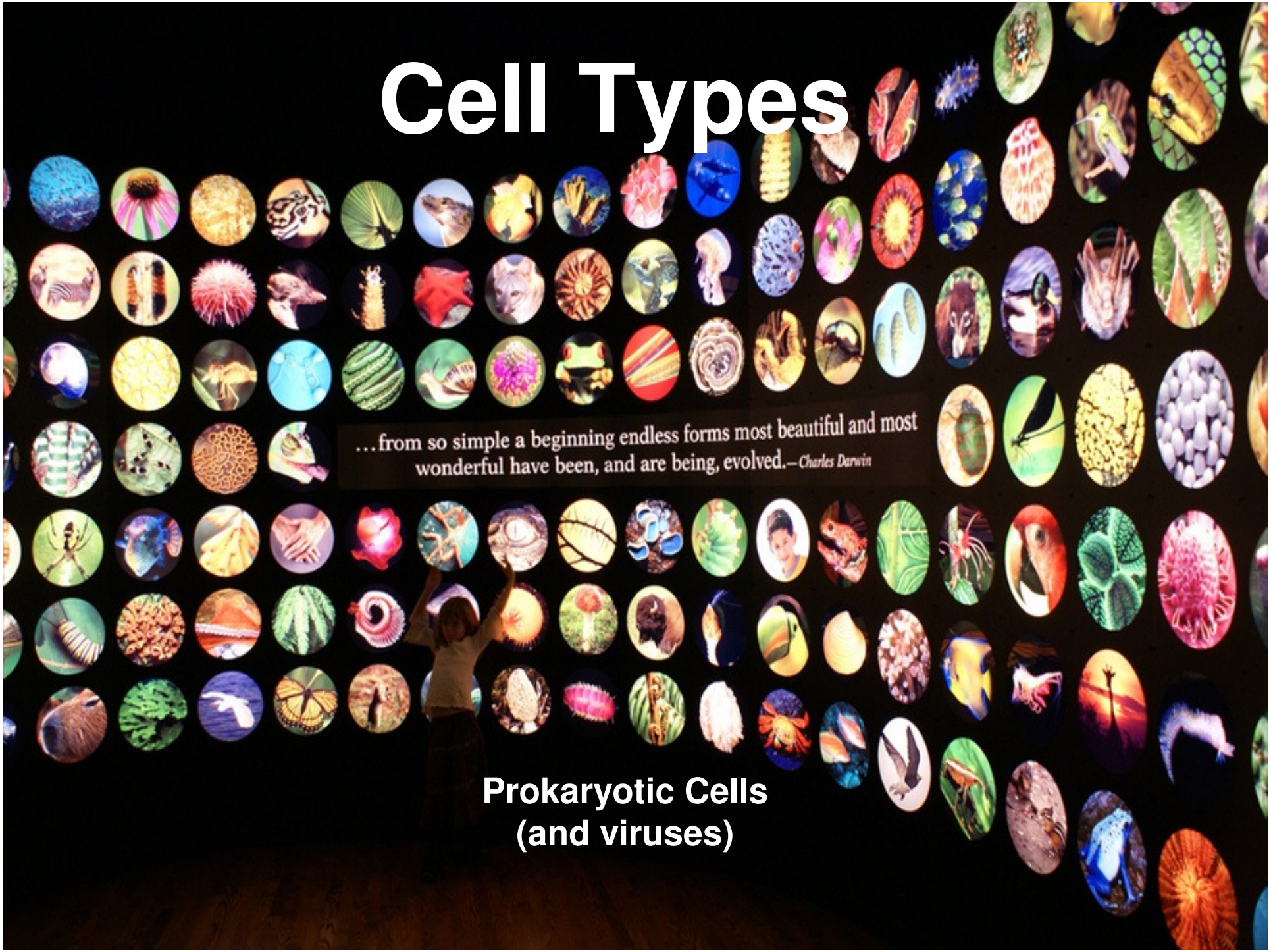
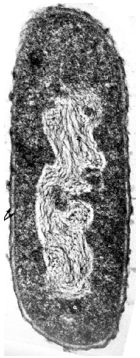
Cell Types

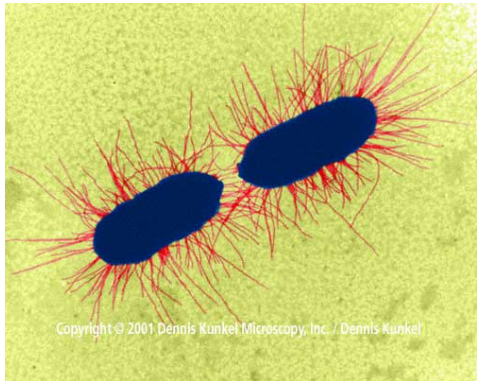


Prokaryotic Cells
(and viruses)

Terminology

- Prokaryotic Cell:
  - Pro karyote = “before” “nucleus”
  - Bacteria & Archaea

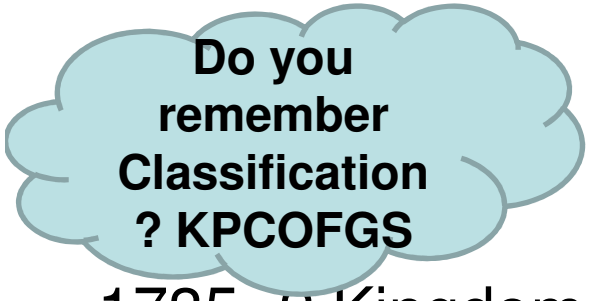




- Eukaryotic:
  - Eu karyote = “true” “nucleus”

  - Plantae, Animalia, Fungi, Protista

The Evolving Understanding of Living Things



- 1735- 2 Kingdoms: Animalia & Vegetalia
- 1866- 3 Kingdoms: Animalia, Plantae, Protista
- 1925- 2 Kingdoms: Eukaryote, Prokaryote
- 1938- 4 Kingdoms: Animalia, Plantae,Protista, Monera
- 1940+- 5 Kingdoms: Animalia, Plantae, Fungi, Protista, Monera
- 1990's- 6 Kingdoms: Animalia, Plantae, Fungi, Protista, Eubacteria, Archaebacteria
- Current-
  - **3 Domains: Archaea, Eubacteria, Eukaryote**
  - 4 Eukaryote Kingdoms: Animalia, Plantae, Fungi, Protista ??

(Of course THIS too is debated)

Archaea are Prokaryotes, but NOT bacteria

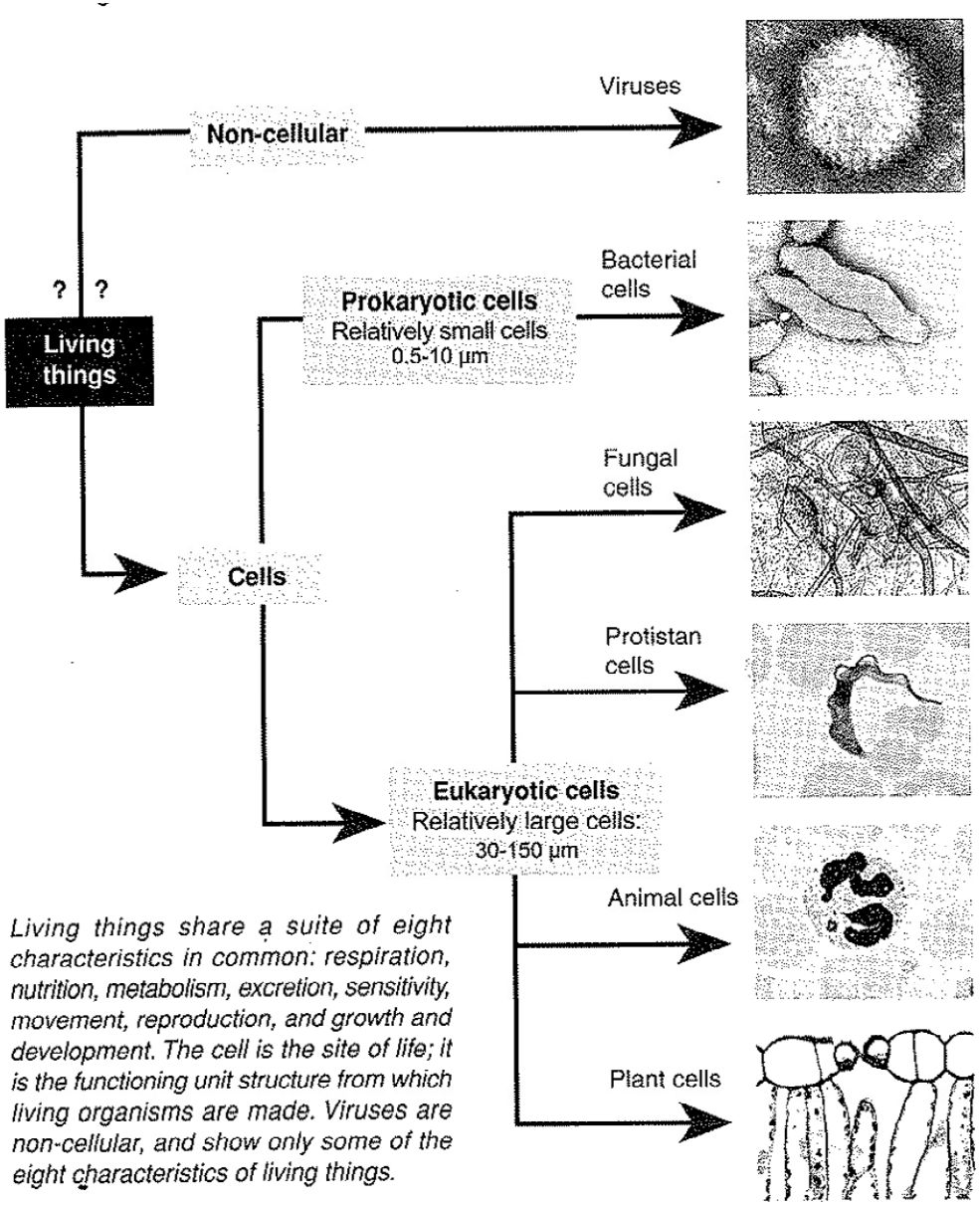
Why do we know this?

- Evolutionary Biology
- Genetic Research

A new level of classification (Domain) above Kingdom was required to make our model fit our observations.

TOK: Classification as an invention

Types of Living Things



Living things share a suite of eight characteristics in common: respiration, nutrition, metabolism, excretion, sensitivity, movement, reproduction, and growth and development. The cell is the site of life; it is the functioning unit structure from which living organisms are made. Viruses are non-cellular, and show only some of the eight characteristics of living things.

Viruses
- Non-cellular. Typical size range: 20-300 nm.
- Contain no cytoplasm or organelles.
- No chromosome, just RNA or DNA strands.
- Covered in protein coat.
- Depend on cells for metabolism and reproduction.

Bacterial cells
- Single-celled. Typical size range: 2-8 µm length.
- Lack a distinct nucleus. DNA usually a single, naked chromosome, sometimes also with plasmid DNA.
- Have no membrane-bound organelles.
- Cell walls of peptidoglycan. Many secrete a capsule.

