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Correct answers located at the end of the chapter.

1) A hypothesis must be tested many times before it can be considered a theory.
   - ◎ true
   - ◎ false

2) Many chronic medical conditions have been found to be associated with microbial agents.
   - ◎ true
   - ◎ false

3) All bacteria and archaea are microorganisms, but only some eukaryotes are microorganisms.
   - ◎ true
   - ◎ false

4) The scientific method involves formulating a tentative explanation, called the hypothesis, to account for what has been observed or measured.
   - ◎ true
   - ◎ false

5) Members of the same species share many more characteristics compared to those shared by members of the same kingdom.
   - ◎ true
   - ◎ false

6) The names of the three proposed domains are: Bacteria, Protista, and Eukarya.
   - ◎ true
   - ◎ false

7) Photosynthetic microorganisms contribute more oxygen to the atmosphere than plants.
   - ◎ true
   - ◎ false

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8) Most microorganisms that are found in and on humans do not cause harm and can sometimes benefit the host.
   - ◎ true
   - ◎ false

9) All organisms studied in microbiology must be viewed with a microscope.
   - ◎ true
   - ◎ false

10) Choose the term(s) identifying professions that involve the use of microorganisms.
   - A) The food industry
   - B) Biotechnology
   - C) Epidemiology
   - D) Astrology
   - E) Genetic engineering
   - F) Agriculture and dairy industries

11) Select all answers that are roles played by microorganisms in our environment.
   - A) Carry out photosynthesis
   - B) Biological decomposition
   - C) Nutrient recycling
   - D) Complex relationships with animals but not plants

12) Select statements that apply to the theory of evolution to test your understanding of evolution.
   - A) The theory has undergone years of testing.
   - B) The theory is a new untested hypothesis.
   - C) The theory has not been disproven.
   - D) The theory lacks supportive evidence.
   - E) The theory is a well-established natural phenomenon.

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13) Choose the response(s) that pertain to the relative burden of human infectious diseases in the world today.
   A) More than 2,000 microbes can cause human disease today.
   B) The number of deaths from emerging and reemerging diseases, such as COVID-19, is on the decline worldwide.
   C) Many diseases that used to be considered noninfectious probably do involve microbial infection based upon current studies.
   D) There is an increase in microbes that are resistant to drugs today.
   E) Infectious diseases are more frequent in developed countries, whereas noncommunicable diseases are more common in developing countries.

14) Choose all of the responses that pertain to the relative burden of human infectious diseases in the world today.
   A) Noncommunicable disease causes the highest percentage of deaths in both developing and developed countries.
   B) Deaths due to communicable diseases are highest in low-income, developing countries.
   C) Developed countries like the United States exhibit deaths only due to chronic disease.
   D) The infectious diseases that cause the most deaths worldwide and in the United States are pneumonia, influenza, and COVID-19.
   E) HIV is the most concerning infectious disease worldwide.

15) Select the three major areas involved in the science of taxonomy.
   A) Classification
   B) Genetics
   C) Nomenclature
   D) Analysis
   E) Identification

16) Select all of the answers that reflect the contributions that molecular approaches have made to modern taxonomy.
   A) Revealed that ssu RNA is highly conserved so can be used for classification
   B) Have led to the development of a new taxonomic system divided into domains
   C) Have not changed the overall tree of life
   D) Revealed that archaea are more closely related to bacterial cells than eukaryotic cells

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17) Which of the following are true regarding spontaneous generation?
A) It was definitively disproven by John Needham.
B) Louis Pasteur designed an experiment with swan-necked flasks that disproved this theory once and for all.
C) This theory was based on idea of abiogenesis.
D) The meat maggot experiment indicated that the concept of abiogenesis was likely true.

18) Microorganisms are best defined as organisms that
A) cause human disease.
B) lack a cell nucleus.
C) are infectious particles.
D) are too small to be seen with the unaided eye.
E) can only be found growing in laboratories.

19) Which of the following are not considered microorganisms?
A) Mosquitoes
B) Protozoa
C) Bacteria
D) Viruses
E) Fungi

20) Helminths are
A) bacteria.
B) protozoa.
C) molds.
D) parasitic worms.
E) infectious particles.

