

Appendix A

Fundamentals Of Physics And Chemistry Important To Microbiology

Like all other matter, the matter that comprises microorganisms is governed by the laws of chemistry and physics. The chemical and physical properties of microbial pathogens—both cellular and acellular—dictate their habitat, control their metabolic processes, and determine how they interact with the human body. This appendix provides a review of some of the fundamental principles of chemistry and physics that are essential to an understanding of microbiology. Many of the chapters in this text—especially **Microbial Biochemistry** and **Microbial Metabolism**—assume that the reader already has an understanding of the concepts reviewed here.

Atomic Structure

Life is made up of matter. Matter occupies space and has mass. All matter is composed of **atoms**. All atoms contain **protons**, **electrons**, and **neutrons** (**Figure A1**). The only exception is hydrogen (H), which is made of one proton and one electron. A proton is a positively charged particle that resides in the nucleus (the core of the atom) of an atom and has a mass of 1 atomic mass unit (amu) and a charge of +1. An electron is a negatively charged particle that travels in the space around the nucleus. Electrons are distributed in different energy levels called electron shells. Electrons have a negligible mass and a charge of -1 . Neutrons, like protons, reside in the nucleus of an atom. They have a mass of 1 amu and no charge (neutral). The positive (proton) and negative (electron) charges balance each other in a neutral atom, which has a net zero charge. Because protons and neutrons each have a mass of 1 amu, the mass of an atom is equal to the number of protons and neutrons of that atom. The number of electrons does not factor into the overall mass because electron mass is so small.

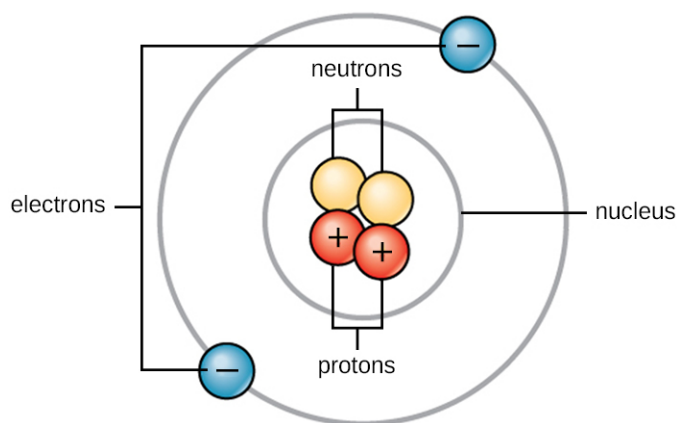


Figure A1 Atoms are made up of protons and neutrons located within the nucleus and electrons surrounding the nucleus.

Chemical Elements

All matter is composed of atoms of **elements**. Elements have unique physical and chemical properties and are substances that cannot easily be transformed either physically or chemically into other substances. Each element has been given a name, usually derived from Latin or English. The elements also have one- or two-letter symbols

representing the name; for example, sodium (Na), gold (Au), and silver (Ag) have abbreviations derived from their original Latin names *natrium*, *aurum*, and *argentum*, respectively. Examples with English abbreviations are carbon (C), hydrogen (H), oxygen (O), and nitrogen (N). A total of 118 different elements (92 of which occur naturally) have been identified and organized into the periodic table of elements. Of the naturally occurring elements, fewer than 30 are found in organisms on Earth, and four of those (C, H, O, and N) make up approximately 96% of the mass of an organism.^[1]

Each unique element is identified by the number of protons in its atomic nucleus. In addition to protons, each element's atomic nucleus contains an equal or greater number of neutrons (with the exception of hydrogen, which has only one proton). The total number of protons per element is described as the **atomic number**, and the combined mass of protons and neutrons is called the atomic mass or **mass number**. Therefore, it is possible to determine the number of neutrons by subtracting the atomic number from the mass number.

Isotopes are different forms of the same element that have the same number of protons, but a different number of neutrons. Many elements have several isotopes with one or two commonly occurring isotopes in nature. For example, carbon-12 (^{12}C), the most common isotope of carbon (98.6% of all C found on Earth),^[2] contains six protons and six neutrons. Therefore, it has a mass number of 12 (6 protons + 6 neutrons) and an atomic number of 6.

There are two additional types of isotopes in nature: heavy isotopes, and radioisotopes. Heavy isotopes have one or more extra neutrons while still maintaining a stable atomic nucleus. An example of a heavy isotope is carbon-13 (^{13}C) (1.1% of all carbon).^[3] ^{13}C has a mass number of 13 (6 protons + 7 neutrons). Since the atomic number of ^{13}C is 6, it is still the element carbon; however, it has more mass than the more common form of the element, ^{12}C , because of the extra neutron in the nucleus. Carbon-14 (^{14}C) (0.0001% of all carbon)^[4] is an example of a radioisotope. ^{14}C has a mass number of 14 (6 protons + 8 neutrons); however, the extra neutrons in ^{14}C result in an unstable nucleus. This instability leads to the process of radioactive decay. Radioactive decay involves the loss of one or more neutrons and the release of energy in the form of gamma rays, alpha particles, or beta particles (depending on the isotope).

Heavy isotopes and radioisotopes of carbon and other elements have proven to be useful in research, industry, and medicine.

Chemical Bonds

There are three types of chemical bonds that are important when describing the interaction of atoms both within and between molecules in microbiology: (1) covalent bonds, which can be either polar or non-polar, (2) ionic bonds, and (3) hydrogen bonds. There are other types of interactions such as *London* dispersion forces and *van der Waals* forces that could also be discussed when describing the physical and chemical properties of the intermolecular interactions of atoms, but we will not include descriptions of these forces here.

Chemical bonding is determined by the outermost shell of electrons, called the valence electrons (VE), of an atom. The number of VE is important when determining the number and type of chemical bonds an atom will form.

Covalent Bonds

The strongest chemical bond between two or more atoms is a **covalent bond**. These bonds form when an electron is shared between two atoms, and these are the most common form of chemical bond in living organisms. Covalent bonds form between the atoms of elements that make up the biological molecules in our cells. An example of a simple molecule formed with covalent bonds is water, H_2O , with one VE per H atom and 6 VE per O atom. Because of the VE configuration, each H atom is able to accept one additional VE and each O atom is able to accept two additional VE. When sharing electrons, the hydrogen and oxygen atoms that combine to form water molecules become bonded

1. Schrijver, Karel, and Iris Schrijver. *Living with the Stars: How the Human Body Is Connected to the Life Cycles of the Earth, the Planets, and the Stars*. Oxford University Press, USA, 2015.

2. National Oceanic and Atmospheric Administration, "Stable and Radiocarbon Isotopes of Carbon Dioxide." Web page. Accessed Feb 19, 2016 [<http://www.esrl.noaa.gov/gmd/outreach/isotopes/chemistry.html>]

3. *ibid.*

4. *ibid.*

together by covalent bonds (**Figure A2**). The electron from the hydrogen atom divides its time between the outer electron shell of the hydrogen atom and the outermost electron shell of the oxygen atom. To completely fill the outer shell of an oxygen atom, two electrons from two hydrogen atoms are needed, hence the subscript “2” indicating two atoms of H in a molecule of H_2O . This sharing is a lower energy state for all of the atoms involved than if they existed without their outer shells filled.

There are two types of covalent bonds: polar and nonpolar. **Nonpolar covalent** bonds form between two atoms of the same or different elements that share the electrons equally (**Figure A2**). In a **polar covalent bond**, the electrons shared by the atoms spend more time closer to one nucleus than to the other nucleus. Because of the unequal distribution of electrons between the different nuclei, a slightly positive (δ^+) or slightly negative (δ^-) charge develops. Water is an example of a molecule formed with **polar covalent bonds** (**Figure A2**).

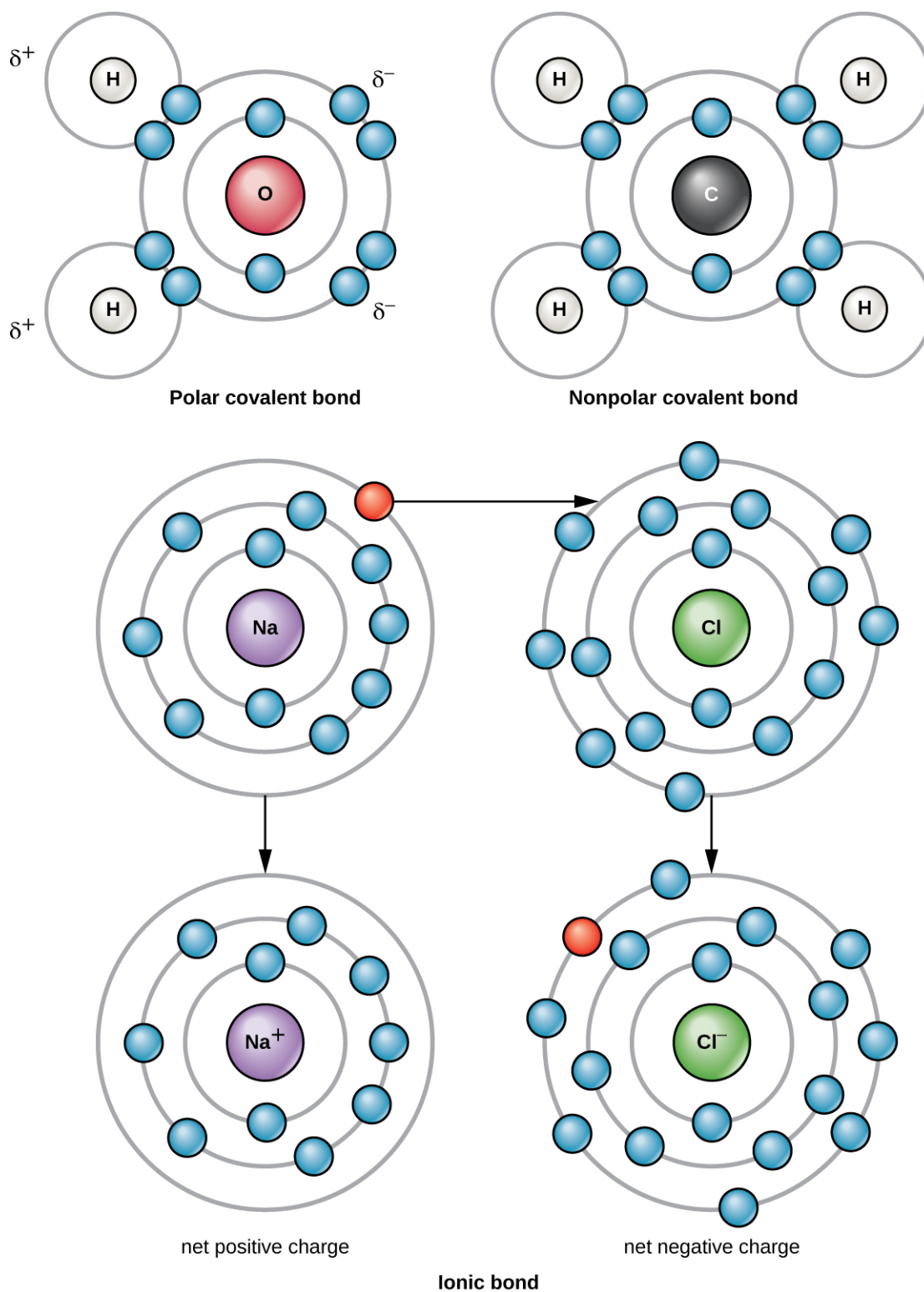


Figure A2 The water molecule (top left) depicts a polar bond with a slightly positive charge on the hydrogen atoms and a slightly negative charge on the oxygen. Methane (top right) is an example of a nonpolar covalent bond. Sodium chloride (bottom) is a substance formed from ionic bonds between sodium and chlorine.

Ions and Ionic Bonds

When an atom does not contain equal numbers of protons and electrons, it is called an **ion**. Because the number of electrons does not equal the number of protons, each ion has a net charge. Positive ions are formed by losing electrons and are called **cations**. Negative ions are formed by gaining electrons and are called **anions**.

For example, a sodium atom has only one electron in its outermost shell. It takes less energy for the sodium atom to donate that one electron than it does to accept seven more electrons, which it would need to fill its outer shell. If the sodium atom loses an electron, it now has 11 protons and only 10 electrons, leaving it with an overall charge of +1. It is now called a sodium ion (Na^+).

A chlorine atom has seven electrons in its outer shell. Again, it is more energy efficient for the chlorine atom to gain one electron than to lose seven. Therefore, it will more likely gain an electron to form an ion with 17 protons and 18 electrons, giving it a net negative (-1) charge. It is now called a chloride ion (Cl^-). This movement of electrons from one atom to another is referred to as electron transfer. Because positive and negative charges attract, these ions stay together and form an **ionic bond**, or a bond between ions. When Na^+ and Cl^- ions combine to produce NaCl , an electron from a sodium atom stays with the other seven from the chlorine atom, and the sodium and chloride ions attract each other in a lattice of ions with a net zero charge (**Figure A2**).

Polyatomic ions consist of multiple atoms joined by covalent bonds; but unlike a molecule, a polyatomic ion has a positive or negative charge. It behaves as a cation or anion and can therefore form ionic bonds with other ions to form ionic compounds. The atoms in a polyatomic ion may be from the same element or different elements.

Table A1 lists some cations and anions that commonly occur in microbiology. Note that this table includes monoatomic as well as polyatomic ions.

Some Common Ions in Microbiology

Cations		Anions	
sodium	Na^+	chloride	Cl^-
hydrogen	H^+	bicarbonate	HCO_3^-
potassium	K^+	carbonate	CO_3^{2-}
ammonium	NH_4^+	hydrogen sulfate	$\text{H}_2\text{SO}_4^{2-}$
copper (I)	Cu^+	hydrogen sulfide	HS^-
copper (II)	Cu^{2+}	hydroxide	OH^-
iron (II)	Fe^{2+}	hypochlorite	ClO^-
iron (III)	Fe^{3+}	nitrite	NO_2^-
		nitrate	NO_3^-
		peroxide	O_2^{2-}
		phosphate	PO_4^{3-}
		pyrophosphate	$\text{P}_2\text{O}_7^{4-}$
		sulfite	SO_3^{2-}
		thiosulfate	$\text{S}_2\text{O}_3^{2-}$

Table A1

Molecular Formula, Molecular Mass, and the Mole

For molecules formed by covalent bonds, the molecular formula represents the number and types of elemental atoms that compose the molecule. As an example, consider a molecule of glucose, which has the molecular formula $C_6H_{12}O_6$. This molecular formula indicates that a single molecule of glucose is formed from six carbon atoms, twelve hydrogen atoms, and six oxygen atoms.

The **molecular mass** of a molecule can be calculated using the molecular formula and the atomic mass of each element in the molecule. The number of each type of atom is multiplied by the atomic mass; then the products are added to get the molecular mass. For example the molecular mass of glucose, $C_6H_{12}O_6$ (**Figure A3**), is calculated as:

$$\begin{aligned}\text{mass of carbon} &= 12 \frac{\text{amu}}{\text{atom}} \times 6 \text{ atoms} = 72 \text{ amu} \\ \text{mass of hydrogen} &= 1 \frac{\text{amu}}{\text{atom}} \times 12 \text{ atoms} = 12 \text{ amu} \\ \text{mass of oxygen} &= 16 \frac{\text{amu}}{\text{atom}} \times 6 \text{ atoms} = 96 \text{ amu} \\ \text{molecular mass of glucose} &= 72 \text{ amu} + 12 \text{ amu} + 96 \text{ amu} = 180 \text{ amu}\end{aligned}$$

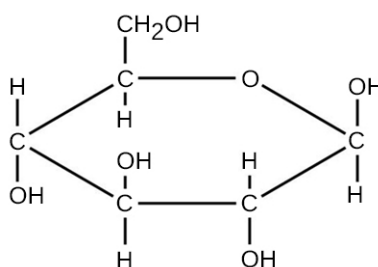


Figure A3 The molecular structure of glucose showing the numbers of carbon, oxygen, and hydrogen atoms. Glucose has a molecular mass of 180 amu.

The number of entities composing a mole has been experimentally determined to be 6.022×10^{23} , a fundamental constant named **Avogadro's number** (N_A) or the Avogadro constant. This constant is properly reported with an explicit unit of “per mole.”

Energy

Thermodynamics refers to the study of energy and energy transfer involving physical matter.

Matter participating in a particular case of energy transfer is called a system, and everything outside of that matter is called the surroundings. There are two types of systems: open and closed. In an **open system**, energy can be exchanged with its surroundings. A **closed system** cannot exchange energy with its surroundings. Biological organisms are open systems. Energy is exchanged between them and their surroundings as they use energy from the sun to perform photosynthesis or consume energy-storing molecules and release energy to the environment by doing work and releasing heat. Like all things in the physical world, energy is subject to physical laws. In general, energy is defined as the ability to do work, or to create some kind of change. Energy exists in different forms. For example, electrical energy, light energy, and heat energy are all different types of energy. The **first law of thermodynamics**, often referred to as the law of conservation of energy, states that the total amount of energy in the universe is constant and conserved. Energy exists in many different forms. According to the first law of thermodynamics, energy may be transferred from place to place or transformed into different forms, but it cannot be created or destroyed.

The challenge for all living organisms is to obtain energy from their surroundings in forms that they can transfer or transform into usable energy to do work. Microorganisms have evolved to meet this challenge. Chemical energy stored within organic molecules such as sugars and fats is transferred and transformed through a series of cellular chemical reactions into energy within molecules of ATP. Energy in ATP molecules is easily accessible to do work. Examples of the types of work that cells need to do include building complex molecules, transporting materials,

powering the motion of cilia or flagella, and contracting muscle fibers to create movement.

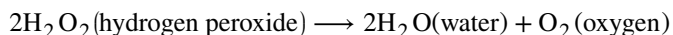
A microorganism's primary tasks of obtaining, transforming, and using energy to do work may seem simple. However, the **second law of thermodynamics** explains why these tasks are more difficult than they appear. All energy transfers and transformations are never completely efficient. In every energy transfer, some amount of energy is lost in a form that is unusable. In most cases, this form is **heat energy**. Thermodynamically, heat energy is defined as the energy transferred from one system to another that is not work. For example, some energy is lost as heat energy during cellular metabolic reactions.

The more energy that is lost by a system to its surroundings, the less ordered and more random the system is. Scientists refer to the measure of randomness or disorder within a system as **entropy**. High entropy means high disorder and low energy. Molecules and chemical reactions have varying entropy as well. For example, entropy increases as molecules at a high concentration in one place diffuse and spread out. The second law of thermodynamics says that energy will always be lost as heat in energy transfers or transformations. Microorganisms are highly ordered, requiring constant energy input to be maintained in a state of low entropy.

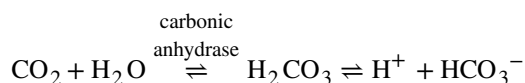
Chemical Reactions

Chemical reactions occur when two or more atoms bond together to form molecules or when bonded atoms are broken apart. The substances used in a chemical reaction are called the **reactants** (usually found on the left side of a chemical equation), and the substances produced by the reaction are known as the **products** (usually found on the right side of a chemical equation). An arrow is typically drawn between the reactants and products to indicate the direction of the chemical reaction; this direction is not always a “one-way street.”

An example of a simple chemical reaction is the breaking down of hydrogen peroxide molecules, each of which consists of two hydrogen atoms bonded to two oxygen atoms (H_2O_2). The reactant hydrogen peroxide is broken down into water, containing one oxygen atom bound to two hydrogen atoms (H_2O), and oxygen, which consists of two bonded oxygen atoms (O_2). In the equation below, the reaction includes two hydrogen peroxide molecules and two water molecules. This is an example of a balanced chemical equation, wherein the number of atoms of each element is the same on each side of the equation. According to the law of conservation of matter, the number of atoms before and after a chemical reaction should be equal, such that no atoms are, under normal circumstances, created or destroyed.



Some chemical reactions, such as the one shown above, can proceed in one direction until the reactants are all used up. Equations that describe these reactions contain a unidirectional arrow and are irreversible. **Reversible reactions** are those that can go in either direction. In reversible reactions, reactants are turned into products, but when the concentration of product rises above a certain threshold (characteristic of the particular reaction), some of these products will be converted back into reactants; at this point, the designations of products and reactants are reversed. The changes in concentration continue until a certain relative balance in concentration between reactants and products occurs—a state called **chemical equilibrium**. At this point, both the forward and reverse reactions continue to occur, but they do so at the same rate, so the concentrations of reactants and products do not change. These situations of reversible reactions are often denoted by a chemical equation with a double-headed arrow pointing towards both the reactants and products. For example, when carbon dioxide dissolves in water, it can do so as a gas dissolved in water or by reacting with water to produce carbonic acid. In the cells of some microorganisms, the rate of carbonic acid production is accelerated by the enzyme carbonic anhydrase, as indicated in the following equation:



Properties of Water and Solutions

The hydrogen and oxygen atoms within water molecules form polar covalent bonds. There is no overall charge to a water molecule, but there is one δ^+ on each hydrogen atom and two δ^- on the oxygen atom. Each water molecule attracts other water molecules because of the positive and negative charges in the different parts of the molecule (**Figure A4**). Water also attracts other polar molecules (such as sugars), forming hydrogen bonds. When a substance

readily forms hydrogen bonds with water, it can dissolve in water and is referred to as **hydrophilic** (“water-loving”). Hydrogen bonds are not readily formed with nonpolar substances like oils and fats. These nonpolar compounds are **hydrophobic** (“water-fearing”) and will orient away from and avoid water.

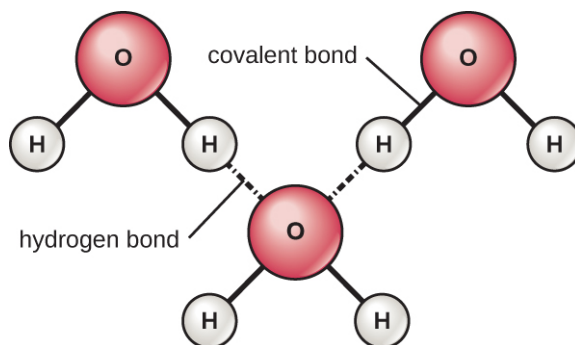


Figure A4 Hydrogen bonds form between slightly positive ($\delta+$) and slightly negative ($\delta-$) charges of polar covalent molecules such as water.

The hydrogen bonds in water allow it to absorb and release heat energy more slowly than many other substances. This means that water moderates temperature changes within organisms and in their environments. As energy input continues, the balance between hydrogen-bond formation and breaking swings toward fewer hydrogen bonds: more bonds are broken than are formed. This process results in the release of individual water molecules at the surface of the liquid (such as a body of water, the leaves of a plant, or the skin of an organism) in a process called **evaporation**.

Conversely, as molecular motion decreases and temperatures drop, less energy is present to break the hydrogen bonds between water molecules. These bonds remain intact and begin to form a rigid, lattice-like structure (e.g., ice). When frozen, ice is less dense (the molecules are farther apart) than liquid water. This means that ice floats on the surface of a body of water. In lakes, ponds, and oceans, ice will form on the surface of the water, creating an insulating barrier to protect the animal and plant life beneath from freezing in the water. If this did not happen, plants and animals living in water would freeze in a block of ice and could not move freely, making life in cold temperatures difficult or impossible.

Because water is polar, with slight positive and negative charges, ionic compounds and polar molecules can readily dissolve in it. Water is, therefore, what is referred to as a solvent—a substance capable of dissolving another substance. The charged particles will form hydrogen bonds with a surrounding layer of water molecules. This is referred to as a **sphere of hydration** and serves to keep the ions separated or dispersed in the water (**Figure A5**). These spheres of hydration are also referred to as hydration shells. The polarity of the water molecule makes it an effective solvent and is important in its many roles in living systems.

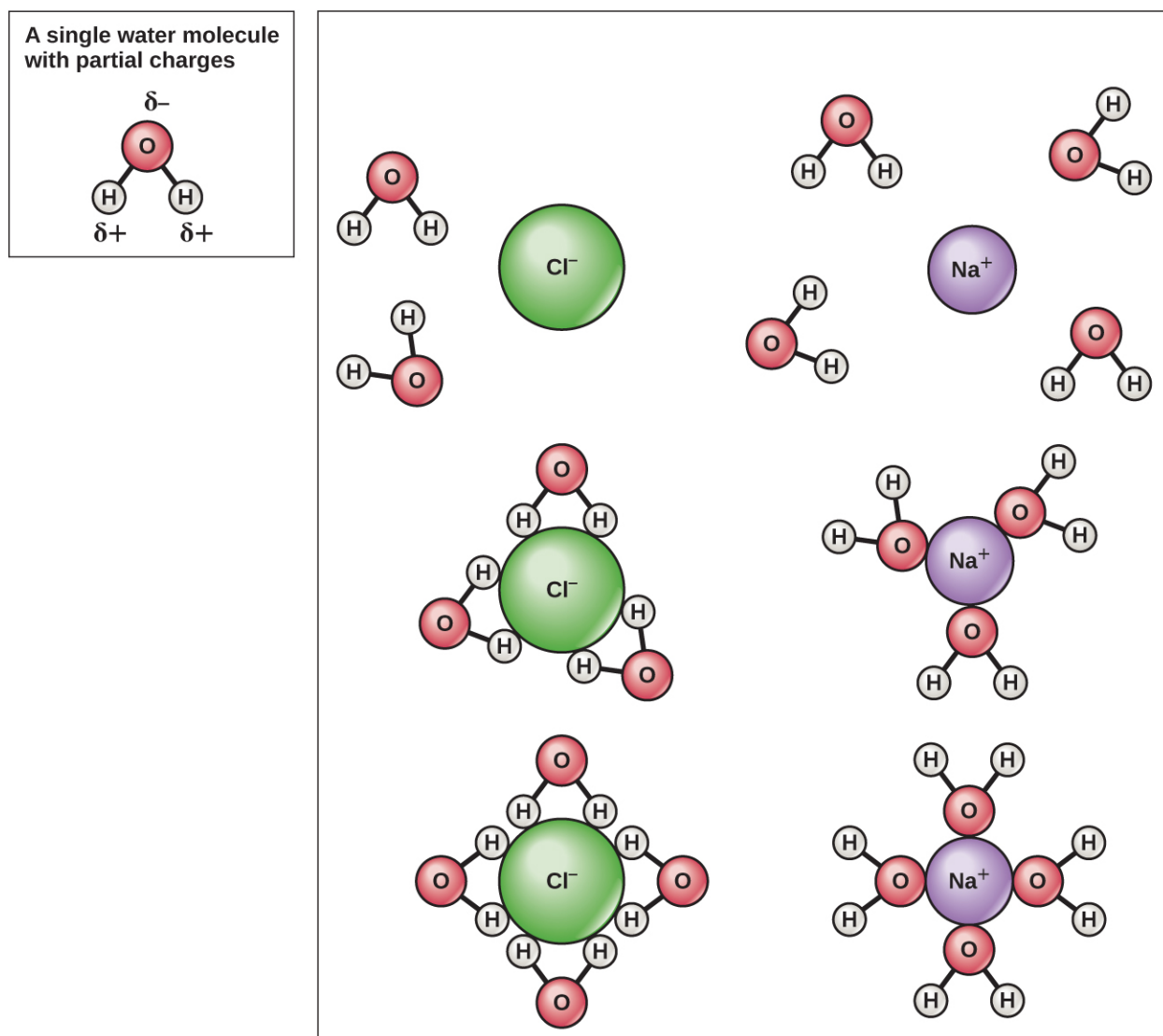


Figure A5 When table salt (NaCl) is mixed in water, spheres of hydration form around the ions.

The ability of insects to float on and skate across pond water results from the property of **cohesion**. In cohesion, water molecules are attracted to each other (because of hydrogen bonding), keeping the molecules together at the liquid-air (gas) interface. Cohesion gives rise to surface tension, the capacity of a substance to withstand rupture when placed under tension or stress.

These cohesive forces are also related to water's property of **adhesion**, or the attraction between water molecules and other molecules. This is observed when water “climbs” up a straw placed in a glass of water. You will notice that the water appears to be higher on the sides of the straw than in the middle. This is because the water molecules are attracted to the straw and therefore adhere to it.

Cohesion and adhesion are also factors in bacterial colonies and biofilm formation. Cohesion keeps the colony intact (helps it “stick” to a surface), while adhesion keeps the cells adhered to each other. Cohesive and adhesive forces are important for sustaining life. For example, because of these forces, water in natural surroundings provides the conditions necessary to allow bacterial and archaeal cells to adhere and accumulate on surfaces.

Acids and Bases

The **pH** of a solution is a measure of hydrogen ion (H^+) and hydroxide ion (OH^-) concentrations and is described as

acidity or **alkalinity**, respectively. Acidity and alkalinity (also referred to as basicity) can be measured and calculated. pH can be simply represented by the mathematic equation, $\text{pH} = -\log_{10}[\text{H}^+]$. On the left side of the equation, the "p" means "the negative logarithm of " and the H represents the $[\text{H}^+]$. On the right side of the equation, $[\text{H}^+]$ is the concentration of H^+ in moles/L. What is not represented in this simple equation is the contribution of the OH^- , which also participates in acidity or alkalinity. Calculation of pH results in a number range of 0 to 14 called the pH scale (**Figure A6**). A pH value between 0 and 6.9 indicates an acid. It is also referred to as a low pH, due to a high $[\text{H}^+]$ and low $[\text{OH}^-]$ concentration. A pH value between 7.1 and 14 indicates an alkali or base. It is also referred to as a high pH, due to a low $[\text{H}^+]$ and high $[\text{OH}^-]$ concentration. A pH of 7 is described as a neutral pH and occurs when $[\text{H}^+]$ equals $[\text{OH}^-]$.

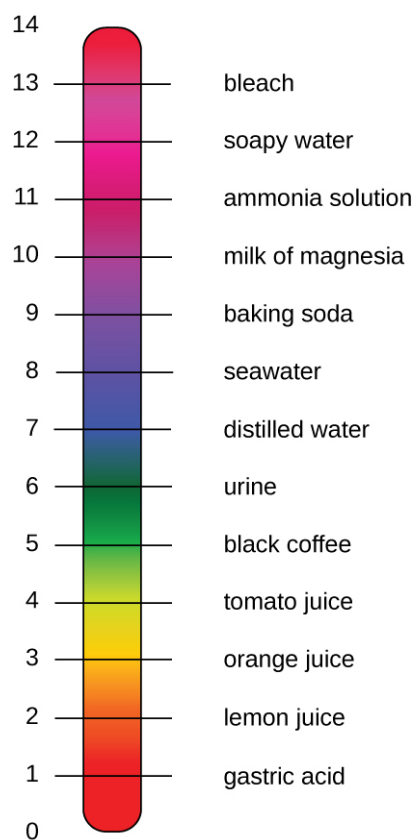


Figure A6 The pH scale measures the concentration of hydrogen ions $[\text{H}^+]$ and $[\text{OH}^-]$ in a substance. (credit: modification of work by Edward Stevens)

A change of one unit on the pH scale represents a change in the $[\text{H}^+]$ by a factor of 10, a change in two units represents a change in the $[\text{H}^+]$ by a factor of 100. Thus, small changes in pH represent large changes in $[\text{H}^+]$.

Appendix B

Mathematical Basics

Squares and Other Powers

An exponent, or a power, is mathematical shorthand for repeated multiplications. For example, the exponent “2” means to multiply the base for that exponent by itself (in the example here, the base is “5”):

$$5^2 = 5 \times 5 = 25$$

The exponent is “2” and the base is the number “5.” This expression (multiplying a number by itself) is also called a square. Any number raised to the power of 2 is being squared. Any number raised to the power of 3 is being cubed:

$$5^3 = 5 \times 5 \times 5 = 125$$

A number raised to the fourth power is equal to that number multiplied by itself four times, and so on for higher powers. In general:

$$n^x = n \times n^{x-1}$$

Calculating Percents

A percent is a way of expressing a fractional amount of something using a whole divided into 100 parts. A percent is a ratio whose denominator is 100. We use the percent symbol, %, to show percent. Thus, 25% means a ratio of $\frac{25}{100}$, 3% means a ratio of $\frac{3}{100}$, and 100 % percent means $\frac{100}{100}$, or a whole.

Converting Percents

A percent can be converted to a fraction by writing the value of the percent as a fraction with a denominator of 100 and simplifying the fraction if possible.

$$25\% = \frac{25}{100} = \frac{1}{4}$$

A percent can be converted to a decimal by writing the value of the percent as a fraction with a denominator of 100 and dividing the numerator by the denominator.

$$10\% = \frac{10}{100} = 0.10$$

To convert a decimal to a percent, write the decimal as a fraction. If the denominator of the fraction is not 100, convert it to a fraction with a denominator of 100, and then write the fraction as a percent.

$$0.833 = \frac{833}{1000} = \frac{83.3}{100} = 83.3\%$$

To convert a fraction to a percent, first convert the fraction to a decimal, and then convert the decimal to a percent.

$$\frac{3}{4} = 0.75 = \frac{75}{100} = 75\%$$

Suppose a researcher finds that 15 out of 23 students in a class are carriers of *Neisseria meningitides*. What percentage of students are carriers? To find this value, first express the numbers as a fraction.

$$\frac{\text{carriers}}{\text{total students}} = \frac{15}{23}$$

Then divide the numerator by the denominator.

$$\frac{15}{23} = 15 \div 23 \approx 0.65$$

Finally, to convert a decimal to a percent, multiply by 100.

$$0.65 \times 100 = 65\%$$

The percent of students who are carriers is 65%.

You might also get data on occurrence and non-occurrence; for example, in a sample of students, 9 tested positive for *Toxoplasma* antibodies, while 28 tested negative. What is the percentage of seropositive students? The first step is to determine the “whole,” of which the positive students are a part. To do this, sum the positive and negative tests.

$$\text{positive} + \text{negative} = 9 + 28 = 37$$

The whole sample consisted of 37 students. The fraction of positives is:

$$\frac{\text{positive}}{\text{total students}} = \frac{9}{37}$$

To find the percent of students who are carriers, divide the numerator by the denominator and multiply by 100.

$$\frac{9}{37} = 9 \div 37 \approx 0.24$$

$$0.24 \times 100 = 24\%$$

The percent of positive students is about 24%.

