



**General Microbiology Course**  
**Lecture 4**  
**(Microbial Growth and Metabolism)**  
**2023-2024**

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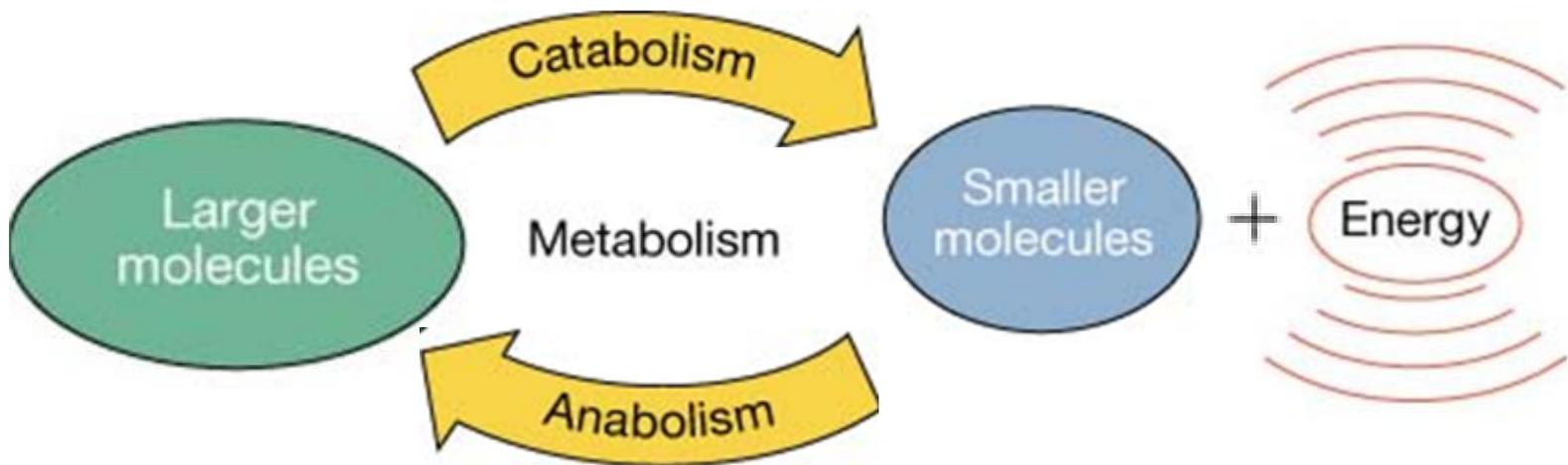
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# Lecture **Outlines**

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

# Definitions

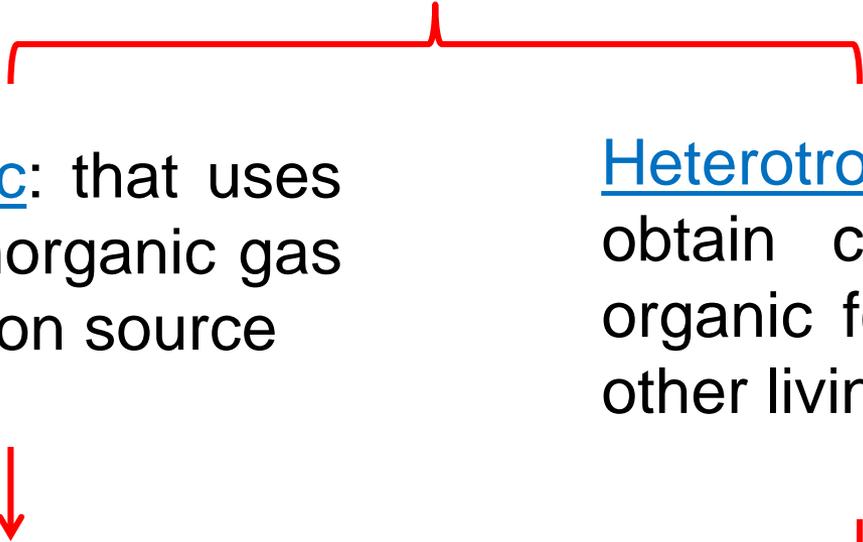
- **Bacterial growth:** refers to an increase in **cell number** , not in cell size.
- **Metabolism:** the sum of the chemical reactions in an organism.
- **Catabolism:** provides energy and building blocks for anabolism
- **Anabolism:** uses energy and building blocks to build large molecules



