

Environmental Factors That Influence Microbes

Lecture 11

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Environmental Factors That Influence Microbes

- Environmental factors affect the function of metabolic enzymes
- Factors include:
 - Temperature
 - Oxygen requirements
 - pH
 - Osmotic pressure
 - Barometric pressure

Cardinal Temperatures

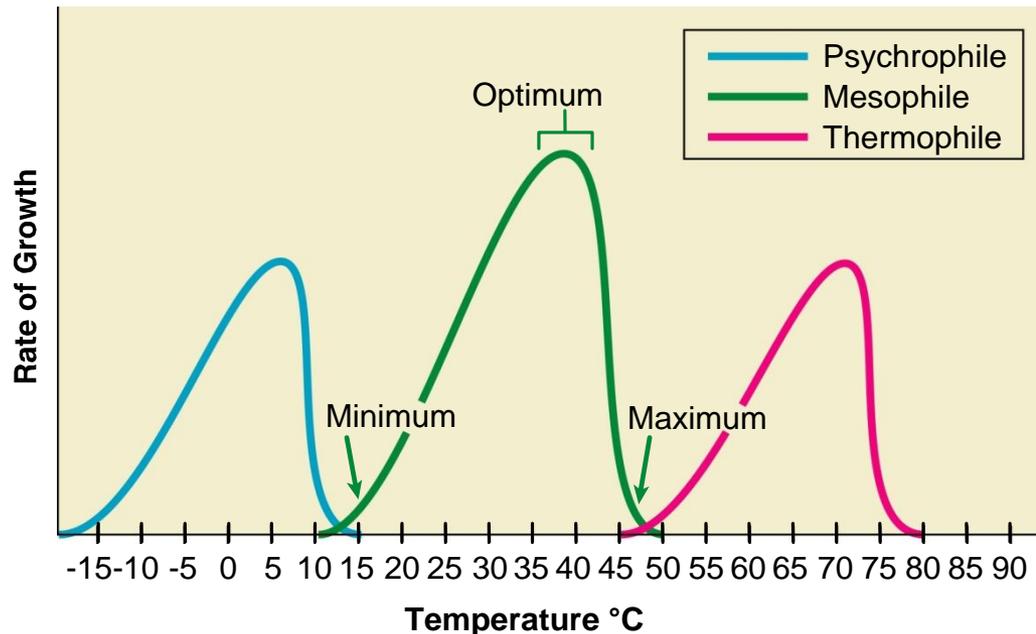
- **Minimum temperature** – lowest temperature that permits a microbe's growth and metabolism
- **Maximum temperature** – highest temperature that permits a microbe's growth and metabolism
- **Optimum temperature** – promotes the fastest rate of growth and metabolism.
- How to maintain T.M?
 1. Maintain plasma membrane.
 2. Controlling structural stability of proteins
 3. Controlling Enzyme activities

