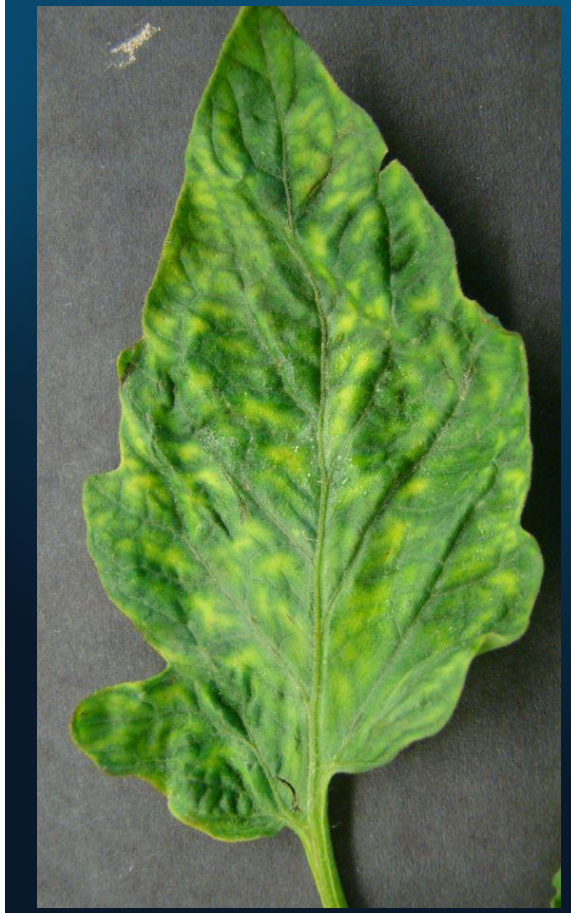
Microbiology

Case Study: Tobacco Mosaic Disease

A disease is making tobacco plants very sick. You are trying to find the bacteria responsible for this disease.

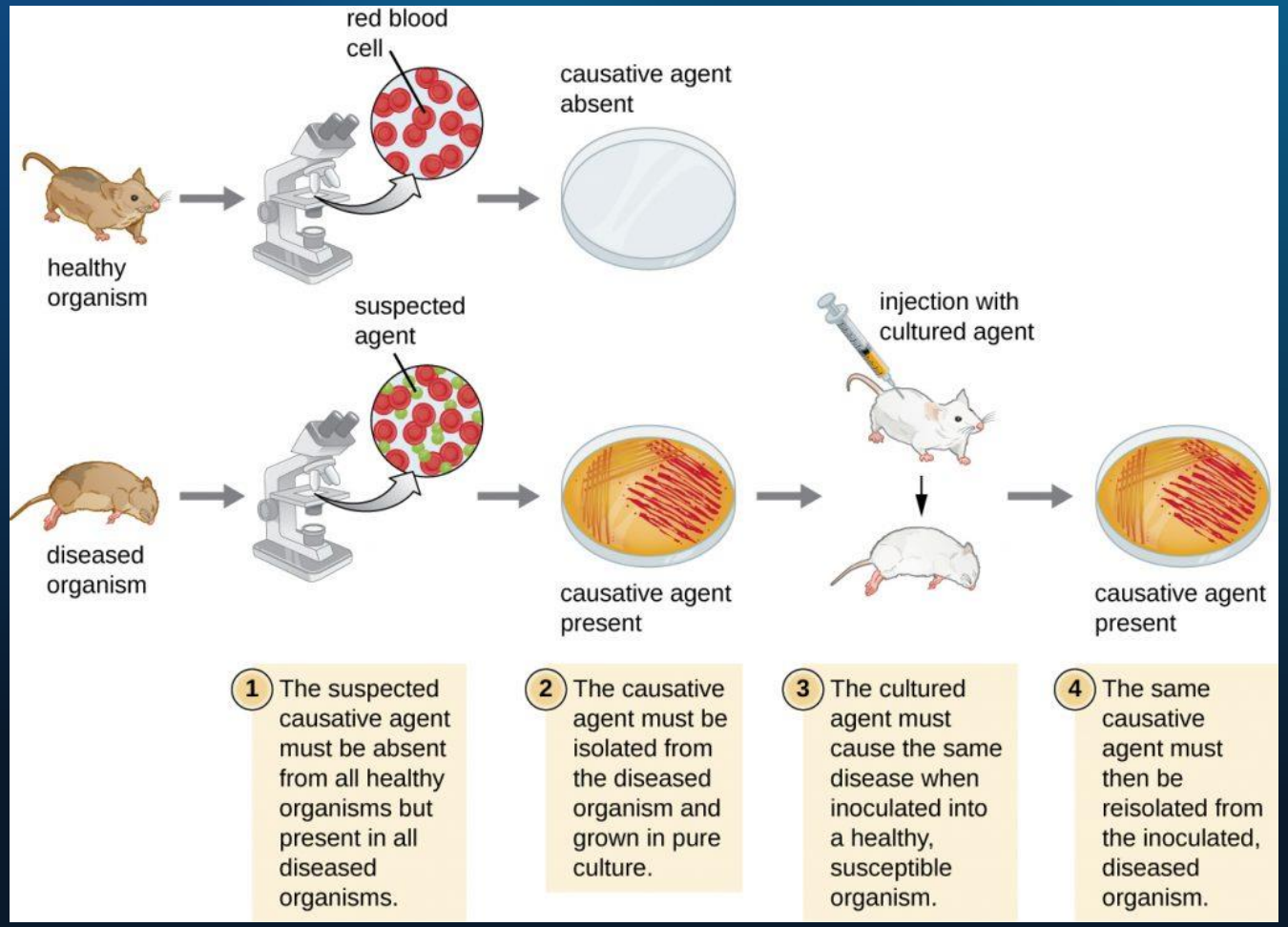
How do you go about this? Design an experiment.

(Hint: how would you know for sure you had found the right bacteria?)



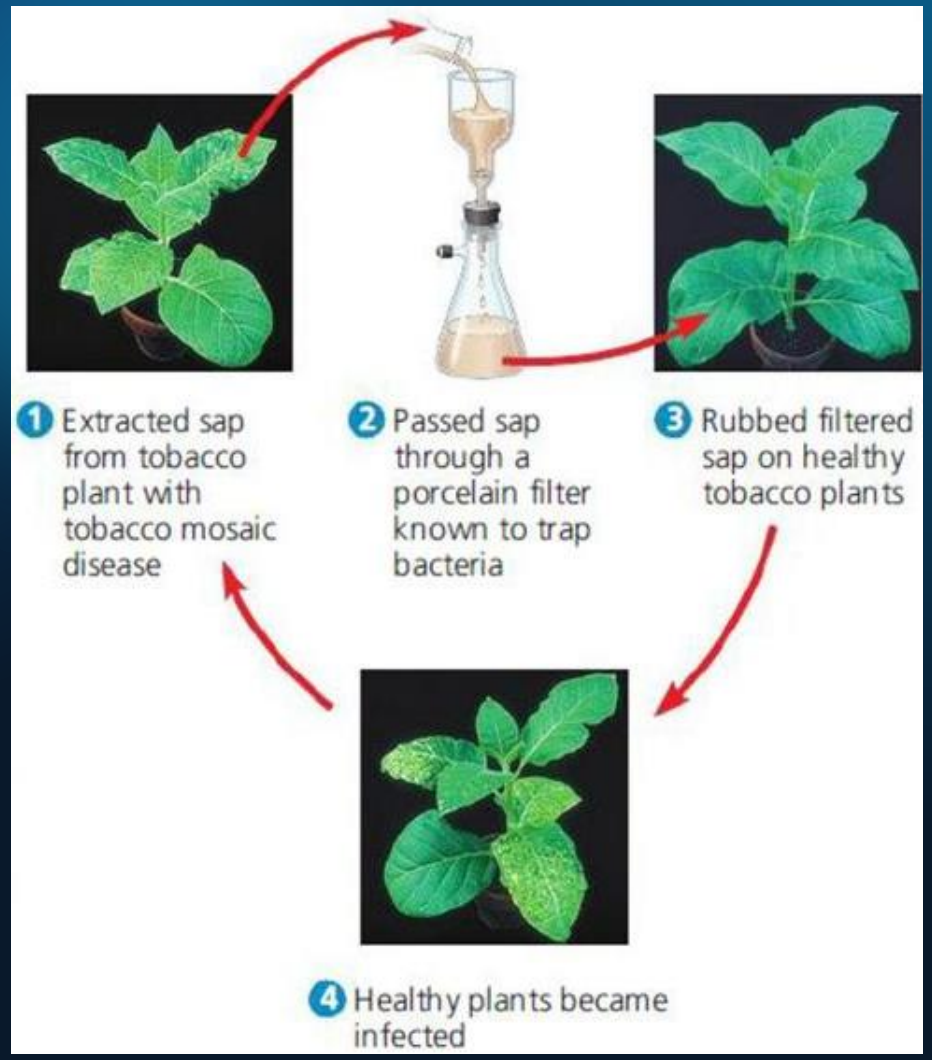
Microbiology in the 19th century

- Louis Pasteur published his ‘germ theory’ in 1861, proving that bacteria caused diseases.
- Robert Koch set out “Koch’s Postulates” in 1890: a list of criteria to determine whether a disease was caused by bacteria.

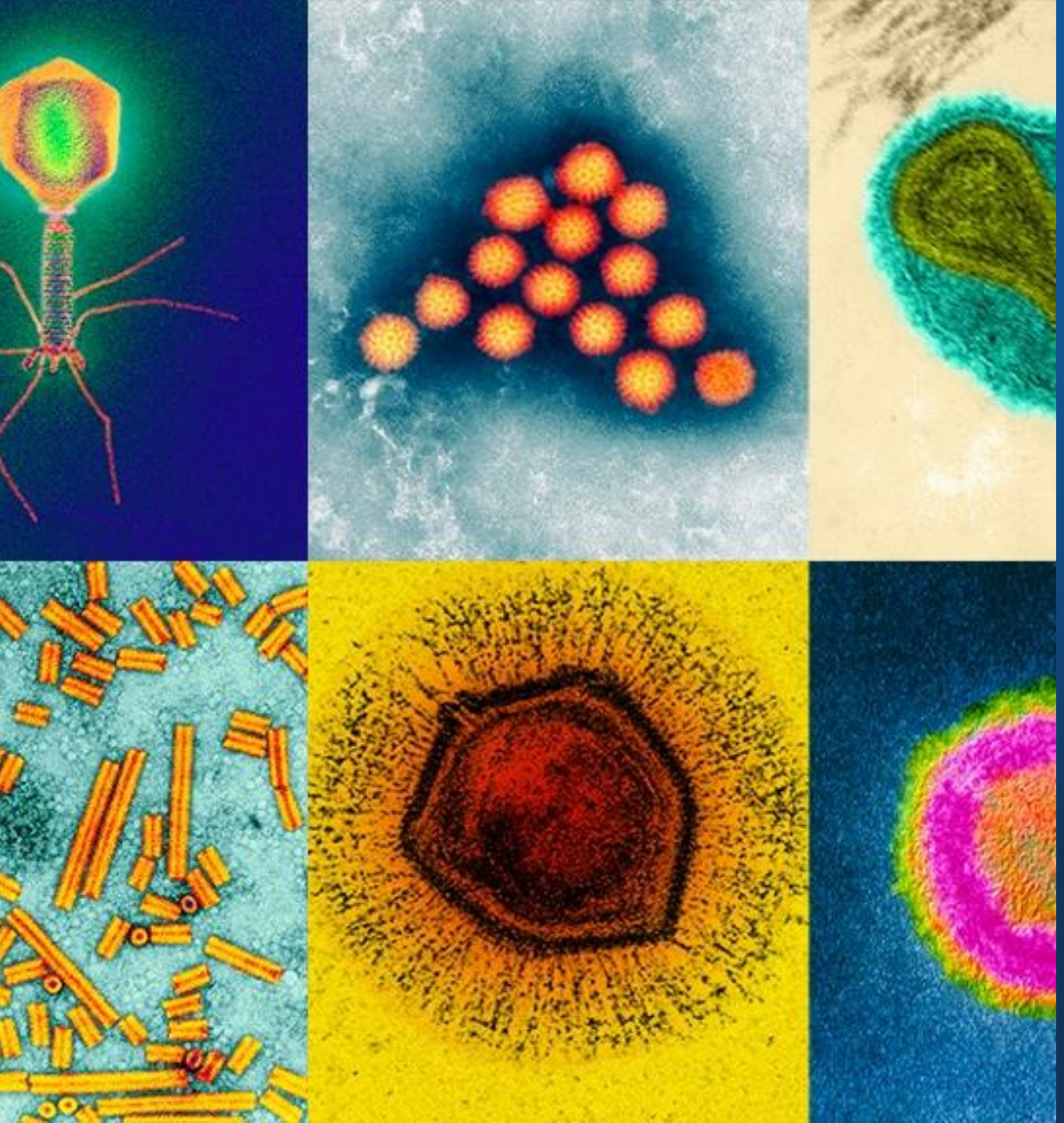


Tobacco Mosaic Disease

- Dmitri Ivanovsky (1892) completed experiments to show that infectious agent is non-bacterial and very small
- Martinus Beijerinck (1898): replicated Ivanovsky's experiments
- Wendell Stanley (1935): isolated tobacco mosaic virus



Viruses

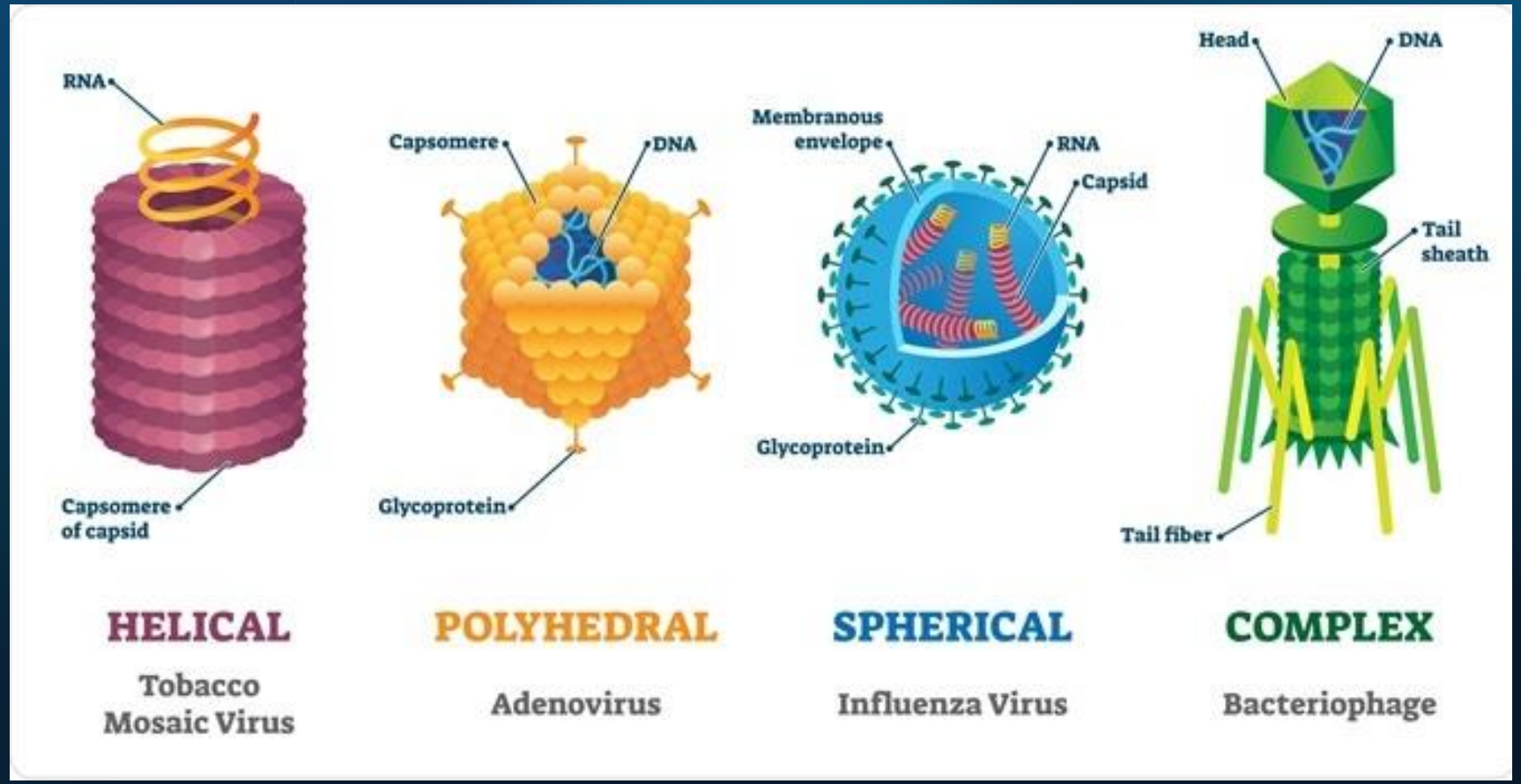


What is a Virus?

