

**MSc I Sem – Life Sciences**

**Course – Cell Biology**

**Origin of Life and**

**Evolution of**

**Prokaryotic Cells**

# Early Earth

- 4.6 billion years ago (bya)
- Early atmosphere:
  - No free oxygen
  - Primarily nitrogen and carbon dioxide
  - High energy from lightning, UV radiation



# When did life begin?

- Stromatolites (3.5 bill. Yr)
  - Rocks with distinctive layer structure
- Look identical to living mats of microbes
  - Layers of microbes and sediment
  - Top layer uses photosynthesis
  - Lower layers use top layer's byproducts

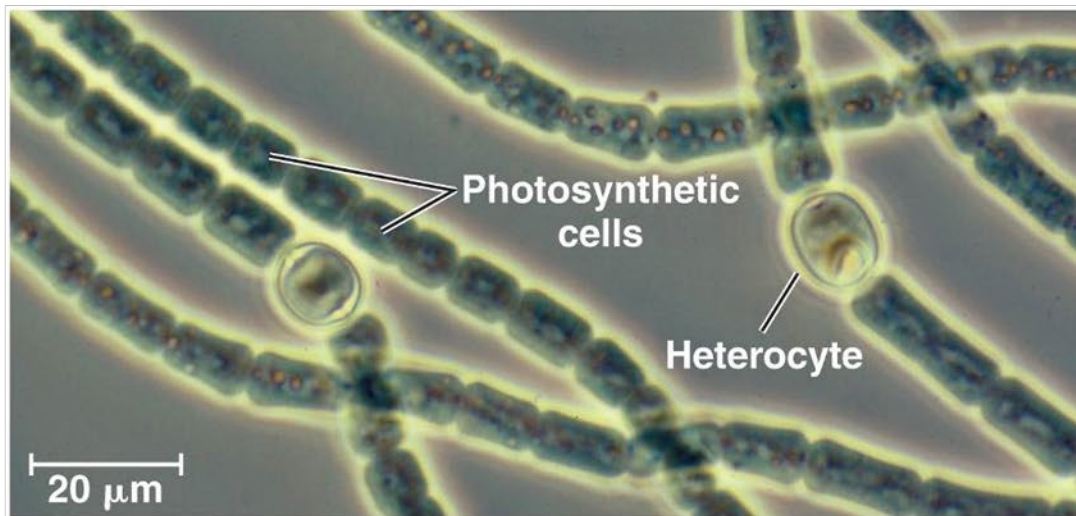


# Earliest Evidence of Life

- Oldest fossil organisms: photosynthetic cyanobacteria
- Western Australia - 3.5 bya