21) Among these types of microorganisms, the_____ are noncellular.
A) viruses
B) helminths
C) protozoans
D) bacteria

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22) Studies of the immune response to an infection caused by microorganisms would be performed by a/an
A) hypersensitivity specialist.
B) epidemiologist.
C) immunologist.
D) geomicrobiologist.

23) Which of the following pairs of career descriptions and work tasks is not correctly matched?
A) Industrial microbiologist -- manipulate bacterial strains to be less pathogenic
B) Agricultural microbiologist -- identify bacterial causes of crop disease
C) Public health microbiologist -- track the incidence of AIDS in a population
D) Medical microbiologist -- identify the cause of a bladder infection at a hospital lab

24) A scientist who studies the influence of microbes in the formation of caves is called a/an
A) geomicrobiologist.
B) astrobiologist.
C) epidemiologist.
D) immunologist.

25) Astrobiology is considered a sub-discipline of microbiology because
A) life elsewhere in the universe is likely to be microbial.
B) microbes are known to exist on other planets.
C) all extraterrestrials known are microbial.
D) only microbes can reproduce under the extreme conditions in outer space.

26) Which of the following does not indicate microbe involvement in energy and nutrient flow?
A) Thermal hot springs warmed by heat from earth's interior
B) Formation of greenhouse gases, CO_2 and methane
C) Digestion of complex carbohydrates in animal diets
D) Decomposition of dead matter and wastes

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27) The microorganisms that recycle nutrients by breaking down dead matter and wastes are called
A) decomposers.
B) prokaryotes.
C) pathogens.
D) eukaryotes.
E) fermenters.

28) The majority of oxygen in earth's atmosphere is a product of photosynthesis by
A) microorganisms.
B) rain forests.
C) agricultural lands.
D) green plants.

29) The three cell types discussed, eukaryotes, archaea, and bacteria, all derived from
A) a common ancestral cell.
B) photosynthetic bacteria.
C) archaea.
D) cells with a true nucleus.

30) The first cells appeared a little more than_____ billion years ago.
A) 5
B) 4
C) 3.5
D) 2
E) 1

31) Which area of biology states that living things undergo gradual structural and functional changes over long periods of time?
A) Morphology
B) Phylogeny
C) Evolution
D) Genetics
E) Transformation

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32) When humans manipulate the genes of microorganisms, the process is called
A) bioremediation.
B) recombinant DNA technology.
C) epidemiology.
D) immunology.
E) taxonomy.

33) Which activity is an example of biotechnology?
A) Bacteria in the soil secreting an antibiotic to kill competitors
B) A microbiologist using the microscope to view bacteria
C) Egyptians using moldy bread on wounds
D) *Escherichia coli*producing human insulin
E) Public health officials monitoring diseases in a community

34) Which of the following is a traditional human use of microorganisms?
A) Baking bread
B) Treating water and sewage
C) Mass-producing antibiotics
D) Cleaning up oil spills

35) Using microbes to detoxify a site contaminated with heavy metals is an example of
A) biotechnology.
B) bioremediation.
C) decomposition.
D) immunology.
E) epidemiology.

36) Disease-causing microorganisms are called
A) decomposers.
B) bacteria.
C) pathogens.
D) eukaryotes.
E) fermenters.

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37) Worldwide, most infectious diseases that result in death are
A) AIDS-related diseases.
B) diarrheal diseases.
C) malaria and other protozoan diseases.
D) measles and other rash diseases.
E) respiratory diseases.

38) The incidence of deaths from communicable disease is_____ in the United States compared to the entire world.
A) less
B) greater
C) about the same

39) In which way are bacteria and eukaryotes the same?
A) Contain membrane-bound organelles
B) Possess a cell membrane
C) Contain a nucleus to hold DNA
D) Always have a cell wall for rigidity

40) In which way are archaea and eukaryotes the same?
A) Contain membrane-bound organelles
B) Have similar ssu rRNA sequences
C) Contain mitochondria for energy production
D) Possess RNA instead of DNA

41) Which of the following is a unique characteristic of viruses that distinguishes them from the other major groups of microorganisms?
A) Cause human disease
B) Lack a nucleus
C) Cannot be seen without a microscope
D) Contain genetic material
E) Lack cell structure

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42) Which group of microorganisms is composed only of hereditary material wrapped in a protein covering?
A) Viruses
B) Bacteria
C) Parasites
D) Fungi
E) Yeasts

43) Eukaryotic cells are larger than bacterial or archaeal cells; all cells are larger than macromolecules. Where do viruses fit on this scale?
A) Viruses are larger than eukaryotic cells.
B) Viruses are smaller than eukaryotic cells, but larger than bacterial or archaeal cells.
C) Viruses are smaller than bacterial or archaeal cells, but larger than macromolecules.
D) Viruses are smaller than macromolecules.

