GLOSSARY

A

A site See **acceptor site** .

ABC transporter An ATP-powered transport system that contains an ATP-binding cassette.

aberration An imperfection in a lens.

abiotic Produced without living organisms; occurring in the absence of life.

abortive infection A class of antiphage defenses that kill the host cell before the phage can complete replication.

absorption In optics, the capacity of a material to absorb light.

acceptor site (A site) The region of a ribosome that binds an incoming charged tRNA.

accessory protein A protein found in the viral capsid or tegument that is needed early in the viral life cycle.

acid-fast stain A diagnostic stain for mycobacteria, which retain the dye fuchsin because of mycolic acids in the cell wall.

Acidobacteria (Acidobacteriota) A phylum of Gram-negative bacteria with an outer membrane, related to the Proteobacteria; often found in soil habitats.

acidophile An organism that grows fastest in acid (generally defined as below pH 5).

ACP See **acyl carrier protein** .

acquired immunodeficiency syndrome (AIDS) A disease caused by HIV that leads to the destruction of T cells and the inability to fight off opportunistic infections.

actin filament See **microfilament** .

Actinobacteria (Actinomycetota) A phylum of Gram-positive bacteria with high GC content.

actinomycete A member of the Actinomycetales, an order of Actinobacteria that includes branched spore formers such as *Streptomyces* , as well as irregularly shaped corynebacteria.

activated sludge See **floc** .

activation energy (E_a) The energy needed for reactants to reach the transition state between reactants and products.

activator A regulatory protein that can bind to a specific DNA sequence and increase transcription of genes.

active transport An energy-requiring process that moves molecules across a membrane against their electrochemical gradient.

acyl carrier protein (ACP) A protein that can carry an acetyl group for anabolic pathways such as fatty acid synthesis.

adaptive immunity Immune responses activated by a specific antigen and mediated by B cells and T cells.

ADCC See **antibody-dependent cell-mediated cytotoxicity** .

addressin A tissue-specific protein that is selectively present on vascular endothelial cells in different tissues.

adenosine triphosphate (ATP) A ribonucleotide with three phosphoryl groups and the base adenine. It has many functions in the cell, including precursor for RNA synthesis and energy carrier.

adenylate cyclase An enzyme that converts ATP into cyclic adenosine monophosphate (cAMP).

adhesin Any cell-surface factor that promotes attachment of an organism to a substrate.

ADP-ribosyltransferase A bacterial toxin that enzymatically transfers the ADP-ribose group from NAD^+ to target proteins, altering the target protein's structure and function.

aerial mycelium A mass of hyphae (branched filaments) that extend above the surface and produce spores at the tips.

aerobe An organism that grows only in the presence of oxygen.

aerobic respiration The use of oxygen as the terminal electron acceptor in an electron transport chain. A proton gradient is generated and used to drive ATP synthesis.

aerosol Water droplets suspended in air, of size 5 μm or smaller. The term also refers to suspension of dust or volcanic ash.

aerotolerant anaerobe An organism that does not use oxygen for metabolism but can grow in the presence of oxygen.

affinity chromatography A chromatographic technique that uses the ability of biological molecules to bind to certain ligands specifically and reversibly.

affinity maturation The process by which the antigen-binding site of an antibody gains increased affinity for its target antigen or epitope.

AFM See **atomic force microscopy** .

agar A polymer of galactose that is used as a gelling agent.

AIDS See **acquired immunodeficiency syndrome** .

Aigarchaeota A phylum of archaea in the TACK superphylum that contains filamentous aerobic hyperthermophiles in hot springs.

airborne transmission In disease, the transfer of a pathogen via dust particles or on respiratory droplets produced when an infected person sneezes or coughs.

air recirculation The passage of air through a filter followed by return to the source.

alcoholic fermentation See **ethanolic fermentation** .

alga *pl.* algae A microbial eukaryote that contains chloroplasts.

algal bloom An overgrowth of algae on the water surface, caused by an increase in a limiting nutrient.

alkaline fermentation Bacterial fermentation in conjunction with proteolysis and amino acid catabolism that generates ammonia in amounts that raise pH.

alkaliphile An organism that grows fastest in alkali (generally defined as above pH 9).

allergen An antigen that causes an allergic hypersensitivity reaction.

allosteric site A regulatory site on a biological molecule distinct from the ligand/substrate-binding site.

allotype An amino acid difference in the antibody constant region that distinguishes different individuals within a species.

alpha diversity The species richness, as measured by the average number of different species in a number of samples from a specific community.

Alphaproteobacteria A class of Proteobacteria (Pseudomonadota) that includes, for example, rhizobia and rickettsias.

alternation of generations A life cycle that alternates between populations of haploid cells and diploid cells, which undergo meiosis and fertilization.

alternative sigma factor A sigma factor, distinguished from the housekeeping sigma factor, sigma-70, that has a distinct promoter consensus sequence to which it binds. Genes under control of an alternative sigma factor typically protect the cell from environmental stresses, such as heat shock or starvation.

alveolar macrophage A type of macrophage, located in the lung alveoli, that phagocytoses foreign material.

alveolate A member of the eukaryotic group Alveolata—ciliated or flagellated protists with complex cortical structure.

ameba or amoeba A protist that moves via pseudopods.

amensalism An interaction between species that harms one partner but not the other.

amino acid The monomer unit of proteins. Each amino acid contains a central carbon covalently bonded by a hydrogen, an amino group, a carboxyl group, and a side chain. An exception is proline, in which the side chain is cyclized with the central carbon.

aminoacyl-tRNA synthetase An enzyme that condenses a specific amino acid with the 3′ OH group of the correct tRNA, thereby charging the tRNA.

ammonification The generation of ammonia from organic nitrogen.

amoeba See **ameba** .

amphibolic Describing a metabolic pathway that is reversible and can be used for both catabolism and anabolism.

amphipathic Having both hydrophilic and hydrophobic portions.

amphotericin B An antifungal drug that binds the fungus-specific sterol ergosterol and destroys membrane integrity.

amplicon A specific PCR product in which a small DNA sequence is amplified (many copies are synthesized).

anabolism See **biosynthesis** .

anaerobe An organism that grows in an environment lacking oxygen.

anaerobic Lacking oxygen.

Anaerobic Methane-Oxidizing Euryarchaeota (ANME) ***or*** **anaerobic methane oxidizers** A group of archaea in the superphylum Euryarchaeota that oxidize methane. Some, such as the *Methanoperedenaceae* , oxidize methane independently

whereas others oxidize methane syntrophically with sulfate-reducing bacteria (SRB).

anaerobic respiration The use of a molecule other than oxygen as the final electron acceptor of an electron transport chain.

anammox reaction The anaerobic oxidation of ammonium to nitrogen gas, using nitrite as electron acceptor; yields energy.

anaphylaxis A severe type I hypersensitivity reaction caused by chemically induced contraction of smooth muscles and dilation of capillaries.

anaplerotic reaction A type of metabolic reaction, occurring in all organisms, that fixes small amounts of CO_2 to regenerate TCA cycle intermediates.

angle of aperture The width of a light cone (theta, θ) that projects from the midline of a lens. Greater angles of aperture increase resolution.

anion A negatively charged ion.

ANME See **Anaerobic Methane-Oxidizing Euryarchaeota** .

annotation The deciphering of genome sequences, including identification of genes and prediction of gene function.

antenna complex A complex of chlorophylls and accessory pigments in the photosynthetic membrane that collects photons and funnels them to a reaction center.

anti-anti-sigma factor A protein that inhibits an anti-sigma factor, allowing the target sigma factor to participate in initiating transcription.

anti-attenuator stem loop An mRNA secondary structure whose formation prevents assembly of a downstream transcriptional termination (attenuator) stem loop. The anti-attenuator stem loop structure permits transcription of the downstream structural genes.

antibiotic A molecule that can kill or inhibit the growth of selected microorganisms.

antibody A host defense protein produced by B cells in response to a specific antigenic determinant. Antibodies, a type of immunoglobulin, bind to their corresponding antigenic determinants.

antibody-dependent cell-mediated cytotoxicity (ADCC) The process by which natural killer cells destroy antibody-coated host cells that are infected by a virus.

antibody tag The attachment of a stain to an antibody to visualize cell components recognized by the antibody with high specificity.

anticodon A set of three nucleotides in the middle loop of a tRNA that base-pairs with a codon in mRNA.

antigen A compound, recognized as foreign by the cell, that elicits an adaptive immune response. See also **immunogen** .

antigen-presenting cell (APC) An immune cell that can process antigens into antigenic determinants and display those determinants on the cell surface for recognition by other immune cells.

antigenic determinant Also called *epitope* . A small segment of an antigen that is capable of eliciting an immune response. An antigen can have many different antigenic determinants.

antigenic shift A major genetic alteration in a virus that results in a new pandemic strain.

antimicrobial agent A chemical substance that can kill microbes or slow their growth.

antiparallel Oriented such that the two strands are in opposite directions. Commonly refers to a nucleic acid double helix with one strand in the 5′-to-3′ orientation and the other strand in the 3′-to-5′ orientation.

antiport Coupled transport in which the molecules being transported move in opposite directions across the membrane.

antiretroviral therapy (ART) A three-drug antiretroviral cocktail that is highly effective at inhibiting the replication of HIV in patients.

antisepsis The removal of pathogens from living tissues.

antiseptic Describing a chemical that kills microbes. Also, the chemical itself.

anti-sigma factor A protein that inhibits a specific sigma factor, preventing transcription initiation.

AP site See **apurinic site** .

APC See **antigen-presenting cell** .

apicomplexan A member of the eukaryotic group Apicomplexa—parasitic alveolates that possess an apical complex used for entry into a host cell.

apoptosis A cell death program triggered during tissue differentiation or in certain damaged or infected cells.

apurinic site A DNA site missing a purine base because the bond linking the base to the sugar has been hydrolyzed. Also called **AP site** .

Aquificae (Aquificota) A phylum of hyperthermophilic bacteria.

arbuscular mycorrhizae Also called *vesicular-arbuscular mycorrhizae* or *endomycorrhizae* . Mutualistic associations between plant roots and certain fungi, involving hyphal penetration of plant root cells.

Archaea One of the three domains of life, consisting of organisms with a last common ancestor not shared with members of Bacteria or Eukarya. Organisms are prokaryotic (lacking nuclei, unlike eukaryotes) and possess ether-linked phospholipid membranes (unlike bacteria).

Archean eon The second eon (major time period) of Earth's existence, from 4.0 gigayears (Gyr, 10^9 years) to 2.5 Gyr before the present. The earliest geological evidence for life dates to this eon.

archaellum *pl.* archaella A rotary complex for motility in archaea, analogous to the bacterial flagellum.

archaeon *pl.* archaea A prokaryotic organism that is a member of the domain Archaea, distinct from bacteria (domain Bacteria) and eukaryotes (domain Eukarya).

Archaeplastida See **Plantae** .

aromatic Describing a planar, unsaturated, ring-shaped organic molecule whose bonding electrons are delocalized equally around the ring.

ART See **antiretroviral therapy** .

artifact A structure viewed through a microscope that is incorrectly interpreted.

ascomycete A member of the eukaryotic group Ascomycota—fungi whose mycelia form paired nuclei. Haploid ascospores are produced in pods called asci.

ascospore The spore produced by an ascomycete fungus.

ascus *pl.* asci A spore-containing pod produced by ascomycete fungi.

aseptic Free of microbes.

asexual reproduction Reproduction of a cell by fission or by mitosis to form identical daughter cells.

asRNA See ***cis* -antisense RNA** .

assembly 1. In a virus, the packaging of a viral genome into the capsid to form a complete virion. 2. In metagenomics, the piecing together of DNA sequence reads into contigs, and of contigs into a scaffold.

assimilation An organism's acquisition of an element, such as carbon from CO_2, to build into body parts.

assimilatory nitrate reduction The uptake of nitrate and reduction to NH_4^+ by plants, fungi, archaea, and bacteria for use in biosynthetic pathways.

asymptomatic carrier Person or animal that lacks symptoms of a disease despite being infected and can unknowingly transmit that pathogen to others.

atomic force microscopy (AFM) A technique that maps the 3D topography of a object using van der Waals forces between the object and a probe.

atomic mass The mass (in grams) of 1 mole of an element.

atomic number The number of protons in an atom; it is unique for each element.

ATP See **adenosine triphosphate** .

ATP synthase A protein complex that synthesizes ATP from ADP and inorganic phosphate using energy derived from the transmembrane proton potential. It is located in the prokaryotic cell membrane and in the mitochondrial inner membrane.

attenuator stem loop Also called *terminator stem loop* . An intramolecular mRNA structure consisting of a base-paired stem connected by a single-stranded loop. The stem loop structure causes transcription to terminate. Its formation requires efficient translation of a leader peptide sequence.

autoclave A device that uses pressurized steam to sterilize materials by raising the temperature above the boiling point of water at standard pressure.

autofluorescence Fluorescence of living cells with no added fluorophore.

autoimmune response A pathology caused by lymphocytes that can react to self antigens.

autoinducer A secreted molecule that induces quorum-sensing behavior in bacteria.

autoinduction A mode of gene regulation independent of outside intervention, involving the conditioning of the medium by the cells. Usually refers to quorum-sensing control mediated by secreted autoinducer molecules.

autophagy Eukaryotic cell function normally used to degrade damaged organelles. Also used to kill intracellular pathogens.

autoradiography The visualization of a radioactive probe by exposing the probed material to X-ray film and then photographically developing the film.

autotrophy The metabolic reduction of carbon dioxide to produce organic carbon for biosynthesis.

auxotrophic Describing a mutant state in which the cell has lost the ability to synthesize a substance required for growth. An auxotroph has a nutritional requirement not shared by the parent.

azidothymidine (AZT) A nucleotide analog that inhibits reverse transcriptase and was the first drug clinically used to fight HIV infections.

AZT See **azidothymidine** .

B

B cell An adaptive immune cell, developed in bone marrow tissue, that can give rise to antibody-producing cells.

B-cell receptor (BCR) A B-cell membrane protein complex containing an antibody in association with the Igα and Igβ immunoglobulins.

B-cell tolerance The exposure of B cells to a high antigen dose, preventing future antibody production against that antigen.

bacillus *pl.* bacilli A rod-shaped bacterial or archaeal cell.

bacitracin A topical antibiotic that affects cell wall synthesis.

bacteremia A bacterial infection of the blood.

Bacteria One of the three domains of life, consisting of organisms with a last common ancestor not shared with members of Archaea or Eukarya. Organisms are prokaryotic (lacking nuclei, unlike eukaryotes) and possess primarily ester-linked phospholipid membranes (like eukaryotes, unlike archaea).

bactericidal Having the ability to kill bacterial cells.

bacteriochlorophyll The chlorophyll of anaerobic phototrophic bacteria; it absorbs photons most strongly in the far-red end of the light spectrum.

bacteriophage Also called *phage* . A virus that infects bacteria.

bacteriorhodopsin A haloarchaeal membrane-embedded protein that contains retinal and acts as a light-driven proton pump; it is homologous to the bacterial proteorhodopsin.

bacteriostatic Having the ability to inhibit the growth of bacterial cells.

bacterium *pl.* bacteria A prokaryotic organism that is a member of the domain Bacteria, distinct from archaea (domain Archaea) and eukaryotes (domain Eukarya).

bacteroid A cell wall–less, undividing, differentiated rhizobial cell within a plant cell. The bacteroid provides fixed nitrogen for the plant.

