Prokaryotic cells

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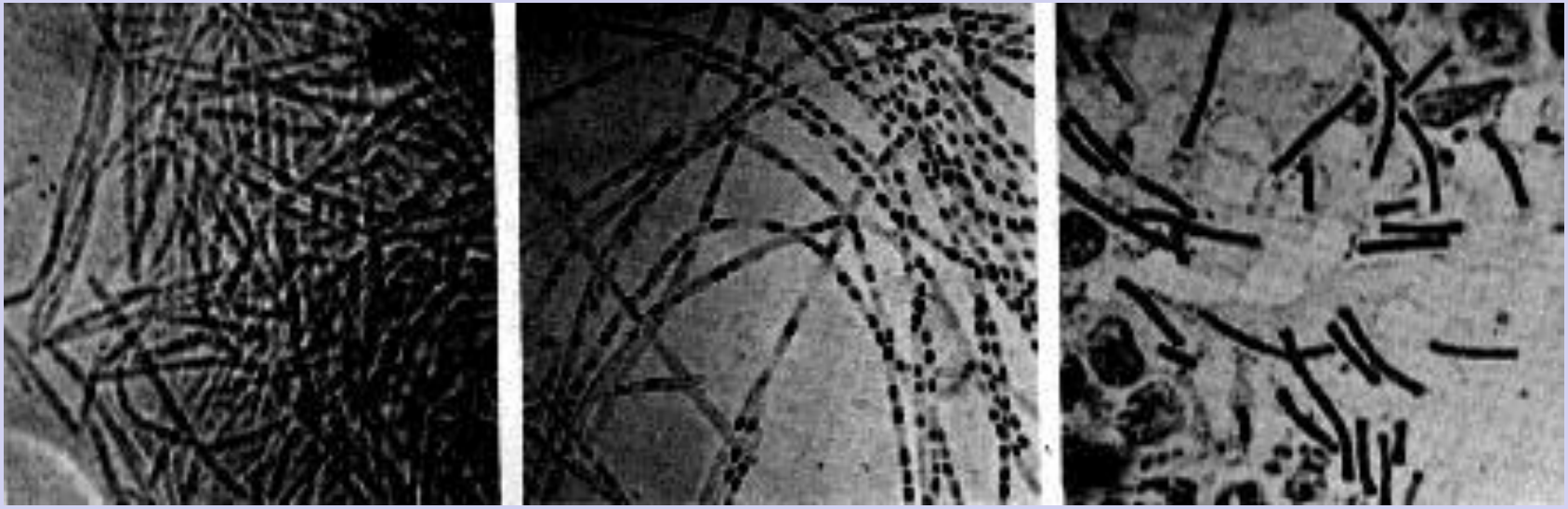
Prokaryotes and eukaryotes

- The main distinction in the living world is not “plants – animals” and not “unicellular – multicellular”, but “prokaryotes – eukaryotes”.
- The distinguishing trait is the absence or presence of a nucleus, but there are many other differences.
- We must begin with prokaryotes because they are simpler than eukaryotes and have evolved earlier.
- Most prokaryotes are unicellular (organism = cell). Some are colonial.
- In order to know basic life functions and the munimum equipment of life structures, you must study the prokaryotic cell. In many respects, it is “***the*** cell”.
- During most of its existence, life on Earth has been prokaryotic-only.

The first prokaryote shown to cause disease

Bacillus anthracis, as photographed by Robert Koch in 1877.