## Fossil vs. Living Cyanobacteria

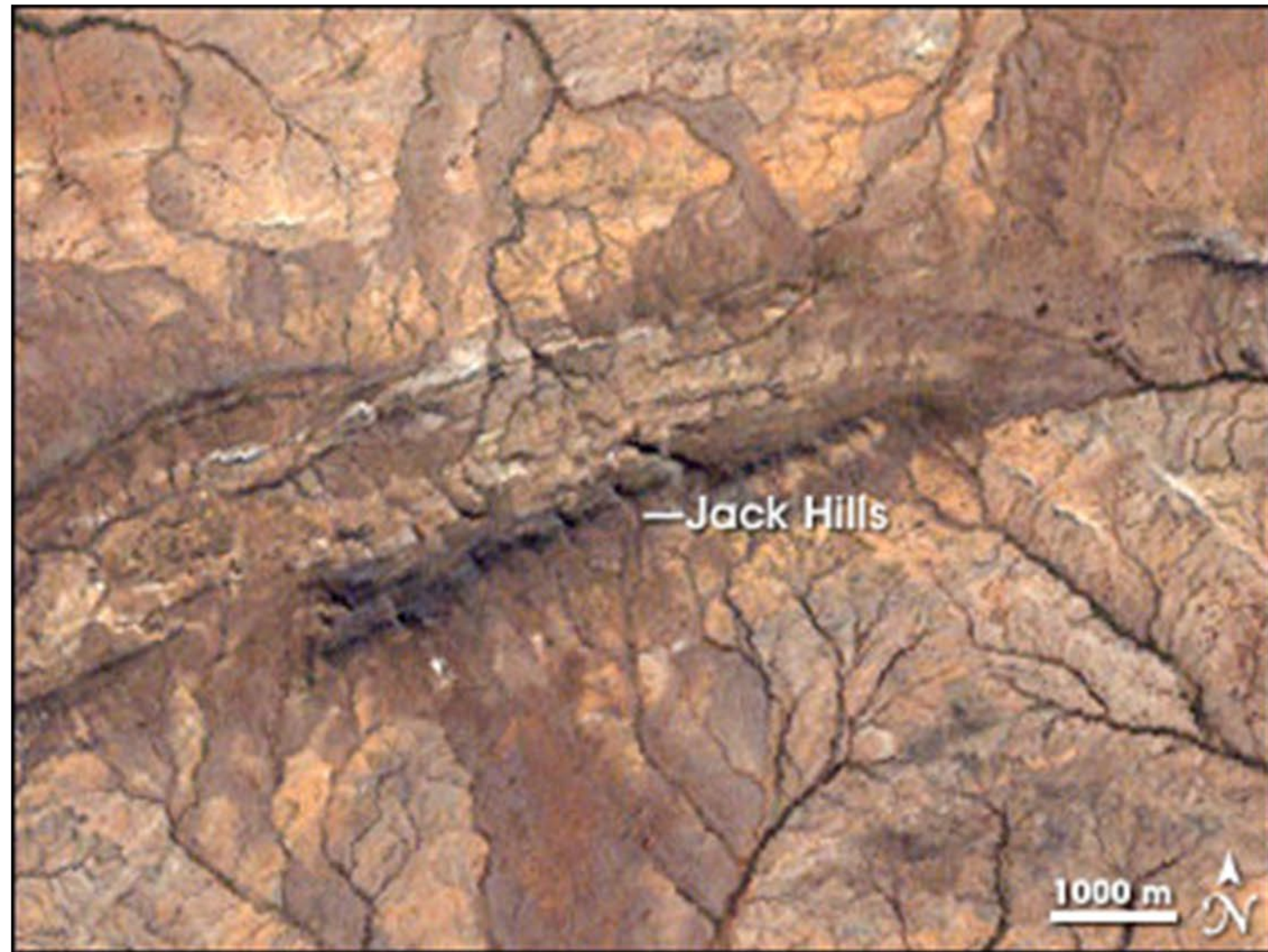


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# Earliest Life

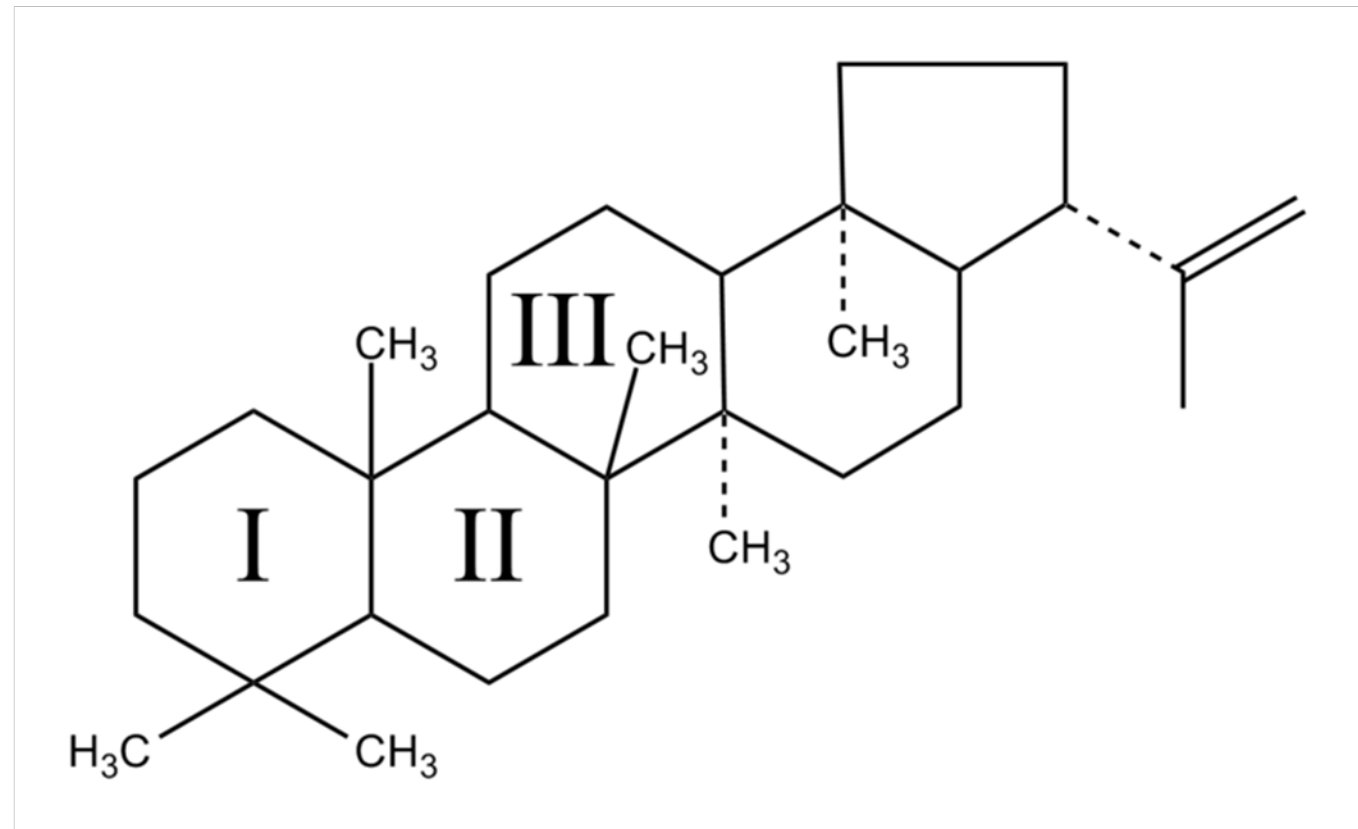
- Single-celled organisms probably evolved before 3.9 bya
- No 3.9 bya fossils



