HISTORY OF MICROBIOLOGY

- Hook and Leeuwenhoek’s observations
- Spontaneous generation and biogenesis
- Contributions of Needham, Spallanzani, Virchow and Pasteur
- Importance of Koch's Postulates
- Jenner’s contributions
- Ehrlich and Fleming’s contributions

Brief history of microbiology

- 1665: Robert Hooke (England): Discovered the smallest structure of life (“cell”) with a crude microscope -> opened the “Cell Theory”.

- 1673: Anton van Leeuwenhoek (Netherlands): 400 microscopes with magnifying lenses: observed living cells.

- 1673-1723: Leeuwenhoek wrote a letter describing “animalcules” to the British Royal Family.

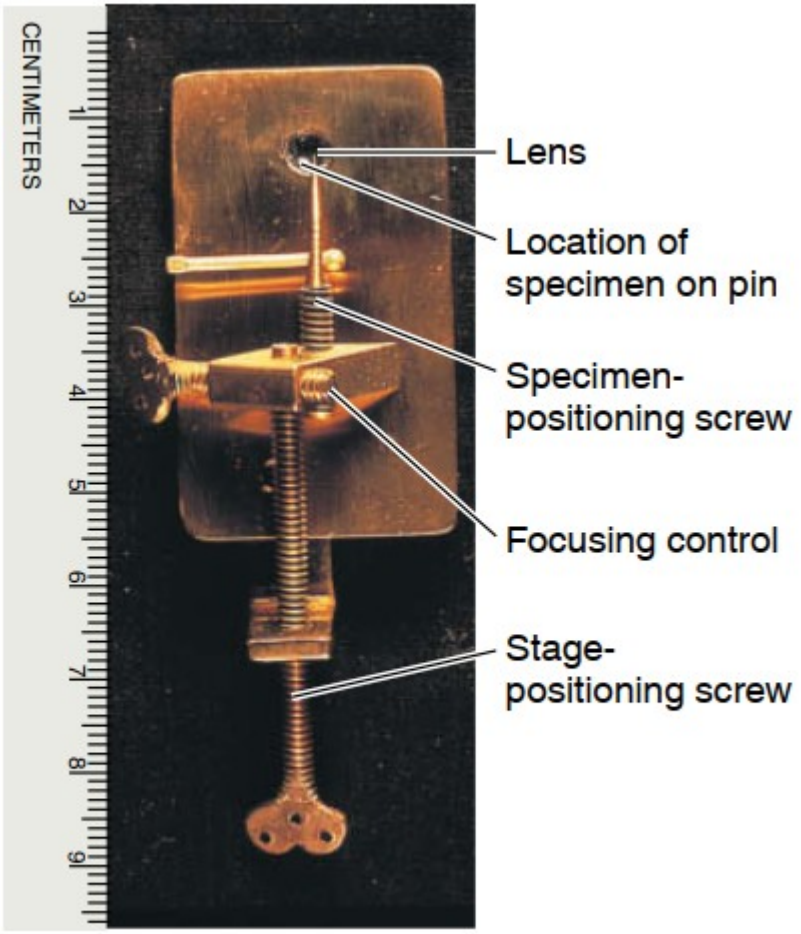
Brief history of microbiology

FIGURE 1.7

An oil painting of Antonie van Leeuwenhoek (1632–1723) sitting in his laboratory. J.R. Porter and C. Dobell have commented on the unique qualities Leeuwenhoek brought to his craft: "He was one of the most original and curious men who ever lived. It is difficult to compare him with anybody because he belonged to a genus of which he was the type and only species, and when he died his line became extinct."

