

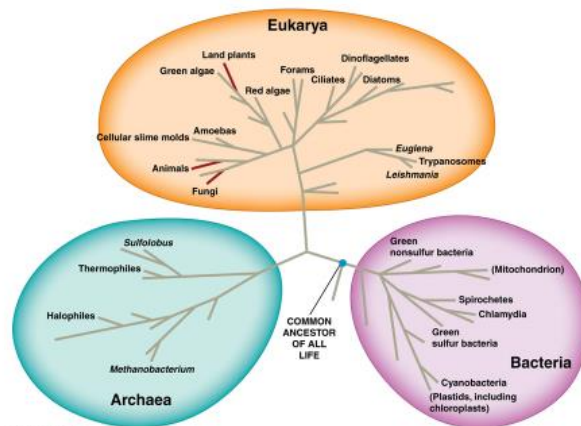
“We learn . . . 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we see and hear, 70% of what we discuss, 80% of what we experience, 95% of what we teach others.”
~ William Glasser

Bacteria and Archaea

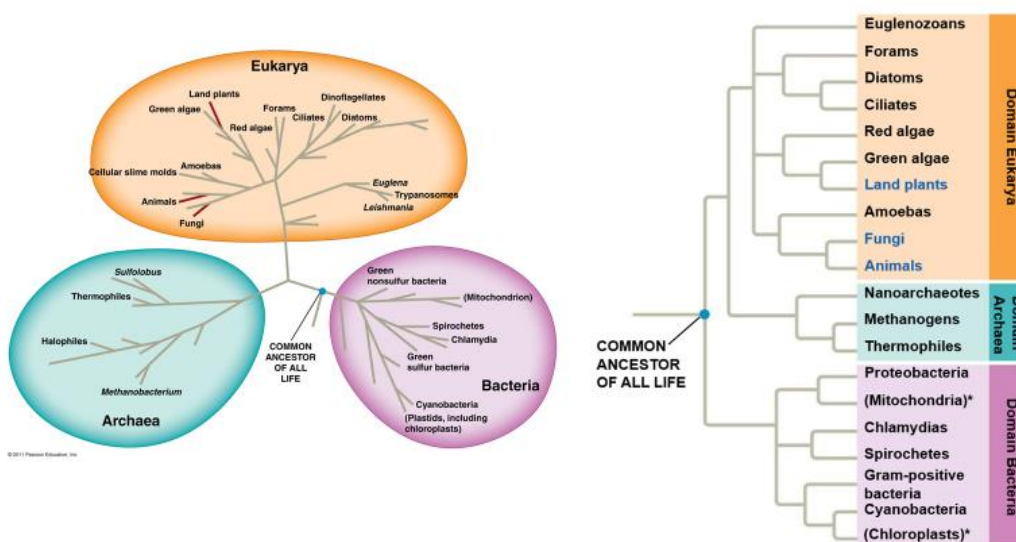
Chapter 27

Domains of Life

- ▶ **Bacteria**
 - ▶ Unicellular prokaryotes
- ▶ **Archaea**
 - ▶ Unicellular prokaryotes
 - ▶ Extremeophiles
- ▶ **Eukarya**
 - ▶ Unicellular and multicellular eukaryotes
 - ▶ Protists
 - ▶ Fungi
 - ▶ Plants
 - ▶ Animals

