



BIOLOGY ROOTS



Engaging Science Lessons



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1 Pathogens

Not all pathogens are created equal.

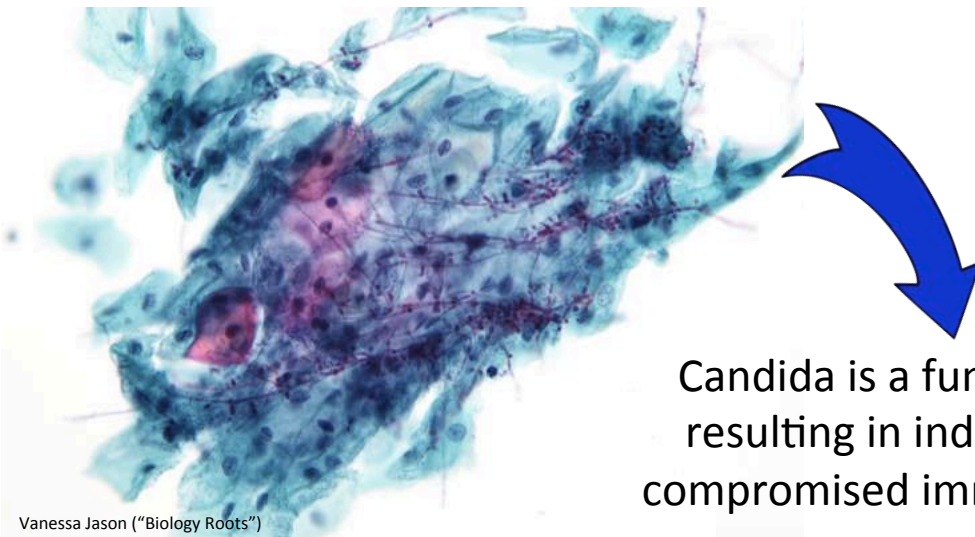
Some are highly pathogenic, and others are “opportunistic” pathogens, meaning they only cause disease in hosts that are already unhealthy and have compromised immune systems.

Pathogens are **microorganisms** that are capable of causing disease.

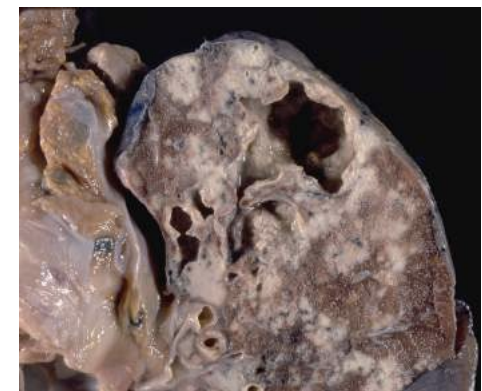
Examples include bacteria, viruses, protozoa, and fungi.

Pathogens release toxins that can destroy our cells and make us sick.

Pathogenic activity that is not stopped can lead to necrosis, which is tissue or organ damage.



Candida is a fungal infection resulting in individuals with compromised immune systems.

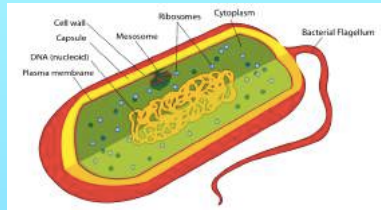


Severe necrosis of the lung caused by bacteria.

2

4 General Types of Pathogens

Bacteria

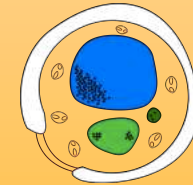


Single celled prokaryotes.

The most common pathogen; though most bacteria is not harmful or highly pathogenic.

Treated with antibiotics.

Fungi

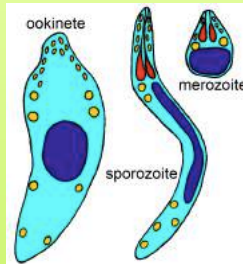


Fungi can be single celled or multicellular. Made up of eukaryotic cells (molds, yeasts)

Fungi is a necessary component of the earth cycle's; most fungi is not harmful.

Infectious fungi is treated with antifungals.

Protozoan Parasites

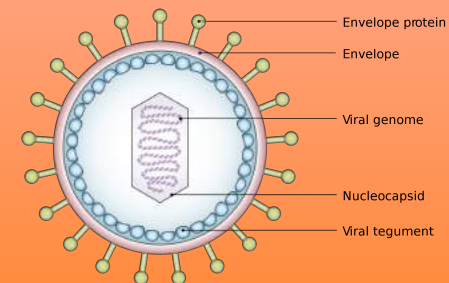


Single celled eukaryotes.

Many need multiple hosts throughout their life cycle (such as an insect or rodent vector).

Treated with antiprotozoal agents.

Viruses



Viruses are made up of encapsulated DNA and protein; NOT cells.

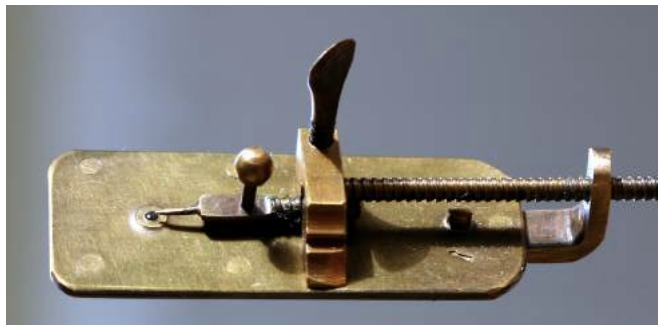
Not all viruses are harmful to humans.

Can be treated using antivirals.

3



↑ Anton van Leeuwenhoek, and his homemade microscope ↓



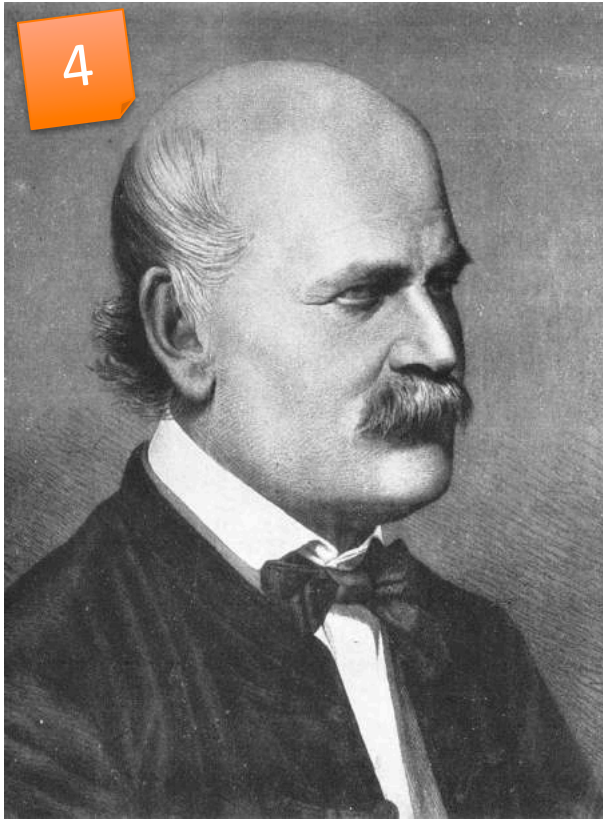
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Discovery

In 1676, Anton van Leeuwenhoek was the first scientist to document his discovery of microorganisms under his microscope. He referenced as "animalcules", but what he was really seeing were bacteria.

It still took scientists nearly 200 years to understand bacteria after Leeuwenhoek discovered them. For example, syphilis is an STD transmitted by bacteria. However, for many years it was considered a disease for the immoral, or some type of punishment from God.

4

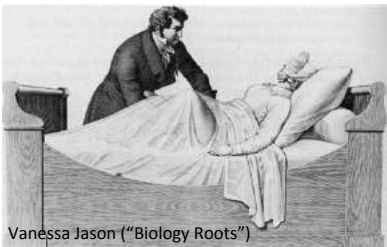


Ignaz Semmelweis: "The Savior of Mothers"

Ignaz Semmelweis was an Austrian obstetrician in the mid 1800s.

He discovered that if he washed his hands before delivering a baby, the mother was far less likely to die of "childbed fever".

Though Semmelweis decreased the mortality rate of mothers at his hospital from 25% to less than 1%, many of his colleagues were offended or in disbelief that washing their hands could help save lives. Bacteria were not yet relevant in the medical field.



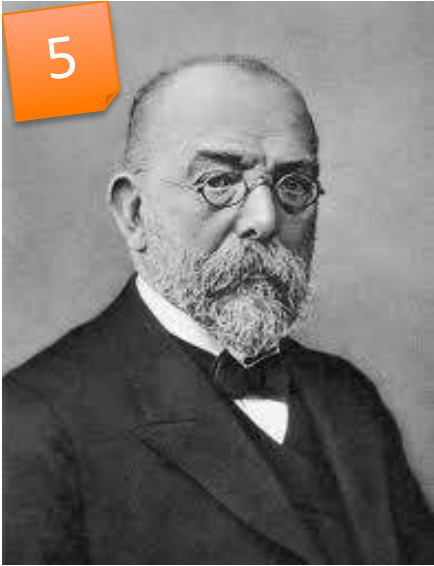
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Childbed fever, or puerperal fever, is an infection in the female reproductive tracts caused by bacteria on the doctors' hands.

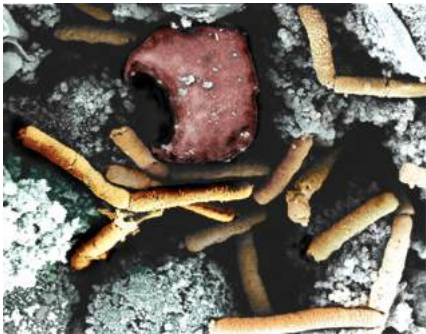
5

Robert Koch:

Founder of modern bacteriology



Robert Koch proved that anthrax (bacteria) was causing the death of many farm animals. He did this by using two groups of mice: one group was exposed to blood from healthy animals; the other group was exposed to blood from ill farm animals. The mice exposed to the blood of sick farm animals died, while the other group lived.

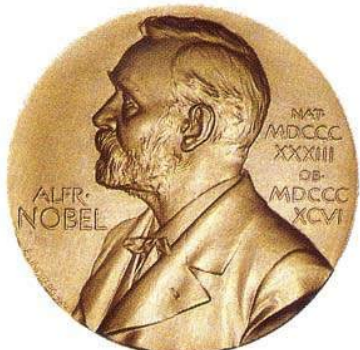


← Anthrax

Tuberculosis



In 1905 Robert Koch was awarded a Nobel Prize for his findings in tuberculosis. He also developed a sugar-based gelatin to grow bacteria in, and produced one of the first antibiotics.



