Chapter 1 The Microbial World and You

Answers

Review

1. The observations of flies coming out of manure and maggots coming out of dead animals, and the appearance of microorganisms in liquids after a day or two, led people to believe that living organisms arose from nonliving matter.

2. Pasteur’s S-neck flasks allowed air to get into the beef broth, but the curves of the S trapped bacteria before they could enter the broth.

3. a. Certain microorganisms cause diseases in insects. Microorganisms that kill insects can be effective biological control agents because they are specific for the pest and do not persist in the environment.
   b. Carbon, oxygen, nitrogen, sulfur, and phosphorus are required for all living organisms. Microorganisms convert these elements into forms that are useful for other organisms. Many bacteria decompose material and release carbon dioxide into the atmosphere for plants to use. Some bacteria can take nitrogen from the atmosphere and convert it into a form that can be used by plants and other microorganisms.
   c. Normal microbiota are microorganisms that are found in and on the human body. They do not usually cause disease, and can be beneficial.
   d. Organic matter in sewage is decomposed by bacteria into carbon dioxide, nitrates, phosphates, sulfate, and other inorganic compounds in a wastewater treatment plant.
   e. Recombinant DNA techniques have resulted in insertion of the gene for insulin production into bacteria. These bacteria can produce human insulin inexpensively.
   f. Microorganisms can be used as vaccines. Some microbes can be genetically engineered to produce components of vaccines.

4. Matching
   
   a, c  Studies biodegradation of toxic wastes.
   h  Studies the causative agent of *Hantavirus* pulmonary syndrome.
   a, d, f  Studies the production of human proteins by bacteria.
   b  Studies the symptoms of AIDS.
   e  Studies the production of toxin by *E. coli*.
   c  Studies the life cycle of *Cryptosporidium*.
   b, d  Develops gene therapy for a disease.
   g  Studies the fungus *Candida albicans*. 
5. Matching

k_ Avery, MacLeod, and McCarty
n_ Beadle and Tatum
o_ Berg

q_ Ehrlich
c_ Fleming
i_ Hooke
j_ Iwanowski
b_ Jacob and Monod
a_ Jenner
l_ Koch
r_ Lancefield
d_ Lederberg and Tatum
g_ Lister
e_ Pasteur
f_ Stanley
h_ van Leeuwenhoek
m_ Virchow
p_ Weizmann

6. *Erwinia carotovora* is the correct way to write this scientific name. Scientific names can be derived from the names of scientists. In this case, *Erwinia* is derived from Erwin F. Smith, an American plant pathologist. Scientific names also can describe the organism, its habitat, or its niche. *E. carotovora* is a pathogen of carrots (*vora* = “eat”).

7. Matching

d_ Algae
g_ Archaea
c_ Bacteria
b_ Fungi
f_ Helminths
e_ Protozoa
a_ Viruses

8. a. *B. thuringiensis* is sold as a biological insecticide.
   b. *Saccharomyces* is the yeast sold for making bread, wine, and beer.
Chapter 2 Chemical Principles

Answers

Review

1. Atoms with the same atomic number and chemical behavior are classified as chemical elements.
2. Refer to Figure 2.1.
3. \(^{14}\text{C}\) and \(^{12}\text{C}\) are isotopes of carbon. \(^{12}\text{C}\) has 6 neutrons in its nucleus and \(^{14}\text{C}\) has 8 neutrons.
5. a. Ionic  
   b. Single covalent bond  
   c. Double covalent bonds  
   d. Hydrogen bond
6. \(10^4\) or 10,000 times.
7. Element | Atomic Weight | Number of Atoms | Total Weight of That Element
           |             |                |                          |
           | C           | 12             | 6 | = | 72 |
           | H           | 1              | 12 | = | 12 |
           | O           | 16             | 6 | = | 96 |

The molecular weight of \(\text{C}_6\text{H}_{12}\text{O}_6\) is 180 grams.
8. a. Synthesis reaction, condensation, or dehydration  
    b. Decomposition reaction, digestion, or hydrolysis  
    c. Exchange reaction  
    d. Reversible reaction
9. The enzyme lowers the activation energy required for the reaction, and therefore speeds up this decomposition reaction.
10. a. Lipid  
    b. Protein  
    c. Carbohydrate  
    d. Nucleic acid
11. a. Acetic acid  
   b. Ethyl alcohol  
   c. Acetaldehyde  
   d. Ethanolamine  
   e. Diethylether

12. a. Amino acids  
   b. Right to left  
   c. Left to right
13. Breaking of bonds between phosphorus and oxygen. These are covalent bonds.
14. The entire protein shows tertiary structure. No quaternary structure.

Multiple Choice

Chapter 2
1. c
2. b
3. b
4. e
5. b
6. c
7. a
8. a
9. b
10. c
Chapter 3 Observing Microorganisms
Through a Microscope

Answers

1. 1 µm = 10⁻⁶ m
   1 nm = 10⁻⁹ m
   1 µm = 10³ nm

2. a. Ocular lens
   b. Objective lens
   c. Diaphragm
   d. Condensor
   e. Illuminator

3. Ocular lens magnification × oil immersion lens magnification = total magnification of specimen
   \[ 10\times \times 100\times = 1000\times \]

4. a. Compound light microscope
   b. Darkfield microscope
   c. Phase-contrast microscope
   d. Fluorescence microscope
   e. Electron microscope
   f. Differential interference contrast microscope

5. . . . that a beam of electrons focused by magnets . . . on a television-like screen or photographic plate.

6. Type of Microscope | Maximum Magnification | Resolution
    Compound light   | 2,000×              | 0.2 µm
    Electron         | 100,000×            | 0.0025 µm

7. Bacterial cells have a slightly negative charge, and the colored positive ion of a basic dye is attracted to the negative charge of the cell. Acid dyes do not stain bacterial cells because the negatively charged colored ion is repelled by the like charge of the cell.

8. a. A simple stain is used to determine cell shape and arrangement.
   b. A differential stain is used to distinguish kinds of bacteria based on their reaction to the differential stain.
   c. A negative stain does not distort the cell and is used to determine cell shape, size, and the presence of a capsule.
   d. A flagella stain is used to determine the number and arrangement of flagella.
9. In a Gram stain, the mordant combines with the basic dye to form a complex that will not wash out of gram-positive cells. In a flagella stain, the mordant accumulates on the flagella so that they can be seen with a light microscope.

10. A counterstain stains the colorless non–acid-fast cells so that they are easily seen through a microscope.

11. In the Gram stain, the decolorizer removes the color from gram-negative cells. In the acid-fast stain, the decolorizer removes the color from non–acid-fast cells.

12. Endospore: safranin is the \textit{counterstain}.
   
   Gram: safranin is the \textit{counterstain}.

13. 

\begin{center}
\begin{tabular}{l l l}
\hline
Steps & Gram-positive cells & Gram-negative cells \\
\hline
Crystal violet & Purple & Purple \\
Iodine & Purple & Purple \\
Alcohol-acetone & Purple & Colorless \\
Safranin & Purple & Red \\
\hline
\end{tabular}
\end{center}

\textbf{Multiple Choice}

\textbf{Chapter 3}

1. e
2. c
3. b
4. a
5. a
6. e
7. d
8. b
9. a
10. c
Chapter 4 Functional Anatomy of Prokaryotic and Eukaryotic Cells

Answers

Review

1. a. 
   b. 
   c. 

2. Endospore formation is called sporogenesis. It is initiated by certain adverse environmental conditions. Formation of a new cell from an endospore is called germination. This process is triggered by favorable growth conditions.

3. 
   a. 
   b. 
   c. 
   d. 
   e. 
   f. 

4. Matching
   d Cell wall
   f Endospore
   a Fimbriae
   c Flagella
   a, e Glycocalyx
5. An endospore is called a resting structure because it is a method of one cell “resting,” or surviving, as opposed to growing and reproducing. The protective endospore wall allows a bacterium to withstand adverse conditions in the environment.

6. a. Both allow materials to cross the plasma membrane from a high concentration to a low concentration without expending energy. Facilitated diffusion requires carrier proteins.
   b. Both require enzymes to move materials across the plasma membrane. In active transport, energy is expended.
   c. Both move materials across the plasma membrane with an expenditure of energy. In group translocation, the substrate is changed after it crosses the membrane.

7. Mycoplasmas do not have cell walls.

8. a. Both lack cell walls. A spheroplast is a gram-negative cell whose wall has been destroyed by lysozyme. An L form is a cell that is not synthesizing a complete wall.
   b. Both lack cell walls. Mycoplasmas do not normally (genetically) make walls. L forms do not make walls because of environmental reasons, e.g., penicillin.

9. a. Diagram (a) refers to a gram-positive bacterium because the lipopolysaccharide–phospholipids–lipoprotein layer is absent.
   b. The gram-negative bacterium initially retains the violet stain, but it is released when the outer membrane is dissolved by the decolorizing agent. After the dye–iodine complex enters, it becomes trapped by the peptidoglycan of gram-positive cells.
   c. The outer layer of the gram-negative cells prevents penicillin from entering the cells.
   d. Essential molecules diffuse through the gram-positive wall. Porins and specific channel proteins in the gram-negative outer membrane allow passage of small water-soluble molecules.
   e. Gram-negative.

10. An extracellular enzyme (amylase) hydrolyzes starch into disaccharides (maltose) and monosaccharides (glucose). A carrier enzyme (maltase) hydrolyzes maltose and moves one glucose into the cell. Glucose can be transported by group translocation as glucose-6-phosphate.

11. Matching
   - c Centriole
   - d Chloroplasts
   - g Golgi complex
   - a Lysosomes
   - f Mitochondria
   - b Peroxisomes
   - e Rough ER

12. A mitochondrion is an example of an organelle that resembles a prokaryotic cell. The inner membrane of a mitochondrion is arranged in folds similar to mesosomes. ATP is generated on this membrane just as it is in prokaryotic plasma membranes. Mitochondria can reproduce by binary fission, and they contain circular DNA and 70S ribosomes.

14. Erythromycin inhibits protein synthesis in a prokaryotic cell; it will inhibit protein synthesis in mitochondria and chloroplasts.

**Multiple Choice**

Chapter 4
1. e
2. d
3. b
4. a
5. d
6. e
7. b
8. e
9. a
10. b

**Chapter 5 Microbial Metabolism**

**Answers**

**Review**

1. Metabolism is the sum of all chemical reactions that occur within a living organism.
2. Catabolic reactions break down organic compounds and release energy, while anabolic reactions use the products of catabolism and energy to build cell material.

3. ![Diagram of enzyme, substrate, competitive inhibitor, and noncompetitive inhibitor]

4. a. When the enzyme and substrate combine, the substrate molecule will be transformed.
   b. When the competitive inhibitor binds to the enzyme, the enzyme will not be able to bind with the substrate.
   c. When the noncompetitive inhibitor binds to the enzyme, the active site of the enzyme will be changed so the enzyme cannot bind with the substrate.
   d. The noncompetitive inhibitor.

5. (a) is the Calvin–Benson cycle, (b) is glycolysis, and (c) is the Krebs cycle.

6. Glycerol is catabolized by pathway (b) as dihydroxyacetone phosphate. Fatty acids by pathway (c) as acetyl groups.
7. In pathway (c) at $\alpha$-ketoglutaric acid.

8. Glyceraldehyde-3-phosphate from the Calvin–Benson cycle enters glycolysis. Pyruvic acid from glycolysis is decarboxylated to produce acetyl for the Krebs cycle.

9. In (a), between glucose and glyceraldehyde-3-phosphate.

10. The conversion of pyruvic acid to acetyl, isocitric acid to $\alpha$-ketoglutaric acid, and $\alpha$-ketoglutaric acid to succinyl-CoA.

11. By pathway (c) as acetyl groups.

<table>
<thead>
<tr>
<th>Uses</th>
<th>Produces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calvin–Benson cycle</td>
<td>6 NADPH</td>
</tr>
<tr>
<td>Glycolysis</td>
<td>2 NADH</td>
</tr>
<tr>
<td>Pyruvic acid $\rightarrow$ acetyl</td>
<td>1 NADH</td>
</tr>
<tr>
<td>Isocitric acid $\rightarrow$ $\alpha$-ketoglutaric acid</td>
<td>1 NADH</td>
</tr>
<tr>
<td>$\alpha$-ketoglutaric acid $\rightarrow$ Succinyl-CoA</td>
<td>1 NADH</td>
</tr>
<tr>
<td>Succinic acid $\rightarrow$ Fumaric acid</td>
<td>1 FADH$_2$</td>
</tr>
<tr>
<td>Malic acid $\rightarrow$ Oxaloacetic acid</td>
<td>1 NADH</td>
</tr>
</tbody>
</table>

13. Dihydroxyacetone phosphate; acetyl; oxaloacetic acid; $\alpha$-ketoglutaric acid.

14. The optimum temperature for an enzyme is one that favors movement of molecules so the enzyme can “find” its substrate. Lower temperatures will decrease the rate of collisions and the rate of reactions. Increased temperatures will denature the enzyme.

