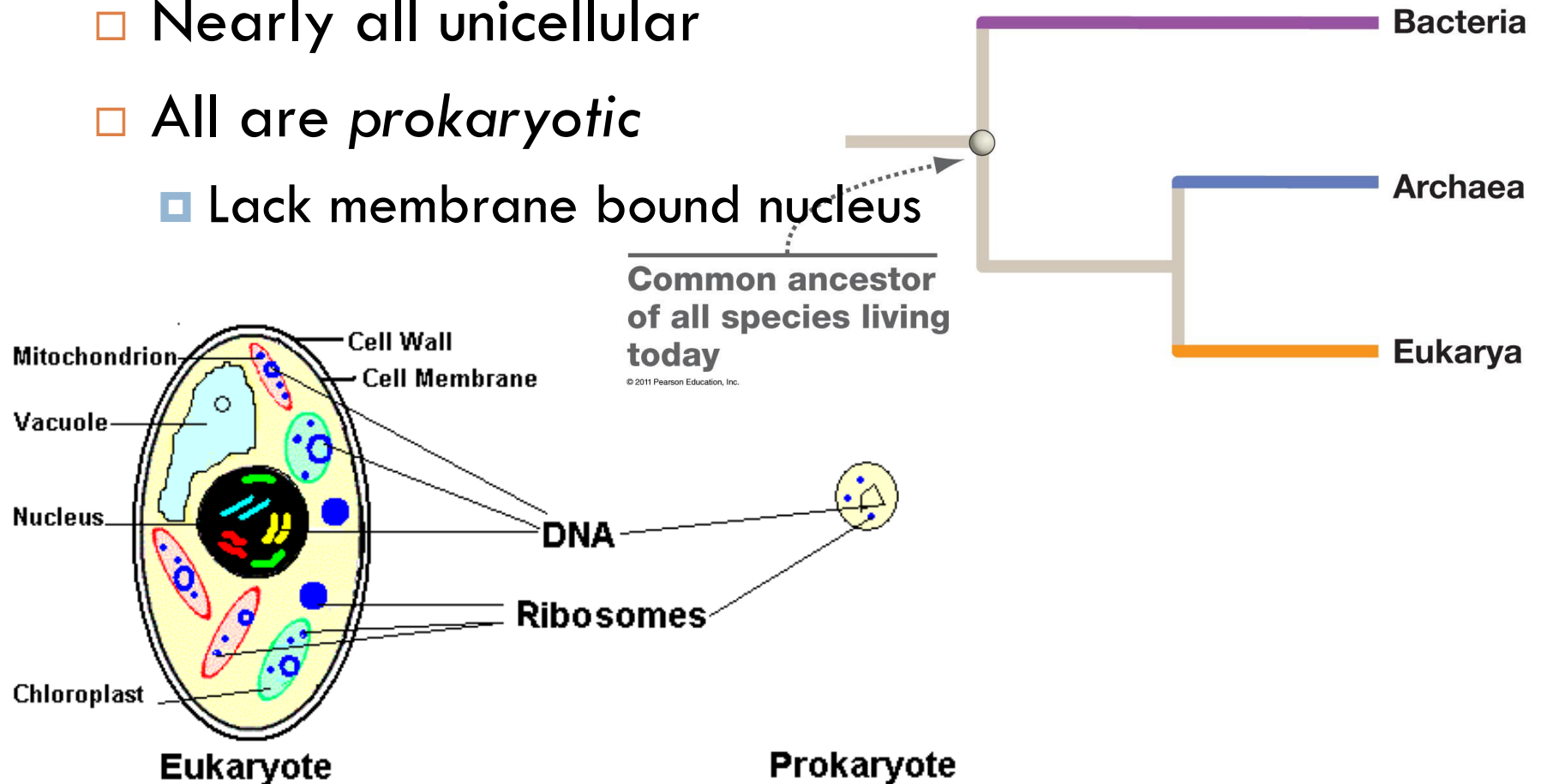


BACTERIA & ARCHAEA

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Bacteria & Archaea: overview