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Aerobic vs. Anaerobic Pathogens

AEROBIC

- Microorganisms that are aerobic are known as “aerobes”.
- Can use oxygen to break down food molecules for energy
- Growth is limited to how much oxygen is available
 - Live in areas where oxygen is readily available
- Aerobic bacteria are the leading cause of clinical infections among cellular pathogens

ANAEROBIC

- Cannot grow in oxygen; it is toxic for them.
- Are not able to make as much energy as aerobes.
 - Live in places where oxygen is absent
- Break down food without oxygen in a process called fermentation

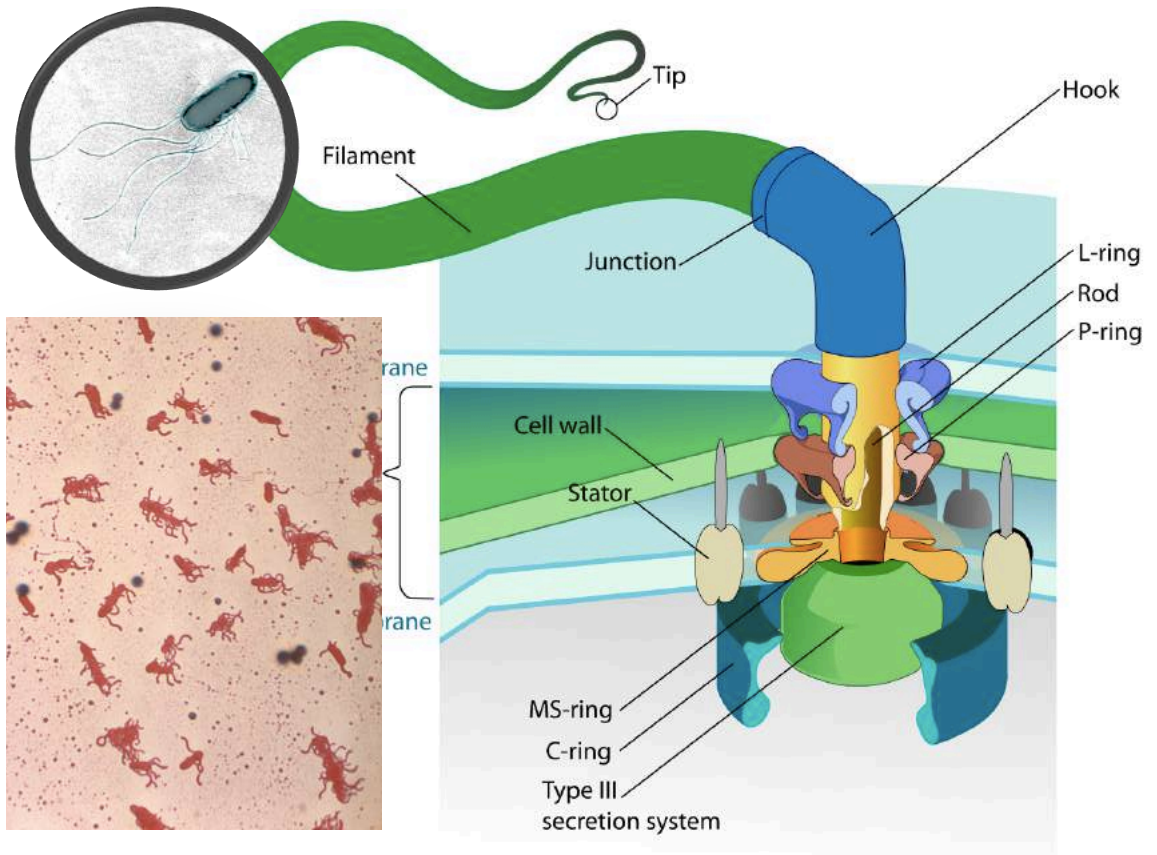
Facultative anaerobes typically use oxygen to break down food, but can switch to anaerobic mode if oxygen is not available.

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Flagella

- Singular= flagellum
- Plural=flagella
- Meaning= “whip”

Flagella are used for movement. The back and forth propeller motion propels the cell forward.



Arrangement of Flagella	Example
Monotrichous	1 flagellum
Amphitrichous	A flagellum at each end
Lophotrichous	2 or more flagella at one end
Peritrichous	Flagella all over
Endoflagella	Flagella are tightly wrapped against the cell

Flagella can be found in bacteria, fungi, protozoans, though the structure differs among each.

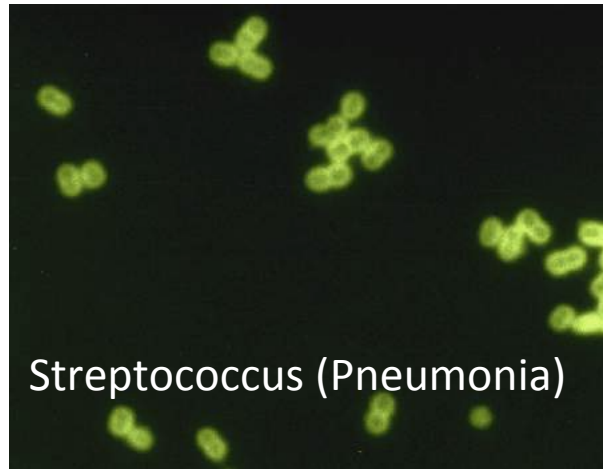
8

Bacteria

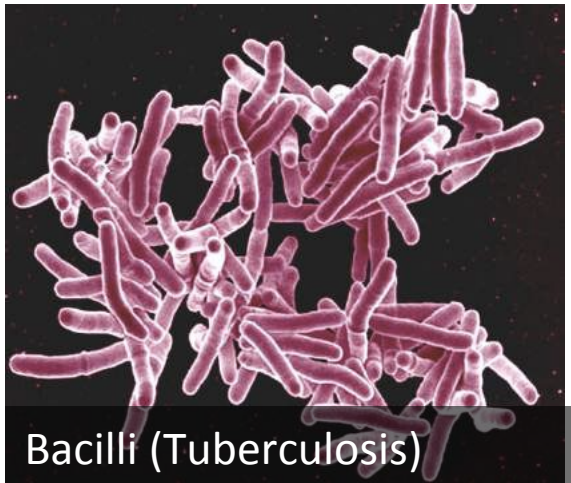
Bacteria are categorized into 3 general shapes: coccus (plural: cocci), bacillus (plural: bacilli), and spiral.



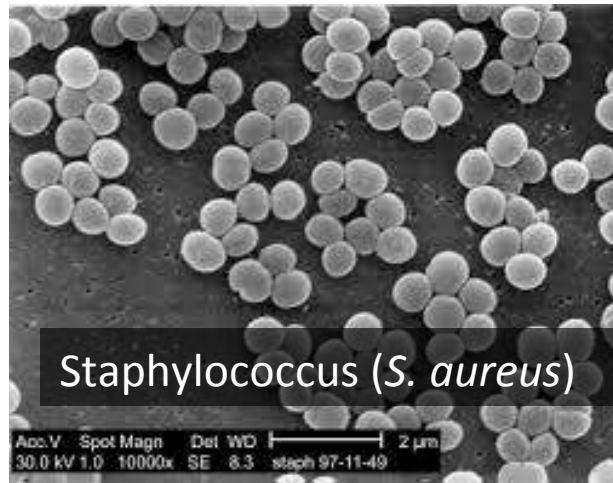
Spirochete (Lyme disease)



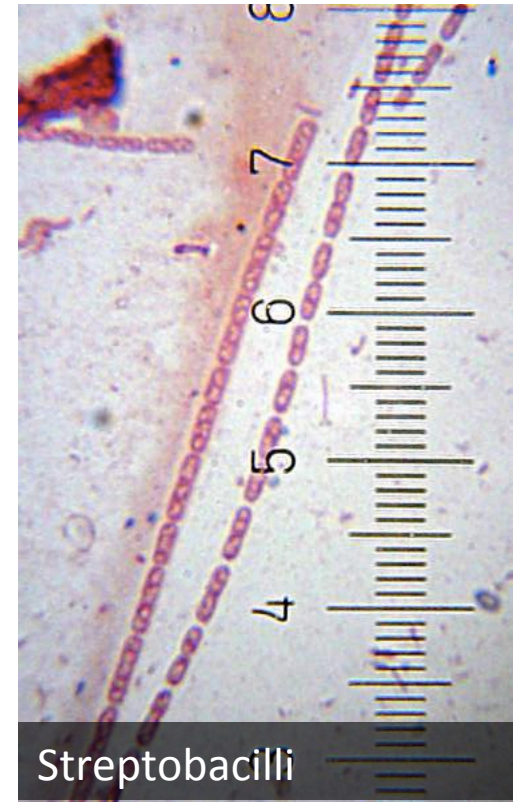
Streptococcus (Pneumonia)



Bacilli (Tuberculosis)



Staphylococcus (*S. aureus*)



Streptobacilli

ALL bacteria are **PROKARYOTES** (single celled organisms that lack a nucleus).

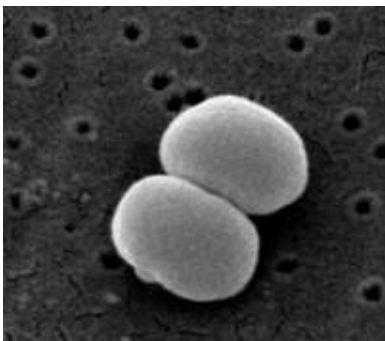
Nonpathogenic Bacteria

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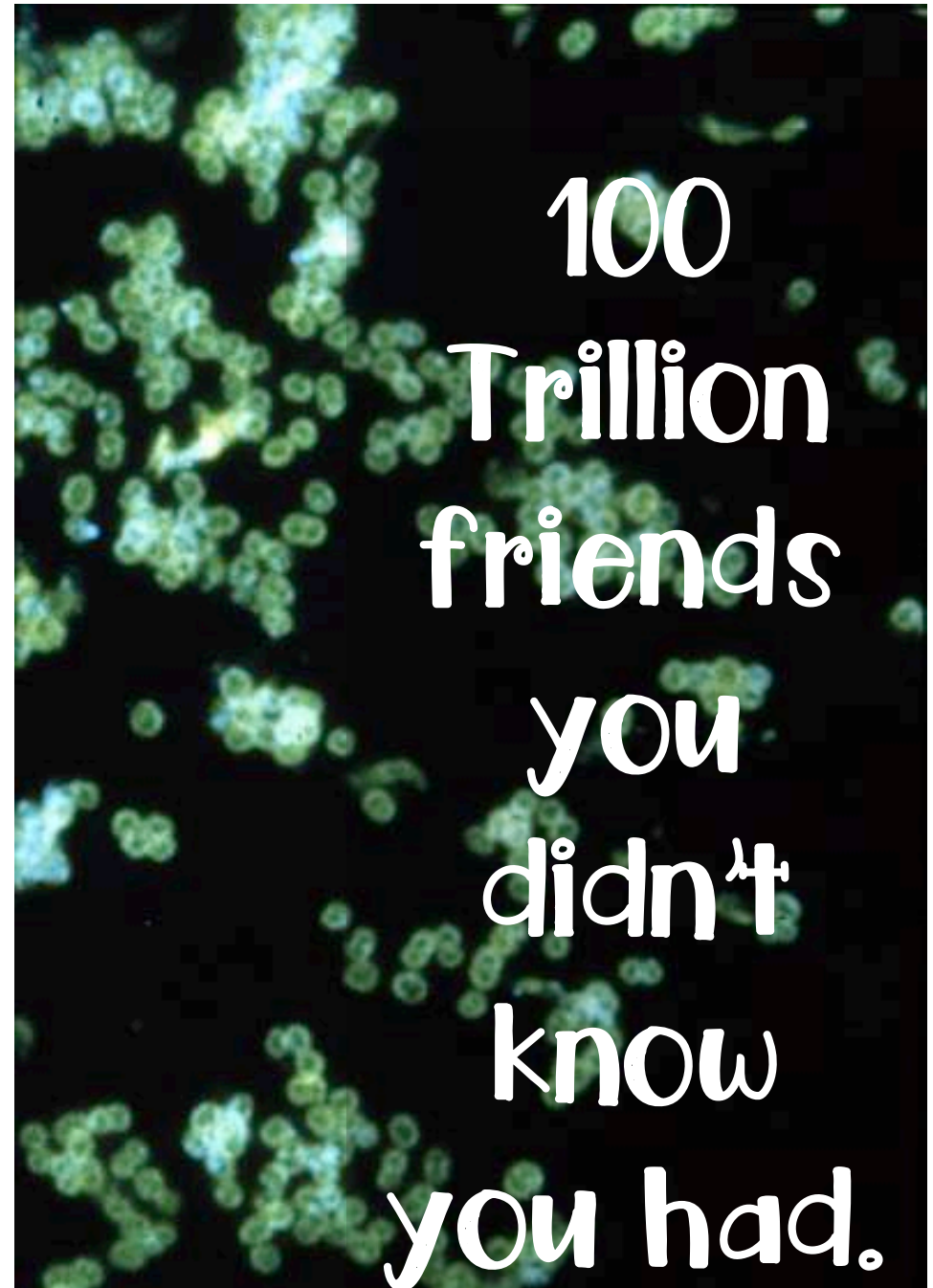
Not all bacteria are pathogens. There are plenty of bacteria around us that are actually beneficial.

In fact, there are more bacterial cells in/on your body right now than there are human cells!

These are also known as “commensal bacteria”.



Staphylococcus epidermidis are common skin flora.