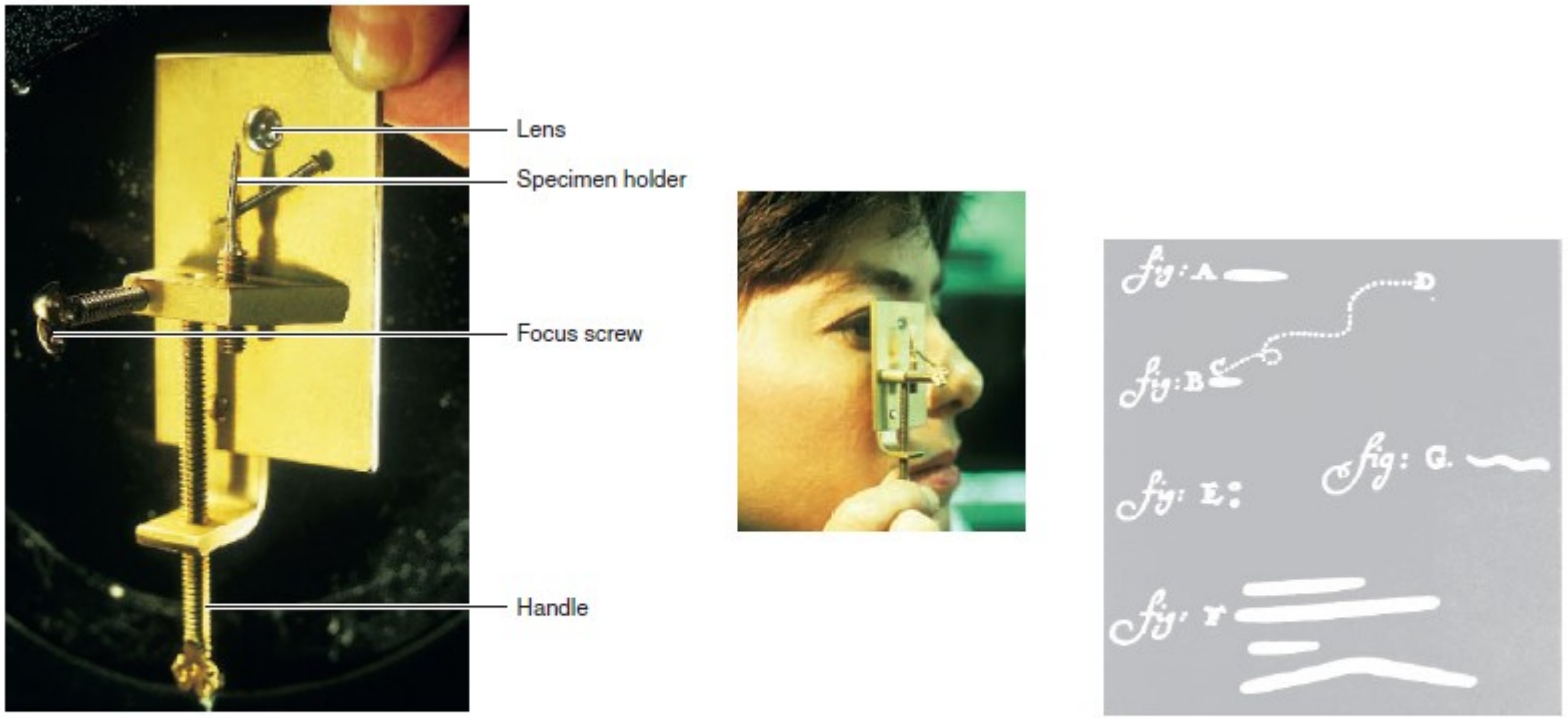
Brief history of microbiology

(a) Van Leeuwenhoek using his microscope



(b) Microscope replica

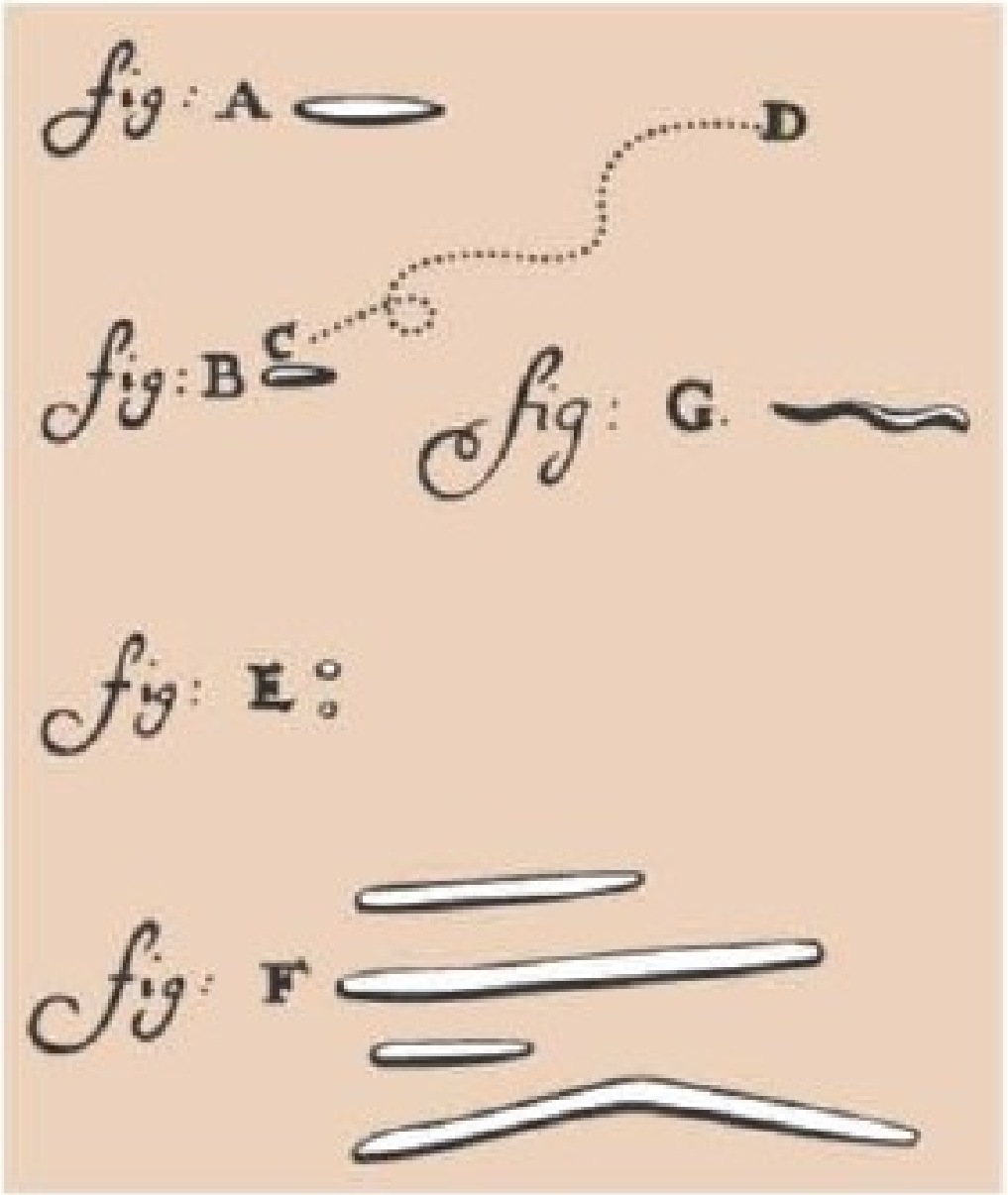
Brief history of microbiology



(a) (b)

FIGURE 1.8

Leeuwenhoek's microscope. (a) A brass replica of a Leeuwenhoek microscope and how it is held. **(b)** Examples of bacteria drawn by Leeuwenhoek. He keenly observed, "I discovered living creatures in rain water which had stood but a few days in a new earthen pot. This invited me to view this water with great attention, especially those little animals appearing to me ten thousand times less than those which may be perceived in the water with the naked eye." This is probably the first observation of bacteria.

