



General Microbiology Course
Lecture 3
(Microbial Growth and Metabolism)

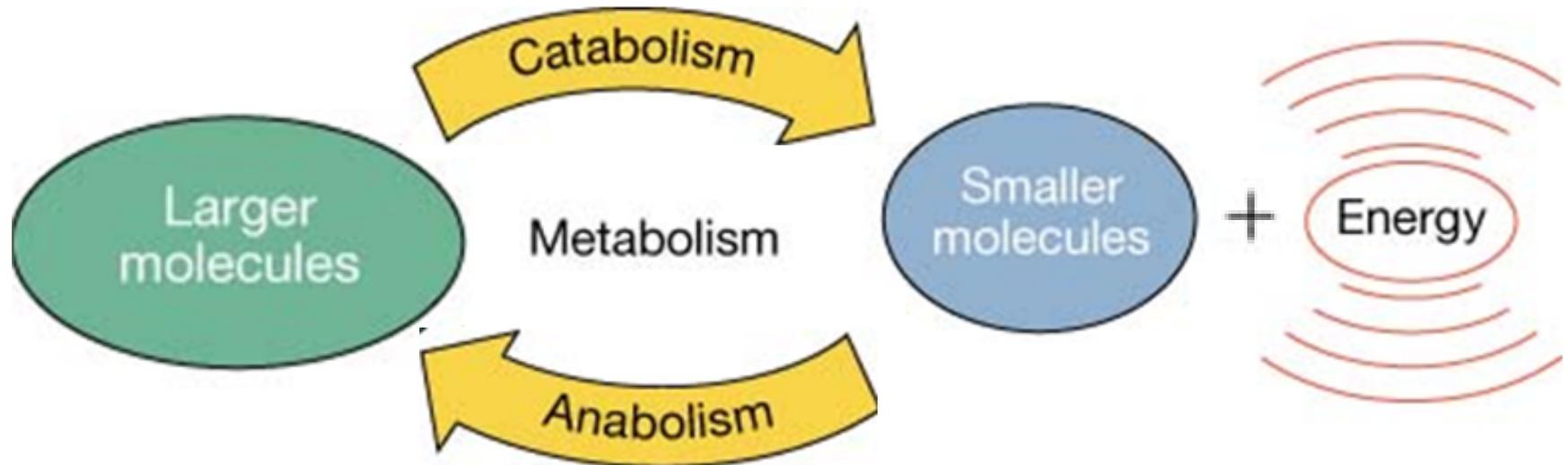
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Lecture Outlines

- Some definitions.
- **Microbial nutrition.**
- **Microbial growth and its requirements.**
- **Reproduction of microbes.**
- **Bacterial respiration.**

Definitions

- **Metabolism:** the sum of the chemical reactions in an organism.
- **Catabolism:** provides energy and building blocks for anabolism
- **Anabolism:** uses energy and building blocks to build large molecules



Microbial nutrition

Types of microbial nutrition

Carbon source

- ⊠ **Heterotrophs** – must obtain carbon in an organic form made by other living organisms such as proteins, carbohydrates, lipids and nucleic acids
 - nutritionally dependent on other living things
- ⊠ **Autotrophs (self feeding)**: an organism that uses CO_2 , an inorganic gas as its carbon source

Microbial Growth:

- ☒ Refers to an increase in cell number, not in cell size.
- ☒ Bacteria grow and divide by binary fission, a rapid and relatively simple process.

Requirements for Growth

Physical Requirements

1. Temperature

Microbes classified into several groups based on their preferred temperature ranges.

A. Psychrophiles : “Cold-loving”. Can grow at 0°C. **Two groups:**

☒ True Psychrophiles

Optimum growth at 15 C or below. Found in very cold environments (North pole, ocean depths). Seldom cause disease or food spoilage.

☒ Psychrotrophs : Optimum growth at 20 to 30 C.

Responsible for most low temperature food spoilage.

Requirements for Growth

Physical Requirements

1. Temperature :

B. Mesophiles : “Middle loving”. Most bacteria.

☒ Best growth between 25 to 40 °C.

☒ Optimum temperature commonly 37 °C.

☒ Many have adapted to live in the bodies of animals.

C. Thermophiles : “Heat loving”.

☒ Optimum growth between 50 to 60 °C.

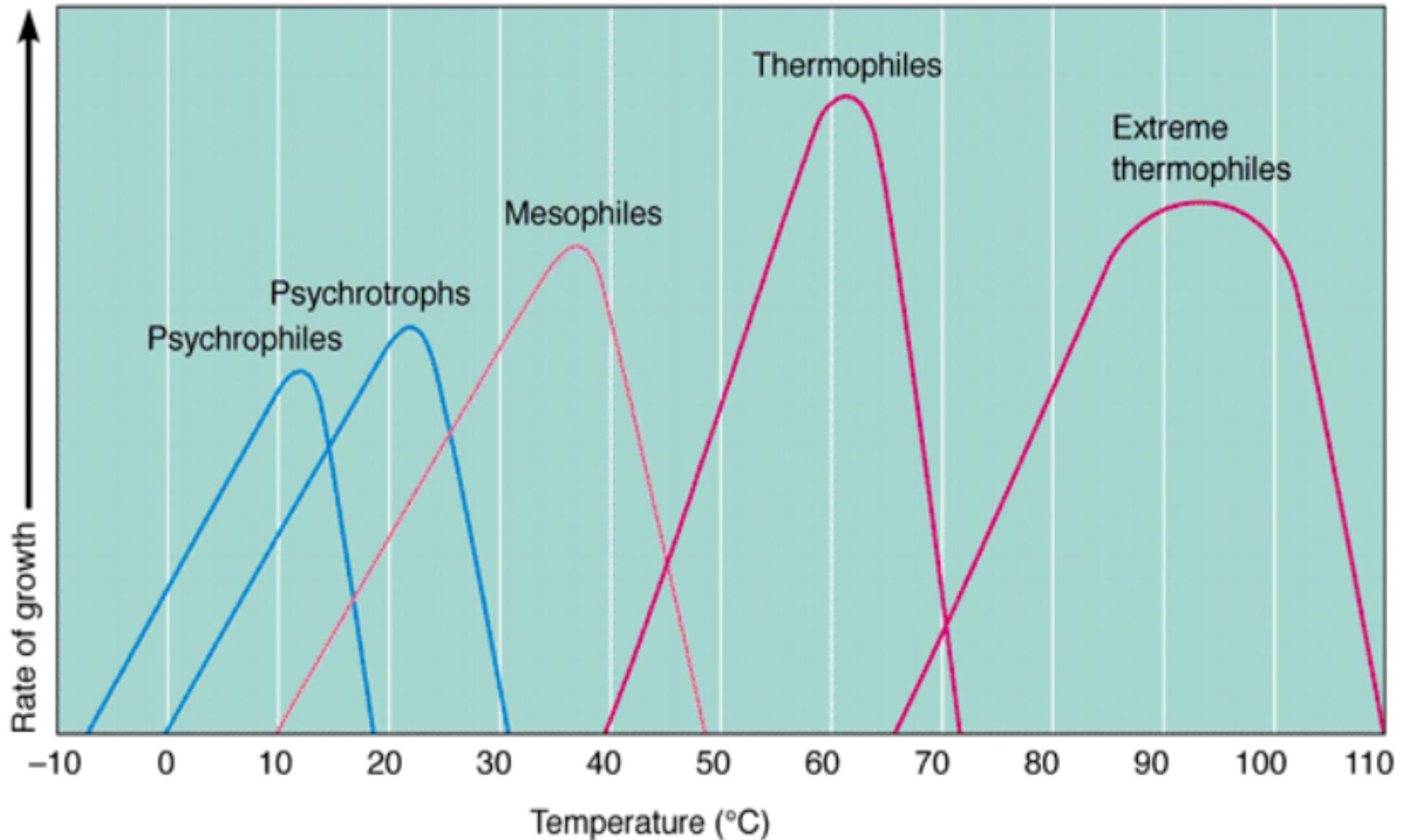
☒ Adapted to live in sunlit soil, compost piles, and hot springs.

