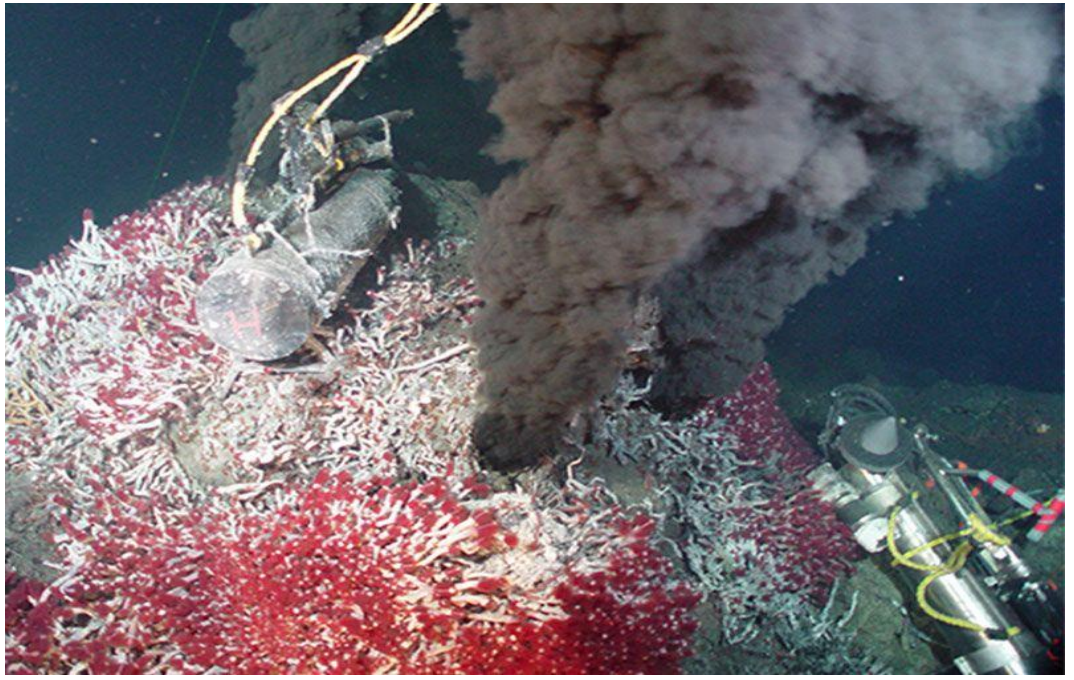
Domain Bacteria & Archaea

The Prokaryotes

- Prokaryotes thrive almost **everywhere**, including places too acidic, salty, cold, or hot for most other organisms
- There are more prokaryotes in a handful of fertile soil than the number of people who have ever lived
- **Prokaryotes** are divided into two domains: **bacteria** and **archaea**

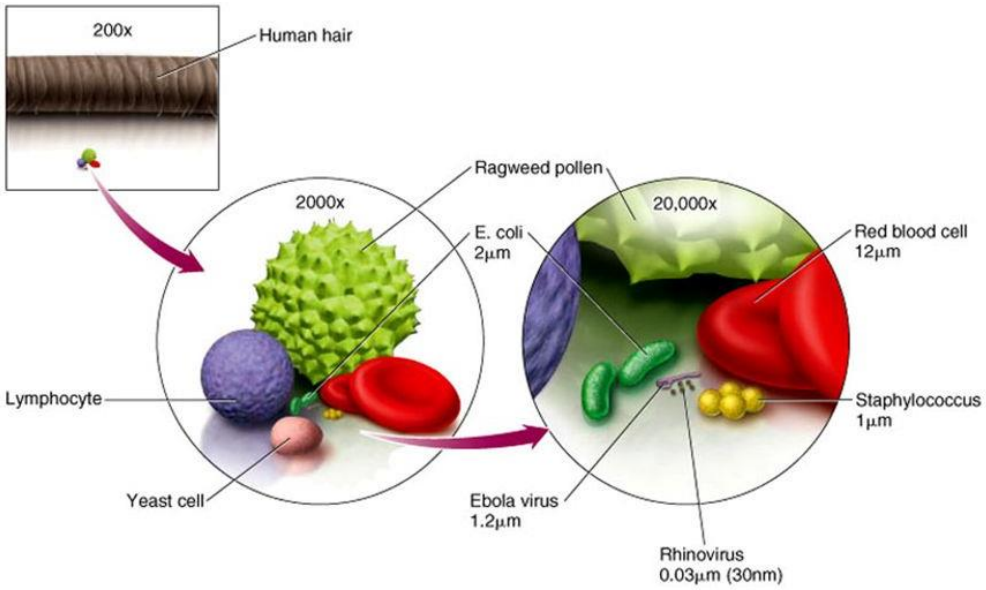


Orange and yellow colonies of thermophilic prokaryotes grow in the hot water of Yellowstone National Park's Grand Prismatic Spring

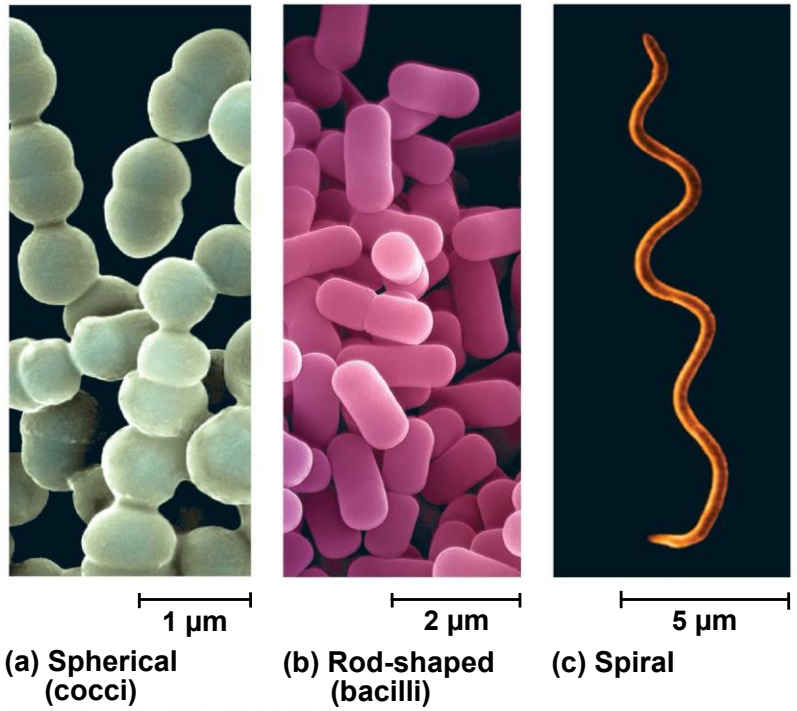


Hyperthermophilic bacteria that live on high-temperature, high-pressure hydrothermal vents in the Pacific Ocean

- Most prokaryotes are **unicellular**
- Most prokaryotic cells are **0.5–5 µm**, much smaller than the 10–100 µm of many eukaryotic cells
- Prokaryotic cells three **most common shapes** are **spheres (cocci), rods (bacilli),** and **spirals**
- Prokaryotes reproduce **asexually quickly** (some can divide every 10 min) by **binary fission**