Bacteroidetes (Bacteroidota) A phylum of Gram-negative bacteria; nearly all members are obligate anaerobes.

banded iron formation (BIF) A geological formation containing layers of oxidized iron (Fe^{3+}), which indicates formation

under oxygen-rich conditions.

barcoding The use of a short DNA sequence, such as the gene for SSU rRNA, to identify single taxa.

barophile Also called *piezophile* . An organism that requires high pressure to grow.

base excision repair (BER) A DNA repair mechanism that cleaves damaged bases off the sugar-phosphate backbone. After endonuclease activity at the AP site, a new, correct DNA strand is synthesized complementary to the undamaged strand.

basic reproduction number R_0 The average number of infections resulting from a single infected person in a population with no immunity.

basidiomycete A member of the eukaryotic group Basidiomycota—fungi that form mushrooms.

basidiospore A haploid spore formed by a basidiomycete through meiosis of a basidium, a reproductive cell of a mushroom.

basophil A white blood cell, stained by basic dyes, that secretes compounds that aid innate immunity.

batch culture The growth of bacteria in a closed system without additional input of nutrients.

Bathyarchaeota A phylum of thermophilic archaea in the TACK superphylum, widely distributed in anoxic soil, water, and marine sediments.

BCR See **B-cell receptor** .

benthic organism An organism that lives on the ocean floor or within the sediment.

BER See **base excision repair** .

Betaproteobacteria A class of Proteobacteria (Pseudomonadota) that includes, for example, species of *Neisseria* and *Burkholderia* .

BIF See **banded iron formation** .

bin A set of sequences composed from metagenomic DNA reads showing a given level of similarity; each bin defines an operational taxonomic unit.

binary fission The process of replication in which one cell divides to form two genetically equivalent daughter cells of equal size.

binning The sorting of metagenomic sequences into taxonomic bins.

biochemical oxygen demand (BOD) Also called *biological oxygen demand* . The amount of oxygen removed from an environment by aerobic respiration.

biocontrol Use of a beneficial organism to control a harmful organism.

biofilm A community of microbes growing on a solid surface.

biogenic Formed by living organisms.

biogeochemical cycle The recycling of elements needed for life (such as carbon or nitrogen) through the biotic and abiotic components of the biosphere.

biogeochemistry Also called *geomicrobiology* . The metabolic interactions of microbial communities with the abiotic (mineral) components of their ecosystems.

bioinformatics A discipline at the intersection of biology and computing that analyzes gene and protein sequence data.

biological carbon pump The fixation of carbon dioxide by phototrophs and gravitational settling of biomass particles within the oceans.

biological oxygen demand See **biochemical oxygen demand** .

biological signature See **biosignature** .

biomass The mass found in the bodies of living organisms.

bioprospecting The search for organisms with potential commercial applications.

bioremediation The use of microbes to detoxify environmental contaminants.

biosignature Also called *biological signature* . A type of chemical believed to be formed only by specific life processes.

biosphere The region containing the sum total of all life on Earth.

biosynthesis Also called *anabolism* . The building of complex biomolecules from smaller precursors.

biotic Caused by living organisms.

black smoker An oceanic thermal vent containing high concentrations of dark minerals such as iron sulfide.

blood-brain barrier A selectively permeable membrane made up of tightly packed capillaries that supply blood to the brain and spinal cord. Large molecules and most pathogens cannot permeate the narrow spaces. Fat-soluble (lipophilic) molecules and oxygen can dissolve through the capillary cell membranes and are absorbed into the brain.

BOD See **biochemical oxygen demand** .

borreliosis Any of a variety of diseases caused by *Borrelia* species and transmitted by ticks or lice. Lyme disease is a form of borreliosis.

botulism A food-borne disease caused by a *Clostridium botulinum* toxin, involving muscle paralysis.

bradykinin A cell signaling molecule that promotes extravasation, activates mast cells, and stimulates pain perception.

branch A lineage of organisms that share a common ancestor.

Braun lipoprotein See **murein lipoprotein** .

bright-field microscopy A type of light microscopy in which the specimen absorbs light and appears dark against a light background.

bubonic plague A disease caused by the bacterium *Yersinia pestis* ; it is characterized by swollen lymph nodes that often turn black.

budding A form of reproduction in which mitosis of the mother cell generates daughter cells of unequal size.

built environment Buildings and other human-built constructs that humans inhabit or use for work and recreation.

burst See **lysis** .

burst size The number of virus particles released from a lysed host cell.

C

c-di-GMP Bis-(3′-5′)-cyclic dimeric guanosine monophosphate; a second messenger molecule that plays a key role in regulating biofilm formation.

C-reactive protein A peptide that stimulates the complement cascade, induced by cytokines in the liver. Elevated levels in the blood are associated with inflammatory processes such as heart disease.

calorimeter A device used to measure the amount of heat released or absorbed during a reaction.

Calvin cycle *or* Calvin-Benson cycle *or* Calvin-Benson-Bassham (CBB) cycle Also called *pentose phosphate cycle* or *reductive pentose phosphate cycle* . The metabolic pathway of carbon fixation in which the CO_2 -condensing step is catalyzed by Rubisco. Found in chloroplasts and in many bacteria.

Candidate Phyla Radiation (CPR) A recently described group of bacterial phyla whose members represent broad genetic diversity but small genome size and limited metabolic capabilities.

candidate species A newly described microbial isolate that may become accepted as an official species.

cannula *pl.* cannulae A narrow tubule. For *Pyrodictium* species, glycoprotein cannulae interconnect cells at their periplasm.

cannulated cow See **fistulated cow** .

capping The clustering of B-cell receptor molecules on the surface of B cells after binding antigens or epitopes.

capsid The protein shell that surrounds a virion's nucleic acid. Within an enveloped virus, such as HIV, the capsid may be called a *core particle* .

capsule A slippery outer layer composed of polysaccharides that surrounds the cell envelope of some bacteria.

carbon-concentrating mechanism (CCM) The inducible expression of transporters of CO_2 and bicarbonate (HCO_3^-) into carboxysomes to enhance CO_2 levels near Rubisco.

carbon dioxide fixation The enzymatic reduction and covalent incorporation of inorganic carbon dioxide (CO_2) into an organic compound.

carbon sequestration In environmental science, the fixation of carbon into biomass, resulting in removal of a greenhouse gas from the atmosphere.

carboxysome A protein-enclosed compartment containing Rubisco to fix CO_2 .

cardiolipin Diphosphatidylglycerol, a double phospholipid linked by glycerol.

carotenoid An accessory photosynthetic pigment that absorbs photons in the green wavelengths of the spectrum.

catabolism The cellular breakdown of large molecules into smaller molecules, releasing energy.

catabolite repression The inhibition of transcription of an operon encoding catabolic proteins in the presence of a more favorable catabolite, such as glucose.

catabolites The products of catabolism, usually excreted from the cell.

catalytic domain 1. Also called *catalytic site* . The portion of an enzyme that performs catalysis. 2. The A subunit of a toxin, which carries the ADP-ribosyltransferase activity.

catalytic RNA Also called *ribozyme* . An RNA molecule that is capable of catalyzing reactions.

catalytic site See **catalytic domain** (definition 1).

catenane A pair of linked rings of DNA that occurs as a by-product of replication of circular chromosomes.

cation A positively charged ion.

CBB cycle See **Calvin cycle** .

CCM See **carbon-concentrating mechanism** .

CCR See **chemokine receptor** .

cell fractionation A procedure to separate cell components that often includes ultracentrifugation.

cell-mediated (cellular) immunity A type of adaptive immunity employing mainly T-cell lymphocytes.

cell membrane Also called *cytoplasmic membrane* or *plasma membrane* . The phospholipid bilayer that encloses the cytoplasm.

cell sorting The separation and collection of classes of cells using fluorescent markers, as detected by flow cytometry.

cell-surface receptor A transmembrane protein that senses a specific extracellular signal and may be the docking site for a

specific virus.

cell wall A rigid structure external to the cell membrane. The molecular composition depends on the organism; in bacteria, it is composed of peptidoglycan.

cellular slime mold A slime mold in which the individual bacterial cells retain their own cell membranes; not a fungus.

cellulitis A spreading infection (with inflammation) of connective tissue just below the skin.

CFTR See **cystic fibrosis transmembrane conductance regulator** .

chain of infection The serial passage of a pathogenic organism from an infected individual to an uninfected individual, thus transmitting disease.

chancre A painless, hard lesion due to an inflammatory reaction at the site of infection by *Treponema pallidum* , the causative agent of syphilis.

chaperone or chaperonin A protein that helps other proteins fold into their correct tertiary structure.

cheddared curd Curd that has been cut and piled in order to remove the liquid whey.

cheese A solid or semisolid food product prepared by coagulating milk proteins, forming curd. Its production commonly involves microbial fermentation.

chemical imaging microscopy A method of microscopy that maps the distribution of specific elements or chemicals within a sample.

chemiosmotic theory A theory stating that the products of oxidative metabolism store their energy in an electrochemical gradient that can drive cellular processes such as ATP synthesis.

chemoautotrophy See **chemosynthesis** .

chemoheterotrophy See **organotrophy** .

chemokine An attractant for white blood cells that is produced by damaged tissues.

chemokine receptor (CCR) A human T-cell membrane protein that binds chemokine hormones but is also used by HIV for attachment and infection.

chemolithoautotrophy Metabolism in which single-carbon compounds are fixed into organic biomass, using energy from chemical reactions without light absorption.

chemolithotrophy See **lithotrophy** .

chemoorganoheterotrophy A form of metabolism that uses organic carbon sources to obtain energy and build biomass. Also called *heterotrophy* .

chemoorganotrophy See **organotrophy** .

chemoreceptor See **methyl-accepting chemotaxis protein** .

chemostat A continuous culture system in which the introduced medium contains a limiting nutrient.

chemosynthesis The fixation of single-carbon molecules (usually carbon dioxide) into organic biomass, using energy from oxidation of inorganic electron donors. Also called *chemoautotrophy* .

chemotaxis The ability of organisms to move toward or away from specific chemicals.

chemotrophy Metabolism that yields energy from oxidation-reduction reactions without using light energy.

chimeric antigen receptor T-cell therapy (CAR-T therapy) CAR-T therapy uses a lentivector to modify the T cells of a cancer patient. The CAR (chimeric antigen receptor) gene enables T cells to recognize malignant B cells and destroy them.

ChIP See **chromatin immunoprecipitation** .

ChIP sequencing (ChIP-seq) A procedure that scans a genome for all DNA sequences capable of binding to a specific DNA-binding protein.

chiral carbon A carbon bonded to four different types of functional groups. A molecule with a chiral carbon can thus take two different forms that exhibit mirror symmetry.

chlamydia 1. A pathogenic bacterium lacking a cell wall; chlamydias (or chlamydiae) grow within human or animal cells, transmitting as elementary bodies to other cells. 2. A disease caused by chlamydia cells. The most frequently reported sexually transmitted disease in the United States. Symptoms range from none, to a burning sensation upon urination, to sterility.

Chlamydiae (Chlamydiota) A phylum of intracellular parasitic bacteria that grow only within a host cell and generate multiple spore-like structures that escape to infect the next host.

chloramphenicol A bacteriostatic antibiotic that acts by inhibiting peptidyltransferase activity of the bacterial ribosome.

Chlorobi (Chlorobiota) A phylum of Gram-negative bacteria. They are obligate anaerobes, "green sulfur" phototrophs that photolyze sulfides or H_2.

Chloroflexi (Chloroflexota) A phylum of bacteria that are filamentous phototrophs having chlorosomes.

chlorophyll A magnesium-containing porphyrin pigment that captures light energy at the start of photosynthesis.

chlorophyte See **green alga**.

chloroplast An organelle of endosymbiotic origin (sharing descent with cyanobacteria) that conducts oxygenic photosynthesis; found in algae and plant cells.

chlorosome A membranous photosynthetic organelle found in some "green" bacteria of the phyla Chloroflexi and Chlorobi.

cholesterol A sterol lipid found in eukaryotic cell membranes.

chromatin Chromosomal DNA complexed with proteins. Usually refers to a eukaryotic chromosome.

chromatin immunoprecipitation (ChIP) An experimental method used to determine the DNA-binding sites on a chromosome to which a DNA protein binds.

chromophore A light-absorbing redox cofactor.

chronic inflammation Inflammation that has persisted over long periods of time, usually months or years.

chrysophyte A member of the eukaryotic group Chrysophyceae (also known as "golden algae")—flagellated heterokont protists possessing chloroplasts as secondary endosymbionts.

ciliate An alveolate that has paired cilia.

cilium *pl.* cilia A short, hairlike structure of eukaryotes that is structurally similar to the prokaryotic flagellum. Cilia beat in waves to propel the cell.

circadian clock From the Latin *circa* ("about") and *dies* ("day"). A regulatory machine akin to a clock that controls cellular activity as a function of time of day.

***cis* -antisense RNA (asRNA)** Noncoding RNA from transcription of a DNA sequence complementary to the template strand of a gene that encodes a protein. A *cis* -antisense RNA binds and regulates the coding transcript made from the template strand of the gene. These regulatory RNAs can stop transcription, promote transcript degradation, or prevent translation.

clade Also called *monophyletic group* . A group of organisms that includes an ancestral species and all of its descendants.

class I MHC molecule A membrane surface protein on all nucleated cells of the human body (absent from red blood cells and platelets) that present intracellular foreign antigen epitopes to cytotoxic T cells.

class II MHC molecule A membrane surface protein on antigen-presenting cells (dendritic cells, macrophages) and lymphocytes that present phagocytosed extracellular foreign antigen epitopes to helper T cells.

class switching See **isotype switching** .

classical complement pathway An antibody-mediated pathway for complement activation.

classification The recognition of different forms of life and their placement into different categories.

clonal selection The rapid proliferation of a subset of B cells during the primary or secondary antibody response.

clone A population of organisms possessing identical genomes.

cloning The insertion of DNA into a plasmid where it can be replicated.