Temperature Adaptation Groups

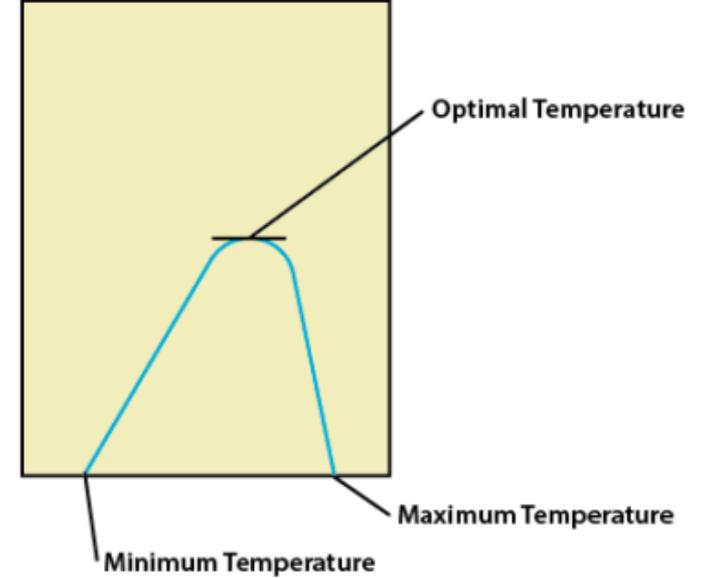
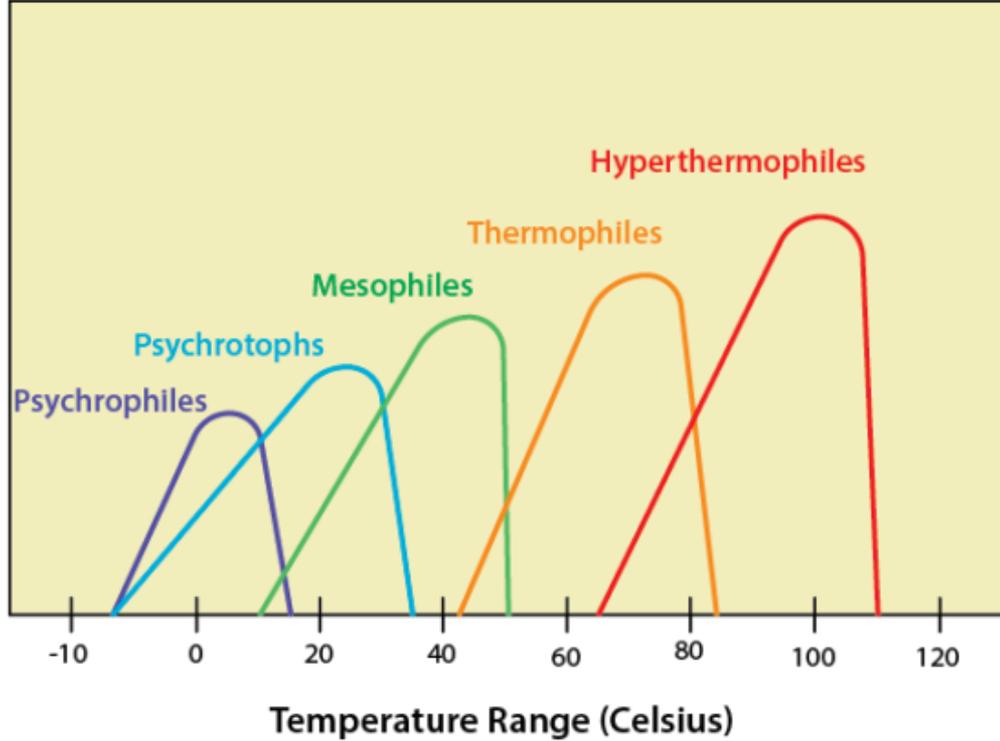
Psychrophiles – optimum growth temperature 0-20°C

Mesophiles – optimum temperature 30°-37°C; most human pathogens

Thermophiles – optimum temperature greater than 45°C (50-60)



Rate of Microbe Growth



Psychrophiles 0-20

Psychrotrophs 20-30

Mesophiles 25-45

Thermophiles 45-70

Hyperthermophiles 70-110

Food spoilage

Disease causing

Gas Requirements

Oxygen

- As oxygen is utilized it is transformed into several toxic products:
 - Singlet oxygen ($^1\text{O}_2$), superoxide ion (O_2^-), peroxide (H_2O_2), and hydroxyl radicals (OH^\cdot)
- Most cells have developed enzymes that neutralize these chemicals:
 - Superoxide dismutase, catalase
- If a microbe is not capable of dealing with toxic oxygen, it is forced to live in oxygen free habitats

Categories of Oxygen Requirement

- **Aerobe** – utilizes oxygen and can detoxify it (*P. aeruginosa*)
- **Obligate aerobe** – cannot grow without oxygen.
- **Facultative anaerobe** – utilizes oxygen but can also grow in its absence
- **Microaerophilic** – requires only a small amount of oxygen (*Campylobacter jejuni* and *H. pylori*)
- **Anaerobe** – does not utilize oxygen
- **Obligate anaerobe** – lacks the enzymes to detoxify oxygen so cannot survive in an oxygen environment (*Bacteroides fragilis*)
- **Aerotolerant anaerobes** – do not utilize oxygen but can survive and grow in its presence (*Clostridium perfringens*). Its lack some Enzymes.