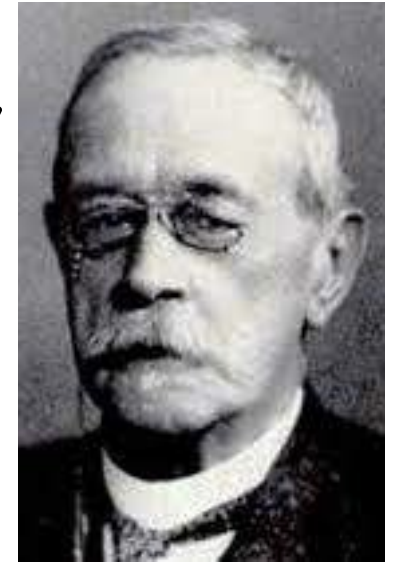


100
Trillion
friends
you
didn't
know
you had.

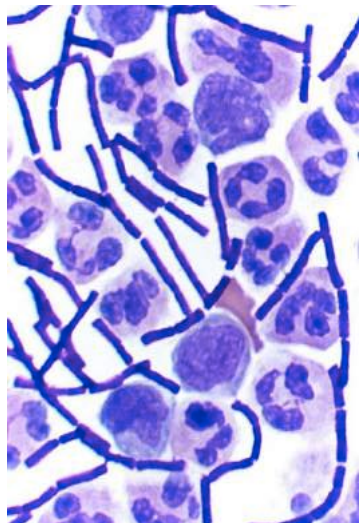
10

Gram Positive vs. Gram Negative

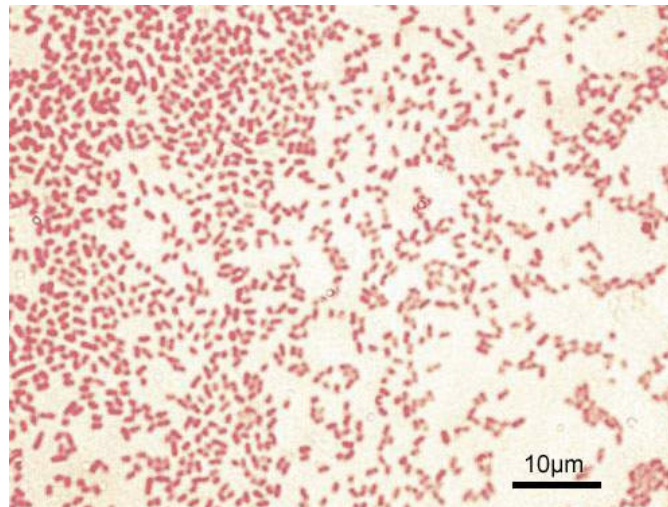
Hans Christian Gram devised a method to differentiate two types of bacteria based on the structural differences in their cell walls. He did this using a strong dye called crystal violet.



Gram positive bacteria can be dyed because of a thick layer of peptidoglycan.



Gram-negative bacteria do not retain the violet dye and are colored red or pink; they do not contain a thick outer layer of peptidoglycan.



Common staining dyes include methylene blue and crystal violet dye.

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Gram Positive vs. Gram Negative continued

Gram-negative bacteria are more resistant against antibodies than gram-positive bacteria.

This is because of their impenetrable cell wall.

Many antibiotics work by inhibiting the growth of the cell wall by acting specifically against peptidoglycan.



Plasma Membrane

Periplasmic space

Peptidoglycan

(easily stains)

Plasma Membrane

Periplasmic space

Peptidoglycan

Outer membrane
(lipopolysaccharide and protein)




This is a sugar coating consisting of multiple types of molecules. The sugar coating helps the bacteria adhere to surfaces.

Gram Positive

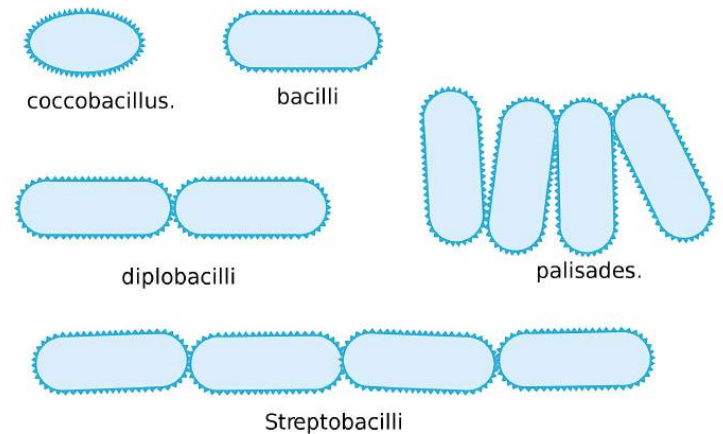
Gram Negative

Bacteria-shapes



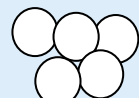
Bacteria are categorized into 3 general shapes: coccus, bacillus, and spiral

Shape	Description
Bacillus	Rod shaped 
Coccus	Spherical shape 
Spiral	Spiral shaped 

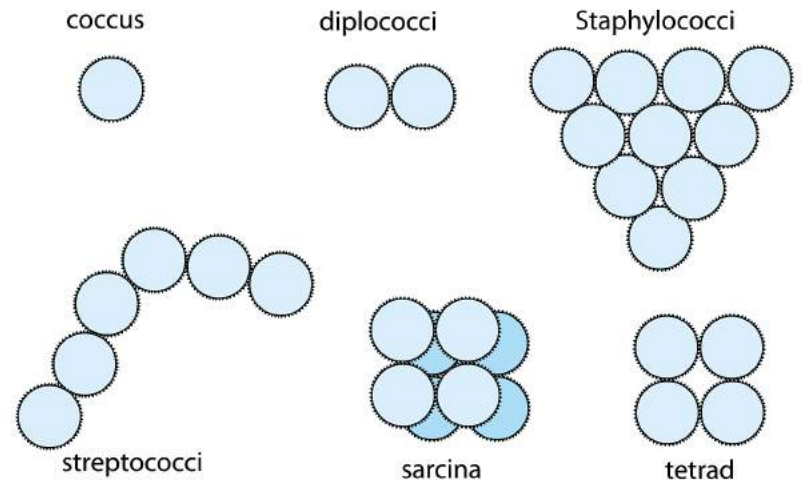
Arrangements of Bacilli



The general shapes can contain more specific prefixes:

Special Prefixes	Examples
Diplo=paired	Diplococcus 
Strepto= chain-like	Streptococcus 
Staphylo= grape-like clusters	Staphylococcus 

Arrangements of Cocci



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Looking at Bacteria

At each microscope, sketch the different types of bacteria on your answer sheet in the proper space. Please use pencil!



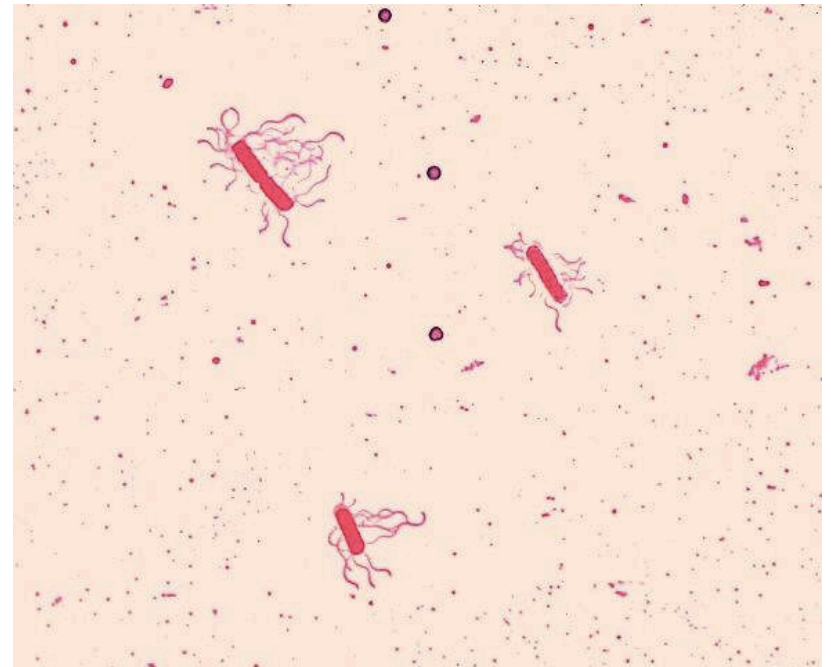
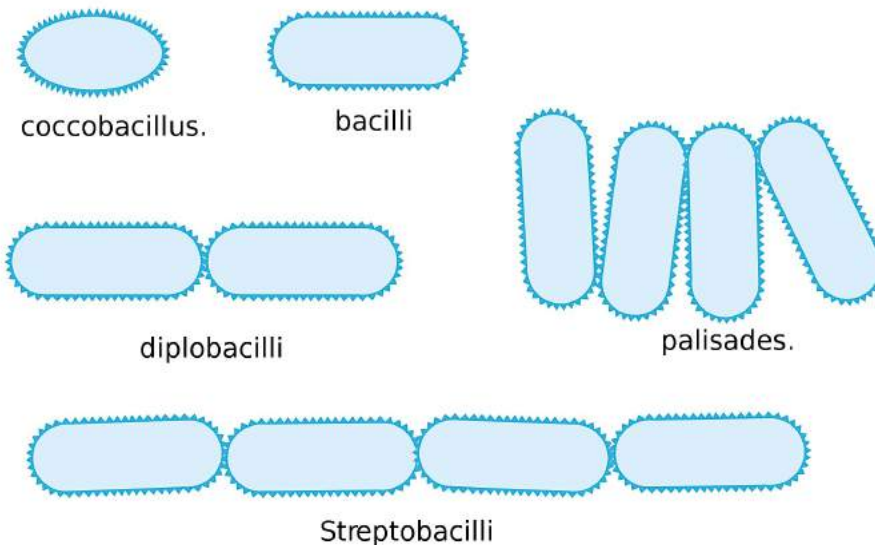
Have your teacher sign off on your sketches!

John Hancock

Bacilli Bacteria

- Typically rod shaped (can be singular, paired {diplo} or linked in chains {strepto})
- Often times contain flagella (whip-like propeller for locomotion)
- Gram-positive
- Can be aerobic or facultative anaerobic

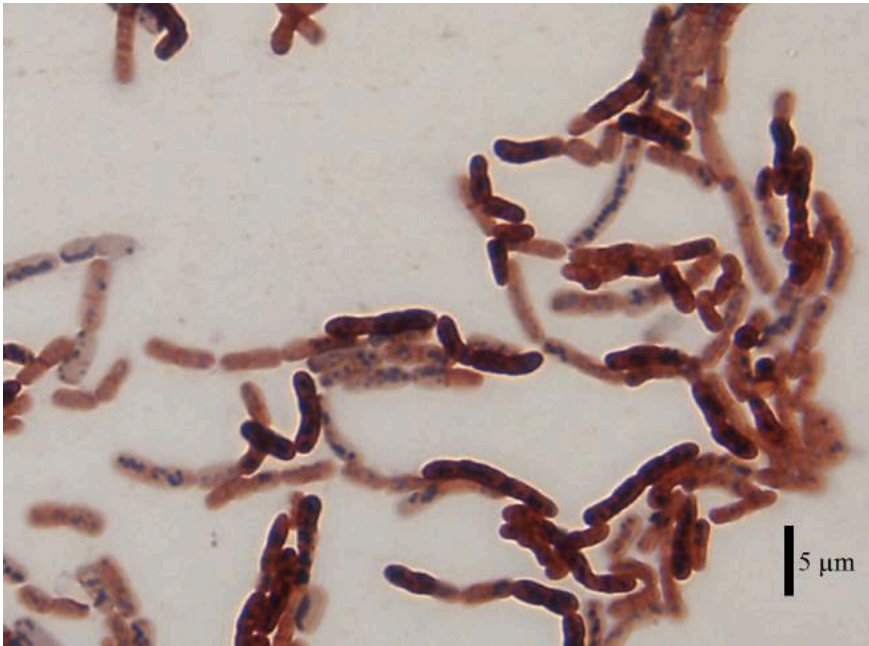
Arrangements of Bacilli



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Bacilli Bacteria continued

Found virtually anywhere in nature (soil, living things, water) and depending on the species can thrive in high temperatures and extreme environments).

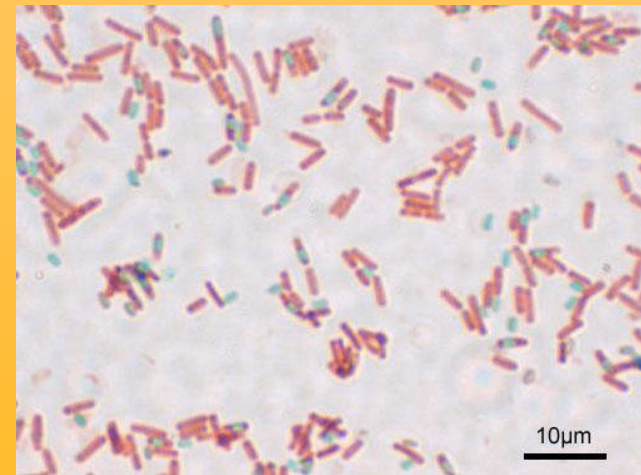


Bacillus megaterium is one of the largest bacteria species and be found virtually everywhere, including honey, paper, leather, and soil.

