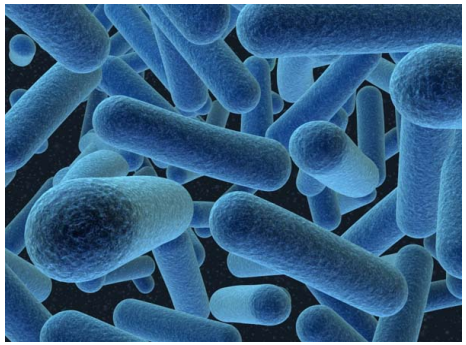
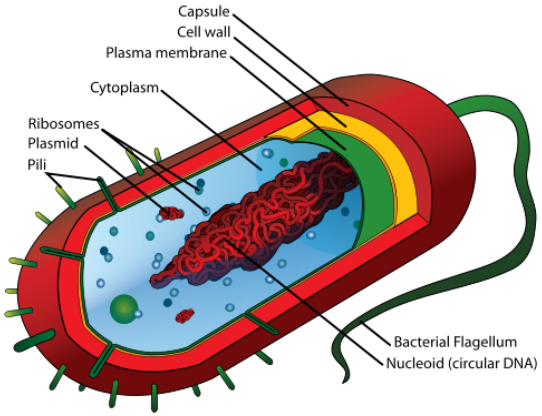
20 - Bacteria (Monera)

Learning objectives

- To describe the distribution of bacteria and fungi in nature
- To describe the basic structure of bacterial cells, including plasmid DNA
- To describe the three main types of bacteria
- To describe the reproduction and nutrition of bacteria, and the factors affecting their growth
- To understand the economic importance of bacteria and give two examples of beneficial bacteria and two examples of harmful bacteria
- To define the terms 'pathogenic' and 'antibiotic' and describe the use and potential abuse of antibiotics in medicine
- HIGHER To describe the prokaryotic nature of bacteria
- HIGHER To explain the growth curves of micro-organisms and describe batch and continuous flow food processing.





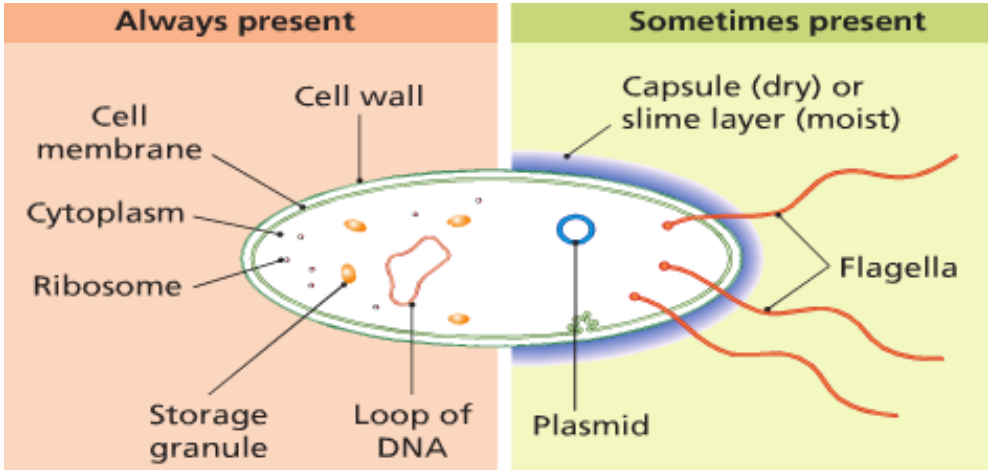
Bacteria are very small. They are measured in µm (nanometres).
There are 1000 **nanometres** in 1 mm.

Bacteria can be 1 µm in size.

Bacteria have a **cell wall** that protects them from bursting due to **osmosis**.
It's made from sugar and protein.