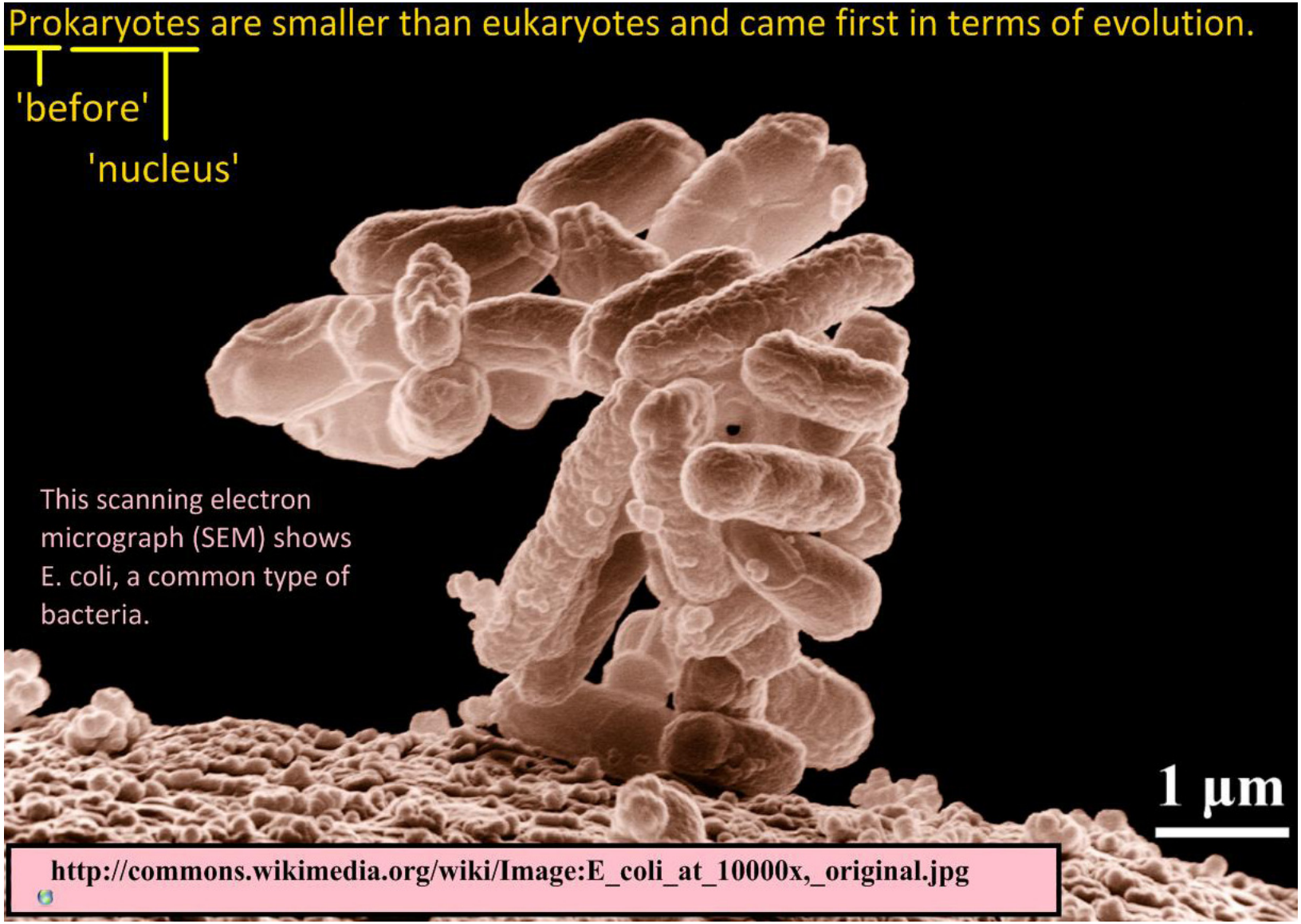
Fungal cells
- Rarely discrete cells.
- Possess nucleus and membrane-bound organelles.
- Plant-like but lack chlorophyll.
- Rigid cell walls that contain chitin.
- Heterotrophic.

Protistan cells
- Mainly single-celled or exist as cell colonies.
- Possess nucleus and membrane-bound organelles.
- Some are photosynthetic autotrophs.
- Some are heterotrophic.

Animal cells
- Exist as part of multicellular organism with specialization of cells into many types.
- Possess nucleus and membrane-bound organelles.
- Lack cell walls. Exhibit many cell types.
- Heterotrophic.

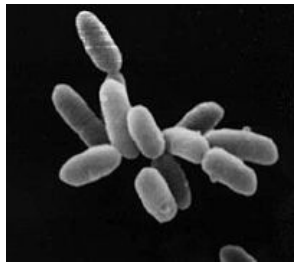
Plant cells
- Exist as part of multicellular organism with specialization of cells into many types.
- Possess nucleus and membrane-bound organelles.
- Autotrophic: photosynthetic cells have chloroplasts.
- Cell walls of cellulose.

Prokaryotic Cells

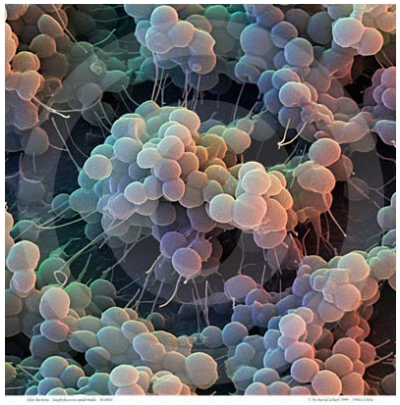


Types of Prokaryotic Cells

- Archaea

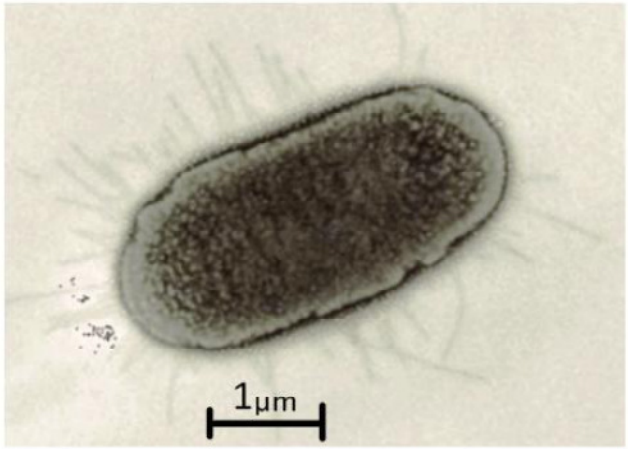


- Eubacteria



Prokaryotic Cell Structure

The ultrastructure of *E. coli* as an example of a prokaryote



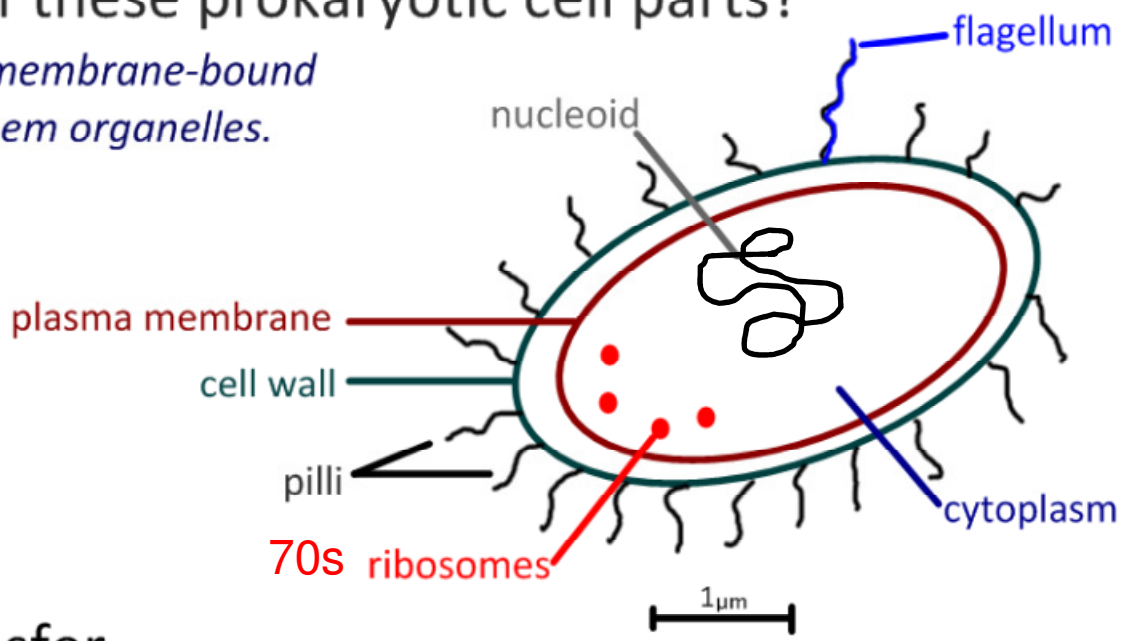
http://www.cbs.dtu.dk/staff/dave/roanoke/genetics980325f.html

E. coli is the classic 'model' microbe, used in many kinds of pathogenic and genetic research.

Prokaryotic cell parts are not generally membrane-bound, so we don't refer to them as organelles.

What are the functions of these prokaryotic cell parts?

Remember, these cell parts are not membrane-bound as in a eukaryote, so we don't call them organelles.



Movement

Protein synthesis

Attachment, DNA transfer

Protective coating, can be Gram-positive or Gram-negative

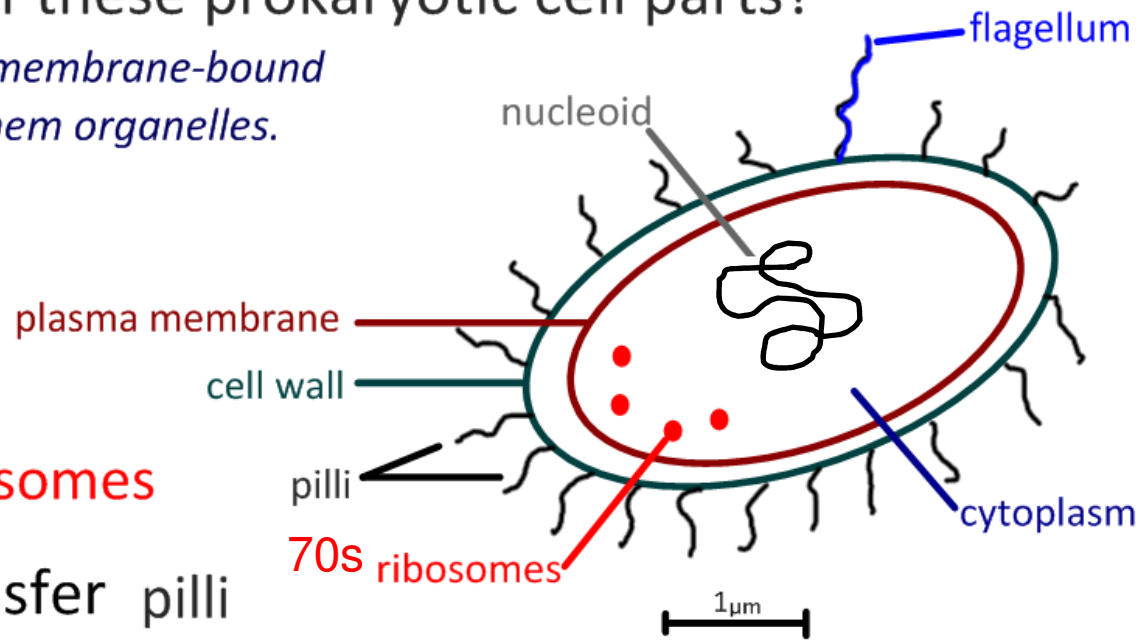
Contains enzymes for metabolism

Region containing closed-loop DNA

Controls entry and exit of substances

What are the functions of these prokaryotic cell parts?

Remember, these cell parts are not membrane-bound as in a eukaryote, so we don't call them organelles.



Movement flagellum

Protein synthesis ribosomes

Attachment, DNA transfer pilli

Protective coating, can be Gram-positive or Gram-negative cell wall

Contains enzymes for metabolism cytoplasm

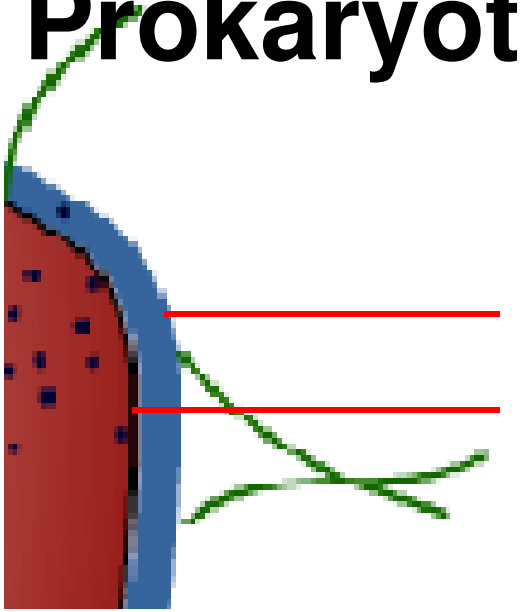
Region containing closed-loop DNA nucleoid

"Naked" DNA!

Controls entry and exit of substances plasma membrane

What’s weird here?

