they lower the quality of the crop. Farmers control them to protect the yield.

Pesticides

Pesticides are chemicals that kill pests, for example insecticides that kill insects.

Pesticides	
Advantages	Disadvantages
Kill pests quickly and effectively, so the yield is protected	Can kill harmless or useful organisms, such as bees, that are not the pest
Easy to apply over a large area	Can build up in food chains, so top consumers get a high dose
Cheap compared with the value of the crop saved	Pests can evolve resistance, so the pesticide stops working
Can be used as soon as the pest appears	Can wash into rivers and harm wildlife; may leave residues on food

Biological control

Biological control uses a living organism to reduce the pest population. For example, ladybirds are released to eat aphids, or a parasite is introduced that lays its eggs in the pest.

Biological control	
Advantages	Disadvantages
No chemicals, so no harmful residues on food or in the environment	Slower than pesticides and rarely removes the pest completely
Usually targets only the pest, so other organisms are not harmed	The control organism may become a pest itself, or may feed on other species
Pests do not become resistant in the same way as they do to chemicals	The control organism may not survive or may leave the area, so it needs to be managed

Exam tip: An evaluation needs both sides. Give at least one advantage and one disadvantage, each explained, not just named.

Quick check

- 1 . Name two ways a glasshouse can increase the yield of a crop.
- 2 . Why does adding carbon dioxide increase yield?
- 3 . What do fertilisers supply to crop plants?
- 4 . Give one disadvantage of using pesticides.
- 5 . What is biological control?

2 Food production: micro-organisms and fish farming Spec 5.5–5.9B

Yeast and bread making Spec 5.5

Yeast is a single-celled fungus. It is used to make bread because of the way it respire.

When yeast has no oxygen, it respire **anaerobically**. This is also called **fermentation**. It breaks down sugar (glucose) to make ethanol and carbon dioxide, and releases energy.

glucose → ethanol + carbon dioxide

Making bread

1. Flour, water, sugar and yeast are mixed to make a dough. The dough is kneaded.
2. The dough is left in a warm place. The yeast respire the sugar and releases **carbon dioxide**.
3. The bubbles of carbon dioxide are trapped in the dough, so the dough **rises**.
4. The dough is baked. The heat kills the yeast, the gas bubbles expand to make the bread light and full of holes, and the ethanol evaporates.

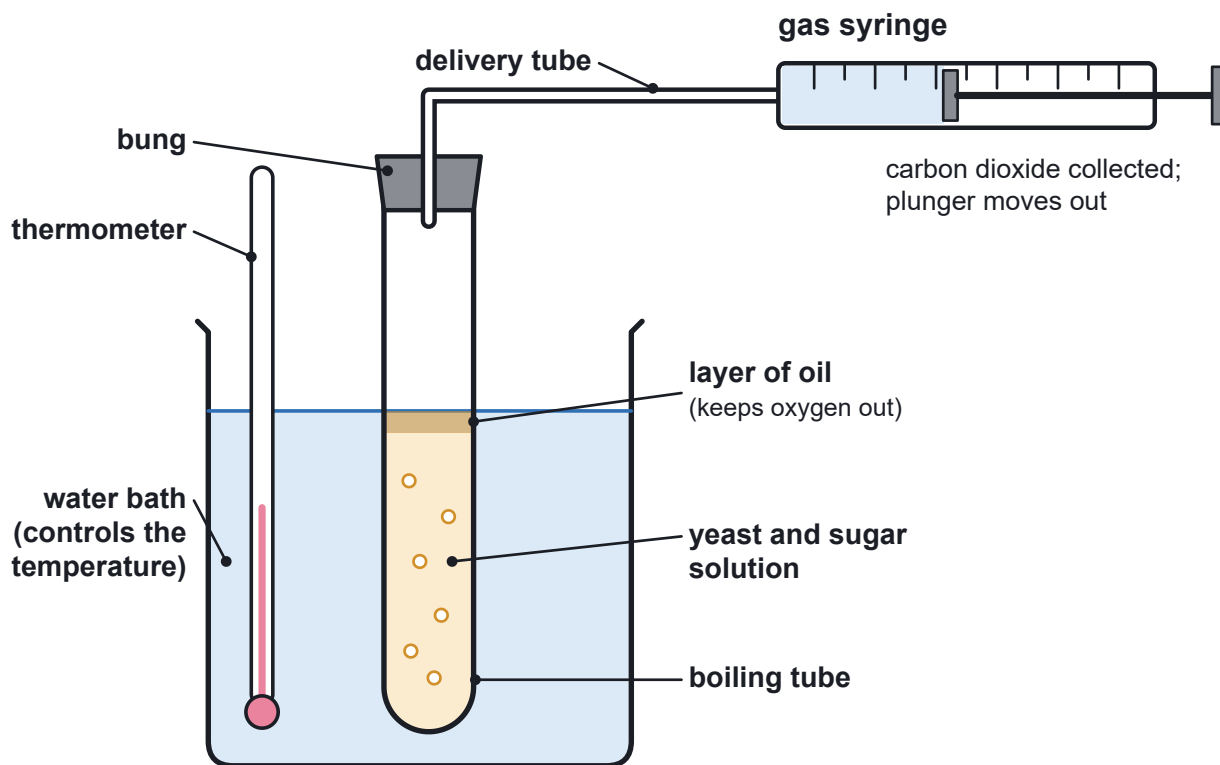
Exam tip: It is the carbon dioxide that makes the dough rise, not the ethanol. Keep the warm temperature in your answer: it is the optimum range for the yeast enzymes.