- Non-living, not made of cells, requires a host to reproduce
- Parasitic: invades living cells and hijacks cellular machinery to make more copies of virus
- Very specific: in general, each virus only infects one type of cell

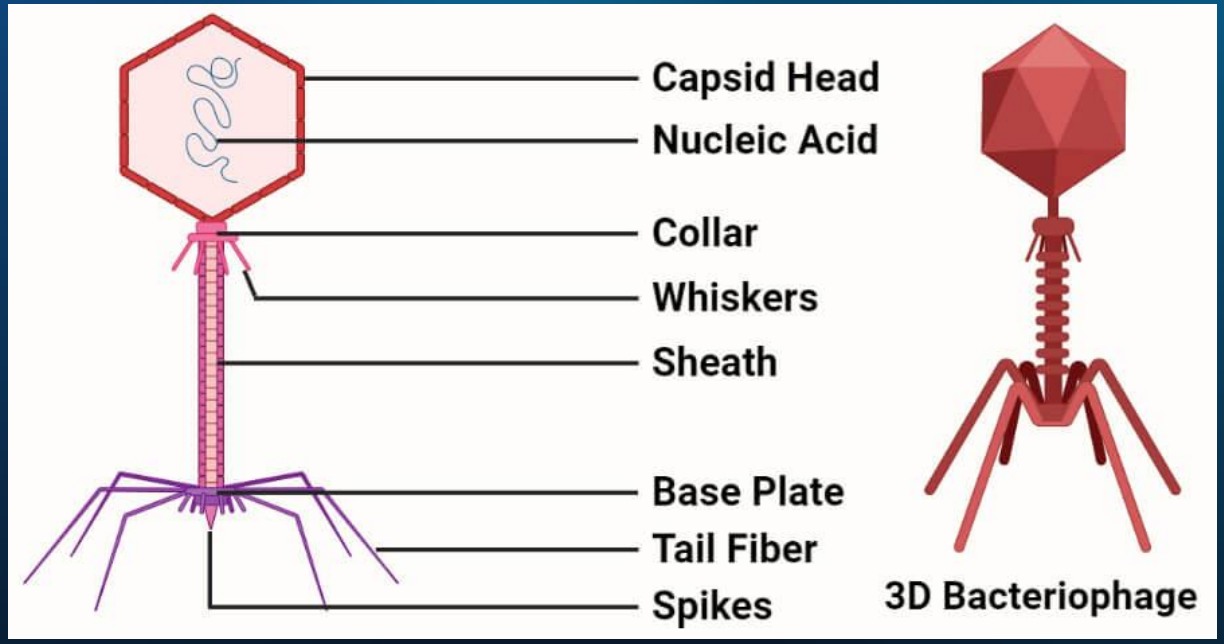
Virus Structure

- Extremely small (10-400 nm)
- All viruses have a ***nucleic acid*** core surrounded by a protein coat called a ***capsid***



Virus Structure: Bacteriophages

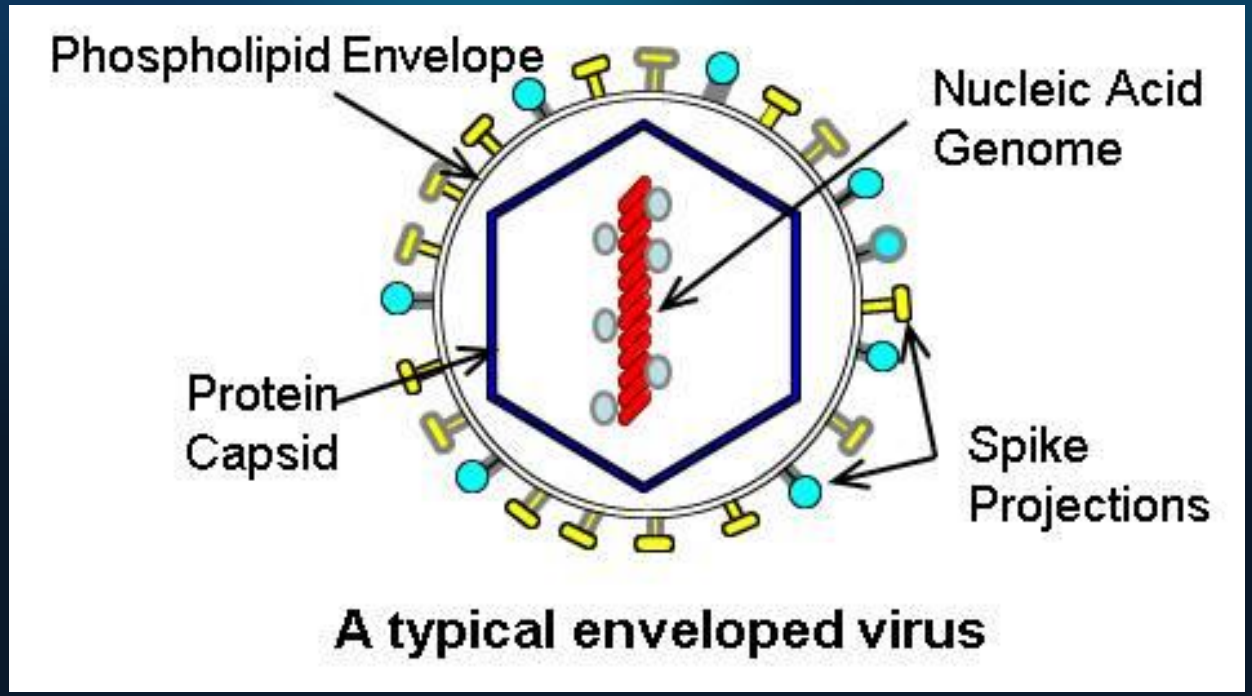
- ***Bacteriophages*** are viruses that infect prokaryotes (bacteria and archaea)
- Genetic material in ***capsid***; tail used to recognize and infect cell



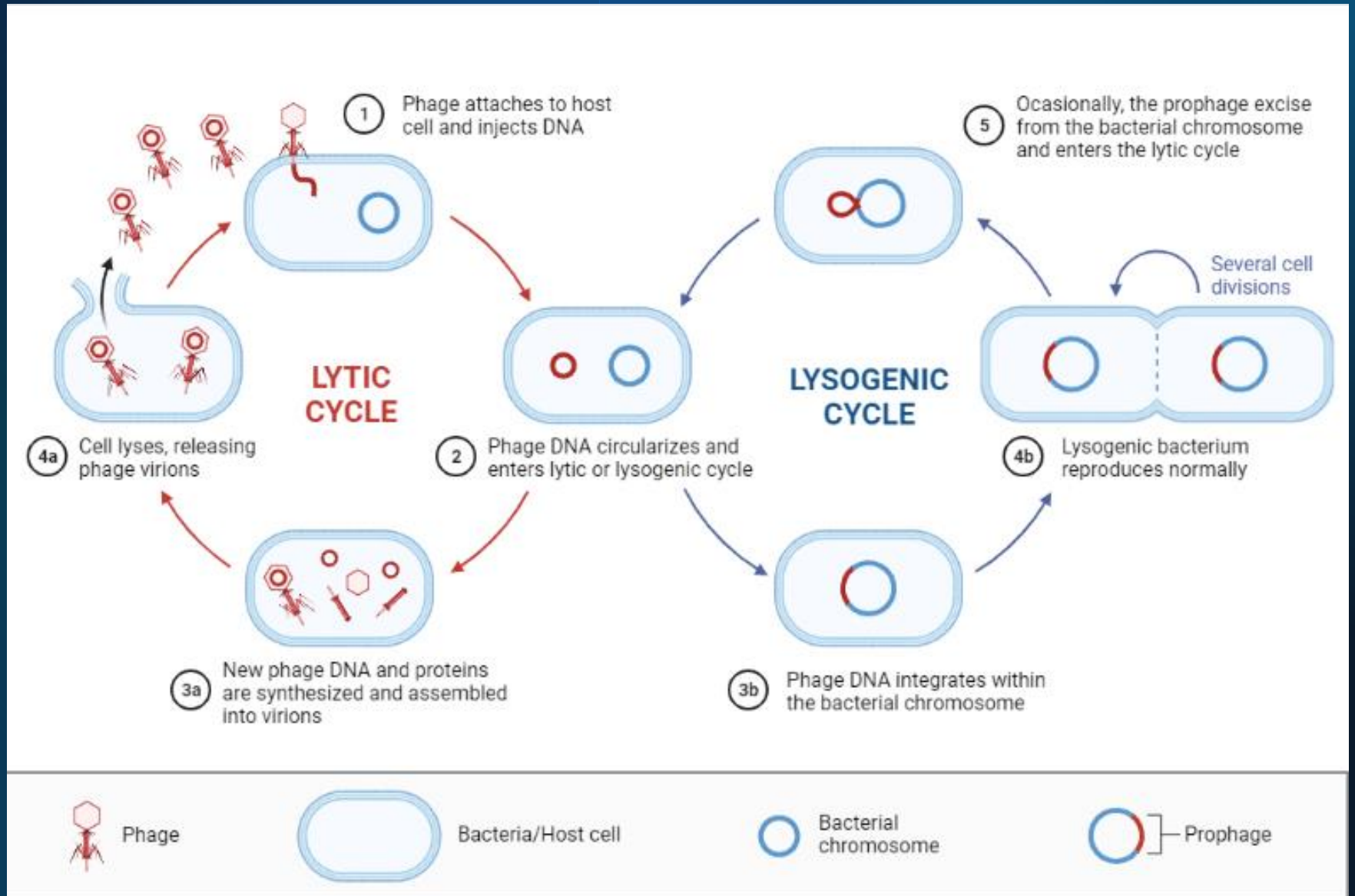
https://www.youtube.com/watch?v=V73nEGXUeBY&ab_channel=biolution
https://www.youtube.com/watch?v=YI3tsmFsrOg&ab_channel=Kurzgesagt%E2%80%93InaNutshell

Virus Structure: Enveloped Viruses

- ***Enveloped viruses*** are surrounded by an envelope
- ***Spike proteins*** are proteins embedded in the viral envelope. They recognize and attach to the host cell's surface.
- Examples: influenza, coronaviruses



‘Life’ Cycle of a Virus



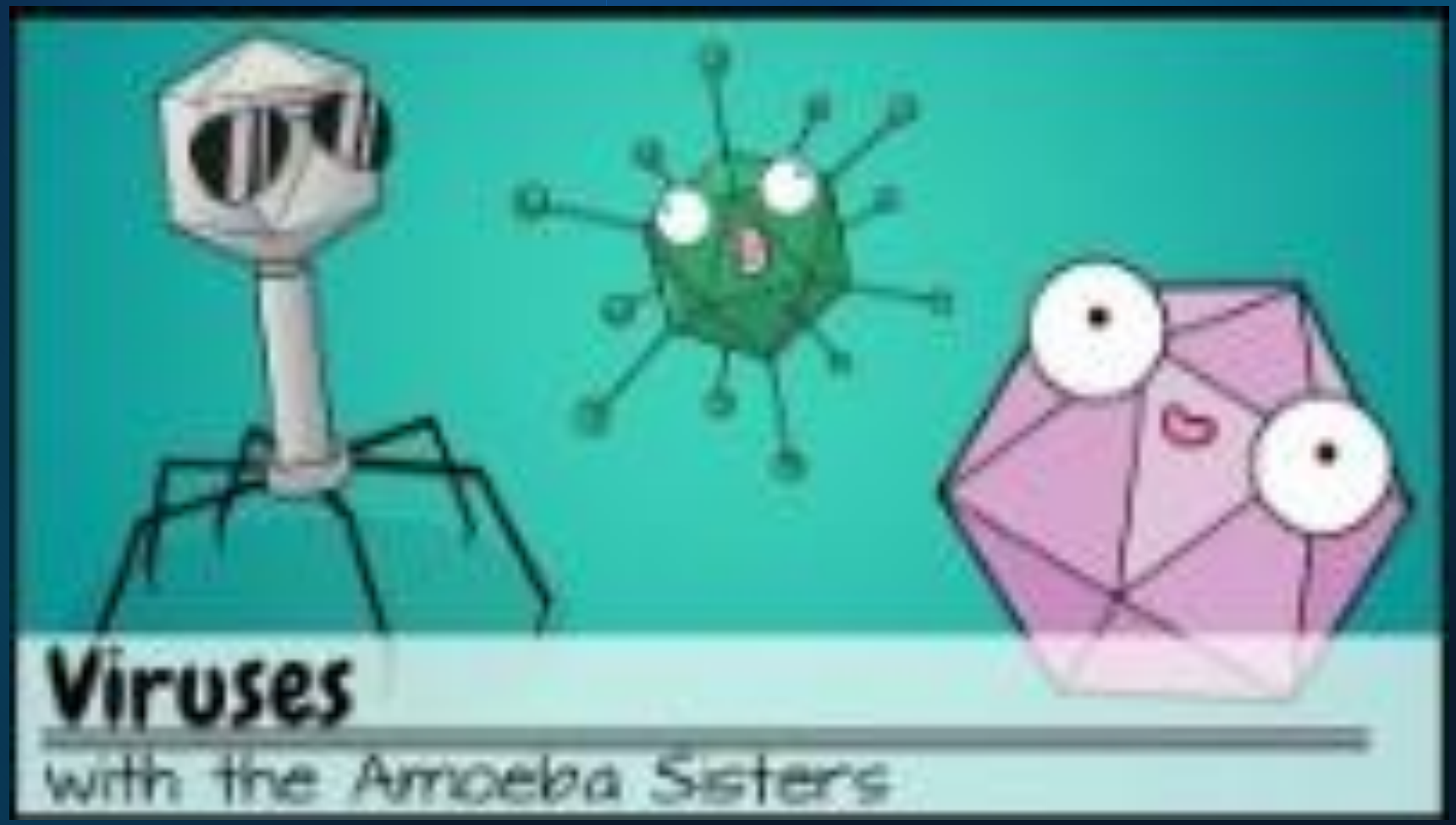
Lytic Cycle

- Infection: virus contacts specific cell type and injects genetic material into the cell
- Growth and Replication:
  - Cell uses viral genetic material to make viral proteins, often shutting down or destroying cellular DNA in the process
  - Host cell fills up with virus molecules
- ***Lysis***: cell bursts, freeing up virus to infect other cells

Lysogenic Cycle

- Infection: virus contacts specific cell type and inserts its genetic material into the DNA of the host cell (this inserted viral genetic material is now known as a ***prophage***)
- Dormant Phase: cell reproduces normally, making more copies of itself and the viral genetic material
- Activation: an environmental factor activates the viral genetic material, causing it to enter the lytic cycle

https://www.youtube.com/watch?v=8FqlTslU22s&ab_channel=AmoebaSisters



Research: "How does COVID-19 infect our cells and bodies?"