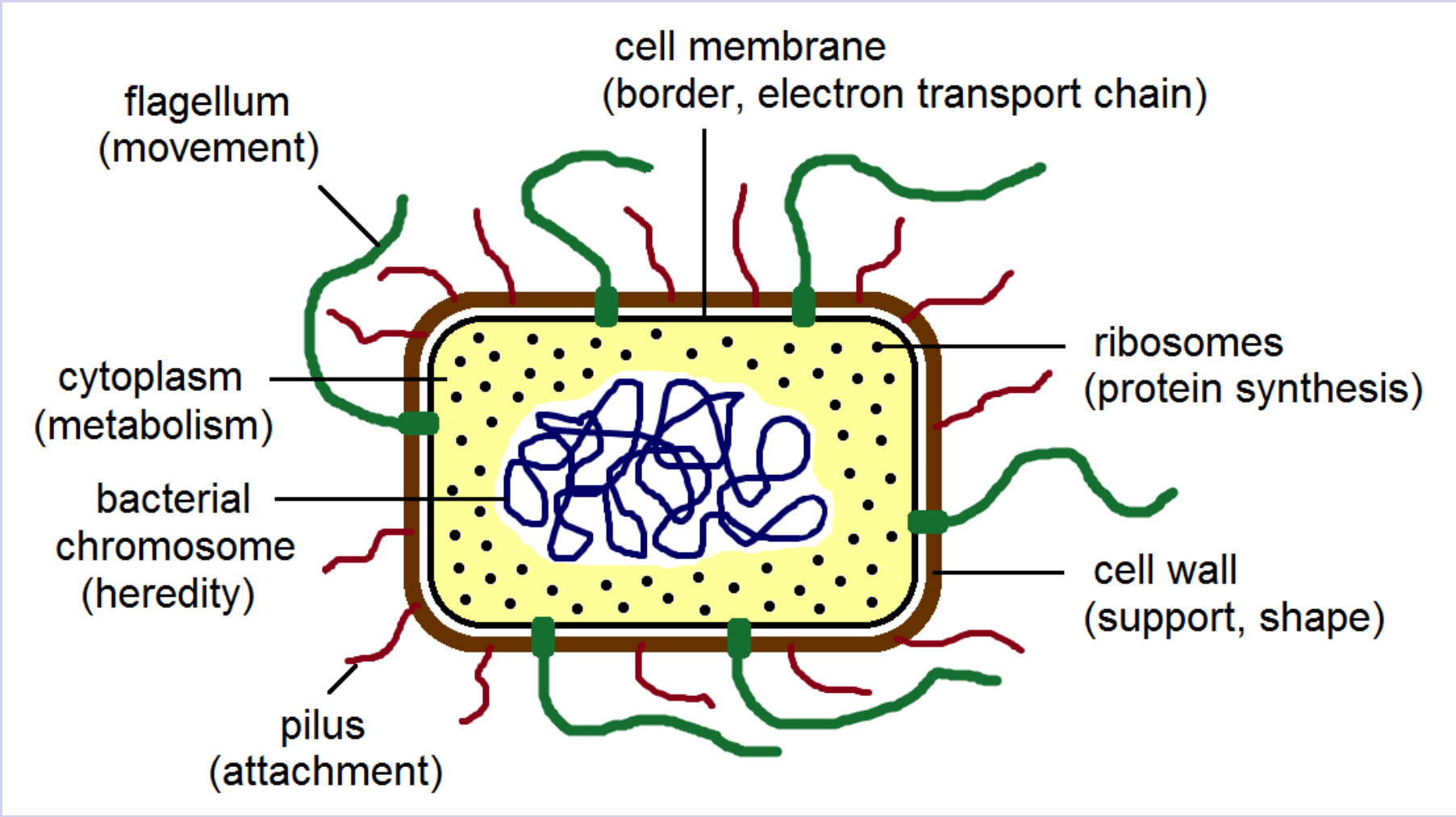


Source: Todar's Online Textbook of Bacteriology

Structure of prokaryotic cell

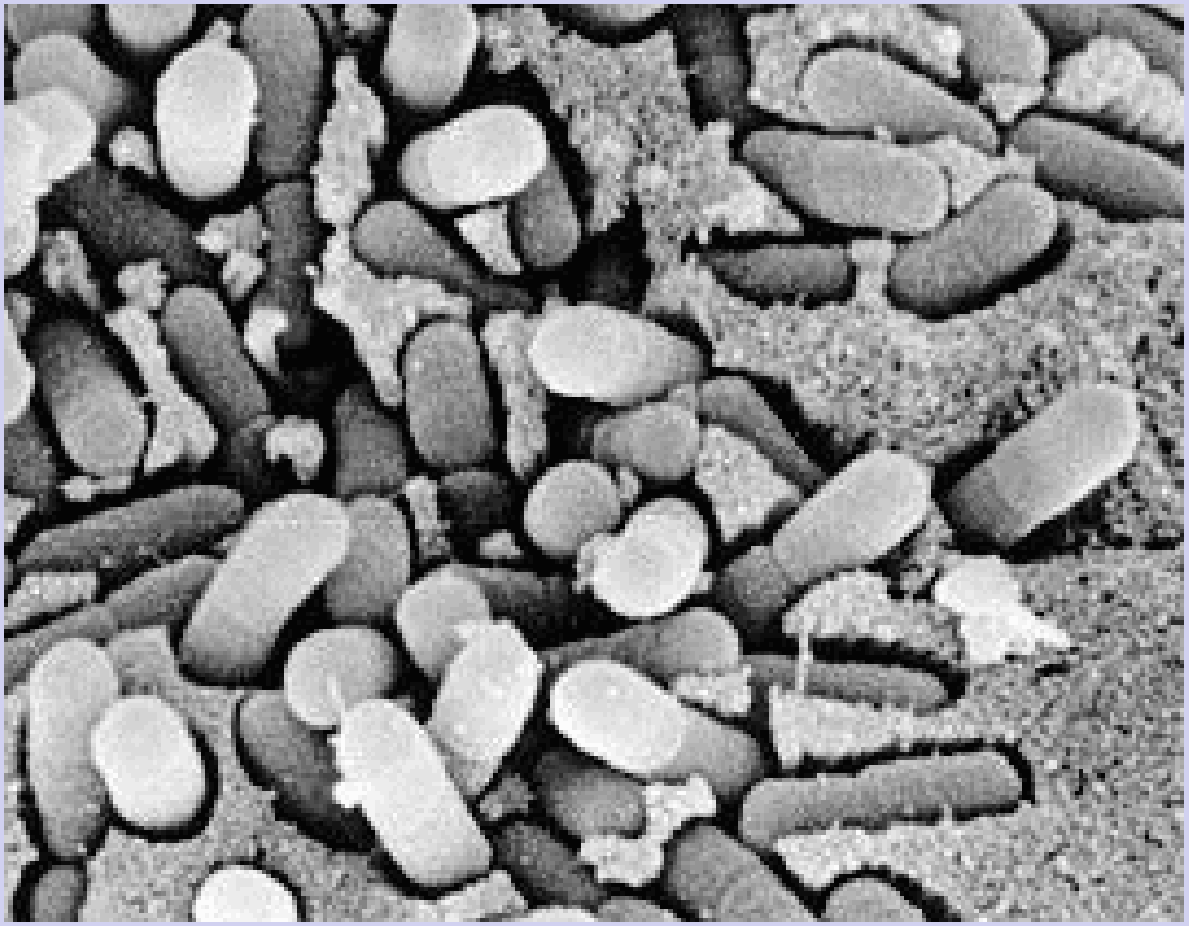
- Small (typically 1-10 μm).
- Shape of sphere, rod or bent rod.
- Surrounded by a lipid cell membrane.
- The cell's central region, called nucleoid, is occupied by a large circular DNA molecule, called bacterial chromosome.
- Between the nucleoid and the cell membrane there is cytoplasm full of ribosomes. It can contain small DNA molecules called plasmids.
- Above the membrane, there is polysaccharide cell wall.
- Above the cell wall, some prokaryotes have a capsule, and others (Gram-negative bacteria) – a second, outer lipid membrane.
- The wall often has appendages with attachment function called pili or fimbriae.
- Some bacteria move by flagella.
- Some bacteria (the bacilli) under harsh conditions turn into metabolically inactive, highly resistant form called spore.
- Cyanobacteria are photoautotrophs and have intracellular pigment-containing membranes (this is an exception in prokaryotes).