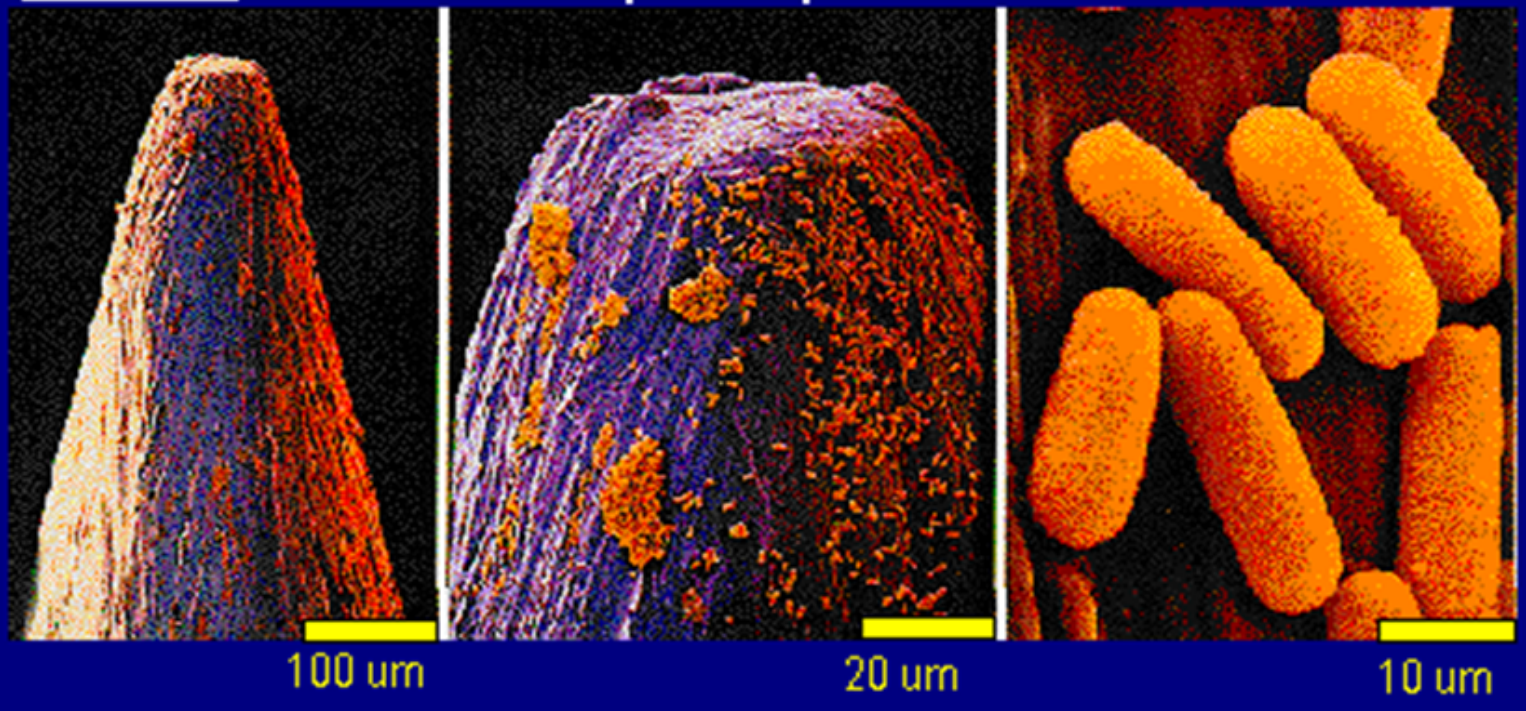
Bacteria have no nucleus but do have a chromosome or **plasmid**.A plasmid is a loop of **DNA** that helps it be resistant to antibiotics.

Also known as prokaryotes as they have no truenucleus or membrane bound cell organelles.



Size of Bacteria

Bacillus cells on the tip of a pin.



Bacterial Types

They are classified according to three shapes

- **Round (cocci)**

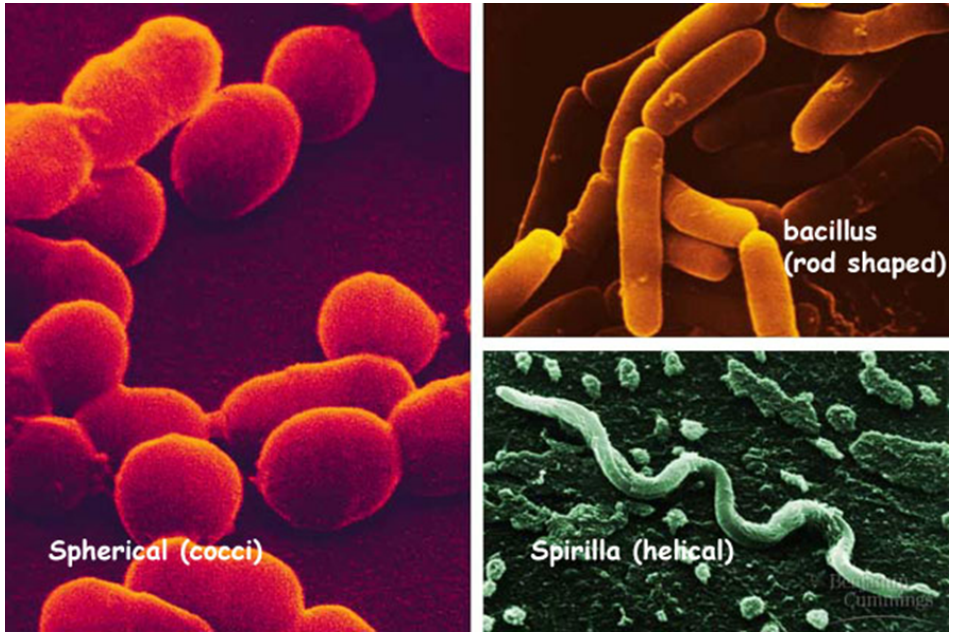
e.g. Pneumonia

- **Rod (bacillus)**

e.g. Tetanus (lockjaw)

