BIO 311c
Spring 2010

Lecture 3 – Monday 25 Jan. 2010

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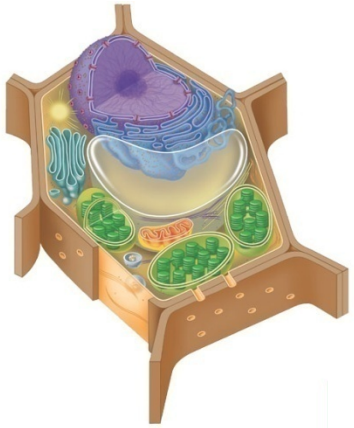
Categories of Living organisms

Historically, living organisms have been categorized according to their broad structural characteristics.

Since the development of electron microscopy in the 1950s, living organisms have been divided into broad categories based primarily on the internal structures of their cells.



Since the development of modern molecular biology during the last 20 years, living organisms are increasingly defined according to their genetic information content.

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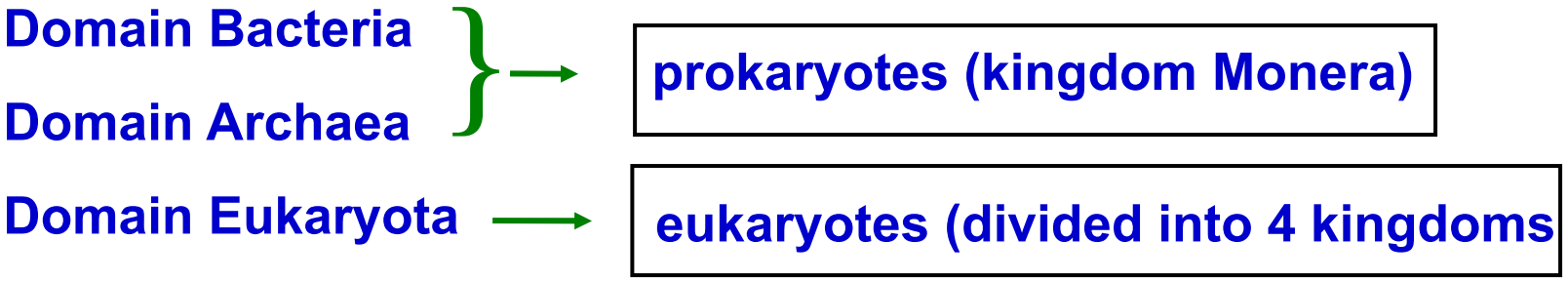
A modern way of classifying all living organisms is to separate them into three broad groups, called domains.



Organisms are categorized into these three domains based on differences in the genetic information contained in their cells.

In this course we will consider the prokaryotes (bacteria and Archaea) together since their cell structures and many of their functions are very similar.

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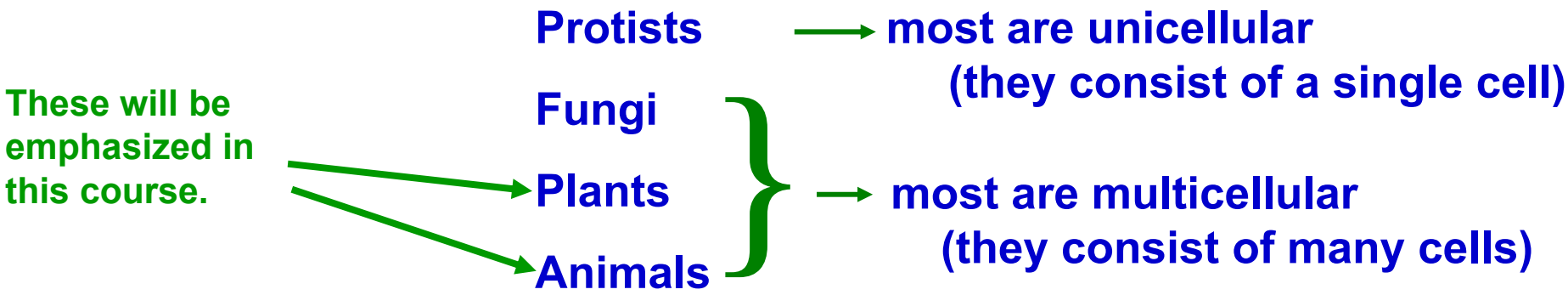
The Domain Eukaryota may be divided into 4 Kingdoms



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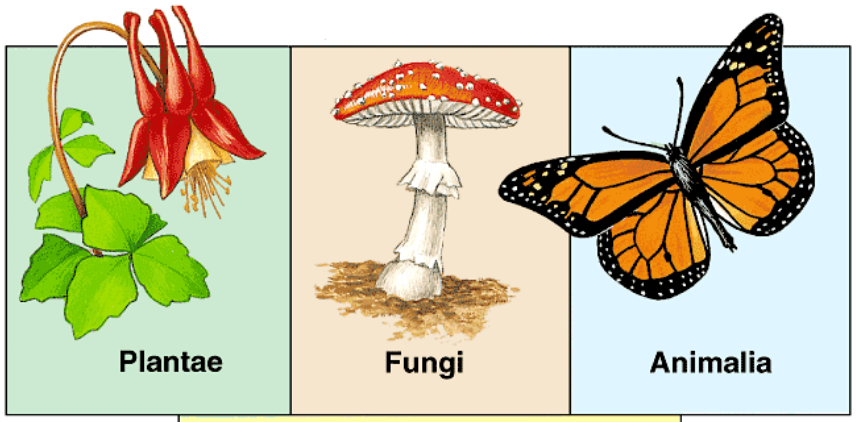
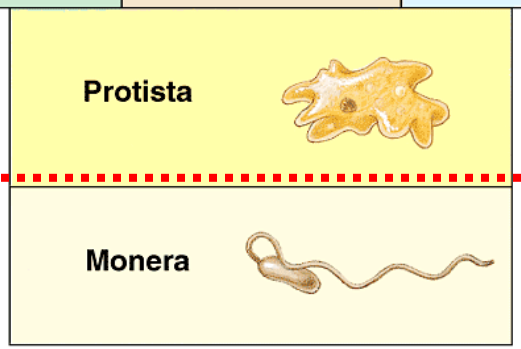
A Five-kingdom System for Classifying all Living organisms