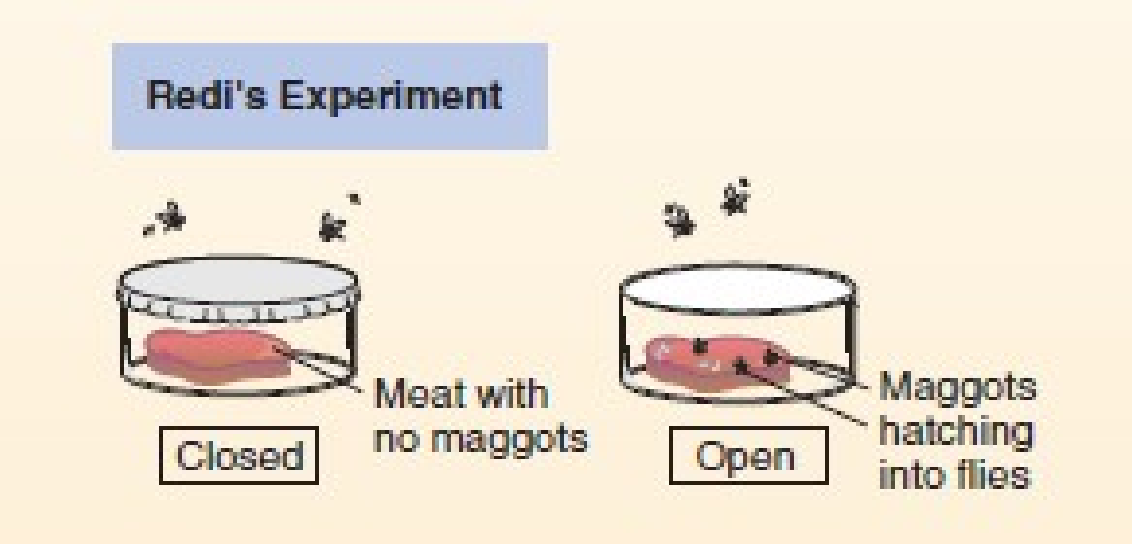


(c) Drawings of bacteria

Spontaneous generation & biogenesis

- Spontaneous generation: Life can originate from nonliving things. Toads, snakes, and rats can arise from moist soil; flies can arise from dung; maggots, the larvae of flies, can arise from rotting corpses.

- 1668: Francesco Redi (Italy): The maggot-creating experiment undermined the theory of spontaneous generation. However, many scientists still believed that microorganisms were simple enough to be created from nonliving matter



Spontaneous generation & biogenesis

- Spontaneous generation:

- 1745: John Needham (England): Heating the corn and chicken broths before being poured into covered containers, the broth when cooled quickly became turbid due the microorganisms regrew. Needham believed that the microorganisms spontaneously grew from the nutrient broth.

- 1765: Lazzaro Spallanzani (Italy): Spallanzani suggested that microorganisms from air might have entered Needham's nutrient solution after heating. Lazzaro showed that *the flask after being sealed* showed no growth of microorganisms. Needham countered that the essential element necessary for autogenesis had been destroyed by the heat and kept outside the flask by the sealing.

Spontaneous generation & biogenesis

- The Theory of biogenesis:

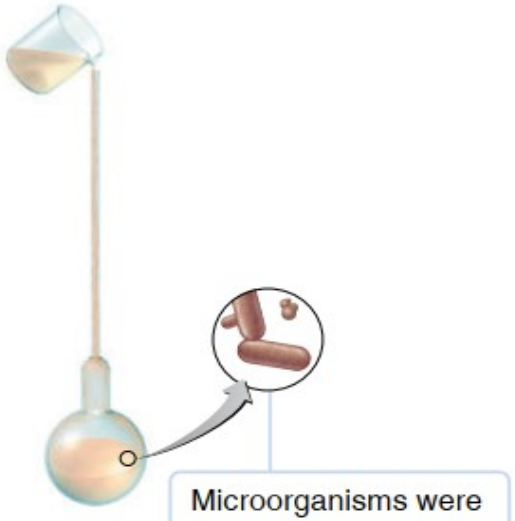
- 1858: Rudolf Virchow (Germany): Virchow introduced the concept of biogenesis, which stated that living cells could only be created from living cells. The debate over spontaneous generation continued until 1861, when the issue was resolved by Louis Pasteur.

- 1861: Louis Pasteur (France): Pasteur showed that microorganisms present in the air could contaminate sterilized nutrient broths; **The air itself does not produce microorganisms**:
  - Experiment with a short-neck flask containing beef extract
  - Experiment with a long-neck flask (Figure 1.3):

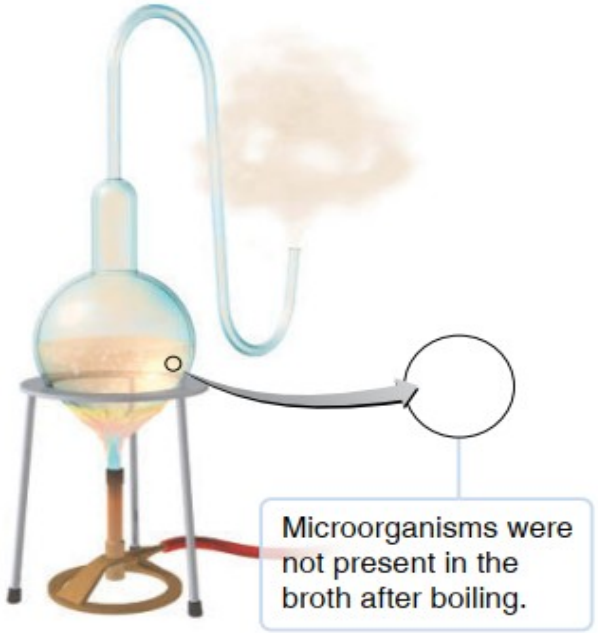
Spontaneous generation & biogenesis

According to the hypothesis of spontaneous generation, life can arise spontaneously from nonliving matter, such as dead corpses and soil. Pasteur's experiment, described below, demonstrated that microbes are present in nonliving matter—air, liquids, and solids.

