



BACTERIA AND VIRUSES

ANTIBIOTICS AND BACTERIAL RESISTANCE TO ANTIBIOTICS

MARR
Michigan Agricultural Experiment Station



Module One: What We Will Learn

- What are microbes?
- What are viruses?
- What are bacteria?
 - Where do they live?
 - What is their structure?
- Bacteria and humans
 - How to identify bacteria
 - Colonization
 - Host cell defenses
 - How bacteria cause infection



Text:

This is part one of two 45 minute modules we will study over the next two days. We will learn about bacteria, how bacteria invade host cells, how antibiotics work, the development of antibiotic resistance and its global impact.

What Are Microbes?

- Microscopic living organisms
- Four major types of microbes:
 1. Viruses
 2. Bacteria
 3. Fungi
 4. Parasites
 - **We will provide some information about viruses and then spend most of our time focusing on bacteria.**



Text:

We will talk briefly about viruses but our focus will be on bacteria, antibiotics and the development of antibiotic resistance.

Viruses and Bacteria

Viruses

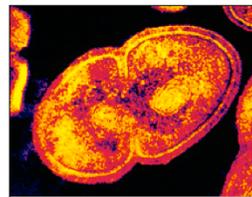
- Genetic material (DNA or RNA) in a protective coat
- Attach themselves to a host cell to reproduce inside that cell



Rhinovirus (cold)

Bacteria

- Independent cell
- Able to live and reproduce outside human or animal cells



Streptococcus pneumoniae

Text:

Key points:

There are two main types of microbes: viruses and bacteria. The viruses and bacteria are very different from each other.

Viruses are genetic material (DNA or RNA) in a protective coat; they are not alive. They invade living cells, like the ones inside your body, and turn them into copy machines to make more viruses. When these virus copies are released into your body, you become sick.

Bacteria are living, independent organisms that can survive and reproduce on their own.

Most bacteria are good, helping us digest food and keep our systems in balance.

Some types of bacteria can make you sick and antibiotics are used to fight those infections.

When we use antibiotics, even to kill bad bacteria and cure infections, we are also killing some of the good bacteria.

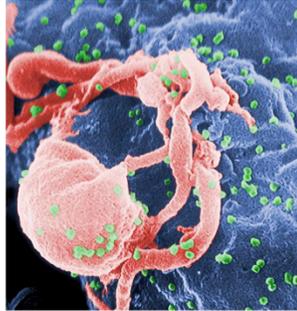
What Are Viruses?

- The smallest infectious particles with a core of genetic material (DNA or RNA)
- Surrounded by:
 - a protein,
 - a lipid (fat), or
 - a combination of a lipid and a sugar-protein coat

Viruses are the smallest infectious particles that have a core of genetic material such as DNA or RNA. They are surrounded by either a protein, a lipid (fat) or a combination of a lipid and a protein.

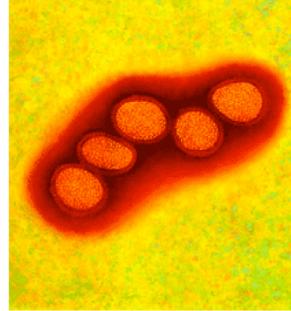
What Some Viruses Look Like

(not to scale)



HIV

- Human immunodeficiency virus (HI-V budding in green)



Influenza Virus

- Flu

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Text:

Key points:

There are many different kinds of viruses.

Viruses are extremely tiny and can be seen only under a highly magnifying microscope