CoA See **coenzyme A** .

coastal shelf Shallow regions of the ocean, less than 200 meters deep, that are adjacent to land.

coccolithophore Marine secondary algae of the Haptista, possessing round scales of calcium carbonate.

coccus *pl. cocci* A spherically shaped bacterial or archaeal cell.

codon A set of three nucleotides that encodes a particular amino acid.

coenzyme A (CoA) A nonprotein cellular organic molecule that can carry acetyl groups and participates in metabolism.

coevolution The evolution of two species in response to one another.

cofactor A metallic ion or a coenzyme required by an enzyme to perform normal catalysis.

colony A visible cluster of microbes on a plate, all derived from a single founding microbe. Usually consists of a **clone** , except for infrequent mutations.

commensalism An interaction between two different species that benefits only one partner.

community The sum of all populations of organisms interacting within an ecosystem.

compatible solute A small molecule that does not disrupt normal cell metabolism even at high intracellular concentrations.

competent Able to take up DNA from the environment.

complement Innate immunity proteins produced by the liver; they circulate in the blood, where they can form holes in bacterial membranes, killing the bacteria.

complex medium Also called *rich medium* . A nutrient-rich growth solution including undefined chemical components such as beef broth.

compound microscope A microscope with multiple lenses to compensate for lens aberration and increase magnification.

compromised host An animal with a weakened immune system.

computational pipeline A linear series of programs that combine mathematical tools with biological assumptions to interpret genetic sequences.

concatemer A long line of tandemly repeated genomes; commonly formed during rolling-circle replication.

condensation In biochemistry, the joining of two molecules to form a covalent bond, releasing a water molecule.

condenser In a microscope, a lens that focuses parallel light rays from the light source onto a small area of the specimen to improve the resolution of the objective lens.

confluent Describing a mode of growth that results in a lawn of organisms completely covering a surface.

confocal laser scanning microscopy *or* confocal microscopy A type of fluorescence microscopy in which the excitation light from a laser and the emitted light from the specimen are focused together, producing high-resolution images.

congenital syphilis Syphilis contracted in utero.

conjugation Horizontal gene transfer involving cell-to-cell contact. In bacteria, pili draw together the donor and recipient cell envelopes, and a protein complex transmits DNA across. In ciliated eukaryotes, a conjugation bridge forms between two cells connecting their cytoplasm, through which micronuclei are exchanged.

conjugative transposon A transposon that can be transferred from one cell to another via conjugation.

consensus sequence A sequence of nucleotides or amino acids with a common function at many nucleic acid or protein positions. Consists of the base pair or amino acid most frequently found at each position in the sequence.

constant region The region of an antibody that defines the class of a heavy chain or a light chain.

constructed wetland A built environment designed to provide environmental services comparable to those of natural wetlands.

consumer An organism that acquires nutrients from producers, either directly or indirectly.

contig A sequence of overlapping fragments of cloned DNA that are contiguous along a chromosome.

continuous culture A culture system in which new medium is continuously added to replace old medium.

contractile vacuole An organelle in eukaryotic microbes that pumps water out of the cell.

contrast Differential absorption or reflection of electromagnetic radiation between an object and a background that allows the object to be distinguished from the background.

coral bleaching The death or expulsion of coral algal symbionts. One cause is an increase in temperature.

core genome A set of genes shared by a group of related bacterial strains, showing stable inheritance.

core particle A viral capsid that encloses its nucleic acid genome and is surrounded by an envelope.

coreceptor A cell-surface receptor needed for viral entry along with a primary receptor.

corepressor A small molecule that must bind to a repressor to allow the repressor to bind operator DNA.

cortical alveolus One of the vesicles that forms a network in the outer covering of an alveolate protist.

counterstain A secondary stain used to visualize cells that do not retain the first stain.

coupled transport The movement of a substance against its electrochemical gradient (from lower to higher concentration or from opposite charge to like charge) using the energy provided by the simultaneous movement of a different chemical down its electrochemical gradient.

covalent bond A chemical bond in which two atoms share a pair of electrons.

CPR See **Candidate Phyla Radiation** .

CRISPR Clustered regularly interspaced short palindromic repeats. CRISPR consists of short repeated DNA sequences in a bacterial or archaeal genome, derived from previous bacteriophage or viral infection and conferring protection from future infection; considered a prokaryotic "immune system." In biotechnology, provides a means of editing the human genome.

cross-bridge An attachment that links parallel molecules, such as the peptide link between glycan chains in peptidoglycan.

cryo-electron microscopy (cryo-EM) Also called *electron cryomicroscopy* . Electron microscopy in which the sample is cooled rapidly in a cryoprotectant medium that prevents freezing. The sample does not need to be stained.

cryo-electron tomography Also called *electron cryotomography* . A method of cryo-electron microscopy in which the electron beam generates multiple views in parallel planes through the specimen.

cryptogamic crust A low-growing desert ground cover composed of cyanobacteria, lichens, and nonlichenous algae, fungi, and mosses.

curd Coagulated milk proteins produced by the combined action of lactic acid–producing bacteria and stomach enzymes of certain mammals, such as cattle.

Cyanobacteria or Cyanophyta A phylum of oxygen-producing photoautotrophic bacteria containing chlorophylls *a* and *b* . They share an ancient ancestor of chloroplasts.

cyclic photophosphorylation A photosynthetic process in which chlorophyll serves as both the initial electron donor and the final electron acceptor. ATP is produced via the proton potential from an electron transport system, but no NADPH is generated.

cycloserine A polypeptide antibiotic that inhibits peptidoglycan synthesis.

cystic fibrosis transmembrane conductance regulator (CFTR) A chloride channel found in respiratory epithelia. Mutations in the CFTR gene lead to cystic fibrosis.

cystitis Bladder infection.

cytochrome A membrane protein that donates and receives electrons.

cytochrome system See **electron transport system** .

cytokine A small, secreted host protein that binds to receptors on various endothelial and immune system cells, regulating the cells' responses.

cytokine storm An exaggerated inflammatory immune response produced during certain infections and autoimmune diseases that triggers a rapid, unbalanced release of cytokines.

cytoplasm Also called *cytosol* . The aqueous solution contained by the cell membrane in all cells and outside the nucleus (in eukaryotes).

cytoplasmic membrane See **cell membrane** .

cytoskeleton A collection of filamentous proteins that impart structure to and aid movement of cells; in a eukaryote, these include microfilaments, intermediate filaments, and microtubules.

cytosol See **cytoplasm** .

cytotoxic T cell (T_C cell) A T cell that expresses CD8 on its cell surface and can secrete toxic proteins such as perforin and granzymes.

D

D-value See **decimal reduction time** .

daptomycin A lipopeptide antibiotic that forms ion channels in Gram-positive bacteria.

dark-field microscopy A type of light microscopy in which structures that are too small to be resolved by light rays are detected by observing the light they scatter.

dead zone Also called *zone of hypoxia* . An anoxic region of an ocean or freshwater system, devoid of most fish and invertebrates.

death phase A period of cell culture, following stationary phase, during which bacteria die faster than they replicate.

death rate The rate at which cells die; it is exponential during the death phase.

decay-accelerating factor A host cell membrane protein that stimulates the decay of complement factors and prevents their deposition at the cell surface.

decimal reduction time (D-value) The length of time it takes for a treatment to kill 90% of a microbial population, and hence a measure of the efficacy of the treatment.

decomposer An organism that consumes dead biomass.

deep-branching taxon A lineage whose genome sequences diverged early, at or before the well-known phyla.

defensin A type of small, positively charged peptide, produced by animal tissues, that destroys the cell membranes of invading microbes.

degenerative evolution See **reductive evolution** .

degranulate To release antimicrobial granule contents by fusing granule membranes to cytoplasmic or vacuolar membranes.

degranulation The process whereby preformed chemical mediators in vesicles called granules are released to the outside of the cell.

Deinococcus-Thermus (Deinococcota) A phylum of bacteria that are resistant to ionizing radiation and high temperature.

delayed-type hypersensitivity (DTH) See **type IV hypersensitivity** .

deletion The loss of nucleotides from a DNA sequence.

Deltaproteobacteria A class of Proteobacteria (Pseudomonadota) that includes, for example, the Desulfobacterales (sulfate reducers) and the myxobacteria.

denature To lose secondary and tertiary structure in a protein or nucleic acid because of high temperature or chemical treatment.

dendritic cell An antigen-presenting white blood cell that primarily takes up small soluble antigens from its surroundings.

denitrification Also called *dissimilatory nitrate reduction* . Energy-yielding metabolism in which nitrate (NO_3^-) is reduced to nitrite (NO_2^-), diatomic nitrogen (N_2), and in some cases ammonia (NH_3).

depth of field In a microscope, a region of the optical column over which a specimen appears in focus.

derepression An increase in gene expression caused by the decrease in concentration of a corepressor.

desensitization A clinical treatment to decrease allergic reactions by exposing patients to small doses of an allergen.

Desulfurococcales A phylum of thermophilic archaea in the TACK superphylum that metabolize sulfur and organic compounds.

detection The ability to determine the presence of an object.

detritus Discarded biomass that can be consumed by decomposers.

DGC See **diguanylate cyclase** .

diapedesis See **extravasation** .

diatom A member of the eukaryotic group Bacillariophyceae—protists that possess intricate bipartite shells that contain silica.

diauxic growth A biphasic cell growth curve caused by depletion of the favored carbon source and a metabolic switch to the second carbon source.

DIC See **differential interference contrast microscopy** .

DIC See **disseminated intravascular coagulation** .

dichotomous key A tool for identifying organisms, in which a series of yes/no decisions successively narrows down the possible categories of species.

diderm Enclosed by two phospholipid membranes—an inner membrane and an outer membrane.

differential In disease, the list of possible causes of an infection.

differential interference contrast microscopy (DIC) Also called *Nomarski microscopy* . A form of microscopy based on the interference pattern between two light beams split and polarized, one of which passes through a sample. The interference between the two beams generates contrast in a transparent sample.

differential medium A growth medium that can distinguish between various bacteria on the basis of metabolic differences.

differential stain A stain that differentiates among objects by staining only particular types of cells or specific subcellular structures.

diffusion The energy-independent net movement of a substance from a region of high concentration to a region of lower concentration.

diguanylate cyclase (DGC) A class of enzymes that synthesize the second messenger molecule c-di-GMP.

dilution streaking A method of spreading bacteria on a plate in order to obtain colonies arising from an individual bacterium.

dinoflagellate A member of the eukaryotic group Dinoflagellata —secondary or tertiary endosymbiont algae, alveolates with two flagella, one of which is wrapped distinctively around the cell equator.

diplococcus The paired cocci of *Neisseria* species.

direct contact The process by which a disease-causing microbe is transmitted from an infected person to an uninfected person by direct physical contact with skin, blood, or body fluids.

direct repeat A DNA sequence that is found close to another sequence with the identical form and that is aligned in the same direction (e.g., 5′-ATCGATCGnnnnnnATCGATCG-3′).

disinfection The removal of pathogenic organisms from inanimate surfaces.

dispersion The process by which cells escape the biofilm structure and reenter the planktonic state.

disseminated intravascular coagulation (DIC) The uncontrolled formation of small clots in blood vessels that impedes blood flow to organs and results in multi-organ system failure.

dissimilation An organism's catabolism or oxidation of nutrients to inorganic minerals that are released into the environment.

dissimilatory denitrification Metabolic reduction of nitrate or nitrite to yield energy; anaerobic respiration of nitrate or nitrite.

dissimilatory metal reduction A type of anaerobic respiration that uses metal cations as terminal electron acceptors.

dissimilatory nitrate reduction See **denitrification** .

diversity A measure of the genetic differences across the taxa of a microbial community.

divisome A protein complex that manages the overall process of septation.

DNA-binding protein A protein that binds to DNA and modulates its function.

DNA-dependent RNA polymerase See **RNA polymerase** .

DNA ligase An enzyme that cells use to form a covalent bond at a nick in the phosphodiester backbone. It is also used in molecular biology laboratories to join pieces of DNA.

DNA microarray A technique, used for measuring the amount of specific mRNA molecules transcribed in cells, in which DNA fragments from every open reading frame in a genome are affixed

to separate locations on a solid support surface (a DNA microchip), producing a grid, or array.

DNA replication The biological process of making an identical copy of double-stranded DNA using existing DNA as a template.

DNA reverse-transcribing virus See **pararetrovirus** .

DNA sequencing A technique to determine the order of bases in a DNA sample.

DNA shuffling A method of artificially evolving new genes in which fragments of different examples (or orthologs) of a given gene are randomly mixed and PCR-amplified to make a new functional gene. It is an example of directed evolution.

DNase I footprinting A technique that identifies the specific DNA sequence to which regulatory proteins bind. Stretches of DNA bound by the regulatory protein are protected from digestion by DNase I, and this zone of protection shows up as a "footprint" in gel electrophoresis of the DNA.

domain 1. In taxonomy, one of three major subdivisions of life: Archaea, Bacteria, and Eukarya. 2. In protein structure, a portion of a protein that possesses a defined function, such as binding DNA. 3. In membranes, a region of membrane consisting of certain types of phospholipids that are distinct from surrounding lipids.

doubling time The generation time of bacteria in culture. The amount of time it takes for the population to double.

downstream processing The recovery and purification of a commercial product produced by industrial microbes.

dRNAseq See **differential RNA sequencing** .

DTH See **type IV hypersensitivity** .

duplication The production of a second copy of a sequence fragment on a DNA molecule, usually adjacent to the original copy.

dysbiosis An imbalance in microbiome composition that can lead to disease.

E

E site See **exit site** .

early gene A viral gene expressed early in the infection cycle.

eclipse period The time in the viral life cycle after viral genome injection into a host cell but before complete virions are formed.

ecosystem A community of species plus their environment (habitat).

ectomycorrhizae Mycorrhizae that colonize the surface of plant roots. Their mycelia do not penetrate the root cells.

ED pathway See **Entner-Doudoroff pathway** .

edema Tissue swelling due to fluid accumulation.

eDNA See **extracellular DNA** .

effective reproduction number *R* The average number of infections resulting from a single infected person in a population with partial immunity.

electrochemical potential A type of potential energy formed by the combined concentration gradient of a molecule and the electrical potential across a membrane.

electrogenic biofilm A biofilm that generates electricity in a human-made device.

electromagnetic radiation Energy radiating in the form of alternating electrical and magnetic waves, quantized in photons.

electron acceptor An oxidized molecule (e.g., NAD^+) that can accept electrons.

electron bifurcation A biochemical reaction in which an electron transfer that yields energy is coupled to an electron transfer that consumes energy.

electron cryomicroscopy See **cryo-electron microscopy** .

electron cryotomography See **cryo-electron tomography** .

electron donor Also called *reducing agent* . A reduced molecule (e.g., NADH) that can donate electrons.

electron microscope A microscope that obtains high resolution and magnification by using magnetic lenses to focus electron beams on samples.

electron microscopy (EM) A form of microscopy in which a beam of electrons accelerated through a voltage potential is focused by magnetic lenses onto a specimen.

electron shuttle An aromatic molecule that allows low-energy transitions for gaining or losing an electron.

electron transport system (ETS) ***or*** **electron transport chain (ETC)** Also called *cytochrome system* . A series of membrane-embedded proteins that converts the energy of redox reactions into a proton potential.

electronegativity The affinity of an atom for electrons. The greater the electronegativity, the stronger the attraction for electrons.

electrophoresis A technique to separate charged proteins and nucleic acids that is based on how rapidly they migrate in an electrical field through a gel.

electrophoretic mobility shift assay (EMSA) A technique to observe DNA-protein interactions that is based on the ability of a bound protein to slow the voltage-driven migration of DNA through a gel.

elementary body The endospore-like form of chlamydias transmitted outside host cells.

EM See **electron microscopy** .

Embden-Meyerhof-Parnas (EMP) pathway See **glycolysis** .

emerging Describing an organism or other entity that is newly isolated, defined, or recognized, as in "emerging clade," "emerging

pathogen," or "emerging disease."

emerging disease A new infectious disease that has recently appeared in a population.

emission wavelength The wavelength of light emitted by a fluorescent molecule. It is longer than the excitation wavelength and has lower energy.

EMP pathway See **glycolysis** .

empiric therapy An approach to treating infection before the infective organism is known, in which multiple antibiotics are administered in an effort to kill the most likely causative agents.

empty magnification Magnification without an increase in resolution.

EMSA See **electrophoretic mobility shift assay** .

enantiomer See **optical isomer** .

endemic Describing a disease that is always present in a population, although the frequency of infection may be low.

endocarditis An inflammation of the heart's inner lining.

endocytosis The invagination of the cell membrane to form a vesicle that contains extracellular material.

endogenous retrovirus A retroelement (genome sequence descended from a retrovirus) that contains *gag* , *env* , and *pol* genes.

endogenous virus A virus whose genome is encoded within the germ line of a host animal; may be considered a functional part of the host.

endolith A bacterium that grows within the crystals of solid rock.

endomembrane system A series of membranous organelles that organize uptake, transport, digestion, and expulsion of particles through a eukaryotic cell. It includes endosomes, lysosomes, endoplasmic reticulum, and the Golgi complex.

endomycorrhizae Also called *arbuscular mycorrhizae* or *vesicular-arbuscular mycorrhizae* . Mycorrhizae whose fungal hyphae penetrate plant root cells.

endophyte An endosymbiont of vascular plants.

endosome A vesicle formed from the pinching in of the cell membrane.

endospore A durable, inert, heat-resistant spore that can remain viable for thousands of years.

endosymbiont An organism that lives as a symbiont inside another organism.

endosymbiosis An intimate association between different species in which one partner population grows within the body of another organism.

endothermic Absorbing heat.

endotoxin A lipopolysaccharide in the outer membrane of Gram-negative bacteria that becomes toxic to the host after the bacterial cell has lysed.

energy The ability to do work.

energy carrier A molecule in the cell, such as ATP or NADH, that serves as energy currency. Energy carriers are produced during catabolic reactions and can be used to drive energy-requiring reactions.

enhancer A noncoding DNA regulatory region in eukaryotes that can lead to activation of transcription when bound by an appropriate transcription factor. Its location on the chromosome can be far removed from the regulated gene.

enriched medium A growth solution for fastidious bacteria, consisting of complex medium plus additional components.

enrichment culture The use of selective growth media to allow only certain microbes to grow.

enrichment medium A medium whose composition favors the growth of one microbial species over others, increasing (enriching) the presence of the favored species.

enthalpy A measure of the heat energy in a system.