https://learn.genetics.utah.edu/content/cells/scale/



Prokaryotic Cell Structural Organization

1. Internal structures

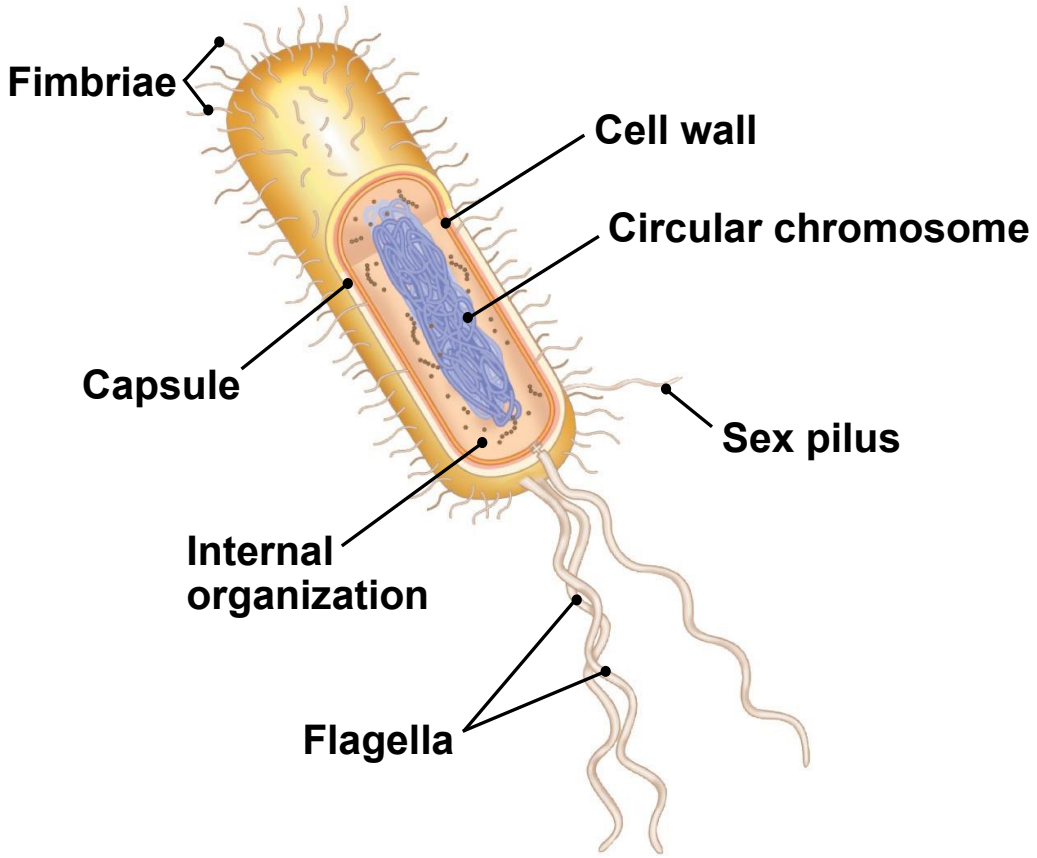
- **In all prokaryotes:** cytoplasm, chromosome, and ribosomes
- **In some prokaryotes:** plasmids and endospores

2. Cell surface (envelope)

- **In all prokaryotes:** cytoplasmic membrane and cell wall
- **In some prokaryotes:** capsule

3. External structures

- **In some prokaryotes:** flagella and pili/fimbriae



Some Distinguishable Prokaryotic cell Structures

Cell wall

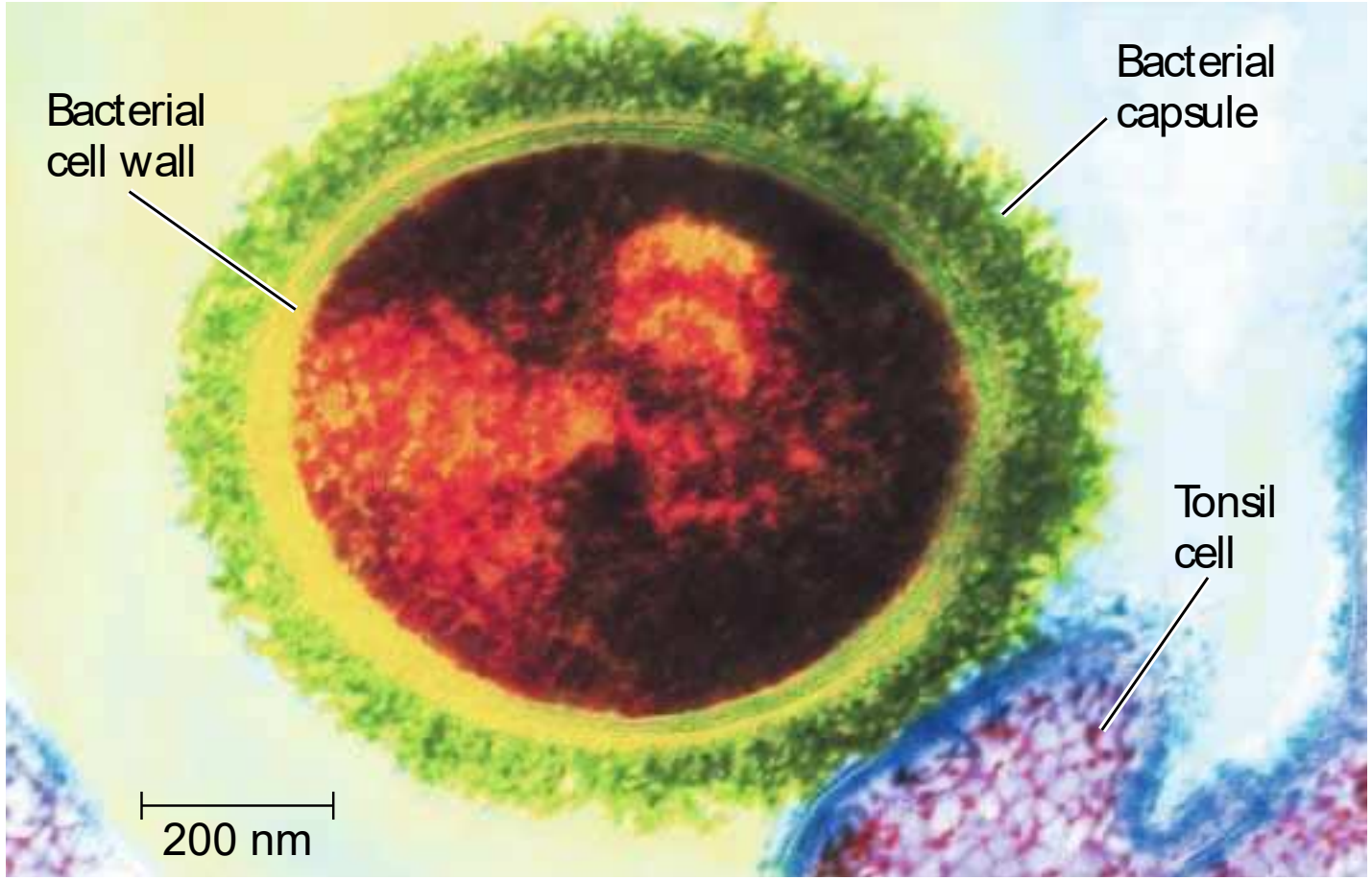
- An important feature of nearly all prokaryotic cells is their **cell wall**, which **maintains** cell shape, provides physical **protection**, and **prevents** the cell from **bursting** in a hypotonic environment
- Bacterial cell walls made of **peptidoglycan;** a network of sugar polymers cross-linked by polypeptides.

