Bacteria and Viruses Lecture Outline

Written by Miranda Dudzik, for LBCC iLearn BI 101

*Number in outline corresponds to slide number the PowerPoint presentation.

1. Bacteria and Viruses
- **a.** Prokaryote Diversity is the first installment of our diversity unit. Prokaryotic cells are the simplest of all cells, and encompass all bacteria. Prokaryotes were the first forms of life to appear on earth approximately 3.7 billion years ago.
- **b.** Bacteria are such a diverse and complicated group of life forms that we will not be looking at specific species, but rather spend our time looking at some basic characteristics of all bacteria, with some special attention being placed on disease causing bacteria(pathogens), and a few examples of extreme bacteria.

2. Prokaryotes—Characteristics
- **a.** We need to look at some basic characteristics of all prokaryotic cells. First and foremost, if you are to be classified as prokaryotic, you are a single celled organism. Most of the organisms that we have talked about so far this term are multi-cellular organisms, meaning that it is a species that has lots of cells that must cooperate and live in close association to survive. These types of cells are eukaryotic.
- **b.** Prokaryotic cells are much simpler than those that are found in multi-cellular organisms. Prokaryotes for example only have a single chromosome, whereas multi-cellular organisms have multiple chromosomes. Bacteria also have a cell wall that can be used to classify bacterial types.
- **c.** A eukaryotic cell is also much larger, and has compartments that carry out specific functions. For instance, eukaryotes have nucleus that holds the DNA of that cell in a central location. There are compartments that are responsible for making proteins, for harvesting energy form glucose molecules and for processing waste materials.
- **d.** Prokaryotes on the other hand do not have these specialized compartments. They are small enough that all cellular processes necessary to sustain life can happen right in the cytoplasm of the cell. Bacteria do not go through the process of sexual reproduction, which is the process of combining genetic material from another individual to create genetically unique offspring. Instead, they make genetically identical copies of themselves in a process called binary fission. Bacteria also have unique structures that aid in movement that are different from structures that are found in eukaryotic cells.

3. Different Ways to Describe Bacteria
- **a.** There is such a vast array of bacteria, so much diversity in this group of organisms that learning all of the different classification schemes is well beyond the scope of this course. But, there are 4 main characteristics that are always used in characterizing a species of bacteria.
- **b.** Bacteria are microscopic, meaning that they are not visible with the naked eye and must be viewed using a microscope. Generally speaking there are three basic shapes that most bacteria can have: rods, spheres, and spiral shaped. E. coli. Whooping cough and some bacteria that live in our own digestive system are examples of rod shaped bacteria. Staph, salmonella (responsible for many forms of food poisoning) and the bacteria that causes strep throat are spherical and spiral shaped species include the bacteria that causes Lyme disease and syphilis.
- **c.** Shape, is one of course, but the composition of the cell wall is another. There are two basic types of cell walls and can be identified in microscopy based on the types of dyes that can bond to the components of the cell wall. This process of dyeing is known as gram staining. Bacteria fall into two basic categories, based on the structure of their cell wall: gram negative and gram positive.
- **d.** Another way bacteria can be classified is whether they can survive in the presence of oxygen. Aerobic bacteria are those that require oxygen, and anaerobic are those species that cannot survive in the presence of oxygen. There are also a group of bacteria, most often that are rod shaped, that can form a special protective coating when environmental conditions are not optimal for their survival. They have the ability to create endospores that protect them against harsh conditions.

4. Nutritional Modes
   a. We have already seen some of these terms when we were learning about food webs. Generally speaking, autotrophs are those species that get their carbon from carbon dioxide, and heterotrophs obtain their carbon from organic molecules that are found in the bodies of other organisms. We already know photoautotrophs are organisms that obtain energy through the process of photosynthesis. This is only one type of nutritional mode that can be found in prokaryotes.
   b. Where photo- indicates energy comes from the sun, chemo indicates that energy is obtain and processed using chemicals that are obtained in the organism environment. So ultimately, breaking down each of these words into its parts will tell you both where that species gets its carbon and its energy source as well.

5. Prokaryotic Fission
   a. As mentioned at the beginning of the lecture, bacteria reproduce using binary fission. In basic terms, this means that the bacteria creates a copy of its single chromosome, and then splits itself into two separate, but genetically identical cells. So in theory, every single generation of bacteria are identical to the original cell it arose from.

6. Conjugation
   a. However, most bacteria have devised an ingenious process to swap genetic material. This gives a species of bacteria the ability to increase the genetic diversity of the species, and is one of the ways antibiotic resistant bacteria have come to be.

7. Eubacteria
   a. There are two main classifications of bacteria: Eubacteria (most often just referred to as bacteria) and archaebacteria, AKA Archaea. Most bacteria that we know and love are classified as bacteria. Archaea are often referred to as extremophiles. These are bacteria that live in extreme environments. Since the vast majority of bacteria are classified as the former, we will focus on them first.

8. Ecological Importance
   a. Although the tendency is to think of bacteria as bad, or germs that cause disease, only a small fraction fo bacteria are considered pathogenic. Many more are actually play important ecological roles in nearly every environment. We already talked about the importance of nitrogen fixers and decomposers when we explored nutrient cycles and food webs. But practically every animal has a mutualistic relationship with bacteria
   b. Fun fact to share at parties: there are more bacteria living in or on your body than there are cells of your own body. And without those bacteria, we would not be able to digest and or process our food or protect ourselves against invasion by the “bad” bacteria.