15. Ethyl alcohol, lactic acid, butyl alcohol, acetone, and glycerol are some of the possible products. Refer to Table 5.4 and Figure 5.18b.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Carbon Source</th>
<th>Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photoautotroph</td>
<td>CO$_2$</td>
<td>Light</td>
</tr>
<tr>
<td>Photoheterotroph</td>
<td>Organic molecules</td>
<td>Light</td>
</tr>
<tr>
<td>Chemoautotroph</td>
<td>CO$_2$</td>
<td>Inorganic molecules</td>
</tr>
<tr>
<td>Chemo heterotroph</td>
<td>Organic molecules</td>
<td>Organic molecules</td>
</tr>
</tbody>
</table>

17. ATP generated by Reaction

**Photophosphorylation**
An electron, liberated from chlorophyll by light, is passed down an electron transport chain.

**Oxidative phosphorylation**
Cytochrome c passes two electrons to cytochrome a.

**Substrate-level phosphorylation**

\[
\text{Phosphoenolpyruvic acid} \xrightarrow{\text{CH}_3} \text{Pyruvic acid}
\]
18. a. Oxidation–reduction: A coupled reaction in which one substance is oxidized and one is reduced.
   b. The final electron acceptor in aerobic respiration is molecular oxygen; in anaerobic respiration, it is another inorganic molecule.
   c. In cyclic photophosphorylation, electrons are returned to chlorophyll. In noncyclic photophosphorylation, chlorophyll receives electrons from hydrogen atoms.

19. The pentose phosphate pathway produces pentoses for the synthesis of nucleic acids, precursors for the synthesis of glucose by photosynthesizing organisms, precursors in the synthesis of certain amino acids, and NADPH.

20. Oxidation

21. Reactions requiring ATP are coupled with reactions that produce ATP.

22.

The reaction rate will increase until the enzymes are saturated.

**Multiple Choice**

**Chapter 5**

1. a
2. d
3. b
4. c
5. c
6. b
7. b
8. a
9. c
10. b
Chapter 6 Microbial Growth

Answers

Review

1. In binary fission, the cell elongates and the chromosome replicates. Next, the nuclear material is evenly divided. The plasma membrane invaginates toward the center of the cell. The cell wall thickens and grows inward between the membrane invaginations; two new cells result.

2. Refer to Figure 6.14. The period of no cell division is called lag phase. During lag phase, the bacteria are synthesizing enzymes that are necessary for growth. In log phase, the cells are dividing at the maximum rate under the conditions provided. The number of cells dividing equals the number of cells dying in stationary phase. When the number of deaths exceeds the number of divisions, death phase is observed.

3. Carbon (C) is required for synthesis of molecules that make up a living cell. Carbon-containing compounds also are required as an energy source for heterotrophs.

4. Most bacteria grow best between pH 6.5 and 7.5.

5. The addition of salt or sugar to foods increases the osmotic pressure for microorganisms on the food. The resulting hypertonic environment causes plasmolysis of the microbial cells.

6. a. Catalyzes the breakdown of H₂O₂ to O₂ and H₂O.
   b. H₂O₂; peroxide ion is O₂²⁻.
   c. Catalyzes the breakdown of H₂O₂;
   d. O₂⁻·; this diatom has one unpaired electron.
   e. Converts superoxide to O₂ and H₂O₂;

7. Both environments prevent molecular oxygen from reaching the bacterial cells. In reducing media, thioglycolate combines with dissolved oxygen, thereby removing it from the medium. In an anaerobic incubator, air is replaced with an atmosphere of CO₂ (and N₂). Clostridium is an obligate anaerobe that lacks superoxide dismutase and catalase. Consequently, the accumulation of superoxides and peroxides will kill the cell in an aerobic environment.

8. Direct methods are those in which the microorganisms are seen and counted. Direct methods are direct count, standard plate count, filtration, and most probable number.

9. The growth rate of bacteria slows down with decreasing temperatures. Mesophilic bacteria will grow slowly at refrigeration temperatures and will remain dormant in a freezer. Bacteria will not spoil food quickly in a refrigerator.

10. Number of cells \( \times 2^n \text{ generations} = \) Total number of cells
    \[
    6 \times 2^7 = 768
    \]

11. Petroleum can meet the carbon and energy requirements for an oil-degrading bacterium; however, nitrogen and phosphate are usually not available in large quantities. Nitrogen and phosphate are essential for making proteins, phospholipids, nucleic acids, and ATP.

12. A chemically defined medium is one in which the exact chemical composition is known. A complex medium is one in which the exact chemical composition is not known.
Multiple Choice

Chapter 6
1. c
2. a
3. c
4. a
5. c
6. d
7. e
8. a
9. b
10. b

Chapter 7 The Control of Microbial Growth

Answers

Review
1. a. Lysis.
   b. Altered permeability and leakage of cell contents.
   c. Destruction of enzymes and structural proteins such as those in the plasma membrane.
   d. Interference with protein synthesis and cell division.
2. Autoclave. Due to the high specific heat of water, moist heat is readily transferred to cells.
3. Most organisms that cause disease or rapid spoilage of food are destroyed by pasteurization.

4. Variables that affect determination of the thermal death point are
   a. The innate heat resistance of the strain of bacteria.
   b. The past history of the culture, whether it was freeze-dried, wetted, etc.
   c. The clumping of the cells during the test.
   d. The amount of water present.
   e. The organic matter present.
   f. Media and incubation temperature used to determine viability of the culture after heating.

5. a. Ionizing radiation can break DNA directly. However, due to the high water content of cells, the
    formation of free radicals (H· and OH·) that break DNA strands is likely to occur.
   b. Ultraviolet radiation damages DNA by the formation of thymine dimers.

6. Microorganisms tend to die at a constant rate over a period of time. The constant rate is indicated
   by the straight line after exposure to the bactericidal compound.

7.

<table>
<thead>
<tr>
<th>Sterilization Method</th>
<th>Temp.</th>
<th>Time</th>
<th>Type</th>
<th>Preferred Use</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autoclaving</td>
<td>121°C</td>
<td>15 min</td>
<td>Moist</td>
<td>Media, equipment</td>
<td>Protein denaturation</td>
</tr>
<tr>
<td>Hot air</td>
<td>170°C</td>
<td>2 hr</td>
<td>Dry</td>
<td>Glassware</td>
<td>Oxidation</td>
</tr>
<tr>
<td>Pasteurization</td>
<td>72°C</td>
<td>15 sec</td>
<td>Moist</td>
<td>Milk, alcoholic drinks</td>
<td>Protein denaturation</td>
</tr>
</tbody>
</table>

8. All three processes kill microorganisms; however, as moisture and/or temperatures are increased,
   less time is required to achieve the same result.

9. Salts and sugars create a hypertonic environment. Salts and sugars (as preservatives) do not directly
   affect cell structures or metabolism; instead, they alter the osmotic pressure. Jams and jellies are pre-
   served with sugar; meats are usually preserved with salt. Molds are more capable of growth in high
   osmotic pressure than bacteria.

    2. Attacks all, or a wide range of, microbes.
    3. Is able to penetrate.
    4. Readily mixes with water.
    5. Is not hampered by organic matter.
    7. Does not stain or corrode.
    8. Nontoxic.
    10. Economical.
    11. Safe to transport.
11. 

<table>
<thead>
<tr>
<th>Method of Action</th>
<th>Standard Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Disrupts plasma membrane</td>
<td>Skin surfaces</td>
</tr>
<tr>
<td>b. Inhibits protein function</td>
<td>Antiseptic</td>
</tr>
<tr>
<td>c. Oxidation</td>
<td>Disinfect water</td>
</tr>
<tr>
<td>d. Denatures proteins, destroys lipids</td>
<td>Skin surfaces</td>
</tr>
<tr>
<td>e. Oligodynamic</td>
<td>AgNO₃ to prevent gonococcal eye infections</td>
</tr>
<tr>
<td>f. Inactivation of proteins</td>
<td>Chemical sterilizer</td>
</tr>
<tr>
<td>g. Denatures proteins</td>
<td>Chemical sterilizer</td>
</tr>
<tr>
<td>h. Oxidation</td>
<td>Antiseptic</td>
</tr>
</tbody>
</table>

12. Disinfectant B is preferable because it can be diluted more and still be effective.

13. Quaternary ammonium compounds are most effective against gram-positive bacteria. Gram-negative bacteria that were stuck in cracks or around the drain of the tub would not have been washed away when the tub was cleaned. These gram-negative bacteria could survive the washing procedure. Some pseudomonads can grow on quats that have accumulated.

**Multiple Choice**

**Chapter 7**

1. d
2. b
3. d
4. d
5. b
6. b
7. b
8. a
9. a
10. b

**Chapter 8 Microbial Genetics**

**Answers**

**Review**

1. DNA consists of a strand of alternating sugars (deoxyribose) and phosphate groups with a nitrogenous base attached to each sugar. The bases are adenine, thymine, cytosine, and guanine. DNA exists in a cell as two strands twisted together to form a double helix. The two strands are held together by hydrogen bonds between their nitrogenous bases. The bases are paired in a specific, complementary way: A-T and C-G. The information held in the sequence of nucleotides in DNA is the basis for synthesis of RNA and proteins in a cell.
2. a. DNA polymerases synthesize a complementary strand of DNA from a DNA template. RNA polymerase starts each fragment of the lagging strand with an RNA primer.
   b. Each new double-stranded DNA molecule contains one original strand and one new strand.

3. a. ATATTACTTTGCATGGACT.
   b. met-lys-arg-thr-(end).
   c. TATAATGAAACGTTCCTGA.
   d. No change.
   e. Cysteine substituted for arginine.
   f. Proline substituted for threonine (missense mutation).
   g. Frameshift mutation.
   h. Adjacent thymines might polymerize.
   i. ACT.

4. One end of the mRNA molecule becomes associated with a ribosome. Ribosomes are composed of rRNA and protein. The anticodon of a tRNA with its activated amino acid pairs with the mRNA codon at the ribosome.

5. A mutant is isolated by direct selection because it grows on a particular medium. The colonies on an antibiotic-containing medium can be identified as resistant to that antibiotic.
   A mutant is isolated by indirect selection because it does not grow on a particular medium. Replica plating could be employed to inoculate an antibiotic-containing medium. Colonies that did not grow on this medium can be isolated from the original plate and are antibiotic sensitive.

6. Matching
   b. A mutagen that is incorporated into DNA in place of a normal base.
   d. A mutagen that causes the formation of highly reactive ions.
   c. A mutagen that alters adenine so that it base-pairs with cytosine.
   a. A mutagen that causes insertions.
   e. A mutagen that causes the formation of pyrimidine dimers.

7. The basis for the Ames test is that a mutated cell can revert to a cell resembling the original, non-mutant cell by undergoing another mutation. The reversion rate of histidine auxotrophs of *Salmonella* in the presence of a mutagen will be higher than the spontaneous rate (in the absence of a mutagen).
8. Plasmids are small, self-replicating circles of DNA that are not associated with the chromosome. The F plasmid can be integrated into the chromosome. The F plasmid can be transferred from a donor to a recipient cell in conjugation. When the F plasmid becomes integrated into the chromosome, the cell is called an Hfr. During conjugation between an Hfr and an F cell, the chromosome of the Hfr cell, with its integrated F factor, replicates, and the new copy of the chromosome is transferred to the recipient cell.

9. a. ... a repressor protein must be bound tightly to the operator site ... it will bind to the repressor so that transcription can occur.
   b. ... called a corepressor, causes the repressor to bind to the operator. Derepression is by removal of the corepressor, C in this case, when the corepressor is needed in the cell.
   c. None; constitutive enzymes are produced at certain necessary levels regardless of the amount of substrate or end-product.

10. Light repair; dark repair; proofreading by DNA polymerase.

11. a. The genetic makeup of an organism.
    b. The external manifestations of the genotype.
    c. Rearrangement of genes to form new combinations; in nature, this usually occurs between members of the same species; in vitro, recombinant DNA is made from genes of different species.

12. CTTTGA. Endospores and pigments offer protection against UV radiation. Additionally, repair mechanisms can remove and replace thymine polymers.

13. a. Culture 1 will remain the same. Culture 2 will convert to F+ but will have its original genotype.
    b. The donor and recipient cells’ DNA can recombine to form combinations of A+B+C+ and A−B−C−. If the F plasmid also is transferred, the recipient cell may become F+.