Practical: anaerobic respiration in yeast Spec 5.6

In this practical you investigate how conditions, such as temperature or the type or concentration of sugar, affect the rate of **anaerobic respiration** in yeast. The rate is measured from the **carbon dioxide** produced.

Practical: Investigating the effect of temperature on anaerobic respiration in yeast. The same method can be used with different sugars or sugar concentrations as the independent variable.

1. Boil the sugar solution and let it cool, to remove dissolved oxygen. (It must be cool, or it would kill the yeast.)
2. Mix yeast with the sugar solution in a boiling tube. Add a **layer of oil** on top to stop oxygen getting back in, so the yeast respire anaerobically.
3. Attach a delivery tube to a gas syringe, or run it into water so the bubbles can be counted.
4. Stand the tube in a water bath at the first temperature, for example 20 °C. Leave it to reach that temperature.
5. Measure the volume of gas collected, or count the bubbles, in a set time such as 5 minutes.
6. Repeat at other temperatures, such as 30, 40, 50 and 60 °C, and repeat each temperature to calculate a mean.



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The **layer of oil** keeps oxygen out; the volume of gas collected in a set time gives the rate of anaerobic respiration.

Variables	
Type of variable	What it is
Independent	The condition changed, for example temperature
Dependent	The volume of gas collected, or bubbles counted, in a set time
Control	Mass or volume of yeast, volume and concentration of sugar solution, type of sugar, time allowed for each reading, depth of the oil layer

Safety: wear eye protection, take care with hot water, and wash your hands after handling the yeast. Tie back long hair.

Expected results: the rate is slow at low temperatures. It increases as the temperature rises towards an optimum, usually about 35–40 °C, because the enzymes work faster. Above the optimum the rate falls, because the enzymes are denatured. You can confirm the gas is carbon dioxide by bubbling it through limewater, which turns cloudy.