Cell structures and their functions



Most important model prokaryote is the enteric bacterium *Escherichia coli*

The species most often used as research objects are called biological models.

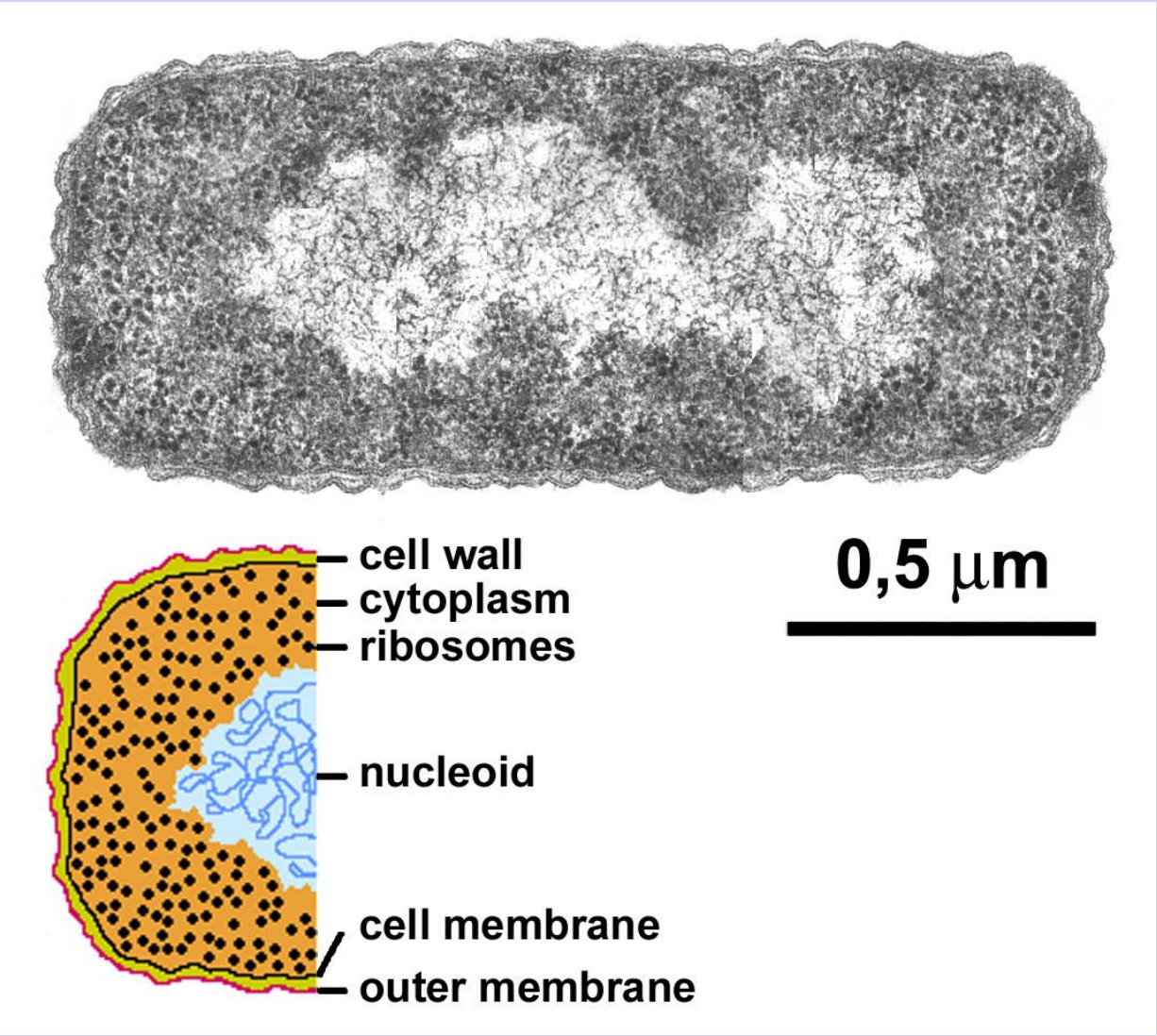


E. coli is a member of our normal gut flora, i.e. it lives in our intestines without causing harm. Some strains, however, are pathogenic.

Left: enteropathogenic *E. coli* under scanning electron microscope.

Photo kindly provided by Stuart Knutton.

