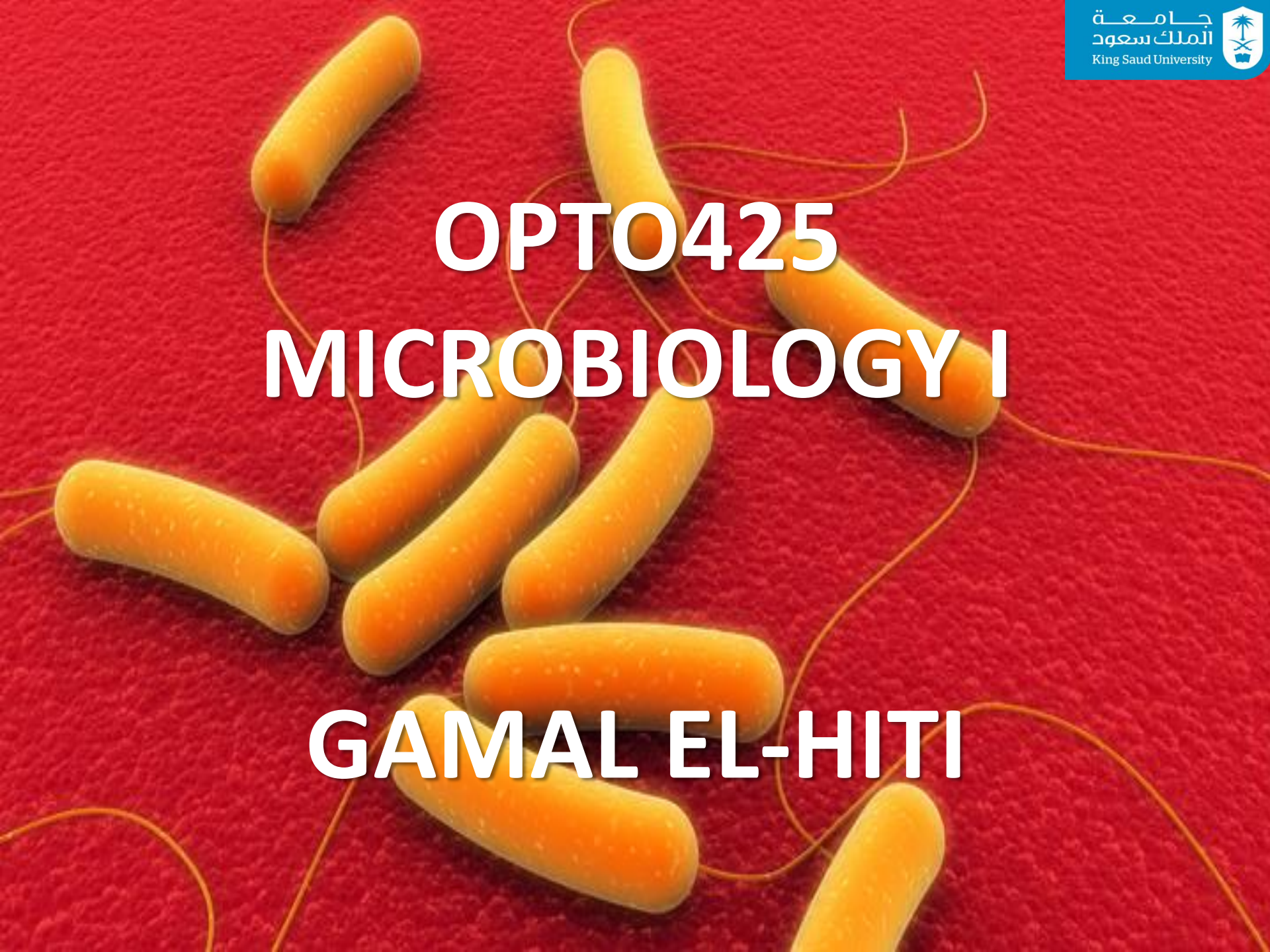
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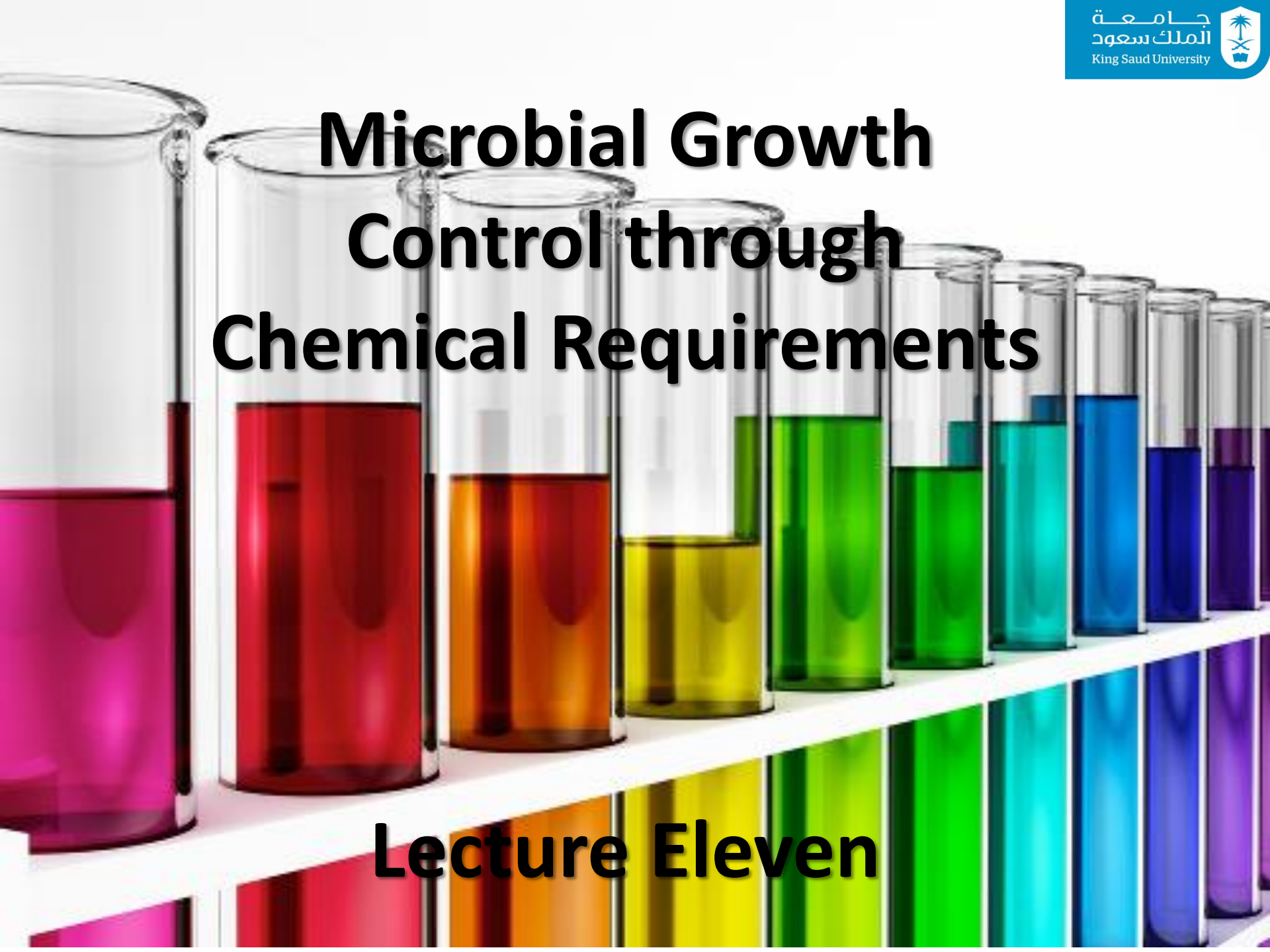
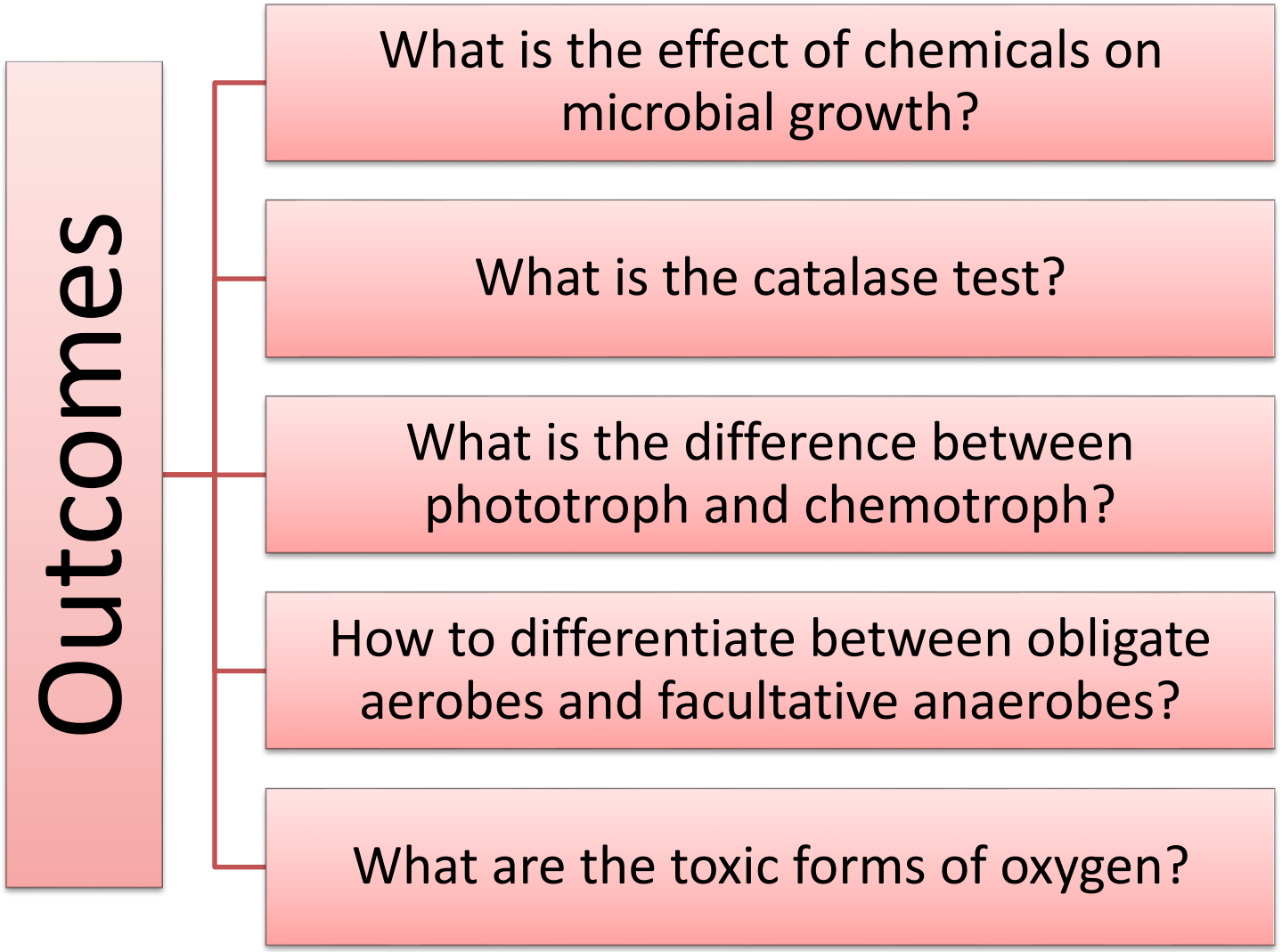
King Saud University
OPTO425
MICROBIOLOGY I
GAMAL EL-HITI