Another way to think about calculating a percent is to set up equivalent fractions, one of which is a fraction with 100 as the denominator, and cross-multiply. The previous example would be expressed as:

$$\frac{9}{37} = \frac{x}{100}$$

Now, cross multiply and solve for the unknown:

$$\begin{array}{rcl} 9 \times 100 & = & 37x \\ \frac{9 \times 100}{37} & = & x \qquad \text{Divide both sides by 37} \\ \frac{900}{37} & = & x \qquad \text{Multiply} \\ 24 \approx & x & \text{Divide} \end{array}$$

The answer, rounded, is the same.

Multiplying and Dividing by Tens

In many fields, especially in the sciences, it is common to multiply decimals by powers of 10. Let's see what happens when we multiply 1.9436 by some powers of 10.

$$\begin{array}{rcl} 1.9436(10) & = & 19.436 \\ 1.9436(100) & = & 194.36 \\ 1.9436(1000) & = & 1943.6 \end{array}$$

The number of places that the decimal point moves is the same as the number of zeros in the power of ten. **Table B1** summarizes the results.

Multiply by	Zeros	Decimal point moves . . .
10	1	1 place to the right
100	2	2 places to the right
1,000	3	3 places to the right
10,000	4	4 places to the right

Table B1

We can use this pattern as a shortcut to multiply by powers of ten instead of multiplying using the vertical format. We can count the zeros in the power of 10 and then move the decimal point that same number of places to the right.

So, for example, to multiply 45.86 by 100, move the decimal point 2 places to the right.

$$45.86 \times 100 = 4586.$$


Sometimes when we need to move the decimal point, there are not enough decimal places. In that case, we use zeros as placeholders. For example, let's multiply 2.4 by 100. We need to move the decimal point 2 places to the right. Since there is only one digit to the right of the decimal point, we must write a 0 in the hundredths place.

$$2.4 \times 100 = 240.$$


When dividing by powers of 10, simply take the opposite approach and move the decimal to the left by the number of zeros in the power of ten.

Let's see what happens when we divide 1.9436 by some powers of 10.

$$\begin{aligned} 1.9436 \div 10 &= 0.19436 \\ 1.9436 \div 100 &= 0.019436 \\ 1.9436 \div 1000 &= 0.0019436 \end{aligned}$$

If there are insufficient digits to move the decimal, add zeroes to create places.

Scientific Notation

Scientific notation is used to express very large and very small numbers as a product of two numbers. The first number of the product, the digit term, is usually a number not less than 1 and not greater than 10. The second number of the product, the exponential term, is written as 10 with an exponent. Some examples of scientific notation are given in **Table B2**.

Standard Notation	Scientific Notation
1000	1×10^3
100	1×10^2
10	1×10^1
1	1×10^0
0.1	1×10^{-1}
0.01	1×10^{-2}

Table B2

Scientific notation is particularly useful notation for very large and very small numbers, such as $1,230,000,000 = 1.23 \times 10^9$, and $0.00000000036 = 3.6 \times 10^{-10}$.

Expressing Numbers in Scientific Notation

Converting any number to scientific notation is straightforward. Count the number of places needed to move the decimal next to the left-most non-zero digit: that is, to make the number between 1 and 10. Then multiply that number by 10 raised to the number of places you moved the decimal. The exponent is positive if you moved the decimal to the left and negative if you moved the decimal to the right. So

$$2386 = 2.386 \times 1000 = 2.386 \times 10^3$$

and

$$0.123 = 1.23 \times 0.1 = 1.23 \times 10^{-1}$$

The power (exponent) of 10 is equal to the number of places the decimal is shifted.

Logarithms

The common logarithm (log) of a number is the power to which 10 must be raised to equal that number. For example, the common logarithm of 100 is 2, because 10 must be raised to the second power to equal 100. Additional examples are in **Table B3**.

Number	Exponential Form	Common Logarithm
1000	10^3	3
10	10^1	1
1	10^0	0
0.1	10^{-1}	-1
0.001	10^{-3}	-3

Table B3

To find the common logarithm of most numbers, you will need to use the LOG button on a calculator.

Rounding and Significant Digits

In reporting numerical data obtained via measurements, we use only as many significant figures as the accuracy of the measurement warrants. For example, suppose a microbiologist using an automated cell counter determines that there are 525,341 bacterial cells in a one-liter sample of river water. However, she records the concentration as 525,000 cells per liter and uses this rounded number to estimate the number of cells that would likely be found in 10 liters of river water. In this instance, the last three digits of the measured quantity are not considered *significant*. They are rounded to account for variations in the number of cells that would likely occur if more samples were measured.

The importance of significant figures lies in their application to fundamental computation. In addition and subtraction, the sum or difference should contain as many digits to the right of the decimal as that in the *least* certain (indicated by underscoring in the following example) of the numbers used in the computation.

Suppose a microbiologist wishes to calculate the total mass of two samples of agar.

$$\begin{array}{r} 4.38\underline{3} \text{ g} \\ 3.002\underline{1} \text{ g} \\ 7.38\underline{5} \text{ g} \end{array}$$

The least certain of the two masses has three decimal places, so the sum must have three decimal places.

In multiplication and division, the product or quotient should contain no more digits than in the factor containing the *least* number of significant figures. Suppose the microbiologist would like to calculate how much of a reagent would be present in 6.6 mL if the concentration is 0.638 g/mL.

$$0.638 \frac{\text{g}}{\text{mL}} \times 6.\underline{6} \text{ mL} = 4.1 \text{ g}$$

Again, the answer has only one decimal place because this is the accuracy of the least accurate number in the calculation.

When rounding numbers, increase the retained digit by 1 if it is followed by a number larger than 5 (“round up”). Do

not change the retained digit if the digits that follow are less than 5 (“round down”). If the retained digit is followed by 5, round up if the retained digit is odd, or round down if it is even (after rounding, the retained digit will thus always be even).

Generation Time

It is possible to write an equation to calculate the cell numbers at any time if the number of starting cells and doubling time are known, as long as the cells are dividing at a constant rate. We define N_0 as the starting number of bacteria, the number at time $t = 0$. N_i is the number of bacteria at time $t = i$, an arbitrary time in the future. Finally we will set j equal to the number of generations, or the number of times the cell population doubles during the time interval. Then we have,

$$N_i = N_0 \times 2^j$$

This equation is an expression of growth by binary fission.

In our example, $N_0 = 4$, the number of generations, j , is equal to 3 after 90 minutes because the generation time is 30 minutes. The number of cells can be estimated from the following equation:

$$\begin{aligned} N_i &= N_0 \times 2^j \\ N_{90} &= 4 \times 2^3 \\ N_{90} &= 4 \times 8 = 32 \end{aligned}$$

The number of cells after 90 minutes is 32.

Most Probable Number

The table in **Figure B1** contains values used to calculate the most probable number example given in **How Microbes Grow**.

Most Probable Number Table					
Number of tubes giving a positive reaction for a 5-tube set			MPN (per 100 ml)	95% Confidence Limits	
10 ml	1 ml	0.1 ml		Low	High
0	0	0	<2	<1	7
0	1	0	2	<1	7
0	2	0	4	<1	11
1	0	0	2	<1	7
1	0	1	4	<1	11
1	1	0	4	<1	11
1	1	1	6	<1	15
2	0	0	5	<1	13
2	0	1	7	1	17
2	1	0	7	1	17
2	1	1	9	2	21
2	2	0	9	2	21
2	3	0	12	3	28
3	0	0	8	1	19
3	0	1	11	2	25
3	1	0	11	2	25
3	1	1	14	4	34
3	2	0	14	4	34
3	2	1	17	5	46
3	3	0	17	5	46
4	0	0	13	3	31
4	0	1	17	5	46
4	1	0	17	5	46
4	1	1	21	7	63
4	1	2	26	9	78
4	2	0	22	7	67
4	2	1	26	9	78
4	3	0	27	9	80
4	3	1	33	11	93
4	4	0	34	12	93
5	0	0	23	7	70
5	0	1	31	11	89
5	0	2	43	15	110
5	1	0	33	11	93
5	1	1	46	16	120
5	1	2	63	21	150
5	2	0	49	17	130
5	2	1	70	23	170
5	2	2	94	28	220
5	3	0	79	25	190
5	3	1	110	31	250
5	3	2	140	37	340
5	3	3	180	44	500

Figure B1

Appendix C

Metabolic Pathways

Glycolysis

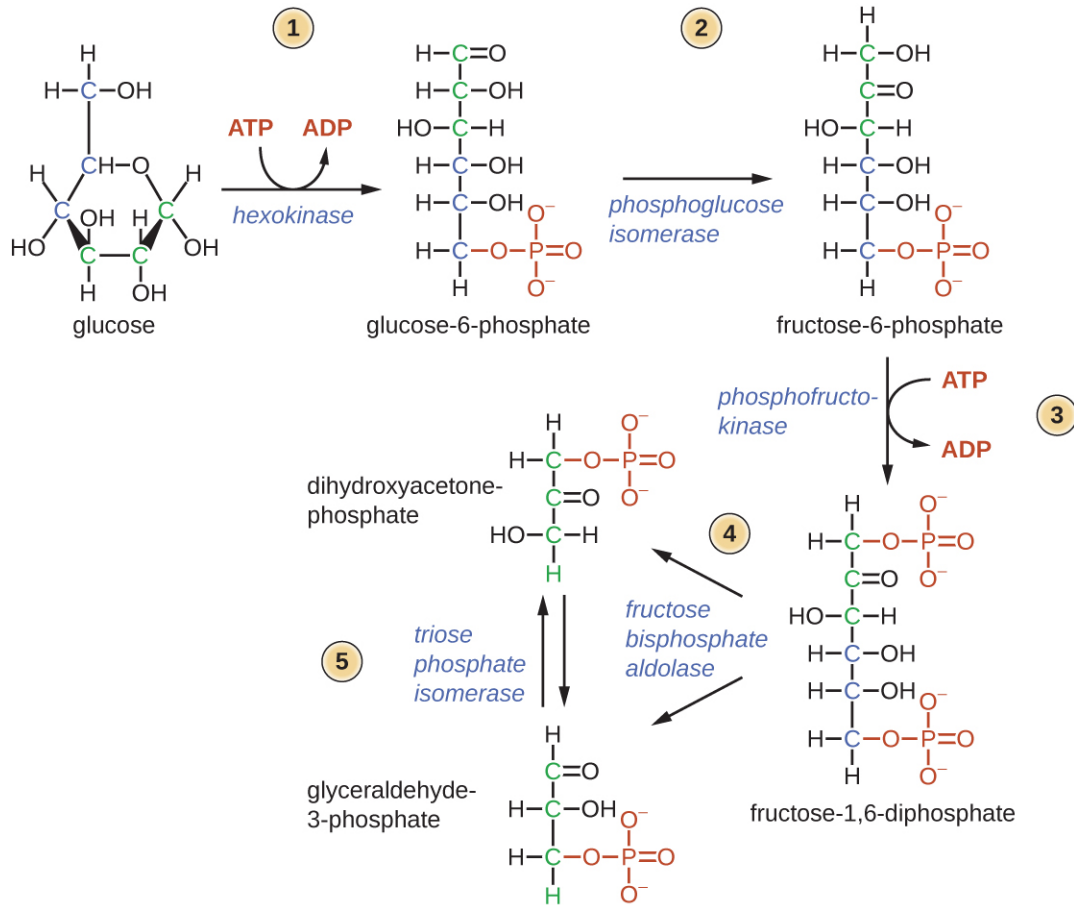


Figure C1 The first half of glycolysis uses two ATP molecules in the phosphorylation of glucose, which is then split into two three-carbon molecules.

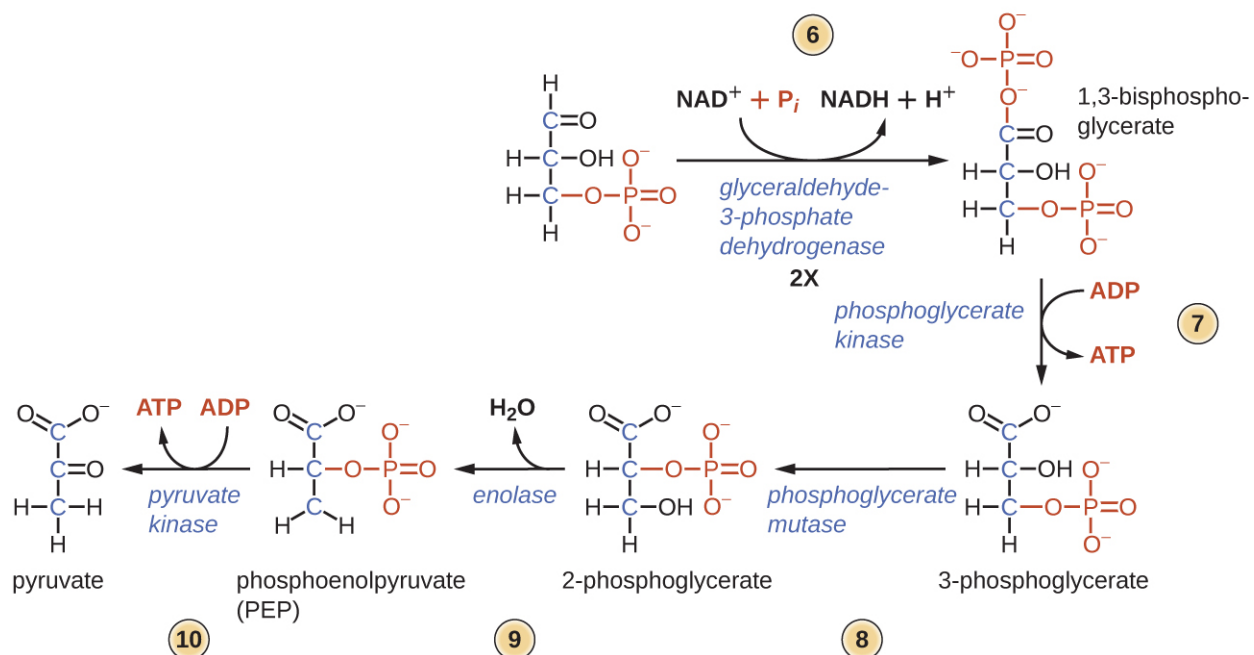


Figure C2 The second half of glycolysis involves phosphorylation without ATP investment (step 6) and produces two NADH and four ATP molecules per glucose.

Entner–Doudoroff Pathway

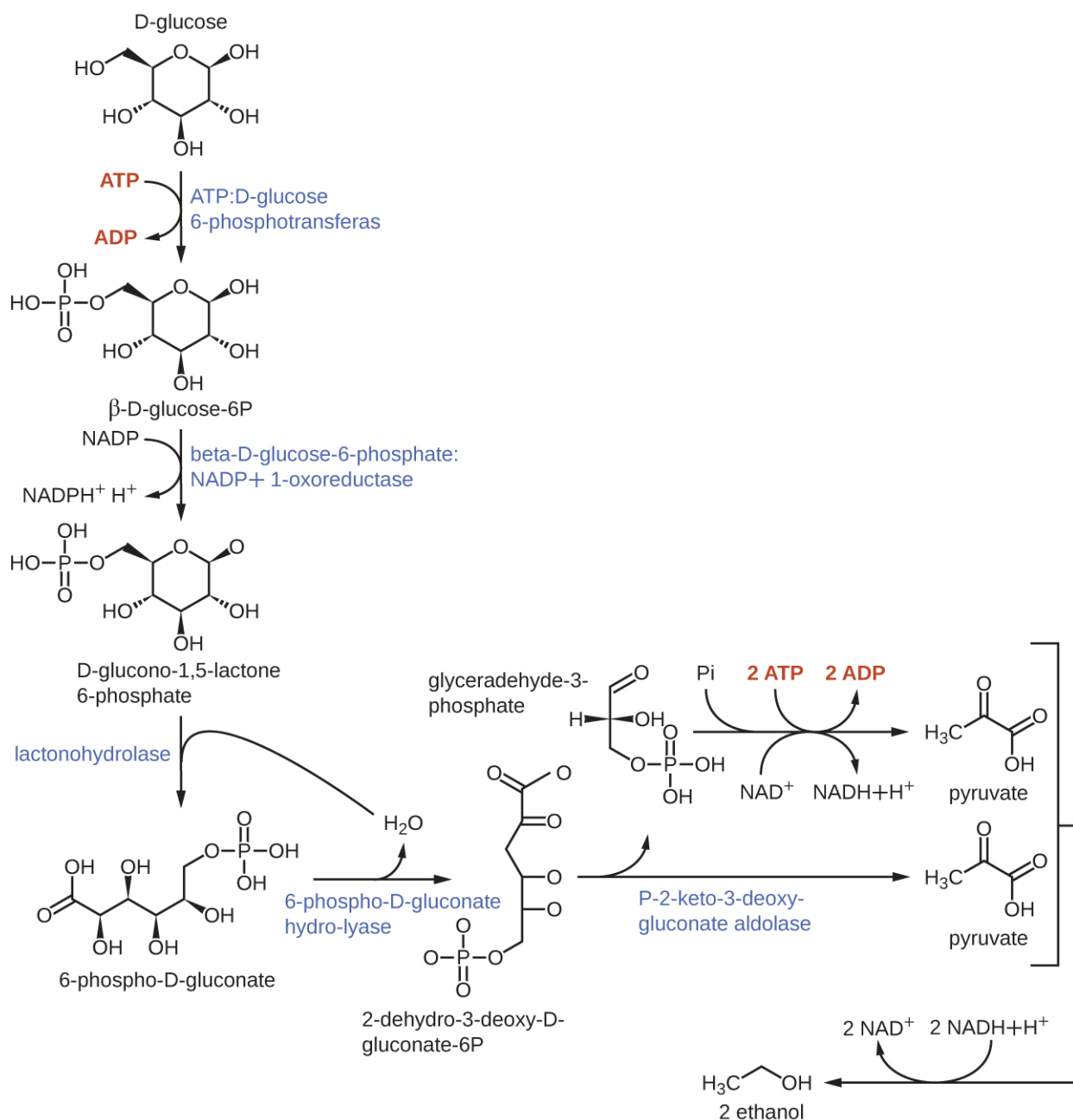


Figure C3 The Entner–Doudoroff Pathway is a metabolic pathway that converts glucose to ethanol and nets one ATP.

The Pentose-Phosphate Pathway

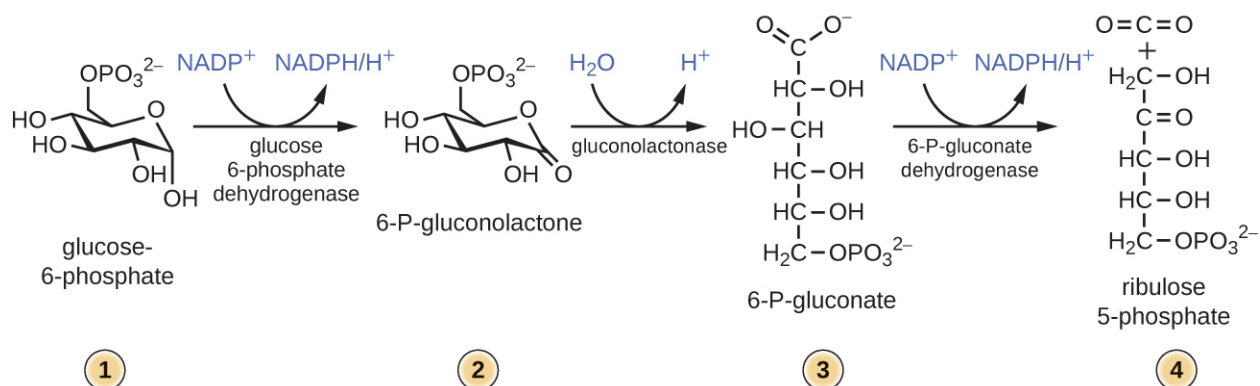


Figure C4 The pentose phosphate pathway, also called the phosphogluconate pathway and the hexose monophosphate shunt, is a metabolic pathway parallel to glycolysis that generates NADPH and five-carbon sugars as well as ribose 5-phosphate, a precursor for the synthesis of nucleotides from glucose.

TCA Cycle

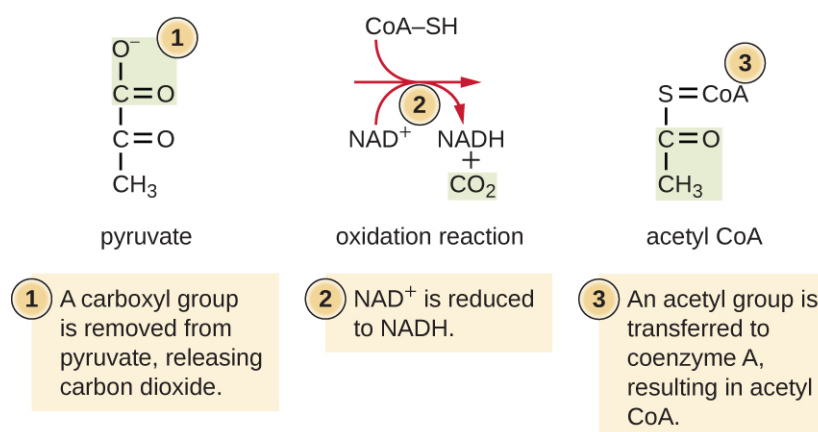


Figure C5 In this transition reaction, a multi-enzyme complex converts pyruvate into one acetyl (2C) group plus one carbon dioxide (CO_2). The acetyl group is attached to a Coenzyme A carrier that transports the acetyl group to the site of the Krebs cycle. In the process, one molecule of NADH is formed.

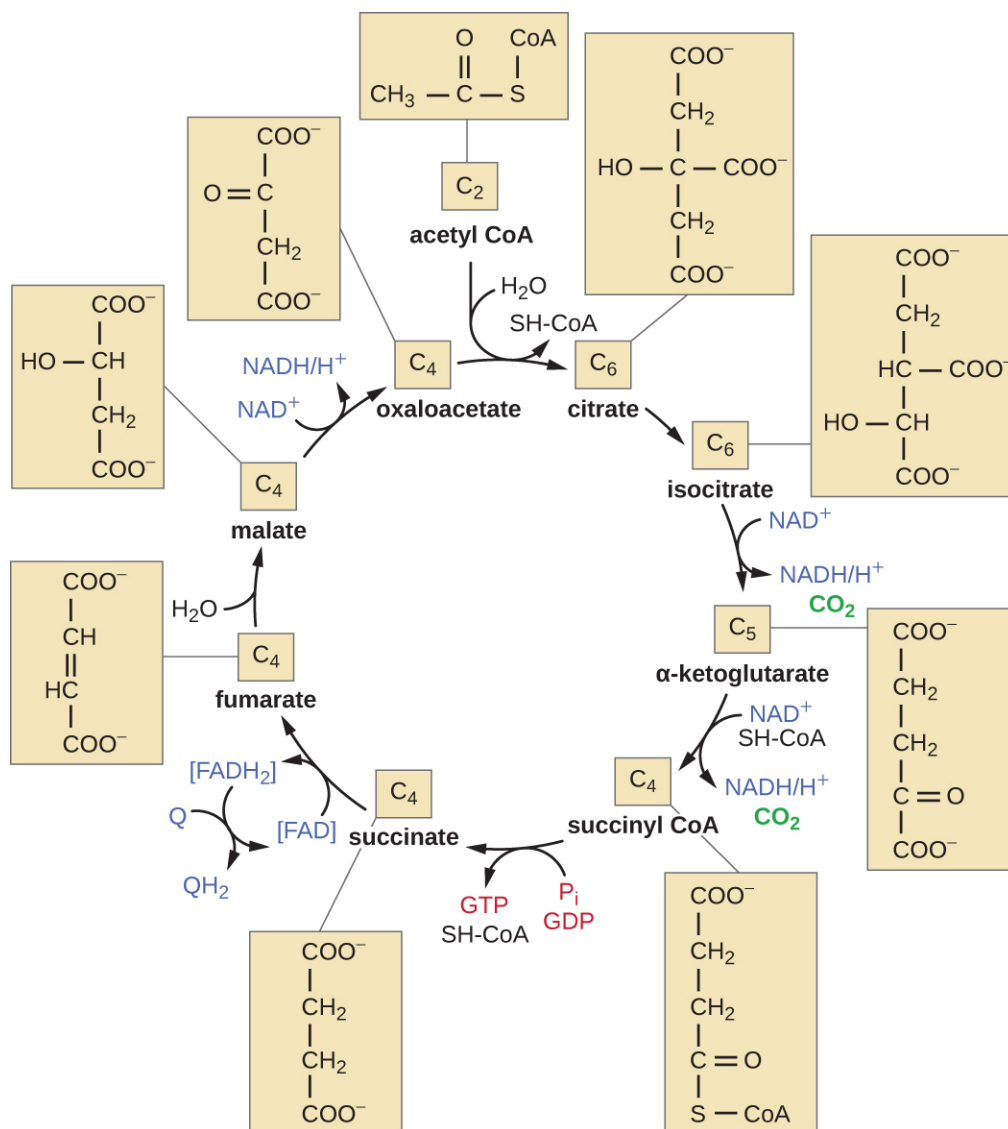


Figure C6 In the citric acid cycle, the acetyl group from acetyl CoA is attached to a four-carbon oxaloacetate molecule to form a six-carbon citrate molecule. Through a series of steps, citrate is oxidized, releasing two carbon dioxide molecules for each acetyl group fed into the cycle. In the process, three NADH, one FADH₂, and one ATP or GTP (depending on the cell type) is produced by substrate-level phosphorylation. Because the final product of the citric acid cycle is also the first reactant, the cycle runs continuously in the presence of sufficient reactants. (credit: modification of work by “Yikrazuul”/Wikimedia Commons)

Beta Oxidation

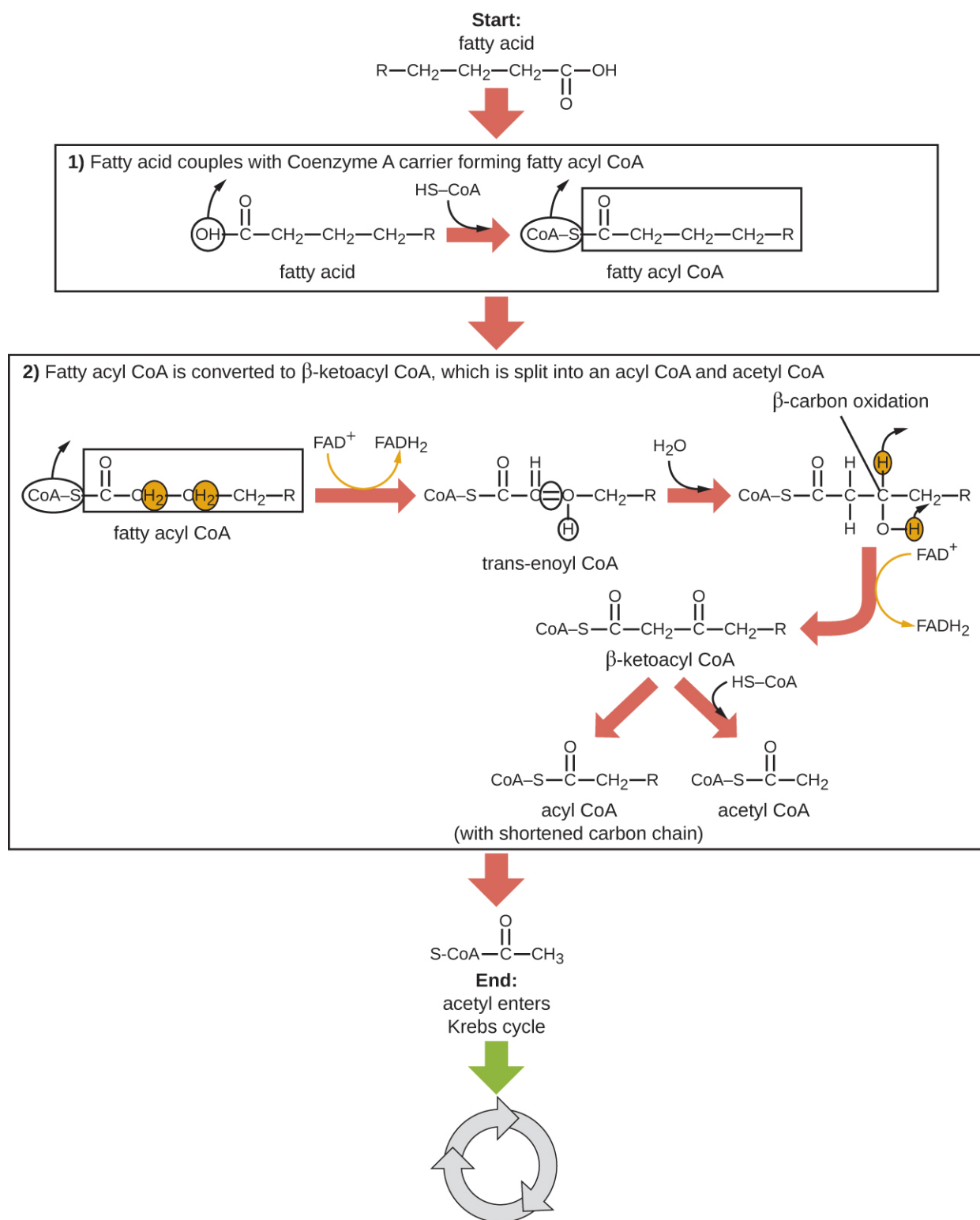


Figure C7 During fatty acid oxidation, triglycerides can be broken down into 2C acetyl groups that can enter the Krebs cycle and be used as a source of energy when glucose levels are low.

Electron Transport Chain and Oxidative

Phosphorylation

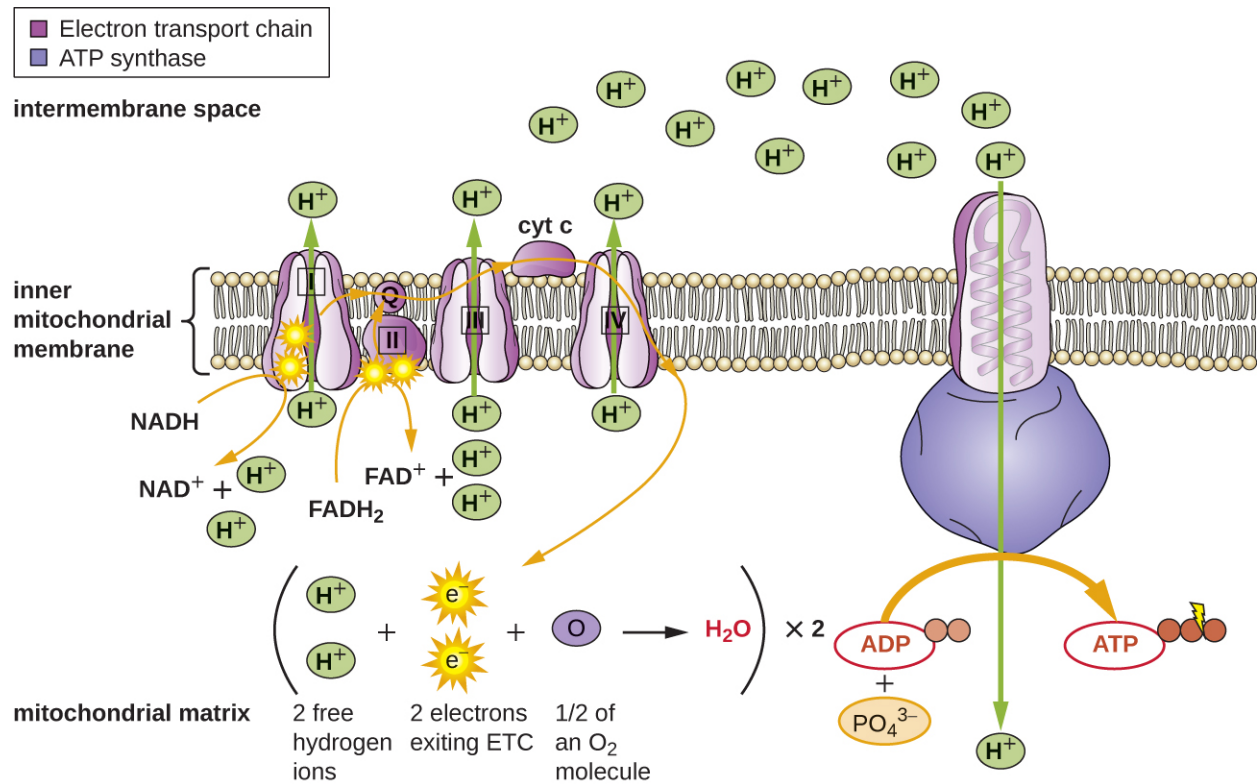


Figure C8 The electron transport chain is a series of electron carriers and ion pumps that are used to pump H^+ ions across a membrane. H^+ then flow back through the membrane by way of ATP synthase, which catalyzes the formation of ATP. The location of the electron transport chain is the inner mitochondrial matrix in eukaryotic cells and cytoplasmic membrane in prokaryotic cells.

