

A Systemic Approach to **MICROBIOLOGY** and **PARASITOLOGY** for the **HEALTH SCIENCES**

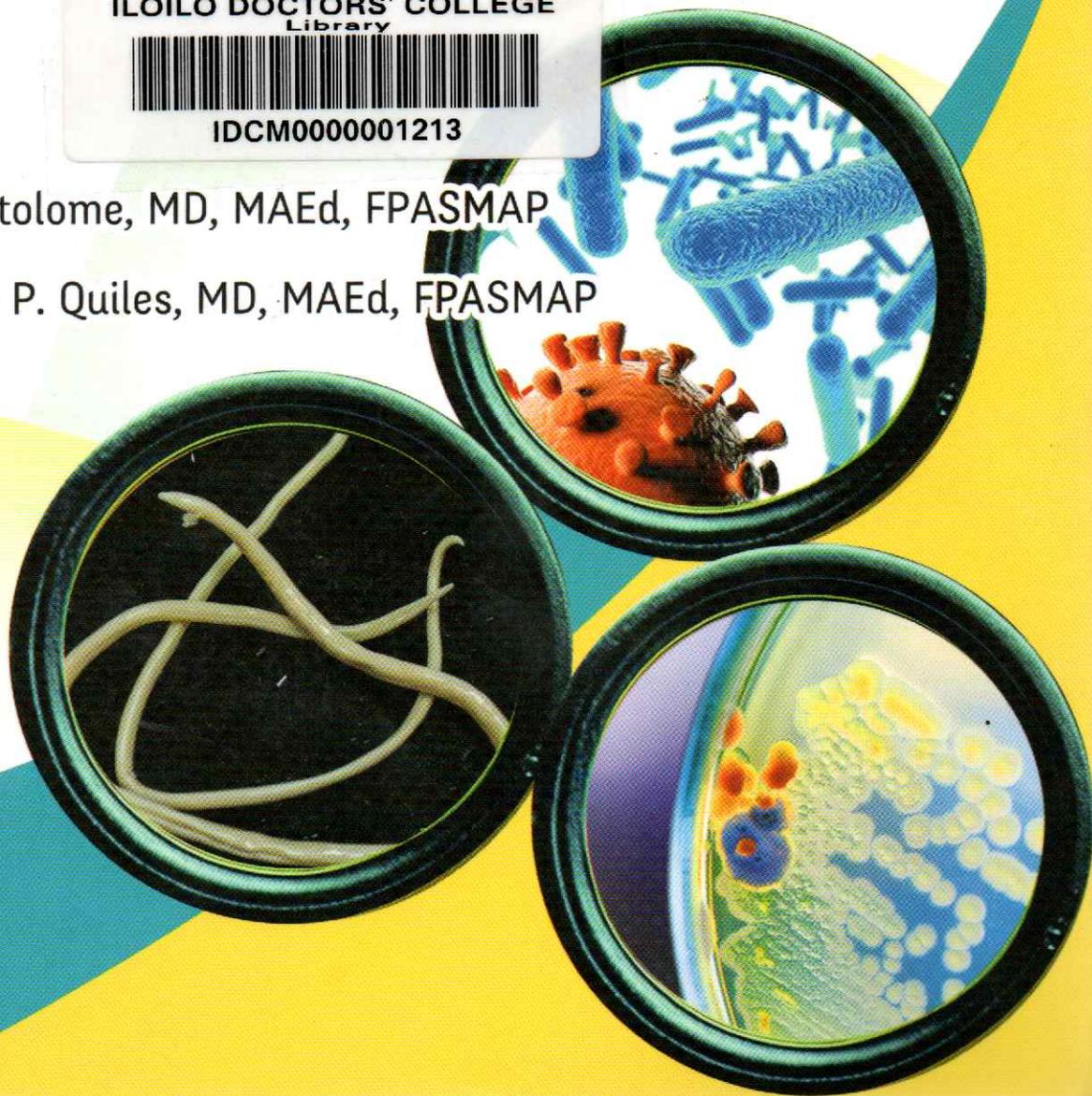
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Dr. Fe A. Bartolome, MD, MAEd, FPASMAP

