CHAPTER 1: Microbial Life: Origin and Discovery

MULTIPLE CHOICE

1. The eukaryotic predators of the microscopic world are:
   a. viruses
   b. bacteria
   c. algae
   d. cyanobacteria
   e. protists

   ANS: E DIF: Easy REF: Introduction OBJ: Factual
   TOP: Introduction

2. A human body contains _____ times as many microbes as it does human cells.
   a. 2
   b. 5
   c. 10
   d. 50
   e. 100

   ANS: C DIF: Easy REF: Introduction OBJ: Factual
   TOP: Introduction

3. What are the primary producers of major food webs?
   a. plants
   b. microbes
   c. animals
   d. fungi
   e. viruses

   ANS: B DIF: Easy REF: Introduction OBJ: Factual
   TOP: Introduction

4. What type of gas do cyanobacteria produce for planet Earth?
   a. oxygen
   b. hydrogen
   c. nitrogen
   d. carbon dioxide
   e. water vapor

   ANS: A DIF: Easy REF: Introduction OBJ: Factual
   TOP: Introduction

5. Bacteria that produce enzymes used in the polymerase chain reaction were isolated from:
   a. lake water
   b. ocean
   c. soil
   d. intestines
   e. hot springs

   ANS: E DIF: Easy REF: Introduction OBJ: Factual
   TOP: Introduction

6. What percentage of microbes in our biosphere can be cultured in the laboratory?
   a. less than 1%
   b. approximately 10%
   c. approximately 25%
   d. approximately 50%
   e. more than 90%

   ANS: A DIF: Medium REF: Introduction OBJ: Factual
   TOP: Introduction

7. Which of these is currently the number one cause of human mortality?
   a. cardiovascular disease
   b. cancer
   c. accidents
   d. microbial disease
   e. strokes

   ANS: D DIF: Easy REF: Introduction OBJ: Applied
   TOP: Introduction

8. The presence of _____ on Mars today would increase the chance that microbial life exists there.
   a. liquid water
   b. oxygen
   c. nitrogen gas
   d. ammonia
   e. DNA

   ANS: A DIF: Easy REF: Introduction OBJ: Applied
   TOP: Introduction

9. Which of these groups are considered to be microbes but NOT considered to be cells?
   a. viruses
   b. bacteria
   c. archaea
   d. protists
   e. prions

   ANS: A DIF: Easy REF: 1.1 OBJ: Applied
   TOP: I.A

10. The first genomes to be sequenced were those of:
    a. humans
    b. bacteria
    c. viruses
    d. prions
    e. fungi

    ANS: C DIF: Easy REF: 1.1 OBJ: Factual
    TOP: I.B.i

11. Which century is known as the golden age of microbiology?
    a. the seventeenth
    b. the eighteenth
    c. the nineteenth
    d. the twentieth
    e. the twenty-first

    ANS: C DIF: Easy REF: 1.2 OBJ: Factual
    TOP: II

12. All of the following have been found in mummies and tomb art EXCEPT:
    a. tuberculosis
    b. polio
    c. leprosy
    d. smallpox
    e. prions

    ANS: E DIF: Medium REF: 1.2 OBJ: Applied
    TOP: II

13. How did European invaders to North America kill much of the native population?
    a. tuberculosis
    b. leprosy
    c. smallpox
    d. HIV
    e. bubonic plague

    ANS: C DIF: Medium REF: 1.2 OBJ: Applied
    TOP: II.A.i

14. Who developed the concept of medical statistics?
    a. Francis Crick
    b. Florence Nightingale
    c. Edward Jenner
    d. Louis Pasteur
    e. Alexander Fleming

    ANS: B DIF: Easy REF: 1.2 OBJ: Factual
    TOP: II.A.ii

15. Which technique was developed to distinguish bacteria from human cells?
    a. Gram stain
    b. electron microscopy
    c. X-ray diffraction
    d. DNA sequencing
    e. PCR