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ZOMBIE BACTERIA??

Bacilli bacteria can produce endospores, which can lie dormant for hundreds of years and revive themselves when the conditions are favorable.



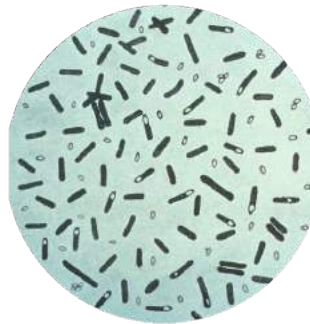
*The endospores are shown above in green

Endospores are typically produced when current environmental conditions are not favorable. They consist of a capsule containing DNA and ribosomes. Endospores are resistant against antibiotics

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Bacilli continued -Common Diseases

- Tuberculosis
- Tetanus
- Botulism
- Whooping Cough
- Plague
- Diphtheria



Tetanus is caused by a bacteria known as *Clostridium tetani*. It is found in soil, dust and manure. It can enter the body through an open wound and infect its host. *C. tetani* produces toxins that affect muscle contractions.



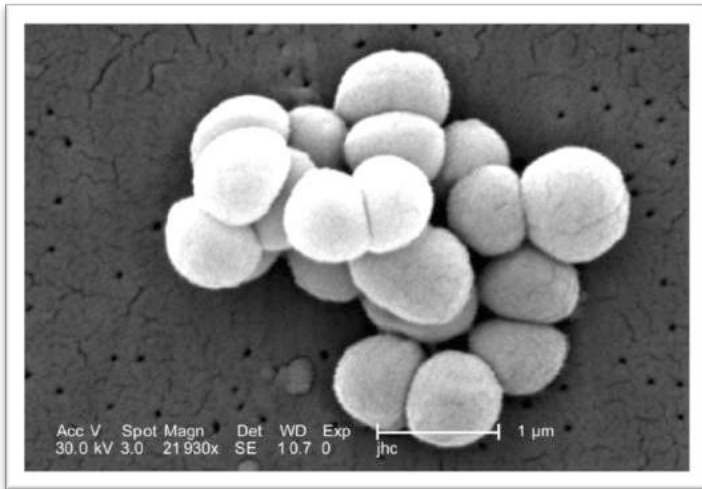
Yersinia pestis

Yersinia pestis is a bacteria that is passed on from rats to other hosts via fleas. It is responsible for the Bubonic Plague or "Black Death".

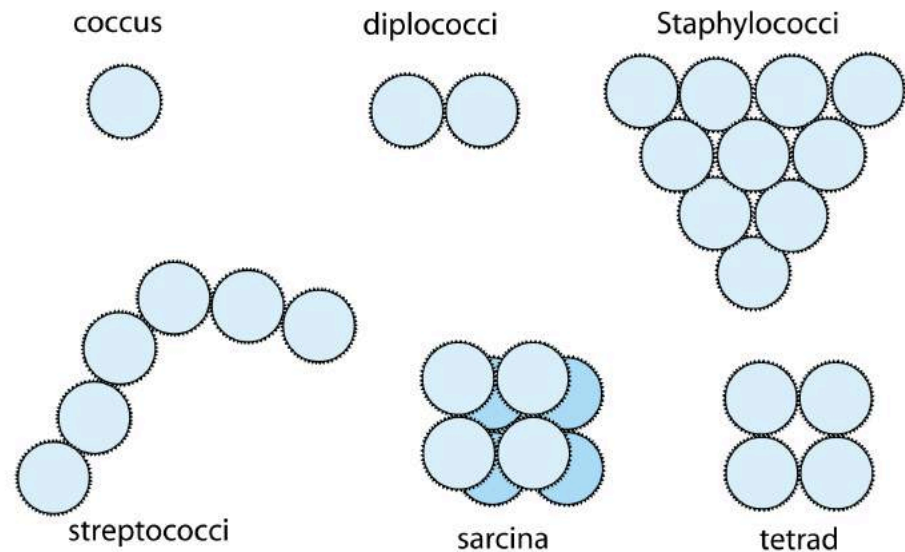


Cocci Bacteria

- Spherical in shape (can be paired, clustered, linked, etc.)
- Mostly gram positive; some gram negative
- Mostly aerobic; some are facultative anaerobes and a few are true anaerobes.



Arrangements of Cocci



Gram positive cocci are the leading pathogens of human infections.

14 Cocci Bacteria continued- examples

Gram-positive:

- Strep Throat
- Meningitis
- Food Poisoning
- Toxic Shock Syndrome
- Sepsis (blood poisoning)

Gram-negative:

- Gonorrhea
- Meningococcal meningitis



MRSA: Methicillin Resistant Staphylococcus aureus

Staph infection of the skin that is resistant to most antibiotics.

Problematic in hospitals where many patients have compromised immune systems.



Strep throat
(streptococcus)



Gonorrhea requires a lot of moisture to thrive, and can infect the eyes, mouth, and genitalia.

Spiral Bacteria

-Gram negative

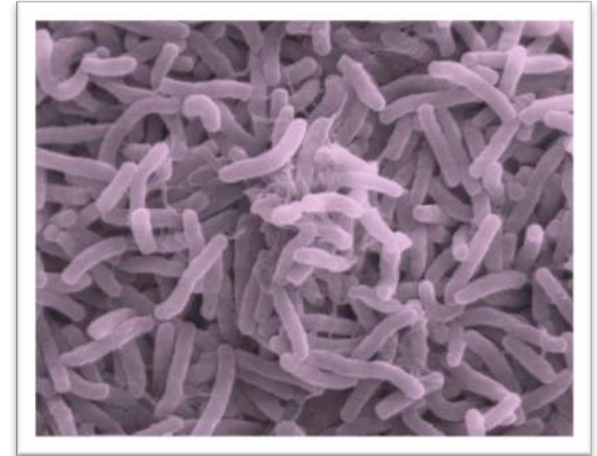
-Mostly anaerobic

Can be divided into 3 categories:

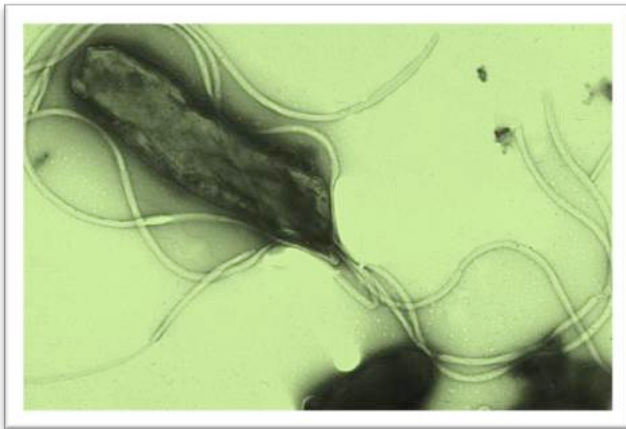
Spirillum- frequently have flagella

Spirochete- very long and thin with endoflagella

Vibrio- comma shaped with a partial twist



Vibrio cholerae are bacteria that can cause **cholera**- water borne disease



Spirillum, such as *Helicobacter pylori* which cause stomach ulcers, typically contain flagella.



Spirochetes, such as the bacteria *Borrelia burgdorferi*, which causes Lyme disease, are corkscrew shaped with tightly wrapped endoflagella.

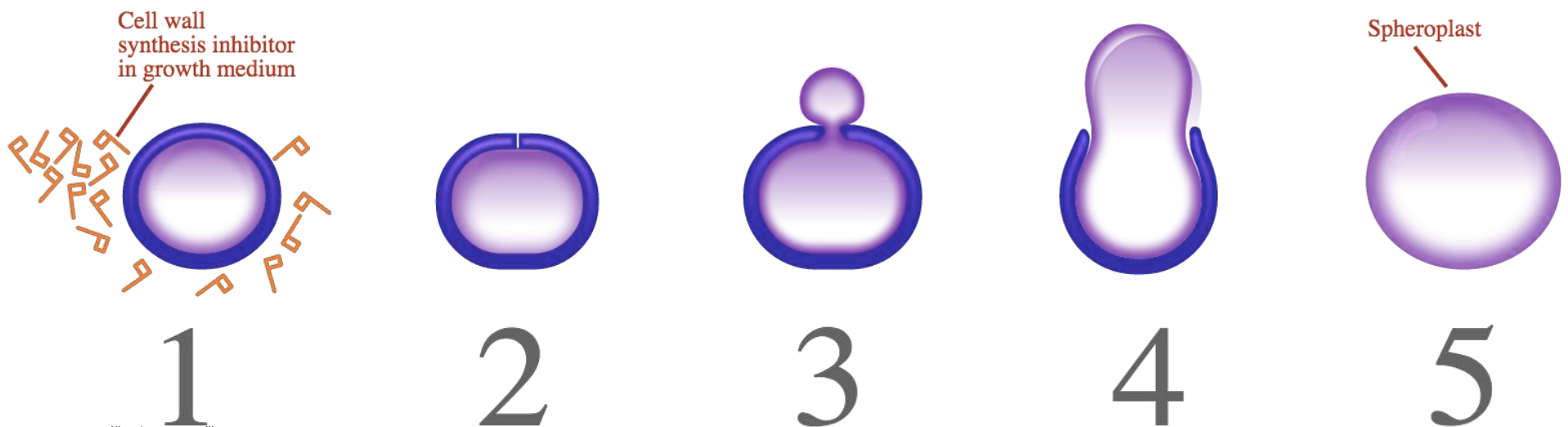
Antibiotics

Antibiotics are used to treat serious **bacterial** infections (or potentially serious infections).

Examples of antibiotics include sulfa drugs and penicillin.

The antibiotics work by prohibiting certain enzymes that the bacteria need to build their cell walls. Without a cell wall, bacteria cannot grow or multiply.

Some types of antibiotics prohibit the enzymes that bacteria need to replicate their DNA, thus preventing them from multiplying.



Antibiotics continued



Other types of synthetic derivatives of penicillin have been developed, such as methicillin and amoxicillin.

MRSA

Methicillin-resistant
Staphylococcus aureus

This new strain of Staph emerged in the 1950s. It can be treated using a combination of higher order antibiotics, but antibiotic resistance is problematic.

Penicillin was discovered by accident in the lab in the 1920s. Penicillin is actually a fungus that can prohibit bacterial growth.



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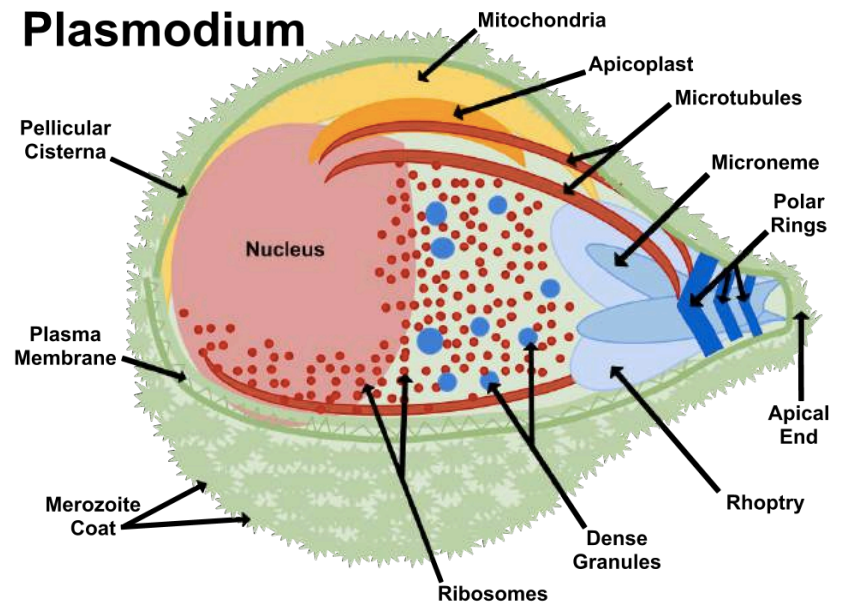
Pathogenic Protozoa

Protozoa are a group of single-celled eukaryotic cells. Most of them do not pose a threat to humans, but a few species can cause disease.