Dr. Elizabeth P. Quiles, MD, MAEd, FPASMAP



Jan. 2024

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for the Health Sciences**

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The Authors

Foreword

Being healthy is the only state in which an individual may truly experience wealth and can function maximally in his/her daily activities. A healthy person performs more efficiently and is more productive than someone who is always ill. It must be everyone's goal to attain good health so as to fully enjoy life.

Healthcare professionals have the responsibility of providing not only health services but also education and awareness to the public. People who are equipped with basic knowledge about diseases, including how they are transmitted, are capable of taking preventive measures, and thus have greater chances of containing them. People will benefit greatly when they are able avoid lost hours at work due to sickness. Personal health expenditure (i.e., doctor's fees, hospitalization costs, medication) will be minimized, and the money saved can be allotted for other physiological needs (e.g., food, clothing, and education of one's children). Maintaining one's health is essential especially in a nation where the majority of the people live in poverty.

Students of the health sciences are expected to impart to the public the value of keeping a healthy well-being, and this book is aimed at honing the students to be effective health advocates. Through this book, the students can have deeper understanding about common infectious and parasitic diseases, thereby becoming better equipped educators and promoters of public health and health awareness.



Preface

A Systemic Approach to Microbiology and Parasitology for the Health Sciences includes **discussions** on various microbiology and parasitology concepts, as well as **self-assessment** questions and laboratory exercises. The book is designed as a teaching and **learning** material for students of allied health and other health-related sciences. The **topics** included are aligned with the recommendations of the Commission on Higher Education (CHED).

The book consists of two parts: **Part I** – Textbook and **Part II** – Laboratory Exercises. **The** first part contains 24 chapters, with topics ranging from fundamental microbiology and parasitology concepts to discussions on infections and diseases. Each chapter ends **with** a set of self-assessment questions designed to evaluate the student's understanding **of** the concepts discussed.

From Chapter 1 to Chapter 5, the discussions deal with the scope of microbiology, **including** its evolution and branches. The principles of microscopy are also included, **as** well as the principles in staining and culturing of microorganisms. Bacterial growth requirements and the concept of normal or indigenous flora are also discussed. Chapters 6 to 8 include concepts involved in microbial control, such as medical and surgical asepsis, physical and chemical methods of sterilization, and antibiotics. The very important issue of drug resistance is also discussed. Chapters 9 and 10 are concerned **with** infection and the body's responses to infection. Concepts regarding bacteria and how they cause disease are discussed. Definitions of the various types of infection are given and events occurring in the different stages of an infectious disease process are explained. These chapters also include the body's defense mechanisms against infectious agents, our immune response to these agents as well as hypersensitivity reactions.



Parasitic diseases in humans are the main focus of chapters 11 to 15, with the classification of medically important parasites presented in the discussions. Included in the discussions on these parasites are their sources, mode of transmission, specific diseases they cause, and treatment and prevention.

Toward the end of the textbook part, chapters 16 to 24 are devoted to the different infectious diseases that affect the different organ systems of the human body. Covered in the discussions on these diseases are the characteristics of their etiologic agents, mode of transmission, clinical manifestations, diagnosis, and treatment and prevention.

The second part of the book consists of 20 laboratory exercises that are designed to reinforce the students' understanding of microbiology and parasitology concepts. Included also as laboratory exercises are case studies which aim at developing clinical judgment among the students.