For this exercise, you will be presented with a number of different information sources. For each source, record the following:

1. What are 3 key takeaways from this information source?
2. What questions do you still have? What did you find confusing?

After compiling a summary of your research from 3 different sources, write a paragraph that summarizes your answer to the research question: "How does COVID-19 infect our cells and bodies?" Cite specific sources in your answer.

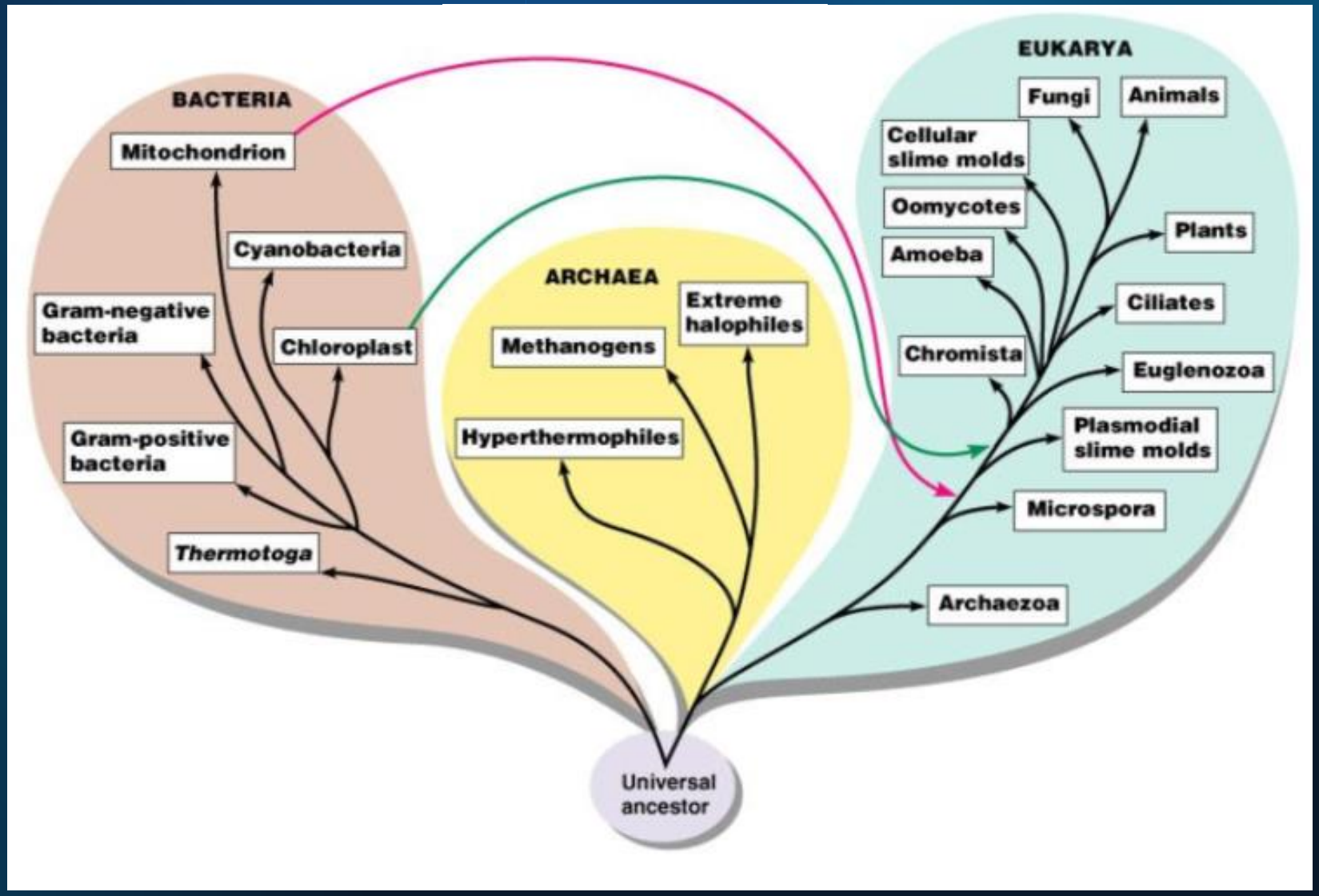
Research: "How does COVID-19 infect our cells and bodies?"

Reflect on your experience with this research assignment.

1. Which types of information sources did you find most helpful *or* easiest to understand? Why?
2.
    a) Which types of information sources did you find most difficult to understand? Why?
    b) When encountering this type of information source in the future, what are some strategies you can use to help yourself understand what is being communicated?

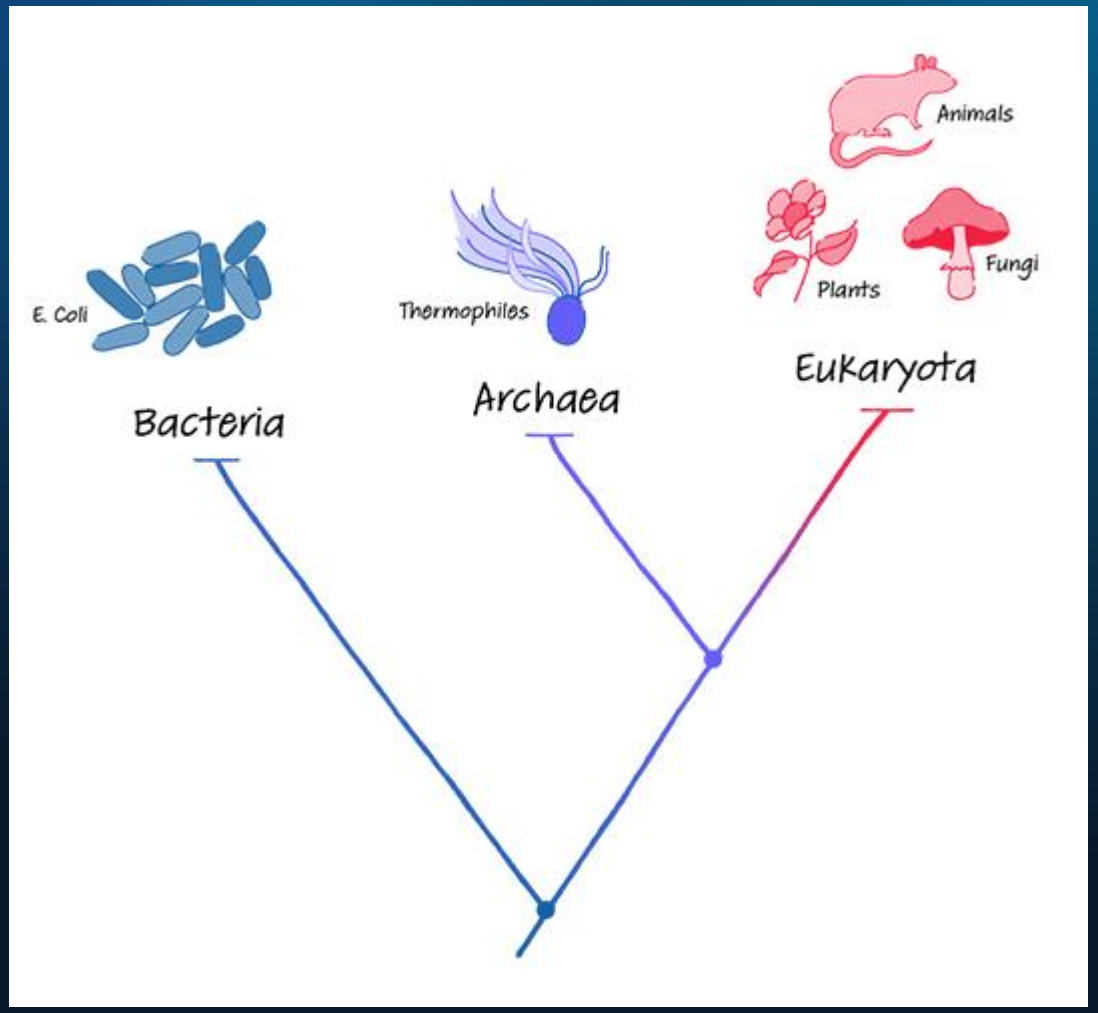
Prokaryotes

The 3 Domains of Life



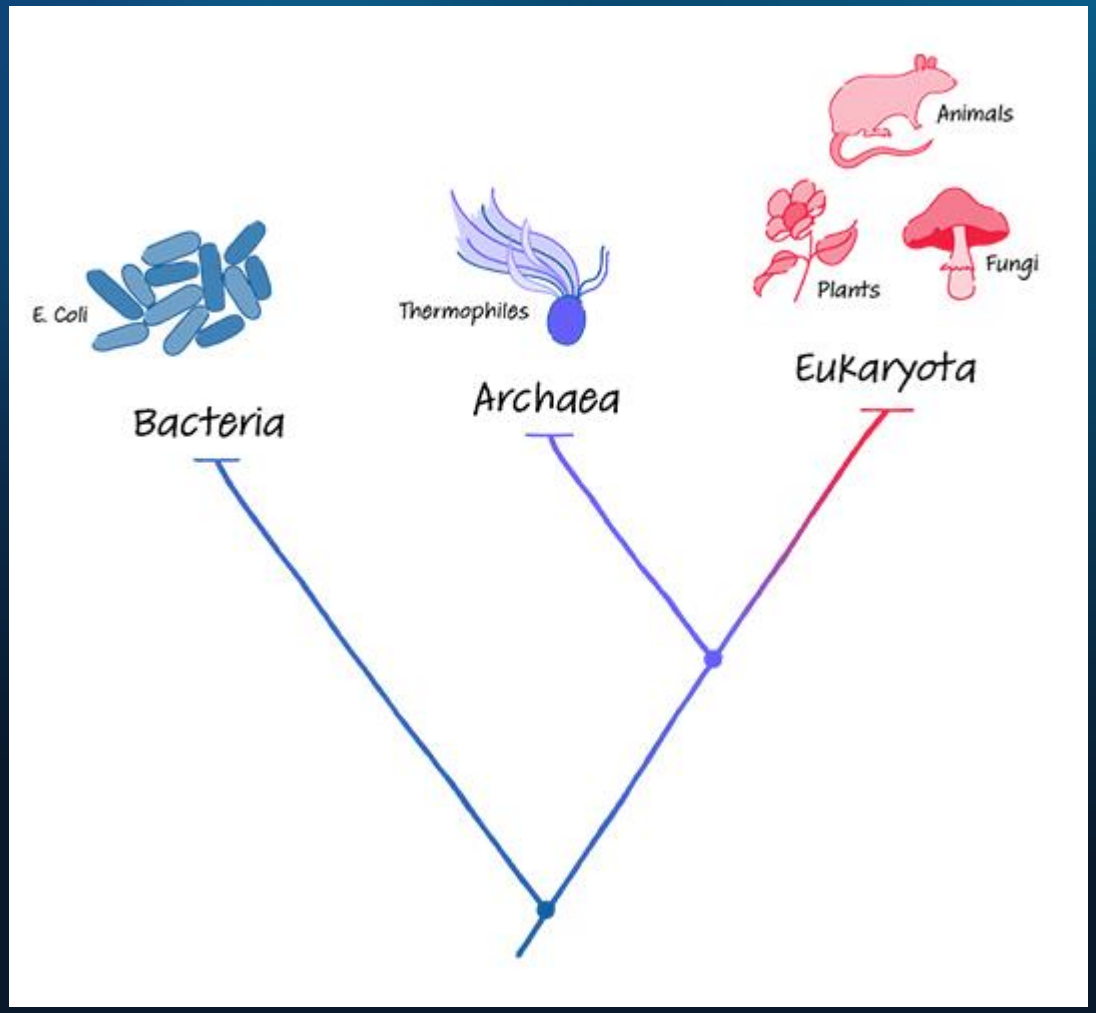
The 3 Domains of Life

- All living things can be grouped into 3 domains: Bacteria, Archaea, and Eukarya



Prokaryotes

- Unicellular organisms
- Made of prokaryotic cells
- Includes Bacteria and Archaea



Prokaryotic Cells

- Smallest type of cell (1-10 um long)
- Lack a nucleus and other membrane-bound organelles
- Bacteria and Archaea made of prokaryotic cells

Domain Bacteria

SIMPLE PROKARYOTES, INTERACT WITH US DAILY

CHAPTER 17

(NOTE: YOUR TEXTBOOK REFERS TO THIS AS KINGDOM EUBACTERIA. RECENT PHYLOGENETIC ADVANCES CLASSIFY BACTERIA AS THEIR OWN DOMAIN.)