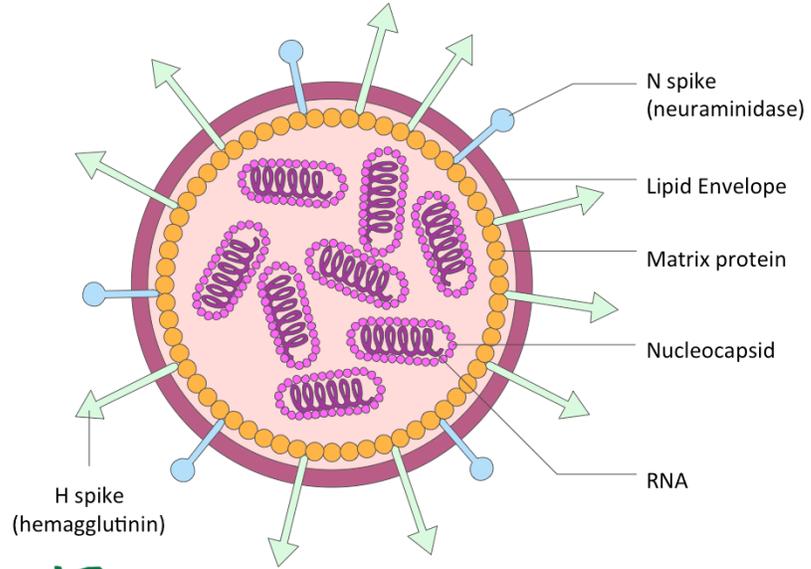
The human immunodeficiency virus (HI-V budding in green from a cultured cell) causes HIV

The Influenza virus causes the flu

Instructor's note: You may ask the class these questions to begin a discussion:

Have you or someone you know recently had a cold or the flu? How did they feel? What were the symptoms? Did they use any medicine to help them get better? How long did it take for them to get over their viral infection?

Influenza Virus Structure



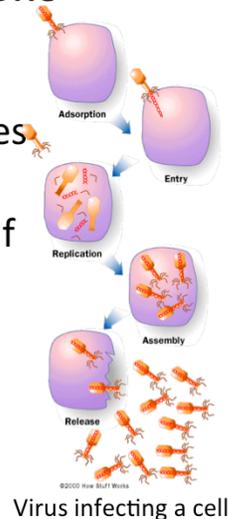
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Viruses Invade Host Cells

- Viruses lack some of the machinery to grow and reproduce by themselves
- A virus invades a live host cell inside your body and starts replicating itself
- The host cell releases the copied viruses
- Each released virus will look for a new live host cell to invade and repeat the process



Virus infecting a cell

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Text:

How Viruses Make You Sick

Key points:

Germs enter your body through any opening they can find.

Viruses infect a cell in your body and turn it into a virus copy machine.

This graphic shows the stages of a viral infection:

Adsorption: the virus finds a suitable cell and attaches itself

Entry: the virus injects its genetic information (DNA or RNA) into the cell and takes control

Replication: the virus transforms the cell into a miniature copy machine and makes millions of copies of its genetic information

Assembly: new copies of the virus are assembled inside the cell

Release: the new viruses are released and the process starts all over again, spreading the infection to more and more healthy cells

Additional activity

This 3½ minute animated video shows how viruses in your body can multiply and make you sick (from National Public Radio website):

<http://www.npr.org/blogs/krulwich/2011/06/01/114075029/flu-attack-how-a-virus-invades-your-body>

The Host Defends Itself

- The Immune System
 - Detects the virus
 - Produces specific antibodies to inactivate the virus
 - Sends white blood cells to fight and destroy the virus



Text:

The virus attempts to invade the host cell. The host cell has its own first-line defenses (called the Immune System) it uses to fight and destroy the virus. Most of the time, the host cell defenses can fight off the virus attack. Other times, the virus will win and enter the cell to make more copies of itself and in doing so, makes you sick.

What Are Some Diseases Caused by Viruses?

- Common cold
- Influenza
- Measles, chickenpox, mononucleosis
- Herpes (e.g., cold sores)
- HIV
- Genital warts (Human Papillomavirus or HPV can result in cervical cancer)
- Hepatitis
- Rabies



Text:

Here are some diseases caused by viruses that you all may be familiar with: read above

How Do We Contract Viruses?



- Simple contact with an infected person (shaking hands [direct contact] or sneezing [respiratory or airborne spread])
- Exchange of bodily fluids such as saliva
- Sexual contact (e.g., HIV, HPV)
- Contaminated food or water
- Insects (e.g., mosquitoes)
- Infected animals (e.g., animals with rabies)

The Power of a Sneeze

- Did you know that a sneeze can blast microbes into the air at 100 miles per hour?!



Photograph of a real sneeze

Text:

When you sneeze, it can blast viruses into the air at up to 100 miles per hour. If you have a virus, coughing and sneezing sends your viruses into the air where they can make other people sick. Holding back your sneeze can cause pressure and hurt your ears. The best way to sneeze is into your sleeve or into a tissue to prevent spreading viruses.