Calvin-Benson Cycle

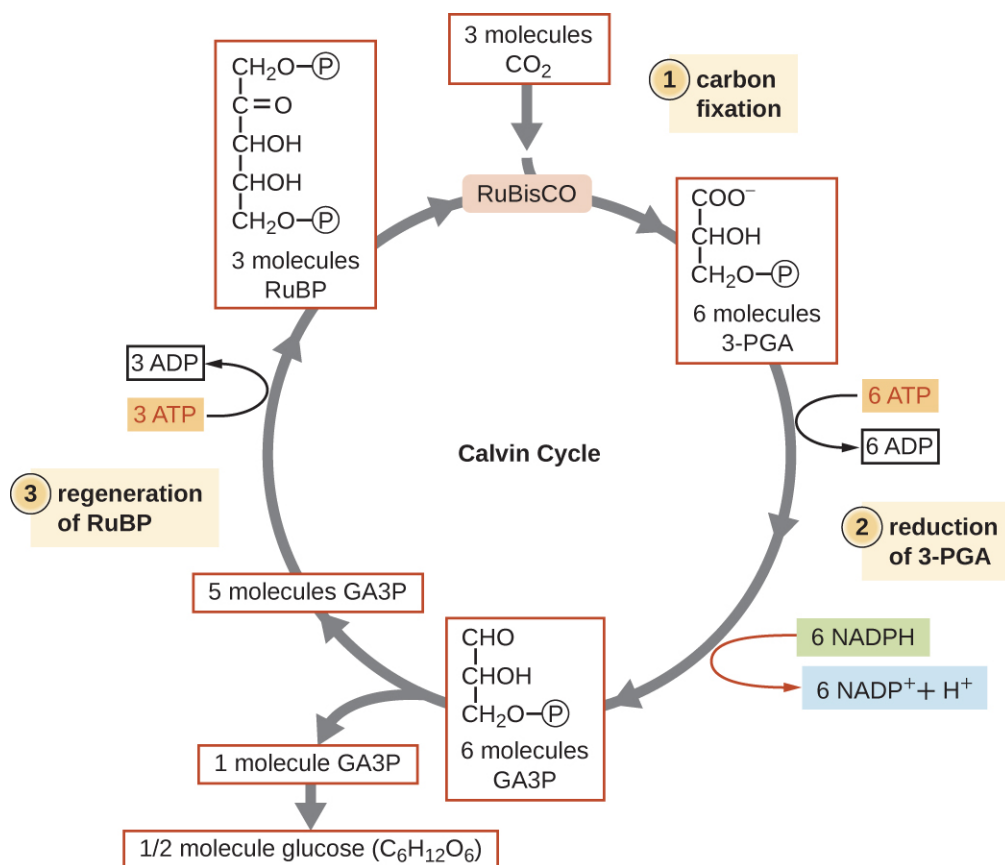


Figure C9 The Calvin-Benson cycle has three stages. In stage 1, the enzyme RuBisCO incorporates carbon dioxide into an organic molecule, 3-PGA. In stage 2, the organic molecule is reduced using electrons supplied by NADPH. In stage 3, RuBP, the molecule that starts the cycle, is regenerated so that the cycle can continue. Only one carbon dioxide molecule is incorporated at a time, so the cycle must be completed three times to produce a single three-carbon GA3P molecule, and six times to produce a six-carbon glucose molecule.

Appendix D

Taxonomy Of Clinically Relevant

Microorganisms

Bacterial Pathogens

The following tables list the species, and some higher groups, of pathogenic Eubacteria mentioned in the text. The classification of Bacteria, one of the three domains of life, is in constant flux as relationships become clearer through sampling of genetic sequences. Many groups at all taxonomic levels still have an undetermined relationship with other members of the phylogenetic tree of Bacteria. *Bergey's Manual of Systematics of Archaea and Bacteria* maintains a published list and descriptions of prokaryotic species. The tables here follow the taxonomic organization in the *Bergey's Manual Taxonomic Outline*.^[1]

We have divided the species into tables corresponding to different bacterial phyla. The taxonomic rank of kingdom is not used in prokaryote taxonomy, so the phyla are the subgrouping below domain. Note that many bacterial phyla not represented by these tables. The species and genera are listed only under the class within each phylum. The names given to bacteria are regulated by the International Code of Nomenclature of Bacteria as maintained by the International Committee on Systematics of Prokaryotes.

Phylum Actinobacteria

Class	Genus	Species	Related Diseases
Actinobacteria	<i>Corynebacterium</i>	<i>diphtheriae</i>	Diphtheria
	<i>Gardnerella</i>	<i>vaginalis</i>	Bacterial vaginosis
	<i>Micrococcus</i>		Opportunistic infections
	<i>Mycobacterium</i>	<i>bovis</i>	Tuberculosis, primarily in cattle
	<i>Mycobacterium</i>	<i>leprae</i>	Hansen's disease
	<i>Mycobacterium</i>	<i>tuberculosis</i>	Tuberculosis
	<i>Propionibacterium</i>	<i>acnes</i>	Acne, blepharitis, endophthalmitis

Table D1

Phylum Bacteroidetes

Class	Genus	Species	Related Diseases
Bacteroidia	<i>Porphyromonas</i>		Periodontal disease
	<i>Prevotella</i>	<i>intermedia</i>	Periodontal disease

Table D2

1. Bergey's Manual Trust. *Bergey's Manual of Systematics of Archaea and Bacteria, Taxonomic Outline*. 2012. <http://www.bergeys.org/outlines.html>

Phylum Chlamydiae

Class	Genus	Species	Related Diseases
Chlamydiae	<i>Chlamydia</i>	<i>psittaci</i>	Psittacosis
	<i>Chlamydia</i>	<i>trachomatis</i>	Sexually transmitted chlamydia

Table D3

Phylum Firmicutes

Class	Genus	Species	Related Diseases
Bacilli	<i>Bacillus</i>	<i>anthracis</i>	Anthrax
	<i>Bacillus</i>	<i>cereus</i>	Diarrheal and emetic food poisoning
	<i>Listeria</i>	<i>monocytogenes</i>	Listeriosis
	<i>Enterococcus</i>	<i>faecalis</i>	Endocarditis, septicemia, urinary tract infections, meningitis
	<i>Staphylococcus</i>	<i>aureus</i>	Skin infections, sinusitis, food poisoning
	<i>Staphylococcus</i>	<i>epidermidis</i>	Nosocomial and opportunistic infections
	<i>Staphylococcus</i>	<i>hominis</i>	Opportunistic infections
	<i>Staphylococcus</i>	<i>saprophyticus</i>	Urinary tract infections
	<i>Streptococcus</i>	<i>agalactiae</i>	Postpartum infection, neonatal sepsis
	<i>Streptococcus</i>	<i>mutans</i>	Tooth decay
	<i>Streptococcus</i>	<i>pneumoniae</i>	Pneumonia, many other infections
	<i>Streptococcus</i>	<i>pyogenes</i>	Pharyngitis, scarlet fever, impetigo, necrotizing fasciitis
Clostridia	<i>Clostridium</i>	<i>botulinum</i>	Botulinum poisoning
	<i>Clostridium</i>	<i>difficile</i>	Colitis
	<i>Clostridium</i>	<i>perfringens</i>	Food poisoning, gas gangrene
	<i>Clostridium</i>	<i>tetani</i>	Tetanus

Table D4

Phylum Fusobacteria

Class	Genus	Species	Related Diseases
Fusobacteriia	<i>Fusobacterium</i>		Periodontal disease, Lemierre syndrome, skin ulcers
	<i>Streptobacillus</i>	<i>moniliformis</i>	Rat-bite fever

Table D5

Phylum Proteobacteria

Class	Genus	Species	Related Diseases
Alphaproteobacteria	<i>Anaplasma</i>	<i>phagocytophilum</i>	Human granulocytic anaplasmosis
	<i>Bartonella</i>	<i>henselae</i>	Peliosis hepatitis, bacillary angiomatosis, endocarditis, bacteremia
	<i>Bartonella</i>	<i>quintana</i>	Trench fever
	<i>Brucella</i>	<i>melitensis</i>	Ovine brucellosis
	<i>Ehrlichia</i>	<i>chaffeensis</i>	Human monocytic ehrlichiosis
	<i>Rickettsia</i>	<i>prowazekii</i>	Epidemic typhus
	<i>Rickettsia</i>	<i>rickettsii</i>	Rocky Mountain spotted fever
	<i>Rickettsia</i>	<i>typhi</i>	Murine typhus
Betaproteobacteria	<i>Bordetella</i>	<i>pertussis</i>	Pertussis
	<i>Eikenella</i>		Bite-injury infections
	<i>Neisseria</i>	<i>gonorrhoeae</i>	Gonorrhea
	<i>Neisseria</i>	<i>meningitidis</i>	Meningitis
	<i>Spirillum</i>	<i>minus (alt. minor)</i>	Sodoku (rat-bite fever)
Epsilonproteobacteria	<i>Campylobacter</i>	<i>jejuni</i>	Gastroenteritis, Guillain-Barré syndrome
	<i>Helicobacter</i>	<i>pylori</i>	Gastric ulcers
Gammaproteobacteria	<i>Aeromonas</i>	<i>hydrophila</i>	Dysenteric gastroenteritis
	<i>Coxiella</i>	<i>burnetii</i>	Q fever
	<i>Enterobacter</i>		Urinary and respiratory infections
	<i>Escherichia</i>	<i>coli</i> Strains: shiga toxin-producing (STEC) (e.g., O157:H7) also called enterohemorrhagic <i>E. coli</i> (EHEC) or verocytotoxin-producing <i>E. coli</i> (VTEC)	Foodborne diarrhea outbreaks, hemorrhagic colitis, hemolytic-uremic syndrome
	<i>Escherichia</i>	<i>coli</i> Strain: enterotoxigenic <i>E. coli</i> (ETEC)	Traveler's diarrhea
	<i>Escherichia</i>	<i>coli</i> Strain: enteropathogenic <i>E. coli</i> (EPEC)	Diarrhea, especially in young children

Table D6

Phylum Proteobacteria

Class	Genus	Species	Related Diseases
	<i>Escherichia</i>	<i>coli</i> Strain: enteroaggregative <i>E. coli</i> (EAEC)	Diarrheal disease in children and travelers
	<i>Escherichia</i>	<i>coli</i> Strain: diffusely adherent <i>E. coli</i> (DAEC)	Diarrheal disease of children
	<i>Escherichia</i>	<i>coli</i> Strain: enteroinvasive <i>E. coli</i> (EPEC)	Bacillary dysentery, cells invade intestinal epithelial cells
	<i>Francisella</i>	<i>tularensis</i>	Tularemia
	<i>Haemophilus</i>	<i>ducreyi</i>	Chancroid
	<i>Haemophilus</i>	<i>influenzae</i>	Bacteremia, pneumonia, meningitis
	<i>Klebsiella</i>	<i>pneumoniae</i>	Pneumonia, nosocomial infections
	<i>Legionella</i>	<i>pneumophila</i>	Legionnaire's disease
	<i>Moraxella</i>	<i>catarrhalis</i>	Otitis media, bronchitis, sinusitis, laryngitis, pneumonia
	<i>Pasteurella</i>		Pasteurellosis
	<i>Plesiomonas</i>	<i>shigelloides</i>	Gastroenteritis
	<i>Proteus</i>		Opportunistic urinary tract infections
	<i>Pseudomonas</i>	<i>aeruginosa</i>	Opportunistic, nosocomial pneumonia and sepsis
	<i>Salmonella</i>	<i>bongori</i>	Salmonellosis
	<i>Salmonella</i>	<i>enterica</i>	Salmonellosis
	<i>Serratia</i>		Pneumonia, urinary tract infections
	<i>Shigella</i>	<i>boydii</i>	Dysentery
	<i>Shigella</i>	<i>dysenteriae</i>	Dysentery
	<i>Shigella</i>	<i>flexneri</i>	Dysentery
	<i>Shigella</i>	<i>sonnei</i>	Dysentery
	<i>Vibrio</i>	<i>cholerae</i>	Cholera
	<i>Vibrio</i>	<i>parahemolyticus</i>	Seafood gastroenteritis

Table D6

Phylum Proteobacteria

Class	Genus	Species	Related Diseases
	<i>Vibrio</i>	<i>vulnificus</i>	Seafood gastroenteritis, necrotizing wound infections, septicemia
	<i>Yersinia</i>	<i>enterocolitica</i>	Yersiniosis
	<i>Yersinia</i>	<i>pestis</i>	Plague
	<i>Yersinia</i>	<i>pseudotuberculosis</i>	Far East scarlet-like fever

Table D6

Phylum Spirochaetes

Class	Genus	Species	Related Diseases
Spirochaetia	<i>Borrelia</i>	<i>burgdorferi</i>	Lyme disease
	<i>Borrelia</i>	<i>hermsii</i>	Tick-borne relapsing fever
	<i>Borrelia</i>	<i>recurrentis</i>	Louse-borne relapsing fever
	<i>Leptospira</i>	<i>interrogans</i>	Leptospirosis
	<i>Treponema</i>	<i>pallidum</i>	Syphilis, bejel, pinta, yaws

Table D7

Phylum Tenericutes

Class	Genus	Species	Related Diseases
Mollicutes	<i>Mycoplasma</i>	<i>genitalium</i>	Urethritis, cervicitis
	<i>Mycoplasma</i>	<i>hominis</i>	Pelvic inflammatory disease, bacterial vaginosis
	<i>Mycoplasma</i>	<i>pneumoniae</i>	<i>Mycoplasma pneumoniae</i>
	<i>Ureaplasma</i>	<i>urealyticum</i>	Urethritis, fetal infections

Table D8

Viral Pathogens

There are several classification systems for viruses. The International Committee on Taxonomy of Viruses (ICTV) is the international scientific body responsible for the rules of viral classification. The ICTV system used here groups viruses based on genetic similarity and presumed monophyly. The viral classification system is separate from the classification system for cellular organisms. The ICTV system groups viruses within seven orders, which contain related families. There is, presently, a large number of unassigned families with unknown affinities to the seven orders. Three of these orders infect only Eubacteria, Archaea, or plants and do not appear in this table. Some families may be divided into subfamilies. There are also many unassigned genera. Like all taxonomies, viral taxonomy is in constant flux. The latest complete species list and classification can be obtained on the ICTV website.^[2]

Viral Pathogens					
Order	Family	Sub-family	Genus	Species	Related diseases
<i>Herpesvirales</i>	<i>Herpesviridae</i>	<i>Betaherpesvirinae</i>	<i>Human cytomegalovirus group</i>	<i>Human herpesvirus 5</i>	Cytomegalovirus hepatitis and other infections in immunocompromised people
		<i>Gammapherpesvirinae</i>	<i>Lymphocryptovirus</i>	<i>Human herpesvirus 4 (HHV-4; Epstein-Barr virus)</i>	Infectious mononucleosis
		<i>Alphaherpesvirinae</i>	<i>Simplexvirus</i>	<i>Human herpesvirus 1, human herpesvirus 2</i>	Herpes simplex virus 1, herpes simplex virus 2
			<i>Varicellovirus</i>	<i>Human herpesvirus 3</i>	Chicken pox, shingles
<i>Mononegavirales</i>	<i>Filoviridae</i>		<i>Ebolavirus</i>	<i>Zaire ebolavirus (EBOV)</i>	Ebola
			<i>Marburgvirus</i>	<i>Marburg marburgvirus (MARV)</i>	Marburg virus disease
	<i>Rhabdoviridae</i>		<i>Lyssavirus</i>	<i>Rabies virus</i>	Rabies
	<i>Paramyxoviridae</i>	<i>Pneumovirinae</i>	<i>Pneumovirus</i>	<i>Human respiratory syncytial virus</i>	Lower respiratory tract infection
		<i>Paramyxovirinae</i>	<i>Morbillivirus</i>	<i>Measles virus</i>	Measles (rubeola)
<i>Nidovirales</i>	<i>Coronaviridae</i>	<i>Coronavirinae</i>	<i>Coronavirus</i>		Common cold, pneumonia, SARS
<i>Picornavirales</i>	<i>Picornaviridae</i>		<i>Hepatovirus</i>	<i>Hepatitis A virus</i>	Hepatitis A
			<i>Enterovirus</i>	<i>Enterovirus C</i>	Polio
				<i>Rhinovirus A</i>	Common cold
				<i>Rhinovirus B</i>	Common cold
				<i>Rhinovirus C</i>	Common cold
Unassigned	<i>Adenovirus</i>		<i>Mastadenovirus</i>		Respiratory and other infections
	<i>Arenaviridae</i>		<i>Mammarenavirus</i>	<i>Lassa mammarenavirus</i>	Lassa fever
	<i>Astroviridae</i>				Gastroenteritis
	<i>Bunyaviridae</i>		<i>Hantavirus</i>	Several species	Hantavirus hemorrhagic fever with renal syndrome (HFRS), hantavirus pulmonary syndrome (HPS)
			<i>Nairovirus</i>	<i>Crimean-Congo hemorrhagic fever virus (CCHF)</i>	Crimean-Congo hemorrhagic fever
	<i>Caliciviridae</i>		<i>Norovirus</i>	<i>Norwalk virus</i>	Gastroenteritis

Figure D1

2. International Committee on Taxonomy of Viruses. "ICTV Master Species List." http://talk.ictvonline.org/files/ictv_documents/m/msl/default.aspx

Viral Pathogens (continued)					
Order	Family	Sub-family	Genus	Species	Related diseases
Unassigned	<i>Flaviviridae</i>		<i>Flavivirus</i>	<i>Dengue virus</i>	Dengue fever
				<i>Yellow fever virus</i>	Yellow fever
			<i>Hepacivirus</i>	<i>Hepatitis C virus</i>	Hepatitis C
	<i>Hepadnaviridae</i>		<i>Orthohepadnavirus</i>	<i>Hepatitis B virus</i>	Hepatitis B
	<i>Hepeviridae</i>		<i>Orthohepevirus</i>	<i>Hepatitis E virus</i>	Hepatitis E
	<i>Orthomyxoviridae</i>		<i>Influenzavirus A</i>	<i>Influenza A virus</i>	Pandemic flu
			<i>Influenzavirus B</i>	<i>Influenza B virus</i>	Flu
			<i>Influenzavirus C</i>	<i>Influenza C virus</i>	Flu
	<i>Papillomaviridae</i>		<i>Alphapapillomavirus</i>	<i>Human papillomavirus</i>	Skin warts
	<i>Parvoviridae</i>	<i>Parvovirinae</i>	<i>Erythroparvovirus</i>	<i>Human parvovirus B19</i>	Fifth disease (erythema infectiosum)
	<i>Poxviridae</i>	<i>Chordopoxvirinae</i>	<i>Orthopoxvirus</i>	<i>Variola virus</i>	Variola major, Variola minor (smallpox)
				<i>Vaccinia virus</i>	Cowpox
	<i>Reoviridae</i>	<i>Sedoreovirinae</i>	<i>Rotavirus</i>	Eight species	Gastroenteritis
	<i>Retroviridae</i>	<i>Orthoretrovirinae</i>	<i>Lentivirus</i>	<i>Human immunodeficiency virus</i>	AIDS
	<i>Togaviridae</i>		<i>Alphavirus</i>	<i>Chikungunya virus (CHIKV)</i>	Chikungunya
			<i>Rubivirus</i>	<i>Rubella virus</i>	Rubella (German measles)
	Unassigned		<i>Deltavirus</i>	<i>Hepatitis D virus</i>	Hepatitis D

Figure D2

Fungal Pathogens

The Fungi are one of the kingdoms of the domain Eukarya. Fungi are most closely related to the animals and a few other small groups and more distantly related to the plants and other groups that formerly were categorized as protist. At present, the Fungi are divided into seven phyla (or divisions, a hold over from when fungi were studied with plants), but there are uncertainties about some relationships.^[3] Many groups of fungi, particularly those that were formerly classified in the phylum Zygomycota, which was not monophyletic, have uncertain relationships to the other fungi. The one species listed in this table that falls into this category is *Rhizopus arrhizus*. Fungal names are governed by the International Code of Nomenclature for Algae, Fungi, and Plants,^[4] but the International Commission on the Taxonomy of Fungi (ICTF) also promotes taxonomic work on fungi. One activity of the ICTF is publicizing name changes for medically and otherwise important fungal species. Many species that formerly had two names (one for the sexual form and one for the asexual form) are now being brought together under one name.

3. D. S. Hibbett et al. "A Higher-level Phylogenetic Classification of the Fungi." *Mycological Research* 111 no. 5 (2007):509–547.

4. J. McNeill et al. *International Code of Nomenclature for Algae, Fungi, and Plants (Melbourne Code)*. Oberreifenberg, Germany. Koeltz Scientific Books; 2012. <http://www.iapt-taxon.org/nomen/main.php>

Fungal Pathogens

Division	Genus	Species	Related Diseases
Ascomycota	<i>Aspergillus</i>	<i>flavus</i>	Opportunistic aspergillosis
	<i>Aspergillus</i>	<i>fumigatus</i>	Opportunistic aspergillosis
	<i>Blastomyces</i>	<i>dermatitidis</i>	Blastomycosis
	<i>Candida</i>	<i>albicans</i>	Thrush (candidiasis)
	<i>Coccidioides</i>	<i>immitis</i>	Valley fever (coccidioidomycosis)
	<i>Epidermophyton</i>		Tinea corporis (ringworm), tinea cruris (jock itch), tinea pedis (athlete's foot), tinea unguium (onychomycosis)
	<i>Histoplasma</i>	<i>capsulatum</i>	Histoplasmosis
	<i>Microsporum</i>		Tinea capitis (ringworm), tinea corpus (ringworm), other dermatophytoses
	<i>Pneumocystis</i>	<i>jirovecii</i>	Opportunistic pneumonia
	<i>Sporothrix</i>	<i>schneckii</i>	Sporotrichosis (rose-handler's disease)
	<i>Trichophyton</i>	<i>mentagrophytes</i> var. <i>interdigitale</i>	Tinea barbae (barber's itch), dermatophytoses
	<i>Trichophyton</i>	<i>rubrum</i>	Tinea corporis (ringworm), tinea cruris (jock itch), tinea pedis (athlete's foot), tinea unguium (onychomycosis)
Basidiomycota	<i>Cryptococcus</i>	<i>neoformans</i>	Opportunistic cryptococcosis, fungal meningitis, encephalitis
	<i>Malassezia</i>		Dandruff, tinea versicolor
uncertain	<i>Rhizopus</i>	<i>arrhizus</i>	Mucormycosis

Table D9

Protozoan Pathogens

The relationships among the organisms (and thus their taxonomy) previously grouped under the name Protists are better understood than they were two or three decades ago, but this is still a work in progress. In 2005, the Eukarya were divided into six supergroups.^[5] The latest high-level classification combined two of the previous supergroups to produce a system comprising five supergroups.^[6] This classification was developed for the Society of Protozoologists, but it is not the only suggested approach. One of the five supergroups includes the animals, fungi, and some smaller protist groups. Another contains green plants and three algal groups. The other three supergroups (listed in the three tables below) contain the other protists, many of them which cause disease. In addition, there is a large number of protist groups whose relationships are not understood. In the three supergroups represented here we have indicated the phyla to which the listed pathogens belong.

5. S.M. Adl et al. "The New Higher Level Classification of Eukaryotes with Emphasis on the Taxonomy of Protists." *Journal of Eukaryotic Microbiology* 52 no. 5 (2005):399–451.

6. S.M. Adl et al. "The Revised Classification of Eukaryotes." *Journal of Eukaryotic Microbiology* 59 no. 5 (2012):429–514.

Supergroup Amoebozoa

Phylum	Genus	Species	Related Diseases
Amoebozoa	<i>Acanthamoeba</i>		Granulomatous amoebic encephalitis, acanthamoebic keratitis
	<i>Entamoeba</i>	<i>histolytica</i>	Enterobiasis

Table D10

Supergroup SAR (Stramenopiles, Alveolata, Rhizaria)

Phylum	Genus	Species	Related Diseases
Apicomplexa	<i>Babesia</i>		Babesiosis
	<i>Cryptosporidium</i>	<i>hominis</i>	Cryptosporidiosis
	<i>Cryptosporidium</i>	<i>parvum</i>	Cryptosporidiosis
	<i>Cyclospora</i>	<i>cayetanensis</i>	Gastroenteritis
	<i>Plasmodium</i>	<i>falciparum</i>	Malaria
	<i>Plasmodium</i>	<i>malariae</i>	“Benign” or “quartan” (3-day recurrent fever) malaria
	<i>Plasmodium</i>	<i>ovale</i>	“Tertian” (2-day recurrent fever) malaria
	<i>Plasmodium</i>	<i>vivax</i>	“Benign” “tertian” (2-day recurrent fever) malaria
	<i>Plasmodium</i>	<i>knowlesi</i>	Primate malaria capable of zoonosis, quotidian fever
	<i>Toxoplasma</i>	<i>gondii</i>	Toxoplasmosis

Table D11

Supergroup Excavata

Phylum	Genus	Species	Related Diseases
Metamonada	<i>Giardia</i>	<i>lamblia</i>	Giardiasis
	<i>Trichomonas</i>	<i>vaginalis</i>	Trichomoniasis
Euglenozoa	<i>Leishmania</i>	<i>braziliensis</i>	Leishmaniasis
	<i>Leishmania</i>	<i>donovani</i>	Leishmaniasis
	<i>Leishmania</i>	<i>tropica</i>	Cutaneous leishmaniasis
	<i>Trypanosoma</i>	<i>brucei</i>	African sleeping sickness (African trypanosomiasis)
	<i>Trypanosoma</i>	<i>cruzi</i>	Chagas disease
Percolozoa	<i>Naegleria</i>	<i>fowleri</i>	Primary amoebic meningoencephalitis (naegleriasis)

Table D12

Parasitic Helminths

The taxonomy of parasitic worms, all of which belong to the kingdom Animalia still contains many uncertainties. The

pathogenic species are found in two phyla: the Nematoda, or roundworms, and the Platyhelminthes, or flat worms. The Nematoda is tentatively divided into two classes^[7], one of which, Chromadorea, probably contains unrelated groups. The parasitic flatworms are contained within three classes of flatworm, of which two are important to humans, the trematodes and the cestodes.

Phylum Nematoda

Class	Genus	Species	Related Diseases
Chromadorea	<i>Ancylostoma</i>	<i>caninum</i>	Dog hookworm infection
	<i>Ancylostoma</i>	<i>duodenale</i>	Old World hookworm infection
	<i>Ascaris</i>	<i>lumbricoides</i>	Ascariasis
	<i>Enterobius</i>	<i>vermicularis</i>	Enterobiasis (pin worm)
	<i>Loa</i>	<i>loa</i>	Loa loa filariasis (eye worm)
	<i>Necator</i>	<i>americanus</i>	Necatoriasis (New World hookworm infection)
	<i>Strongyloides</i>	<i>stercoralis</i>	Strongyloidiasis
Enoplea	<i>Trichinella</i>	<i>spiralis</i>	Trichinosis
	<i>Trichuris</i>	<i>trichiura</i>	Trichuriasis (whip worm infection)

Table D13

Phylum Platyhelminthes

Class	Genus	Species	Related Diseases
Trematoda	<i>Clonorchis</i>	<i>sinensis</i>	Chinese liver fluke
	<i>Fasciolopsis</i>	<i>buski</i>	Fasciolopsiasis
	<i>Fasciola</i>	<i>gigantica</i>	Fascioliasis
	<i>Fasciola</i>	<i>hepatica</i>	Fascioliasis
	<i>Opisthorchis</i>	<i>felineus</i>	Opisthorchiasis
	<i>Opisthorchis</i>	<i>viverrini</i>	Opisthorchiasis
	<i>Schistosoma</i>	<i>haematobium</i>	Urinary schistosomiasis
	<i>Schistosoma</i>	<i>japonicum</i>	Schistosomiasis
	<i>Schistosoma</i>	<i>mansoni</i>	Intestinal schistosomiasis
Cestoda	<i>Diphyllobothrium</i>	<i>latum</i>	Diphyllobothriosis
	<i>Echinococcus</i>	<i>granulosus</i>	Hydatid cysts (cystic echinococcosis)
	<i>Echinococcus</i>	<i>multilocularis</i>	Echinococcosis
	<i>Taenia</i>	<i>asiatica</i>	Intestinal taeniasis

Table D14

7. National Center for Biotechnology Information. "Taxonomy Browser: Nematoda." <http://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?id=6231>

Phylum Platyhelminthes

Class	Genus	Species	Related Diseases
	<i>Taenia</i>	<i>saginata</i>	Intestinal taeniasis
	<i>Taenia</i>	<i>solium</i>	Intestinal taeniasis, cysticercosis

Table D14

Appendix E

Glossary

454 sequencing (pyrosequencing) a next generation sequencing technique in which fragmented DNA has DNA adapters attached, is amplified by PCR, is attached to a bead, and then placed into a well with sequencing reagents, and the flash of light produced by the release of pyrophosphate on addition of a nucleotide is monitored

5' cap methylguanosine nucleotide added to 5' end of a eukaryotic primary transcript

70S ribosome a ribosome composed of 50S and 30S subunits

80S ribosome cytoplasmic eukaryotic ribosome composed of 60S and 40S subunits

A

α -helix secondary structure consisting of a helix stabilized by hydrogen bonds between nearby amino acid residues in a polypeptide

A (aminoacyl) site functional site of an intact ribosome that binds incoming charged aminoacyl tRNAs

A-B exotoxin class of exotoxin that contains A subunits, which enter the cell and disrupt cellular activities, and B subunits, which bind to host cell receptors

ABO blood group system set of glycoprotein antigens found on the surface of red blood cells; the presence or absence of specific carbohydrates determining blood type

absorbance when a molecule captures energy from a photon and vibrates or stretches, using the energy

Acanthamoeba keratitis a condition characterized by damage to the cornea and possible blindness caused by parasitic infection of the protozoan *Acanthamoeba*

acellular not made of cells

acid-fast stain a stain that differentiates cells that have waxy mycolic acids in their gram-positive cell walls

acidic dye a chromophore with a negative charge that attaches to positively charged structures

acidophile organism that grows optimally at a pH near 3.0

acne a skin disease in which hair follicles or pores become clogged, leading to the formation of comedones and infected lesions

acquired immunodeficiency syndrome (AIDS) disease caused by HIV, characterized by opportunistic infections and rare cancers

actin a protein that polymerizes to form microfilaments

activation energy energy needed to form or break chemical bonds and convert a reactant or reactants to a product or products

activator protein that increases the transcription of a gene in response to an external stimulus

active carrier an infected individual who can transmit the pathogen to others regardless of whether symptoms are currently present

active immunity stimulation of one's own adaptive immune responses

active site location within an enzyme where substrate(s) bind

acute disease disease of a relatively short duration that develops and progresses in a predictable pattern

acute glomerulonephritis inflammation of the glomeruli of the kidney, probably resulting from deposition of immune complexes and an autoimmune response caused by self-antigen mimicry by a pathogen

acute necrotizing ulcerative gingivitis a severe form of gingivitis, also called trench mouth

acute otitis media inflammatory disease of the middle ear resulting from a microbial infection

acute rheumatic fever sequela of streptococcal pharyngitis; comorbidities include arthritis and carditis

acute-phase proteins antimicrobial molecules produced by liver cells in response to pathogen-induced stimulation events

acyclovir antiviral guanosine analog; inhibits DNA replication

adaptive immunity third-line defense characterized by specificity and memory

Addison disease autoimmune disease affecting adrenal gland function

adenine purine nitrogenous base found in nucleotides

adenosine diphosphate (ADP) nucleotide derivative and relative of ATP containing only one high-energy phosphate bond

adenosine monophosphate (AMP) adenine molecule bonded to a ribose molecule and to a single phosphate group, having no high-energy phosphate bonds

adenosine triphosphate (ATP) energy currency of the cell; a nucleotide derivative that safely stores chemical energy in its two high-energy phosphate bonds

adhesins molecules on the surface of pathogens that promote colonization of host tissue

adhesion the capability of microbes to attach to host cells

aerobic respiration use of an oxygen molecule as the final electron acceptor of the electron transport system

aerotolerant anaerobe organism that does not use oxygen but tolerates its presence

affinity maturation function of the immune system by which B cells, upon re-exposure to antigen, are selected to produce higher affinity antibodies

affinity measure of how tightly an antibody-binding site binds to its epitope

afatoxin chemical produced by the fungus *Aspergillus flavus*; both a toxin and the most potent known natural carcinogen

African sleeping sickness see *human African trypanosomiasis*

agarose gel electrophoresis a method for separating populations of DNA molecules of varying sizes by differential migration rates caused by a voltage gradient through a horizontal gel matrix

agglutination binding of different pathogen cells by Fab regions of the same antibody to aggregate and enhance elimination from body

agranulocytes leukocytes that lack granules in the cytoplasm

alarmone small intracellular derivative of a nucleotide that signals a global bacterial response (i.e., activating a regulon of operons) to an environmental stress

albendazole antihelminthic drug of the benzimidazole class that binds to helminthic β -tubulin, preventing microtubule formation

algae (singular: alga) any of various unicellular and multicellular photosynthetic eukaryotic organisms; distinguished from plants by their lack of vascular tissues and organs

alkaliphile organism that grows optimally at pH above 9.0

alkylating agent type of strong disinfecting chemical that acts by replacing a hydrogen atom within a molecule with an alkyl group, thereby inactivating enzymes and nucleic acids

allergen antigen capable of inducing type I hypersensitivity reaction

allergy hypersensitivity response to an allergen

allograft transplanted tissue from an individual of the same species that is genetically different from the recipient

allosteric activator molecule that binds to an enzyme's allosteric site, increasing the affinity of the enzyme's active site for the substrate(s)

allosteric site location within an enzyme, other than the active site, to which molecules can bind, regulating enzyme activity

allylamines class of antifungal drugs that inhibit ergosterol biosynthesis at an early point in the pathway

Alphaproteobacteria class of Proteobacteria that are all oligotrophs

alveoli cul-de-sacs or small air pockets within the lung that facilitate gas exchange

amantadine antiviral drug that targets the influenza virus by preventing viral escape from endosomes upon host cell uptake, thus preventing viral RNA release and subsequent viral replication

amensalism type of symbiosis in which one population harms the other but remains unaffected itself