- **Spiral (spirillum)**

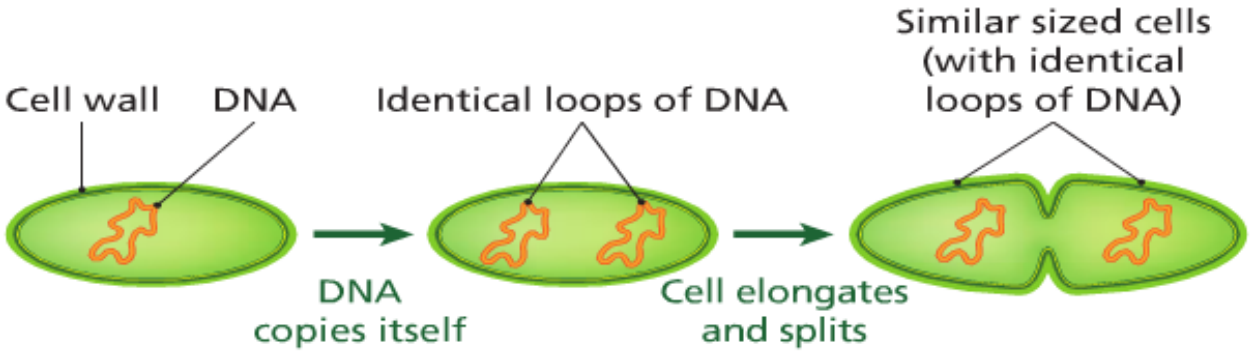
e.g. Cholera



Reproduction

Bacteria reproduce by **binary fission** (split in two).
The bacterial chromosome reproduces itself and then the cell divides.
Bacteria can divide every 20 minutes in ideal conditions.
This growth can make 1 million bacteria from 1 bacterium in 7 hours.

Any **mutation** in the bacterial DNA thathelps the bacteria survive will be passed on. This means new species of bacteria can evolve very quickly. e.g. MRSA

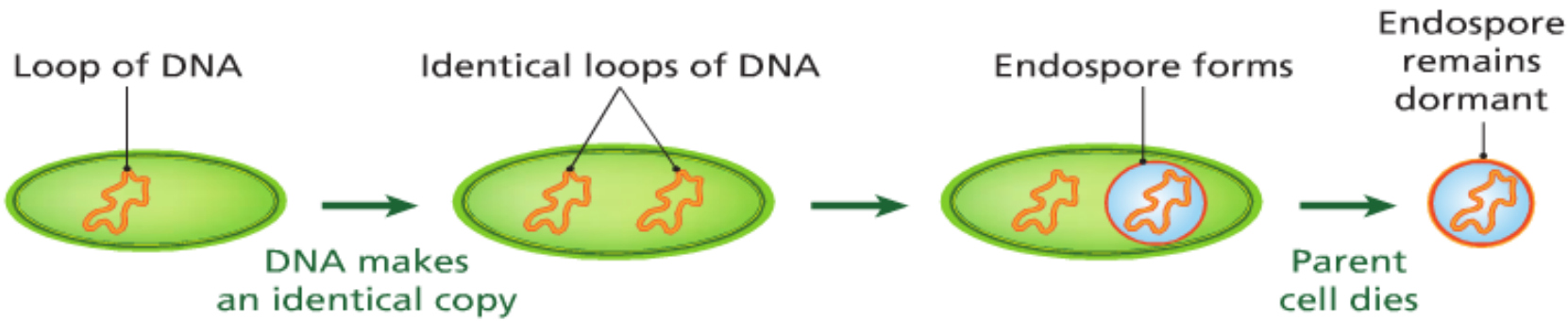


Reproduction

Bacteria reproducing by **binary fission.**

Reproduction with Endospores

When conditions for life are harsh, a bacteria produces an **endospore**.
A **thick wall** forms around a spore that contains the bacterial DNA.
This spore can survive for hundreds of years.
They can be boiled and poisoned without harm.
When conditions become better then water is taken into the spore and it grows into a new bacterium.