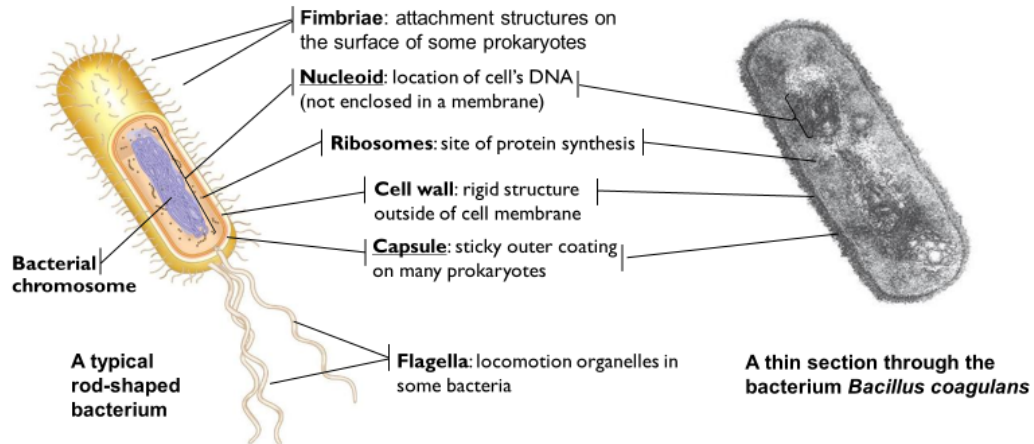


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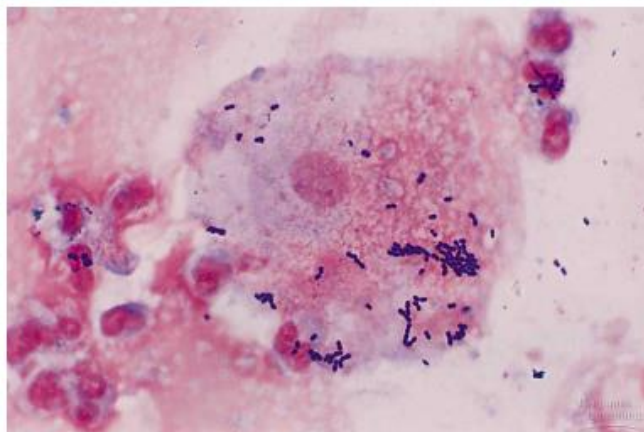
Prokaryotic Cells



Prokaryotic and Eukaryotic Cells

Characteristics	Prokaryotic Cells	Eukaryotic Cells
Cell Size	Small (0.2 – 2.0 μm in diameter)	Large (10 – 100 μm in diameter)
Nucleus	_____ or nucleoli, Nucleoid	Nuclear membrane and nucleoli
Membrane-enclosed organelles	_____	Present (e.g. lysosomes, Golgi complex, mitochondria)
Flagella	Consists of two protein building blocks	Consists of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present, _____ (bacteria)	Chemically simple when present (cellulose and chitin)
Plasma membrane	No carbohydrates, typically lack sterols	Sterols and Carbohydrates serve as receptors
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton, cytoplasmic streaming
Ribosomes	Smaller size (____)	Larger size (____), smaller size (70S) in organelles
Chromosomes (DNA)	Usually _____ chromosome	_____ chromosomes
Cell division	_____	Involves mitosis
Sexual Recombination	None, transfer of DNA only	Involves meiosis

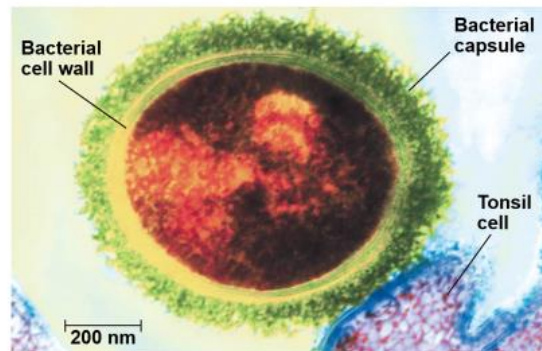
Prokaryotic and Eukaryotic Cells



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Bacteria Capsule

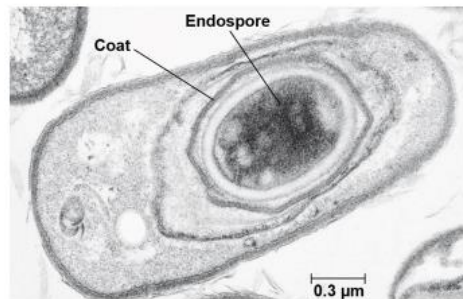
Capsule: sticky outer layer of _____ that enables bacteria to adhere to substrates or other individuals in the colony



Bacterial Endospore

Endospore: structure consisting of a copy of the bacterium's chromosome protected by a _____