Ames test method that uses auxotrophic bacteria to detect mutations resulting from exposure to potentially mutagenic chemical compounds

amino acid a molecule consisting of a hydrogen atom, a carboxyl group, and an amine group bonded to the same carbon. The group bonded to the carbon varies and is represented by an *R* in the structural formula

aminoacyl-tRNA synthetase enzyme that binds to a tRNA molecule and catalyzes the addition of the correct amino acid to the tRNA

aminoglycosides protein synthesis inhibitors that bind to the 30S subunit and interfere with the ribosome's proofreading ability, leading to the generation of faulty proteins that insert into and disrupt the bacterial cytoplasmic membrane

amoebiasis intestinal infection caused by *Entamoeba histolytica*

amoebic dysentery severe form of intestinal infection caused by *Entamoeba histolytica*, characterized by severe diarrhea with blood and mucus

amphipathic a molecule containing both polar and nonpolar parts

amphitrichous having two flagella or tufts of multiple flagella, with one flagellum or tuft located at each end of the bacterial cell

amphotericin B antifungal drug of the polyene class that is used to treat several systemic fungal infections

amplitude the height of a wave

anabolism chemical reactions that convert simpler molecules into more complex ones

anaerobe chamber closed compartment used to handle and grow obligate anaerobic cultures

anaerobe jar container devoid of oxygen used to grow obligate anaerobes

anaerobic respiration use of a non-oxygen inorganic molecule, like CO₂, nitrate, nitrite, oxidized iron, or sulfate, as the final electron acceptor at the end of the electron transport system

analytical epidemiology study of disease outbreaks to establish associations between an agent and a disease state through observational studies comparing groups of individuals

anaphylactic shock another term for anaphylaxis

anaphylaxis systemic and potentially life-threatening type I hypersensitivity reaction

anergy peripheral tolerance mechanism that prevents self-reactive T cells from being activated by self-antigens through lack of co-stimulation

annealing formation of hydrogen bonds between the nucleotide base pairs of two single-stranded complementary nucleic acid sequences

anoxygenic photosynthesis type of photosynthesis found in many photosynthetic bacteria, including the purple and green bacteria, where an electron donor other than H₂O is used to replace an electron lost by a reaction center pigment, resulting no oxygen production

anthrax a disease caused by *Bacillus anthracis*; the cutaneous form causes a skin lesion to develop; gastrointestinal and inhalation anthrax have high mortality rates

antibiogram compilation of the antimicrobial susceptibilities recorded for local bacterial strains, which is useful for monitoring local trends in antimicrobial resistance and aiding the prescription of appropriate empiric antibacterial therapy

antibiotic-associated diarrhea diarrhea that develops after antibiotic treatment as a result of disruption to the normal microbiota; *C. difficile* is a particularly serious example

antibody screen test to make sure that a potential blood recipient has not produced antibodies to antigens other than the ABO and Rh antigens

antibody Y-shaped glycoprotein molecule produced by B cells that binds to specific epitopes on an antigen

antibody-dependent cell-mediated cytotoxicity (ADCC) mechanism by which large pathogens are marked for destruction by specific antibodies and then killed by secretion of cytotoxins by natural killer cells, macrophages, or eosinophils

anticodon three-nucleotide sequence of a mature tRNA that interacts with an mRNA codon through complementary base pairing

antigen (also, immunogen) a molecule that stimulates an adaptive immune response

antigenic able to stimulate an adaptive immune response

antigenic drift form of slight antigenic variation that occurs because of point mutations in the genes that encode surface proteins

antigenic shift form of major antigenic variation that occurs because of gene reassortment

antigenic variation changing of surface antigens (carbohydrates or proteins) such that they are no longer recognized by the host's immune system

antigen-presenting cells (APC) macrophages, dendritic cells, and B cells that process and present foreign pathogen antigens for the purpose of activating T cells and adaptive immune defenses

antimetabolites compounds that are competitive inhibitors for bacterial metabolic enzymes

antimicrobial drugs chemical compounds, including naturally produced drugs, semisynthetic derivatives, and synthetic compounds, that target specific microbial structures and enzymes, killing specific microbes or inhibiting their growth

antimicrobial peptides (AMPs) class of nonspecific, cell-derived chemical mediators with broad-spectrum antimicrobial properties

antiparallel two strands of DNA helix oriented in opposite directions; one strand is oriented in the 5' to 3' direction, while the other is oriented in the 3' to 5' direction

antisense RNA small noncoding RNA molecules that inhibit gene expression by binding to mRNA transcripts via complementary base pairing

antisense strand transcription template strand of DNA; the strand that is transcribed for gene expression

antiseptics protocol that removes potential pathogens from living tissue

antiseptic antimicrobial chemical that can be used safely on living tissue

antiserum serum obtained from an animal containing antibodies against a particular antigen that was artificially introduced to the animal

apoenzyme enzyme without its cofactor or coenzyme

apoptosis programmed and organized cell death without lysis of the cell

arachnoid mater middle membrane surrounding the brain that produces cerebrospinal fluid

arboviral encephalitis infection by an arthropod-borne virus that results in an inflammation of the brain

arbovirus any of a variety of viruses that are transmitted by arthropod vectors

archaea any of various unicellular prokaryotic microorganisms, typically having cell walls containing pseudopeptidoglycan

Archaea domain of life separate from the domains Bacteria and Eukarya

artemisinin antiprotozoan and antifungal drug effective against malaria that is thought to increase intracellular levels of reactive oxygen species in target microbes

artery large, thick-walled vessel that carries blood from the heart to the body tissues

Arthus reaction localized type III hypersensitivity

artificial active immunity immunity acquired through exposure to pathogens and pathogen antigens through a method other than natural infection

artificial passive immunity transfer of antibodies produced by a donor to another individual for the purpose of preventing or treating disease

ascariasis soil-transmitted intestinal infection caused by the large nematode roundworm *Ascaris lumbricoides*

ascocarps cup-shaped fruiting bodies of an ascomycete fungus

ascospore asexual spore produced by ascomycete fungi

ascus structure of ascomycete fungi containing spores

asepsis sterile state resulting from proper use of microbial control protocols

aseptic technique method or protocol designed to prevent microbial contamination of sterile objects, locations, or tissues

aspergillosis fungal infection caused by the mold *Aspergillus*; immunocompromised patients are primarily at risk

asymptomatic carrier an infected individual who exhibits no signs or symptoms of disease yet is capable of transmitting the pathogen to others

asymptomatic not exhibiting any symptoms of disease

atomic force microscope a scanning probe microscope that uses a thin probe that is passed just above the specimen to measure forces between the atoms and the probe

ATP synthase integral membrane protein that harnesses the energy of the proton motive force by allowing hydrogen ions to diffuse down their electrochemical gradient, causing components of this protein to spin, making ATP from ADP and P_i

attachment binding of phage or virus to host cell receptors

attenuation regulatory system of prokaryotes whereby secondary stem-loop structures formed within the 5' end of an mRNA being transcribed determine both if transcription to complete the synthesis of this mRNA will occur and if this mRNA will be used for translation

autoclave specialized device for the moist-heat sterilization of materials through the application of pressure to steam, allowing the steam to reach temperatures above the boiling point of water

autocrine function refers to a cytokine signal released from a cell to a receptor on its own surface

autograft tissue transplanted from a location on an individual to a different location on the same individual

autoimmune disease loss of tolerance to self, resulting in immune-mediated destruction of self cells and tissues

autoinducer signaling molecule produced by a bacterial cell that can modify the activity of surrounding cells; associated with quorum sensing

autoradiography the method of producing a photographic image from radioactive decay; in molecular genetics the method allows the visualization of radioactively-labeled DNA probes that have hybridized to a nucleic acid sample

autotroph organism that converts inorganic carbon dioxide into organic carbon

auxotroph nutritional mutant with a loss-of-function mutation in a gene encoding the biosynthesis of a specific nutrient such as an amino acid

avidity strength of the sum of the interactions between an antibody and antigen

axon long projection of a neuron along which an electrochemical signal is transmitted

azithromycin semisynthetic macrolide with increased spectrum of activity, decreased toxicity, and increased half-life compared with erythromycin

B

β-lactamases bacterially produced enzymes that cleave the β-lactam ring of susceptible β-lactam antimicrobials, rendering them inactive and conferring resistance

β-lactams group of antimicrobials that inhibit cell wall synthesis; includes the penicillins, cephalosporins, carbapenems, and monobactams; inhibits the transpeptidase cross-linking activity of penicillin-binding proteins

β-oxidation process of fatty acid degradation that sequentially removes two-carbon acetyl groups, producing NADH and FADH₂, on entry into the Krebs cycle

β-pleated sheet secondary structure consisting of pleats formed by hydrogen bonds between localized segments of amino acid residues on the backbone of the polypeptide chain

B-cell receptors (BCRs) membrane-bound IgD and IgM antibody that bind specific antigen epitopes with Fab antigen-binding region

B lymphocyte antibody-producing cells of humoral immunity; B cell

babesiosis tickborne protozoan infection caused by *Babesia* spp. and characterized by malaise, fatigue, fever, headache, myalgia, and joint pain

bacillary dysentery gastrointestinal illness caused by *Shigella* bacteria, also called shigellosis

bacillus (bacilli) rod-shaped prokaryotic cell

bacitracin group of structurally similar peptides that block the movement of peptidoglycan precursors across the cell membrane, inhibiting peptidoglycan synthesis

bacteremia condition marked by the presence of bacteria in the blood

bacteria (singular: bacterium) any of various unicellular prokaryotic microorganisms typically (but not always) having cell walls that contain peptidoglycan

bacterial lawn layer of confluent bacterial growth on an agar plate

bacterial meningitis bacterial infection that results in an inflammation of the meninges

bacterial vaginosis a condition caused by an overgrowth of bacteria in the vagina that may or may not cause symptoms

bactericidal irreversible inhibition of a microbe's ability to divide

bactericide chemical or physical treatment that kills bacteria

bacteriochlorophylls green, purple, or blue pigments of bacteria; they are similar to chlorophyll of plants

bacteriology the study of bacteria

bacteriophage virus that infects bacteria

bacteriostatic having the ability to inhibit bacterial growth, generally by means of chemical or physical treatment; reversible inhibition of a microbe's ability to divide

barophile organism that grows under high atmospheric pressure

basal body component of eukaryotic flagellum or cilium composed of nine microtubule triplets and attaches the flagellum or cilium to the cell

base sequence identity of the specific nucleotides present in a nucleic acid strand and their order within the strand

basic dye a chromophore with a positive charge that attaches to negatively charged structures

basidia (basidium, sing.) small club-shaped structures of basidiomycete fungi where basidiospores are produced

basidiocarps fruiting bodies of basidiomycete fungi

basidiospores spores produced sexually via budding in basidiomycete fungi

basophils leukocytes with granules containing histamine and other chemicals that facilitate allergic responses and inflammation when released

benzimidazoles class of antihelminthic drugs that bind to helminthic β -tubulin, preventing microtubule formation

Betaproteobacteria class of Proteobacteria that are all eutrophs

binary fission predominant form of bacterial reproduction in which one cell divides into two daughter cells of equal size, which separate, each offspring receiving a complete copy of the parental genome

binocular having two eyepieces

binomial nomenclature a universal convention for the scientific naming of organisms using Latinized names for genus and species

biofilm complex ecosystem of bacteria embedded in a matrix

biogeochemical cycle recycling of inorganic matter between living organisms and their nonliving environment

bioinformatics the analysis of large amounts of information required for interpretation of these data

biological transmission movement of a pathogen between hosts facilitated by a biological vector in which the pathogen grows and reproduces

biological vector an animal (typically an arthropod) that is infected with a pathogen and is capable of transmitting the pathogen from one host to another

biomarker a protein expressed by a cell or tissue that is indicative of disease

biomolecule a molecule that is part of living matter

bioremediation use of microbes to remove xenobiotics or environmental pollutants from a contaminated site

biosynthesis replication of viral genome and other protein components

biotechnology the science of using living systems to benefit humankind

bisbiguanide type of chemical compound with antiseptic properties; disrupts cell membranes at low concentrations and causes congealing of intracellular contents at high concentrations

blastomycosis fungal disease associated with infections by *Blastomyces dermatitidis*; can cause disfiguring scarring of the hands and other extremities

blepharitis inflammation of the eyelids

blocking antibodies antigen-specific antibodies (usually of the IgG type) produced via desensitization therapy

blood-brain barrier tight cell junctions of the endothelia lining the blood vessels that serve the central nervous system, preventing passage of microbes from the bloodstream into the brain and cerebrospinal fluid

blue-white screening a technique commonly used for identifying transformed bacterial cells containing recombinant plasmids using *lacZ*-encoding plasmid vectors

blunt ends ends of DNA molecules lacking single-stranded complementary overhangs that are produced when some restriction enzymes cut DNA

botulism form of flaccid paralysis caused by the ingestion of a neurotoxin produced by *Clostridium botulinum*

bradykinin activated form of a proinflammatory molecule induced in the presence of invader microbes; opens gaps between cells in blood vessels, allowing fluid and cells to leak into surrounding tissue

bridge reaction reaction linking glycolysis to the Krebs cycle during which each pyruvate is decarboxylated and oxidized (forming NADH), and the resulting two-carbon acetyl group is attached to a large carrier called coenzyme A, resulting in the formation of acetyl-CoA and CO₂; also called the *transition reaction*

brightfield microscope a compound light microscope with two lenses; it produces a dark image on a bright background

broad-spectrum antimicrobial drug that targets many different types of microbes

bronchi major air passages leading to the lungs after bifurcating at the windpipe

bronchioles smaller air passages within the lung that are formed as the bronchi become further subdivided

bronchitis inflammation of the bronchi

brucellosis zoonotic disease caused by bacteria of the genus *Brucella* that results in undulant fever

bubo swollen, inflamed lymph node that forms as a result of a microbial infection

bubonic plague most common form of plague in humans, marked by the presence of swollen lymph nodes (buboes)

budding unequal reproductive division in which a smaller cell detaches from the parent cell

budding yeasts yeasts that divide by budding off of daughter cells

Burkitt lymphoma disease characterized by rapidly growing solid tumor; caused by Epstein-Barr virus (HHV-4)

burst release of new virions by a lysed host cell infected by a virus

burst size the number of virions released from a host cell when it is lysed because of a viral infection

C

Calvin-Benson cycle most common CO₂ fixation pathway in most photoautotrophs; involves light-independent reactions of photosynthesis that occur in the cytoplasm of photosynthetic bacteria and in the stroma of eukaryotic chloroplasts

Campylobacter jejuni gastroenteritis gastroenteritis caused by *C. jejuni*; generally mild but sometimes with serious complications

candidiasis fungal infection caused by *Candida* spp., especially *C. albicans*; can affect various regions of the body, e.g., skin (cutaneous candidiasis), oral cavity (oral thrush), or vagina (yeast infection)

candle jar container with a tight-fitting lid in which a burning candle consumes oxygen and releases carbon dioxide, thereby creating an environment suitable for capnophiles

capillary small blood vessel found in the interstitial space of tissue; delivers nutrients and oxygen, and removes waste products

capnophile organism that requires carbon dioxide levels higher than atmospheric concentration

capsid protein coat surrounding the genome of the virus

capsomere individual protein subunits that make up the capsid

capsule staining a negative staining technique that stains around a bacterial capsule while leaving the capsule clear

capsule type of glycocalyx with organized layers of polysaccharides that aid in bacterial adherence to surfaces and in evading destruction by immune cells

carbapenem-resistant Enterobacteriaceae (CRE) group of bacteria that have developed resistance to all β -lactams, including carbapenems, and many other drug classes

carbohydrate the most abundant type of biomolecule, consisting of carbon, hydrogen, and oxygen

carbon skeleton chain of carbon atoms to which one or more functional groups are bound

carboxysome an inclusion composed of an outer shell of thousands of protein subunits. Its interior is filled with ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) and carbonic anhydrase, which are both used for carbon metabolism

carbuncle abscess containing a large, deep, purulent skin lesion

carcinogen agent that causes cancer

case-control study a type of observational study in which a group of affected individuals are compared, usually retrospectively, to a similar group of unaffected individuals

catabolic activator protein (CAP)/cAMP receptor protein (CRP) protein that, when bound to cAMP in the presence of low levels of glucose, binds to the promoters of operons that control the processing of alternative sugars

catabolism chemical reactions that break down complex molecules into simpler ones

catabolite repression repression of the transcription of operons encoding enzymes for the use of substrates other than glucose when glucose levels are high

catalase enzyme that breaks down hydrogen peroxide to water and oxygen

catalyst molecule that increases the rate of a chemical reaction but is not used or changed during the chemical reaction and, thus, is reusable

catarrhal stage in pertussis, a disease stage marked by inflammation of the mucous membranes combined with excessive secretions

cat-scratch disease bacterial infection of the lymph nodes caused by *Bartonella henselae*; frequently transmitted via a cat scratch

causative agent the pathogen or substance responsible for causing a particular disease; etiologic agent

CCA amino acid binding end region of a mature tRNA that binds to an amino acid

celiac disease disease largely of the small intestine caused by an immune response to gluten that results in the production of autoantibodies and an inflammatory response

cell envelope the combination of external cellular structures (e.g., plasma membrane, cell wall, outer membrane, glycocalyxes) that collectively contain the cytoplasm and internal structures of a cell

cell membrane lipid bilayer with embedded proteins and carbohydrates that defines the boundary of the cell (also called the cytoplasmic membrane or plasma membrane)

cell morphology cell shape, structure, and arrangement, as viewed microscopically

cell theory the theory that all organisms are composed of cells and that the cell is the fundamental unit of life

cell wall a structure in the cell envelope of some cells that helps the cell maintain its shape and withstand changes in osmotic pressure

cellular immunity adaptive immunity involving T cells and the destruction of pathogens and infected cells

cellulitis a subcutaneous skin infection that develops in the dermis or hypodermis, resulting in a red, painful inflammation

cellulose a structural polysaccharide composed of glucose monomers linked together in a linear chain by glycosidic bonds

Centers for Disease Control and Prevention (CDC) the national public health agency in the United States

central dogma scientific principle explaining the flow of genetic information from DNA to RNA to protein

central nervous system (CNS) portion of the nervous system made up of the brain and spinal cord

central tolerance negative selection of self-reactive T cells in thymus

centriole a component of a centrosome with the structural array of nine parallel microtubules arranged in triplets; involved in eukaryotic cell division

centrosome a microtubule-organizing center for the mitotic spindle found in animal cells; it separates chromosomes during cell division and is composed of a pair of centrioles positioned at right angles to each other

cephalosporins a group of cell wall synthesis inhibitors within the class of β -lactams

cercarial dermatitis inflammation of the skin caused by a reaction to cercaria of *Schistosoma* spp., which can penetrate the skin and blood vessels; also called swimmer's itch or clam digger's itch

cerebrospinal fluid (CSF) sterile liquid produced in the brain that fills the subarachnoid space of the brain and spinal column

cervix the part of the uterus that connects to the vagina

CFB group phylum consisting of the gram-negative, rod-shaped nonproteobacteria genera *Cytophaga*, *Fusobacterium*, and *Bacteroides*

Chagas disease potentially fatal protozoan infection caused by *Trypanosoma cruzi* and endemic to Central and South America; transmitted by the triatomine bug (kissing bug)

chancroid an STI caused by *Haemophilus ducreyi* that produces soft chancres on genitals

charged tRNA activated tRNA molecule carrying its cognate amino acid

chemical mediators chemicals or enzymes produced by a variety of cells; provide nonspecific antimicrobial defense mechanisms

chemically defined media media in which all components are chemically defined

chemiosmosis flow of hydrogen ions across the membrane through ATP synthase

chemokines chemotactic cytokines that recruit specific subsets of leukocytes to infections, damaged tissue, and sites of inflammation

chemotaxis directional movement of a cell in response to a chemical attractant

chemotroph organism that gets its energy from the transfer of electrons originating from chemical compounds

chickenpox common childhood disease caused by the varicella-zoster virus and marked by the formation of pustular lesions on the trunk

chikungunya fever mosquito-borne viral disease caused by the chikungunya virus and characterized by high fever, joint pain, rash, and blisters

chirality property of stereoisomer molecules by which their structures are nonsuperimposable mirror-images

chitin polysaccharide that is an important component of fungal cell walls

chlamydia a common STI caused by *Chlamydia trachomatis*

chloramphenicol protein synthesis inhibitor with broad-spectrum activity that binds to the 50S subunit, inhibiting peptide bond formation

chlorophyll a type of photosynthetic pigment found in some prokaryotic and eukaryotic cells

chloroplast organelle found in plant and algal cells in which photosynthesis occurs

cholera gastrointestinal illness caused by *Vibrio cholera* characterized by severe diarrhea

chromatin combination of DNA with DNA binding proteins

chromogenic substrate colorless substrate (chromogen) that is converted into a colored end product by the enzyme

chromophores pigments that absorb and reflect particular wavelengths of light (giving them a color)

chromosome discrete DNA structure within a cell that controls cellular activities

chronic disease any disease that progresses and persists over a long time

chronic granulomatous disease primary immunodeficiency caused by an impaired ability of phagocytic cells to kill ingested bacteria in the phagolysosome

chronic wasting disease prion disease of deer and elk in the United States and Canada

cilia (singular: cilium) short filamentous structures found on some eukaryotic cells; each is composed of microtubules in a 9+2 array, and may be used for locomotion, feeding, and/or movement of extracellular particles that come in contact with the cell

ciliated epithelial cells hair-like cells in the respiratory tract that beat, pushing mucus secretions and trapped debris away from the sensitive tissues of the lungs

ciliates protists with cilia (Ciliophora), including *Paramecium* and *Stentor*, classified within the Chromalveolata

cisternae the sacs of the endoplasmic reticulum

citric acid cycle see *Krebs cycle*

class switching genetic rearrangement of constant region gene segments in plasma cells to switch antibody production from IgM to IgG, IgA, or IgE

clindamycin semisynthetic protein synthesis inhibitor of the lincosamide class that binds to the 50S subunit, inhibiting peptide bond formation

clone a genetically identical cell or individual

***Clostridium perfringens* gastroenteritis** relatively mild gastrointestinal illness caused by *C. perfringens*

clusters of differentiation (CD) cell-surface glycoproteins that serve to identify and distinguish white blood cells

coagulase enzyme that causes the activation of fibrinogen to form fibrin, promoting clotting of the blood

coarse focusing knob a knob on a microscope that produces relatively large movements to adjust focus

coccidioidomycosis disease caused by the highly infectious fungal pathogen *Coccidioides immitis* and related species

codon three-nucleotide sequence within mRNA that specifies a particular amino acid to be incorporated into the polypeptide being synthesized

coenocyte multinucleated eukaryotic cell that forms as a result of multiple rounds of nuclear division without the accompanying division of the plasma membrane

coenocytic hyphae nonseptate hyphae that are multinucleate and lack cell walls or membranes between cells; characteristic of some fungi

coenzyme organic molecule required for proper enzyme function that is not consumed and is reusable

cofactor inorganic ion that helps stabilize enzyme conformation and function

cognate amino acid amino acid added to a specific tRNA molecule that correctly corresponds to the tRNA's anticodon and, hence, the mRNA's codon, reflecting the genetic code

cohort method a method used in observational studies in which a group of individuals is followed over time and factors potentially important in the development of disease are evaluated

colistin membrane-active polymyxin that was historically used for bowel decontamination but now used for systemic infections with drug-resistant pathogens

colitis inflammation of the large intestine

collagenase enzyme that digests collagen, the dominant protein in connective tissue

colony-forming unit (CFU) a counting quantity represented by a colony formed on solid medium from a single cell or a few cells

commensalism type of symbiosis in which one population benefits and the other is not affected

commercial sterilization type of sterilization protocol used in food production; uses conditions that are less harsh (lower temperatures) to preserve food quality but still effectively destroy vegetative cells and endospores of common foodborne pathogens such as *Clostridium botulinum*

common cold most common cause of rhinitis in humans; associated with a variety of adenoviruses, coronaviruses, and rhinoviruses

common source spread a mode of disease transmission in which every infection originates from the same source

communicable able to be transmitted directly or indirectly from one person to another

community group of interacting populations of organisms

competitive inhibitor molecule that binds to an enzyme's active site, preventing substrate binding

competitive interactions interactions between populations in which one of them competes with another for resources

complement activation cascading activation of the complement proteins in the blood, resulting in opsonization, inflammation, and lysis of pathogens

complement fixation test test for antibodies against a specific pathogen using complement-mediated hemolysis

complement system series of proteins that can become activated in the presence of invading microbes, resulting in opsonization, inflammation, and lysis of pathogens

complementary base pairs base pairing due to hydrogen bonding that occurs between a specific purine and a specific pyrimidine; A bonds with T (in DNA), and C bonds with G

complementary DNA (cDNA) a DNA molecule complementary to mRNA that is made through the activity of reverse transcriptase

complex media media that contain extracts of animals and plants that are not chemically defined

complex virus virus shape that often includes intricate characteristics not seen in the other categories of capsid

compound microscope a microscope that uses multiple lenses to focus light from the specimen

condenser lens a lens on a microscope that focuses light from the light source onto the specimen

conditional mutation mutant form of a gene whose mutant phenotype is expressed only under certain environmental conditions

confocal microscope a scanning laser microscope that uses fluorescent dyes and excitation lasers to create three-dimensional images

conidia asexual fungal spores not enclosed in a sac; produced in a chain at the end of specialized hyphae called conidiophores

conjugate vaccine a vaccine consisting of a polysaccharide antigen conjugated to a protein to enhance immune response to the polysaccharide; conjugate vaccines are important for young children who do not respond well to polysaccharide antigens

conjugated protein protein carrying a nonpolypeptidic portion

conjugation mechanism of horizontal gene transfer in bacteria in which DNA is directly transferred from one bacterial cell to another by a conjugation pilus

conjugation pilus (sex pilus) hollow tube composed of protein encoded by the conjugation plasmid that brings two bacterial cells into contact with each other for the process of conjugation

conjunctiva the mucous membranes covering the eyeball and inner eyelid

conjunctivitis inflammation of the conjunctiva, the mucous membrane covering the eye and inside of the eyelid

constitutively expressed describes genes that are transcribed and translated continuously to provide the cell with constant intermediate levels of the protein products

contact dermatitis inflammation of the skin resulting from a type IV hypersensitivity to an allergen or irritant

contact see *exposure*

contact transmission movement of a pathogen between hosts due to contact between the two; may be direct or indirect

contagious easily spread from person to person

continuous cell line derived from transformed cells or tumors, these cells are often able to be subcultured many times, or, in the case of immortal cell lines, grown indefinitely

continuous common source spread a mode of disease transmission in which every infection originates from the same source and that source produces infections for longer than one incubation period

contractile vacuoles organelles found in some cells, especially in some protists, that take up water and then move the water out of the cell for osmoregulatory purposes (i.e., to maintain an appropriate salt and water balance)

contrast visible differences between parts of a microscopic specimen

convalescence stage the final stage of a whooping cough infection, marked by a chronic cough

Coombs' reagent antiserum containing antihuman immunoglobulins used to facilitate hemagglutination by cross-linking the human antibodies attached to red blood cells

cooperative interactions interactions between populations in which both benefit

cortex tightly packed layer of fungal filaments at the outer surface of a lichen; foliose lichens have a second cortex layer beneath the medulla

counterstain a secondary stain that adds contrasting color to cells from which the primary stain has been washed out by a decolorizing agent

crenation shriveling of a cell

Creutzfeldt-Jakob disease form of transmissible spongiform encephalopathy found in humans; typically a fatal disease

crisis phase point at which a fever breaks, reaching a peak before the hypothalamus resets back to normal body temperature

critical item object that must be sterile because it will be used inside the body, often penetrating sterile tissues or the bloodstream

cross-match in the major cross-match, donor red blood cells are checked for agglutination using recipient serum; in the minor cross-match, donor serum is checked for agglutinating antibodies against recipient red blood cells

cross-presentation a mechanism by which dendritic cells process antigens for MHC I presentation to CD8 T cells through phagocytosis of the pathogen (which would normally lead to MHC II presentation)

cross-resistance when a single resistance mechanism confers resistance to multiple antimicrobial drugs

cross-sectional study a type of observational study in which measurements are made on cases, both affected and unaffected, at one point in time and the measurements analyzed to uncover associations with the disease state

crustose lichens lichens that are tightly attached to the substrate, giving them a crusty appearance

cryptococcosis fungal pneumonia caused by the encapsulated yeast *Cryptococcus neoformans* commonly found in bird droppings

cryptosporidiosis intestinal infection caused by *Cryptosporidium parvum* or *C. hominis*

culture density the number of cells per volume of broth

culture medium combination of compounds in solution that supports growth

cutaneous mycosis any fungal infection that affects the surface of the skin, hair, or nails

cyanobacteria phototrophic, chlorophyll-containing bacteria that produce large amounts of gaseous oxygen

cyclic AMP (cAMP) intracellular signaling molecule made through the action of adenyl cyclase from ATP when glucose levels are low, with the ability to bind to a catabolite activator protein to allow it to bind to regulatory regions and activate the transcription of operons encoding enzymes for metabolism of alternative substrates

cyclic photophosphorylation pathway used in photosynthetic organisms when the cell's need for ATP outweighs that for NADPH, thus bypassing NADPH production

cyclosporiasis intestinal infection caused by *Cyclospora cayetanensis*

cystic echinococcosis hydatid disease, an infection caused by the tapeworm *Echinococcus granulosus* that can cause cyst formation

cysticerci larval form of a tapeworm

cystitis inflammation of the bladder

cysts microbial cells surrounded by a protective outer covering; some microbial cysts are formed to help the microbe survive harsh conditions, whereas others are a normal part of the life cycle

cytochrome oxidase final ETS complex used in aerobic respiration that transfers energy-depleted electrons to oxygen to form H₂O

cytokine storm an excessive release of cytokines, typically triggered by a superantigen, that results in unregulated activation of T cells

cytokines protein molecules that act as a chemical signals; produced by cells in response to a stimulation event

cytomegalovirus (CMV) infection human herpesvirus 5 infection that is typically asymptomatic but can become serious in immunocompromised patients, transplant recipients, and developing fetuses

cytopathic effect cell abnormality resulting from a viral infection

cytoplasm the gel-like material composed of water and dissolved or suspended chemicals contained within the plasma membrane of a cell

cytoplasmic membrane see *cell membrane*

cytoproct a protozoan cell structure that is specialized for excretion

cytosine pyrimidine nitrogenous base found in nucleotides

cytoskeleton a network of filaments or tubules in the eukaryotic cell that provides shape and structural support for cells; aids movement of materials throughout the cell

cytostome a protozoan cell structure that is specialized for phagocytosis (i.e., to take in food)

cytotoxic T cells effector cells of cellular immunity that target and eliminate cells infected with intracellular pathogens through induction of apoptosis

cytotoxicity harmful effects to host cell

D

dacryocystitis inflammation of the lacrimal sac often associated with a plugged nasolacrimal duct

daptomycin cyclic lipopeptide that disrupts the bacterial cell membrane

darkfield microscope a compound light microscope that produces a bright image on a dark background; typically a modified brightfield microscope

death phase (decline phase) phase of the growth curve at which the number of dying cells exceeds the number of new cells formed

decimal reduction time (DRT) or D-value amount of time it takes for a specific protocol to produce a one order of magnitude decrease in the number of organisms; that is, death of 90% of the population

decolorizing agent a substance that removes a stain, usually from some parts of the specimen

deeply branching bacteria bacteria that occupy the lowest branches of the phylogenetic tree of life

definitive host the preferred host organism for a parasite, in which the parasite reaches maturity and may reproduce sexually

degeneracy redundancy in the genetic code because a given amino acid is encoded by more than one nucleotide triplet codon

degerming protocol that significantly reduces microbial numbers by using mild chemicals (e.g., soap) and gentle scrubbing of a small area of skin or tissue to avoid the transmission of pathogenic microbes

degranulation release of the contents of mast cell granules in response to the cross-linking of IgE molecules on the cell surface with allergen molecules

dehydration synthesis chemical reaction in which monomer molecules bind end to end in a process that results in the formation of water molecules as a byproduct

deletion type of mutation involving the removal of one or more bases from a DNA sequence