    ANS: A DIF: Medium REF: 1.2 OBJ: Factual
    TOP: I.B

16. The first person to visualize individual microbes was:
    a. Antoni van Leeuwenhoek
    b. Robert Hooke
    c. Louis Pasteur
    d. Lady Montagu
    e. Edward Jenner

    ANS: A DIF: Easy REF: 1.2 OBJ: Factual
    TOP: II.B.ii

17. Suppose Pasteur's swan-necked flasks containing boiled broth became cloudy 24 hours after boiling. Which choice could best explain the turbidity or cloudiness in the broth without supporting spontaneous generation?
    a. Endospores in the broth survived boiling and grew after the broth cooled.
    b. Contaminating organisms in the broth killed by boiling became alive again after the broth cooled.
    c. Chemicals in the broth came together to form living organisms.
    d. The broth allowed light to pass through it with less interference after boiling.
    e. Solid material in the broth dissolved during boiling.

    ANS: A DIF: Difficult REF: 1.2 OBJ: Applied
    TOP: II.C.ii.b

18. How is most sterilization performed for the controlled study of microbes?
    a. boiling
    b. pasteurization
    c. filter sterilization
    d. autoclaving
    e. irradiation

    ANS: D DIF: Medium REF: 1.2 OBJ: Applied
    TOP: II.C.iii

19. The use of agar as the gelling agent in solid media was suggested by:
    a. Robert Koch
    b. Ignaz Semmelweis
    c. Angelina Hesse
    d. Louis Pasteur
    e. Richard Petri

    ANS: C DIF: Easy REF: 1.3 OBJ: Factual
    TOP: III.B.i.a

20. Robert Koch's greatest accomplishment in the field of medical bacteriology was with:
    a. *Escherichia coli*
    b. *Bacillus subtilis*
    c. *Mycobacterium tuberculosis*
    d. rabies
    e. smallpox

    ANS: C DIF: Medium REF: 1.3 OBJ: Applied
    TOP: III.B.ii

21. You have isolated a bacterium that you believe to be the causative agent of a new disease in frogs. How would you test the third of Koch's postulates?
    a. Determine the shape of the bacterial cells.
    b. Inject the bacteria into a healthy frog.
    c. Isolate the bacterium from a sick frog.
    d. Show that the bacterium is NOT present in healthy frogs.
    e. Grow a pure culture of the bacterium outside the frog.

    ANS: B DIF: Difficult REF: 1.3 OBJ: Applied
    TOP: III.B.ii

22. It took the advent of the PCR to detect the presence of the causative agent for which disease?
    a. anthrax
    b. tuberculosis
    c. AIDS
    d. rabies
    e. smallpox

    ANS: C DIF: Difficult REF: 1.3 OBJ: Applied
    TOP: III.B.ii

23. The word "vaccination" is derived from the Latin word *vacca*, which means:
    a. inject
    b. smallpox
    c. immunize
    d. cow
    e. pustule

    ANS: D DIF: Easy REF: 1.3 OBJ: Factual
    TOP: III.C.i

24. What is the basis for the modern smallpox vaccine?
    a. chickenpox virus
    b. cowpox virus
    c. rabies virus
    d. smallpox virus
    e. anthrax

    ANS: B DIF: Easy REF: 1.3 OBJ: Factual
    TOP: III.C.i

25. Penicillin was first used to save the lives of many people during which war?
    a. Civil War
    b. Korean War
    c. Vietnam War
    d. World War I
    e. World War II

    ANS: E DIF: Easy REF: 1.3 OBJ: Factual
    TOP: III.C.iv

26. Which of the following can safely be ingested to fight bacterial infections?
    a. antiseptics
    b. disinfectants
    c. phenol
    d. chlorine
    e. antibiotics

    ANS: E DIF: Easy REF: 1.3 OBJ: Applied
    TOP: III.C.iv

27. All of the following are true about penicillin EXCEPT:
    a. It was discovered by Alexander Fleming.
    b. It was an accidental discovery.
    c. It is produced by a bacterium.
    d. It was the first antibiotic used by humans.
    e. It was purified by Florey and Chain.