14. Semiconservative replication ensures the offspring cell will have one correct strand of DNA. Any mutations that may have occurred during DNA replication have a greater chance of being correctly repaired.

15. Mutation and recombination provide genetic diversity. Environmental factors select for the survival of organisms through natural selection. Genetic diversity is necessary for the survival of some organisms through the processes of natural selection. Organisms that survive may undergo further genetic change, resulting in the evolution of the species.

Multiple Choice

Chapter 8

1. c
2. d
3. c
4. d
5. c
6. b
7. a
8. c
9. d
10. a
Chapter 9 Biotechnology and Recombinant DNA

Answers

Review

1. Recombinant DNA (rDNA) is DNA that is combined from different sources. In nature, rDNA results from conjugation, transduction, and transformation. Genetic engineering is the artificial making of rDNA.

2. a. Both are DNA. cDNA is a segment of DNA made by RNA-dependent DNA polymerase. It is not necessarily a gene; a gene is a transcribable unit of DNA that codes for protein or RNA.

   b. Both are DNA. A restriction fragment is a segment of DNA produced when a restriction endonuclease hydrolyzes DNA. It is not usually a gene; a gene is a transcribable unit of DNA that codes for protein or RNA.

   c. Both are DNA. A DNA probe is a short, single-stranded piece of DNA. It is not a gene; a gene is a transcribable unit of DNA that codes for protein or RNA.

   d. Both are enzymes. DNA polymerase synthesizes DNA one nucleotide at a time using a DNA template; DNA ligase joins pieces (strands of nucleotides) together.

   e. Both are DNA. Recombinant DNA results from joining DNA from two different sources; cDNA results from copying a strand of RNA.

   f. The proteome is the expression of the genome. An organism’s genome is one complete copy of its genetic information. The proteins encoded by this genetic material comprise the proteome.

3. a. A desired gene can be spliced into a plasmid and inserted into a cell by transformation.

   b. A desired gene can be spliced into a viral genome and inserted into a cell by transduction.

   c. Antibiotic resistance genes are used as markers or labels on plasmids so that the cell containing the plasmid can be found by direct selection on an antibiotic-containing medium.

   d. A genetically engineered bacterium should be producing a new protein product. Radioactively labeled antibodies against a specific protein can be used to locate the bacterial colony producing the protein.

4. Restriction fragments from one source can be cloned in microbial cells to make a gene library. Synthetic DNA is made in a lab.

5. In protoplast fusion, two wall-less cells fuse together to combine their DNA. A variety of genotypes can result from this process. In b, c, and d, specific genes are inserted directly into the cell.

6. BamHI, EcoRI, and HindIII make sticky ends. Fragments of DNA produced with the same restriction enzyme will spontaneously anneal to each other at their sticky ends.

7. The gene can be spliced into a plasmid and inserted into a bacterial cell. As the cell grows, the number of plasmids will increase. The polymerase chain reaction can make copies of a gene using DNA polymerase in vitro.

8. In a eukaryotic cell, RNA polymerase copies DNA; RNA processing removes the introns, leaving the exons in the mRNA. cDNA can be made from the mRNA by reverse transcriptase.


10. You probably used a few plant cells in a Petri plate for your experiment. How will you select the plant cells that actually have the new Ti plasmid? You can grow these cells on plant-cell culture media with tetracycline. Only the cells with the new plasmid will grow.
Multiple Choice

Chapter 9

1. b
2. b
3. b
4. b
5. c
6. d
7. c
8. b
9. e
10. a

Chapter 10 Classification of Microorganisms

Answers

Review

1. Taxonomy is the science of classifying organisms to establish the relatedness between groups of organisms.

2. The three distinct chemical types of cells (see Table 10.1).

3. Living organisms cannot be grouped into two groups. For example, plant and animal is not acceptable because if fungi are grouped with plants, the definition of plants can’t include cellulose and photosynthesis. If fungi are grouped with animals, the definition of animals can’t include no cell wall and ingestive. The goal is to look for a “natural” scheme; that is, what criteria can be used to characterize all organisms.

4. Fungi: Unicellular or multicellular organisms that absorb organic nutrients; noncellulose cell walls; lack flagella.

   Plantae: Multicellular eukaryotes with tissue formation; cellulose cell walls; generally photosynthetic.

   Animalia: Multicellular eukaryotes with tissue formation; develop from an embryo (gastrula); lacking cell walls; ingest organic nutrients through a mouth of some kind.

5. a. Both are prokaryotic. They differ in composition of their cell walls, plasma membranes, and rRNAs.
   b. Both are bound by ester-linked plasma membranes. Eukarya have membrane-bound organelles.
   c. Both use methionine as the start signal. Eukarya have membrane-bound organelles and ester-linked membranes.

6. Binomial nomenclature is the system of assigning a genus and specific epithet to each organism.

7. Common names are not specific and can be misleading. According to the rules of scientific nomenclature, each organism has only one binomial.

8. The genus name must be written out so the reader knows what organism is being discussed, since the abbreviation for both of these species is E. coli.

9. Domain, kingdom, phylum, class, order, family, genus, species.
10. Domain: Bacteria
    Phylum: Firmicutes
    Class: Bacilli
    Order: Bacillales
    It is more related to *Gemella*. Family: Staphylococcaceae

11. A eukaryotic species is a group of closely related organisms having limited geographical distribution that interbreeds but does not breed with other species. Species can be distinguished morphologically. Because of the distinct differences between eukaryotic organisms and bacteria, a bacterial species is defined as a population of cells with similar characteristics. A viral species is a population of viruses with similar characteristics that occupies a particular ecological niche.

12. (See Table 10.5)
    Used primarily for identification:
    morphological characteristics
    differential staining
    biochemical tests
    serology
    phage typing
    fatty acid profiles
    Used primarily for taxonomic classification:
    flow cytometry
    DNA base composition
    DNA fingerprinting
    rRNA sequencing
    PCR
    nucleic acid hybridization
    Data obtained from laboratory tests employing any (or all) of these twelve techniques can be assimilated using numerical taxonomy to provide information on classification.

13. Most microorganisms do not contain structures that are readily fossilized, making it difficult to obtain information on the evolution of microorganisms. Recent developments in molecular biology have provided techniques for determining evolutionary relationships amongst bacteria.

14. A and D appear to be most closely related because they have similar G-C moles %. No two are the same species.

**Multiple Choice**

Chapter 10

1. b
2. e
3. d
4. b
5. e
6. a
7. a
8. e
9. a
10. b
Chapter 11 The Prokaryotes: Domains Bacteria and Archaea

Answers

Review

1. I. Gram-positive
   A. Endospore-forming rod
      1. *Clostridium*
      2. *Bacillus*
   B. Non-endospore-forming
      1. Cells are rods
         a. *Streptomyces*
         b. *Mycobacterium*
      2. Cells are cocci
         a. *Streptococcus*
         b. *Staphylococcus*

II. Gram-negative
   A. Cells are helical or curved
      1. *Treponema*
      2. *Spirillum*
   B. Cells are rods
      1. *Pseudomonas*
      2. *Escherichia*

III. Lack of cell walls
   A. *Mycoplasma*
   B. *Chlamydia*

IV. Obligate intracellular parasites
   A. *Rickettsia*
   B. *Coxiella*

2. a. Both are oxygenic photoautotrophs. Cyanobacteria are prokaryotes; algae are eukaryotes.
   b. Both are chemoheterotrophs capable of forming mycelia; some form conidia. Actinomycetes are prokaryotes; fungi are eukaryotes.
   c. Both are large rod-shaped bacteria. *Bacillus* forms endospores, *Lactobacillus* is a fermentative non-endospore-forming rod.
   d. Both are small rod-shaped bacteria. *Pseudomonas* has an oxidative metabolism; *Escherichia* is fermentative. *Pseudomonas* has polar flagella; *Escherichia* has peritrichous flagella.
   e. Both are helical bacteria. *Leptospira* (a spirochete) has an axial filament. *Spirillum* has flagella.
   f. Both are gram-negative, rod-shaped bacteria. *Escherichia* are facultative anaerobes, and *Bacteroides* are anaerobes.
   g. Both are obligatory intracellular parasites.
   h. Both lack peptidoglycan cell walls. *Ureaplasmata* are archaea; *Mycoplasma* are bacteria (see Table 10.2).
3. **Matching**

Nitrogen-fixing (d) *Frankia*

Anoxygenic (i) Purple bacteria

Oxyergic (a) Cyanobacteria

Oxidize NO₂⁻ (h) *Nitrobacter*

Reduce CO₂ (f) Methanogens

Slime layer (b) *Cytophaga* and (g) Myxobacteria

Myxocysts (g) Myxobacteria

Anaerobic (c) *Desulfovibrio*

Thermophilic (k) *Sulfolobus*

Filaments (j) *Sphaerotilus*

Projections (e) *Hyphomicrobiuim*

---

**Multiple Choice**

Chapter 11

1. d

2. b

3. e

4. a

5. b

6. d

7. e

8. b

9. b

10. a

---

**Chapter 12 The Eukaryotes: Fungi, Algae, Protozoa, and Helminths**

**Answers**

**Review**

1. Conidiospores are asexual spores formed by the aerial mycelia of one organism. Ascospores are sexual spores resulting from the fusion of the nuclei of two opposite mating strains of the same species of fungus.
2. **Spore Type(s)**

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Asexual</th>
<th>Sexual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zygomycota</td>
<td>Zygospore</td>
<td>Sporangiospore</td>
</tr>
<tr>
<td>Ascomycota</td>
<td>Blastoconidia, Arthrospore</td>
<td>Ascospore</td>
</tr>
<tr>
<td>Basidiomycota</td>
<td>Blastoconidia</td>
<td>Basidiospore</td>
</tr>
</tbody>
</table>

3. **Genus**

<table>
<thead>
<tr>
<th></th>
<th><strong>Mycosis</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Blastomyces</td>
<td>Systemic</td>
</tr>
<tr>
<td>Sporothrix</td>
<td>Subcutaneous</td>
</tr>
<tr>
<td>Microsporum</td>
<td>Cutaneous</td>
</tr>
<tr>
<td>Trichosporon</td>
<td>Superficial</td>
</tr>
<tr>
<td>Aspergillus</td>
<td>Systemic</td>
</tr>
</tbody>
</table>

4. a. *E. coli*  
   b. *P. chrysogenum*

5. The alga produces carbohydrates for the lichen, and the fungus provides both the holdfast and protection from desiccation.

6. As the first colonizers on newly exposed rock or soil, lichens are responsible for the chemical weathering of large inorganic particles and the consequent accumulation of soil.

7. **Phylum**

<table>
<thead>
<tr>
<th>Cell wall composition</th>
<th>Special features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oomycetes</td>
<td>Chitin</td>
</tr>
<tr>
<td>Dinoflagellates*</td>
<td>Cellulose and silica</td>
</tr>
<tr>
<td>Diatoms*</td>
<td>Pectin and silica</td>
</tr>
<tr>
<td>Red algae</td>
<td>Cellulose</td>
</tr>
<tr>
<td>Brown algae</td>
<td>Cellulose and alginic acid</td>
</tr>
<tr>
<td>Green algae</td>
<td>Cellulose</td>
</tr>
</tbody>
</table>

*Unicellular

The green algae (Chlorophyta) could be placed in the plant kingdom. They have chlorophyll b, as do land plants, and have colonial forms. In the most advanced colonial form (*Volvox*), groups of *Chlamydomonas*-like cells live together; some are specialized for reproductive functions, which suggests a possible evolutionary route for the formation of plant tissue. The other algae are most often classified as protists.

8. Cellular slime molds exist as individual amoeboïd cells. Plasmodial slime molds are multinucleate masses of protoplasm. Both survive adverse environmental conditions by forming spores.

9. Complete the following table.
<table>
<thead>
<tr>
<th>Phylum</th>
<th>Method of Motility</th>
<th>One Human Parasite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaezoa</td>
<td>Flagella</td>
<td>Giardia</td>
</tr>
<tr>
<td>Microsporidia</td>
<td>None</td>
<td>Nosema</td>
</tr>
<tr>
<td>Rhizopoda</td>
<td>Pseudopods</td>
<td>Entamoeba</td>
</tr>
<tr>
<td>Apicomplexa</td>
<td>None</td>
<td>Plasmodium</td>
</tr>
<tr>
<td>Ciliophora</td>
<td>Cilia</td>
<td>Balantidium</td>
</tr>
<tr>
<td>Euglenozoa</td>
<td>Flagella</td>
<td>Trypanosoma</td>
</tr>
</tbody>
</table>

10. *Trichomonas* cannot survive for long outside of a host because it does not form a protective cyst. *Trichomonas* must be transferred from host to host quickly.