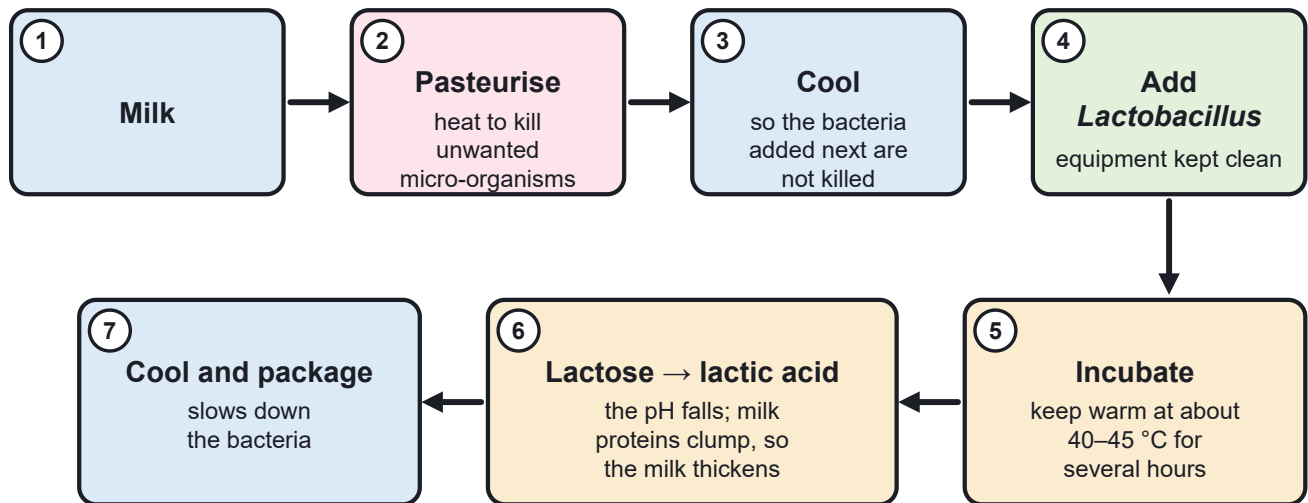
Exam tip: Name the control variables and say how they are kept the same. Measuring in a fixed time lets you calculate a rate, such as bubbles per minute. A gas syringe is more accurate than counting bubbles, because bubbles can be different sizes.

Bacteria and yoghurt Spec 5.7

Yoghurt is made from milk using the bacterium **Lactobacillus**. The bacteria respire the sugar in milk, called **lactose**, and make **lactic acid**.

- The milk is heated to a high temperature (**pasteurised**) to kill unwanted micro-organisms. It is then cooled.

2. *Lactobacillus* is added to the milk. The equipment is kept clean so that other bacteria do not get in.
3. The mixture is incubated (kept warm), at about 40–45 °C, for several hours, so the bacteria grow and respire.
4. The bacteria turn lactose into lactic acid. The pH falls, and the acid makes the milk proteins clump together, so the milk thickens and gets a sour taste. The low pH also stops many other micro-organisms growing, so the yoghurt keeps for longer.
5. The yoghurt is cooled to slow down the bacteria, then packaged.



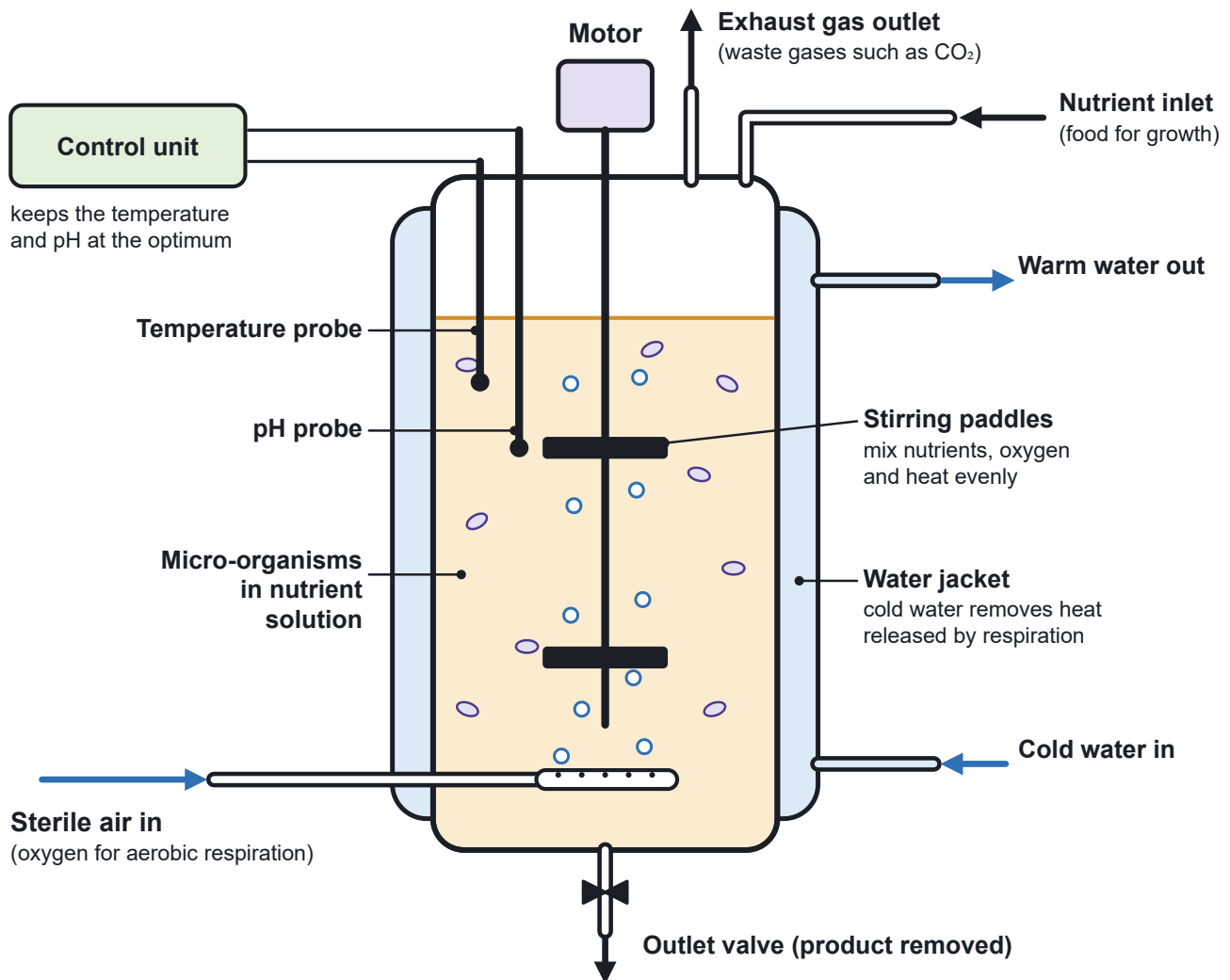
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Lactobacillus turns **lactose into lactic acid**, which lowers the pH and thickens the milk.