HTTPS://MICROBIOLOGYSOCIETY.ORG/WHY-MICROBIOLOGY-MATTERS/WHAT-IS-MICROBIOLOGY/BACTERIA.HTML

HTTPS://FLEXBOOKS.CK12.ORG/CBOOK/CK-12-MIDDLE-SCHOOL-LIFE-SCIENCE-2.0/SECTION/5.4/PRIMARY/LESSON/BACTERIA-REPRODUCTION-MS-LS/

Summary

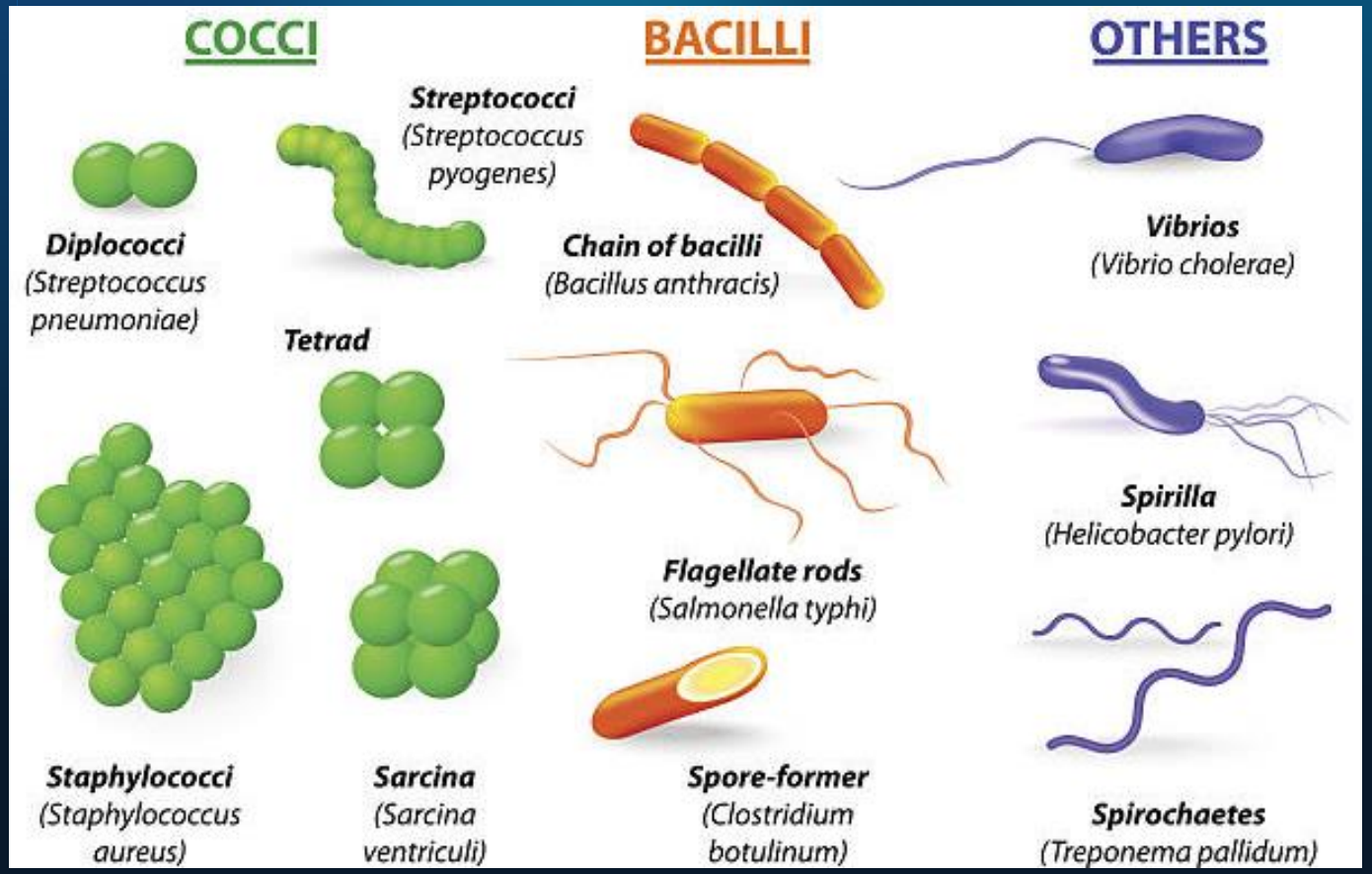
- Appearance and Structure
- Gram Staining
- Genetic Info, Reproduction
- Locomotion
- Obtaining Energy
- Helpful Bacteria
- Harmful Bacteria
- Antibiotics and Resistance

What do Bacteria Look Like?

Bacteria can be classified according to their shapes:

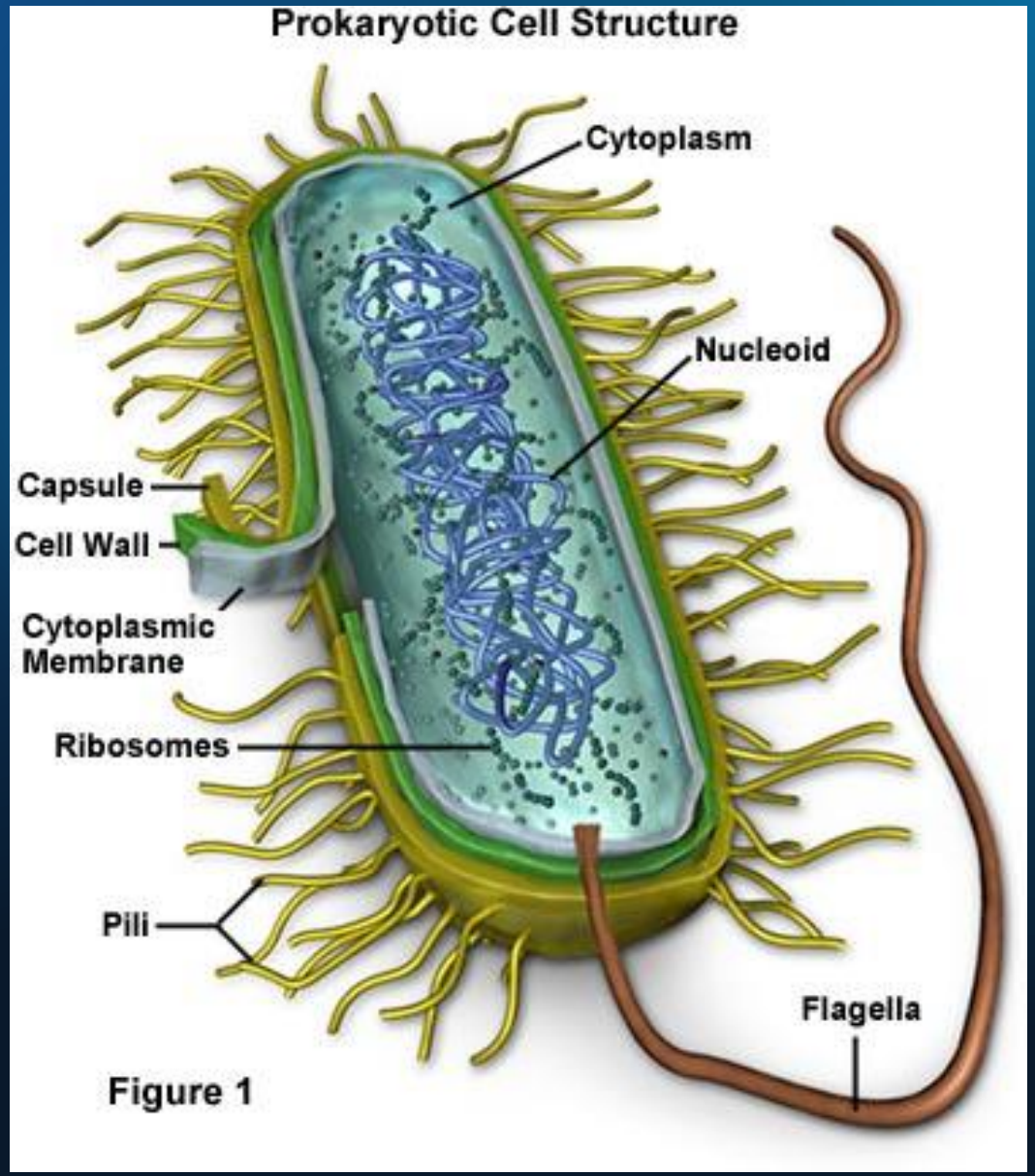
- Spherical (**cocci**)
- Rod (**bacilli**)
- Spiral (**spirilla**)
- … and more!

Bacteria can exist alone, in pairs, chains, or clusters



Structure

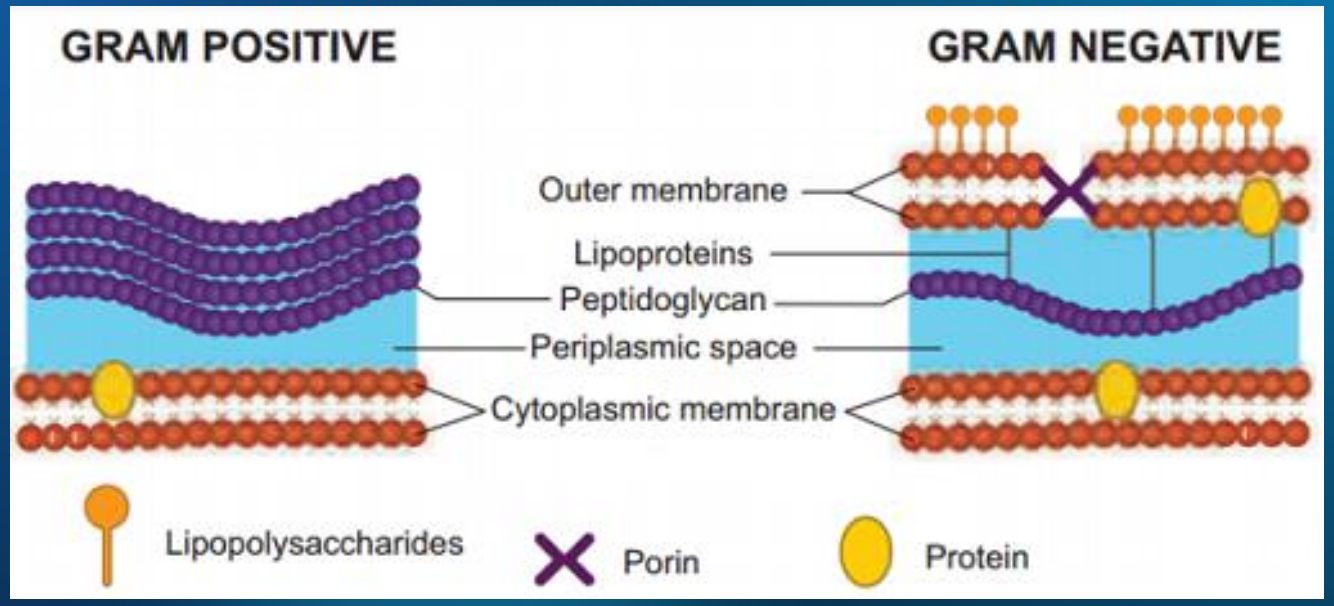
- **Unicellular prokaryotes**
- **Cell wall** for protection
- Cell membrane surrounding cytoplasm
- **No nucleus** or membrane-bound organelles

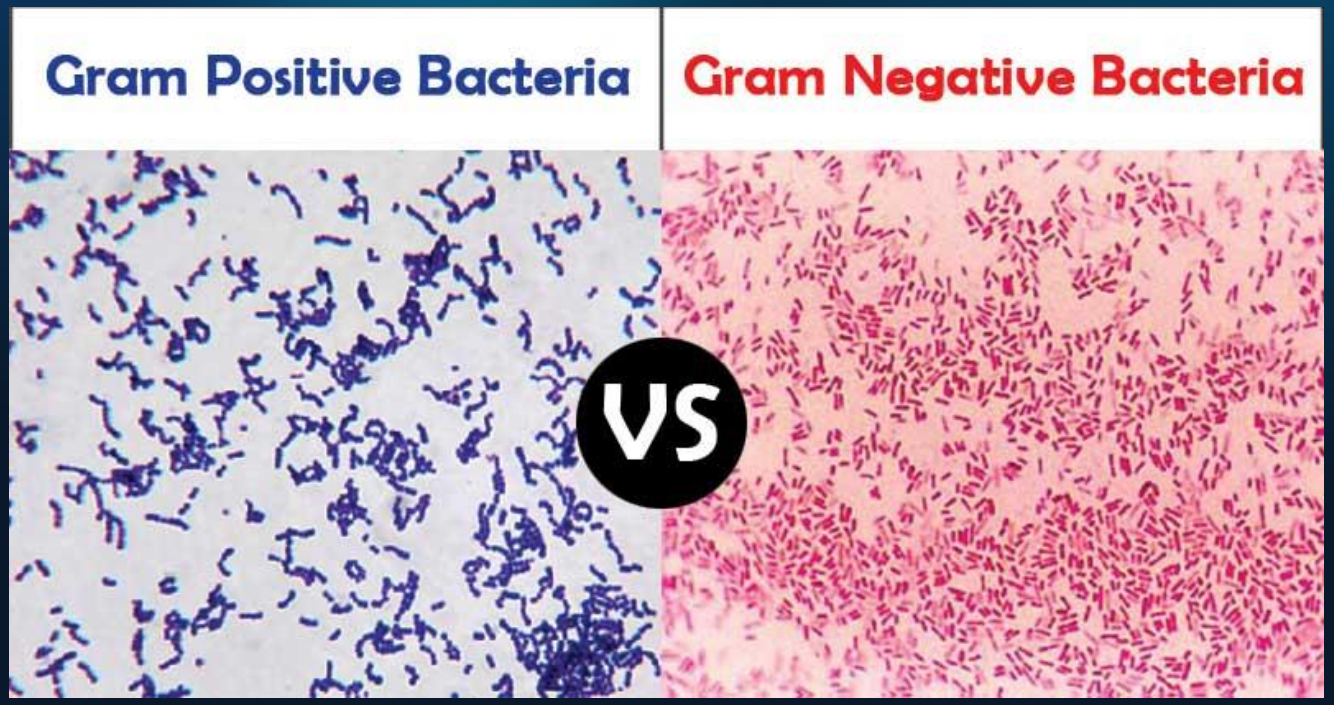


Gram-Staining

Gram-staining is a lab technique to distinguish between two categories of bacteria: **Gram-positive** and **Gram-negative**.

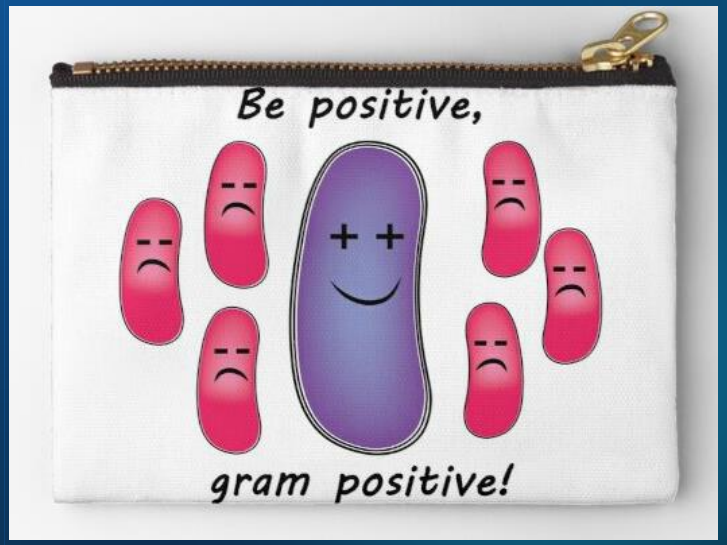
The purple Gram stain is absorbed by peptidoglycan.