- 2 of 3 major forms of life
- Nearly all unicellular
- All are *prokaryotic*
 - ▣ Lack membrane bound nucleus

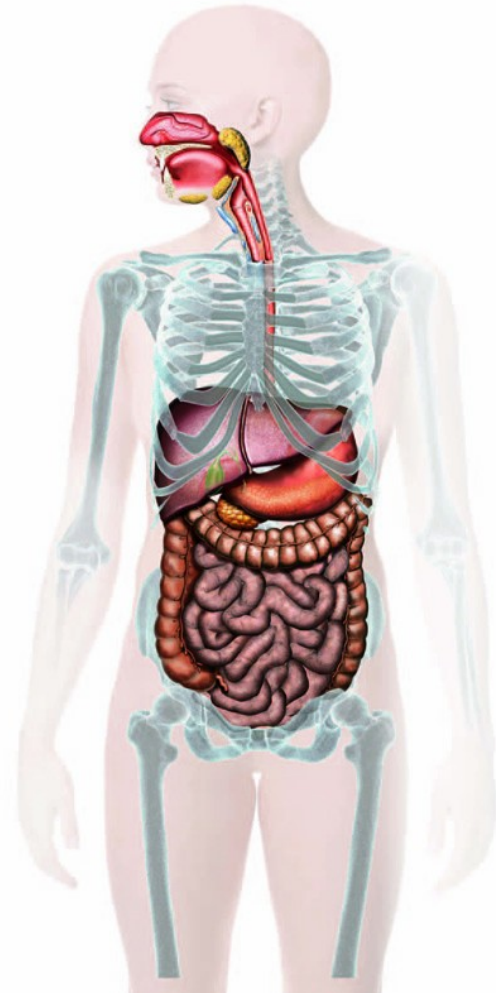


Impact of Bacteria & Archaea

- Lineages are ancient, diverse, abundant, and ubiquitous
- Oldest fossils
 - ▣ 3.5 billion year old bacteria
 - ▣ Eukaryotes (1.7 billion years later)
- 5000 species of Bacteria and Archaea names
 - ▣ Millions are likely

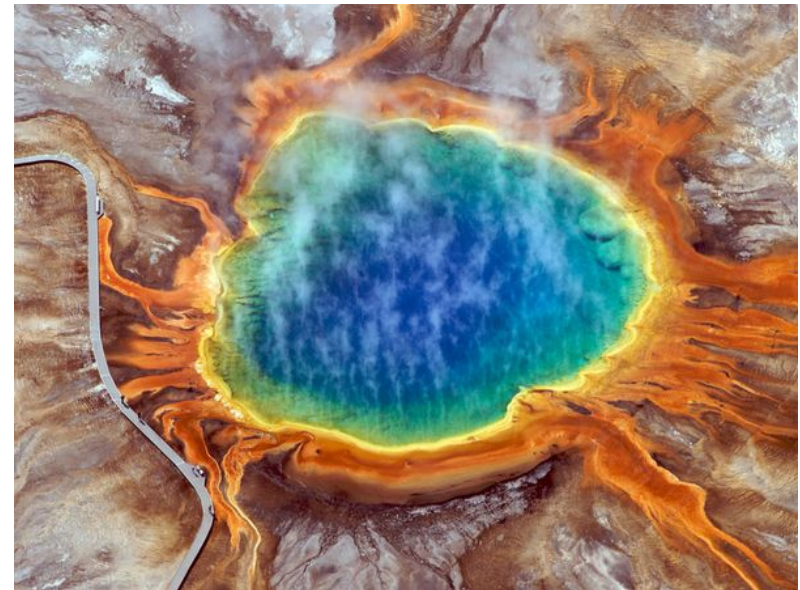
Humans and bacteria

- Bacteria are abundant
 - ▣ 400 species in digestive tract
 - ▣ 128 species in stomach
 - ▣ 500 species in mouth
- 10^{13} human cells in body
 - ▣ 10^{12} bacteria cells on skin
 - ▣ 10^{14} in digestive tract