# Microbial nutrition

## Types of microbial nutrition

Bacteria are classified in two nutritional types on the basis of their carbon requirement into:



Autotrophic: that uses  $\text{CO}_2$ , an inorganic gas as its carbon source

- ✓ Photosynthetic bacteria.
- ✓ Chemosynthetic bacteria

Heterotrophic must obtain carbon in an organic form made by other living organisms

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- ✓ Saprophytic
  - ✓ Symbiotic
  - ✓ Parasitic bacteria

# Requirements for Growth

## Physical Requirements

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### 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

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### 1. Temperature:

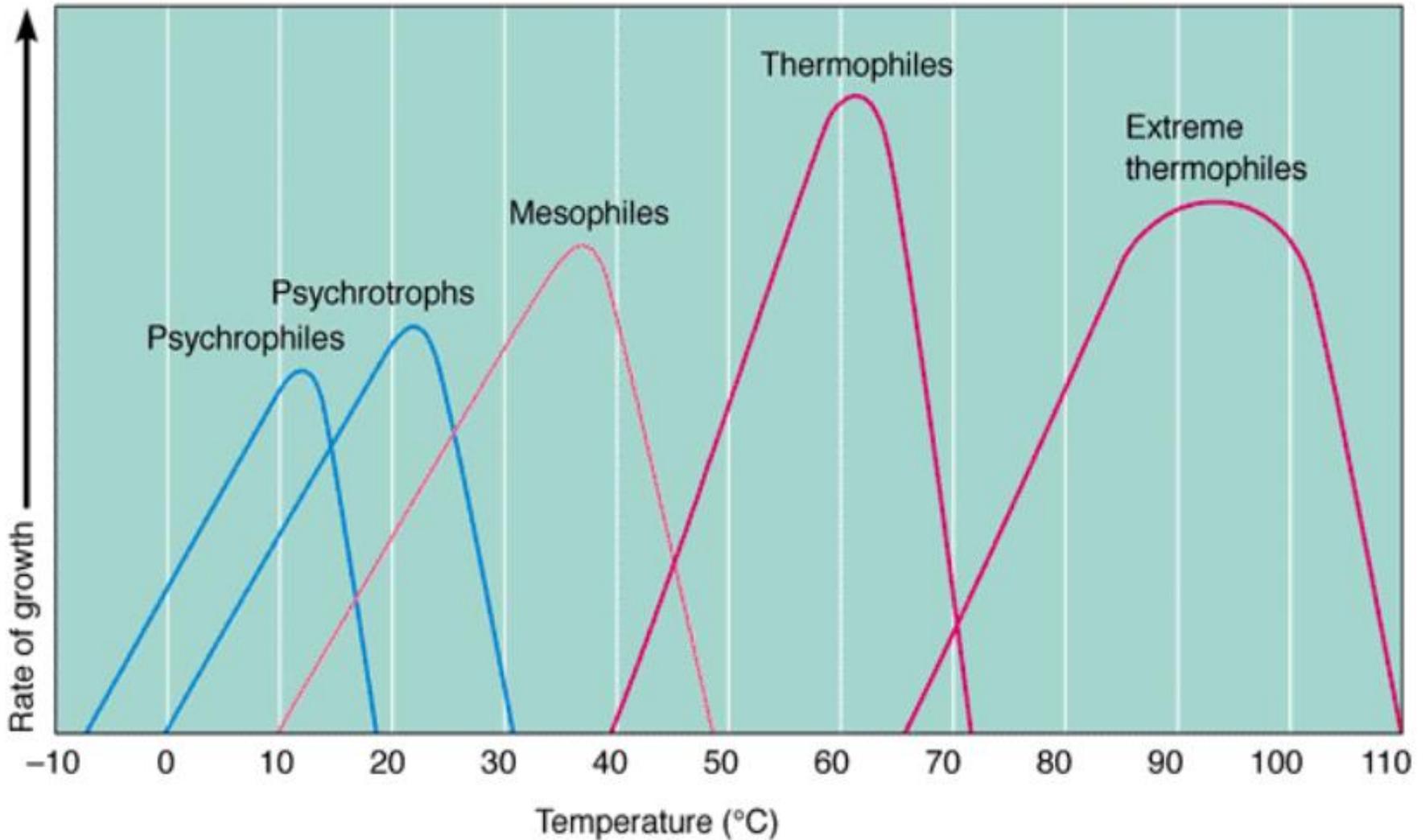
**B. Mesophiles**: “Middle loving”. Most bacteria.