Other Facts About Viruses

- Some viral infections can be prevented by vaccines (e.g., influenza, HPV, hepatitis B, measles and mumps)
- Treatment for the common cold is directed toward relief of symptoms with over-the-counter (OTC) medicines while the body's immune system is fighting the virus
- Antiviral medications are available for certain viruses



Text: Facts About Viruses

Antiviral medications are available for certain viruses; e.g., neuraminidase inhibitors for influenza, inhibitors of DNA replication for Herpes Simplex, various types of anti-HIV medications that interfere with different functions of viral infection and proliferation.

Although immunization to prevent some viral infections or symptomatic relief for others, such as colds, are common methods for treating viral infections, antiviral medications are available for some viral infections, such as influenza, herpes simplex, and HIV infection.

Key points:

Some viruses can make you sick.

The flu, colds, and most coughs are caused by viruses.

Antibiotics don't work on viruses.

Some viral infections can be prevented by vaccines (examples: influenza and chicken pox).

The best way to treat a viral infection, like a cold or flu, is with rest, plenty of liquids, and over-the-counter medicine designed to relieve your specific symptoms such as body aches and fever.

What Are Bacteria?

- Single-celled microscopic organisms
- Larger than viruses but smaller than human cells
 - Majority play a positive role in nature:
 - Aid in digestion
 - Digest sewage into simple chemicals
 - Extract nitrogen from air and make it available to plants for protein production
 - Some are harmful (pathogenic):
 - Damage tissues or produce toxins that cause disease



Text:

Now we will move into one of our major topics - bacteria. Bacteria are extremely small and can be seen only through a microscope. They are single-celled organisms but they are larger than a virus – viruses are even smaller than bacteria. Most bacteria are good and play a positive role in nature. They aid in digestion, change sewage into simple chemicals, extract nitrogen from the air which plants use for protein production. Some bacteria, however, are harmful – also known as pathogenic. Pathogenic bacteria can damage tissues in the body or produce toxins, causing disease.

What Some Bacteria Look Like

(not to scale)



***Escherichia coli* (*E. coli*)**

- Urinary Tract Infection

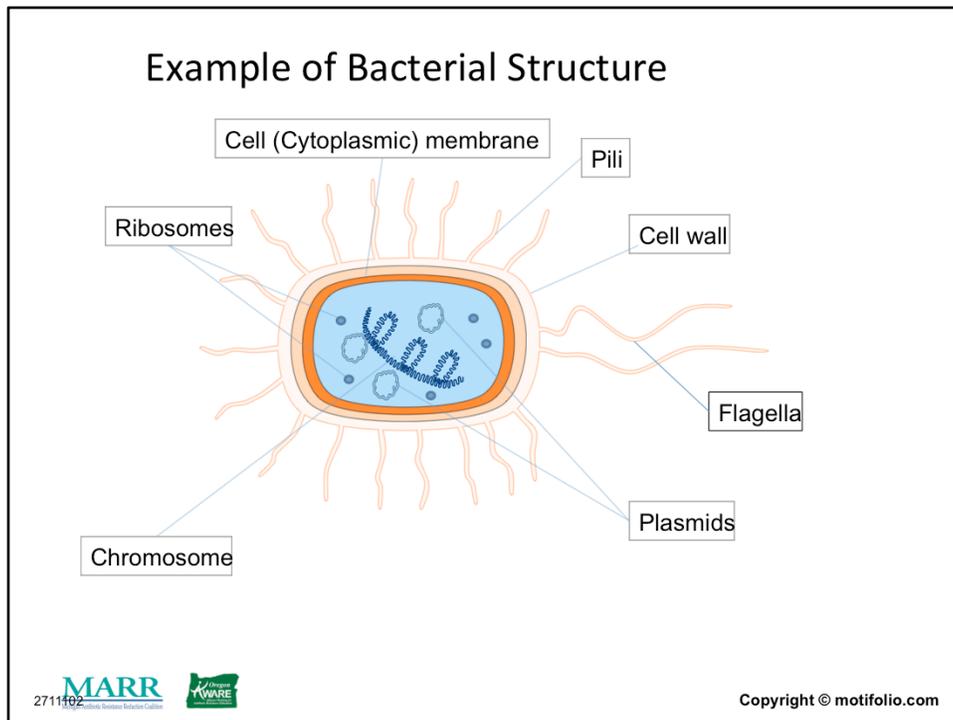


***Streptococcus pyogenes*
(Group A Streptococcus)**

- Strep throat (pharyngitis),
skin infections

Text:

Here are a couple of examples of what some bacteria look like. These are not to scale, but, the one on the left is known as *E. coli* which often causes urinary tract infections. Some specific types of *E. coli* can cause very serious gastrointestinal infections or foodborne illnesses. The strep bacteria on the right (purple) can cause strep throat or skin infections.



