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3.1.3 Monera – Bacteria

Bacteria

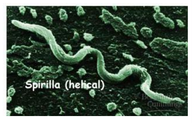
- Bacteria belong to the kingdom Monera. They are unicellular organisms
- Also known as prokaryotes as they have no membrane bound nucleus or membrane bound cell organelles
- They are classified according to three shapes
    - **Spherical (cocci)**
    - **Rod (bacillus)**
    - **Spiral (spirillum)**

Bacterial Shapes

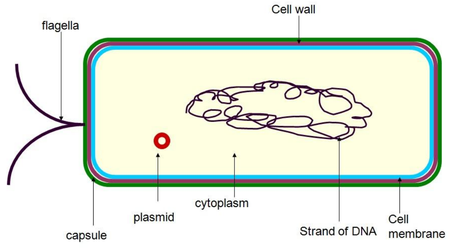
Spherical (cocci)
E.g. Staphlococcus aureus
causes pneumonia

Rod (bacillus)
E.g. Bacillus anthracis causes anthrax
Escherichia coli (E.coli) live in human gut

Spirillum (spiral)
E.g.Treponema pallidum causes syphilis



Bacterial Structure



Cell Parts & Function

Cell wall - shape & structure
Cytoplasm - contains ribosomes and storage granules but **no** mitochondria or chloroplasts
Nuclear material - single chromosome of DNA
Capsule* - protection
Flagella* - movement
Plasmid* - circular piece of DNA containing few genes for drug resistance

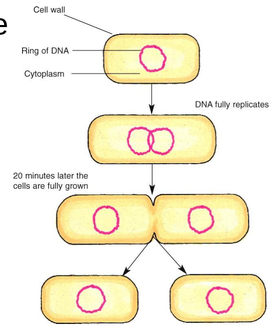
***** Sometimes present.

Bacterial reproduction

- Bacteria reproduce asexually
- The method used is called **Binary Fission**

Binary Fission

- The chromosome attaches to the plasma membrane and the DNA is replicated
- The cell elongates and the two chromosomes separate
- The cell wall grows to divide the cell in two
- Two identical daughter cells are formed



Bacterial Reproduction

- Bacteria reproduce asexually - their offspring are genetically identical
- As there is little recombination of genetic material in this method of reproduction one would expect that bacteria would be slow to evolve
- Bacteria has a very short lifecycle (some can reproduce every 20 minutes).
- New mutations can spread very quickly
- This is how bacteria evolve resistance to new antibiotics

Endospore formation

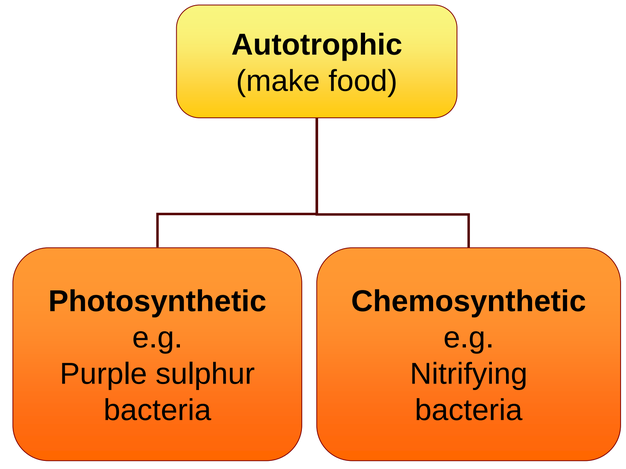
- Some bacteria can withstand unfavourable conditions by producing endospores
- Formed when the bacterial chromosome replicates
- One of the new strands becomes enclosed in a tough-walled capsule called an endospore
- Parent cell breaks down - endospore remains dormant
- When conditions are favourable the spores absorb water, break their walls and reproduce by binary fission