Nutrition in Bacteria

There are 4 main ways that bacteria get food.
These can be split into 2 main headings,

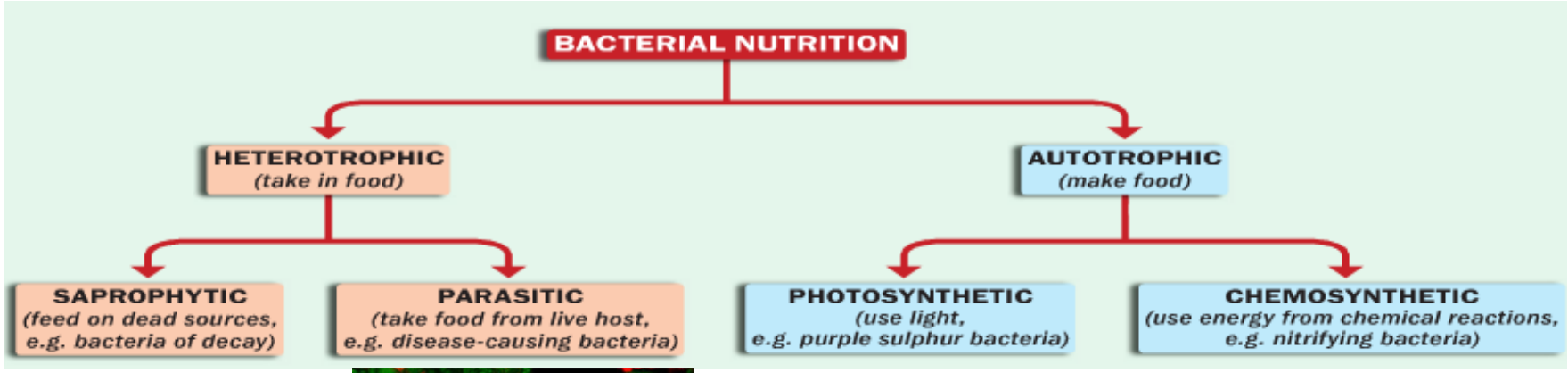
Autotrophic (make their own)

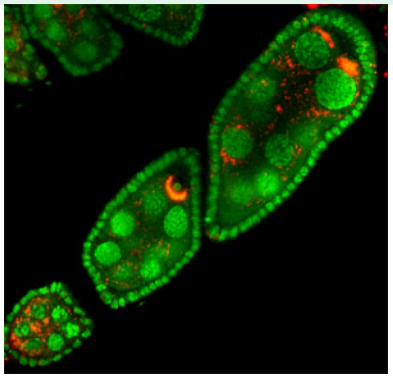
1. Photosynthetic bacteria - often have chlorophyll to catch sunlight. They don't have chloroplasts but instead use special membranes.
   e.g. purple sulfur bacteria
2. Chemosynthetic bacteria - use ammonia, sulfur or iron compounds to make energy. e.g. bacteria in the Nitrogen cycle.
   e.g. nitrifying bacteria

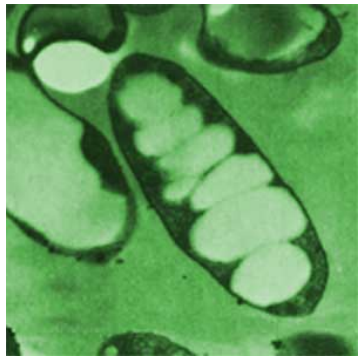
Heterotrophic (other places)

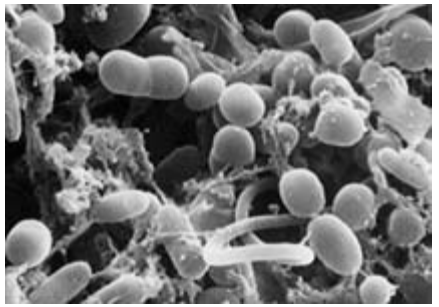
3. Saphrophytes - are organisms that live off dead matter.
e.g. leaves that have fallen. They are essential for **nutrient recycling**.
4. Parasites - live off a live host and usually cause harm to the host.
e.g. E.Coli bacteria cause food poisoning.

Nutrition in Bacteria









Growth of Bacteria

Five Factors that effect the growth of bacteria are,

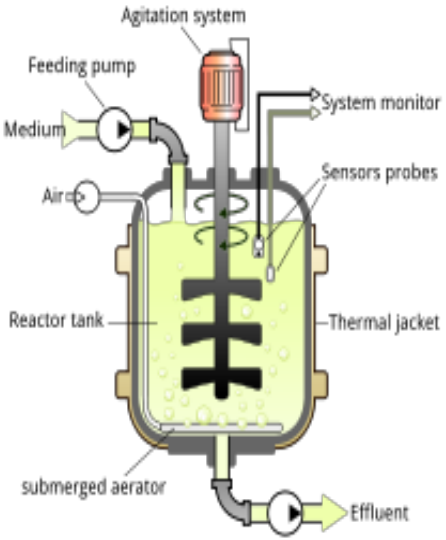
1. Temperature - Low temperatures slow bacterial growth, e.g. fridge
   Ideal conditions for most are from 20-30 °C.