- ◆ 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

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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

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**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

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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

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### 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

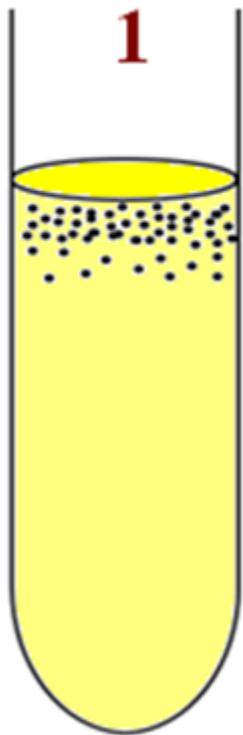
- **obligate anaerobes**: lack the enzymes to detoxify oxygen so cannot survive in an oxygen environment
- **aerotolerance anaerobes**: do not utilize oxygen but can survive and grow in its presence

# Requirements for Growth

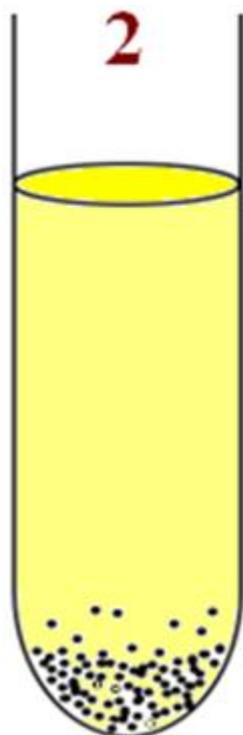
## Chemical Requirements

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### Categories of oxygen requirement