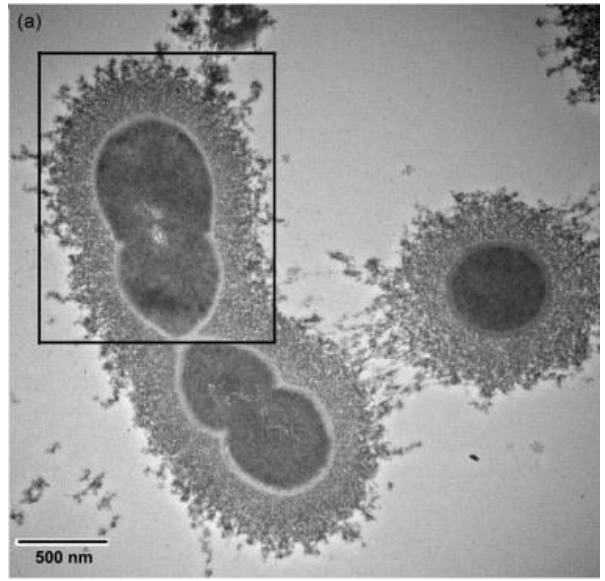
Capsule

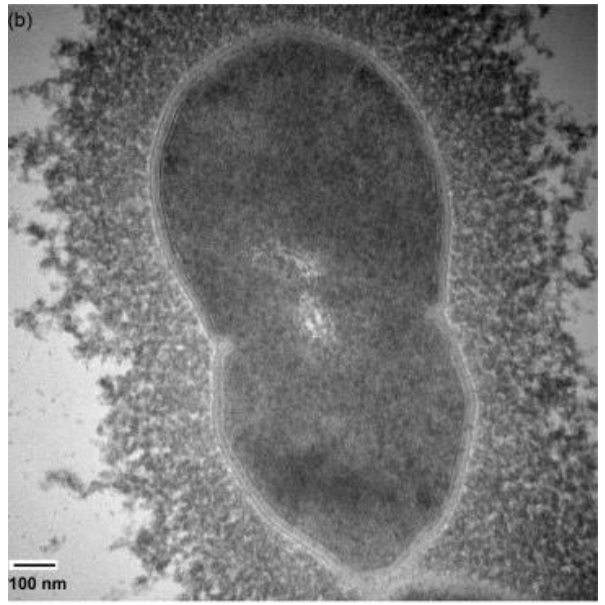
- The cell wall of many prokaryotes is surrounded by a sticky layer of polysaccharide or protein, which is called a **capsule**
- The capsule enables prokaryotes to **adhere** to their substrate or to other individuals in a colony, protect against **dehydration**, and some capsules **shield** pathogenic prokaryotes from attacks by their host's immune system

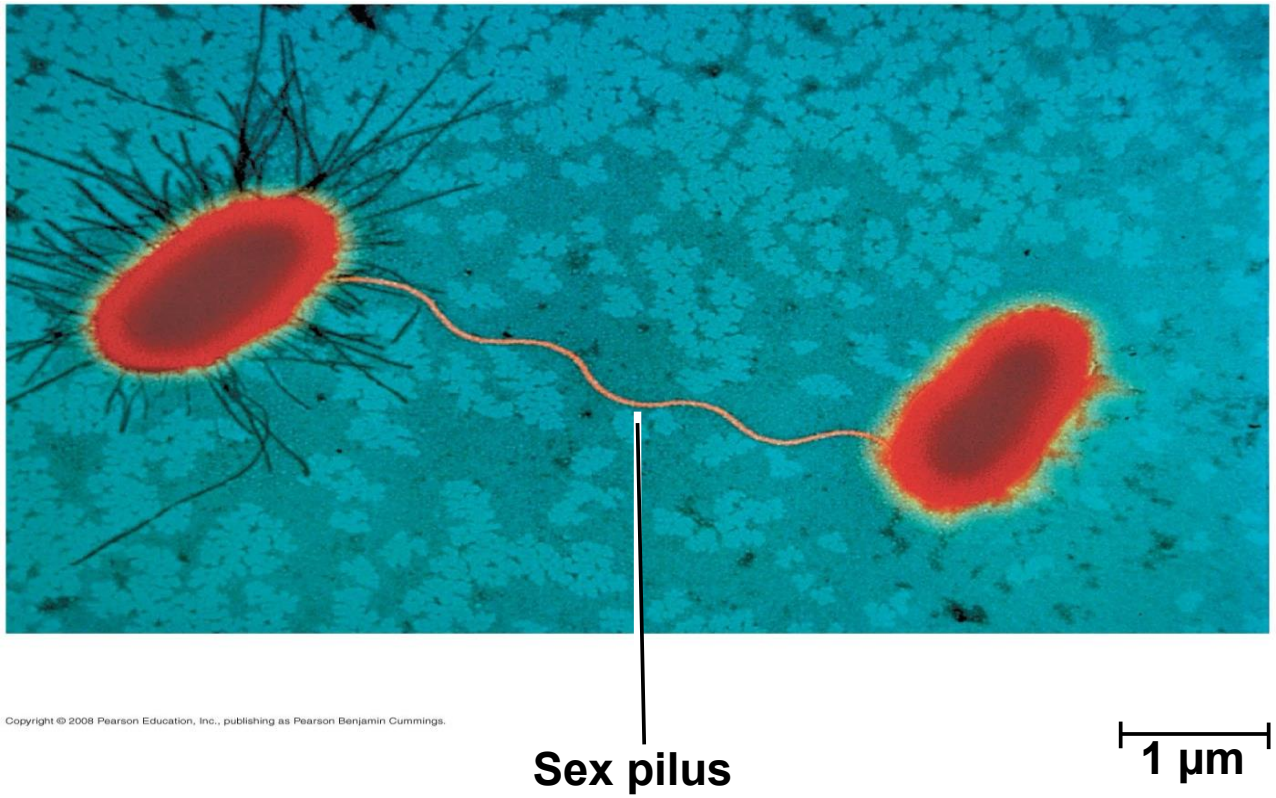
Pili/fimbriae

- Some prokaryotes have **fimbriae** (also called **attachment pili**), which allow them to **stick** to their substrate or other individuals in a colony
- **Sex pili** are longer than fimbriae and allow prokaryotes to exchange DNA by **conjugation**

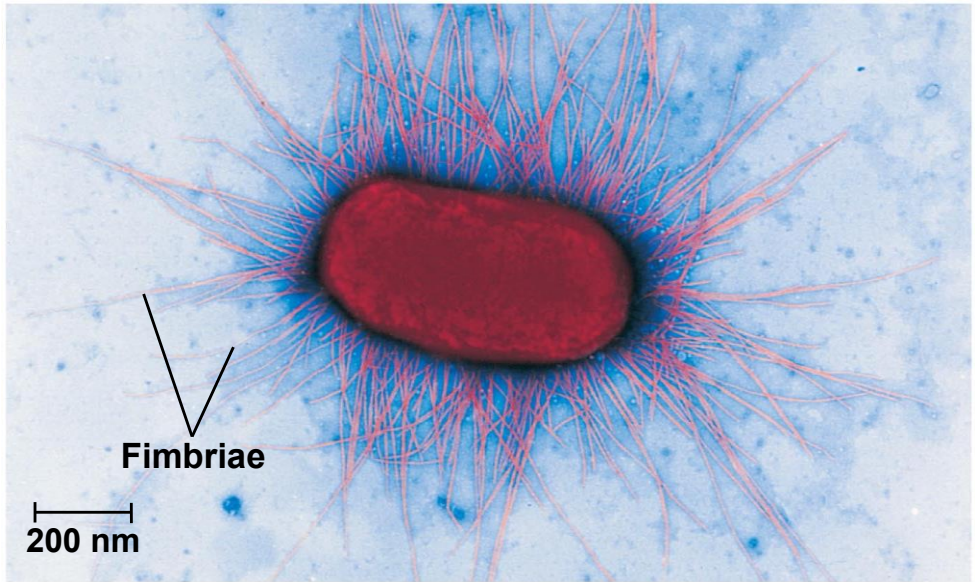

Bacterial cell wall
Bacterial capsule
Tonsil cell
200 nm

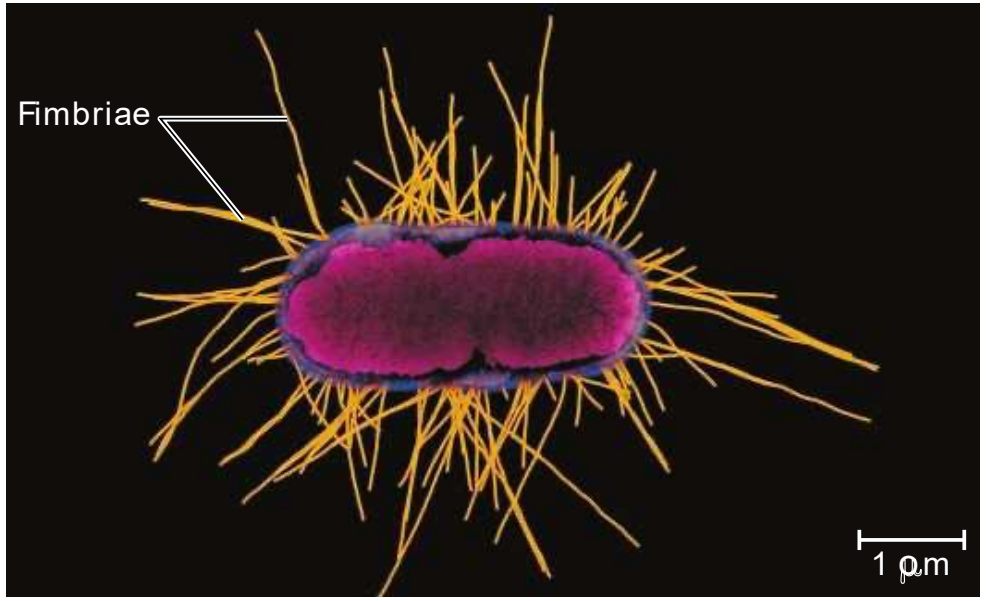

(a)
500 nm


(b)
100 nm



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Some Distinguishable Prokaryotic cell Structures