    ANS: C DIF: Difficult REF: 1.3 OBJ: Applied
    TOP: III.C.iv

28. Which of the following does NOT contain DNA or RNA?
    a. prokaryote
    b. eukaryote
    c. virus
    d. viroid
    e. prion

    ANS: E DIF: Medium REF: 1.3 OBJ: Factual
    TOP: III.D

29. The environment of early Earth may have contained all EXCEPT:
    a. ferrous iron
    b. methane
    c. ammonia
    d. oxygen
    e. hydrogen gas

    ANS: D DIF: Easy REF: Special Topic 1.1
    OBJ: Applied TOP: Special Topic 1.1

30. The development of the theory of the "RNA world" resulted from the discovery of:
    a. archaea
    b. prions
    c. bacteria
    d. ribozymes
    e. endosymbionts

    ANS: D DIF: Medium REF: Special Topic 1.1
    OBJ: Applied TOP: Special Topic 1.1

31. Which microbes may resemble those of the earliest life forms?
    a. archaea
    b. photosynthetic microbes
    c. viruses
    d. cyanobacteria
    e. protists

    ANS: A DIF: Medium REF: Special Topic 1.1
    OBJ: Applied TOP: Special Topic 1.1

32. Early metabolism may have been catalyzed by:
    a. DNA
    b. RNA
    c. protein
    d. amino acids
    e. carbohydrates

    ANS: B DIF: Medium REF: Special Topic 1.1
    OBJ: Applied TOP: Special Topic 1.1

33. Which types of compounds have a strong tendency to accept electrons?
    a. oxidized
    b. reduced
    c. neutral
    d. protons
    e. neutrons

    ANS: B DIF: Medium REF: Special Topic 1.1
    OBJ: Applied TOP: Special Topic 1.1

34. How did Sergei Winogradsky grow lithotrophs?
    a. enrichment culture
    b. aseptic technique
    c. pure culture
    d. endosymbiosis
    e. chain of infection

    ANS: A DIF: Easy REF: 1.4 OBJ: Applied
    TOP: IV.A.iii

35. Organisms which live symbiotically inside a larger organism are known as:
    a. organelles
    b. cyanobacteria
    c. mitochondria
    d. endosymbionts
    e. chloroplasts

    ANS: D DIF: Easy REF: 1.4 OBJ: Factual
    TOP: IV.B

36. Which group of microorganisms includes many that grow in extreme environments?
    a. algae
    b. bacteria
    c. protists
    d. archaea
    e. fungi

    ANS: D DIF: Easy REF: 1.5 OBJ: Applied
    TOP: V.B

37. The genetic expression machinery of archaea is most similar to:
    a. monera
    b. prokaryotes
    c. bacteria
    d. eukaryotes
    e. mitochondria

    ANS: D DIF: Medium REF: 1.5 OBJ: Applied
    TOP: V.B

38. In the three-domain model, the bacterial ancestor of mitochondria derives from ancient:
    a. fungi
    b. cyanobacteria
    c. proteobacteria
    d. archaea
    e. protists

    ANS: C DIF: Medium REF: 1.5 OBJ: Applied
    TOP: V.C

39. Which of the following organelles are thought to be of prokaryotic origin?
    a. chloroplast
    b. mitochondria
    c. nucleus
    d. chloroplast and mitochondria
    e. chloroplast and nucleus

    ANS: A DIF: Medium REF: 1.5 OBJ: Applied
    TOP: V.C

40. In the three-domain model, the bacterial ancestor of chloroplasts derives from ancient:
    a. fungi
    b. cyanobacteria
    c. proteobacteria
    d. archaea
    e. protists