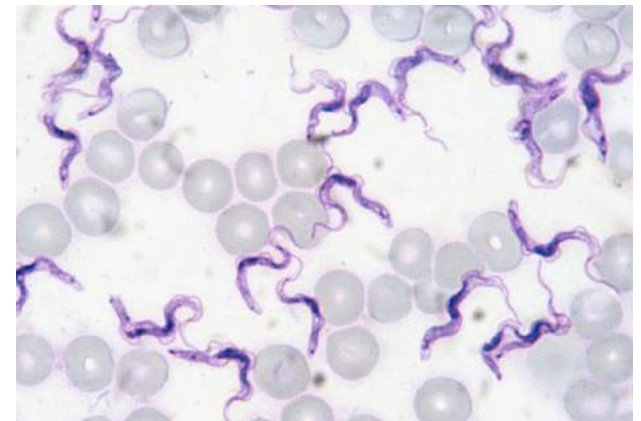
Examples of Pathogenic Protozoa:

- Malaria
- Brain-eating amoeba
- Amoebic dysentery
- Trichomonas
- Chagas disease
- Leishmaniasis

Antiprotozoals are used to treat infection. Antiprotozoals target specific enzymes that affect the growth of protozoa.



Protozoa are made up of single eukaryotic cells (unlike bacteria, which are prokaryotic).



Pathogenic Protozoa

Parasites can be **monoxenous** or **heteroxenous**.

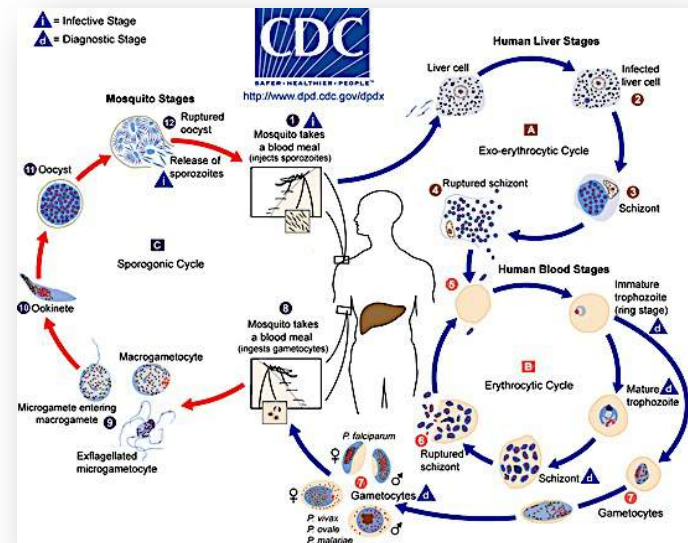
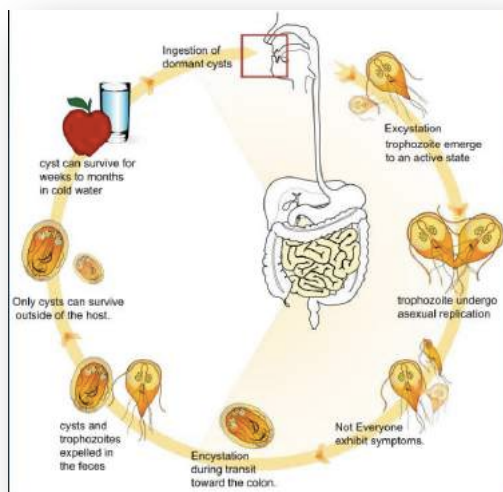
Monoxenous= direct contact with host.

Mono= one
Xenous=person

The protozoa parasite can be directly transmitted from itself to its host (example: drinking dirty water).

Heteroxenous= Requires multiple hosts.
Can infect via a vector (insect, rodent)
Hetero = different Xenous=person

The protozoa parasite relies on multiple hosts in order to survive. This may include vector diseases, such as malaria (mosquitoes) and Chagas disease (kissing bugs).



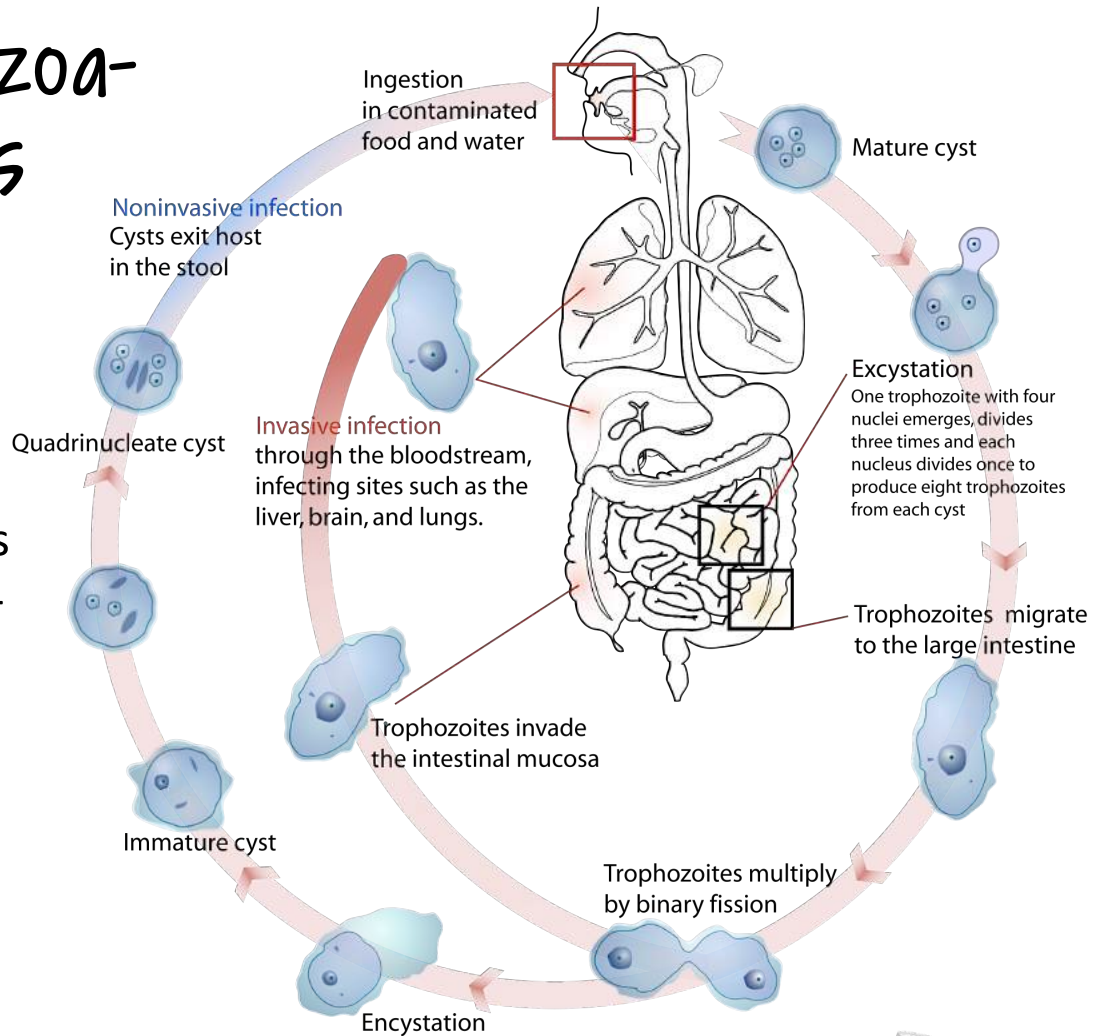
Pathogenic Protozoa- Entamoebas

Most protozoans require warm climates to thrive.

Entamoeba histolytica

Is an amoeba that infects the intestines and causes dysentery (severe diarrhea-blood and mucous usually present).

In fact, the greatest killer of the Civil War was amoebic dysentery. The soldiers often fought with the seat of their trousers cut from their pants to provide relief.

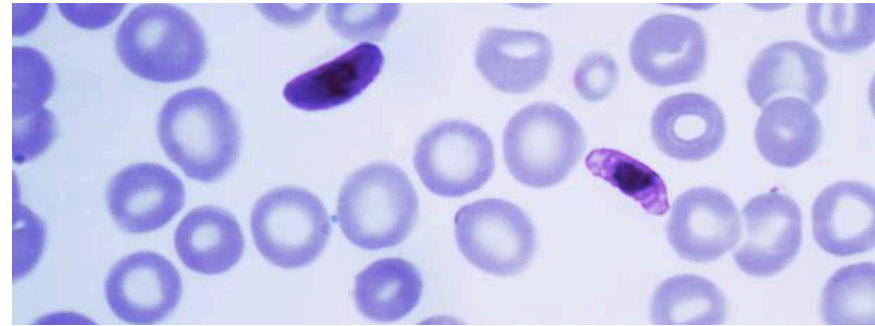


Entamoebas enter the body through contaminated water.



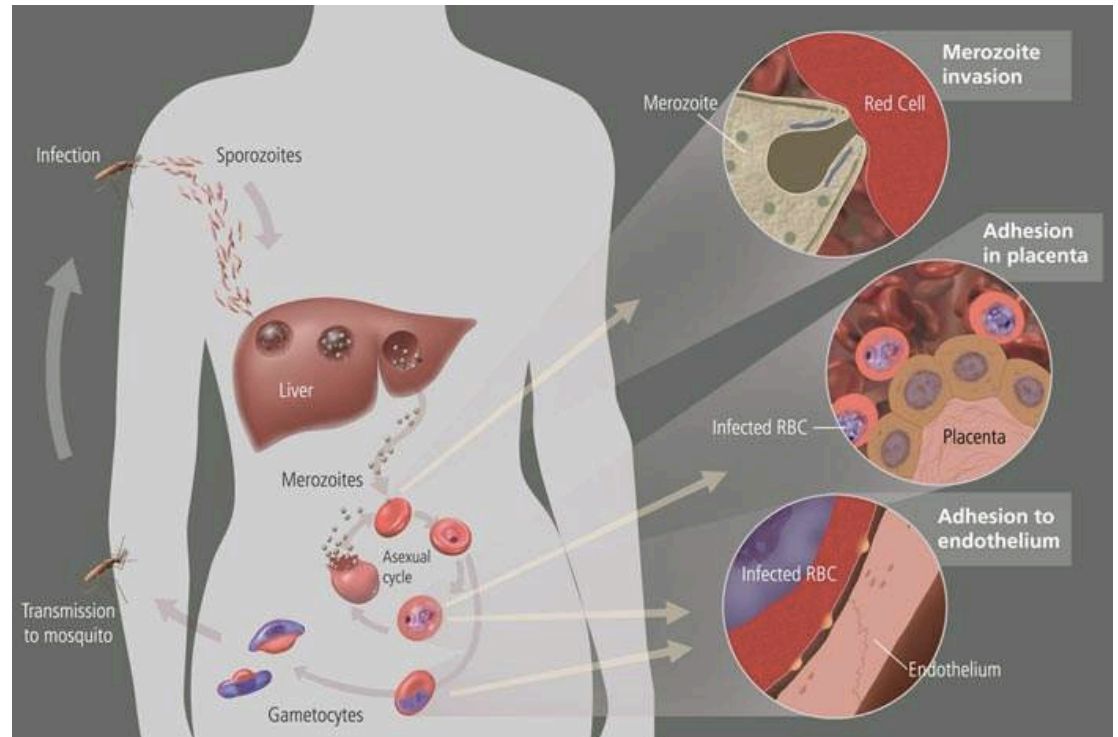
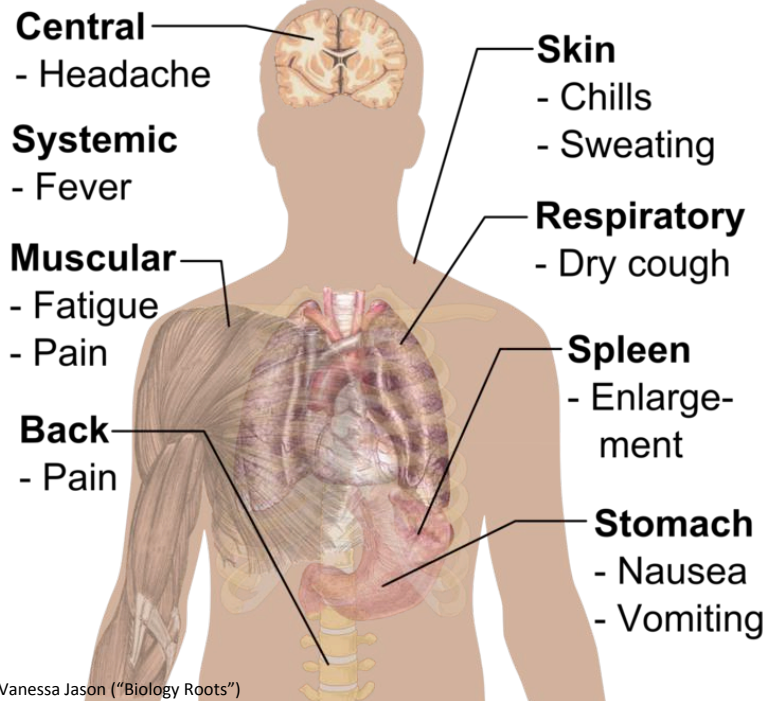
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Pathogenic Protozoa- Plasmodia



Plasmodia are responsible for causing **malaria**, which is transmitted via female mosquitoes. If a mosquito feeds from an infected host, they can contract malaria and pass it on to other sources of their blood meal.