Prokaryotic Cell Parts



mesosome

cell wall

plasma membrane

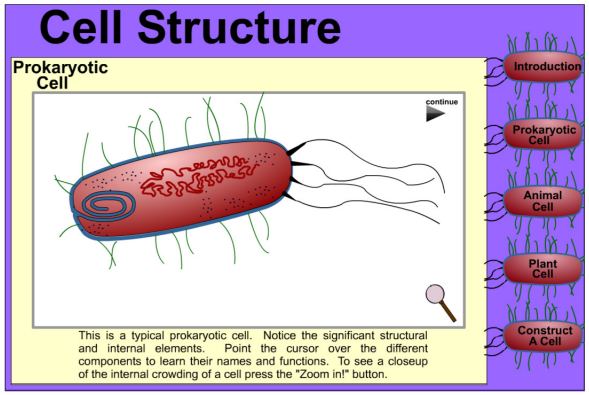
pili

cytoplasm

nucleoid

ribosomes

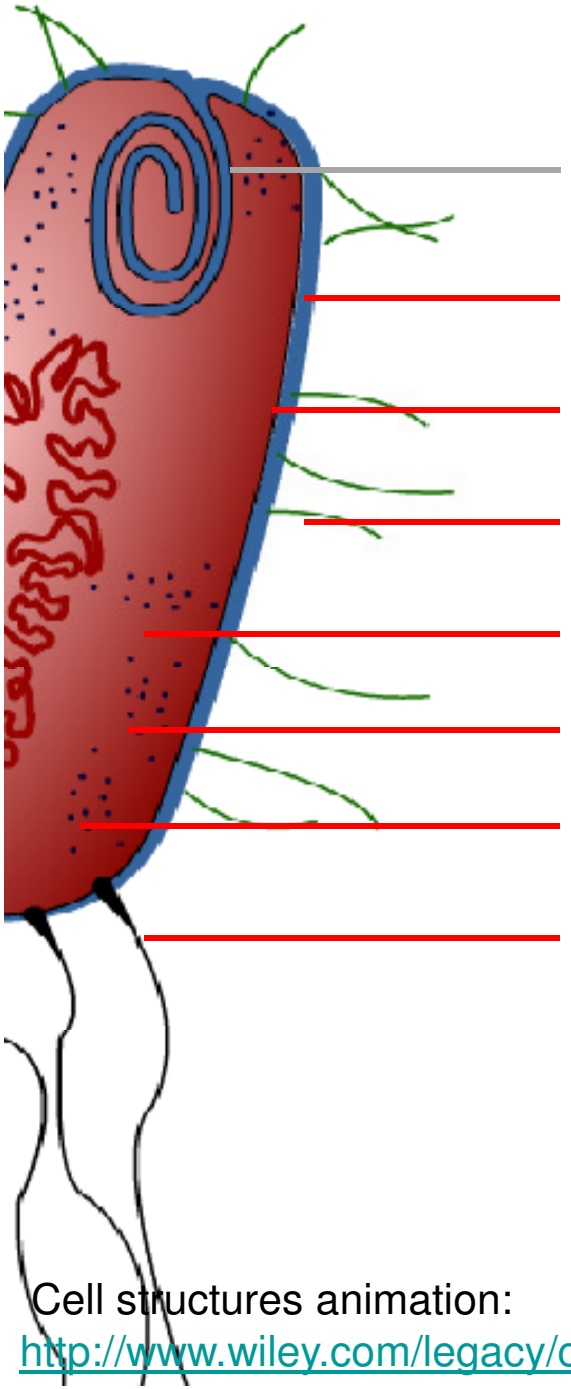
flagella



Prokaryotic cell parts are not generally membrane-bound, so we don't refer to them as organelles.

Cell structures animation:
http://www.wiley.com/legacy/college/boyer/0470003790/animations/cell_structure/cell_structure.swf

Prokaryotic Cell Parts



mesosome

cell wall: protective **protein-based coating** (Gram + / Gram -)

plasma membrane: *selectively permeable*, controls entry & exit of materials to and from the cell.

pili: **attach** to other bacteria for **DNA transfer**

cytoplasm: contains **enzymes** for metabolic reactions

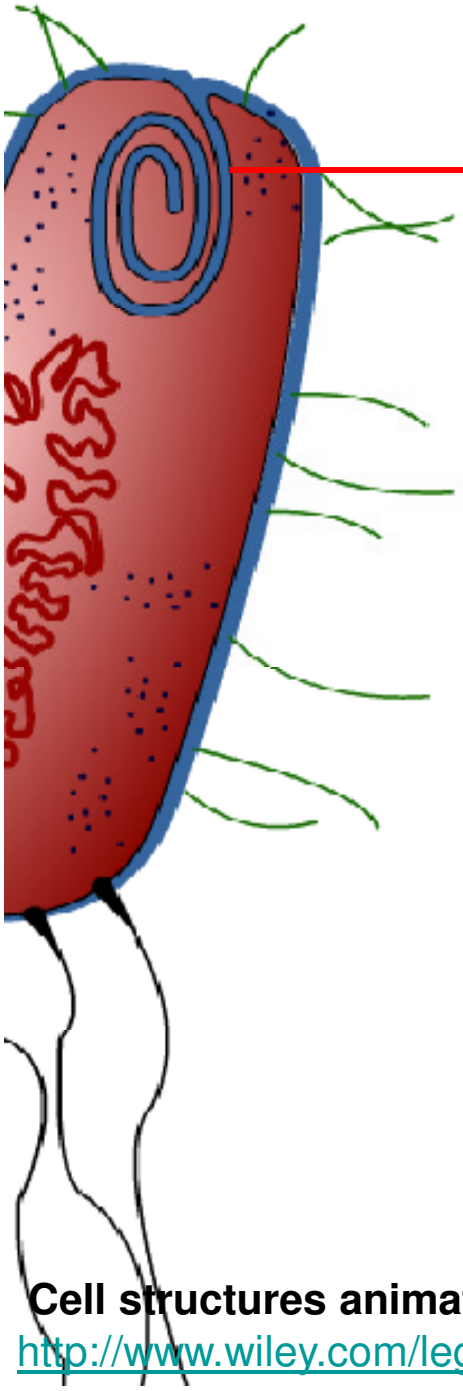
nucleoid: closed-loop of **bacterial DNA** in a condensed area

ribosomes: **protein synthesis** (transcription & translation)

flagella: whiplash-like motion causes **movement**

Cell structures animation:
http://www.wiley.com/legacy/college/boyer/0470003790/animations/cell_structure/cell_structure.swf

Prokaryotic Cell Parts

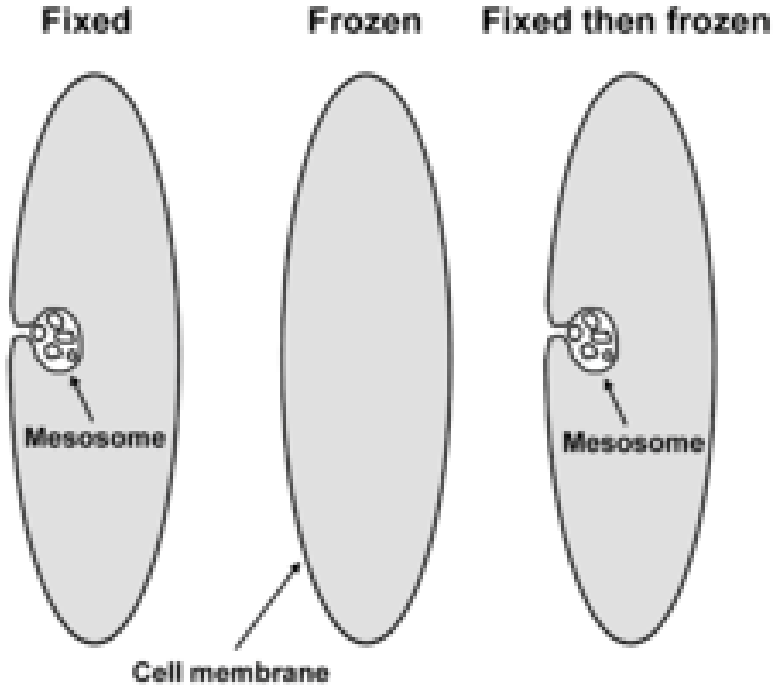


mesosomes

These don't really exist naturally as bacterial cell parts, and could be an example of a **paradigm shift** in thinking.

They were observed in some electron micrographs and thought to be in-folds of membrane used for division, respiration or making cell walls…

… turns out they are ar artifact of the preparation method for some electron microscope images.

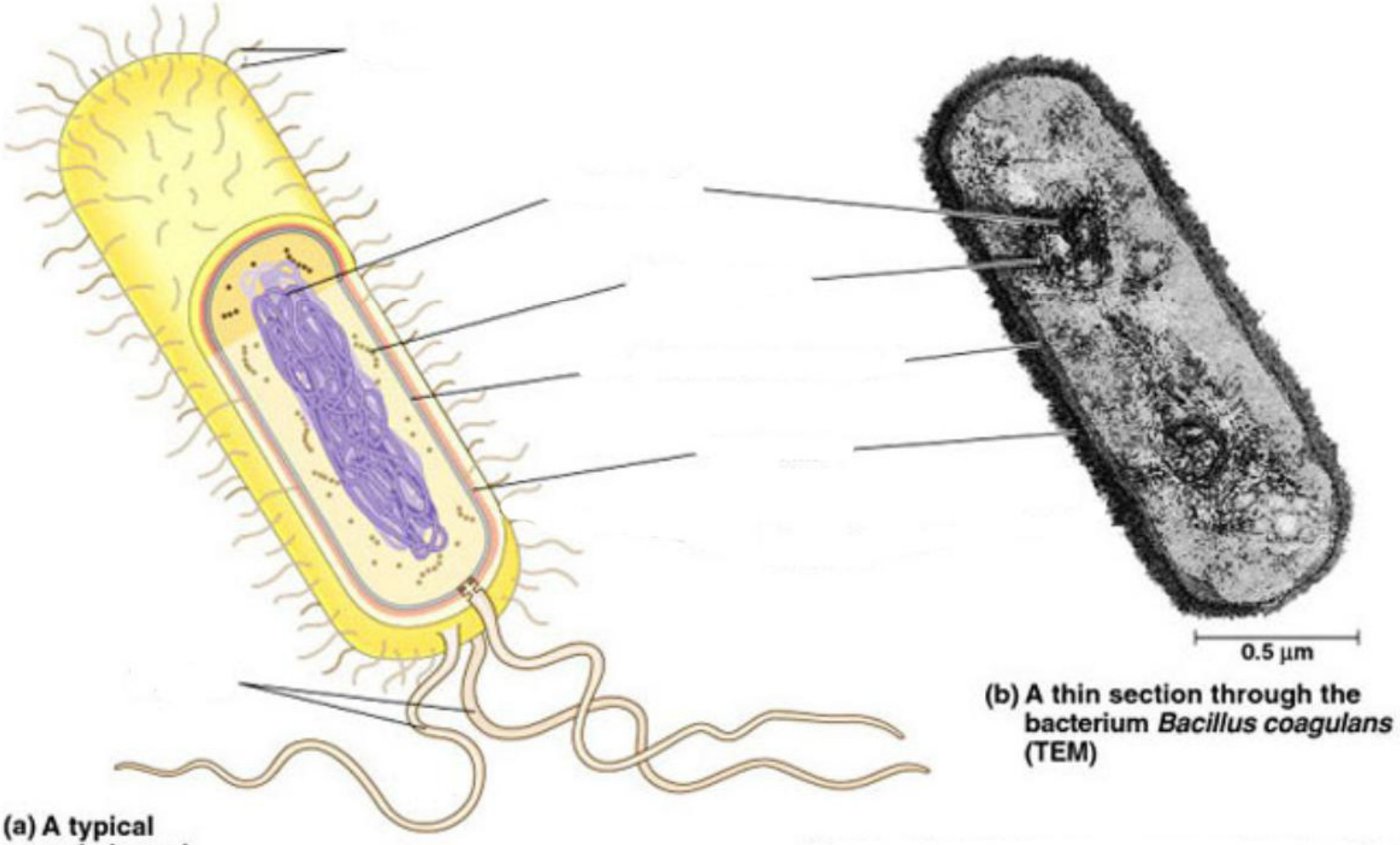


http://en.wikipedia.org/wiki/Mesosome

Cell structures animation:
http://www.wiley.com/legacy/college/boyer/0470003790/animations/cell_structure/cell_structure.swf

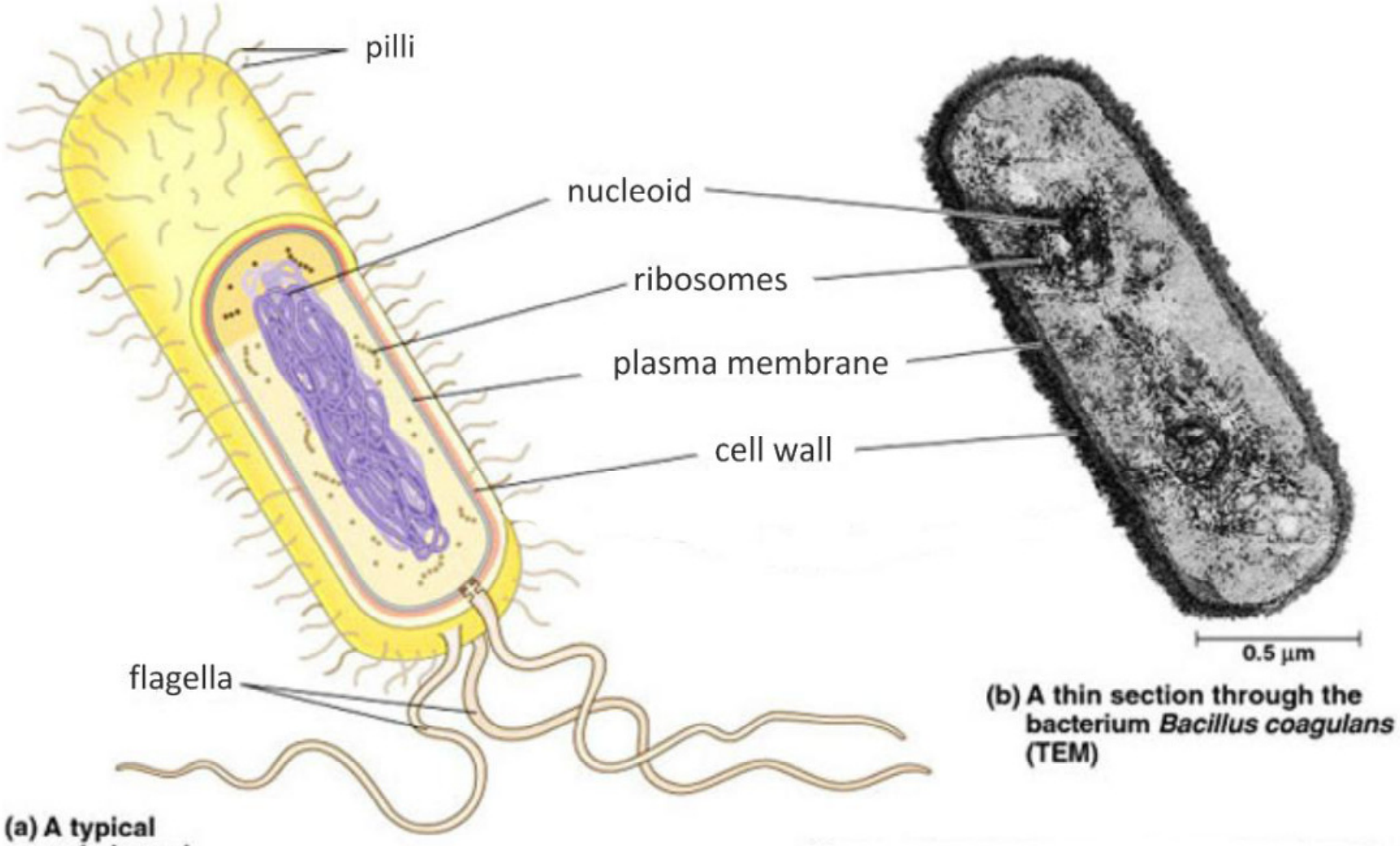
Identifying Prokaryotic Structures in an Electron Micrograph

Which structures can you identify in this electron micrograph?