Bacterial Nutrition

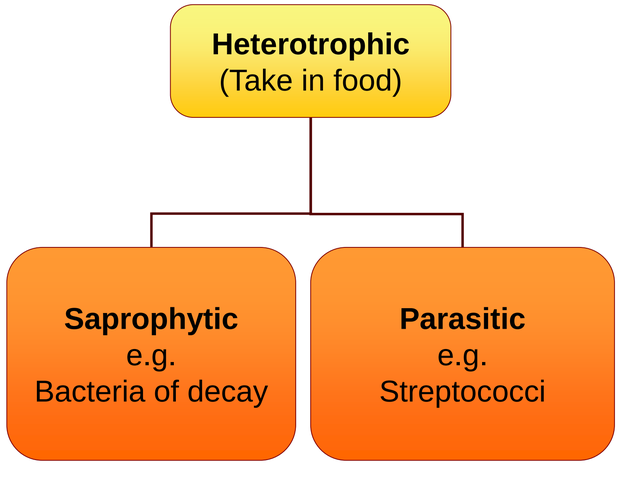
Autotrophic and Heterotrophic

Autotrophic – organisms which make their own food
Heterotrophic – organisms which take in food made by other organisms

Autotrophic Bacteria



Heterotrophic Bacteria



3.1.3 Monera – Bacteria

Factors affecting the growth of bacteria

- For the maximum growth rate bacteria must have access to a food source and the conditions of their environment must be monitored closely
- Too much or too little of any of the following factors will slow down the growth of bacteria:
    1. Temperature
    2. pH
    3. Oxygen concentration
    4. External solute concentration
    5. Pressure

1. Temperature

- Most bacteria grow well between 20°C and 30°C.
- Some can tolerate much higher temperatures without their enzymes becoming denatured.
- Low temperatures slow down the rate of reaction of enzymes resulting in slower growth

2. pH

- If a bacterium is placed in an unsuitable pH its enzymes will become denatured

3. Oxygen concentration

- Aerobic bacteria require oxygen for respiration e.g. Streptococcus
- This is why oxygen is sometimes bubbled through bioreactors
- Anaerobic bacteria do not require oxygen to respire
    - **Facultative anaerobes** can respire with or without oxygen e.g. *E. Coli* (found in intestines)
    - **Obligate anaerobes** can only respire in the absence of oxygen e.g. *Clostridium tetani* (causes tetanus)

4. External Solute concentration

- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
    - higher than the bacterial cytoplasm water will move out of the bacteria (Dehydration)
    - Food preservation techniques are based on this
- Bacteria can gain or lose water by osmosis
- If the external solute concentration is
    - lower than the bacterial cytoplasm solute concentration water will enter the bacteria
    - Cell wall will prevent bursting in most cases

5. Pressure

- The growth of most bacteria is inhibited by high pressures.
- Some bacteria can withstand high pressures. Pressure tolerant bacteria for use in bioreactors can be formed by genetic engineering techniques.

Economic importance of bacteria

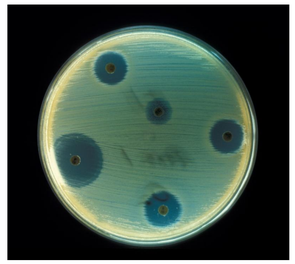
Beneficial bacteria

- Bacteria such as Lactobacillus are used to convert milk to products such as cheese and yoghurt
- Genetically modified bacteria e.g. E. Coli are used to make products such as insulin, enzymes, drugs, food flavourings and vitamins
- Antibiotics can be formed by some microorganisms
- Bacteria in the colon help produce vitamins
- Bacteria are active in the Carbon and Nitrogen Cycles

Harmful bacteria

- Pathogenic micro-organisms cause disease in plants and animals, e.g. tuberculosis, pneumonia, etc.
- If they enter the body through a wound they can multiply and effect the nerves and activity of muscles
- Bacteria can cause food spoilage and tooth decay.

Antibiotics



- Antibiotics are substances produced by micro-organisms that stop the growth of, or kill, other micro-organisms without damaging human tissue.
- Antibiotics can be used to control bacterial and fungal infections but do not effect viruses
- The first antibiotic, Penicillin, was isolated from a fungus was by Sir Alexander Fleming
- Now antibiotics are mostly produced by genetically engineered bacteria
- When an antibiotic is used to treat an infection most of the bacteria are killed
- **Mutations** in bacterial genes can allow bacteria to develop **antibiotic resistance**.
- Antibiotics will then kill 'sensitive' bacteria and favour resistant bacteria.
- Bacterial strains have emerged which are resistant to almost all known antibiotics (**multi-resistant**). As a result present day antibiotics become ineffective. **MRSA** is one example.