Common mistake: The acid is made from lactose, not from the milk fat or protein. The acid is what thickens the milk, by making its proteins clump.

Industrial fermenters Spec 5.8

A **fermenter** is a large container in which micro-organisms are grown in large numbers to make a product such as a food, a medicine or an enzyme. The **conditions are controlled** so that the micro-organisms grow and make the product as quickly as possible.



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Each part of a fermenter keeps the **conditions at the optimum** for the micro-organisms to grow.

Conditions in a fermenter

Condition	Why it is needed
Aseptic precautions	The fermenter and nutrients are sterilised, so no other micro-organisms get in. Unwanted microbes would compete for nutrients, spoil the product or cause disease.
Nutrients	A supply of a carbon source such as glucose, plus nitrogen and mineral ions, so the micro-organisms can grow and make the product.
Optimum temperature	Enzymes work fastest at the optimum. Respiration releases heat, so a cooling water jacket keeps the temperature constant. Too hot would denature enzymes.
Optimum pH	Enzymes work best at the optimum pH. A probe monitors pH, and acid or alkali is added to keep it steady.
Oxygenation	Sterile air is bubbled in, so the micro-organisms can respire aerobically, release more energy and grow faster.
Agitation	Stirring paddles mix the contents, so nutrients, oxygen and heat are spread evenly and the micro-organisms are in contact with the nutrients.

Exam tip: For each condition, say what it is and why it is needed. Mark schemes link it to growth: for example, the optimum temperature gives the fastest enzyme activity, so faster growth and more product.

Quick check

- 1 . What gas makes bread dough rise?
- 2 . Write the word equation for anaerobic respiration in yeast.
- 3 . Which bacterium is used to make yoghurt, and what does it make from lactose?
- 4 . Why are aseptic precautions used in a fermenter?

3 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.

