Chapter 16

The Origin and Evolution of Microbial Life: Prokaryotes and Protists

PowerPoint Lectures for

Biology: Concepts & Connections, Sixth Edition

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Lecture by Dr. Prince

How Ancient Bacteria Changed the World

- Prokaryotes were, and are, the inovators of almost all metabolic pathways on Earth even before the evolution of eukaryotes.
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The incredible number of prokaryotes were able to changed the atmosphere and rocks of the Earth with the products of their metabolism.

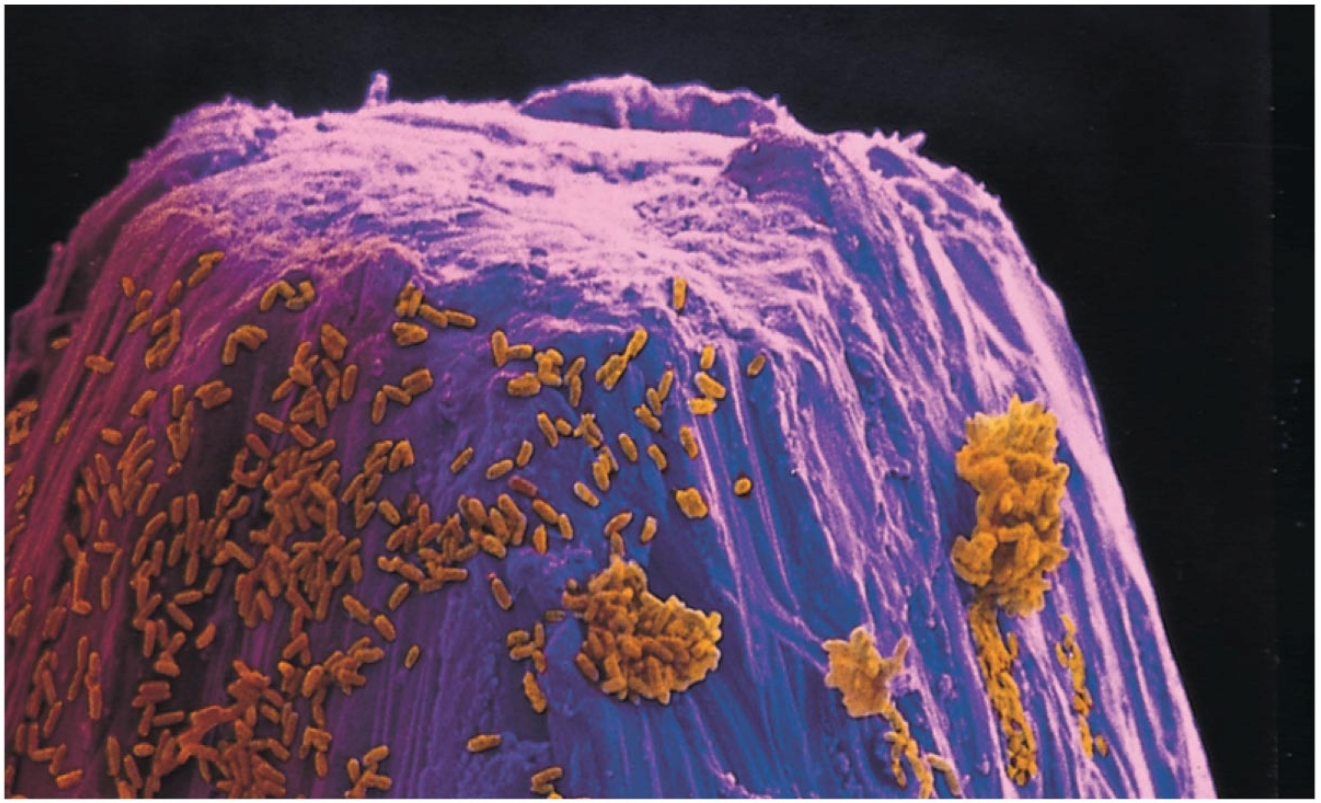
3 billion year old photosynthetic cyanobacteria in stomatolites are responsible for Earth's aerobic atmosphere.

PROKARYOTES

PROKARYOTES

- Prokaryotes were the first living things and remained the only living things for over 1 billion years
- Their time on Earth helped them become the most numerous and widespread of all living things
- There are more prokaryotes in your large intestine than all the humans that have ever lived!!!

The tip of a pin!!!



Most prokaryotes are 1–5 μm in diameter (vs. 10–100 μm for eukaryotic cells)

Prokaryotes are diverse and widespread

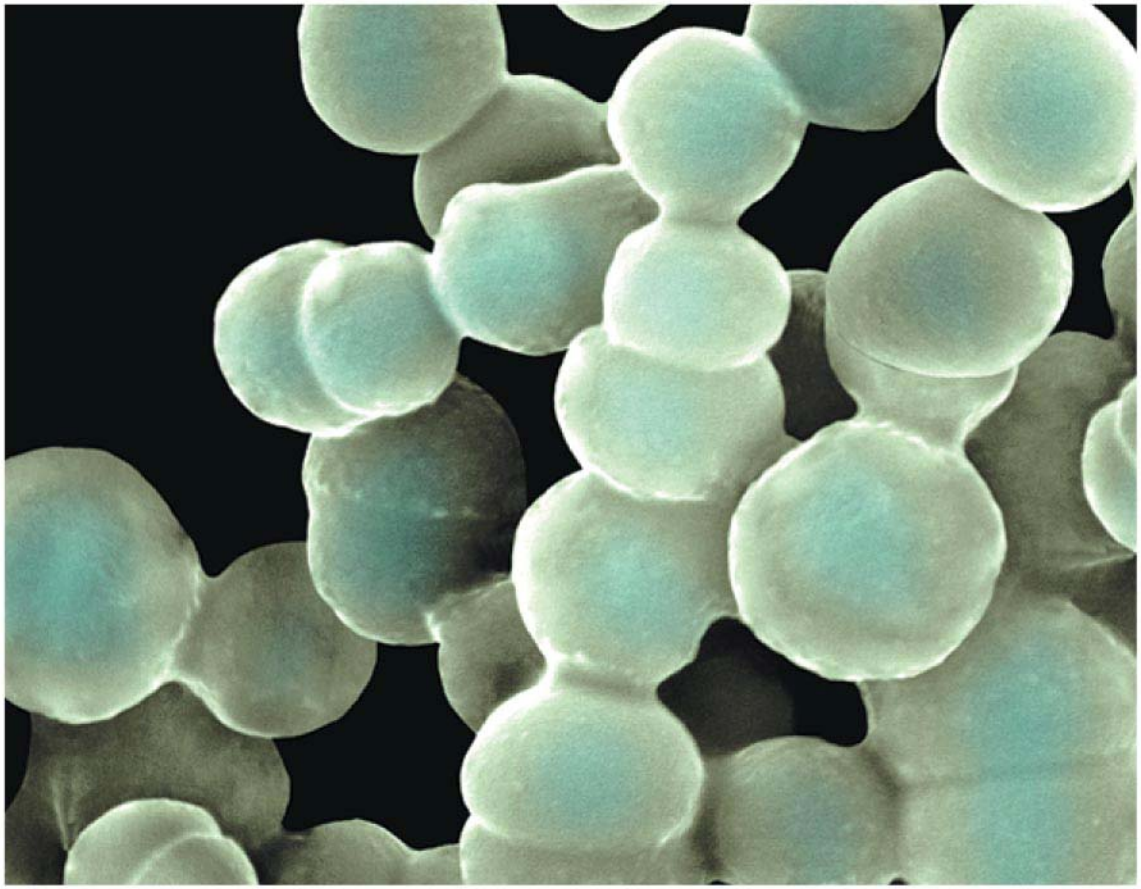
- Prokaryotes live in every environment on the planet, cold, hot, salty, acidic, and/or alkaline. Just think if they can thrive in your colon most other places are cake!!!
- Yes, some bacteria are **pathogenic** and cause disease but most bacteria are beneficial and even essential to all other living things.