Flagella

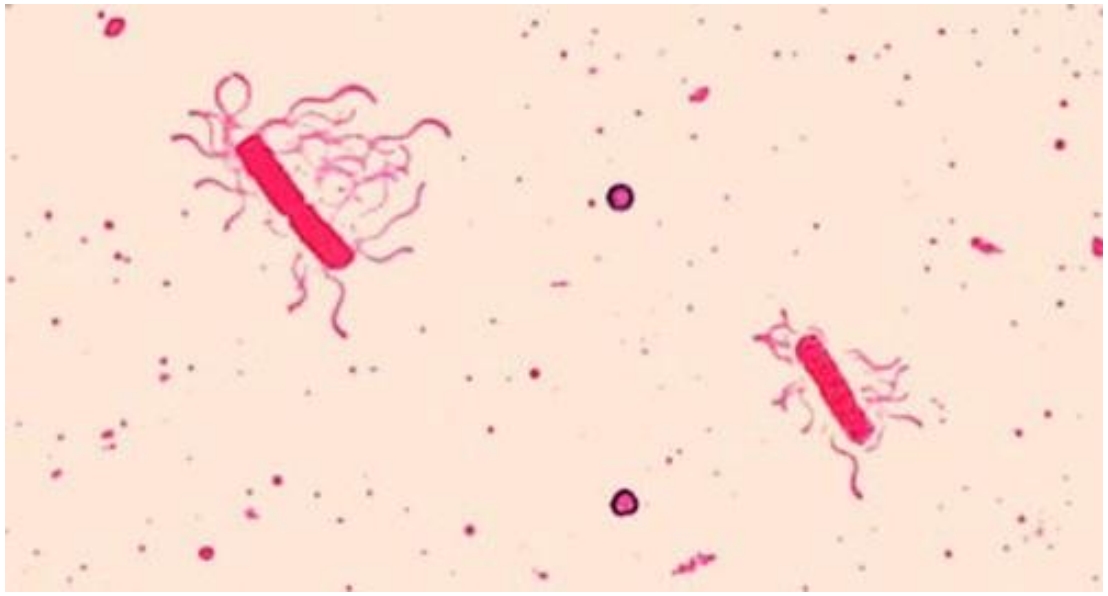
- Most **motile bacteria** move themselves by **flagella** that are structurally and functionally different from eukaryotic flagella
- They can move toward or away from a stimulus. For example, they may move toward nutrients or oxygen or away from a toxic substance

Endospores

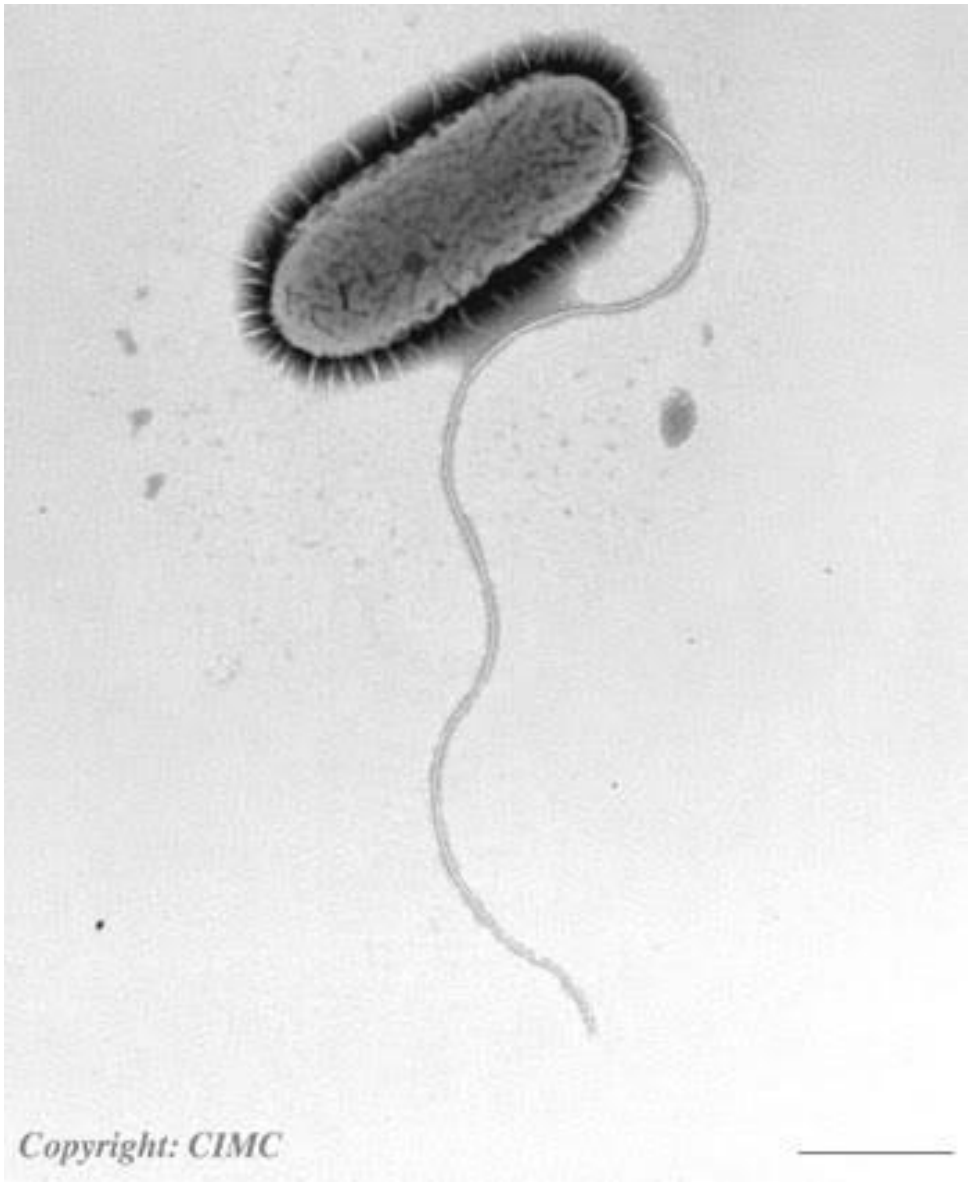
- Many prokaryotes form metabolically inactive **endospores**, which can remain **dormant** and viable in **harsh conditions** for centuries

