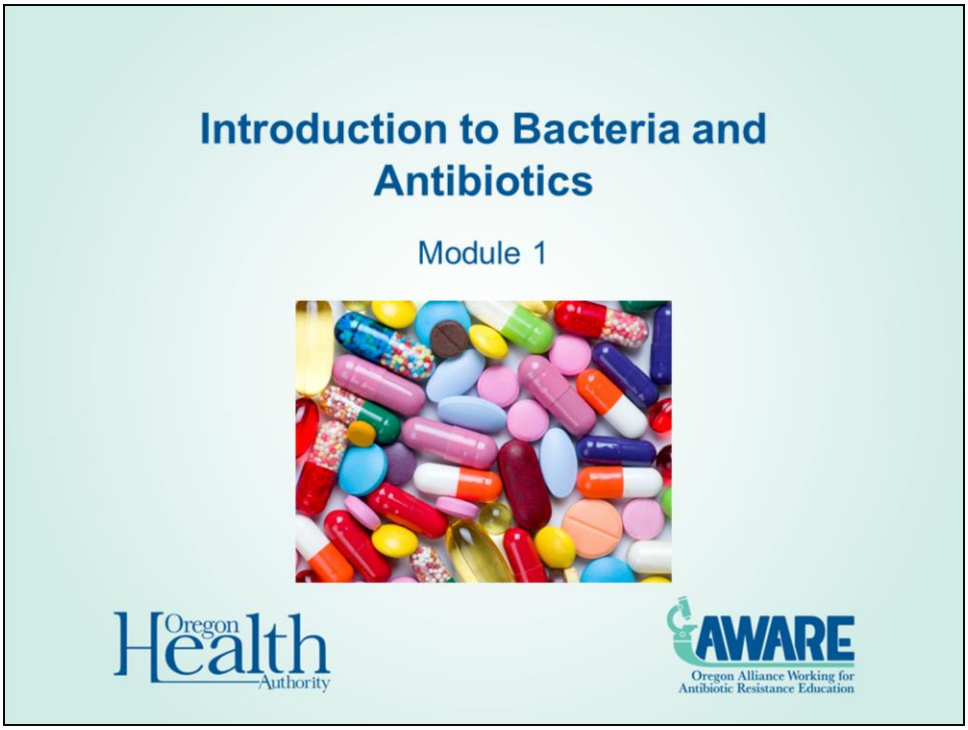


Text:
This is part one of two 45 minute modules we will study over the next two days. We will learn about bacteria, how bacteria invade host cells, how antibiotics work, the development of antibiotic resistance and its global impact.

Scenario 1

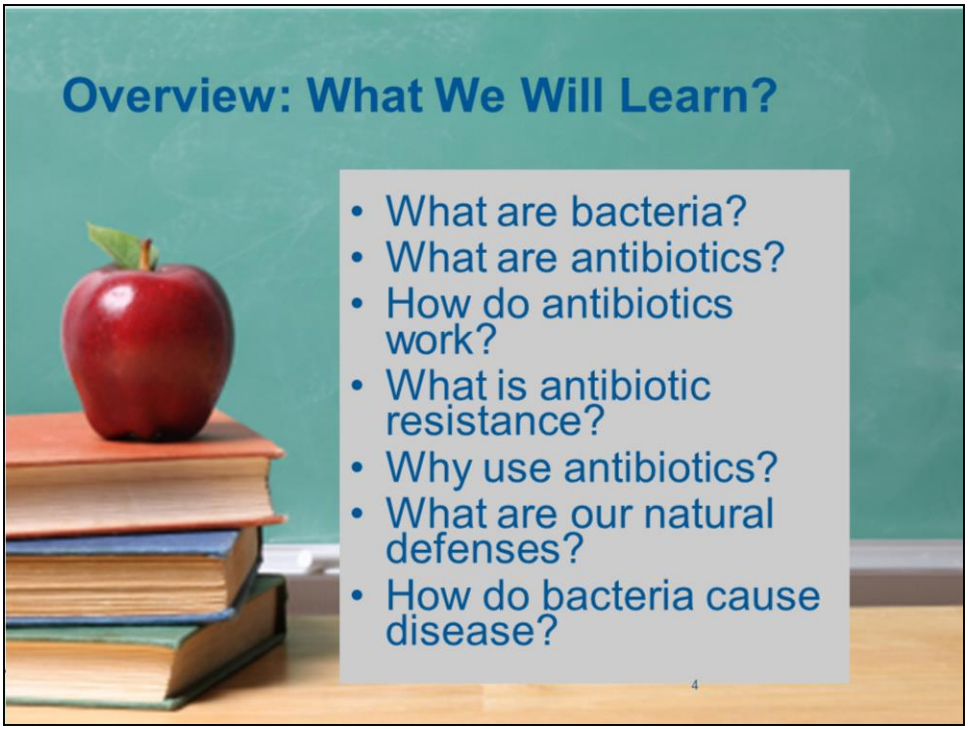
- A woman comes into the ER with a high fever and is diagnosed with a bacterial infection.
- She is prescribed intravenous antibiotics, and put under observation
- The infection does not respond to the drugs, and the patient worsens
- A new course of drugs is used, but the patient goes into shock and dies from the infection