eukaryotes

prokaryotes

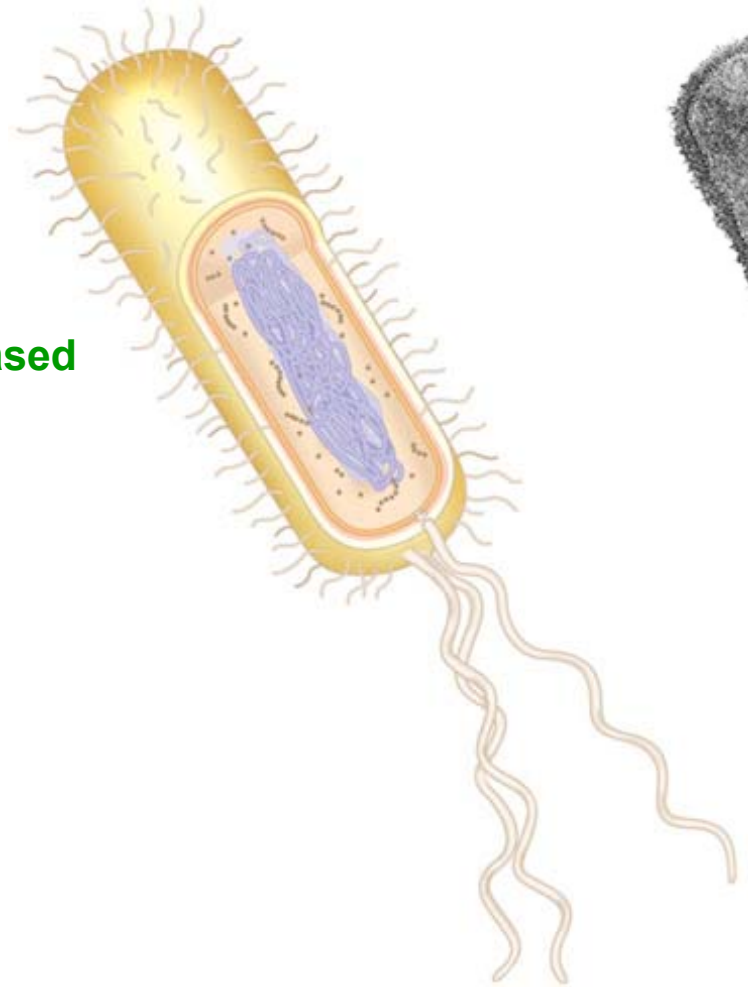
Includes organisms of the domains Bacteria and Archaea

This system, although considered outdated, is a practical conceptual way of categorizing living organisms, based on structures and functions of their cells.

All prokaryote organisms consist only of prokaryotic cells and all eukaryotic organisms consist only of eukaryotic cells. *

A prokaryotic cell

Textbook Fig. 6.6, p. 98
Also see Concept 27.1, p. 573



diagrammatic illustration based on electron microscope observations

Transmission electron microscope image

Most prokaryotic cells are less than 5 µm in diameter.
Many are less than 1 µm in diameter.

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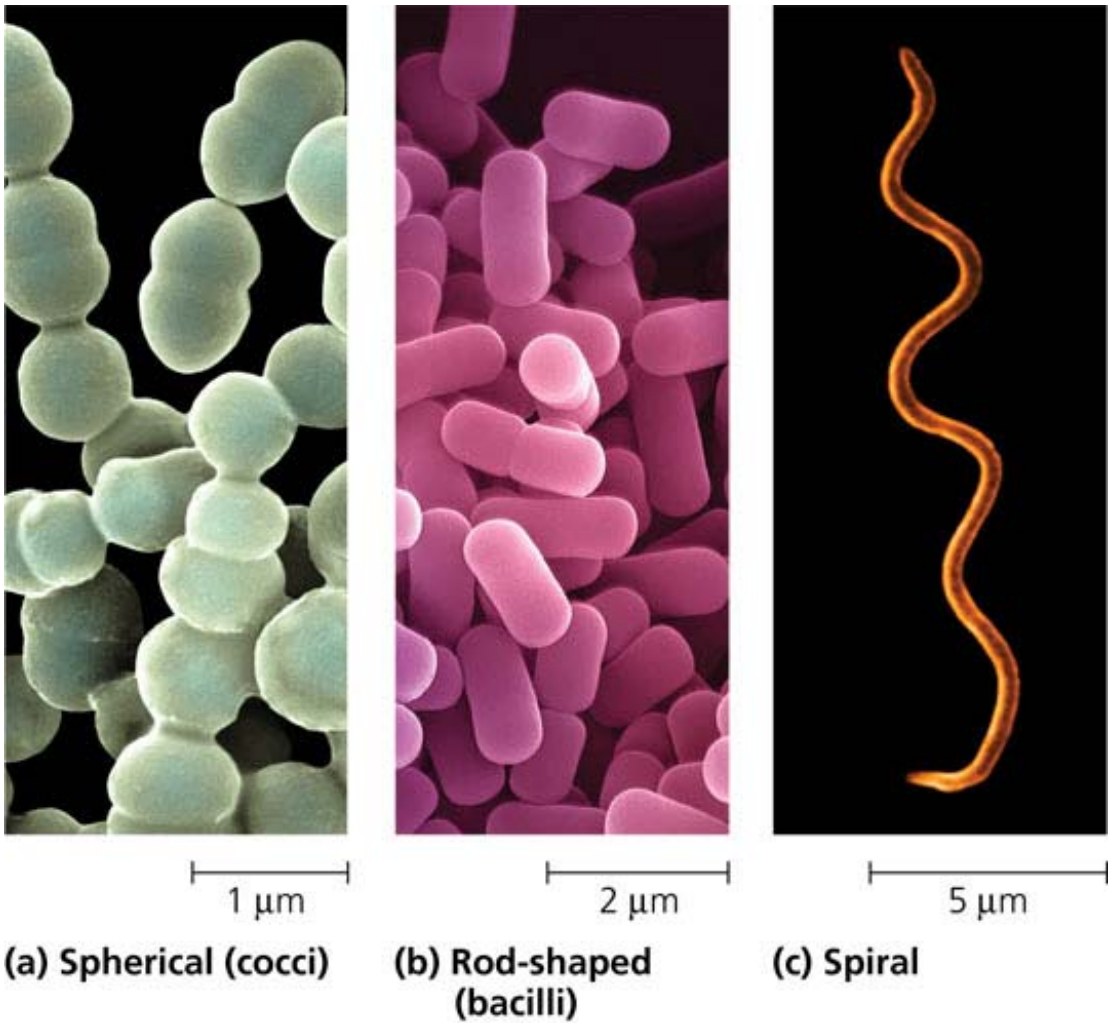
Examples of the appearance of prokaryotes at high magnification