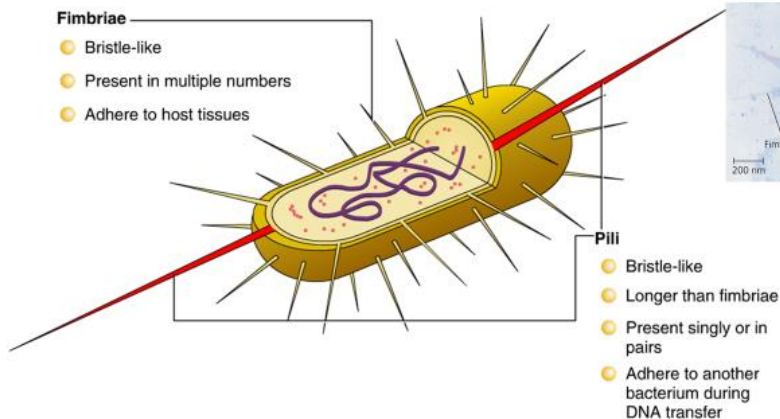
- ▶ Resistance to _____ conditions



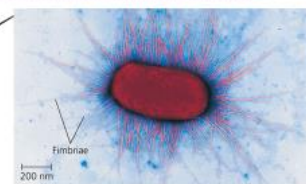
Prokaryotic Fimbriae and Pili

Fimbriae

- Bristle-like
- Present in multiple numbers
- Adhere to host tissues



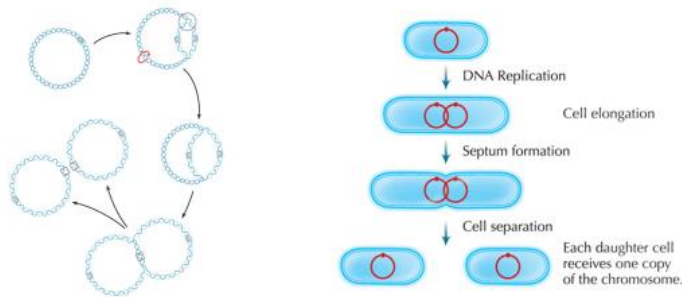
- ### Pili
- Bristle-like
 - Longer than fimbriae
 - Present singly or in pairs
 - Adhere to another bacterium during DNA transfer



Prokaryotic Reproduction

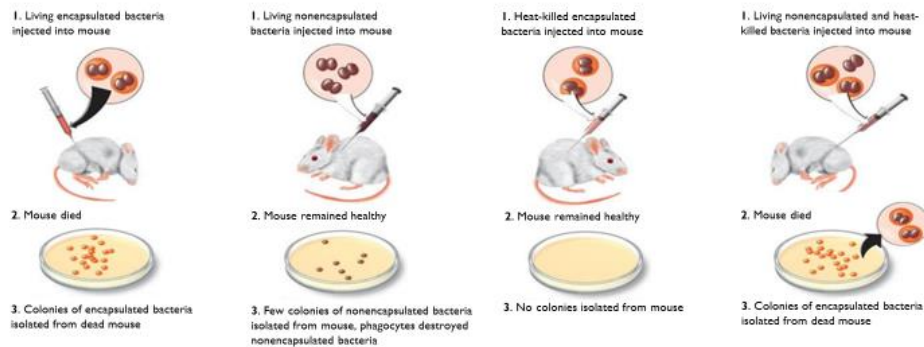
Asexual Reproduction

- Binary fission: DNA replicates and then the cell divides into two separate cells



Genetic Recombination

Transformation: DNA of prokaryotic cells are altered by the uptake of foreign DNA from its surroundings.

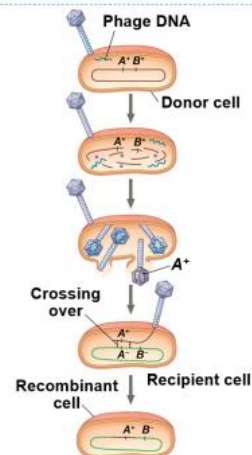


Genetic Recombination

Transduction: bacteriophages (viruses) transfer DNA from one host cell to another.

- Crossing over incorporates new genetic material into recipient cell DNA creating recombinant cell

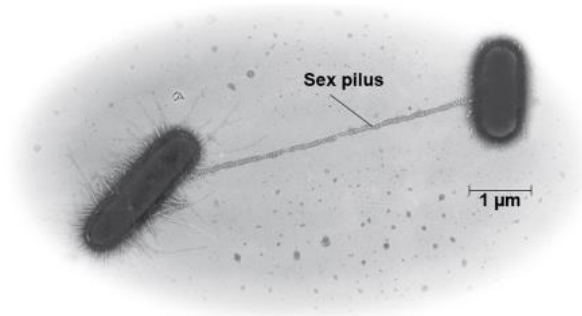
- 1 Phage infects bacterial donor cell with A^+ and B^+ alleles.
- 2 Phage DNA is replicated and proteins synthesized.
- 3 Fragment of DNA with A^+ allele is packaged within a phage capsid.
- 4 Phage with A^+ allele infects bacterial recipient cell with A^- allele.
- 5 Incorporation of phage DNA creates recombinant cell with genotype $A^+ B^-$.