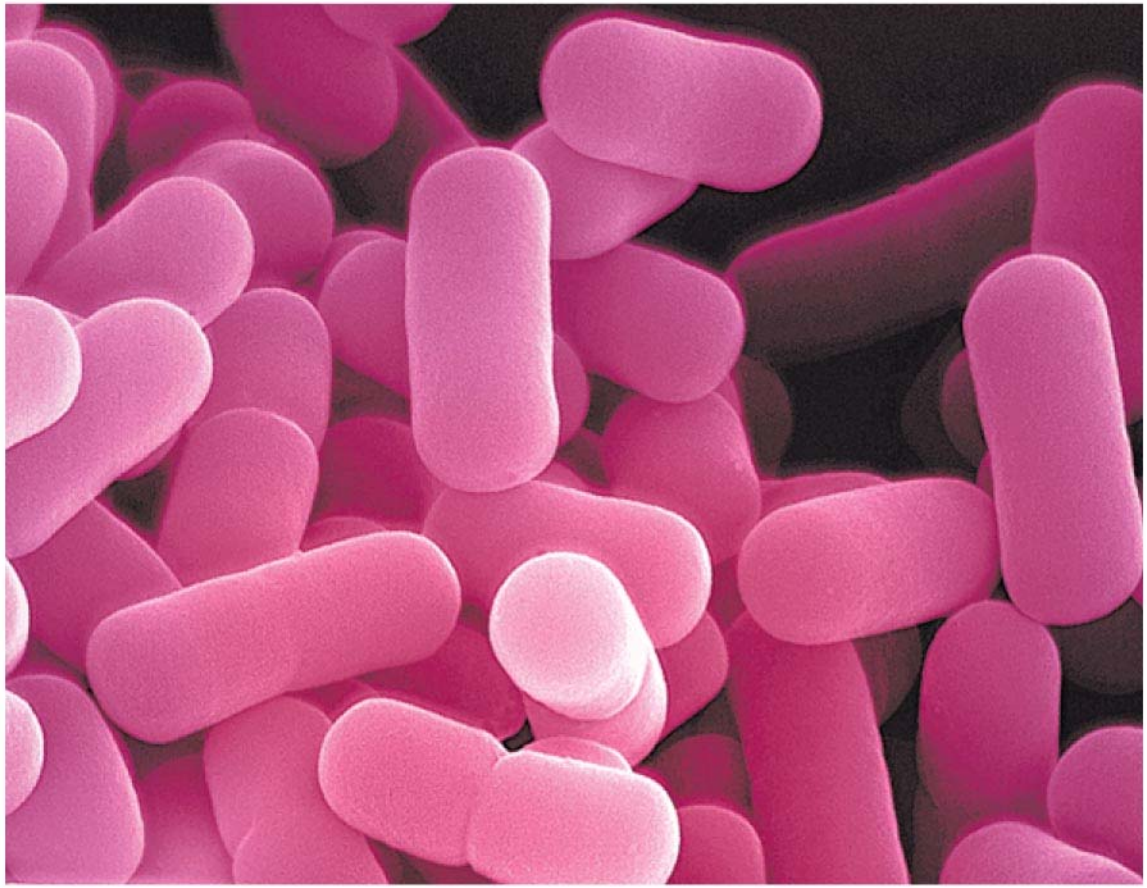
Bacteria and Archaea

The prokaryotic domains, **Bacteriaea** & **Archaea** diverged from a common ancestor soon after life on Earth arose.

TABLE 16.2 DIFFERENCES AMONG THE DOMAINS BACTERIA, ARCHAEA, AND EUKARYA

Characteristic	Bacteria	Archaea	Eukarya
rRNA sequences	Some unique to bacteria	Some unique to archaea; some match eukaryotic sequences	Some unique to eukarya; some match archaea sequences
RNA polymerase	One kind; relatively small and simple	Several kinds; complex	Several kinds; complex
Introns	Rare	In some genes	Present
Response to antibiotics streptomycin and chloram-phenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Peptidoglycan in cell wall	Present	Absent	Absent
Histones associated with DNA	Absent	Present in some species	Present





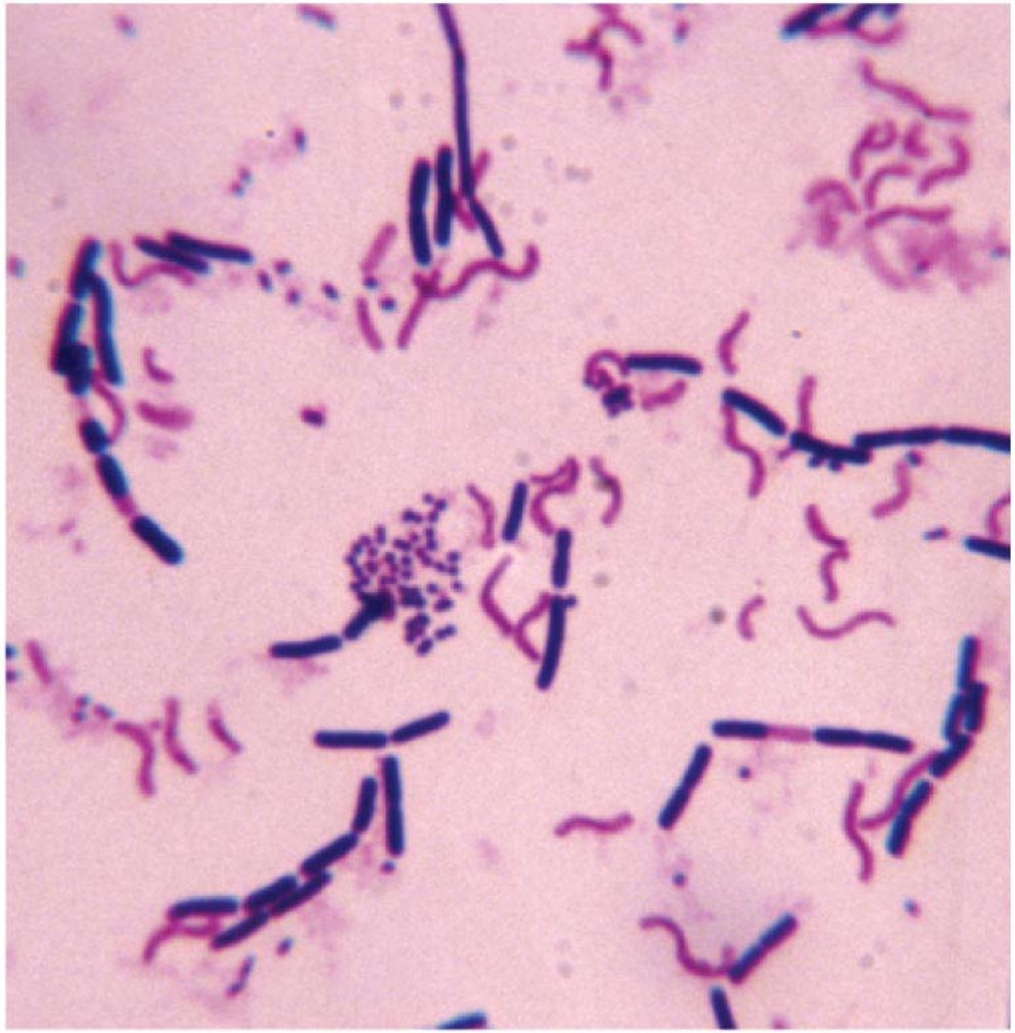
Structural features for success

- Prokaryotic **cell walls**
- maintain cell shape
- provide physical protection
- prevent the cell from bursting in a hypotonic environment