Respiration

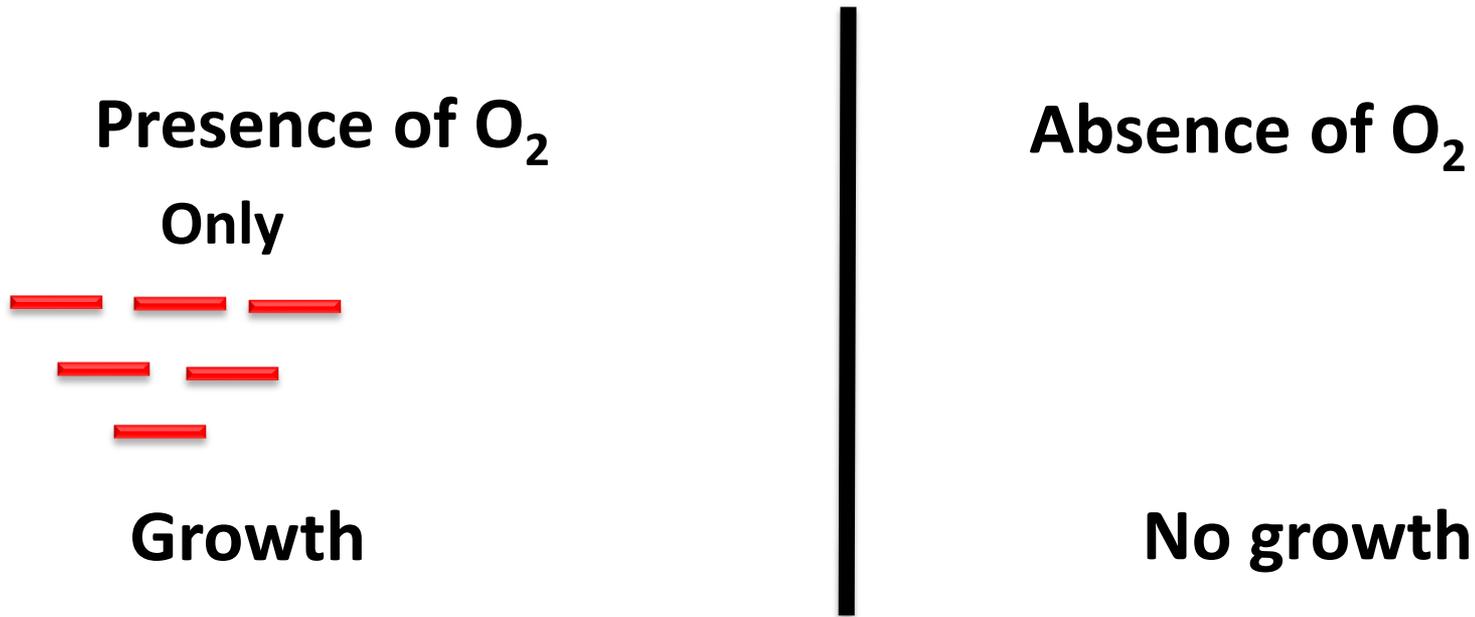
☐ Glucose catabolism

❖ Energy production

✓ Aerobic respiration
(O₂)

✓ Anaerobic respiration
(No O₂)

1- Obligate aerobes (Aerobic respiration)



e.g. Pseudomonas aeruginosa

1- Obligate aerobes (Aerobic respiration)

Aerobic respiration



For production Energy (ATP)



Glucose catabolism (glycolysis)

1- Obligate aerobes (Aerobic respiration)



Oxidative phosphorylation

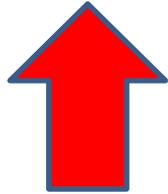


38 ATP

1- Obligate aerobes

Highly toxic molecules

Superoxide (O_2^{\cdot})



(H_2O_2)



Superoxide dismutase

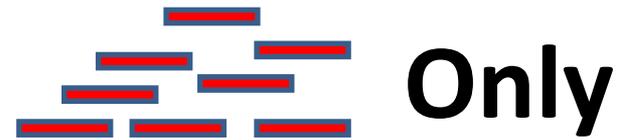
Catalase

2- Obligate anaerobes

Presence of O₂

Absence of O₂

No growth



Growth

Bacteroides fragilis

2- Obligate anaerobes (Anaerobic respiration)



4 ATP

× O_2



Other pathway

Lack Superoxide dismutase & Catalase

2- Obligate anaerobes (Anaerobic respiration)

