

Chapter 1 Microbiology—The Science



Terms Introduced in This Chapter

After reading Chapter 1, you should be familiar with the following terms. These terms are defined in Chapter 1 and in the Glossary.

Abiogenesis	Mycology
Antibiotic	Nonpathogens
Bacteriologist	Obligate intracellular pathogens
Bacteriology	Opportunistic pathogens
Biogenesis	Paleomicrobiology
Biology	Parasites
Bioremediation	Parasitologist
Biotechnology	Parasitology
Decomposers	Pasteurization
Etiologic agent	Pathogens
Etiology	Petri dish
Fastidious microorganisms	Phycologist
Genetic engineering	Phycology
In vitro	Phytoplankton
In vivo	Plankton
Indigenous microflora	Protozoologist
Infectious diseases	Protozoology
Koch's Postulates	Pure culture
Microbial ecology	Saprophyte
Microbial intoxications	Toxin
Microbiologist	Ubiquitous
Microbiology	Virologist
Microorganisms	Virology
Microscope	Zoonoses (sing., <i>zoonosis</i>)
Mycologist	Zooplankton



Insight

Additional Careers in Microbiology

Agricultural Microbiology

Agricultural microbiology is an excellent career field for individuals with interests in agriculture and microbiology. Included in the field of agricultural microbiology are studies of the beneficial and harmful roles of microbes in soil formation and fertility; in carbon, nitrogen, phosphorus, and sulfur cycles; in diseases of plants; in the digestive processes of cows and other ruminants; and in the production of crops and foods. Many different viruses, bacteria, and fungi cause plant diseases. A food microbiologist is concerned with the production, processing, storage, cooking, and serving of food, as well as the prevention of food spoilage, food poisoning, and food toxicity. A dairy microbiologist oversees the grading, pasteurization, and processing of milk and cheeses to prevent contamination, spoilage, and transmission of diseases from environmental, animal, and human sources. Certain aspects of agricultural microbiology are discussed in Chapter 10.

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Biotechnology (Industrial Microbiology)

Biotechnology (Industrial Microbiology)—the use of microorganisms in industry—is an excellent career field for individuals with interests in industry and microbiology. Many businesses and industries depend on the proper growth and maintenance of certain microbes to produce beer, wine, alcohol, and organic materials such as enzymes, vitamins, and antibiotics. Industrial microbiologists monitor and maintain the microorganisms that are essential for these commercial enterprises. Applied microbiologists conduct research aimed at producing new products and more effective antibiotics. Biotechnology is discussed more fully in Chapter 10.

Environmental Microbiology and Bioremediation

The field of environmental microbiology, or microbial ecology, has become increasingly important in recent years because of heightened awareness and concern about dangers to the environment. Environmental microbiologists are concerned about water and sewage treatment. The purification of waste water is partially accomplished by bacteria in the holding tanks of sewage disposal plants, in which feces, garbage, and other organic materials are collected and reduced to harmless waste (discussed in Chapter 11). Some microorganisms, such as the iron- and sulfur-utilizing bacteria even break down metals and minerals. Bioremediation involves the use of microorganisms to clean up after ourselves—that is, to clean up landfills and industrial and toxic wastes. The beneficial activities of microbes affect every part of our environment, including soil, water, and air. Environmental microbiology and bioremediation are excellent career fields for individuals with interests in ecology and microbiology.

Microbial Genetics and Genetic Engineering

Microbial genetics involves the study of microbial DNA, chromosomes, plasmids, and genes. (Plasmids are small, circular molecules of extrachromosomal DNA; they are discussed in Chapter 3.) Genetic engineering involves the insertion of foreign genes into microorganisms (usually into bacteria or yeasts). These foreign genes may come from any other organism (e.g., another microorganism, an animal, or even a plant). The primary purpose of inserting a foreign gene into a microorganism is to create a microbe that is capable of either producing a product of importance to us or accomplishing some task of importance to us. Genetic engineering has applications in agricultural, environmental, industrial, and medical microbiology. The intestinal bacterium, *Escherichia coli*, has been used extensively in microbial genetics, genetic engineering, and microbial physiology. Microbial genetics and genetic engineering are excellent career fields for individuals with interests in genetics and microbiology. Microbial physiology and genetics are discussed in Chapter 7.