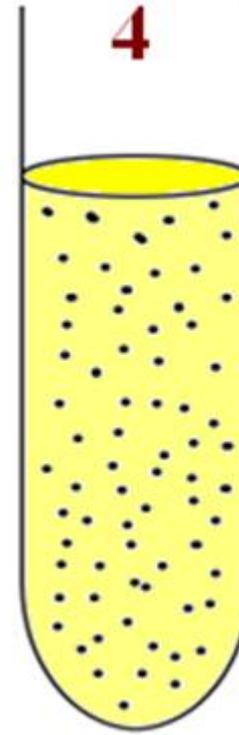
**Obligate  
aerobe**



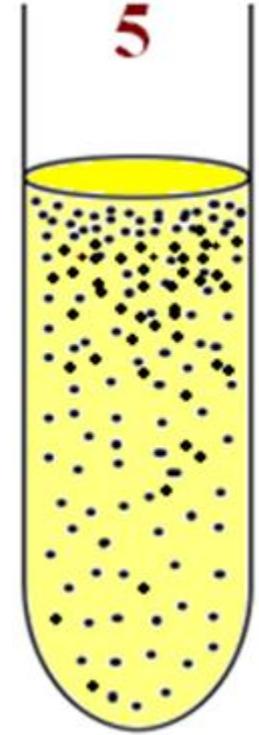
**Obligate  
anaerobe**



**Microaerophile**



**Aerotolerant  
anaerobe**

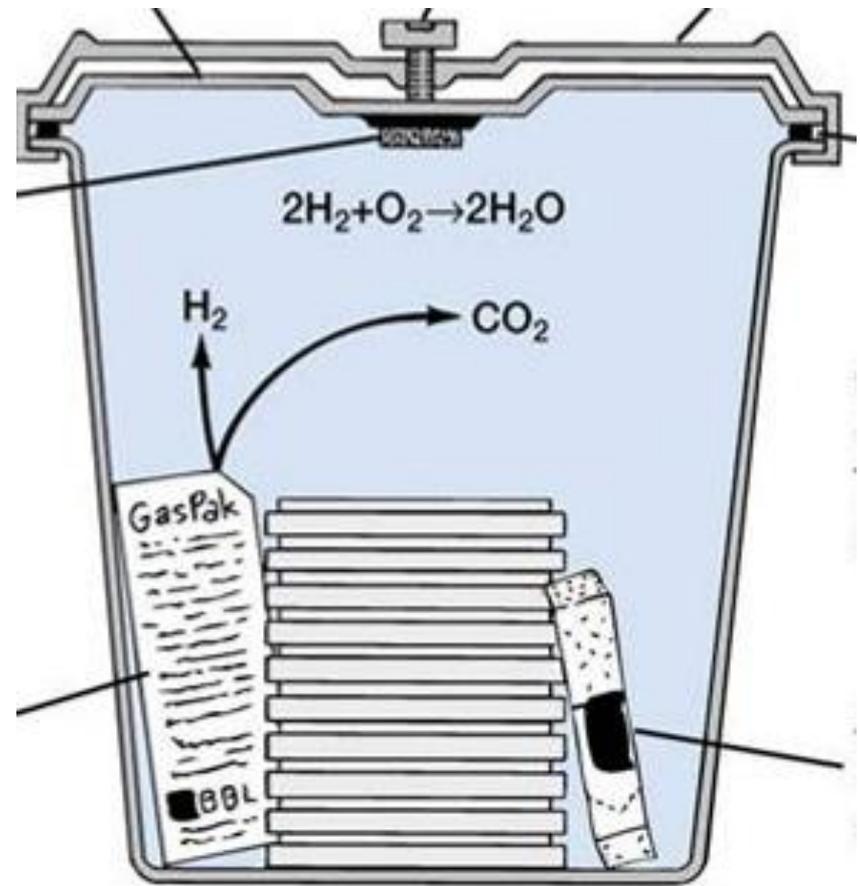


**Facultative  
anaerobe**

# Requirements for Growth

## Chemical Requirements

### Anaerobic conditions



# Requirements for Growth

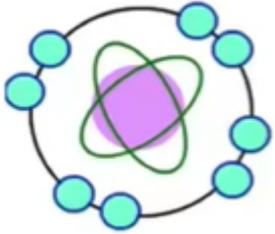
## Chemical Requirements

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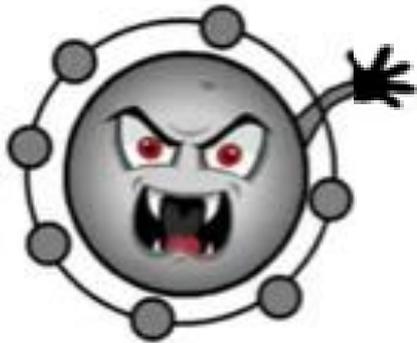
**Q: Why do some bacteria are forced to live in oxygen free environment?**

- 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 ( $O_2^-$ )
  - B. Hydrogen Peroxide ( $H_2O_2$ )

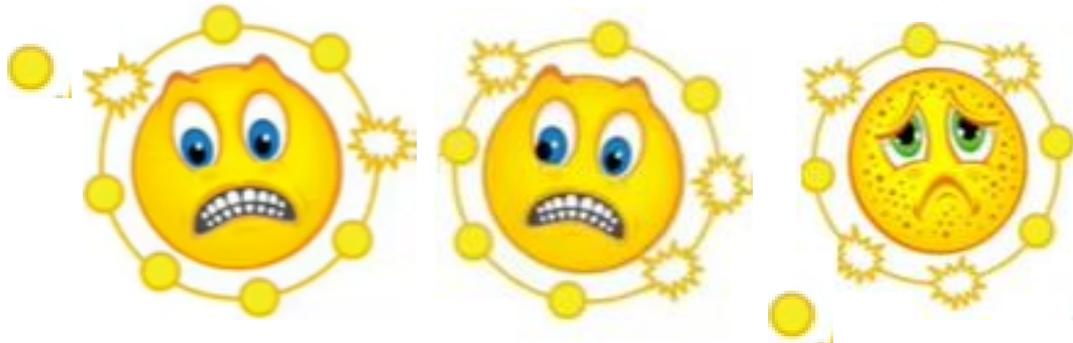
# FREE RADICALS - What are they?



