**Study Plan: Episode 1—The Microbial Universe**

1. **Read the UNIT OVERVIEW on the following pages.**
2. **Read UNIT OBJECTIVES and KEY CONCEPTS on the following pages.**
3. **View the Video and take any notes that are not already on this study plan. Pay particular attention to the topics identified by the UNIT OBJECTIVES or KEY CONCEPTS as significant. *Note this write up augments the description of the microbes found in the video - the video shows excellent pictures!***
4. **Read Chapter 1 of the textbook (pgs. 3 – 26) and take notes, as well.**
5. **Test your mastery of the material by answering the Review Questions (*based upon information in the study plan write-up*).**
6. **Check your answers against the answer key.**

**UNIT OVERVIEW**

Microbes, a highly diverse assemblage of organisms too small to be seen with the naked eye, are everywhere! Centuries before their presence was suspected, microbes were cultivated for their ability to ferment beverages, leaven bread, preserve foods, and revitalize soils. Centuries before their presence was suspected, they shaped the course of human history with sweeping plagues and shattered individual lives with their ability to cause disease. From the invention of the microscope to modern molecular techniques, technological advances have driven the study of microorganisms. Early microscopes confirmed their presence; modern molecular techniques reveal their astonishing diversity.

Microbiology is a young and challenging science. The control of disease-causing organisms presents renewed challenges as antibiotic-resistant microbes emerge. Today, the fermentative abilities of microbes are important not only in the food and beverage industry, but in the pharmaceutical industry as well. Microbes have unique nutrient cycling abilities, making them an important tool in the treatment of toxic wastes and recalcitrant compounds. Modern technology has shown us that we are familiar with only a fraction of the microbes that share and shape our world. Armed with new investigative tools, tomorrow's microbiologists will explore a little known and poorly understood element of the biosphere.

**Unit Objectives**

**To Understand:**

* The diversity of microorganisms.
* The impact of microorganisms on human affairs.
* The scope of microbiology.
* The key participants in the development of microbiology as a science.
* Microbiology today and where it is headed in the future.

**Key Terms**

* agar
* algae
* anthrax
* antibody
* *Bacillus thuringiensis*
* bacteria
* bioremediation
* biotechnology
* fermentation
* fungi
* germ theory of disease
* Golden Age of Microbiology
* microbe
* protozoan
* spontaneous generation
* virus

**Key Concepts**

**THE UNSEEN WORLD AND OUR WORLD**

* Microorganisms are living things too small to be seen by the unaided eye.
* Microbes, in terms of number and distribution, are the most dominant organisms on earth. They account for the majority of the earth’s biomass.
* We estimate that only 1% of the microorganisms are actually known to man.
* Microbes are part of our "normal biota;" Microbes that live on and in us outnumber us by 10-fold (10 trillion human cells as compared to 100 trillion microbes).
* Microbes are extremely diverse and have important roles in maintaining our ecosystem.
  + They provide greater than 50% on the oxygen (algae and cyanobacteria)
  + They recycle nutrients.
* Most microbes are yet to be discovered and many cannot be cultured (for example SAR11 in the ocean).
  + Microbes make vitamins and help protect us from disease-causing organisms.
* A small fraction of microorganisms are pathogenic.
  + Throughout history, pathogens (disease-causing microorganisms) have had a tremendous negative impact on human affairs. Epidemic disease brought social and political chaos along with human suffering. Fortunately, only about 1% of the microbes actually cause disease (pathogens).
  + Much of history was dictated by infectious disease; more soldiers died in the Civil War from infectious disease than from any other cause.
  + In 1800s and earlier many mothers died after childbirth – as much as 25%. Better control methods were developed when we gained a better understanding of microbes; improved hygiene (soap and water!), safe water supply and sanitation had major effects.
  + Disinfectants, antiseptics, vaccines all led to prevention of infectious disease.
* We can now prevent and cure many diseases with vaccines and antibiotics. However there are new emerging diseases and well as antibiotic resistant bacteria.
* The development of microbiology as a science has allowed us to control microbes and use them for our benefit.
* Infectious disease still devastates certain areas of the world due to the lack of clean water, sanitation systems, and the lack of appropriate medical care.