2

Scenario 1

- Why do you think the drugs used to treat the patient did not eliminate the infection?

3


Overview: What We Will Learn?
What are bacteria?
What are antibiotics?
How do antibiotics work?
What is antibiotic resistance?
Why use antibiotics?
What are our natural defenses?
How do bacteria cause disease?
4

What are bacteria?

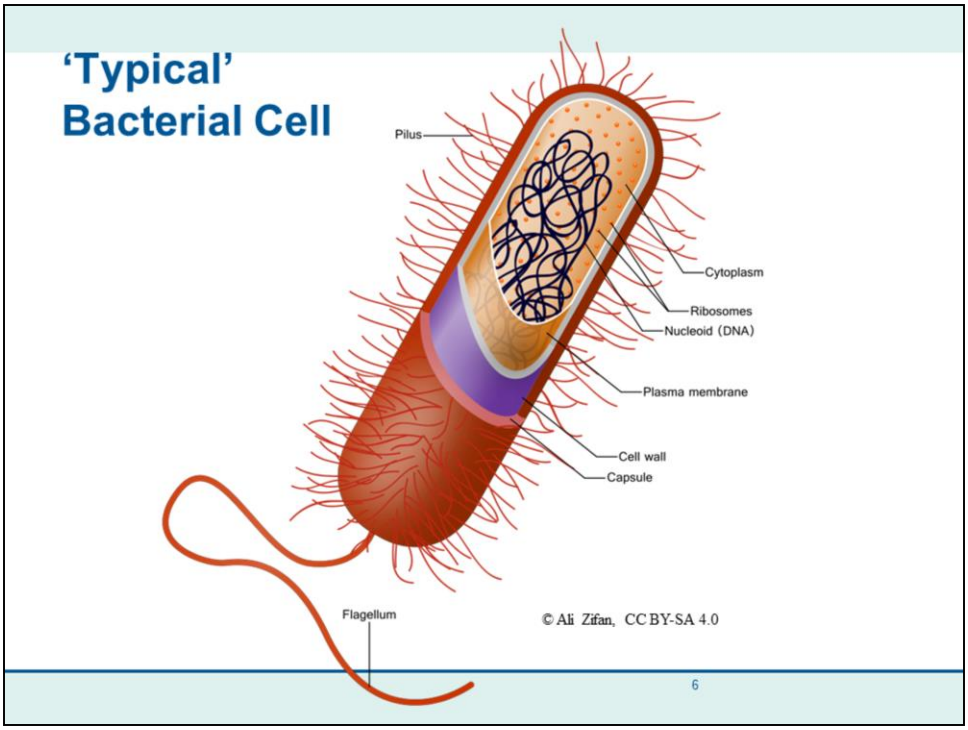
- Bacteria are microscopic, single-celled organisms
  - Have no nucleus
  - Cell structure is different from that of human cells

- Other types of microorganisms
  - Virus (common cold)
  - Fungi (athletes foot)
  - Parasite (tapeworm)

5

Bacteria are extremely small and can only be seen through microscope. They are single-celled organisms but they are larger than a virus – viruses are even smaller than bacteria.

(This slide contains the answer to question 1 on the student worksheet)



Provide the students with an unlabeled illustration, have them label it to learn the basic anatomy of a bacterial cell

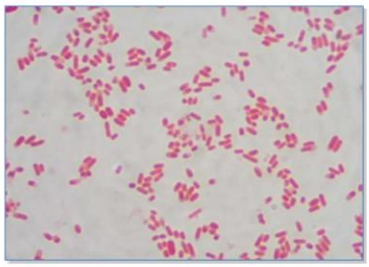
(The illustration is question 9 on the back side of worksheet)

Identification of Bacteria

- Bacteria are identified in part using physical traits and microscopy
  - Cell shape when viewed under the microscope
  - Gram stain procedure that detects the presence of an outer membrane (Gram negative) or an outer cell wall (Gram positive)

Text:
There are certain features that allow us to identify the presence of bacteria. 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.