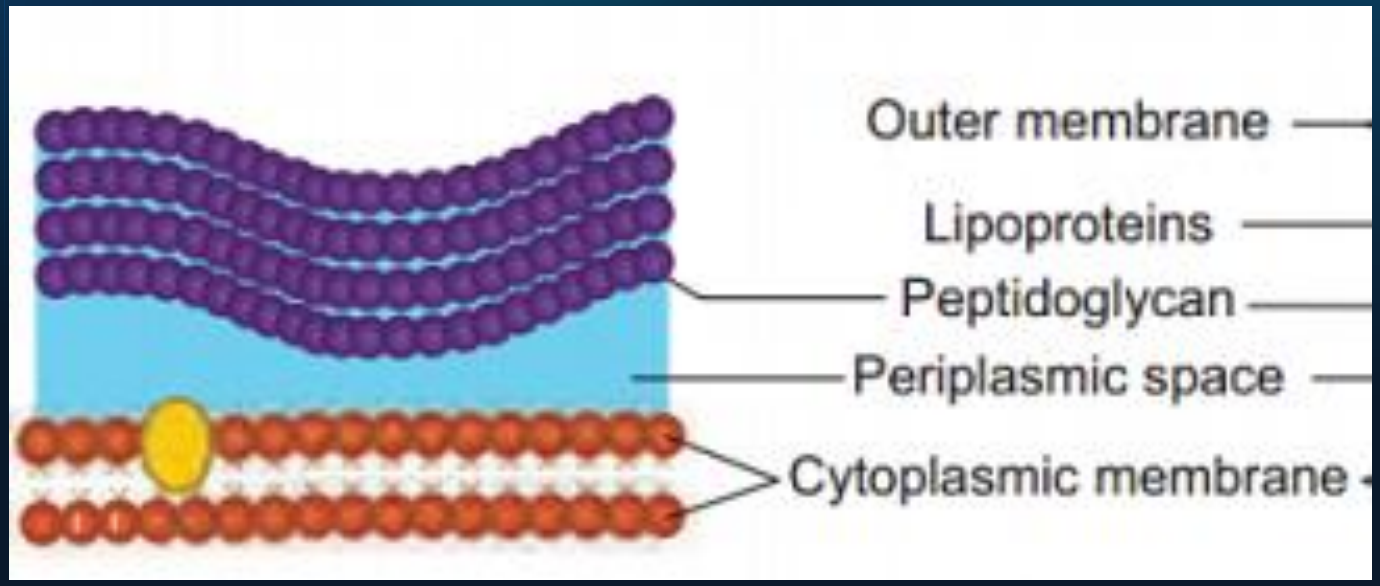




Gram-Positive

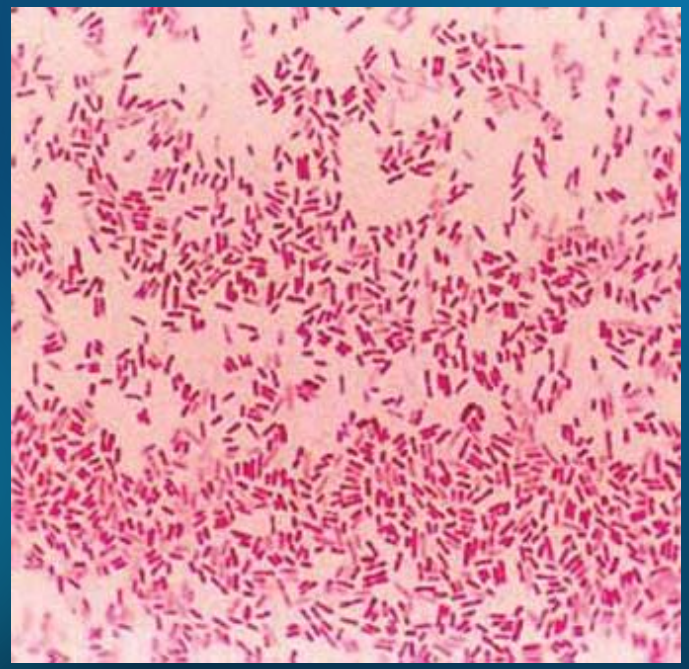
- Thick peptidoglycan cell wall
- Stains purple
- Examples:
  - MRSA
  - Strep bacteria
  - Toxic shock

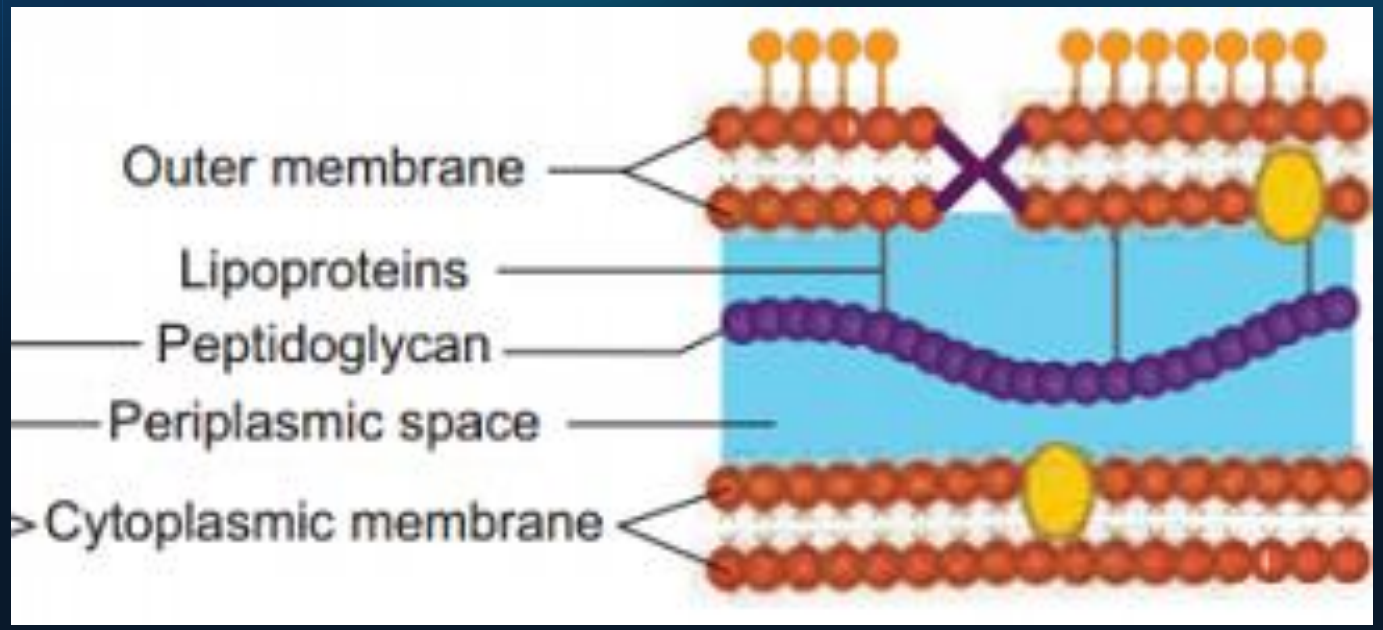


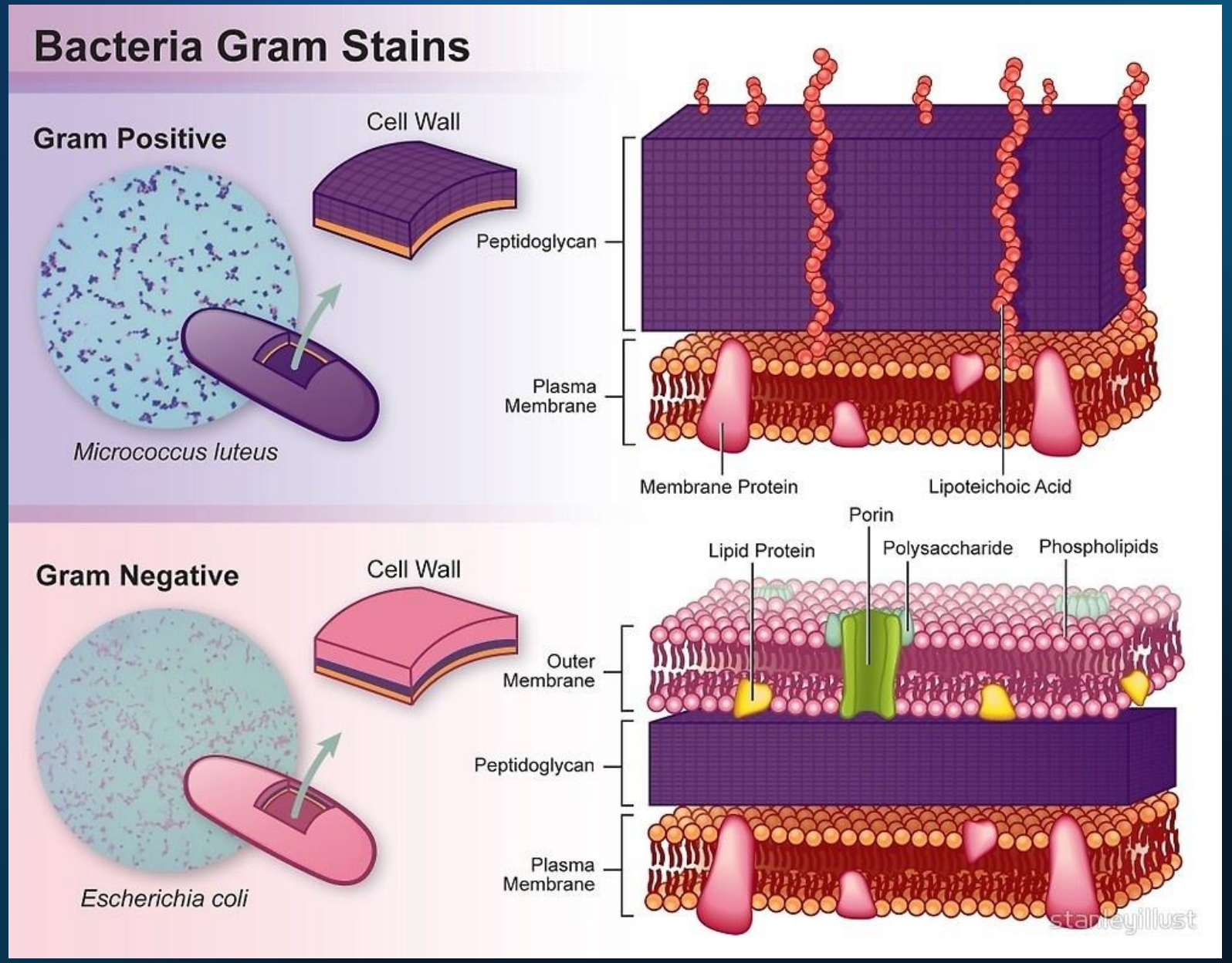


Gram-Negative

- Cell wall is a thin peptidoglycan layer and an extra membrane layer
- Stains red or pink
- Examples:
  - Salmonella
  - Pneumonia
  - Urinary tract infections
  - Gonorrhea



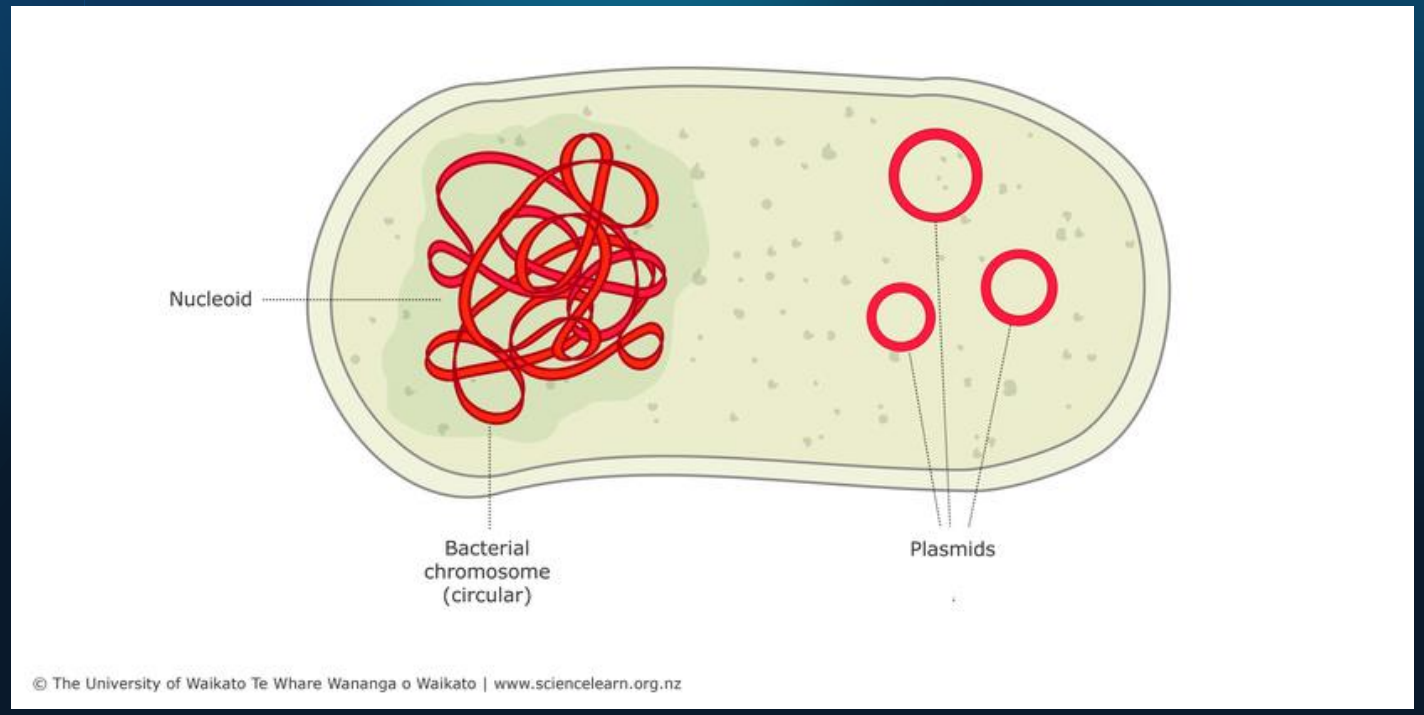




Video on gram positive and negative: https://www.youtube.com/watch?v=Didrc3wJ3E8&ab_channel=NeuralAcademy

Genetic Information

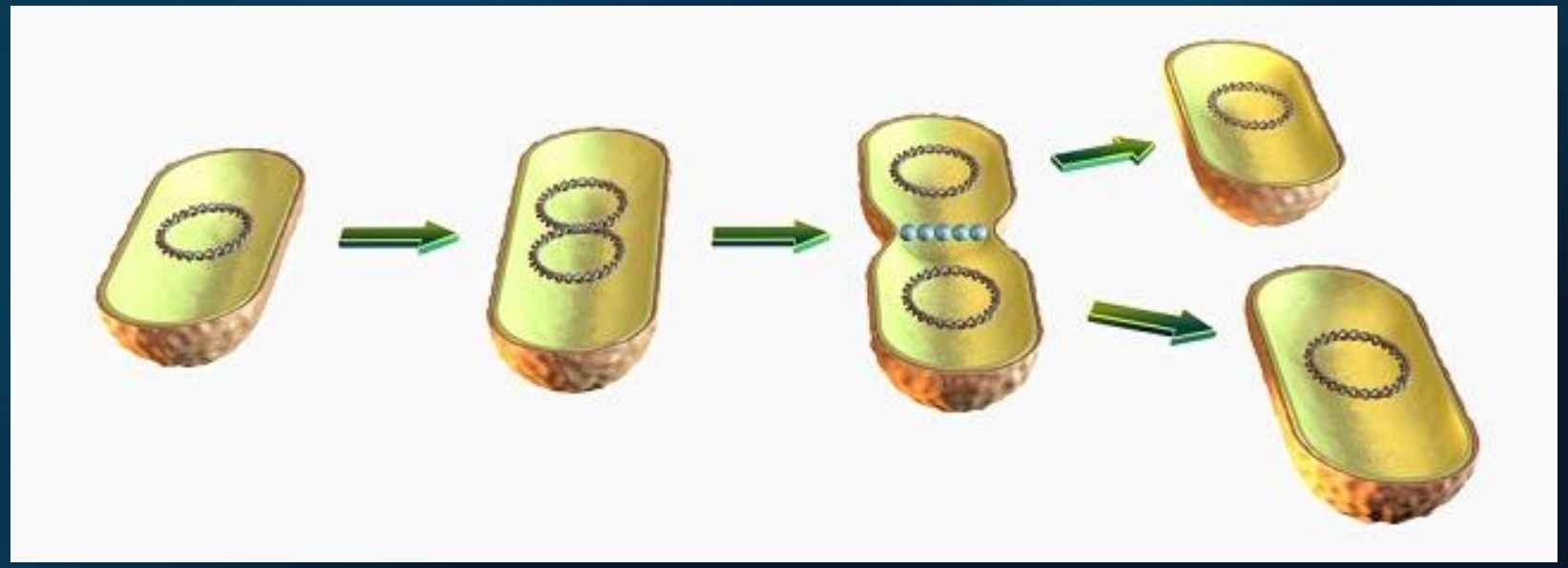
- Bacterial chromosome is a circular molecule of **DNA**
- Sometimes, bacteria also have **plasmids**: small circular pieces of DNA



Asexual Reproduction

Binary fission:

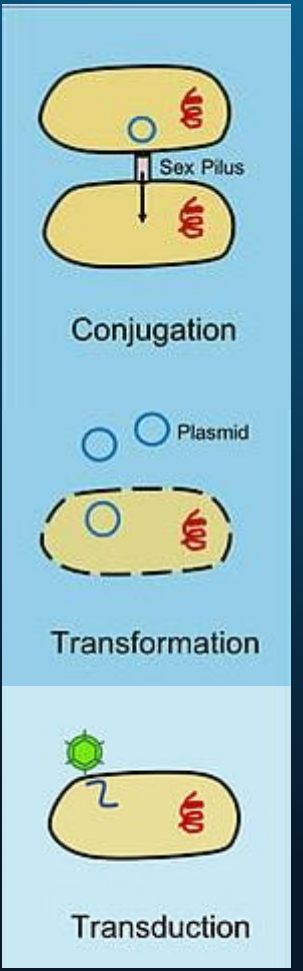
- Chromosome copies itself
- Cell divides into identical two daughter cells



Sexual Reproduction… Sort Of.