Bacterial cell walls can be distinguished with gram stain

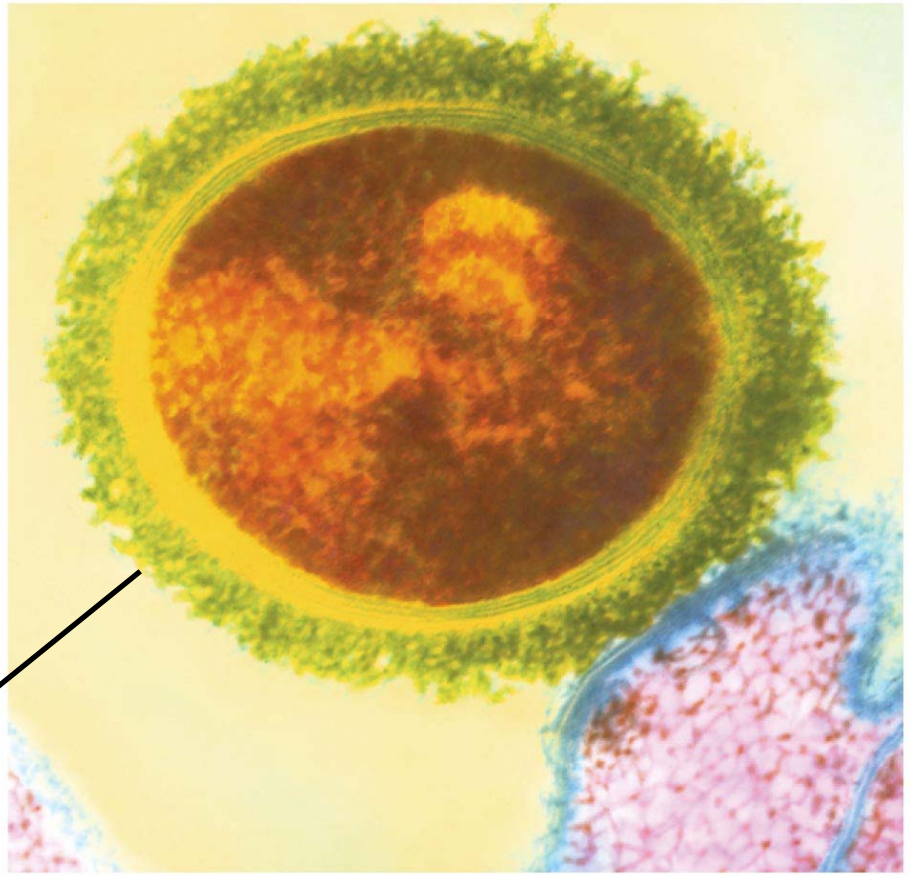
Gram-positive bacteria have simple walls with a thick layer of peptidoglycan

Gram-negative bacteria have complex walls with less peptidoglycan and an outer membrane of lipids bonded to carbohydrates



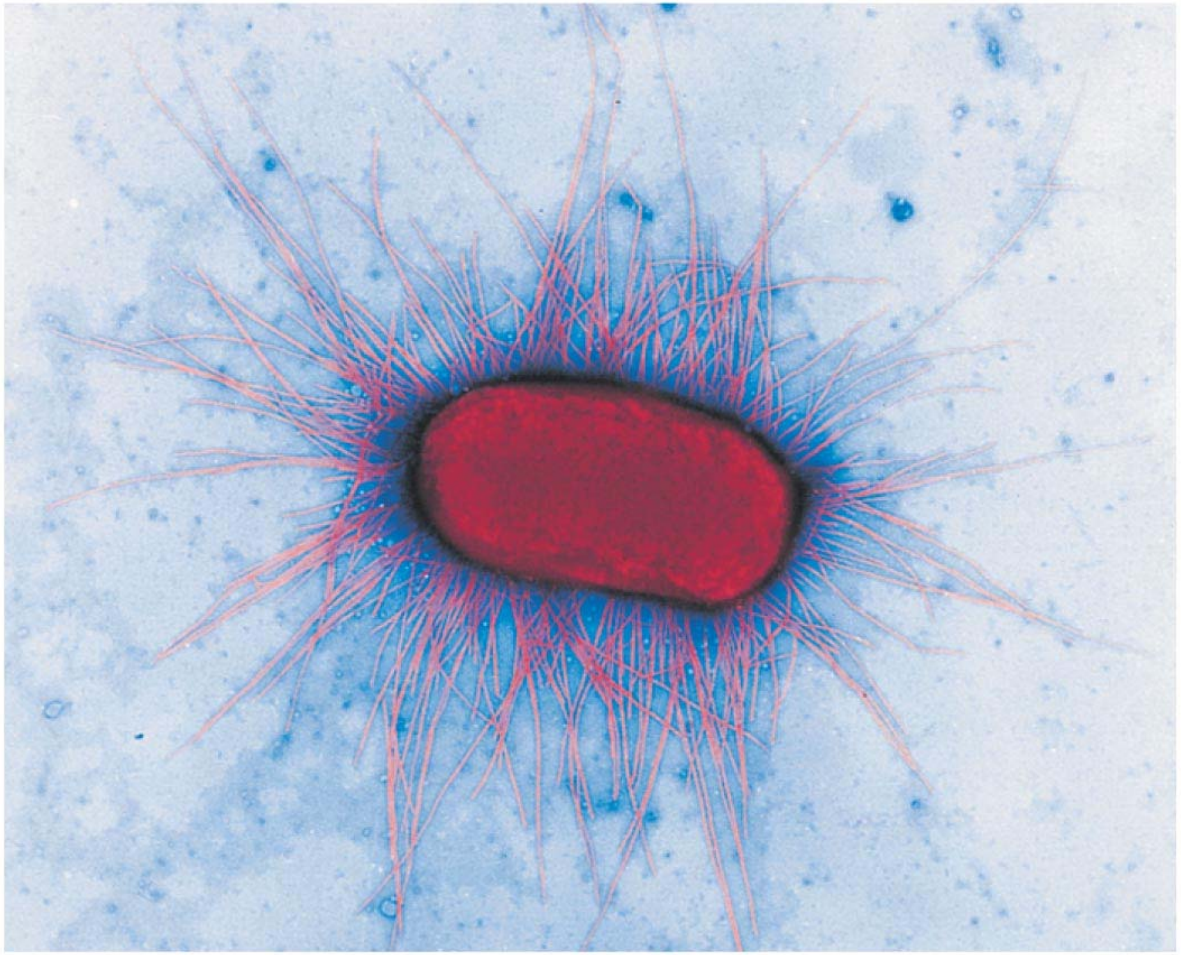
Bacterial cell walls can be distinguished with gram stain

Gram-negative bacteria have complex walls with less peptidoglycan and an outer membrane of lipids bonded to carbohydrates



