Edexcel IGCSE Biology

Your notes

Food Production

Contents

Your notes

Crop Plants: Glasshouses & Polythene Tunnels

Limiting factors and the growth of crop plants

- The knowledge about **limiting factors** and how they affect the rate of photosynthesis can be used by farmers to **improve crop yields**
- Growing crops **outside** does not allow farmers to control any of these factors
- Glasshouses and polythene tunnels provide an **enclosed environment** in which farmers can, to some extent, control the climate inside and **increase their crop yields**

Glasshouses

- In a glasshouse, several conditions can be manipulated to increase the rate of photosynthesis, including:
  - **Artificial heating** (enzymes controlling photosynthesis can work faster at slightly higher temperatures - only used in temperate countries such as the UK)
  - **Artificial lighting** (plants can photosynthesise for longer)
  - **Increasing carbon dioxide content** of the air inside (plants can photosynthesise quicker)
  - **Regular watering**
- When considering the use of glasshouses and manipulating conditions like this, farmers need to balance the **extra cost** of providing heating, lighting and carbon dioxide against the **increased income**
- In **tropical countries** where temperatures are much hotter, glasshouses may still be used to control other conditions however they may need to be **ventilated** to release hot air and **avoid temperatures rising too high**, which could cause the denaturation of the enzymes controlling the photosynthesis reaction

Polythene tunnels

- More commonly called polytunnels, these are large plastic tunnels that cover crops
- They can protect crops grown outside from the **effects of the weather**, including excessive wind, rain and extreme temperatures
- They also **increase the temperature** slightly inside the tunnel
- They can **prevent the entry of pests** that can damage plants or diseases that can kill plants

Your notes

Crop Plants: Increasing Carbon Dioxide & Temperature

- If a plant is given unlimited light, carbon dioxide and water and is at a warm temperature, the only thing limiting the rate at which it can photosynthesise is its own ability to absorb these materials and make them react
- However, most often plants do not have unlimited supplies of these things, so their rate of photosynthesis is **limited** by whatever **factor** is the **lowest** at that time (known as the **limiting factor**)
- There are **three** main factors that limit the rate of photosynthesis:
  - **Temperature**
  - **Light intensity**
  - **Carbon dioxide concentration**

Temperature

- As temperature increases the rate of photosynthesis increases as the reaction is **controlled by enzymes**
- However, as the reaction is controlled by enzymes, this trend only continues up to a certain temperature beyond which the enzymes begin to **denature** and the rate of reaction **decreases**

Light intensity

- The **more light** a plant receives, the **faster the rate** of photosynthesis
- This trend will continue until some other factor required for photosynthesis prevents the rate from increasing further because it is now in short supply

Carbon dioxide concentration

- Carbon dioxide is one of the raw materials required for photosynthesis
- This means the **more carbon dioxide** that is present, the **faster the reaction** can occur
- This trend will continue until some other factor required for photosynthesis prevents the rate from increasing further because it is now in short supply

Your notes

Crop Plants: Fertilisers

- Modern technology has increased food supply substantially in two key ways:
  - **Fertilisers** - fertilisers increase the amount of key nutrients in the soil for crop plants, meaning that they can grow larger and are more healthy, which increases yields
  - **Pesticides** - these chemicals kill off unwanted insects and weed species, meaning that there is **less damage done** to crop plants by insects, as well as **reducing competition** from other plant species, which increases yields

Using fertilisers to increase crop yields

- Plants require a **range** of **mineral ions** in order to **grow well**
- As crop plants take up these mineral ions from the soil, the mineral ions need to be **replaced** if crops are grown repeatedly in the same field (i.e. year after year)
- **Fertilisers** are used to replace these mineral ions
- They can make crops grow **faster** and **bigger** so that **yields are increased**
- Fertilisers can be in the form of **organic fertiliser** or **chemical fertiliser**
- Organic fertilisers commonly used by farmers include farmyard **manure** and **compost**
- Chemical fertilisers are often applied to the soil as **dry granules** or can be **sprayed on in liquid form**
- They mainly provide crop plants with **nitrogen**, **phosphorus** and **potassium:**
- **Nitrogen**:
  - Absorbed in the form of **nitrates**
  - Needed to make **amino acids** which are the building blocks of proteins
  - Lack of nitrogen causes **weak growth and yellowing of the leaves of plants**
- **Phosphorous**:
  - Absorbed in the form of **phosphates**
  - Needed to make **DNA and cell membranes**
  - Lack of phosphorus can cause **poor root growth and discoloured leaves**
- **Potassium**:
  - Absorbed in the form of various **compounds of potassium**
  - Allows **enzyme reactions** to take place to produce ATP in respiration as well as being needed for the enzymes involved in photosynthesis