The organism used inorganic molecules

❖ Nitrate

❖ Sulfate

❖ Co₂



Carry H⁺

13 ATP + 4

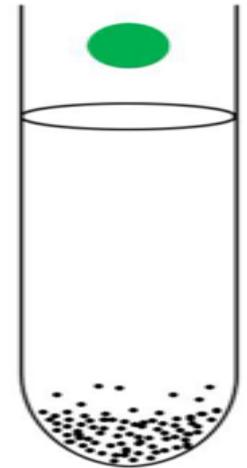
17 ATP

Lack

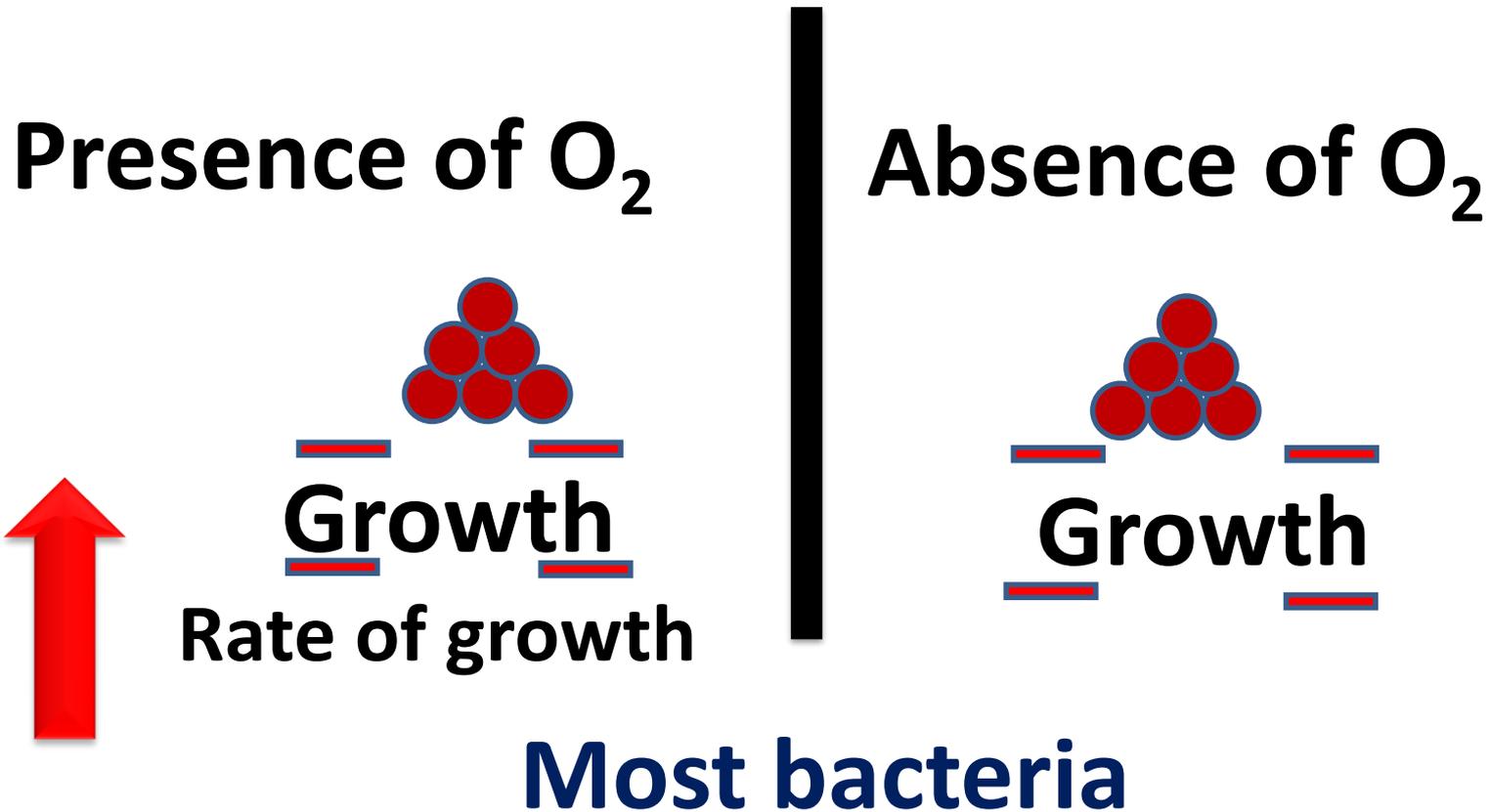
Superoxide dismutase

Catalase

Obligate
Anaerobe



3- Facultative anaerobes



3- Facultative anaerobes

Anaerobes

Fermentation

Glucose  **glycolysis** **2 Pyruvate +**  **2ATP**

**No Kreb's cycle &
other pathway**

**(Absence of
carriers)**

Acid & Alcohol



4- Micro-aerophilic

Presence of O₂

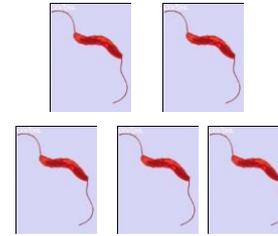


superoxide & H₂O₂

No growth

- ❖ *Campylobacter*
- ❖ *Helicobacter*

Low O₂



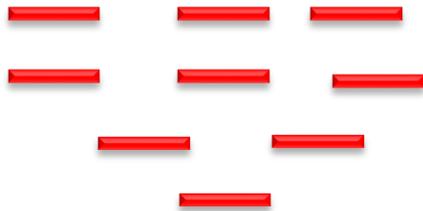
2-10% O₂

Growth

Low superoxide
dismutase &
catalase

5- Aero-tolerant anaerobes

Low O₂

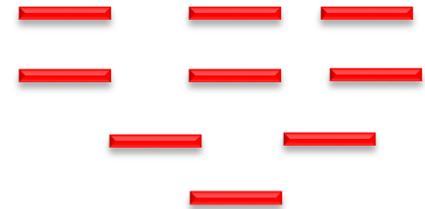


Superoxide dismutase



❖ *C.perfringens*

Absence of O₂



Growth

Carbon Dioxide Requirement

All microbes require some carbon dioxide in their metabolism

- **Capnophile** – grows best at higher CO₂ than normally present in the atmosphere

- Can use CO₂ as their sole source of carbon.
- Cellular building blocks
- **Growth requirements:** human gut microbes