☒ **Extreme Thermophiles (Hyperthermophiles)**:

Optimum growth at 80 °C or higher. Archaeobacteria.

Most live in volcanic and ocean vents.

Growth Rates of Bacterial Groups at Different Temperatures



Requirements for Growth

Physical Requirements

2. pH: Organisms can be classified as:

A. Acidophiles : “Acid loving”.

- ☒ Grow at very low pH (0.1 to 5.4)

- ☒ *Lactobacillus* produces lactic acid, tolerates mild acidity.

B. Neutrophiles :

- ☒ Grow at pH 5.4 to 8.5.

- ☒ Includes most human pathogens.

C. Alkaliphiles : “Alkali loving”.

- ☒ Grow at alkaline or high pH (7 to 12 or higher)

- ☒ *Vibrio cholerae* optimal pH 9.

Requirements for Growth

Physical Requirements

3. Osmotic Pressure : Cells are 80 to 90% water.

☒ **Halophiles** : Require moderate to large salt concentrations. Ocean water contains 3.5% salt.

☒ Most bacteria in oceans.

☒ **Extreme or Obligate Halophiles** : Require very high salt concentrations (20 to 30%).

☒ Bacteria in Dead Sea.

☒ **Facultative Halophiles** : Do not require high salt concentrations for growth, but tolerate 2% salt or more.

Requirements for Growth

Chemical Requirements

1. **Carbon**: Makes up 50% of dry weight of cell.

☒ Structural backbone of all organic compounds.

☒ **Chemoheterotrophs**: Obtain carbon from their energy source: lipids, proteins, and carbohydrates.

☒ **Chemoautotrophs and Photoautotrophs**: Obtain carbon from carbon dioxide.

Requirements for Growth

Chemical Requirements

2. Oxygen: bacteria are classified into

1- **Aerobes**: utilizes oxygen and can detoxify it

- **obligate aerobes**: cannot grow without oxygen
- **facultative anaerobes**: utilize oxygen but can also grow in its absence
- **microaerophilic** : requires only a small amount of oxygen

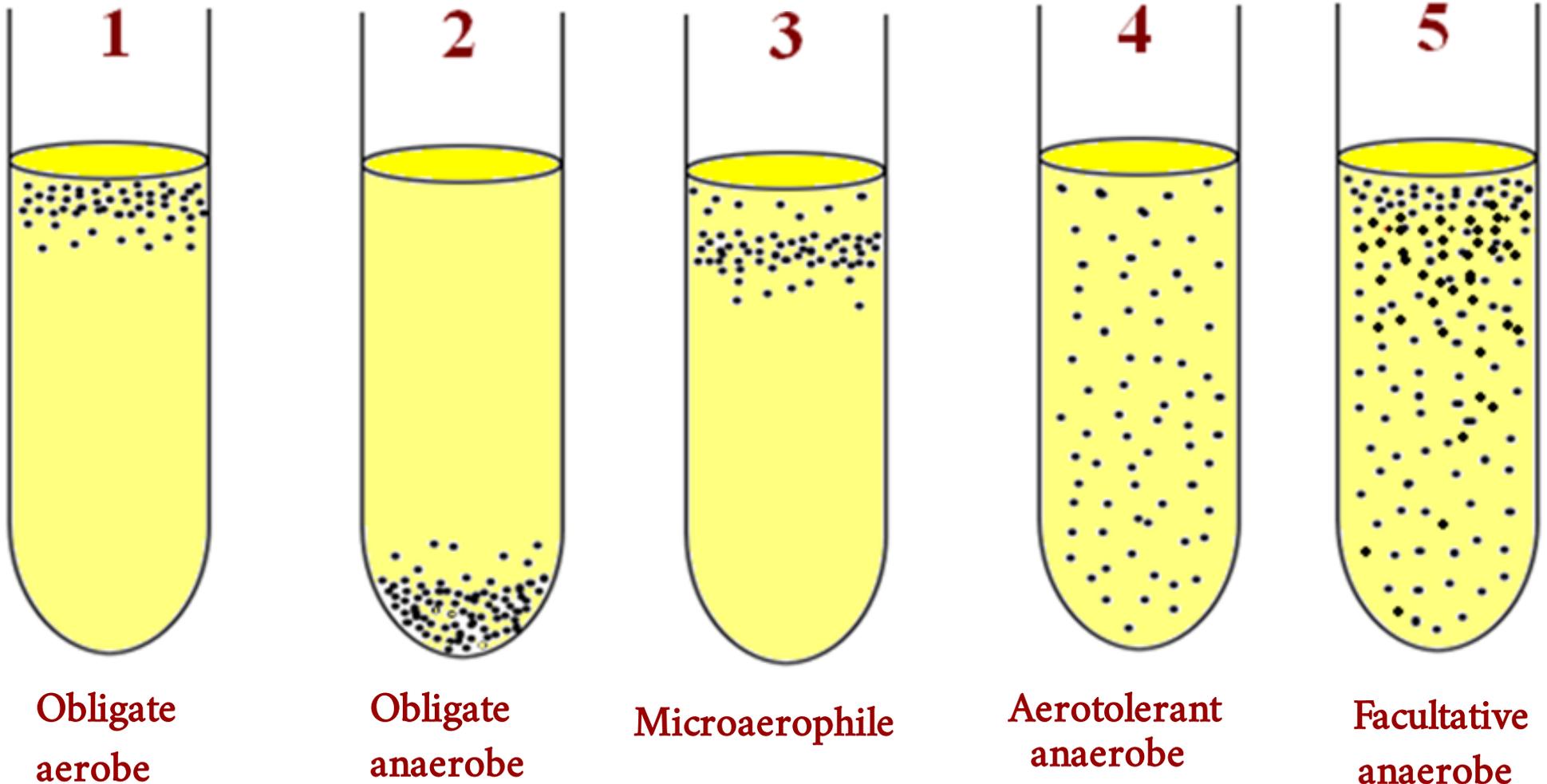
2- **Anaerobes** : do not utilize oxygen