- Lack of potassium can cause **poor growth of flowers and fruits, as well as brown spots on leaves**

Your notes

Your notes

Crop Plants: Pest Control

Using pest control to increase crop yields

- Pests such as **insects and other animals** can damage crops by eating them
- Weeds can **outcompete** crop plants for **space, water and soil nutrients**
- Fungi can **infect crop plants and spread disease** which can affect growth and yield
- All of these can be controlled by using **pesticides** (chemical control) or by **introducing other species** (biological control)
- Examples of pesticides include:
  - **Insecticides** kill insect pests
  - **Herbicides** kill plant pests
  - **Fungicides** kill fungal pests

Advantages and disadvantages of pesticides table

Advantages	Disadvantages
Easily accessible and relatively cheap	Organisms they are meant to kill can develop resistance to them
Have an immediate effect	They are non-specific chemicals and can often kill other beneficial organisms (e.g., some insecticides might kill bees, which are important pollinators of crops)
Kills the entire population of pests	They can be persistent chemicals – this means they do not break down in the body and can accumulate in great concentrations at the top of food chains and harm top predators (known as bioaccumulation)
	Need to be repeatedly applied

Biological control

- Biological control involves using a **natural predator** to eat the pest species and therefore reduce the impact of the pest on crop yields
- This can happen naturally – for example, ladybirds eat aphids

- Usually, a **species is introduced specifically to prey on the pest** species – for example, parasitic wasps can control whitefly in glasshouse tomato crops
- As they are **based on a predator–prey cycle**, they do not completely remove a pest, but keep it at lower levels

Your notes

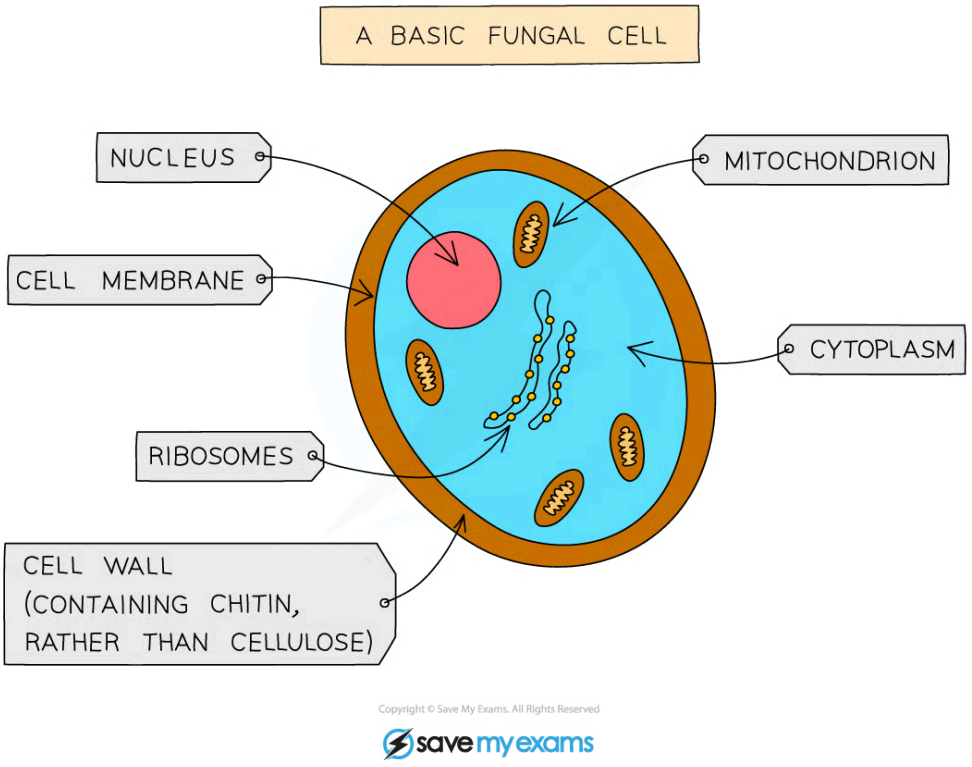
Advantages and disadvantages of biological control table