11. Asexual reproduction occurs in the human host and sexual reproduction takes place in the mosquito. The definitive host and the vector are the mosquito.

12. Ingestion.

13. This is a cestode. The encysted larva is called a cisticercus. Tapeworms are dorsoventrally flattened and have an incomplete digestive system.

14. The male reproductive organs are in one individual, and the female reproductive organs in another. Nematodes belong to the Phylum Aschelminthes.

15. | Vector Type                                      | Example | Disease       |
    |-------------------------------------------------|---------|---------------|
    | Mechanical                                      | Housefly| Salmonellosis |
    | Suitable for reproduction of parasite           | *Ixodes*| Lyme disease  |
    | As a host                                       | *Anopheles* | Malaria     |

**Multiple Choice**

Chapter 12

1. c
2. b
3. b
4. a
5. d
6. b
7. a
8. c
9. a
10. d
Chapter 13 Viruses, Viroids, and Prions

Answers

Review

1. The term filterable describes the property of passing through filters that retain bacteria. Viruses are too small to be seen with a light microscope, but their presence is known because material passed through a filter is still capable of causing a disease.

2. Viruses absolutely require living host cells to multiply.

3. A virus:
   a. Contains DNA or RNA;
   b. Has a protein coat surrounding the nucleic acid;
   c. Multiplies inside a living cell using the synthetic machinery of the cell; and
   d. Causes the synthesis of virions. A virion is a fully developed virus particle that transfers the viral nucleic acid to other cells and initiates multiplication.

4. The capsid of a helical virus is a hollow cylinder with a helical shape, which surrounds the nucleic acid (see Figure 13.4). An example of a helical virus is tobacco mosaic virus. Polyhedral viruses are many-sided (Figure 13.2). A polyhedral virus in the shape of an icosahedron is adenovirus. Polyhedral or helical viruses surrounded by an envelope are called enveloped viruses. An example of an enveloped helical virus is *Influenzavirus* (Figure 13.3), and herpes simplex is an enveloped polyhedral virus.

5. A sample of bacteriophage is mixed with host bacteria and melted nutrient agar. The mixture is then poured over a layer of nutrient agar in a Petri plate. Each phage infects a bacterium, multiplies, and releases new phages. These newly produced phages infect other bacteria, and more new viruses are produced. Following multiplication, the bacteria are destroyed. This produces a number of clearings or plaques in the layer of bacteria. The number of phages in the original sample can be estimated by counting the number of plaques.

6. Primary cell lines tend to die after a few generations. Continuous cell lines can be maintained through an indefinite number of generations. Continuous cell lines then allow long-term observations of viruses. Continuous cell lines are transformed cells.

7. A prophage gene codes for the cholera toxin. When phage DNA is incorporated into the cell’s DNA, toxin can be produced.

8. Adsorption: The virus attaches to the cell membrane by means of spikes located on its envelope.
   Penetration: The virus gains entrance by piriocytosis, or its envelope may fuse with the plasma membrane of the host cell, allowing the virus to enter the cell.
   Uncoating: Uncoating refers to the separation of the capsid from the viral DNA.
   Biosynthesis: Viral DNA is released into the cell’s nucleus, and transcription and translation from viral DNA occur. Viral DNA is synthesized.
   Maturation: Capsids form around strands of viral DNA.
   Release: The assembled capsid-containing nucleic acid pushes through the plasma membrane; a portion of the plasma membrane adheres to the capsid, thus forming the envelope.

9. a. Viruses cannot easily be observed in host tissues. Viruses cannot easily be cultured in order to be inoculated into a new host. Additionally, viruses are specific for their hosts and cells, making it difficult to substitute a laboratory animal for the third step of Koch’s postulates.
   b. Some viruses can infect cells without inducing cancer. Cancer may not develop until long after infection. Cancers do not seem to be contagious.
10. **Subacute sclerosing panencephalitis** . . . common viruses . . . Students will have to suggest a mechanism to fill in the last blank; some examples are latent, in an abnormal tissue.

11. **Proivirus**

   TSTA appear on the host cell surface, or T antigens appear in the nucleus. Transformed cells do not exhibit contact inhibition.

   RNA-containing oncogenic viruses produce a double-stranded DNA molecule using reverse transcriptase. The DNA is integrated into the host cell’s DNA as a provirus. The provirus may transform the host cell into a tumor cell.

12. Prions are infectious proteins that appear to lack any nucleic acid. Viroids are infectious RNAs that do not have a protein coat. A prion causes CJD. A viroid causes potato spindle tuber viroid disease.

13. Of the rigid cell walls . . . vectors such as sap-sucking insects . . . plant protoplasts and insect cell cultures.

**Multiple Choice**

**Chapter 13**

1. e
2. c
3. b
4. c
5. b
6. e
7. c
8. d
9. d
10. c

**Chapter 14 Principles of Disease and Epidemiology**

**Answers**

**Review**

1. a. Etiology is the study of the cause of a disease, whereas pathogenesis is the manner in which the disease develops.

   b. Infection refers to the colonization of the body by a microorganism. Disease is any change from a state of health. A disease may, but does not always, result from infection.

   c. A communicable disease is a disease that is spread from one host to another, whereas a non-communicable disease is not transmitted from one host to another.

2. Microorganisms that reside more or less permanently on the body are called normal microbiota. Microorganisms that are present for a few days or weeks are transient microbiota.
3. Symbiosis refers to different organisms living together. Commensalism is a symbiotic relationship in which one of the organisms is benefited and the other is unaffected. Corynebacteria living on the surface of the eye are commensals. Mutualism is a symbiosis in which both organisms are benefited. *E. coli* receives nutrients and a constant temperature in the large intestine and produces vitamin K and certain B vitamins that are useful for the human host. In parasitism, one organism benefits while the other is harmed. *Salmonella enterica* receives nutrients and warmth in the large intestine, and the human host experiences gastroenteritis or typhoid fever.

4. A reservoir of infection is a source of continual infection.

Matching

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>c</td>
</tr>
<tr>
<td>a</td>
<td></td>
</tr>
</tbody>
</table>

Influenza

Rabies

Botulism

5. Koch’s postulates establish the etiology of an infectious disease because the microorganism is removed from a sick organism, grown in a laboratory culture, and introduced into a healthy, susceptible organism. This shows that the microorganism caused the disease—not contact with a sick individual or environmental conditions.

Some organisms are not easily seen in a host. Some microorganisms cannot be cultured on laboratory media. And some microorganisms are specific for one host. In a human, these pathogens will give rise to a group of signs and symptoms, but they will not cause the same disease in laboratory animals.

6. a. In transmission by direct contact, some kind of body contact between an infected individual and a susceptible host is required.
   b. Pathogens are transmitted from one host to another by fomites via indirect contact.
   c. Arthropod vectors can transmit pathogens mechanically where the pathogen is carried on external body parts. When an arthropod ingests a pathogen and the pathogen reproduces in the vector, it is called biological transmission.
   d. Droplet transmission also is a method of contact transmission. Pathogens are transmitted by droplets of saliva or mucus.
   e. Pathogens can be transmitted to a large number of individuals by food or water. This is called common-vehicle transmission.
   f. Airborne transmission refers to the spread of pathogens by droplet nuclei or dust.

7. Nutrition, fatigue, age, habits, lifestyle, occupation, preexisting illness, chemotherapy.

8. a. Acute
   b. Chronic
   c. Subacute

9. Hospital patients may be in a weakened condition and therefore predisposed to infection. Pathogenic microorganisms are generally transmitted to patients by contact and airborne transmission. The reservoirs of infection are the hospital staff, visitors, and other patients.

10. A disease constantly present in a population is an endemic disease. When many people acquire the disease in a relatively short time, it is an epidemic disease.

11. Epidemiology is the science dealing with when and where diseases occur and how they are transmitted in the human population. The Centers for Disease Control and Prevention (CDC) is a central source of epidemiological information.

12. Changes in body function felt by the patient are called symptoms. Symptoms such as weakness or pain are not measurable by a physician. Objective changes that the physician can observe and measure are called signs.
13. When microorganisms causing a local infection enter a blood or lymph vessel and are spread throughout the body, a systemic infection can result.

14. Mutualistic microorganisms are providing a chemical or environment that is essential for the host. In a commensal relationship, the microorganisms are obtaining nutrients from sloughed-off cells and secretions, which benefits the host by removing materials that might be invaded by pathogens. These organisms, however, are not essential; another microorganism might serve the function as well.

15. Incubation period, prodromal period, period of illness, period of decline (may be crisis), period of convalescence.

**Multiple Choice**

Chapter 14
1. a
2. b
3. a
4. d
5. b
6. c
7. d
8. a
9. c
10. b

**Chapter 15 Microbial Mechanisms of Pathogenicity**

**Answers**

**Review**

1. Mucous membranes: Microorganisms can adhere to and then penetrate mucous membranes. Skin: Microorganisms can penetrate unbroken skin through hair follicles and sweat ducts. Parenteral route: Pathogens can be introduced into tissues beneath the skin and mucous membranes by punctures, injections, bites, and cuts.

2. The ability of a microorganism to produce a disease is called pathogenicity. The degree of pathogenicity is virulence.

3. a. Would prevent adherence by making the mannose attachment site unavailable.
   
   b. Would prevent adherence of *N. gonorrhoeae*.

   c. *S. pyogenes* would not be able to attach to host cells and would be more susceptible to phagocytosis.
4. Cytopathic effects are observable changes produced in cells infected by viruses. Five examples are:
   a. Cessation of mitosis.
   b. Autolysis.
   c. The presence of inclusion bodies.
   d. Cell fusion producing syncytia.
   e. Transformation.

5. 

<table>
<thead>
<tr>
<th></th>
<th>Exotoxin</th>
<th>Endotoxin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacterial source</td>
<td>Gram +</td>
<td>Gram −</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Proteins</td>
<td>Lipid A</td>
</tr>
<tr>
<td>Toxigenicity</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Pharmacology</td>
<td>Destroy certain cell parts</td>
<td>Systemic, fever, weakness,</td>
</tr>
<tr>
<td></td>
<td>or physiological functions</td>
<td>aches, and shock</td>
</tr>
<tr>
<td>Example</td>
<td>Botulinum toxin</td>
<td>Salmonellosis</td>
</tr>
</tbody>
</table>

6. Encapsulated bacteria can resist phagocytosis and continue growing. *Streptococcus pneumoniae* and *Klebsiella pneumoniae* produce capsules that are related to their virulence. M protein found in the cell walls of *Streptococcus pyogenes* and A protein in the cell walls of *Staphylococcus aureus* help these bacteria resist phagocytosis.

7. Hemolysins are enzymes that cause the lysis of red blood cells; hemolysis might supply nutrients for bacterial growth. Leukocidins destroy neutrophils and macrophages that are active in phagocytosis; this decreases host resistance to infection. Coagulase is an enzyme that causes the fibrinogen in blood to clot; the clot may protect the bacterium from phagocytosis and other host defenses. Bacterial kinases break down fibrin; kinases can destroy a clot that was made to isolate the bacteria, thus allowing the bacteria to spread. Hyaluronidase dissolves the hyaluronic acid that binds cells together; this could allow the bacteria to spread through tissues. Siderophores take iron from host iron-transport proteins, thus allowing bacteria to get iron for growth. IgA proteases destroy IgA antibodies; IgA antibodies protect mucosal surfaces.

8. Pathogenic fungi do not have specific virulence factors; capsules, metabolic products, toxins, and allergic responses contribute to the virulence of pathogenic fungi. Some fungi produce toxins that, when ingested, produce disease. Protozoa and helminths elicit symptoms by destroying host tissues and producing toxic metabolic wastes.


10. Botulinum toxin is more potent than *Salmonella* toxin. A much smaller amount of botulinum toxin will kill 50 percent of the inoculated hosts.

11. Food infection refers to a disease that results from pathogens entering through the gastrointestinal route. The pathogens infect the gastrointestinal tract and produce endotoxins while they are growing. Food intoxication results from ingestion of a toxin formed in food. Pathogens grow in the food and excrete an exotoxin. The pathogens do not infect the host; symptoms are due to the toxin.