- **obligate anaerobes**: lack the enzymes to detoxify oxygen so cannot survive in an oxygen environment
- **aerotolerance anaerobes**: do not utilize oxygen but can survive and grow in its presence

Requirements for Growth

Chemical Requirements

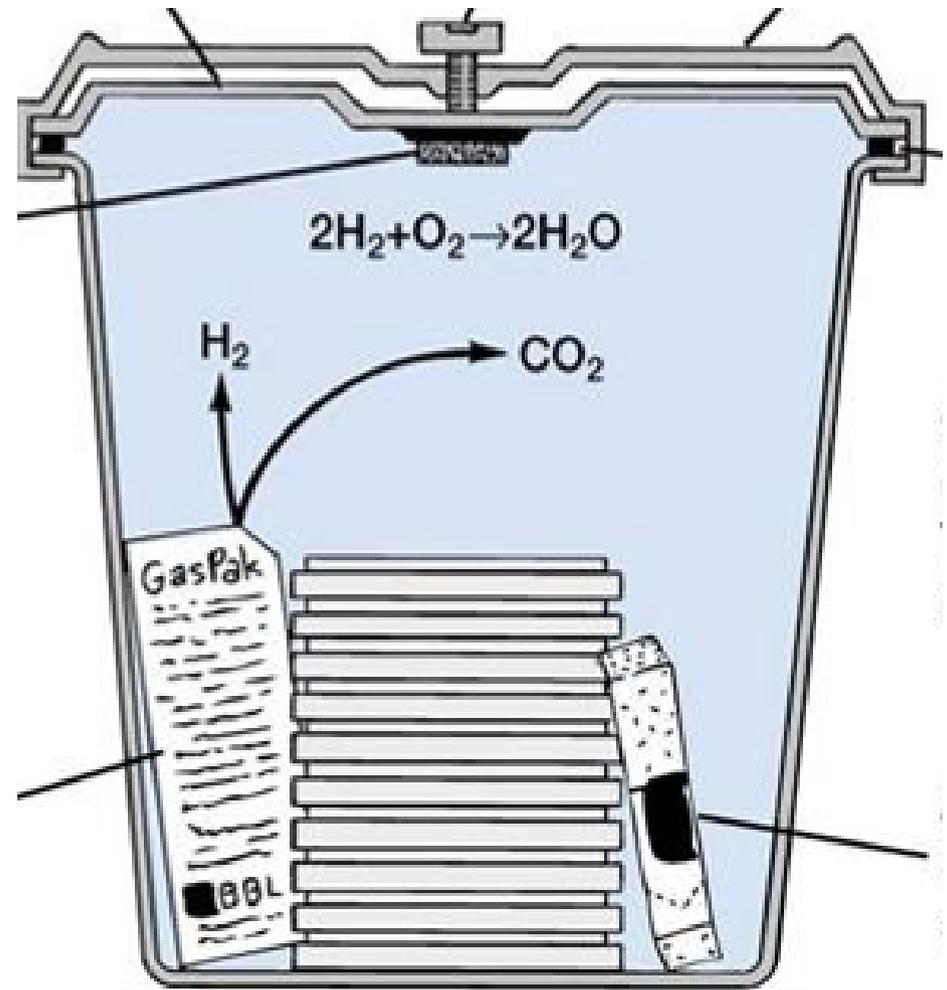
Categories of oxygen requirement



Requirements for Growth

Chemical Requirements

Anaerobic conditions



Requirements for Growth

Chemical Requirements

Q: Why do some bacteria are forced to live in oxygen free habitats?

- To avoid the toxic forms of oxygen (Oxygen free radicals)
- If a microbe is not capable of dealing with toxic oxygen, it is forced to live in oxygen free habitats.
- The oxygen free radicals including:
 - A. Superoxide Free Radicals ($O_2^{\cdot-}$)
 - B. Hydrogen Peroxide (H_2O_2)

Requirements for Growth

Chemical Requirements

The oxygen free radicals

1. Hydrogen Peroxide (H_2O_2):

There are two different enzymes that break down H_2O_2 :