Prokaryotes live everywhere

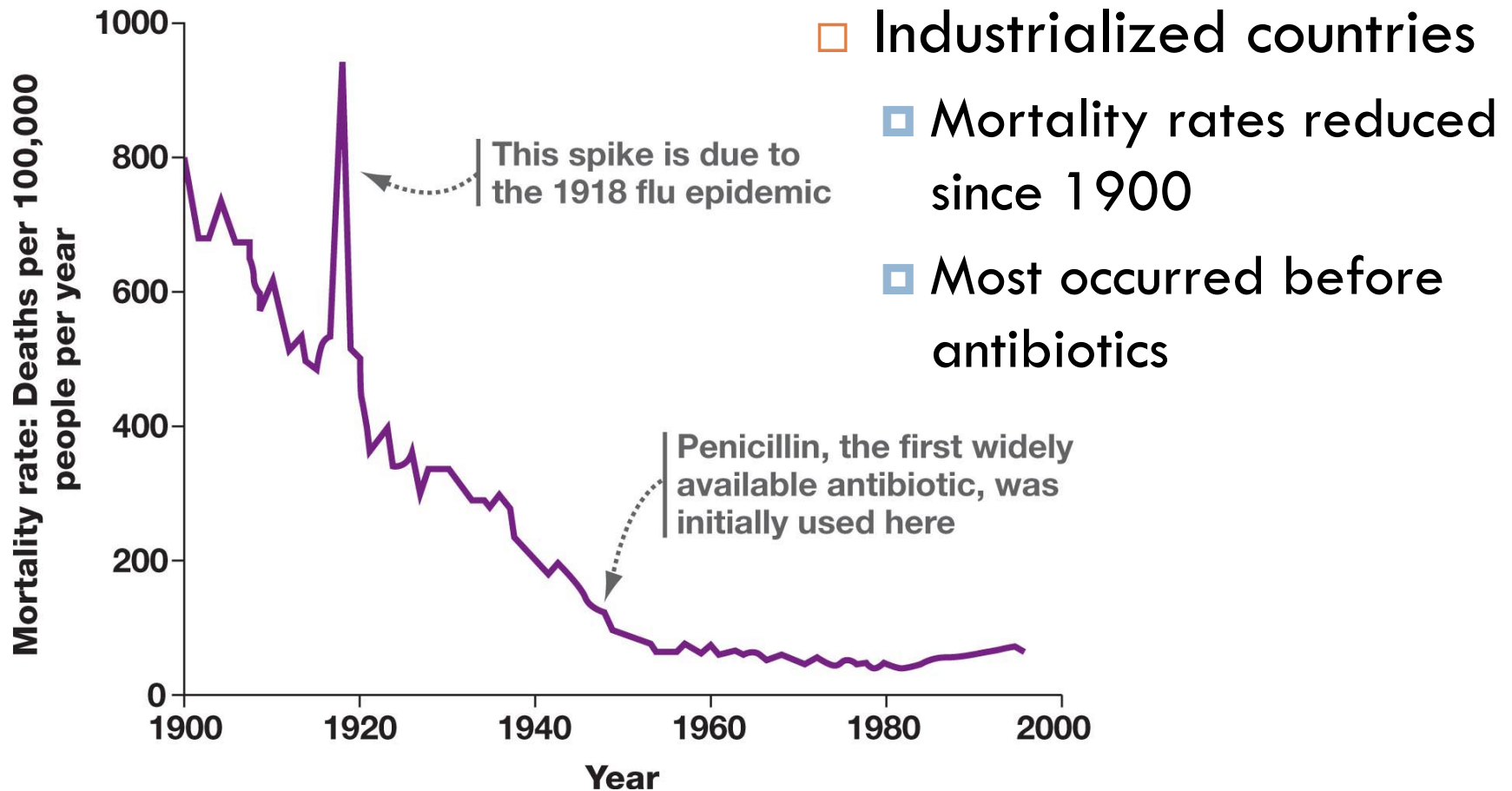
- From hot springs to below Antarctica
- 10% of world's biomass
 - ▣ prokaryotes under the ocean floor
- Found at
 - ▣ depths of 10 km below surface
 - ▣ Temperatures 0-121°C