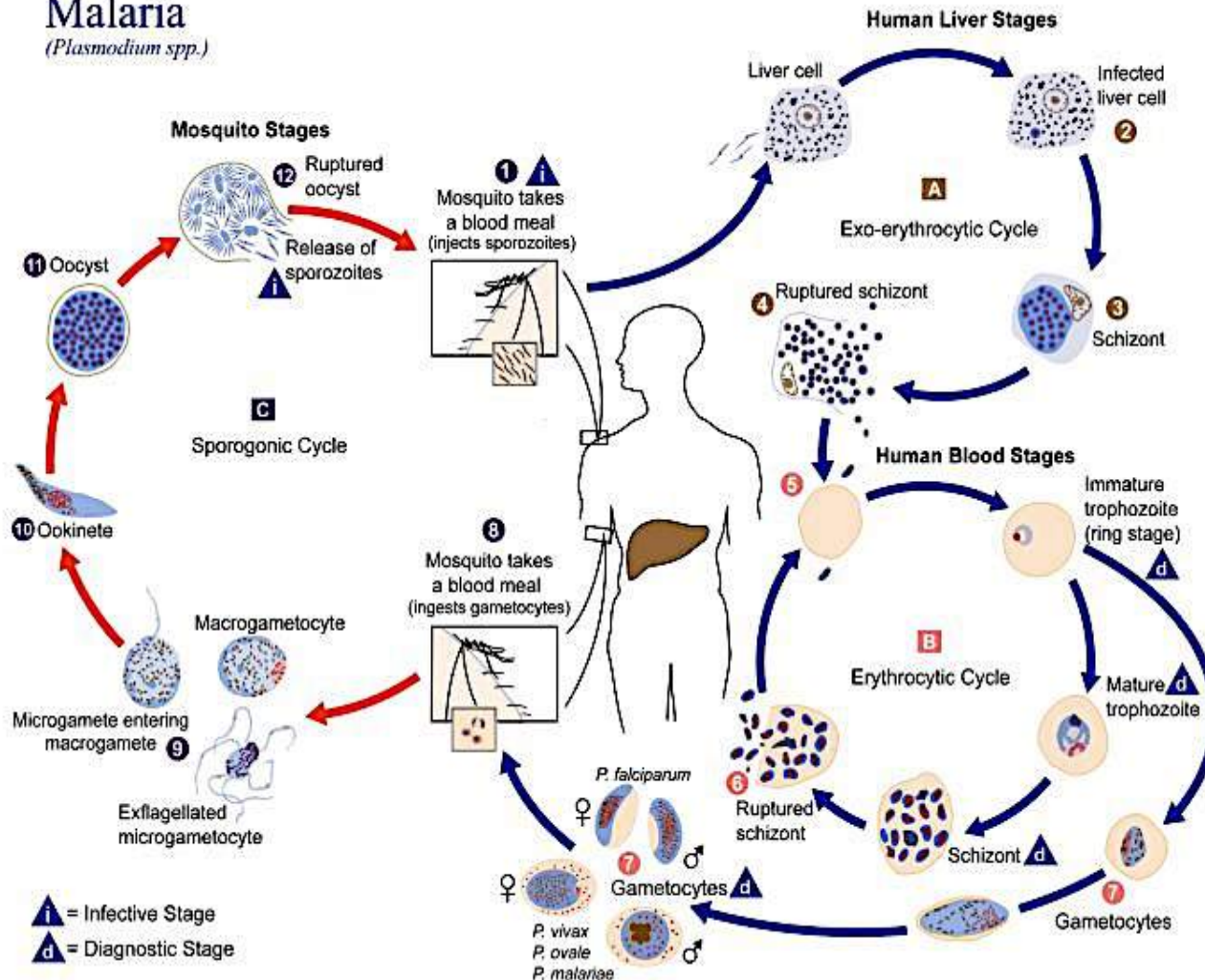
Symptoms of Malaria



Pathogenic Protozoa- Plasmodia (continued)

The female mosquitoes saliva is contaminated with plasmodia. When they bite their host, the plasmodia sporozoites are introduced to the bloodstream, where they develop in the liver.

Malaria (*Plasmodium spp.*)



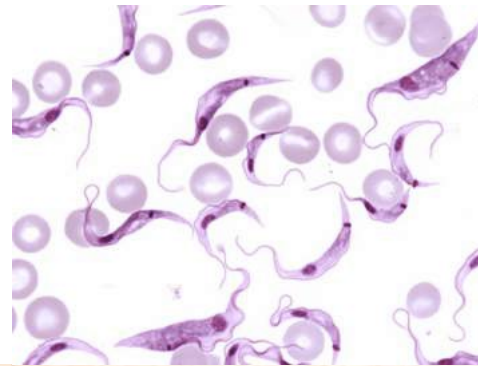
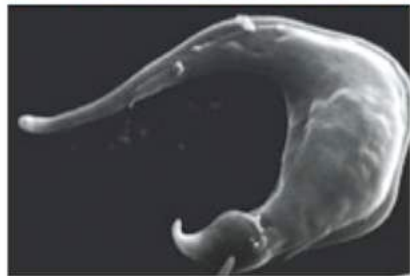
The sporozoites grow in the liver, until eventually they are released into the blood stream, where they attack red blood cells.

Over **one million people** die from malaria each year, mostly children under five years of age, with **90 per cent** of malaria cases occurring in Sub-Saharan Africa. **300-600 million people** suffer from malaria each year.

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Pathogenic Protozoa- Chagas Disease

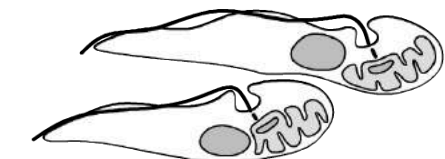
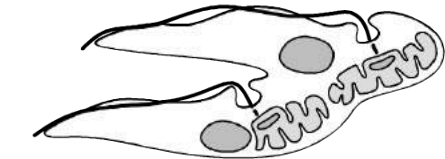
Protozoans known as trypanosomes live in the gut of blood sucking flies. If the fly bites a human, they immediately poop near the site of the bite. If the person tries to smack the bug off, or itch the bite, they might smear some of the poop into the bite, which transfers the trypanosomes into the bloodstream.



The single-celled protozoans (trypanosomes) live inside the gut of the triatomine bug and can be found in their feces.

The triatome bug is often called "the kissing bug" because they tend to bite the face region.

Trypanosome growth and replication



Pathogenic Protozoa- Chagas Disease (continued)

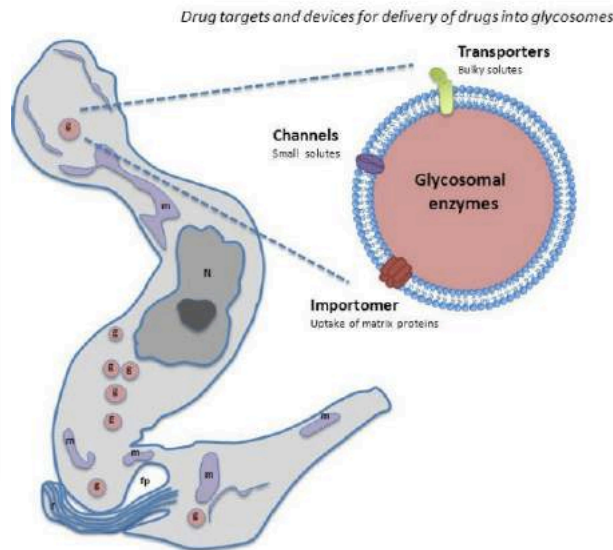


The parasite that causes Chagas, trypanosomes, attack the nervous system. This eventually leads to organ damage, specifically in the heart, colon, and esophagus.

These organs can no longer contract, and they become stretched and dilated as a result.

Approximately 50,000 South Americans die of Chagas every year.

Glycosomes and drug targeting in trypanosomes



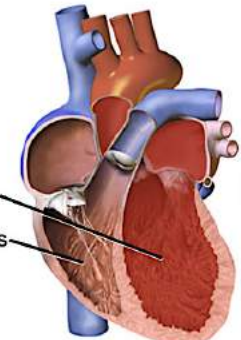
Structures found within the trypanosomes called glycosomes can be targeted during drug treatment to help cure patients.

Normal Heart



Chambers relax and fill, then contract and pump.

Heart with Dilated Cardiomyopathy



Muscle fibers have stretched. Heart chambers enlarge.

22

Pathogenic Fungi

Most fungi is *not* pathogenic.

-Only yeast and mold can be pathogenic.

Fungi can be found in decaying matter, but can also live on warm moist parts outside the human body, such as skin folds, the mouth, feet, ears, and genitals. Some types are inhaled into the lungs and bloodstream.

Some mold produces spores, which can infect the lungs if inhaled.



Vanessa Jason ("Biology Roots")

Black mold is commonly found in houses where there is excessive moisture and lacks the proper barrier.



Oral Thrush

Mycotoxins are toxins produced by harmful fungi.



Fungal Infections of the Skin and Nails

"There's a fungus among us"

Dermatophytes are fungi that can infect the skin.

Fungal infections can occur if the skin is damaged somehow, if the host's immune system is compromised or if the conditions are just right (warm; moist).

Common fungal skin infections include:

Ringworm (← not actually a worm)

Athlete's Foot

Candida (yeast)

Jock itch



Tinea fungal infection on toenails (athlete's foot)



Ringworm fungal infection (also caused by a Tinea fungus).

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Airborne Fungal Infection

Mold can produce spores, which are very tiny and can become airborne and inhaled into the lungs.

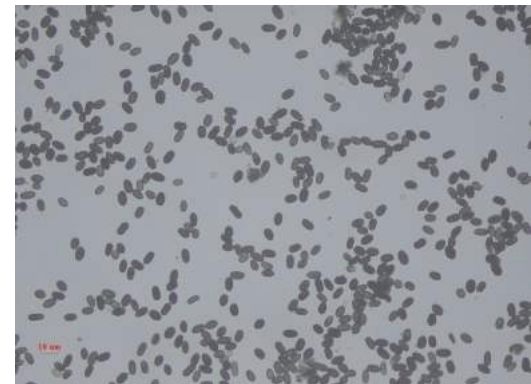
The two most common types of fungal lung infections seen in hospitals are those caused by *Candida* and *Aspergillus*. Left untreated, these can result in respiratory failure.



Pulmonary hemorrhage caused by an untreated *Candida* infection within the lungs.

Most people breathe in mold spores every day (including *Aspergillus* and *Candida*), but never get sick. These typically only affect those with a compromised immune system.
-The CDC

Black mold, or *Stachybotrys chartarum*, produces toxic mold spores that can be inhaled. Symptoms include coughing, wheezing, headaches, lightheadedness.



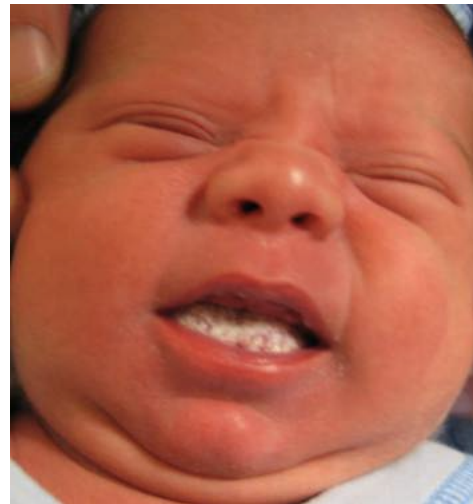
Candida

Candida is a family of yeast that are very common for fungal infections. Candida gets an honorable mention because it can be found not only on the skin or in the lungs, but also in the ears, mouth, intestines, and genitals.