A. Catalase: Breaks hydrogen peroxide into water and O_2
Common. Produced by humans, as well as many bacteria.



Hydrogen
peroxide

Gas
Bubbles

B. Peroxidase: Converts hydrogen peroxide into water.

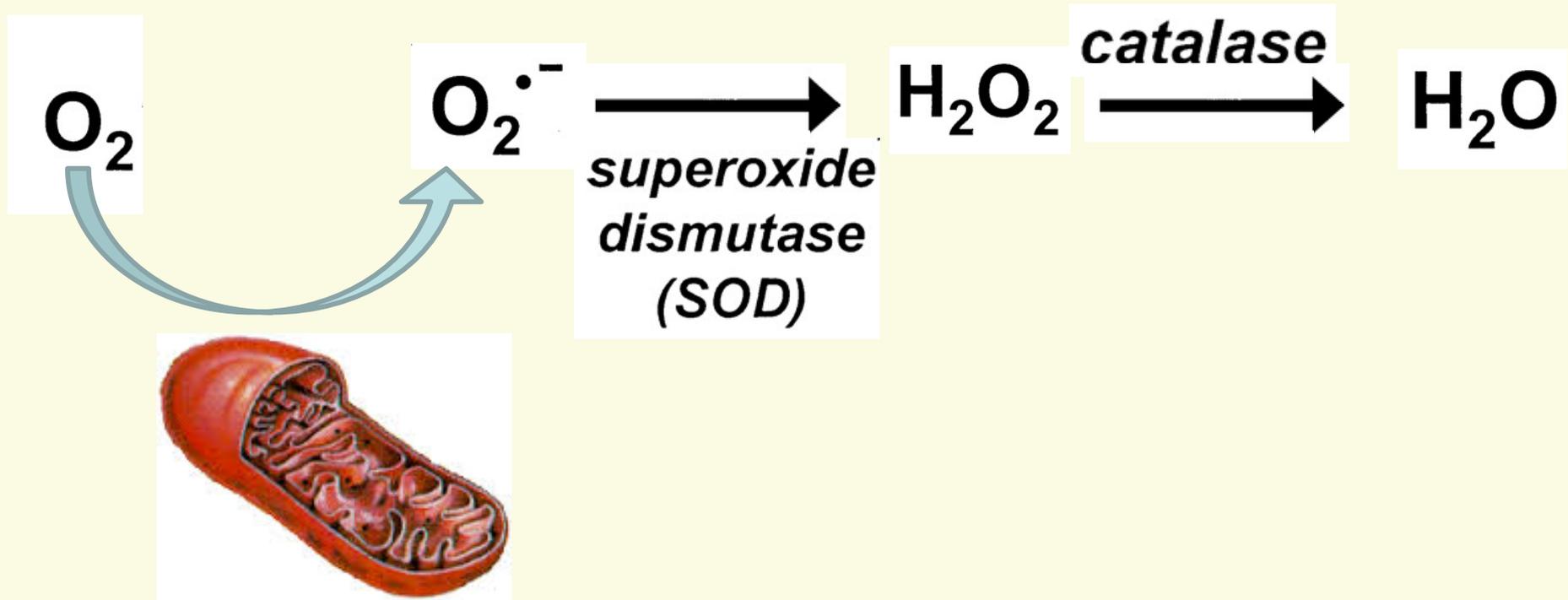


Hydrogen
peroxide

Requirements for Growth

Chemical Requirements

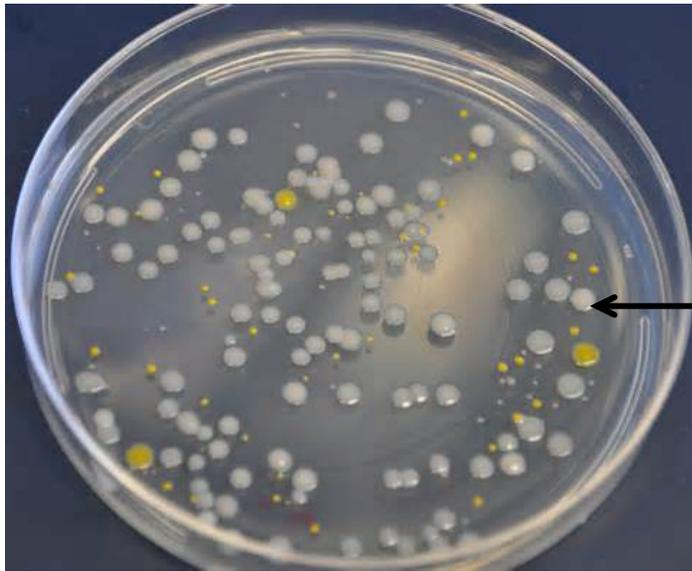
The oxygen free radicals



Microbial Growth

Reproduction of microbes

- Microbial growth – an increase in a population of microbes rather than an increase in size of an individual
- Result of microbial growth is discrete colony – an aggregation of cells arising from single parent cell



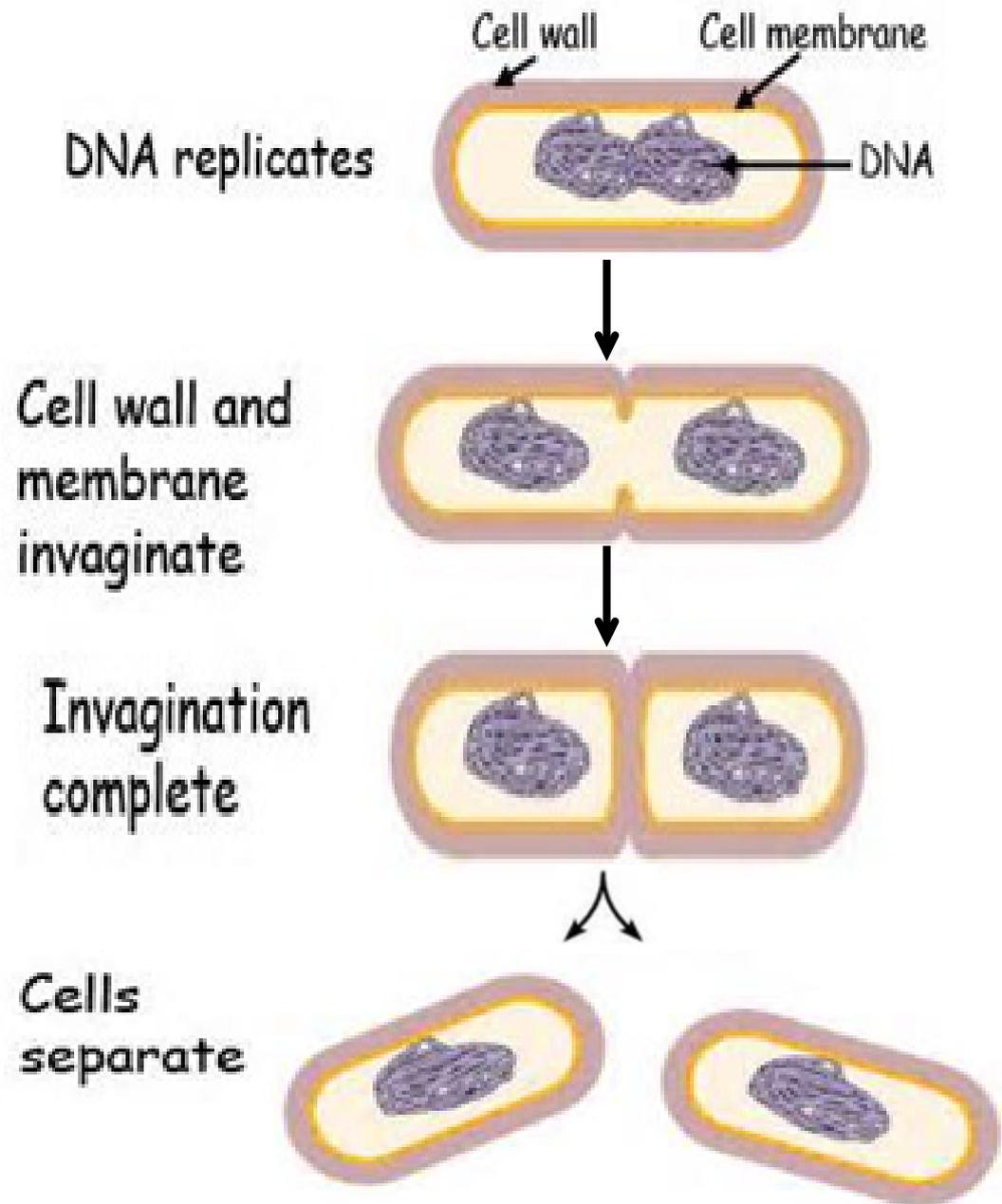
Bacterial colony
(made up from one
bacterial cell)