HEALTHY  
STABLE  
MOLECULE



UNPAIRED  
UNSTABLE  
MOLECULE



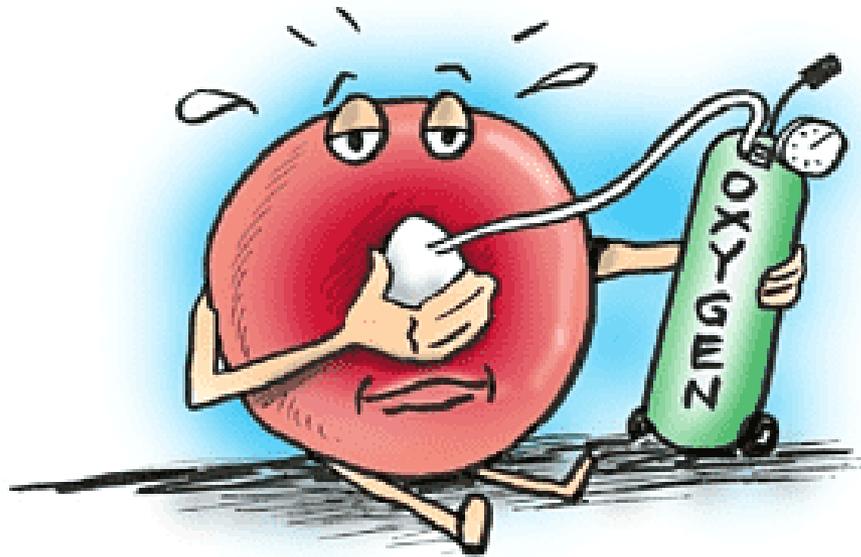
Oxidative stress reaction  
leading to cell damage



