

Microbial Metabolism

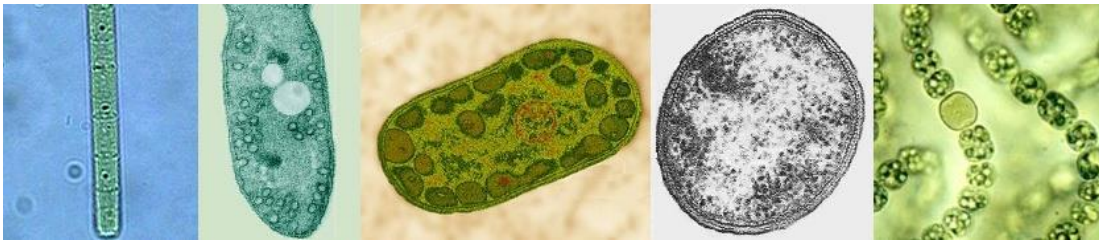
- Microbes are distinguished by their great metabolic diversity
- Classified according to their nutritional pattern, their source of energy and their source of carbon
- Energy source, phototrophs or chemotrophs
- Phototrophs use light, chemotrophs depend on oxidation-reduction reactions of inorganic or organic compounds for energy
- Autotrophs (“self-feeders”) use carbon dioxide; Heterotrophs require an organic carbon source
- By combining the energy and carbon sources, Photoautotrophs, photoheterotrophs, chemoautotrophs, chemoheterotrophs

Photoautotrophs

- Photoautotrophs: include photosynthetic bacteria, algae, green plants
- Photosynthetic process - Oxygenic or Anoxygenic
- Green sulfur bacteria, *Chlorobium* use sulfur (S), sulfur compounds, or hydrogen gas (H₂) to reduce carbon dioxide and form organic compounds



- Purple sulfur bacteria, *Chromatium*, use sulfur, sulfur compounds, or hydrogen gas to reduce carbon dioxide. In purple sulfur bacteria, the bacteriochlorophylls are located in invaginations of the plasma membrane
- Bacteriochlorophylls of green sulfur bacteria are found in vesicles called chlorosomes



Photoheterotrophs

- Photoheterotrophs use light as a source of energy, cannot convert carbon dioxide to sugar; rather, they use organic compounds
- Photoheterotrophs are the green nonsulfur bacteria, *Chloroflexus*, purple nonsulfur bacteria, *Rhodospseudomonas*

Chemoautotrophs

- Chemoautotrophs use the electrons from reduced inorganic compounds as a source of energy, they use CO₂ as their principal source of carbon
- Inorganic sources of energy for include hydrogen sulfide (H₂S) for *Beggiatoa*; elemental sulfur (S) for *Thiobacillus thiooxidans*; ammonia (NH₃) for *Nitrosomonas*; nitrite ions (NO₂⁻) for *Nitrobacter*; hydrogen gas (H₂) for *Hydrogenomonas*; ferrous iron (Fe²⁺) for *Thiobacillus ferrooxidans*

Chemoheterotrophs

- chemoheterotrophs, the distinction of energy and is not so clear because energy source, carbon source are usually the same organic compound—glucose
- Heterotrophs are further classified: saprophytes, parasites
- Most bacteria, all fungi, protozoa, and animals are chemoheterotrophs

Chemical requirements

Carbon

Nutritional type	Energy source	Carbon source	Example
Photoautotrophs	Light	CO ₂	Photosynthetic bacteria, cyanobacteria, algae, plants
Photoheterotrophs	Light	Organic compounds	Green non-sulphur bacteria
Chemoautotrophs	Electrons from inorganic compounds	CO ₂	Nitrifying bacteria, sulphur bacteria, iron bacteria
Chemoheterotrophs	Electrons from organic compounds	Organic compounds	Most bacteria, all fungi, protozoa and animals.

