**Chapter 1**

**The Main Themes of Microbiology**

This chapter introduces the student to the world of microbiology, both the positive aspects and the detrimental. The chapter reveals the scope of microbiology and gives a broad overview of the areas of science included in this topic. The student will receive an introduction to the history of microbiology, covering the major scientific contributions to the development of microbiology, including the development of the microscope and the formation of germ theory.

The student will also be introduced to the hierarchy of classification. The basis of taxonomy is discussed, and the order of assigning specific names is clearly presented. Different systems of classification are outlined, as well as the origin and evolution of microorganisms.

**Learning Outcomes**

**1.01.** List the six types of microorganisms we will be studying in this book.

**1.02.** Identify multiple professions using microbiology.

**1.03.** Describe the role and impact of microbes on the earth.

**1.04.** Explain the theory of evolution and why it is called a theory.

**1.05.** Explain one old way and one new way that humans manipulate organisms for their own uses.

**1.06.** Summarize the relative burden of human disease caused by microbes, emphasizing the differences between developed countries and developing countries.

**1.07.** Differentiate among bacteria, archaea, and eukaryotic microorganisms.

**1.08.** Identify two types of acellular microorganisms.

**1.09.** Compare and contrast the relative sizes of the different microbes.

**1.10.** Make a time line of the development of microbiology from the 1600s to today.

**1.11.** List some recent microbiological discoveries of great impact.

**1.12.** Explain what is important about the scientific method.

**1.13.** Differentiate among the terms *nomenclature, taxonomy,* and *classification.*

**1.14.** Create a mnemonic device for remembering the taxonomic categories.

**1.15.** Correctly write the binomial name for a microorganism.

**1.16.** Draw a diagram of the three major domains.

**1.17.** Explain the difference between traditional and molecular approaches to taxonomy.

**Chapter Outline**

1. The Scope of Microbiology
2. Organisms too small to be seen without magnification
3. Bacteria, viruses, fungi, protozoa, helminths, and prions
4. Microbes are both easy and difficult to study
5. Microbiology: A sampler of fields of study
6. Agricultural, epidemiology, public health, immunology, and so on.
7. The Impact of Microbes on Earth: Small Organisms With a Giant Effect
8. Bacteria and archaea
9. Eukaryotic cells: 1 billion years later
10. Microbes are ubiquitous and have evolved
11. Microbes participate in processes (decomposition, photosynthesis, etc.)
12. Human Use of Microorganisms
13. Historic use in food fermentations
14. Biotechnology and genetic engineering
15. Bioremediation
16. Infectious Diseases and the Human Condition
17. Pathogens
18. Worldwide infectious disease statistics
19. Communicable and noncommunicable diseases
20. Emerging and reemerging diseases
21. Microbe role in other diseases, such as ulcers
22. Insight: Infections of the Heroin Epidemic
23. The General Characteristics of Microorganisms
24. Three basic cell lines
25. Cellular organization: Organelles, unicellular versus multicellular
26. Prokaryotic cells
27. Eukaryotic cells
28. A note on viruses and prions
29. The Historical Foundations of Microbiology
30. The development of the microscope: "Seeing Is Believing"
31. Spontaneous generation
32. Scientists
33. Disease connection: colonization of teeth
34. Recent advances in microbiology
35. Insight: What Is a Microbiome?
36. Scientific method and inductive and deductive reasoning
37. The development of medical microbiology
38. Spores and sterilization
39. Aseptic technique
40. Pathogens and germ theory of disease
41. Naming, Classifying, and Identifying Microorganisms
42. Nomenclature: Scientific names
43. Classification: Constructing taxonomy
44. Origin and evolution of microorganisms
45. Universal life tree
46. Five-kingdom system
47. Three-domain system

**Key Terms and Phrases**

Microbiology

Microscopic

Microorganisms

Microbes

Bacteria

Viruses

Fungi

Protozoa

Helminths

Viruses

Prions

Public health

Epidemiology

Immunology

Industrial microbiology

Agricultural microbiology

Environmental microbiology

Archaea

Eukaryotes

Akaryotes

Ubiquitous

Evolution

Theory of evolution

Photosynthesis

Decomposition

Empirical

Genetic engineering

Recombinant DNA

Bioremediation

Pathogen

Eukarya

Virion

Abiogenesis

Biogenesis

Microbiome

Scientific method

Hypothesis

Deductive reasoning

Inductive reasoning

Theory

Sterile

Aseptic techniques

Germ theory of disease

Nomenclature

Taxonomy

Taxa

Phylogeny

Classification

Identification

Macroorganism

Binomial system

Domain

Kingdom

Phylum

Division

Class

Order

Family

Genus

**High Impact Study: Concepts**

1. The six types of microorganisms we will study
2. The three biological cell types appearing in evolutionary history
3. The theory of evolution
4. The role of deduction in the scientific method
5. Spontaneous generation
6. Relative size of the six types of microorganisms
7. Phylogeny and taxonomy
8. The tree of life; the web of life

**High Impact Study: Terms**

1. Bacteria
2. Archaea
3. Eukaryote
4. Recombinant DNA technology
5. Bioremediation
6. Pathogen
7. Taxa
8. Nomenclature
9. Phylogeny
10. ssuRNA