Entner-Doudoroff (ED) pathway A glycolytic pathway in which glucose 6-phosphate is initially oxidized to 6-phosphogluconate, and ultimately yields 1 pyruvate, 1 ATP, 1 NADH, and 1 NADPH.

entropy A measure of the disorder in a system.

envelope A structure external to the cell membrane, such as the cell wall or outer membrane of a bacterium. For a virus, the envelope is a membrane enclosing the capsid or core particle.

enzyme A biological catalyst; a protein or RNA that can speed up the progress of a reaction without itself being changed.

eosinophil A white blood cell that stains with the acidic dye eosin and secretes compounds that facilitate innate immunity.

epidemic A disease outbreak in which large numbers of individuals in a population become infected over a short time.

epidemiology The study of factors affecting the health and illness of populations.

epidermis The outer protective cell layer in most multicellular animals.

epifluorescence See **fluorescence** .

epitope See **antigenic determinant** .

EPS See **exopolysaccharides** .

Epsilonproteobacteria A class of Proteobacteria (Pseudomonadota) that includes, for example, species of *Campylobacter* and *Helicobacter* .

equilibrium *pl.* equilibria A dynamic state in which there is no net change in a reaction.

error-prone repair Low-accuracy DNA repair mechanisms that allow mutations.

error-proof repair DNA repair mechanisms that minimize the occurrence of mutations.

erythema migrans A bull's-eye rash characteristic of borreliosis (Lyme disease).

essential gene A gene that is required for cell viability under all environmental conditions.

essential nutrient A compound that an organism cannot synthesize and must acquire from the environment in order to survive.

ETC See **electron transport system** .

ethanolic fermentation Also called *alcoholic fermentation* . A fermentation reaction yielding 2 ethanol and $2CO_2$ as products.

ETS See **electron transport system** .

Eukarya One of the three domains of life, consisting of organisms with a last common ancestor not shared with members of Archaea or Bacteria. Cells possess nuclei, unlike cells of bacteria and archaea.

eukaryote An organism whose cells contain a nucleus. All eukaryotes are members of the domain Eukarya.

Eumycota True fungi, a taxonomic group of opisthokont eukaryotes with chitinous cell walls; the group most closely related to animals.

euphotic zone Also called *photic zone* . The region of the ocean that receives sunlight capable of supporting photosynthesis.

Euryarchaeota A major division of Archaea, containing methanogens, halophiles, acidophiles, and thermophiles, as well as soil archaea that are not extremophiles.

eutrophic Describing a lake in which a high concentration of nutrients supports growth of algae to high densities.

eutrophication A sudden increase of a formerly limiting nutrient in an aquatic environment, leading to overgrowth of algae and grazing bacteria and subsequent oxygen depletion.

evolutionary arms race The escalation of adaptations and counteradaptations that develop between predator and prey or between competing species.

excitation wavelength The wavelength of light that must be absorbed by a molecule in order for the molecule to fluoresce. It is shorter than the emission wavelength and has higher energy.

exergonic reaction A spontaneous chemical reaction that releases free energy.

exit site (E site) The region of a ribosome that holds the uncharged, exiting tRNA.

exocytosis The fusion of vesicles with the cell membrane to release vesicle contents extracellularly.

exon An expressed (protein-coding) portion of a eukaryotic gene.

exonuclease An enzyme that cleaves DNA from the end.

exopolysaccharides (EPS) Also called *extracellular polymeric substance* . Polysaccharides and entrapped materials that form a thick extracellular matrix around the microbes in a biofilm.

exothermic Releasing heat.

exotoxin A protein toxin, secreted by bacteria, that kills or damages host cells.

experimental evolution Also called *laboratory evolution* . The repeated culturing of a population in a laboratory under defined environmental conditions, leading to evolution of adapted genotypes.

expression Synthesis of the products encoded by a gene. This includes RNA and, for mRNAs that are translated, protein.

exponential phase Also called *logarithmic (log) phase* . A period of cell culture during which bacteria grow exponentially at their maximal possible rate, given the conditions.

extracellular DNA (eDNA) DNA located outside the cell, often released by cells to provide stability and structure to biofilms.

extracellular polymeric substances (EPS) See **exopolysaccharides** .

extravasation Also called *diapedesis* . The movement of cells of the immune system out of blood vessels and into surrounding infected tissue.

extreme thermophile See **hyperthermophile** .

extremophile An organism that grows only in an extreme environment; that is, an environment including one or more conditions that are "extreme" relative to the conditions for human life.

F

F $^{-}$ cell The DNA recipient cell in bacterial conjugation.

F $^{+}$ cell The DNA donor cell that transmits the fertility factor F $^{+}$ to an F $^{-}$ cell during bacterial conjugation.

F factor See **fertility factor** .

F-prime (F ′) factor *or* F-prime (F ′) plasmid A fertility factor plasmid that contains some host chromosomal DNA.

facilitated diffusion A process of passive transport across a membrane that is facilitated by transport proteins.

FACS See **fluorescence-activated cell sorting** .

factor H A normal serum protein that prevents the inadvertent activation of complement in the absence of infection.

facultative anaerobe An organism that can grow in either the presence or absence of oxygen.

facultative intracellular pathogen A pathogen that can replicate either inside host cells or outside host cells.

FAD See **flavin adenine dinucleotide** .

Fc region The region of an antibody that binds to specific receptors on host cells in an antigen-independent manner. It is found in the carboxy-terminal "tail" region of the antibody.

fecal-oral route of transmission A method by which pathogens or parasites excreted in the fecal matter of an infected person are then indirectly ingested by an uninfected person.

fermentation Also called *fermentative metabolism* . 1. The production of ATP via substrate-level phosphorylation, using organic compounds as both electron donors and electron acceptors. 2. Industrial fermentation is the production of microbial products that are made by microbes grown in fermentation vessels; it may include respiratory metabolism to maximize microbial growth.

fermentation industry Commercial production of microbial products that are made by microbes grown in fermentation vessels; it may include respiratory metabolism to maximize microbial growth.

fermentative metabolism See **fermentation** .

fermented food Food products that are biochemically modified by microbial growth.

ferredoxin An iron- and sulfur-containing protein that transfers electrons in electron transport systems.

fertility factor (F factor) A specific plasmid (transferred by an F^+ donor cell) that contains the genes needed for pilus formation and DNA export.

filamentous virus A viral structure type consisting of a helical capsid surrounding a single-stranded nucleic acid.

fimbria *pl.* fimbriae See **pilus** .

Firmicutes (Bacillota) A phylum of Gram-positive bacteria with relatively low GC content.

FISH See **fluorescence in situ hybridization** .

fistulated cow Also called *cannulated cow* . A cow in which a hole in the skin has been connected surgically to a hole in the rumen and fitted with a cannula, allowing access for experimental analysis of the rumen.

fitness trade-off The situation where a trait improves fitness in one condition, but lowers fitness in a different condition.

fix To incorporate an inorganic compound into biomass, the organic molecules that form the cell.

fixation The adherence of cells to a slide by a chemical or heat treatment.

flagellate A protist that has one or more flagella.

flagellum *pl.* flagella A filamentous structure for motility. In prokaryotes, a helical protein filament attached to a rotary motor; in eukaryotes, an undulating membrane-enclosed complex of microtubules and ATP-driven motor proteins.

flavin adenine dinucleotide (FAD) An energy carrier in the cell that can donate ($FADH_2$) or accept (FAD) electrons.

flesh-eating disease See **necrotizing fasciitis** .

floc Also called *activated sludge* . Particulate matter formed by clumps of microbes during wastewater treatment.

flow cytometry A tool for analyzing cell populations, in which cells of multiple types are detected individually and distinguished by light scatter and fluorescence emission.

fluid mosaic model A model of the cell membrane in which proteins are free to diffuse laterally within the membrane.

fluorescence Also called *epifluorescence* . The emission of light from a molecule that absorbed light of a shorter, higher-energy wavelength.

fluorescence-activated cell sorting (FACS) A technique in which cells are counted (via flow cytometry), and then different classes of cells are collected into fractions according to differences in fluorescence (via cell sorting).

fluorescence in situ hybridization (FISH) A technique to detect individual microbes in an ecological or clinical sample, using a fluorophore-labeled oligonucleotide probe (usually a short DNA sequence) that hybridizes to microbial DNA or rRNA.

fluorescence resonance energy transfer (FRET) The detectable transfer of fluorescent energy from one molecule to another. Because the participating molecules must be near each other, FRET can be used to monitor protein-protein interactions in cells and is also used in real-time PCR.

fluorophore A fluorescent molecule used to stain specimens for fluorescence microscopy.

focal point The position at which light rays that pass through a lens intersect.

focus *pl.* foci The point at which rays of energy converge; in light microscopy, the convergence of light rays maximizes the clarity of the optical image.

folate Folic acid, a heteroaromatic cofactor that is required by some enzymes.

fomite An inanimate object on which pathogens can be transmitted from one host to another.

food poisoning Food contamination, the presence of human-disease-causing microbial pathogens or toxins in food.

food spoilage Microbial changes that render a food unfit or unpalatable for consumption.

food web A network of interactions in which organisms obtain or provide nutrients for each other; for example, by predation or by mutualism.

foraminiferan or foram An ameba with a calcium carbonate shell and a helical arrangement of chambers.

forespore In sporulation of Gram-positive bacteria, the smaller cell compartment formed through asymmetrical cell division; it develops into the endospore.

fossil fuel Ancient organismal remains that have been converted to hydrocarbons (petroleum and natural gas) or sedimentary rock (coal) through microbial digestion followed by reduction under high pressure underground. Fossil fuels are extracted and burned by humans for energy.

frameshift mutation A gene mutation involving the insertion or deletion of nucleotides that cause a shift in the codon reading frame.

free energy change See **Gibbs free energy change** .

freeze-drying Also called *lyophilization* . The removal of water from food, by freezing under vacuum, to limit microbial growth.

FRET See **fluorescence resonance energy transfer** .

fruiting body A multicellular fungal or bacterial reproductive structure.

frustule The silica bipartite shell produced by a diatom.

functional group A cluster of covalently bonded atoms that behaves with specific properties and functions as a unit.

fungus *pl.* fungi A heterotrophic opisthokont eukaryote with chitinous cell walls. Includes Eumycota, but traditionally may refer to fungus-like protists such as the oomycetes.

fusion peptide A portion of a viral envelope protein that changes shape to facilitate envelope fusion with the host cell membrane.

Fusobacteria (Fusobacteriota) A phylum of anaerobic Gram-negative bacteria with an outer membrane, related to the Proteobacteria; includes human pathogens.

G

gain-of-function mutation A mutation that enhances the activity or allows new activity of a gene product.

GALT See **gut-associated lymphoid tissue** .

Gammaproteobacteria A class of Proteobacteria (Pseudomonadota) that includes, for example, the Enterobacteriales (enteric facultative anaerobes) and the pseudomonads.

gamogony The differentiation of parasitic haploid cells into male and female gametes.

gas vesicle An organelle that traps gases to increase the buoyancy of aquatic microbes.

GC content The proportion of an organism's genome consisting of guanine-cytosine base pairs.

GDH See **glutamate dehydrogenase** .

gene A sequence of nucleotides that has a distinct function (regulatory) or whose encoded product (protein or RNA) has a distinct function. The functional unit of heredity.

gene duplication The formation of an extra copy of a gene within a genome.

gene fusion In biotechnology, the construction of a recombinant gene composed of portions from two different genes, one of which may be a reporter for gene expression.

gene switching Switching between two (out of five) different classes of immunoglobulin genes (e.g., from IgM to IgG) during B-cell development.

gene transfer vector A mobile DNA engineered from a virus or plasmid, designed to insert a genetic sequence into the genome of an organism for experimental study or for medical therapy.

generalized transduction A phage-mediated gene transfer process in which any donor gene can be transferred to a recipient cell.

generation time The species-specific time period for doubling of a population (e.g., by bacterial cell division) in a given environment, assuming no depletion of resources.

genome The complete genetic content of an organism. The sequence of all the nucleotides in a haploid set of chromosomes.

genome reduction The large-scale loss of genes through evolution.

genomic island A region of DNA sequence whose properties indicate that it has been transferred from another genome. Genomic islands usually comprise a set of genes with shared function, such as pathogenicity or symbiosis support.

genotype The genome sequence of an organism.

genus *pl.* genera A group of closely related species.

Geoarchaeota A clade of Thermoproteota, thermophilic archaea including mats at thermal vents, in the TACK superphylum.

geochemical cycling The global interconversion of various inorganic and organic forms of elements.

geomicrobiology See **biogeochemistry** .

germ theory of disease The theory that many diseases are caused by microbes.

germicidal Able to kill cells but not spores.

germination The activation of a dormant spore to generate a vegetative cell.

Gibbs free energy change *or* Gibbs energy change (ΔG) Also called *free energy change*. In a chemical reaction, a measure of how much energy available to do work is released or required as the reaction proceeds.

gliding motility The movement of cells individually or as a collective over surfaces using specialized pili.

gluconeogenesis The biosynthesis of glucose from single-carbon compounds.

glutamate dehydrogenase (GDH) An enzyme that condenses NH_4^+ with 2-oxoglutarate to form glutamate. The condensation requires reduction by NADPH.

glutamate synthase Glutamine:2-oxoglutarate aminotransferase (GOGAT), an enzyme that converts 2-oxoglutarate plus glutamine into two molecules of glutamate.

glutamine synthetase (GS) An enzyme that condenses NH_4^+ with glutamate to form glutamine.

glycan A polysaccharide chain composed of oxygen-linked (O-linked) monosaccharides.

glycolysis Also called *Embden-Meyerhof-Parnas (EMP) pathway*. The catabolic pathway of glucose oxidation to pyruvate, in which glucose 6-phosphate isomerizes to fructose 6-phosphate, ultimately yielding 2 pyruvate, 2 ATP, and 2 NADH.

glyoxylate bypass An alternative to the tricarboxylic acid cycle in which isocitrate is converted to glyoxylate and then malate; induced under low glucose conditions.

gnotobiotic animal An animal that is germ-free or colonized by a known set of microbes.

GOGAT See **glutamate synthase**.

Golgi complex *or* Golgi apparatus A series of membrane stacks that modifies proteins and helps sort them to the correct eukaryotic cell compartment.

Gram-negative Describing cells that do not retain the Gram stain.

Gram-positive Describing cells that retain the Gram stain and appear dark purple after staining.