Jack Hills: Rock formation in Australia; rocks > 3.6 bya; 4.4 bya zircon crystal found in this formation

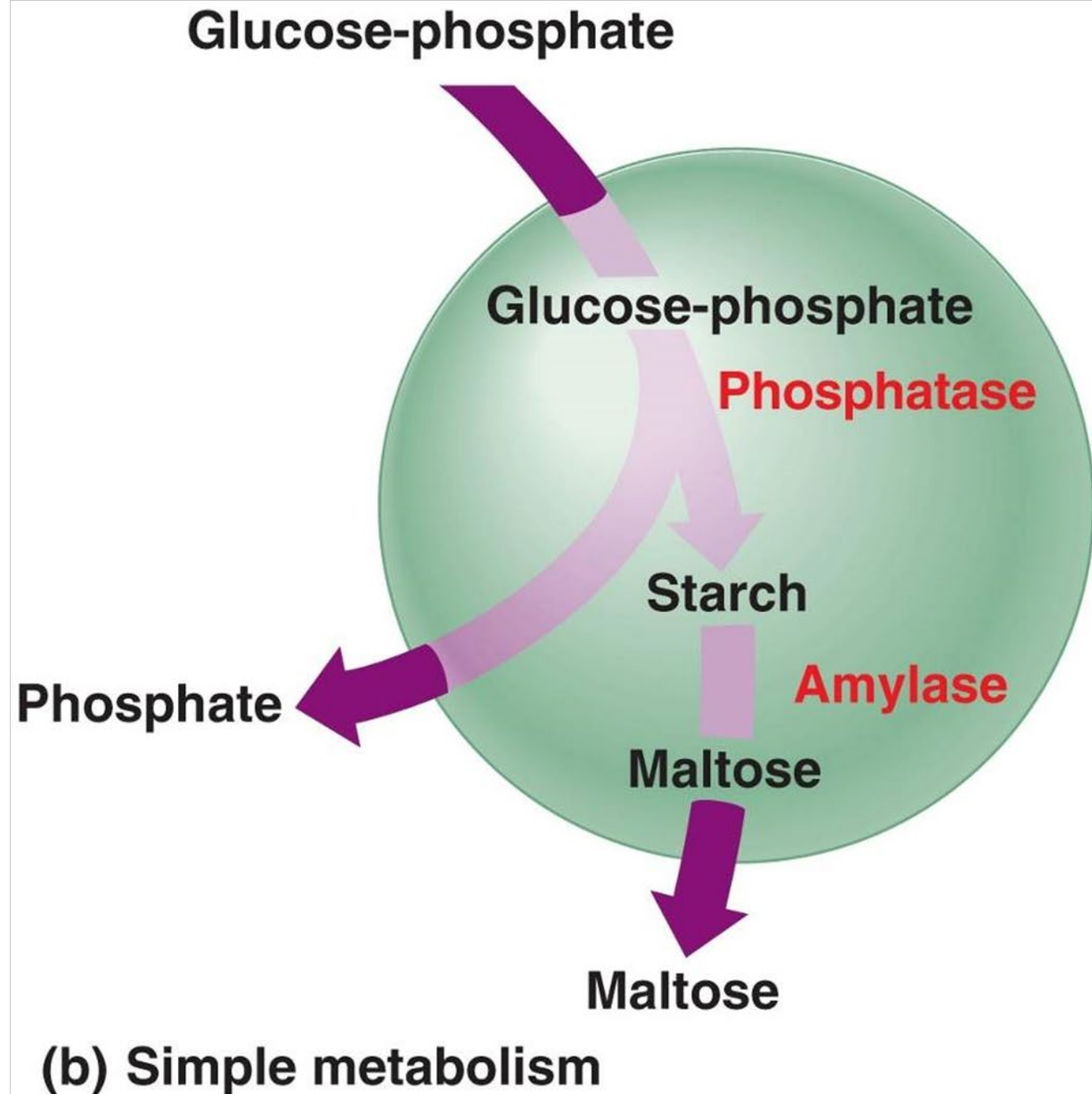
# Molecular Fossils

- Chemical traces of biomolecules
- 3.9 bya evidence of prokaryotic lipids



# Protobionts

- Life-like properties:
  - Reproduce
  - Simple Metabolism
  - Membrane potentials





# Evolution of Prokaryotes?

Absorptive Anaerobic Heterotrophs



Anaerobic Autotrophs  
(Non-oxygenic photosynthesis)



Anaerobic Ingestive Heterotrophs



Aerobic Autotrophs  
(Oxygenic photosynthesis)