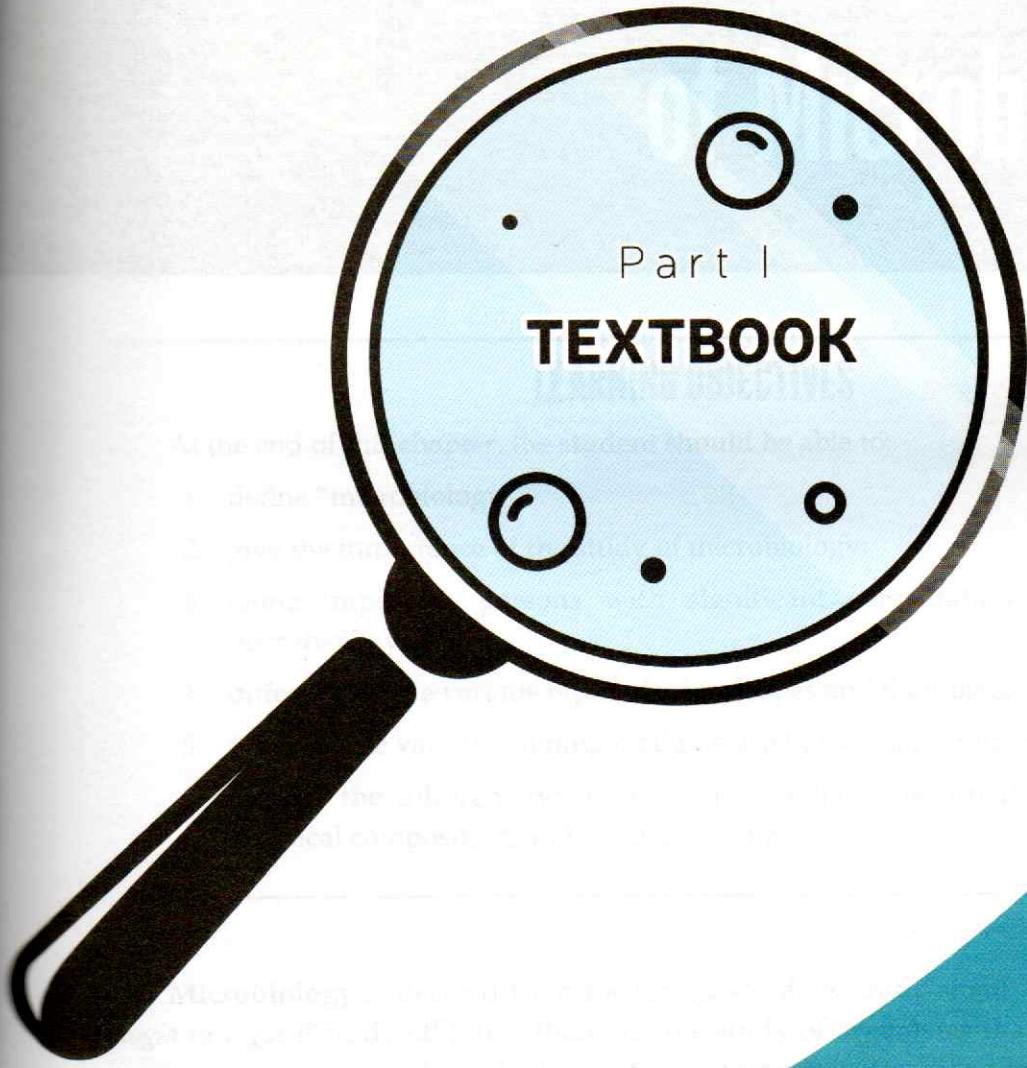
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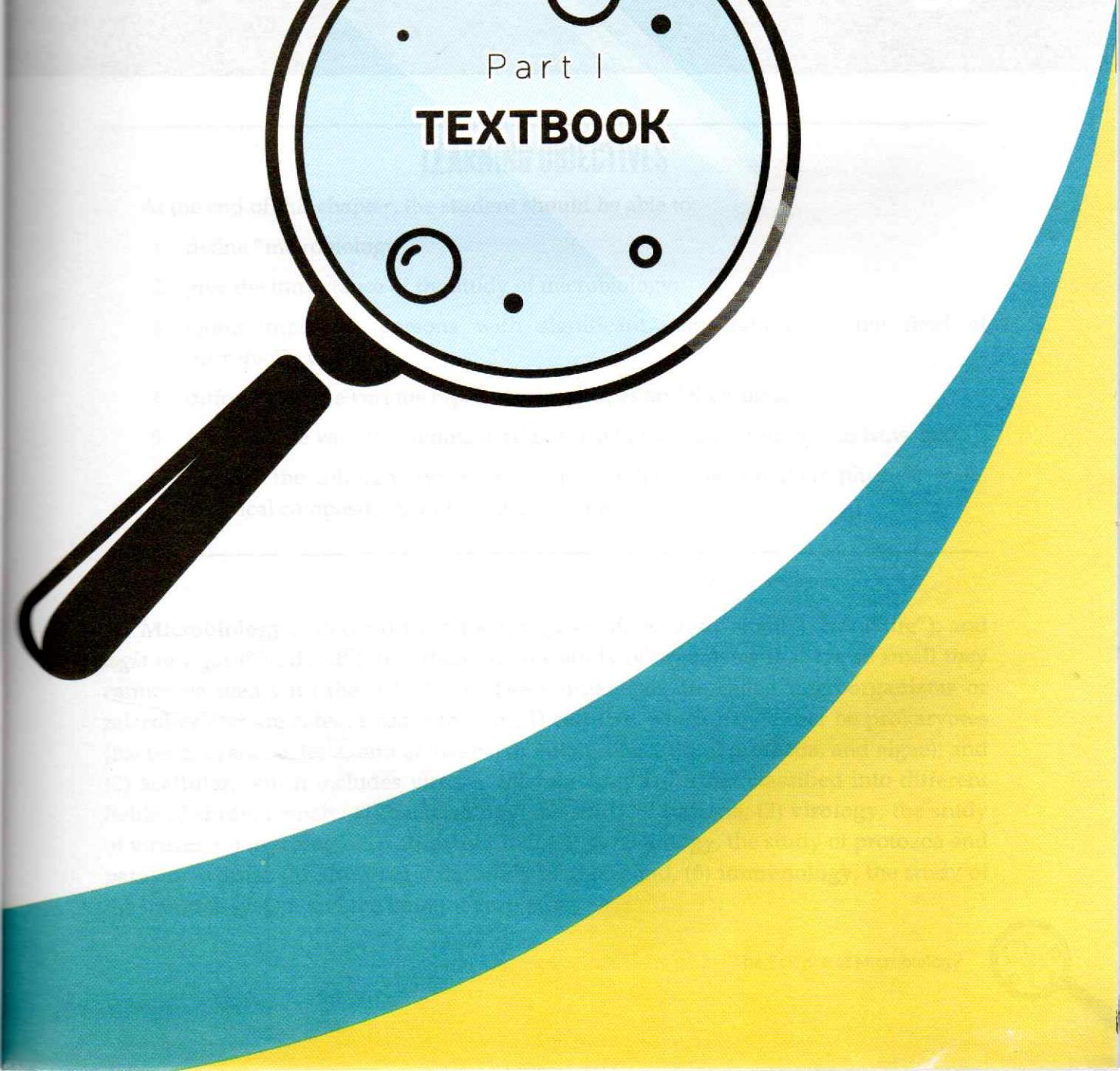
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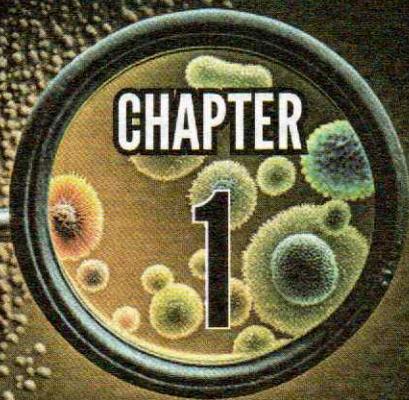
Technology