Gram stain A differential stain that distinguishes cells that possess a thick cell wall and retain a positively charged stain (Gram-positive) from cells that have a thin cell wall and outer membrane and fail to retain the stain (Gram-negative).

gramicidin A peptide antibiotic that acts as a channel for monovalent cations to cross the cell membrane, thus collapsing the transmembrane ion gradients.

granuloma A thick lesion formed around a site of infection.

granzyme An enzyme, secreted by cytotoxic T cells, that damages target cells.

grazer A first-level consumer, feeding directly on producers.

green alga Also called *chlorophyte* . A member of the eukaryotic group Chlorophyta—microbes that have chloroplasts; closely related to plants (Plantae).

greenhouse effect The trapping of solar radiation heat in the atmosphere by CO_2 ; a cause of global warming.

griseofulvin An antifungal antibiotic that inhibits cell division.

group translocation A form of active transport in which the transported molecule is modified after it enters the cell, thus keeping a favorable inward concentration gradient for the unmodified extracellular molecule.

growth factor A compound needed for the growth of only certain cells.

growth rate The rate of increase in population number or biomass.

growth rate constant The number of organismal generations per unit time; k .

GS See **glutamine synthetase** .

gut-associated lymphoid tissue (GALT) Lymphatic tissues such as tonsils and adenoids that are found in conjunction with the gastrointestinal tract and contain immune cells.

gut microbiome The microbial community normally present in the intestinal lumen of a healthy host.

H

Haber process Industrial nitrogen fixation, in which dinitrogen is hydrogenated by methane (natural gas) under extreme heat and pressure to form ammonia.

Hadean eon The first eon (major time period) of Earth's existence, from 4.6 to approximately 4.0 gigayears (Gyr, 10^9 years) before the present.

HAI See **health care–associated infection** .

half-life The amount of time it takes for one-half of a radioactive sample to decay.

Haloarchaea A monophyletic clade of Euryarchaeota that contains extremely halophilic archaea, inhabiting high-salt environments. Formerly known as Halobacteria.

halophile An organism that requires a high extracellular sodium chloride concentration for optimal growth.

halorhodopsin A haloarchaeal membrane-embedded protein that contains retinal and acts as a light-driven chloride pump; it is homologous to bacteriorhodopsin.

hamus *pl.* hami An archaeal cell appendage with grappling hooks that enable cells to connect with each other, adhere to a surface, and form biofilms.

hapten A small compound that must be conjugated to a larger carrier antigen in order to elicit production of an antibody that binds to it.

haustorium *pl.* haustoria A bulbous hyphal extension of a fungal plant pathogen into the host cell.

HAV See **hepatitis A virus** .

HBV See **hepatitis B virus** .

HCV See **hepatitis C virus** .

health care–associated infection (HAI) Any infection contracted by a patient while receiving treatment for a medical condition at a health care facility, such as hospitals, nursing homes, doctor offices, or rehabilitation centers.

health care disparities Differences in the access to and quality of care given to white and minority populations, or to populations of different socioeconomic status.

health disparities Differences in the incidence, prevalence, mortality, and social burden of diseases that exist between white and minority populations, or between populations of different socioeconomic status.

heat map A graph that represents data values as a range of colors to allow a visual grasp of trends.

heat-shock protein (HSP) A chaperone protein whose synthesis is induced by high-temperature stress.

heat-shock response A coordinated response of cells to higher-than-normal temperatures. It includes changes in the membrane and expression of heat-shock genes.

heavy chain The larger of the two protein types that make up an antibody. Each antibody contains two heavy chains and two light

chains.

helper T cell (T_H cell) A T cell that expresses CD4 on its cell surface and secretes cytokines that modulate B-cell isotype, or class, switching.

heme An organic molecule containing a ring of conjugated double bonds surrounding an iron atom. It is involved in redox reactions and oxygen binding.

hemolysin A toxin that lyses red blood cells.

hepatitis An inflammation of the liver, caused by infection or by exposure to a toxic substance.

hepatitis A virus (HAV) A single-stranded RNA picornavirus that causes an acute infection of the liver spread person-to-person by the fecal-oral route.

hepatitis B virus (HBV) A partially double-stranded, circular-DNA hepadnavirus that causes diseases of the liver of varying severity, including acute and chronic hepatitis, cirrhosis, and hepatocarcinoma.

hepatitis C virus (HCV) A single-stranded, positive-sense, linear-RNA flavivirus that is transmitted by blood transfusions and causes 90% of transfusion-related cases of hepatitis.

heterocyst In filamentous cyanobacteria, a specialized nitrogen-fixing cell that maintains a reducing environment and excludes O_2.

heteroduplex A double-stranded nucleic acid in which the two strands come from different sources.

Heterokonta See **Stramenopiles**.

heterolactic fermentation A fermentation reaction in which the products are lactic acid, ethanol, and CO_2.

heterologous host An organism engineered for expression of a recombinant product from genes obtained from a species that expresses the product in a natural environment.

heterotrophy Also called *chemoorganoheterotrophy* . The use of external sources of organic carbon compounds for biosynthesis.

Hfr strain A high-frequency recombination bacterial strain, caused by the presence of a chromosomally integrated F factor.

high-efficiency particulate air filter (HEPA filter) A medical-grade filter that is certified by government standards to remove at least 99.97% of all airborne particles and droplets of diameter 0.3 μm or larger.

histone A protein that binds eukaryotic DNA and compacts chromosomes in nucleosomes.

HIV See **human immunodeficiency virus** .

HMO See **human milk oligosaccharide** .

Holliday junction A cross-like configuration of recombining DNA molecules that forms during generalized recombination.

holobiont An entity composed of multiple types of organisms, including microbes.

homolog *or* homologous gene A gene derived from a common ancestral gene. Homologs may be orthologs or paralogs.

homologous recombination The process by which two DNA molecules exchange arms by cutting and splicing their helix backbones. Exchange occurs between sequences that are identical or nearly identical, as the machinery requires complementary base pairing to exchange the DNA molecules.

hopanoid *or* hopane A five-ringed hydrocarbon lipid found in bacterial cell membranes.

horizontal gene transfer Also called *lateral gene transfer* . The natural movement of genes from one genome into another, nonprogeny genome.

horizontal transmission In disease, the transfer of a pathogen from one organism into another, nonprogeny organism.

hormogonium *pl.* hormogonia A short, motile chain of three to five cells produced by filamentous cyanobacteria to disseminate their cells.

host factor A trait of an individual host that affects susceptibility to disease, in comparison with other individuals.

host range The species that can be infected by a given pathogen.

HSP See **heat-shock protein** .

human immunodeficiency virus (HIV) A human-specific retrovirus that causes AIDS.

human milk oligosaccharide (HMO) A glycan secreted in milk by a lactating human.

humic material Also called *humus* . Phenolic molecules, derived from lignin, that are resistant to degradation and hence very stable in soil.

humoral immunity (antibody-dependent immunity) A type of adaptive immunity mediated by antibodies.

humus See **humic material** .

hybridization The annealing of a nucleic acid strand with another nucleic acid strand containing a complementary sequence of bases. The binding of one nucleic acid strand with a complementary strand.

hydric soil Soil that undergoes periods of anoxic water saturation.

hydrogen bond An electrostatic attraction between a hydrogen bonded to an oxygen or nitrogen and a second, nearby oxygen or nitrogen.

hydrogenotrophy The use of molecular hydrogen (H_2) as an electron donor for a variety of electron acceptors.

hydrologic cycle Also called *water cycle* . The cyclic exchange of water between atmospheric water vapor and Earth's bodies of liquid water.

hydrolysis The cleaving of a bond by the addition of a water molecule.

hydrophilic Soluble in water; either ionic or polar.

hydrophobic Insoluble in water; nonpolar.

hydrothermal vent Also called *thermal vent* . An opening in the seafloor through which superheated water arises, carrying high concentrations of reduced minerals such as sulfides.

3-hydroxypropionate cycle A carbon fixation process in which hydrated CO_2 condenses with acetyl-CoA to form 3-hydroxypropionate.

hyperthermophile Also called *extreme thermophile* . An organism adapted for optimal growth at extremely high temperatures, generally above 80°C, and as high as 121°C.

hypertonic Having more solutes than another environment separated by a semipermeable membrane. Water will tend to flow toward the hypertonic solution.

hypha *pl.* hyphae The threadlike filament that forms the mycelium of a fungus.

hypotonic Having fewer solutes than another environment separated by a semipermeable membrane. Water will tend to flow away from the hypotonic solution.

hypoxia A state of lower-than-normal oxygen concentration.

I

icosahedral capsid For a virus, a crystalline protein shell with 20 identical faces, enclosing the nucleic acid.

ID_{50} See **infectious dose 50%** .

identification The recognition of the species (or higher taxonomic category) of a microbe isolated in pure culture.

idiotype An amino acid difference in the antigen-binding site (N terminus of heavy or light chains) that distinguishes different antibodies within an individual.

IEF See **isoelectric focusing** .

IEL See **intraepithelial lymphocyte** .

IgA An antibody isotype that contains the alpha heavy chain. It can be secreted and is found in tears, saliva, breast milk, and so on.

IgD An antibody isotype that contains the delta heavy chain. It is found on B-cell membranes.

IgE An antibody isotype that contains the epsilon heavy chain. It is involved in degranulation of mast cells.

IgG An antibody isotype that contains the gamma heavy chain. Produced by plasma cells, it is found in serum and is the predominant class of circulating antibodies for adaptive immunity.

IgM The first antibody isotype detected during the early stages of an immune response. It contains the mu heavy chain and is found as a pentamer in serum.

IL-1 See **interleukin 1** .

ILC See **innate lymphoid cell** .

immediate hypersensitivity See **type I hypersensitivity** .

immersion oil An oil with a refractive index similar to glass that minimizes light-ray loss at wide angles, thereby minimizing wavefront interference and maximizing resolution.

immune complex disease See **type III hypersensitivity** .

immune system An organism's cellular defense system against pathogens.

immunity A body's resistance to a specific disease.

immunization The stimulation of an immune response by deliberate inoculation with a weakened pathogen, in hopes of providing immunity to disease caused by the pathogen.

immunogen An antigen that, by itself, can elicit antibody production.

immunogenicity (antigenicity) A measure of the effectiveness of an antigen in eliciting an immune response.

immunoglobulin A member of a family of proteins that contain a 110-amino-acid domain with an internal disulfide bond. Members include antibodies and major histocompatibility proteins.

immunohistochemistry The use of a labeled antibody to stain and visualize specific structures in tissue.

immunological specificity (antigenic specificity) The ability of antibodies produced in response to a particular epitope to bind that epitope almost exclusively. Antibodies made to one epitope bind only weakly, if at all, to other epitopes.

immunopathogenesis The process by which an immune response or the products of an immune response cause disease.

immunoprecipitation The antibody-mediated cross-linking of antigens to form large, insoluble complexes. It is used in research labs and is normally seen only in vitro.

imperfect fungus See **mitosporic fungus** .

in vivo expression technology (IVET) Techniques that identify bacterial genes that are expressed only when the organism is growing inside a host.

incidence The number of new cases of a disease in a given location over a specified time.

index case Also called *patient zero* . The first case of an infectious disease, and an important piece of data for helping to contain the spread of disease.

indigenous microbiota Microbes found naturally in a particular location, often in association with a food substrate.

indirect contact The process by which a disease-causing microbe is transferred from an infected person to an inanimate object (fomite), food, or water and then to an uninfected person that touched or ingested the contaminated material.

inducer A molecule that stimulates transcription of gene(s) by changing the DNA-binding properties of a regulatory protein. When an inducer binds a repressor protein, the repressor loses the ability to bind the operator and block transcription. When an inducer binds an activator protein, the activator gains the ability to bind the DNA and the RNA polymerase to stimulate transcription.

inducer exclusion The ability of glucose to cause metabolic changes that prevent the cellular uptake of less favorable carbon sources that could cause unnecessary induction.

induction Increased transcription of target genes because an inducer binds to a repressor and prevents repressor-operator binding.

industrial fermentor The equipment used to grow microbes on an industrial scale.

industrial microbiology The commercial exploitation of microbes.

industrial strain A microbial strain whose characteristics are optimized for industrial use.

infection The growth of a pathogen or parasite in or on a host.

infection cycle The route a pathogen takes as it moves from one host into another.

infectious dose 50% (ID_{50}) The number of bacteria or virions required to cause disease symptoms in 50% of an experimental group of hosts.

inflammasome A cytoplasmic multiprotein complex that promotes the maturation of inflammatory cytokines IL-1β and IL-18. Inflammasome assembly is triggered by NLR interactions with microbe-associated molecular patterns (MAMPs).

injera A highly fermented Ethiopian flatbread made from the grain teff.

innate immunity Also called *nonadaptive immunity* . Nonspecific mechanisms for protecting against pathogens.

innate lymphoid cell (ILC) A lymphocyte-like cell in the intestinal lamina propria that lacks B- or T-cell receptors but secretes pro-inflammatory cytokines.

inner leaflet The layer of the cell membrane phospholipid bilayer that faces the cytoplasm.

inner membrane *or* inner cell membrane In Gram-negative bacteria, the membrane in contact with the cytoplasm, equivalent to the cell membrane.

insertion The addition of nucleotides to the middle of a DNA sequence.

insertion sequence (IS) A simple transposable element consisting of a transposase gene flanked by short, inverted-repeat sequences that are the target of transposase.

integral protein See **transmembrane protein** .

integron A large and complex mobile element that can accept, or capture, different antibiotic resistance gene cassettes to use later, when needed.

interactome All of the proteins that interact with other proteins in a cell.

interference The interaction of two wavefronts. Interference can be additive (amplitudes in phase, constructive) or subtractive (amplitudes out of phase, destructive).

interferon A host-secreted immunomodulatory protein that inhibits viral replication.

interleukin 1 (IL-1) A cytokine released by macrophages.

intermediate filament A eukaryotic cytoskeletal protein that is composed of various proteins depending on the cell type.

internal ribosome entry site (IRES) A site within an mRNA sequence where a ribosome can bind and initiate translation.

intimin A pathogenic *Escherichia coli* adhesion protein that binds tightly to an *E. coli* –produced receptor injected into host cells.

intracellular pathogen A pathogen that lives within a host cell.

intraepithelial lymphocyte (IEL) A lymphocyte embedded among epithelial cells that line the intestine.

intron In eukaryotic genes, an intervening sequence that does not code for protein and is spliced out of the mRNA prior to translation.

inversion A mutation in which a DNA fragment is flipped within a chromosome. It may allow or repress the transcription of a particular gene.

inverted repeat A DNA sequence that is found in an identical but inverted form at two sites on the same double helix (e.g., 5'-ATCGATCGnnnnnnCGATCGAT-3').

ion An atom or molecule containing negative or positive charge; that is, a number of electrons, respectively, greater than or less than the number of protons.

ion gradient A difference in concentration of an ion across a membrane.

ionic bond A chemical bond between ions of positive and negative charge.

IRES See **internal ribosome entry site** .

IS See **insertion sequence** .

isoelectric focusing (IEF) A technique that separates proteins according to their charge, via the migration of proteins to their isoelectric point in a pH gradient.

isoelectric point The pH at which there is no net charge on an amino acid or a protein.

isolate A microbe that has been obtained from a specific location and grown in pure culture.

isoprenoid A condensed isoprene chain, found in archaeal membrane lipids.

isotonic Being in osmotic balance, having equal concentrations of solutes on both sides of a semipermeable membrane. A cell in an isotonic environment will neither gain nor lose water.

isotope An atom of an element with a specific number of neutrons. For example, carbon-12 (^{12} C), carbon-13 (^{13} C), and carbon-14 (^{14} C) are all isotopes of carbon.

isotope ratio The ratio of amounts of two different isotopes of an element. It may serve as a biosignature if the ratio between certain isotopes of a given element is altered by biological activity.

isotype An antibody class within a species that is defined by the structure of the antibody's heavy chain. IgG, IgA, IgD, and IgE are examples of isotypes. An isotype from one species contains species-specific amino acid sequences that are present in the heavy chain of all members of that species.

isotype switching Also called *class switching* . A change in the predominant antibody type produced by a cell.

iTAG analysis See **metabarcoding** .