Aerobic Heterotrophs

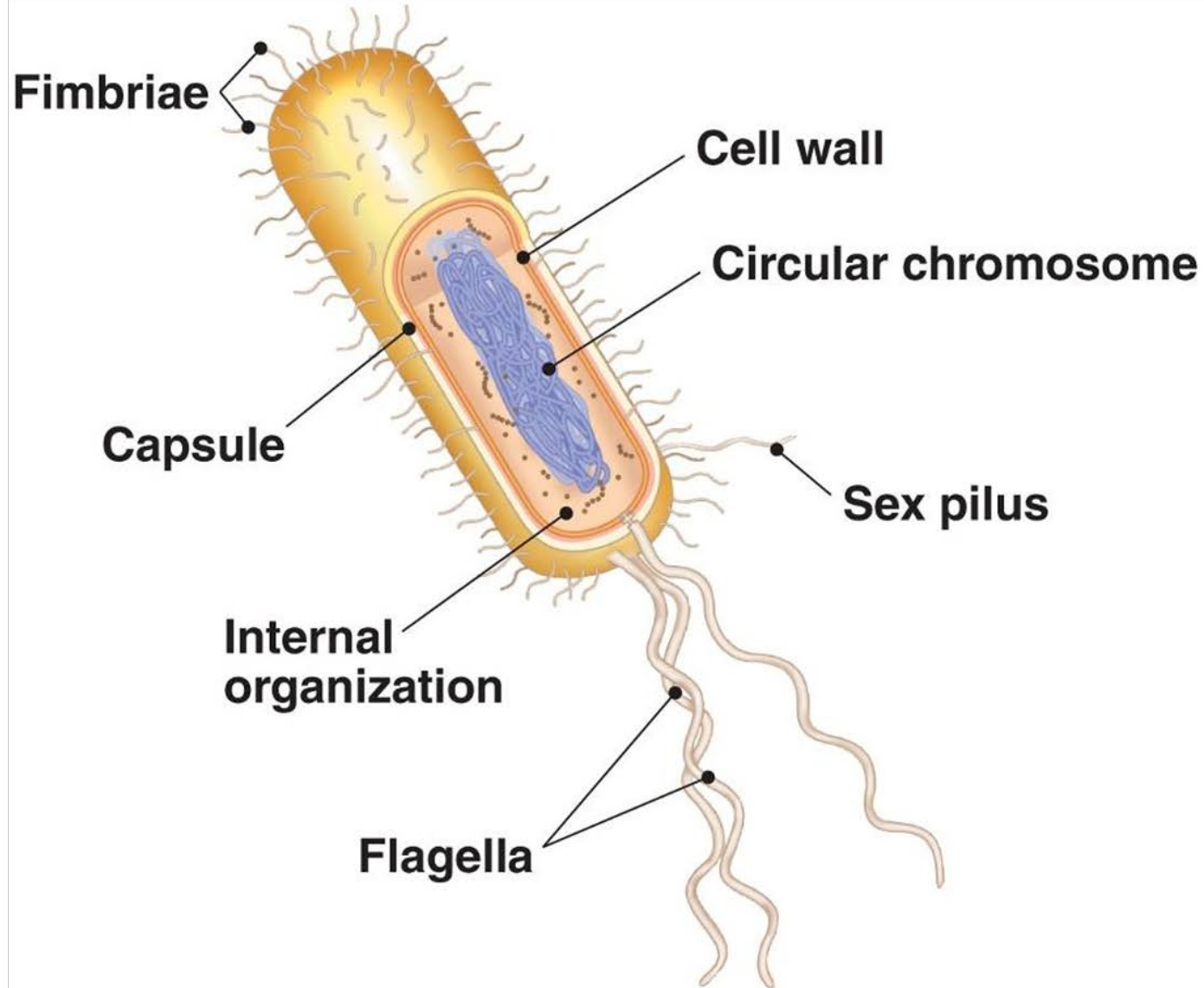


Photo Credit of Lassen Volcanic National Park Hot Springs:  
Walter Siegmund, 2005, Wikimedia Commons