Advantages	Disadvantages
Natural method - no pollution	May eat other organisms instead of the pest
No resistance	Takes a longer period of time to be effective
Can target specific species	Cannot kill entire population - some pests will always be present
Long lasting	May not adapt to new environment or may move out of the area
Does not need to be repeatedly applied	May become a pest itself

Your notes

Yeast in Food Production

- Microorganisms can be used by humans to produce foods and other useful substances
- One example of this is the **production of bread using yeast**
- Yeast is a **single-celled fungus** that can carry out both **aerobic** and **anaerobic** respiration

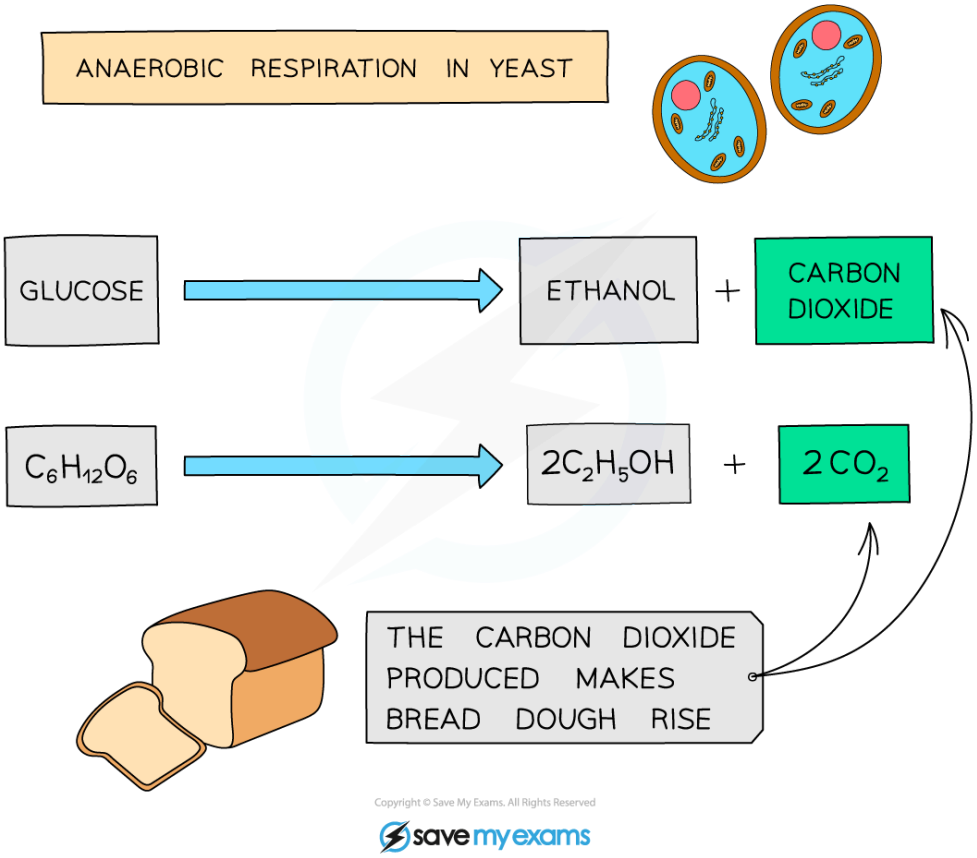


Yeast is a single-celled fungus, similar to the one shown in the diagram above

Making bread

- During bread making yeast is added to bread dough
- The yeast produces **enzymes** that break down the **starch** in **flour**, releasing **sugars** that can be used by the yeast in respiration
  - The yeast begin to respire aerobically but will **switch to anaerobic respiration** when oxygen runs out
- When yeast carries out **anaerobic respiration** it produces **alcohol (ethanol)** and **carbon dioxide**
- The **carbon dioxide** produced by the yeast is trapped in small air-pockets in the dough, causing the dough to **rise** (increase in volume)