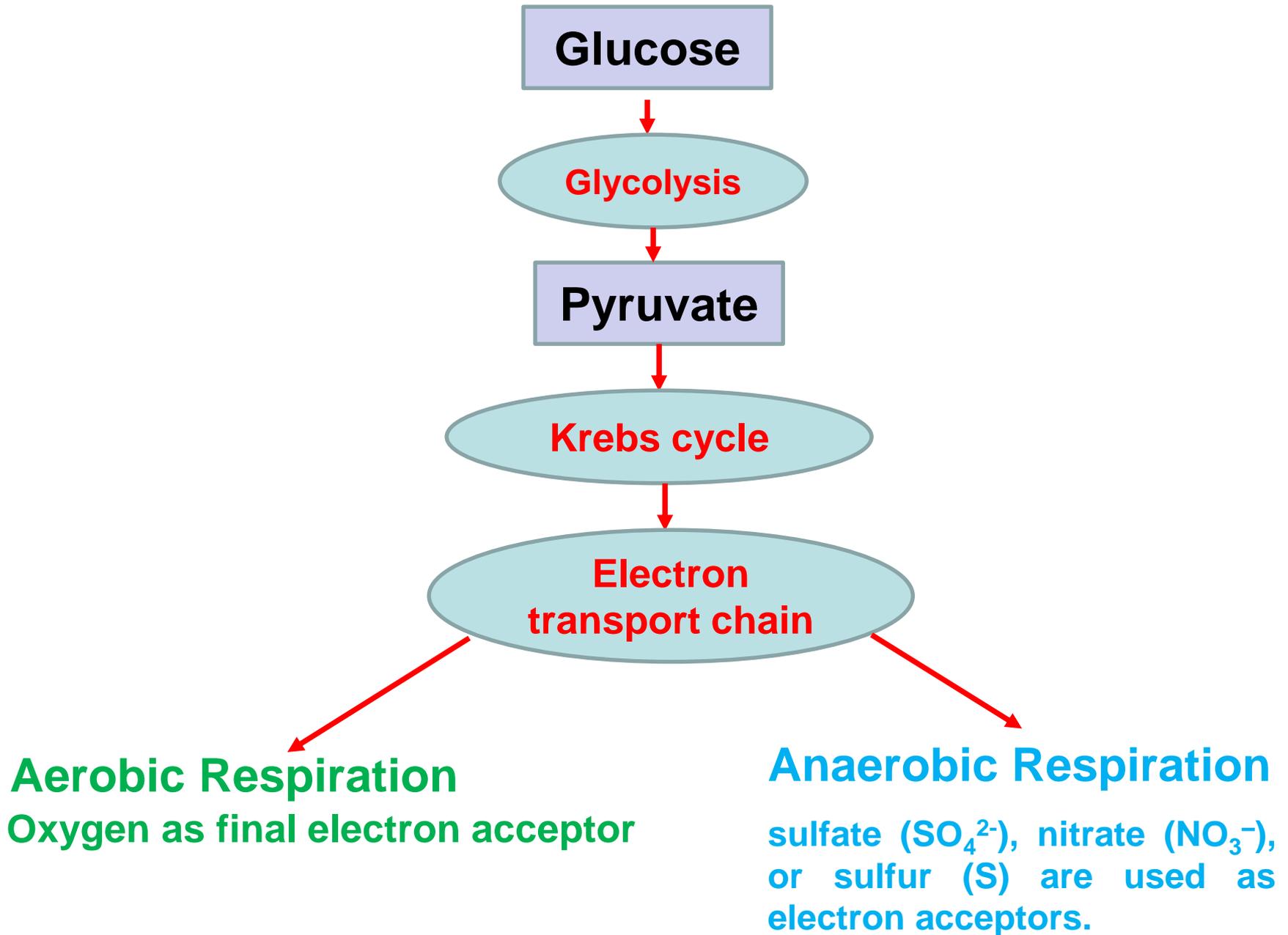


# Bacterial Respiration

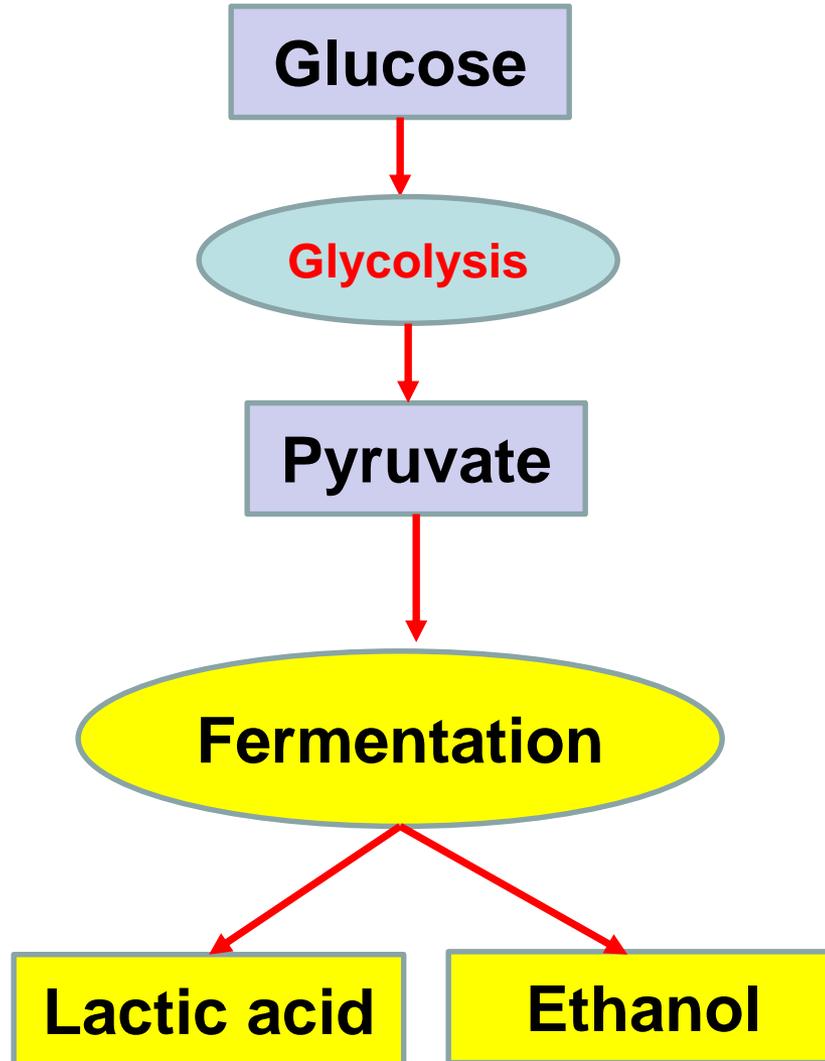
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# Aerobic vs Anaerobic Respiration