Deltaproteobacteria class of Proteobacteria that includes sulfate-reducing bacteria

denatured protein protein that has lost its secondary and tertiary structures (and quaternary structure, if applicable) without the loss of its primary structure

dendrites branched extensions of the soma of a neuron that interact with other cells

dengue fever mosquito-borne viral hemorrhagic disease; also known as breakbone fever

dental calculus calcified heavy plaque on teeth, also called tartar

dental caries cavities formed in the teeth as a result of tooth decay caused by microbial activity

deoxyribonucleic acid (DNA) double-stranded nucleic acid composed of deoxyribonucleotides that serves as the genetic material of the cell

deoxyribonucleotides DNA nucleotides containing deoxyribose as the pentose sugar component

dermatophyte any fungus of the genera *Microsporum*, *Epidermophyton*, or *Trichophyton*, which feed on keratin (a protein found in skin, hair, and nails) and can cause cutaneous infections

dermis the second layer of human skin, found between the epidermis and the hypodermis

descriptive epidemiology a method of studying a disease outbreak using case histories, contact interviews, medical information, and other sources of information

desensitization injections of antigen that lead to production of antigen-specific IgG molecules, effectively outcompeting IgE molecules on the surface of sensitized mast cells for antigen

desiccation method of microbial control involving the removal of water from cells through drying or dehydration

desquamation peeling and shedding of outermost skin

diapedesis process by which leukocytes pass through capillary walls to reach infected tissue; also called extravasation

diaphragm a component of a microscope; typically consists of a disk under the stage with holes of various sizes; can be adjusted to allow more or less light from the light source to reach the specimen

differential interference-contrast microscope a microscope that uses polarized light to increase contrast

differential media media that contain additives that make it possible to distinguish bacterial colonies based on metabolic activities of the organisms

differential staining staining that uses multiple dyes to differentiate between structures or organisms

diffraction the changing of direction (bending or spreading) that occurs when a light wave interacts with an opening or barrier

dikaryotic having two separate nuclei within one cell

dimorphic fungus a fungus that can take the form of a yeast or a mold, depending on environmental conditions

dioecious refers to sexually reproducing organisms in which individuals have either male or female reproductive organs (not both)

diphtheria serious infection of the larynx, caused by the toxigenic bacterium *Corynebacterium diphtheriae*

diploid having two copies of each chromosome

direct agglutination assay assay that can be used to detect the agglutination of bacteria by the action of antibodies in patient serum

direct antihuman globulin test (DAT) another name for a direct Coombs' test

direct contact transmission movement of a pathogen between hosts by physical contact or transfer in droplets at a distance less than one meter

direct Coombs' test assay that looks for antibodies *in vivo* against red blood cells caused by various types of infections, drug reactions, and autoimmune disorders

direct ELISA enzyme-linked immunoabsorbent assay in which the antigens are immobilized in the well of a microtiter plate; only a single antibody is used in the test

direct fluorescent antibody (DFA) test FA technique in which the labeled antibody binds to the target antigen

direct hemagglutination assay test that determines the titer of certain bacteria and viruses that causes clumping of red blood cells

direct microscopic cell count counting of cells using a calibrated slide under a light microscope

direct repair (light repair or photoreactivation) light-dependent mechanism for repairing pyrimidine dimers involving the enzyme photolyase

disaccharide one of two monosaccharides linked together by a glycosidic bond

disease any condition in which the normal structure or function of the body is damaged or impaired

disinfectant antimicrobial chemical applied to a fomite during disinfection that may be toxic to tissues

disinfection protocol that removes potential pathogens from a fomite

disk-diffusion method a technique for measuring of the effectiveness of one or more antimicrobial agents against a known bacterium; involves measuring the zone(s) of inhibition around the chemical agent(s) in a culture of the bacterium

dispersion the separation of light of different frequencies due to different degrees of refraction

disulfide bridge covalent bond between the sulfur atoms of two sulfhydryl side chains

DNA gyrase (topoisomerase II) bacterial topoisomerase that relaxes the supercoiled chromosome to make DNA more accessible for the initiation of replication

DNA ligase enzyme that catalyzes the formation of a covalent phosphodiester linkage between the 3'-OH end of one DNA fragment and the 5' phosphate end of another DNA fragment

DNA packaging process in which histones or other DNA binding proteins perform various levels of DNA wrapping and attachment to scaffolding proteins to allow the DNA to fit inside a cell

DNA polymerase class of enzymes that adds nucleotides to the free 3'-OH group of a growing DNA chain that are complementary to the template strand

DNA primers short, synthetic, single-stranded DNA fragments of known sequence that bind to specific target sequences within a sample due to complementarity between the target DNA sequence and the primer; commonly used in PCR but may be used in other hybridization techniques

DNA probe a single-stranded DNA fragment that is complementary to part of the gene (DNA or RNA) of interest

DNase pathogen-produced nuclease that degrades extracellular DNA

dosage amount of medication given during a certain time interval

double immunodiffusion see Ouchterlony assay

doubling time the time it takes for the population to double; also referred to as generation time

droplet transmission direct contact transmission of a pathogen transferred in sneezed or coughed droplets of mucus that land on the new host within a radius of one meter

drug resistance ability of a microbe to persist and grow in the presence of an antimicrobial drug

dry-heat sterilization protocol that involves the direct application of high heat

dura mater tough, outermost membrane that surrounds the brain

dynein motor proteins that interact with microtubules in eukaryotic flagella and cilia

dysentery intestinal inflammation that causes diarrhea with blood and mucus

dysuria urination accompanied by burning, discomfort, or pain

E

E (exit) site functional site of an intact ribosome that releases dissociated uncharged tRNAs so that they can be recharged with free amino acids

East African trypanosomiasis acute form of African trypanosomiasis caused by *Trypanosoma brucei rhodesiense*

eastern equine encephalitis serious, but rare, mosquito-borne viral infection of the brain that is found primarily on the Atlantic and Gulf coast states of the United States

Ebola virus disease (EVD) potentially fatal viral hemorrhagic fever found primarily in western Africa and transmitted through contact with body fluids

eclipse phase period after viral infection during which the infective virus is not detected, either intracellularly or extracellularly, and biosynthesis is occurring

ectoplasm outer, more gelatinous layer of cytoplasm under a protist cell membrane

edema swelling due to accumulation of fluid and protein in tissue as a result of increased permeability of capillary walls during an inflammatory response; chronic edema can also result from blockage of lymphatic vessels, as in the case of elephantiasis

effector cells activated cells of cellular immunity that are involved in the immediate immune response, primarily to defend the body against pathogens

electron carrier cellular molecule that accepts high-energy electrons from reduced molecules like foods and later serves as an electron donor in subsequent redox reactions

electron microscope a type of microscope that uses short-wavelength electron beams rather than light to increase magnification and resolution

electron transport system (ETS) series of membrane-associated protein complexes and associated mobile accessory electron carriers important in the generation of the proton motive force required for ATP production by chemiosmosis; the last component involved in the cellular respiration of glucose

electroporation a genetic engineering technique in which cells are exposed to a short electric pulse, inducing them to take up DNA molecules from their environment

elementary bodies metabolically and reproductively inactive, endospore-like form of intracellular bacteria that spreads infection outside of cells

elongation in DNA replication stage of DNA replication during which DNA polymerase adds nucleotides, complementary to the parental strand, to the 3' end of a growing DNA strand

elongation in transcription stage of transcription during which RNA polymerase extends the RNA molecule by adding RNA nucleotides, complementary to the template DNA strand

elongation of translation stage of translation during which amino acids are added one by one to the C-terminus of the growing polypeptide

Emden-Meyerhof-Parnas (EMP) pathway type of glycolysis found in animals and the most common in microbes

emerging infectious disease a disease that is new to the human population or has increased in prevalence over the previous 20 years

enantiomers stereoisomers that are mirror images of each other and nonsuperimposable

encephalitis inflammation of the tissues of the brain

encystment the process of forming a cyst

endemic disease an illness that is constantly present (often at low levels) in a population

endergonic reaction chemical reaction that requires energy beyond activation energy to occur

endocarditis inflammation of the endocardium, especially the heart valves

endocrine function refers to a cytokine signal released from a cell and carried by the bloodstream to a distant recipient cell

endocytosis the uptake of molecules through plasma membrane invagination and vacuole/vesicle formation

endomembrane system a series of organelles (endoplasmic reticulum, Golgi apparatuses, lysosomes, and transport vesicles) arranged as membranous tubules, sacs, and disks that synthesize many cell components

endoplasm inner, more fluid layer of cytoplasm under a protist cell membrane (inside of the ectoplasm)

endoplasmic reticulum part of the endomembrane system that is an interconnected array of tubules and flattened sacs with a single lipid bilayer that may be either rough or smooth; important in synthesizing proteins and lipids

endospore a cellular structure formed by some bacteria in response to adverse conditions; preserves DNA of the cell in a dormant state until conditions are favorable again

endospore staining a differential staining technique that uses two stains to make bacterial endospores appear distinct from the rest of the cell

endosymbiotic theory the theory that mitochondria and chloroplasts arose as a result of prokaryotic cells establishing a symbiotic relationship within a eukaryotic host

endothelia layer of epithelial cells lining blood vessels, lymphatics, the blood-brain barrier, and some other tissues

endotoxin lipid A component of lipopolysaccharides in the outer membrane of gram-negative bacteria

enriched media media that contain additional essential nutrients to support growth

enrichment culture media providing growth conditions that favor the expansion of an organism present in low numbers

enteric bacteria of the family Enterobacteriaceae, which live in the human intestinal tract

enteritis inflammation of the lining of the intestine

enterobiasis intestinal infection caused by the pinworm *Enterobius vermicularis*

enterohemorrhagic *E. coli* (EHEC) *E. coli* bacteria that cause severe gastrointestinal illness with potential serious complications such as hemolytic uremic syndrome

enteroinvasive *E. coli* (EIEC) *E. coli* bacteria that cause relatively mild gastrointestinal illness

enteropathogenic *E. coli* (EPEC) *E. coli* bacteria that cause serious gastrointestinal illness

enterotoxigenic *E. coli* (ETEC) *E. coli* bacteria that cause a relatively mild illness commonly called traveler's diarrhea

enterotoxin toxin that affects the intestines

Entner-Doudoroff (ED) pathway alternative glycolytic pathway used by some bacteria

enveloped virus a virus formed with a nucleic-acid packed capsid surrounded by a lipid layer

enzyme catalyst for biochemical reactions inside cells

enzyme immunoassay (EIA) type of assay wherein an enzyme is coupled to an antibody; addition of a chromogenic substrate for the antibody allows quantification or identification of the antigen bound by the antibody

enzyme-linked immunosorbent assay (ELISA) specialized form of EIA in which either the primary antibody or the antigen is first attached to a solid surface such as the well of a microtiter plate

eosinophils leukocytes with granules containing histamine and major basic protein; facilitate allergic responses and protection against parasitic protozoa and helminths

epidemic disease an illness with a higher-than-expected incidence in a given period within a given population

epidemic typhus severe and sometimes fatal infection caused by *Rickettsia prowazekii* and transmitted by body lice

epidemiology the study of where and when infectious diseases occur in a population and how they are transmitted and maintained in nature

epidermis the outermost layer of human skin

epididymis coiled tube that collects sperm from the testes and passes it on to the vas deferens

epididymitis inflammation of the epididymis caused by a bacterial infection

epigenetic regulation chemical modification of DNA or associated histones to influence transcription

epiglottis flap of cartilage that covers the larynx during swallowing; diverts food to the esophagus and prevents it from entering the respiratory tract

epiglottitis inflammation of the epiglottis

epiphyte a plant that grows on another plant

epitope smaller exposed region on an antigen that is recognized by B-cell and T-cell receptors and antibodies

Epsilonproteobacteria class of Proteobacteria that are microaerophilic

equivalence zone region where the antibody-antigen ratio produces the greatest amount of precipitin in a precipitin reaction

erysipelas a skin infection, typically caused by *Streptococcus pyogenes*, that presents as a red, large, intensely inflamed patch of skin involving the dermis, usually with clear borders, typically on the legs or face

erythema nodosum a condition that causes inflammation in the subcutaneous fat cells of the hypodermis resulting in red nodules

erythema redness at the site of inflammation, usually due to dilation of blood vessels in the area to help bring in white blood cells

erythrocyte red blood cell

erythrogenic toxin exotoxin produced by some strains of *Streptococcus pyogenes*; activity of the toxin can produce the characteristic rash of scarlet fever

erythromycin protein synthesis inhibitor of the macrolide class that is often used as an alternative to penicillin

eschar a localized mass of dead skin tissue

Etest simple, rapid method for determining MIC, involving commercially available plastic strips that contain a gradient of an antimicrobial and are placed on an agar plate inoculated with a bacterial lawn

etiologic agent the pathogen or substance responsible for causing a particular disease; causative agent

etiology the science of the causes of disease

Eukarya the domain of life that includes all unicellular and multicellular organisms with cells that contain membrane-bound nuclei and organelles

eukaryote an organism made up of one or more cells that contain a membrane-bound nucleus and organelles

eukaryotic cell has a nucleus surrounded by a complex nuclear membrane that contains multiple, rod-shaped chromosomes

eustachian tube small passage between the nasopharynx and the middle ear that allows pressure to equalize across the tympanic membrane

eutrophs microorganisms that require a copious amount of organic nutrients; also called copiotrophs

excystment the process of emerging from a cyst

exergonic reaction chemical reaction that does not require energy beyond activation energy to proceed; releases energy when the reaction occurs

exocytosis the release of the contents of transport vesicles to the cell's exterior by fusion of the transport vesicle's membrane with the plasma membrane

exoenzyme secreted enzyme that enhances the ability of microorganisms to invade host cells

exon protein-coding sequence of a eukaryotic gene that is transcribed into RNA and spliced together to code for a polypeptide

exonuclease enzymatic activity that removes RNA primers in DNA introduced by primase

exotoxin biologically active product that causes adverse changes in the host cells

experimental epidemiology the use of laboratory and clinical studies to directly study disease in a population

experimental study a type of scientific study that involves manipulation of the study subjects by the researcher through application of specific treatments hypothesized to affect the outcome while maintaining rigorously controlled conditions

exposure contact between potential pathogen and host; also called contamination or contact

extended-spectrum β -lactamases (ESBLs) β -lactamases carried by some gram-negative bacteria that provide resistance to all penicillins, cephalosporins, monobactams, and β -lactamase-inhibitor combinations, but not carbapenems

extensively drug resistant *Mycobacterium tuberculosis* (XDR-TB) strains of *M. tuberculosis* that are resistant to rifampin and isoniazid, and also are resistant to any fluoroquinolone and at least one of three other drugs (amikacin, kanamycin, or capreomycin)

extracellular matrix material composed of proteoglycans and fibrous proteins secreted by some eukaryotic cells that lack cell walls; helps multicellular structures withstand physical stresses and coordinates signaling from the external surface of the cell to the interior of the cell

extracellular polymeric substances (EPS) hydrated gel secreted by bacteria in a biofilm containing polysaccharides, proteins, nucleic acids, and some lipids

extrachromosomal DNA additional molecules of DNA distinct from the chromosomes that are also part of the cell's genome

extravasation process by which leukocytes pass through capillary walls to reach infected tissue; also called diapedesis

F

F⁻ (recipient) cell *E. coli* cell lacking the F plasmid and thus incapable of forming a conjugation pilus but capable of receiving the F plasmid during conjugation

F pilus (F pili) specialized type of pilus that aids in DNA transfer between cells; conjugation pilus of *E. coli*

F plasmid (fertility factor) bacterial plasmid in *E. coli* containing genes encoding the ability to conjugate, including genes encoding the formation of the conjugation pilus

F⁺ plasmid integrated F plasmid imprecisely excised from the chromosome; carries with it some chromosomal DNA adjacent to the integration site

F⁺ (donor) cell *E. coli* cell containing the F plasmid, capable of forming a conjugation pilus

Fab region arm of an antibody molecule that includes an antigen-binding site

facultative anaerobe organism that grows better in the presence of oxygen but can proliferate in its absence

false negative negative result to a test for an infection or condition (e.g., presence of antigen, antibody, or nucleic acid) when the infection or condition is actually present

false positive positive result to a test for an infection or condition (e.g., presence of antigen, antibody, or nucleic acid) when the infection or condition is actually absent

fastidious organism organism that has extensive growth requirements

fatty acid lipid that contains long-chain hydrocarbons terminated with a carboxylic acid functional group

fatty acid methyl ester (FAME) analysis technique in which the microbe's fatty acids are extracted, converted to volatile methyl esters, and analyzed by gas chromatography, yielding chromatograms that may be compared to reference data for identification purposes

Fc region region on the trunk of an antibody molecule involved in complement activation and opsonization

feedback inhibition mechanism of regulating metabolic pathway whereby the product of a metabolic pathway noncompetitively binds to an enzyme early on in the pathway, temporarily preventing the synthesis of the product

fermentation process that uses an organic molecule as a final electron acceptor to regenerate NAD⁺ from NADH such that glycolysis can continue

fever system-wide sign of inflammation that raises the body temperature and stimulates the immune response

fifth disease a highly contagious illness, more commonly affecting children, marked by a distinctive "slapped-cheek" rash and caused by parvovirus B19

fimbriae filamentous appendages found by the hundreds on some bacterial cells; they aid adherence to host cells

fine focusing knob a knob on a microscope that produces relatively small movements to adjust focus

fixation the process by which cells are killed and attached to a slide

flagella long, rigid, spiral structures used by prokaryotic cells for motility in aqueous environments; composed of a filament made of flagellin, a hook, and motor (basal body) that are attached to the cell envelope

flagella staining a staining protocol that uses a mordant to coat the flagella with stain until they are thick enough to be seen

flagellum (eukaryotic) (plural: flagella) long, whip-like, filamentous external structure found on some eukaryotic cells; composed of microtubules in a 9+2 arrangement; used for locomotion

flavin adenine dinucleotide (FAD/FADH₂) oxidized/reduced forms of an electron carrier in cells

flocculant visible aggregation that forms between a substance in suspension (e.g., lipid in water) and antibodies against the substance

flow cytometry technique analyzing cells for fluorescence intensity; specific subsets of cells are usually labeled in some way prior to the analysis

fluconazole antifungal drug of the imidazole class that is administered orally or intravenously for the treatment of several types of systemic yeast infections

fluid mosaic model refers to the ability of membrane components to move fluidly within the plane of the membrane, as well as the mosaic-like composition of the components

flukes any of the parasitic nonsegmented flatworms (trematodes) that have an oral sucker and sometimes a second ventral sucker; they attach to the inner walls of intestines, lungs, large blood vessels, or the liver in human hosts

fluorescence microscope a microscope that uses natural fluorochromes or fluorescent stains to increase contrast

fluorescence-activated cell sorter (FACS) technique for using a flow cytometer to physically separate cells into two populations based on fluorescence intensity

fluorescent antibody (FA) techniques suite of assays that use a fluorescently labeled antibody to bind to and so make an antigen easy to visualize

fluorescent enzyme immunoassay (FEIA) EIA in which the substrate is a fluorogen that becomes fluorescent following reaction with the enzyme

fluorescent the ability of certain materials to absorb energy and then immediately release that energy in the form of light

fluorochromes chromophores that fluoresce (absorb and then emit light)

fluorogen nonfluorescent molecule that becomes fluorescent on enzyme or laser activation

fluorophore molecule that fluoresces when excited by light

fluoroquinolones class of synthetic antimicrobials that inhibit the activity of DNA gyrase, preventing DNA replication

focal infection infection in which the pathogen causes infection in one location that then spreads to a secondary location

focal length the distance from the lens to the image point when the object is at a definite distance from the lens (this is also the distance to the focal point)

focal point a property of the lens; the image point when light entering the lens is parallel (i.e., the object is an infinite distance from the lens)

foliose lichens lichens that have lobes that may appear to resemble leaves

folliculitis a skin infection characterized by localized inflammation of hair follicles, typically producing an itchy red rash

fomite inanimate item that may harbor microbes and aid in disease transmission

foodborne disease disease that is transmitted through contaminated food

fragmentation newly formed cells split away from the parent filament in actinomycetes and cyanobacteria

frameshift mutation mutation resulting from either an insertion or a deletion in a number of nucleotides that, if not a multiple of three, changes every amino acid after the mutation

free ribosome eukaryotic 80S ribosome found in the cytoplasm; synthesizes water-soluble proteins

frequency the rate of vibration for a light wave or other electromagnetic wave

fruticose lichens lichens that are generally branched with a rounded appearance

functional groups specific groups of atoms that may occur within a molecule, conferring specific chemical properties

fungi (singular: fungus) any of various unicellular or multicellular eukaryotic organisms, typically having cell walls made out of chitin and lacking photosynthetic pigments, vascular tissues, and organs

fungicide chemical or physical treatment that kills fungi

fungistatic having the ability to inhibit fungal growth, generally by means of chemical or physical treatment

furuncle a small, purulent skin lesion; sometimes called a boil

fusion inhibitor antiviral drug that blocks the fusion of HIV receptors to the coreceptors required for virus entry into the cell, specifically, chemokine receptor type 5

G

Gammaproteobacteria class of Proteobacteria that is very diverse and includes a number of human pathogens

gas gangrene rapidly spreading infection of necrotic tissues caused by the gram-positive anaerobe *Clostridium perfringens* and other *Clostridium* spp.

gastritis inflammation of the lining of the stomach

gastroenteritis inflammation of the lining of the stomach and intestine

gene expression production of proteins from the information contained in DNA through the processes of transcription and translation

gene gun an apparatus that shoots gold or tungsten particles coated with recombinant DNA molecules at high speeds into plant protoplasts

gene silencing a genetic engineering technique in which researchers prevent the expression of a particular gene by using small interfering RNAs (siRNAs) or microRNAs (miRNAs) to interfere with translation

gene therapy a form of treatment for diseases that result from genetic mutations; involves the introduction of nonmutated, functional genes into the genome of the patient, often by way of a viral vector

generalized transduction transfer of a random piece of bacterial chromosome DNA by the phage

generation time see *doubling time*

genes segments of DNA molecules that code for proteins or stable RNA molecules

genetic code correspondence between mRNA nucleotide codons and the translated amino acids

genetic engineering the direct alteration of an organism's genetics to achieve desirable traits

genital herpes an STI caused by the herpes simplex virus

genital warts soft, pink, irregular growths that develop in the external genitalia or anus as a result of human papillomavirus infection

genome entire genetic content of a cell

genomic library a repository of an organism's entire genome maintained as cloned fragments in the genomes of strains of a host organism

genomics the study and comparison of entire genomes, including the complete set of genes, their nucleotide sequence and organization, and their interactions within a species and with other species

genotype full collection of genes that a cell contains within its genome

germ theory of disease the theory that many diseases are the result of microbial infection

germination process of an endospore returning to the vegetative state

Ghon complex calcified lesion containing *Mycobacterium tuberculosis*; forms in the lungs of patients with tuberculosis

giardiasis intestinal infection caused by *Giardia lamblia*

gingivitis inflammation of the gums that can cause bleeding

glial cell assists in the organization of neurons, provides a scaffold for some aspects of neuron function, and aids in recovery from neural injury

glomerulonephritis a type of kidney infection involving the glomeruli of the nephrons

glomerulus capillary bed in the nephron of the kidney that filters blood to form urine

glycocalyx cell envelope structure (either capsules or slime layer) outside the cell wall in some bacteria; allows bacteria to adhere to surfaces, aids in biofilm formation, and provides protection from predation

glycogen highly branched storage polysaccharide in animal cells and bacteria

glycolipid complex lipid that contains a carbohydrate moiety

glycolysis first step in the breakdown of glucose, the most common example of which is the Embden-Meyerhoff-Parnas pathway, producing two pyruvates, two NADH molecules, and two (net yield) ATP per starting glucose molecule

glycopeptides class of antibacterials that inhibit cell wall synthesis by binding to peptidoglycan subunits and blocking their insertion into the cell wall backbone, as well as blocking transpeptidation

glycoprotein conjugated protein with a carbohydrate attached

glycosidic bond forms between the hydroxyl groups of two sugar molecules

Golgi apparatus an organelle of the endomembrane system that is composed of a series of flattened membranous disks, called dictyosomes, each having a single lipid bilayer, that are stacked together; important in the processing of lipids and proteins

gonorrhea a common STI of the reproductive system caused by *Neisseria gonorrhoeae*

graft-versus-host disease specific type of transplantation reaction in which a transplanted immune system (e.g., a bone marrow transplant) contains APCs and T cells that are activated and attack the recipient's tissue

Gram stain procedure a differential staining technique that distinguishes bacteria based upon their cell wall structure

granulocytes leukocytes found in the peripheral blood that are characterized by numerous granules in the cytoplasm; granulocytes include neutrophils, eosinophils, and basophils

granuloma walled-off area of chronically inflamed tissue containing microbial pathogens, macrophages, and cellular materials unable to be eliminated

granulomatous amoebic encephalitis (GAE) serious brain infection of immunocompromised individuals caused by *Acanthamoeba* or *Balamuthia mandrillaris*

granzymes proteases released from a natural killer cell that enter the cytoplasm of a target cell, inducing apoptosis

Graves disease hyperthyroidism caused by an autoimmune disease affecting thyroid function

green nonsulfur bacteria similar to green sulfur bacteria but use substrates other than sulfides for oxidation

green sulfur bacteria phototrophic, anaerobic bacteria that use sulfide for oxidation and produce large amounts of green bacteriochlorophyll

growth curve a graph modeling the number of cells in a culture over time

guanine purine nitrogenous base found in nucleotides

Guillain-Barré syndrome an autoimmune disease, often triggered by bacterial and viral infections, characterized by the destruction of myelin sheaths around neurons, resulting in flaccid paralysis

gummas granulomatous lesions that develop in tertiary syphilis

H

hair follicle a structure embedded in the dermis from which hair grows

halophile organism that depends on high concentrations of salt in the environment to grow

halotolerant organism that grows in the presence of high salt concentration but does not require it

Hansen's Disease chronic bacterial infection of peripheral nervous tissues caused by the acid-fast bacterium, *Mycobacterium leprae*; also known as leprosy

hantavirus pulmonary syndrome acute lung infection by a hantavirus following inhalation of aerosols from the urine or feces of infected rodents

haploid having one copy of each chromosome

haptens a molecule that is too small to be antigenic alone but becomes antigenic when conjugated to a larger protein molecule

hard chancre a generally painless ulcer that develops at the site of infection in primary syphilis

Hashimoto thyroiditis hypothyroidism caused by an autoimmune disease affecting thyroid function

healthcare-associated infection (HAI) an infection acquired in a hospital or other health-care facility unrelated to the reason for which the patient was initially admitted; nosocomial infection

heavy chains longest identical peptide chains in antibody molecules (two per antibody monomer), composed of variable and constant region segments

helical virus cylindrical or rod shaped

helicase enzyme that unwinds DNA by breaking the hydrogen bonds between the nitrogenous base pairs, using ATP

helminth a multicellular parasitic worm

helper T cells class of T cells that is the central orchestrator of the cellular and humoral defenses of adaptive immunity and the cellular defenses of innate immunity

hemagglutination visible clumping of red blood cells that can be caused by some viruses, bacteria, and certain diseases in which antibodies are produced that bind to self-red blood cells

hematopoiesis formation, development, and differentiation of blood cells from pluripotent hematopoietic stem cells

hematuria condition in which there is blood in the urine

hemolysin class of exotoxin that targets and lyses red blood cells, as well as other cells

hemolytic disease of the newborn (HDN) type II hypersensitivity reaction that occurs when maternal anti-Rh antibodies cross the placenta and target fetal Rh+ red blood cells for lysis

hemolytic transfusion reaction (HTR) condition resulting after an incompatible blood transfusion; caused by type II hypersensitivity reaction and destruction of red blood cells

hemorrhagic fever with renal syndrome serious hemorrhagic fever caused by hantavirus infection

HEPA filter high-efficiency particulate air filter with an effective pore size that captures bacterial cells, endospores, and viruses as air passes through, removing them from the air

hepatitis inflammation of the liver

herd immunity a reduction in disease prevalence brought about when few individuals in a population are susceptible to an infectious agent

herpes keratitis eye infection caused by herpes simplex virus

herpes simplex virus type 2 (HSV-2) the type of herpesvirus most commonly associated with genital herpes

herpetic gingivostomatitis inflammation of the mouth and gums often caused by the HSV-1 virus

heterolactic fermentation process producing a mixture of lactic acid, ethanol and/or acetic acid, and CO₂ as fermentation products; the microbes that do this use pentose phosphate pathway glycolysis, which is why they generate multiple fermentation products

heterotroph organism that uses fixed organic carbon compounds as its carbon source

hexose monophosphate shunt see *pentose phosphate pathway*

Hfr cell *E. coli* cell in which an F plasmid has integrated into the host cell's chromosome

high G+C gram-positive bacteria bacteria that have more than 50% guanine and cytosine nucleotides in their DNA

high-energy phosphate bond bond between the negatively charged phosphate groups that holds a lot of potential energy

histamine proinflammatory molecule released by basophils and mast cells in response to stimulation by other cytokines and chemical mediators

histones DNA-binding proteins found in eukaryotes and archaea that aid in orderly packaging of chromosomal DNA

histoplasmosis fungal disease caused by the dimorphic fungus *Histoplasma capsulatum*

holoenzyme enzyme with a bound cofactor or coenzyme

holozoic refers to protozoans that consume food particles through phagocytosis

homolactic fermentation process producing only lactic acid as a fermentation product; the microbes that do this use Embden-Meyerhof-Parnas glycolysis

hookworm infection soil-transmitted intestinal infection caused by the nematodes *Necator americanus* and *Ancylostoma doudeale*

horizontal direct transmission movement of a pathogen from one host to another (excluding mother to embryo, fetus, or infant) in a population through physical contact or through droplet transmission

horizontal gene transfer introduction of genetic material from one organism to another organism within the same generation

host range the types of host cells that a particular virus is able to infect

HTST high-temperature short-time pasteurization is a method of pasteurization commonly used for milk in which the milk is exposed to a temperature of 72 °C for 15 seconds

human African trypanosomiasis serious infection caused by *Trypanosoma brucei* and spread by the bite of the tsetse fly

human granulocytic anaplasmosis zoonotic tickborne disease caused by the obligate intracellular pathogen *Anaplasma phagocytophilum*

human immunodeficiency virus (HIV) retrovirus responsible for acquired immune deficiency syndrome (AIDS) in humans

human papillomavirus (HPV) a group of common sexually transmitted viruses that may be associated with genital warts or with cervical cancer

humanized monoclonal antibodies chimeric antibodies with mouse variable regions and human constant regions

humoral immunity adaptive immunity mediated by antibodies produced by B cells

hyaluronidase enzyme produced by pathogens that degrades hyaluronic acid between adjacent cells in connective tissue

hybridization the joining of two complementary single-stranded DNA molecules

hybridoma clones of cell produced by fusing a normal B cell with a myeloma cell that is capable of producing monoclonal antibodies indefinitely

hydatid disease cystic echinococcosis, an infection caused by the tapeworm *Echinococcus granulosus*

hydrophilic “water loving”; refers to a polar molecule or portion of a molecule capable of strong attraction to water molecules

hydrophobic “water fearing”; refers to a nonpolar molecule or portion of a molecule not capable of strong attraction to water molecules

hypersensitivity pneumonitis (HP) type III and IV hypersensitivities in the lungs that are caused by environmental or occupational exposure to allergens such as mold and dust

hypersensitivity potentially damaging immune response against an antigen

hyperthermophile a microorganism that has an optimum growth temperature close to the temperature of boiling water

hypertonic medium an environment in which the solute concentration outside a cell exceeds that inside the cell, causing water molecules to move out of the cell, resulting in crenation (shriveling) or plasmolysis.

hyphae tubular, filamentous structures that makes up most fungi

hypodermis the layer of tissue under the dermis, consisting primarily of fibrous and adipose connective tissue

hypotonic medium an environment in which the solute concentration inside a cell exceeds that outside the cell, causing water molecules to move into the cell, possibly leading to swelling and possibly lysis

iatrogenic disease disease caused by or acquired during a medical procedure

icosahedral three-dimensional, 20-sided structure with 12 vertices

IgA antibody dimer primarily found in breast milk, mucus, saliva, and tears

IgD membrane-body antibody monomer functioning as receptor on the surface of B cells

IgE antibody monomer involved in defense against parasites and allergic reactions

IgG antibody monomer most abundant in serum; able to cross placenta; most versatile class of antibody in terms of function

IgM antibody that is a monomer when functioning as a receptor on surface of B cells but a pentamer when secreted in response to specific pathogens; first antibody to respond during primary and secondary responses

illuminator the light source on a microscope

image point (focus) a property of the lens and the distance of the object to the lens; the point at which an image is in focus (the image point is often called the focus)

imidazoles class of antifungal drugs that inhibit ergosterol biosynthesis

immune complex large group of antigens bound by antibodies; large enough to settle out of fluid suspension

immunochromatographic assay assay in which fluids are pulled through test strips by capillary action and antigen captured by mobile antibody-colored bead conjugates; a second, fixed antibody localizes the colored bead, allowing visualization

immunocytochemistry (ICC) staining technique in which cells are fixed and holes dissolved in the membrane to allow passage of labeled antibodies to bind specific intracellular targets

immunoelectrophoresis (IEP) assay following protein electrophoresis (PAGE) of serum, in which antisera against specific serum proteins are added to troughs cut parallel to the electrophoresis track, causing the formation of precipitin arcs

immunofiltration technique in which antibody or antigen can be concentrated by passing fluids through porous membranes, and target molecules are captured as they pass

immunofluorescence a technique that uses a fluorescence microscope and antibody-specific fluorochromes to determine the presence of specific pathogens in a specimen

immunoglobulin antibody

immunohistochemistry (IHC) staining technique in which labeled antibodies are bound to specific cells in a tissue section

immunology the study of the immune system

immunostain use of EIA technology to deliver stain to particular cells in a tissue (immunohistochemistry) or specific targets within a cell (immunocytochemistry)

impetigo a skin infection that may result in vesicles, blisters, or bullae especially around the mouth, commonly caused by *Staphylococcus aureus*, *S. pyogenes*, or a combination of both *S. aureus* and *S. pyogenes*

in vitro outside the organism in a test tube or artificial environment

in vivo inside the organism

inactivated vaccine vaccine composed of whole pathogen cells or viruses that have been killed or inactivated through treatment with heat, radiation, or chemicals

incidence the number of individuals with new infections of a particular disease in a given period of time

inclusion conjunctivitis inflammation of the conjunctiva in newborns caused by *Chlamydia trachomatis* transmitted during childbirth

inclusions prokaryotic cell cytoplasmic structures for storing specific nutrients and other resources needed by cells

incubation period the first stage of acute disease, during which the pathogen begins multiplying in the host and signs and symptoms are not observable

indirect agglutination assay assay that can be used to detect the agglutination of small latex beads; beads may be coated with antigen when looking for the presence of specific antibodies, or with antibody when looking for the presence of antigen

indirect antiglobulin test (IAT) see indirect Coombs' test

indirect contact transmission transfer of an infectious agent between hosts through contact with a fomite

indirect Coombs' test assay, performed *in vitro* prior to blood transfusions, that looks for antibodies against red blood cell antigens (other than the A and B antigens) that are unbound in a patient's serum

indirect ELISA EIA in which an antigen from a pathogen is first attached to the wells of a microtiter plate; the antigen then captures antibodies from patient serum to determine whether the patient currently has or previously had the disease

indirect fluorescent antibody test assay for antigen-specific antibodies wherein the antigen captures the antibody, which is subsequently detected using a labeled anti-immunoglobulin mAb

induced mutation mutation caused by a mutagen

inducer small molecule that either activates or represses transcription

inducible operon bacterial operon, typically containing genes encoding enzymes in a degradative pathway, whose expression is induced by the substrate to be degraded when the substrate is available for the cell to use, but that is otherwise repressed in the absence of the substrate

induction prophage DNA is excised from the bacterial genome

infection the successful colonization of a microorganism within a host

infectious arthritis (septic arthritis) inflammation of joint tissues in response to a microbial infection

infectious disease disease caused by a pathogen

infectious mononucleosis common and mild infection caused by Epstein-Barr virus (HBV-4) or cytomegalovirus (HBV-5); transmitted by direct contact with body fluids such as saliva

inflammation innate nonspecific immune response characterized by erythema, edema, heat, pain, and altered function, typically at the site of injury or infection but sometimes becoming systemic.

influenza highly contagious and acute viral disease of the respiratory tract caused by the influenza virus

initiation factors proteins that participate in ribosome assembly during initiation

initiation of DNA replication stage of replication during which various proteins bind to the origin of replication to begin the replication process

initiation of transcription stage of transcription during which RNA polymerase binds to a promoter and transcription begins

initiation of translation stage of translation during which an initiation complex composed of the small ribosomal subunit, the mRNA template, initiation factors, GTP, and a special initiator tRNA forms, and the large ribosomal subunit then binds to the initiation complex

inoculum small number of cells added to medium to start a culture

inorganic phosphate (P_i) single phosphate group in solution

insertion type of mutation involving the addition of one or more bases into a DNA sequence

integrase inhibitors antiviral drugs that block the activity of the HIV integrase responsible for recombination of a DNA copy of the viral genome into the host cell chromosome

intercalating agent molecule that slides between the stacked nitrogenous bases of the DNA double helix, potentially resulting in a frameshift mutation

interference distortion of a light wave due to interaction with another wave

interferons cytokines released by cells that have been infected with a virus; stimulate antiviral responses in nearby cells as well as the cells secreting the interferons

interleukins cytokines largely produced by immune system cells that help coordinate efforts against invading pathogens

intermediate filament one of a diverse group of cytoskeletal fibers that act as cables within the cell and anchor the nucleus, comprise the nuclear lamina, or contribute to the formation of desmosomes

intermediate host a host in which a parasite goes through some stages of its life cycle before migrating to the definitive host

intermittent common source spread a mode of disease transmission in which every infection originates from the same source and that source produces infections for a period before stopping and then starting again

intertrigo a rash that occurs in a skin fold

intestinal fluke a trematode worm that infects the intestine, often caused by *Fasciolopsis buski*

intracellular targeting toxin see *A-B exotoxin*

intrinsic growth rate genetically determined generation time under specific conditions for a bacterial strain

intron intervening sequence of a eukaryotic gene that does not code for protein and whose corresponding RNA sequences are removed from the primary transcript during splicing

intubation placement of a tube into the trachea, generally to open the airway or to administer drugs or oxygen

in-use test a technique for monitoring the correct use of disinfectants in a clinical setting; involves placing used, diluted disinfectant onto an agar plate to see if microbial colonies will grow

invasion dissemination of a pathogen through local tissues or throughout the body

iodophor compound in which iodine is complexed to an organic molecule, increasing the stability and efficacy of iodine as a disinfectant

ionizing radiation high-energy form of radiation that is able to penetrate surfaces and sterilize materials by damaging microbial cell components and DNA

ischemia condition marked by the inadequate flow of blood to the tissues

isograft tissue grafted from one monozygotic twin to another

isoheamagglutinins IgM class antibodies produced against A or B red blood cell antigens

isomers molecules that have the same atomic makeup but differ in the structural arrangement of the atoms

isoniazid antimetabolite that inhibits biosynthesis of mycolic acid; used for the treatment of mycobacterial infections

isoprenoid branched lipid derived from five-carbon isoprene molecules

isotonic medium a solution in which the solute concentrations inside and outside the cell are approximately equal, thereby creating no net movement of water molecules across the cell membrane

ivermectin antihelminthic drug of the avermectin class that binds to invertebrate glutamate-gated chloride channels to block neuronal transmission in helminths

J

Japanese encephalitis arboviral disease caused by the Japanese encephalitis virus (JEV) and endemic to Asia

jaundice yellowish color of the skin and mucous membranes caused by excessive bilirubin caused by a failure of the liver to effectively process the breakdown of hemoglobin

K

keratin a fibrous protein found in hair, nails, and skin

keratitis inflammation of the cornea

keratoconjunctivitis inflammation of both the cornea and the conjunctiva

kidney organ that filters the blood, producing urine

Kinyoun technique a method of acid-fast staining that does not use heat to infuse the primary stain, carbolfuchsin, into acid-fast cells

Kirby-Bauer disk diffusion test simple, rapid method for determining susceptibility and resistance of a bacterial pathogen to antibacterial drugs. The test involves drug-impregnated disks placed on an agar plate inoculated with a bacterial lawn.