Genetic Recombination

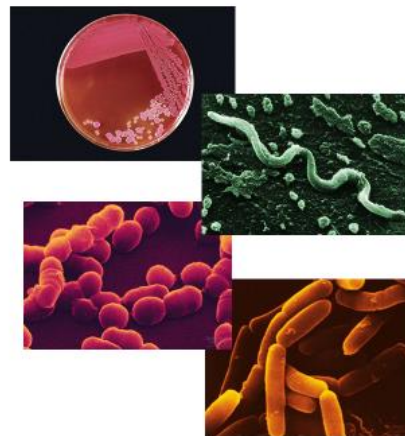
_____ : DNA transferred between two prokaryotic cells that are temporarily joined together.

- ▶ _____ transfer
- ▶ Pili



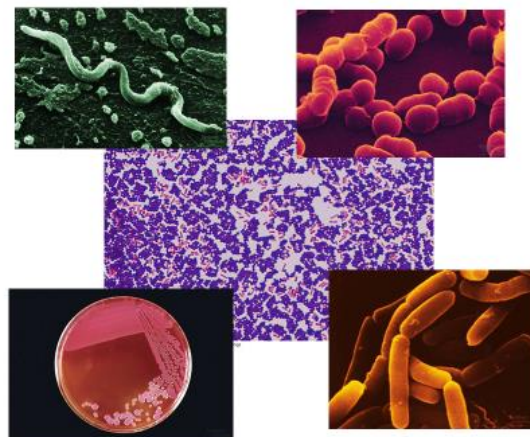
Domain: Bacteria

- ▶ No membrane bound nucleus or organelles
- ▶ Single-celled organisms
- ▶ Asexual reproduction
- ▶ _____ in cell wall separates bacteria from archaea



Classifying Bacteria

- ▶ Shape
- ▶ Gram-stain
- ▶ Oxygen requirements
- ▶ Nutritional requirements



Bacterial Shapes

Coccus or cocci

- ▶ Round or spherical shaped

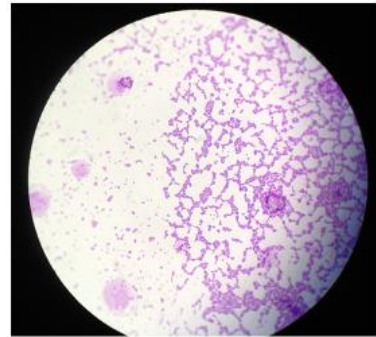
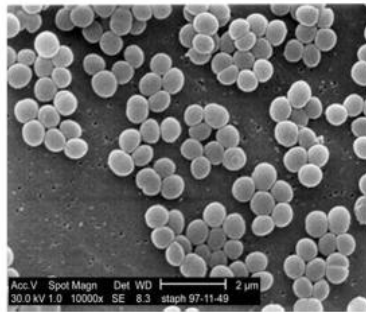
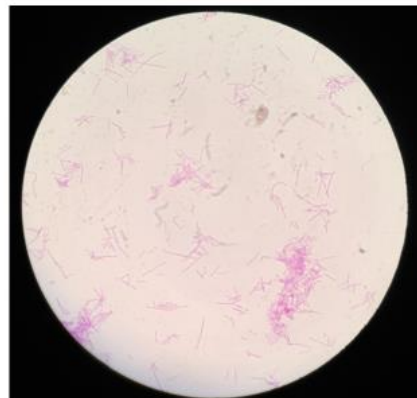
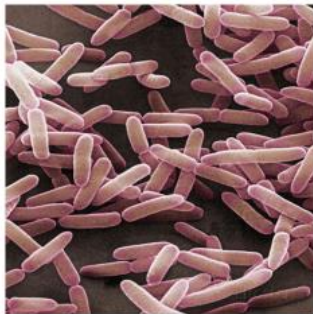