Microbial Growth Control through Chemical Requirements

Lecture Eleven

Learning Outcomes



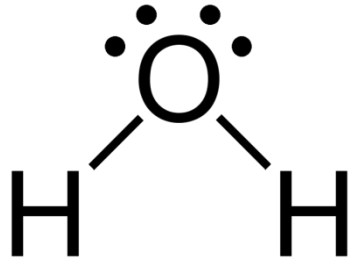
Microbial Growth Control

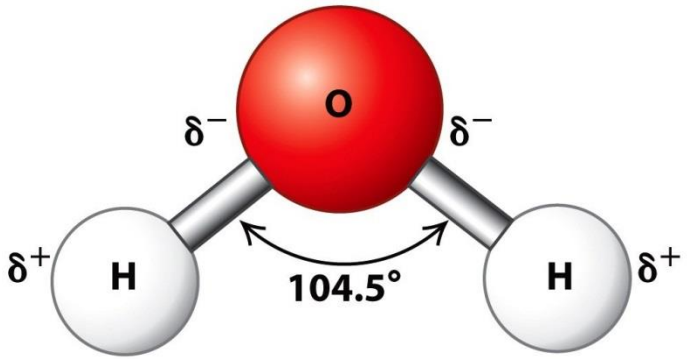
- **Chemical Requirements**

1– Water

2– Elements

- Carbon
- Nitrogen
- Sulfur
- Traces of other elements (P, *etc*.)