# Prokaryotic Cells

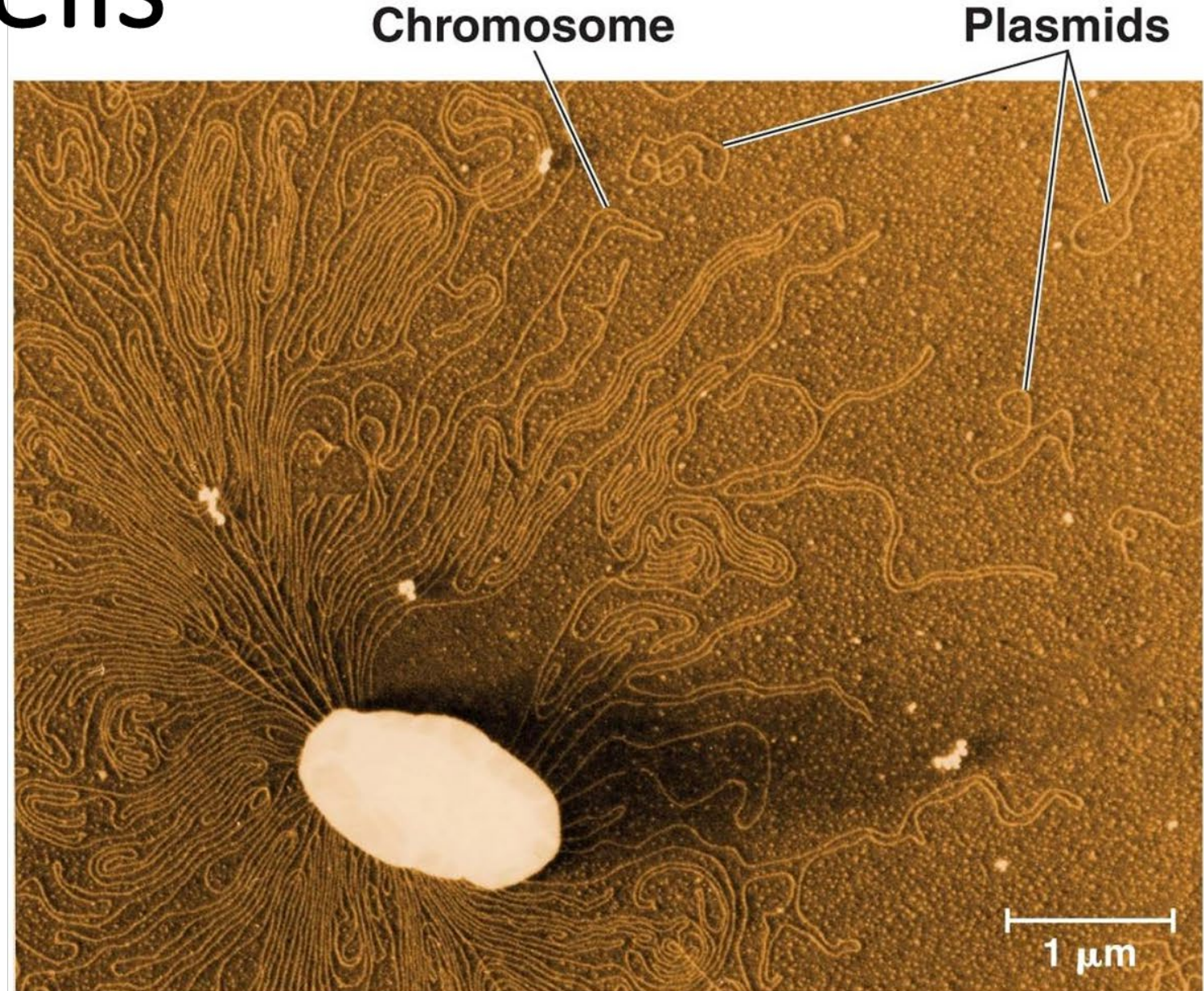
- **Review**

- Prokaryotic cell structure
- Cell wall present



# Prokaryotic Cells

- Circular chromosome
- Plasmids