Koplik's spots white spots that form on the inner lining of the cheek of patients with measles

Krebs cycle cyclic pathway during which each two-carbon unit entering the cycle is further oxidized, producing three NADH, one FADH₂, and one ATP by substrate-level phosphorylation, releasing two CO₂ molecules and regenerating the molecule used in the first step; also called the *citric acid cycle* or the *tricarboxylic acid cycle*

kuru rare form of transmissible spongiform encephalopathy endemic to Papua New Guinea

L

lacrimal duct connects the lacrimal gland to the lacrimal sac

lacrimal gland a gland situated above the eye that secretes tears

lacrimal punctum opening in each upper and lower eyelid

lacrimal sac a to a reservoir for tears; also known as the dacryocyst or tear sac

lag period the time between antigen exposure and production of antibodies

lag phase interval before exponential growth of a microbial population during which cells adjust to a new environment

lagging strand strand of DNA made discontinuously by DNA polymerase

laryngitis inflammation of the larynx

laryngopharynx lower portion of the pharynx that connects to the larynx

larynx region of the respiratory tract containing the vocal cords; also referred to as the voice box

latent disease disease that goes into a dormant nonreplicative state after the acute disease and can persist in this state for years, with the risk of reactivation back into acute disease

latent virus virus that remains dormant in the host genome

lateral flow test see immunochromatographic assays

leading strand strand of DNA made continuously in the 5' to 3' direction by DNA polymerase

Legionnaires disease atypical pneumonia occurring in older individuals; caused by the inhalation of *Legionella pneumophila* aerosolized in water

leishmaniasis protozoan infection caused by *Leishmania* spp. and transmitted by sand flies

leprosy see *Hansen's disease*

leptospirosis bacterial infection of the kidney caused by *Leptospira* spp.; may spread to the liver, lungs, brain, and other organs

leukocidin class of exotoxin that targets and lyses leukocytes

leukocytes white blood cells of various types, including granulocytes, lymphocytes, and monocytes

leukotrienes lipid-based chemical mediators produced by leukocytes and other tissue cells; promote inflammation and allergic responses

lichen symbiotic association of a fungus with an algae or cyanobacterium

ligation repair of the sugar-phosphate backbone of the DNA, making the DNA molecule continuous

light chains the shorter identical peptide chains of an antibody molecule (two per antibody monomer), composed of variable and constant region segments

light-dependent reaction process by which energy from sunlight is absorbed by pigment molecules in photosynthetic membranes and converted into stored chemical energy in the forms of ATP and NADPH

light-harvesting complex group of multiple proteins and associated pigments that each may absorb light energy to become excited, and transfer this energy from one pigment molecule to another until the energy is delivered to a reaction center pigment

light-independent reaction process by which chemical energy, in the form of ATP and NADPH produced by the light-dependent reactions, is used to fix inorganic CO₂ into organic sugar; usually referred to as the Calvin-Benson cycle

lincomycin naturally produced protein synthesis inhibitor of the lincosamide class that binds to the 50S subunit, inhibiting peptide bond formation

lincosamides class of protein synthesis inhibitors that are similar to macrolides

linked recognition a mechanism whereby a B cell and the helper T cell with which it interacts recognize the same antigen

lipase extracellular enzyme that degrades triglycerides

lipid bilayer biological membranes composed of two layers of phospholipid molecules with the nonpolar tails associating to form a hydrophobic barrier between the polar heads; also called unit membrane

lipid macromolecule composed primarily of carbon and hydrogen; source of nutrients for organisms, a storage form for carbon and energy, a part of the structure of membranes, and may function as hormones, pharmaceuticals, fragrances, and pigments

lipopolysaccharide (LPS) lipid molecules with attached sugars that are found as components of gram-negative outer membranes

lipoprotein conjugated protein attached to a lipid

listeriosis bacterial disease caused from the ingestion of the microbe *Listeria monocytogenes*

lithotroph chemotroph that uses inorganic chemicals as its electron source; also known as chemoautotroph

live attenuated vaccine vaccine with live pathogen that has been attenuated to become less virulent in order to produce an active but subclinical infection

liver fluke a trematode worm that affects the bile duct of the liver, including *Fasciola hepatica* and *F. gigantica*

local infection infection in one limited area

log phase interval of growth when cells divide exponentially; also known as the exponential growth phase

loiasis a disease caused by the parasitic *Loa loa* worm, which is transmitted by deerflies; adult worms live in the subcutaneous tissue and cause inflammation, swelling, and eye pain as they migrate through the skin and the conjunctiva of the eye

lophotrichous having a single tuft of flagella located at one end of a bacterial cell

low G+C gram-positive bacteria bacteria that have less than 50% of guanine and cytosine nucleotides in their DNA

lumen space inside the cisternae of the endoplasmic reticulum in eukaryotic cells

Lyme disease tickborne disease caused by the spirochete *Borrelia burgdorferi*

lymph nodes bean-shaped organs situated throughout the body that contain areas called germinal centers, which are rich in B and T lymphocytes; also contain macrophages and dendritic cells for antigen presentation

lymphadenitis inflammation of the lymph nodes

lymphangitis inflammation of the lymphatic vessels

lymphogranuloma venereum infection caused by *Chlamydia trachomatis* in tropical regions

lyophilization rapid freezing, followed by placement under a vacuum, of a material so that water is lost by sublimation, thereby inhibiting microbial growth

lysis destruction of the host cell

lysogen bacterium carrying the prophage

lysogenic conversion (phage conversion) alteration of host characteristics or phenotypes due to the presence of phage

lysogenic cycle life cycle of some phages in which the genome of the infecting phage is integrated into the bacterial chromosome and replicated during bacterial reproduction until it excises and enters a lytic phase of the life cycle

lysogeny process of integrating the phage into the host genome

lysosome an organelle of the endomembrane system that contains digestive enzymes that break down engulfed material such as foodstuffs, infectious particles, or damaged cellular components

lytic cycle infection process that leads to the lysis of host cells

M

M protein a streptococcal cell wall protein that protects the bacteria from being phagocytized. It is associated with virulence and stimulates a strong immune response

macrolides class of protein synthesis inhibitors containing a large, complex ring structure that binds to the 50S subunit, inhibiting peptide bond formation

macromolecule polymer assembled from of individual units, monomers, that bind together like building blocks

macronucleus larger nucleus in ciliate protists that have two nuclei; polyploid with a reduced genome of metabolic genes and derived from the micronucleus

macronutrient element required in abundance in cells; account for approximately 99% of the cell's dry weight

macrophages monocytes that have left the bloodstream and differentiated into tissue-specific phagocytes

mad cow disease form of transmissible spongiform encephalopathy primarily affecting cattle; can be transmitted to humans by consumption of contaminated cattle products

magnetosomes inclusions in certain bacterial cells containing magnetic iron oxide or iron sulfide, which allows bacteria to align along a magnetic field by magnetotaxis

magnetotaxis directional movement of bacterial cells using flagella in response to a magnetic field

magnification the power of a microscope (or lens) to produce an image that appears larger than the actual specimen, expressed as a factor of the actual size

major histocompatibility complex (MHC) collection of genes that code for MHC glycoproteins expressed on the surface of all nucleated cells

malaise a general feeling of being unwell

malaria potentially fatal, mosquito-borne protozoan infection caused by several species of *Plasmodium* and characterized by a relapsing fever, nausea, vomiting, and fatigue

mast cells granulocytes similar in origin and function to basophils, but residing in tissues

matrix assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF) technique in which the sample (e.g., a microbe colony) is mixed with a special matrix and irradiated with a high-energy laser to generate characteristic gaseous ions that are subjected to mass spectral analysis, yielding mass spectra that may be compared to reference data for identification purposes

maturation assembly of viral components to produce a functional virus

mature naïve T cell a T cell that has exited the thymus after thymic selection but has not yet been activated

maximum growth pH highest pH value that an organism can tolerate for growth

maximum growth temperature highest temperature at which a microorganism will divide or survive

maximum permissible oxygen concentration highest concentration of oxygen at which an organism will grow

measles highly contagious respiratory disease caused by the measles virus (MeV); marked by an intense macular rash and high fever; also known as rubeola

mebendazole antihelminthic drug of the benzimidazole class that binds to helminthic β -tubulin, preventing microtubule formation

mechanical transmission transfer of a pathogen between hosts by a mechanical vector

mechanical vector an animal that transfers a pathogen from one host to another or from a reservoir to a host without being infected by the pathogen itself

median infectious dose (ID₅₀) concentration of pathogen that will produce active infection in 50% of test animals inoculated

median lethal dose (LD₅₀) concentration of pathogen that kills 50% of infected test animals

medulla loosely packed layer of fungal filaments located underneath the cortex of a lichen

membrane attack complex (MAC) ring structure formed from complement proteins C6 through C9 that penetrates the membranes of a targeted cell, causing cell lysis and death

membrane filtration method to remove bacteria from liquid, typically heat-sensitive solutions, using filters with an effective pore size of 0.2 μm or smaller, depending on need

membrane filtration technique known volumes are vacuum filtered aseptically through a membrane with a pore size small enough to trap microorganisms, which are counted after growth on plates

membrane-bound ribosome 80S eukaryotic ribosome attached to rough endoplasmic reticulum

membrane-disrupting toxin toxin that affects cell membrane function by either forming pores or disrupting the phospholipid bilayer

memory B cell an activated and differentiated B cell that is programmed to respond to secondary exposures to a specific antigen

memory helper T cell a long-lived T cell programmed to recognize and quickly mount a secondary response to a specific pathogen upon re-exposure

memory the ability of the specific adaptive immune system to quickly respond to pathogens to which it has previously been exposed

meninges membranes that surround the brain

meningitis inflammation of the meningeal membranes that surround the brain

meningococcal meningitis bacterial infection caused by *Neisseria meningitidis* that results in an inflammation of the meninges

meningoencephalitis inflammatory response that involves both the brain and the membranes that surround it

MERS Middle East respiratory syndrome; first described in Saudi Arabia in 2013; caused by a zoonotic coronavirus that results in flu-like symptoms

mesophile a microorganism that grows best at moderate temperatures, typically between about 20 °C and 45 °C

metabolism all of the chemical reactions inside of cells

metachromatic granule a type of inclusion containing volutin, a polymerized inorganic phosphate that appears red when stained with methylene blue

metagenomics the sequencing of genomic fragments from microbial communities, allowing researchers to study genes from a collection of multiple species

metatranscriptomics the science of studying a collection of mRNA molecules produced from microbial communities; involves studying gene expression patterns from a collection of multiple species

methanogen microorganism that produces gaseous methane

methicillin-resistant *Staphylococcus aureus* (MRSA) pathogen resistant to all β -lactams through acquisition of a new low-affinity penicillin-binding protein, and often resistant to many other drug classes

metronidazole antibacterial and antiprotozoan drug of the nitroimidazole class that is activated in anaerobic target cell and introduces DNA strand breakage, thus interfering with DNA replication in target cells

MHC I molecule glycoprotein expressed on the surface of all nucleated cells and involved in the presentation of normal “self” antigens and foreign antigens from intracellular pathogens

MHC II molecule glycoprotein expressed only on the surface of antigen-presenting cells and involved in the presentation of foreign antigens from pathogens ingested by phagocytosis

micelle simple spherical arrangement of amphipathic lipid molecules with nonpolar tails aggregated within the interior and polar heads forming the outer surface

microaerophile organism that requires oxygen at levels lower than atmospheric concentration

microarray analysis a technique used to compare two samples of genomic DNA or cDNA; the DNA or cDNA fragments are immobilized on a chip and labeled with different fluorescent dyes, allowing for comparison of sequences or gene-expression patterns

microbe generally, an organism that is too small to be seen without a microscope; also known as a microorganism

microbial death curve graphical representation of the progress of a particular microbial control protocol

microbial ecology study of the interactions between microbial populations microbiology the study of microorganisms

microbiome all prokaryotic and eukaryotic microorganisms that are associated with a certain organism

microfilament cytoskeletal fiber composed of actin filaments

microinjection the direct injection of DNA into the cytoplasm of a eukaryotic cell using a glass micropipette

micronucleus smaller nucleus in ciliate protists that have two nuclei; diploid, somatic, and used for sexual reproduction through conjugation

micronutrient indispensable element present in cells in lower amounts than macronutrients; also called *trace element*

microorganism generally, an organism that is too small to be seen without a microscope; also known as a microbe

microsporidia fungi that lack mitochondria, centrioles, and peroxisomes; some can be human pathogens

microtiter plates plastic dishes with multiple small wells

microtubule hollow tube composed of tubulin dimers (α and β tubulin); the structural component of the cytoskeleton, centrioles, flagella, and cilia

miliary tuberculosis hematogenous dissemination and spread of *Mycobacterium tuberculosis* from tubercles

minimal bactericidal concentration (MBC) lowest antibacterial drug concentration that kills $\geq 99.9\%$ of a starting inoculum of bacteria

minimal inhibitory concentration (MIC) lowest concentration of an antibacterial drug that inhibits visible growth of a bacterial strain

minimum growth pH lowest pH value that an organism can tolerate for growth

minimum growth temperature lowest temperature at which a microorganism will divide or survive

minimum permissible oxygen concentration lowest concentration of oxygen at which an organism will grow

missense mutation point mutation that results in a different amino acid being incorporated into the resulting polypeptide

mitochondrial matrix the innermost space of the mitochondrion enclosed by two membranes; the location of many metabolic enzymes as well as the mitochondrial DNA and 70S ribosomes

mitochondrion (plural: mitochondria) large, complex organelle that is the site of cellular respiration in eukaryotic cells

mode of action way in which a drug affects a microbe at the cellular level

moist-heat sterilization protocol that involves steam under pressure in an autoclave, allowing the steam to reach temperatures higher than the boiling point of water

mold a multicellular fungus, typically made up of long filaments

molecular cloning the purposeful fragmentation of DNA followed by attachment to another piece of DNA to produce a recombinant molecule, followed by introduction of this recombinant molecule into an easily manipulated host to allow for the creation of multiple copies of a gene of interest

monoclonal antibodies (mAbs) antibodies produced *in vitro* that only bind to a single epitope

monocular having a single eyepiece

monocytes large, agranular, mononuclear leukocytes found in the peripheral blood; responsible for phagocytosis of pathogens and damaged cells

monoecious refers to sexually reproducing organisms in which individuals have both male and female reproductive organs

monomer small organic molecule that binds with like molecules, forming a polymer or macromolecule

monosaccharide monomer for the synthesis of carbohydrate polymers; the simplest carbohydrate, called a *simple sugar*

monotrichous having one flagellum, typically located on one end of the bacterial cell

morbidity a state of illness

Morbidity and Mortality Weekly Report (MMWR) the trade/industry publication for epidemiologists, reporting US public health data compiled by the CDC

morbidity rate the number of cases of a disease expressed as a percentage of the population or number per standard part of the population, such as 100,000

mordant a chemical added to a specimen that sets a stain

mortality death

mortality rate the number of deaths from a disease expressed as a percentage of the population or number per standard part of the population, such as 100,000

most probable number (MPN) statistical value representing the viable bacterial population in a sample obtained after a series of dilutions and multiple tube inoculations

mRNA short-lived type of RNA that serves as the intermediary between DNA and the synthesis of protein products

mucociliary escalator system by which mucus and debris are propelled up and out of the respiratory tract by the beating of respiratory cilia and the mechanical actions of coughing or swallowing

mucormycosis rare form of pneumonia that can be caused by an invasive infection of different fungi in the order Mucorales, such as *Rhizopus* or *Mucor*

mucous membrane moist layer of epithelial cells and interspersed goblet cells that lines the inner surfaces of the body, usually bathed in antimicrobial secretions from the cells of the membrane

mucus viscous secretion produced by cells and glands in various mucous membranes throughout the body; helps trap and remove microbes and debris from the body

multidrug-resistant microbes (MDR) group of pathogens that carry one or more resistance mechanisms, making them resistant to multiple antimicrobials; also called superbugs

multidrug-resistant *Mycobacterium tuberculosis* (MDR-TB) strains of *M. tuberculosis* that are resistant to both rifampin and isoniazid, the drug combination typically prescribed for the treatment of tuberculosis

multiple sclerosis autoimmune attack on the myelin sheaths and nerve cells in the central nervous system

mumps a viral illness that causes swelling of the parotid glands; rare in the United States because of effective vaccination

murine typhus fleaborne infection caused by *Rickettsia typhi* and characterized by fever, rash, and pneumonia

mutagen type of chemical agent or radiation that can induce mutations

mutant organism harboring a mutation that often has a recognizable change in phenotype compared to the wild type

mutation heritable change in the DNA sequence of an organism

mutualism type of symbiosis in which two populations benefit from, and depend on, each other

myasthenia gravis autoimmune disease affecting the acetylcholine receptors in the neuromuscular junction, resulting in weakened muscle contraction capability

mycelium vegetative network of branched, tubular hyphae

mycolic acids waxy molecules associated with peptidoglycan in some gram-positive, acid-fast bacteria, chiefly mycobacteria

mycology the study of fungi

Mycoplasma pneumoniae also known as walking pneumonia; a milder form of atypical pneumonia caused by *Mycoplasma pneumoniae*

mycoses (mycosis, sing.) refers to diseases caused by fungi

mycotoxin biologically active product of pathogenic fungi that causes adverse changes in the host cells

myelin sheath insulating layer that surrounds the axon of some neurons and helps to promote signal propagation

myocarditis inflammation of the heart muscle tissues

N

naïve mature B cell a B cell that has not yet been activated

naked virus virus composed of a nucleic acid core, either DNA or RNA, surrounded by a capsid

nalidixic acid member of the quinolone family that functions by inhibiting the activity of DNA gyrase, blocking DNA replication

narrow-spectrum antimicrobial drug that targets only a specific subset of microbes

nasal cavity air-filled space in the skull immediately behind the nose

nasolacrimal duct tear duct connecting the lacrimal glands to the nasal cavity

nasolacrimal duct tear fluid flows from each eye through this duct to the inner nose

nasopharynx part of the upper throat (pharynx) extending from the posterior nasal cavity; carries air inhaled through the nose

native structure three-dimensional structure of folded fully functional proteins

natural active immunity immunity that develops as a result of natural infection with a pathogen

natural antibiotic antimicrobial compound that is produced naturally by microorganisms in nature

natural killer cells (NK cells) lymphoid cells that recognize and destroy abnormal target cells by inducing apoptosis

natural passive immunity transfer of maternal antibodies from mother to fetus (transplacentally) or infant (via breastmilk)

necrotizing fasciitis a serious infection, also known as flesh-eating disease, that leads to rapid destruction of tissue through the action of exotoxin A; it can be caused by *S. pyogenes* or several other bacterial species

negative (–) single-strand RNA (–ssRNA) a viral RNA strand that cannot be translated until it is replicated into positive single-strand RNA by viral RNA-dependent RNA polymerase

negative stain a stain that produces color around the structure of interest while not coloring the structure itself

Nematoda phylum comprising roundworms

neonatal herpes herpes infection of the newborn, generally caused by infection during birth

neonatal meningitis meningitis caused by Group B streptococcus and occurring primarily in neonates (less than 2 months old)

neonatal tetanus tetanus acquired through infection of the cut umbilical cord

neurocysticercosis parasitic invasion of brain tissues by the larvae of the pork tapeworm, *Taenia solium*

neuromycosis any fungal infection of the nervous system

neuron specialized cell found throughout the nervous system that transmits signals through the nervous system using electrochemical processes

neuropathy numbness or tingling sensation caused by damage to peripheral nerves

neurotoxoplasmosis disease caused by the invasion of brain tissues by the protozoan *Toxoplasma gondii*; typically only affects immunocompromised patients

neurotransmitter compound that is released at the synapse of neurons to stimulate or suppress the actions of other cells

neutralism type of symbiosis that does not affect either of the two populations

neutralization binding of an antibody to a pathogen or toxin, preventing attachment to target cells

neutrophile organism that grows best at a near a neutral pH of 6.5–7.5

neutrophils leukocytes with a multilobed nucleus found in large numbers in peripheral blood; able to leave the bloodstream to phagocytose pathogens in infected tissues; also called polymorphonuclear neutrophils (PMNs)

next generation sequencing a group of automated techniques used for rapid DNA sequencing

nicotine adenine dinucleotide (NAD⁺/NADH) oxidized/reduced forms of an electron carrier in cells

nicotine adenine dinucleotide phosphate (NADP⁺/NADPH) oxidized/reduced forms of an electron carrier in cells

nitrogen fixation bacterial biochemical pathways that incorporate inorganic nitrogen gas into organic forms more easily used by other organisms

nitrogenous base nitrogen-containing ring structure within a nucleotide that is responsible for complementary base pairing between nucleic acid strands

noncoding DNA regions of an organism's genome that, unlike genes, do not encode proteins

noncommunicable disease disease that is not transmitted from one person to another

noncompetitive (allosteric) inhibitor molecule that binds to allosteric sites, inducing a conformational change in the enzyme's structure that prevents it from functioning

noncritical item object that may contact intact skin but does not penetrate it; requires cleanliness but not a high level of disinfection

noncyclic photophosphorylation pathway used in photosynthetic organisms when both ATP and NADPH are required by the cell

nonenveloped virus naked virus

nongonococcal urethritis (NGU) a nonspecific infection of the urethra that is not caused by *Neisseria gonorrhoeae*

noninfectious disease disease caused by something other than an infectious agent (e.g., genetics, environment, nutritional deficiencies)

nonionizing radiation low-energy radiation, like ultraviolet light, that can induce dimer formation between two adjacent pyrimidine bases, resulting in DNA polymerase stalling and possible formation of a frameshift mutation

nonsense mutation point mutation that converts a codon encoding an amino acid (a sense codon) into a stop codon (a nonsense codon)

nontreponemal serologic tests qualitative and quantitative indirect diagnostic tests for syphilis

northern blot a technique in molecular genetics used to detect the amount of RNA made by gene expression within a tissue or organism sample; RNA fragments within a sample are separated by agarose gel electrophoresis, immobilized on a membrane, and then exposed to a specific DNA probe labeled with a radioactive or fluorescent molecular beacon to aid in detection

nosocomial disease disease acquired in a hospital setting

notifiable disease a disease for which all cases must legally be reported to regional, state, and/or federal public health agencies

nuclear envelope (also called the nuclear membrane) a structure defining the boundary of the nucleus; composed of two distinct lipid bilayers that are contiguous with each other and with the endoplasmic reticulum

nuclear lamina a meshwork of intermediate filaments (mainly lamins) found just inside the nuclear envelope; provides structural support to the nucleus

nucleic acid class of macromolecules composed of nucleotide monomers polymerized into strands

nucleoid concentrated area of DNA genome and associated proteins found in a prokaryotic cell that is not surrounded by a membrane

nucleoid-associated protein (NAP) protein that assists in the organization and packaging of the chromosome in prokaryotic cells

nucleolus a dense region within the nucleus where ribosomal RNA biosynthesis occurs and preribosomal complexes are made

nucleoside analog chemical that is structurally similar to a normal nucleotide base that can be incorporated into DNA instead of normal bases during replication but that has different base pairing rules than the normal base for which it was substituted, inducing mutation

nucleotide excision repair (dark repair) enzymatic mechanism to repair pyrimidine dimers by cutting the dimer-containing DNA strand on both sides of dimer, removing the intervening strand and replacing the bases with the correct ones

nucleotide nucleic acid monomer composed of a pentose sugar, a phosphate group, and a nitrogenous base

nucleus a membrane-bound structure of eukaryotic cells that houses the DNA genome

numerical aperture a measure of a lens's ability to gather light

O

objective lenses on a light microscope, the lenses closest to the specimen, typically located at the ends of turrets

obligate aerobe organism that requires oxygen for growth

obligate anaerobe organism that dies in the presence of oxygen

obligate intracellular pathogen microorganism that cannot synthesize its own ATP and, therefore, must rely on a host cell for energy; behaves like a parasite when inside a host cell, but is metabolically inactive outside of a host cell

observational study a type of scientific study that involves measurement of study subjects on variables hypothesized to be associated with the outcome of interest, but without any manipulation of the subjects

ocular lens on a microscope, the lens closest to the eye (also called an eyepiece)

oil immersion lens a special objective lens on a microscope designed to be used with immersion oil to improve resolution

Okazaki fragment short fragment of DNA made during lagging strand synthesis

oligopeptide peptide having up to approximately 20 amino acids

oligotroph organism capable of living in low-nutrient environments

opacity the property of absorbing or blocking light

operator DNA sequence located between the promoter region and the first coding gene to which a repressor protein can bind

operon a group of genes with related functions often found clustered together within the prokaryotic chromosome and transcribed under the control of a single promoter and operator repression sequence

ophthalmia neonatorum inflammation of the conjunctiva in newborns caused by *Neisseria gonorrhoeae* transmitted during childbirth

opisthotonos characteristic symptom of tetanus that results in uncontrolled muscular spasms and backward arching of the neck and spine

opportunistic pathogen microorganism that can cause disease in individuals with compromised host defenses

opsonin any molecule that binds to and coats the outside of a pathogen, identifying it for destruction by phagocytes (examples include antibodies and the complement proteins C3b and C4b)

opsonization process of coating a pathogen with a chemical substance (an opsonin) that allows phagocytic cells to recognize, engulf, and destroy the pathogen more easily

optimum growth pH the pH at which an organism grows best

optimum growth temperature the temperature at which a microorganism's growth rate is highest

optimum oxygen concentration the ideal concentration of oxygen for a particular microorganism

oral herpes an infection caused by herpes simplex virus that results in cold sores, most commonly on and around the lips

oral thrush *Candida* infection of the mouth

orchitis inflammation of one or both of the testes

organic molecule composed primarily of carbon; typically contains at least one carbon atom bound to one or more hydrogen atoms

organotroph chemotroph that uses organic molecules as its electron source; also known as chemoheterotroph

origin of replication specific nucleotide sequence where replication begins

oropharynx area where air entering mouth enters the pharynx

osmosis diffusion of water across a semipermeable membrane

osmotic pressure the force or pressure generated by water diffusing across a semipermeable membrane, driven by differences in solute concentration across the membrane

osteomyelitis inflammation of bone tissue

otitis externa an infection of the external ear canal, most commonly caused by *Pseudomonas aeruginosa*; often called swimmer's ear

otitis inflammation of the ear

otitis media with effusion accumulation of fluid inside the middle ear with or without infection

Ouchterlony assay test in which antigen and antisera are added to neighboring wells in an agar gel, allowing visualization of precipitin arcs

outer membrane a phospholipid bilayer external to the peptidoglycan layer found in gram-negative cell walls

oxazolidinones class of synthetic protein synthesis inhibitors that interfere with formation of the initiation complex for translation and prevent translocation of the growing protein from the ribosomal A site to the P site

oxidation reaction chemical reaction that removes electrons (often as part of H atoms) from donor molecules, leaving them oxidized

oxidative phosphorylation mechanism for making ATP that uses the potential energy stored within an electrochemical gradient to add P_i to ADP

oxygenic photosynthesis type of photosynthesis found in plants, algae, and cyanobacteria, and in which H₂O is used as the electron donor to replace an electron lost by a reaction center pigment, resulting in oxygen as a byproduct