Gram Stain



- Gram negative

- Gram positive

8

The pink cells are gram-negative bacilli, the purple cells are gram-positive cocci

It is important for everyone to know that bacteria are found everywhere – we are constantly exposed to them.

This will be useful in the next module when discussing how to prevent the spread of antibiotic resistance – if we do not acquire bacteria, we will not become infected, and will not have to use drugs.
(Question 2 on the student worksheet)

A brief discussion of the importance of hand washing would go well here.

Optional video: https://www.youtube.com/watch?v=znnp-Ivj2ek

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?

Most Bacteria are Beneficial

- Nutrient cycling in ecosystems
- Digest sewage into simple chemicals
- Extract nitrogen from air and make it available to plants for protein production

11

Most bacteria are good and play a positive roll in nature. They aid in digestion, change sewage into simple chemicals, extract nitrogen from the air which plants use for protein production.

Most Bacteria are Beneficial

- Aid in digestion
- Provide essential nutrients (vitamin K)
- Occupy (colonize) sites that might otherwise be invaded by harmful (pathogenic) bacteria

12

(Question 3 on the worksheet)

Cows and Bacteria

- What is the importance of bacteria in cows and other ruminants?

Cellulose Digestion

- Cows, termites and other animals do not have the ability to digest cellulose
- Without bacteria, cows could eat grass, hay and other plants, but they could not break it down

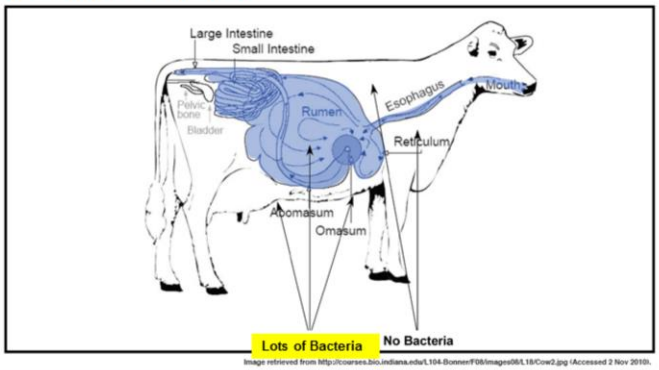


Image retrieved from http://courses.bio.indiana.edu/L104-Bonner/F08/images08/L18/Cow2.jpg (Accessed 2 Nov 2010).

14

No eukaryotic organism possesses the enzymes necessary to digest cellulose.

Without bacteria, these animals would not be able to digest the food that they eat.

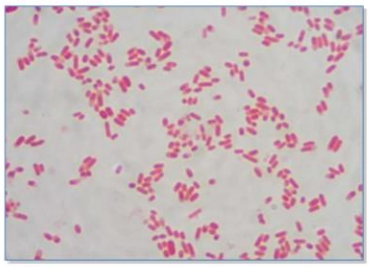
Some Bacteria are Harmful

- Some are harmful (pathogenic):
  - Damage tissues or produce toxins that cause disease (Staphylococcus aureus, group A strep)
- Opportunistic pathogens
  - Do not cause disease in most health people, take advantage of already weakened host (certain gram negative bacteria that inhabit the gut, parasites, fungi)
- True pathogens
  - Cause infection in otherwise healthy people (influenza, bacterial meningitis)
  - Have mechanisms to evade the immune system

15

Some bacteria, however, are harmful – also known as pathogenic. Pathogenic bacteria can damage tissues in the body or produce toxins, causing disease.

Pathogenic Bacteria



Escherichia coli (*E. coli*)
- Gram negative
- Urinary Tract Infection

Streptococcus pyogenes (Group A Streptococcus)
- Gram positive
- Strep throat (pharyngitis), skin infections

16

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.

What is an Antibiotic?