12. Viruses avoid the host’s immune response by growing inside host cells; some can remain latent in a host cell for prolonged periods. Some protozoa avoid the immune response by mutations that change their antigens.
Multiple Choice

Chapter 15
1. e
2. c
3. d
4. d
5. c
6. a
7. b
8. a
9. d
10. c

Chapter 16 Nonspecific Defenses of the Host

Answers

Review
1. a. The ability of the human body to ward off diseases.
   b. The lack of resistance to an infectious disease.
   c. Host defenses that tend to protect the body from any kind of pathogen.
2.  
<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>Dry, packed cells</td>
</tr>
<tr>
<td>Eyes</td>
<td>Tears</td>
</tr>
<tr>
<td>Digestive tract</td>
<td>Movement out</td>
</tr>
<tr>
<td>Respiratory tract</td>
<td>Ciliary escalator</td>
</tr>
<tr>
<td>Urinary tract</td>
<td>Movement out</td>
</tr>
<tr>
<td>Genital tract</td>
<td>Movement out</td>
</tr>
</tbody>
</table>
3. See Table 16.1.
4. Phagocytosis is the ingestion of a microorganism or any foreign particulate matter by a cell.
5. Granulocytes have granules in the cytoplasm. Among the granulocytes, neutrophils have the most prominent phagocytic activity. Monocytes are agranulocytes (without granules) that develop into macrophages.
   When an infection occurs, granulocytes migrate to the infected area. Monocytes follow the granulocytes to the infected tissue. During migration, monocytes enlarge and develop into actively phagocytic cells called macrophages. Macrophages phagocytize dead or dying bacteria.
6. Phagocytic cells that migrate to the infected area are called wandering macrophages. Fixed macrophages remain in certain tissues and organs.
7. Refer to Figures 16.8 and 16.9.
8. Inflammation is the body’s response to tissue damage. The characteristic symptoms of inflammation are redness, pain, heat, and swelling.
9. The functions of inflammation are:
   1. To destroy the injurious agent, if possible, and to remove it and its by-products from the body;
   2. If destruction is not possible, to confine or wall off the injurious agent and its by-products by forming an abscess;
   3. To repair or replace tissues damaged by the injurious agent or its by-products.

10. Leukocytic pyrogen, released from phagocytic granulocytes, has the ability to raise body temperature. The higher temperature is believed to inhibit the growth of some microorganisms. The higher temperature speeds up body reactions and may help body tissues to repair themselves more quickly.

11. The chill is an indication that body temperature is rising. Shivering and cold skin are mechanisms for increasing internal temperature. Crisis indicates body temperature is falling. The skin becomes warm as circulation is returned to it when the body attempts to dissipate extra heat.

12. Complement is a group of proteins found in normal blood serum. The classical pathway is activated by an antigen-antibody complex and C1 (see Figure 16.13). The alternative pathway is activated by microbial lipid-carbohydrate complex and factor B, factor D, and factor P (see Figure 16.14). The lectin pathway is initiated by carbohydrate-binding proteins (lectins) binding the mannose on microbes (see Figure 16.15).

13. Activation of complement can result in immune adherence and phagocytosis, local inflammation, and cell lysis.

14. Endotoxin binds C3b, which activates C5–C9 to cause cell lysis. This can result in free cell wall fragments, which bind more C3b, resulting in C5–C9 damage to host cell membranes.

15. Interferons are antiviral proteins produced by infected cells in response to viral infections. Alpha-IFN and β-IFN induce uninfected cells to produce antiviral proteins. Gamma-IFN is produced by lymphocytes and activates neutrophils to kill bacteria.

Multiple Choice

Chapter 16
1. a
2. d
3. c
4. d
5. b
6. a
7. c
8. b
9. d
10. e
Chapter 17 Specific Defenses of the Host: The Immune Response

Answers

Review

1. The ability to produce antibodies against microorganisms and their toxins provides a type of resistance called immunity.

2. a. Acquired immunity is the resistance to infection obtained during the life of the individual. Acquired immunity results from the production of antibodies. Innate resistance refers to the resistance of species or individuals to certain diseases that is not dependent on antigen-specific immunity such as antibodies.

   b. Humoral immunity is due to antibodies (and B cells). Cell-mediated immunity is due to T cells.

   c. Active immunity refers to antibodies produced by the individual who carries them. Passive immunity refers to antibodies produced by another source and then transferred to the individual who needs the antibodies.

   d. $T_{H1}$ cells produce cytokines that activate T cells. Cytokines produced by $T_{H2}$ cells activate B cells.

   e. Natural immunity is acquired naturally, i.e., from mother to newborn, or following an infection. Artificial immunity is acquired from medical treatment, i.e., by injection of antibodies or by vaccination.

   f. T-dependent antigens: Certain antigens must combine with self-antigens to be recognized by $T_{H}$ cells and then by B cells. T-independent antigens can elicit an antibody response without T cells.

   g. T cells can be classified by their surface antigens: $T_{H}$ cells possess the CD4 antigen; $T_C$ and $T_S$ cells have the CD8 antigen.

3. a. Artificially acquired active immunity.

   b. Naturally acquired active immunity.

   c. Naturally acquired passive immunity.

   d. Artificially acquired passive immunity.

4. An antigen is a chemical substance that causes the body to produce specific antibodies and can combine with these antibodies. A hapten is a low-molecular-weight substance that is not antigenic unless it is attached to a carrier molecule. Once an antibody has been formed against the hapten, the hapten alone will react with the antibodies independently of its carrier.

5. An antibody is a protein produced by the body in response to the presence of an antigen; it is capable of combining specifically with that antigen. Antibodies are proteins and usually consist of four polypeptide chains. Two of the chains are identical and are called heavy (H) chains. The other two chains are identical to each other but are of lower molecular weight and are called light (L) chains. The variable portions of the H and L chains are where antigen binding occurs. The variable portion is different for each kind of antibody. The remaining constant portions of each chain are identical for all of the antibodies in one class of antibody. Refer to Figure 17.5 for the structure of IgG antibodies.

6. Each person has a population of B cells with receptors for different antigens. When the appropriate antigen contacts the antigen receptor on a B cell, the cell proliferates to produce a clone of cells. Plasma cells in this clone produce antibodies specific to the antigen that caused their formation.

7. See Figures 17.8, 17.13, 17.14, 17.16, 17.18, and 17.19.
8. Cytotoxic T cells (T_c) destroy target cells upon contact. Delayed hypersensitivity T cells (T_d) produce lymphokines. Helper T cells (T_h) interact with an antigen to “present” it to a B cell for antibody formation. Suppressor T cells (T_s) inhibit the conversion of B cells into plasma cells. Lymphokines cause an inflammatory response. An example of a cytokine is macrophage chemotactic factor, which attracts macrophages to the infection site. See Table 17.2 for functions of other cytokines.

9. a. Area a shows the primary response to the antigen. Area b shows the anamnestic response, in which the antibody titer is greater and remains high longer than in the primary response. The booster dose stimulated the memory cells to respond to the antigen.

10. Neutralize toxins, inactivate viruses, fix complement to initiate cytolysis.

11. Surface recognition sites for antigen peptides and MHC proteins.

12. NK cells lyse target cells (usually tumor cells and virus-infected cells) on contact.

13. Both would prevent attachment of the pathogen; (a) interferes with the attachment site on the pathogen and (b) interferes with the pathogen’s receptor site.

14. See Figure 17.11.

15. The person recovered because s/he produced antibodies against the pathogen. The memory response will continue to protect the person against that pathogen.

16. Human gamma globulin is the fraction of human serum in which antibodies are found. If antibodies against hepatitis are in the gamma globulin, this would be artificially acquired passive immunity.

Multiple Choice

Chapter 17

1. d
2. e
3. b
4. d
5. e
6. c
7. d
8. d
9. a
10. d
Chapter 18 Practical Applications of Immunology

Answers

Review

1. a. Whole-agent. Live, avirulent virus that can cause the disease if it mutates back to its virulent state.
   b. Whole-agent; (heat-) killed bacteria.
   c. Subunit; (heat- or formalin-) inactivated toxin.
   d. Subunit
   e. Subunit
   f. Conjugated
   g. Nucleic acid

2. If excess antibody is present, an antigen will combine with several antibody molecules. Excess antigen will result in an antibody combining with several antigens. Refer to Figure 18.2.

3. Particulate antigens react in agglutination reactions. The antigens can be cells or soluble antigens bound to synthetic particles. Soluble antigens take part in precipitation reactions.

4. a. Some viruses are able to agglutinate red blood cells. This is used to detect the presence of large numbers of virions capable of causing hemagglutination (e.g., Influenzavirus).
   b. Antibodies produced against viruses that are capable of agglutinating red blood cells will inhibit the agglutination. Hemagglutination inhibition can be used to detect the presence of antibodies against these viruses.
   c. This is a procedure to detect antibodies that react with soluble antigens by first attaching the antigens to insoluble latex spheres. This procedure may be used to detect the presence of antibodies that develop during certain mycotic or helminthic infections.

5. See Figure 18.10.

6. a. Direct test (see Figure 18.10a)
   b. Indirect test (see Figure 18.10b)

7. An indirect ELISA test is used to detect the presence of antibodies. A known antigen is fixed to a small well, and the patient’s serum is added. Patient’s antibodies will react with the antigen in the well. Antihuman immunoglobulins bound to an enzyme are added to the well. The antihuman immunoglobulins will bind to the patient’s antibodies. Substrate for the enzyme is then added and a positive reaction indicating presence of the antibody in the patient’s serum is shown by the enzyme–substrate reaction.

   A direct ELISA test is used to detect the presence of an antigen. Antibodies are fixed to a small well, and the unknown antigen is added. If the antigen reacts with the antibodies, the antigen will be bound to the well. Antibodies specific for the antigen are then added to the well. This second layer of antibodies is bound to an enzyme. Substrate for the enzyme is then added, and a positive reaction indicating the identity of the antigen is shown by the enzyme–substrate reaction (see Figure 18.12).

8. a. Direct test
   b. Indirect test

   The direct test provides definitive proof.
Matching

e Precipitation
d, f Immunoelectrophoresis
a Agglutination
c Complement fixation
f Neutralization
b, d ELISA

Multiple Choice

Chapter 18
1. c
2. d
3. b
4. a
5. a
6. b
7. c
8. a
9. b
10. c

Chapter 19 Disorders Associated with the Immune System

Answers

Review

1. The immune state that results in altered immunologic reactions leading to pathogenic changes in tissue.
2. **Mediator**

<table>
<thead>
<tr>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histamine</td>
</tr>
<tr>
<td>Increases blood capillary permeability, mucus secretion, and smooth</td>
</tr>
<tr>
<td>muscle contraction.</td>
</tr>
<tr>
<td>Leukotrienes</td>
</tr>
<tr>
<td>Increase blood capillary permeability and smooth muscle contraction.</td>
</tr>
<tr>
<td>Prostaglandins</td>
</tr>
<tr>
<td>Increase smooth muscle contraction and mucus secretion.</td>
</tr>
</tbody>
</table>

3. Recipient’s antibodies will react with donor’s tissues.

4. The recipient will experience symptoms due to lysis of the donor RBCs. Hemolysis occurs because the antigen (donor RBCs)-antibody reaction fixes complement.

5. This condition develops when an Rh− mother becomes sensitized to the Rh+ antigens of her fetus. The mother’s anti-Rh antibodies (IgG) can cross the placenta and react with fetal RBCs, causing their destruction. This condition can be prevented by passive immunization of the Rh− mother with anti-Rh antibodies shortly after birth. These anti-Rh antibodies combine with fetal Rh+ RBCs, which may have entered maternal circulation, and enhance their clearance, thereby reducing the sensitization of the mother’s immune system to this antigen.

6. Refer to Figure 19.7.
   a. The observed symptoms are due to lymphokines.
   b. When a person contacts poison oak initially, the antigen (catechols on the leaves) binds to tissue cells, is phagocytized by macrophages, and is presented to receptors on the surface of T cells. Contact between the antigen and the appropriate T cell stimulates the T cell to proliferate and become sensitized. Subsequent exposure to the antigen results in sensitized T cells releasing lymphokines, and a delayed hypersensitivity occurs.
   c. Small repeated doses of the antigen are believed to cause the production of IgG (blocking) antibodies.

7. Autografts and isografts are the most compatible. Xenotransplants are the least compatible.

8. a. Compatible. There are no Rh antigens on the donor’s RBCs.
   b. Incompatible. The recipient will produce anti-Rh antibodies. If the recipient receives Rh+ RBCs in a subsequent transfusion, a hemolytic reaction will develop.
   c. Incompatible. The recipient has anti-A antibodies that will result in lysis of the donor’s RBCs.

9. Autoimmunity is a humoral (types I, II, and III) or cell-mediated (type IV) immune response against a person’s own tissue antigen. During development, T cells that recognize self may not be eliminated. During adulthood, inactive T cells may become active or antibodies could cross-react with host cell antigens. New or altered antigens may be formed on the surface of host cells. These antigens may result from the use of certain drugs, or from infections by certain viruses.