Germ theory of disease

- Experiments by Robert Koch (late 1800s)
 - ▣ Specific disease came from specific microbe
- Koch's postulates
 1. Microbes present in diseased individuals, not healthy ones
 2. Organisms must be isolated and grown away from host
 3. Organisms from culture injected into healthy, disease should appear
 4. Repeat 1-3 with healthy individuals, disease should not appear

Effects of sanitation & nutrition



Pathogenic bacteria

□ Virulence

- ▣ Ability to cause disease
- ▣ Varies among individuals in a population

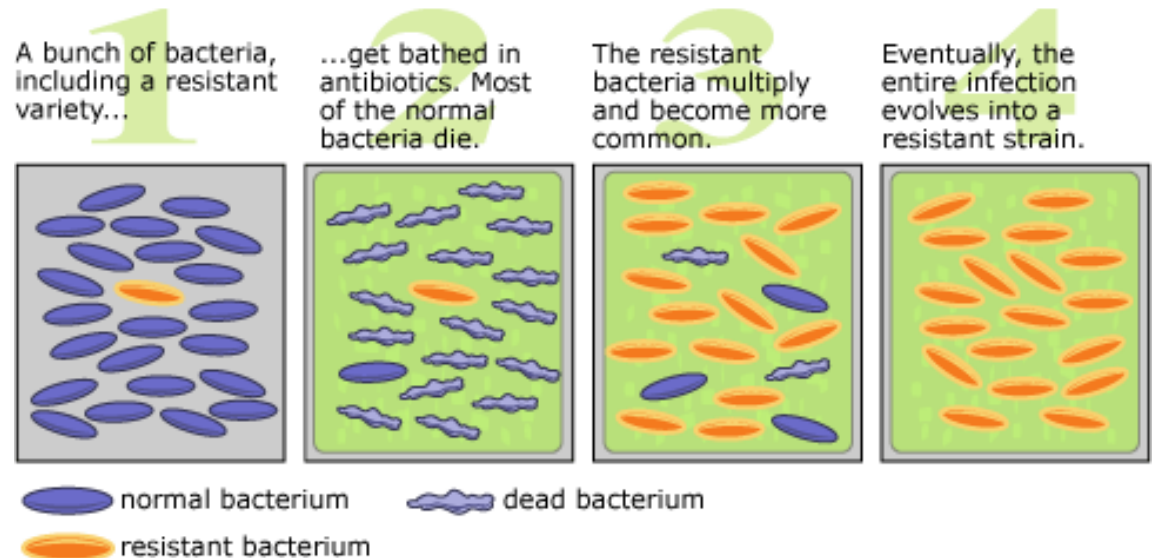
□ *Escherichia coli*

- ▣ Virulence depends on length of genome



Antibiotics

- ❑ Molecules that kill bacteria
- ❑ Discovered 1928
- ❑ Widespread use in 1940s
 - ▣ Combated most bacterial infections
- ❑ Overuse led to antibiotic-resistant strains



Extremophiles

- Bacteria or Archaea living in habitats:
 - ▣ High-salt
 - ▣ High or low temperature
 - ▣ High pressure



Researching extremophiles

- May help explain how life on Earth began
- Serve as model organism for search for extraterrestrial life
- Enzymes found help DNA research

Finding new bacteria species

- Enrichment culture
 - ▣ Cells sampled from environment
 - ▣ Grown under specific conditions
 - Temperature
 - Lighting
 - Substrate
 - Available food
 - ▣ Increase abundance of individuals with specified conditions for study