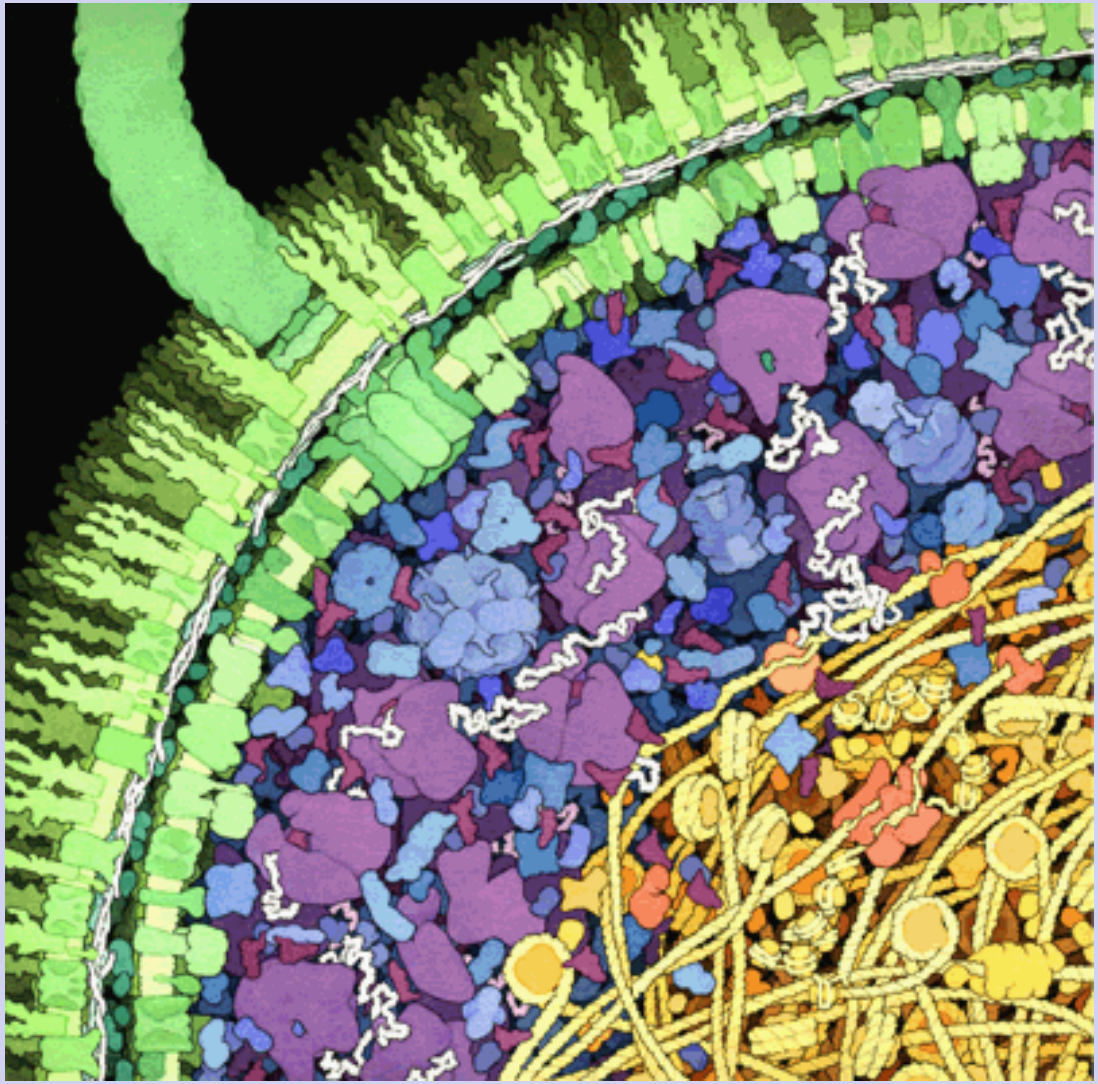
Structure of *E. coli*, a gram-negative bacterium



Electron microscopic photo, kindly provided by Carl Robinow.

Drawing from mayamarkov.com

A small segment of the *E. coli* cell

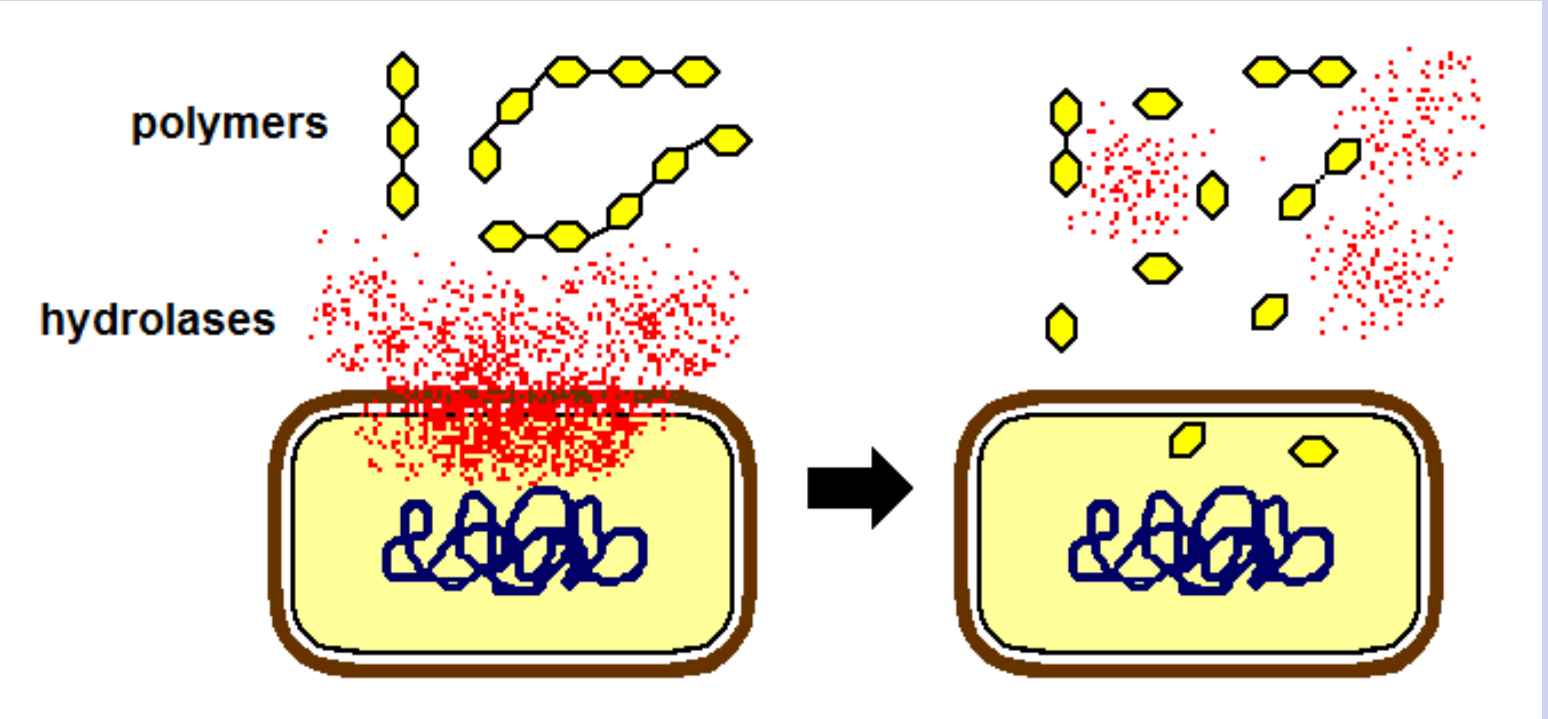


Cell membrane, cell wall and outer membrane are green. The flagellum, also green, grows out of a “basal body” inserted into the cell membrane and wall. The basal body also serves as a motor producing rotational movement. In the cytoplasm, enzymes are blue, ribosomes and tRNAs are purple, mRNAs are white. In the nucleoid, DNA and the DNA-binding proteins are yellow and orange.