Microbial Physiology

Research in microbial physiology has contributed immensely to our understanding of the structure and functions of microbial cells. What microbiologists learn about microbial cells quite often applies to cells, in general. Microbial physiology is an excellent career field for individuals with interests in biochemistry and microbiology.

Paleomicrobiology

The field of *paleomicrobiology* involves the study of ancient microbes. Although life is thought to have originated between 3.7 and 4 billion years ago, there are no cellular fossils available from that time period. But there are *molecular fossils*—molecules (usually lipids) known to be made only by organisms or, in some cases, only by particular organisms. Finding such molecular fossils in ancient rocks serves as evidence that life existed at that time. The earliest molecular fossils date back to between 3.7 and 4 billion years ago. Some paleomicrobiologists examine and study skeletons and mummified human remains to determine the infectious diseases that occurred in ancient civilizations. Such studies often involve the recovery of microbial DNA from bone and mummified tissue samples. For example, finding *Mycobacterium tuberculosis* DNA in Egyptian mummies has revealed that tuberculosis existed as far back as 3000 BC. Paleomicrobiology is an excellent career field for individuals with interests in anthropology, archaeology, and microbiology.

Parasitology

Technically, any organism that lives on or in another living organism is called a *parasite*. It would seem, then, that the term parasite would apply to all of the microorganisms of our indigenous microflora—the viruses and bacteria that live on or in the human body. However, the field of parasitology involves only the following three categories of parasites: parasitic protozoa, helminths (parasitic worms), and arthropods (specifically, certain insects and arachnids). A parasitologist studies these organisms and their life cycles in an attempt to discover the best ways to control and treat the diseases that they cause. Chapter 18 contains a wealth of information about medical parasitology.

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Sanitary Microbiology

The field of sanitary microbiology includes the processing and disposal of garbage and sewage wastes, as well as the purification and processing of water supplies to ensure that no pathogens are carried to the consumer by drinking water. These topics are discussed in Chapter 11. Sanitary microbiologists also inspect food processing installations and eating establishments to ensure that proper food handling procedures are being enforced.

Veterinary Microbiology

A wide variety of microbes—including viruses, bacteria, fungi, and protozoa—cause infectious diseases in animals. Control of such diseases is the concern of veterinary microbiologists. The production of food from livestock, the raising of other agriculturally important animals, the care of pets, and the transmission of diseases from animals to humans are areas of major importance in this field. Infectious diseases of humans that are acquired from animal sources are called *zoonoses* or *zoonotic diseases*. Zoonoses are discussed in Chapter 11. Veterinary microbiology is an excellent career field for a person who is fond of animals and microbiology.



Increase Your Knowledge

1. For additional information about careers in microbiology, visit the American Society for Microbiology (ASM) web site (www.asm.org), and read the book, *Many Faces, Many Microbes: Personal Reflections in Microbiology*, edited by Ronald M. Atlas (ASM Press, Washington, D.C., 2000). The ASM web site also contains information about colleges and universities offering undergraduate and graduate degrees in microbiology.
2. Students wishing to learn more about the history of microbiology should read any of the following books: *Microbe Hunters*, by Paul de Kruif (Harcourt, Brace, 1926), *Milestones in Microbiology*, edited by Thomas Brock (ASM Press, Washington, D.C., 1961), *Microbe Hunters Then and Now*, edited by Hilary Koprowski and Michael B.A. Oldstone (Medi-Ed Press, Bloomington, IL, 1996), and *A Chronology of Microbiology in Historical Context*, by Raymond W. Beck (ASM Press, Washington, D.C., 2000).
3. For in-depth information about Louis Pasteur and Robert Koch, you might want to read the following books (information about these books can be found at <http://estore.asm.org>):
Pasteur and Modern Science, by Rene Dubos and Thomas D. Brock. ASM Press, Washington, D.C., 1998.
Robert Koch: A Life in Medicine and Bacteriology, by Thomas D. Brock. ASM Press, Washington, D.C., 1998.