2. Oxygen Concentration -
   Aerobic bacteria need Oxygen to live.
   Anaerobic bacteria do not require oxygen.
   Facultive bacteria can live with or without oxygen.
   Obligate anaerobes - can only live where there is no oxygen.

3. pH -
   Bacteria have enzymes that only work near optimum pH levels.
   Most work at pH7 but some work at very acidic or alkaline levels.

4. **External Solute Concentration**
   Bacteria gain or lose water by **osmosis**. If they lose water then their enzymes don't work. If they gain water they will fill with water but won't burst as they have a cell wall.

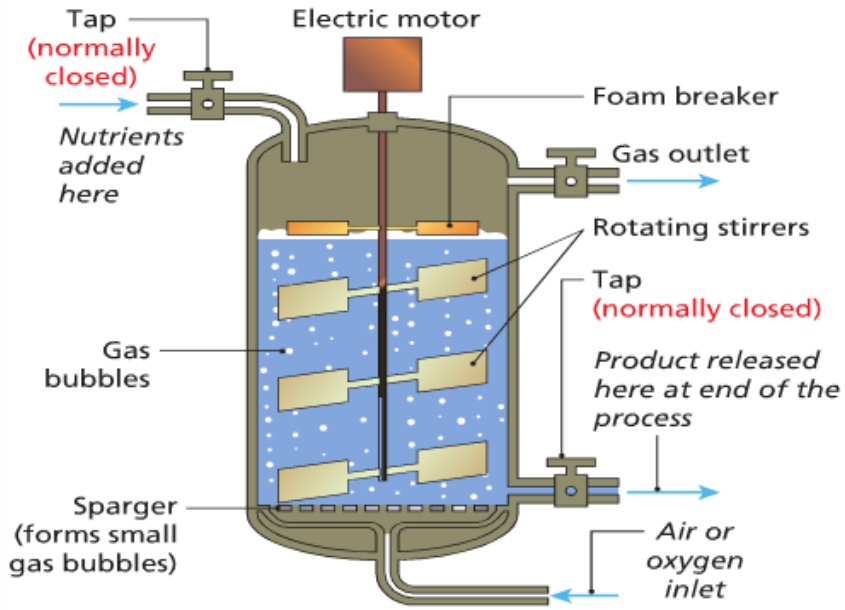
5. **Pressure**
   Some bacteria in deep-sea vents have evolved very **strong cell walls**. The cell walls of normal bacteria can't survive strong pressure. Scientists can genetically engineer bacteria to have stronger walls so they can grow them in a bioreactor.



Bioreactors

Bacteria can be grown in **Bioreactors**.
These are vessels to which **food** and **oxygen** are added.
The bacteria have to be kept at a certain temperature and pressure.

The bacteria also produce **wastes** that must be removed so that they don't get contaminated.



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The bacteria are grown to make **antibiotics, food colouring, perfumes**, etc.

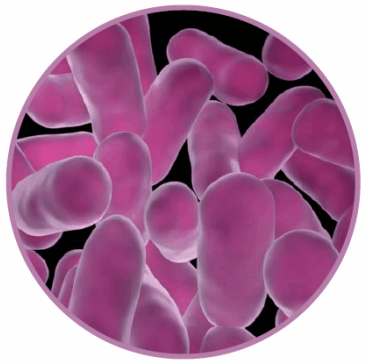
Economic Importance - Benefits

Bacteria such as **Lactobacillus** are used to change milk into yoghurt and cheese. Other products are vinegar, silage, pickles, and antibiotics.

Genetically modified bacteria (E.coli) are used to make insulin, drugs, enzymes, amino acids, vitamins, food flavouring, alcohol and more.

Disadvantages

Bacteria can cause many diseases in humans and animals. e.g. whooping cough and food poisoning.
Bacteria cause food to decay (e.g. Lactobascilli cause milk to go sour)



Growth of Bacteria

Bacteria grow in a certain way in a bioreactor.