Microbial Growth

Reproduction of microbes

Binary Division

- division exactly in half
- most common means of bacterial reproduction
 - forming two equal size progeny
 - genetically identical offspring
 - cells divide in a geometric progression doubling cell number



Microbial Growth

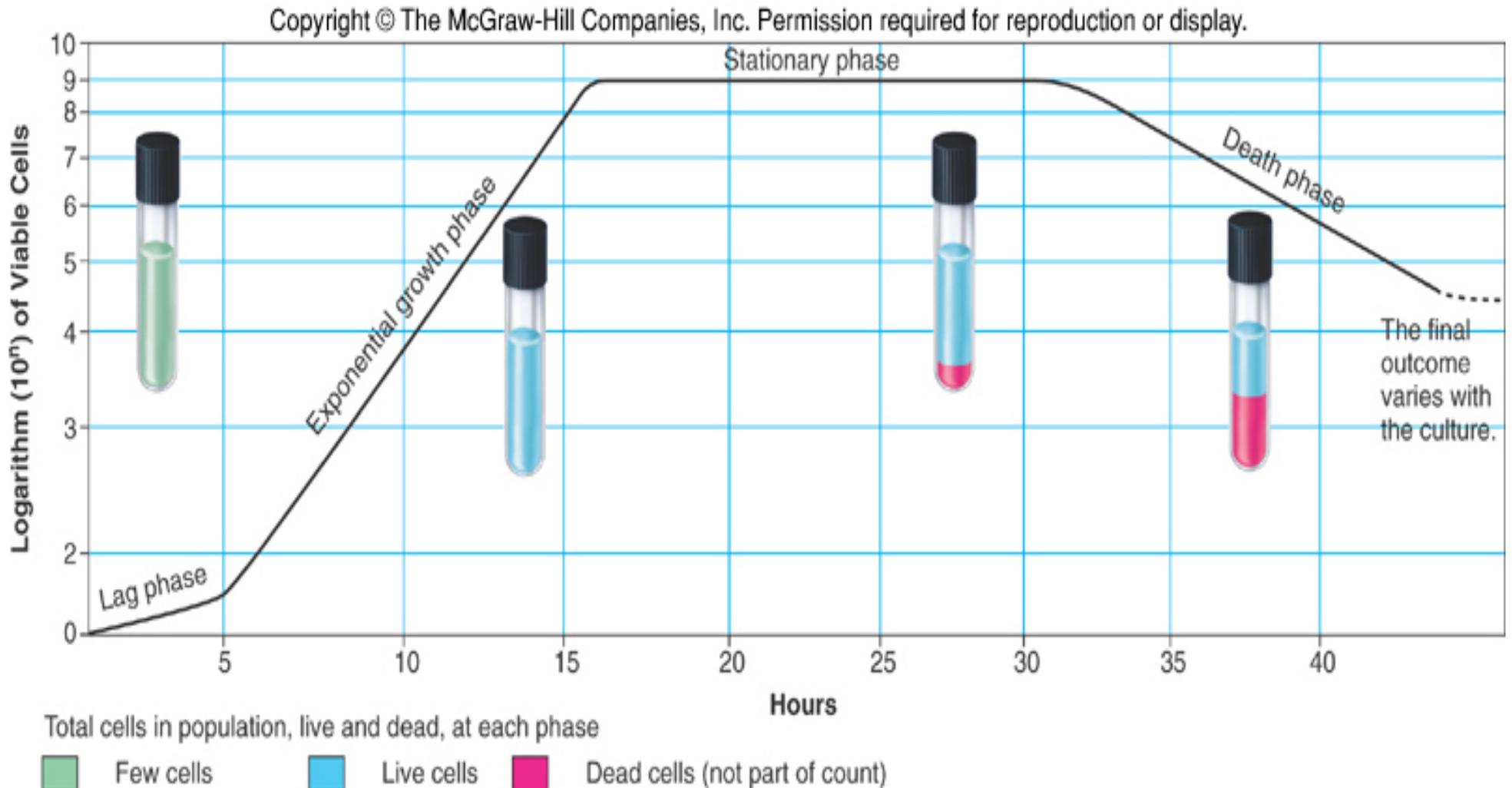
Bacteria grow in four stages

1. **lag phase** – “flat” period of adjustment, enlargement; little growth
2. **exponential or log phase** – a period of maximum growth will continue as long as cells have adequate nutrients and a favorable environment
3. **stationary phase** – rate of cell growth equals rate of cell death caused by depleted nutrients and O_2 , excretion of organic acids and pollutants
4. **death phase** – as limiting factors intensify, cells die exponentially in their own wastes

