The Theory of Evolution

The theory of evolution by natural selection is a scientific theory. **Evolution** is a change in the characteristics of living things over time. Evolution occurs by a process called **natural selection**. In natural selection, some living things produce more offspring than others, so they pass more genes to the next generation than others do. Over many generations, this can lead to major changes in the characteristics of living things. The theory of evolution by natural selection explains how living things are changing today and how modern living things have descended from ancient life forms that no longer exist on Earth. No evidence has been identified that proves this theory is incorrect, and evidence from many facets of science support this theory. You will learn more about evolution later in this course.

The Cell Theory

The cell theory is another important scientific theory of biology. According to the **cell theory**, the cell is the smallest unit of structure and function of all living organisms, all living organisms are made up of at least one cell, and living cells always come from other living cells. Once again, no evidence has been identified that proves this theory is incorrect. More on the cell theory will be presented in the next unit.

The Germ Theory

The **germ theory** of disease, also called the pathogenic theory of medicine, is a scientific theory that proposes that microorganisms are the cause of many diseases. Like the other scientific theories, lots of evidence has been identified that supports this theory, and no evidence has been identified that proves the theory is incorrect. This one may seem obvious to you, but before the discovery of disease-causing bacteria and viruses, diseases were thought to be caused by "bad air" or getting chilled or that sort of thing.

Experimental Variables

A quick reminder of what you learned in class recently:

- **Independent variable (IV)**: what you are testing, what you are changing in an experiment. On a graph, this will always go on the X-axis. It's sometimes called the *experimental variable*.
- **Dependent variable (DV)**: what you are measuring in your experiment, as a result of the changes in the IV. On a graph, this will always go on the Y-axis.
- Controlled variables (or better yet, **controlled factors**): these are all the other factors that could affect the outcome of the experiment, but you don't want them to, so you must make sure these factors are the same for all your tests in an experiment.

Examples:Let's say you set up an experiment to see if amount of light affects how many radish seeds will germinate

- The **IV** (independent or experimental variable) is the different amounts of light (always dark, always light, or half dark/half light).
- The **DV** is the number of radish seeds that germinate in each of the lighted conditions - it *depends on* how much light is present, which is why it's called the **dependent** variable. It's the *results* of your experiment.
- Some of the **controlled factors** include same number of seeds, same amount of water, same temperature, and same type of soil in all the different lighted conditions.

Summary

- With repeated testing, some hypotheses may eventually become scientific theories. A scientific theory is a broad explanation for events that is widely accepted as true.

Prokaryote Structure (outside)

Many prokaryotes have an extra layer, called a capsule, outside the cell wall. The **capsule** protects the cell from chemicals and from drying out. It also allows the cell to stick to surfaces and to other cells. Because of this, many prokaryotes can form biofilms, like the one shown in **Figure** 3.4. A **biofilm** is a colony of prokaryotes that is stuck to a surface such as a rock or a host's tissues. The sticky plaque that collects on your teeth between brushings is a biofilm. It consists of millions of bacteria.

Most prokaryotes also have long, thin protein structures called **flagella** (singular, **flagellum**). They extend from the cell membrane. Flagella help prokaryotes move. They spin around a fixed base, causing the cell to roll and tumble. As shown in **Figure** 3.5, prokaryotes may have one or more flagella.

A third outside structure are small extensions called **pili**. Bacteria use these to hold onto each other, as well as to a surface such as your skin.