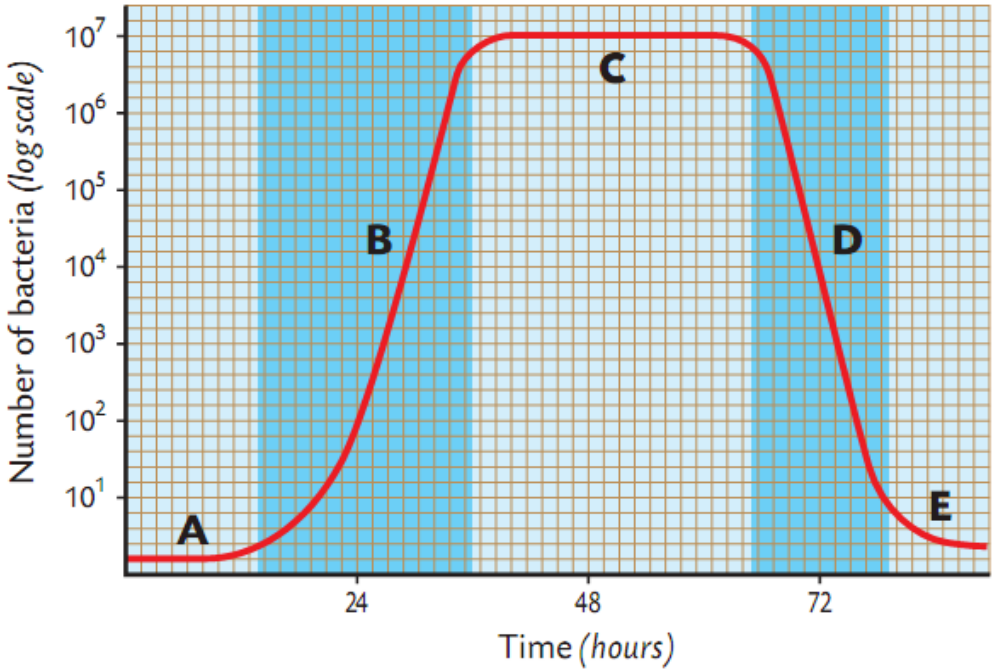
A - Lag Phase

B - Log Phase

C - Stationary Phase

D - Decline Phase

E - Death or Survival Phase



Growth Curve

Growth Curve

A - Lag Phase - bacteria adapt to their environment and make chemicals to prepare for growth.

B - Log Phase - Bacteria divide as fast as possible. Growth is exponential due to ideal conditions.

C - Stationary Phase - The number of bacteria dying is the same as the number growing.

D - Decline Phase - Most of the bacteria start to die.

E - Death or Survival Phase - A few survive as Endospores.

Culture types in Bioreactors

Batch Flow

In batch flow the bacteria are grown until the **stationary** phase.
After this the bacteria are stopped and removed.
The Bacteria are stored then till more product is needed.
This is the better system and costs less money.
Many **antibiotics** are made this way.

Continuous Flow

In continuous flow the bacteria are kept growing in the Log Phase.
The dead **bacteria and wastes are removed** constantly to save the live bacteria.
The Bacteria are kept growing to produce constant product (e.g. **insulin**).
This system needs constant monitoring and costs more money.
Single Cell Proteins (**Quorn/TVP**) are made this way.

Food Processing

Modern **bioprocessing** uses bacteria and fungi to make food products.
These include cheese, yoghurt, sweetners, amino acids, vitamins, flavourings, flavour enhancers, beer and wines.

Humans usually get **protein** from meat but other sources are now available.
These **Single Cell Proteins** may be better for the environment and for our health

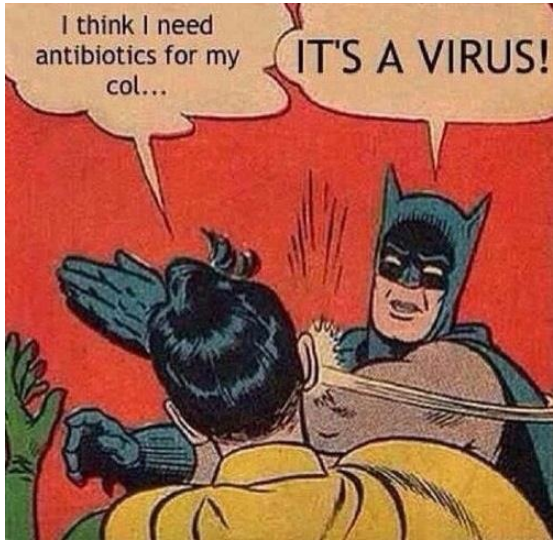
TVP
Textured Vegetable Protein

Quorn
Fermented Fungi

Antibiotics

Antibiotics - are chemicals produced by microorganisms that stop the growth of, or kill, other microorganisms without damaging human tissue.

Antibiotics only kill **bacteria** and not viruses.