- A chemical that kills bacteria or stops them from growing
- Antibiotics work only against **bacteria**, not **viruses**
- **Antivirals** are drugs against viruses

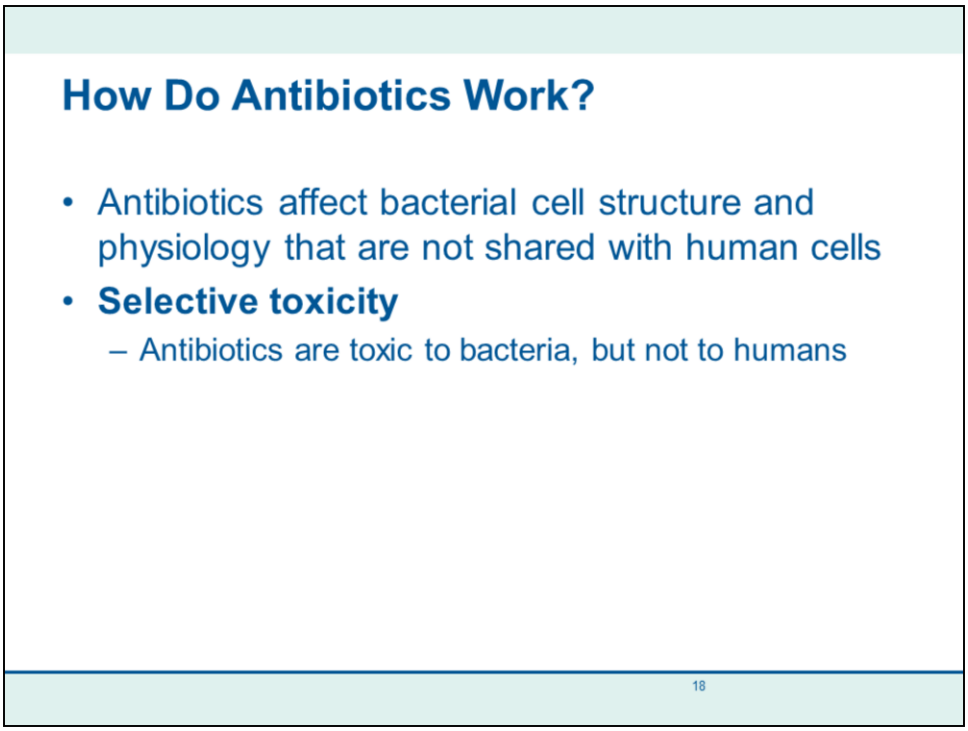
17

What is an antibiotic?

Key points:
Antibiotics are chemicals that kill bacteria or stop them from growing.
There are different types of antibiotics, each designed to work on specific types of bacteria.
Only a healthcare provider can prescribe the right antibiotic for your bacterial infection. It is important to use the right drug for your bug!

Instructor's note:
Ask the students if they have ever taken an antibiotic. Ask them about their experience: did they visit the doctor? Did they take all of the medicine? Did the medicine make them feel better?

(Question 4 is answered on this slide and the next)

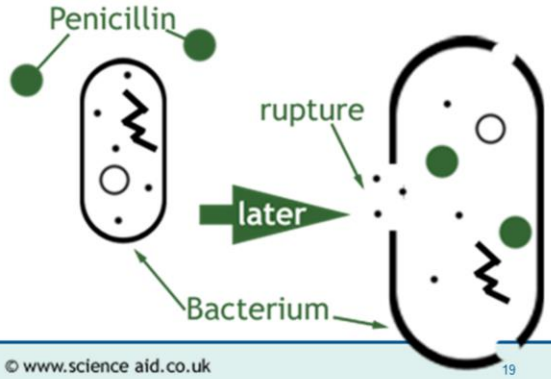


Drug toxicity and drug allergy are often confused. If a drug is toxic to a human cell, it is toxic to all humans. Allergies depend upon the immune response of the individual.

Even though all cells are related, bacteria and human cells are very different – peptidoglycan in cell wall,

Selective Toxicity

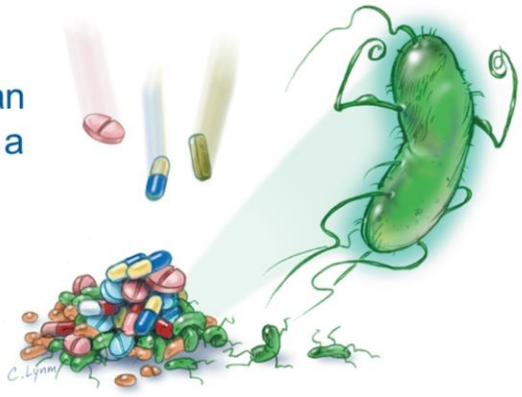
- Some examples of how antibiotics work
  - Disrupt cell wall synthesis
  - Disrupt ribosome function and protein synthesis
  - Disrupt cell membrane structure



