
بسم الله الرحمن الرحيم

Bacterial metabolism & growth

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Intended Learning outcomes (ILOs)

1. Define bacterial reproduction
2. Outline the process of bacterial metabolism
3. Classify bacteria based on nutrition Requirement and oxygen Requirements
4. Describe bacterial growth curve in an open and closed system
5. Outline applications of bacterial growth phases

Bacterial Reproduction producing a replica of oneself

❖**Binary Fission:** one cell **divides into 2 equal daughter cells** similar to the mother cell by:

1-Elongation of bacterial cell

2-Duplication of chromosome

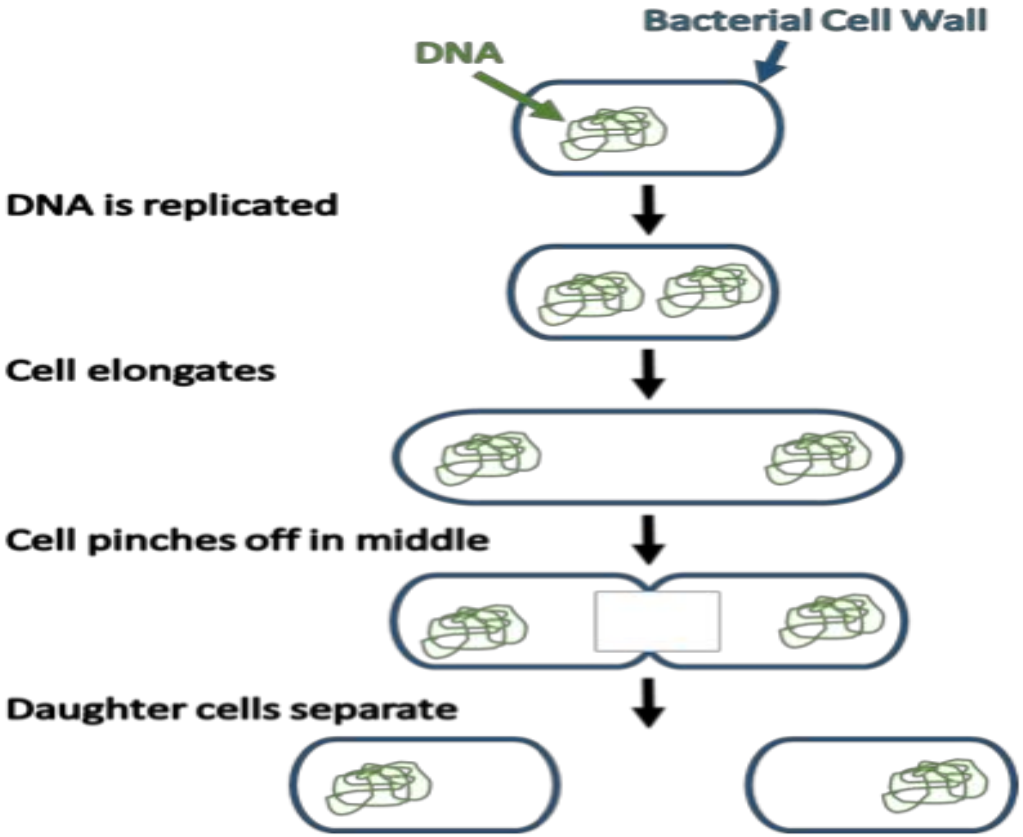
3-Projections from mesosome start to appear forming a septum dividing the cell

4- Daughter cells may remain attached to each other giving the characteristic arrangement as **clusters, pairs, chains**

Bacterial Reproduction

❖ **Doubling (generation) Time:**

- ➢ Time required by bacteria to double its number.
- ➢ Varies from one bacteria to another.
- ✓ In E. coli 20min
- ✓ In M. Tuberculosis 1 - 3 days



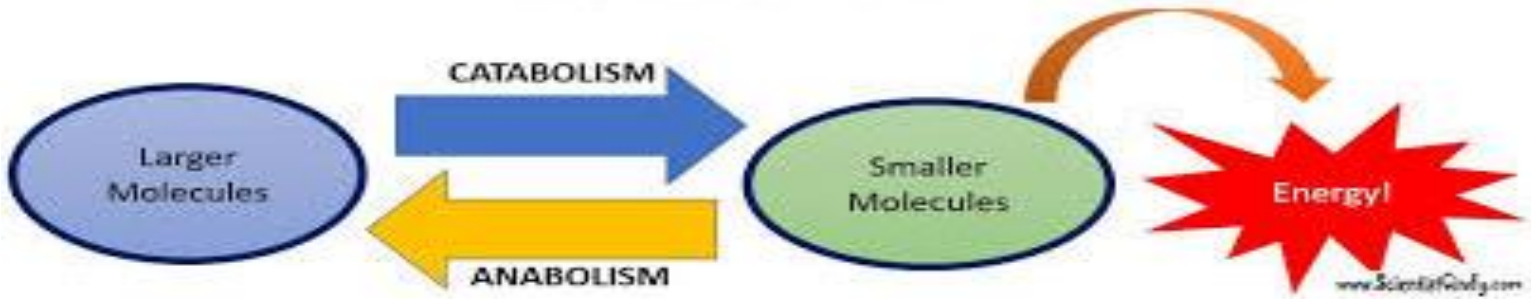
Bacterial Metabolism

*Bacteria don't have a mouth to chew!!