P

P (peptidyl) site functional site of an intact ribosome that binds charged tRNAs carrying amino acids that have formed peptide bonds with the growing polypeptide chain but have not yet dissociated from their corresponding tRNA

palatine tonsil lymphoid tissue located near the oropharynx

pandemic disease an epidemic that is worldwide as opposed to regional

papilloma growth on the skin associated with infection by any of the human papilloma viruses (HPV); commonly known as a wart

paracrine function refers to a cytokine signal released from a cell to a receptor on a nearby cell

parasitism type of symbiosis in which one population benefits while harming the other parasitology the study of parasites

parenteral route means of entry by a pathogen through skin or mucous membranes when these barriers are breached

paroxysmal stage most serious stage of pertussis (whooping cough), characterized by severe and prolonged coughing spells

passive carrier an individual capable of transmitting a pathogen to another individual without becoming infected

passive immunity adaptive immune defenses received from another individual or animal

pasteurization form of microbial control using heat that is applied to foods; kills pathogens and reduces the number of spoilage-causing microbes while maintaining food quality

pathogen a disease-causing microorganism

pathogen-associated molecular patterns (PAMPs) common molecular motifs found on pathogens

pathogenicity ability of a microbial agent to cause disease

pattern recognition receptors (PRRs) receptors on the surface or in the interior of phagocytic cells that bind to pathogen-associated molecular patterns (PAMPs)

pellicle structure that underlies the plasma membrane in protists, providing additional support

pelvic inflammatory disease (PID) infection of the female reproductive organs that may spread from the vagina to the cervix, uterus, fallopian tubes, and ovaries

penetration entry of phage or virus into a host cell through injection, endocytosis, or membrane fusion

penicillin β-lactam antibacterial that was the first cell wall synthesis inhibitor developed

penis external genital organ in males through which urine and semen are discharged

pentamidine antiprotozoan drug that appears to degrade kDNA in target cells, as well as inhibit protein synthesis

pentose phosphate pathway (PPP) alternative glycolytic pathway that produces intermediates used for the biosynthesis of nucleotides and amino acids; also called the *phosphogluconate pathway* or the *hexose monophosphate shunt*

peptic ulcer an ulcer in the lining of the stomach or duodenum, often associated with *Helicobacter pylori*

peptide bond bond between the carboxyl group of one amino acid and the amine group of another; formed with the loss of a water molecule

peptidoglycan (murein) the polymer of alternating N-acetylmuramic acid NAM and N-acetylglucosamine (NAG) subunits linked together by peptide chains; a major constituent of bacterial cell walls

peptidyl transferase RNA-based ribozyme that is part of the 50S ribosomal subunit and catalyzes formation of the peptide bond between the amino acid bound to a tRNA and the growing polypeptide chain

perforin compound released from a natural killer cell that creates pores in the target cell through which other toxins (particularly granzymes) can gain access to the cytoplasm

pericarditis inflammation of the sac that surrounds the heart

period of convalescence fifth stage of acute disease, during which the patient returns to normal function

period of decline fourth stage of disease, during which the number of pathogens present in the host decreases, along with signs and symptoms of disease

period of illness third stage of acute disease, during which the number of pathogens present in the host is greatest and the signs and symptoms of disease are most severe

periodontal disease a condition in which the gums are inflamed and may erode

periodontitis inflammation of the gums that is more severe than gingivitis, spreading deeper into the tissues

peripheral nervous system network of neurons that connects the CNS with organs, sensory organs, and muscles throughout the body

peripheral tolerance mechanism by which regulatory T cells inhibit self-reactive immune responses in T cells that have already exited the thymus

periplasmic space the space between the cell wall and the plasma membrane, primarily in gram-negative bacteria

peristalsis muscular contractions of the gastrointestinal tract that propel ingested material through the stomach, intestines, and, eventually, through the rectum and out of the body

peritrichous having numerous flagella covering the entire surface of a bacterial cell

peroxidase enzyme that catalyzes the detoxification of peroxides

peroxisome in eukaryotic cells, a membrane-bound organelle (not part of the endomembrane system) that produces hydrogen peroxide to break down various types of molecules; also plays a role in lipid biosynthesis

peroxygen type of strong oxidizing agent that causes free radical formation in cells; can be used as a disinfectant or antiseptic

persister dormant cell that survives in the death phase and is resistant to most antibiotics

pertussis contagious illness caused by *Bordetella pertussis* that causes severe coughing fits followed by a whooping sound during inhalation; commonly known as whooping cough

pertussis toxin main virulence factor accounting for the symptoms of whooping cough

petechiae small red or purple spots on the skin that result from blood leaking out of damaged vessels

Petroff-Hausser counting chamber calibrated slide that allows counting of bacteria in a specific volume under a microscope

Peyer's patches lymphoid tissue in the ileum that monitors and fights infections

phagemid a plasmid capable of being replicated as a plasmid and also incorporated into a phage head

phagocytosis a type of endocytosis in which large particles are engulfed by membrane invagination, after which the particles are enclosed in a pocket, which is pinched off from the membrane to form a vacuole

phagolysosome compartment in a phagocytic cell that results when the phagosome is fused with the lysosome, leading to the destruction of the pathogens inside

phagosome compartment in the cytoplasm of a phagocytic cell that contains the phagocytosed pathogen enclosed by part of the cell membrane

pharmacogenomics (toxicogenomics) the evaluation of the effectiveness and safety of drugs on the basis of information from an individual's genomic sequence as well as examination of changes in gene expression in response to the drug

pharyngitis inflammation of the pharynx

pharynx region connecting the nose and mouth to the larynx; the throat

phase-contrast microscope a light microscope that uses an annular stop and annular plate to increase contrast

phenol coefficient measure of the effectiveness of a chemical agent through comparison with that of phenol on *Staphylococcus aureus* and *Salmonella enterica* serovar Typhi

phenolics class of chemical disinfectants and antiseptics characterized by a phenol group that denatures proteins and disrupts membranes

phenotype observable characteristics of a cell or organism

phosphodiester bonds linkage whereby the phosphate group attached to the 5' carbon of the sugar of one nucleotide bonds to the hydroxyl group of the 3' carbon of the sugar of the next nucleotide

phosphogluconate pathway see *pentose phosphate pathway*

phospholipase enzyme that degrades phospholipids

phospholipid complex lipid that contains a phosphate group

phospholipid-derived fatty acids (PLFA) analysis technique in which membrane phospholipids are saponified to release the fatty acids of the phospholipids, which can be subjected to FAME analysis for identification purposes

phosphorescence the ability of certain materials to absorb energy and then release that energy as light after a delay

photosynthesis process whereby phototrophic organisms convert solar energy into chemical energy that can then be used to build carbohydrates

photosynthetic pigment pigment molecule used by a cell to absorb solar energy; each one appears the color of light that it transmits or reflects

photosystem organized unit of pigments found within a photosynthetic membrane, containing both a light-harvesting complex and a reaction center

phototaxis directional movement using flagella in response to light

phototroph organism that gets its energy from light

phototrophic bacteria nontaxonomic group of bacteria that use sunlight as their primary source of energy

phylogeny the evolutionary history of a group of organisms

phytoplankton photosynthetic plankton

pia mater fragile and innermost membrane layer surrounding the brain

pili long protein extensions on the surface of some bacterial cells; specialized F or sex pilus aids in DNA transfer between cells

pinocytosis a type of endocytosis in which small dissolved materials are endocytosed into smaller vesicles

plague infectious epidemic disease caused by *Yersinia pestis*

plankton microscopic organisms that float in the water and are carried by currents; they may be autotrophic (phytoplankton) or heterotrophic (zooplankton)

planktonic free-floating or drifting in suspension

plantibodies monoclonal antibodies produced in plants that are genetically engineered to express mouse or human antibodies

plaque clear area on bacterial lawn caused by viral lysis of host cells

plasma cell activated and differentiated B cell that produces and secretes antibodies

plasma fluid portion of the blood that contains all clotting factors

plasma membrane (also called the cell membrane or cytoplasmic membrane) lipid bilayer with embedded proteins that defines the boundary of the cell

plasmalemma protist plasma membrane

plasmid small, circular, double-stranded DNA molecule that is typically independent from the bacterial chromosome

plasmolysis the separation of the plasma membrane away from the cell wall when a cell is exposed to a hypertonic environment

platelets cell fragments in the peripheral blood that originate from megakaryocyte cells in the bone marrow; also called thrombocytes

Platyhelminthes phylum comprising flatworms

pleconaril an antiviral drug targeting picornaviruses that prevents the uncoating of virus particles upon their infection of host cells

pleomorphic able to change shape

pneumococcal meningitis bacterial infection caused by *Streptococcus pneumoniae* that results in an inflammation of the meninges

Pneumocystis pneumonia common pulmonary infection in patients with AIDS; caused by *P. jirovecii*

pneumonia pulmonary inflammation that causes the lungs to fill with fluids

pneumonic plague rare form of plague that causes massive hemorrhages in the lungs and is communicable through aerosols

point mutation mutation, most commonly a base substitution, that affects a single base pair

point source spread a form of common source spread in which the transmission of a disease from the source occurs for a brief period that is less than the pathogen's incubation period

polar tubule a tube-like structure produced by spores of parasitic Microsporidia fungi that pierces host cell membranes

poliomyelitis (polio) disease caused by an infection of the enteric polio virus characterized by inflammation of the motor neurons of the brain stem and spinal cord; can result in paralysis

poly-A tail string of approximately 200 adenine nucleotides added to the 3' end of a eukaryotic primary mRNA transcript to stabilize it

polyacrylamide gel electrophoresis (PAGE) a method for separating populations of proteins and DNA fragments during Sanger sequencing of varying sizes by differential migration rates caused by a voltage gradient through a vertical gel matrix

polycistronic mRNA single mRNA molecule commonly produced during prokaryotic transcription that carries information encoding multiple polypeptides

polyclonal antibodies antibodies produced in a normal immune response, in which multiple clones of B cells respond to many different epitopes on an antigen

polyenes class of antifungal drugs that bind to ergosterol to form membrane pores, disrupting fungal cell membrane integrity

polyhedral virus virus with a three-dimensional shape with many facets

polyhydroxybutyrate (PHB) a type of cellular inclusion surrounded by a phospholipid monolayer embedded with protein

polylinker site or **multiple cloning site (MCS)** a short sequence containing multiple unique restriction enzyme recognition sites that are used for inserting foreign DNA into the plasmid after restriction digestion of both the foreign DNA and the plasmid

polymer macromolecule composed of individual units, monomers, that bind together like building blocks.

polymerase chain reaction (PCR) an *in vitro* molecular technique that rapidly amplifies the number of copies of specific DNA sequences to make the amplified DNA available for other analyses

polymorphonuclear neutrophil (PMN) see *neutrophils*

polymyxins lipophilic polypeptide antibiotics that target the lipopolysaccharide component of gram-negative bacteria and ultimately disrupt the integrity of their outer and inner membranes

polypeptide polymer having from approximately 20 to 50 amino acids

polyphyletic refers to a grouping of organisms that is not descended from a single common ancestor

polysome (polysome) structure including an mRNA molecule that is being translated by multiple ribosomes concurrently

polysaccharide polymer composed of hundreds of monosaccharides linked together by glycosidic bonds; also called *glycans*

portal of entry anatomical feature of the body through which pathogens can enter host tissue

portal of exit anatomical feature of the body through which pathogens can leave diseased individual

positive (+) strand viral RNA strand that acts like messenger RNA and can be directly translated inside the host cell

positive stain a stain that colors the structure of interest

pour plate method a technique used for inoculating plates with diluted bacterial samples for the purpose of cell counting; cells are mixed with warm liquid agar before being poured into Petri dishes

praziquantel antihelminthic drug that induces a calcium influx into tapeworms, leading to spasm and paralysis

precipitin complex lattice of antibody and antigen that becomes too large to stay in solution

precipitin ring test assay in which layers of antiserum and antigen in a test tube form precipitin at the interface of the two solutions

prevalence the total number or proportion of individuals in a population ill with a specific disease

primary amoebic meningoencephalitis (PAM) acute and deadly parasitic infection of brain tissues by the amoeba *Naegleria fowleri*

primary antibody in a sandwich ELISA, the antibody that is attached to wells of a microtiter plate to capture antigen from a solution, or in an indirect ELISA, the antigen-specific antibody present in a patient's serum

primary cell culture cells taken directly from an animal or plant and cultured in vitro

primary immunodeficiency genetic condition that results in impaired immune function

primary infection initial infection produced by a pathogen

primary lymphoid tissue one of two types of lymphatic tissue; comprises bone marrow and the thymus

primary pathogen microorganism that can cause disease in the host regardless of the effectiveness of the host's immune system

primary response the adaptive immune response produced upon first exposure to a specific antigen

primary stain refers, in differential staining techniques, to the first dye added to the specimen

primary structure bonding sequence of amino acids in a polypeptide chain **protein** macromolecule that results when the number of amino acids linked together becomes very large, or when multiple polypeptides are used as building subunits

primary transcript RNA molecule directly synthesized by RNA polymerase in eukaryotes before undergoing the additional processing required to become a mature mRNA molecule

primase RNA polymerase enzyme that synthesizes the RNA primer required to initiate DNA synthesis

primer short complementary sequence of five to 10 RNA nucleotides synthesized on the template strand by primase that provides a free 3'-OH group to which DNA polymerase can add DNA nucleotides

prion acellular infectious particle consisting of just proteins that can cause progressive diseases in animals and humans

prodromal period second stage of acute disease, during which the pathogen continues to multiply in the host and nonspecific signs and symptoms become observable

progeny virus newly assembled virions ready for release outside the cell

proglottid body segment of a cestode (tapeworm)

prokaryote an organism whose cell structure does not include a membrane-bound nucleus

prokaryotic cell a cell lacking a nucleus bound by a complex nuclear membrane

promoter DNA sequence onto which the transcription machinery binds to initiate transcription

propagated spread the progression of an infectious disease from person to person, either indirectly or directly, through a population of susceptible individuals as one infected individual transmits the agent to others, who transmit it to others yet again

prophage phage genome that has incorporated into the host genome

prospective study a research design that follows cases from the beginning of the study through time to associate measured variables with outcomes

prostate gland gland that contributes fluid to semen

prostatitis inflammation of the prostate gland

protease enzyme involved in protein catabolism that removes individual amino acids from the ends of peptide chains

protease inhibitor class of antiviral drugs, used in HIV therapy and hepatitis C therapy, that inhibits viral-specific proteases, preventing viral maturation

protein signature an array of proteins expressed by a cell or tissue under a specific condition

Proteobacteria phylum of gram-negative bacteria

proteomic analysis study of all accumulated proteins of an organism

proteomics the study of the entire complement of proteins in an organism; involves monitoring differences in gene expression patterns between cells at the protein level

protists informal name for diverse group of eukaryotic organisms, including unicellular, colonial, and multicellular types that lack specialized tissues

proton motive force electrochemical gradient formed by the accumulation of hydrogen ions (also known as protons) on one side of a membrane relative to the other protozoan (plural: protozoa) a unicellular eukaryotic organism, usually motile

protozoans informal term for some protists, generally those that are nonphotosynthetic, unicellular, and motile protozoology the study of protozoa

provirus animal virus genome that has integrated into the host chromosome

pseudohyphae short chains of yeast cells stuck together

pseudomembrane grayish layer of dead cells, pus, fibrin, red blood cells, and bacteria that forms on mucous membranes of the nasal cavity, tonsils, pharynx, and larynx of individuals with diphtheria

pseudomembranous colitis inflammation of the large intestine with the formation of a pseudomembrane; caused by *C. difficile*

pseudopodia temporary projections involved in amoeboid movement; these "false feet" form by gel-sol cycling of actin polymerization/depolymerization

psittacosis zoonotic *Chlamydia* infection from birds that causes a rare form of pneumonia

psoriasis autoimmune disease involving inflammatory reactions in and thickening of skin

psychrophile a microorganism that grows best at cold temperatures; most have an optimum growth temperature of about 15 °C and can survive temperatures below 0 °C; most cannot survive temperatures above 20 °C

psychrotroph a microorganism that grows best at cool temperatures, typically between about 4 °C and 25 °C, with optimum growth at about 20 °C

puerperal sepsis sepsis associated with a bacterial infection incurred by a woman during or after childbirth

purines nitrogenous bases containing a double-ring structure with a six-carbon ring fused to a five-carbon ring; includes adenine and guanine

purple nonsulfur bacteria phototrophic bacteria that are similar to purple sulfur bacteria except they use hydrogen rather than hydrogen sulfide for oxidation

purple sulfur bacteria phototrophic bacteria that oxidize hydrogen sulfide into elemental sulfur and sulfuric acid; their purple color is due to the pigments bacteriochlorophylls and carotenoids

purulent an infection that produces pus; suppurative

pus accumulation of dead pathogens, neutrophils, tissue fluid, and other bystander cells that may have been killed by phagocytes at the site of an infection

pyelonephritis an infection of one or both kidneys

pyocyanin blue pigments produced by some strains of *Pseudomonas aeruginosa*

pyoderma any suppurative (pus-producing) infection of the skin

pyoverdinin a water-soluble, yellow-green or yellow-brown pigment produced by some strains of *Pseudomonas aeruginosa*

pyrimidines nitrogenous bases containing a single six-carbon ring; includes cytosine and thymine in DNA

pyrophosphate (PPi) two connected phosphate groups in solution

pyuria pus or white blood cells in the urine

Q

Q fever highly infectious zoonotic disease caused by *Coxiella burnetii* that farmers can contract from their animals by inhalation

quarantine the isolation of an individual for the purpose of preventing the spread of disease

quaternary ammonium salts (quats) group of cationic detergents, named for the characteristic quaternary nitrogen atom that confers a positive charge, that make up an important class of disinfectants and antiseptics

quaternary structure structure of protein complexes formed by the combination of several separate polypeptides or subunits

quinolines class of antiprotozoan drugs long used for the treatment of malaria; interferes with heme detoxification

quorum sensing cell-to-cell communication in bacteria; enables a coordinated response from cells when the population reaches a threshold density

R

R plasmid plasmid containing genes encoding proteins that make a bacterial cell resistant to one or more antibiotics

rabies contagious viral disease primarily transmitted by the bite of infected mammals that can cause acute encephalitis resulting in madness, aggressiveness, coma, and death

radial immunodiffusion precipitin reaction in which antigen added to a well in an antiserum-impregnated gel diffuses, producing a precipitin ring whose diameter squared is directly proportional to antigen concentration

rat-bite fever relapsing fever caused by either *Bacillus moniliformis* or *Spirillum minor*; can be transmitted by the bite of a rat or through contact with rat feces or urine

reaction center protein complex in a photosystem, containing a pigment molecule that can undergo oxidation upon excitation by a light-harvesting pigment, actually giving up an electron

reactivation tuberculosis secondary infection by *Mycobacterium tuberculosis* that forms later in life; occurs when the bacteria escape from the Ghon complexes and establish focal infections at other sites in immunocompromised individuals

reactive oxygen species (ROS) unstable and toxic ions and molecules derived from partial reduction of oxygen

reading frame way nucleotides in mRNA are grouped into codons

real-time PCR (quantitative PCR, qPCR) a variant of PCR involving the use of fluorescence to allow for the monitoring of the increase in double-stranded template during a PCR reaction as it occurs, allowing for the quantitation of the original target sequence

receptor-mediated endocytosis a type of endocytosis in which extracellular ligands are targeted to specific cells through their binding to specific cell surface receptors

recognition site a specific, often palindromic, DNA sequence recognized by a restriction enzyme that is typically four to six base pairs long and reads the same in the 5' to 3' direction on one strand as it does in the 5' to 3' direction on the complementary strand

recombinant DNA molecule a DNA molecule resulting from the cutting and insertion of DNA from one organism into the DNA of another organism, resulting in a new combination of genetic material

recombinant DNA pharmaceuticals pharmaceuticals produced as a result of genetic engineering

recombinant DNA technology the process by which DNA from one organism is cut and new pieces of foreign DNA from a second organism are inserted, artificially creating new combinations of genetic material within the organism

redox potential tendency for a molecule to acquire electrons and become reduced; electrons flow from molecules with lower redox potentials to those with higher redox potentials

redox reaction pairing of an oxidation reaction with a reduction reaction

reduction reaction chemical reaction that adds electrons to acceptor molecules, leaving them reduced

reemerging infectious disease a disease that was once under control or largely eradicated that has begun causing new outbreaks due to changes in susceptible populations, the environment, or the pathogen itself

reflection when light bounces back from a surface

refraction bending of light waves, which occurs when a light wave passes from one medium to another

refractive index a measure of the magnitude of slowing of light waves by a particular medium

regulatory T cells class of T cells that are activated by self-antigens and serve to inhibit peripheral self-reacting T cells from causing damage and autoimmunity

rejection process by which adaptive immune responses recognize transplanted tissue as non-self, mounting a response that destroys the tissue or leads to the death of the individual

relapsing fever louse- or tickborne disease caused by *Borrelia recurrentis* or *B. hermsii* and characterized by a recurrent fever

replica plating plating technique in which cells from colonies growing on a complete medium are inoculated onto various types of minimal media using a piece of sterile velvet, ensuring that the orientation of cells deposited on all plates is the same so that growth (or absence thereof) can be compared between plates

replication bubble circular structure formed when the DNA strands are separated for replication

replication fork Y-shaped structure that forms during the process of replication as DNA unwinds and opens up to separate the DNA strands

replication process by which DNA is copied

reporter genes genes that encode easily observable characteristics, allowing for their expression to be easily monitored

repressible operon bacterial operon, that typically containing genes encoding enzymes required for a biosynthetic pathway and that is expressed when the product of the pathway continues to be required but is repressed when the product of the pathway accumulates, removing the need for continued expression

repressor protein that suppresses transcription of a gene or operon in response to an external stimulus

reservoir a living host or nonliving site in which a pathogenic organism can survive or multiply

resident microbiota microorganisms that constantly live in the human body

resolution the ability to distinguish between two points in an image

restriction endonuclease (restriction enzyme) bacterial enzyme that cuts DNA fragments at a unique, often palindromic, recognition site; used in genetic engineering for splicing DNA fragments together into recombinant molecules

restriction fragment length polymorphism (RFLP) a genetic variant identified by differing numbers or sizes of DNA fragments generated after digestion of a DNA sample with a restriction endonuclease; the variants are caused by the loss or gain of restriction sites, or the insertion or deleting of sequences between restriction sites.

retort large industrial autoclave used for moist heat sterilization on a large scale

retrospective study a research design that associates historical data with present cases

retrovirus positive ssRNA virus that produces and uses reverse transcriptase to make an ssDNA copy of the retroviral genome that can then be made into dsDNA and integrate into the host cell chromosome to form a provirus within the host chromosome.

reverse transcriptase enzyme found in retroviruses that can make a copy of ssDNA from ssRNA

reverse transcriptase inhibitor classes of antiviral drugs that involve nucleoside analog competitive inhibition and non-nucleoside noncompetitive inhibition of the HIV reverse transcriptase

reverse transcriptase PCR (RT-PCR) a variation of PCR used to obtain DNA copies of a specific mRNA molecule that begins with the conversion of mRNA molecules to cDNA by the enzyme reverse transcriptase

Reye syndrome potentially life-threatening sequelae to some viral infections that result in the swelling of the liver and brain; aspirin use has also been linked to this syndrome

Rh factor red blood cell surface antigen that can trigger type II hypersensitivity reactions

rheostat a dimmer switch that controls the intensity of the illuminator on a light microscope

rheumatic fever serious clinical sequela of an infection with *Streptococcus pyogenes* that can result in damage to joints or the valves of the heart

rheumatoid arthritis systemic autoimmune disease in which immune complexes form and deposit in the joints and their linings, leading to inflammation and destruction

rhinitis inflammation of the nasal cavity

rhizines structures made of hyphae found on some lichens; aid in attachment to a surface

ribonucleic acid (RNA) single-stranded nucleic acid composed of ribonucleotides; important in transcription and translation (protein synthesis)

ribonucleotides RNA nucleotides containing ribose as the pentose sugar component and a nitrogenous base

ribosome a complex intracellular structure that synthesizes proteins

riboswitch small region of noncoding RNA found within the 5' end of some prokaryotic mRNA molecules that may bind to a small intracellular molecule, influencing the completion of transcription and/or translation

ribulose biphosphate carboxylase (RuBisCO) first enzyme of the Calvin cycle responsible for adding a CO₂ molecule onto a five-carbon ribulose biphosphate (RuBP) molecule

rifampin semisynthetic member of the rifamycin class that blocks bacterial RNA polymerase activity, inhibiting transcription

rimantadine antiviral drug that targets the influenza virus by preventing viral escape from endosomes upon host cell uptake, preventing viral RNA release and subsequent viral replication

ringworm a tinea (cutaneous mycosis of the skin), typically characterized by a round, red, slightly raised lesion that heals outward from the center, giving it the appearance of a round worm

RNA interference (RNAi) process by which antisense RNAs or small interfering RNAs (siRNAs) interfere with gene expression by binding to mRNA, preventing translation and protein synthesis

RNA polymerase enzyme that adds nucleotides to the 3'-OH group of the growing mRNA molecule that are complementary to the template strand, forming covalent phosphodiester bonds between the nucleotides in the RNA

RNA splicing process of removing intron-encoded RNA sequences from eukaryotic primary transcripts and reconnecting those encoded by exons

RNA transcript mRNA produced during transcription

Rocky Mountain spotted fever potentially fatal tickborne disease caused by *Rickettsia rickettsii* characterized by fever, body aches, and a rash

rogue form misfolded form of the PrP protein that is normally found in the cell membrane and has the tendency to aggregate in neurons, causing extensive cell death and brain damage

rolling circle replication type of rapid unidirectional DNA synthesis of a circular DNA molecule

roseola a rash-causing illness, most commonly affecting children, associated with human herpesvirus 6 (HHV-6)

rough endoplasmic reticulum a type of endoplasmic reticulum containing bound 80S ribosomes for the synthesis of proteins destined for the plasma membrane

route of administration method used to introduce a drug into the body

rRNA type of stable RNA that is a major constituent of ribosomes, ensuring proper alignment of the mRNA and the ribosomes as well as catalyzing the formation of the peptide bonds between two aligned amino acids during protein synthesis

rubella German measles, caused by the rubella virus

runs (running) purposeful, directional movement of a prokaryotic cell propelled by counterclockwise flagellar rotation

S

σ factor subunit of bacterial RNA polymerase conferring promoter specificity that can be substituted with a different version in response to an environmental condition, allowing for a quick and global change of the regulon transcribed

saccharide carbohydrate

salmonellosis gastrointestinal illness caused by *Salmonella* bacteria

salpingitis inflammation of the fallopian tubes

sandwich ELISA EIA in which the primary antibody is first attached to the wells of a microtiter plate, allowing it to capture antigen from an unknown solution to be quantified

Sanger DNA sequencing (dideoxy method, chain termination method) the original DNA sequencing technique in which dideoxy nucleotides, each labeled with a molecular beacon, are used to terminate chain elongation; the resulting incrementally sized fragments are then separated by electrophoresis to determine the sequence of the DNA molecule

sanitization protocol that reduces microbial load on inanimate surfaces to levels deemed safe for public health

saprozoic refers to protozoans that ingest small, soluble food molecules

SARS severe acute respiratory syndrome; caused by a zoonotic coronavirus that results in flu-like symptoms

saturated fatty acid lipid with hydrocarbon chains containing only single bonds, which results in the maximum number of hydrogen atoms per chain

scanning electron microscope (SEM) a type of electron microscope that bounces electrons off of the specimen, forming an image of the surface

scanning probe microscope a microscope that uses a probe that travels across the surface of a specimen at a constant distance while the current, which is sensitive to the size of the gap, is measured

scanning tunneling microscope a microscope that uses a probe that is passed just above the specimen as a constant voltage bias creates the potential for an electric current between the probe and the specimen

scarlet fever bacterial infection caused by *Streptococcus pyogenes*, marked by a high fever and a disseminated scarlet rash

schistosomiasis helminthic infection caused by *Schistosoma* spp.; transmitted from a snail intermediate host to human swimmers or bathers in freshwater

schizogony asexual reproduction in protozoans that is characterized by multiple cell divisions (one cell dividing to form many smaller cells)

scolex the head region of a cestode (tapeworm), which typically has suckers and/or hooks for attachment to the host

scrapie form of transmissible spongiform encephalopathy that primarily affects sheep

sebaceous gland a gland located in hair follicles that secretes sebum

sebum lipid-rich substance secreted by the sebaceous glands of the skin

secondary antibody antibody to which an enzyme is attached for use in ELISA assays; in direct and sandwich ELISAs, it is specific for the antigen being quantified, whereas in indirect ELISA, it is specific for the primary antibody

secondary immunodeficiency impaired immune response due to infection, metabolic disturbance, poor diet, stress, or other acquired factors

secondary infection second infection that develops after a primary infection as a result of the primary disease compromising immune defenses or antibiotics, thus eliminating protective microbiota

secondary lymphoid tissue one of two types of lymphatic tissue; comprises the spleen, lymph nodes, Peyer's patches, and mucosa associated lymphoid tissue (MALT)

secondary response the adaptive immune response produced in response to a specific antigen to which the body has previously been exposed

secondary structure structure stabilized by hydrogen bonds between the carbonyl and amine groups of a polypeptide chain; may be an α -helix or a β -pleated sheet, or both

secretory vesicle membranous sac that carries molecules through the plasma membrane to be released (secreted) from the cell

selective IgA deficiency primary immunodeficiency in which individuals produce normal levels of IgG and IgM, but are unable to produce secretory IgA

selective media media that contain additives that encourage the growth of some bacteria while inhibiting others

selective toxicity desirable quality of an antimicrobial drug indicating that it preferentially kills or inhibits the growth of the target microbe while causing minimal or no harm to the host

semiconservative DNA replication pattern of DNA replication process whereby each of the two parental DNA strands acts as a template for new DNA to be synthesized, producing hybrid old- and new-strand daughter molecules

semicritical item object that contacts mucous membranes or nonintact skin but does not penetrate tissues; requires a high level of disinfection

seminal vesicles glands that contribute fluid to semen

semisynthetic antimicrobial chemically modified derivative of a natural antibiotic

sense strand strand of DNA that is not transcribed for gene expression; it is complementary to the antisense strand

sepsis systemic inflammatory response to an infection that results in high fever and edema, causing organ damage and possibly leading to shock and death

septate hyphae hyphae that contain walls between individual cells; characteristic of some fungi

septic arthritis see *infectious arthritis*

septic shock serious condition marked by the loss of blood pressure resulting from an inflammatory response against a systemic infection

septic the condition of being septicemic; having an infection in the blood

septicemia condition in which pathogens are multiplying in blood

septicemic plague form of plague that occurs when the bacterial pathogen gains access to the bloodstream

septum separating structure that forms during cell division; also describes the separating wall between cells in a filament

sequela (plural: sequelae) condition that arises as a consequence of a prior disease

serial dilution sequential transfer of known volumes of culture samples from one tube to another to perform a several-fold dilution of the original culture

seroconversion point in an infection at which antibody to a pathogen is detectable using an immunoassay

serotype strain or variation of the same species of bacteria; also called serovar

serovar specific strain of bacteria identified by agglutination using strain-specific antisera

serum fluid portion of the blood after clotting has occurred; generally lacks clotting factors

serum sickness systemic type III hypersensitivity reaction

sessile attached to a surface

severe combined immunodeficiency disease (SCID) genetic disorder resulting in impaired function of B cells and T cells

sex pilus specialized type of pilus that aids in DNA transfer between some prokaryotic cells

sheath part of the tail on a bacteriophage that contracts to introduce the viral DNA into the bacterium

shigellosis gastrointestinal illness caused by *Shigella* bacteria, also called bacillary dysentery

shingles acute and painful rash that forms following the reactivation of a latent chickenpox infection

shock extreme drop in blood pressure that, among other causes, can result from a strong immune response to the activity of toxins or response to bacterial products and can result in death

shuttle vector a plasmid that can move between bacterial and eukaryotic cells

side chain the variable functional group, *R*, attached to the α carbon of an amino acid

sign objective and measurable indication of a disease

silent mutation point mutation that results in the same amino acid being incorporated into the resulting polypeptide

simple microscope a type of microscope with only one lens to focus light from the specimen

simple staining a staining technique that uses a single dye

single-stranded binding protein protein that coats the single strands of DNA near each replication fork to prevent the single-stranded DNA from rewinding into a double helix

sinusitis inflammation of the sinuses

S-layer cell envelope layer composed of protein covering the cell walls of some bacteria and archaea; in some archaea, may function as the cell wall

slime layer a type of glycocalyx with unorganized layers of polysaccharides that aid bacterial adherence to surfaces

smear a thin layer of a specimen on a slide

smooth endoplasmic reticulum a type of endoplasmic reticulum that lacks ribosomes, is involved in the biosynthesis of lipids and in carbohydrate metabolism, and serves as the site of detoxification of toxic compounds within the cell

soft chancres soft, painful ulcers associated with the STI chancroid

soma cell body of a neuron

sonication method of microbial control that involves application of ultrasound waves to form cavitation within a solution, including inside cells, disrupting cell components as a result

Southern blot a technique in molecular genetics used to detect the presence of certain DNA sequences within a given DNA sample; DNA fragments within the sample are separated by agarose gel electrophoresis, immobilized on a membrane, and then exposed to a specific DNA probe labeled with a radioactive or fluorescent molecular beacon to aid in detection

specialized transduction transfer of a specific piece of bacterial chromosomal DNA near the site of integration by the phage

specificity the ability of the specific adaptive immune system to target specific pathogens or toxins

spike viral glycoprotein embedded within the viral capsid or envelope used for attachment to host cells

spirochetes a group of long, thin, spiral-shaped fastidious bacteria that includes the human pathogens that cause syphilis, Lyme disease, and leptospirosis

spleen abdominal organ consisting of secondary lymphoid tissue that filters blood and captures pathogens and antigens that pass into it; also contains specialized macrophages and dendritic cells that are crucial for antigen presentation

spliceosome protein complex containing small nuclear ribonucleoproteins that catalyzes the splicing out of intron-encoded RNA sequences from the primary transcript during RNA maturation in eukaryotes

spontaneous generation the now-disproven theory that life can arise from nonliving matter

spontaneous mutation mutation not caused by a mutagen that occurs through DNA replication errors

sporadic disease an illness that occurs at relatively low levels with no discernible pattern or trend, frequently with no geographic focus

spores specialized cells that may be used for reproduction or may be specialized to withstand harsh conditions

sporotrichosis subcutaneous infection caused by the fungus *Sporothrix schenckii*, which causes skin lesions and can potentially spread to the lymphatic system; also known as rose gardener's disease or rose thorn disease

sporulation the process by which a vegetative cell produces a dormant endospore

spread plate method a technique used for inoculating plates with diluted bacterial samples for the purpose of cell counting; the liquid sample is pipetted onto solid medium and spread uniformly across the plate