**Microbes and Life Today**

* Microbiology includes many sub-disciplines including:
  + Medical microbiology (also called public health microbiology) which focuses on preventing and treating infectious diseases (i.e. sanitation, clean water, vaccination recommendations)
  + Environmental microbiology which is the study of how microorganisms affect the earth and its atmosphere.
  + Industrial microbiology which deals with microorganism-dependent industries such as those producing foodstuffs (also called agricultural microbiology), fermented beverages and pharmaceuticals.
* Microbiologists will increasingly apply genetic engineering to solve medical, environmental and agricultural problems.

**THE SCOPE OF MICROBIOLOGY**

* Agriculture – microbes break down wastes and fix nitrogen (otherwise, we have to use a lot of fertilizers).
* Industry – microbes are used to treat sewage, clean up industrial wastes, decompose garbage in landfills, and used to produce many different foods. Microbes are used to produce citric acid, acetic acid, lactic acid, enzymes used in laundry, vitamins, food additives, and medically important proteins, such as insulin, clotting factors, and growth hormones.
* Microbes are used in bioremediation – for cleaning up oil spills and degrading waste products of explosives or radioactive wastes.
* In herbivores microbes break down the cellulose, which the animals cannot breakdown. This provides glucose to the animal for converting into energy that the animal can use.
* Microorganisms are usually divided into six subgroups: bacteria, archaea, algae, fungi, protozoa and viruses.
  + *the first video lumps bacteria and archaea into the group bacteria. We will consider them as two groups which is more accurate.*
* Microbes are very diverse and include both prokaryotic and eukaryotic cells.
* Microbiology is a cohesive science because of its methodology and approach to problems, not because of the relatedness of the organisms it studies.
* Microbes play a key role in cycling of atoms, such as nitrogen, sulfur, phosphorous, oxygen, and carbon.
* Algae and plants are primary producers that get energy from sunlight and take in CO2 and release O2; consumers use O2 and give off CO2; in other words they work together.

**Bacteria**

* Bacteria are prokaryotes (have no nucleus) and are very small, even for microorganisms. They vary in shape, motility and how they get energy.
* Some bacteria cause disease, but others keep our environment in life-sustaining balance.
* About 70 times larger than viruses
* Surrounded by a membrane and a tough cell wall; sometimes that have flagella to propel them through the environment.

**Archaea**

* Archaea were discovered as a separate group of microorganisms in the 1970s; they were at first called archaebacteria.
* Archaea are prokaryotes and are very small; they resemble bacteria superficially, but have characteristics similar to both eukaryotes (have a nucleus) and prokaryotes.
* Many archaea live in hostile /extreme environments (archaea = "ancient")

**Algae**

* Algae are eukaryotic organisms that carry out photosynthesis.
* Some algae are unicellular and microscopic; others consist of many cells and are macroscopic.
  + only the microscopic forms are considered in microbiology
* Algae are not important medically, but they are critically important to global ecology.

**Fungi**

* Fungi include mushrooms, yeasts and molds. Fungi are eukaryotic and nonphotosynthetic. Some are microscopic; others are macroscopic
  + only the microscopic forms are considered in microbiology
* A few fungi are pathogenic to humans and many are pathogenic to plants causing, for example, corn smut, wheat rust and potato blight.
  + The potato blight in the 1800s caused starvation in Ireland and lead to mass immigration to the U.S.

**Protozoa**

* Protozoa are eukaryotic microorganisms that are superficially animal-like, nonphotosynthetic and usually motile.
* Protozoa include the amoebae, flagellates and ciliates.
* The study of protozoan- and helminthes-caused disease is called parasitology.

**Helminths** (not in the video)

* Helminths are macroscopic worms; some go through microscopic stages in their life cycle.
* Helminths cause parasitic diseases in plants and animals, including humans.
* Flatworms and roundworms are helminths important to health studies.