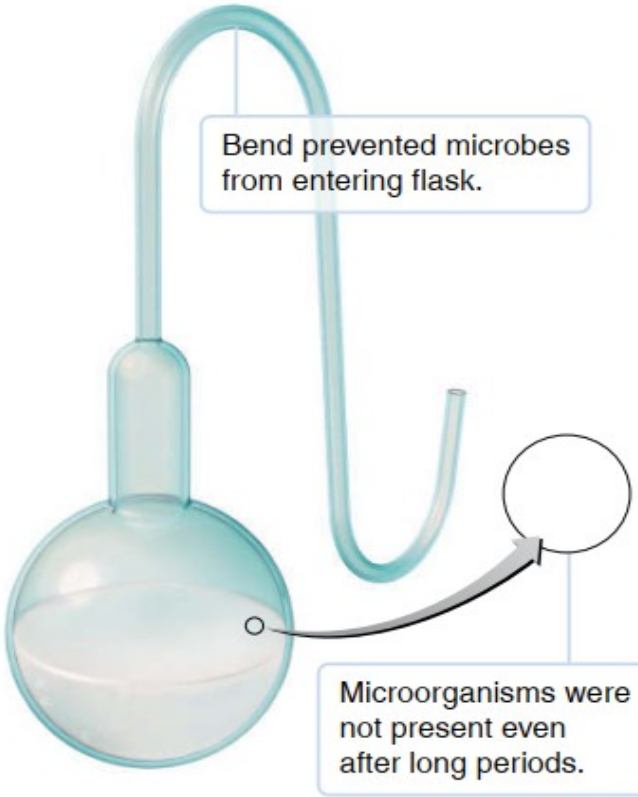
1 Pasteur first poured beef broth into a long-necked flask.



2 Next he heated the neck of the flask and bent it into an S-shape; then he boiled the broth for several minutes.

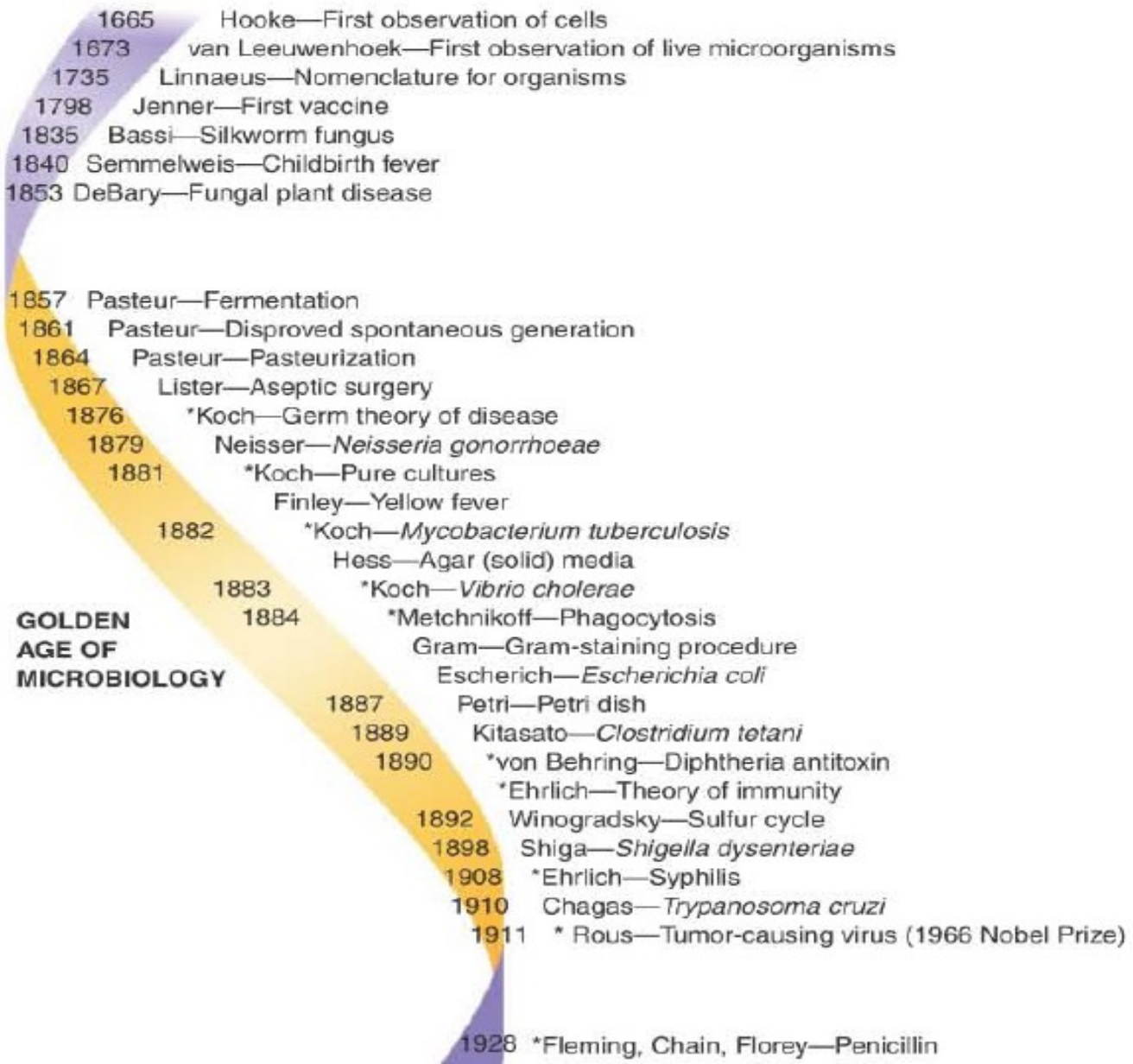


3 Microorganisms did not appear in the cooled solution, even after long periods.



Some of these original vessels are still on display at the Pasteur Institute in Paris. They have been sealed but show no sign of contamination more than 100 years later.