IVET See **in vivo expression technology** .

J

joule (J) The standard SI unit for energy.

jumping gene See **transposable element** .

K

kimchi A popular Korean food based on brine-fermented cabbage.

Kirby-Bauer assay A method for determining antibiotic susceptibility. Antibiotic-impregnated disks are placed on an agar plate whose surface has been confluently inoculated with a test organism. The antibiotic diffuses away from the disk and inhibits growth of susceptible bacteria. The width of the inhibitory zone is proportional to the susceptibility of the organism.

knockout mutation A mutation that completely eliminates the activity of a gene product.

Koch's postulates Four criteria, developed by Robert Koch, that should be met for a microbe to be designated the causative agent of an infectious disease.

Korarchaeota A phylum of archaea in the TACK superphylum that contains anaerobic hyperthermophiles in hot springs and deep-sea thermal vents.

Krebs cycle See **tricarboxylic acid cycle** .

L

labile toxin (LT) An *Escherichia coli* enterotoxin, destroyed by heat, that increases cellular cAMP concentrations.

laboratory evolution See **experimental evolution** .

lactic acid fermentation A fermentation reaction that generates lactic acid from reduction of pyruvic acid.

lag phase A period of cell culture, occurring right after bacteria are inoculated into new media, during which there is slow growth or

no growth.

laminar flow biological safety cabinet An air filtration appliance that removes pathogenic microbes from within the cabinet.

Langerhans cell A specialized, phagocytic dendritic cell that is the predominant cell type in skin-associated lymphatic tissue.

late gene A viral gene expressed late in the replication cycle.

late-phase anaphylaxis Anaphylaxis caused by leukotrienes that are released by eosinophils recruited by mast cells.

latent period The time in the viral life cycle when progeny virions have formed but are still within the host cell.

latent state A period of the infection process during which a pathogenic agent is dormant in the host and cannot be cultured.

lateral gene transfer See **horizontal gene transfer** .

law of mass action The rate of a chemical reaction is proportional to the substrate concentrations. At equilibrium, the ratio of the concentrations of products to substrates is constant.

LD_{50} See **lethal dose 50%** .

leading indicator In epidemiology, a signal that appears ahead of a trend such as increasing cases of a disease.

leaflet One of the two lipid layers in a phospholipid bilayer. The inner leaflet of the cell membrane faces the cytoplasm.

leaven For bread dough, to cause to rise by generating air spaces, usually through carbon dioxide production by microbial fermentation.

leghemoglobin An iron-bearing plant protein that sequesters oxygen to maintain an anoxic environment for nitrogenase within cells containing bacteroids.

lens An object composed of transparent, refractive material that bends light rays to converge at a focal point (or to diverge from an

imaginary point). For electron microscopy, a series of magnets arranged as a magnetic lens bends electron beams to converge or diverge.

lentivector *or* lentiviral vector A gene transfer vector derived from a lentivirus such as HIV; designed to integrate genes into a host chromosome.

lentivirus A member of a family of retroviruses with a long incubation period. An example is HIV.

lethal dose 50% (LD_{50}) A measure of virulence; the number of bacteria or virions required to kill 50% of an experimental group of hosts.

leukocidin A toxin that lyses white blood cells.

leukocyte White blood cell.

library construction The amplification and processing of DNA for sequencing reactions, such as those of next-generation sequencing (NGS).

lichen A simple multicellular organism formed by a mutualistic relationship between a fungus and an alga or cyanobacterium.

light chain The smaller of the two protein types that make up an antibody. Each antibody contains two heavy chains and two light chains.

light microscopy (LM) Observation of a microscopic object on the basis of light absorption and transmission.

lignin A complex aromatic organic compound that forms the key structural support for trees and woody stems.

limiting nutrient A nutrient whose depletion generally restricts growth in a given ecosystem.

lincosamide Any of a class of bacteriostatic antibiotics that include a pyrrolidine ring linked to a pyranose (e.g., clindamycin).

lineage In a phylogenetic tree, a line of individuals, past and present, that descends from one common ancestor. Also called a **branch** .

lipid A The anchor lipid of lipopolysaccharide (LPS), composed of glucosamine plus six lipid chains.

lipopolysaccharides (LPS) Structurally unique phospholipids found in the outer leaflet of the outer membrane in Gram-negative bacteria. Many are endotoxins.

lithotrophy Also called *chemolithotrophy* . The metabolic oxidation of inorganic compounds to yield energy and fix single-carbon compounds into biomass.

LM See **light microscopy** .

logarithmic (log) phase See **exponential phase** .

Lokiarchaeota A phylum in the Asgard superphylum of Archaea that contains deep-sea thermophiles isolated from a thermal vent named Loki's Castle. Formerly known as the Deep-Sea Archaeal Group or Marine Benthic Group B (DSAG or MBGB).

long terminal repeat (LTR) A repeated nucleic acid sequence at the 5′ and 3′ ends of a provirus.

loss-of-function mutation A mutation that eliminates or decreases the function of the gene product.

LPS See **lipopolysaccharides** .

LT See **labile toxin** .

LTR See **long terminal repeat** .

Lyme disease One form of borreliosis. A tick-borne disease caused by *Borrelia burgdorferi* , which may involve skin lesions and arthritis.

lymph node A secondary lymphatic organ, formed by the convergence of lymphatic vessels, that traps foreign particles from local tissue and presents them to resident immune cells.

lymphocyte A mononuclear leukocyte (white blood cell) that is a product of lymphoid tissue and participates in immunity (e.g., B cell and T cell).

lyophilization See **freeze-drying** .

lysate The contents of broken cells; may include virus particles.

lysis Also called *burst* The rupture of the cell by a break in the cell wall and membrane.

lysogeny A viral life cycle in which the viral genome integrates into and replicates with the host genome but retains the ability to initiate host cell lysis.

lysosome An acidic eukaryotic organelle that aids digestion of molecules. Not found in plant cells.

M

M cell A phagocytic innate immune cell (microfold cell) found between intestinal epithelial cells.

MAC See **membrane attack complex** .

macrocolony A large cluster of cells embedded within an extracellular matrix. Macrocolonies constitute the mushroom-shaped structures of mature biofilms.

macrolide Any of a group of antibiotics containing a large lactone ring (e.g., erythromycin).

macronucleus A form of nucleus found in ciliates that is derived from gene amplification and rearrangement of micronuclear DNA; contains actively transcribed genes.

macronutrient A nutrient that an organism needs in large quantity.

macrophage A mononuclear, phagocytic, antigen-presenting cell of the immune system.

magnetosome An organelle that contains the mineral magnetite and thus enables microbes to sense a magnetic field.

magnetotaxis The ability to direct motility along magnetic field lines.

magnification An increase in the apparent size of a viewed object as an optical image.

major histocompatibility complex (MHC) Transmembrane cell proteins important for recognizing self and for presenting foreign antigens to the adaptive immune system.

malaria A disease caused by the apicomplexan *Plasmodium falciparum* , transmitted by mosquitoes.

malolactic fermentation Fermentation of L -malate (a side product of glucose fermentation) by *Oenococcus oeni* bacteria; an important process in winemaking.

MAMP See **microbe-associated molecular pattern** .

marine snow Microbial biofilms on particles suspended in marine water.

marker sequence A short sequence of base pairs or of amino acid residues that is found specifically in one class of genes or proteins but absent from other known genes or proteins.

mass spectrometry An analytical technique that measures the mass of molecules. Molecules are ionized and sorted according to their mass-to-charge (m / z) ratio.

mast cell A white blood cell that secretes proteins that aid innate immunity. Mast cells reside in connective tissues and mucosa and do not circulate in the bloodstream.

matrix protein A protein, found in some viruses, that is located between the capsid and the membrane envelope.

MCP See **methyl-accepting chemotaxis protein** .

MDR efflux pump See **multidrug resistance efflux pump** .

mechanical transmission A nonspecific means of transfer of a pathogen to a host, such as the transmission of a virus through a wound or of a bacterial pathogen from the body surface of a vector (such as a fly).

mechanical vector A vector that conveys pathogens to a susceptible individual or food without the pathogen needing to replicate in the vector; a housefly, for example.

meiosis A form of cell division by which a diploid eukaryotic cell generates haploid sex cells that contain recombinant chromosomes.

membrane attack complex (MAC) A cell-destroying pore produced in the membrane of invading bacteria by the host cell complement cascade.

membrane-permeant weak acid An acid that exists in equilibrium between negatively charged and uncharged forms, such as acetic acid. The uncharged form can penetrate the membrane.

membrane-permeant weak base A base that exists in equilibrium between positively charged and uncharged forms, such as methylamine. The uncharged form can penetrate the membrane.

membrane potential Energy stored as an electrical voltage difference across a membrane.

memory B cell A long-lived type of lymphocyte preprogrammed to produce a specific antibody. After encountering their activating antigen, memory B cells differentiate into antibody-producing plasma cells.

merozoite The form of *Plasmodium falciparum* , the causative agent of malaria, that invades red blood cells.

mesocosm A small, controlled model ecosystem.

mesophile An organism with optimal growth between 20°C and 40°C.

messenger RNA (mRNA) An RNA molecule that encodes a protein.

messenger RNA (mRNA) vaccine An mRNA vaccine is made from a cloned gene that expresses mRNA encoding an immunogenic viral protein. The mRNA is encased in liposomes for delivery to the body.

metabarcoding Also called *iTAG analysis* . The use of a short DNA sequence, such as the gene for SSU rRNA, to screen taxa from a metagenome.

metabolic island A genomic island that contributes genes involved in metabolism.

metabolomics The study of the overall collection of small molecules (metabolites) within a cell.

metagenome The sum of genomes of all members of a community of organisms.

metagenomics The study of community genomes, or metagenomes.

metatranscriptomics The study of all the RNA transcripts expressed by members of a community, known as a metatranscriptome.

methane gas hydrate A crystalline material in which methane molecules are surrounded by a cage of water molecules. This molecular configuration is found in the deep ocean.

methanogen An archaeon that uses hydrogen to reduce CO_2 and other single-carbon compounds or acetate to methane, yielding energy. Clades of methanogens branch within the superphylum Euryarchaeota.

methanogenesis An energy-yielding metabolic process that releases methane, commonly from hydrogen gas and oxidized one- or two-carbon compounds. It is unique to archaea.

methanotrophy The metabolic oxidation of methane to yield energy.

methyl-accepting chemotaxis protein (MCP) Also called *chemoreceptor* . A cell-membrane signal transduction protein that becomes methylated during adaptation to a chemotactic signal.

methyl-directed mismatch repair A DNA repair system that fixes misincorporation of a nucleotide after DNA synthesis. The unmethylated daughter strand is corrected to complement the methylated parental strand.

methylome All of the bases in the genome that are chemically modified by methylation.

methylotrophy The metabolic oxidation of single-carbon compounds such as methanol, methylamine, or methane to yield energy.

methyltransferase An enzyme that adds a methyl group to a base in DNA.

MGI See **mobilizable genomic island** .

MHC See **major histocompatibility complex** .

MHC restriction The ability of T cells to recognize only those antigens complexed to self MHC molecules.

MIC See **minimal inhibitory concentration** .

microaerophilic Requiring oxygen at a concentration lower than that of the atmosphere, but unable to grow in high-oxygen environments.

microbe An organism or virus too small to be seen with the unaided human eye.

microbe-associated molecular pattern (MAMP) Formerly called *pathogen-associated molecular pattern (PAMP)* . Molecules associated with groups of microbes, both pathogenic and nonpathogenic, that are recognized by cells of the innate immune system.

microbial mat A complex biofilm of microbes, usually containing multiple layers.

microbiome-gut-brain axis A complex bidirectional network of communication between the central nervous system, the intestine, and intestinal microbiota.

microbiota *or* microbiome The total community of microbes associated with an organism (such as the human body) or with a defined habitat (such as soil or plants).

microcolony A small assembly of cells on a surface that initiate biofilm formation.

microfilament Also called *actin filament* . A eukaryotic cytoskeletal protein composed of polymerized actin.

microfossil A microscopic fossil in which calcium carbonate deposits have filled in the form of ancient microbial cells.

micronucleus A form of nucleus found in ciliates; contains a diploid set of chromosomes and undergoes meiosis for sexual exchange by conjugation.

micronutrient A nutrient that an organism needs in small quantity, typically a vitamin or a mineral.

microplankton Plankton consisting of microbes approximately 20–1,000 mm in diameter.

microscope A tool that increases the magnification of specimens to enable viewing at higher resolution.

microtubule A eukaryotic cytoskeletal protein composed of polymerized tubulin.

minimal defined medium A solution of chemically defined compounds for organismal growth that contains only the minimal components required for growth.

minimal inhibitory concentration (MIC) The lowest concentration of a drug that will prevent the growth of an organism.

MIS-C See **multisystem inflammatory syndrome in children** .

miso A Japanese condiment, made from ground soy and rice, salted and fermented by the mold *Aspergillus oryzae* .

missense mutation A point mutation that alters the sequence of a single codon, leading to a single amino acid substitution in a protein.

mitochondrion pl. mitochondria An organelle of endosymbiotic origin that produces ATP through the use of an electron transport system to generate a proton potential. O_2 is the final electron acceptor to produce H_2O.

mitosis The orderly replication and segregation of eukaryotic chromosomes, usually prior to cell division.

mitosporic fungus Also called *imperfect fungus* . A species of fungus that generates spores by mitosis and lacks a known sexual cycle.

mixed-acid fermentation A bacterial fermentation process in which pyruvate is converted to several different organic acids, as well as ethanol, CO_2 , and H_2O.

mixotrophy Metabolism that includes CO_2 fixation through photosynthesis and catabolism of organic compounds.

mobilizable genomic island (MGI) A genomic island that can be transferred to another cell via the machinery of a conjugative transposon.

modular enzyme A multifunctional enzyme in which several domains or subunits conduct sequential steps to generate a product.

modular synthesis The construction of a polymeric molecule based on incorporation of repeating units.

MOI See **multiplicity of infection** .

molarity A unit of concentration measured as the number of moles of solute per liter of solution.

molecular clock The use of DNA or RNA sequence information to measure the time of divergence among different species.

molecular formula A notation indicating the number and type of atoms in a molecule. For example, H_2O is the molecular formula for water.

Mollicutes A class of bacteria (phylum Mycoplasmatota) mostly lacking a cell wall; includes genus *Mycoplasma* . Closely related to Firmicutes.

monocyte A white blood cell with a single nucleus that can differentiate into a macrophage or a dendritic cell.

monosaccharide The monomer unit of sugars. Monosaccharides have a molecular formula of $(CH_2O)_n$.

monoderm Enclosed by a single phospholipid membrane.

mononuclear phagocyte system (MPS) An amorphous part of the immune system that consists mostly of monocytes and macrophages present in connective tissue that surrounds kidney, liver, spleen, lymph nodes, Peyer's patches, and bone marrow.

monophyletic Having a single evolutionary origin; that is, diverging from a common ancestor.

monophyletic group See **clade** .

mordant A chemical binding agent that causes specimens to retain stains better.

mother cell In sporulation of Gram-positive bacteria, the larger cell that forms during the asymmetrical cell division leading to spore formation. The mother cell will engulf the forespore, but then disintegrates as the forespore matures.

motility The ability of a microbe to direct its own movement.