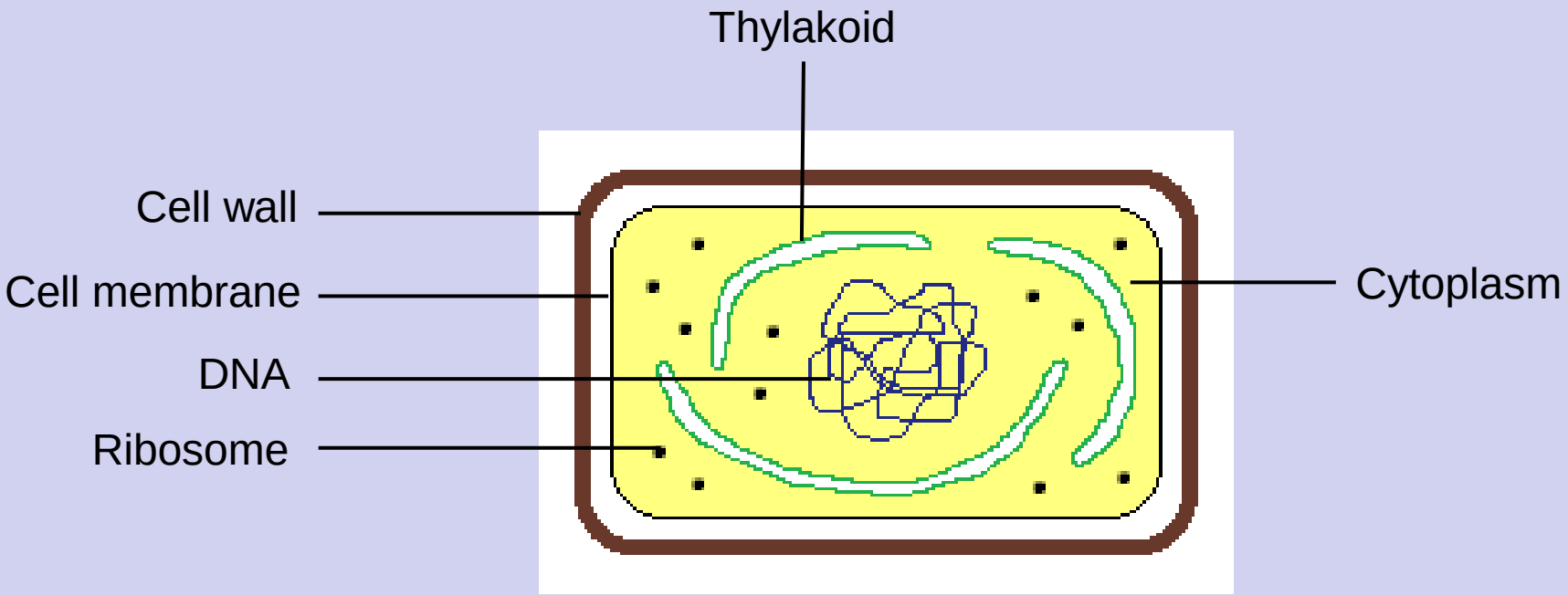
Courtesy of David S. Goodsell, Scripps Research Institute, http://mgl.scripps.edu/people/goodsell/illustration/public.

How heterotrophic prokaryotes “digest”

Most nutrients are in the form of polymers and cannot pass through the cell membrane. Heterotrophic prokaryotes secrete enzymes that hydrolyze polymers to monomers. Then, the monomers are taken across the membrane. Because of this mechanism of feeding, bacteria can make bad much more food than they actually eat.