The Golden Age of Microbiology



The Golden Age of Microbiology

First Golden Age of MICROBIOLOGY

1857	**Pasteur**—Fermentation
1861	**Pasteur**—Disproved spontaneous generation
1864	**Pasteur**—Pasteurization
1867	**Lister**—Aseptic surgery
1876	**Koch***—Germ theory of disease
1879	**Neisser**—*Neisseria gonorrhoeae*
1881	**Koch***—Pure cultures
	Finlay—Yellow fever
1882	**Koch***—*Mycobacterium tuberculosis*
	Hess—Agar (solid) media
1883	**Koch***—*Vibrio cholerae*
1884	**Metchnikoff***—Phagocytosis
	Gram—Gram-staining procedure
	Escherich—*Escherichia coli*
1887	**Petri**—Petri dish
1889	**Kitasato**—*Clostridium tetani*
1890	**von Bering***—Diphtheria antitoxin
	Ehrlich*—Theory of immunity
1892	**Winogradsky**—Sulfur cycle
1898	**Shiga**—*Shigella dysenteriae*
1908	**Ehrlich***—Syphilis treatment
1910	**Chagas**—*Trypanosoma cruzi*
1911	**Rous***—Tumor-causing virus (1966 Nobel Prize)

Louis Pasteur (1822–1895)
Demonstrated that life did not arise spontaneously from nonliving matter.

Joseph Lister (1827–1912)
Performed surgery under aseptic conditions using phenol. Proved that microbes caused surgical wound infections.

Robert Koch (1843–1910)
Established experimental steps for directly linking a specific microbe to a specific disease.

Second Golden Age of MICROBIOLOGY

1940s
Fleming, Chain, and Florey—Penicillin

1950s
Waksman—Streptomycin
H. Krebs—Chemical steps of the Krebs cycle
Enders, Weller, and Robbins—Poliovirus cultured in cell cultures
Beadle and Tatum—Genetic control of biochemical reactions

1960s
Medawar—Acquired immune tolerance

1980s
Sanger and Gilbert—Techniques for sequencing DNA
Jerne, Köhler, and Milstein—Technique for producing monoclonal (single pure) antibodies
Tonegawa—Genetics of antibody production
Bishop and Varmus—Cancer-causing genes (oncogenes)

Third Golden Age of MICROBIOLOGY

1990s
Murray and Thomas—First successful transplants using immunosuppressive drugs
Fischer and E. Krebs—Enzymes that regulate cell growth (protein kinases)
Roberts and Sharp—Genes can be present in separated segments of DNA
Mullis—Polymerase chain reactions that amplify (make multiple copies of) DNA
Doherty and Zinkernagel—Cell-mediated immunity

2000s
Agre and MacKinnon—Water and ion channels in plasma membranes
Marshall and Warren—*Helicobacter pylori* as the cause of peptic ulcers
Barré-Sinoussi and Montagnier—Discovery of HIV

2010s
Ramakrishnan, Steitz, and Yonath—Detailed structure and function of ribosomes
Beutler, Hoffmann, and Steinman—Innate immunity; dendritic cells in adaptive immunity
Tu—Treatment for malaria

César Milstein (1927–)
Fused cancerous cells with antibody-producing cells to produce a hybrid cell that grows continuously and produces therapeutic antibodies.

Françoise Barré-Sinoussi (1947–)
Discovered a virus in a patient with swollen lymph nodes; the virus was human immunodeficiency virus.

Youyou Tu (1930–)
Extracted artemisinin from a Chinese sage plant. Artemisinin inhibits the malaria parasite.

Figure 1.7 Second and Third Golden Ages of Microbiology. All researchers listed are Nobel laureates.

Q What advances occurred during the Second Golden Age of Microbiology?

The Golden Age of Microbiology

❖After Pasteur's experiments, discoveries in microbiology exploded. The period from 1857 to 1914 was the Golden Age of Microbiology:

✓Pasteur and Robert Koch founded the field of microbiology:

- Discovery of pathogens
- Discovery of the role of immunity in disease prevention and control

✓During this period, microbiologists studied the chemical activities of microorganisms, improved microscopy and microbial culture techniques, and developed vaccines and surgical techniques.

The Golden Age of Microbiology

❑ Fermentation and pasteurization

❖Fermentation:

- ✓Why do wines and beers sour? -> find ways to preserve fermented drinks for long distance transport
- ✓Pasteur: sour and spoiled beers are caused by different bacteria

❖Pasteurization: heat the beer to the temperature hot enough to kill microorganisms that cause beer spoilage

The Golden Age of Microbiology

❑ The Germ Theory of Disease

 Before the time of Pasteur: causative agents were unknown. The diseases were cured by trial and error.

The Germ Theory of Disease's ideas:

- Yeasts <-> fermentation?
- Microorganisms <-> disease?

The Golden Age of Microbiology

❑ The Germ Theory of Disease

- It was difficult for the germ theory to be accepted because of the belief in monsters appearing as the stench of sewage or the poisonous vapors from swamps; it was difficult to believe that microorganisms moved from somewhere into plants or animals to cause diseases.