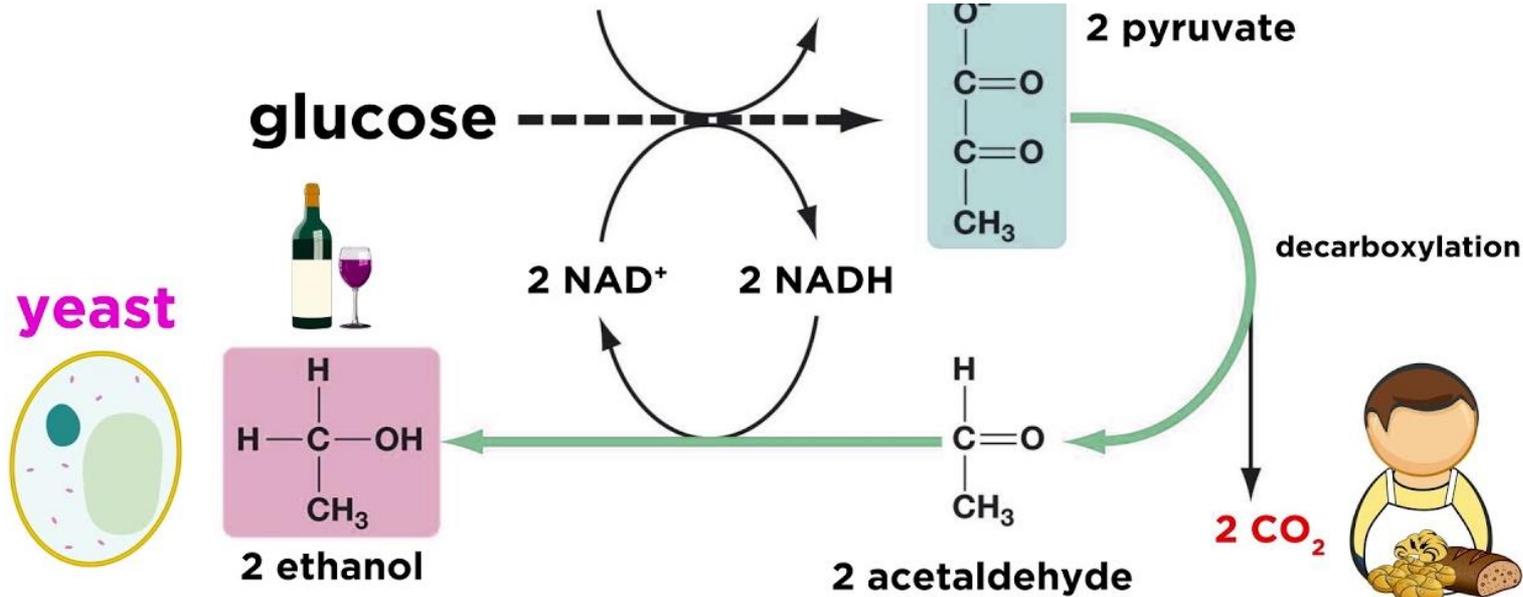


**Fermentation = Oxygen not present**



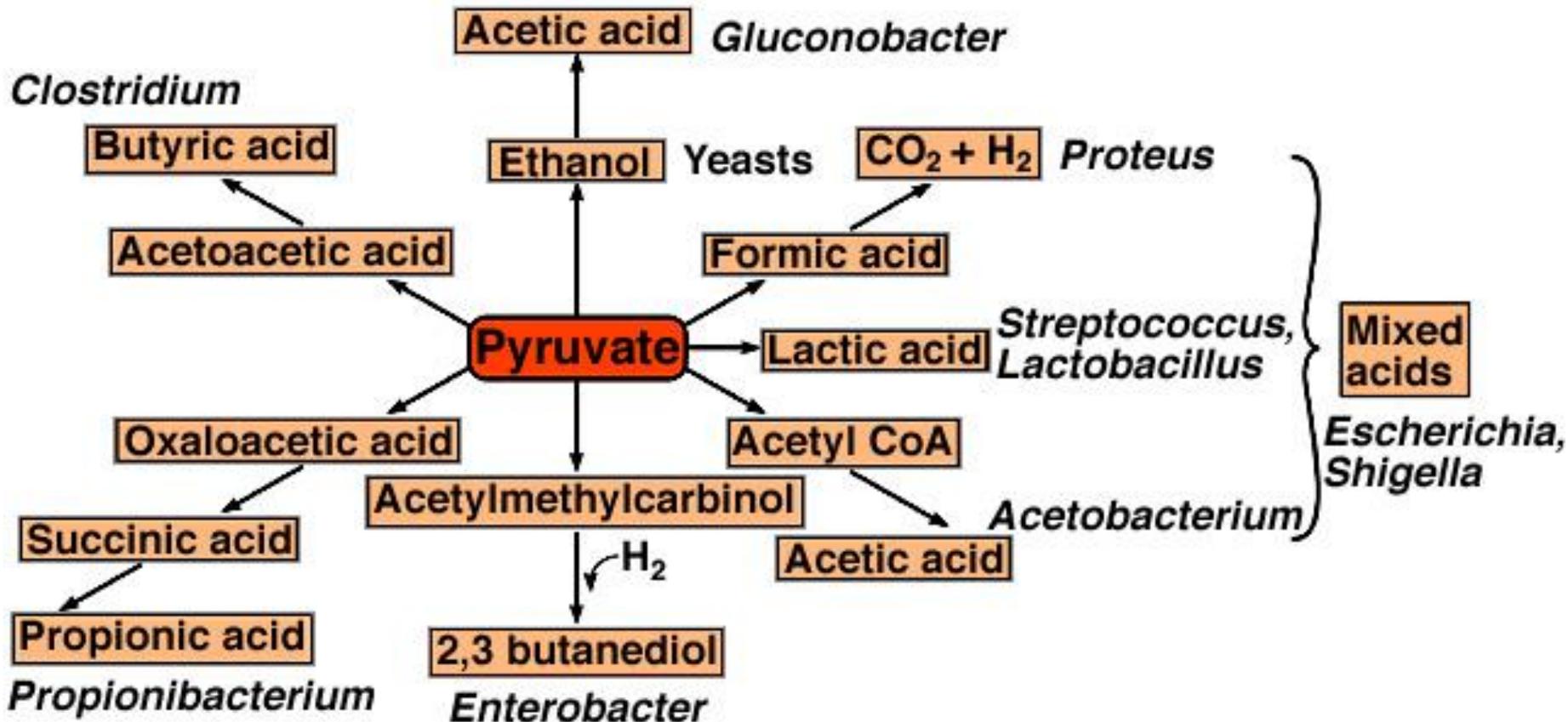
# Products of Fermentation

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 back to NAD<sup>+</sup> (ox.) by passing its electrons to pyruvate. Reaction pathways that do this convert pyruvate to many other compounds, depending on the organism.



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# General Pathways