- The dough is then **baked** in a hot oven to form bread
  - During baking any **ethanol** produced by the yeast is **evaporated** in the heat, so bread doesn't contain any alcohol
- The yeast is killed by the high temperatures used during baking
  - This ensures there is no further respiration by the yeast



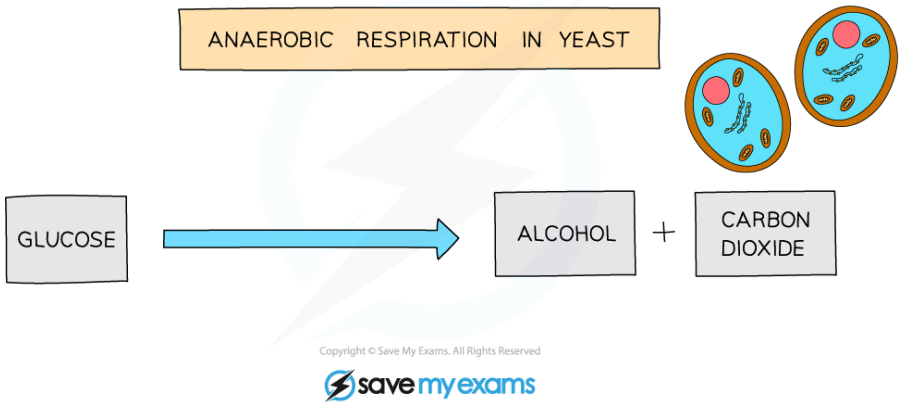
The carbon dioxide produced by the anaerobic respiration of glucose is what makes bread dough rise

Your notes

Your notes

Practical: investigating anaerobic respiration in yeast

- Yeast can respire **anaerobically** (without oxygen), breaking down glucose in the absence of oxygen to produce **ethanol** and **carbon dioxide**
- Anaerobic respiration in yeast cells is called **fermentation**
- Fermentation is economically important in the manufacture of **bread** (where the production of carbon dioxide makes dough rise) and alcoholic drinks (as ethanol is a type of alcohol)
- It is possible to investigate **the effect of temperature on yeast fermentation**, by seeing how temperature affects the **rate of anaerobic respiration** in yeast