Microbial Growth Control

3– Other Elements

- Potassium
- Magnesium
- Calcium

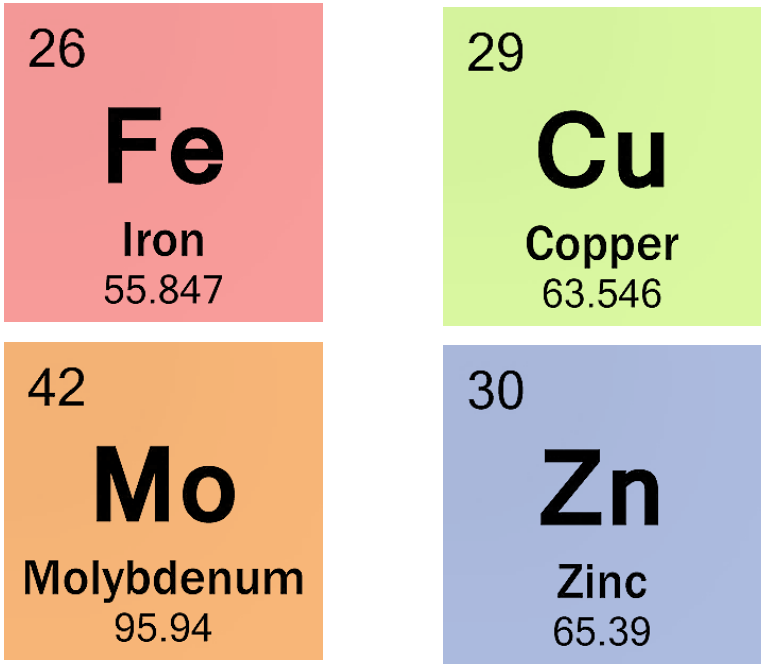
- These elements are often required as enzyme cofactors.

- For example, calcium is required for cell wall synthesis in Gram positive bacteria.

Microbial Growth Control

4– Trace Elements

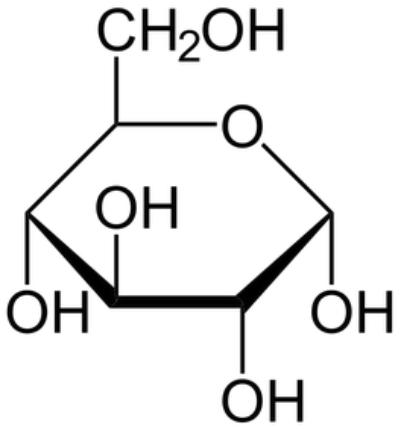
- Many elements are used as enzyme cofactors.
- These elements commonly found in tap water.
  - Iron
  - Copper
  - Molybdenum
  - Zinc



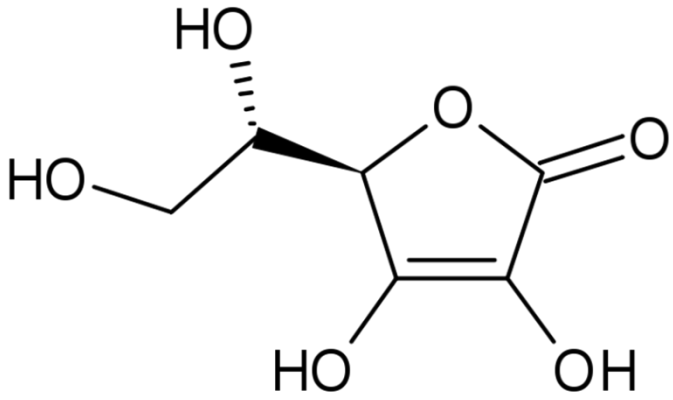
Microbial Growth Control

5– Organic Compounds

- Organic Compounds Containing Oxygen
- Glucose
- Source of energy

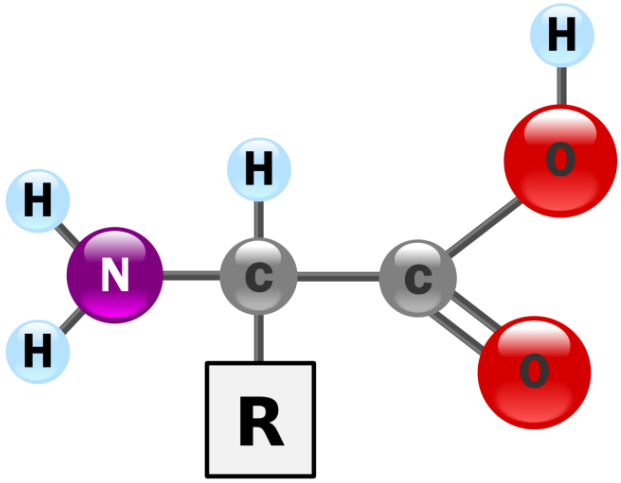


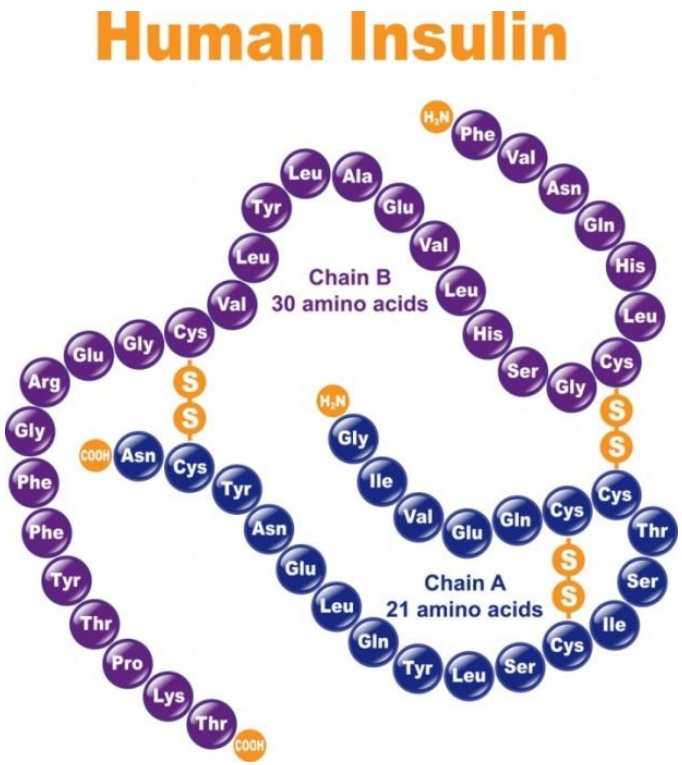
- Vitamins (coenzymes)
- *e.g.* Vitamin C or *L*-ascorbic acid