St. Louis encephalitis mosquito-borne viral infection of the brain that occurs primarily in the central and southern United States

stage the platform of a microscope on which slides are placed

staining the addition of stains or dyes to a microscopic specimen for the purpose of enhancing contrast

staphylococcal food poisoning gastrointestinal illness caused by toxins produced by *Staphylococcus aureus*

staphylolysins a class of staphylococcal exotoxins that are cytotoxic to skin cells and white blood cells

starch energy-storage polysaccharide in plants; composed of two types of glucose polymers: amylose and amylopectin

start codon AUG codon, specifying methionine, which is typically the codon that initiates translation

stationary phase interval during which the number of cells formed by cell division is equal to the number of cells dying

stereoisomers isomers that differ in the spatial arrangements of atoms

sterilant strong chemical that effectively kills all microbes and viruses in or on an inanimate item

sterile field specified area that is free of all vegetative microbes, endospores, and viruses

sterilization protocol that completely removes all vegetative cells, endospores, and viruses from an item

steroid lipid with complex, ringed structures found in cell membranes and hormones

sterol the most common type of steroid; contains an OH group at one specific position on one of the molecule's carbon rings

sticky ends short, single-stranded complementary overhangs that may be produced when many restriction enzymes cut DNA

stigma light-sensing eyespot found in *Euglena*

stop codon (nonsense codon) one of three codons for which there is no tRNA with a complementary anticodon; a signal within the mRNA for termination of translation

stratum corneum a layer of dead, keratinized cells that forms the uppermost layer of the epidermis

strep throat (streptococcal pharyngitis) bacterial pharyngitis caused by *Streptococcus pyogenes*

streptococcal toxic shock-like syndrome (STSS) condition similar to staphylococcal toxic shock syndrome but with greater likelihood of bacteremia, necrotizing fasciitis, and acute respiratory distress syndrome

stroma a gel-like fluid that makes up much of a chloroplast's volume, and in which the thylakoids float

strongyloidiasis soil-transmitted intestinal infection caused by the helminth *Strongyloides stercoralis*

structural formula graphic representation of the molecular structure showing how the atoms are arranged

structural isomers molecules composed of the same numbers and types of atoms but with different bonding sequences

subacute bacterial endocarditis form of endocarditis in which damage to the valves of the heart occurs over months as a result of blood clot formation and immune-response-induced fibrosis of the valves

subclinical disease disease that does not present any signs or symptoms

subcutaneous mycosis any fungal infection that penetrates the epidermis and dermis to enter deeper tissues

substrate chemical reactants of an enzymatic reaction

substrate-level phosphorylation direct method of ATP production in which a high-energy phosphate group is removed from an organic molecule and added to an ADP molecule

subunit vaccine vaccine that contains only key antigens as opposed to whole pathogens

sugar-phosphate backbone alternating sugar-phosphate structure composing the framework of a nucleic acid strand that results from phosphodiester bond formation between nucleotides

sulfonamides (sulfa drugs) group of structurally related synthetic antimicrobial compounds that function as antimetabolites, competitively inhibiting an enzyme in the bacterial folic acid synthesis pathway

superantigen class of exotoxin that triggers a strong nonspecific immune response with excessive production of cytokines (cytokine storm) causing inflammation, high fever, shock, and, potentially, death

supercoiled extensive wrapping and twisting of a DNA molecule, allowing the DNA to fit within a small space

supercoiling process in which DNA is underwound or overwound to fit inside a cell

supercritical fluid molecule, commonly carbon dioxide, brought to high pressures to reach a state that has physical properties between those of liquids and gases, allowing it to effectively penetrate surfaces and cells to form carbonic acid, which lowers the pH of cells considerably, leading to sterilization

superinfection secondary infection that may develop as a result of long-term, broad-spectrum antimicrobial use

superoxide dismutase enzyme that catalyzes the breakdown of superoxide anions

suppurative producing pus; purulent

surfactant group of chemical compounds used for degerming; lower the surface tension of water, creating emulsions that mechanically carry away microorganisms

sweat gland one of numerous tubular glands embedded in the dermis that secretes the watery substance known as perspiration

symbiosis any interaction between different species that are associated with each other within a community

symptom subjective experience of disease felt by the patient

synapse junction between a neuron and another cell

syncytia multinucleated cells that form from the fusion of normal cells during infections or other processes

syndrome group of signs and symptoms characteristic of a particular disease

syngamy process in which haploid gametes fuse

synthetic antimicrobial antimicrobial developed from a chemical not found in nature

syphilis an STI caused by the bacterium *Treponema pallidum*

systemic autoimmune disease autoimmune disease that affect the organism as a whole, rather than a single organ

systemic infection infection that has spread to multiple locations or body systems

systemic inflammatory response syndrome (SIRS) severe inflammatory response to the presence of microbes in the blood; can lead to sepsis

systemic lupus erythematosus (SLE) systemic autoimmune disease producing inflammatory type III hypersensitivities as antibodies form immune complexes with nuclear and cytoplasmic antigens

systemic mycosis a fungal infection that spreads throughout the body

T

T-cell receptors (TCR) molecules on T cells involved in the recognition of processed foreign epitopes presented with MHC I or MHC II

T lymphocyte lymphocyte that serves as the central orchestrator, bridging humoral, cellular, and innate immunity, and serves as the effector cells of cellular immunity; T cell

taeniasis infection caused by *Taenia* or *Diphyllobothrium*

tail fiber long protein component on the lower part of a phage used for specific attachment to bacterial cell

tail pins points extended at the base of a bacteriophage sheath that, along with tail fibers, lead to phage attachment to a bacterial cell

tapeworms segmented, hermaphroditic, parasitic flatworms (Platyhelminthes)

tartar calcified heavy plaque on teeth, also called dental calculus taxonomy the classification, description, identification, and naming of living organisms

T-dependent antigen a protein antigen that is only capable of activating a B cell with the cooperation of a helper T cell

TDP thermal death point is the lowest temperature at which all microorganisms are killed in a 10-minute exposure

TDT thermal death time is the length of time needed to kill all microorganisms in a sample at a given temperature

telomerase enzyme that attaches to the end of a linear chromosome and adds nucleotides to the 3' end of one of the DNA strands, maintaining the telomere sequence, thus preventing loss of DNA from the end of the chromosome

telomere repetitive, noncoding sequence found at the end of a linear eukaryotic chromosome that protects the genes near the end of the chromosome from deletion as the DNA molecule is repeatedly replicated

temperate phage bacteriophage that can incorporate viral genome into the host cell chromosome and replicate with the host cell until new viruses are produced; a phage that undergoes the lysogenic cycle

teratogenic able to disrupt the normal development of a fetus in utero

terbinafine antifungal drug of the allylamine class that is used topically for the treatment of dermatophytic skin infections

termination of DNA replication stage of replication during which DNA replication is halted once the chromosome has been fully replicated

termination of transcription stage of transcription that occurs when RNA polymerase has reached specific DNA sequences, leading to release of the enzyme from the DNA template, freeing the RNA transcript and, thus, halting transcription

termination of translation stage of translation during which a nonsense codon aligns with the A site, signaling release factors to release of the polypeptide, leading to the dissociation of the small and large ribosomal subunits from the mRNA and from each other

tertiary structure large-scale, three-dimensional structure of a polypeptide

test sensitivity probability that a diagnostic test will find evidence of the targeted disease when the pathogen is present

test specificity probability that a diagnostic test will not find evidence of the targeted disease when the pathogen is absent

testes (singular *testis*) pair of glands located in the scrotum of males that produce sperm and testosterone

tetanus bacterial disease caused by exotoxin produced by *Clostridium tetani* that causes a rigid paralysis

tetracyclines class of protein synthesis inhibitors that bind to the 30S subunit, blocking the association of tRNAs with the ribosome during translation

T_H1 cells subtype of T cells that stimulate cytotoxic T cells, macrophages, neutrophils, and NK cells

T_H17 cells subtype of T cell that are essential for defense against specific pathogens and infections, such as chronic mucocutaneous infections with *C. albicans*

T_H2 cells subtype of T cells that stimulate B cells and direct their differentiation; also involved in directing antibody class switching

thallus body of fleshy fungi (more generally, a body without a root, stem, or leaf) that commonly co-occurs with HIV infection; the microbes move to the lymphatic system in the groin

thermophile a microorganism that grows best at warm temperatures, typically between about 50 °C and 80 °C

thin sections thin slices of tissue for examination under a TEM

thioglycolate medium medium designed to test the aerotolerance of bacteria; it contains a low concentration of agar to allow motile bacteria to move throughout the medium

thioglycolate tube culture contains reducing medium through which oxygen diffuses from the tube opening, producing a range of oxygen environments down the length of the tube

thrombocytes see *platelets*

thylakoids a highly dynamic collection of membranous sacs found in the stroma of chloroplasts; site of photosynthesis

thymic selection a three-step process of negative and positive selection of T cells in the thymus

thymine dimer covalent linkage between two adjacent thymine bases on exposure to ultraviolet radiation

thymine pyrimidine nitrogenous base found only in DNA nucleotides

tincture solution of an antiseptic compound dissolved in alcohol

T-independent antigen a nonprotein antigen that can activate a B cell without cooperation from a helper T cell

tinea any cutaneous fungal infection caused by dermatophytes, such as tinea corporis, tinea capitis, tinea cruris, and tinea pedis

tinea capitis cutaneous mycosis of the scalp; also known as ringworm of the scalp

tinea corporis cutaneous mycosis of the body; also known as ringworm of the body

tinea cruris cutaneous mycosis of the groin region; also known as jock itch

tinea pedis cutaneous mycosis of the feet; also known as athlete's foot

tissue tropism tendency of most viruses to infect only certain tissue types within a host

titer concentration obtained by titration; the reciprocal of a measurement of biological activity determined by finding the dilution of an unknown (e.g., antigen-specific antibody in an antiserum) that shows the defined end-point; always expressed as a whole number

tolerance lack of an anti-self immune response

toll-like receptors (TLRs) pathogen recognition receptors (PRRs) that may be found on the external surface of phagocytes or facing inward in interior compartments

tonsillitis inflammation of the tonsils

topoisomerase type of enzyme that helps maintain the structure of supercoiled chromosomes, preventing overwinding of DNA during certain cellular processes like DNA replication

topoisomerase II enzyme responsible for facilitating topological transitions of DNA, relaxing it from its supercoiled state

total magnification in a light microscope is a value calculated by multiplying the magnification of the ocular by the magnification of the objective lenses

toxemia presence of toxins in the blood

toxic shock syndrome severe condition marked by the loss of blood pressure and blood clot formation caused by a bacterial superantigen, toxic shock syndrome toxin

toxigenicity ability of a pathogen to produce toxins to cause damage to host cells

toxin poison produced by a pathogen

toxoid vaccine vaccine that contains inactivated bacterial toxins

toxoplasmosis typically asymptomatic protozoan infection caused by *Toxoplasma* spp. and transmitted through contact with cysts in cat feces; infections in pregnant women may cause birth defects or miscarriage

trace element indispensable element present in cells in lower amounts than macronutrients; also called *micronutrient*

trachea also known as the windpipe, this is a stiffened tube of cartilage that runs from the larynx to the bronchi

trachoma a type of conjunctivitis, caused by *Chlamydia trachomatis*, that is a major cause of preventable blindness

transcription bubble region of unwinding of the DNA double helix during transcription

transcription factors proteins encoded by regulatory genes that function by influencing the binding of RNA polymerase to the promoter and allowing its progression to transcribe structural genes

transcription process of synthesizing RNA using the information encoded in DNA

transcriptomics the study of the entire collection of mRNA molecules produced by cells; involves monitoring differences in gene expression patterns between cells at the mRNA level

transduction mechanism of horizontal gene transfer in bacteria in which genes are transferred through viral infection

transendothelial migration process by which circulating leukocytes exit the bloodstream via the microvascular endothelium

transfection the introduction of recombinant DNA molecules into eukaryotic hosts

transformation mechanism of horizontal gene transfer in bacteria in which naked environmental DNA is taken up by a bacterial cell

transgenic describing an organism into which foreign DNA from a different species has been introduced

transient microbiota microorganisms, sometimes pathogenic, that are only temporarily found in the human body

transition reaction reaction linking glycolysis to the Krebs cycle, during which each pyruvate is decarboxylated and oxidized (forming NADH), and the resulting two-carbon acetyl group is attached to a large carrier molecule called coenzyme A, resulting in the formation of acetyl-CoA and CO₂; also called the *bridge reaction*

translation (protein synthesis) process of protein synthesis whereby a ribosome decodes an mRNA message into a polypeptide product

transmissible spongiform encephalopathy degenerative disease caused by prions; leads to the death of neurons in the brain

transmission electron microscope (TEM) a type of electron microscope that uses an electron beam, focused with magnets, that passes through a thin specimen

transmittance the amount of light that passes through a medium

transparency the property of allowing light to pass through

transport vesicle membranous sac that carries molecules between various components of the endomembrane system

transposition process whereby a DNA sequence known as a transposon independently excises from one location in a DNA molecule and integrates elsewhere

transposon (transposable element) molecule of DNA that can independently excise from one location in a DNA molecule and integrate into the DNA elsewhere

trench fever louseborne disease caused by *Bartonella quintana* and characterized by high fever, body aches, conjunctivitis, ocular pain, severe headaches, and severe bone pain

trench mouth a severe form of gingivitis, also called acute necrotizing ulcerative gingivitis

treponemal serologic tests tests for syphilis that measure the amount of antibody directed against antigens associated with *Treponema pallidum*

triacylglycerol three fatty acids chemically linked to a glycerol molecule; also called a triglyceride

triazoles ergosterol biosynthesis inhibitors used to treat several types of systemic yeast infections; exhibit more selective toxicity than the imidazoles and are associated with fewer side effects

tricarboxylic acid cycle see *Krebs cycle*

trichinosis soil-transmitted intestinal infection caused by the nematode *Trichinella spiralis*; associated with cyst formation

trichomoniasis a common STI caused by *Trichomonas vaginalis*

trichuriasis intestinal infection caused by the whipworm *Trichuris trichiura*

triglyceride three fatty acids chemically linked to a glycerol molecule; also called a triacylglycerol

trimethoprim synthetic antimicrobial compound that functions as an antimetabolite to an enzyme in the bacterial folic acid synthesis pathway

tRNA small type of stable RNA that carries the correct amino acid to the site of protein synthesis in the ribosome and base pairs with the mRNA to allow the amino acid it carries to be inserted in the polypeptide chain being synthesized

trophozoite a life cycle phase in which protists are actively feeding and growing

tubercle small, rounded lesion

tuberculosis life-threatening form of microbial infection marked by the presence of acid-fast bacteria growing in nodules (especially in the lungs)

tularemia infection of the lymphatic system by *Francisella tularensis*; also known as rabbit fever

tumbles (tumbling) random, circuitous movement of a bacterial cell, propelled by clockwise flagellar rotation

tumor collection or aggregate of cells; can be benign (noncancerous) or malignant (cancerous)

tumor-inducing (Ti) plasmid a naturally occurring plasmid of the bacterium *Agrobacterium tumefaciens* that researchers use as a shuttle vector to introduce a desired DNA fragment into plant cells

turbidity cloudiness of a culture due to refraction of light by cells and particles

two-photon microscope a microscope that uses long-wavelength or infrared light to fluoresce fluorochromes in the specimen

tympanic membrane also referred to as the ear drum, this structure separates the outer and middle ear

type 1 diabetes mellitus hyperglycemia caused by an autoimmune disease affecting insulin production by β cells of the pancreas

type I hypersensitivity rapid-onset allergic reaction due to cross-linking of antigen-specific IgE on the outside of mast cells, resulting in release of inflammatory mediators

type II hypersensitivity cytotoxic reaction triggered by IgG and IgM antibodies binding to antigens on cell surfaces

type III hypersensitivity inflammatory reaction induced by formation of immune complexes and their deposition in tissues and blood vessels

type IV hypersensitivity delayed T-cell-mediated inflammatory reaction that takes longer to manifest than the first three hypersensitivity types, due to the need for activation of antigen-presenting cell and T-cell subsets

typhoid fever serious illness caused by infection with certain serotypes of *Salmonella*

U

UHT pasteurization method of pasteurization that exposes milk to ultra-high temperatures (near 140 °C) for a few seconds, effectively sterilizing it so that it can be sealed and stored for long periods without refrigeration

ulcer open sore

ultramicrotome a device that cuts thin sections for electron microscopy

unit membrane biological membrane composed of two layers of phospholipid molecules with the nonpolar tails associating to form a hydrophobic barrier between the polar heads; also called lipid bilayer

unsaturated fatty acid lipid with hydrocarbon chains containing one or more carbon-carbon double bonds and subsequently fewer than the maximum number of hydrogen atoms per chain

uracil pyrimidine nitrogenous base found only in RNA nucleotides

ureter duct that transports urine from the kidneys to the urinary bladder

urethritis inflammation of the ureter

urethra duct through which urine passes from the urinary bladder to leave the body through the urinary meatus

urethritis inflammation of the urethra

urinary bladder an organ that stores urine until it is ready to be excreted

urinary meatus the opening through which urine leaves the body

use-dilution test a technique for determining the effectiveness of a chemical disinfectant on a surface; involves dipping a surface in a culture of the targeted microorganism, disinfecting the surface, and then transferring the surface to a fresh medium to see if bacteria will grow

uterus female reproductive organ in which a fertilized egg implants and develops

V

vaccination inoculation of a patient with attenuated pathogens or antigens to activate adaptive immunity and protect against infection

vagina female reproductive organ that extends from the vulva to the cervix

vaginitis inflammation of the vagina

vaginosis an infection of the vagina caused by overgrowth of resident bacteria

vancomycin cell wall synthesis inhibitor of the glycopeptide class

vancomycin-intermediate *Staphylococcus aureus* (VISA) pathogen with intermediate vancomycin resistance due to increased targets for and trapping of vancomycin in the outer cell wall

vancomycin-resistant enterococci (VRE) pathogens resistant to vancomycin through a target modification of peptidoglycan subunit peptides that inhibit binding by vancomycin

vancomycin-resistant *Staphylococcus aureus* (VRSA) pathogen with resistance to vancomycin that has arisen as a result of the horizontal gene transfer of vancomycin resistance genes from VRE

variolation the historical practice of inoculating a healthy patient with infectious material from a person infected with smallpox in order to promote immunity to the disease

vas deferens pair of ducts in the male reproductive system that conduct sperm from the testes and seminal fluid to the ejaculatory duct

vasculitis inflammation affecting blood vessels (either arteries or veins)

VDRL (Venereal Disease Research Laboratory) test test for syphilis that detects anti-treponemal antibodies to the phospholipids produced due to the tissue destruction by *Treponema pallidum*; antibodies are detected through a flocculation reaction with cardiolipin extracted from beef heart tissue

vector animal (typically an arthropod) that transmits a pathogen from one host to another host; DNA molecules that carry DNA fragments from one organism to another

vegetative cell a cell that is actively growing and dividing, and does not contain an endospore

vehicle transmission transfer of a pathogen between hosts via contaminated food, water, or air

vein blood vessel that returns blood from the tissues to the heart for recirculation

vertical direct transmission transfer of a pathogen from mother to child during pregnancy, birth, or breastfeeding

vertical gene transfer transfer of genes from parent to offspring

viable cell live cell; live cells are usually detected as colony-forming units

viable plate count direct method of measuring microbial growth in a culture; the number of viable or live cells is usually expressed in CFU/mL

viral conjunctivitis inflammation of the conjunctiva caused by a viral infection

viral envelope lipid membrane obtained from phospholipid membranes of the cell that surrounds the capsid

viral hemagglutination inhibition assay assay used to quantify the amount of neutralizing antibody against a virus by showing a decrease in hemagglutination caused by a standardized amount of virus

viral titer number of virions per unit volume

viremia presence of virus in blood

viricide chemical or physical treatment that destroys or inactivates viruses

virion inert particle that is the reproductive form of a virus

viroid infectious plant pathogen composed of RNA

virology the study of viruses

virulence degree to which an organism is pathogenic; severity of disease signs and symptoms

virulence factor product of a pathogen that assists in its ability to cause infection and disease

virulent phage bacteriophage for which infection leads to the death of the host cell; a phage that undergoes the lytic cycle

virus an acellular microorganism, consisting of proteins and genetic material (DNA or RNA), that can replicate itself by infecting a host cell

virusoid small piece of RNA associated with larger RNA of some infectious plant viruses

volutin inclusions of polymerized inorganic phosphate; also called metachromatic granules

vulva the female external genitalia

W

water activity water content of foods or other materials

wavelength the distance between one peak of a wave and the next peak

Weil's disease advanced stage of leptospirosis in which the kidney and liver become seriously infected

West African trypanosomiasis chronic form of African trypanosomiasis caused by *Trypanosoma brucei gambiense*

West Nile encephalitis mosquito-borne disease caused by the West Nile virus (WNV) that can result in swelling of the brain and death in severe cases

western blot technique used to detect the presence of a certain protein within a given protein sample in which proteins within the sample are separated by PAGE, immobilized on a membrane, and then exposed first to an antibody that binds to the protein of interest and then second to an antibody equipped with a molecular beacon that will bind to the first antibody

western equine encephalitis serious but rare mosquito-borne viral infection of the brain that is found primarily in the central and western United States

wet mount a slide preparation technique in which a specimen is placed on the slide in a drop of liquid

wheel-flare reaction localized type I hypersensitivity reaction, involving a raised, itchy bump (wheel) and redness (flare), to injected allergen

whooping cough common name for pertussis

wild type phenotype of an organism that is most commonly observed in nature

Winterbottom's sign acute swelling of lymph nodes at the back of the neck that is an early sign of African trypanosomiasis

wobble position third position of a codon that, when changed, typically results in the incorporation of the same amino acid because of the degeneracy of the genetic code

World Health Organization (WHO) international public health organization within the United Nations; monitors and communicates international public health information and coordinates international public health programs and emergency interventions

X

xenobiotic compound synthesized by humans and introduced to an environment in much higher concentrations than expected in nature

xenograft transplanted tissue from a donor that is of a different species than the recipient

X-linked agammaglobulinemia genetic disorder resulting in an inability to produce antibodies

x-y mechanical stage knobs knobs on a microscope that are used to adjust the position of the specimen on the stage surface, generally to center it directly above the light

Y

yeast any unicellular fungus

yeast infection fungal infection of the vagina typically caused by an overgrowth of resident *Candida* spp.

yellow fever mild to potentially fatal mosquito-borne viral disease caused by the yellow fever virus

Z

Ziehl-Neelsen technique a method of acid-fast staining that uses heat to infuse the primary stain, carbolfuchsin, into acid-fast cells

zone of inhibition clear zone around a filter disk impregnated with an antimicrobial drug, indicating growth inhibition due to the antimicrobial drug

zoonosis see *zoonotic disease*

zoonotic disease any disease that is transmitted to humans by animals

zooplankton heterotrophic plankton

Z-scheme electron flow seen in noncyclic photophosphorylation in plants, algae, and cyanobacteria due to the use of both PSI and PSII

zygospores spores used by Zygomycetes for sexual reproduction; they have hard walls formed from the fusion of reproductive cells from two individuals

Answer Key

Chapter 1

1. D 2. D 3. A 4. B 5. C 6. C 7. D 8. A 9. B 10. D 11. C 12. A 13. D 14. B 15. scientific history 16. Lyme 17. fermentation 18. genus, species 19. Protista and Monera 20. Prokaryotes 21. Viruses 22. pathogen 23. helminths 24. virology 25. nucleus

Chapter 2

1. C 2. A 3. D 4. B 5. C 6. D 7. B 8. E 9. D 10. D 11. B 12. refraction 13. compound 14. fluorochromes 15. atomic force microscope 16. 400× 17. acid-fast 18. Gram stain

Chapter 3

1. C 2. D 3. D 4. A 5. C 6. B 7. C 8. C, D 9. A 10. D 11. D 12. D 13. B 14. C 15. D 16. B 17. A 18. False 19. False 20. True 21. spontaneous generation 22. epidemiology 23. miasma 24. Robert Hooke 25. bacilli 26. volutin (or metachromatic granule) 27. hydrogen peroxide 28. actin

Chapter 4

1. B 2. C 3. B 4. A 5. A 6. D 7. C 8. B 9. D 10. A 11. A 12. B 13. B 14. D 15. B 16. True 17. parasitism 18. Eukarya 19. antibiotic 20. ammonia 21. obligate 22. *Helicobacter pylori* 23. Gammaproteobacteria 24. *Treponema pallidum pallidum* 25. purple nonsulfur 26. genus 27. pyogenic 28. high 29. distance 30. common ancestor 31. vents 32. ionizing radiation 33. *Sulfolobus* 34. *Methanobrevibacter oralis*

Chapter 5

1. C 2. C 3. C 4. A 5. C 6. D 7. A 8. B 9. D 10. A 11. C 12. B 13. A 14. B 15. plasmalemma 16. Fungi 17. Trematoda 18. dioecious 19. coenocytic 20. yeasts 21. antibiotics 22. pyrenoids 23. secondary endosymbiosis

Chapter 6

1. B 2. A and B 3. B 4. B 5. C 6. B 7. D 8. D 9. B 10. A 11. B 12. D 13. C 14. D 15. C 16. True 17. bacteriophage 18. complex 19. naked or nonenveloped 20. tail fibers 21. reverse transcriptase 22. eclipse 23. Electron 24. cytopathic effects 25. RNA, helper virus

Chapter 7

1. A 2. D 3. C 4. D 5. E 6. B 7. C 8. D 9. A 10. B 11. D 12. C 13. D 14. A 15. True 16. False 17. True 18. False 19. False 20. False 21. True 22. False 23. C, D, A, B 24. alcohols; fatty acids 25. steroid; double; hydroxyl 26. Primary structure 27. secondary, tertiary, primary 28. fatty acids, methyl esters, gas chromatography

Chapter 8

1. A 2. D 3. B 4. C 5. B 6. B 7. B 8. D 9. C 10. D 11. C 12. D 13. A 14. B 15. D 16. C 17. B 18. B 19. A 20. C 21. A 22. B 23. A 24. D 25. B 26. C 27. A 28. C 29. D 30. False 31. False 32. True 33. False 34. True 35. e; 2. a; 3. d; 4. b; 5. c 36. anabolic 37. oxidation 38. active site 39. 2; 1; 3; 1 40. Embden-Meyerhof 41. cytochrome oxidase 42. ATP synthase 43. yeast (*Saccharomyces cerevisiae*) 44. Heterolactic fermentation 45. glycolysis 46. β -oxidation 47. ATP by oxidative phosphorylation 48. Skim milk agar 49. ribulose biphosphate carboxylase (RuBisCO) 50. chlorophylls and carotenoids 51. carbon dioxide 52. bioremediation

Chapter 9

1. B 2. A 3. C 4. B 5. B 6. C 7. C 8. C 9. D 10. A 11. B 12. A 13. B 14. D 15. C 16. B 17. A 18. B 19. D 20. C 21. C 22. A 23. D 24. C 25. D 26. D 27. D, C, A, B 28. (a) obligate anaerobe, (b) obligate aerobe, (c) microaerophile, (d) facultative anaerobe 29. A, D, E, B, C 30. hemocytometer, Petroff-Hausser counting chamber 31. plate count 32. most probable number 33. turbidity 34. ATP, acid from fermentation 35. alkaliphile

36. acidophile 37. halophile 38. barophiles 39. halotolerant 40. complex, differential 41. complex, selective

Chapter 10

1. D 2. C 3. A 4. B 5. D 6. D 7. C 8. B 9. D 10. A 11. B 12. D 13. C 14. A 15. C 16. A 17. C 18. B 19. C 20. D
21. True 22. False 23. True 24. False 25. True 26. False 27. C, A, B 28. phosphorus 29. protein 30. 5' end
31. horizontal

Chapter 11

1. D 2. B 3. B 4. A 5. D 6. C 7. A 8. C 9. A 10. B 11. B 12. C 13. A 14. B 15. B 16. B 17. C 18. D 19. A 20. B
21. C 22. D 23. A 24. A 25. B 26. C 27. A 28. C 29. False 30. True 31. False 32. True 33. False 34. transcription
35. genotype or genome 36. DNA gyrase or topoisomerase II 37. rolling circle replication 38. polycistronic
39. Spliceosome 40. wobble position 41. aminoacyl-tRNA synthetase 42. nucleoside analog 43. photolyase 44. wild
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Chapter 12

1. D 2. C 3. C 4. C 5. B 6. A 7. C 8. B 9. B 10. C 11. B 12. D 13. false 14. true 15. false 16. true 17. transfection
18. northern 19. denaturation 20. Sanger sequencing, dideoxy method, or chain termination method
21. pharmacogenomics or toxicogenomics 22. reporter gene 23. Adenovirus

Chapter 13

1. A 2. B 3. B 4. D 5. C 6. D 7. C 8. A 9. B 10. A 11. B 12. B 13. C 14. C 15. A 16. C 17. False 18. True 19. False
20. False 21. True 22. noncritical 23. commercial sterilization 24. steam 25. copper, nickel, zinc 26. greater
27. high-level 28. susceptibility or sensitivity

Chapter 14

1. B 2. A 3. B 4. A 5. C 6. D 7. B 8. A 9. C 10. C 11. B 12. D 13. A 14. C 15. A 16. D 17. A 18. A 19. C 20. D
21. D 22. False 23. false 24. true 25. false 26. true 27. actinomycetes 28. *Clostridium difficile* 29. prokaryotic
30. neuraminidase inhibitors 31. nasal 32. Etest

Chapter 15

1. C 2. B 3. A 4. D 5. A 6. C 7. A 8. C 9. A 10. C 11. A 12. D 13. B 14. C 15. illness 16. noncommunicable
17. opportunistic 18. LD₅₀ 19. focal 20. adhesion 21. CD4 22. surface; proteins; sugars 23. protein synthesis
24. shift; drift 25. protease and phospholipase 26. protease

Chapter 16

1. D 2. B 3. D 4. A 5. D 6. D 7. B 8. B 9. D, E, B, A, C 10. C, D, E, B, A 11. C, D, B, A 12. Centers for Disease
Control and Prevention, or CDC 13. Propagated spread 14. point source 15. nosocomial or healthcare-associated
16. vector 17. WHO (World Health Organization)

Chapter 17

1. B 2. A 3. C 4. A 5. D 6. B 7. C 8. B 9. C 10. B 11. D 12. A 13. A 14. C 15. B 16. A 17. C, A, D, B 18. A, C, B
19. peristalsis 20. cilia 21. goblet 22. bacteriocins 23. plasma 24. chemotaxis 25. thrombocytes 26. pluripotent
hematopoietic stem cell (HSC) 27. neutrophils 28. macrophage 29. mast cells 30. extravasation 31. pattern-
recognition receptors (PRRs) 32. granuloma 33. hypothalamus 34. erythema

Chapter 18

1. A 2. B 3. D 4. C 5. A 6. B 7. B 8. B 9. D 10. B 11. A 12. D 13. B 14. C 15. D 16. B 17. D 18. A 19. d, e, c, a, b
20. C, A, B, D 21. memory 22. Humoral 23. constant 24. antigen-binding 25. presentation 26. β_2 microglobulin
27. cytotoxic 28. helper 29. variable 30. thymus 31. memory 32. T-dependent 33. repetitive 34. attenuated

35. Artificial passive 36. variolation

Chapter 19

1. B 2. A 3. A 4. A 5. C 6. A 7. B 8. D 9. C 10. D 11. A 12. B 13. C 14. C 15. A 16. B, D, A, C 17. IgE 18. IgG 19. B 20. IV 21. thyroid-stimulating hormone receptor 22. MHC 23. graft-versus-host 24. genetic 25. acquired 26. preventive 27. therapeutic

Chapter 20

1. A 2. A 3. A 4. D 5. B 6. B 7. A 8. D 9. D 10. A 11. D 12. A 13. D 14. B 15. D 16. B 17. A 18. affinity maturation 19. humanized 20. neutralizing antibodies 21. epitopes 22. equivalence zone or zone of equivalence 23. antiserum 24. patient serum 25. immunoglobulins/antibodies and/or complement 26. indirect ELISA 27. laser 28. fragments

Chapter 21

1. C 2. B 3. A 4. D 5. C 6. A 7. A 8. B 9. C 10. A 11. A 12. B 13. C 14. B 15. A 16. A 17. C 18. A 19. A 20. stratum corneum 21. conjunctiva 22. pus 23. roseola 24. sporotrichosis 25. loiasis 26. cornea

Chapter 22

1. C 2. A 3. B 4. C 5. A 6. D 7. A 8. C 9. A 10. C 11. D 12. A 13. D 14. B 15. C 16. B 17. D 18. A 19. C 20. D 21. mucociliary escalator 22. capsules 23. IgA 24. Laryngitis 25. Alveolar macrophages 26. Ghon complexes 27. otitis media 28. quellung reaction 29. Psittacosis 30. erythrogenic toxin 31. rubella 32. cytokine storm 33. acyclovir 34. antigenic drift 35. MMR 36. spherules 37. capsule 38. aspergillomas 39. the desert southwest 40. arthrospores

Chapter 23

1. C 2. D 3. A 4. B 5. C 6. B 7. A 8. C 9. C 10. A 11. D 12. C 13. A 14. *Lactobacillus* 15. kidneys 16. chancroid 17. warts 18. *C. albicans* 19. *Trichomonas vaginalis* 20. vaginosis 21. An STI is a broader term, including colonization by organisms that may not necessarily cause disease.

Chapter 24

1. D 2. A 3. B 4. C 5. C 6. B 7. C 8. C 9. B 10. A 11. D 12. D 13. C 15. B 16. A 17. Large intestine or colon 18. tartar 19. *Clostridium difficile* 20. bilirubin 21. giardia 22. bile

Chapter 25

1. D 2. C 3. B 4. B 5. B 6. D 7. C 8. A 9. C 10. B 11. A 12. D 13. A 14. C 15. A 16. petechiae 17. the subclavian veins 18. bull's eye-rash 19. Septic shock 20. Burkitt lymphoma 21. Arboviruses 22. Epstein-Barr virus 23. *Anopheles* 24. Chagas disease 25. swimmer's itch

Chapter 26

1. C 2. A 3. B 4. D 5. D 6. B 7. B 8. C 9. D 10. C 11. D 12. A 13. C 14. D 15. A 16. C 17. C 18. A 19. B 20. D 21. A 22. D, C, A, B 23. soma 24. axon 25. subarachnoid space 26. blood-brain barrier 27. meninges 28. *Neisseria meningitidis* 29. tetanospasmin 30. Hansen's disease 31. acetylcholine 32. Tetanus 33. opisthotonos 34. PrP^{Sc} 35. Dogs 36. Jonas Salk 37. Chronic wasting disease 38. beta sheet 39. capsule 40. Amphotericin B 41. cysticerci 42. Winterbottom's 43. West 44. cats 45. antigenic

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