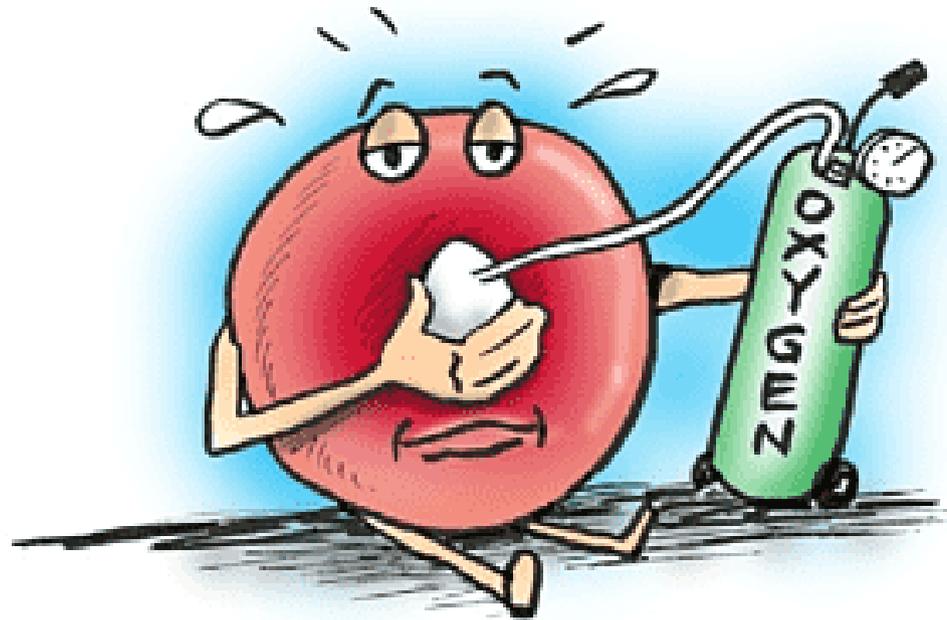
Bacterial physiology

4- Reproduction of microbes

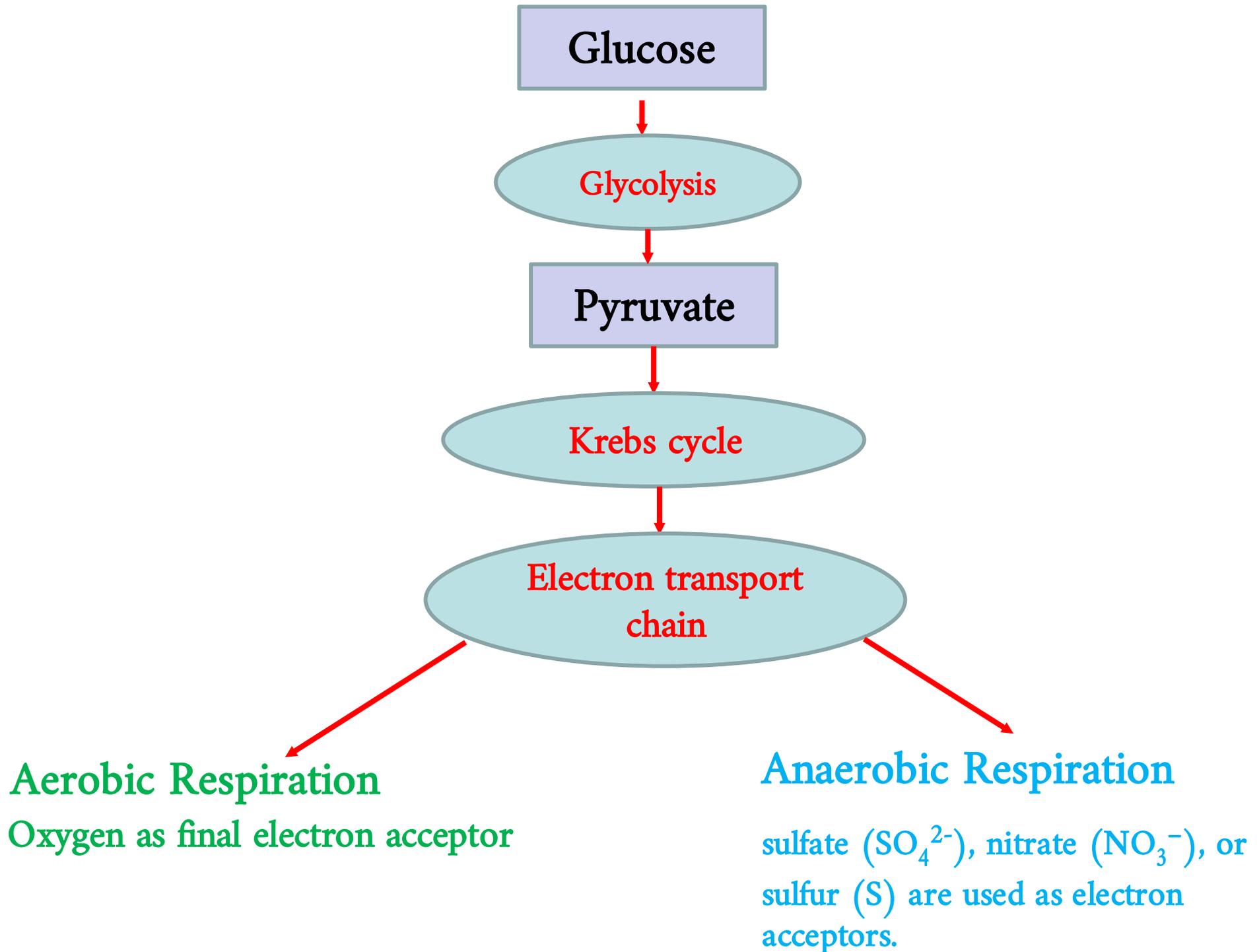
The population Growth Curve