# Prokaryotic Cells

- Reproduction (binary fission)
- Membrane transport
  - Gases
  - Water
  - Wastes
  - Ions

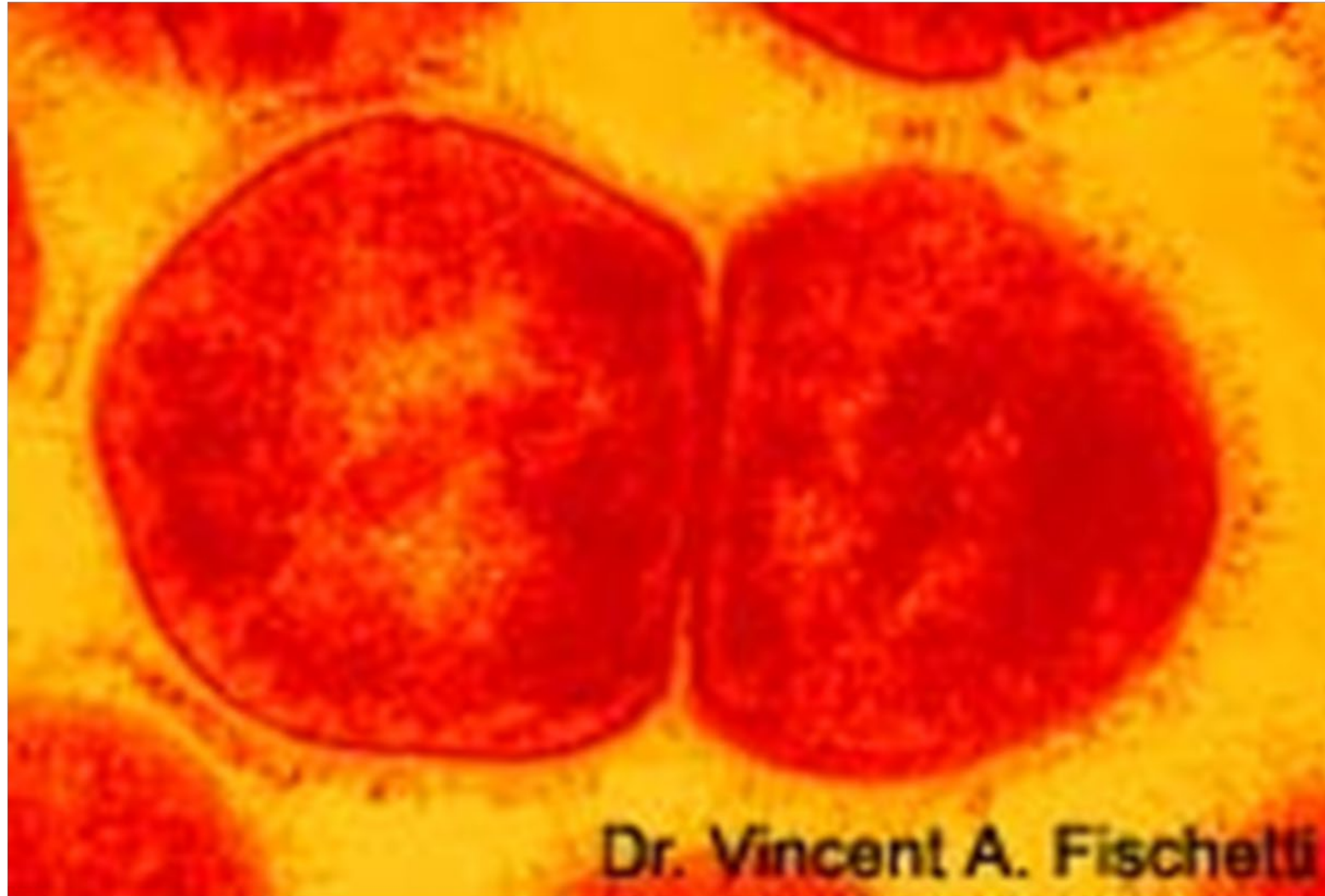
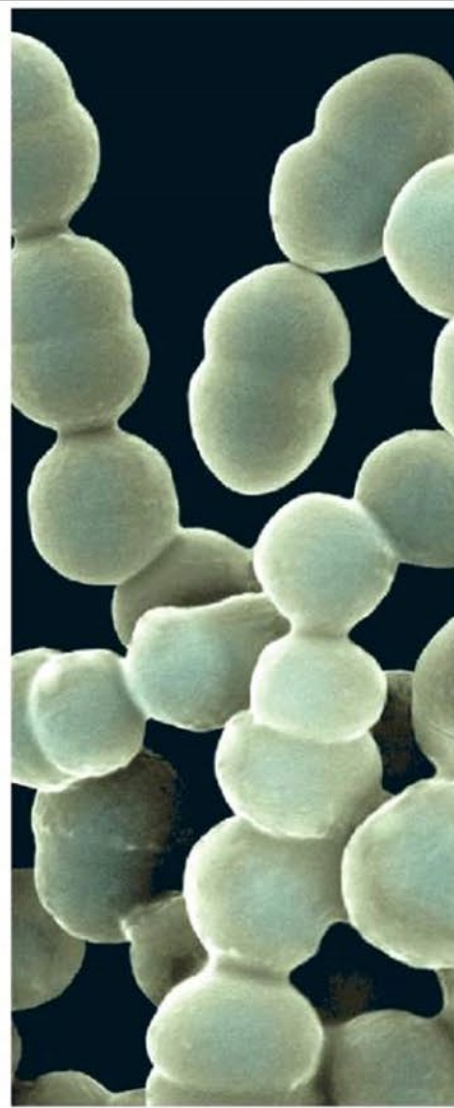