Structural features for success

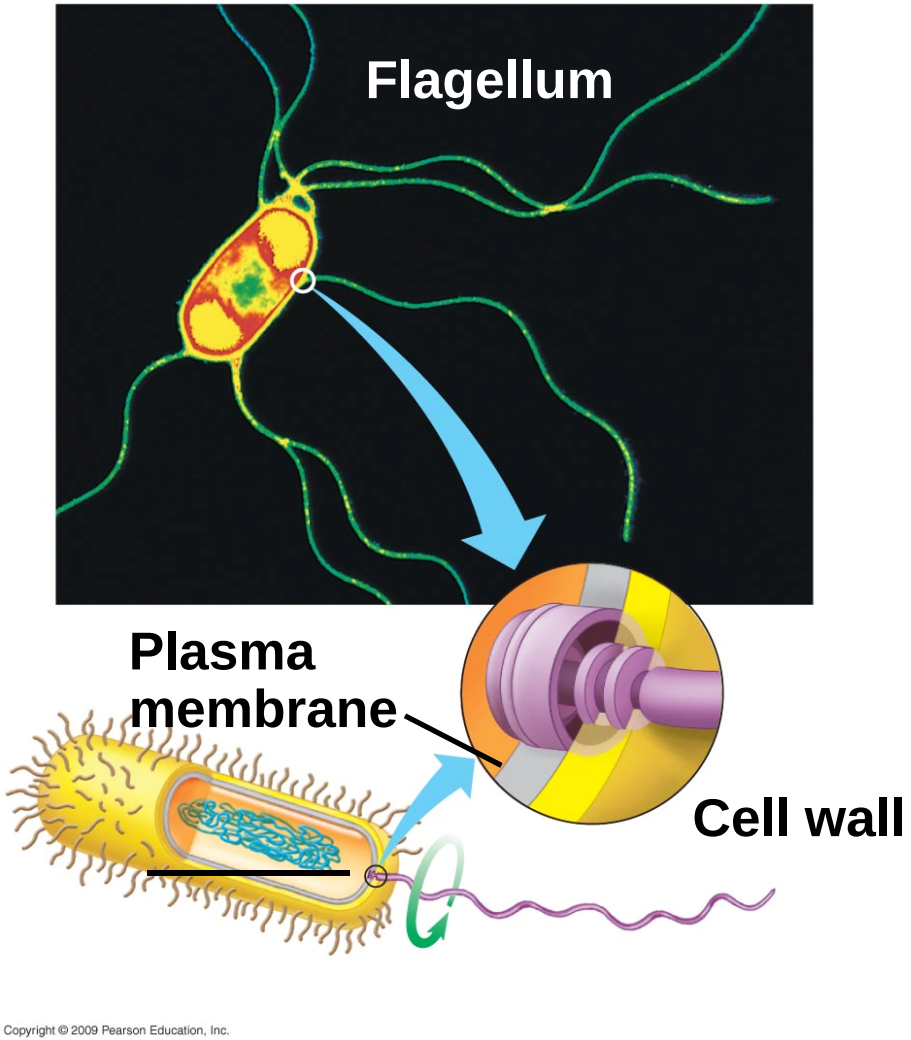
- Some prokaryotes stick to the substrate or each other with hair-like appendages called **pili**
- Sex pili join prokaryotes during conjugation



Structural features for success

The **flagella** of Bacteria allow them to move in response to their environment

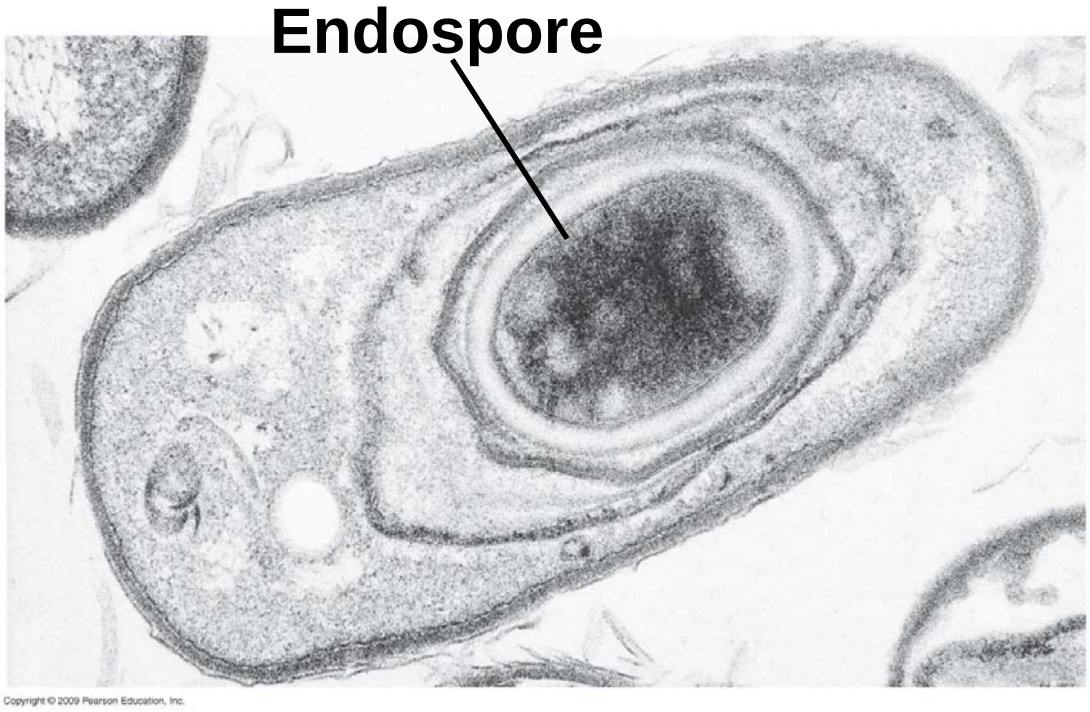
The flagellum is a naked protein without microtubules and rotates like a propeller



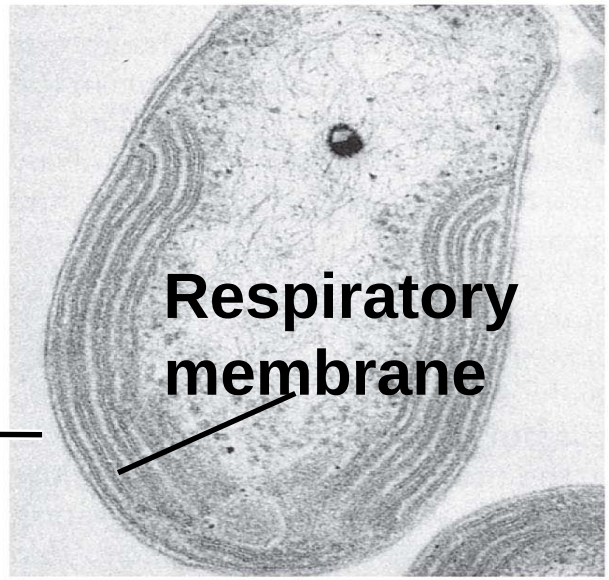
Rotary movement of each flagellum

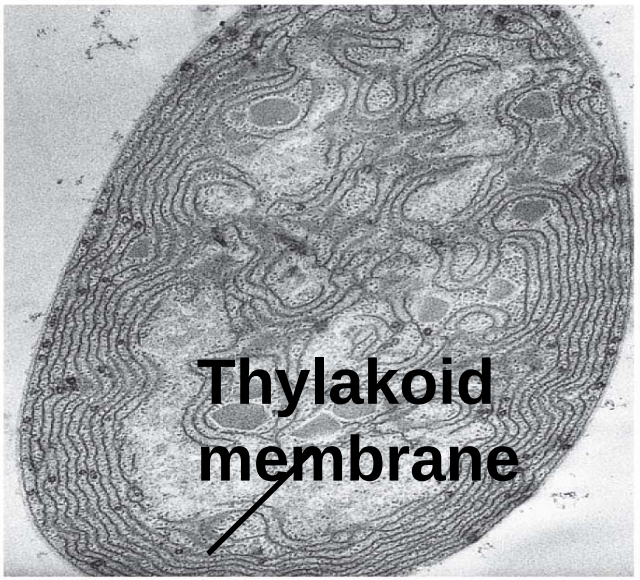
Structural features for success

Some prokaryotes can withstand harsh conditions by forming **endospores** (thick protective coat) within an outer cell for as long as needed even centuries.