See textbook Figure 27.2, p 557



These are all scanning electron microscope images

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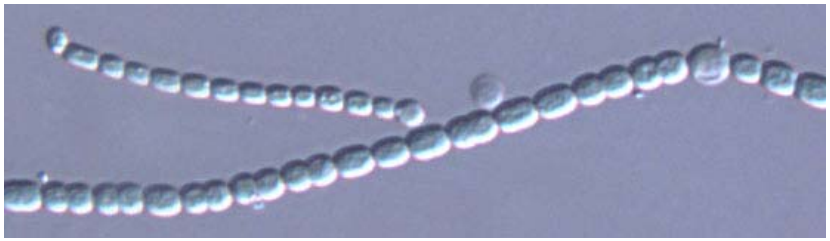
Prokaryotic cells are very simple in shape.

Prokaryotes occur as single cells or as simple organizations of cells.

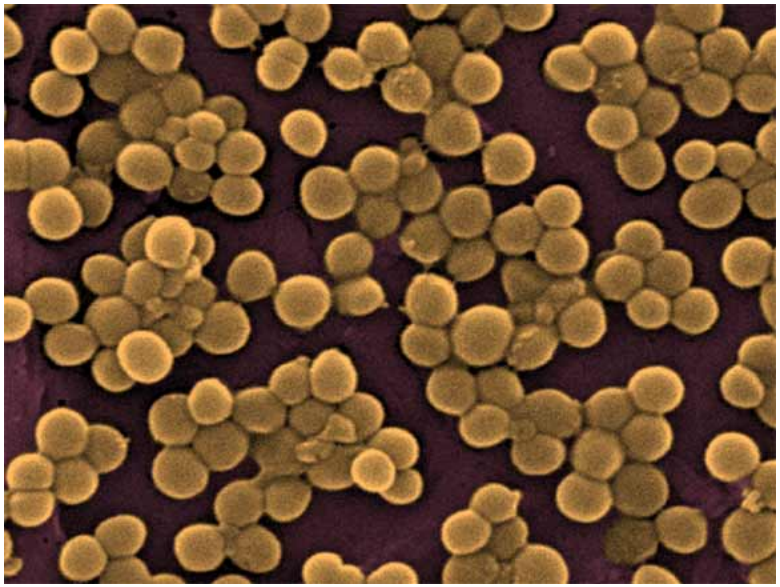
Prefix diplo- : Two cells together
Prefix strepto- : Chains of cells
Prefix staphylo- : packets of cells



streptobacillus
(light microscope image)

Prokaryotes can be given descriptive names based on the shapes of their cells and how their cells are arranged.

Examples:
diplococcus
Streptobacillus
Staphylococcus



staphylococcus
(scanning electron microscope image)

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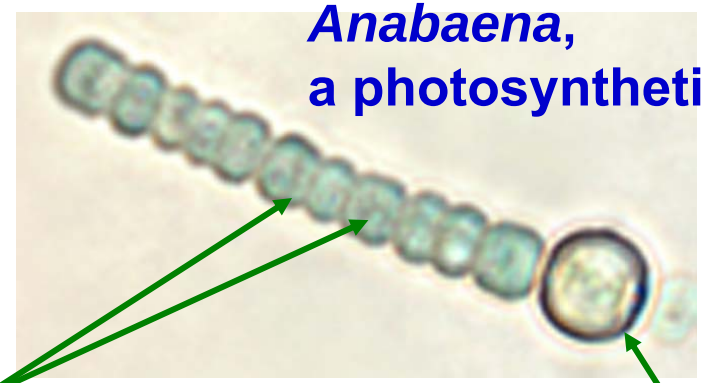
Typically there is no differentiation of cells into different cell types within a prokaryotic organism.

An exception: Some streptobacillus-type prokaryotes that are classified as cyanobacteria produce specialized cells called heterocysts which convert atmospheric nitrogen (N_2) to ammonia.