Microbial Growth Control

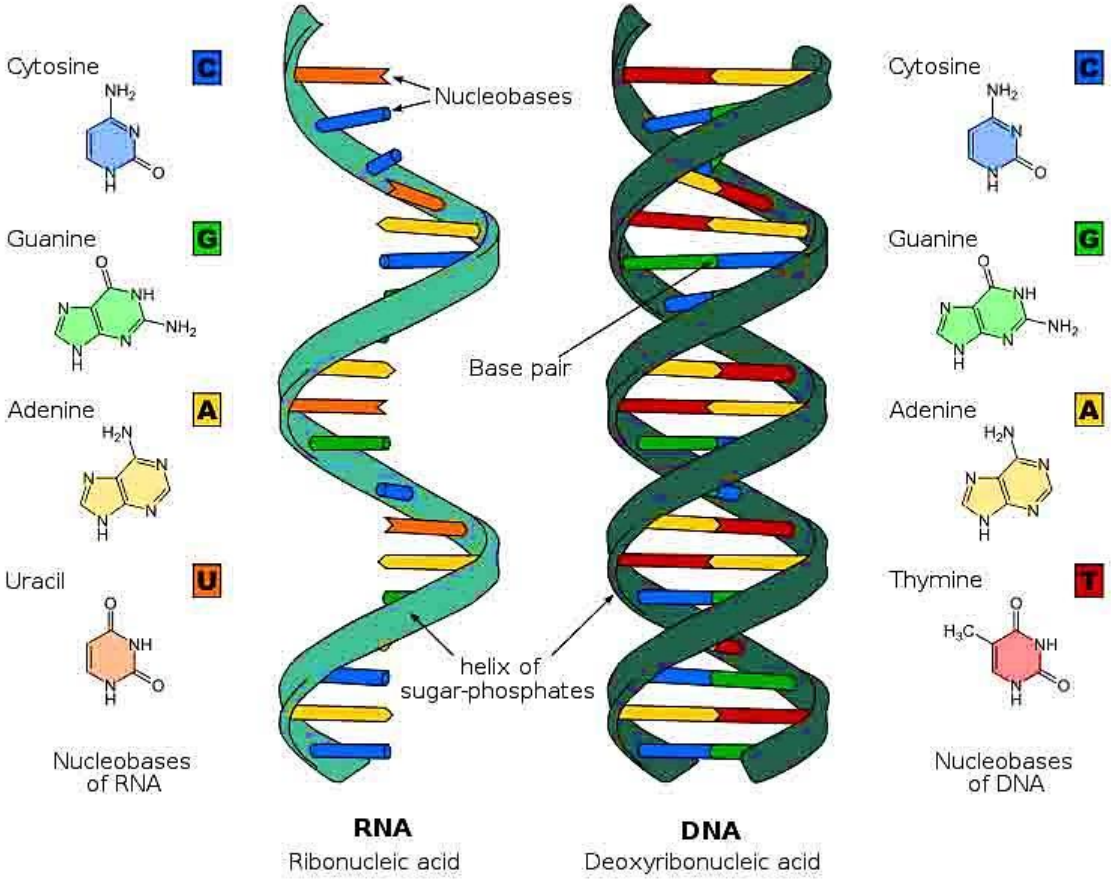
- Organic Compounds Containing Nitrogen
- Nitrogen makes up 14% of dry cell weight.
- Used to form amino acids, DNA and RNA.
- Amino acids
- Proteins





Microbial Growth Control

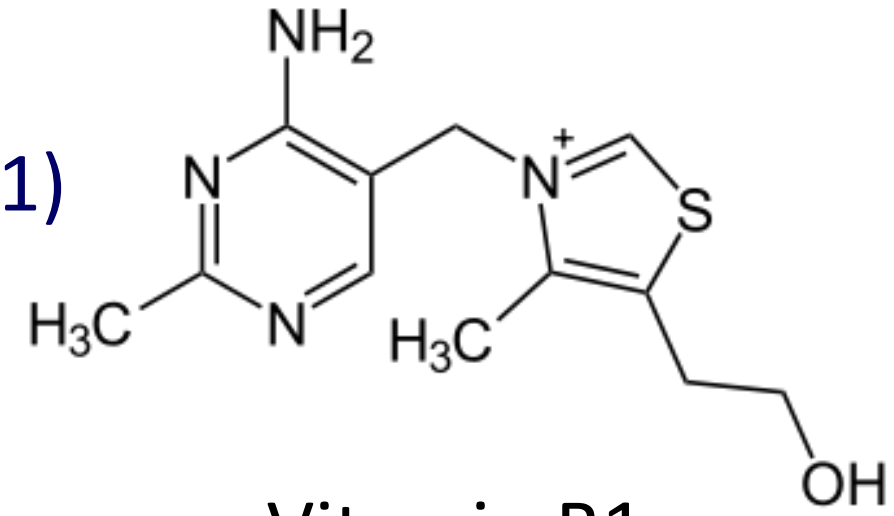
- Purines and Pyrimidines



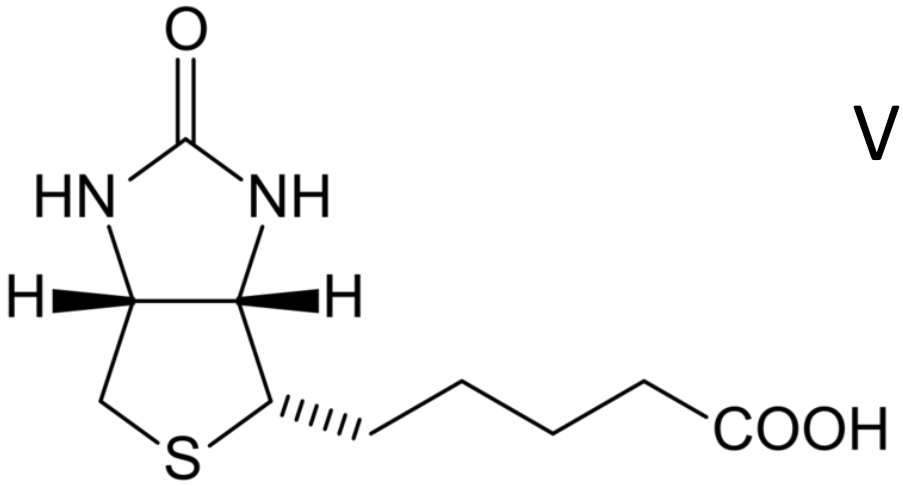
- Most bacteria decompose proteins.

Microbial Growth Control

- Organic Compounds Containing Sulfur
- Thiamine (vitamin B1)
- Biotin (vitamin H)



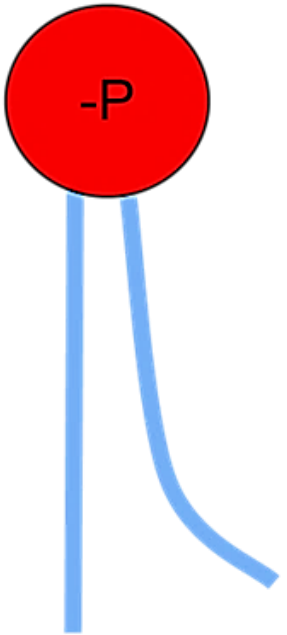
Vitamin B1



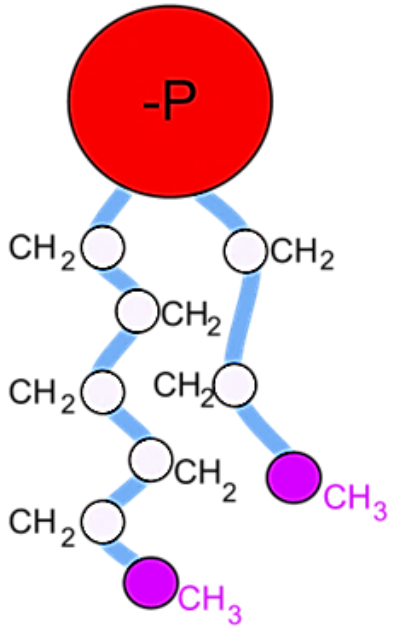
Vitamin H

Microbial Growth Control

- Organic Compounds Containing phosphorous
- DNA, RNA, ATP and phospholipids.