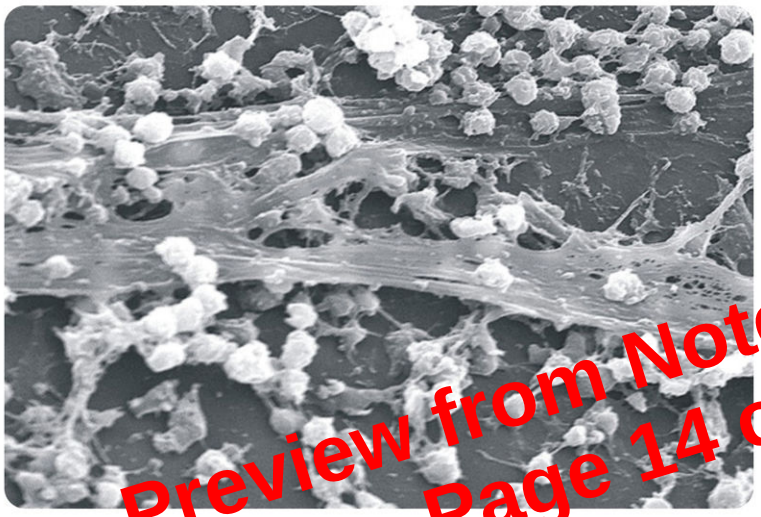

FIGURE 3.4

Bacterial Biofilm. The greatly magnified biofilm shown here was found on a medical catheter (tubing) removed from a patient's body.

Archaea

Archaeans are an unusual group of prokaryotes. They are similar to Bacteria, described above, but there are some key differences. Use the information here to help you complete the table in your notes about differences between Bacteria and Archaea.

- The cell wall of Bacteria contains **peptidoglycan**, composed of sugars and amino acids. The cell wall of Archaea lacks peptidoglycan.
- The **DNA sequences** for certain structures (like ribosomes) of Archaea are very similar to those in eukaryotic cells, and not at all like bacterial DNA sequences.
- Archaea can live in **extreme conditions**, often resembling those of early Earth, where no other organisms can live. This indicates that they probably evolved very early in Earth's history.

Here are the three main groups of Archaea, based on the environment where they live. Use this information to help you complete the table about Archaea in your notes.

1. **Thermophiles** live in high heat conditions, such as in hot sulphur springs in Yellowstone, and deep sea vents. They do NOT live in active volcanoes (*too* hot!)

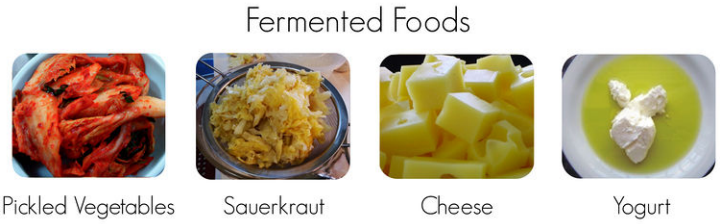

FIGURE 3.6
Various fermented foods

Bacteria and Disease

You have ten times as many bacteria as human cells in your body. Wow! Most of these bacteria are harmless. However, some bacteria can also cause disease. Examples of bacterial diseases include tetanus, syphilis, and food poisoning, as well as strep throat and Lyme disease. Bacteria may spread directly from one person to another. For example, they can spread through touching, coughing, or sneezing. They may also spread via food, water, or objects.

Another way bacteria can spread is by vectors. A **vector** is an organism that spreads pathogens from host to host. (A **pathogen** generally means anything that can cause a disease.) Insects are the most common vectors of human diseases. The **Figure** below shows two examples.

FIGURE 3.7
Bacterial disease vectors include ticks and deerflies

Humans have literally walked into some new bacterial diseases. When people come into contact with wild populations, they may become part of natural cycles of disease transmission. Consider Lyme disease. It's caused by bacteria (*Borrelia burgdorferi*) that normally infect small, wild mammals, such as mice. A tick bites a mouse and picks up the bacteria. The tick may then bite a human who invades the natural habitat. Through the bite, the bacteria are transmitted to the human host.

Controlling Bacteria

Bacteria in food or water usually can be killed by heating it to a high temperature (generally, at least 71°C, or 160°F). Bacteria on many surfaces can be killed with chlorine bleach or other disinfectants. Bacterial infections in people can be treated with **antibiotic drugs**. For example, if you ever had "strep" throat, you were probably treated with an antibiotic. You will get to test some antibiotics in lab. You will also get to test some other substances to see how effective they are at controlling bacterial growth.

Antibiotics have saved many lives. However, misuse and over-use of the drugs have led to **antibiotic resistance** in bacteria. **Figure** below shows how antibiotic resistance evolves. Some strains of bacteria are now resistant to most common antibiotics. These infections are very difficult to treat.