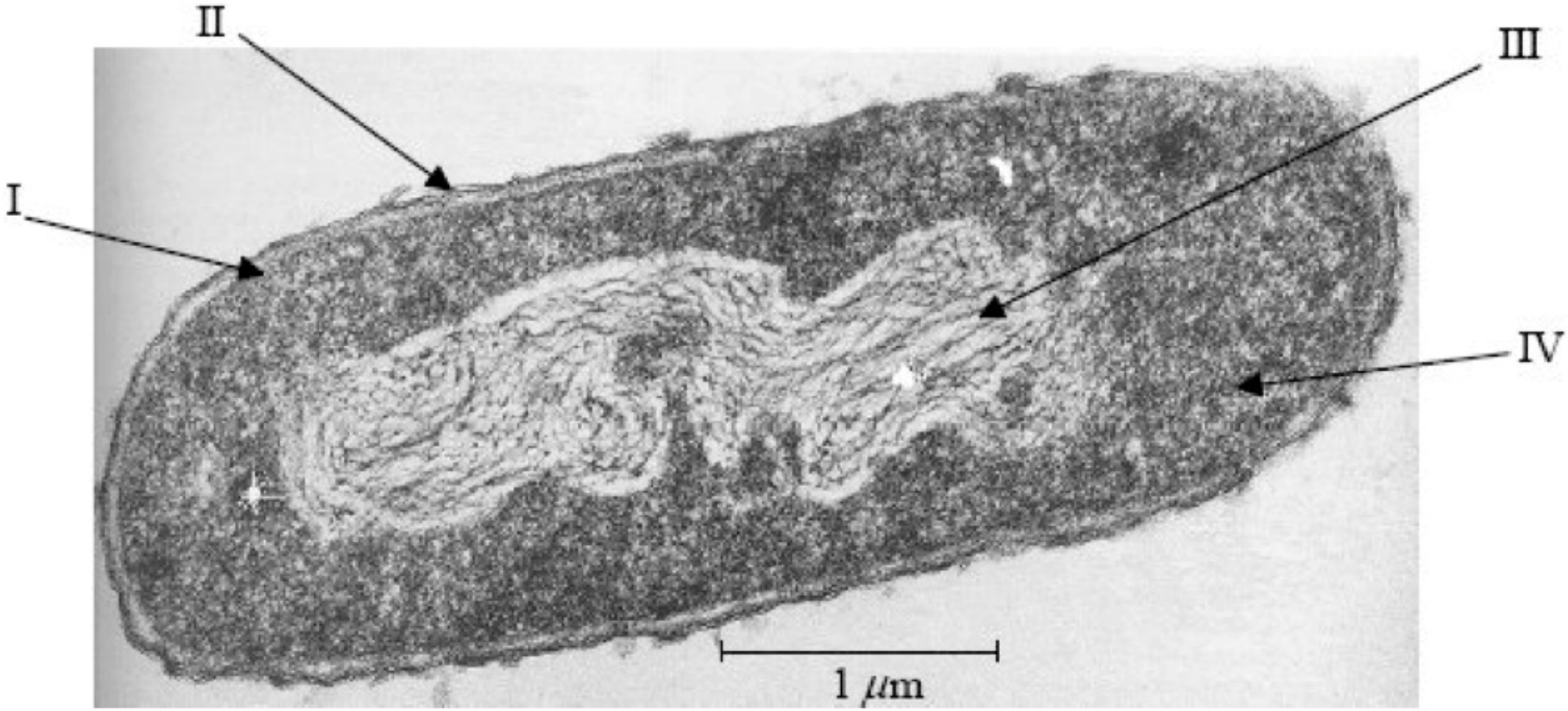
http://fig.cox.miami.edu/~cmallery/150/proceuc/c7x4prokaryote.jpg

Which structures can you identify in this electron micrograph?



http://fig.cox.miami.edu/~cmallery/150/proceuc/c7x4prokaryote.jpg

Past-paper question: *E. coli* TEM image



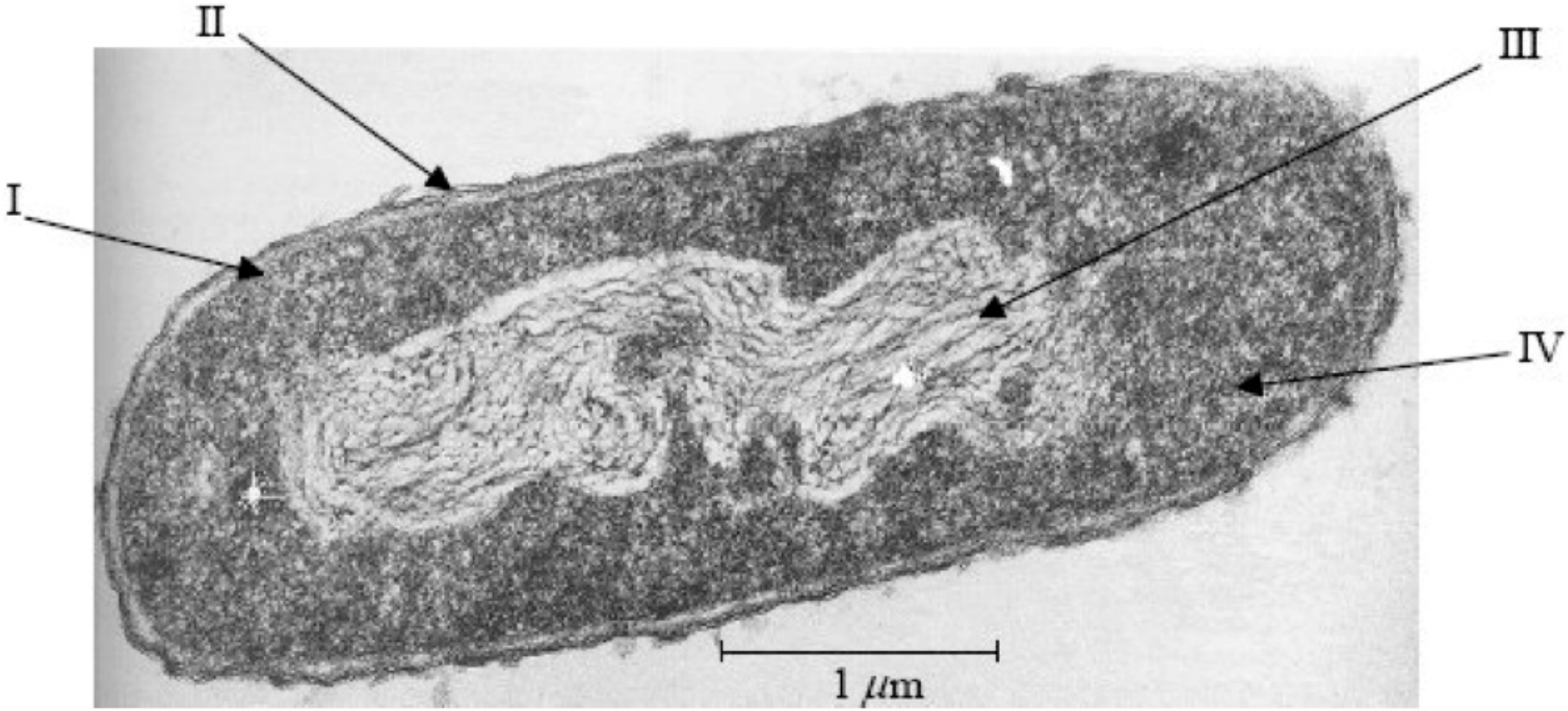
Identify these structures:

I.
II.
III.
IV.

Calculate the magnification of the image.

Image from IB Biology QuestionBank CDRom – get a copy here: https://store.ibo.org/biology

Past-paper question: *E. coli* TEM image



Identify these structures:

I. Plasma membrane
II. Cell wall / pili
III. Nucleoid
IV. Cytoplasm / ribosomes

Calculate the magnification of the image.

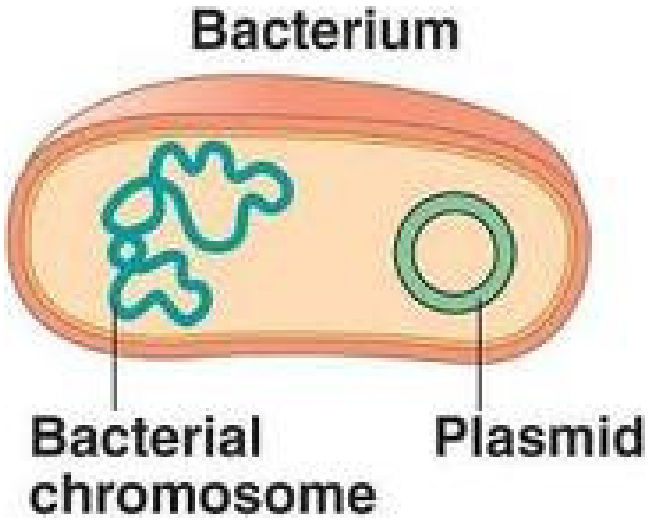
1. Measure the scale bar in mm.
2. Multiply x 1000 to convert to μm.

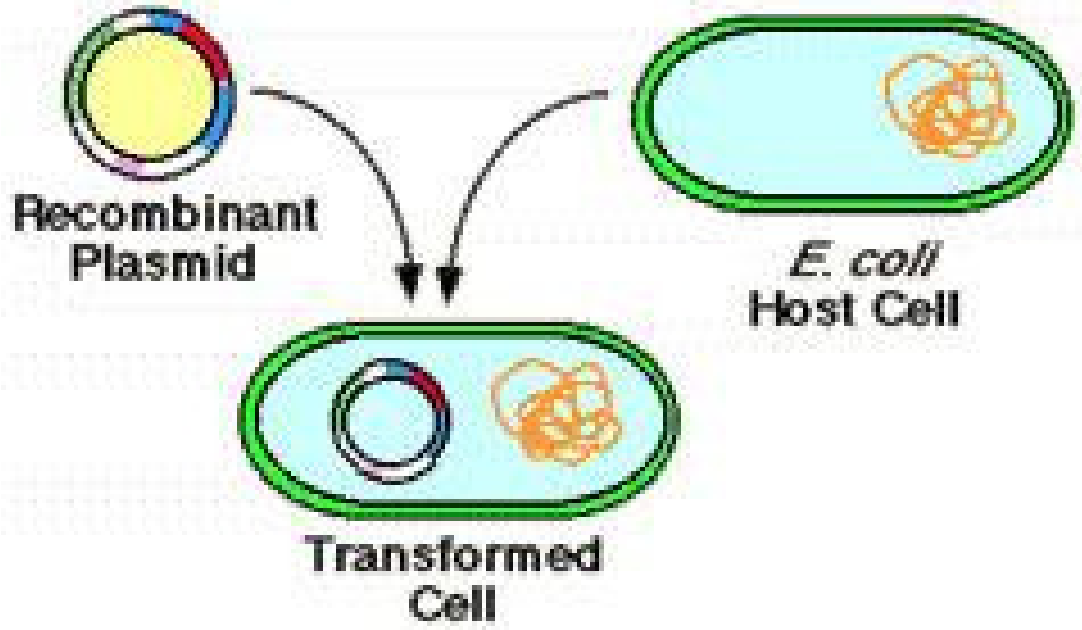
That is the magnification.