A phospholipid with a hydrophilic head and a hydrophobic tail



Chemical makeup of a single phospholipid

Microbial Growth Control

6– Carbon

- All chemical substances in microbes contain carbon in some form, whether in the form of proteins, carbohydrates or lipids.
- Perhaps 50% of a bacterium's dry weight is carbon.
- Carbon can be obtained from organic materials in the environment, or it may be derived from carbon dioxide.

Microbial Growth Control

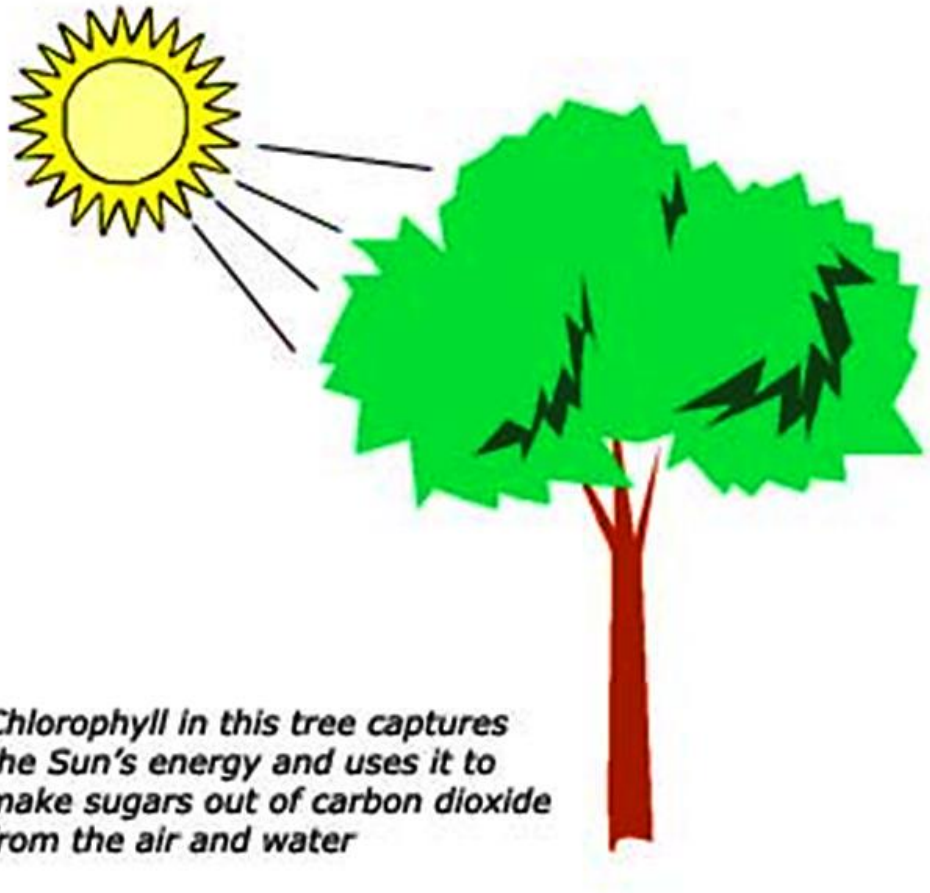
- What are chemoheterotrophs, chemoautotrophs and photoautotrophs?
- Chemoheterotrophs are microorganisms that obtain energy from the oxidation of organic compounds (derive both carbon and energy from organic compounds).
- Organic compounds could be proteins, carbohydrates and lipids (such as fats, waxes, sterols, *etc.*; natural molecules).
- Chemoautotrophs and photoautotrophs obtain carbon from carbon dioxide.

Microbial Growth Control

- Carbon Sources
- CO_2: autotroph
- Organic: heterotroph
- Energy Sources
- Sunlight: phototroph
- Organic: chemotroph
- Saprobe: lives on organics of dead organisms.
- Parasite: lives on organics of living host.