Anabaena,
a photosynthetic prokaryote

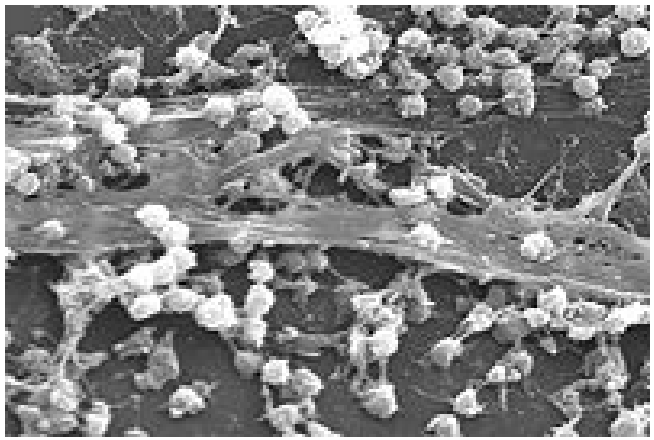
"vegetative" cells
(do photosynthesis)

a heterocyst
(performs nitrogen "fixation")

*

Typically there is no communication among cells within a prokaryotic organism.

Exception: Many kinds of prokaryotes are known to be capable of quorum sensing. This is a process whereby a prokaryote senses whether there many other bacteria of the same species in the vicinity. It slows or stops its own growth if the population density is high.



***Staphylococcus* biofilm.**

Many kinds of bacteria that form biofilms are capable of quorum sensing.

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The genetic information of prokaryotic cells consists of a single circular molecule of DNA.

The DNA, and proteins that are bound to it, are called the chromosome.

A typical length (circumference) of a prokaryotic cell chromosome is ~ 1.5 mm. That is approximately 1,000 times the length of a typical prokaryotic cell.

Electron microscope photograph (electron micrograph) of a prokaryotic cell that has been lysed (broken open), with its chromosome released into the surroundings. This demonstrates the great length of the chromosome with respect to the length of the cell.

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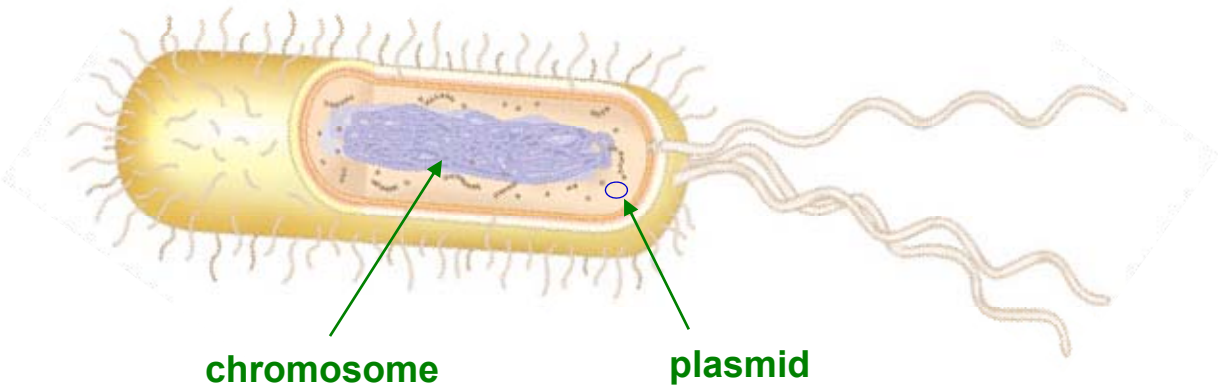
Also see Textbook Fig. 27.8, p. 559

The chromosome occurs in a portion of the cell called the nucleoid.

The nucleoid occupies over half of the interior of some prokaryote cells.

The nucleoid is not surrounded by its own membrane.



Some prokaryotic cells contain additional tiny circles of DNA with associated proteins, called plasmids.

Plasmids are typically less than 1% of the length of a prokaryotic chromosome. Some kinds of prokaryotic cells contain many identical copies of a plasmid.

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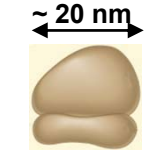
Ribosomes

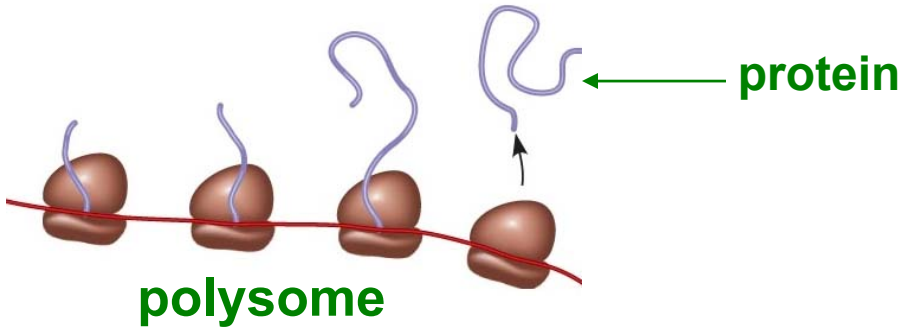
All living cells must make (synthesize) proteins.

The structures that contain the chemical machinery for protein synthesis are called ribosomes.



ribosome

Sometimes several ribosomes in the process of synthesizing proteins are held together as a unit, aligned in a row. This entire unit is called a polysome.



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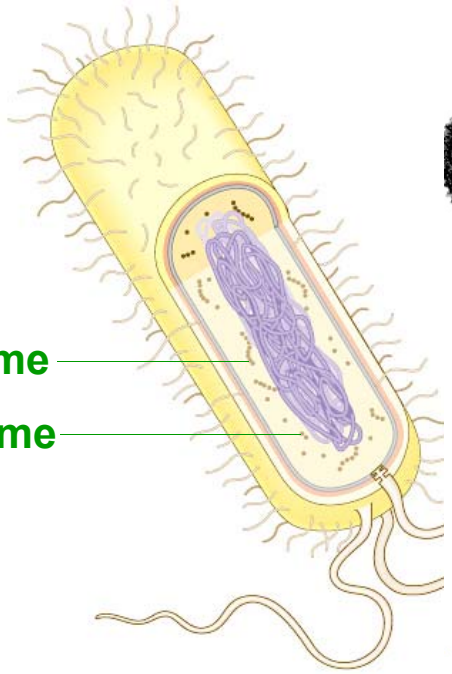
Prokaryotic cells contain slightly smaller ribosomes than do eukaryotic cells. Prokaryotie-type ribosomes are called 70S ribosomes.