44) In general, eukaryotic cells are about_____ times larger than bacterial or archaeal cells.
A) 2
B) 10
C) 50
D) 1000

45) Archaeal cells are about_____ bacterial cells.
A) the same size as
B) ten times larger than
C) ten times smaller than

46) Which of the following historical microbiologists is incorrectly paired with his contribution to the science?
A) Robert Koch: established a series of proofs that could be used to establish which organism caused which disease
B) Antonie van Leeuwenhoek: made and used quality magnifying lenses to observe and record microorganisms
C) Louis Pasteur: demonstrated that anthrax was caused by a bacterium
D) Joseph Lister: promoted disinfecting hands and air prior to surgery

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47) In the experiments constructed by Pasteur to disprove spontaneous generation, swan-necked flasks were used. Why was this shape of flask used in this experiment?
A) The glass necks needed to be open to the air, yet constructed so that bacteria would settle in the lowest part of the neck.
B) These flask shapes were the easiest and cheapest to produce.
C) The shape of the glass neck allowed the bacteria into the flask and then into the media, but air could not enter.
D) Because the glass necks were stretched out, the heat used to sterilize the medium inside of the flask could not kill the bacteria in the neck.

48) Koch's postulates are criteria used to establish that
A) microbes are found on dust particles.
B) a specific microbe is the cause of a specific disease.
C) life forms can only arise from preexisting life forms.
D) a specific microbe should be classified in a specific kingdom.
E) microbes can be used to clean up toxic spills.

49) Which of the following is NOT a **recent** discovery that has had a huge impact on the understanding of microbiology?
A) CRISPR
B) Microscopy
C) Human microbiome project
D) Use of mRNA in vaccines

50) The sum total of all the microbes in a certain environment is termed the
A) microbiome.
B) biofilm.
C) microbial niche.
D) domain.
E) phylogeny.

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51) Which of the following is not a process in the scientific method?
A) Belief in a preconceived idea
B) Formulation of a hypothesis
C) Systematic observation
D) Laboratory experimentation
E) Development of a theory

52) Experimentation
A) is designed to refute an hypothesis.
B) is designed to support an hypothesis.
C) provides a means to gather subjective data.
D) provides a means to gather objective data.
E) is the first step in the scientific method.

53) The scientific method includes all of the following except
A) hypothesis.
B) experimentation.
C) observation.
D) publication.

54) Caring for patients infected with a new virus requires safety precautions for medical personnel. Choosing appropriate procedures is an example of a/an_____ process.
A) deductive
B) inductive
C) hypothetical
D) pathogenic

55) Sterile is best described as
A) pathogen-free.
B) absence of spores.
C) absence of any life forms and viral particles.
D) pasteurized.
E) homogenized.

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56) Taxonomy does not involve
A) nomenclature.
B) classification.
C) identification.
D) a common name.

57) Which scientific field is involved in the identification, classification, and naming of organisms?
A) Nomenclature
B) Taxonomy
C) Phylogeny
D) Pathology
E) Epidemiology

58) The orderly arrangement of organisms into a hierarchy of taxa is called
A) classification.
B) identification.
C) nomenclature.
D) experimentation.
E) biotechnology.

59) Which of the following is a taxon that contains all the other taxa listed?
A) Species
B) Phylum
C) Kingdom
D) Genus
E) Family

60) The smallest and most significant taxon is a
A) genus.
B) species.
C) kingdom.
D) family.
E) phylum.

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61) Select the correct descending taxonomic hierarchy (left to right).
A) Family, order, class
B) Family, genus, species
C) Genus, species, family
D) Class, phylum, order
E) Kingdom, domain, phylum

62) A mnemonic for remembering the taxonomic levels from Domain to Species is "Dear King Phillip Came Over for Good Soup." The word "came" here is a reminder of the taxonomic level of
A) class.
B) category.
C) chain.
D) colony.
E) culture.