Structural features for success





Aerobic prokaryotes carry out cellular respiration on infoldings of the plasma membrane

Cyanobacteria carry out photosynthesis on infolded thylakoid membranes

Structural features for success

Prokaryotic DNA forms a circular chromosome and plasmids that can be used to transfer things such as antibiotic resistance

Structural features for success

- **Biofilms** are colonies of prokaryotes. Some cause ear infections, others urinary tract infections, and dental plaque.

Archaea thrive in extreme environments

Archaea are among the most abundant cells on Earth and are a major life-form in the oceans

Bacteria are a diverse assemblage of prokaryotes

Clades of **gram-negative** bacteria

Alpha proteobacteria

- *Rhizobium* species live in legume nodules and fix atmospheric N_2

Photosynthetic gamma proteobacteria

Delta proteobacteria

- Myxobacteria form elaborate colonies and congregate into fruiting bodies that release resistant spores

Chlamydias live inside eukaryotic host cells

- Chlamydias cause blindness and sexually transmitted disease

Spirochetes are helical bacteria

- Spirochetes cause syphilis and Lyme disease

Bacteria are a diverse assemblage of prokaryotes

Clades of **gram-positive** bacteria

Actinomycetes are common soil bacteria that decompose organic matter

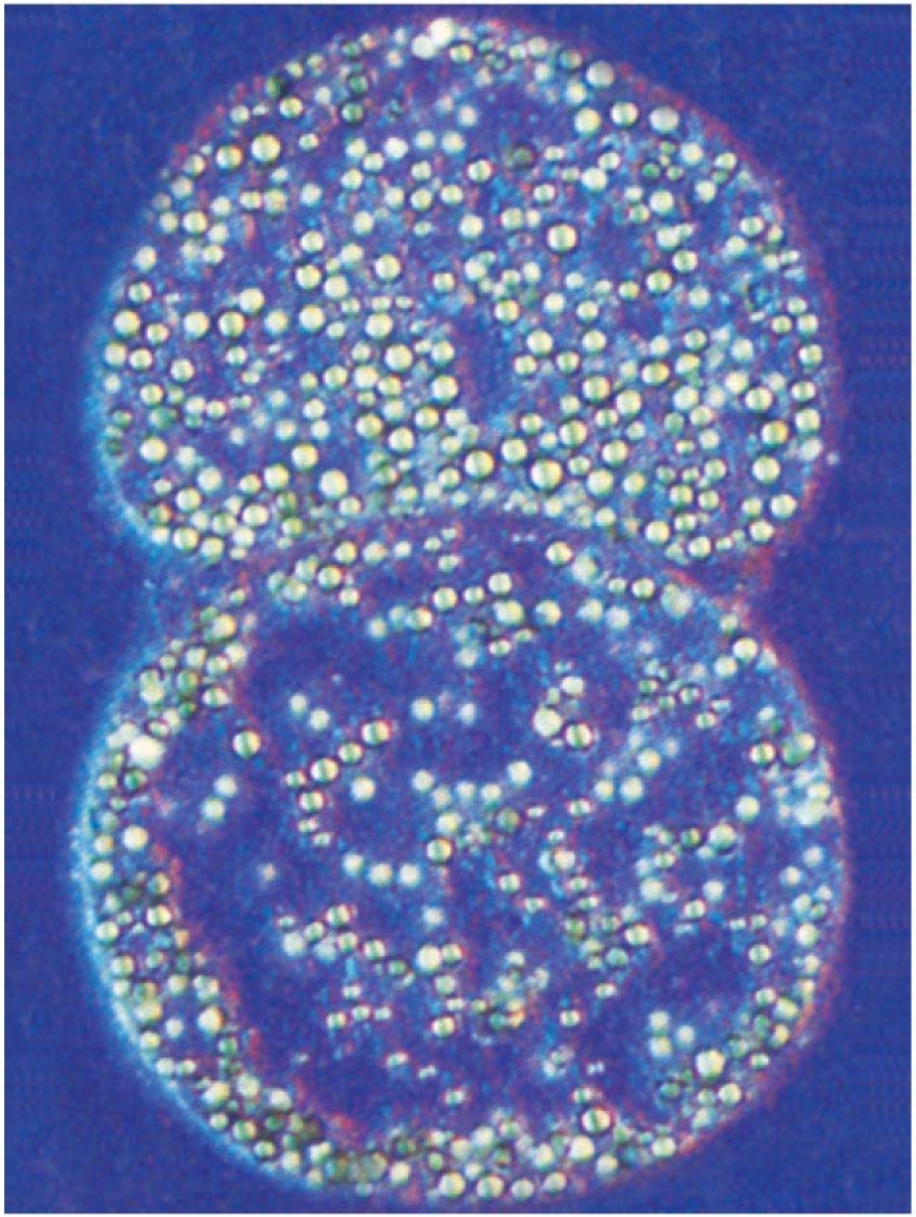
- *Streptomyces* is a source of many antibiotics