- 1865: Pasteur called for the fight against silkworm disease. Before that (1835), the microbiologist Agostino Bassi proved that there was a fungus that caused disease in silkworms. Pasteur found another agent, a protozoan -> developed a method of identifying the disease.

The Golden Age of Microbiology

- 1860s: Joseph Lister (England): applied germ theory to medicine: treated surgical wounds with phenol solution.

- 1876: Robert Koch (Germany): first evidence of pathogenic bacteria: *Bacillus anthracis* caused anthrax, killing cattles and sheeps in Europe. He grew these bacteria and injected them into healthy animals -> sick -> isolated the bacteria and compared -> established experimental steps to form Koch's postulates.

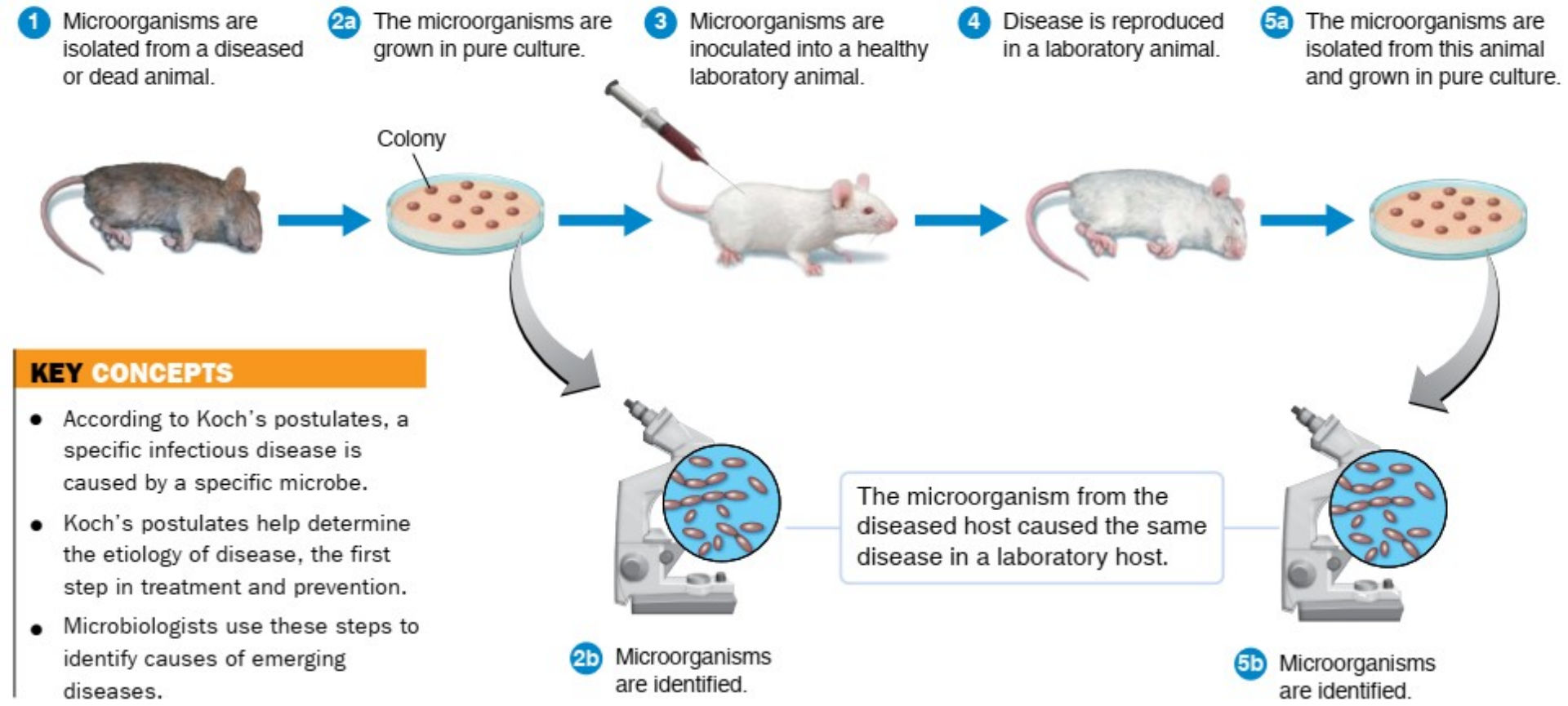
- Koch's postulates: a sequence of experimental steps for directly relating a specific microbe to a specific disease (see Figure 14.3):

The Golden Age of Microbiology

- Koch's

FOUNDATION FIGURE 14.3

Koch's Postulates: Understanding Disease



KEY CONCEPTS

- According to Koch's postulates, a specific infectious disease is caused by a specific microbe.
- Koch's postulates help determine the etiology of disease, the first step in treatment and prevention.
- Microbiologists use these steps to identify causes of emerging diseases.

The Golden Age of Microbiology

- **Vaccines**

- 1796: Edward Jenner (England): injected healthy people with fluid from smallpox blisters -> sick -> recovered -> no more smallpox. This process is called vaccination. Protecting the body from disease through vaccination is called immunity.

-1880: Pasteur discovered how vaccines worked: cholera bacteria lost their ability to cause disease when cultured for a long time in the laboratory. However, they have the ability to cause immunity. These bacteria are called vaccines.