Finding new bacterial species

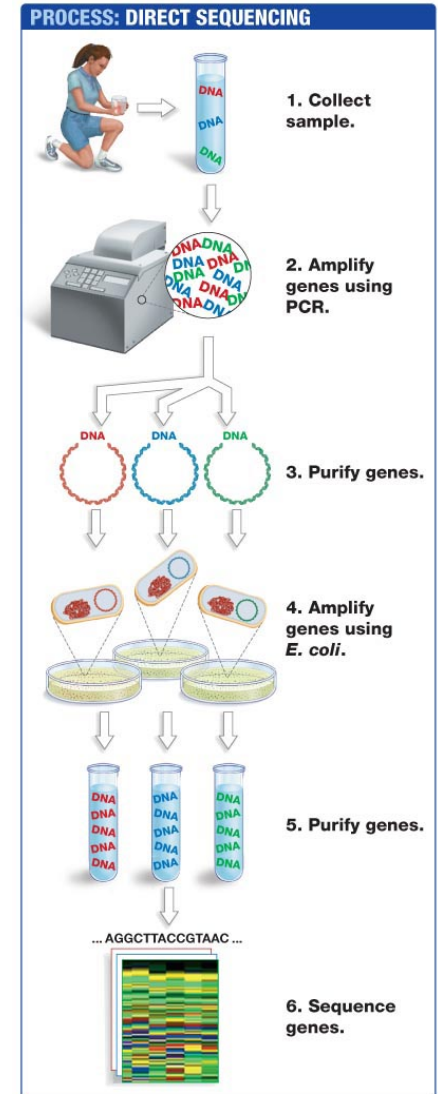
□ Direct sequencing

▣ Identifying phylogenetic species

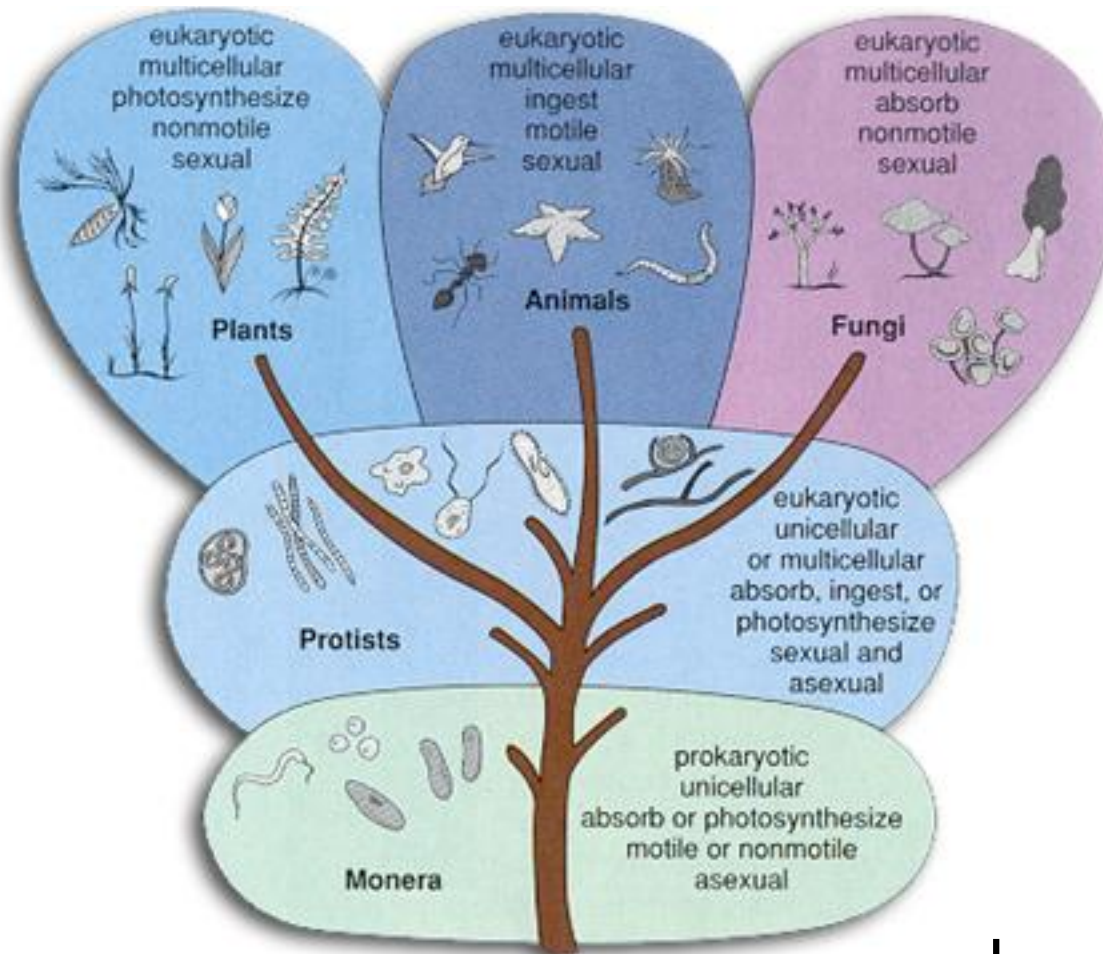
- Population w/ distinctive characteristics