**Viruses**

* Viruses are particles of nucleic acid (either RNA or DNA), usually enclosed in a protein coat and sometimes surrounded by a membrane. Viruses are very small, even compared to bacteria and cannot be seen with the light microscope. They are not cells
* Viruses are obligate intracellular parasites that infect animals, plants and microorganisms.
* The book incorrectly refers to viruses as a life form, but they should really be thought of as an infectious particle that is incapable of carrying out any biological reactions in the absence of a host cell.
* FYI: Prions are even smaller infectious agents than viruses. They are composed entirely of protein and their method of reproduction is not clearly understood.
  + mad cow disease (or bovine spongiform encephalopathy) is caused by a prion

**A BRIEF HISTORY OF MICROBIOLOGY**

*(background information to augment the video and textbook)*

* Robert Hooke observed that thin slices of cork, when viewed through a microscope, exhibited a honeycomb of chambers, or cellulae. This led him to the formulation of the cell theory: cells are the basic unit of organization for all living things.
* Anton van Leeuwenhoek, whose hobby was making microscopes, was the first person to see microbes. He called them animalcules.
* Louis Pasteur developed the germ theory of disease: microorganisms cause infectious diseases and specific microorganisms cause specific diseases. He demonstrated the presence and activity of microorganisms (bacteria and yeasts) in the fermentation of wine. He also disproved the theory of spontaneous generation – the thought that life could rise from lifeless substances.
* Robert Koch proved the germ theory. He developed four postulates that, if fulfilled, provide absolute proof that a particular microorganism causes a particular disease. Most of his work was done with the notorious pathogen, anthrax. He further went on to develop many important isolation techniques.
* Using agar-solidified nutrient medium, Koch developed a technique for obtaining a pure culture containing one and only one type of microorganism.
* Acceptance of the germ theory advanced the idea of public hygiene. Promoting cleanliness and reducing exposure to disease has saved many lives.
* Competition between the French and German scientists led to the discovery of many things in regards to infectious disease.
* Concern for public hygiene has led to clean drinking water, improvements in food preservation and hand washing.
* Immunity is the body's ability to recognize and combat infection; it is stimulated by exposure. Immunization is based on the recognized fact that people, having sustained certain diseases, did not get them again.
* Edward Jenner used fluid from cowpox blisters to provide protection against smallpox. Induced immunity against infectious diseases is known as vaccination.
* Pasteur developed vaccines against anthrax and rabies using attenuated forms of the disease-causing microbe (attenuated = weakened forms that do not cause disease).
* Antibiotics are natural chemotherapeutic agents produced by microorganisms. They have been effective in the treatment of many bacterial infections.
  + Sulfa drugs, which are synthetic chemicals, were the first major class of antimicrobial agents to gain widespread use clinically .
  + Penicillin, discovered by Alexander Fleming in 1926, is the first natural antibiotic. It was called the miracle drug. In 1940, the antibiotic became widely available.
  + Antibiotic resistant strains are emerging, along with new pathogens
* Several scientists/doctors were involved in linking diseases to their transmission by various vectors:
  + Ross – mosquitoes transmit malaria
  + Bruce – tsetse flies transmit African sleeping sickness
  + Ogata – fleas transmit the bubonic plague
  + Ricketts – ticks transmit Rocky Mountain Spotted Fever
  + Reed – mosquitoes transmit yellow fever

**MICROBIOLOGY TODAY**

* Microorganisms lend themselves to experimentation because their metabolism is remarkably similar to those of plants and animals, they are easy to culture, multiply rapidly and enormous numbers can be studied in a short period of time.
* Advances in twentieth-century microbiology have been striking in the areas of chemotherapy, immunology, virology and genetic engineering.
  + The search for new antibiotics is increasingly important as antibiotic-resistant pathogens emerge.
  + Understanding of the microbes and immunology has lead to the development of new vaccines
  + Virology is the study of viruses; the development of the electron microscope in the 1950s has advanced this discipline.
  + Genetic engineering (recombinant DNA technology), is a group of techniques for manipulating DNA outside the organism from which it was obtained and introducing it into another cell, most commonly *Escherichia coli* to exert its effect.
* The ability to manipulate and study DNA outside the organism from which it was obtained has fueled an explosion of knowledge about microbes. Physical appearance of microbes is not always the best way to distinguish between different microbes.
* Genetic engineering and bioremediation (using microorganisms to clean up toxic chemicals) are research fields experiencing rapid progress.
* SAR11 (Sargasso gene #11) has been found in different water samples (lakes and oceans) and is believed to supply nutrients to algae. SAR11 was discovered by Steve Giovannoni (at Oregon State University)
* The development of the electron microscope led to the visualization of viruses for the first time.