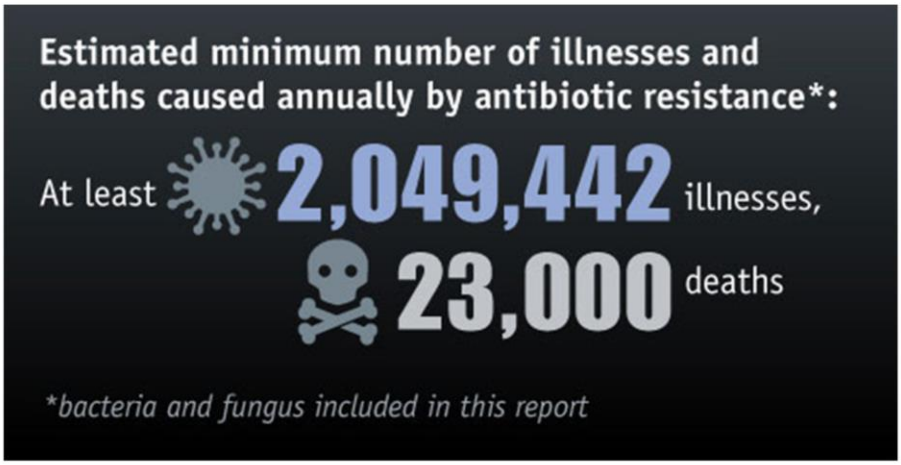
(Question 5 on the worksheet)

What is Antibiotic Resistance?

- Decreased effectiveness of an antibiotic against a particular type of bacteria
- Bacteria evolve rapidly, and develop ways to prevent drugs from working