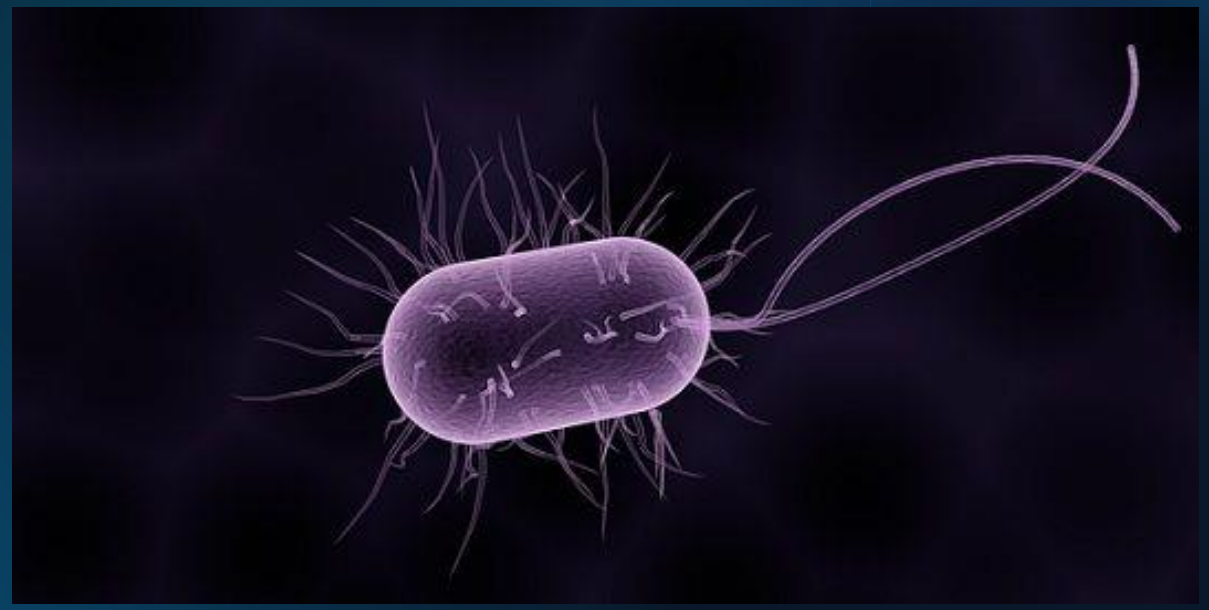
Bacteria do not have sexes. However, they have different strategies for exchanging DNA.

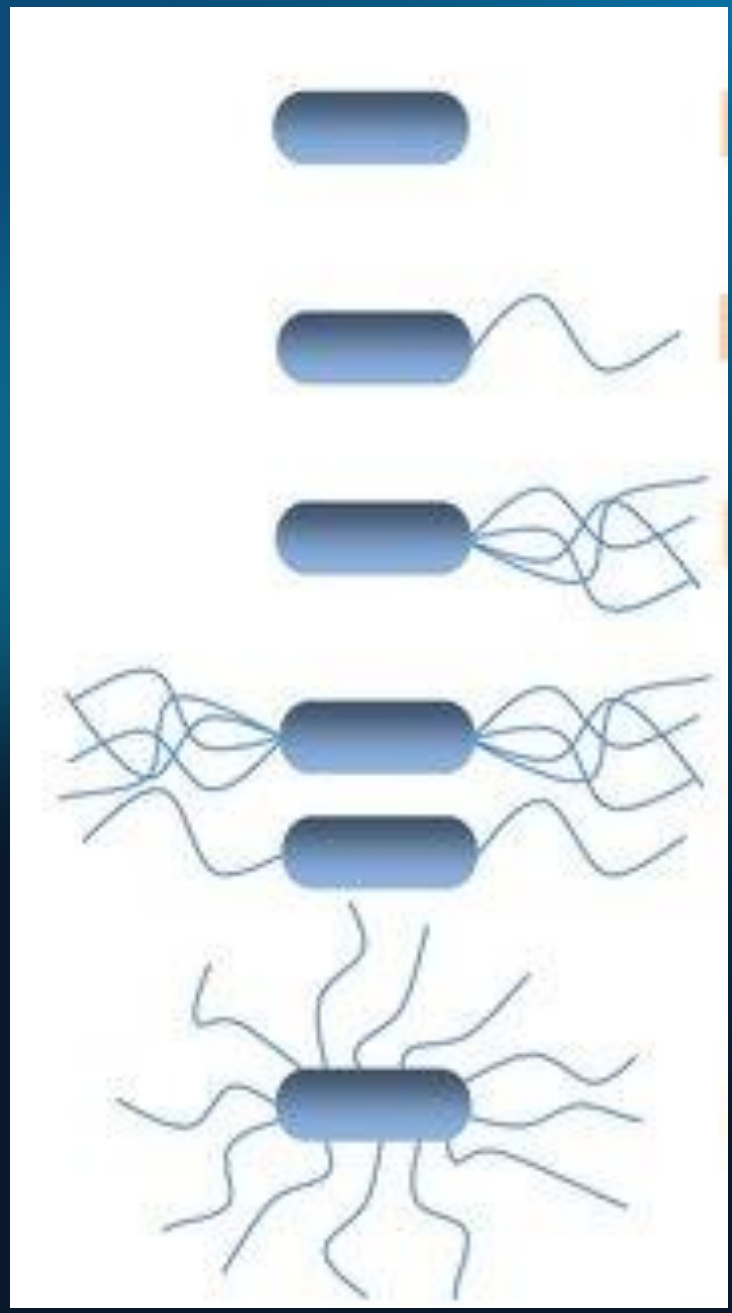
- **Conjugation:** DNA is passed from one bacterium to another
- **Transformation:** DNA is picked up from the environment
- **Transduction:** viruses carry DNA from one bacterium to another



Locomotion

- Different strategies for locomotion, including **flagella**
- Flagella rotate in a corkscrew motion





https://www.youtube.com/watch?v=jIoTzaWUQWk&ab_channel=TheMicrobiology09

Obtaining Energy

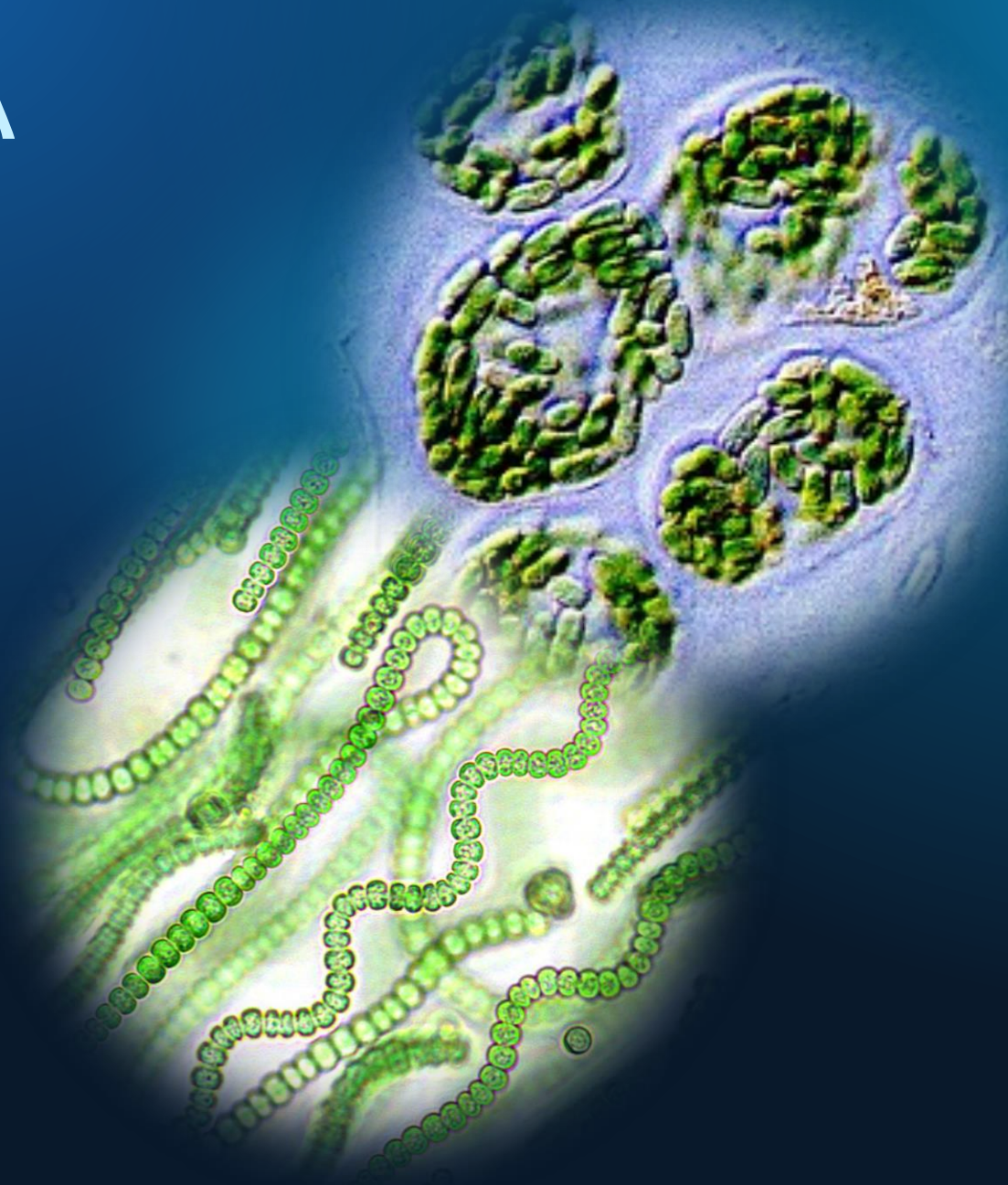
Many strategies:

- **Phototrophs**: trap the energy of sunlight through photosynthesis
- **Chemotrophs**: break down organic or inorganic compounds to obtain energy

Helpful Bacteria

Cyanobacteria

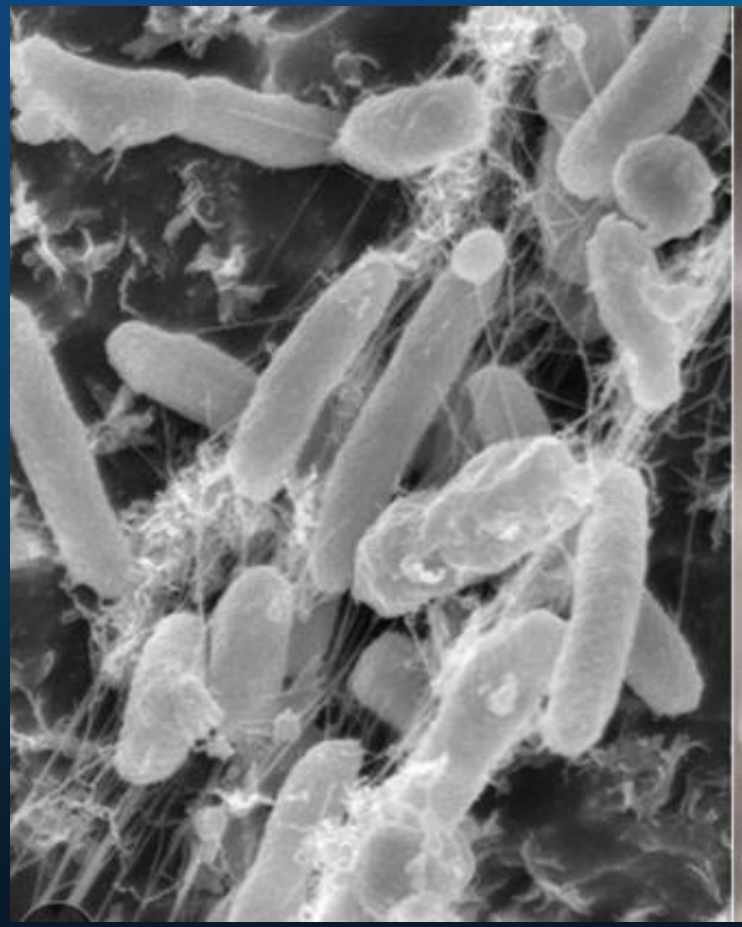
- Phototroph, has photosynthetic pigments
- Is responsible for 10% of global **oxygen production**



Helpful Bacteria

Ideonella sakaiensis is a chemotroph that **breaks down** PET - a type of **plastic** used in plastic bottles

Bacteria may be used in the near future to solve many types of pollution

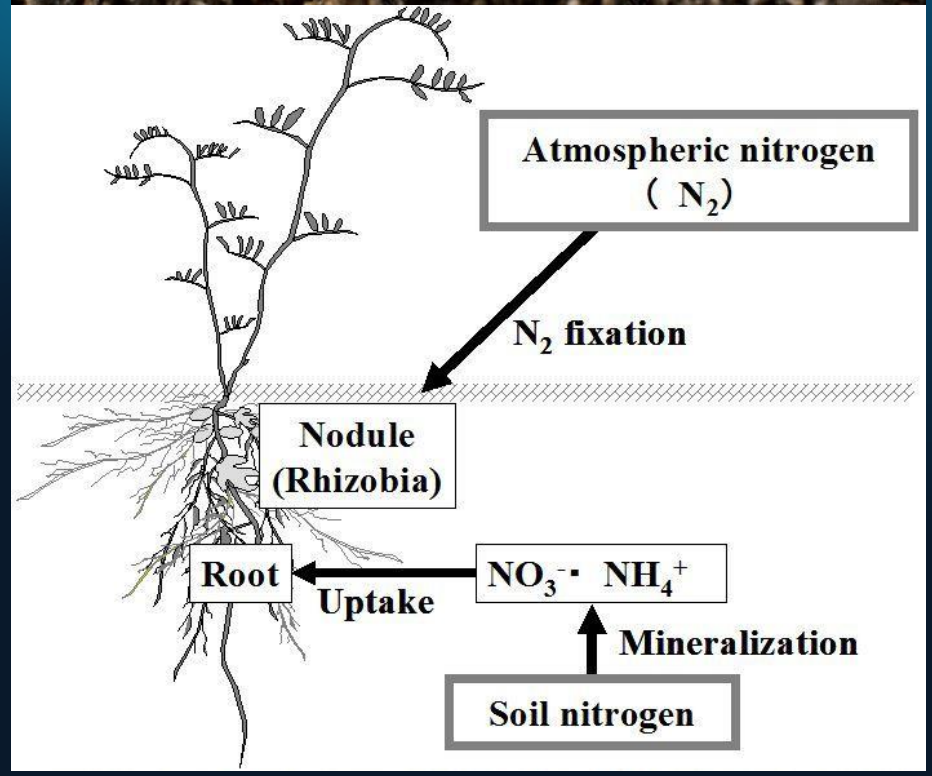


More reading on bioremediation https://microbiologysociety.org/blog/bioremediation-the-pollution-solution.html