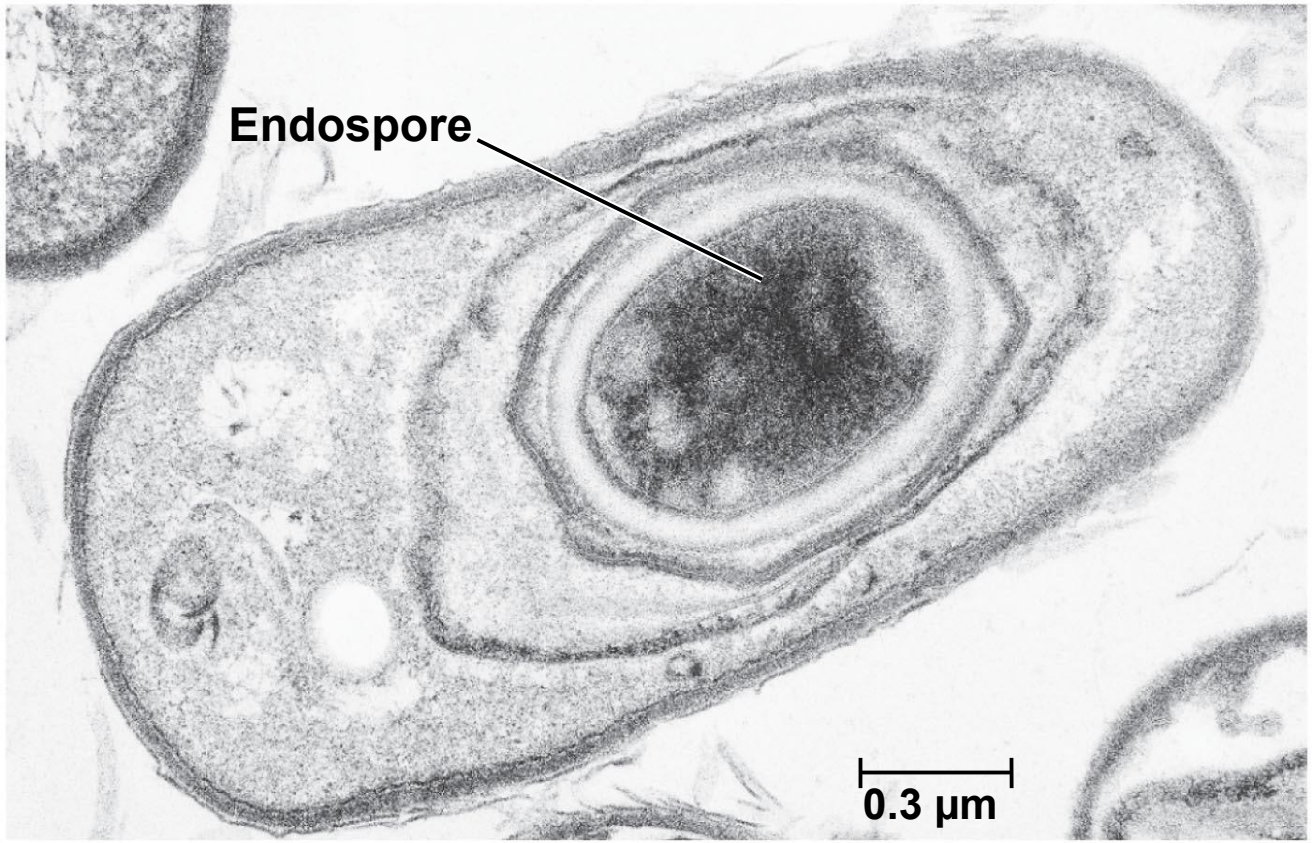
Genome

- The prokaryotic genome has **less DNA** than the eukaryotic genome
- Most of the genome consists of a **circular chromosome** that is NOT contained within a nucleus, but rather located in the irregularly shaped region known as the nucleoid
- Some species of bacteria also have smaller rings of **extra-chromosomal** DNA called **plasmids**

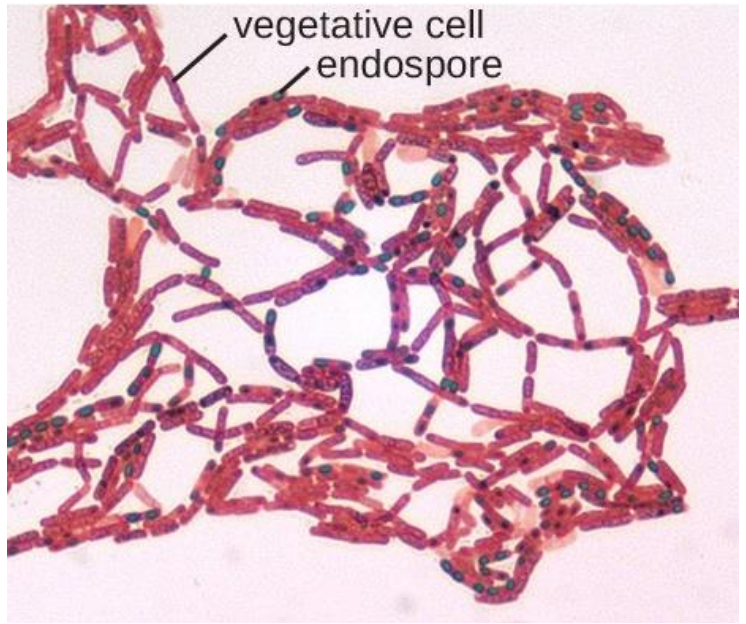


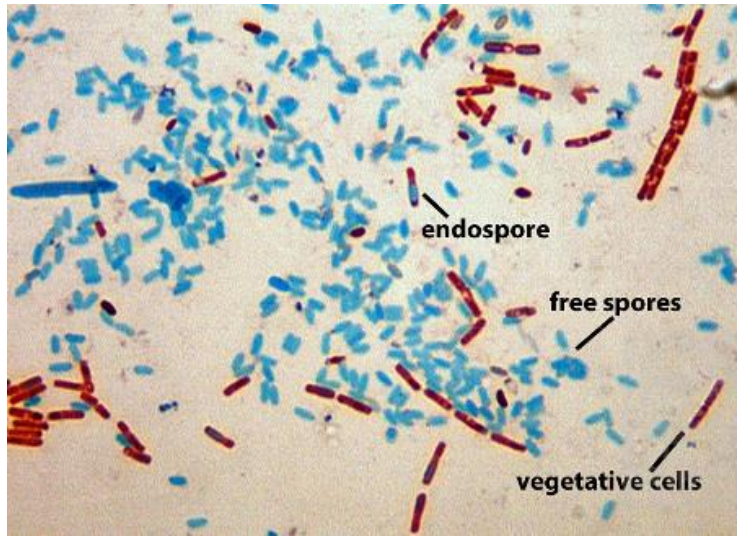


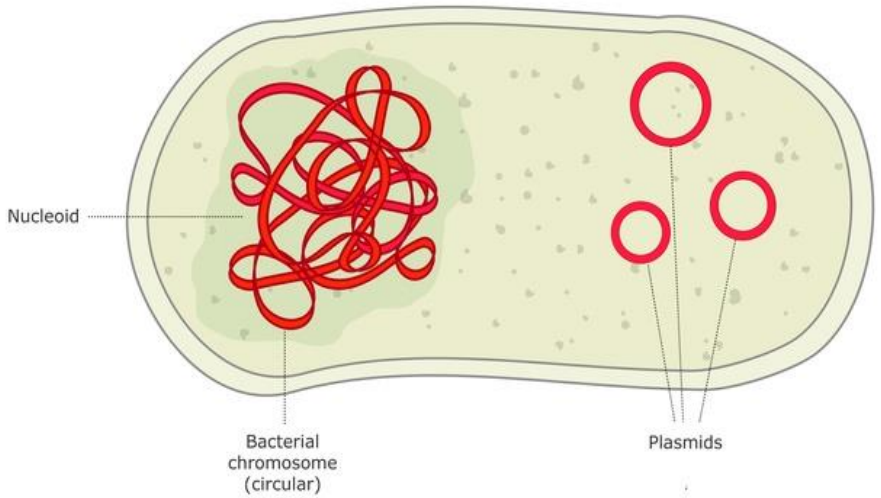

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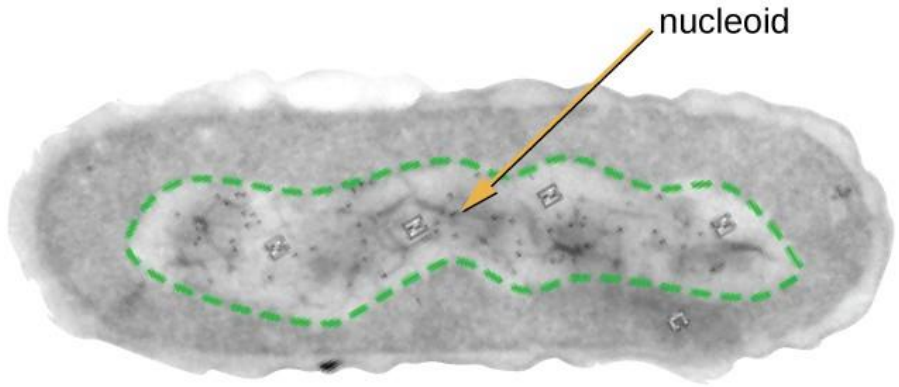