70S ribosomes are approximately 20 nm in diameter.

Most other occlusions in prokaryotic cells are:
- stored sources of food and/or energy,
- packets of enzymes,
- viruses, or
- waste products



In cell biology, an occlusion is a structure within a cell that is not surrounded by its own membrane.

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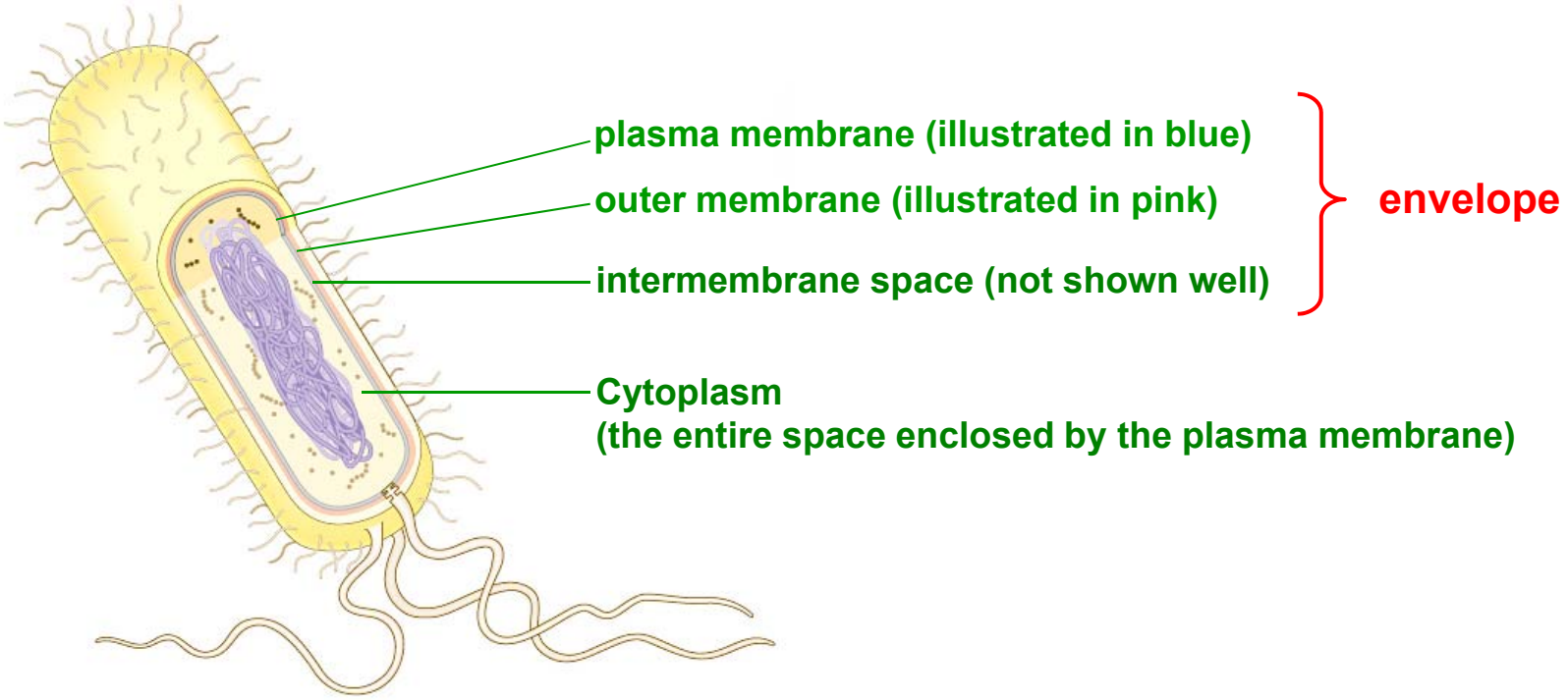
Most kinds of prokaryotic cells are surrounded by an envelope that consists of an inner membrane and an outer membrane, along with a liquid-filled space enclosed between them:

The inner membrane is the plasma membrane.

The outer membrane is sometimes called the cell wall.

The space between the two membranes is called the periplasmic space or the intermembrane space.