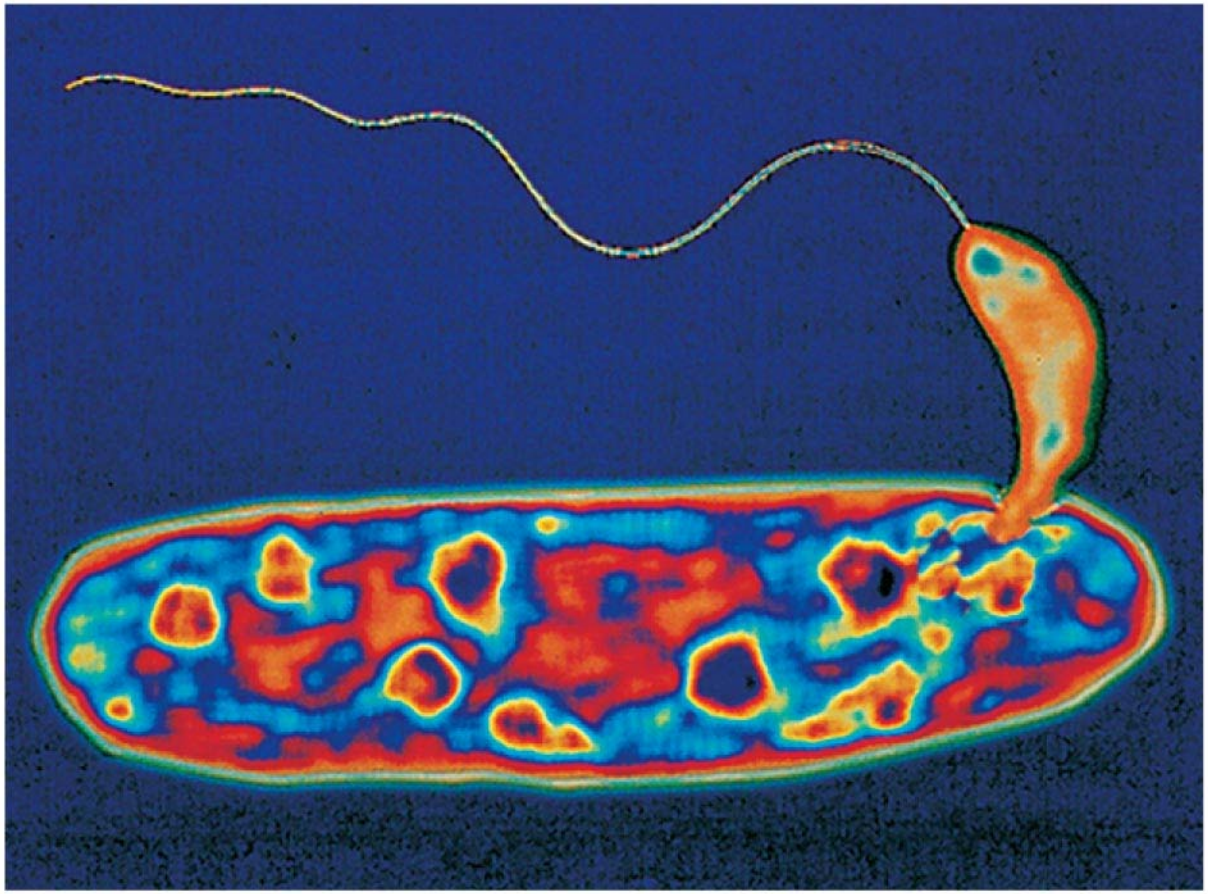
Mycoplasmas lack cell walls

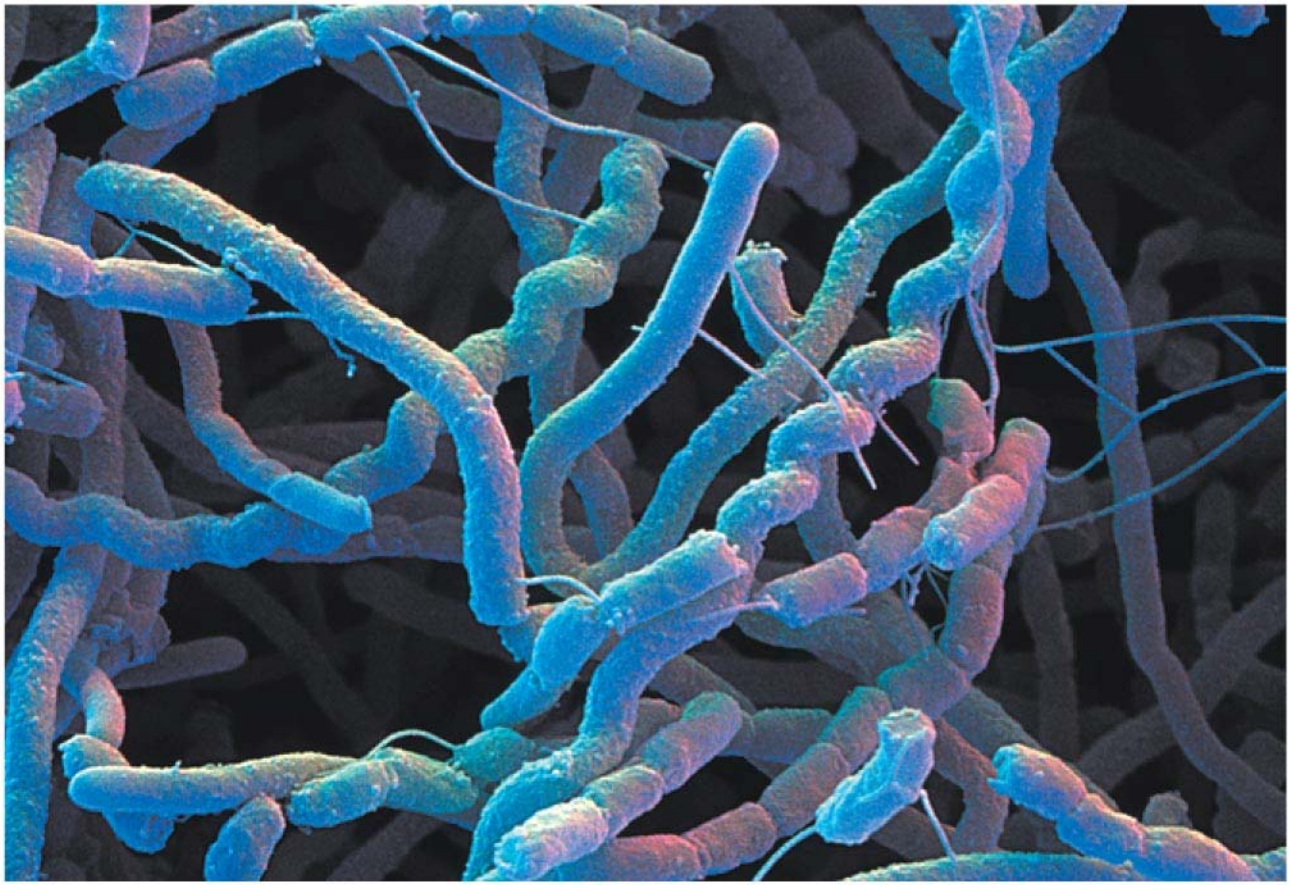
- They are the tiniest of all known cells, with diameters as small as 0.1 μm (about 5 times the size of a ribosome)

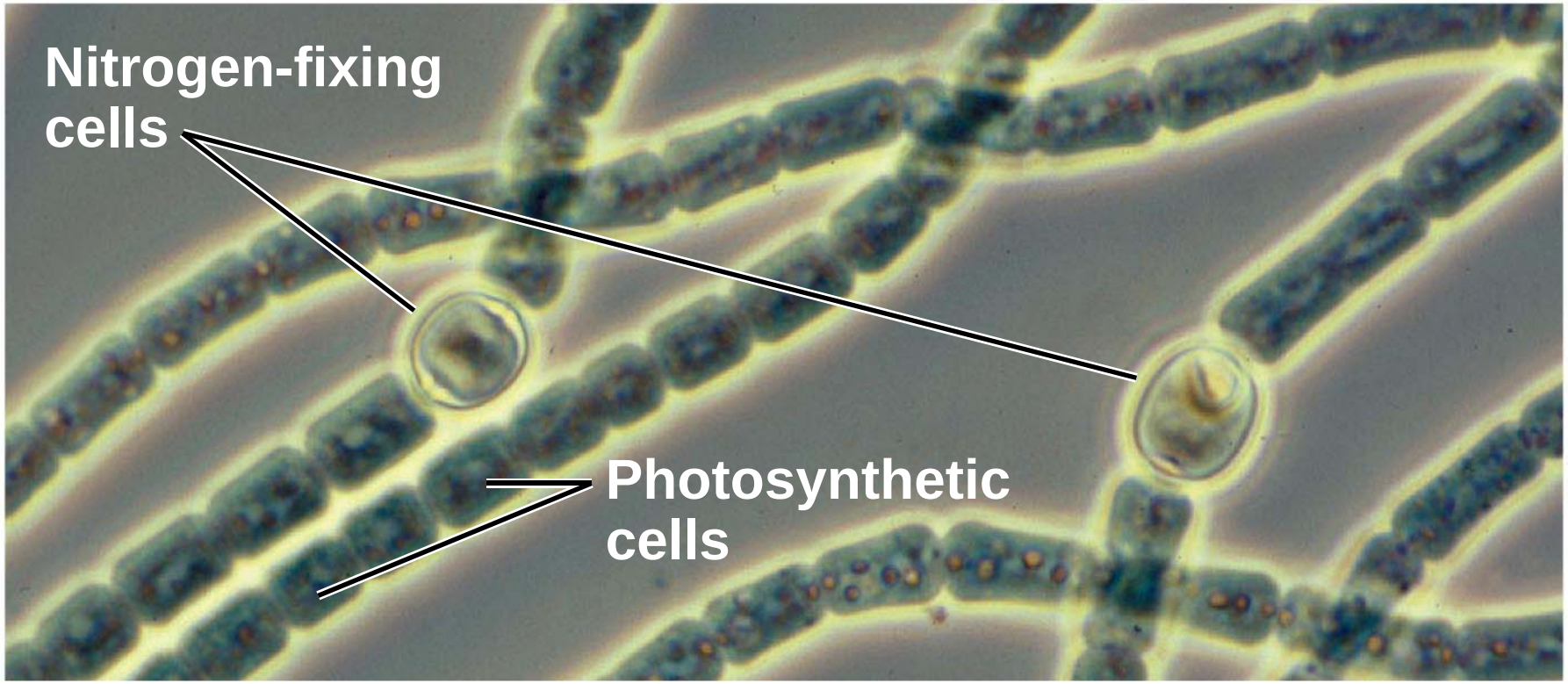
Cyanobacteria carry out oxygen-generating photosynthesis