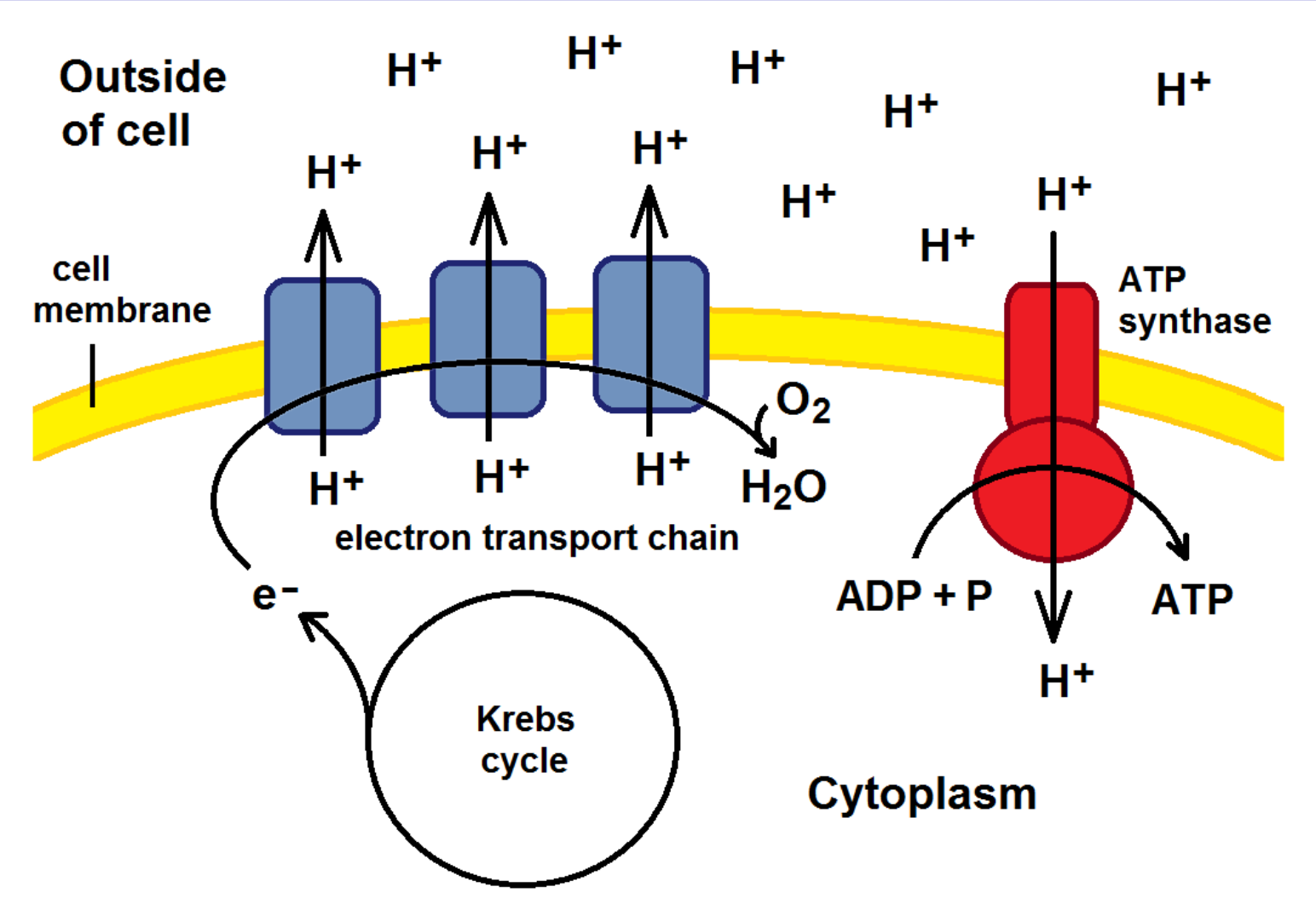


Cyanobacteria: phototrophic prokaryotes



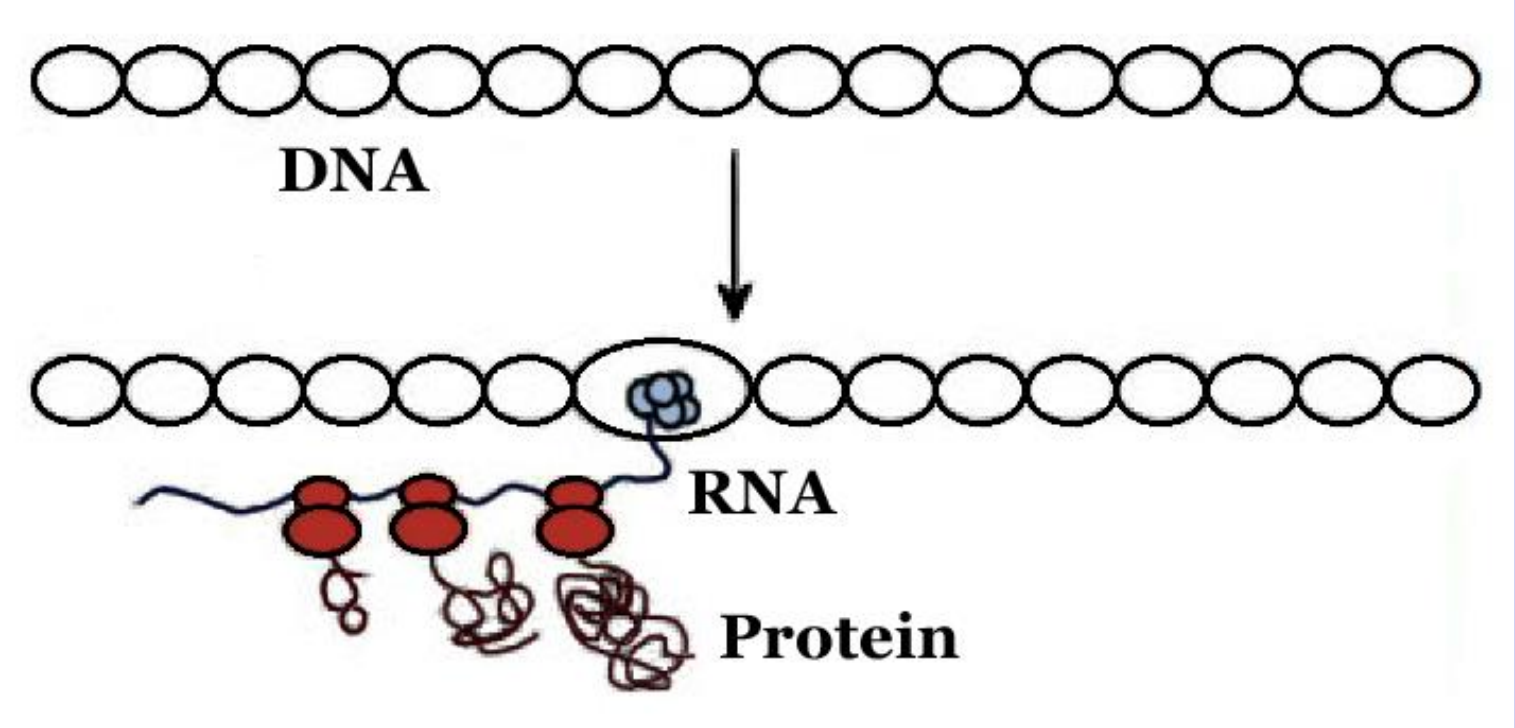
Respiration and oxidative phosphorylation

Electron transport chains and ATP synthase are in the cell membrane.