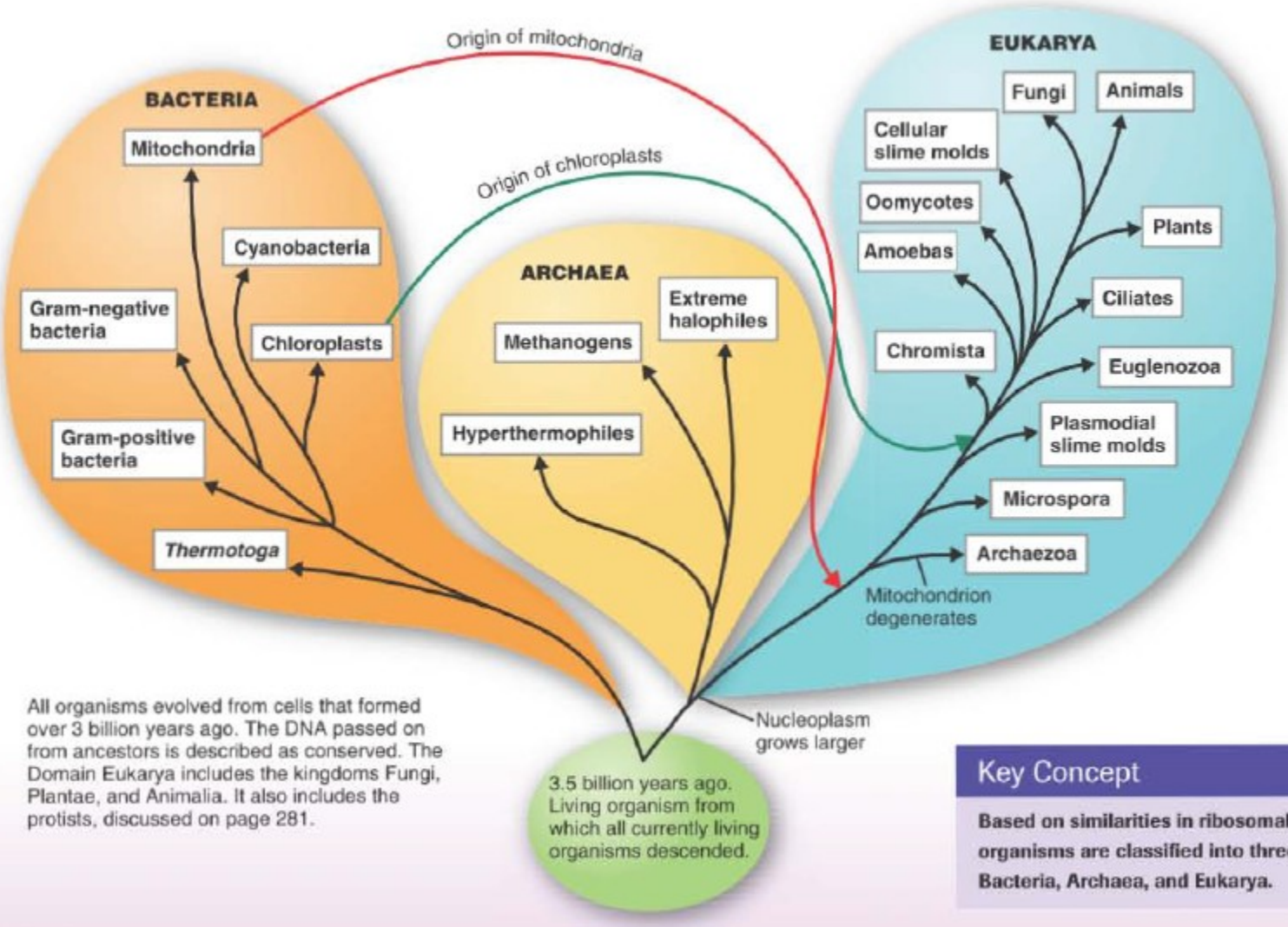
The Golden Age of Microbiology

❑ Antibiotics

- 1910: Paul Ehrlich (Germany): Discovered an arsenic derivative – salvarsan – that was resistant to the bacteria that caused syphilis.

-Years after 1930: Many other compounds with the ability to suppress the growth of pathogenic microorganisms were found. Most of them were derivatives of dyes. Sulfonamides were also synthesized during this period.

-1928: Alexander Fleming (Scotland): discovered that the fungus *Penicillium notatum* (*Penicillium chrysogenum*) had the ability to suppress the bacterial growth. The compound called penicillin, was produced on an industrial scale after 1940. Thanks to this discovery, thousands of other antibiotics were found. However, many antibiotics were toxic to humans and animals. Also,



All organisms evolved from cells that formed over 3 billion years ago. The DNA passed on from ancestors is described as conserved. The Domain Eukarya includes the kingdoms Fungi, Plantae, and Animalia. It also includes the protists, discussed on page 281.

Key Concept

Based on similarities in ribosomal RNA, living organisms are classified into three domains: Bacteria, Archaea, and Eukarya.

- Bacteria
- Fungi
  - Yeasts
  - Molds
  - Macroscopic fungi
- Protists
  - Protozoa
  - Algae
  - Oomycetes
  - Slime molds