The process of anaerobic respiration in yeast

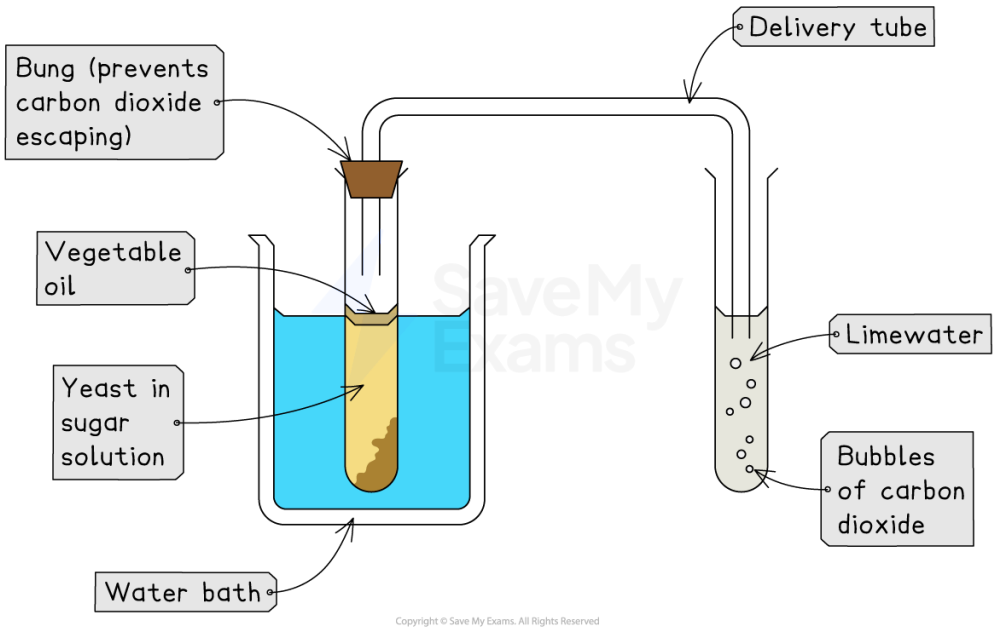
Apparatus

- Boiling tubes
- Capillary tubes
- Bungs
- Yeast
- Sugar solution
- Oil
- Stopwatch
- Water bath
- Limewater

Method

Your notes

- Mix yeast with sugar solution in a boiling tube
  - The sugar solution provides the yeast with **glucose** for anaerobic respiration
- Carefully add a layer of oil on top of the solution
  - This prevents oxygen from entering the solution (**prevents aerobic respiration in the yeast**)
- Using a capillary tube, connect this boiling tube with another boiling tube that is filled with **limewater**
- Place the boiling tube with yeast and sugar solution into a **water bath** at a **set temperature** and **count the number of bubbles produced in a fixed time** (e.g. 2 minutes)
  - The rate that carbon dioxide is produced by yeast can be used to measure the **rate of anaerobic respiration** (i.e. the **rate of fermentation**)
- Change the temperature of the water bath and repeat

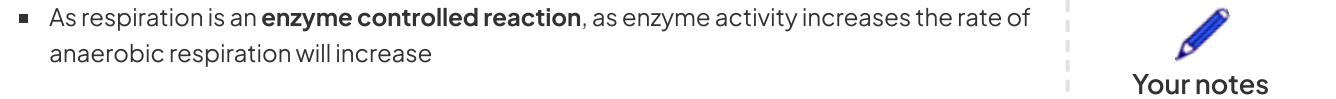


Experimental set up for investigating anaerobic respiration in yeast

Results and analysis

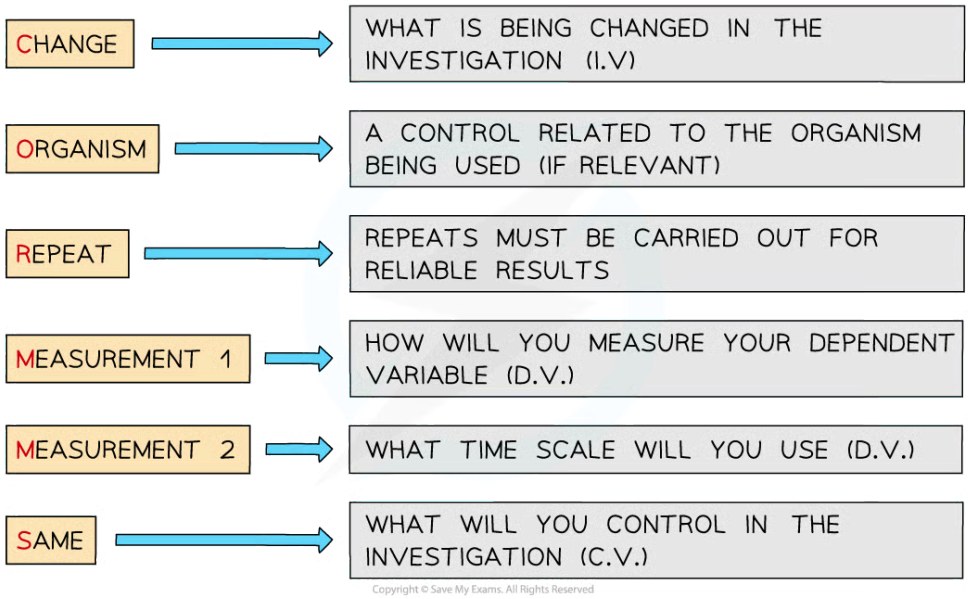
- Compare results at **different temperatures** to find out at which temperature yeast **respires fastest**
- The **higher the temperature**, the **more bubbles** of carbon dioxide should be produced as higher temperatures will be closer to the **optimum temperature** of enzymes in yeast, **increasing enzyme activity**