Photo of Gram + bacteria from lab

Bacterial Shapes

Bacillus or Bacilli

- ▶ Rod or pill shaped

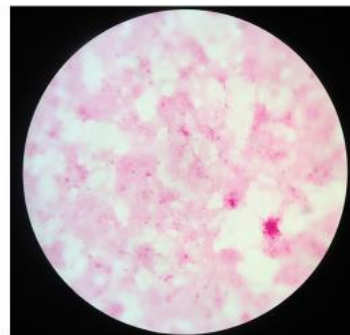


Clostridium tetani from lab photo

Bacterial Shapes

Helical

- ▶ Spiral shaped



Treponema pallidum from lab photo

Bacterial Shapes

Filamentous

- ▶ Elongated “chain” of cells



Cyanobacteria from lab photo

Cell Walls and Gram Staining

Gram staining identifies differences in bacterial cell wall structures

Most bacterial cell walls contain peptidoglycan

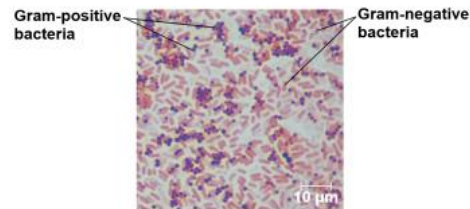
- ▶ _____: a polymer composed of modified sugars cross-linked by short polypeptides
- ▶ Antibiotics inhibit polypeptide formation

The staining procedure is as follows:

1. Application of *crystal violet*
2. Application of iodine
3. Alcohol wash
4. Application of *safranin*

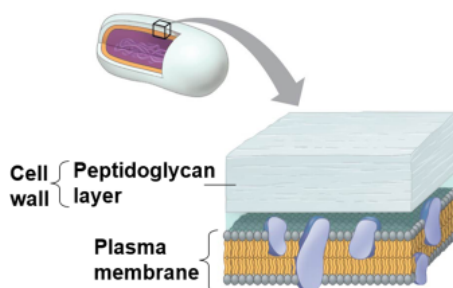
Gram-positive – Violet in Color

Gram-negative – Red in Color



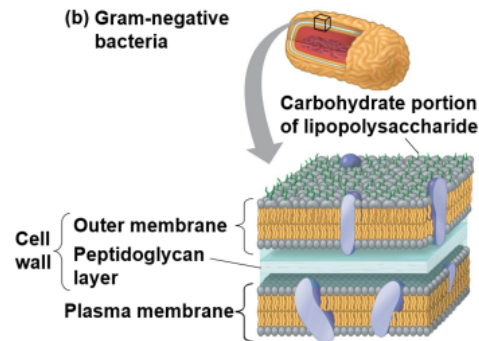
Gram+ and Gram- Bacteria

(a) Gram-positive bacteria



Peptidoglycan traps crystal violet, which masks the safranin dye.

(b) Gram-negative bacteria



Crystal violet is easily rinsed away, revealing the red safranin dye.

Check Your Understanding

True or False: Eukaryotic and prokaryotic cells both have a membrane-bound nucleus

True or False: Spherical shaped bacteria are known as bacillus



Check Your Understanding

The sticky outer coating that enables many prokaryotic cells to stick to each other or their host is known as the _____.

- a. capsule
- b. endospore
- c. cell wall
- d. flagella



Check Your Understanding

The recombination of bacterial DNA as a result of introductions by bacteriophages is known as _____.

- a. conjugation
- b. transformation
- c. transduction
- d. binary fission



Oxygen Requirements

- ▶ **Obligate aerobes:** must use oxygen (O_2) for cellular respiration
- ▶ **Obligate anaerobes:** _____ by oxygen and live by fermentation or anaerobic respiration (ions other than O_2 act as electron acceptors)
- ▶ _____ **anaerobes:** use O_2 if present, but can survive by fermentation or anaerobic respiration in anaerobic environments

Nutritional Requirements

Energy source: how they obtain energy

- ▶ **Phototrophs:** obtain energy from light
- ▶ **Chemotrophs:** obtain energy from _____

