

- 1 **Chapter 1**
The Microbial World and You
- 2 **Microbes in Our Lives**
 - Microorganisms are organisms that are too small to be seen with the unaided eye
 - Includes: bacteria, fungi, protozoa, and microscopic algae.
 - "Germ" refers to a rapidly growing cell
- 3 **Microbes in Our Lives**
 - A few are pathogenic (disease-causing)
 - Decompose organic waste
 - Are producers in the ecosystem by photosynthesis
 - Produce industrial chemicals such as ethanol and acetone
 - Produce fermented foods such as vinegar, cheese, and bread
 - Produce products used in manufacturing (e.g., cellulase) and treatment (e.g., insulin)
- 4 **Designer Jeans: Made by Microbes?**
 - Stone-washing: *Trichoderma*
 - Cotton: *Gluconacetobacter*
 - Debleaching: Mushroom peroxidase
 - Indigo: *E. coli*
 - Plastic: Bacterial polyhydroxyalkanoate
- 5 **Microbes in Our Lives**
 - Knowledge of microorganisms
 - Allows humans to
 - Prevent food spoilage
 - Prevent disease occurrence
 - Led to aseptic techniques to prevent contamination in medicine and in microbiology laboratories
- 6 **Naming and Classifying Microorganisms**
 - Linnaeus established the system of scientific nomenclature
 - Each organism has two names: the genus and specific epithet
- 7 **Scientific Names**
 - Are italicized or underlined. The genus is capitalized, and the specific epithet is lowercase.
 - Are "Latinized" and used worldwide.
 - May be descriptive or honor a scientist.
- 8 **Escherichia coli**
 - Honors the discoverer, Theodor Escherich
 - Describes the bacterium's habitat—the large intestine, or colon
- 9 **Staphylococcus aureus**
 - Describes the clustered (*staphylo-*) spherical (*cocci*) cells
 - Describes the gold-colored (*aureus*) colonies
- 10 **Scientific Names**
 - After the first use, scientific names may be abbreviated with the first letter of the genus and the specific epithet:

- *Escherichia coli* and *Staphylococcus aureus* are found in the human body. *E. coli* is found in the large intestine, and *S. aureus* is on skin.

11 **Types of Microorganisms**

- Bacteria
- Archaea
- Fungi
- Protozoa
- Algae
- Viruses
- Multicellular animal parasites

12 **Types of Microorganisms**

13 **Bacteria**

- Prokaryotes (know their characteristics)
- Peptidoglycan cell walls
- Binary fission
- For energy, use organic chemicals, inorganic chemicals, or photosynthesis

14 **Archaea**

- Prokaryotic
- Lack peptidoglycan
- Live in extreme environments
- Include
 - Methanogens
 - Extreme halophiles
 - Extreme thermophiles

15 **Fungi**

- Eukaryotes (know characteristics)
- Chitin cell walls
- Use organic chemicals for energy
- Molds and mushrooms are multicellular, consisting of masses of mycelia, which are composed of filaments called hyphae
- Yeasts are unicellular

16 **Protozoa**

- Eukaryotes
- Absorb or ingest organic chemicals
- May be motile via pseudopods, cilia, or flagella

17 **Algae**

- Eukaryotes
- Cellulose cell walls
- Use photosynthesis for energy
- Produce molecular oxygen and organic compounds

18 **Viruses**

- Acellular
- Consist of DNA or RNA core
- Core is surrounded by a protein coat
- Coat may be enclosed in a lipid envelope

- Viruses are replicated only when they are in a living host cell

19 **Multicellular Animal Parasites**

- Eukaryotes
- Multicellular animals
- Parasitic flatworms and roundworms are called *helminths*.
- Microscopic stages in life cycles.

20 **Classification of Microorganisms**

- Developed by Carl Woese in 1978
- Three domains
 - Bacteria
 - Archaea
 - Eukarya
 - Protists
 - Fungi
 - Plants
 - Animals

21 **A Brief History of Microbiology**

- Ancestors of bacteria were the first life on Earth- bacteria date back to 3.4 bya in fossils.
- Cells discovered in 1665.
- The first live microbes were observed microscopically in 1673.