Text:

This is a typical bacillus, or rod-shaped bacterium. The external structures include pili and flagella. Pili are short tubular structures that facilitate the binding of cells to one another and through which DNA can pass from one cell to another in a mating. Flagella can move in a coordinated fashion to propel a bacterium through liquid and along mucous membranes. The exoskeleton of a bacterium is the cell wall, which defines the shape and keeps the cell from bursting, yet it is flexible. Some bacteria, so-called Gram-negative bacteria, have an outer membrane that surrounds the cell wall and limits the entry and exit of nutrients, toxins, and antibiotics. Just inside the cell wall is the cell membrane, which encases the cytoplasm within which are all of the internal structures of the bacterium, such as the chromosome and the ribosomes. The chromosome consists of the complete DNA sequence of the bacterium, which embodies the genetic instructions for all of the bacterial structures and functions. The chromosome replicates in the process of cell division. The ribosomes, which are orderly structures consisting of RNAs and proteins, carry out protein synthesis as directed by the DNA genes and mediated by messenger RNA.

Natural Habitats of Bacteria

Environment

- Soil, plants, water

Animals and Humans

- Skin
- Upper airway and mouth
- Gastrointestinal tract
- Genital tract



Text:

Bacteria proliferate more in certain types of environments. They favor moisture and are often found in soil, around plants and in water. Bacteria also thrive in or on animals and humans such as on their skin, upper airway and mouth (where it is moist), in the stomach and intestines and in the vagina.

Most Bacteria Are Harmless And Even Beneficial

- Soil, water, plants
 - Recycle organic matter and wastes
- Animals
 - Aid in digestion of cellulose in stomachs of cows
- Humans
 - Occupy (colonize) sites that might otherwise be invaded by harmful (pathogenic) bacteria
 - Aid in digestion



Text:

It is important to emphasize that most bacteria are harmless or even helpful. Bacteria recycle organic matter and wastes in soil, water and plants. Bacteria aid in the digestion of cellulose in the stomachs of cows or llamas. Bacteria can reside (or colonize) humans in sites that might otherwise become invaded by harmful or pathogenic bacteria. Bacteria also aid in human digestion.

Bacteria May Inhabit Other Sites

- Bacteria may survive for various times on a variety of surfaces
 - toilets
 - sinks
 - cell phones
 - desks
 - remote controls
 - food
 - computers



Bacteria may survive for various periods of time on other surfaces that have come in contact with a bacterium. Examples include: toilets, sinks, cell phones, desks, remote controls, and on food. I am sure you can think of other things that bacteria could live on. Do any of you have other ideas?

Colonization vs. Infection

- **Colonization:** The presence of bacteria in or on your body without causing any symptoms of infection
- **Infection:** Bacteria invade and damage tissue, or produce a toxin that damages tissue



Text:

When your body has bacteria on it or in it that do not cause any symptoms of infection – you are only colonized with the bacteria. The bacteria are living in or on your body as their residence, but, not causing any problem. Once the bacteria invade and damage tissue or produce toxins that damage tissue, the body is considered to have a bacterial infection.

Identification of Bacteria

Generally identified by:

1. shape when viewed with the microscope
2. a procedure called the Gram stain which is positive or negative, depending on the absence or presence of an outer membrane and the thickness of the cell wall
3. whether they require oxygen to grow or are poisoned by oxygen
4. nutrients they can use to grow
5. identification of sequences of proteins made by the bacteria, or sequences of the bacteria's DNA or RNA



Text:

There are certain features that allow us to identify what kind of bacteria are present. These include: the shape when viewed under a microscope, a Gram stain procedure that determines the absence or presence of an outer membrane and the correlated thickness of the cell wall, whether it requires oxygen or is poisoned by oxygen, nutrients to grow, and the sequences of proteins made by the bacteria, or sequences of the bacterial DNA or RNA.