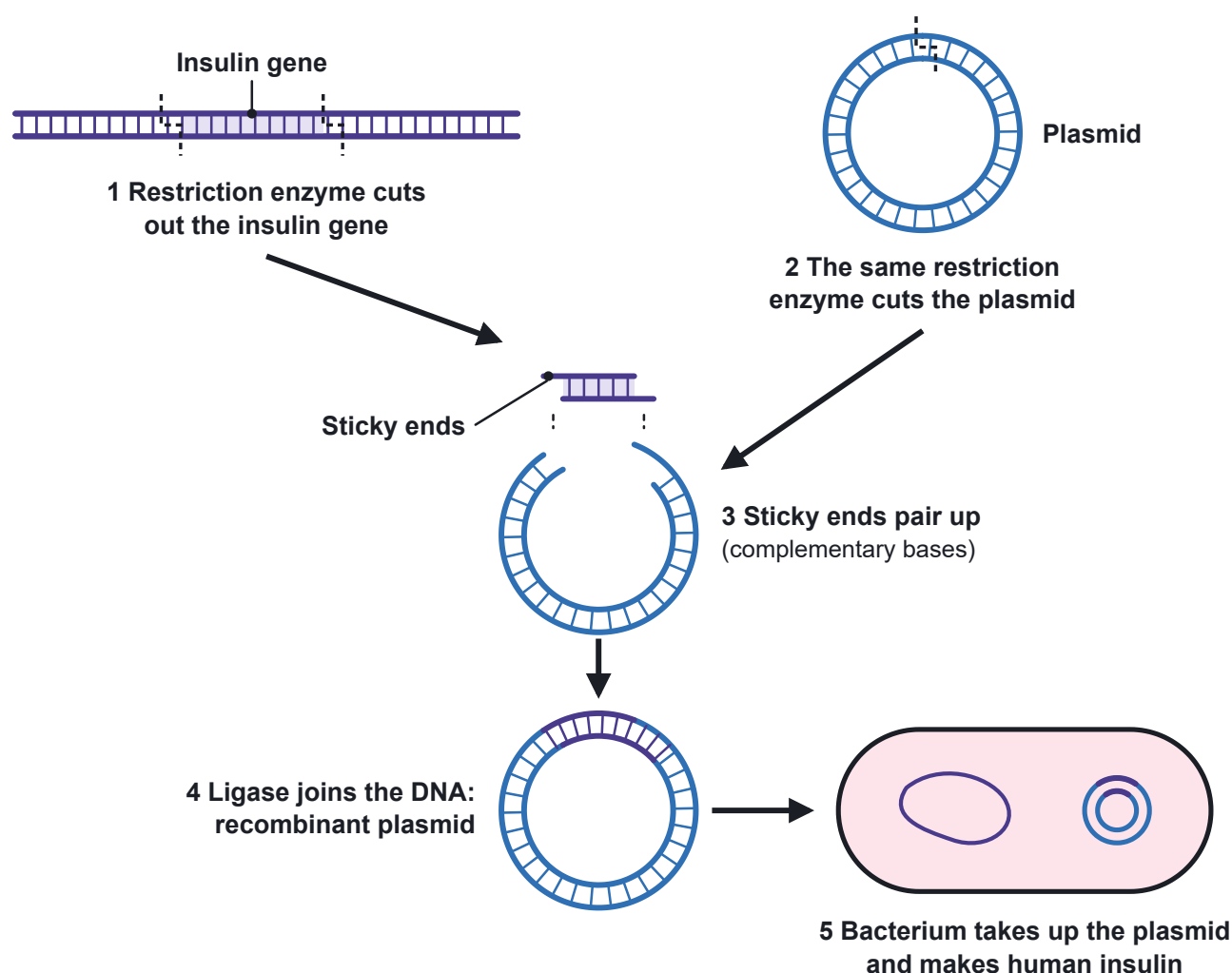
Exam tip: Always say that selection is repeated over many generations. Mark schemes award a mark for this.

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.
4. 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.
5. 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.



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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