Microbial Growth Control

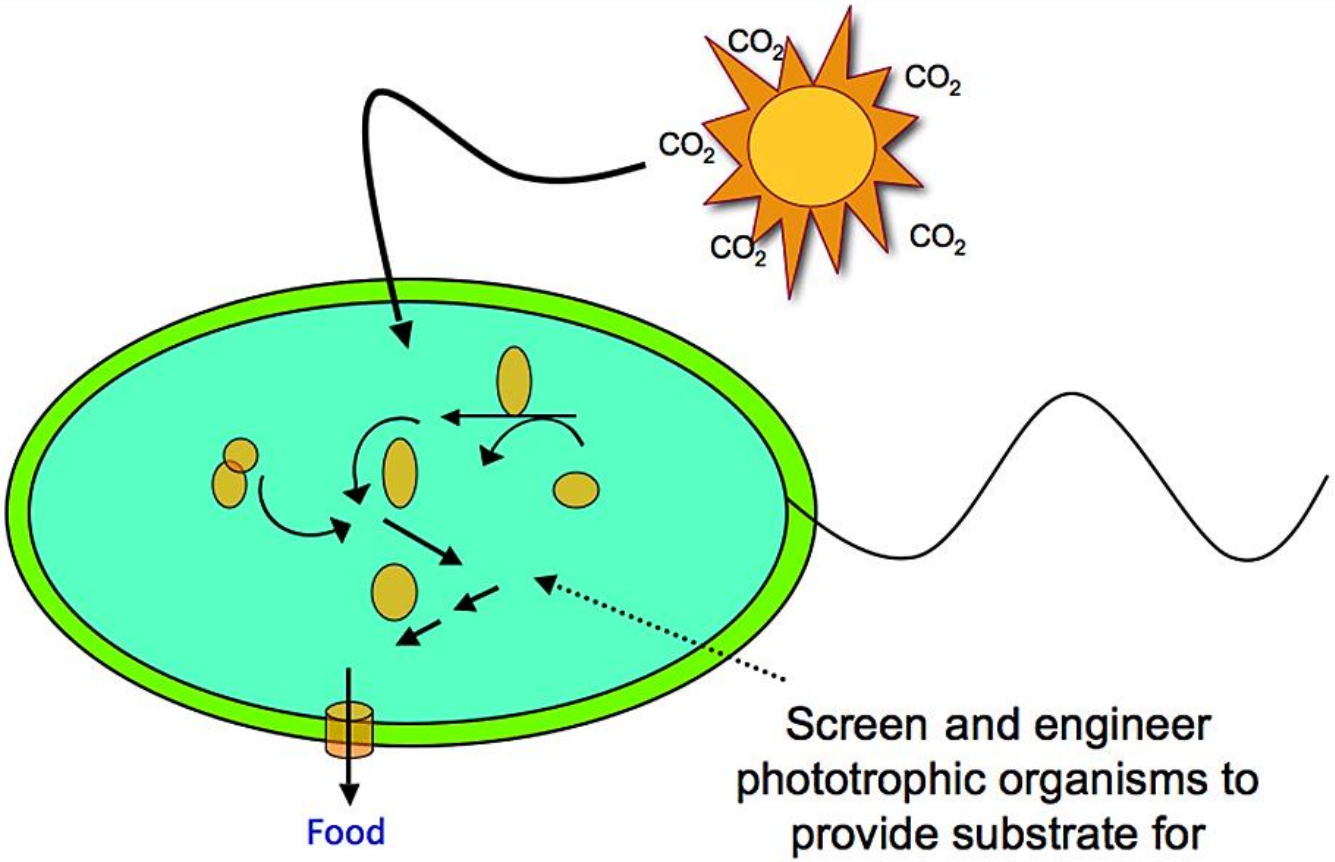
Autotroph



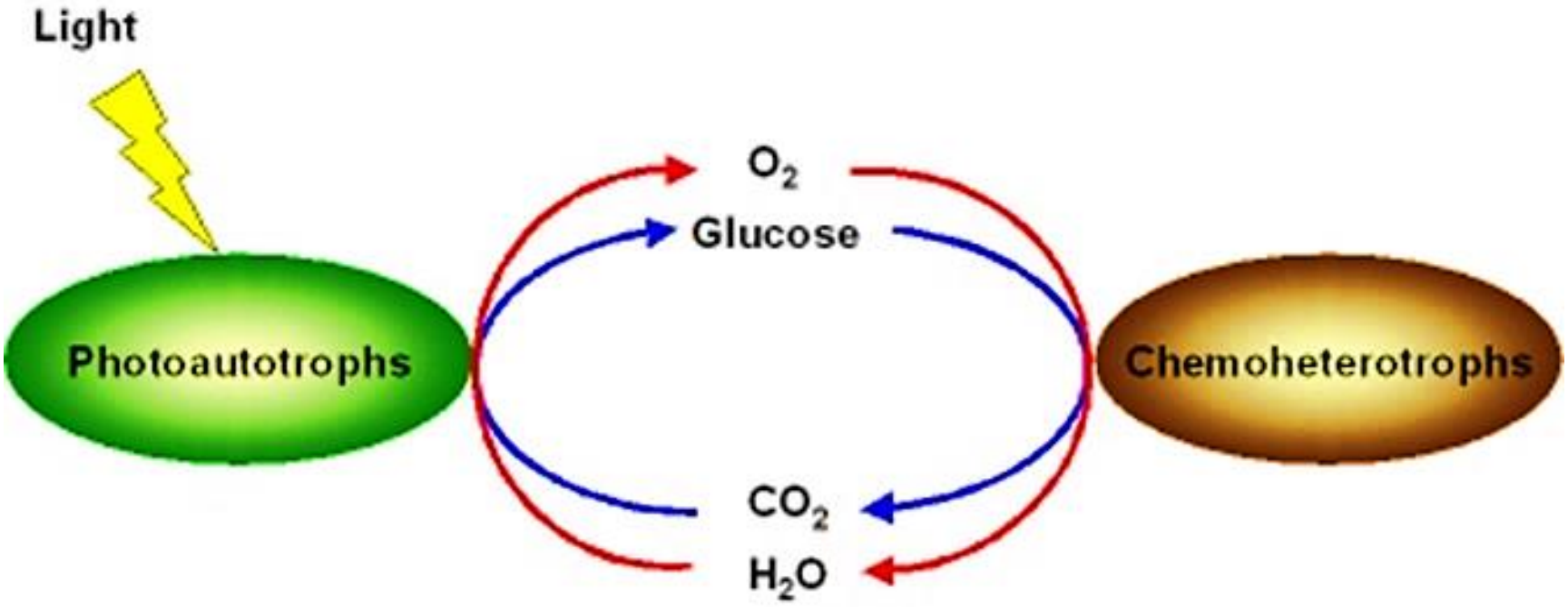
Chlorophyll in this tree captures the Sun's energy and uses it to make sugars out of carbon dioxide from the air and water