Basic genetic processes

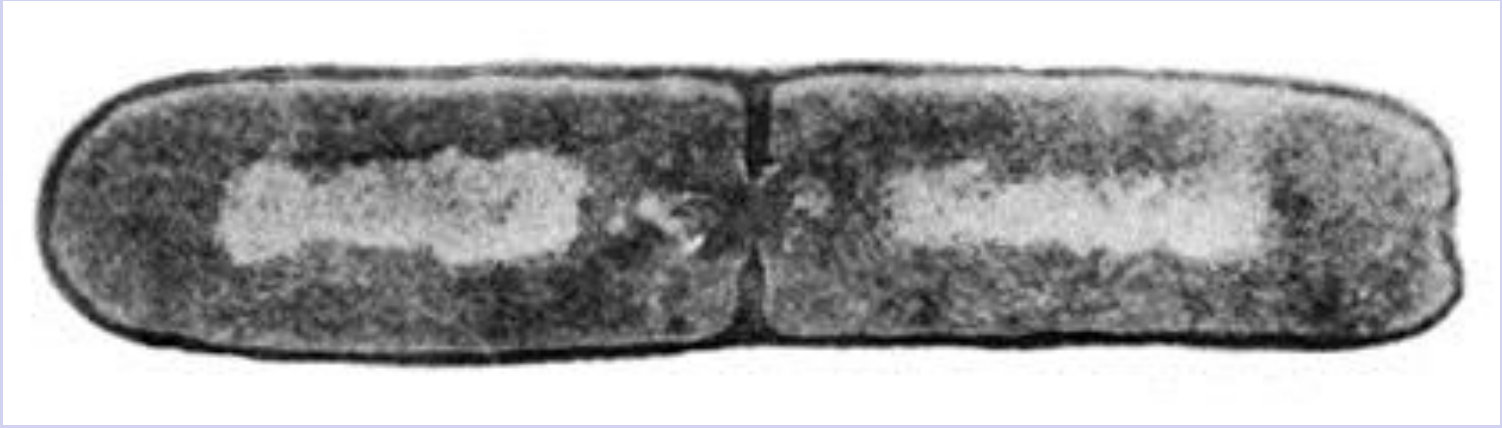
The lack of nuclear envelope and mRNA processing allows translation to start while mRNA is still being synthesized.



Drawing courtesy of Timothy Paustian.

Cell division

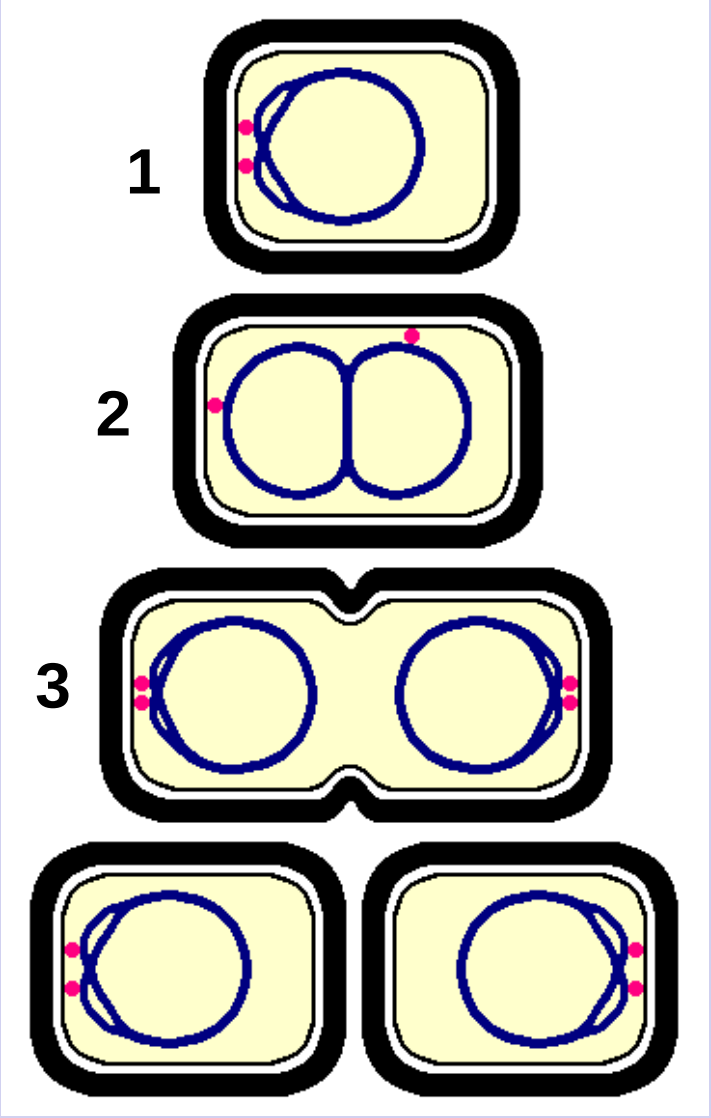
Prokaryotic cells divide by binary fission. After replication, the two bacterial chromosomes are segregated to the opposite poles of the cell and new wall is formed in the middle.



Dividing *Bacillus subtilis*

(photomicrograph courtesy of N. Cherepova)