Part I

TEXTBOOK





The Science of Microbiology

LEARNING OBJECTIVES

At the end of this chapter, the student should be able to:

1. define “microbiology”;
2. give the importance of the study of microbiology;
3. name important persons with significant contributions to the field of microbiology;
4. differentiate the various types of microscopes and their uses;
5. compare the various staining methods used to visualize microorganisms; and
6. classify the different types of culture media based on their physical state, chemical composition, and functional type.

Microbiology is derived from the Greek words *mikros* (“small”), *bios* (“life”), and *logia* or *logos* (“study of”). It is therefore the study of organisms that are so small they cannot be seen with the naked eye. These organisms are called **microorganisms** or **microbes** and are categorized into two: (1) **cellular**, which may either be prokaryotes (bacteria, cyanobacteria, and archeans) or eukaryotes (fungi, protozoa, and algae); and (2) **acellular**, which includes viruses. Microbiology is further classified into different fields of study, namely: (1) **bacteriology**, the study of bacteria; (2) **virology**, the study of viruses; (3) **mycology**, the study of fungi; (4) **parasitology**, the study of protozoa and parasitic worms; (5) **phycology**, the study of algae; and, (6) **immunology**, the study of the immune system and the immune response.



Why study microbiology? The study of microbiology is important for the following reasons:

1. Microbiology has an impact in the daily lives of humans. Microorganisms are everywhere—in the air one breathes, in the environment, and even in one's body. About a thousand or more organisms inhabit the human body. These are collectively called **normal flora** or **indigenous flora**, which only produce disease in persons with compromised immune systems.
2. Some microorganisms are essential in biotechnology and a wide range of industries, which include food and beverage, pharmaceuticals, mining, genetics, and many more. Much of the knowledge available in the study of genetics and biochemistry utilize microorganisms as model organisms.
3. Some microorganisms, especially bacteria and fungi, are important sources of antimicrobial agents. For example, penicillin was derived from the fungus *Penicillium*.
4. Some microorganisms act as saprophytes or decomposers of waste products and dead organisms, making them essential in maintaining a balanced ecosystem.
5. The study of microorganisms has led to a better understanding of how microorganisms cause disease, paving the way to better disease management and control. This was further improved through the discovery of vaccines that helped prevent sickness from infectious diseases. By knowing the sources of disease-causing microbes, sanitation practices improved immensely, leading to better mitigation of infectious diseases.
6. Certain diseases which were thought to have been eradicated are now re-emerging. Some have the potential as biological warfare agents. At the same time, there are now a number of pathogens that are developing resistance to antibiotics. In this context, the study of microbiology is relevant for better understanding of the negative instances in which science can be used.

Evolution of Microbiology

Archaeologists and evolutionists have uncovered evidence demonstrating the existence of primitive microorganisms. In Western Australia, as many as 11 different types of fossils of primitive microorganisms have been found in ancient rock formations, dating back to as early as 3.5 billion years ago, long before the existence of animals and humans.

Infectious diseases have existed for thousands of years. In 3180 BC, an epidemic known as the "plague" broke out in Egypt. In 1122 BC, an outbreak of a smallpox-like disease that originated in China spread worldwide. The exhumed mummified remains of Rameses V showed skin lesions resembling smallpox.



In the late 16th century, the first so-called compound microscope was invented. Then in the mid-1600s, the microscope was improved and with the use of this instrument, **Robert Hooke** was able to discover the cell—the basic unit of living organisms. His discovery heralded the **cell theory** that stated living organisms are made up of cells. Then in the 1670s, **Anton van Leeuwenhoek**, a Dutch merchant, created a single-lens microscope that he used to make observations of microorganisms which he then called **animalcules**. Through his observations and contributions, he became known as the “Father of Microbiology” and was the one who first provided accurate descriptions of bacteria, protozoa, and fungi.