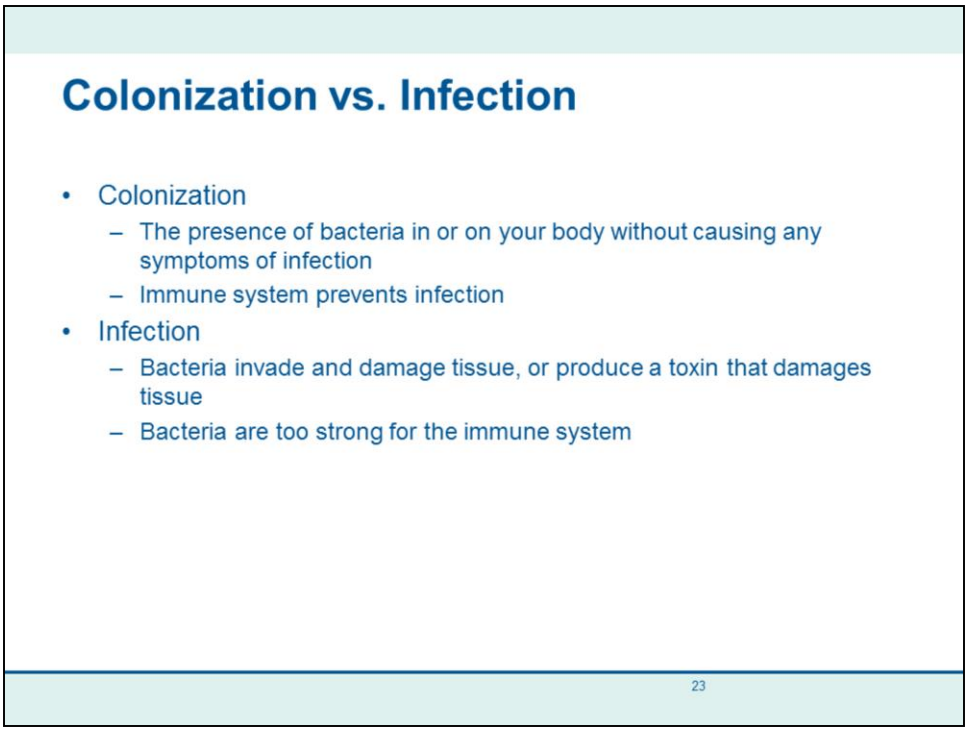


Antibiotic Resistance



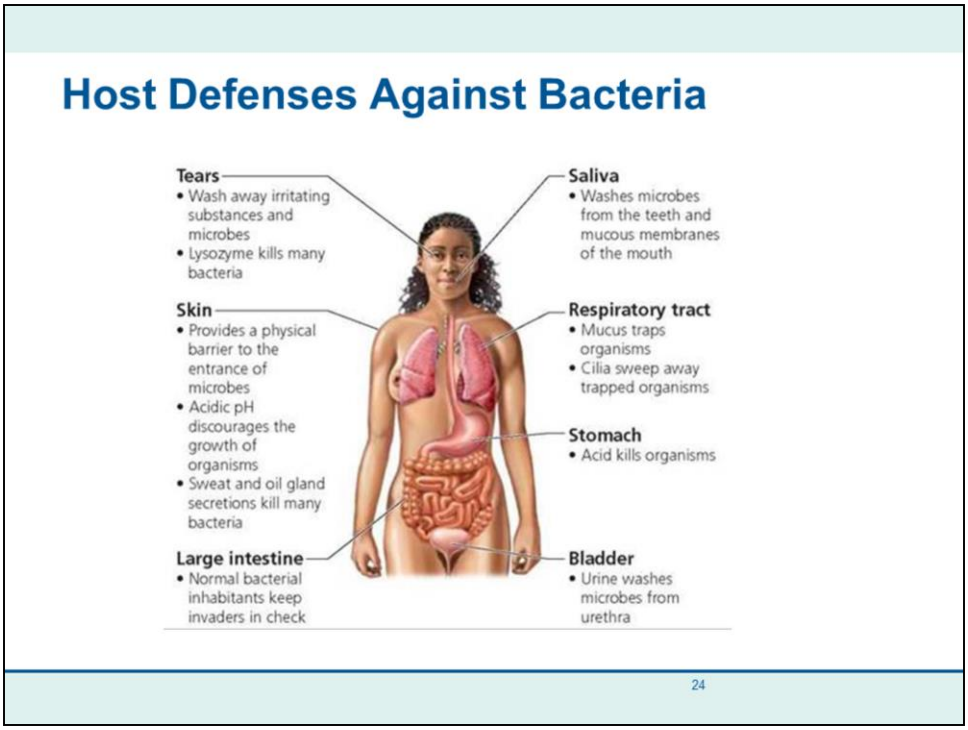
Why Use Antibiotics

- Sometimes, bacteria are able to fight off and escape the human immune system
- In these instances, drugs are necessary to fight the infection



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 is "living in or on your body as its house", but, 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.

(Question #6 on the student worksheet)



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.

(Question #7 on the student worksheet)

Host Defenses Against Bacteria

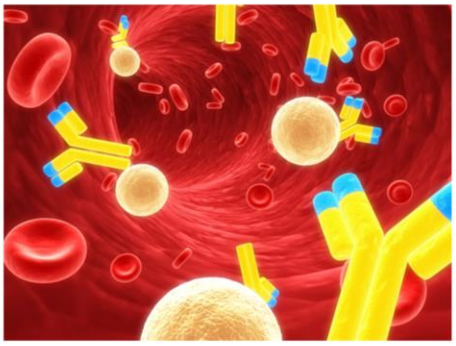
- Adaptive Immune System
  - Detects bacteria and their products
  - Produces specific antibodies (proteins)

25

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.

Host Defenses Against Bacteria

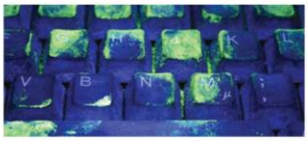
- Antibodies work at the infection site to:
  - Bind and inactivate the bacteria
  - Cause inflammation and increase blood flow
  - Recruit white blood cells to ingest and kill the bacteria



Text:
These antibodies go to the site of the infection to bind an 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.

Spread of Bacteria

- Direct contact with infectious particles
  - Computer keyboards, money, doorknobs



- Fecal/oral spread
  - From eating or drinking contaminated food or water
  - Food handler with diarrhea who doesn't wash hands well after using bathroom

- Blood-borne spread
  - Transfusion or injection (HIV, hepatitis B, hepatitis C)

27

This is a good place to perform an exercise using glo-germ powder. There is a white powder available that is difficult to detect under visible light, but under UV fluoresces green. The instructor can place powder on their hands, then shake hands with a few students, then have students shake each others' hands around the room. Visualize with portable UV lights

Spread of Bacteria

- Respiratory contact
  - Inhaling infectious particle in the air from someone coughing or sneezing
- Sexual contact
  - Examples: HIV, syphilis, chlamydia
- Vector-borne examples
  - Animal bite (cat, dog, bat)--rabies
  - mosquito—West Nile or Zika virus

28

(#8 on the student worksheet.)