Candida is a highly **opportunistic** pathogen— it is usually kept in check by your immune system, but if that is compromised it can spread nearly anywhere!



Candida albicans (pictured above) typically infects the mouth or genitals or ears.



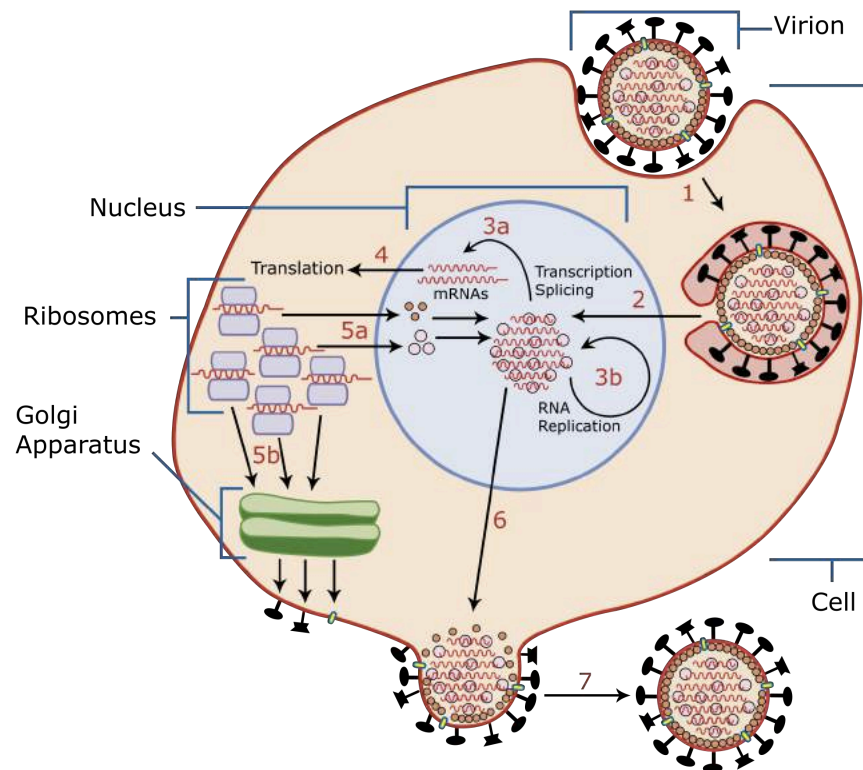
Oral thrush
(Candida)



Candida Otomycosis
(Fungal ear infection)

Viruses

Viruses are the smallest of all pathogens. Some may argue that they are not “living creatures” because they rely on a host’s DNA replicating mechanisms in order to make more of itself. They do this by releasing their DNA into the host cell.



Viruses are not made up of cells. They are simply DNA in a protein capsule. They can be very difficult to treat.

Antivirals do not target viruses, instead they inhibit their growth by preventing them from unpacking their genes into host cells.

Viruses (continued)

Viruses are the number one killer pathogen of all time, though not all viruses are harmful.

Viruses can be transmitted by inhaling or swallowing them, sexually transmitted, or from insect or rodent bites.

Common viruses include:

Influenza

HIV

Measles

Mumps

Ebola

Hepatitis

Polio

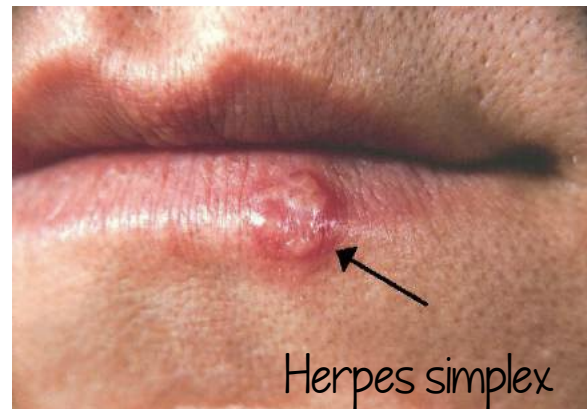
Enterovirus

Rhinovirus

Rabies

Chicken pox

Small pox

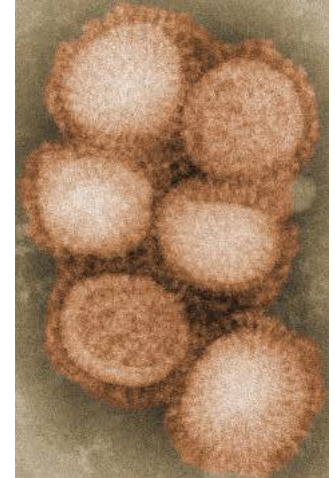


Viruses- Influenza

The influenza virus is a highly contagious virus of the respiratory tract (typically transmitted by sneezing, coughing, poor hand washing).

There are 3 types of influenza viruses: A, B, and C

Type	Species Affected	Symptoms	Age Affected
A	Multiple species	Moderate to Severe	All
B	Humans only	Mild	Mostly children
C	Humans and Swine	Mild	All



The flu alone causes 250,000 to 500,000 deaths per year. (Compared to bacterial infections, which in total accounts for approximately 25,000 deaths per year).

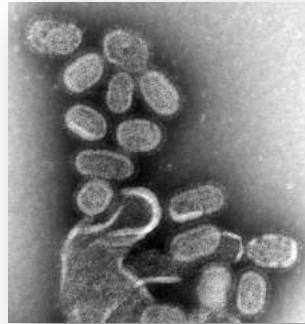
In 1918, the Spanish Flu epidemic took the lives of 50 million people. That's about how many people died in WWII.



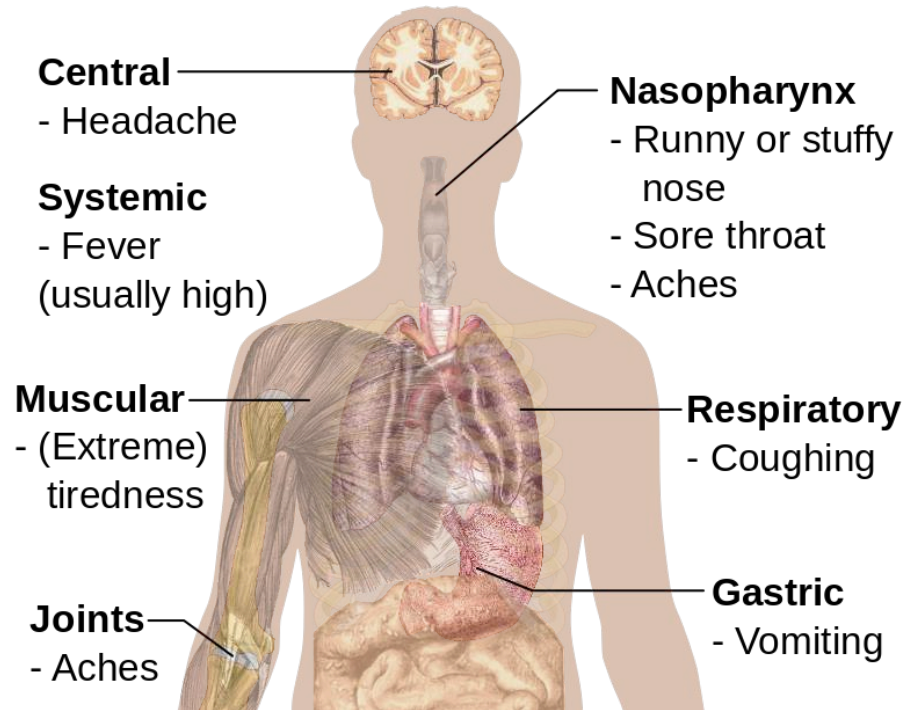
Viruses- Influenza (continued)

Influenza symptoms:

Fever
Cough
Sore throat
Runny nose
Muscle aches
Fatigue
Vomiting (not common)
Diarrhea (mostly in children)



Symptoms of Influenza



The influenza virus tends to be ever changing (evolving; mutating). The flu vaccine's effectiveness depends on how well the vaccine matches the flu viruses that are causing illness.

The flu can lead to pneumonia (both viral and/or bacterial), which can be potentially fatal.

Some people are at more risk for complications than others, including people ages 65+, children, and pregnant women.

Viruses-Herpes Simplex Virus

There are 2 categories of the Herpes Simplex Virus:

Those infected with HSV are usually asymptomatic (showing no symptoms), as the virus can remain dormant for long periods of time. During outbreaks, the infected person shows fluid-filled blisters on the skin. These can be painful for itchy, and may eventually break open and ooze. A patient may experience flu-like symptoms during an outbreak.

Herpes Simplex Virus 1 (HSV-1)

Typically found around the mouth. Often first appears in childhood (cold sores). Can spread with contact of saliva.



Herpes Simplex Virus 2 (HSV-2)

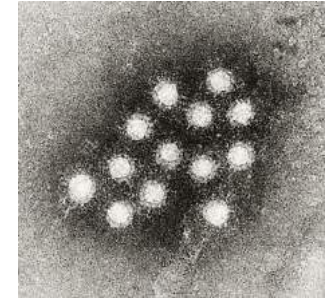
Typically found on genitals and is sexually transmitted (Genital Herpes).



There is no cure for Herpes. Antivirals can help reduce outbreaks. If you've ever had a cold sore, the HSV-1 remains dormant within a facial nerve. As long as it is dormant, it is not contagious or problematic.

Viruses-Hepatitis

There are 5 main types of Hepatitis Viruses:
A, B, C, D and E.



All Hepatitis viruses can cause liver disease. The hepatitis virus is the most common cause of liver cancer and cirrhosis. Approximately 1 million deaths per year occur due to liver failure caused by the hepatitis viruses.

Hepatitis A and E are spread through contaminated water or human waste.

Hepatitis B, C and D are spread through blood and bodily fluids such as semen.

Symptoms include:

Mild fever

Jaundice (Yellowing of skin or eyes)

Loss of Appetite

Pain in the belly region

Dark urine or light stools

Inflamed liver



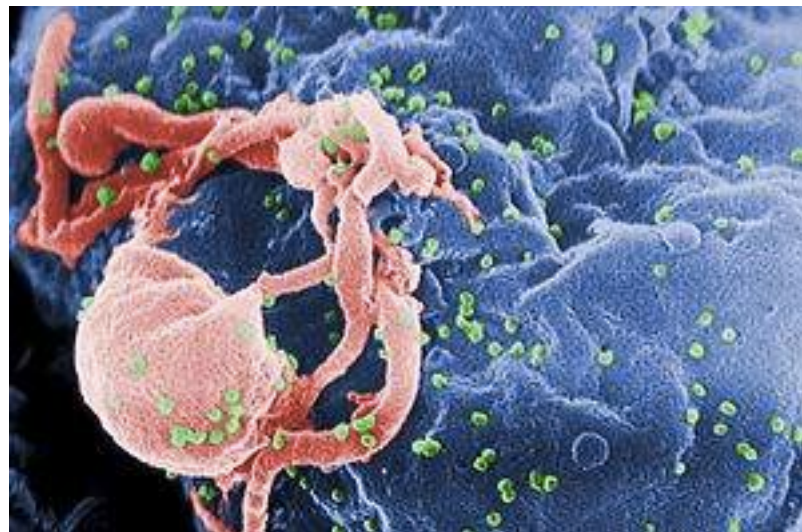
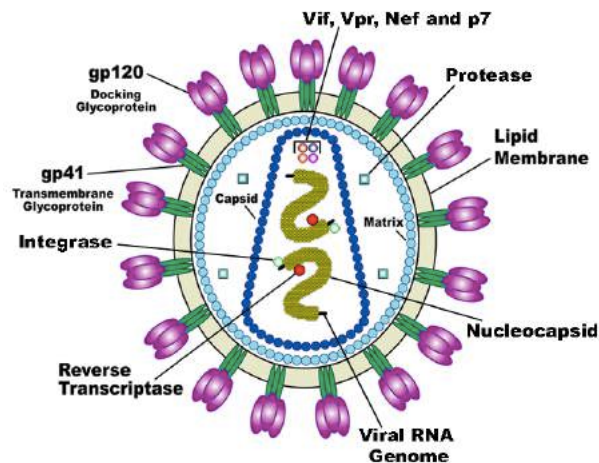
Swollen
abdomen
caused by
inflammation
of the liver



Viruses-HIV and AIDS

AIDS stands for **A**cquired **I**mmunodeficiency **S**yndrome and can be a result of HIV (Human Immunodeficiency Virus).