How long is the bacterium?

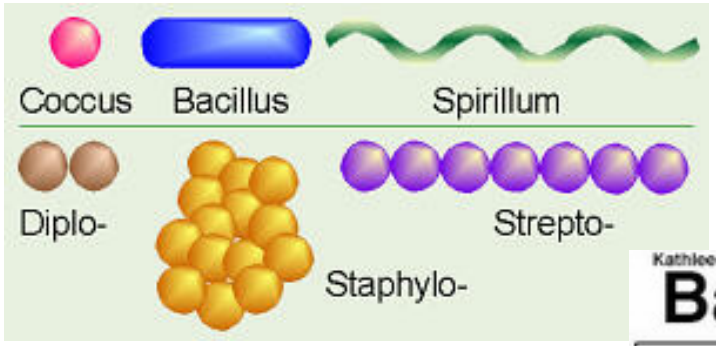
Image from IB Biology QuestionBank CDRom – get a copy here: https://store.ibo.org/biology

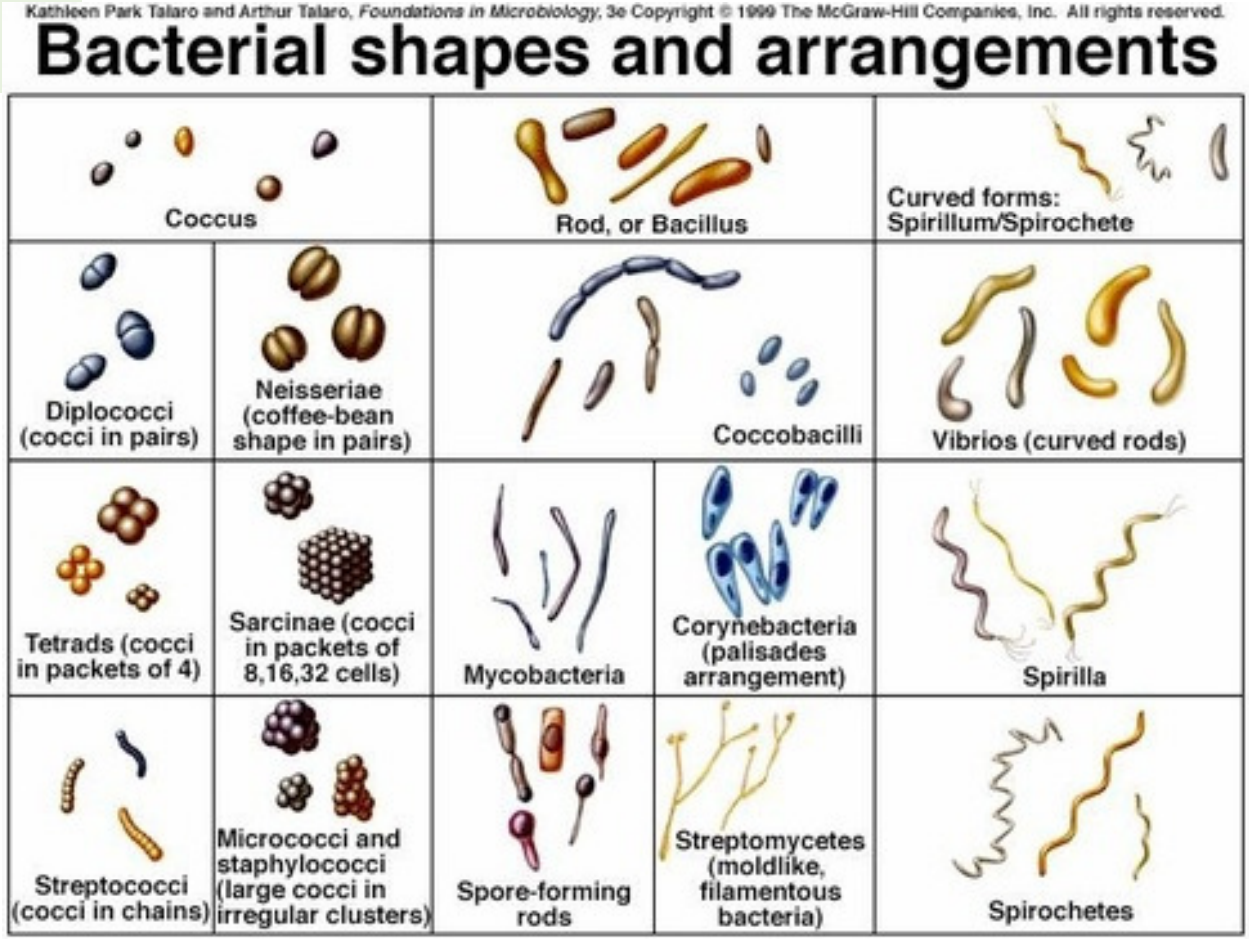
Plasmids


Bacterium
Bacterial chromosome
Plasmid


Recombinant Plasmid
E. coli Host Cell
Transformed Cell

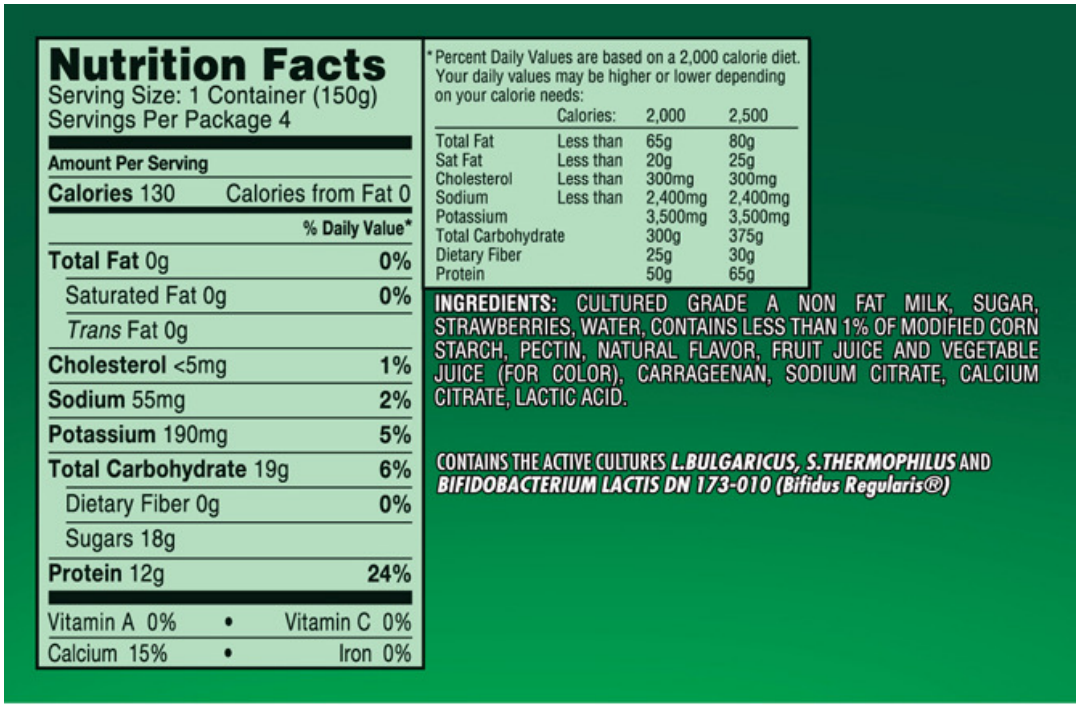
Bacterial Shapes





Pathogenic and Probiotic Bacteria Lab

- There is bacteria in yogurt?!



Nutrition Facts
Serving Size: 1 Container (150g)
Servings Per Package 4

Amount Per Serving	
Calories 130	Calories from Fat 0
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol <5mg	1%
Sodium 55mg	2%
Potassium 190mg	5%
Total Carbohydrate 19g	6%
Dietary Fiber 0g	0%
Sugars 18g	
Protein 12g	24%
Vitamin A 0% •	Vitamin C 0%
Calcium 15% •	Iron 0%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Potassium		3,500mg	3,500mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g
Protein		50g	65g

INGREDIENTS: CULTURED GRADE A NON FAT MILK, SUGAR, STRAWBERRIES, WATER, CONTAINS LESS THAN 1% OF MODIFIED CORN STARCH, PECTIN, NATURAL FLAVOR, FRUIT JUICE AND VEGETABLE JUICE (FOR COLOR), CARRAGEENAN, SODIUM CITRATE, CALCIUM CITRATE, LACTIC ACID.

CONTAINS THE ACTIVE CULTURES *L.BULGARICUS, S.THERMOPHILUS* AND *BIFIDOBACTERIUM LACTIS DN 173-010 (Bifidus Regularis®)*

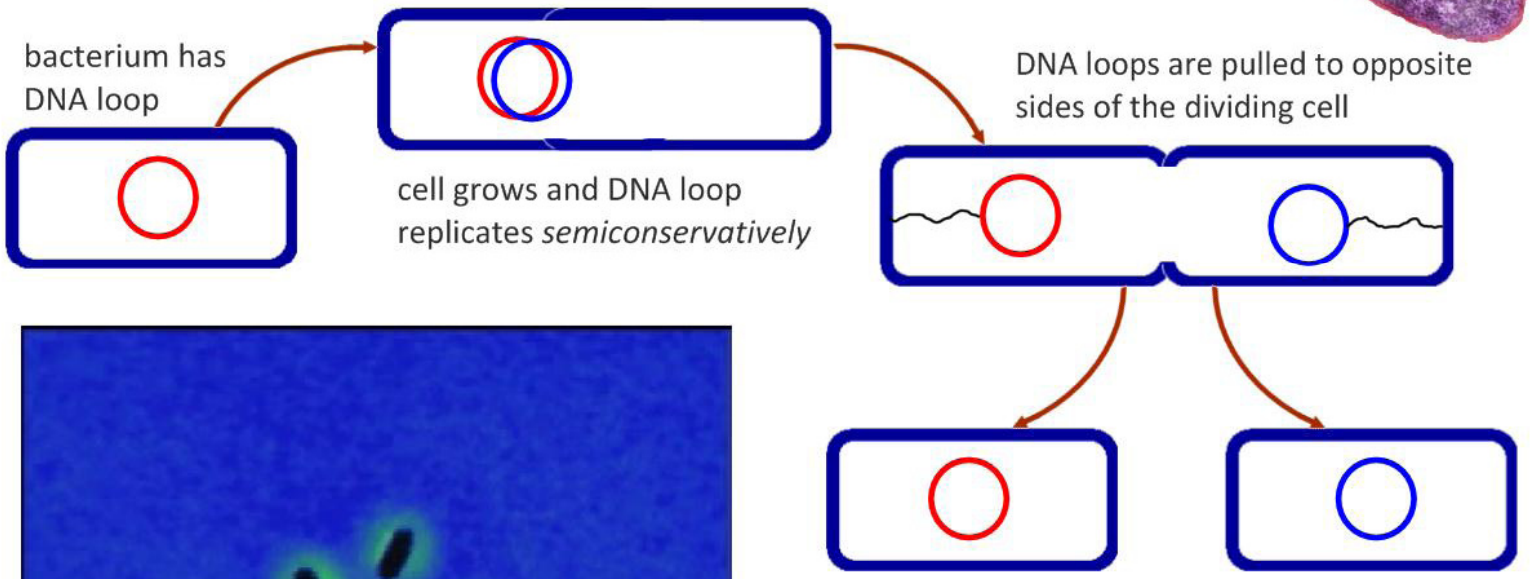
What about antibiotics?