The Power of a Sneeze

- Did you know that a sneeze can blast microbes into the air at 100 miles per hour?!
- The spray from a sneeze can travel up to 30 feet from the person who sneezed!

www.discovery.com/tv-shows/mythbusters/mythbusters.../**sneeze**-travel-100-mph/

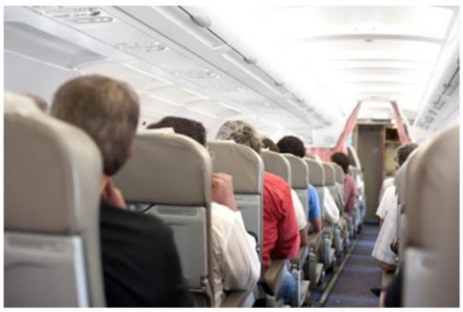
29

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.

Instructor's note: to demonstrate germ transmission, you can use the balloon popping exercise.
Instructions:
Put a small amount of water into a balloon (a few drops is all you need). Blow up the balloon and tie it off. Gather some of the students into a circle; hold the balloon above their heads, count to three and pop the balloon. Water droplets will disperse through the air, just like an uncovered sneeze.

Scenario 2

- A man who carries extensively drug resistant tuberculosis (XDR-TB) in his lungs is on a flight of a major airline
- Upon arrival at the airport, he is detained and isolated by authorities who have learned of his condition



Scenario 2

- Why do you think the man with TB was detained by officials?
- What do you think the dangers are of this individual being on a commercial flight?
- Why do you think XDR-TB is especially dangerous?

Battle Between Bacteria and Host

- When a pathogenic (disease-causing) bacteria attacks healthy host, there are three potential outcomes:
  - Host wins, bacteria are removed, no infection, or
  - Host and bacteria live together (colonization), or
  - Bacteria win and infect host
- Under which situation would antibiotics be needed?

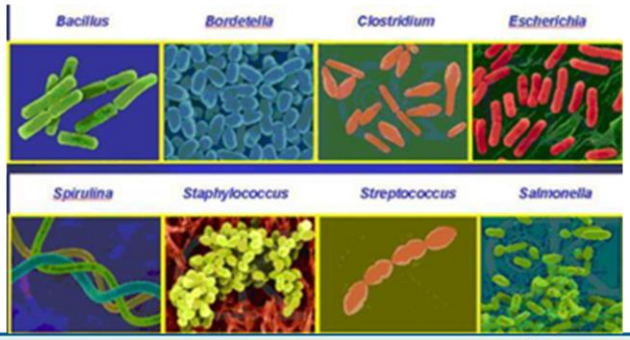
32

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.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.
3.Bacteria win and infect the host

Effects of Bacteria on the Host

- Pathogenic bacteria (cause serious infections) have certain features used to invade tissues and avoid the immune system
- These features and traits are called “virulence factors”
- Some of these virulence factors act to suppress the immune system

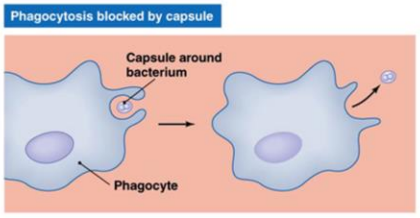


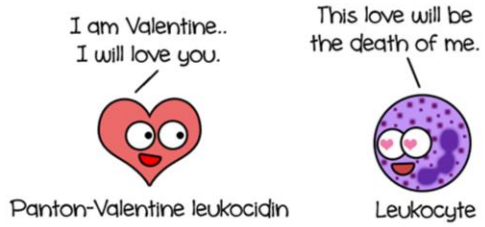
33

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

Inhibition of Immune Response

- Capsules
  - Layer of sugars on surface of cell that prevent immune system cells from catching bacteria
  - *Streptococcus pneumoniae* (ear infection, pneumonia)
- Leukocidins
  - Proteins that kill white blood cells
  - *Staphylococcus aureus* (skin and soft tissue, bloodstream, bone/joint infections)





Text:
These are some of the features that allow bacteria to be strong enough to overcome the immune system and harm the host cells': 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.