9. Commercial Uses
   a. We also rely very heavily on bacteria in many commercial aspects of human life. Bacteria are essential in our treatment of wastewater and other important chemicals. Many of the foods we eat are produced using bacteria.
   b. Another fun fact to share at parties: most of the colors and flavors that make the different kinds of cheeses are from metabolic waste products of bacteria used in the making of that cheese. The holes in swiss cheese for instance are caused by the gasses that are excreted by bacteria. So you are in essence eating cheese formed by bacteria farts.

10. Humans & Disease
- **a.** Of course, even though disease causing bacteria only make up a small fraction of bacteria that are important to humans, they are still worthy of our attention. In terms of the types of diseases that come from bacteria, there are 4 ways that they can be categorized: Sporadic, epidemic, endemic, and pandemic.
- **b.** Epidemics and pandemics are the categories that the Center for Disease Control (CDC) are most concerned about. The recent overblown scare of the swine flu, now commonly referred to as H1N1, although is caused by a virus not a bacteria, was feared to be the next great pandemic. If you look across the course of human history, a pandemic disease has unleashed itself on humanity with global consequences approximately every 75 years or so.
- **c.** Previous to the 20th century, you could practically set your watch to pandemic breakouts. The last global pandemic occurred in 1918 with the outbreak of the spanish flu (Also a H1N1 strain of the flu!) during WWI.

11. Archaea
- **a.** Now just a brief introduction to the Archaea. These bacteria are newer in terms of when they arose in the history of life on earth, and they are more closely related to eukaryotic cells than the Eubacteria.

12. Extremophiles
- **a.** Archaea can be found in every environment, but are most likely to be found living in conditions that most other organism cannot tolerate. For this reason they are often referred to as extremophiles and are rarely known to cause human diseases.

13. Viruses
- **a.** Regardless of what type of organism you are talking about, there are some basic characteristics that define it as a living entity:
  - **1)** Being composed of one or more living cells,
  - **2)** the ability to maintain homeostasis,
  - **3)** respond to stimuli in the environment,
  - **4)** the ability to acquire and use materials and energy (AKA Metabolism),
  - **5)** contains DNA,
  - **6)** have the ability to reproduce and
  - **7)** the ability to evolve.
- **b.** It is generally accepted by most biologists that if an object doesn't fulfill all of these requirements then it cannot be considered a living organism. As we learn more about viruses, I want you to keep these characteristics in your mind. Let's look at what makes up a virus.
- **c.** Essentially, a virus is nothing more than a bit of genetic material wrapped up in some protein molecules. Sometimes that genetic material is DNA, sometimes it is RNA. In fact, viruses are often classified by what type of genetic material they contain. Viruses are very small, much smaller than prokaryotic cells.

14. HIV Virus
- **a.** Viruses are considered parasites, and are very hot specific. The HIV virus for example is specific to humans, in particular, T cells that are part of the immune system. The HIV virus basically hijacks these cells and converts them to nothing more than virus making machines. These cells are an essential component to immune function, which is why HIV can be such a devastating disease.
- **b.** But it is important to mention that in individual infected by the HIV virus doesn't die from the virus itself. A person who is HIV positive will actually die of something else, another disease that he or she could not fight off because of the presence of the HIV virus.

15. Steps in Viral Replication
- **a.** Continuing with the HIV virus as your representative virus, let's look at steps of viral replication. Regardless of what type of virus, and who is the host, viral replication has 6 basic steps:
- **b.** First is attachment. There are proteins on the surface of the virus that trick its host cell into allowing it to gain access to the cell's interior. These proteins are typically similar if not identical to proteins that the host recognizes as "self" proteins.
- **c.** Penetration can happen in two different ways. There are some viruses that will enter into the cell, like the flu virus. Others, like this HIV virus will simply inject its genetic information into the cell and it is that bit of RNA that hijacks the replication processes of the cell to turn into a virus factory.
- **d.** Once in the cell, the cell begins making thousands of copies of the parasitic DNA or RNA.
- **e.** That genetic material is basically the blueprint for more proteins that can be packaged up into new viruses, and released out of the cell the host cell to seek out new cells to infect.

16. Examples of Viruses
- **a.** Viruses ***cannot*** be treated AFTER infection, symptoms can only be managed. Prevention via vaccinations most effective way of preventing viral diseases, but scientists have not been able to develop vaccinations for all viruses e.g. common cold b/c of rapid mutation rates, and in some cases, the ability to blend DNA with host DNA gaining the ability to jump species. HIV. Influenza and cold viruses are examples of viruses that have this ability.

17. Other Infectious Agents
- **a.** Other infectious particles that are worth mentioning, if only briefly are viroids and prions. These particles are even smaller and simpler than viruses. Viroids are simply short sequences of RNA that infect plants and cause a variety of diseases, most of which you have never, and will never hear about.
- **b.** Prions, however, you have probably heard of, in the form of bovine spongiform encephalopathy, better known as mad cow disease. Prions are proteins that are misfolded and cause the cells around it to die. There is still a lot we don't know about prions and viroids. No one knows where they came from, or why they are so devastating. This area is a huge area a ongoing research right now.