Antibodies to cell-membrane antigens of certain group A streptococci cross-react with human heart tissue. Severe, recurrent infections caused by β-hemolytic group A streptococci sometimes lead to the development of rheumatoid arthritis long after the streptococcal infection has subsided.

10. **Type I** Antibodies against microbes react with self
    **Type II** Antibodies react with self.
    **Type III** Antibody-complement complexes deposit in tissues.
    **Type IV** T cells destroy self cells.

See Table 19.3.

11. Natural
    - Inherited
      - Viral infections, most notably HIV
    - Artificial
      - Induced by immunosuppression drugs

Result: Increased susceptibility to various infections depending on the type of immune deficiency.
12. Tumor cells have tumor-specific antigens such as TSTA and T antigen. Sensitized \( T_C \) cells may react with tumor-specific antigens, initiating lysis of the tumor cells.

13. Some malignant cells can escape the immune system by antigen modulation or immunological enhancement. Immunotherapy might trigger immunological enhancement. The body’s defense against cancer is cell-mediated and not humoral. Transfer of lymphocytes could cause graft-versus-host disease.

14. AIDS is the last stage of an HIV infection. HIV is transmitted by sexual contact, by intravenous drug use, across the placenta, and in mother’s milk. HIV is prevented by using condoms for hetero- and homosexual intercourse and oral and anal copulation, and by not re-using needles.

**Multiple Choice**

Chapter 19

1. b  
2. b  
3. b  
4. b  
5. d  
6. e  
7. a  
8. d  
9. c  
10. b

**Chapter 20 Antimicrobial Drugs**

**Answers**

**Review**

<table>
<thead>
<tr>
<th>Antimicrobial Agents</th>
<th>Synthetic or Antibiotic</th>
<th>Method of Action</th>
<th>Principal Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoniazid</td>
<td>Synthetic</td>
<td>Vitamin B(_6) analog</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>Sulfonamides</td>
<td>Synthetic</td>
<td>Inhibit folic acid synthesis</td>
<td>Gram-negative bacteria</td>
</tr>
<tr>
<td>Ethambutol</td>
<td>Synthetic</td>
<td>Competitive inhibitor</td>
<td>Tuberculosis</td>
</tr>
<tr>
<td>Trimethoprim</td>
<td>Synthetic</td>
<td>Inhibits folic acid synthesis</td>
<td><em>Pneumocystis</em></td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>Synthetic</td>
<td>Inhibit DNA synthesis</td>
<td>Urinary tract infections</td>
</tr>
<tr>
<td>Penicillin, natural</td>
<td>Antibiotic</td>
<td>Inhibits cell wall synthesis</td>
<td>Gram-positive bacteria</td>
</tr>
<tr>
<td>Penicillin, semisynthetic</td>
<td>Antibiotic</td>
<td>Inhibits cell wall synthesis</td>
<td>Broad spectrum; penicillin-resistant bacteria</td>
</tr>
<tr>
<td>Cephalosporins</td>
<td>Antibiotic</td>
<td>Inhibit cell wall synthesis</td>
<td>Penicillin-resistant bacteria</td>
</tr>
<tr>
<td>Antibiotic Class</td>
<td>Mode of Action</td>
<td>Spectrum</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Carbapenems</td>
<td>Inhibit cell wall synthesis</td>
<td>Broad spectrum</td>
<td></td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>Inhibit protein synthesis</td>
<td>Gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td>Tetracyclines</td>
<td>Inhibit protein synthesis</td>
<td>Broad spectrum</td>
<td></td>
</tr>
<tr>
<td>Macrolides</td>
<td>Inhibit protein synthesis</td>
<td>Gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td>Polypeptides</td>
<td>Inhibit cell wall synthesis; injure plasma membrane</td>
<td>Gram-positive bacteria; gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td>Vancomycin</td>
<td>Inhibits cell wall synthesis</td>
<td>Penicillin-resistant Staphylococcus</td>
<td></td>
</tr>
<tr>
<td>Rifamycins</td>
<td>Inhibit mRNA synthesis</td>
<td>Tuberculosis</td>
<td></td>
</tr>
<tr>
<td>Polyenes</td>
<td>Injure plasma membrane</td>
<td>Fungicide</td>
<td></td>
</tr>
<tr>
<td>Griseofulvin</td>
<td>Inhibits mitosis</td>
<td>Antifungal</td>
<td></td>
</tr>
<tr>
<td>Amantadine</td>
<td>Blocks viral entry or uncoating</td>
<td>Influenza A</td>
<td></td>
</tr>
<tr>
<td>Zidovudine</td>
<td>Inhibits DNA synthesis</td>
<td>AIDS</td>
<td></td>
</tr>
<tr>
<td>Niclosamide</td>
<td>Inhibits oxidative phosphorylation</td>
<td>Tapeworms</td>
<td></td>
</tr>
<tr>
<td>Albenazole</td>
<td>Inhibits microtubule formation</td>
<td>Antihelminthic, antiprotozoal</td>
<td></td>
</tr>
</tbody>
</table>

2. A chemotherapeutic agent is a substance taken into the body to combat disease. A synthetic chemotherapeutic agent is prepared in a laboratory, whereas antibiotics are produced naturally by bacteria and some fungi.

3. a. Ehrlich discovered the first chemotherapeutic agent (salvarsan, which was used to treat syphilis).
   b. Fleming discovered the antibiotic penicillin.

4. The drug should be toxic to the undesired microorganisms and not harmful to the host (selective toxicity).
   The drug should be active against many microorganisms (broad spectrum).
   The drug should not produce hypersensitivity in the host.
   The drug should not produce drug resistance in the host.
   The drug should not harm normal microbiota.

5. Because a virus uses the host cell’s metabolic machinery, it is difficult to damage the virus without damaging the host. Fungi, protozoa, and helminths possess eukaryotic cells. Therefore, antiviral, antifungal, antiprotozoan, and antihelminthic drugs must also affect eukaryotic cells.

6. Pyrimidine (idoxuridine) and purine (acyclovir) analogs.
   Prevent release of nucleic acid from viruses into the host cell (amantadine).
   Inhibition of infection of cells (interferon).
   Enzyme inhibitors (indinavir).

7. In the broth dilution test, a series of cultures is prepared in a microtiter plate. To each well of liquid medium, the test organism and a different concentration of chemotherapeutic agent are added. The plate is incubated for 16–20 hours and observed for the presence of microbial growth.
   The minimal inhibitory concentration (MIC) is the lowest concentration of chemotherapeutic agent capable of preventing growth of the test organism. The lowest concentration of the agent that results in no growth in a subculture is the minimal bactericidal concentration (MBC).
   In the agar dilution method, bacterial colonies are replica-plated onto nutrient media plus varying concentrations of antimicrobial agents. The MIC is determined by measuring the colony growth. In the tube dilution test, both the MIC and the MBC can be determined. The agar dilution method has the advantage of ease of inoculation and media preparation.
8. In the disk-diffusion test, filter paper disks impregnated with chemotherapeutic agents are overlaid on an inoculated agar medium. During incubation, the agents diffuse from the disk and a zone of inhibition is observed in the area immediately around the disks. The zone of inhibition indicates susceptibility of the test organism to the agent tested.

9. Drug resistance is the lack of susceptibility of a microorganism to a chemotherapeutic agent. Drug resistance may develop when microorganisms are constantly exposed to an antimicrobial agent. The development of drug-resistant microorganisms can be minimized by judicious use of antimicrobial agents; following directions on the prescription; or by administering two or more drugs simultaneously.

10. a. Prevention of resistant strains of microorganisms;  
b. Take advantage of the synergistic effect;  
c. Provide therapy until a diagnosis is made; and  
d. Lessen the toxicity of individual drugs by reducing the dosage of each in combination.

11. a. Like polymyxin B, causes leaks in the plasma membrane.  
b. Interferes with translation.

12. a. Inhibits formation of peptide bond.  
b. Prevents translocation of ribosome along mRNA.  
c. Interferes with attachment of tRNA to mRNA-ribosome complex.  
d. Changes shape of 30S portion of ribosome, resulting in misreading mRNA.  
e. Prevents 70S ribosomal subunits from forming.  
f. Prevents release of peptide from ribosome.

13. DNA polymerase adds bases to the 3′–OH.


**Multiple Choice**

**Chapter 20**

1. b  
2. a  
3. a  
4. b  
5. a  
6. d  
7. e  
8. b  
9. c  
10. d
## Chapter 21 Microbial Diseases of the Skin and Eyes

### Answers

#### Review

1. Bacteria usually enter through inapparent openings in the skin. Fungal pathogens (except subcutaneous) often grow on the skin itself. Viral infections of the skin (except warts and herpes simplex) most often gain access to the body through the respiratory tract.

2. *Staphylococcus aureus*; *Streptococcus pyogenes*.

3.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Etiology</th>
<th>Symptoms</th>
<th>Treatment</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impetigo</td>
<td><em>Staphylococcus aureus</em></td>
<td>Vesicles that rupture and crust over</td>
<td>Hexachlorophene</td>
<td>May be epidemic</td>
</tr>
<tr>
<td>Erysipelas</td>
<td><em>Streptococcus pyogenes</em></td>
<td>Thickened red patches, swollen at margins</td>
<td>Penicillin</td>
<td>May be endogenous</td>
</tr>
</tbody>
</table>

4.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Etiological Agent</th>
<th>Clinical Symptoms</th>
<th>Method of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acne</td>
<td><em>P. acnes</em></td>
<td>Infected oil glands</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Pimples</td>
<td><em>S. aureus</em></td>
<td>Infected hair follicles</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Warts</td>
<td>Papovavirus</td>
<td>Benign tumor</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Chickenpox</td>
<td>Herpesvirus</td>
<td>Vesicular rash</td>
<td>Respiratory route</td>
</tr>
<tr>
<td>Fever blisters</td>
<td>Herpesvirus</td>
<td>Recurrent “blisters”</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Measles</td>
<td>Paramyxovirus</td>
<td>Papular rash, Koplik’s spots</td>
<td>Respiratory route</td>
</tr>
<tr>
<td>Rubella</td>
<td>Togavirus</td>
<td>Macular rash</td>
<td>Respiratory route</td>
</tr>
</tbody>
</table>

5. Both are fungal infections. Sporotrichosis is a subcutaneous mycosis; athlete’s foot is a cutaneous mycosis.

6. a. Conjunctivitis is an inflammation of the conjunctiva, and keratitis is an inflammation of the cornea.
   b. Table 21.2.

7. Candidiasis is caused by *Candida albicans*. The yeast is able to grow when the normal microbiota are suppressed or when the immune system is suppressed. The yeast can be transferred from another person or be transient microbiota. White patches in the mouth or bright red areas of the skin and mucous membranes are signs of infection. Antifungal agents such as miconazole are used to treat candidiasis. Systemic infections are treated with oral ketoconazole.

8. The test determines the woman’s susceptibility to rubella. If the test is negative, she is susceptible to the disease. If she acquires the disease during pregnancy the fetus could become infected. A susceptible woman should be vaccinated.
9. **Symptoms** | **Disease**
---|---
Koplik’s spots | Measles
Macular rash | Measles
Vesicular rash | Chickenpox
Small, spotted rash | German measles
“Blisters” | Cold sore
Corneal ulcer | Keratoconjunctivitis

10. The central nervous system can be invaded following keratoconjunctivitis; this results in encephalitis.

11. Attenuated measles, mumps, and rubella viruses.

12. Varicella-zoster virus appears to remain latent in nerve cells following recovery from a childhood infection of chickenpox. Later, the virus may be activated and cause a vesicular rash (shingles) in the area of the nerve.

13. To prevent neonatal gonorrheal ophthalmia. This is caused by *N. gonorrhoeae* contracted by the newborn during passage through the birth canal.


15. Scabies is an infestation of mites in the skin. It is treated with permethrin insecticide or gamma benzene hexachloride. The presence of a six-legged arthropod (insect) indicates pediculosis (lice).

---

**Multiple Choice**

Chapter 21

1. c
2. d
3. b
4. c
5. d
6. d
7. e
8. d
9. a
10. d

---

**Chapter 22 Microbial Diseases of the Nervous System**

**Answers**

**Review**

1. Meningitis is an infection of the meninges; encephalitis is an infection of the brain itself.
2. **Causative Agent** | **Susceptible Population** | **Mode of Transmission** | **Treatment**
---|---|---|---
*N. meningitidis* | Children; military recruits | Respiratory | Penicillin
*H. influenzae* | Children | Respiratory | Rifampin
*S. pneumoniae* | Children; elderly | Respiratory | Penicillin
*L. monocytogenes* | Anyone | Foodborne | Penicillin
*C. neoformans* | Immunosuppressed individuals | Respiratory | Amphotericin B

3. “*Haemophilus*” refers to the requirement of this genus for growth factors found in blood (X and V factors) (Chapter 11). “*Influenzae*” because it was thought to be the causative agent of influenza.

