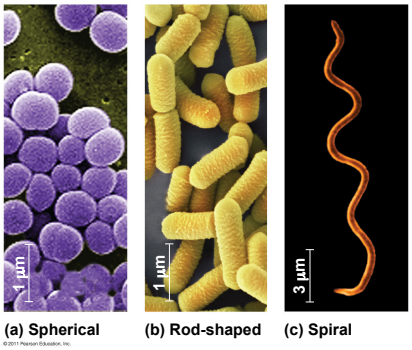
CHAPTER 27: BACTERIA AND ARCHAEA

AP Biology 2013

1

UBIQUITOUS

- Most likely they were Earth's first organisms
- Most are microscopic and unicellular although some species form colonies
- Number of prokaryotes in a single handful of soil is greater than the number of people who have ever lived
- Thrive almost everywhere including places too acidic, too salty, too cold, or too hot for other organisms
- Huge amount of genetic diversity
- Prokaryotes have a variety of shapes (most common are cocci, bacilli, and spirillum)



Fig, 27.2

2

SURFACE STRUCTURES

- Cell wall (made of cellulose and or chitin) that maintains shape, provides protection, and prevents bursting in a hypotonic environment
  - Contain peptidoglycan (network of cross-linked sugar polymers)
  - Archaea do not have peptidoglycan
- Can be classified into two groups based on cell wall composition with a processes called Gram staining
  - Gram-positive - have simpler walls with large amounts of peptidoglycan
  - Gram-negative - have less peptidoglycan and an outer membrane that can be toxic

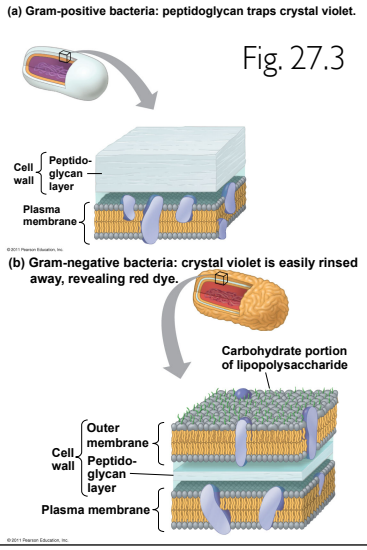
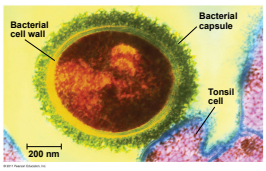


Fig. 27.3

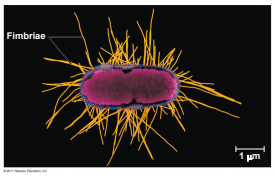
3

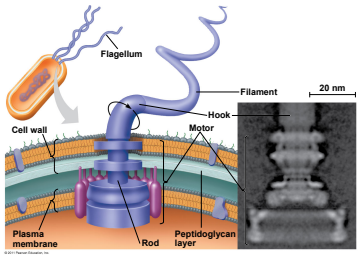
SURFACE STRUCTURES

- Cell wall is covered by a capsule of sticky polysaccharide or protein in many prokaryotes
- Some have fimbriae and pili which allow them to stick to their substrate or other individuals
- Most motile bacteria propel themselves by flagella (they are structurally and functionally different from eukaryotic flagella)



Figs. 27.4-27.6





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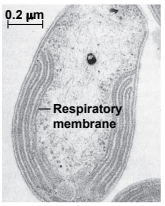
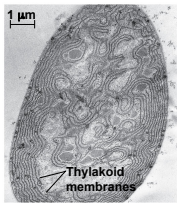
OTHER PROKARYOTE INFORMATION

- Exhibit taxis
- Lack compartmentalization
- Some have specialized membranes for metabolic functions
- Genome - DNA not surrounded by a membrane (nucleoid region)
  - Small circular DNA called plasmids
- Reproduce quickly by binary fission
- Can form endospores which remain viable in harsh conditions (possibly for centuries)

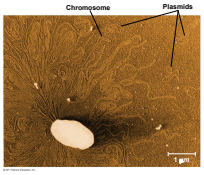




(a) Aerobic prokaryote (b) Photosynthetic prokaryote

Fig. 27.7

Fig. 27.8



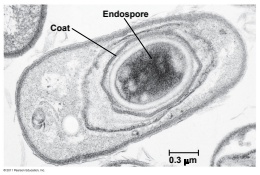


Fig. 27.9

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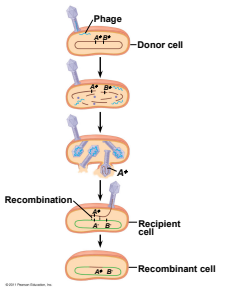
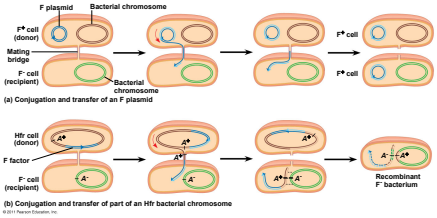
PROKARYOTE GENETIC DIVERSITY