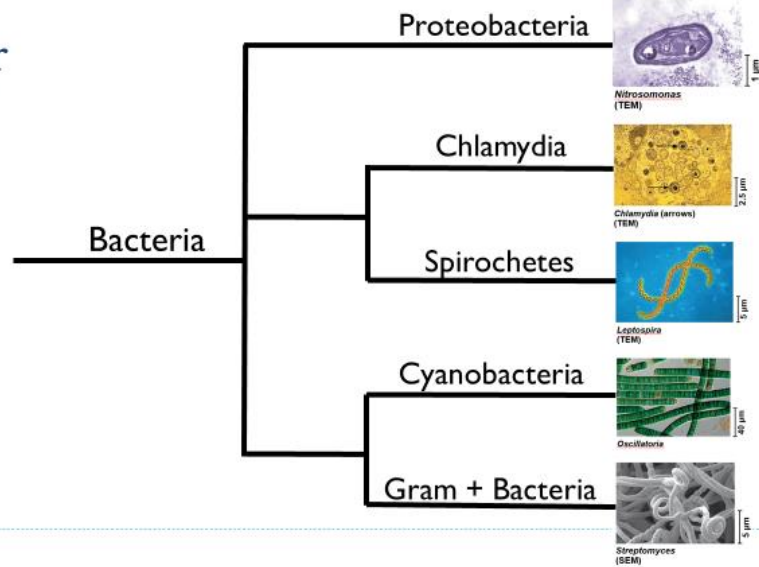
Carbon source: source of carbon used in organic molecules that make up cells

- ▶ **Autotrophs:** need only CO_2 or related compounds for carbon source
- ▶ **Heterotrophs:** require at least one _____ (ex. glucose) to make organic molecules

Nutritional Requirements

	Mode	Energy Source	Carbon Source	Organisms
Autotrophs	Photoautotroph	Light	CO_2	Photosynthetic prokaryotes (cyanobacteria), plants, some protists
	Chemoautotroph	Inorganic compounds (H_2S , NH_3 , or Fe^{2+})	CO_2	Unique to some prokaryotes, usually found in deep sea environments
Heterotrophs	Photoheterotroph	Light	Organic compounds	Unique to some aquatic and salt-loving prokaryotes
	Chemoheterotroph	Organic or inorganic compounds	Organic compounds	Many prokaryotes, protists, fungi, animals, and some plants

Five Major Clades of Bacteria



Bacteria: Proteobacteria

- ▶ Large, diverse group of gram-negative bacteria made up of five subgroups
 - ▶ Group includes pathogens *E. coli*, *Vibrio cholerae*, and *Salmonella*, and *Rhizobium*
 - ▶ _____: finger-like projections for attachment

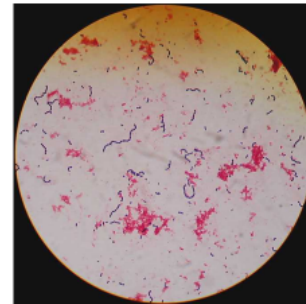
Example: *Escherichia coli* (*E. coli*)

Shape: bacillus

Gram stain: negative

Nutritional requirements: chemoheterotrophs

Oxygen requirements: facultative anaerobic



Bacteria: Chlamydias

- ▶ Parasites that can only survive within animal cells
 - ▶ Intercellular parasite

Example: *Chlamydia trachomatis*

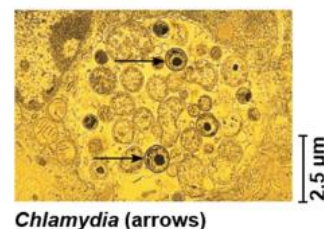
Shape: _____

Gram stain: negative

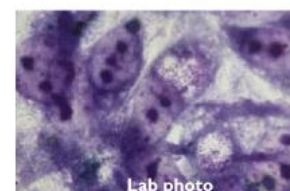
Nutritional requirements: parasitic (heterotrophs)

Oxygen requirements: uncertain

Causes: Blindness, Most common STD in U.S.



Chlamydia (arrows)



Bacteria: Proteobacteria

- ▶ Large, diverse group of gram-negative bacteria made up of five subgroups
 - ▶ Group includes pathogens *E. coli*, *Vibrio cholerae*, and *Salmonella*, and *Rhizobium*
 - ▶ **Fimbriae**: finger-like projections for attachment

Example: *Salmonella*

Shape: bacillus

Gram stain: negative

Nutritional requirements: chemoheterotrophs

Oxygen requirements: _____

Causes: Food poisoning



Bacteria: Spirochetes

- ▶ Some free living, others parasitic
 - ▶ **Fibrils**: flagella like filaments used for movement