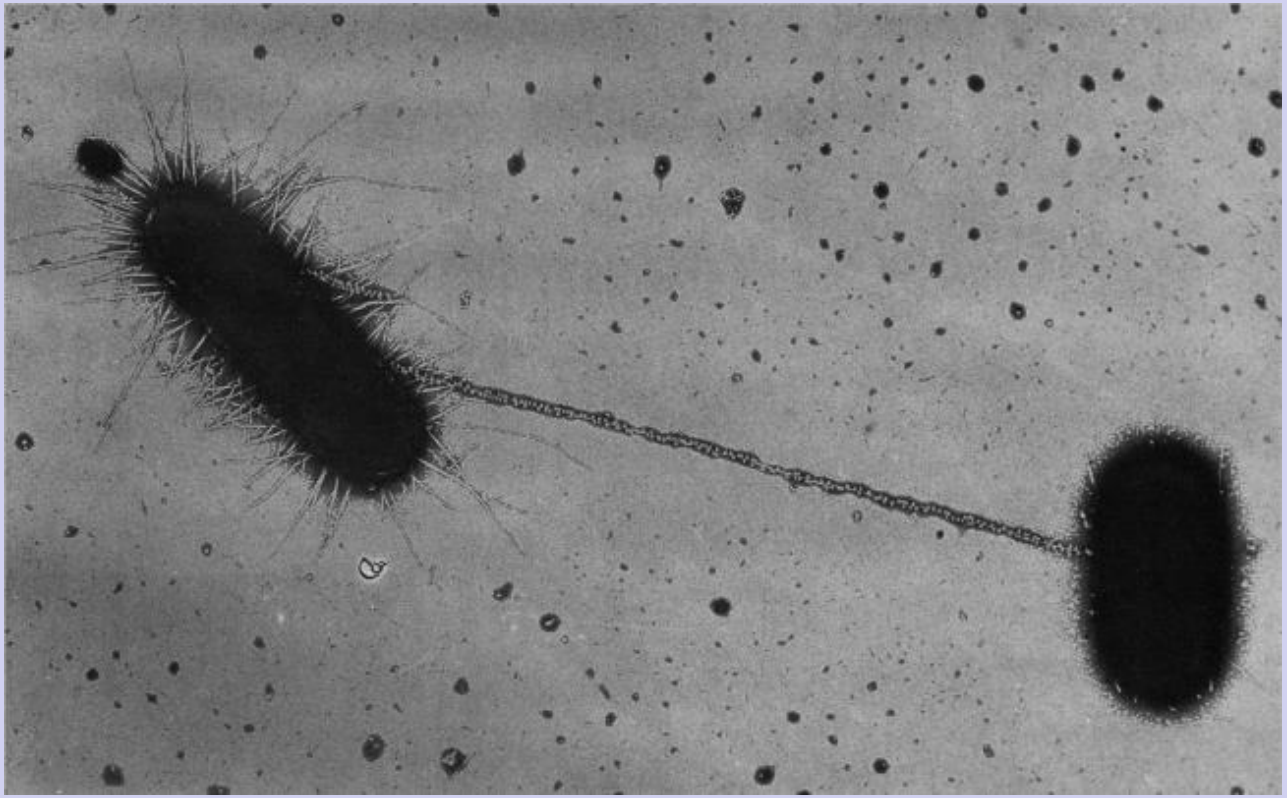
The membrane – chromosome connection



1. The bacterial chromosome is attached to the cell membrane by proteins, one of which is shown in red.
2. After replication, these proteins bring one of the daughter chromosomes to the opposite pole of the cell.
3. When the middle of the cell is cleared of DNA, partition starts. Meanwhile, the chromosomes are replicating again, to prepare for the next division.

Bacterial conjugation

Prokaryotes have no sexual processes. The closest they have to it is the so called bacterial conjugation. It is transfer of a plasmid or a part of the chromosome via a protein “tunnel” from one cell to another. The tunnel is formed by an unusually long pilus. It is called sex or F pilus and is different from other types of pili.



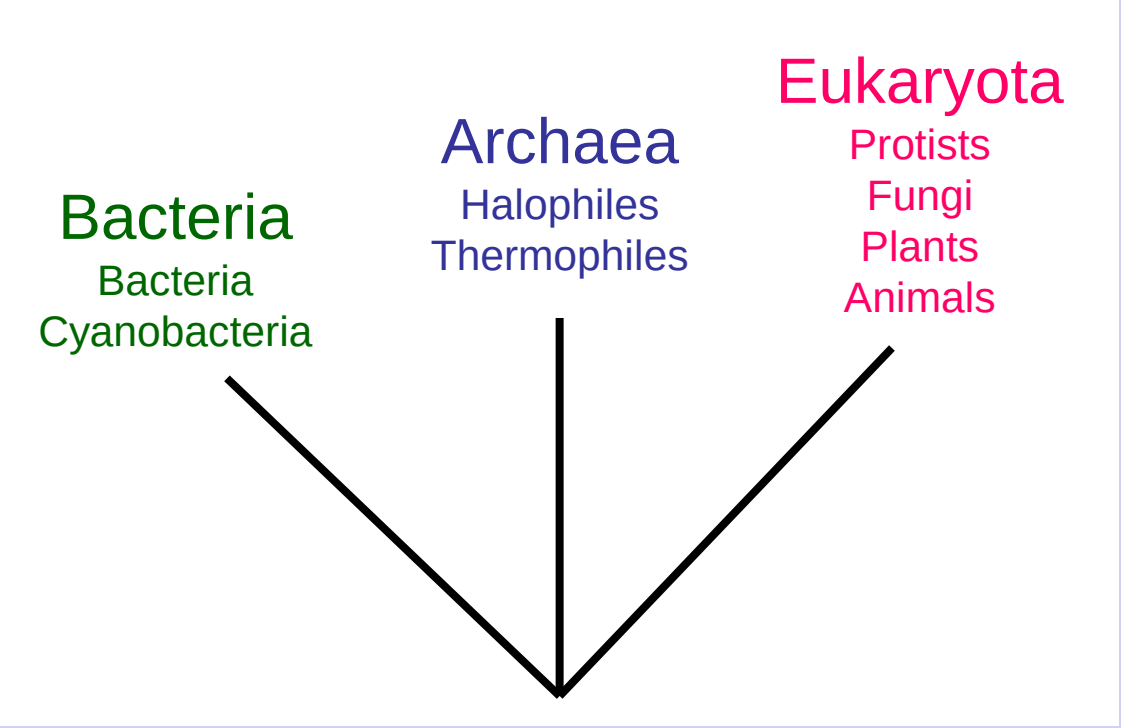
Conjugation of *E. coli*. Photo by Charles C. Brinton Jr.

Diversity of prokaryotes

There are 2 groups of prokaryotes: bacteria (eubacteria) and archaea (archaebacteria). Bacteria are numerous and prosperous. Archaea include a few species living in hot springs and other extreme habitats.

Archaea, however, include also the ancestor of eukaryotes.

This way, the living world is subdivided into three large groups (superkingdoms): Bacteria, Archaea and Eukaryota.



The three superkindgoms
(based on data from www.ucmp.berkeley.edu)