Helpful Bacteria

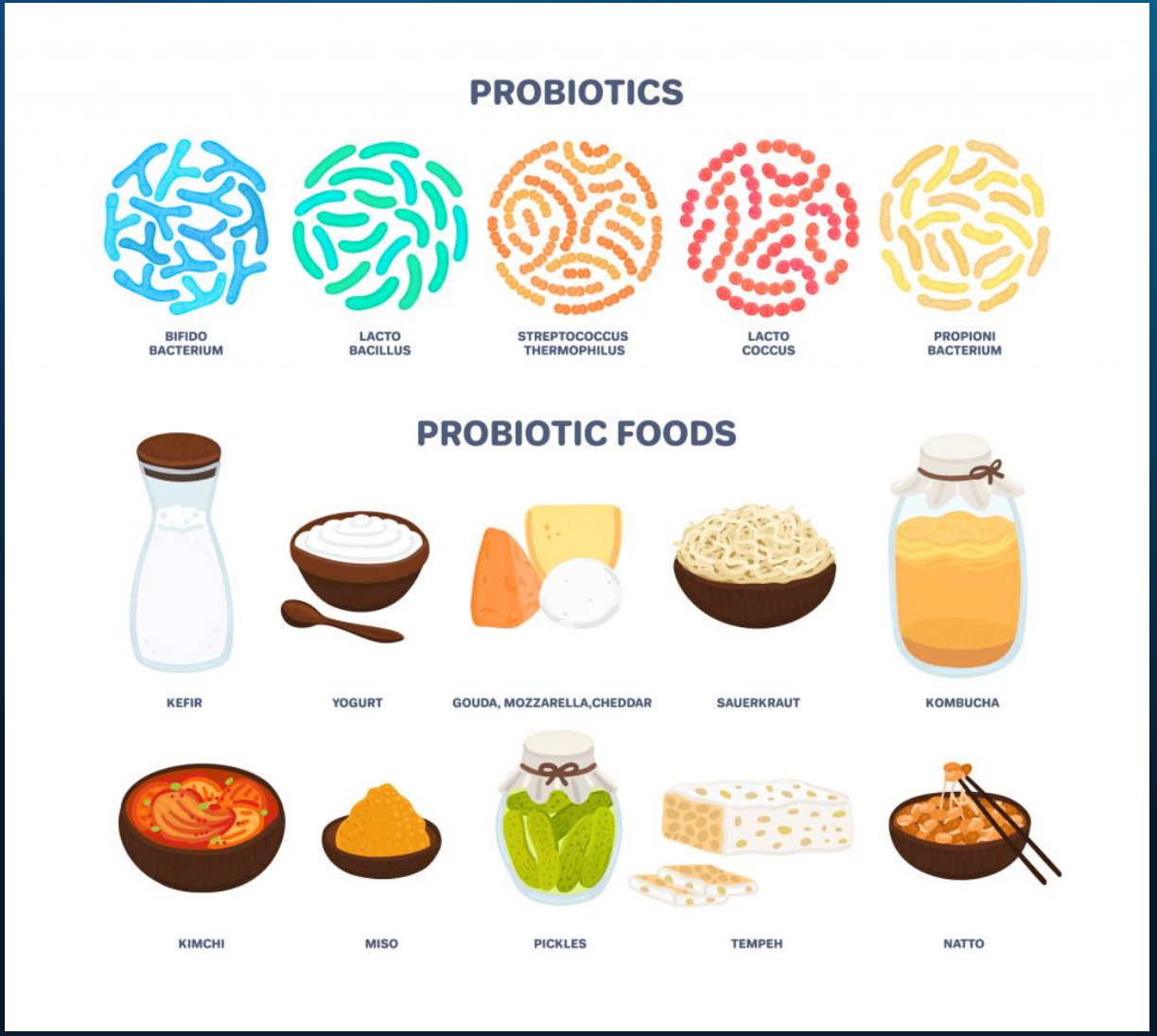
Nitrogen-fixing bacteria (e.g. ***Rhizobium***)

- Live in the roots of legumes (e.g. peas, beans, soy)
- Turn atmospheric nitrogen into forms that are useable by living organisms
- Symbiotic relationship: bacteria provide nitrogen to the plant in exchange for protection, oxygen, and sugar

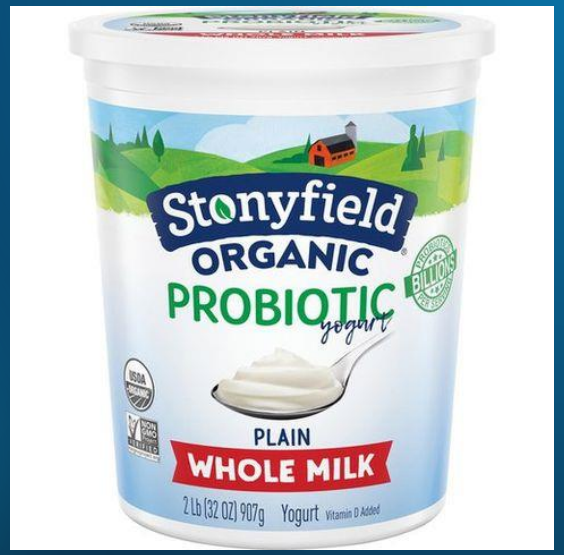


Helpful Bacteria

Bacteria used in the production of yogurt, wine, kimchi, cheese, and many other **fermented foods**

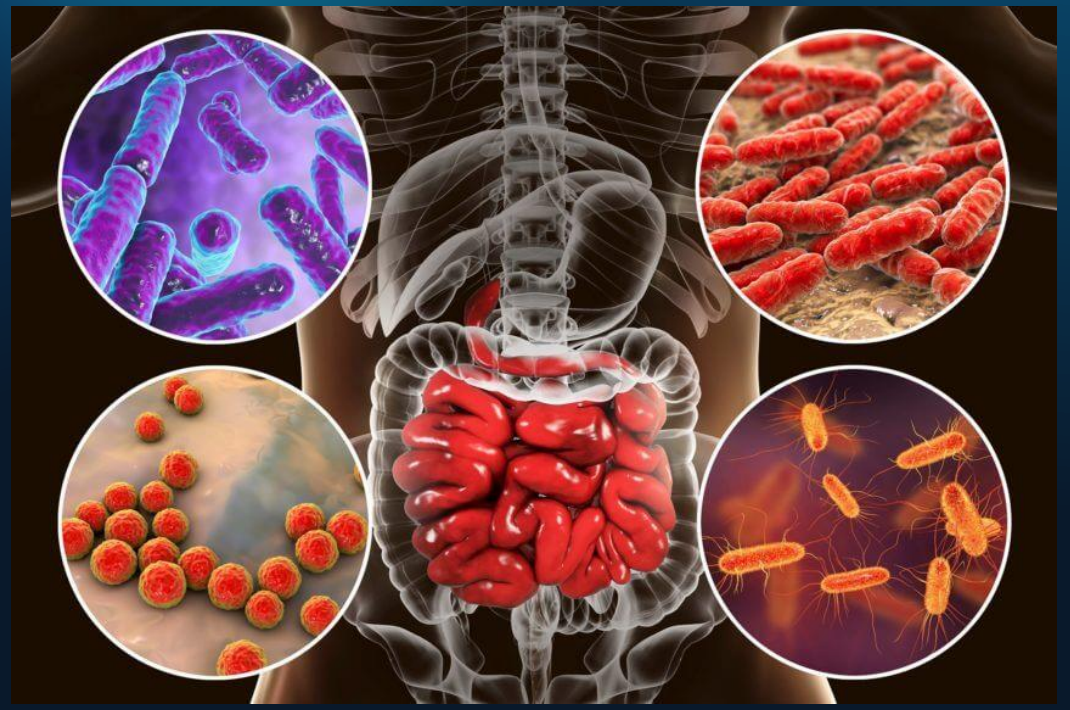


Helpful Bacteria



'Good' bacteria live in your digestive system:

- Help with **digestion**
- **Health**: prevent harmful bacteria from living there

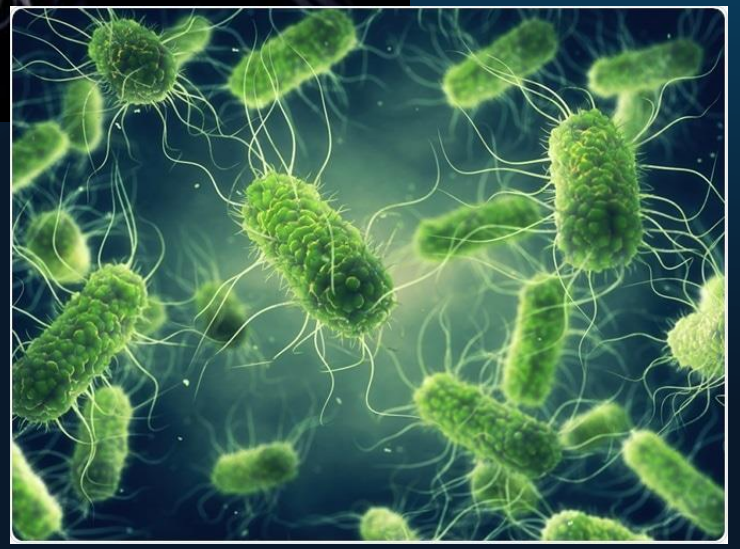


Imbalances in gut microbiota have been linked to many health conditions, including obesity and type 2 diabetes

Harmful Bacteria

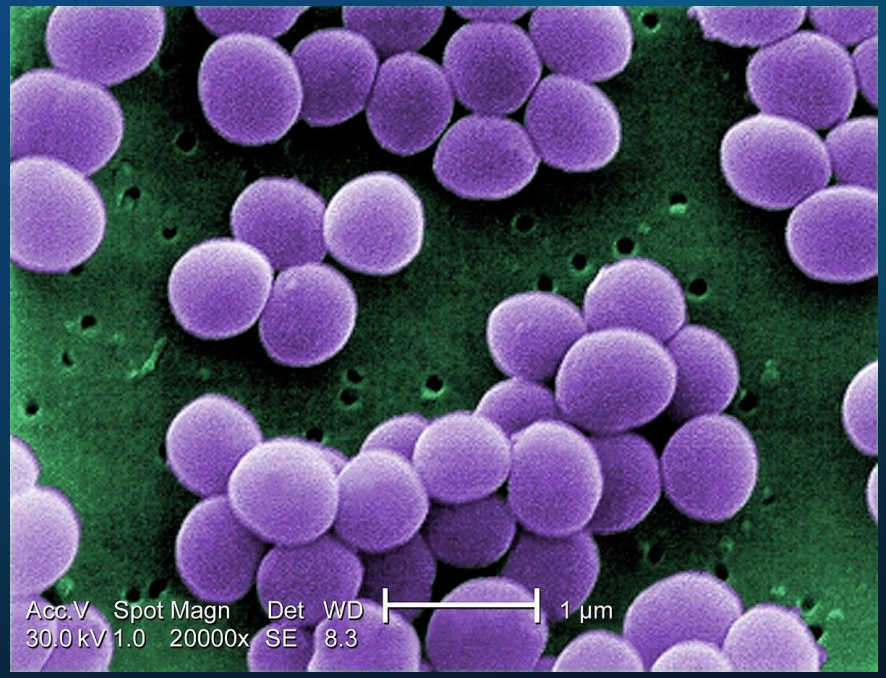
Food poisoning:

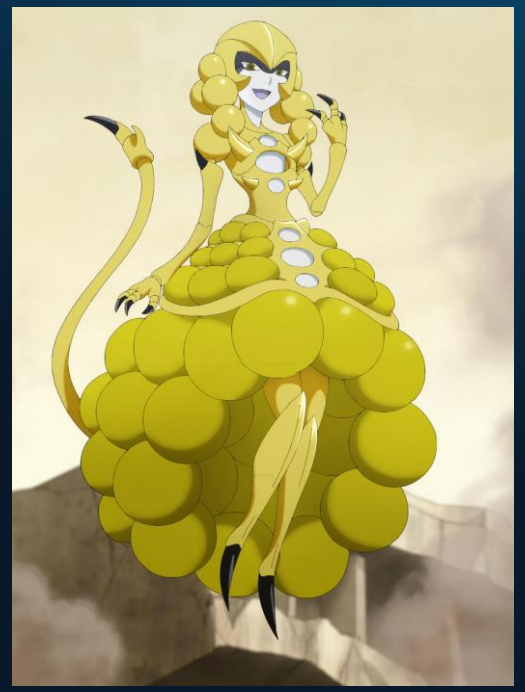
- ***E. coli*** normally lives in the digestive tract. Contaminates food/water to cause food poisoning.
- ***Salmonella*** causes infections through spoiled or contaminated food.