Microbiology—Hollywood Style

Students wishing to gain a better understanding of Louis Pasteur and the 19th-century problems he faced should rent the thoroughly enjoyable video entitled *The Story of Louis Pasteur*. This 1936 black-and-white movie starred Paul Muni, who won an Academy Award for his portrayal of Louis Pasteur.

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Critical Thinking

1. Microorganisms are said to be ubiquitous. Can you think of any locations that would be devoid of microorganisms?
2. Of all the various areas of microbiology mentioned in this chapter, which appeal to you the most as a possible career field? Why?
3. Assume that you are entering a health-related profession. Of what value will knowledge of microbiology be to you?
4. Many people consider Louis Pasteur's contributions to be the foundation of the science of microbiology and a cornerstone of modern medicine. What contributions did he make that would cause people to believe that?
5. You have isolated a bacterium from the blood of a patient with a newly described disease. What steps would you take to prove that the organism that you've isolated is the cause of the patient's disease? (Hint: Remember Koch's Postulates.)



Additional Chapter 1 Self-Assessment Exercises

(Note: Don't peek at the answers before you attempt to solve these self-assessment exercises.)

Matching Questions

- | | | | |
|----|----------------------------|-----------|--|
| A. | Anton van Leeuwenhoek | _____ 1. | Developed vaccines for anthrax and rabies. |
| B. | Robert Koch | _____ 2. | Proposed the theory of biogenesis. |
| C. | Louis Pasteur | _____ 3. | Discovered the causative agent of plague. |
| D. | Rudolf Virchow | _____ 4. | The first person to observe live bacteria and protozoa. |
| E. | Alexandre Emil Jean Yersin | _____ 5. | Developed an experimental procedure that could be used to prove that a specific microorganism is the cause of a specific infectious disease. |
| | | | |
| A. | pathogens | _____ 6. | Organisms that live on dead or decaying organic matter. |
| B. | nonpathogens | _____ 7. | Microorganisms that do not cause disease. |
| C. | opportunistic pathogens | _____ 8. | Microorganisms that usually do not cause disease, but can cause disease under certain circumstances. |
| D. | indigenous microflora | _____ 9. | The microorganisms that live on us and in us. |
| E. | saprophytes | _____ 10. | The most common causes of infectious diseases or microbial intoxications. |

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True/False Questions

- _____ 1. All infectious diseases are caused by pathogens.
- _____ 2. Pathogens greatly outnumber nonpathogens.
- _____ 3. Using microorganisms to clean up the environment is known as bioremediation.
- _____ 4. Microorganisms are essential in the field of genetic engineering.
- _____ 5. Microorganisms probably appeared on earth about 3.5 million years ago.
- _____ 6. Anton van Leeuwenhoek's experiments helped to prove that microorganisms cause disease.
- _____ 7. Louis Pasteur and Robert Koch made significant contributions to the "Germ Theory of Disease."
- _____ 8. Pasteurization is a process that kills all microorganisms present in the liquid being pasteurized.
- _____ 9. Microorganisms contribute more oxygen to our atmosphere than plants do.
- _____ 10. Infectious diseases that are transmitted from animals to humans are known as zoonoses.

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Answers to the Chapter 1 Self-Assessment Exercises in the Text

- | | | | |
|----|---|-----|---|
| 1. | A | 6. | B |
| 2. | B | 7. | D |
| 3. | D | 8. | B |
| 4. | D | 9. | B |
| 5. | B | 10. | B |



Answers to the Additional Chapter 1 Self-Assessment Exercises

Matching Questions

- | | | | |
|----|---|-----|---|
| 1. | C | 6. | E |
| 2. | D | 7. | B |
| 3. | E | 8. | C |
| 4. | A | 9. | D |
| 5. | B | 10. | A |

True/False Questions

1. True
2. False (the reverse is true)
3. True
4. True
5. False (3.5 billion years ago)
6. False (Leeuwenhoek did not make the link between diseases and the microorganisms he observed; scientists like Pasteur and Koch made such connections)
7. True
8. False (pasteurization is a process designed to kill pathogens; it does not kill all of the microorganisms that might be present in the liquid being pasteurized)
9. True
10. True