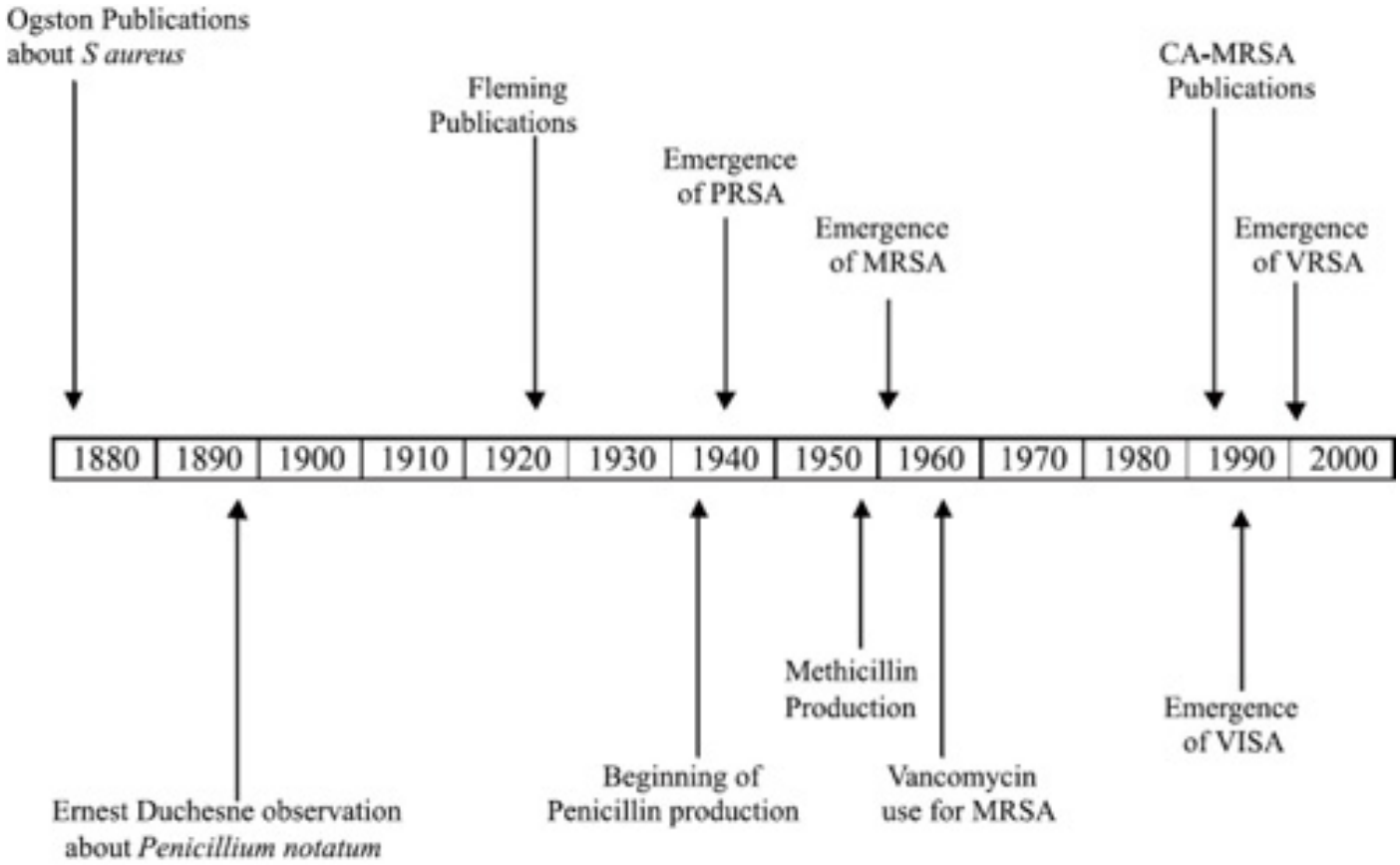


Penicillin was first isolated from a fungus in 1928 by Fleming.
It was used in World War I and from then on.

Resistance

Bacteria that can survive an antibiotic have a **mutation** in their DNA.
This means they have a mistake that allows them not to be killed.
Even if only 1 bacterium has this mutation it will make millions more within a few hours.