Nitrogen, Sulfur and Phosphorus

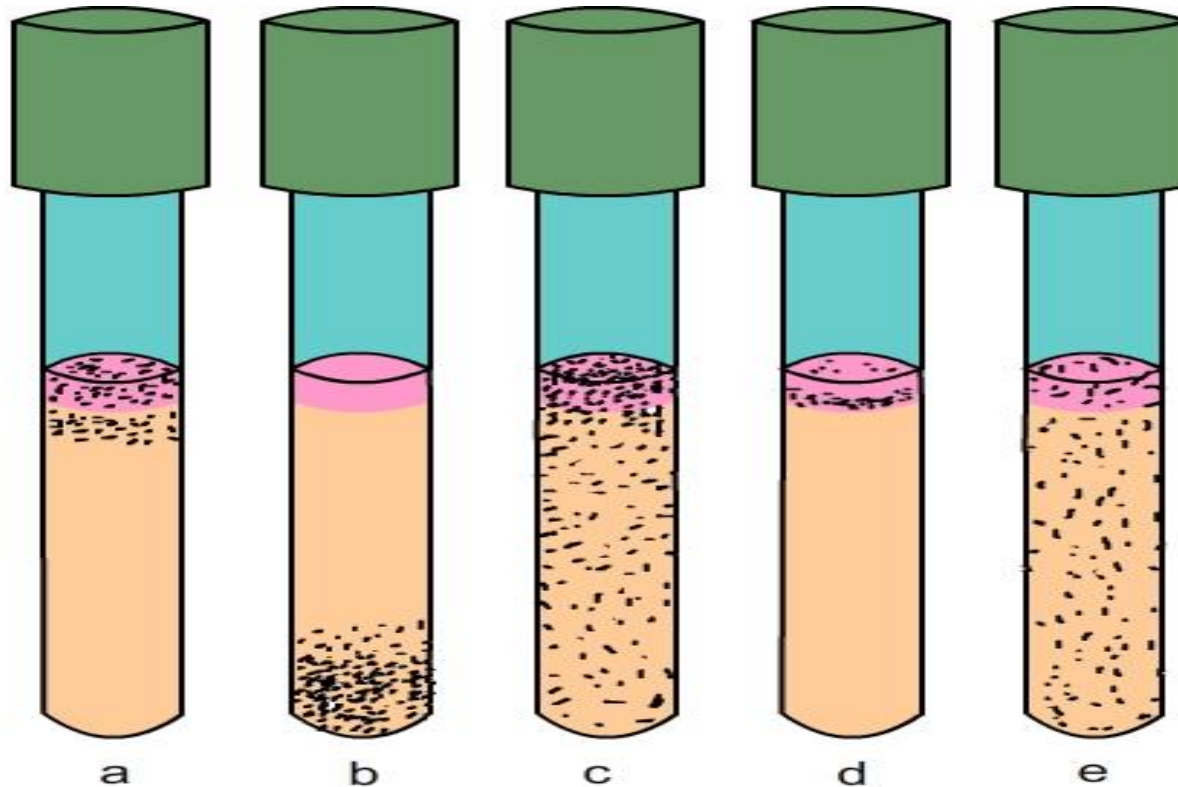
- Nitrogen, sulfur and phosphorus are needed by microbes for synthesis of cellular materials
- Protein synthesis nitrogen and sulfur
- DNA or RNA synthesis nitrogen, Many bacteria derive nitrogen by decomposing protein phosphorus
- ATP synthesis nitrogen and phosphorus
- Some bacteria ammonium ions in organic material
- nitrogen from nitrates
- N-fixation

- natural sources of sulfur include sulphate ion, H_2S and sulfur containing amino acids
- source of phosphorous phosphate ion
- Other elements are potassium, magnesium, calcium, etc
- **Trace elements**
- iron, copper, molybdenum and zinc
- essential for activity of enzymes.

Oxygen

- On the basis of oxygen requirements
- Obligate aerobes
- Facultative anaerobes
- Obligate anaerobes
- Aerotolerant anaerobes
- Microaerophiles
- organisms can be harmed by oxygen
- Oxygen is toxic forms like Hydrogen peroxide (H_2O_2), super oxide radical (O_2^-) and hydroxyl radical (OH)

Growth of bacteria based on oxygen requirement / tolerance



Position of growth of microbial cells in culture medium depending on oxygen requirement and tolerance. a. Obligate aerobes, b. Obligate anaerobes, c. Facultative anaerobes, d. Microaerophiles, e. Aerotolerant anaerobes.