Harmful Bacteria

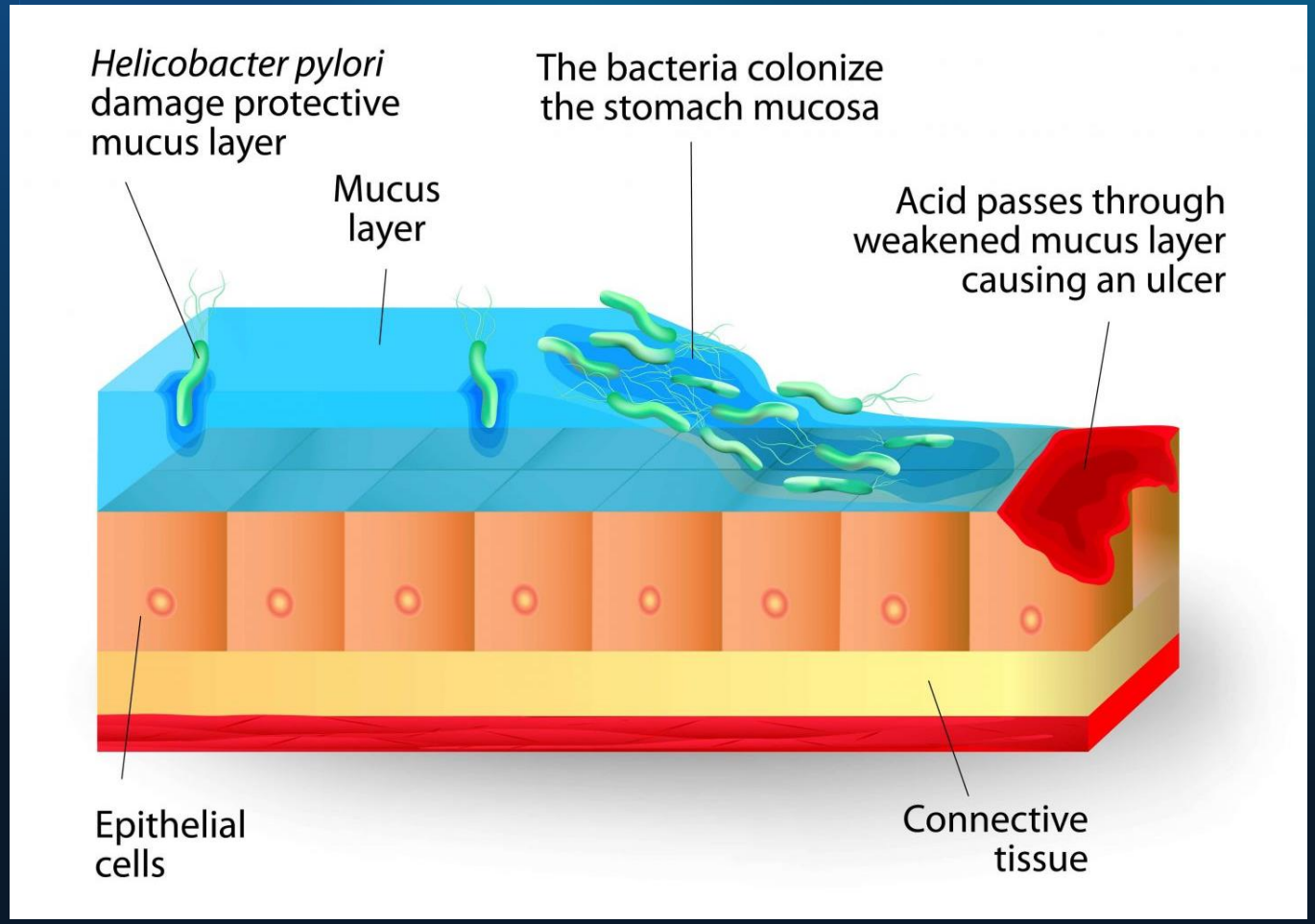
Staphylococcus is harmless and lives on the skin but causes **disease** if it enters the body (e.g. through a wound)





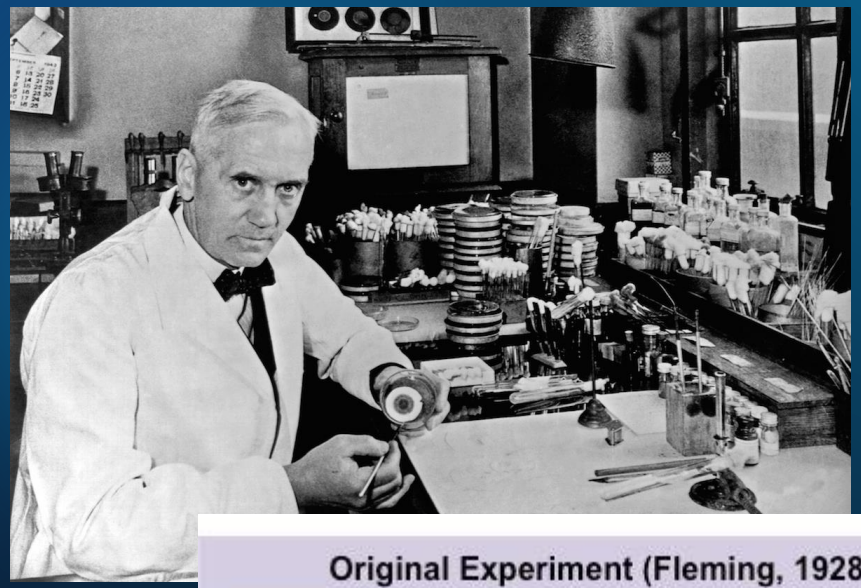
Harmful Bacteria

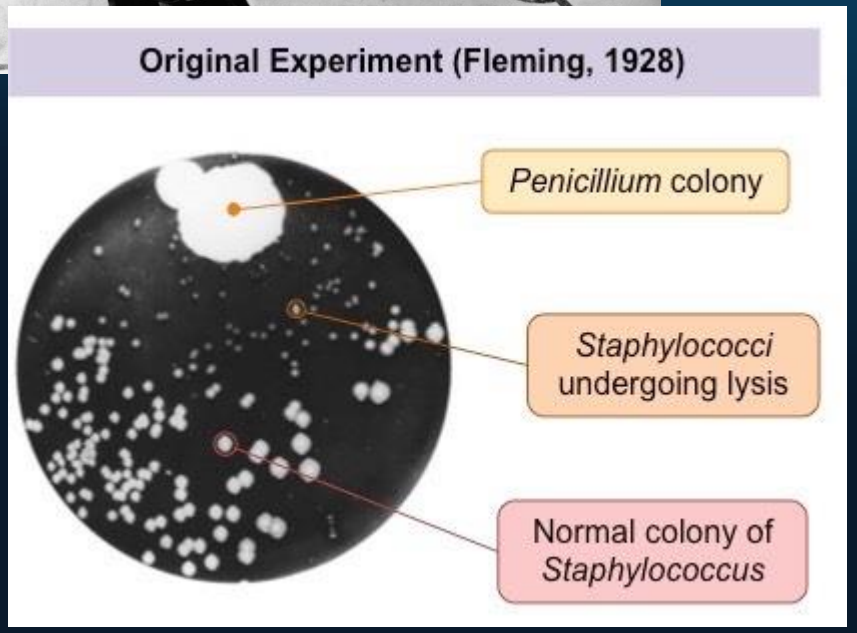
H. pylori lives in the stomach. Under certain conditions, can cause **peptic ulcers**.



Antibiotics and Resistance

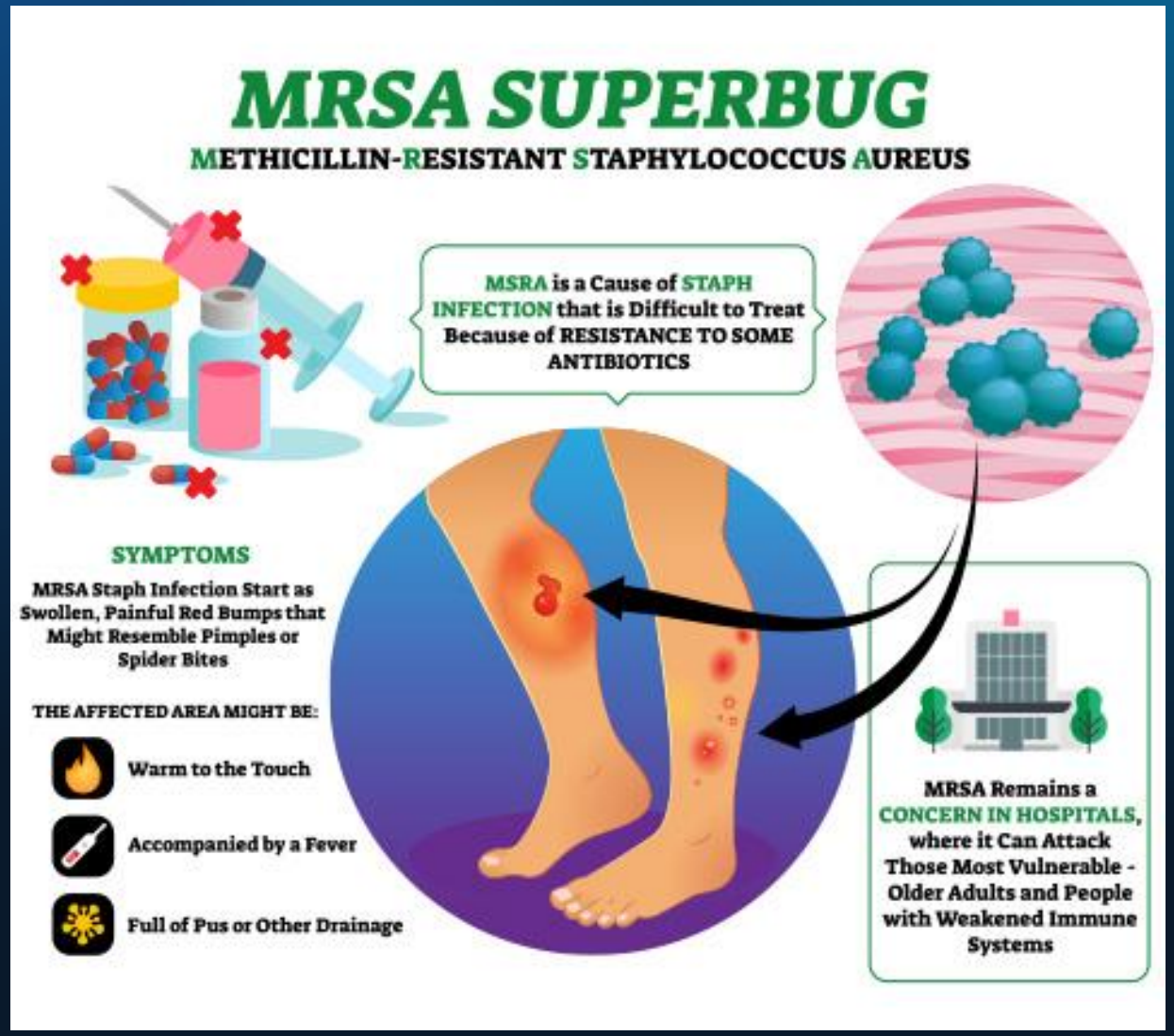
- Bacterial infections are fought through the use of antibiotics (e.g. penicillin, amoxicillin)
- Overuse of antibiotics has sped up bacterial evolution; antibiotic-resistant strains exist.





Antibiotics and Resistance

- MRSA (methicillin-resistant *Staphylococcus aureus*) resists multiple common antibiotics.
- Outbreaks in hospitals are becoming more common.



Questions

1. What are some of the ways that you can differentiate between bacteria? List them, with point-form details.
2. What does gram staining tell you? Why is it useful?
3. Bacteria have different ways of obtaining energy. What is a phototroph and a chemotroph, and give one example of each.
4. Make a table detailing the ways in which bacteria can be helpful and harmful. Include examples of each.

Domain Archaea

SIMPLE PROKARYOTES, LIVE IN OPPRESSIVE ENVIRONMENTS

CHAPTER 17

(NOTE: YOUR TEXTBOOK REFERS TO THIS AS KINGDOM ARCHAEBACTERIA. RECENT PHYLOGENETIC ADVANCES CLASSIFY BACTERIA AS THEIR OWN DOMAIN.)

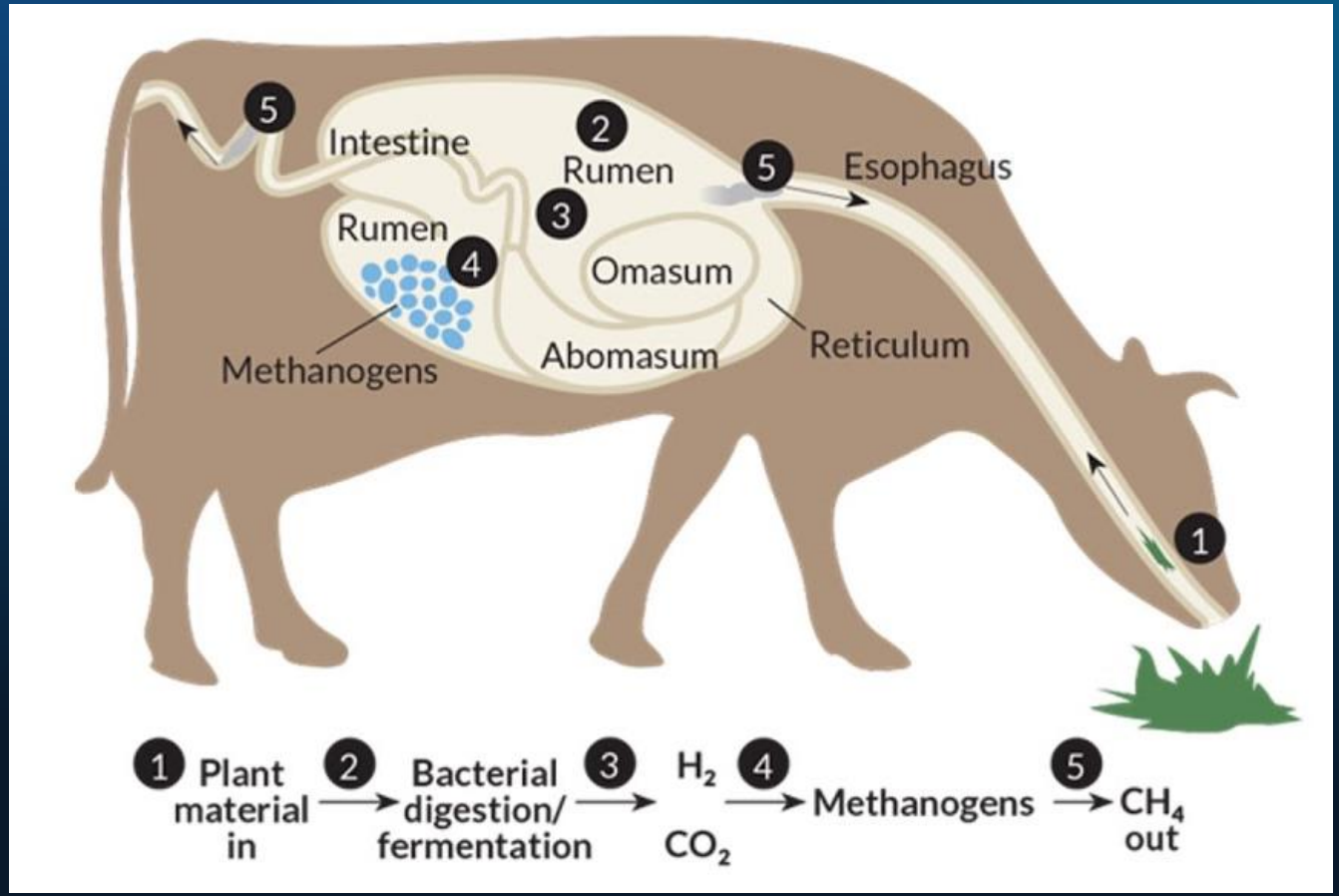
HTTPS://MICROBENOTES.COM/ARCHAEA-VS-BACTERIA/

What are Archaea?

- ‘Archaios’ (Greek) means primitive or ancient; oldest fossils 3.5 billion years old
- Structurally similar to bacteria; have adaptations to permit life in extreme conditions
- Inhabit extreme, low-oxygen environments: deep-sea vents, very salty water, hot springs, oil wells
- Poorly understood – hard to study!

Major Groups of Archaea

- **Methanogens:** live in moderate environments (swamps, intestines), use carbon dioxide and hydrogen to produce methane as byproduct of cellular respiration



Major Groups of Archaea

- **Halophiles:** tolerate high-salt environments (e.g. Dead Sea, Great Salt Lake)

Major Groups of Archaea

- **Thermophiles:** tolerate extremely high temperatures (113°C!)

https://www.youtube.com/watch?v=vAR47-g6tIA&ab_channel=CrashCourse