**Review Questions**

**True/False**

1. \_\_\_t\_\_There are more microbes on/in our bodies than human cells.

2. \_\_\_f\_\_ People no longer need to worry about infectious diseases because antibiotics can now cure all bacterial diseases.

3. \_\_\_f\_\_ Bacteria caused the Irish potato blight of the 1800s.

4. \_\_\_f\_\_ Microbes are critical for nutrient recycling but have an insignificant role in oxygen production.

5. \_\_\_t\_\_ Penicillin was the first medically useful antibiotic.

6. \_\_\_\_f\_ Viruses are much smaller that bacteria but still can be seen in the light microscope.

7. \_\_f\_\_\_ The majority of bacteria have been discovered and are easy to culture.

8. \_\_\_f\_\_ Recombinant DNA experiments led to the invention of antibiotics.

9. \_\_\_t\_\_ Only a small fraction of microbes are disease-causing.

10. \_\_t\_\_\_ The emergence of antibiotic resistance strains of bacteria is a public health concern.

**Fill In**

1. The study of how microorganisms affect the earth and its atmosphere is called \_\_environmental\_\_\_\_\_\_\_\_\_\_ microbiology.

2. Vaccines have been developed to protect humans against \_\_\_\_\_\_\_\_\_\_\_\_ , microbes that cause disease.

3. The first human use of microbes was to make and preserve \_\_\_\_\_\_\_\_\_\_\_\_ .

4. Use of microorganisms to clean up toxic spill is called \_\_\_\_\_\_\_\_\_\_\_\_

5. Water is made safe for human consumption through the advances of \_\_\_\_\_\_\_\_\_\_\_ microbiology.

6. \_\_\_\_\_\_\_\_\_\_\_\_ microbiologists study ways microorganisms can be used to increase the productivity of farmlands.

7. A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ culture contains only one kind of microorganism.

8. Koch developed \_\_\_\_\_\_ \_\_\_\_\_\_\_\_ to test whether a particular microorganism causes a disease.

9. An \_\_\_\_\_\_\_\_\_\_\_\_ contains a weakened form of a microorganism that causes a disease.

10. \_\_\_\_\_\_\_\_\_\_\_\_ engineering is a group of techniques for manipulating DNA

**Multiple Choice**

1. *SAR11*

A) is an important microbe in the ocean

B) has been cultured and well studied.

C) is a pathogen.

D) is a fungus.

2. Which of the following groups is composed of eukaryotic cells?

A) archaea

B) bacteria

C) protozoa

D) viruses

3. Select the incorrect statement about viruses.

A) They can live independent of their host.

B) They contain nucleic acids.

C) They have proteins.

D) They lack a cellular structure.

4. Select the incorrect statement about eukaryotic cells.

A) They lack a true nucleus.

B) Algae are eukaryotic cells.

C) Bacteria are not eukaryotic cells.

D) They have organelles.

5. Which of the following does not apply to algae?

A) They are eukaryotic.

B) Some are photosynthetic.

C) Some are unicellular.

D) Some are fungal.

6. The first natural antibiotic called "the miracle drug" was

A) erythromycin.

B) penicillin.

C) tetracycline.

D) sulfa drug A.

**Discussion Questions (you may want to post your answers to these in the student discussion forum!)**

1. What are some of the benefits of microbes?

2. What did you learn in the video that intrigued you the most? What surprised you the most?

**ANSWERS**

**True/False**

* + 1. T
    2. F
    3. F
    4. F
    5. F
    6. F
    7. F
    8. F
    9. T
    10. T.

**Fill In**

1. environmental

2. pathogens

3. foods

4. bioremediation

5. medical or public health

6. agricultural (or industrial)

7. pure

8. four postulates

9. attenuated vaccine

10. Genetic

**Multiple Choice**

1. A

2. C

3. A

4. A

5. D

6. B

**Readings for those wishing more information**

Brock, T.D. 1988. *Robert Koch, a life in medicine and bacteriology.* Madison, Wis.: Science Tech.

Dubos, R.J. 1988. *Pasteur and modern science.* Edited by Thomas Brock. Madison, Wis.: Science Tech.

McNeil, W. H. 1977. *Plagues and people.* Garden City, N.Y.: Anchor Press.

Rouechem B. 1984. *The medical detectives.* 2 vols. New York Times: Brooks.