- Factors that influence this are rapid reproduction, mutation, and genetic recombination
- Genetic recombination (DNA From at least two sources) via transformation (uptake from environment), transduction (mediated by bacteriophages), and conjugation (one-way transfer through a sex pilus)
  - Movement of genes from different species is called horizontal gene transfer



Figs. 27.11-27.13



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NUTRITION AND METABOLISM

Table 27.1 Major Nutritional Modes

Mode	Energy Source	Carbon Source	Types of Organisms
AUTOTROPH			
Photoautotroph	Light	CO_2, HCO_3^-, or related compound	Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (for example, algae)
Chemoautotroph	Inorganic chemicals (such as H_2S, NH_3, or Fe^{2+})	CO_2, HCO_3^-, or related compound	Unique to certain prokaryotes (for example, *Sulfolobus*)
HETEROTROPH			
Photoheterotroph	Light	Organic compounds	Unique to certain aquatic and salt-loving prokaryotes (for example, *Rhodobacter*, *Chloroflexus*)
Chemoheterotroph	Organic compounds	Organic compounds	Many prokaryotes (for example, *Clostridium*) and protists; fungi; animals; some plants

- Metabolism varies with respect to oxygen
  - Obligate aerobes - require oxygen
  - Facultative anaerobes - can survive with or without oxygen
  - Obligate anaerobes - poisoned by oxygen
- Can metabolize nitrogen in a process called nitrogen fixation (convert atmospheric nitrogen to ammonia)

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COOPERATION BETWEEN PROKARYOTES

- Allows for use of environmental resources they could not use individually
- Cyanobacterium *Anabaena* are photosynthetic cells and nitrogen-fixing cells exchange metabolic products
- Cooperation can also occur in surface coating colonies called biofilms

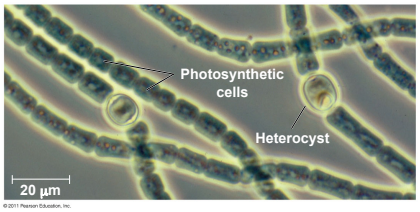

Fig. 27.14

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ARCHAEA

- Archaea share traits with bacteria and eukaryotes
- Some live in extreme environments
  - Thermophiles - hot environments
  - Halophiles - high saline environments
  - Methanogens - found in swamps and marshes and produce methane as a waste product

Fig. 27.16

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BACTERIA

- Diverse nutritional groups
- Largest groups are proteobacteria and Gram-positive bacteria

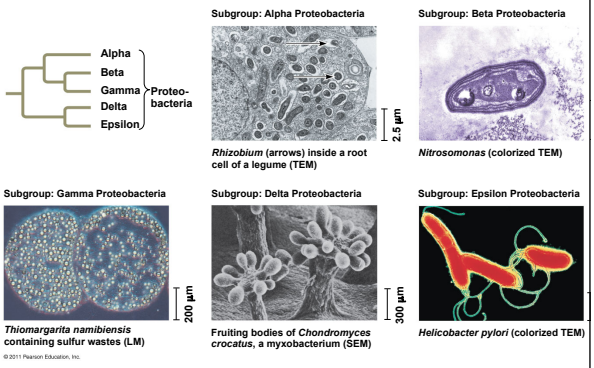

Fig. 27.17

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ROLES OF PROKARYOTES

- Life would not survive without them
- Play a major role in continual recycling of chemical elements between the living and nonliving components of the environment in ecosystems
- Chemoheterotrophic prokaryotes function as decomposers breaking down corpses, dead vegetation, and waste products
- Nitrogen-fixing prokaryotes add usable nitrogen to the environment
- Many prokaryotes live with other organisms in symbiotic relationships such as mutualism and commensalism
- Other types live inside hosts as parasites or pathogens

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IMPACT ON HUMANS

- Mutualistic - aid in digestion
- Pathogens
  - Cause about half of all human diseases (ex. Lyme disease)
  - Cause disease by releasing exotoxins or endotoxins
- Experiments have led to advances in DNA technology
- Used for bioremediation (removing pollutants from the environment)
- Tools in mining, synthesis of vitamins, and production of antibiotics, hormones, and other products

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