Scientists identified a type of chimpanzee in West Africa as the source of HIV infection in humans. They believe that the chimpanzee version of the immunodeficiency virus (called simian immunodeficiency virus or SIV) most likely was transmitted to humans and mutated into HIV when humans hunted these chimpanzees for meat and came into contact with their infected blood. Over decades, the virus slowly spread across Africa and later into other parts of the world.



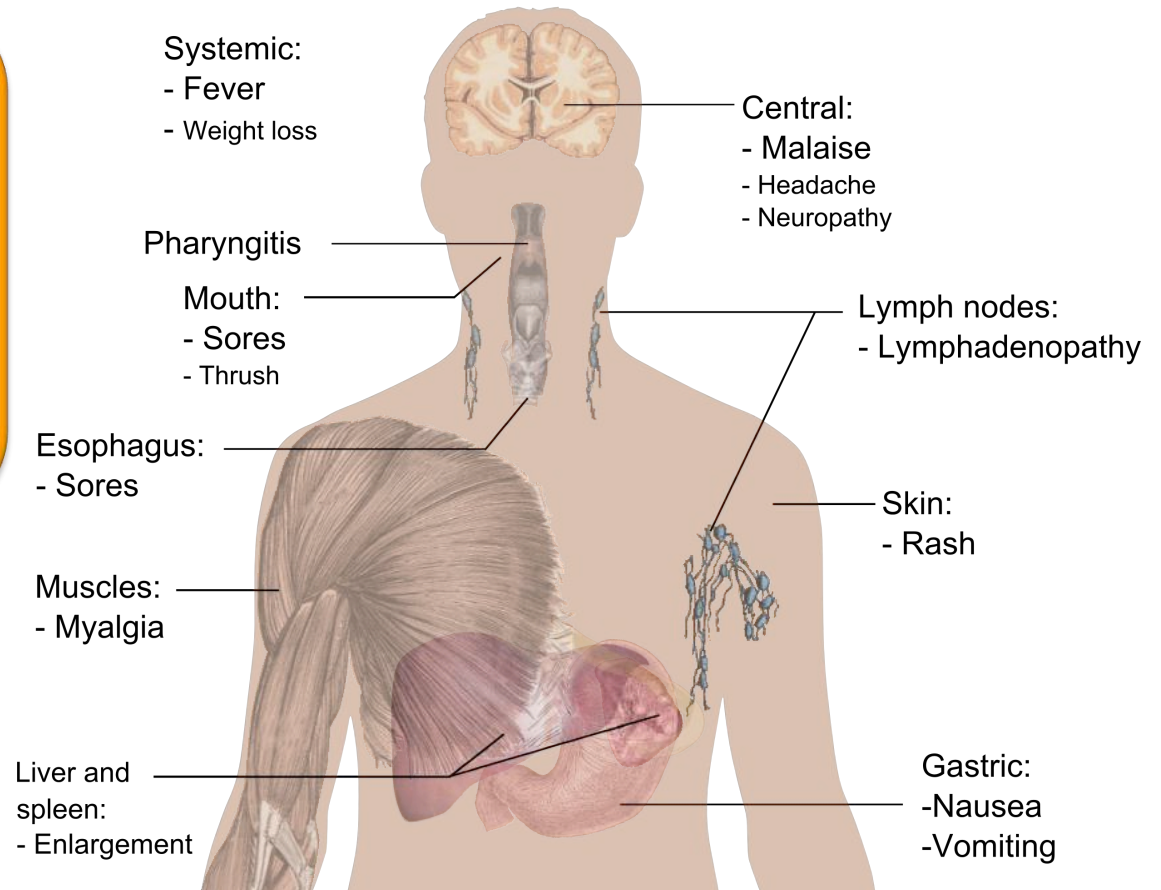
Viruses-HIV and AIDS

Main symptoms of Acute HIV infection

HIV attacks the cells of the immune system (particularly cells known as helper T cells). In attacking and destroying these cells, the virus makes the immune system very weak.

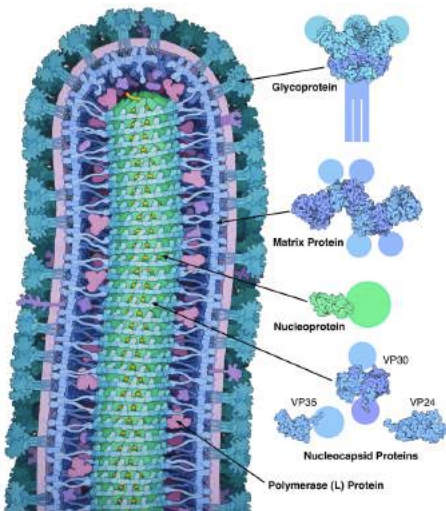
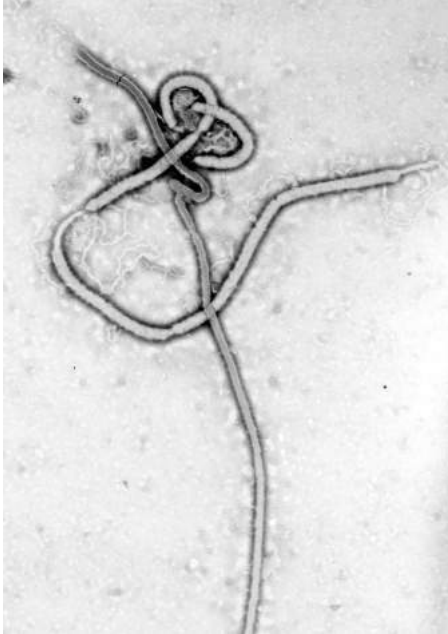
HIV is not curable, but treatable with antiviral medications.

The medication can keep the amount of HIV in the body low, but if it gets too high, the patient is said to have AIDS.

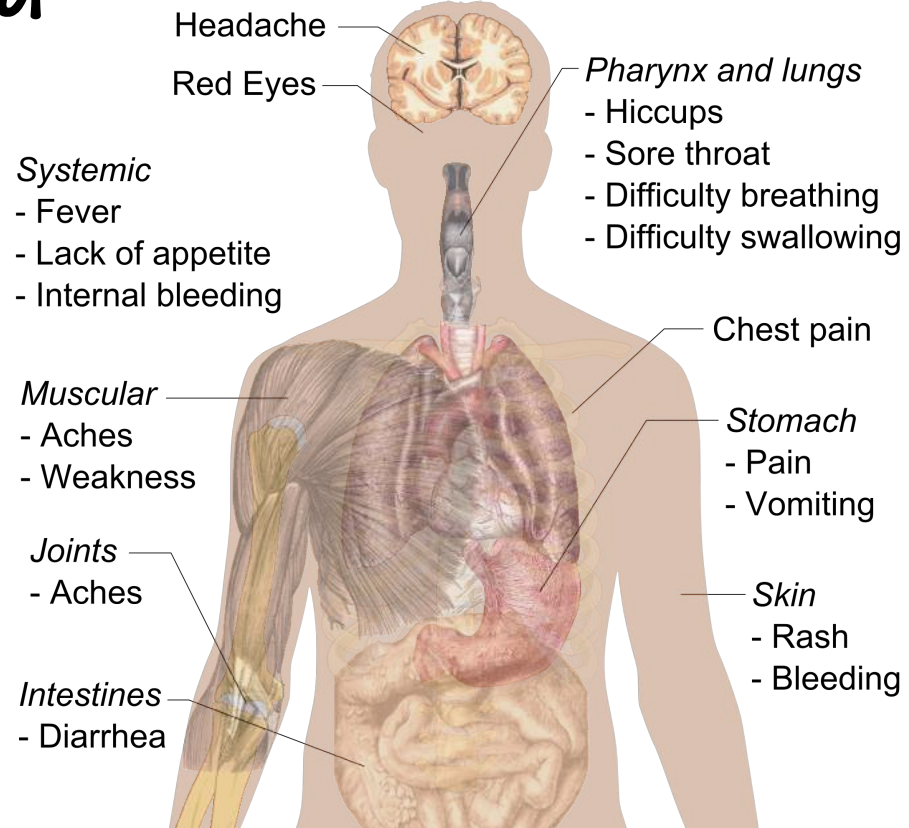


HIV/Aids weaken the immune system. Patients are more susceptible to disease and cancer.

Viruses-Ebola



Symptoms of Ebola

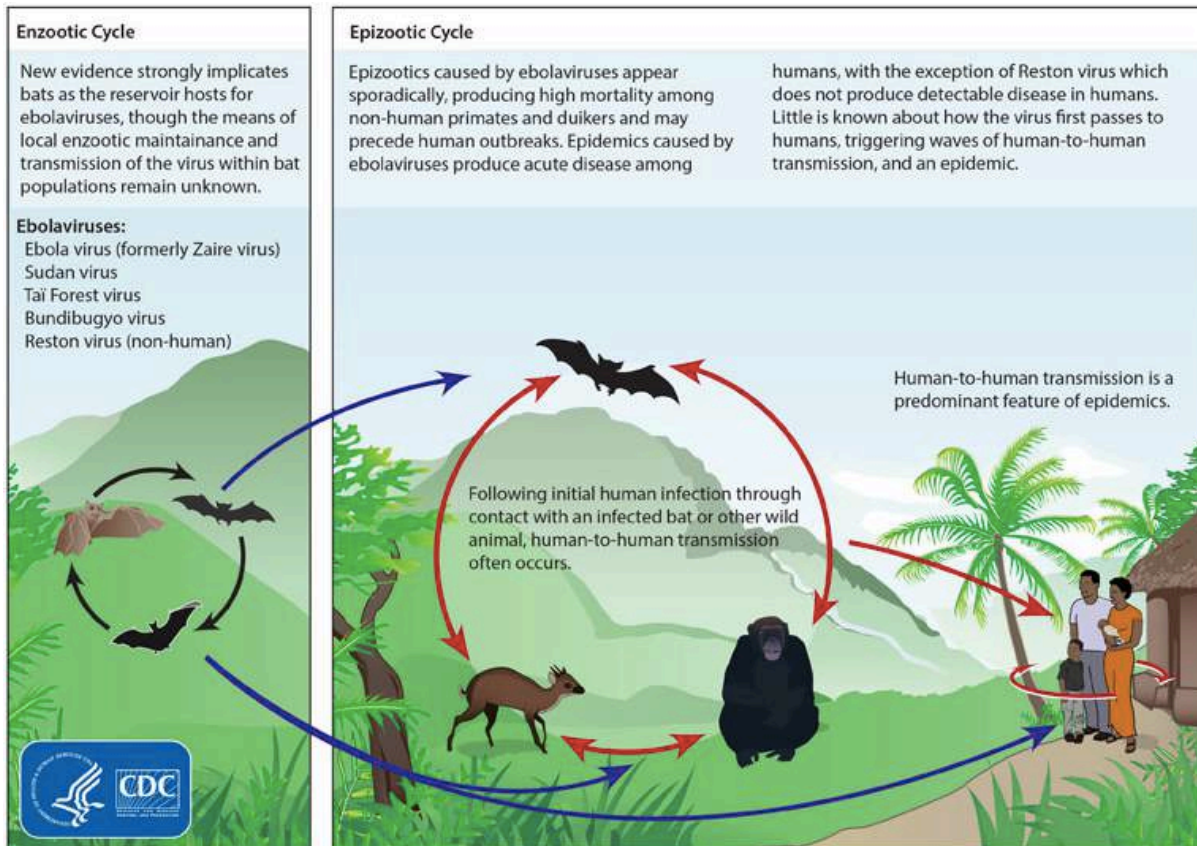


The Ebola virus attacks the immune system and the organs. It also damages cells that cause blood-clotting; this leads to severe internal bleeding. Most cases are fatal. The Ebola virus is highly contagious and must be properly handled. It is spread through contact of bodily fluids.

Viruses-Ebola (continued)

Outbreak

Ebola was most likely first transferred from fruit bats to other animals, and then to humans. Now Ebola can be transferred from diseased animals to humans, or from human to human contact.



In February of 2014, an Ebola outbreak hit West Africa.