    ANS: B DIF: Medium REF: 1.5 OBJ: Applied
    TOP: V.C

41. Carl Woese's discovery replaced the classification scheme of five kingdoms with a scheme of three:
    a. phyla
    b. domains
    c. classes
    d. orders
    e. genera

    ANS: B DIF: Easy REF: 1.5 OBJ: Factual
    TOP: V.D

42. How are microbes classified today?
    a. comparative genomics
    b. microscopy
    c. X-ray diffraction
    d. DNA sequencing
    e. rRNA sequencing

    ANS: E DIF: Medium REF: 1.5 OBJ: Applied
    TOP: V.D

43. What is used to focus the beam of electrons in an electron microscope?
    a. electromagnets
    b. condenser lens
    c. light rays
    d. X-ray diffraction
    e. glass

    ANS: A DIF: Easy REF: 1.6 OBJ: Factual
    TOP: VI.A

44. The X-ray diffraction studies by which of the following scientists concluded that DNA was a double helix?
    a. James Watson
    b. Rosalind Franklin
    c. Francis Crick
    d. Maurice Wilkins
    e. Kary Mullis

    ANS: B DIF: Easy REF: 1.6 OBJ: Factual
    TOP: VI.C

45. The Asilomar Conference was held to regulate and restrict the field of:
    a. recombinant DNA
    b. comparative genomics
    c. DNA sequencing
    d. DNA amplification
    e. forensic microbiology

    ANS: A DIF: Easy REF: 1.6 OBJ: Factual
    TOP: VI.C

46. What type of analysis was used to discover the overall structure of the DNA double helix?
    a. microscopy
    b. X-ray diffraction
    c. Polymerase chain reaction
    d. DNA sequencing
    e. recombinant DNA

    ANS: B DIF: Medium REF: 1.6 OBJ: Factual
    TOP: VI.C

47. Which scientist first discovered the process of transformation?
    a. Francis Crick
    b. Robert Koch
    c. Edward Jenner
    d. Louis Pasteur
    e. Frederick Griffith

    ANS: E DIF: Difficult REF: 1.6 OBJ: Factual
    TOP: VI.C

48. Taq polymerase formed the basis of a multibillion-dollar industry of:
    a. comparative genomics
    b. recombinant DNA
    c. X-ray diffraction
    d. DNA amplification
    e. DNA sequencing

    ANS: D DIF: Difficult REF: 1.6 OBJ: Applied
    TOP: VI.C.ii

49. The study of and cause of disease in humans, animals, and plants is called:
    a. microbiology
    b. phylogeny
    c. genomics
    d. epidemiology
    e. forensics

    ANS: D DIF: Easy REF: 1.6 OBJ: Factual
    TOP: VI.D

50. The analysis of microbial strains as evidence in criminal investigations is known as:
    a. forensic microbiology
    b. recombinant DNA
    c. comparative genomics
    d. classification
    e. gene regulation

    ANS: A DIF: Easy REF: 1.6 OBJ: Factual
    TOP: VI.D

SHORT ANSWER

1. Why did it take so long for humans to determine that microbes cause infectious diseases?

   ANS:
   Microbes are too small to be seen with the naked eye so until microscopes were invented, humans did not know that microbes existed. Even after humans were aware of the presence of microbes, they did not suspect them of causing disease until people such as Joseph Lister and Ignaz Semmelweis performed experiments that showed antiseptics decrease the incidence of infection.

   DIF: Difficult REF: Introduction | 1.2 OBJ: Conceptual
   TOP: II

2. How are prokaryotes and eukaryotes different?

   ANS:
   A prokaryote lacks a nucleus and membrane-bounded organelles, whereas a eukaryote has a nucleus and membrane-bounded organelles.

   DIF: Easy REF: 1.1 OBJ: Applied TOP: I.A

3. What is the most recent evidence suggesting that all life on Earth shares a common ancestry?

   ANS:
   Many genomes have now been sequenced and those sequences are available in databases for comparison. This field is referred to as comparative genomics. Comparisons have revealed that there is a set of core genes shared by all organisms.