CO₂ requirements

CO₂ (0.03%)

Present in air
is sufficient

CO₂ (5-10%)

(Capnophilic)

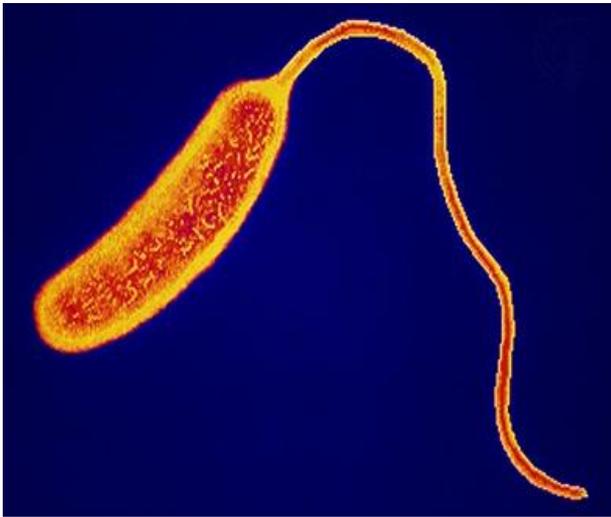
❖ *Neisseria*

❖ *Brucella*

Effects of pH

- Majority of microorganisms grow at a pH between 6 and 8 (**neutrophiles**)
- **Acidophiles** – grow at extreme acid pH
- **Alkaliphiles** – grow at extreme alkaline pH

Alkaline (pH 9)



Vibrio cholerae

Acidic (pH 4)



Lactobacilli

Osmotic Pressure

- Most microbes exist under hypotonic or isotonic conditions
- **Halophiles** – require a high concentration of salt
- **Osmotolerant** – do not require high concentration of solute but can tolerate it when it occurs

Other Environmental Factors

- **Barophiles** – can survive under extreme pressure and will rupture if exposed to normal atmospheric pressure

Concept Check:

Chlamydomonas nivalis grows on Alaskan glaciers and its photosynthetic pigments give the snow a red crust. This organism would be best described as a

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- A. Psychrophile
- B. Alkaliphile
- C. Microaerophile
- D. Osmotolerant
- E. Barophile



Image courtesy Nozomu Takeuchi

(a)