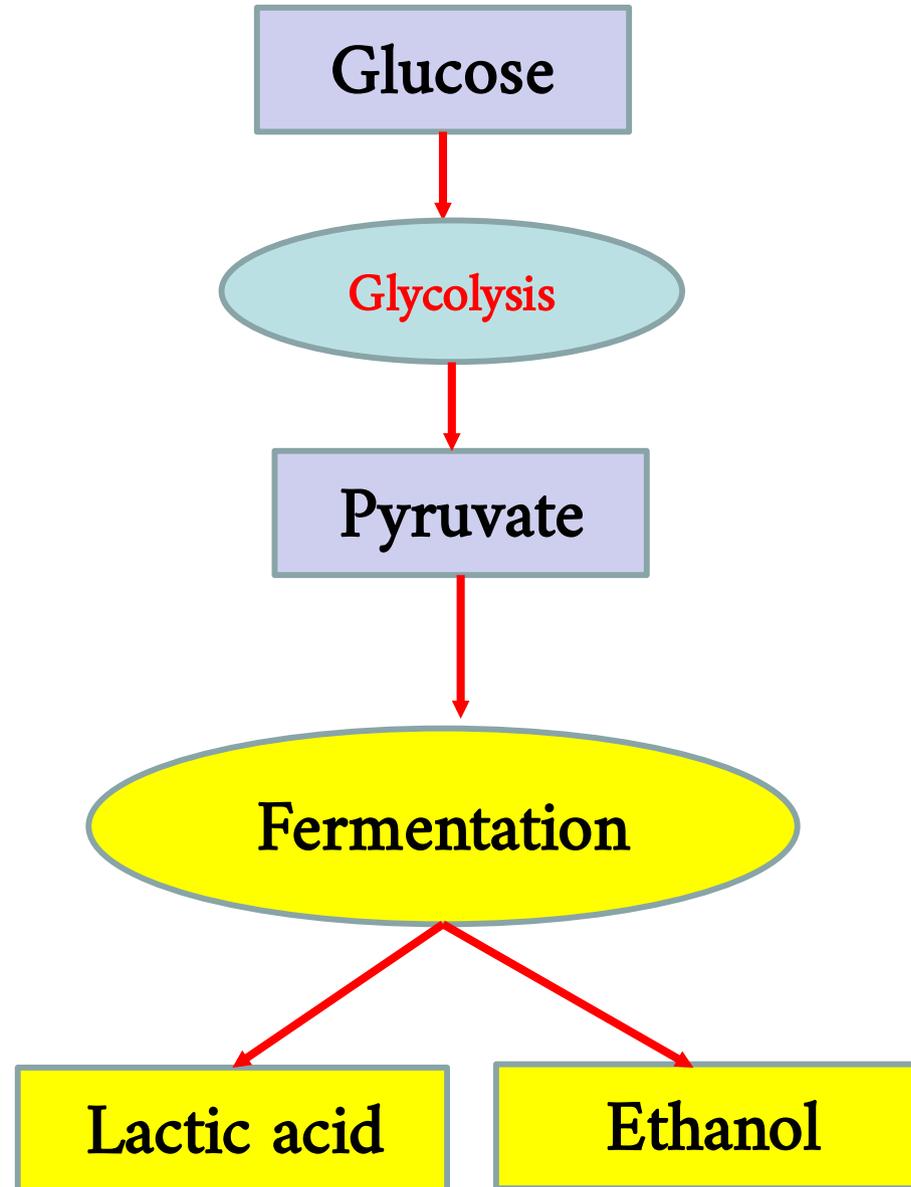
Bacterial Respiration



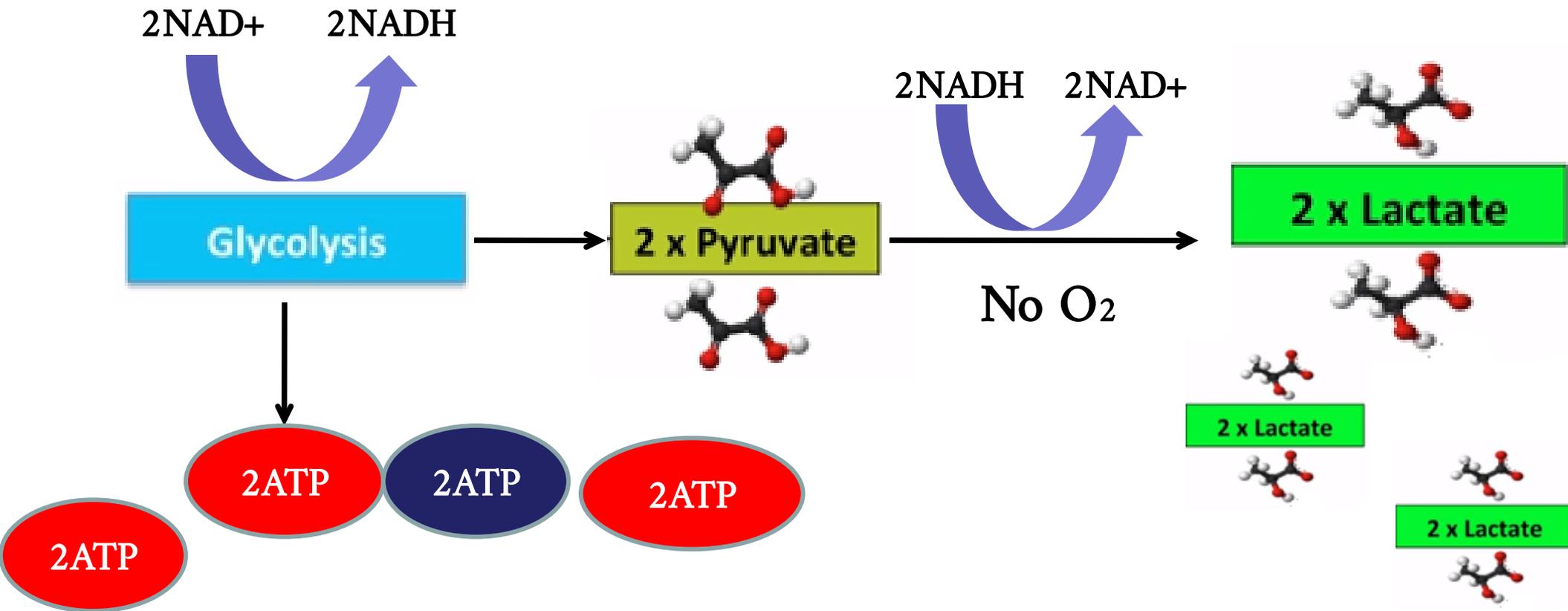
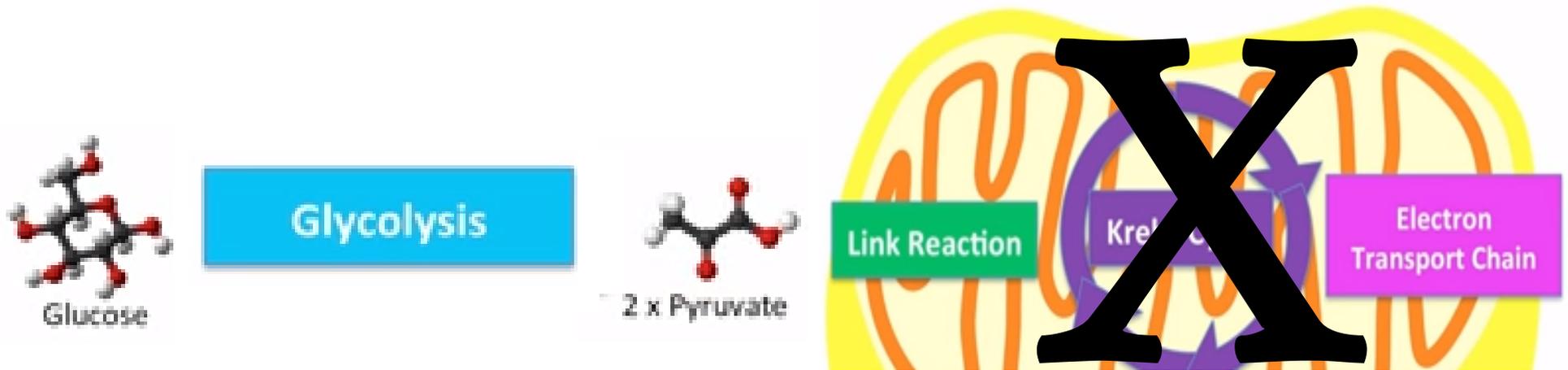
Aerobic vs Anaerobic Respiration