In the middle and late 1800s, **Louis Pasteur** performed countless experiments that led to his **germ theory of disease**. He postulated that microorganisms were in the environment and could cause infectious diseases. He also developed the process of **pasteurization**, which kills microorganisms in different types of liquids, and which became the basis for aseptic techniques. He also introduced the terms **aerobes** and **anaerobes** and developed the fermentation process.

Pasteur’s attempts to prove his germ theory of disease were unsuccessful. It took **Robert Koch** to prove that microorganisms caused certain diseases through a series of scientific steps which led to his formulation of the **Koch’s postulates**. This led to an increased effort by other scientists to prove and illustrate further the germ theory that was initially formulated by Louis Pasteur. Thus, the late 1800s and the first decade of the 1900s came to be known as the **Golden Age of Microbiology**. Since then, numerous scientists have made significant contributions to the field of microbiology. **Edward Jenner** discovered the vaccine for smallpox. **Joseph Lister** applied the theory to medical procedures, paving the way for the development of aseptic surgery.

After World War II, antibiotics were introduced to the medical world. **Paul Ehrlich** discovered **Salvarsan** for the treatment of syphilis. This drug was heralded the “magic bullet” of chemotherapy, which is treatment of disease by using chemical substances. **Alexander Fleming** discovered the antibiotic penicillin from the mold *Penicillium notatum*. With the discovery of antibiotics, the incidence of infectious diseases such as tuberculosis, pneumonia, meningitis, and others, was significantly reduced.

Most of the experiments conducted in the field of microbiology during the early 20th century involved the study of bacteria. During this time, scientists were not yet equipped with advanced technology in their study of microorganisms. It was only in the 1930s when the electron microscope was developed that experimentations in microbiology became more complex. It was also during that time when viral culture was introduced, paving the way for rapid discoveries on viruses. The vast knowledge gained from the experiments performed by microbiologists together with the discovery of other vaccines in the 1940s and 1950s have led to better prevention and control of numerous potentially fatal infectious diseases.



Microscopy

Microorganisms are miniscule organisms that cannot be seen with the naked eye. The discovery of the microscope has led to their close observation, allowing microbiologists and other scientists to study them further.

A **microscope** is an optical instrument that can magnify organisms a hundredfold or even a thousandfold. From the time of its initial development in the 1600s, the microscope has undergone great revolutionary changes, making it more advanced and complex throughout time. The following are the different types of microscopes that have evolved from van Leeuwenhoek's simple prototype.

Compound Microscope

The compound microscope is a type of microscope that contains more than one magnifying lens. It can magnify objects approximately a thousand times their original size. Visible light is its main source of illumination. As such, it is also known as the **compound light microscope**.

The compound microscope utilized today consists of two magnifying lens systems. The **eyepiece** (or ocular) contains what is called the **ocular lens** that has a magnifying power of 10X. The second lens system is located in the **objective** that is positioned directly above the organism to be viewed.