MPS See **mononuclear phagocyte system** .

mRNA See **messenger RNA** .

mucociliary escalator The ciliated mucous lining of the trachea, bronchi, and bronchioles that sweeps foreign particles up and away from the lungs.

mucosal immunity The portion of the innate and adaptive immune systems that protects the mucosa from microbial invasion.

Mueller-Hinton agar A specialized, standardized, *para* -aminobenzoic acid–free medium used for the Kirby-Bauer assay.

multidrug resistance (MDR) efflux pump A transmembrane protein pump that can export many different kinds of antibiotics of diverse structure.

multiplex PCR A polymerase chain reaction that uses multiple pairs of oligonucleotide primers to amplify several different DNA sequences simultaneously.

multiplicity of infection (MOI) The ratio of infecting virions to host cells.

multisystem inflammatory syndrome in children (MIS-C) A systemic multi-organ inflammatory syndrome in children brought on by COVID-19 disease.

murein See **peptidoglycan** .

murein lipoprotein Also called *Braun lipoprotein* . The major lipoprotein that connects the outer membrane of Gram-negative bacteria to the peptidoglycan cell wall.

mutagen A chemical that damages DNA and increases the rate of mutations.

mutation A heritable change in a DNA sequence.

mutator A mutation that inactivates a gene encoding a DNA repair enzyme, leading to increase in frequency of random mutations throughout the genome.

mutator strain A strain of cells with a high mutation rate, usually due to a mutation in a DNA repair enzyme.

mutualism A symbiotic relationship in which both partners benefit.

mycelium *pl.* mycelia A single mass of fungal hyphae that projects into the air (aerial mycelium) or into the growth substrate (surface mycelium).

mycolic acid One of a diverse class of sugar-linked fatty acids found in the cell envelopes of mycobacteria such as *Mycobacterium tuberculosis* .

mycology The study of fungi.

Mycoplasma (Mycoplasmatota) A phylum of bacteria related to Firmicutes and which lack a cell wall. Most known species are class Mollicutes, genus *Mycoplasma* .

mycorrhizae *sing* . mycorrhiza Fungi involved in an intimate mutualism with plant roots, in which nutrients are exchanged.

myxospore A durable spherical cell produced by the fruiting body of myxobacteria.

N

N-terminal rule The tendency of the N-terminal amino acid of a protein to influence protein stability.

NAD See **nicotinamide adenine dinucleotide** .

Nanoarchaeota A phylum in the DPANN superphylum of Archaea that includes very small cells, which are obligate symbionts of vent hyperthermophiles.

nanoparticle A particle of matter that ranges in size from approximately 1 to 100 nanometers.

nanopore DNA strand sequencing A type of nucleic acid sequence determination that relies on the changes in electric current that occur when a single strand of DNA passes through a nanopore structure.

nanoscale secondary ion mass spectrometry (NanoSIMS) A technique of chemical imaging in which an ionizing beam breaks off organic ions from a sample, which fly off the sample and are captured for analysis by a mass spectrometer.

nanotube A tube of plasma membrane that connects the cytoplasm of two cells, forming a conduit through which intracellular materials or pathogens may pass.

nanowire In microbiology, a bacterial appendage that conducts electric current.

nasopharynx The passage leading from the nose to the oral cavity.

native conformation The fully folded, functional form of a protein.

natto A soybean product, similar to tempeh, produced by alkaline fermentation.

natural killer (NK) cell A lymphocyte that does not need antigen stimulation to kill tumor or infected host cells by inserting granules containing perforin.

natural selection The change in frequency of genes in a population under environmental conditions that favor some genes over others.

necrotizing fasciitis Also known as *flesh-eating disease* . A severe skin infection usually caused by the Gram-positive coccus *Streptococcus pyogenes* .

negative selection In immunology, the destruction of T cells bearing T-cell receptors that bind strongly to self MHC proteins displayed on thymus epithelial cells.

negative stain A stain that colors the background and leaves the specimen unstained.

NER See **nucleotide excision repair** .

NET See **neutrophil extracellular trap** .

neuraminidase inhibitor Any of a class of anti-influenza drugs that target neuraminidase on the viral envelope and decrease the number of virus particles produced.

neutralophile An organism with an optimal growth range in environments between pH 5 and 8.

neutrophil A white blood cell of the innate immune system that can phagocytose and kill microbes.

neutrophil extracellular trap (NET) A net of chromatin (including DNA) and antimicrobial peptides expelled by dying neutrophils to trap and injure nearby pathogenic bacteria.

NHEJ See **nonhomologous end joining** .

niche An organism's environmental requirements for existence and its relations with other members of the ecosystem.

niche construction The actions of an organism that alter its environmental niche and change its chance of survival in that niche.

nicotinamide adenine dinucleotide (NAD) An energy carrier in the cell that can donate (NADH) or accept (NAD^+) electrons.

nitrification The oxidation of reduced nitrogen compounds to nitrite or nitrate.

nitrifier An organism that converts reduced nitrogen compounds to nitrite or nitrate.

nitrogen fixation The ability of some prokaryotes to reduce inorganic diatomic nitrogen gas (N_2) to two ammonium ions ($2NH_4^+$).

nitrogen-fixing bacterium A bacterium that can reduce diatomic nitrogen gas (N_2) to two molecules of ammonium ion (NH_4^+).

nitrogenase The enzyme that catalyzes nitrogen fixation.

nitrogenous base See **nucleobase** .

Nitrospirae (Nitrospirota) A phylum of Gram-negative bacteria, many of which are lithotrophs, oxidizing nitrite to nitrate or ammonia to nitrate.

NK cell See **natural killer cell** .

NLR See **NOD-like receptor** .

NOD-like receptor (NLR) A eukaryotic cytoplasmic protein that recognizes particular microbe-associated molecular patterns (MAMPs) present on microorganisms.

node In a phylogenetic tree, the most recent common ancestor of branching descendants.

noise Variance from a mean in an assay. A system in which individual results vary greatly from a mean that was derived from many results is a noisy system.

Nomarski microscopy See **differential interference contrast microscopy** .

nomenclature The naming of different taxonomic groups of organisms.

nonadaptive immunity See **innate immunity** .

nonhomologous end joining (NHEJ) A pathway that repairs double-strand breaks in DNA by direct ligation without the need for large regions of homology.

nonparametric Describes statistical tests that do not require a normal distribution of replicate trials.

nonpolar covalent bond A covalent bond in which the electrons in the bond are shared equally by the two atoms.

nonribosomal peptide A peptide with antimicrobial activity synthesized by modular enzymes and not by ribosomes.

nonribosomal peptide synthetase (NRPS) A modular enzyme that synthesizes a peptide without using a ribosome.

nonsense mutation A mutation that changes an amino acid codon into a premature stop codon.

nori A Japanese food obtained from the red algae *Porphyra* species.

norovirus Also known as *Norwalk virus* . A nonenveloped ssRNA virus that causes severe diarrhea in children and adults.

northern blot A technique to detect specific RNA sequences. Sample RNA is subjected to gel electrophoresis, transferred to a blot, and probed with a labeled cDNA that will hybridize to target RNA sequences.

Norwalk virus See **norovirus** .

nosocomial Hospital-acquired; commonly refers to an infectious agent.

NP See **nucleocapsid protein** .

NRPS See **nonribosomal peptide synthetase** .

nucleobase Also called *nitrogenous base* . A planar, heteroaromatic, nitrogen-containing base that forms a nucleotide of nucleic acids; nucleobases determine the information content of DNA and RNA. There are five nucleobases: adenine, cytosine, guanine, thymine, and uracil.

nucleocapsid protein (NP) A protein that coats a viral genome.

nucleoid The looped coils of a bacterial chromosome.

nucleolus *pl.* nucleoli A region inside the nucleus where ribosome assembly begins.

nucleomorph A vestigial nucleus within a eukaryotic cell, evolved by genetic reduction from the nucleus of an endosymbiont.

nucleotide The monomer unit of nucleic acids, consisting of a five-carbon sugar, a phosphoryl group, and a nitrogenous base.

nucleotide excision repair (NER) A DNA repair mechanism that cuts out damaged DNA. New, correctly base-paired DNA is

synthesized by DNA polymerase I.

nucleus *pl.* nuclei A eukaryotic organelle that contains DNA.

numerical aperture The product of the refractive index of the medium and sin θ (where θ is the angle of aperture). As numerical aperture increases, the magnification increases.

O

O antigen *or* O polysaccharide A sugar chain that connects to the core polysaccharide of lipopolysaccharides.

objective lens In a compound microscope, the lens that is closest to the specimen and generates the initial magnification.

obligate intracellular pathogen A pathogen that can replicate only inside host cells.

ocular lens In a compound microscope, the lens situated closest to the observer's eye; part of the eyepiece.

Okazaki fragments Short fragments of DNA that are synthesized on the lagging strand during DNA synthesis.

oligotrophic Having dilute concentrations of nutrients.

omics Analytical tools that probe community samples at the molecular level (metagenomes, metatranscriptomes, and single-cell genomes), as well as whole-cell protein populations (proteomes). Examples include genomics, metagenomics, metatranscriptomics, and proteomics.

OMZ See **oxygen minimum zone** .

oncogenic virus A virus that causes cancer.

Oomycetes Formerly called *water molds* . A member of the eukaryotic group Oomycetes—heterokont protists whose life cycle resembles that of fungi; formerly classified as fungi (Oomycota).

open reading frame (ORF) A DNA sequence predicted to encode a protein.

operational taxonomic unit (OTU) A taxonomic group that is defined by a designated degree of similarity among members on the basis of DNA sequence.

operator A region of DNA to which the repressor protein binds. Operators are usually located near promoters.

operon A collection of genes that are in tandem on a chromosome and are transcribed into a single RNA.

opportunistic pathogen A microbe that normally is not pathogenic but can cause infection or disease in an immunocompromised host organism.

opsonin An antibody that renders its target (e.g., bacteria) susceptible to phagocytosis.

opsonization The coating of pathogens with antibodies that aid pathogen phagocytosis by innate immune cells.

opsonize To bind IgG antibodies to microbes in order to enhance microbial phagocytosis by host immune cells.

optical density A measure of how many particles are suspended in a solution, based on light scattering by the suspended particles.

optical isomer Also called *enantiomer* . Either of two forms of a molecule that are mirror images of each other. Molecules that contain a chiral carbon can have optical isomers.

oral groove A mouthlike structure of a ciliate cell, for food uptake.

ORF See **open reading frame** .

ORT See **rehydration therapy** .

organelle A membrane-enclosed compartment within eukaryotic cells that serves a specific function.

organic molecule A molecule that contains a carbon-carbon bond.

organotrophy Also called *chemoorganotrophy* or *chemoheterotrophy* . The metabolic oxidation of organic compounds to yield energy without absorption of light.

origin (*oriC*) The region of a bacterial or archaeal chromosome where DNA replication initiates.

oropharynx The area between the soft palate and the upper edge of the epiglottis.

ortholog *or* orthologous gene A gene present in more than one species that derived from a common ancestral gene and encodes the same function.

osmolarity A measure of the concentration of solute molecules in solution.

osmosis The diffusion of water from regions of high water concentration (low solute) to regions of low water concentration (high solute) across a semipermeable membrane.

osmotic pressure Also called *turgor pressure* . Pressure exerted by the osmotic flow of water through a semipermeable membrane.

OTU See **operational taxonomic unit** .

outer leaflet The layer of the cell membrane phospholipid bilayer that faces away from the cytoplasm.

outer membrane In Gram-negative bacteria, a membrane external to the cell wall.

outer membrane–associated protein A protein linked to or embedded in the outer membrane.

outgroup In a phylogenetic tree, a taxon that diverged from a lineage before the ancestor shared by all other taxa in the tree.

oxazolidinone One of a class of synthetic antibiotics, containing an oxazole ring, that inhibit protein synthesis.

oxidative burst A large increase in the oxygen consumption of immune cells during phagocytosis of pathogens as the immune cells produce oxygen radicals to kill the pathogen.

oxidative phosphorylation A process of an electron transport chain that uses diatomic oxygen as a final electron acceptor and generates a proton gradient across a membrane for the production of ATP via ATP synthase.

oxidoreductase An electron transport system protein that accepts electrons from one molecule (oxidizing that molecule) and donates electrons to a second molecule, thereby reducing the second molecule.

oxygen minimum zone (OMZ) The region of the marine water column in which oxygen is depleted by respiration; usually at a mid level, between the aerated upper water and the deeper oxygenated water where organic food is scarce.

oxygenic Z pathway An ATP-producing photosynthetic pathway consisting of photosystems I and II. Water serves as the initial electron donor (generating O_2), and $NADP^+$ is the final electron acceptor (generating NADPH).

P

P site See **peptidyl-tRNA site** .

PA See **protective antigen** .

palindrome A DNA sequence in which the top and bottom strands have the same sequence in the 5′-to-3′ direction.

PAMP See **microbe-associated molecular pattern** .

pandemic An epidemic that occurs over a wide geographic area.

pangenome All the genes possessed by all individual members of a species.

panspermia The hypothesis that life forms originated elsewhere in the universe and "seeded" life on Earth.

paralog *or* paralogous gene A gene that arises by gene duplication within a species and evolves to carry out a different function from that of the original gene.

paraphyletic group A group of organisms that contains members of larger clades that do not share a unique common ancestor excluding members of other groups.

pararetrovirus Also called *DNA reverse-transcribing virus* . A virus with a double-stranded DNA genome that generates an RNA intermediate and thus requires reverse transcriptase to generate progeny DNA genomes.

parasite Any bacterium, virus, fungus, or protozoan (protist) that colonizes and harms its host; the term commonly refers to protozoa and to invertebrates.

parasitism A symbiotic relationship in which one member benefits and the other is harmed.

parenteral route A method by which an infectious agent enters the body via injection into the bloodstream, often by a mosquito or other insect.

parfocal In a microscope with multiple objective lenses, having the objective lenses set at different heights that maintain focus when switching among lenses.

passive transport Net movement of molecules across a membrane without energy expenditure by the cell.

pasteurization The heating of food at a temperature and time combination that will kill spore-like structures of *Coxiella burnetii* .

pathogen A bacterial, viral, or fungal agent of disease.

pathogen-associated molecular pattern (PAMP) See **microbe-associated molecular pattern** .

pathogenesis The processes through which microbes cause disease in a host.

pathogenicity The ability of a microorganism to cause disease.

pathogenicity island A type of genomic island in which the stretch of DNA contains virulence factors and may have been transferred from another genome.

patient zero See **index case** .

pattern recognition receptor (PRR) A protein receptor that recognizes microbe-associated molecular patterns (MAMPs) and signals production of cytokines.

PBP See **penicillin-binding protein** .

PCM See **phase-contrast microscopy** .

PCR See **polymerase chain reaction** .

PDC See **pyruvate dehydrogenase complex** .