4. The symptoms of tetanus are not due to bacterial growth (infection and inflammation) but to neurotoxin.

5. **Salk** | **Sabin**
---|---
**Composition** | Formalin-inactivated viruses | Live, attenuated viruses
**Advantages** | No reversion to virulence | Oral administration
**Disadvantages** | Booster dose needed; injected | Reversion to virulence

6. a. Vaccination with tetanus toxoid.
   b. Immunization with antitetanus toxin antibodies.

7. “*Cleaned*” because *C. tetani* is found in soil that might contaminate a wound. “*Deep puncture*” because it is likely to be anaerobic. “*No bleeding*” because a flow of blood ensures an aerobic environment and some cleansing.

8. *Clostridium botulinum*. Canned foods. Paralysis. Supportive respiratory care; antitoxin. Anaerobic, nonacidic environment. Diagnosis is made by detecting toxin in foods or patient by inoculating mice with suspect samples. Prevention: use of adequate heat in canning; boiling food before consumption to inactivate toxin.

9. **Etiology**—*Mycobacterium leprae*.
   **Transmission**—Direct contact.
   **Symptoms**—Nodules on the skin; loss of sensation.
   **Treatment**—Dapsone and rifampin.
   **Prevention**—BCG vaccine.
   **Susceptible**—People living in the tropics; genetic predisposition.

10. **Etiology**—Picornavirus (poliovirus).
    **Transmission**—Ingestion of contaminated water.
    **Symptoms**—Headache, sore throat, fever, nausea; rarely paralysis.
    **Prevention**—Sewage treatment.
    *These vaccinations provide artificially acquired active immunity because they cause the production of antibodies, but they do not prevent or reverse damage to nerves.*

11. **Etiology**—Rhabdovirus.
    **Transmission**—Bite of infected animal; inhalation.
    **Reservoirs**—Skunks, bats, foxes, raccoons.
    **Symptoms**—Muscle spasms, hydrophobia, CNS damage.

12. **Postexposure treatment**—Passive immunization with antibodies followed by active immunization with HDCV. **Preexposure treatment**—Active immunization with HDCV.
    Following exposure to rabies, antibodies are needed immediately to inactivate the virus. Passive immunization provides these antibodies. Active immunization will provide antibodies over a longer period of time, but they are not formed immediately.
13. | Disease                | Etiology                        | Vector   | Symptoms                        | Treatment        |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arboviral encephalitis</td>
<td>Togaviruses, Arboviruses</td>
<td>Mosquitoes (Culex)</td>
<td>Headache, fever, coma</td>
<td>Immune serum</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>Trypanosoma brucei gambiense, T. b. rhodesiense</td>
<td>Tsetse fly</td>
<td>Decreased physical activity and mental acuity</td>
<td>Suramm; melarsoprol</td>
</tr>
</tbody>
</table>

14. Most antibiotics cannot cross the blood-brain barrier.

15. The causative agent of Creutzfeldt–Jakob disease (CJD) is transmissible. Although there is some evidence for an inherited form of the disease, it has been transmitted by transplants. Similarities with viruses are (1) the prion cannot be cultured by conventional bacteriological techniques and (2) the prion is not readily seen in patients with CJD.

**Multiple Choice**

Chapter 22
1. a
2. c
3. a
4. b
5. a
6. c
7. b
8. a
9. c
10. a

**Chapter 23 Microbial Diseases of the Cardiovascular and Lymphatic Systems**

**Answers**

**Review**

1. Fever, decrease in blood pressure, and lymphangitis. Septic shock occurs when low blood pressure cannot be controlled.

2. Bacteria can spread from an abscess with enzymes such as kinases and invade blood vessels.

3. | Disease | Causative Agent | Predisposing Conditions |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p.s.</td>
<td><em>S. pyogenes</em></td>
<td>Abortion or childbirth</td>
</tr>
<tr>
<td>s.b.e.</td>
<td>α-hemolytic strep.</td>
<td>Preexisting lesions</td>
</tr>
<tr>
<td>a.b.e.</td>
<td><em>S. aureus</em></td>
<td>Abnormal heart valves</td>
</tr>
</tbody>
</table>
4. Rheumatic fever is an autoimmune disease that is precipitated by streptococcal sore throat. It is treated with anti-inflammatory drugs to relieve the symptoms. It is prevented by early diagnosis and treatment of streptococcal sore throat.

5. All are vectorborne rickettsial diseases. They differ from each other in (1) etiologic agent, (2) vector, (3) severity and mortality, and (4) incidence (e.g., epidemic, sporadic).

6. **Causative Agent** | **Vector** | **Symptoms** | **Treatment**
--- | --- | --- | ---
*Plasmodium* | *Anopheles* | Recurrent fever, chills | Quinine derivative
*Flavivirus* | *Aedes aegypti* | Fever, nausea, jaundice | None
*Flavivirus* | *Aedes aegypti* | Muscle and joint pain | None
*Borrelia* | Soft ticks | Recurrent fever | Tetracycline
*Leishmania* | Sandflies | Fever, chills | Antimony

7. **Francisella tularensis** | Animal reservoir, skin abrasions, ingestion, inhalation, bites | Rabbits | Small ulcer | Careful handling of animals
--- | --- | --- | --- | ---
*Brucella spp.* | Animal reservoir, ingestion of milk, direct contact | Cattle | Undulant fever | Pasteurization of milk
--- | --- | --- | --- | ---
*Bacillus anthracis* | Skin abrasions, inhalation, ingestion | Soil, cattle | Malignant pustule | Surveillance and vaccination of cattle
--- | --- | --- | --- | ---
*Borrelia burgdorferi* | Tick bites | Deer, mice | Rash, neurologic; arthritis | Protection from ticks
--- | --- | --- | --- | ---
*Ehrlichia* | Tick bites | Deer | Flulike | Protection from ticks
--- | --- | --- | --- | ---
HHV5 | Saliva, blood | Humans | Cytomegalic inclusion disease of the newborn | Ganciclovir

8. **Plague**
   Causative agent—*Yersinia pestis.*
   Vector—Rat flea.
   Reservoir—Rodents.
   Prognosis—Poor if untreated; good with antibiotic treatment.
   Treatment—Tetracycline, streptomycin.
   Control—Sanitation and ratproofing buildings.

9. **Causative Agent** | **Transmission** | **Reservoir** | **Endemic Area**
--- | --- | --- | ---
*Schistosoma* spp. | Penetrate skin | Aquatic snail | Asia, South America
*Toxoplasma gondii* | Ingestion, inhalation | Cats | United States
*Trypanosoma cruzi* | “Kissing bug” | Rodents | Central America

10. **Reservoir** | **Etiology** | **Transmission** | **Symptoms**
--- | --- | --- | ---
Cat-scratch disease | Cats | *Bartonella henselae* | Scratch; touching eyes, fleas | Swollen lymph nodes, fever, malaise
Toxoplasmosis | Cats | *Toxoplasma gondii* | Ingestion | None, congenital infections, neurologic damage
11. Gangrenous tissue is anaerobic and has suitable nutrients for C. perfringens.

12. Infectious mononucleosis is caused by EB virus and transmitted in oral secretions.


**Multiple Choice**

Chapter 23

1. e
2. b
3. d
4. c
5. a
6. e
7. a
8. c
9. c
10. c

---

**Chapter 24 Microbial Diseases of the Respiratory System**

**Answers**

**Review**

1. **Droplet infection.** Inhalation of cells and spores; ingestion of contaminated food.

2. Coarse hairs in the nose filter dust particles from inspired air. Mucus traps dust and microorganisms, and cilia move the trapped particles toward the throat for elimination. The ciliary escalator of the lower respiratory system moves particles toward the throat. Alveolar macrophages can phagocytize microorganisms that enter the lungs. IgA antibodies are found in mucus, saliva, and tears.

3. Beta-hemolytic streptococci inhibit growth of pneumococci; faster-growing organisms can compete with pathogens.

4. Mycoplasmal pneumonia is caused by *Mycoplasma pneumoniae* bacteria. Viral pneumonia can be caused by several different viruses. Mycoplasmal pneumonia can be treated with tetracyclines, whereas viral pneumonia cannot.

5. Bacteria infecting the nose and throat can move through the eustachian tube to the inner ear. Microorganisms can enter the ear directly via swimming pool water or injury to the eardrum or skull. The bacteria that most commonly cause otitis media are *S. aureus, Streptococcus pneumoniae, β*-hemolytic streptococci, and *H. influenzae*. The middle ear is connected to the nose and throat.

6. **Upper Respiratory System**

   Common cold  Coronaviruses  Sneezing, excessive nasal secretions, congestion
**Lower Respiratory System**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral pneumonia</td>
<td>Several viruses</td>
</tr>
<tr>
<td></td>
<td>Fever, shortness of breath, chest pains</td>
</tr>
<tr>
<td>Influenza</td>
<td>Influenzavirus</td>
</tr>
<tr>
<td></td>
<td>Chills, fever, headache, muscular pains</td>
</tr>
<tr>
<td>RSV</td>
<td>Respiratory syncytial virus</td>
</tr>
<tr>
<td></td>
<td>Coughing, wheezing</td>
</tr>
</tbody>
</table>

Amantadine is used to treat influenza. Ribavirin may reduce RSV symptoms.

7. **Disease**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcal pharyngitis</td>
<td>Pharyngitis and tonsillitis</td>
</tr>
<tr>
<td>Scarlet fever</td>
<td>Rash and fever</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>Membrane across throat</td>
</tr>
<tr>
<td>Whooping cough</td>
<td>Paroxysmal coughing</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Tubercles, weight loss, and coughing</td>
</tr>
<tr>
<td>Pneumococcal pneumonia</td>
<td>Reddish lungs, fever</td>
</tr>
<tr>
<td>H. influenzae pneumonia</td>
<td>Similar to pneumococcal pneumonia</td>
</tr>
<tr>
<td>Chamydial pneumonia</td>
<td>Low fever, cough, and headache</td>
</tr>
<tr>
<td>Legionellosis</td>
<td>Fever and cough</td>
</tr>
<tr>
<td>Psittacosis</td>
<td>Fever and headache</td>
</tr>
<tr>
<td>Q fever</td>
<td>Chills and chest pain</td>
</tr>
<tr>
<td>Epiglottitis</td>
<td>Inflamed, abscessed epiglottis</td>
</tr>
</tbody>
</table>

8. Inhalation of large numbers of spores from *Aspergillus* or *Rhizopus* can cause infections in individuals with impaired immune systems, cancer, and diabetes.

9. No. Many different organisms (gram-positive bacteria, gram-negative bacteria, and viruses) can cause pneumonia. Each of these organisms is susceptible to different antimicrobial agents.

10. **Disease**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Endemic Areas in the United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histoplasmosis</td>
<td>States adjoining the Mississippi and Ohio Rivers</td>
</tr>
<tr>
<td>Coccioidiomycosis</td>
<td>American Southwest</td>
</tr>
<tr>
<td>Blastomycosis</td>
<td>Mississippi</td>
</tr>
<tr>
<td>Pneumocystis</td>
<td>Ubiquitous</td>
</tr>
</tbody>
</table>

Refer to Table 24.2.

11. In the tuberculin test, purified protein derivative (PPD) from *M. tuberculosis* is injected into the skin. Induration and reddening of the area around the injection site indicates an active infection or immunity to tuberculosis.

12. Hypothesis 1: Close indoor contact in winter promotes epidemic transmission.
    Hypothesis 2: The viruses grow best at slightly cooler temperatures.
    Hypothesis 3: A physiological change in humans during winter allows viral growth.

13. Gram-positive cocci

<table>
<thead>
<tr>
<th>Classification</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalase-positive</td>
<td><em>Staphylococcus aureus</em></td>
</tr>
<tr>
<td>β-hemolytic</td>
<td><em>Streptococcus pyogenes</em></td>
</tr>
<tr>
<td>α-hemolytic</td>
<td><em>S. pneumoniae</em></td>
</tr>
<tr>
<td>Gram-positive rods</td>
<td></td>
</tr>
<tr>
<td>Not acid-fast</td>
<td><em>C. diphtheriae</em></td>
</tr>
<tr>
<td>Acid-fast</td>
<td><em>Mycobacterium tuberculosis</em></td>
</tr>
</tbody>
</table>
Gram-negative cocci  
*Moraxella catarrhalis*

Aerobic gram-negative rods

  Coccobacilli  
  *B. pertussis*

  Rods  
  *L. pneumophila*

Facultatively anaerobic gram-negative rods

  Coccobacilli  
  *H. influenzae*

  Rods  
  *K. pneumoniae*

Intracellular

  Elementary bodies  
  *Chlamydia psittaci*

  No elementary bodies  
  *Coxiella burnetii*

Wall-less  
*Mycoplasma pneumoniae*

### Multiple Choice

**Chapter 24**

1. a  
2. c  
3. e  
4. a  
5. c  
6. b  
7. a  
8. e  
9. b  
10. d

### Chapter 25 Microbial Diseases of the Digestive System

**Answers**

**Review**

1. Mouth—Streptococci, including *S. mutans.*  
   Stomach and small intestine—None.  
   Large intestine and rectum—*Lactobacillus, Bacteroides,* and enterics.