**Topics for Discussion**

1. Discuss the latest *Pandoravirus* discovered on July 18, 2013 (<http://www.nature.com/news/giant-viruses-open-pandora-s-box-1.13410>), and how this discovery may impact the classification and characterization of living and nonliving organisms.
2. In light of the emergence of Zika virus, discuss emerging infectious diseases.
3. Write a short paragraph on a topic in the field of applied microbiology.
4. Debate the benefits and the health risks of genetically modified organisms.
5. Discuss the impact of genetically modified organisms on the ecosystem.
6. Draw a concept map discussing the different subdisciplines in microbiology.
7. Draw a Venn diagram comparing the characteristics of living and nonliving entities.
8. Discuss how the understanding of germ theory has been applied in medical microbiology.
9. Discuss the benefit of using binomial nomenclature and Latin and Greek terms when naming organisms.
10. Discuss the advantages of relying on molecular biology to accurately classify species.
11. Discuss why the definition of species cannot be applied to all microorganisms.

The 5 I’s are Used in a Food Poisoning Outbreak Wrap-Up

In instances where the number of bacteria in a sample is expected to be especially large, as would be the case with a fecal sample, many types of specialized media may be used to narrow the possibilities. Selective media contain inhibitory substances that allow only a single type of microbe to grow, while differential media allow most organisms to grow but produce visible differences among the various microbes. In this case, samples of the casserole the prisoners had eaten were analyzed using both selective and differential media and found to contain 43,000 colony-forming units (CFU) of *C. perfringens* per gram of casserole.

Investigators learned that the company distributing meals to the jail routinely froze food that was not served and held it for up to 72 hours before using it to prepare dishes for later consumption. In this case, the ground beef and macaroni had been cooked the previous day, and several other food items were near their expiration dates. Also, proper documentation of cooling temperatures for both the ground beef and the macaroni was unavailable. Investigators concluded that improper handling of food in the kitchen was responsible for the prisoners’ illness.

The 5 I’s are Used in a Food Poisoning Outbreak Case Study

One August morning in 2008**,** a large proportion of the inmates at a Wisconsin county jail awoke complaining of nausea, vomiting, and diarrhea. The local health department suspected an outbreak of foodborne illness, and along with the Wisconsin Division of Public Health, initiated an investigation.

Because of the strict routine and controlled environment of prison life, it was relatively easy to find out what the inmates had eaten in the past 24 hours and how their food had been prepared. A written questionnaire distributed to the inmates revealed 194 probable cases of food intoxication. Four respondents commented on the unusual taste of the casserole they had eaten the night before, which contained macaroni, ground beef, ground turkey, frozen vegetables, and gravy. Stool samples were obtained from six symptomatic inmates and cultured for the presence of pathogenic bacteria.

* What five basic techniques are used to identify a microorganism in the laboratory?
* What types of media might a lab technician use to differentiate bacteria from one another?

**Cowan Microbiology Critical Thinking Questions and Answers**

Chapter 1:

1. **Develop one argument in support of or refuting the following statement: “Viruses are living microorganisms.”** Viruses are noncellular, parasitic, protein-coated genetic elements that rely upon a host cell to complete their life cycle. Although they are not considered living organisms they are still included in the study of microbiology, since they are microscopic and impact both microbes and human health.
2. **Define the term ubiquitous, and provide examples illustrating why it is an appropriate term to use to describe microbes.** Ubiquitous is a term meaning “everywhere,” which is fitting since microbes occupy diverse habitats in the environment and within living organisms.

3. **Differentiate the terms emerging disease and reemerging disease, providing examples of each.** An emerging disease is a new disease that has never been seen before within a population. Examples of recent emerging diseases are West Nile disease, SARS, and the newly identified SARS-like disease called MERS-CoV (Middle East Respiratory Syndrome Coronavirus). A reemerging disease is an older disease that experiences a resurgence in a number of identified cases within a population over time. Examples of recent reemerging diseases are tuberculosis and dengue fever, and it should be noted that many reemerging diseases are often resistant to drug treatment.

4. **Discuss how the findings of Louis Pasteur may have inspired Joseph Lister’s development of aseptic techniques in surgical settings.** In the mid-1800s, Louis Pasteur tested the hypothesis that air and dust were sources of microbes. These historic experiments supported this hypothesis, and surely influenced Joseph Lister to develop the practice of disinfecting the air within operating rooms prior to surgery.

5. **You are a scientist researching West Nile virus, a mosquito-borne pathogen. You note that a number of cases of West Nile disease in your county skyrocketed to their highest levels ever this past summer, which also was the wettest summer in 100 years. Using the scientific method, develop a sound hypothesis explaining the increase in disease cases last summer and a method for testing this hypothesis.** A sound hypothesis to explain this observation would be that the damp summer created the perfect environment for breeding mosquito populations. With a high number of biological vectors present, the virus would have a greater chance of spreading among the human population. A way to test this hypothesis would be to work with entomologists (insect scientists) to study the local mosquito populations through trapping and testing for the West Nile virus. You could then collect data to determine if the numbers of mosquitoes actually increased that summer and if a significant number of them were infected with the virus.