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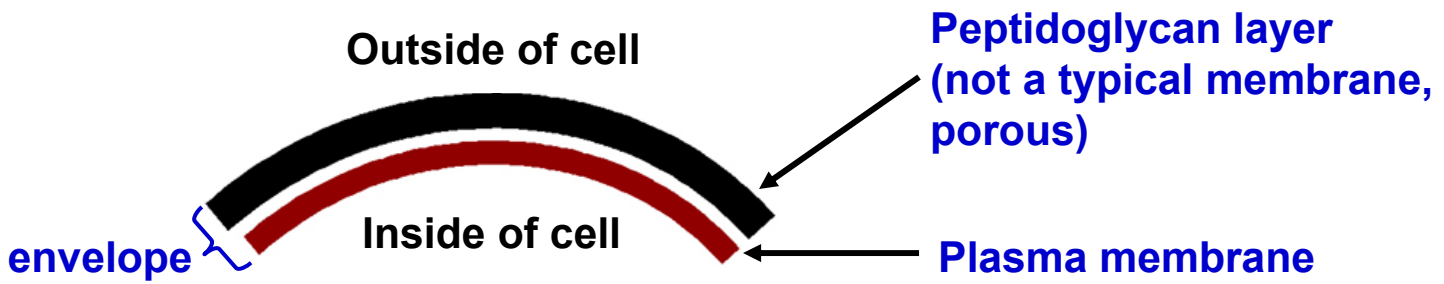
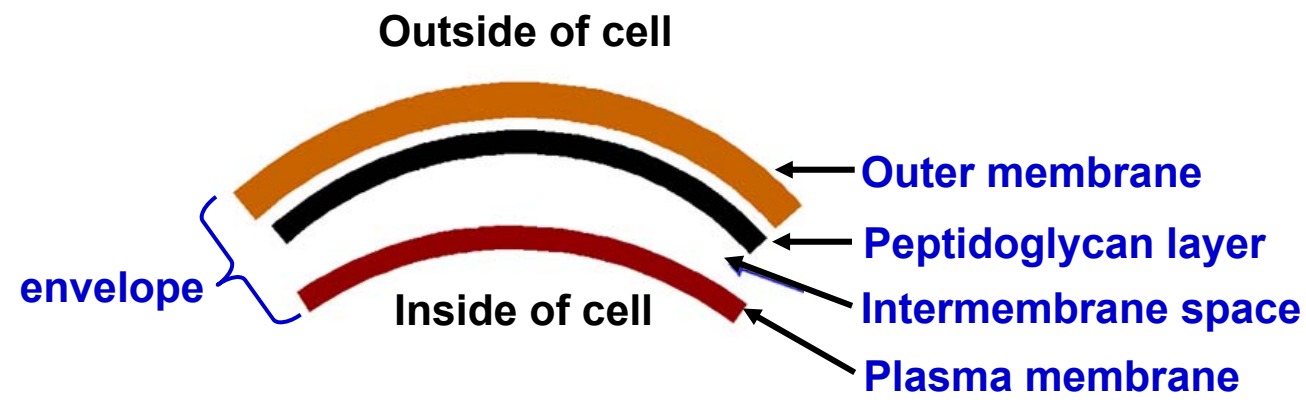
Most prokaryotes fall into one of two categories, depending on the structure of their envelope.

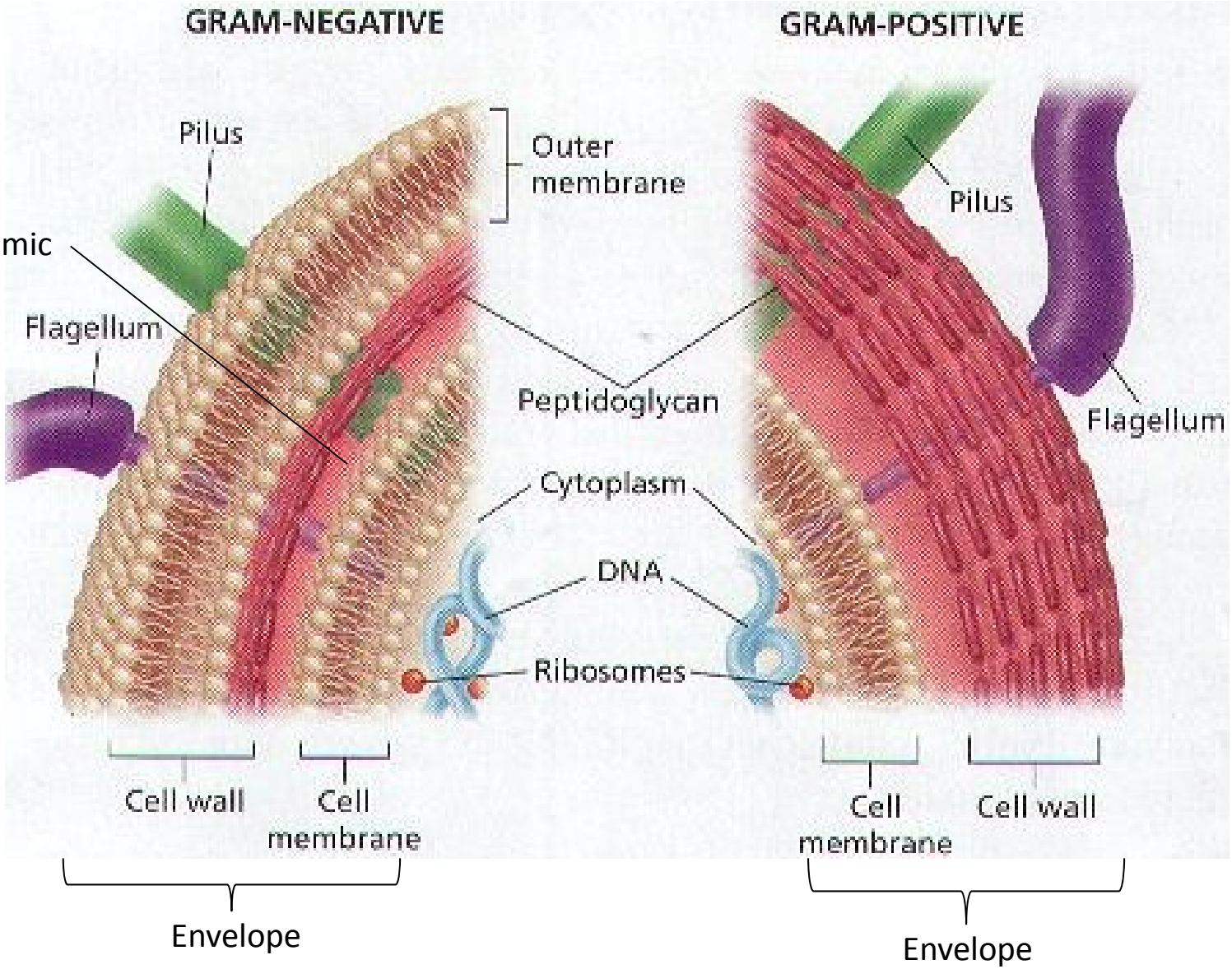
Gram Positive Bacterium



Gram Negative Bacterium



Comparison of the envelope structure of Gram negative and Gram positive prokaryotes.