   DIF: Difficult REF: 1.1 OBJ: Conceptual TOP: I.B.i

4. Identify at least three women and their discoveries that have contributed significantly to the field of microbiology.

   ANS:
   Answers may vary. Several examples are listed in Table 1.2 in the textbook. They include Lady Montagu's rendition of a smallpox vaccine, Florence Nightingale's biomedical statistics, Barbara McClintock and transposons, and Rosalind Franklin and X-ray crystallography studies of DNA.

   DIF: Difficult REF: 1.2 OBJ: Applied TOP: II

5. Describe the effects of three microbial diseases that have significantly affected human populations throughout history.

   ANS:
   Answers may vary. Some examples include bubonic plague, which killed one-third of Europe's population in the fourteenth century; tuberculosis, which was common in the nineteenth century; AIDS, which affects many people today; and smallpox, which killed a large number of native North Americans.

   DIF: Medium REF: 1.2 OBJ: Applied TOP: II.A

6. Antoni van Leeuwenhoek worked as a cloth draper, inspecting the quality of cloth. How did this lead to his interest in microscopy?

   ANS:
   Briefly, his work introduced him to magnifying lenses. He began the hobby of grinding lenses, ultimately making a microscope that enabled him to observe single-celled microbes.

   DIF: Medium REF: 1.2 OBJ: Conceptual TOP: II.B.ii

7. What was the major complaint about Lazzaro Spallanzani's experiment to disprove spontaneous generation, and how did Louis Pasteur's swan-neck flasks overcome this?

   ANS:
   Spallanzini's flasks were plugged so as not to let organisms accidentally enter the boiled medium. Opponents argued that no growth was observed simply due to the lack of oxygen. Pasteur's swan-neck flasks did not allow organisms to enter the flask, but did allow oxygen to enter. Growth was still not observed.

   DIF: Medium REF: 1.2 OBJ: Applied TOP: II.C

8. Describe the discoveries of Louis Pasteur while working with the French beer and wine manufacturers.

   ANS:
   Previously, it was believed that the conversion of grapes and grain to wine and beer was a spontaneous chemical process. He discovered that this fermentation was caused by living yeast which did not require oxygen for growth. He also discovered that when the grapes or grain is contaminated with bacteria instead of yeast, acetic acid is produced instead of alcohol.

   DIF: Medium REF: 1.2 OBJ: Applied TOP: II.C.ii

9. How would you use Robert Koch's postulates to prove that a specific organism causes a new disease in mice?

   ANS:
   See Figure 1.18 in the textbook.
   1. The suspected organism is found in all diseased mice, but absent from healthy mice.
   2. The suspected organism is isolated from the diseased mice and grown in pure culture.
   3. When the suspected organism is introduced into a healthy mouse, the same disease occurs.
   4. The same strain of microbe is obtained from the newly diseased mouse.

   DIF: Medium REF: 1.3 OBJ: Applied TOP: III.B.ii

10. Robert Koch's postulates have not been used to prove HIV as the causative agent of AIDS. Why not?

    ANS:
    Answers may vary, but a major reason is that humans cannot be injected with HIV to see if they develop AIDS!

    DIF: Difficult REF: 1.3 OBJ: Conceptual TOP: III.B.ii

11. Define attenuation and describe some mechanisms used to attenuate pathogens.

    ANS:
    Attenuation results in a weakened organism that will not produce full-blown disease, but will generate immunity. Answers for mechanisms may vary. See discussion in textbook Section 1.3 entitled "Immunization Prevents Disease."

    DIF: Medium REF: 1.3 OBJ: Applied TOP: III.C.i

12. What is the significance of the work of Ignaz Semmelweis and Joseph Lister?

    ANS:
    They showed that use of antiseptics on doctor's hands and medical instruments drastically reduced the mortality rate of hospital patients. They made these observations before Robert Koch's germ theory of disease.