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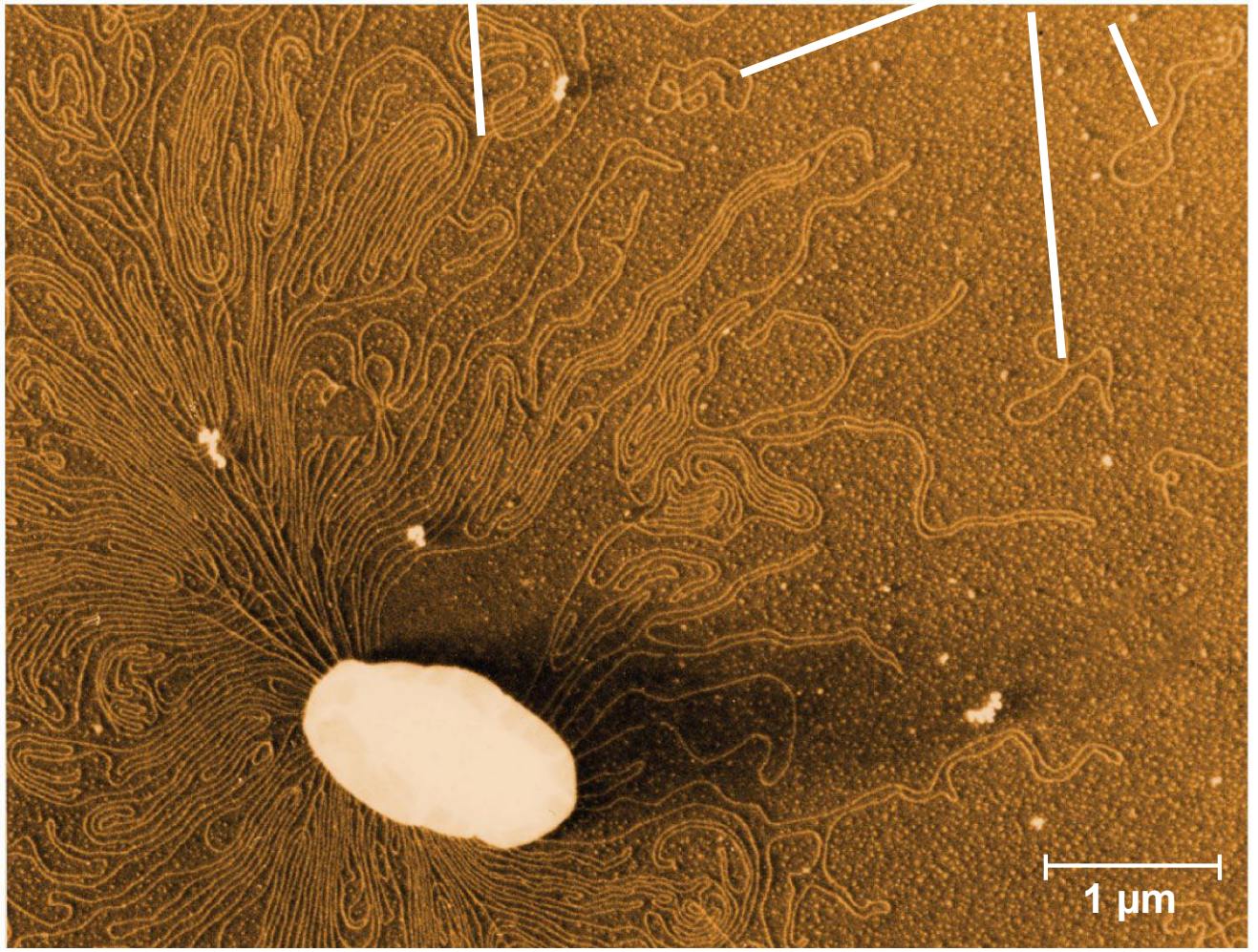




Single Circular Chromosome

Plasmids

smaller DNA rings



Nutrition in Prokaryotes

Diverse nutritional and metabolic adaptations have evolved in prokaryotes:

- **Phototrophs** obtain energy from light
- **Chemotrophs** obtain energy from chemicals
- **Autotrophs** require CO_2 as a carbon source
- **Heterotrophs** require an organic nutrient to make organic compounds

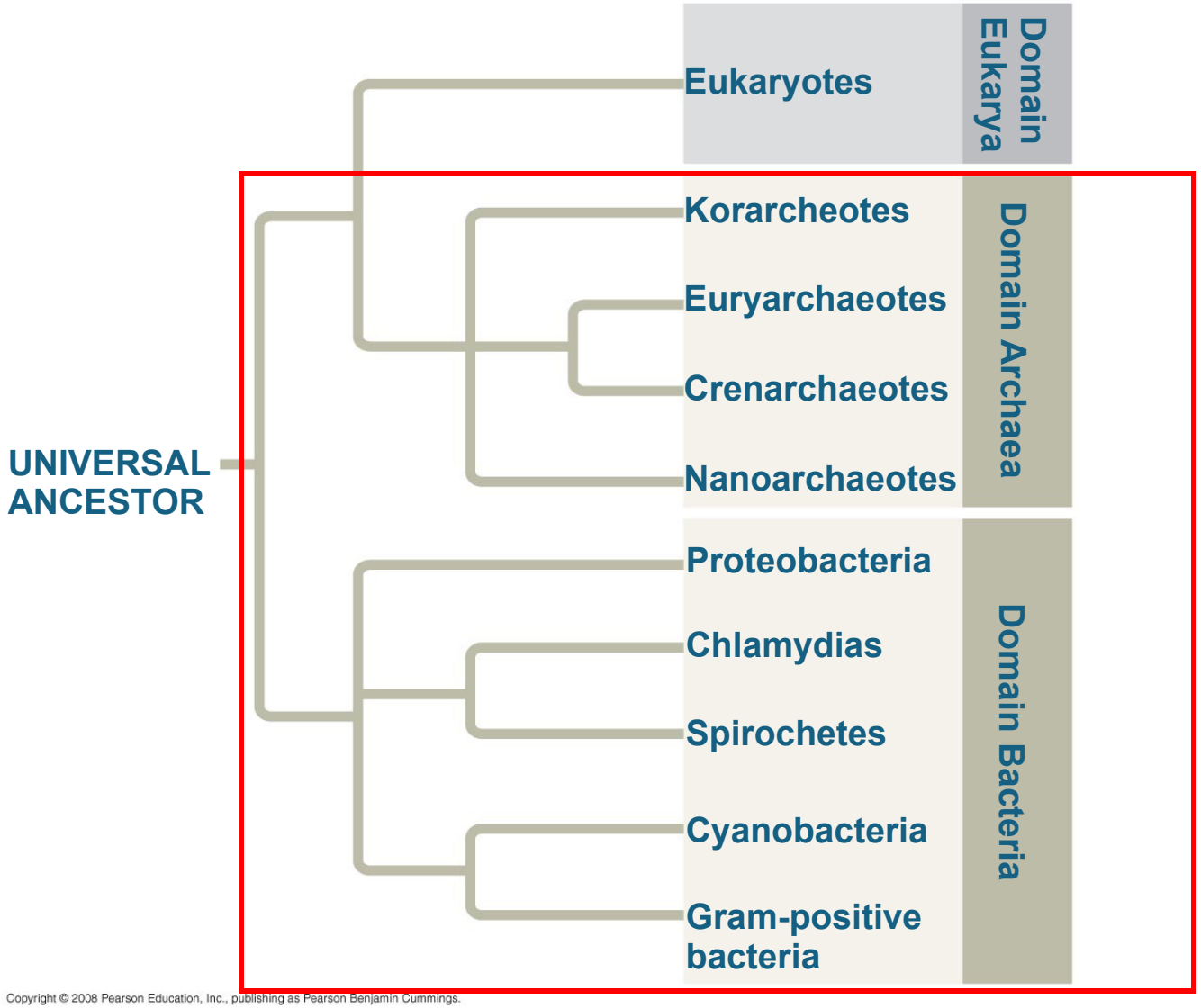
These factors can be combined to give the four major modes of nutrition: photoautotrophy, chemoautotrophy, photoheterotrophy, and chemoheterotrophy.