▣ Process

- Isolate specific genes
- Sequence genes: ATCG
- Compare sequence with database
- If sequence “significantly” differs
 - May have new species



5 Kingdoms of Life



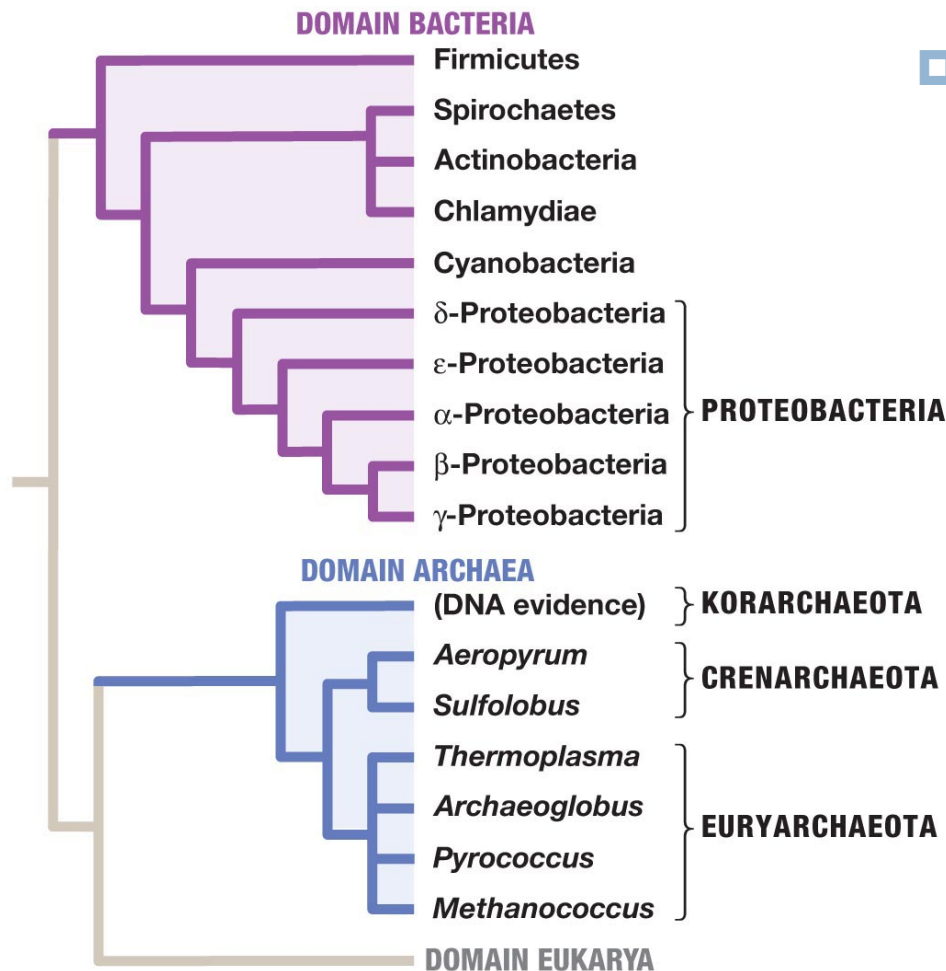
...back in the day

Discovering Archaea



- Carl Woese (1960s)
 - ▣ Studied bits of RNA
 - (16S & 18S)
 - ▣ Wide array of species
 - ▣ Showed division b/n prokaryotes and eukaryotes to be incorrect
 - Not a 5 kingdom system
 - A 3 domain system

Discovering Archaea



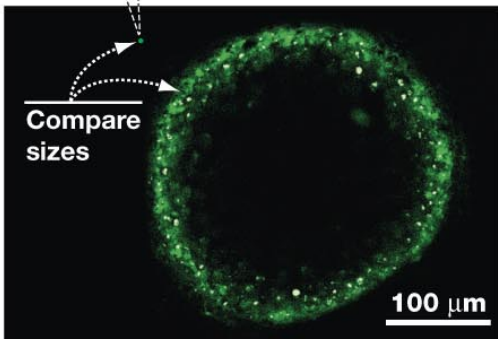
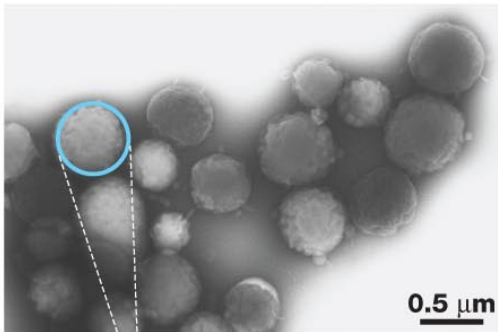
- Argued “tree of life” has three main branches
 - Added Archaea
 - Bacteria as oldest
 - Archaea and Eukaryotes more closely related

Morphological Diversity

(a) Size varies.

Most bacteria are about 1 μm in diameter.

Smallest (*Mycoplasma mycoides*)

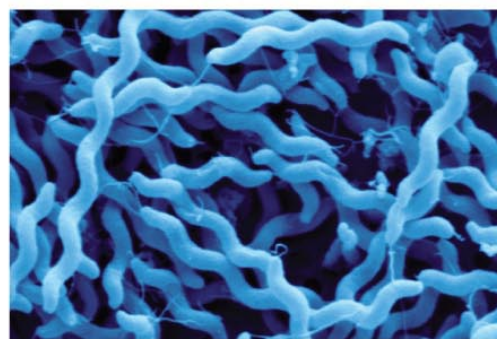


Largest (*Thiomargarita namibiensis*)

(b) Shape varies...

... from rods to spheres to spirals to filaments. In some species, cells adhere to form chains.

Rods, chains of spheres (compost bacteria)



Spirals (*Campylobacter jejuni*)

(c) Mobility varies.

Some bacteria are immotile, but swimming and gliding are common.