- As respiration is an **enzyme controlled reaction**, as enzyme activity increases the rate of anaerobic respiration will increase
- If the temperature is **too high** (beyond the optimum temperature), the enzymes will **denature** causing carbon dioxide production to **slow down** and eventually **stop**



Applying CORMS to practical work

- When working with practical investigations, remember to consider your CORMS evaluation:



CORMS evaluation

- In this investigation, your evaluation should look something like this:
  - **C** – We are changing the temperature in each repeat
  - **O** – The type (species) of yeast we are using must be the **same**
  - **R** – We will repeat the investigation several times at each temperature to make sure our results are reliable
  - **M1** – We will measure the number of bubbles (of carbon dioxide) produced
  - **M2** – in a set time period (e.g. 2 minutes)
  - **S** – We will control the concentration, volume and pH of the sugar solution, as well as the mass of yeast added

Your notes

Bacteria in Food Production

- **Microorganisms** can be used by humans to produce foods and other useful substances
- As well as fungi (e.g. yeast used to make bread), **bacteria** are also used in the production of certain foods
- Bacteria are useful because they are **capable of producing complex molecules** (e.g. certain bacteria added to milk produce enzymes that turn the milk into yoghurt)
- They are also useful because they **reproduce rapidly**, meaning the amount of chemicals they can produce can also rapidly increase