Table 27.1 Major Nutritional Modes

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photoautotroph	Light	CO_2	Photosynthetic prokaryotes (for example, cyanobacteria); plants; certain protists (for example, algae)
Chemoautotroph	Inorganic chemicals	CO_2	Certain prokaryotes (for example, *Sulfolobus*)
Heterotroph			
Photoheterotroph	Light	Organic compounds	Certain prokaryotes (for example, *Rhodobacter, Chloroflexus*)
Chemoheterotroph	Organic compounds	Organic compounds	Many prokaryotes (for example, *Clostridium*) and protists; fungi; animals; some plants

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Phylogenetic Classification of Prokaryotes

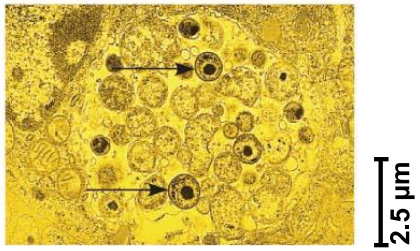


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1. Domain Bacteria

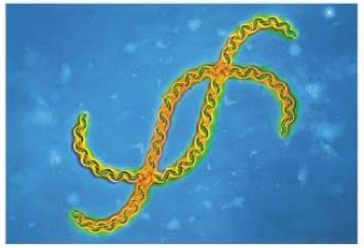
- Bacteria include the **vast majority of prokaryotes** of which **most people are aware** from the pathogenic to the beneficial species
- **Diverse nutritional types** are scattered among the major groups of bacteria as shown below:

CHLAMYDIAS



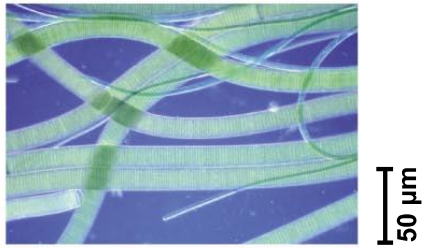
Parasitic bacteria that live within animal cells

SPIROCHETES



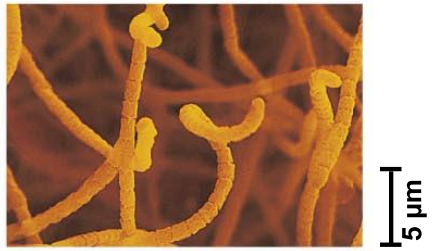
Many are free-living, but others are pathogenic parasites

CYANOBACTERIA



Photoautotrophs that generate O_2

GRAM-POSITIVE BACTERIA



Diverse group of bacteria

2. Domain Archaea

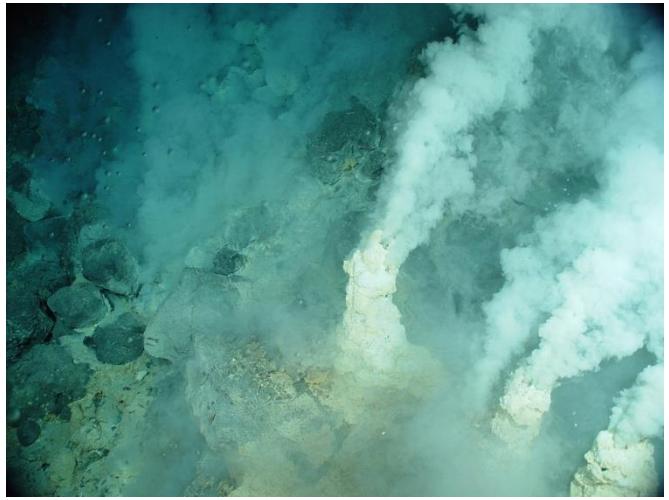
- Archaea are prokaryotes and share certain traits **with bacteria and other traits with eukaryotes**
- Archaea are famous for their **love of living in extreme environments**
- Only archaea are **known to produce methane, know as methanogens**

Spain's Rio Tinto river



Extremely acidic & Full of heavy metals

Hydrothermal vents



The surrounding water can reach over 300 °C

Deep Lake in East Antarctica



Very cold & ultra-salty

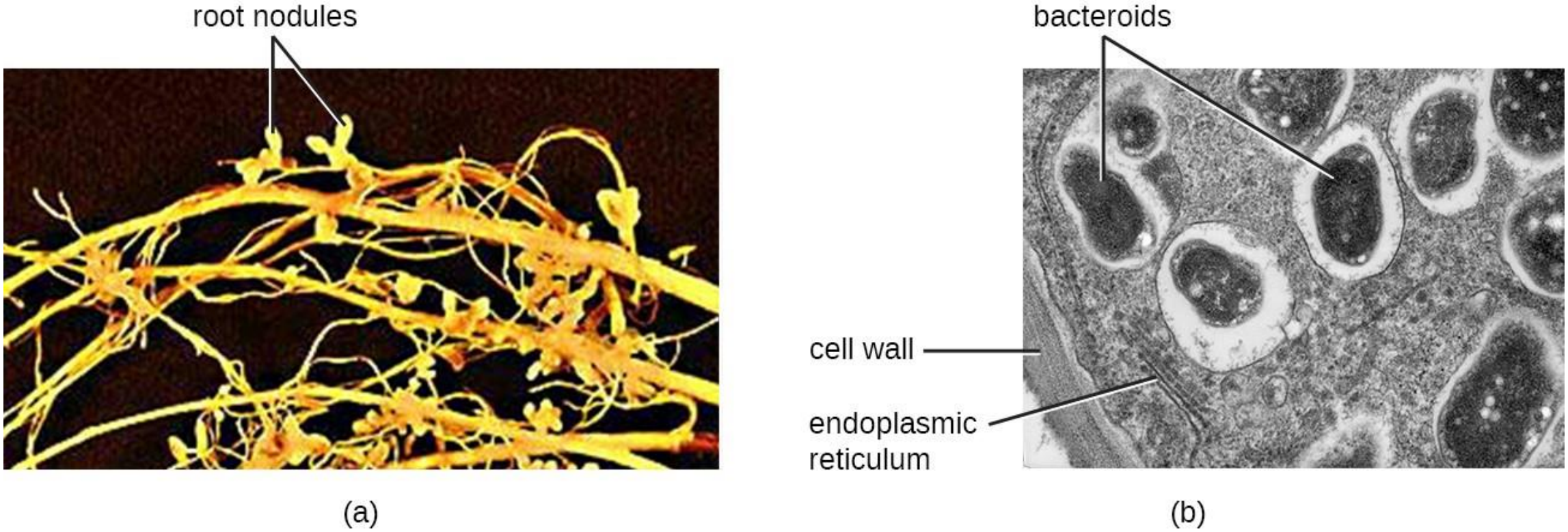
Beneficial Prokaryotes

In the environment

- **Decomposition** by **heterotrophic prokaryotes** and the synthetic activities of **autotrophic and nitrogen-fixing prokaryotes** contribute to the recycling of elements in ecosystems
- Prokaryotes play a central role in many **beneficial ecological interactions**. For instance, members of the **legume family** develop a symbiotic relationship with **Rhizobia bacteria** that operate the nitrogen fixation process

In human

People depend on mutualistic prokaryotes, including hundreds of species that live in our intestines and help digest food.