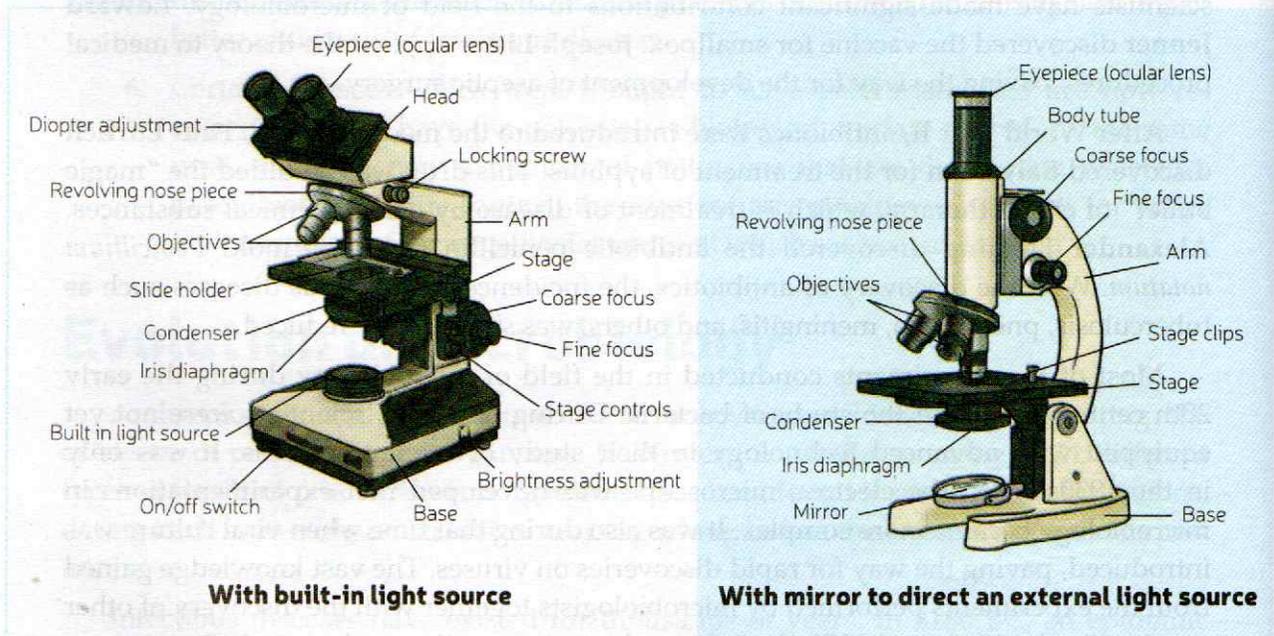


Figure 1.1 Two compound light microscopes which differ in their light source



Table 1.1 Components of the compound light microscope

Component	Function
Ocular lens or eyepiece	This is the topmost part of the microscope; the lens through which the viewer looks to see the specimen.
Revolving nose piece	Located above the stage, it holds the objective lenses.
Diopter adjustment	It is used to change focus on one eyepiece in order to correct any difference in vision between the two eyes.
Body tube or head	It connects the eyepiece to the objective lenses.
Arm	It connects the body tube to the base of the microscope.
Coarse adjustment	It brings the specimen into general focus.
Fine adjustment	It fine-tunes the focus and increases the details of the specimen.
Objective lenses	This is held in place above the stage by the revolving nosepiece and are the lenses that are closest to the specimen. It contains three to five objectives ranging in power from 4X to 100X.
Stage	Located beneath the revolving nosepiece, it is the flat platform on which the specimen is placed.
Stage clips	Situated above the stage, these are metal clips that hold the slide in place.
Stage control	Found beneath the stage, these knobs move the stage either left or right or forward and backward.
Aperture	This is the hole in the middle of the stage that allows light from the illuminator to reach the slide containing the specimen.
On/off switch	This is the switch located at the base of the microscope that turns the illuminator on or off.
Illuminator	This is the light source of the microscope.
Iris diaphragm	Found on the condenser, it is used to adjust the amount of light coming through the condenser.
Condenser	It is found beneath the stage and contains a lens system that focuses light onto the specimen. It gathers and focuses light onto the specimen.
Base	It supports the microscope and it is where the illuminator is found.

Brightfield Microscope

Made up of a series of lenses and utilizing visible light as its source of illumination, the brightfield microscope can magnify an object 1,000 to 1,500 times. This is used to visualize bacteria and fungi. Objects smaller than or thinner than $0.2 \mu\text{m}$ cannot be visualized by this type of microscope. The term "brightfield" is derived from the fact that the specimen appears dark against the surrounding bright viewer field of this microscope. However, it has very low contrast and most of the cells need to be stained to be properly viewed.