Host Defenses Against Pathogenic Bacteria

- First line of defense is a barrier preventing entry into the tissue:
 - Intact skin
 - Lining of upper airway, gastrointestinal (GI) tract, vagina
 - Stomach acid
 - Frequent flushing out of eyes by tears, or of bladder by urine
 - Mucus in the lungs and coughing



Text:

Some of the host cell defenses used to fight off pathogenic bacteria include: intact skin (no cuts, scrapes, etc.), protective lining of the upper airway, GI tract and vagina, stomach acid, and frequent flushing of the eyes by tears, or of the bladder by urine, and mucus in the lungs and coughing. These all help the body protect the host cells from invasion by the pathogenic bacteria.

Host Defenses Against Pathogenic Bacteria (cont.)



- Immune System
 - Detects bacteria and their products
 - Produces specific antibodies (proteins)
- Antibodies work at the infection site to:
 - Bind and inactivate the bacteria
 - Cause inflammation and increase blood flow
 - Recruit white blood cells to ingest and kill the bacteria

Text:

In addition, the body's immune system notifies the body that bacteria and their products are present. This causes the immune system to produce specific antibodies or proteins. These antibodies go to the site of the infection to bind and inactivate the bacteria. Antibodies can cause swelling or inflammation which increases blood flow to the area, and recruits white blood cells to ingest and kill the bacteria.

How Do Bacteria Damage the Host Cell?



I am a sneaky fighter!

Text:

With all of these defenses in place, how do bacteria win and damage the host cell?

How Bacteria Cause Infection



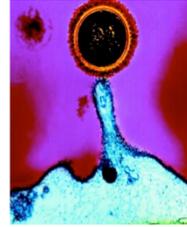
- Pathogenic bacteria have certain disease-producing features
- These features are called “virulence factors”

Text:

Harmful or pathogenic bacteria have special features allowing them to overwhelm the immune system defenses and cause infection. These features are called “virulence factors”.

Bacterial Offense “Virulence Factors”

- Allow bacteria to attach to host cells
- Produce toxic compounds that damage host cells or surround tissue
- Produce proteins that either disrupt the host cells or stimulate uptake into the host cells, allowing them to penetrate deeper into various parts of the body
- Produce factors that inhibit the host’s immune response



A colored transmission electron micrograph of Streptococcus bacteria attached to a human tonsil cell.

Text:

These are some of the features that allow bacteria to be strong enough to overcome the immune system and harm the host cell: ability to attach themselves to the host cells, production of toxic compounds that cause damage to the host cells or the surrounding tissue, production of proteins that disturb the host cells or stimulate uptake into the host cells allowing the bacteria to penetrate deeper into the body, and having a feature or component that prevents or limits the host cells’ immune response.

The Battle Between Bacteria and Host

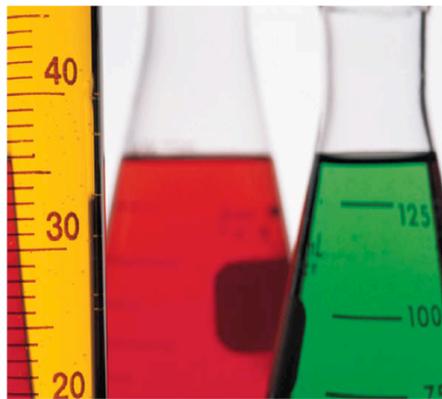
- Pathogenic (disease-causing) bacteria attack healthy host cells
- Three potential outcomes:
 1. host cell wins, bacteria are removed, cell recovers, **or**
 2. bacteria win and kill the host cell, **or**
 3. bacteria and host cell live together



Consider this to be a BATTLE between the bacteria and the host cell. There are three potential outcomes when a pathogenic bacteria attacks a healthy host cell:

1. The host cell wins and the cell recovers from the attack. The bacteria die.
2. Bacteria win and kill the host cell, or
3. The bacteria and host cell live together. In some cases, the cohabitation may be rocky, but in other (e.g., tuberculosis), it may survive for a lifetime.

End of Module I



Text:
This is the End of First Lesson Module.