Example: *Treponema pallidum*

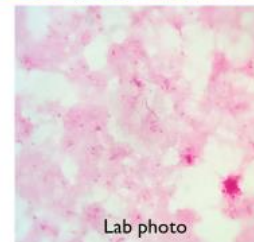
Shape: _____

Gram stain: negative

Nutritional requirements: chemoheterotrophs

Oxygen requirements: anaerobic, but oxygen tolerant

Causes: Syphilis



Bacteria: Spirochetes

- ▶ Some free living, others parasitic
 - ▶ **Fibrils**: flagella like filaments used for movement

Example: *Borrelia burgdorferi*

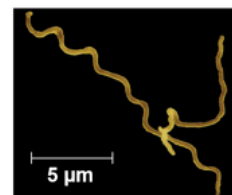
Shape: helical

Gram stain: negative

Nutritional requirements: chemoheterotrophs

Oxygen requirements: _____, but low oxygen requirement

Causes: Lyme disease



Bacteria: Gram Positive Bacteria

- ▶ Large, diverse group of mostly chemoheterotrophic bacteria
- ▶ Endospore

Example: *Clostridium tetani*

Shape: bacillus

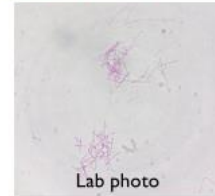
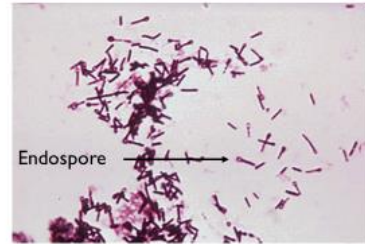
Gram stain: positive

Nutritional requirements: chemoheterotrophs

Oxygen requirements: _____

Causes: lockjaw, tetanus

- ▶ Exotoxin



Bacteria: Gram Positive Bacteria

- ▶ Large, diverse group of mostly chemoheterotrophic bacteria
- ▶ Endospore

Example: *Streptococcus*

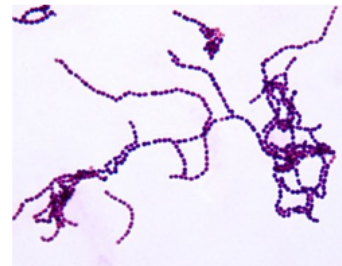
Shape: coccus

Gram stain: positive

Nutritional requirements: chemoheterotrophs

Oxygen requirements: _____, but oxygen tolerant

Causes: Strep throat



Bacteria: Gram Positive Bacteria

- ▶ Large, diverse group of mostly chemoheterotrophic bacteria
- ▶ Endospore

Example: *Staphylococcus*

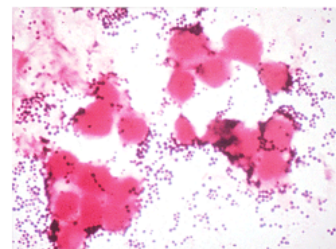
Shape: coccus

Gram stain: positive

Nutritional requirements: chemoheterotrophs

Oxygen requirements: facultative anaerobic

Causes: Food poisoning, toxic shock syndrome



Bacteria: Cyanobacteria

- ▶ Contains Chlorophyll A and phycocyanin
- ▶ Only organism that can _____
_____ (product of photosynthesis)

Example: *Oscillatoria*

Shape: filamentous

Gram stain: no stain

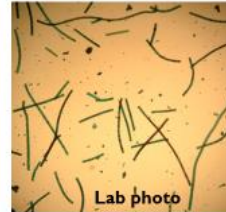
Nutritional requirements: photoautotrophs

Oxygen requirements: facultative anaerobes

Causes: nitrogen fixation and photosynthesis



Oscillatoria

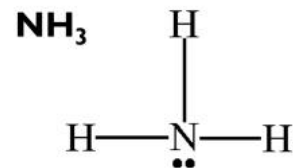
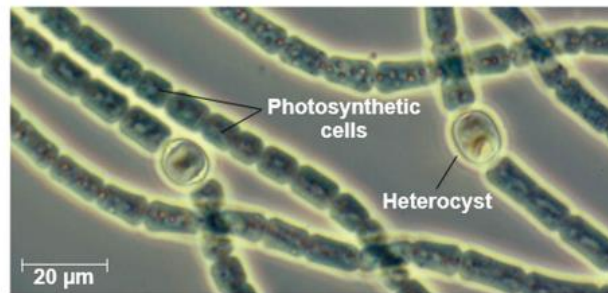