Microbial Growth Control

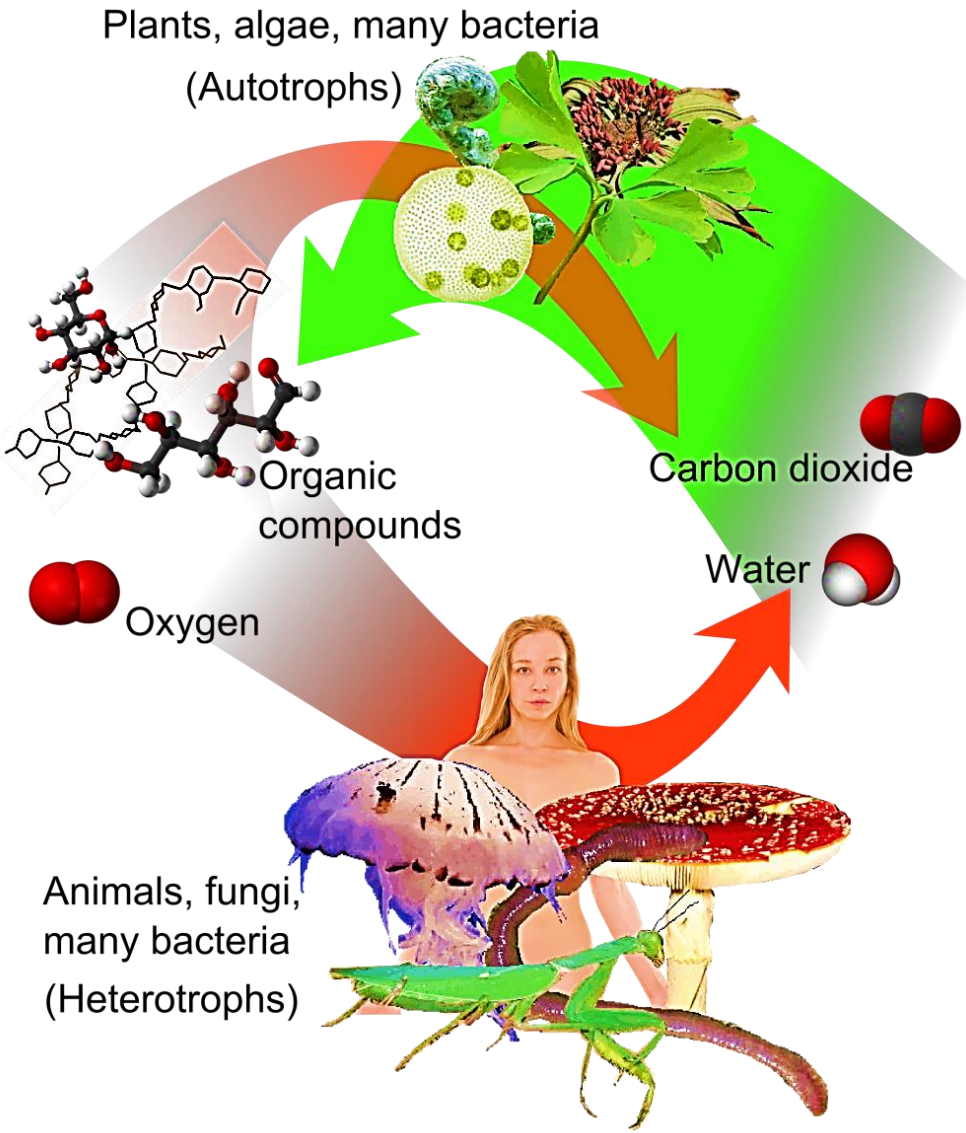
Phototroph



Microbial Growth Control



Microbial Growth Control



Microbial Growth Control

7– Oxygen

- Microorganisms that use molecular oxygen (O_2), produce more energy from nutrients than anaerobes.
- Microorganism can be classified based on their oxygen requirements.
- Obligate Aerobes: require oxygen to live.
- Disadvantage: O_2 dissolves poorly in H_2O.
- Example: *Pseudomonas* which is a common nosocomial pathogen.

Microbial Growth Control

- Facultative Anaerobes
- They can use oxygen, but can grow in its absence.
- Examples: *E. coli*, *Staphylococcus*, *yeasts*, and many intestinal bacteria.
- Obligate Anaerobes
- They cannot use oxygen and are harmed by the presence of toxic forms of oxygen.
- Examples: *Clostridium* bacteria that cause tetanus and botulism.

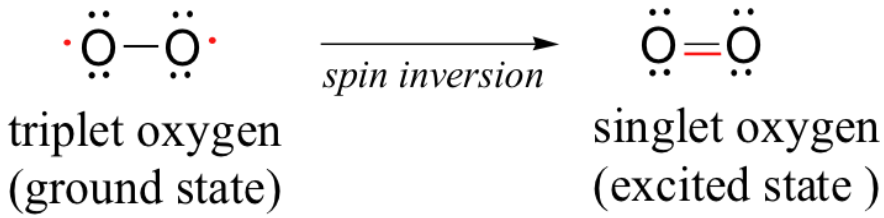
Microbial Growth Control

- Aerotolerant Anaerobes
- They can't use oxygen, but tolerate its presence and can break down toxic forms of oxygen.
- Example: *Lactobacillus* that carries out fermentation regardless of oxygen presence.
- Microaerophiles
- They require oxygen, but at low concentrations and sensitive to the presence of toxic forms of oxygen.
- Example: *Campylobacter*.

Microbial Growth Control

Toxic forms of oxygen

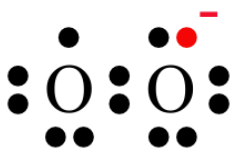
1– Singlet Oxygen: extremely reactive and present in phagocytic cells.



- Singlet oxygen is the common name used for electronically excited molecular oxygen (O_2; *i.e*. higher energy state).
- It is less stable than normal triplet oxygen.

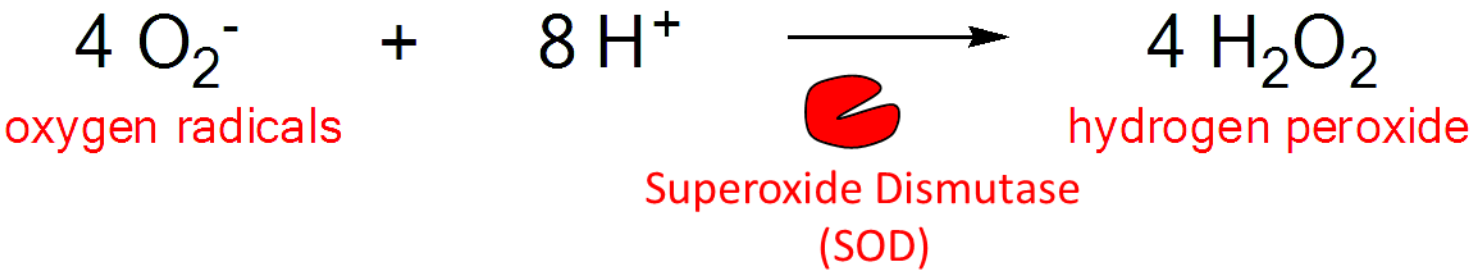
Microbial Growth Control

2– Superoxide Free Radicals ($O_2^{-\cdot}$): extremely toxic and reactive.



- All organisms growing in atmospheric oxygen must produce superoxide dismutase (SOD) enzyme to get rid of toxic forms of oxygen.
- SOD is made by aerobes, facultative anaerobes and aerotolerant anaerobes, but not by anaerobes or microaerophiles.
- How to handle superoxide free radicals?

Microbial Growth Control

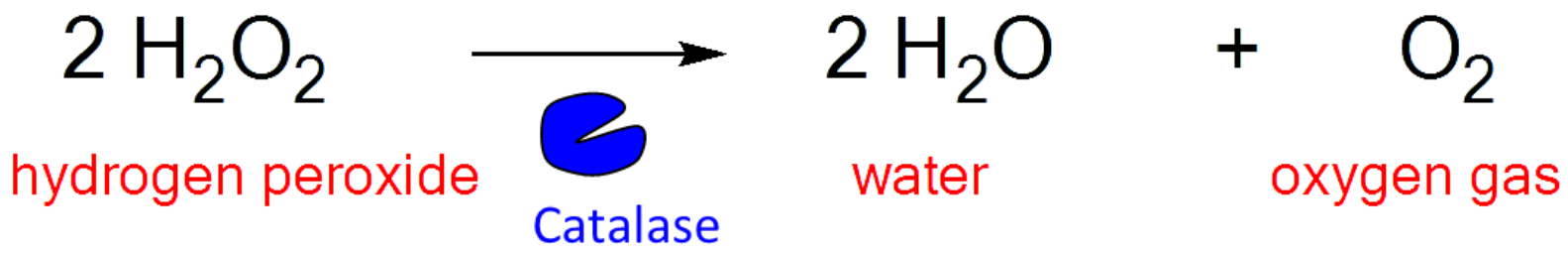


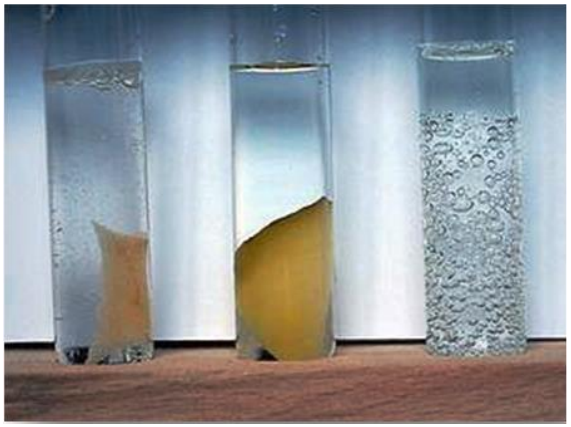
3– Hydrogen Peroxide (H_2O_2) is toxic and the active ingredient of several antimicrobials (*e.g.* benzoyl peroxide).