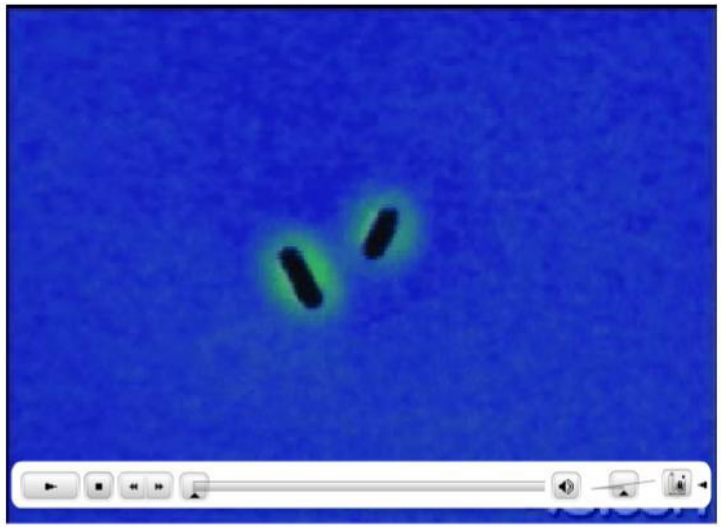
Prokaryotic Reproduction

Prokaryotes reproduce by *binary fission*:

'two' 'splitting'

(This is much simpler than mitosis in eukaryotes)

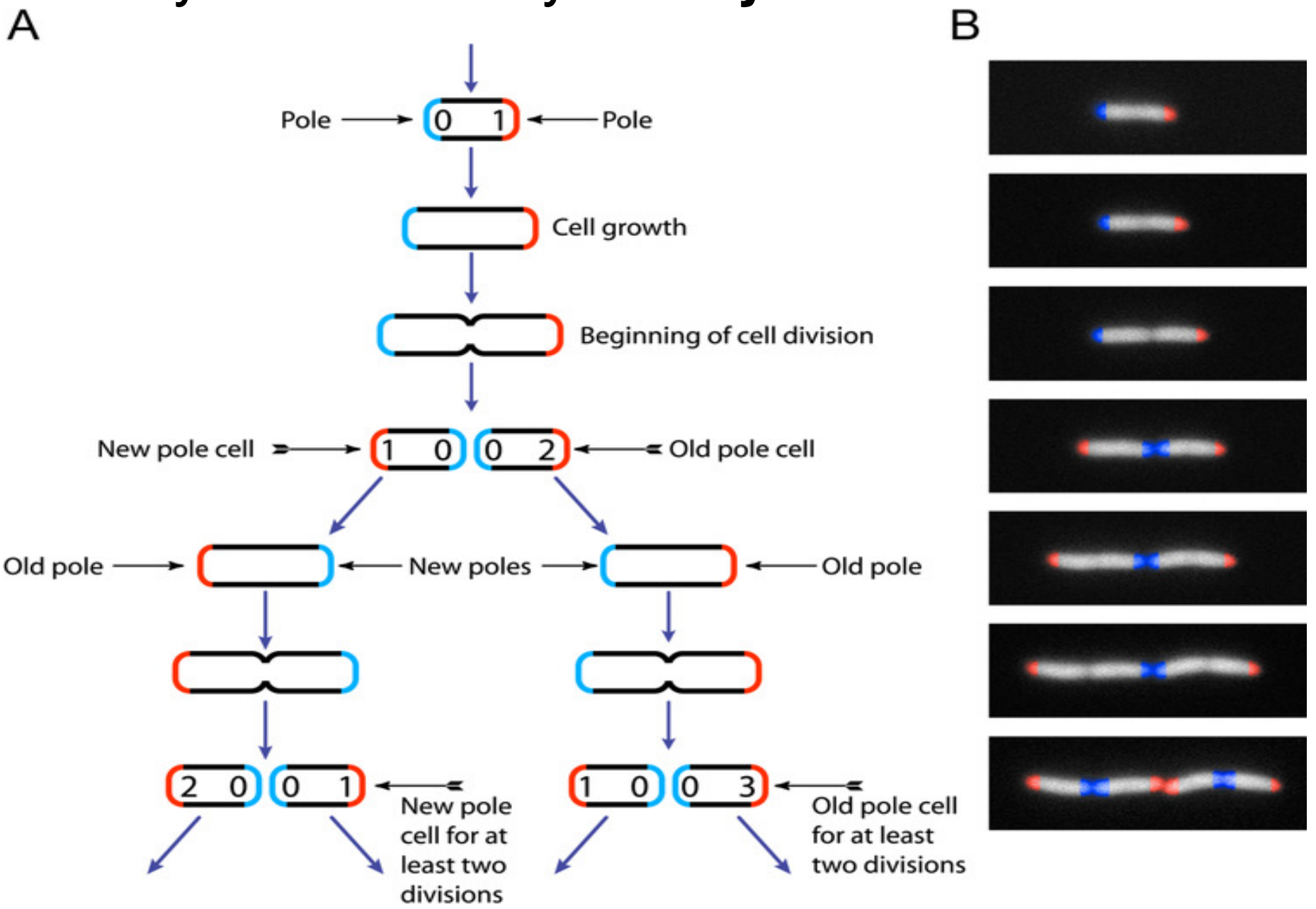




http://www.youtube.com/watch?v=FcjAsTTN8qU

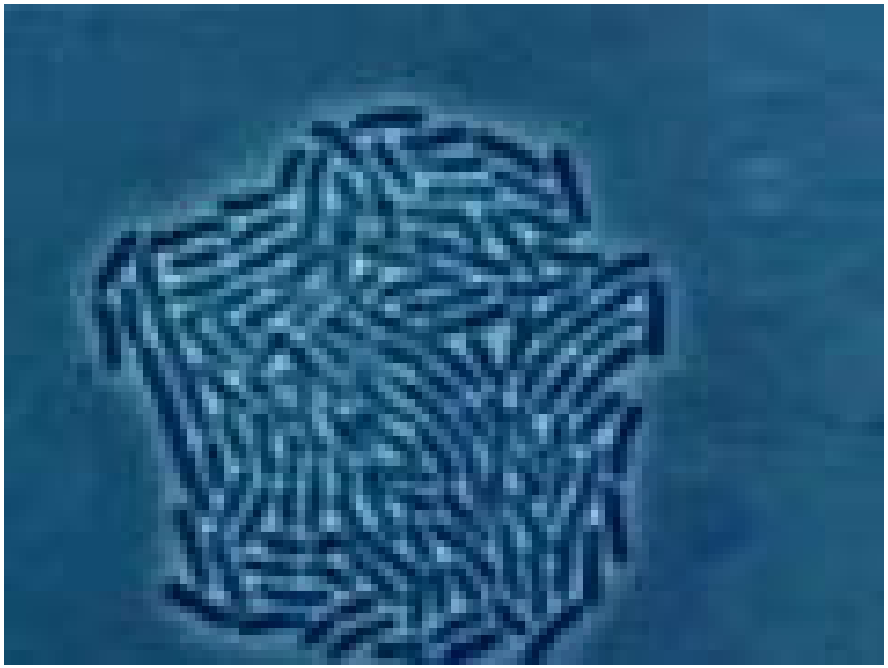
The new cells are called daughter cells. They are clones because they contain identical sets of DNA.

Prokaryotes divide by **binary fission**.

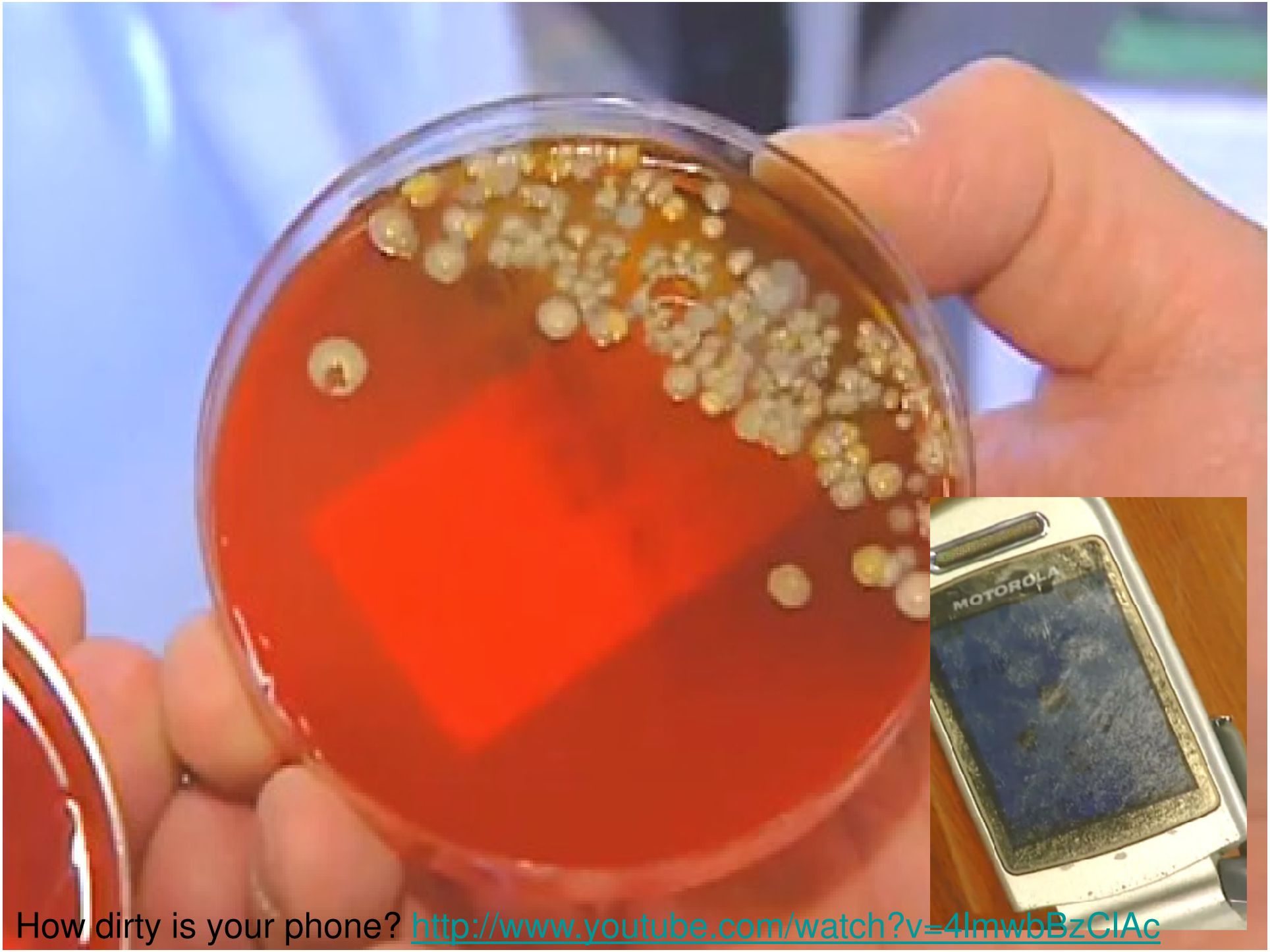


Life cycle of E. coli from: http://en.wikipedia.org/wiki/Escherichia_c

Population Growth



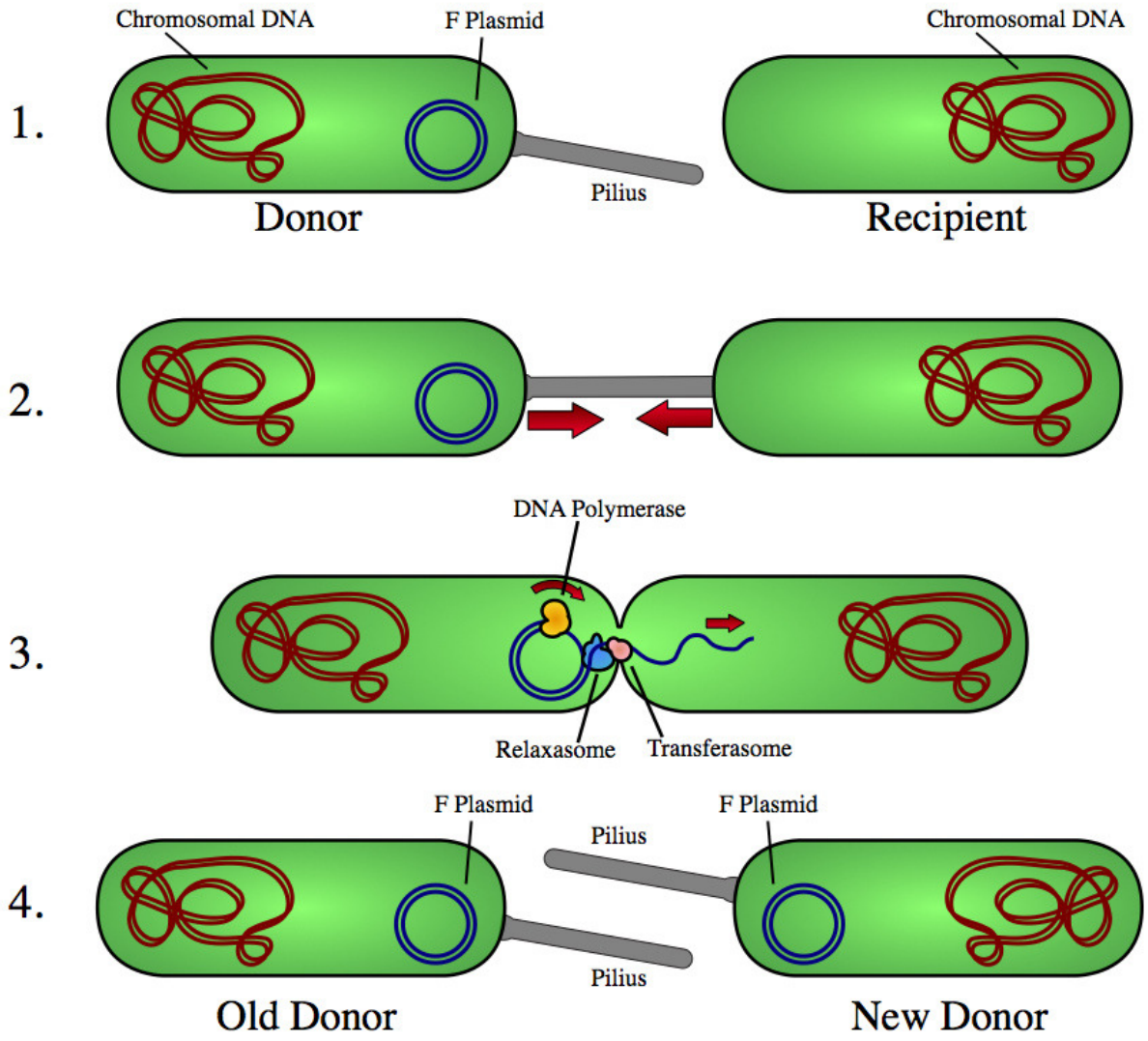
- http://www.youtube.com/watch?v=gEwzDydciWc