Lab photo

Nitrogen Metabolism

Nitrogen fixation: conversion of _____ (N_2) to ammonia (NH_3)

- ▶ _____ carry out nitrogen fixation
- ▶ Nitrogen used in formation of proteins and organic compounds



Bacteria: Cyanobacteria

_____: layered bio-chemical structures formed through the cementation of bio-films produced by cyanobacteria

- ▶ Oldest known fossils
 - ▶ 3.5 billion years old
- ▶ Only organisms for 1.5 billion years
- ▶ Found in shallow seas

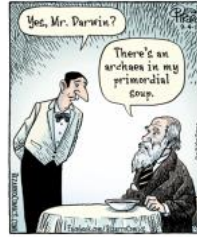


Domain: Archaea

Carl Woese – Prokaryotic cell but similar to Eukaryotes in DNA replication and Protein synthesis

_____: organisms that live grow best in one or more conditions that would kill most organisms

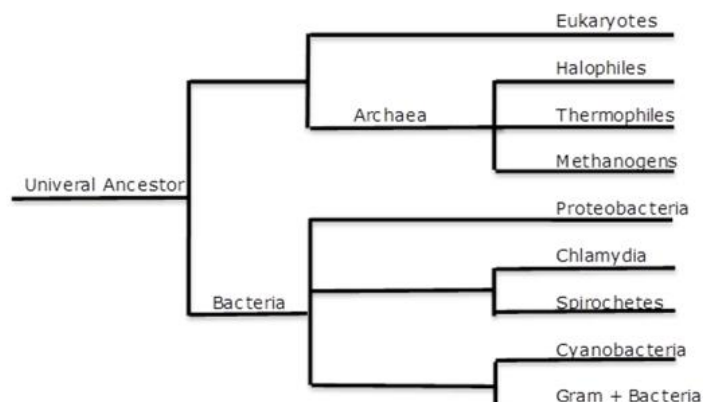
- ▶ **Thermophiles:** live in extremely ____ environments
- ▶ **Halophiles:** live in extremely ____ environments
- ▶ **Methanogens:** Methane releasing archaea that are poisoned by _____



Comparison of Three Domains of Life

Characteristics	Bacteria	Archaea	Eukarya
Nuclear envelope	Absent	_____	Present
Membrane-bound organelles	Absent	_____	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Membrane lipids	Unbranched hydrocarbons	Some branched hydrocarbons	Unbranched hydrocarbons
RNA polymerase	One kind	Several kinds	Several kinds
Initiator amino acid for protein synthesis	Formylmethionine	_____	Methionine
Response to antibiotics	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present in some species	Present
Introns in genes	Very rare	Present in some genes	Present in many genes
Circular chromosome	Present	_____	Absent
Growth at temps above 100°C	No	Some species	No

Comparison of Three Domains of Life



Prokaryotes Role on Earth

Decomposers

- ▶ _____ bacteria breakdown organic matter



Symbiosis with other organisms

- ▶ Mutualism (+ host, + symbiont)
 - ▶ Intestinal bacteria
 - ▶ Sulfate consuming bacteria and methane consuming archaea
- ▶ Commensalism (N/A host, + symbiont)
 - ▶ Bacteria on skin
- ▶ Parasitism (- host, + symbiont)
 - ▶ Pathogens
 - Endotoxins: only release when bacteria die or cell walls break down
 - Exotoxins: released by bacteria



_____ : use of organisms to remove pollutants from soil, air, or water



Check Your Understanding

True or False: Gram-negative bacteria have a thin plasma membrane sandwiched between two layers of peptidoglycan

True or False: Cyanobacteria are the only organism that can perform nitrogen fixation and photosynthesis

True or False: Bacteria and Archaea are both made up of prokaryotic cells



Check Your Understanding

Which of the following modes of nutrient acquisition use inorganic compounds as an energy source and organic compounds as a carbon source?

- a. photoautotrophs
- b. chemoheterotrophs
- c. photoheterotrophs
- d. chemoautotrophs



Check Your Understanding

A bacteria that is poisoned by oxygen and must synthesize energy through fermentation is known as a(n)_____.

- a. obligate anaerobe
- b. obligate aerobe
- c. facultative anaerobe
- d. facultative aerobe