Swimming (*Pseudomonas aeruginosa*)



Gliding (*Oscillatoria limosa*)

Morphological Diversity

□ Cell wall composition

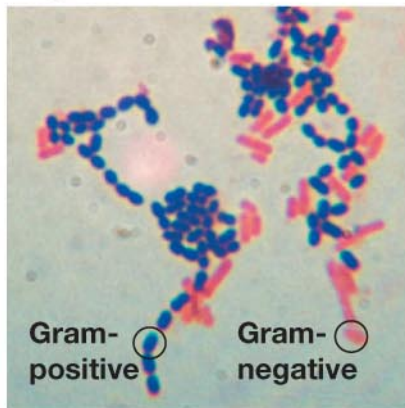
■ Gram-positive

- Look purple
- Contain mostly carbohydrate, peptidoglycan

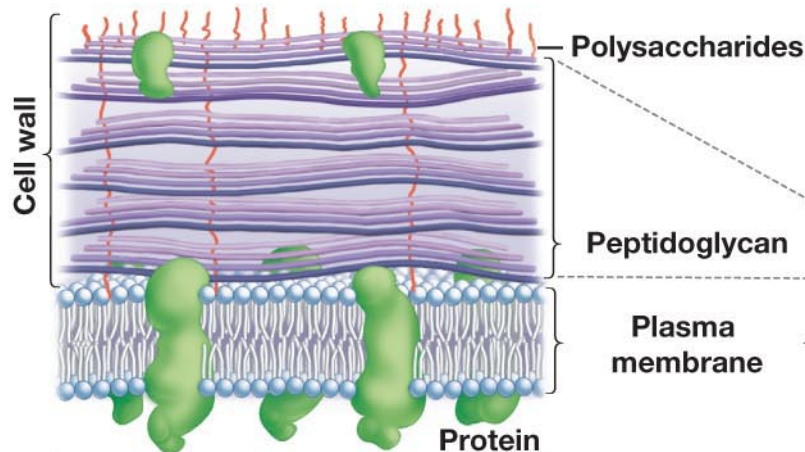
■ Gram-negative

- Look pink
- Contain thin layer of peptidoglycan
- Contain outer phospholipid layer

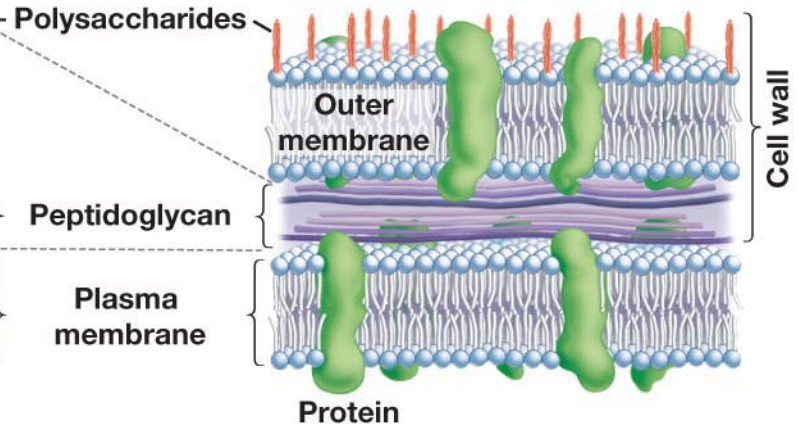
(a) Gram-positive cells stain more than Gram-negative cells.



(b) Gram-positive cell wall



(c) Gram-negative cell wall



Metabolic Diversity

- Autotrophs
 - ▣ Manufacture own carbon-containing compounds
- Heterotrophs
 - ▣ Live by consuming compounds made by others
- Of 6 known ways to produce ATP and obtaining C
 - ▣ Eukaryotes do 2
 - ▣ Bacteria and Archaea do all
 - Can use e^- donor other than sugar
 - Can use e^- receptor other than oxygen

Metabolic Diversity

- Sources of energy for ATP production
 - ▣ Light
 - Phototrophs
 - Photophosphorylation
 - Electrons to top of electron transport chain
 - ▣ Organic molecules
 - Chemoorganotrophs
 - Oxidize organic (C-containing) molecules
 - Cellular respiration (or fermentation)
 - ▣ Inorganic molecules
 - Chemolithotrophs
 - Oxidize inorganic molecules
 - Cellular respiration with inorganic compounds as e^- donor