22 **The First Observations**

- 1665: Robert Hooke reported that living things were composed of little boxes, or cells
- 1858: Rudolf Virchow said cells arise from preexisting cells
- Cell theory: (Schleiden and Schwann) All living things are composed of cells and come from preexisting cells
 - Cells arise from preexisting cells
 - Living things were composed of little boxes, or cells
 - Cells are the basic unit of life.
 -

23 **The First Observations**

- 1673-1723: Anton van Leeuwenhoek described live microorganisms

24 **The Debate over Spontaneous Generation**

- Spontaneous generation: The hypothesis that living organisms arise from nonliving matter; a "vital force" forms life
- Biogenesis: The hypothesis that the living organisms arise from preexisting life

25 **Evidence Pro and Con**

- 1668: Francesco Redi filled 6 jars with decaying meat

26 **Evidence Pro and Con**

- 1745: John Needham put boiled nutrient broth into covered flasks

27 **Evidence Pro and Con**











- 1765: Lazzaro Spallanzani boiled nutrient solutions in flasks

28 **Evidence Pro and Con**

- 1861: Louis Pasteur demonstrated that microorganisms are present in the air

29 **The Theory of Biogenesis**

- Pasteur's S-shaped flask kept microbes out but let air in

- 30  **The Golden Age of Microbiology**
- 1857–1914
 - Beginning with Pasteur’s work, discoveries included the relationship between microbes and disease, immunity, and antimicrobial drugs
- 31  **Fermentation and Pasteurization**
- Pasteur showed that microbes are responsible for fermentation
 - Fermentation is the conversion of sugar to alcohol to make beer and wine
 - Microbial growth is also responsible for spoilage of food
 - Bacteria that use alcohol and produce acetic acid spoil wine by turning it to vinegar (acetic acid)
- 32  **Fermentation and Pasteurization**
- Pasteur demonstrated that these spoilage bacteria could be killed by heat that was not hot enough to evaporate the alcohol in wine
 - Pasteurization is the application of a high heat for a short time
- 33  **The Germ Theory of Disease**
- 1835: Agostino Bassi showed that a silkworm disease was caused by a fungus
 - 1865: Pasteur believed that another silkworm disease was caused by a protozoan
 - 1840s: Ignaz Semmelweis advocated hand washing to prevent transmission of puerperal fever from one OB patient to another
- 34  **The Germ Theory of Disease**
- 1860s: Applying Pasteur’s work showing that microbes are in the air, can spoil food, and cause animal diseases, Joseph Lister used a chemical disinfectant to prevent surgical wound infections
- 35  **The Germ Theory of Disease**
- 1876: Robert Koch proved that a bacterium causes anthrax and provided the experimental steps, Koch’s postulates, to prove that a specific microbe causes a specific disease
 - Germ Theory- specifically linked microorganisms to chemical and physical change in organic material.
- 36  **Vaccination**
- 1796: Edward Jenner inoculated a person with cowpox virus, who was then protected from smallpox
 - Vaccination is derived from *vacca*, for cow
 - The protection is called immunity
- 37  **The Birth of Modern Chemotherapy**
- Treatment with chemicals is chemotherapy
 - Chemotherapeutic agents used to treat infectious disease can be synthetic drugs or antibiotics
 - Antibiotics are chemicals produced by bacteria and fungi that inhibit or kill other microbes
- 38  **The First Synthetic Drugs**
- Quinine from tree bark was long used to treat malaria
 - Paul Ehrlich speculated about a “magic bullet” that could destroy a pathogen without harming the host
 - 1910: Ehrlich developed a synthetic arsenic drug, salvarsan, to treat syphilis
 - 1930s: Sulfonamides were synthesized
- 39  **A Fortunate Accident—Antibiotics**

- 1928: Alexander Fleming discovered the first antibiotic
- Fleming observed that *Penicillium* fungus made an antibiotic, penicillin, that killed *S. aureus*
- 1940s: Penicillin was tested clinically and mass produced

40 **Modern Developments in Microbiology**

- Bacteriology is the study of bacteria
- Mycology is the study of fungi
- Virology is the study of viruses
- Parasitology is the study of protozoa and parasitic worms

41 **Modern Developments in Microbiology**

- Immunology is the study of immunity. Vaccines and interferons are being investigated to prevent and cure viral diseases.
- The use of immunology to identify some bacteria according to serotypes was proposed by Rebecca Lancefield in 1933.