Fermentation = Oxygen not present

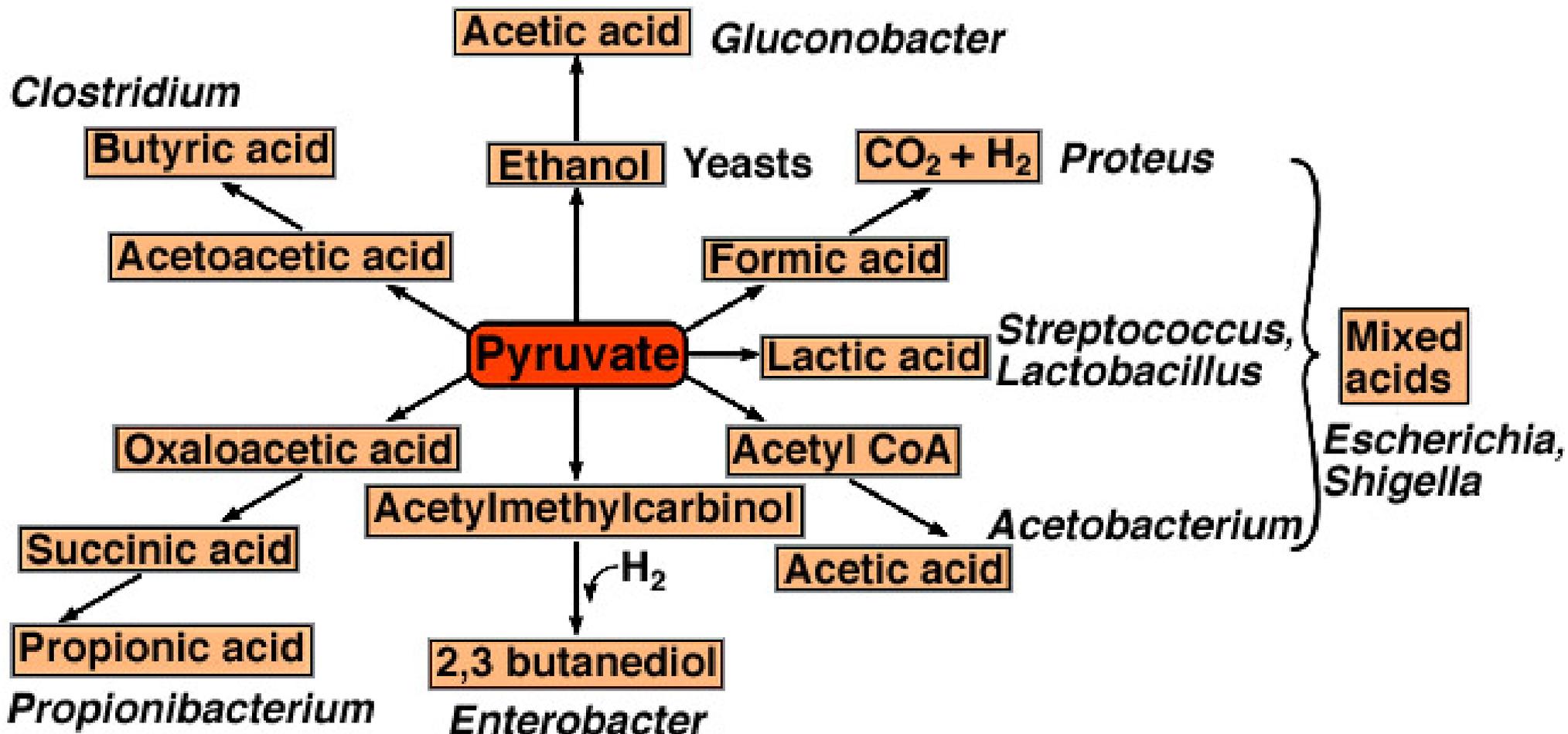


Fermentation

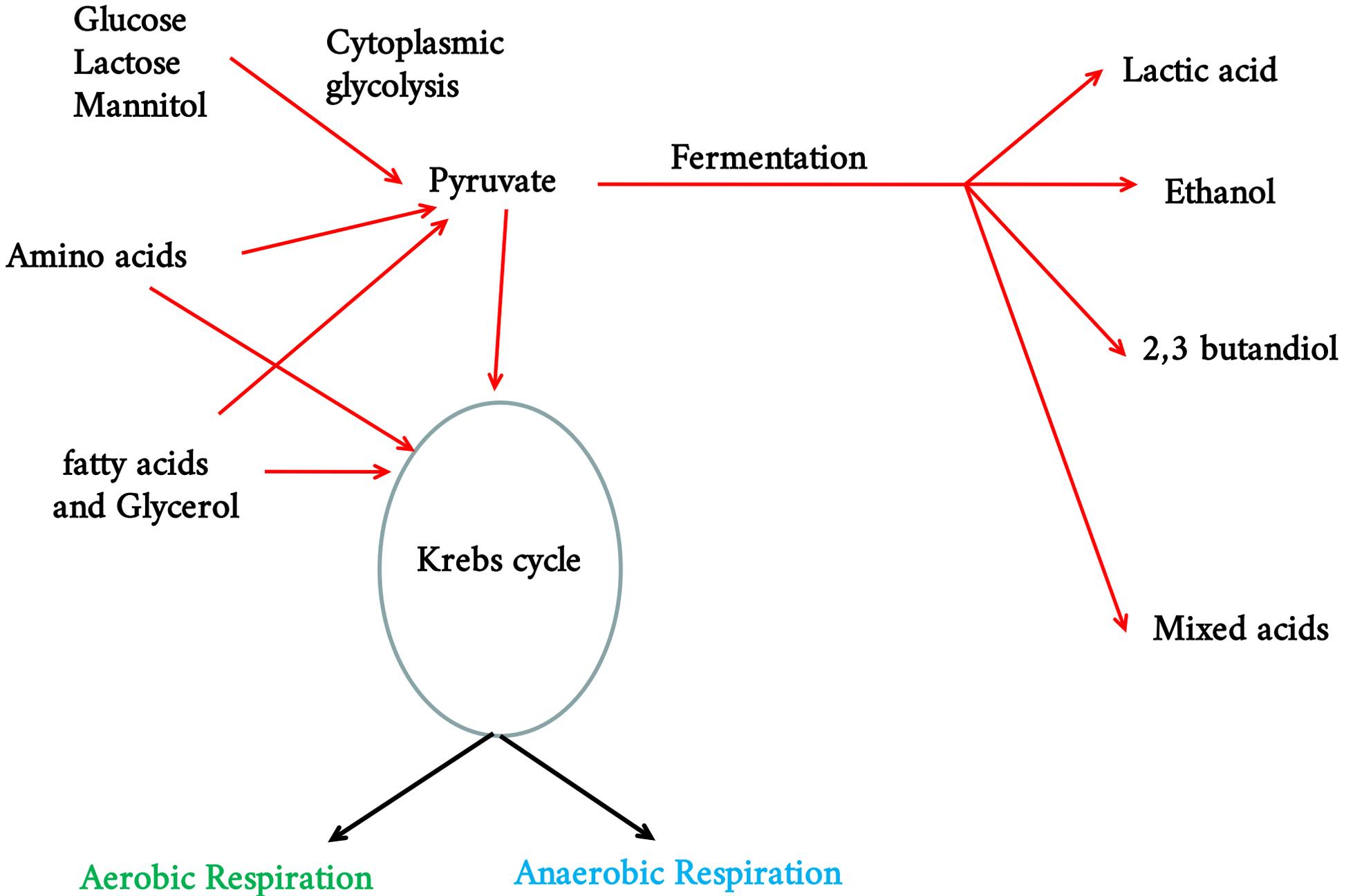


Products of Fermentation

Without any form of respiration, glycolysis products, pyruvate and NADH, will accumulate. To keep making any more ATP by glycolysis, fermenting cells must convert NADH (red.) back to NAD⁺ (ox.) by passing its electrons to pyruvate. Reaction pathways that do this convert pyruvate to many other compounds, depending on the organism.



General Pathways



Thank you