- Aerobes, facultative anaerobes, microaerophiles enzymes that destroy the toxic forms of oxygen super oxide dismutase catalase or peroxidase
- $2\text{O}_2^- + 2\text{H} \longrightarrow \text{O}_2 + \text{H}_2\text{O}_2$
Super oxide dismutase
- $2\text{H}_2\text{O}_2 \longrightarrow 2\text{H}_2\text{O} + \text{O}_2$
Catalase
- $\text{H}_2\text{O}_2 + \text{NADH} + \text{H}^+ \longrightarrow 2\text{H}_2\text{O} + \text{NAD}^+$
Peroxidase

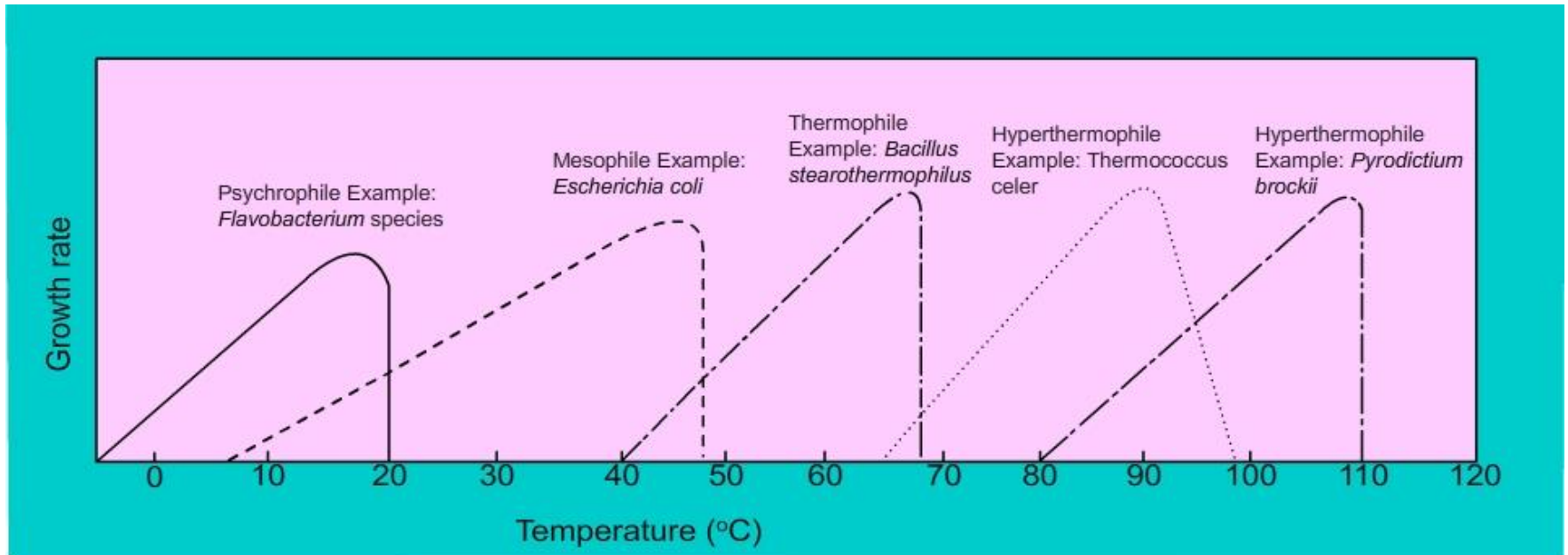
Organic growth factors

- amino acids
- purines and pyrimidines
- vitamins

Physical requirements of growth

- **Temperature**
- Microorganism is divided into three primary groups, range of growth temperature
- Cardinal temperature
- Optimal growth temperature is top of the range
- Temperature influences growth in two ways
- psychrophiles, psychrotrophs
- Thermophilic bacteria important in organic compost
- hyperthermophiles or extreme thermophiles

Growth temperature range of bacteria



Relation of temperature to growth rates of different groups of bacteria with example

pH

- Most bacteria grow best in a near neutrality (6.5 – 7.5) and are called neutrophiles
- few bacteria grow acidic pH below 4.0
- food preservation employs lower pH
- acidophiles are tolerant of acidity
- Molds and yeast grow over a wide range of pH, optimal range is about pH 5-6
- Alkaliphiles
- When bacteria are cultured in laboratory certain chemicals called buffers are included in the medium

Osmotic pressure

- Microbes obtain their nutrients in solution from the surrounding water
- Higher osmotic pressures remove water from a cell
- Hypertonic, cellular water passes out through causing shrinkage
- **Plasmolysis**
- in food preservation, addition of salts helps to prevent microbial growth
- extreme halophiles have good adaptation at high salt concentrations

- facultative halophiles grow normally up to 2% salt
- Osmophiles (grow in sugar solutions) Xerophiles (grow in low moisture conditions)
- water activity
- Water activity is the ratio of the vapour pressure of air in equilibrium with a substance or a solution (P_{soln}) to that of pure water (P_{water}) at the same temperature

P soln

• Water activity (aw) = -----

P water

- Water activity is inversely related to osmotic pressure
- Most microorganism grows well at aw of 0.98