Misuse of Antibiotics

Overuse of antibiotics

- This results in the increased growth of antibiotic resistant bacteria
- Failure of some patients to complete a course of antibiotics prescribed to them by a doctor allows the bacteria to survive and re-grow

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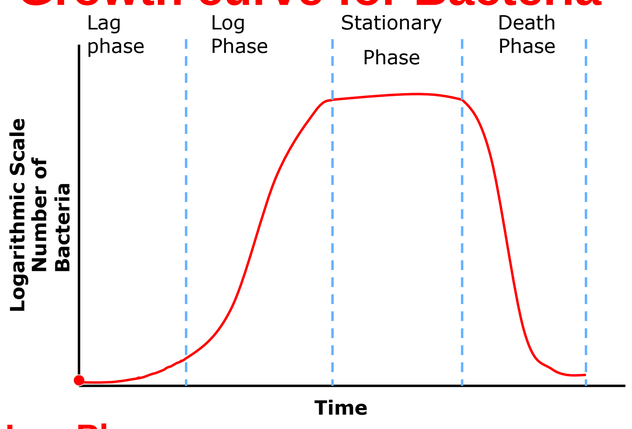
3.1.10.H Growth Curves

Rate of Growth

- Bacteria divide by **Binary Fission**.
- This is a form of **asexual reproduction**.
- Under ideal conditions it can take place every 20 minutes!
- In this way huge numbers of bacteria can be produced very rapidly.
- Because of this we use a special scale called the logarithmic scale to represent their numbers, i.e.
  10^0, 10^1, 10^2, 10^3, 10^4, 10^5... OR
  1, 10, 100, 1,000, 10,000, 100,000 ...

Growth curve for Bacteria



The Lag Phase

- After inoculation there is normally a brief period of adaptation by the cells to the new conditions.
- Bacteria are producing the enzymes necessary to digest the nutrients.
- The rate of growth begins to increase towards the end of this phase.

The Log (Logarithmic OR Exponential) Phase

- There is a rapid period of growth during this phase due to the fact that:
- Bacteria have developed the necessary enzymes and there are plenty of nutrients.
- There are few waste products being produced.
- The rate of cell division is currently at its maximum with the number of bacteria doubling as often as every 20 minutes.

The Stationary Phase

- The rate of growth levels off during this period.
- This is because:
  - The nutrients are becoming used up.
  - The amount of waste produced by the bacteria themselves is increasing.
  - The rate at which new cells are produced is equal to the rate at which other cells are dying.

The Death (Decline) Phase

During this phase more bacteria are dying than are being produced. This is because:

- Very few nutrients are left.
- Many bacteria are poisoned by the waste produced by such large numbers
- Thus the rate of growth is falling.

Endospore Formation

In unfavourable conditions many bacteria can form endospores

These are highly resistant to drought high temperature and other environmental hazards.

How Endospores are formed:

- The bacterial chromosome replicates.
- One of the new strands becomes enclosed by a tough-walled endospore formed inside the parent cell.
- The parent cell then breaks down
- Endospores can remain dormant for a long period of time.
- When conditions are favourable a new bacterium can be formed again and continue to reproduce.

Batch and Continuous Flow Food Processing

A bioreactor is a vessel in which biological reactions take place

Bio-processing

Involves the use of living organisms to produce a wide range of products, e.g. yoghurts, cheeses, vitamins, alcohol products such as wines and beers, etc.

There are two main methods of food processing:

- Batch food processing
- Continuous flow food processing

Batch food processing

A fixed amount of sterile nutrient is added to the micro-organisms in the bioreactor.

The micro-organisms go through the stages of a typical growth curve, i.e. The Lag, Log, Stationary and Death phases

Although the reaction may be stopped before the death phase as very little product will be formed at this stage.

In Batch Processing most of the product is formed during the Log and Stationary phases

At the end of production:

- The product is separated and purified.
- The bioreactor is cleaned and re-sterilised.
- The process can then be repeated.

Continuous Flow food processing

- Nutrients are continuously fed into the bioreactor.
- At the same time the culture medium (containing some micro-organisms) is continually withdrawn.
- Micro-organisms are maintained in the Log phase of growth and the process can continue uninterrupted for weeks, even months.
- Factors such as temperature, pH, rate of stirring, concentration of nutrients, oxygen and waste products are constantly monitored in order to maintain growth and produce the maximum yield.

In Continuous Flow Processing most of the product is formed during the Log phase