CHAPTER SUMMARY

- **Microbiology** is the study of small, living microorganisms or microbes that cannot be seen with the naked eye. These organisms may be cellular (prokaryotes, eukaryotes, and the like) or acellular such as viruses.
- Microbiology is divided into several fields that deal with the study of bacteria (bacteriology), viruses (virology), fungi (mycology), protozoa and parasitic worms (parasitology), algae (phycology), and the immune system (immunology).
- Microorganisms may be beneficial or harmful. Some microorganisms are used in different industries such as in food and beverage manufacturing. Some microorganisms are sources of antibiotics while some are used in the field of biotechnology and genetic engineering. Microorganisms are also important in maintaining a balanced ecosystem.
- While some microorganisms are essential and have beneficial uses, there are also numerous microorganisms that produce disease in humans, some of which are potentially fatal.
- Some microorganisms have the potential to be used as biological warfare agents.
- Microorganisms are so miniscule that for them to be visualized, they need to be stained and studied using the microscope. Several types of microscopes have been developed for this purpose—from the compound microscope to the more sophisticated electron microscopes.
- The use of various staining procedures has made visualization of microorganisms easier. These stains may be classified into simple, differential, and special stains.
 - › Simple stains make use of a single water- or alcohol-based dye that is used to demonstrate the shape and basic structures of the organism.
 - › Differential stains are used to distinguish one group of bacteria from another group. These include the Gram stain and the acid-fast stain.
 - › Special stains are mainly used to demonstrate specific bacterial structures such as the spores (Dorner or Schaeffer-Fulton), flagella (Fisher-Conn), capsule (Hiss stain), or the metachromatic granules (LAMB stain).
- Specific culture media are the most ideal in identifying specific organisms. Several classes of culture media have been developed and these culture media can be classified into three primary levels: physical state (liquid, semi-solid, solid), chemical composition (synthetic and non-synthetic), and functional type (general purpose, enrichment, selective, differential, transport, and anaerobic).



SELF-ASSESSMENT QUESTIONS

Name: _____ Score: _____

Section: _____ Date: _____

MULTIPLE CHOICE. Write the letter of the correct answer on the space provided.

- _____ 1. Which among the following groups of organisms are **not** considered cells?
- a. Bacteria
 - b. Fungi
 - c. Viruses
 - d. Algae
- _____ 2. Which among the following types of microscopes can be used to study the genetic material of a cell (DNA or RNA) by adding a special form of dye?
- a. Phase-contrast microscope
 - b. Scanning probe microscope
 - c. Fluorescence microscope
 - d. Confocal microscope
- _____ 3. Which among the following parts of the microscope can be used to hold the slide in place?
- a. Coarse adjustment
 - b. Fine adjustment
 - c. Eye piece
 - d. Stage clip
- _____ 4. Who among the following scientists discovered the vaccine for smallpox?
- a. Louis Pasteur
 - b. Alexander Fleming
 - c. Edward Jenner
 - d. Robert Koch
- _____ 5. You discovered a new organism and you want to study its three-dimensional image and cell physiology. Which type of microscope will you use?
- a. Electron microscope
 - b. Fluorescence microscope
 - c. Scanning probe microscope
 - d. Confocal microscope
- _____ 6. You are given a new slide to study in the laboratory. Which part of the microscope will you use to move the stage left or right?
- a. Stage control
 - b. Coarse adjustment
 - c. Objective lenses
 - d. Fine adjustment



- _____ 7. Which among the following classes of culture media is classified as differential media?
- a. Thayer-Martin agar c. Sabouraud dextrose agar
b. Löwenstein-Jensen agar d. MacConkey agar
- _____ 8. Which among the following reagents used in Gram staining is used as a counterstain?
- a. Crystal violet c. 95% alcohol
b. Gram's iodine d. Safranin
- _____ 9. You cultured an organism using blood agar, and after 24 hours you noted a greenish zone of hemolysis around the colonies. This is classified as what type of hemolytic reaction?
- a. Alpha hemolysis c. Delta hemolysis
b. Beta hemolysis d. Gamma hemolysis
- _____ 10. Which among the following reagents is used as the counterstain in the Kinyoun method of acid-fast staining?
- a. Safranin c. Malachite green
b. Carbol fuchsin d. Methylene blue