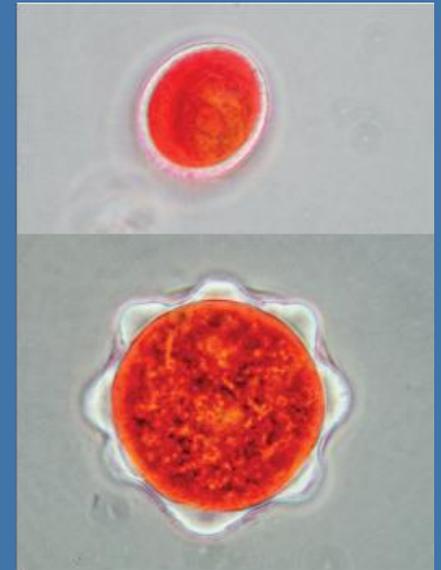


Image courtesy Nozomu Takeuchi

(b)

Ecological Associations Among Microorganisms

Microbial Associations

Symbiotic

Organisms live in close nutritional relationships; required by one or both members.

Nonsymbiotic

Organisms are free-living; relationships not required for survival

Mutualism

Obligatory, dependent; both members benefit.

Commensalism

The commensal benefits; other member not harmed.

Parasitism

Parasite is dependent and benefits; host harmed.

Synergism

Members cooperate and share nutrients.

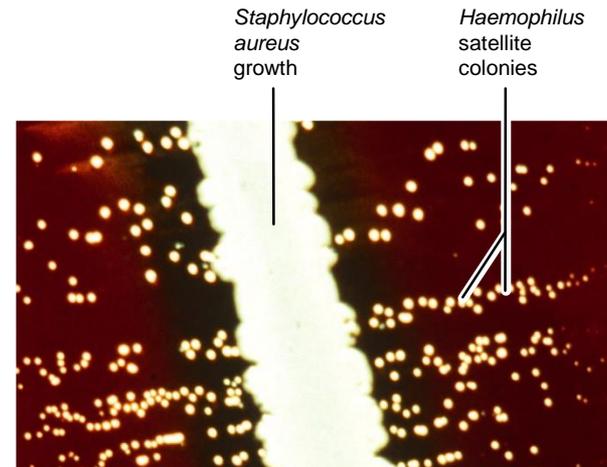
Antagonism

Some members are inhibited or destroyed by others.

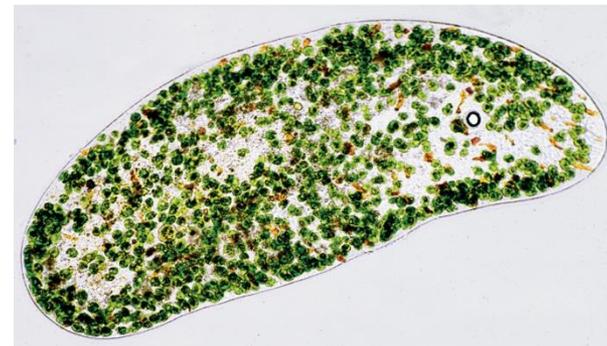
Ecological Associations

- Symbiotic – two organisms live together in a close partnership
 - **Mutualism** – obligatory, dependent; both members benefit
 - **Commensalism** – commensal member benefits, other member neither harmed nor benefited
 - **Parasitism** – parasite is dependent and benefits; host is harmed

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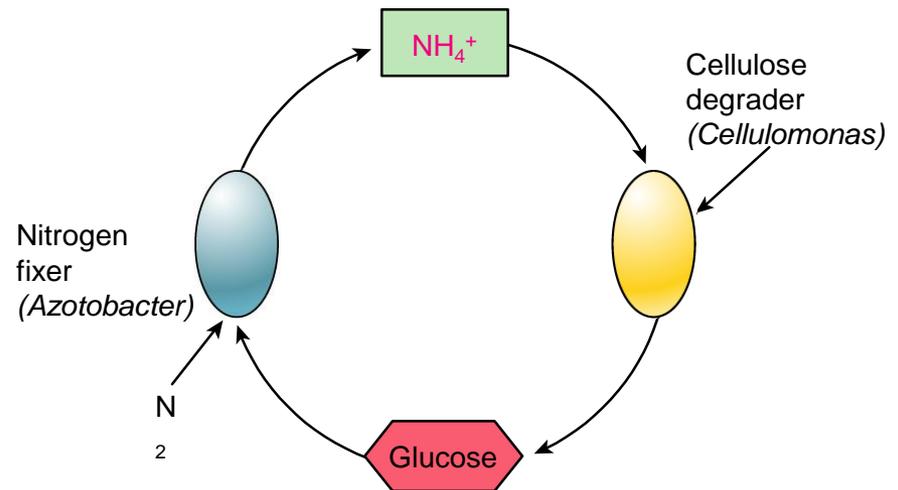
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Courtesy Arthur Hauck (Germany)