    DIF: Medium REF: 1.3 OBJ: Conceptual TOP: III.C.iii

13. Wilderness protection worldwide has been fueled by the need to find novel strains of antibiotic-producing bacteria and fungi.

    ANS:
    Many new and powerful antibiotics have been discovered during the second half of the twentieth century. Most of these were produced by obscure strains of bacteria and fungi from dwindling ecosystems. It is important to preserve wilderness worldwide because there are likely many undiscovered antibiotic-producing organisms.

    DIF: Difficult REF: 1.3 OBJ: Conceptual TOP: III.C.iv

14. Explain why the organisms that were studied by Sergei Winogradsky could not be grown on Robert Koch's plate media containing agar or gelatin.

    ANS:
    The organisms studied by Winogradsky were lithotrophs, which feed solely on inorganic substances. Koch's plate media contained organic nutrient sources.

    DIF: Difficult REF: 1.4 OBJ: Conceptual TOP: IV.A.ii

15. Define the term "endosymbiont" and give an example of an endosymbiotic relationship found in nature.

    ANS:
    An endosymbiont is an organism living symbiotically inside a larger organism. Examples may vary, but include the following: *Rhizobium* in a leguminous plant, bioluminescent bacteria in the light organs of fish and squid, photosynthetic algae and coral.

    DIF: Medium REF: 1.4 OBJ: Applied TOP: IV.B

16. Is it true that only culturable bacteria contribute to ecology and pathology? Explain your answer.

    ANS:
    No, this is not a true statement. It is estimated that barely 0.1% of microbial species can be cultured. The work of Winogradsky and later microbial ecologists showed that bacteria are necessary for geochemical cycling. Many of these organisms can't be grown in pure culture on laboratory media but can be grown in enrichment culture such as a Winogradsky column.

    DIF: Difficult REF: 1.4 OBJ: Conceptual TOP: IV.B

17. Give two reasons why microbes have been difficult to classify.

    ANS:
    First, even with the use of light microscopes, only the basic shape of microbes can be determined and many microbes have similar shapes even though they are very different in other ways. Second, microbes do not fit the classic definition of a species, which is a group of organisms that interbreed. Microbes typically reproduce asexually. When they do exchange genes, they may do so with distantly related species.

    DIF: Medium REF: 1.5 OBJ: Conceptual TOP: V.A

18. Briefly explain the endosymbiosis theory and the evidence that supports it.

    ANS:
    The endosymbiosis theory proposes that mitochondria and chloroplasts evolved from bacteria that were engulfed by pre-eukaryotic cells and that over time these endosymbiotic prokaryotic cells lost the ability to survive outside of the host cell but were maintained as organelles. Evidence supporting the endosymbiosis theory includes the fact that mitochondria and chloroplasts possess circular DNA with similarity to modern bacteria.

    DIF: Difficult REF: 1.5 OBJ: Applied TOP: V.C

19. Briefly describe how the ultracentrifuge is used to determine the sizes of cellular macromolecules.

    ANS:
    The ultracentrifuge uses centrifugal forces to separate cell components. Svedberg calculated that the particle sizes could be determined based on the rate of sedimentation of the particles in an ultracentrifuge.

    DIF: Medium REF: 1.6 OBJ: Applied TOP: VI.B.ii

20. What were the contributions of Rosalind Franklin toward discovering the structure of DNA and why wasn't she one of the recipients of the Nobel Prize for this discovery?

    ANS:
    She was an X-ray crystallographer who studied the structure of DNA. Her X-ray micrographs showed for the first time that DNA was a double helix. A colleague showed her micrographs to James Watson who was also studying the structure of DNA. Watson and Francis Crick published their model of the structure of DNA in the journal *Nature* and denied that they had used Franklin's micrographs.

    DIF: Medium REF: 1.6 OBJ: Conceptual TOP: I.C