(a) Nitrogen-fixing bacteria such as *Rhizobium* live in the root nodules of legumes such as clover. (b) This micrograph of the root nodule shows bacteroids (bacterium-like cells or modified bacterial cells) within the plant cells. The bacteroids are visible as darker ovals within the larger plant cell

Beneficial Prokaryotes

In food production

They make a **wide range of food products by fermentation** such as dairy products (cheese and yogurt), meat products (sausages), and vegetable products (pickles)

In industry

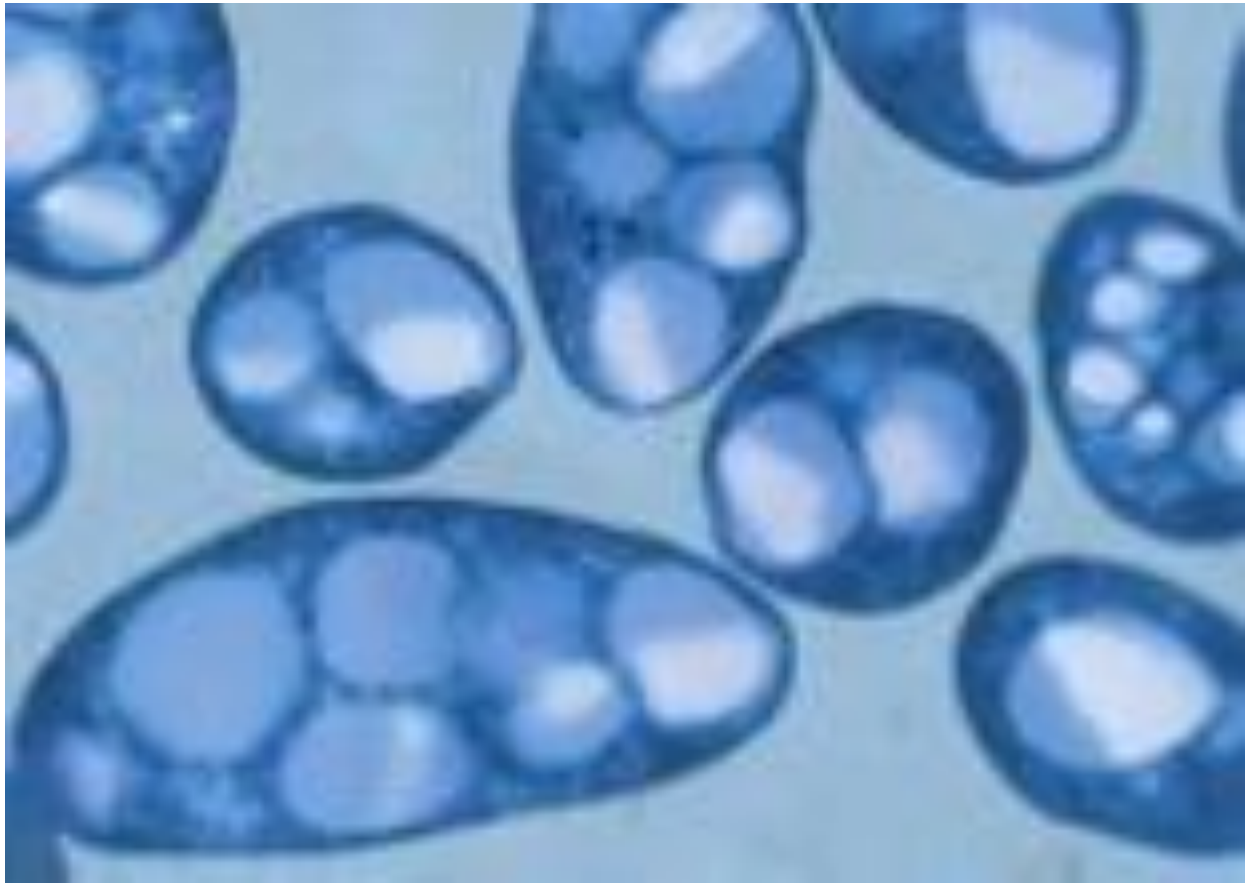
Prokaryotes can be used in **bioremediation** and **production** of plastics, vitamins, antibiotics, and other products

In Research

They are used in **molecular biology, biochemistry and genetic research**, because they **can grow quickly and are relatively easy to manipulate**. Scientists use **bacteria to study how genes and enzymes** work.



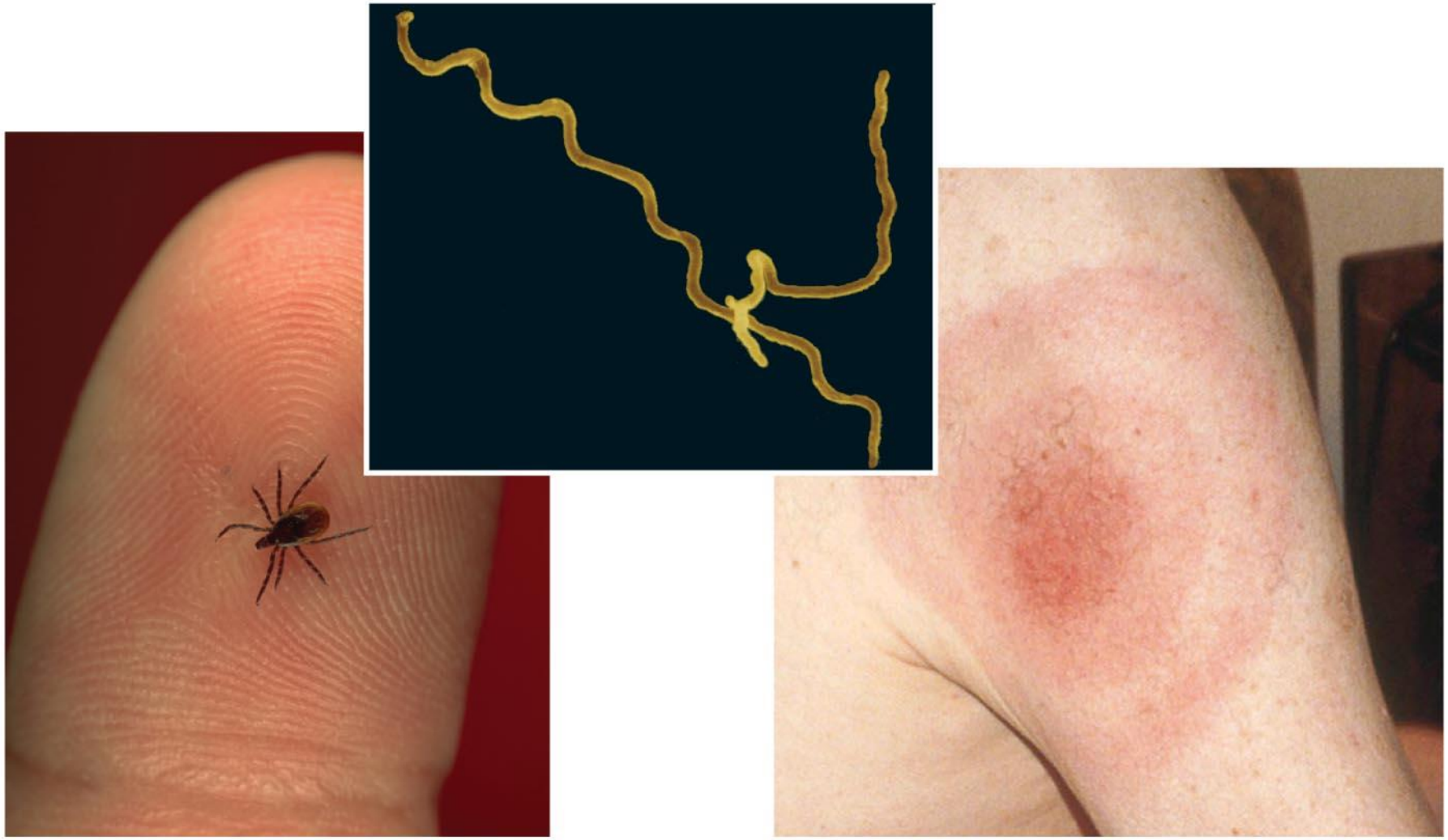
Bioremediation of an oil spill: Spraying fertilizer stimulates the growth of native bacteria that metabolize oil, increasing the speed of the breakdown process up to fivefold



Use of bacteria to produce natural plastics: Bacteria synthesizing and storing PHA (Polyhydroxyalkanoates), a component of biodegradable plastics

Harmful Prokaryotes

- Some types are pathogenic which can **cause diseases** in humans, animals or plants. Examples of human bacterial diseases are strep throat, tuberculosis, and urinary tract infections
- Their growth can **spoil different kind of food** or can pose a **serious health hazard which might lead to food poisoning** when ingested
- Some prokaryotes can **decrease the availability of nutrients in the environment**
- Many pathogenic species are potential **weapons of bioterrorism**



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Pathogens: Bacteria Causing Lyme Disease are transmitted by deer ticks