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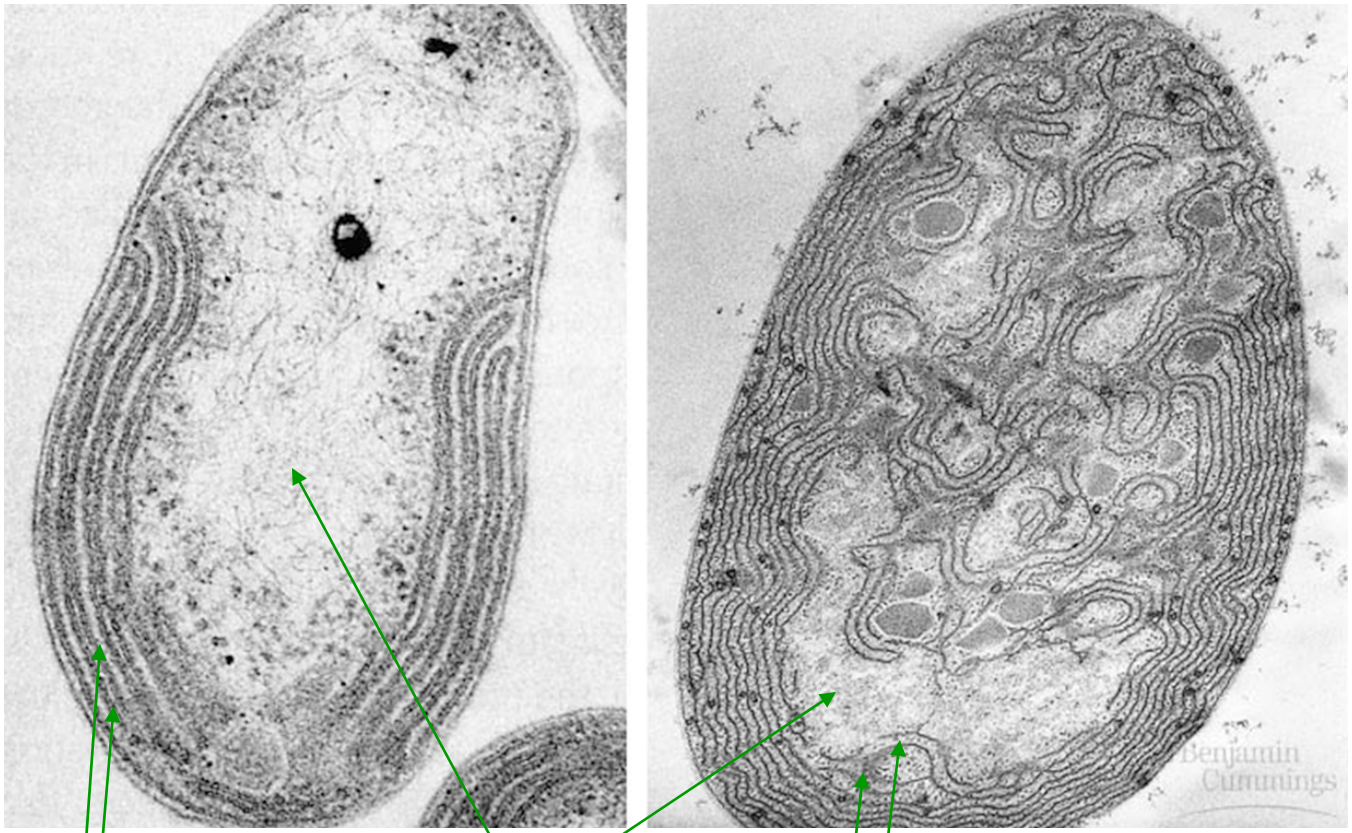
Most prokaryotes do not contain internal membrane-bounded organelles.

Exceptions: prokaryotes that are capable of photosynthesis or respiration.



From textbook
Fig. 27.7, p 559

Pairs of respiratory or photosynthetic membranes separate the cytoplasm from an intermembrane space.

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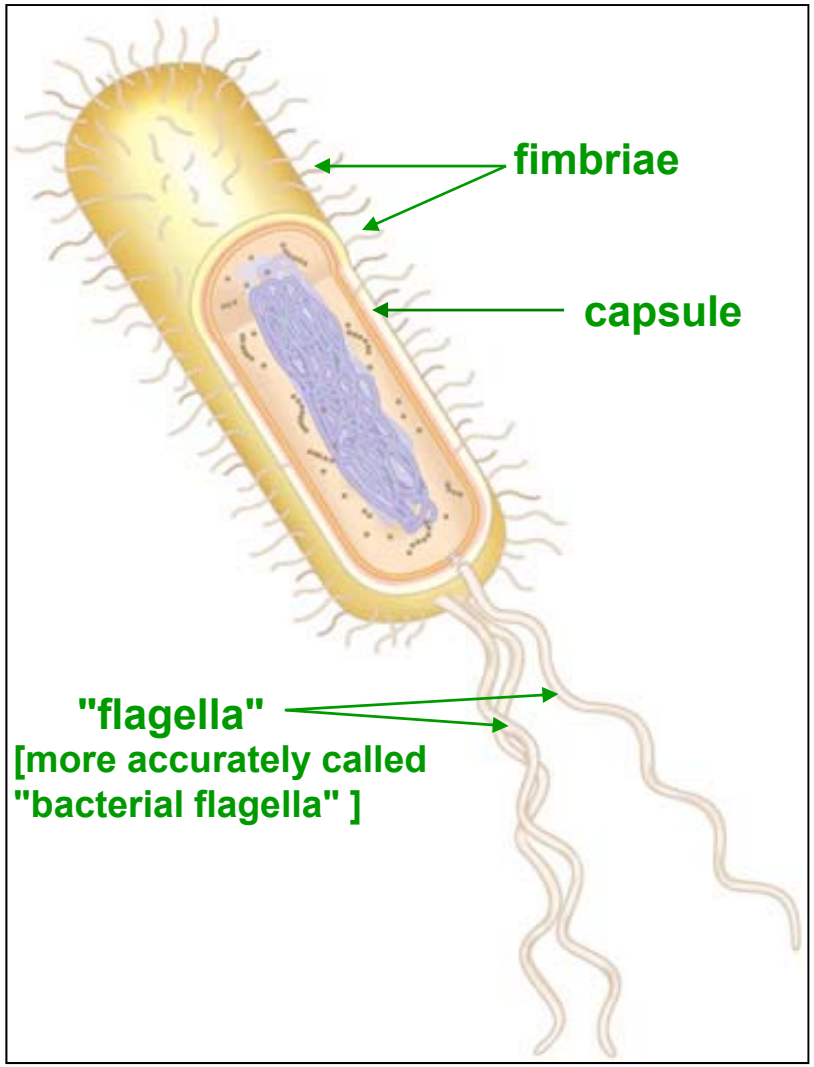
Many prokaryotes contain structures exterior to their envelope.