- Many bacteria secrete enzymes e.g. **lipases**, **nucleases**, **proteinases**, and other hydrolytic enzymes
- These enzymes **breakdown extracellular nutritive material** into simpler molecules that are **actively transported** across the **cytoplasmic membrane**
- These molecules are then **oxidized by bacteria** to yield **energy** (**Catabolism**) and to build up **structural components** for cell metabolism (**Anabolism**)

ATP

e.g: proteins required to build cell wall following replication



Oxidation Processes

❖A series of reactions catalyzed by a set of **enzymes and coenzymes** in which hydrogen ions (electrons) are released in the reaction and are transferred to a hydrogen acceptor

- **The hydrogen acceptor** is molecular oxygen in aerobic respiration or an inorganic compound, (e.g. nitrate) in anaerobic respiration.
- The energy that results from these reactions is stored as high energy bonds, e.g. ATP to be used in anabolic processes.

Fermentation

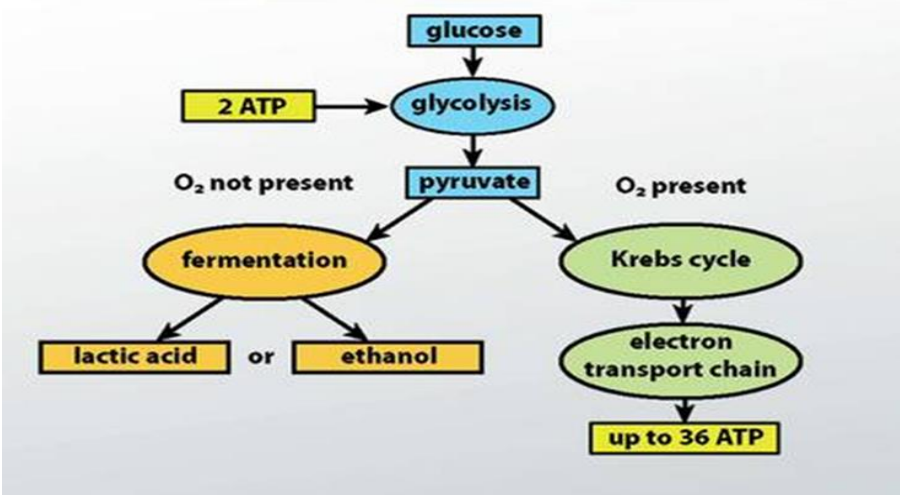
- The breakdown of a **sugar to pyruvic acid** and then, usually, to **lactic acid**.
- Facultative and anaerobic bacteria use fermentation to generate ATP in the absence of oxygen.
- If oxygen is present, the pyruvate produced by fermentation enters the Krebs cycle which generates much more ATP than
- Facultative and anaerobic bacteria ferment
- Aerobic bacteria do not ferment but enter the Krebs cycle directly.

require O_2

Oxidation Vs Fermentation

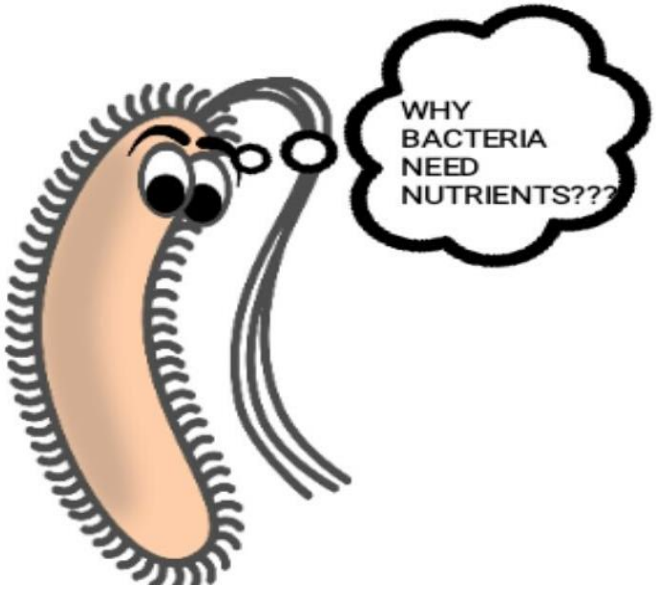
The key difference between oxidation and fermentation:

- Fermentation is the chemical process of producing acids, alcohols and Co2 from sugars in the absence of oxygen.
- Oxidation is the chemical process by which a compound undergoes oxidation in the presence of oxygen



Bacterial Nutrition

- ❑ **Bacteria, like all cells, require nutrients**
- ❑ **Two nutritional groups can be distinguished:**



1- To make carbohydrate
2-To make amino acids
3- To make lipids , vitamins, growth factors
4-To make RNA/ DNA

Heterotrophs
Take in food
- Saprophytic
  e.g: Bacteria of decay
- Parasitic
  e.g: Streptococci

Autotrophs
Make food
- Photosynthetic
  e.g Purple sulfar bacteria
- Chemosynthetic
  e.g: Nitrifying bacteria

Bacterial Nutrition

1 - Autotrophs:

- ✓These bacteria utilize simple **inorganic substances** as a source of **carbon** and **nitrogen** in addition to energy from light so they synthesize organic substances, e.g. proteins, carbohydrates
- ✓are **non-parasitic** organisms of **NO medical importance.**

Bacterial Nutrition

2- Heterotrophs:

- ✓These bacteria require **organic substances**, e.g. sugars, and proteins, which are derived **from plant or animal sources**.
- ✓All bacteria of medical importance are **heterotrophs**.
- ✓They live in or on the animal body and are called **parasitic bacteria**.

Growth Factors

A) Vitamins/ Nucleotides/Amino acid:

✓Bacteria **can not synthesize** it and need these substances in small amounts

B) Gaseous requirement of the bacteria:

➢**Oxygen:** bacteria classified into 5 groups:

*Nagging Pests Must Breath

Nocardia
Pseudomonas Aeroginosa
Mycobacterium Tuberculosis
Bacillus Anthracis

1- Obligate (strict) aerobic:

Grow only in the **presence of oxygen** to form energy

Eg: *M.tuberculosis*, *Pseudomonas aeroginosa*.

2- Obligate anaerobic:

✓Grow only in **complete absence of O_2** and die in its presence Eg: *Clostridium tetani* الكزاز

✓As in presence of O_2 two toxic molecules are formed (hydrogen peroxide as H_2O_2, superoxide as O_3)

✓They lack enzymes such as **catalase**, and **superoxide dismutase** which are required **to break these toxic** molecules.

Glutathione pathway

Growth Factors

3- Facultative anaerobic:

- ✓ Grow in the **presence or absence** of O_2
- ✓ Eg: most bacteria as **staphylococci**, **streptococci**

4-Micro-aerophilic:

- ✓ Require **low O_2 tension** for growth lower than that in the atmosphere
- ✓ Eg: *Campylobacter jejuni*

5- Aerotolerant anaerobic bacteria:

- ✓ Prefer **anaerobic conditions but can tolerate the presence of O_2** as they possess **superoxide dismutase**.
- ✓ Eg: *Clostridium perfringens*

Growth Factors

➢ **Carbon dioxide (CO2):**

- Bacteria need it in **minute amounts**.
- Some bacteria need **high concentrations** as **brucella** (5- 10%).

C) Temperature:

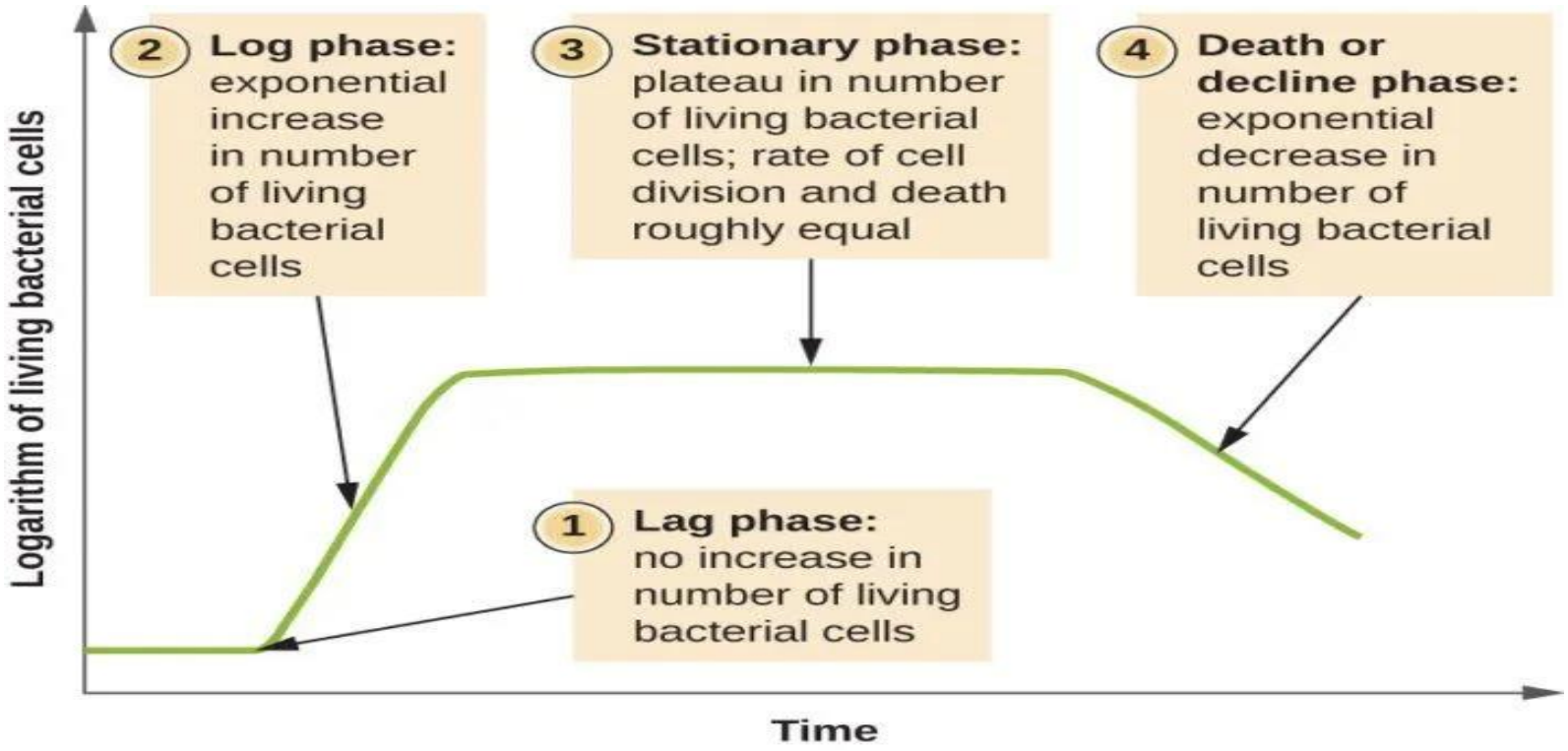
- Bacteria grow between (25-45°C) mostly at 37°C
- Non pathogenic bacteria grow in < 25°C or > 50°C

D) pH:

- Bacteria grow in PH between (7.2-7.6)
- *Vibrio cholera* alkaline PH (8 – 9)
- *Lactobacilli* acidic PH (4 – 5)

Bacterial Growth Curve

If a small number of bacteria inoculated in culture fluid media, the following changes appear:



Bacterial Growth Curve

1- Lag phase:

✓No increase in number of bacteria (no cell division).

✓Bacteria adapt to the environment by the production of enzymes, and nutrients.

2- Log phase (logarithmic phase):

✓Increase in number of bacteria due to rapid cell division.

✓**Antibiotics are effective during this phase** as penicillin on peptidoglycan

3- Stationary phase:

✓No increase in the number of bacteria but there is also cell division

✓As nutrients are exhausted, toxic products start to accumulate.

✓The number of dying bacteria = number of newly formed bacteria, so the number of living bacteria remains constant.

4- Decline phase:

✓Nutrients exhaustion, toxic products continue to accumulate.

✓Number of dying bacteria > number of newly formed bacteria, so thenumber of living bacteria decreasing.

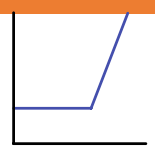
Bacterial Growth Curve

Bacterial Growth Curve In Open and Closed System

- In a **closed system** or batch culture (no food added, no wastes removed) bacteria will grow in a predictable pattern, resulting in a growth curve composed of the four distinct phases of growth

- In an **open system,** fresh sterile medium is added continuously in the vessel so that bacteria growth is not inhibited due to lack of nutrients or accumulation of toxic bacterial metabolites.

* only 2 phases lag & log phases



Bacterial Growth Curve

The bacterial growth curve has the following applications:

- To study nutritional and physical needs for bacterial growth.
- **In an open system,** can be used in the biosynthesis of hormones, vaccines and other proteins of medical importance

* Closed system is used in industrial production of microbes (to get it's toxins, enzymes,...)
* If you have bacterial infection, you have to deprive the bacteria of it's requirements.
  ↳ e.g : closing the wound so aerobic bacteria can't survive

Bacterial Growth Curve

Micro facts:

While the bacterial growth curve has 4 phases the viral growth curve has only 2 phases lag and log phase as in the bacteriophage growth cycle.


Thank You