63) Which of the following is a scientific name?
A) Gram-positive streptococcus
B) *Streptococcus pyogenes*
C) Anthrax
D) Streptobacilli

64) When assigning a scientific name to an organism,
A) the species name is capitalized.
B) the species name is placed first.
C) the species name can be abbreviated.
D) both genus and species names are capitalized.
E) both genus and species names are italicized or underlined.

65) Which scientific name is written correctly?
A) Staphylococcus aureus
B) staphylococcus aureus
C) Staphylococcus Aureus
D) *Staphylococcus aureus*
E) S. aureus

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66) A diagram of the three domains (Bacteria, Archaea, Eukarya) proceeding from the Last Common Ancestor would show Archaea
A) as the original cells from which the others derived.
B) branching off the Domain Eukarya.
C) branching off the Domain Bacteria.

67) Analysis of the small subunit rRNAs from all organisms in the three current domains suggests that
A) the eukaryotes arose from prokaryotes.
B) the Archaea are more closely related to bacteria than eukaryotes.
C) all modern and extinct organisms on earth arose from a common ancestor.
D) bacteria, archaea, and eukaryotes are not related.

68) The study of evolutionary relationships among organisms is called
A) biotechnology.
B) genetics.
C) recombinant DNA.
D) phylogeny.
E) taxonomy.

69) A scientist studying the sequence of nucleotides in the rRNA of a bacterial species is working on
A) determining evolutionary relatedness.
B) bioremediation.
C) recombinant DNA.
D) nomenclature.
E) determining if that species is the cause of a new disease.

70) Trees of life that illustrate the phylogenetic relationships of all organisms were traditionally based on_____; newer methods for determining phylogeny rely on_____.
A) morphology; nucleic acid sequences
B) nucleic acid sequences; morphology
C) morphology; virology
D) morphology; nutritional requirements
E) nucleic acid sequences; microbiomes

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71) The theory of evolution and the germ theory of disease are so called because
A) a single experiment was repeated with consistency many times for each theory, proving the original hypotheses to be true.
B) multiple experiments were designed and repeated to explain all aspects of the observed phenomena without disproving the original hypotheses.
C) individuals had ideas regarding observed phenomena, which both went untested.
D) multiple experiments were conducted; some proved the observed hypotheses and others disproved them.

72) Select the characteristic exhibited by viruses.
A) Independent living cellular organisms
B) Much more complex than cells
C) Composed of DNA and RNA
D) Parasitic particles
E) Lack a protein coat

73) Choose the term that describes the overall system of discovering, arranging, and naming organisms.
A) Nomenclature
B) Identification
C) Classification
D) Taxonomy
E) Hierarchy

74) Early taxonomists relied upon all of the following to classify an organism except
A) analysis of the organism's shape (morphology).
B) analysis of structural and organizational characteristics of the organism.
C) analysis of metabolic (nutritional) characteristics of the organism.
D) genetic analysis of the organism.

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75) Which of the following choices is a correct way to type the binomial name of a microorganism?
A) *Staphylococcus aureus*
B) *Staphylococcus Aureus*
C) *staphylococcus Aureus*
D) *staphylococcus aureus*
E) Staphylococcus aureus

76) Choose the statement or characteristic that best describes the current taxonomic system.
A) Three distinct cell types called domains as the highest taxonomic category
B) Five kingdoms as the highest levels of taxonomy
C) Organisms divided first into groups of plants, animals, and microorganisms
D) First division is based on prokaryote vs eukaryote with all prokaryotes being very genetically distinct from the eukaryotes

77) The major groups of microorganisms studied by microbiologists include bacteria and archaea, algae, helminths, protozoans, viruses, and
A) cysts.
B) spores.
C) fungi.
D) arthropods.

78) The scientific name of a microorganism is a combination of the_____ name, which is capitalized, followed by the_____ name, which begins with a lowercase letter.
A) species; genus
B) phylum; genus
C) genus; species
D) genus; kingdom

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79) The scientific method is used by scientists to explain a certain natural phenomenon, and it involves the formation of a_____ as a tentative explanation of the observed or measured phenomenon.
A) theory
B) variable
C) hypothesis
D) experiment

80) Select the individual below that ground glass lenses to very fine specifications so that he was able to develop a microscope for observing and describing living microscopic animalcules.
A) Antonie van Leeuwenhoek
B) Ibn al-Haytham
C) Kary Mullis
D) Louis Pasteur