Photo: Dr. Vincent A. Fischetti, Laboratory of Bacterial Pathogenesis and Immunology, Rockefeller University, Courtesy of NOAA

# Prokaryotic Cell Shapes



1  $\mu\text{m}$

**(a) Spherical (cocci)**



2  $\mu\text{m}$

**(b) Rod-shaped (bacilli)**

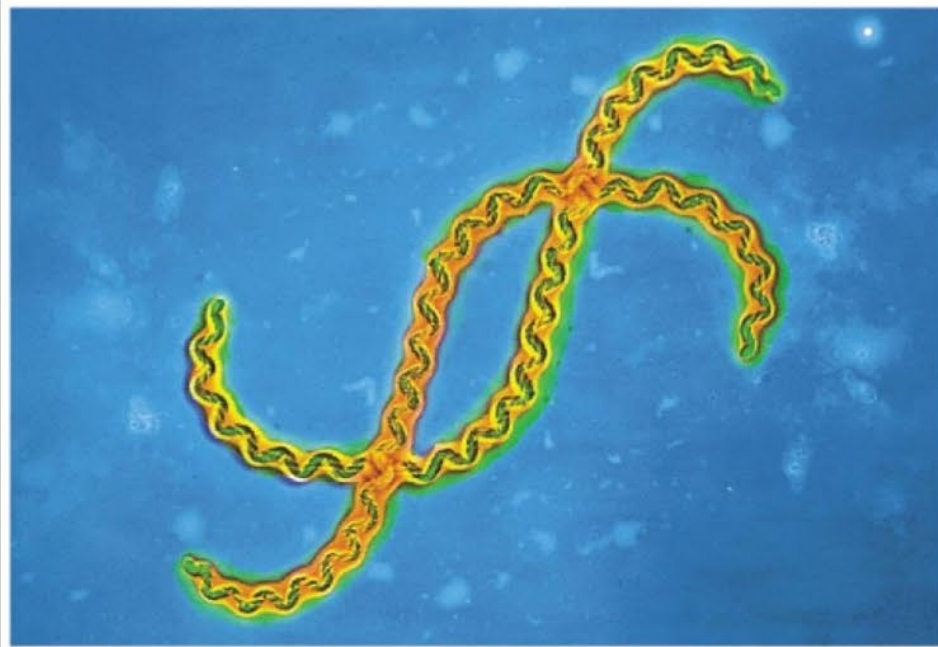


5  $\mu\text{m}$

**(c) Spiral**

# Prokaryotic Nutrition

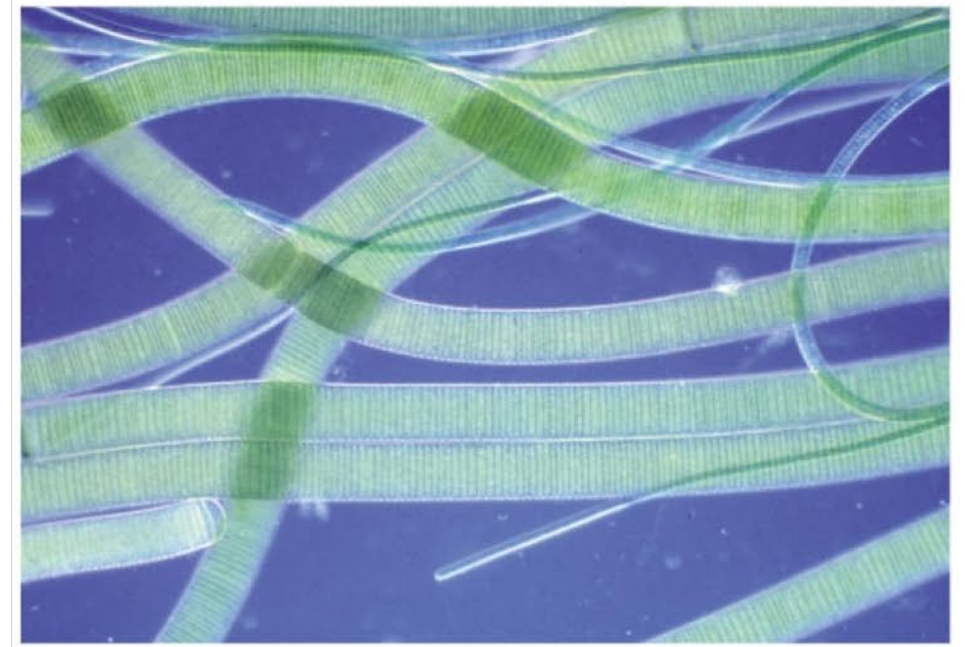
- Heterotrophs
- Autotrophs



5  $\mu\text{m}$

***Leptospira*, a spirochete  
(colorized TEM)**

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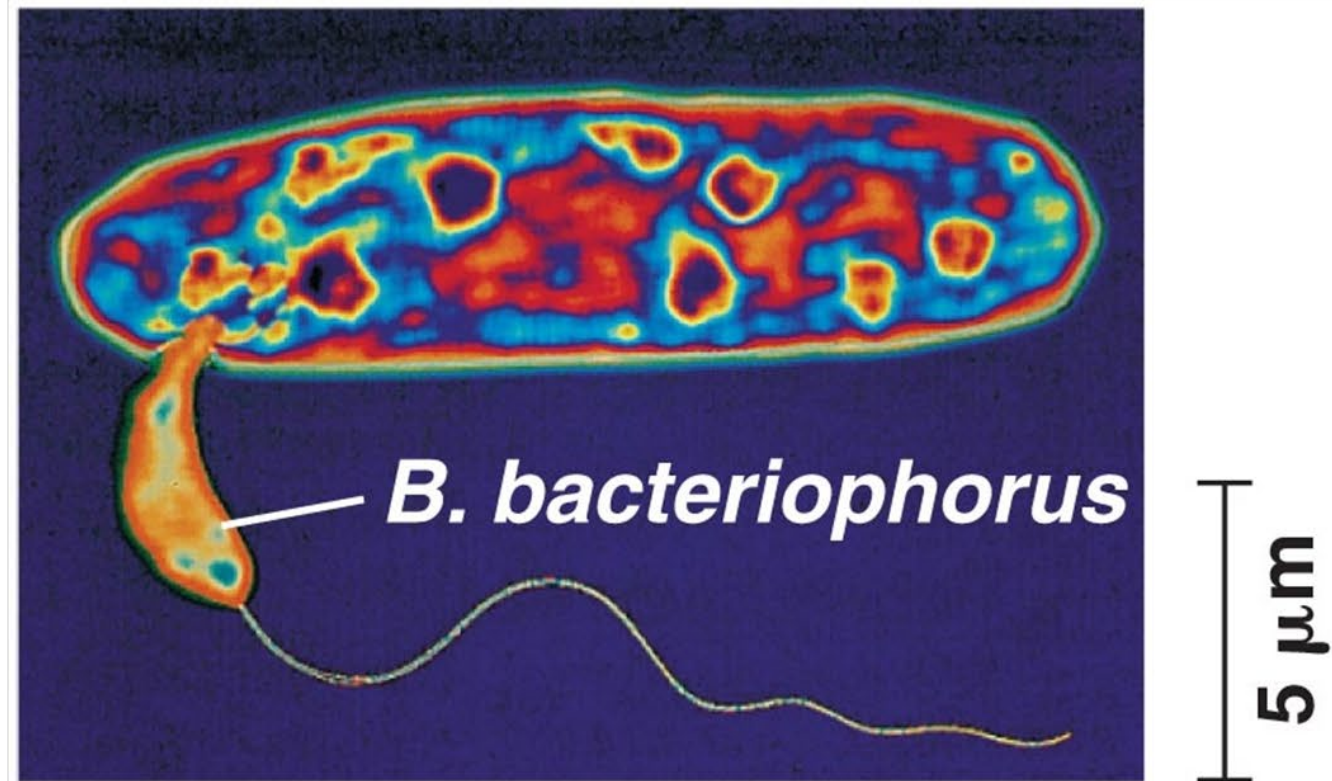
50  $\mu\text{m}$