2. *S. mutans* becomes established in the mouth when the teeth erupt from the gums. A sticky capsule enables the bacteria to adhere to teeth. The dextran capsule is produced when the bacteria grow on sucrose. These bacteria and others that become trapped in the dextran produce lactic acid, which erodes tooth enamel.
3. **Disease** | **Suspect Foods** | **Symptoms**
---|---|---
Staph | Not cooked prior to eating | Vomiting and diarrhea
Shigellosis | Contaminated water | Mucus and blood in stools
Salmonellosis | Poultry; contaminated water | Fever, vomiting, and diarrhea
Cholera | Contaminated water | Rice water stools
Gastro. | Contaminated water | Vomiting and diarrhea
Traveler’s | Contaminated water | Vomiting and diarrhea

Refer to Table 25.2.

4. Both are caused by *Salmonella enterica*. However, typhoid fever is caused by a few strains of *S. enterica* that are invasive. The bacteria can cross the intestinal wall and can be disseminated throughout the body. Typhoid fever is characterized by fever and malaise without diarrhea.

5. Certain strains of *E. coli* may produce an enterotoxin or invade the epithelium of the large intestine.

6. At present there are no treatments for hepatitis. Exposed individuals can be given pooled immune globulin for hepatitis A or HBIG for passive immunity to hepatitis B. Vaccines can prevent hepatitis A and B.

7. Antibodies specific for HBsAg are used to screen blood for HBV. A viral protein is used to test blood for antibodies against HCV.

8. Toxins produced by fungi; see pp. 726–727.

9. All four are caused by protozoa. The infections are acquired by ingesting protozoa in contaminated water. Giardiasis is a prolonged diarrhea. Amoebic dysentery is the most severe dysentry, with blood and mucus in the stools. *Cryptosporidium* and *Cyclospora* produce severe diseases in persons with immune deficiencies.

10. **Disease** | **Etiologic Agent** | **Symptoms**
---|---|---
Amoebic | *Entamoeba histolytica* | Blood and mucus in stools, perforation of the intestinal wall, abscesses
Bacillary | *Shigella* spp. | Leukocytes in feces in addition to the symptoms listed for amoebic dysentery

11. Fever, nausea, abdominal pain, cramps, diarrhea. The diagnosis is based on isolation of the etiologic agent from leftover food or the patient’s stools.

12. **Food intoxication**: Microorganisms must be allowed to grow in food from the time of preparation to the time of ingestion. This usually occurs when foods are stored unrefrigerated or improperly canned. The etiologic agents (*Staphylococcus aureus* or *Clostridium botulinum*) must produce an exotoxin. Onset: 1 to 48 hours. Duration: A few days. Treatment: Antimicrobial agents are ineffective. The patient’s symptoms may be treated.

**Food infection**: Viable microorganisms must be ingested with food or water. The organisms could be present during preparation and survive cooking or be inoculated during later handling. The etiologic agents are usually gram-negative organisms (*Salmonella, Shigella, Vibrio, and Escherichia*) that produce endotoxins. *Clostridium perfringens* is a gram-positive bacterium that causes food infection. Onset: 12 hours to 2 weeks. Duration: Longer than intoxication because the microorganisms are growing in the patient. Treatment: Rehydration.

13. **Disease** | **Site** | **Symptoms**
---|---|---
Mumps | Parotid glands | Inflammation of the parotid glands and fever
Infectious hepatitis | Liver | Anorexia, fever, diarrhea
Serum hepatitis | Liver | Anorexia, fever, joint pains, jaundice
Viral gastroenteritis | Lower GI tract | Nausea, diarrhea, vomiting

Refer to Table 25.2 to complete this question.
14. **Life cycle of the beef tapeworm, Taenia saginata.** The adult tapeworm lives in the intestine of the human, the definitive host. Tapeworm segments and eggs are eliminated with feces and are ingested by intermediate hosts, such as grazing cattle. The tapeworm eggs hatch, and cysticerci form in the animal’s muscles, which are later consumed by humans. The pork tapeworm, Taenia solium, has a similar life cycle, except that cysticerci may also form in human tissue.

15. Refer to Figure 25.25.

16. Adequate sewage treatment and sanitary living conditions.

17. Cook meat thoroughly. Eliminate the source of contamination to cattle and pigs.

**Multiple Choice**

**Chapter 25**

1. d
2. e
3. e
4. c
5. e
6. b
7. b
8. e
9. a
10. d
Chapter 26 Microbial Diseases of the Urinary and Reproductive Systems

Answers

Review

1. Organs of the upper urinary tract are sterile. The resident microbiota of the urethra are *Streptococcus*, *Bacteroides*, *Mycobacterium*, *Neisseria*, and some enterobacteria.

2. Normal microbiota of the male genital system is the same as that of the urinary tract. During reproductive years, lactobacilli predominate in the vagina.

3. Urinary tract infections may be transmitted by improper personal hygiene and contamination during medical procedures. They are often caused by opportunistic pathogens.

4. The proximity of the anus to the urethra and the relatively short length of the urethra can allow contamination of the urinary bladder in females. Predisposing factors for cystitis in females are gastrointestinal infections and vaginal and urinary tract infections.

5. *Escherichia coli* causes about 75% of the cases. From lower urinary tract or systemic infections.

6. **Disease** | **Symptoms** | **Diagnosis**
---|---|---
Gardnerella | Fishy odor | Odor, pH, clue cells
Gonorrhea | Painful urination | Isolation of *Neisseria*
Syphilis | Chancre | FTA–ABS
PID | Abdominal pain | Culture of pathogen
NGU | Urethritis | Absence of *Neisseria*
LGV | Lesion, lymph node enlargement | Observation of *Chlamydia* in cells
Chancroid | Swollen ulcer | Isolation of *Haemophilus*

7. Transmission—Water; enters via wounds.
   Activities—Water contact; contact with animals or rodent-infested places.
   Etiology—*Leptospira interrogans*.

   Etiology: Herpes simplex type 2 (sometimes type 1). When the lesions are not present, the virus is latent and noncommunicable.

   *Trichomonas vaginalis*: Profuse yellow discharge with disagreeable odor.

10. **Disease** | **Prevention of Congenital Disease**
---|---
Gonorrhea | Treatment of newborn’s eyes
Syphilis | Prevention and treatment of mother’s disease
NGU | Treatment of newborn’s eyes
Genital herpes | Cesarean delivery during active infection
Multiple Choice

Chapter 26

1. b
2. e
3. a
4. c
5. d
6. c
7. c
8. e
9. b
10. a

Chapter 27 Environmental Microbiology

Answers

Review

1. Extremophiles include thermophiles such as *Thermus aquaticus*, acidophiles such as *Thiobacillus*, halophiles such as *Halobacterium*, and endoliths.
2. The koala should have an organ housing a large population of cellulose-degrading microorganisms.
3. *Penicillium* might make penicillin to reduce competition from faster-growing bacteria.
4. ![Diagram](image)

   1—Any chemoheterotroph using aerobic respiration
   2—Any aerobic autotroph
   3—Any anaerobic autotroph
   4—Any chemoheterotroph producing CO₂ via fermentation
5. Amino acids; SO₄²⁻; plants and bacteria; H₂S; carbohydrates; S⁰.
6. Phosphorus must be available for all organisms.
7. **Process** | **Reactions** | **Microorganisms**
---|---|---
Ammonification | $\text{NH}_2 \rightarrow \text{NH}_3$ | Proteolytic bacteria
Nitrification | $\text{NH}_3 \rightarrow \text{NO}_2^-$ | *Nitrosomonas*
 | $\text{NO}_2^- \rightarrow \text{NO}_3^-$ | *Nitrobacter*
Denitrification | $\text{NO}_3^- \rightarrow \text{N}_2$ | *Bacillus*
N fixation | $\text{N}_2 \rightarrow \text{NH}_3$ | *Rhizobium*

8. Cyanobacteria: With fungi, cyanobacteria act as the photoautotrophic partner in a lichen; they may also fix nitrogen in the lichen. With *Azolla*, they fix nitrogen.

Mycorrhizae: Fungi that grow in and on the roots of higher plants; increase absorption of nutrients.

*Rhizobium*: In root nodules of legumes; fix nitrogen.

*Frankia*: In root nodules of alders, roses, and other plants; fix nitrogen.

9. **Settling**

Flocculation treatment

Sand filtration (or activated charcoal filtration)

Chlorination

The amount of treatment prior to chlorination depends on the amount of inorganic and organic matter in the water.

10. A coliform count is used to determine the bacteriologic quality of water; that is, the presence of human pathogens or evidence of fecal contamination.

11. **b** Leaching field

   **a** Removal of solids

   **b** Biological degradation

   **b** Activated sludge

   **c** Chemical precipitation of phosphorus

   **b** Trickling filter

   **c** Results in drinking water

12. Activated sludge is an aerobic process that can result in complete oxidation of organic matter.

13. Both require large areas of land and can result in the pollution of surface or groundwater if they are overloaded.

14. | **BOD** | **Rate of Eutrophication** | **Dissolved Oxygen** |
---|---|---|---|
Untreated | 3+ | 3+ | +
Primary | 2+ | 2+ | 2+
Secondary | + | + | 3+

Accumulation of BOD and loss of dissolved oxygen would be much less in a fast-moving river. Continual aeration caused by the river’s movement would result in rapid oxidation of organic matter.

15. Biodegradation of sewage, herbicides, oil, or PCBs.
Multiple Choice

Chapter 27
1. a
2. b
3. b
4. b
5. c
6. c
7. b
8. b
9. e
10. c

Chapter 28 Applied and Industrial Microbiology

Answers

Review

1. Industrial microbiology is the science of using microorganisms to produce products or accomplish a process. Industrial microbiology provides (1) chemicals such as antibiotics that would not otherwise be available, (2) processes to remove or detoxify pollutants, (3) fermented foods that have desirable flavors or enhanced shelf life, and (4) enzymes for manufacturing a variety of goods.

2. The goal of commercial sterilization is to eliminate spoilage and disease-causing organisms. The goal of hospital sterilization is complete sterilization.

3. The acid in the berries will prevent the growth of some microbes.

4. A presterilized package is aseptically filled with presterilized food.

5. Milk → Lactic acid bacteria → Curd + Whey
   ↓   ↓
   Cheese  Waste

   Hard cheese is ripened by lactic acid bacteria growing anaerobically in the interior of the curd. Soft cheese is ripened by molds growing aerobically on the outside of the curd.

6. Fruit juice → Yeast → Ethyl alcohol + CO₂

7. Nutrients must be dissolved in water; water is also needed for hydrolysis. Malt is the carbon and energy source that the yeast will ferment to make alcohol. Malt contains glucose and maltose from the action of amylases on starch in seeds (barley).

8. A bioreactor provides the following advantages over simple flask containers:
   • Larger culture volumes can be grown.
   • Process instrumentation for monitoring and controlling critical environmental conditions such as pH, temperature, dissolved oxygen, and aeration can be used.
   • Sterilization and cleaning systems are designed in place.
   • Aseptic sampling and harvest systems for in-process sampling exist.
   • Improved aeration and mixing characteristics result in improved cell growth and high final cell densities.
• A high degree of automation is possible.
• Process reproducibility is improved.

9. (1) Enzymes don’t produce hazardous wastes; (2) Enzymes work under reasonable conditions, e.g., they don’t require high temperatures or acidity; (3) Eliminates the need to use petroleum in chemical syntheses of solvents such as alcohol and acetone; (4) Enzymes are biodegradable; (5) Enzymes are not toxic.

10. A primary metabolite is produced during trophophase; a secondary metabolite, during idiophase.

11. The production of ethyl alcohol from corn; or methane from sewage. Alcohols and hydrogen are produced by fermentation; methane is produced by anaerobic respiration.

**Multiple Choice**

Chapter 28

1. c
2. b
3. e
4. c
5. b
6. c
7. a
8. a
9. b
10. a