MRSA Timeline

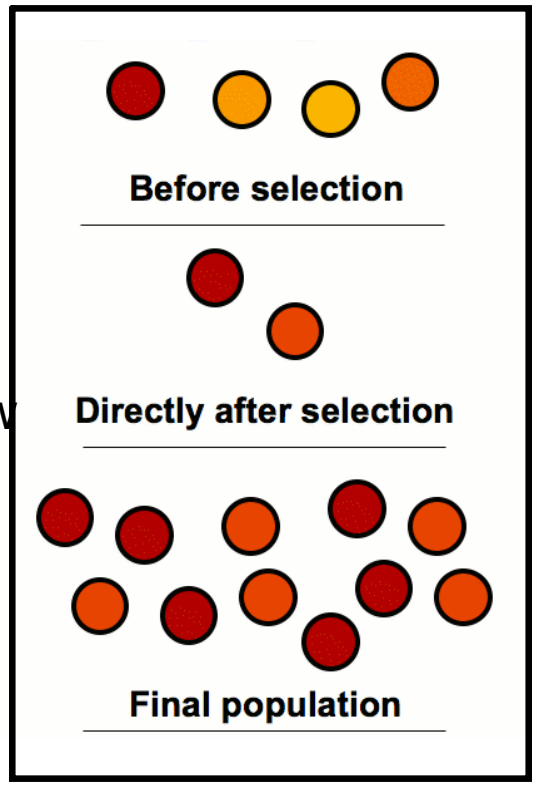


Resistance

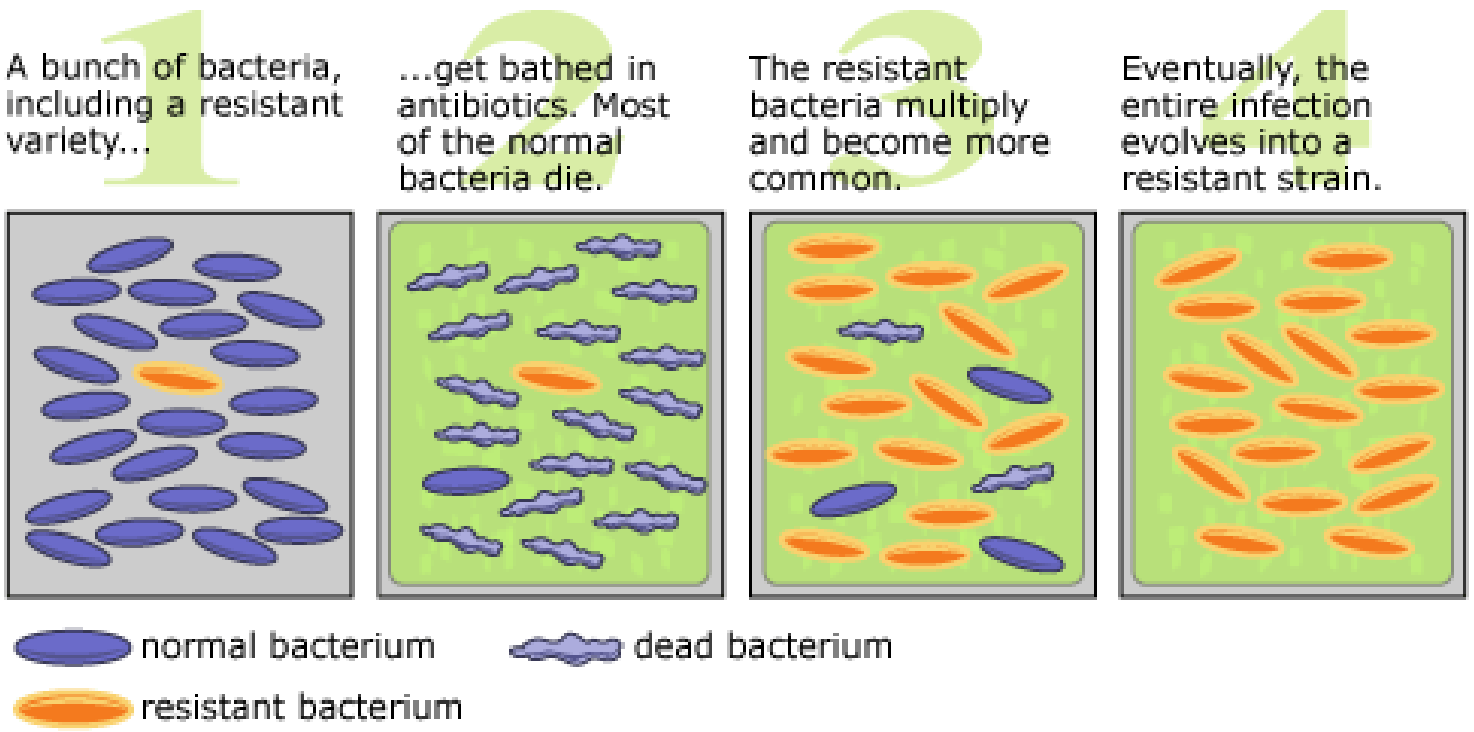
The circles are bacteria. The colours show how resistant or strong they are at surviving.

The bacteria are given an antibiotic. Some with low resistance will die and the resistant ones survive.

The low resistant bacteria are gone.
The resistant bacteria survive and multiply so now all bacteria are very resistant.



Resistance


A bunch of bacteria, including a resistant variety...
...get bathed in antibiotics. Most of the normal bacteria die.
The resistant bacteria multiply and become more common.
Eventually, the entire infection evolves into a resistant strain.
normal bacterium
dead bacterium
resistant bacterium

Not just humans take antibiotics

Antibiotics given to animals can be passed on in meat.
This means that the animals help make resistant bacteria that we may then eat and have inside us.
This could lead to a huge pandemic that could kill millions.