- Ancient cyanobacteria formed stromatolites that made the atmosphere aerobic



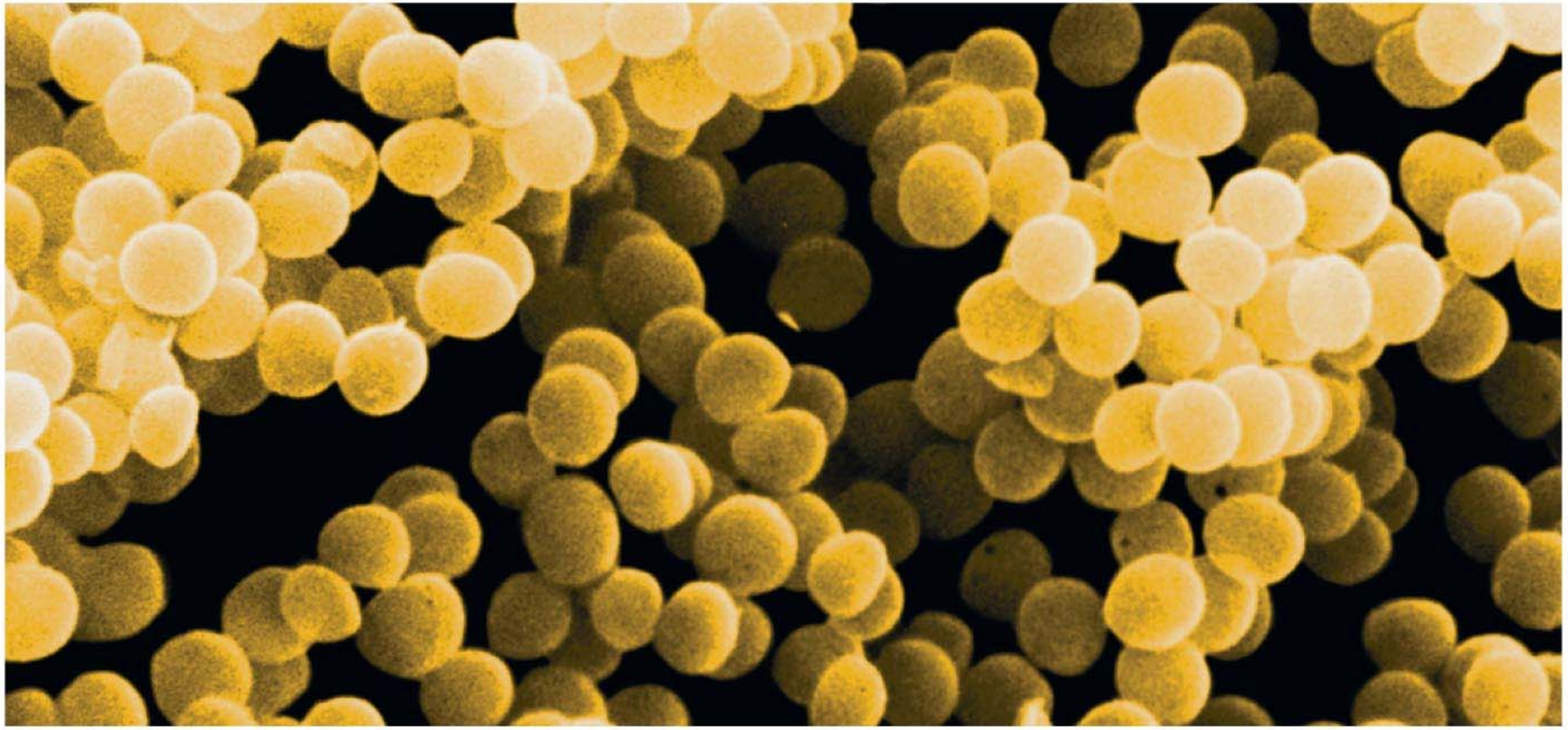






Some bacteria cause disease

- Pathogenic bacteria cause disease by producing poisonous exotoxins or endotoxins
  - **Exotoxins** are proteins secreted by bacterial cells
  - Some of the most powerful toxins known are exotoxins, including the toxin that causes lockjaw
  - *Staphylococcus aureus* produces several exotoxins, including one that causes deadly toxic shock syndrome



Some bacteria cause disease

- **Endotoxins** are components of the outer membrane of gram-negative bacteria, released when the cell dies or is digested by a defensive cell
  - Endotoxins produce septic shock, bacterial meningitis, and food poisoning
  - The most widespread pest-carried disease in the United States is Lyme disease, caused by the spirochaete *Borrelia burgdorferi*