81) The theory of evolution was once a _____ that was tested repeatedly and always supported by the data collected by various scientists around the world.
A) theorem
B) hypothesis
C) fact
D) variable

82) Which example represents deductive reasoning?
A) Having read that refined sugar can lead to disease, you choose not to eat a doughnut at breakfast this morning.
B) You measure your gas mileage for a tank of gas over five different tanks. When you average over 60 mph for the tank, you get less than 300 miles to the tank. When you average 30 mph for the tank, you get over 500 miles. You conclude that driving faster burns gas more quickly.
C) Every time you eat cereal or drink a glass of milk, you experience severe abdominal pain. You conclude that you could possibly have lactose intolerance.

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83) Dr. Wendall Holmes and Dr. Ignaz Semmelweis were pioneers in_____, one of the most important methods to reduce disease in healthcare settings.

A) sterilized operating rooms
B) handwashing
C) use of antiseptics on skin before surgery
D) pasteurization

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Answer Key

Test name: Chapter 01

1) TRUE
2) TRUE
3) TRUE
4) TRUE
5) TRUE
6) FALSE
7) TRUE
8) TRUE
9) FALSE
10) [A, B, C, E, F]
11) [A, B, C]
12) [A, C, E]
13) [A, C, D]
14) [A, B, D]
15) [A, C, E]
16) [A, B]
17) [B, C]
18) D
19) A
20) D
21) A
22) C
23) A
24) A
25) A
26) A
27) A
28) A
29) A
30) B
31) C
32) B
33) D
34) A
35) B
36) C
37) E

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38) A
39) B
40) B
41) E
42) A
43) C
44) B
45) A
46) C
47) A
48) B
49) B
50) A
51) A
52) D
53) D
54) A
55) C
56) D
57) B
58) A
59) C
60) B
61) B
62) A
63) B
64) E
65) D
66) B
67) C
68) D
69) A
70) A
71) B
72) D
73) D
74) D
75) A
76) A
77) C

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78) C
79) C
80) A
81) B
82) A
83) B

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2026 Release

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Instructor's Manual

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Chapter 1
The Main Themes of Microbiology

This chapter introduces the student to the world of microbiology, both positive and detrimental aspects. The chapter reveals the scope of microbiology and gives a broad overview of the areas of science included in this topic. The student will receive an introduction to the history of microbiology, covering the major scientific contributions to the development of microbiology, including the development of the microscope and the formation of germ theory.

The student will also be introduced to the hierarchy of classification. The basis of taxonomy is discussed, and the order of assigning specific names is clearly presented. Different systems of classification are outlined, as well as the origin and evolution of microorganisms.

Learning Outcomes

1.1. List the seven types of microorganisms in the field of human health and disease.
1.2. Identify multiple professions using microbiology.
1.3. Describe the role and impact of microbes on the earth.
1.4. Explain the theory of evolution and why it is called a theory.
1.5. Explain one old way and one new way that humans manipulate organisms for their own uses.
1.6. Summarize the relative burden of human disease caused by microbes, emphasizing the differences between developed countries and developing countries.
1.7. Differentiate among bacteria, archaea, and eukaryotic microorganisms.
1.8. Identify two types of noncellular microorganisms.
1.9. Compare and contrast the relative sizes of the different microbes.
1.10. Make a time line of the development of microbiology from the 1600s to today.
1.11. List some recent microbiological discoveries of great impact.
1.12. Explain what is important about the scientific method.
1.13. Differentiate among the terms *nomenclature, taxonomy,* and *classification*.
1.14. Create a mnemonic device for remembering the taxonomic categories.
1.15. Correctly write the binomial name for a microorganism.
1.16. Draw a diagram of the three major domains.
1.17. Explain the difference between traditional and molecular approaches to taxonomy.

Chapter Outline

I. The Scope of Microbiology
   A. Organisms Too Small to be Seen Without Magnification
      1. Bacteria, archaea, viruses, fungi, protozoa, helminths, and prions
      2. Microbes are both easy and difficult to study
   B. Microbiology: A Sampler of Fields of Study
      1. Medical, agricultural, epidemiology, public health, immunology, and so on.