FIGURE 6.1

Cold Sore. Cold sores are caused by a herpes virus.

FIGURE 6.2

Shingles. Shingles is a disease caused by the same virus that causes chicken pox.

Spread of Viral Diseases

The ability for people to travel quickly has encouraged the spread of some viral diseases that otherwise might only infect a few people in a small area. For example, scientists believe **West Nile Virus** was introduced to the United States by an infected air traveler. With the use of air travel, people are able to go to foreign lands, contract a disease and not have any symptoms of illness until they get home, possibly exposing others to the disease along the way. Watch this 3:50-minute video *Virus Crisis* at https://www.youtube.com/watch?v=91b3MCAlYSI to learn more about the spread of West Nile Virus. It was made in 2009, but is still relevant today.

Several lethal viruses that cause viral hemorrhagic fever have been discovered, two of which are shown in the **Figure** 6.3. Ebola outbreaks have been limited mainly to remote areas of the world. However, they have gained extensive media attention because of the high mortality rate—23 percent to 90 percent—depending on the strain. The primary hosts of the viruses are thought to be apes in west central Africa, but the virus has also been isolated from bats in the same region. The current outbreak of Ebola in West Aftrica (2014) has spread in part because of contact with

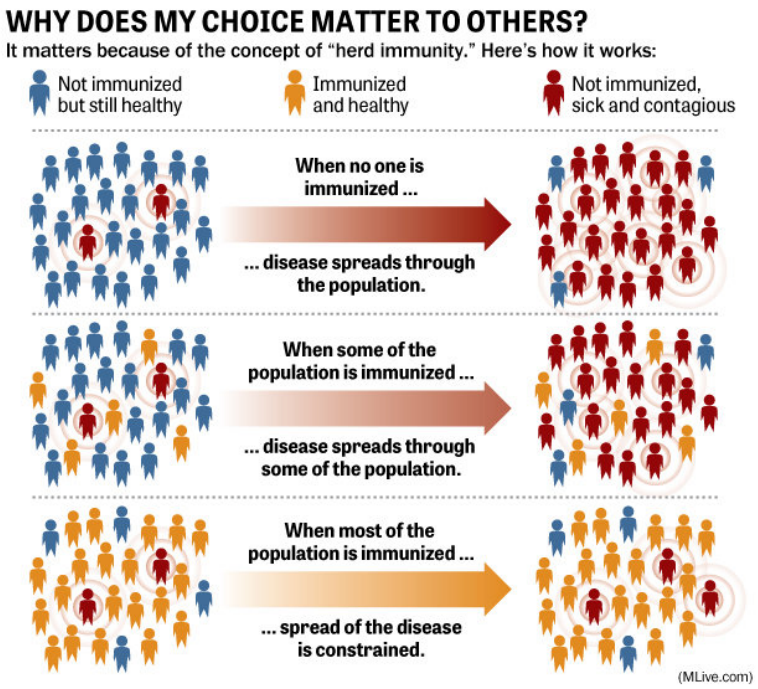

FIGURE 7.3

specifically for treating the symptoms of viral infections. The first antiviral drug was **interferon**, a substance that is naturally produced by certain immune cells when an infection is detected.

Like antibiotics, specific antivirals are used for specific viruses. They are relatively harmless to the host, and therefore can be used to treat infections. Most of the antiviral drugs now available are designed to help deal with HIV and herpes viruses. Antivirals are also available for the influenza viruses and the Hepatitis B and C viruses, which can cause liver cancer.

Summary

- Several viral diseases can be treated with antiviral drugs or prevented with vaccines.
- Herd immunity helps protect everyone as long as most people are immunized.

Be able to answer these questions:

1. What is a vaccine made of?
2. How likely do you think it is for a vaccine to cause the disease it is meant to prevent?
3. What is herd immunity?
4. What are antiviral drugs and how do they do their job?

References

1. PV2 Andrew W. McGalliard. A young student receiving a vaccination. Public Domain