42 **Recombinant DNA Technology**

- Microbial genetics: The study of how microbes inherit traits
- Molecular biology: The study of how DNA directs protein synthesis
- Genomics: The study of an organism's genes; has provided new tools for classifying microorganisms
- Recombinant DNA: DNA made from two different sources.
 - In the 1960s, Paul Berg inserted animal DNA into bacterial DNA, and the bacteria produced an animal protein

43 **Recombinant DNA Technology**

- 1941: George Beadle and Edward Tatum showed that genes encode a cell's enzymes
- 1944: Oswald Avery, Colin MacLeod, and Maclyn McCarty showed that DNA was the hereditary material
- 1961: Francois Jacob and Jacques Monod discovered the role of mRNA in protein synthesis

44 **Nobel Prizes for Microbiology Research**

- * The first Nobel Prize in Physiology or Medicine.
- 1901* von Behring Diphtheria antitoxin
- 1902 Ross Malaria transmission
- 1905 Koch TB bacterium
- 1908 Metchnikoff Phagocytes
- 1945 Fleming, Chain, Florey Penicillin
- 1952 Waksman Streptomycin
- 1969 Delbrück, Hershey, Luria Viral replication
- 1987 Tonegawa Antibody genetics
- 1997 Prusiner Prions
- 2005 Marshall & Warren *H. pylori* & ulcers

45 **Microbial Ecology**

- Bacteria recycle carbon, nutrients, sulfur, and phosphorus that can be used by plants and animals

46 **Bioremediation**

- Bacteria degrade organic matter in sewage
- Bacteria degrade or detoxify pollutants such as oil and mercury

47 **Biological Insecticides**

- Microbes that are pathogenic to insects are alternatives to chemical pesticides in

- preventing insect damage to agricultural crops and disease transmission
 - *Bacillus thuringiensis* infections are fatal in many insects but harmless to other animals, including humans, and to plants
- 48 **Biotechnology**
- Biotechnology, the use of microbes to produce foods and chemicals, is centuries old
- 49 **Biotechnology**
- Recombinant DNA technology, a new technique for biotechnology, enables bacteria and fungi to produce a variety of proteins including vaccines and enzymes
 - Missing or defective genes in human cells can be replaced in gene therapy
 - Genetically modified bacteria are used to protect crops from insects and from freezing
- 50 **Normal Microbiota**
- Bacteria were once classified as plants, giving rise to use of the term *flora* for microbes
 - This term has been replaced by *microbiota*
 - Microbes normally present in and on the human body are called normal microbiota
- 51 **Normal Microbiota on Human Tongue**
- 52 **Normal Microbiota**
- Normal microbiota prevent growth of pathogens
 - Normal microbiota produce growth factors such as folic acid and vitamin K
 - Resistance is the ability of the body to ward off disease
 - Resistance factors include skin, stomach acid, and antimicrobial chemicals
- 53 **Biofilms**
- Microbes attach to solid surfaces and grow into masses
 - They will grow on rocks, pipes, teeth, and medical implants
 - Biofilms can be beneficial, protecting your mucous membranes from harmful invaders.
- 54 **Biofilms**
- 55 **Infectious Diseases**
- When a pathogen overcomes the host's resistance, disease results
 - Emerging infectious diseases (EIDs): New diseases and diseases increasing in incidence
- 56 **Avian influenza A**
- Influenza A virus (H5N1)
 - Primarily in waterfowl and poultry
 - Sustained human-to-human transmission has not occurred yet
- 57 **MRSA**
- Methicillin-resistant *Staphylococcus aureus*
 - 1950s: Penicillin resistance developed
 - 1980s: Methicillin resistance
 - 1990s: MRSA resistance to vancomycin reported
 - VISA: Vancomycin-intermediate-resistant *S. aureus*
 - VRSA: Vancomycin-resistant *S. aureus*
- 58 **West Nile Encephalitis**
- Caused by West Nile virus
 - First diagnosed in the West Nile region of Uganda in 1937
 - Appeared in New York City in 1999
- 59 **Bovine Spongiform Encephalopathy**
- Caused by a prion

- Also causes Creutzfeldt-Jakob disease (CJD)- a degenerative neurological disorder.
- New variant CJD in humans is related to cattle fed sheep offal for protein (Mad Cow)

60 **Escherichia coli O157:H7**

- Toxin-producing strain of *E. coli*
- First seen in 1982
- Leading cause of diarrhea worldwide

61 **Ebola Hemorrhagic Fever**

- Ebola virus
- Causes fever, hemorrhaging, and blood clotting
- First identified near Ebola River, Congo
- Outbreaks every few years

62 **Cryptosporidiosis**

- *Cryptosporidium* protozoa
- First reported in 1976
- Causes 30% of diarrheal illness in developing countries
- In the United States, transmitted via water

63 **Acquired immunodeficiency syndrome (AIDS)**

- Caused by human immunodeficiency virus (HIV)
- First identified in 1981
- Worldwide epidemic infecting 30 million people; 14,000 new infections every day
- Sexually transmitted infection affecting males and females
- HIV/AIDS in the U.S.: 30% are female, and 75% are African American