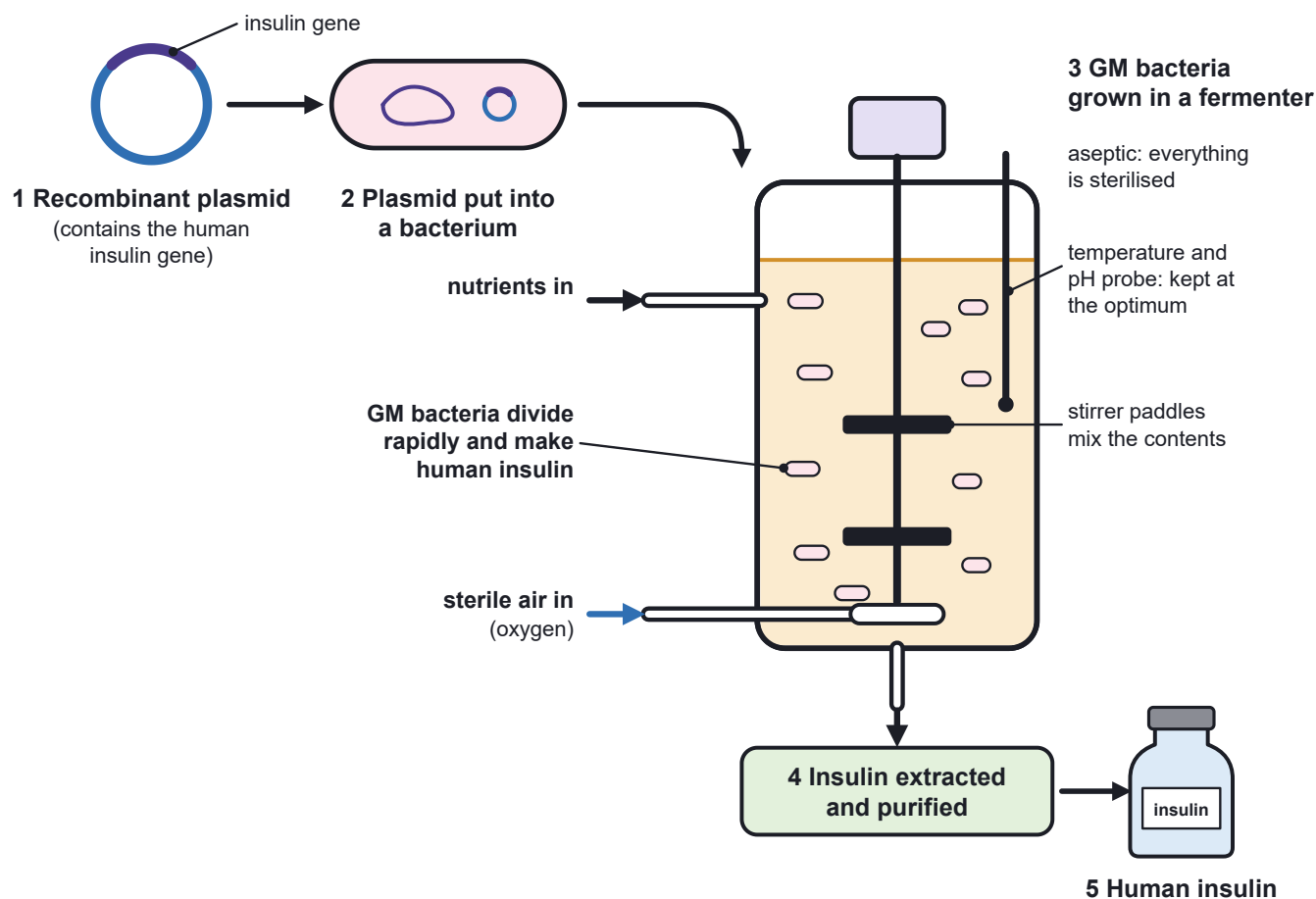
People with type 1 diabetes need insulin. Large amounts of **human insulin** can be made by genetically modified (GM) bacteria grown in a **fermenter**.

1. 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.



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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

Less crop is lost to pests, so yields are higher

Less insecticide needs to be sprayed, which saves money and reduces damage to other organisms

Crops can be given extra characteristics, such as greater nutritional value or resistance to disease

More food can be produced for a growing population

Disadvantages

Possible risk to human health, which some people worry about

Genes may spread to wild plants, and the toxin might harm other insects

GM seeds can be expensive

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

Food production: crop plants

1. Any two from: higher temperature, added carbon dioxide, extra light, protection from pests and weather.
2. If carbon dioxide is limiting, photosynthesis is faster, so more glucose is made for growth.
3. Mineral ions, such as nitrates, phosphates and potassium.
4. Any one from: kill non-target organisms, build up in food chains, pests become resistant, pollute water.
5. Using a living organism to reduce the population of a pest.

Food production: micro-organisms and fish farming

1. Carbon dioxide, from anaerobic respiration in yeast.
2. Glucose → ethanol + carbon dioxide.
3. *Lactobacillus*; it makes lactic acid.
4. To stop unwanted micro-organisms getting in and competing with or spoiling the product.

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.