- **Some have a gelatinous sheath or capsule.**
- **Some have tiny projections, called pili or fimbriae.**
- **Some have larger projections that spin, called bacterial flagella.**



See textbook Fig. 6.6 for view of a gelatinous sheath.

External sheaths and capsules are considered to be non-living components of the cell.

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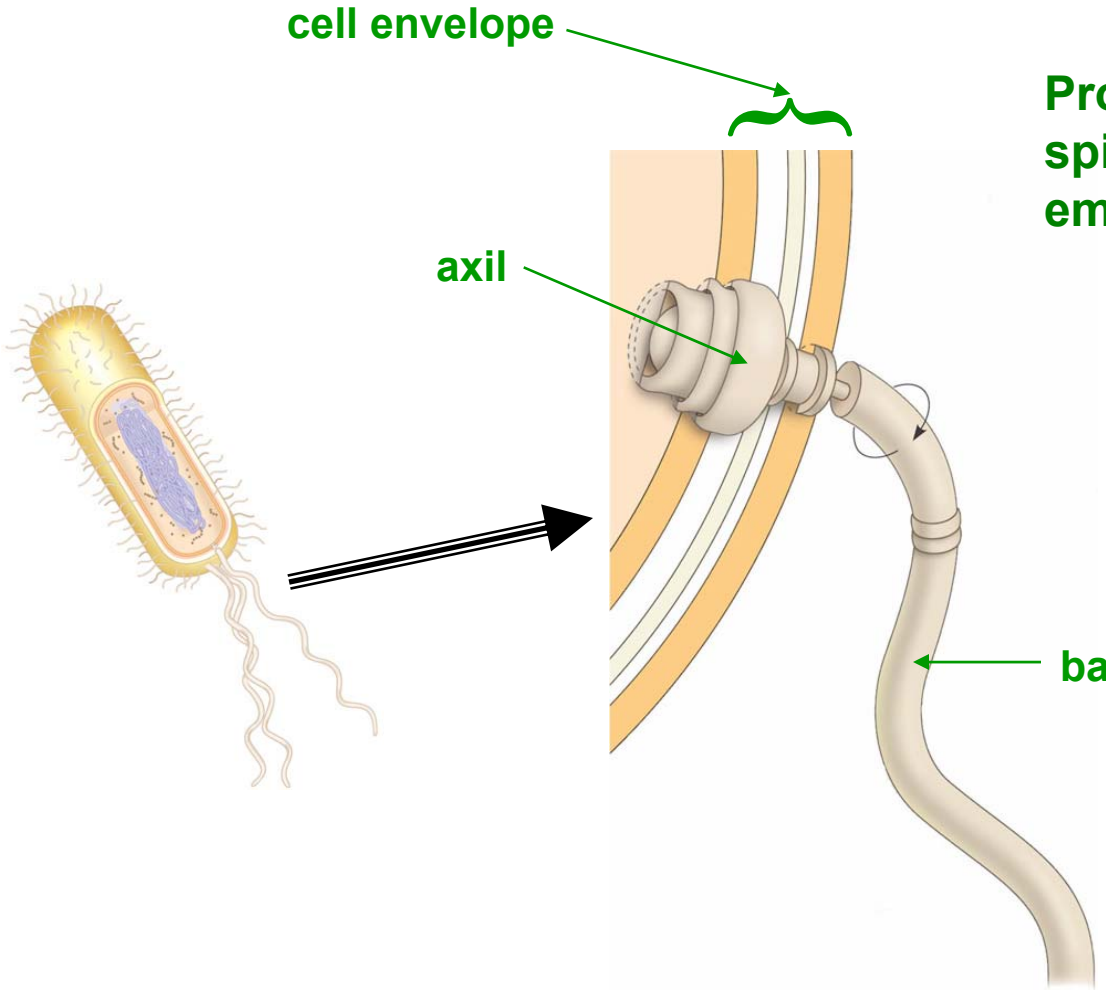
Prokaryotic Flagellum

From textbook Fig. 27.6, p. 536



Prokaryotic flagella function by spinning on an axle that is embedded in the cell envelope.

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Summary

Some Characteristic Features of the Cells of Prokaryotes

- They are typically less than 5 μm in diameter.
- They have relatively simple shapes, typically spherical, rod-like or spiral.
- Most have no internal membrane-bounded organelles.
- Most occur as single cells, or else as simple organizations of several cells, with no communication between cells.
- They contain relatively small and light (70S) ribosomes. Most other occlusions within the cytoplasm are molecules to be used as a reserve of stored food and/or energy, packets of enzymes, viruses, or waste products of metabolism.
- Their cell envelop typically consists of a plasma membrane surrounded by an outer membrane or membrane-like structure.
- Their genetic material typically consists of a single circular molecule of DNA. Some kinds also contain one or more plasmids.
- Most kinds have substance external to the cell envelope such as a sheath, fimbriae and/or bacterial flagella.

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