How dirty is your phone? http://www.youtube.com/watch?v=4lmwbBzClAc

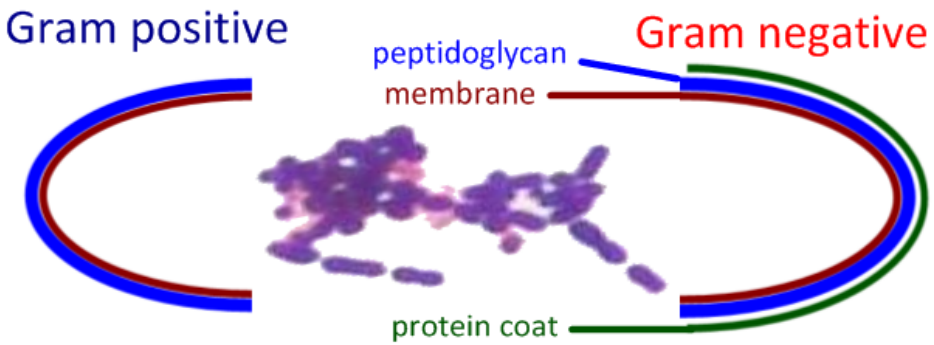
Genetic Transfer via Bacterial Conjugation

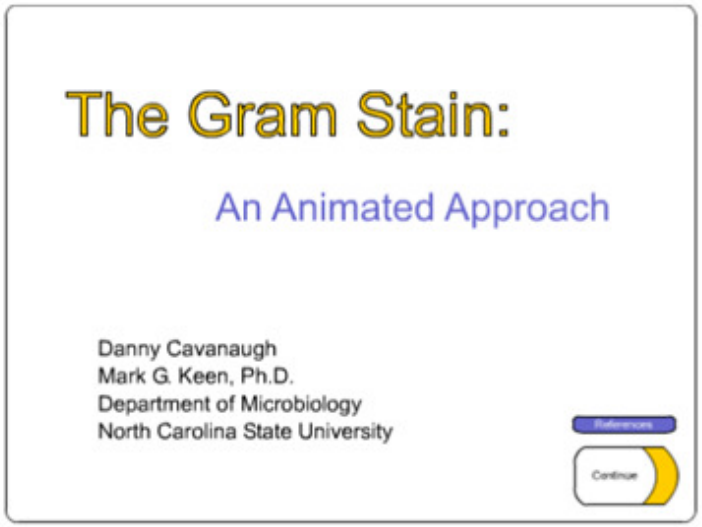
- Sex Pilus
- Plasmid



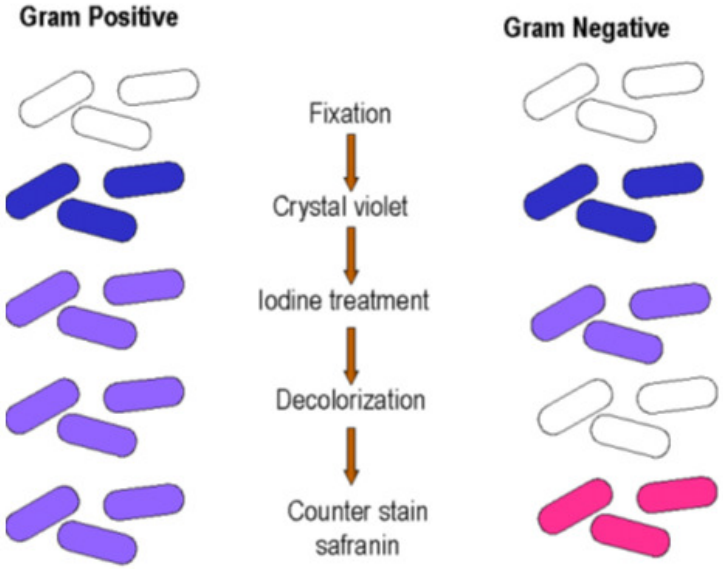
Because it's good to know: *What's gram-staining?*

Bacteria can be classified as either gram-positive or gram-negative. This refers to their ability to hold a purple stain and is used in culture to identify disease-causing bacteria.



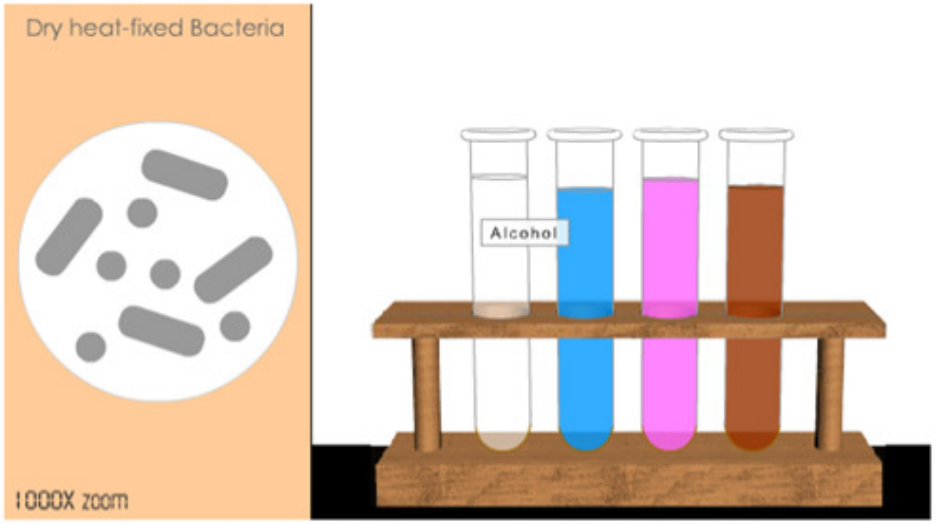


http://www.microbelibrary.org/microbelibrary/files/ccImages/Articleimages/keen/Gramstainkeen.htm



http://pathmicro.med.sc.edu/fox/gram-st.jpg

Now have a go at this:



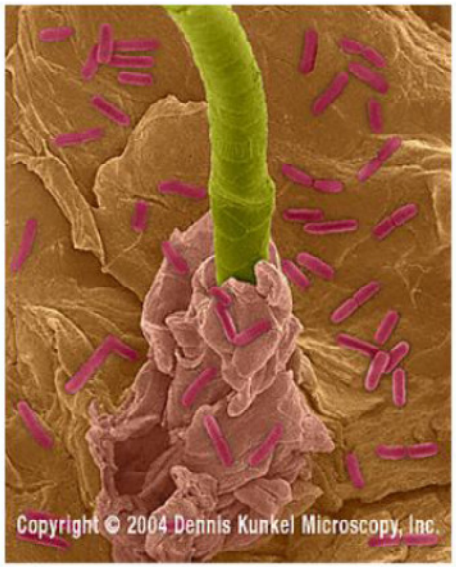
http://vudat.msu.edu/fileadmin/user_upload/vudat/flash/gramstain.swf

Extend Page

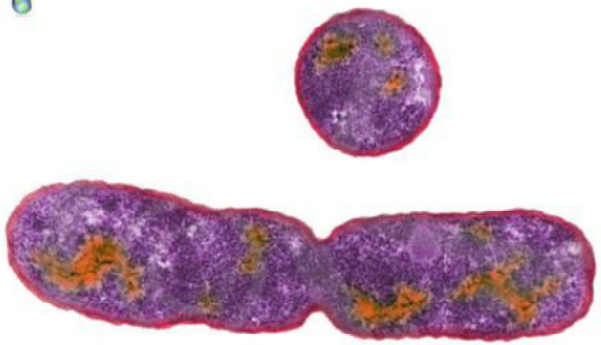
Images

For some great EM images of prokaryotes, visit:

http://www.denniskunkel.com/index.php?cPath=3&sort=1a&page=1



http://www.denniskunkel.com/product_info.php?products_id=946



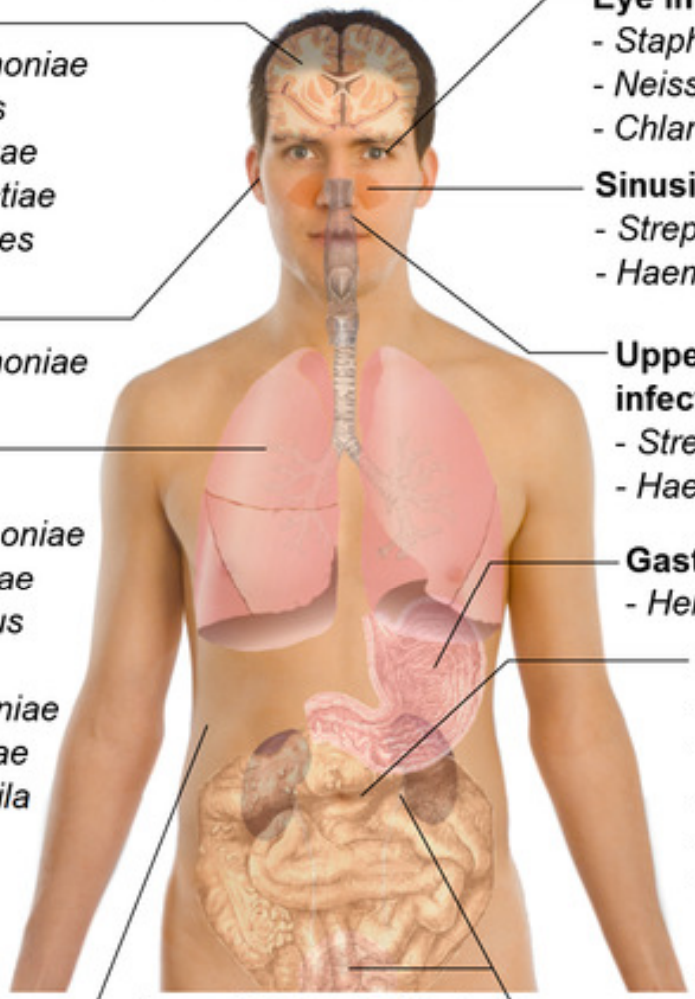
http://www.denniskunkel.com/index.php?cPath=3&sort=1a&page=2

Function / Uses of Prokaryotic Cells

- In humans
  - Digestion- symbiotic relationship/up to 60% of fecal dry mass/ helps digest food we cannot alone / probiotics
  - Skin- might help prevent excessive inflammation like psoriasis/withstands acidic environment and prevents pathogenic bacteria from growing
  - The human microbiome (Thanks to A.V.W.) http://www.economist.com/node/21560523
  - Probiotics & gut bacteria transplants
- In environment (Food Inc.)
  - Angler Fish
  - Cattle Digestion http://www.youtube.com/watch?v=NkhdGG5pVW8
- In food
  - Buttermilk, Cheese, Yogurt
  - Bacteria in Food http://www.youtube.com/watch?v=6FPy5m1-BQI
- Other Uses
  - Transgenic Bacteria

Overview of

Bacterial infections



Bacterial meningitis
- *Streptococcus pneumoniae*
- *Neisseria meningitidis*
- *Haemophilus influenzae*
- *Streptococcus agalactiae*
- *Listeria monocytogenes*

Otitis media
- *Streptococcus pneumoniae*

Pneumonia

Community-acquired:
- *Streptococcus pneumoniae*
- *Haemophilus influenzae*
- *Staphylococcus aureus*

Atypical:
- *Mycoplasma pneumoniae*
- *Chlamydia pneumoniae*
- *Legionella pneumophila*

Tuberculosis
- *Mycobacterium tuberculosis*

Skin infections
- *Staphylococcus aureus*
- *Streptococcus pyogenes*
- *Pseudomonas aeruginosa*

Sexually transmitted diseases
- *Chlamydia trachomatis*
- *Neisseria gonorrhoeae*
- *Treponema pallidum*
- *Ureaplasma urealyticum*
- *Haemophilus ducreyi*

Urinary tract infections
- *Escherichia coli*
- *Other Enterobacteriaceae*
- *Staphylococcus saprophyticus*
- *Pseudomonas aeruginosa*

Food poisoning
- *Campylobacter jejuni*
- *Salmonella*
- *Shigella*
- *Clostridium*
- *Staphylococcus aureus*
- *Escherichia coli*