**Two species of *Oscillatoria*,  
filamentous cyanobacteria (LM)**

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# Heterotrophs

- Energy from:
  - Organic matter
    - Chemoheterotroph
  - Light
    - Photoheterotroph



***Bdellovibrio bacteriophorus*  
attacking a larger bacterium  
(colorized TEM)**

# Autotrophs

- Energy from:
  - Inorganic matter
    - Chemoautotroph
  - Light
    - Photoautotroph



***Nitrosomonas* (colorized TEM)**



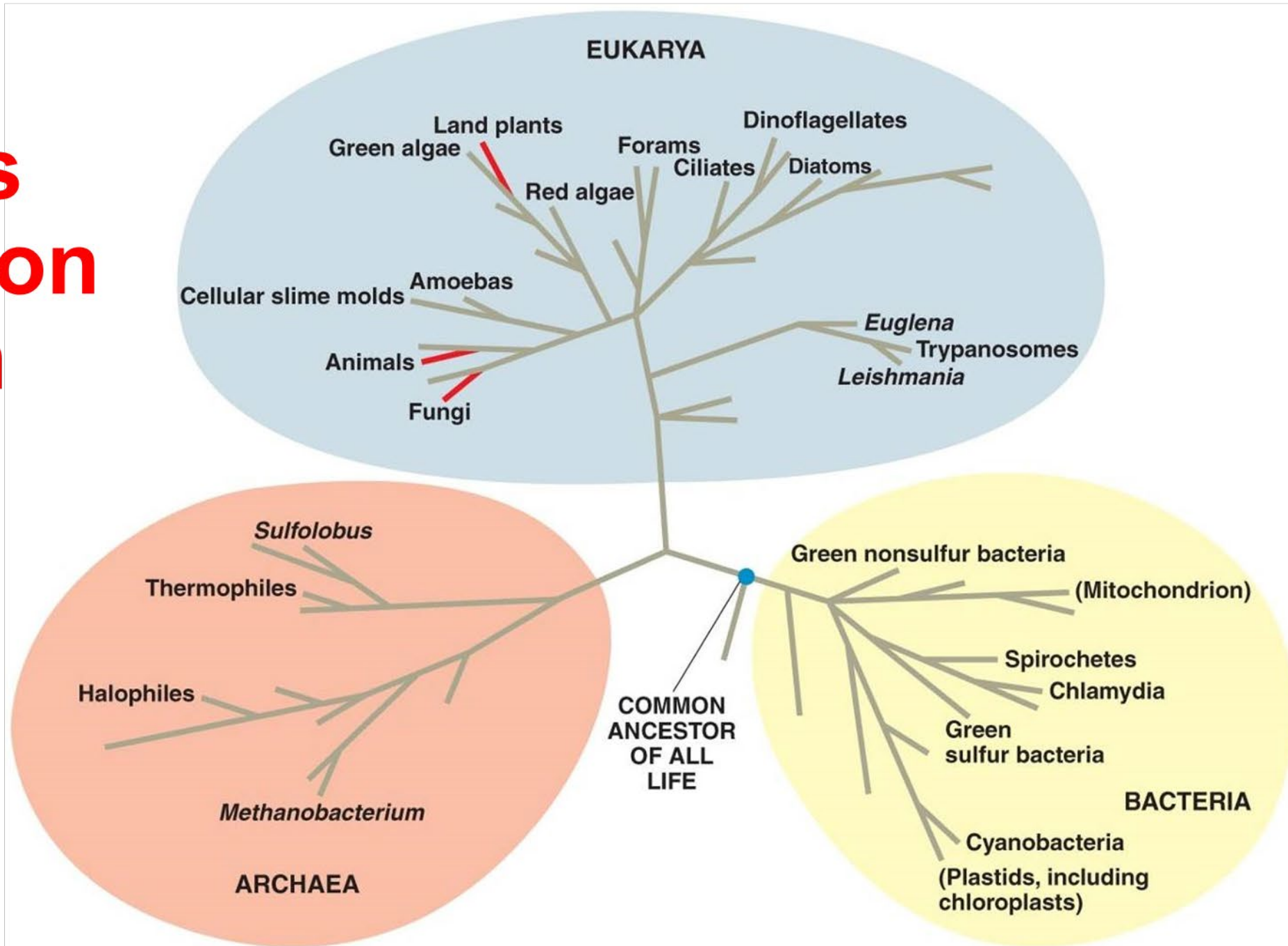
# Photoautotrophs

- Photoautotrophs can be:
  - Non-oxygenic
  - Oxygenic



Photo: Cyanobacteria that uses oxygenic photosynthesis

# Domain Archaea is Sister Taxon to Domain Eukarya



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