II. The Impact of Microbes on Earth: Small Organisms With a Giant Effect
   A. Bacteria and Archaea
   B. Eukaryotic Cells: 1 Billion Years Later
   C. Microbes Are Ubiquitous and Have Evolved
   D. Microbes Participate in Processes (decomposition, photosynthesis, etc.)

III. Human Use of Microorganisms
   A. Used for 1,000 of Years

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B. Biotechnology and Genetic Engineering
C. Bioremediation

IV. Infectious Diseases and the Human Condition
A. Pathogens
1. Vast majority no harm
2. 2000 different microbes can cause disease
B. Worldwide Infectious Disease Statistics
1. Infectious vs noninfectious diseases
2. Communicable and noncommunicable diseases
C. Disease Trends and Discoveries
D. Weakened Immune Systems

V. The General Characteristics of Microorganisms
A. Three Basic Cell Lines: Archaea, Bacteria (both akaryotes), and Eukaryotes
B. Cellular Organization
1. organelles
2. unicellular and multicellular
C. A Note on Viruses and Prions (noncellular microorganisms)

VI. The Historical Foundations of Microbiology
1. The development of the microscope
2. Spontaneous generation
3. Scientists
4. Connection between diseases and microbes
A. Recent Advances in Microbiology
1. Human microbiome
2. CRISPR
3. New akaryotic cells
4. mRNA vaccines
B. Microbiome: What is a Microbiome?
C. Scientific Method and Inductive and Deductive Reasoning
D. The Development of Medical Microbiology
1. Endospores and sterilization
2. Aseptic technique
3. Pathogens and germ theory of disease

VII. Naming, Classifying, and Identifying Microorganisms
A. Nomenclature: Scientific Names
1. Binomial system
2. *Genus & species*
B. Classification: Constructing Taxonomy
C. Origin and Evolution of Microorganisms
D. Universal Tree of Life
1. Five-kingdom system
2. Three-domain system

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Key Terms and Phrases

Microbiology
Microscopic
Microorganisms
Microbes
Bacteria
Viruses
Fungi
Protozoa
Helminths
Viruses
Prions
Public health
Epidemiology
Immunology
Industrial microbiology
Agricultural microbiology
Environmental microbiology
Archaea
Eukaryotes
Akaryotes
Ubiquitous
Evolution
Theory of evolution
Photosynthesis
Decomposition
Empirical
Genetic engineering
Recombinant DNA
Bioremediation
Pathogen
Eukarya
Virion
Abiogenesis
Biogenesis
Microbiome
Scientific method
Hypothesis
Deductive reasoning
Inductive reasoning
Theory
Sterile
Aseptic techniques
Germ theory of disease
Nomenclature
Taxonomy
Taxa
Phylogeny
Classification
Identification
Macroorganism
Binomial system
Domain
Kingdom
Phylum
Division
Class
Order
Family
Genus

High Impact Study: Concepts

1. The types of microorganisms studied in this text
2. The three biological cell types appearing in evolutionary history
3. The theory of evolution
4. The role of deduction in the scientific method
5. Spontaneous generation
6. Relative size of the different types of microorganisms
7. Phylogeny and taxonomy
8. The tree of life; the web of life

High Impact Study: Terms

1. Bacteria
2. Archaea
3. Eukaryote
4. Recombinant DNA technology
5. Bioremediation
6. Pathogen
7. Taxa
8. Nomenclature
9. Phylogeny
10. ssuRNA

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Topics for Discussion

1. Summarize the nature of the "candidate phyla radiation" (https://www.cell.com/current-biology/fulltext/S0960-9822(23)01679-2) and discuss how the discovery of these microorganisms may impact the classification and characterization of living and nonliving entities.
2. Considering the emergence and evolution of the SARS-CoV-2 virus, discuss emerging and reemerging infectious diseases.
3. Write a short paragraph on a topic in the field of applied microbiology.
4. Debate the benefits and the health risks of genetically modified organisms.
5. Discuss the impact of genetically modified organisms on the ecosystem.
6. Draw a concept map discussing the different subdisciplines in microbiology.
7. Draw a Venn diagram comparing the characteristics of living and nonliving entities.
8. Discuss how the understanding of germ theory has been applied in medical microbiology.
9. Discuss the benefit of using binomial nomenclature and Latin and Greek terms when naming organisms.
10. Discuss the advantages of relying on molecular biology to accurately classify species.
11. Discuss why the definition of species cannot be applied to all microorganisms.

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