Spirochete that causes Lyme disease

Tick that carries the Lyme disease bacterium

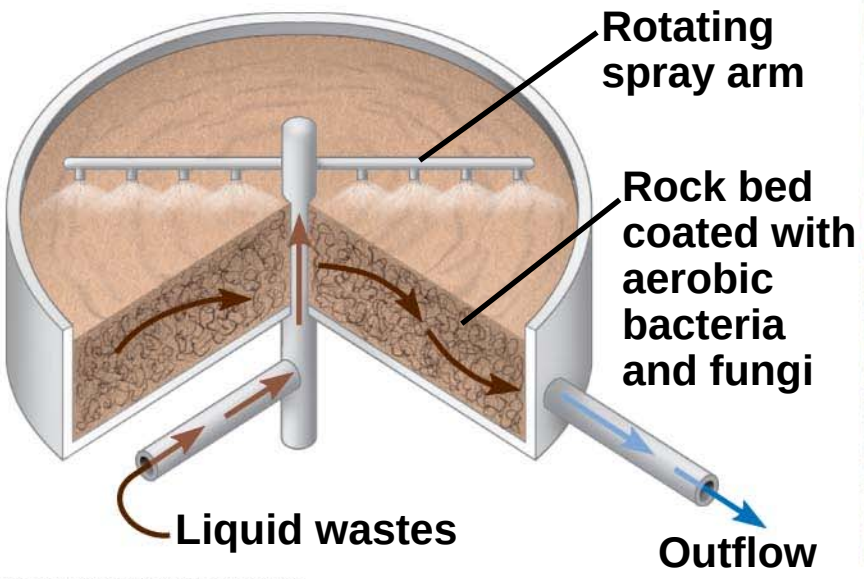
“Bull’s-eye” rash

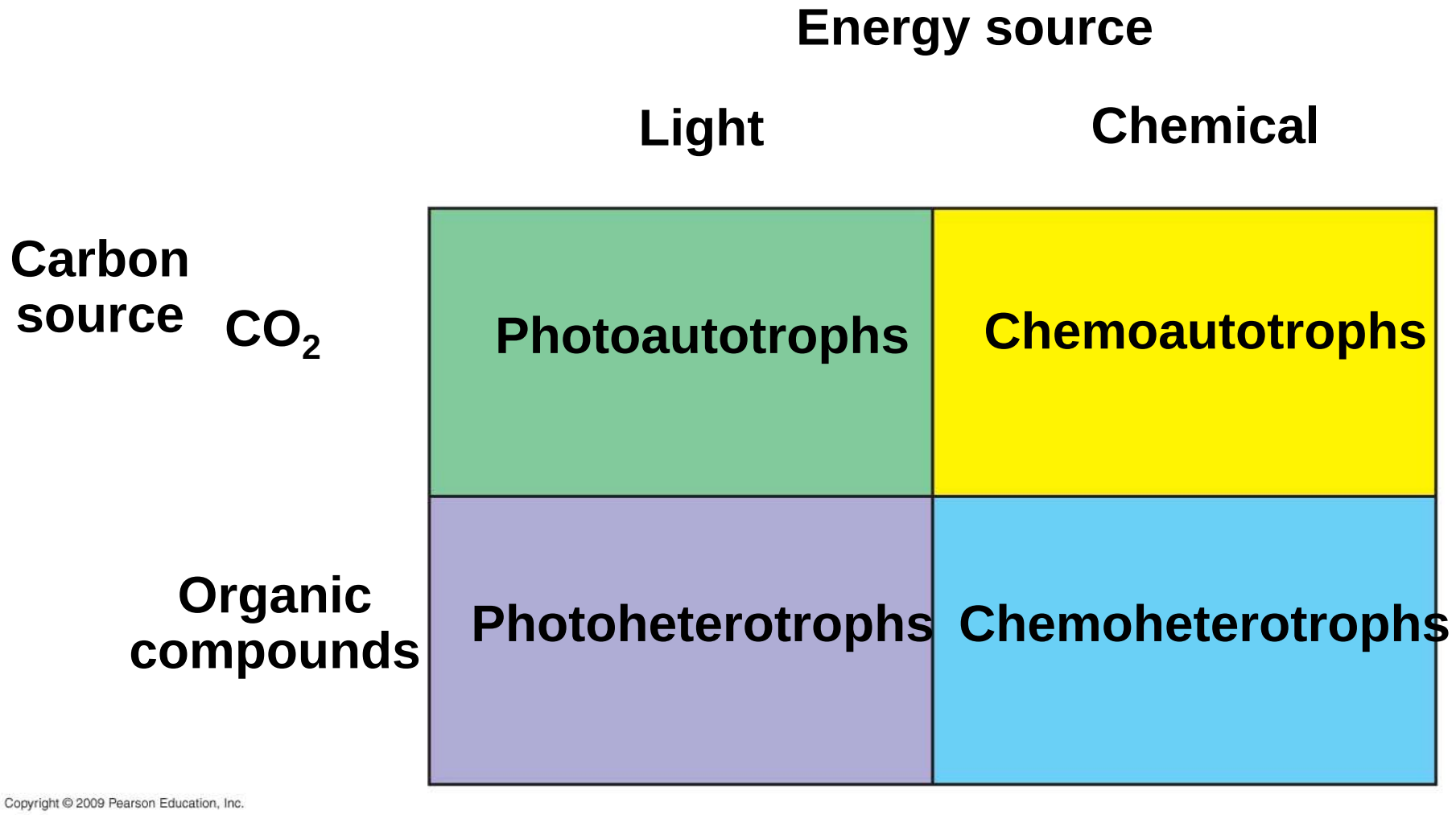
Bacteria can be used as biological weapons

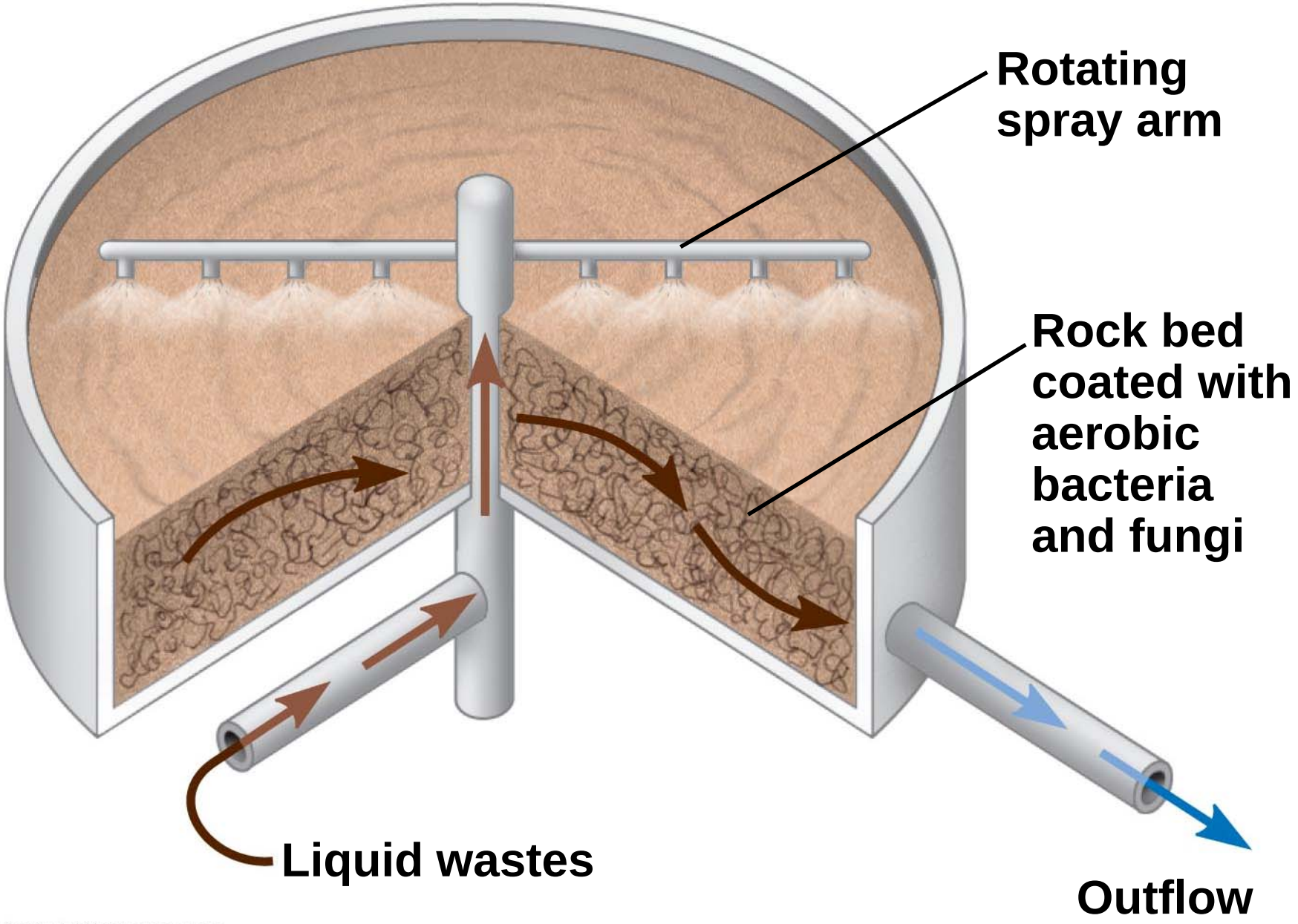
- The bacterium that causes anthrax can be used as biological weapons
  - *Bacillus anthracis* forms hardy endospores
  - Weaponizing anthrax involves manufacturing endospores that disperse easily in air, where they are inhaled and germinate in the lungs
- The Biological Weapons Convention has been signed by 103 nations, who have pledged never to develop or store biological weapons

Prokaryotes help recycle chemicals and clean up the environment

- Prokaryotes are key participants in chemical cycles, making nitrogen available to plants and thus animals
- They also decompose organic wastes and dead organisms to inorganic chemicals
- **Bioremediation** is the use of organisms to remove pollutants from soil, air, or water
  - Prokaryotes are decomposers in sewage treatment and can clean up oil spills and toxic mine wastes







Tick that carries the Lyme disease bacterium