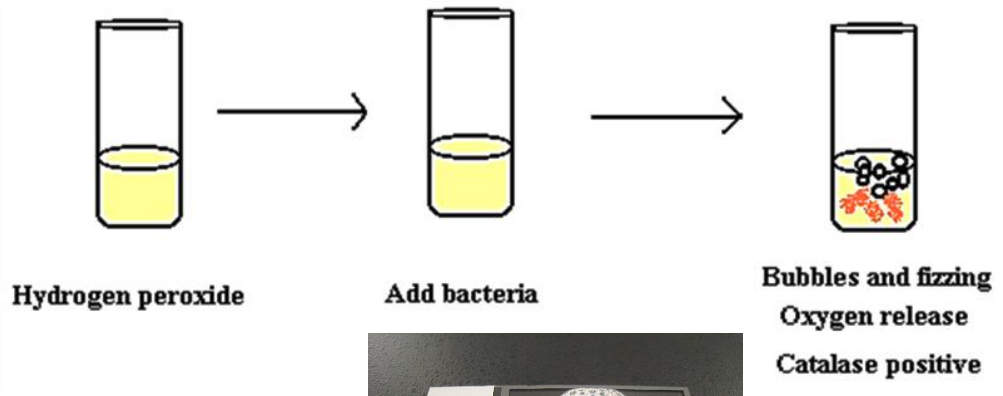
- There are two different enzymes that break down H_2O_2 (catalase and peroxidase).
- Catalase: breaks hydrogen peroxide into water (H_2O)and oxygen (O_2).
- Produced by humans and many bacteria.

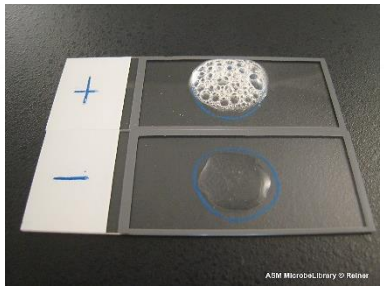
Microbial Growth Control

Catalase Test: Bacteria in the presence of H_2O_2 gives as O_2 as bubbles.



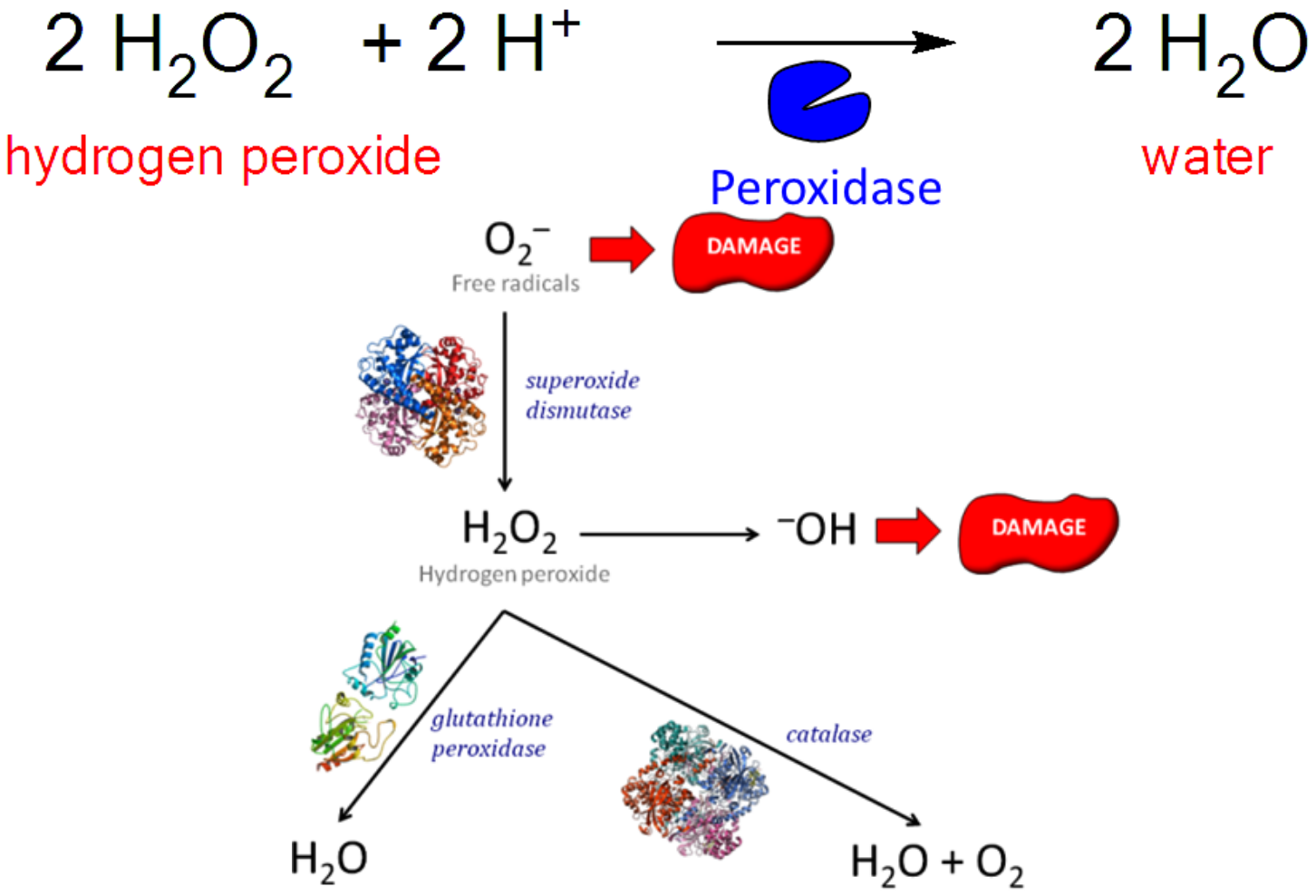






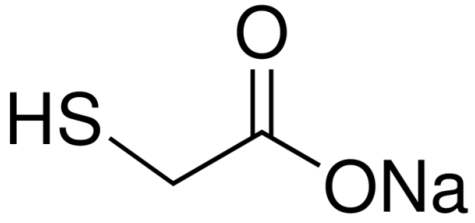
Microbial Growth Control

- Peroxidase: converts H_2O_2 into water (H_2O).



Microbial Growth Control

- Thioglycollate broth
- It is a multi-purpose, enriched, differential medium used to determine the oxygen requirements of microorganisms.
- Sodium thioglycolate in the medium consumes oxygen and permits the growth of obligate anaerobes



Microbial Growth Control

- Oxygen was diffused from the top of the broth produces various oxygen concentrations in the media along its depth.
- The oxygen concentration at a given level is indicated by a redox sensitive dye like resazurine.
- Dye turns pink in the presence of oxygen.

$$R\text{-}SH + O_2 \longrightarrow R\text{-}SO_2$$