  ...
- VIRUSES

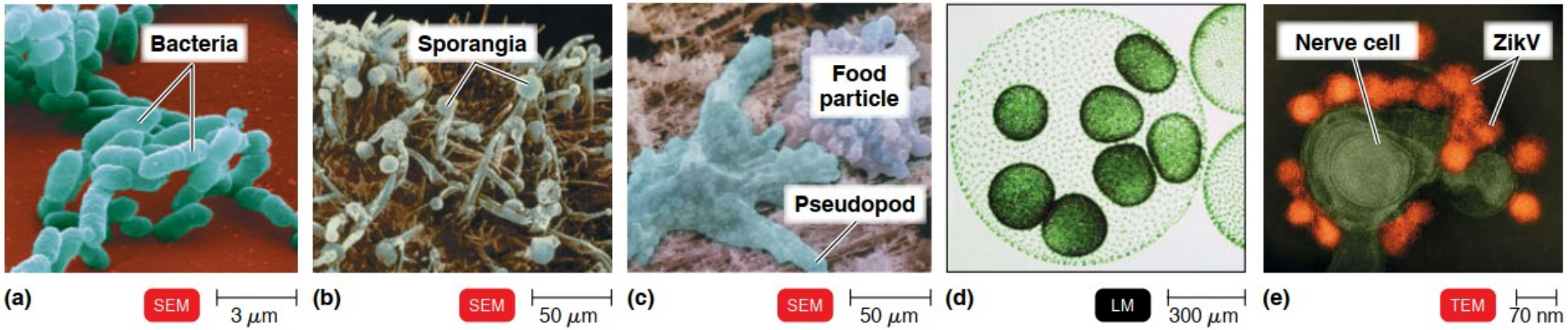
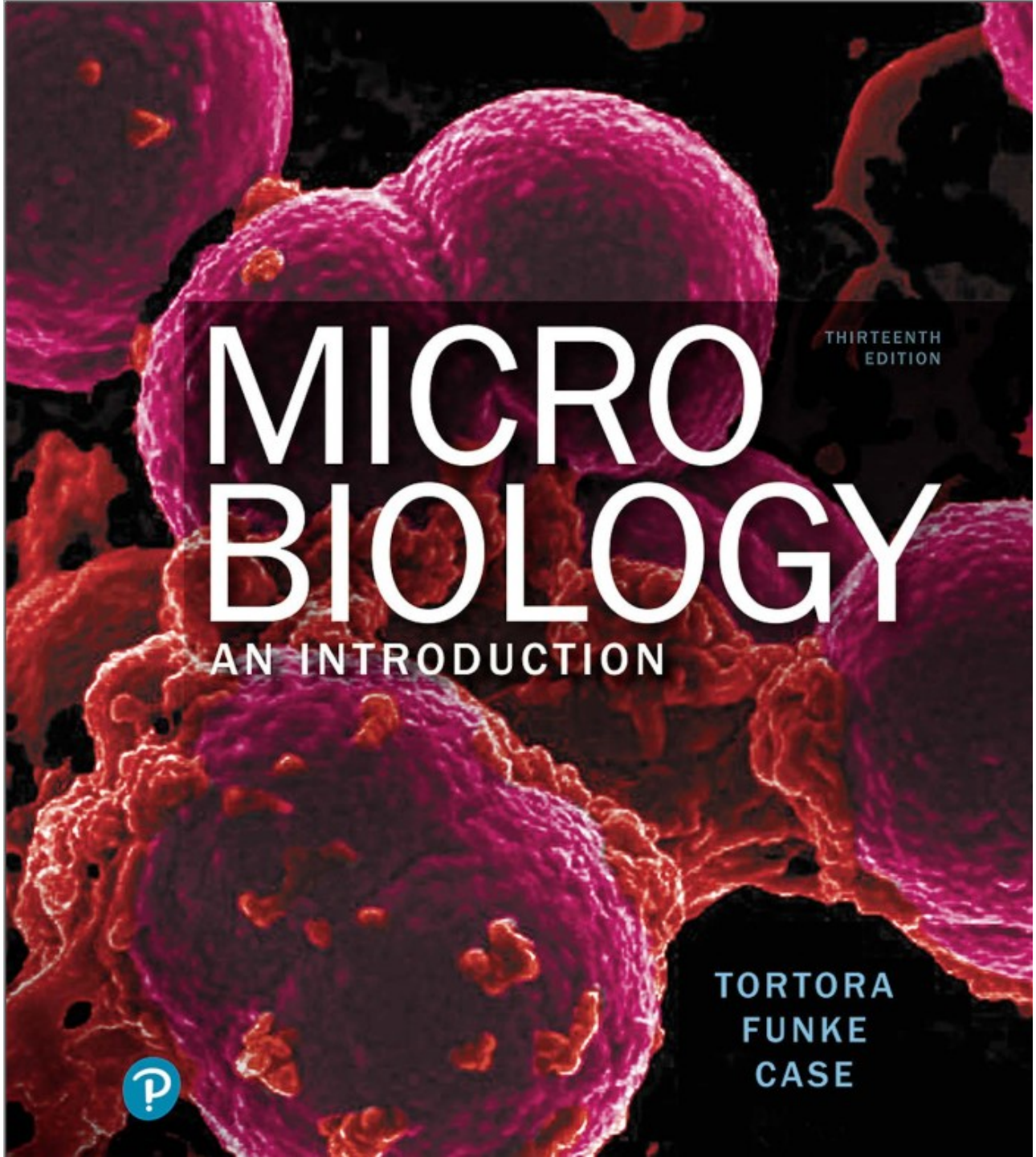


Figure 1.2 Types of microorganisms. **(a)** The rod-shaped bacterium *Haemophilus influenzae*, one of the bacterial causes of pneumonia. **(b)** *Mucor*, a common bread mold, is a type of fungus. When released from sporangia, spores that land on a favorable surface germinate into a network of hyphae (filaments) that absorb nutrients. **(c)** An ameba, a type of protozoan, approaching a food particle. **(d)** The pond alga *Volvox*. **(e)** Zika virus (ZikV). *NOTE:* Throughout the book, a red icon under a micrograph indicates that the micrograph has been artificially colored. SEM (scanning electron microscope) and LM (light microscope) are discussed in detail in Chapter 3.

Q How are bacteria, archaea, fungi, protozoa, algae, and viruses distinguished on the basis of structure?


THIRTEENTH
EDITION
MICRO
BIOLOGY
AN INTRODUCTION
TORTORA
FUNKE
CASE

ELEVENTH EDITION

CAMPBELL BIOLOGY

URRY • CAIN • WASSERMAN
MINORSKY • REECE