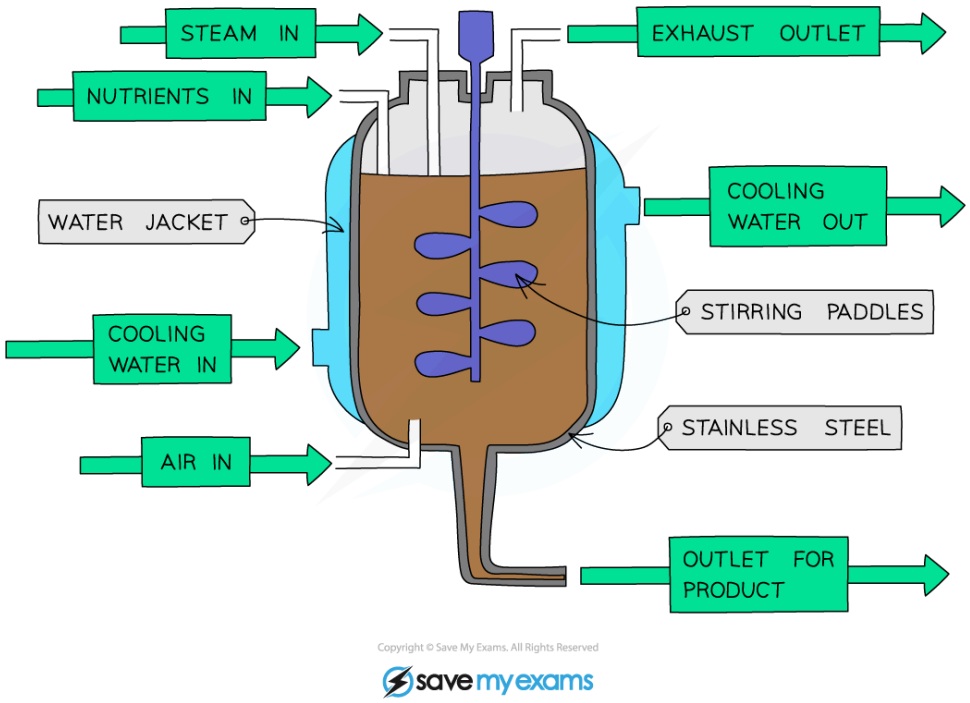
Using bacteria to make yoghurt

- Yoghurt is made in a process that relies on the presence of a specific type of bacterium – in this case, ***Lactobacillus***
- First, all equipment is **sterilised** to kill other, unwanted bacteria and to prevent chemical contamination
- Milk is then **pasteurised** (heated) **at 85–95°C** to kill other, unwanted bacteria
  - Contamination with other bacteria could **slow production of the yoghurt** by **competing** with the *Lactobacillus* for the lactose in the milk
  - It could also **spoil the taste** of the yoghurt
- The milk is then **cooled** to **40–45°C** and ***Lactobacillus* bacteria is added**
- The mixture is **incubated** at this temperature for several hours, while the *Lactobacillus* bacteria **digest milk proteins** and **ferment (digest) the sugar** (i.e. the **lactose**) in the milk
- The *Lactobacillus* bacteria **convert the lactose into lactic acid** and **this increased acidity sours and thickens the milk** to form **yoghurt**
  - This lowering of the pH also helps to prevent the growth of other microorganisms that may be harmful, so acts as a preservative
  - This means the yoghurt can be kept for a longer time (compared to fresh milk)
- The yoghurt is then stirred and **cooled to 5°C** to **halt the action of the *Lactobacillus* bacteria**
- Flavourings, colourants and fruit may be added before packaging

Your notes

Industrial Fermenters

- **Fermenters** are containers used to grow ('**culture**') microorganisms like bacteria and fungi in **large amounts**
- These can then be used for **brewing beer, making yoghurt** and **mycoprotein** and other processes not involving food, like producing **genetically modified bacteria** and **moulds that produce antibiotics** (e.g. 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



A diagram of an industrial fermenter used to produce large quantities of microorganisms

Controlling conditions in an industrial fermenter table

Condition	Why and how is it 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

Your notes

Your notes

Fish Farming

Benefits of fish farming

- Most fish are still caught in the wild (i.e. in the open ocean or in freshwater rivers and lakes)
- However, **overfishing** has lead to dramatic **declines** in many fish populations
- **Fish farms** are ways of **raising large numbers of fish** in a **small space** to provide **food (protein) for humans**
- This has several advantages over wild-caught fish, including:
  - The ability to **selectively breed fish** to ensure high quality, fast-growing fish
  - The ability to **protect against predators**
  - The ability to **control water quality** (many wild-caught fish have significant levels of pollutants such as mercury in their flesh)
  - The ability to **control feeding** to ensure rapid growth
- It is important to note that fish farming can be labour intensive and costly

Methods used in fish farms to ensure high yields

- Within fish farms, large numbers of fish are kept in freshwater or seawater enclosures and are carefully monitored and controlled in many different ways
- This helps to ensure high yields (fast growth of healthy fish)
- The methods used include:
  - The control (and maintenance) of **water quality**
  - The control of **intraspecific** predation
  - The control of **interspecific** predation
  - The control of **disease**
  - The control (and removal) of **waste products**
  - The control of the **quality** and **frequency** of **feeding**
  - The use of **selective breeding**

Fish farming methods table

Method	Explanation

Maintenance of water quality	Water is filtered to **remove waste and harmful bacteria** to prevent diseases. Water is also cleaned to **maintain high levels of oxygen** for aerobic respiration
Control of intraspecific predation	**Intraspecific predation**: predation within the same species Fishes are **separated by size and age** so they don't eat each other or fight
Control of interspecific predation	**Interspecific predation**: predation between different species Different species of fishes **are separated by fences, nets and tanks** to prevent fighting
Control of disease	**Antibiotics are given to fish to prevent disease** which might otherwise spread quickly due to their close confinement, increasing the chances of survival. They are also kept in small numbers to minimise the spread of diseases
Removal of waste products	Water can be **filtered to remove waste products** such as faeces and sewage. Fences, nets and tanks are cleaned or location of fish can be changed to ensure clean water
Quality and frequency of feeding	Fish are **fed food that is high in nutrients** to ensure fast growth. They are **fed frequently but in small amounts** so they do not overeat or start eating each other
Use of selective breeding	Fish are separated by gender so that selective breeding can be used by farmers to only **allow fish with desired characteristics to reproduce**. This ensures that the stock of fish is fast growing as these genes get passed on much more frequently

Your notes