Ecological Associations

- **Non-symbiotic** – organisms are free-living; relationships not required for survival
 - **Synergism** – members cooperate to produce a result that none of them could do alone
 - **Antagonism** – actions of one organism affect the success or survival of others in the same community (competition)
 - Antibiosis



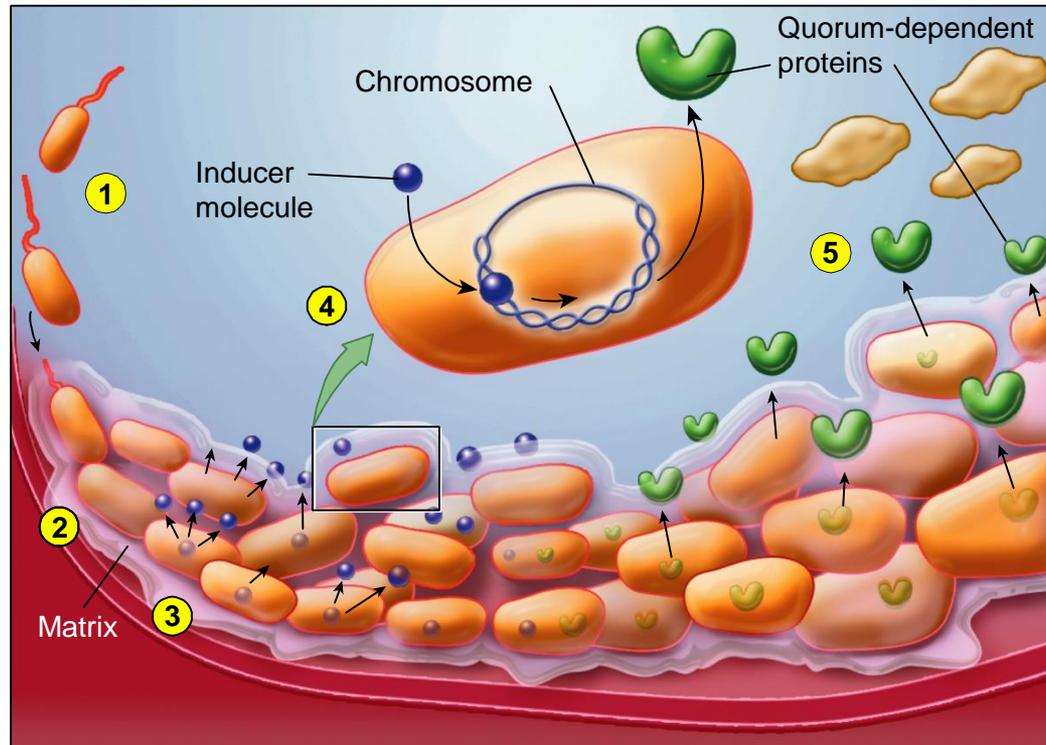
Interrelationships Between Microbes and Humans

- Human body is a rich habitat for symbiotic bacteria, fungi, and a few protozoa – called **normal microbial flora**
- Commensal, parasitic, and synergistic relationships – all exist or can exist on the human body

Microbial Biofilms

- **Biofilms** result when organisms attach to a substrate by some form of extracellular matrix that binds them together in complex organized layers
- Dominate the structure of most natural environments on earth
- Communicate and cooperate in the formation and function of biofilms – **quorum sensing**

Biofilm Formation and Quorum Sensing



- 1** Free-swimming cells settle on a surface and remain there.
- 2** Cells synthesize a sticky matrix that holds them tightly to the substrate.
- 3** When biofilm grows to a certain density (quorum), the cells release inducer molecules that can coordinate a response.
- 4** Enlargement of one cell to show genetic induction. Inducer molecule stimulates expression of a particular gene and synthesis of a protein product, such as an enzyme.
- 5** Cells secrete their enzymes in unison to digest food particles.