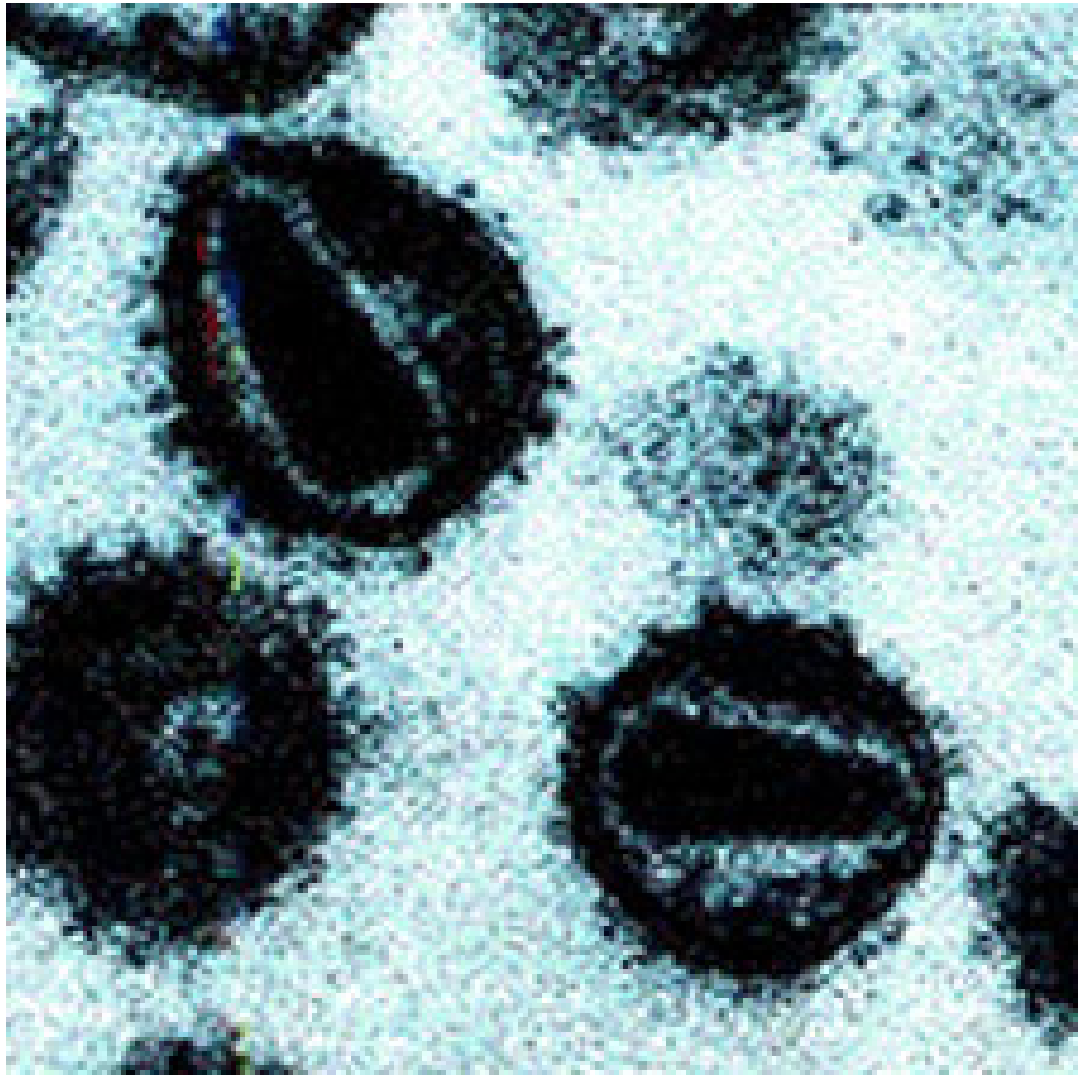
Gastritis
- *Helicobacter pylori*

Upper respiratory tract infection
- *Streptococcus pyogenes*
- *Haemophilus influenzae*

Sinusitis
- *Streptococcus pneumoniae*
- *Haemophilus influenzae*

Eye infections
- *Staphylococcus aureus*
- *Neisseria gonorrhoeae*
- *Chlamydia trachomatis*

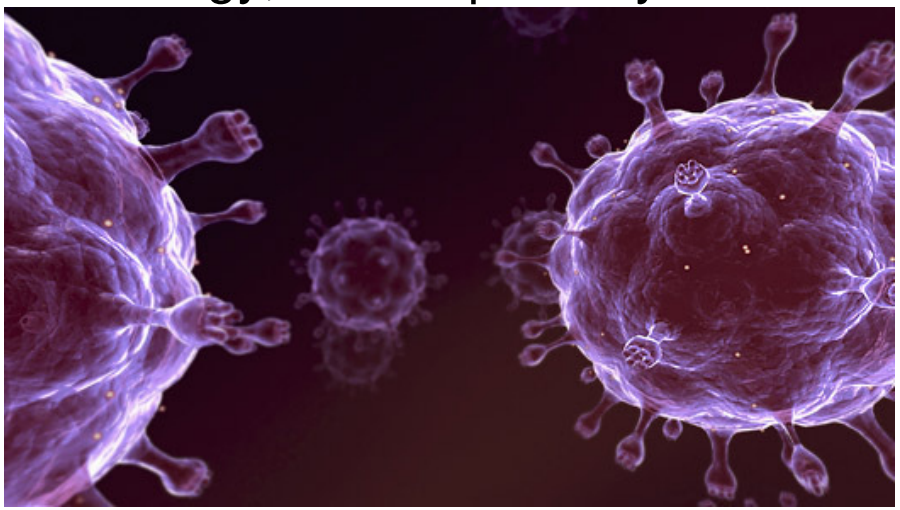
Viruses



What is a virus?

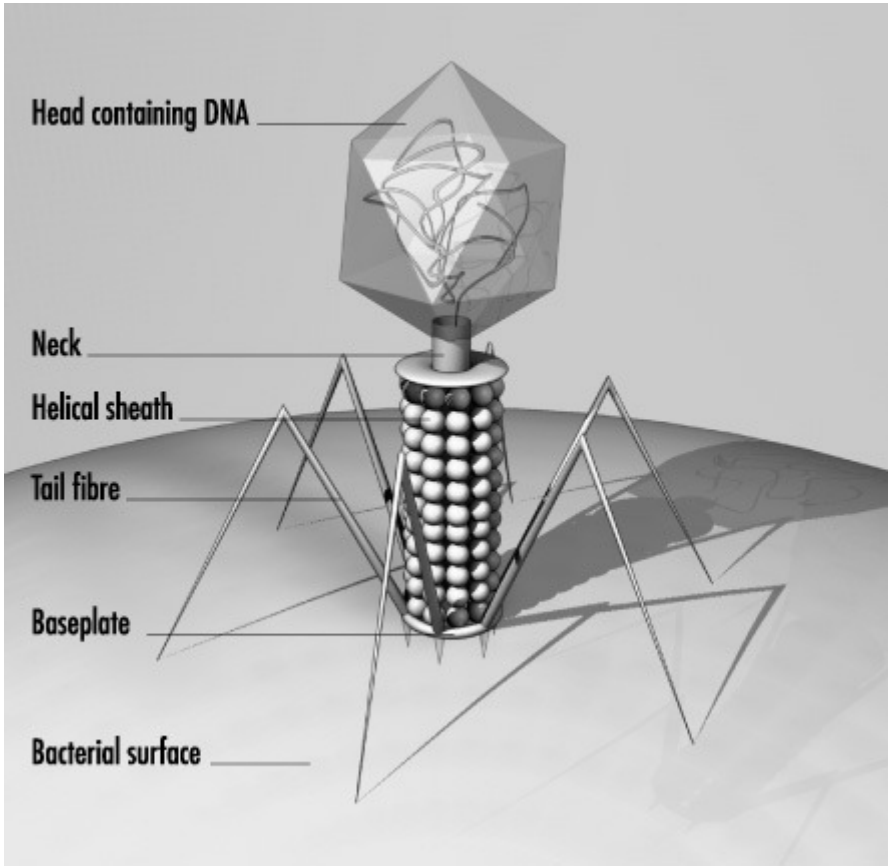
- A virus is a small infectious agent that can replicate only inside the living cells of organisms.
- Most viruses are too small to be seen directly with a light microscope.
- Viruses infect all types of organisms, from animals and plants to bacteria and archaea.
- About 5,000 viruses have been described in detail, although there are millions of different types
- Viruses are found in almost every ecosystem on Earth and are the most abundant type of biological entity.
- The study of viruses is known as virology, a sub-speciality of microbiology.
- We consider viruses to be

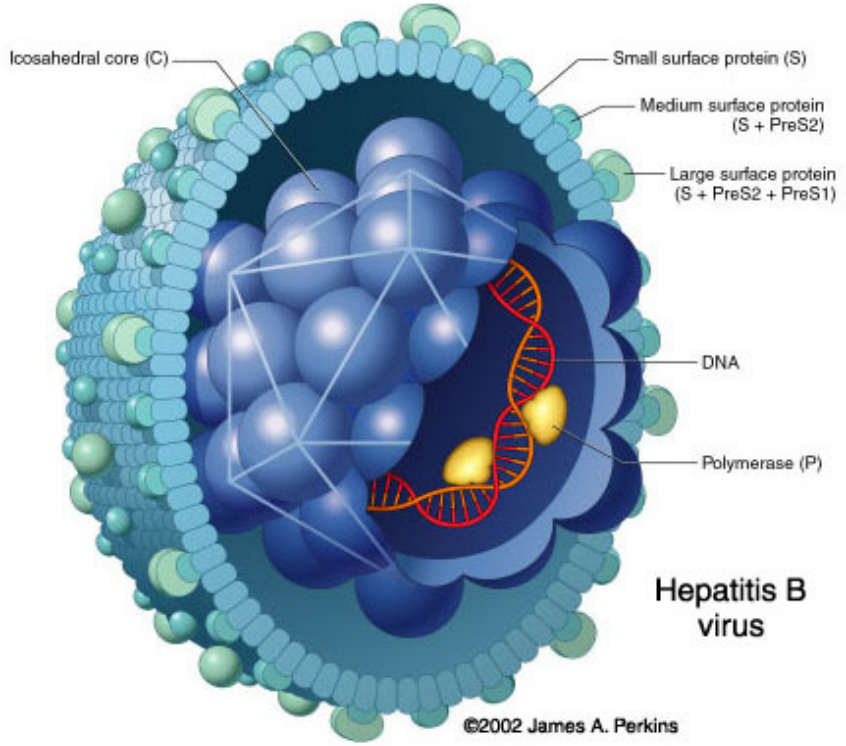
  NON LIVING



- SEM image of HIV

Viral Components



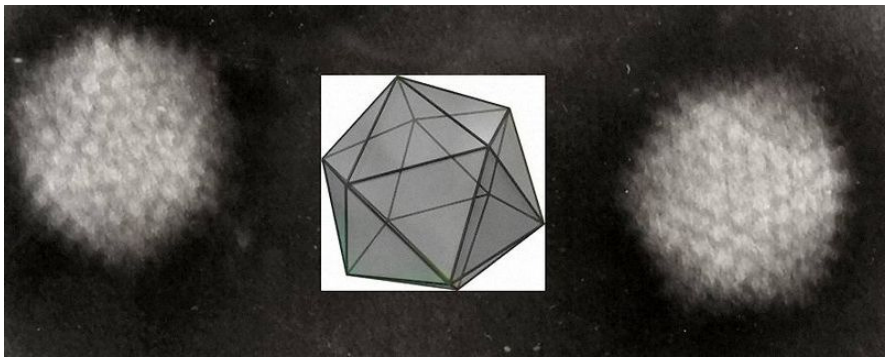


- Virus particles (known as *virions*) consist of two or three parts: the genetic material made from either DNA or RNA, long molecules that carry genetic information; a protein coat that protects these genes; and in some cases an envelope of lipids that surrounds the protein coat when they are outside a cell.

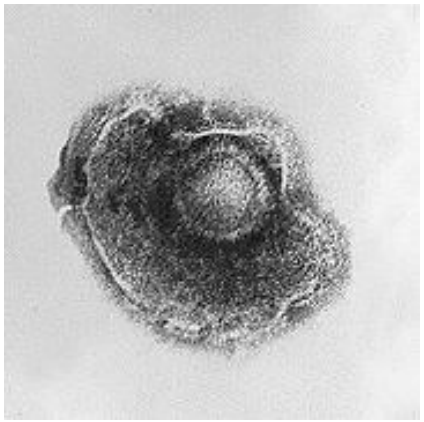
Shapes / Forms?

- The shapes of viruses range from simple helical and icosahedral forms to more complex structures.
- The average virus is about one one-hundredth the size of the average bacterium.
  - Which is…?

Icosahedral Adenovirus



Herpes Virus with lipid envelope



Discovering Viruses

- Dmitri Ivanovsky: 1892 article describing a non-bacterial pathogen infecting tobacco
- Martinus Beijerinck:1898 discovery of the Tobacco Mosaic Virus

Viral Replication

- T4 Bacteriophage: http://www.youtube.com/watch?v=wLoslN6d3Ec
- HIV: **http://www.youtube.com/watch?v=rqDkYJn7w9Y&feature=related**