PDE See **phosphodiesterase** .

pelagic zone The water column of the open ocean, away from the shore and the ocean floor.

penicillin An antibiotic, produced by the *Penicillium* mold, containing a beta-lactam ring; it blocks cross-bridge formation during peptidoglycan synthesis.

penicillin-binding protein (PBP) A bacterial protein, involved in cell wall synthesis, that is the target of the antibiotic penicillin.

pentose phosphate cycle See **Calvin cycle** .

pentose phosphate pathway (PPP) *or* pentose phosphate shunt (PPS) An alternate glycolytic pathway in which glucose 6-phosphate is first oxidized and then decarboxylated to ribulose 5-phosphate, ultimately generating 2 NADPH.

peptide bond The covalent bond that links two amino acid monomers.

peptidoglycan Also called *murein* . A polymer of peptide-linked chains of amino sugars; a major component of the bacterial cell wall.

peptidyltransferase A ribozyme that catalyzes the formation of peptide bonds.

peptidyl-tRNA site (P site) The region of a ribosome that contains the growing protein attached to a tRNA.

perforin A cytotoxic protein, secreted by T cells, that forms pores in target cell membranes.

peripheral membrane protein A protein that is associated with a membrane but does not span the phospholipid bilayer.

periplasm In Gram-negative bacteria, the gel-like solution between the outer and inner membrane; it contains the cell wall.

permease A substrate-specific carrier protein in the membrane.

persister cell Any of a subpopulation of dormant organisms that arise within a population of antibiotic-susceptible bacteria and are tolerant to bactericidal antibiotics during treatment. On removal of the drug, persisters can grow and reestablish infection.

peroxisome A eukaryotic organelle that converts hydrogen peroxide to water.

petechia *pl.* petechiae A pinpoint capillary hemorrhage due to the absence of clotting factors. Petechiae may indicate the presence of endotoxin.

Petri dish *or* Petri plate A round dish with vertical walls covered by an inverted dish of slightly larger diameter. The smaller dish can be filled with a substrate for growing microbes.

PFU See **plaque-forming unit** .

phage See **bacteriophage** .

phage display A technique in which a phage particle contains recombinant coat proteins expressed by genes encoding a coat

protein fused to the protein of interest, such as a vaccine antigen.

phage-inducible chromosomal islands (PICIs) Mobile genetic elements integrated within the host chromosome that hijack the capsids produced by incoming phage for transfer to new host cells.

phagocytosis A form of endocytosis in which a large extracellular particle is brought into the cell.

phagosome A large intracellular vesicle that forms as a result of phagocytosis.

phase-contrast microscopy (PCM) Observation of a microscopic object based on the differences in the refractive index between cell components and the surrounding medium. Contrast is generated as the difference between refracted light and transmitted light shifts out of phase.

phase variation A gene regulatory mechanism that reversibly changes the DNA sequence within or near the gene. One mechanism involves site-specific recombination that flips a DNA sequence in a chromosome.

phenol coefficient test A test of the ability of a disinfectant to kill bacteria; the higher the coefficient, the more effective the disinfectant.

phenotype The observable characteristics of an organism.

phosphodiester bond The phosphoryl bond that includes ester links with two adjacent nucleotides in a nucleic acid.

phosphodiester link The linkage between two adjacent nucleotides in a nucleic acid. A phosphate forms ester bonds with the 5′ carbon of one (deoxy-)ribose and the 3′ carbon of the other (deoxy-)ribose.

phosphodiesterase (PDE) A class of enzymes that degrade the second messenger molecule c-di-GMP.

phospholipid The major component of membranes. A typical phospholipid is composed of a core of glycerol to which two fatty acids and a modified phosphate group are condensed.

phospholipid bilayer Two layers of phospholipids; the hydrocarbon fatty acid tails face the interior of the bilayer, and the charged phosphate groups face the cytoplasm and extracellular environment. The cell membrane is a phospholipid bilayer.

phosphorimaging The use of phosphors for detecting radiolabeled nucleic acids, typically in Southern or northern blots.

phosphorylation The enzyme-catalyzed addition of a phosphoryl group onto a molecule.

phosphotransferase system (PTS) A group translocation system that uses phosphoenolpyruvate to transfer phosphoryl groups onto the incoming molecule.

photic zone See **euphotic zone** .

photoautotrophy The fixation of single-carbon compounds into organic biomass, using light as an energy source.

photoexcitation Light absorption that raises an electron to a higher energy state, as in bacteriorhodopsin or in chlorophyll.

photoferrotrophy Photosynthesis in which light absorption provides energy to separate an electron from reduced iron (Fe^{2+}).

photoheterotrophy Metabolism that includes gain of energy from light absorption with biosynthesis from preformed organic compounds. Usually also includes organotrophy, gain of energy from reactions of organic compounds.

photoionization Light absorption that causes electron separation.

photolithoautotrophy (or **photoautotrophy**) A form of metabolism that yields energy from light absorption and uses that energy to fix CO_2 into biomass.

photolysis The first energy-yielding phase of photosynthesis; the light-driven separation of an electron from a molecule coupled to an electron transport system.

photoorganotrophy A form of metabolism that obtains energy either from the catabolism of organic compounds or through the absorption of light.

photoreactivation A light-induced, photolyase-catalyzed repair of pyrimidine dimers.

photosynthesis The metabolic ability to absorb and convert solar energy into chemical energy for biosynthesis. Autotrophic photosynthesis, or photoautotrophy, includes CO_2 fixation.

photosystem I (PS I) A protein complex that harvests light from a chlorophyll or bacteriochlorophyll, donates an electron to an electron transport system, receives an electron from a small molecule such as H_2S or H_2O, and stores energy in the form of NADPH.

photosystem II (PS II) A protein complex that harvests light from a chlorophyll or bacteriochlorophyll, donates an electron to an electron transport system, and stores energy in the form of a proton potential.

phototrophy The use of chemical reactions powered by the absorption of light to yield energy.

phylogenomics The construction of phylogenetic trees of related clades on the basis of comparison of whole genomes.

phylogenetic tree A diagram depicting estimates of the relative amounts of evolutionary divergence among different species.

phylogeny A measurement of genetic relatedness. The classification of organisms on the basis of their genetic relatedness.

phylum *pl.* phyla The taxonomic rank one level below domain; a group of organisms sharing a common ancestor that diverged early from other groups.

phytoplankton Phototrophic marine bacteria, algae, and protists, the primary producers in pelagic food webs.

PICIs See **phage-inducible chromosomal islands** .

picornavirus A member of a medically important group of RNA viruses. An example is poliovirus.

pidan Pidan, or "century egg," is a food made by alkali treatment and microbial fermentation of eggs over several months.

piezophile See **barophile** .

pilus *pl.* pili Also called *fimbria* . A straight protein filament composed of a tube of protein monomers that extend from the bacterial cell envelope.

pinocytosis A form of endocytosis in which only extracellular fluid and small molecules are brought into the cell.

Planctomycetes (Planctomycetota) A phylum of free-living bacteria that have stalked cells and reproduce by budding. Their nucleoid is surrounded by a membrane.

plankton Organisms that float in water.

planktonic cell An isolated cell, growing individually in a liquid without connections to other cells.

Plantae Also called *Archaeplastida* . A eukaryotic superphylum that includes plants, as well as green and red primary algae.

plaque A cell-free zone on a lawn of bacterial cells caused by viral lysis.

plaque-forming unit (PFU) A measure of the concentration of phage particles in liquid culture.

plasma cell A short-lived antibody-producing cell.

plasma membrane See **cell membrane** .

plasmid An extrachromosomal genetic element that may be present in some cells. Plasmids carry no essential genes.

plasmodesma *pl.* plasmodesmata A membrane channel in plants that connects adjacent plant cells.

plasmodial slime mold A slime mold in which a fertilized zygote undergoes multiple nuclear divisions, generating a multinucleate single cell (plasmodium).

plasmodium *pl.* plasmodia The giant, multinucleate cell formed by a plasmodial slime mold.

platelet A small cell fragment without a nucleus found in blood that is involved in clotting.

PMF See **proton potential** .

pneumonic plague A highly virulent and contagious *Yersinia pestis* lung infection.

point mutation A change in a single nucleotide within a nucleic acid sequence.

polar covalent bond A covalent bond in which the electrons in the bond are distributed unequally between two atoms.

poliomyelitis *or* polio A paralytic disease caused by the poliovirus.

poliovirus A human-specific RNA virus that is the causative agent of poliomyelitis.

poliovirus receptor (PVR) A cell membrane glycoprotein, also known as CD155, found on cells of the intestinal epithelium and on the surface of motor neurons.

polyketide A polymer that consists of alternating carbonyl and CHR groups (–CO–CHR–) in which many diverse R groups are possible; often has antimicrobial properties.

polymerase chain reaction (PCR) A method to amplify DNA in vitro using many cycles of DNA denaturation, primer annealing, and DNA polymerization with a heat-stable polymerase.

polyphyletic Having multiple evolutionary origins.

polyprotein A long peptide translated from one open reading frame but later cleaved into separate proteins with different functions.

polysaccharide A polymer of sugars. See also **glycan** .

polysome A cell structure consisting of multiple ribosomes performing translation on the same mRNA molecule.

population A group of individuals of one species living in a common location.

porin A transmembrane protein complex that allows movement of specific molecules across the cell membrane or the outer membrane.

portals of entry Openings in the body, either natural (e.g., gastrointestinal and respiratory tracts) or caused by trauma (e.g., wound or injection), through which pathogens can gain entrance and cause disease.

positive selection In immunology, the survival of T cells bearing T-cell receptors that don't recognize self MHC proteins displayed on thymus epithelial cells.

pour plate technique A procedure in which organisms are added to melted agar cooled to 42°C–45°C and the mixture is poured into an empty Petri plate. Colonies grow in the agar after the agar solidifies.

PPP See **pentose phosphate pathway** .

PPS See **pentose phosphate pathway** .

prebiotic soup A model for the origin of life that is based on the abiotic formation of fundamental biomolecules and cell structures such as membranes out of a "soup" of nutrients present on early Earth.

pre-catenane A knot of intertwined DNA that is generated during chromosome replication.

predator A consumer that feeds on grazers.

preliminary mRNA transcript (pre-mRNA) A eukaryotic messenger RNA prior to intron removal.

pre-mRNA See **preliminary mRNA transcript** .

prevalence The total number of active cases of a disease in a given location regardless of when the case first developed.

primary algae Algae that are derived from a single endosymbiotic event; closely related to green plants (Plantae).

primary antibody The first antibody added in an immunological assay, such as enzyme-linked immunosorbent assay (ELISA) or western blot. This antibody binds to the antigen of interest.

primary antibody response The production of antibodies upon first exposure to a particular antigen. B cells become activated and differentiate into plasma cells and memory B cells.

primary pathogen A disease-causing microbe that can breach the defenses of a healthy host.

primary producer An organism that produces biomass (reduced carbon) from inorganic carbon sources such as CO_2 .

primary recovery The initial isolation of commercial product from industrial microbes.

primary structure The first level of organization of polymers, consisting of the linear sequence of monomers; for example, the sequence of amino acids in a protein or of nucleotides in a nucleic acid.

primary syphilis The initial inflammatory reaction (chancre) at the site of infection by *Treponema pallidum* .

primase An RNA polymerase that synthesizes short RNA primers complementary to a DNA template to launch DNA replication.

primer An oligonucleotide that anneals to a complementary DNA sequence and serves as the substrate to initiate DNA synthesis by DNA polymerase. The primer is RNA for chromosomal replication

and DNA for PCR applications. Also refers to a primer for RNA virus replication, which can be RNA or protein.

primer extension A technique to determine the 5′ end of an RNA transcript. A primer is used in a reverse-transcription reaction (reverse transcriptase makes DNA from RNA) that extends the primer to the 5′ end (the start) of the message.

prion An infectious agent that causes propagation of misfolded host proteins; usually consists of a defective version of the host protein.

probabilistic indicator A method used to identify an unknown strain of bacteria. The results of a battery of biochemical tests performed on the unknown strain are compared to the probabilities that a known species will have the same results.

probiotic A food or nutritional supplement that contains live microorganisms and aims to improve health by promoting beneficial bacteria.

processivity The ability of a DNA polymerase to elongate a new DNA strand before falling off the template strand.

programmed cell death Cell death mediated by a regulated intracellular process.

prokaryote An organism whose cell or cells lack a nucleus. Both bacteria and archaea are prokaryotes.

promoter A noncoding DNA regulatory region immediately upstream of a structural gene that is needed for transcription initiation.

proofreading An enzymatic activity of some nucleic acid polymerases that attempts to correct mispaired bases.

prophage A phage genome integrated into a host genome.

propionic acid fermentation The fermentation of lactic acid to propionic acid by *Propionibacterium* species; used in the production of Swiss cheese.

protease An enzyme that cleaves protein.

protease inhibitor A molecule that inhibits a protease enzyme; some are used as anti-HIV drugs to block the virally encoded protease needed to complete HIV assembly.

protective antigen (PA) The core subunit of anthrax toxin, so called because immunity to this protein protects against disease.

protein A A *Staphylococcus aureus* cell wall protein that binds to the Fc region of antibodies, hiding the *S. aureus* cells from phagocytes.

Proteobacteria (Pseudomonadota) A large, metabolically and morphologically diverse group of Gram-negative bacteria; possess an outer membrane containing LPS.

proteome All the proteins expressed in a cell at a given time. The "complete proteome" includes all the proteins the cell can express under any condition. The "expressed proteome" represents the set of proteins made under a given condition.

proteorhodopsin A bacterial membrane-embedded protein that contains retinal and acts as a light-driven proton pump; it is homologous to the archaeal protein bacteriorhodopsin.

protist A single-celled eukaryotic microbe, usually motile; not a fungus.

proton potential *or* proton motive force (PMF) The potential energy of the concentration gradient of protons (hydrogen ions; H^+) plus the charge difference across a membrane.

protozoan *pl.* protozoa A heterotrophic eukaryotic microbe, usually motile, that is not a fungus.

provirus A viral genome that is integrated into the host cell genome.

PRR See **pattern recognition receptor** .

PS I See **photosystem I** .

PS II See **photosystem II** .

pseudogene A nonfunctional gene-like sequence that evolved by degenerative evolution.

pseudopeptidoglycan *or* pseudomurein A peptidoglycan-like molecule composed of sugars and peptides that is found in some archaeal cell walls.

pseudopod A locomotory extension of cytoplasm enclosed by the cell membrane.

P site See **peptidyl-tRNA site** .

psychrophile An organism with optimal growth at temperatures below 20°C.

psychrotroph A cold-resistant organism that can grow at temperatures between 0°C and 7°C but shows optimal growth between 20°C and 35°C.

PTS See **phosphotransferase system** .

pure culture A culture containing only a single strain or species of microorganism. A large number of microorganisms that all descended from a single individual cell.

purine A nitrogenous base with fused rings (that is, a bicyclic nucleobase) found in nucleotides; examples are adenine and guanine.

putrefaction Food spoilage due to the decomposition of proteins and amino acids.

PVR See **poliovirus receptor** .

pyelonephritis Kidney infection.

pyrimidine A single-ring nitrogenous base (that is, a monocyclic nucleobase) found in nucleotides; examples are cytosine, thymine, and uracil.

pyrogen Any substance that induces fever.

pyruvate dehydrogenase complex (PDC) The multisubunit enzyme that couples the oxidative decarboxylation of pyruvate, forming acetyl-CoA and NADH.

Q

qPCR See **quantitative PCR** .

quantitative PCR (qPCR) Also called *real-time PCR* . A technique using fluorescence to detect the products of PCR amplification as the reaction progresses, in order to quantify the amount of DNA in a sample.

quarantine The separation of infectious individuals from the general population to limit the spread of infection.

quasispecies A collection of isolates (usually viruses) from a common source of infection that have evolved into many different types within one host.

quaternary structure The fourth (and highest) level of organization of proteins, in which multiple polypeptide chains interact and function together.

quinol A reduced electron carrier that can diffuse laterally within membranes.

quinolone A type of antibiotic drug that inhibits DNA synthesis by targeting bacterial topoisomerases such as DNA gyrase.

quinone An oxidized electron carrier that can diffuse laterally within membranes.

quorum sensing The ability of bacteria to sense the abundance of other bacteria via secreted chemical signals called autoinducers.

R

radial immunodiffusion A technique in which a ring of precipitation is visualized in an agarose gel impregnated with antibody. Antigen placed within a well diffuses outward until reaching a zone of equivalence where antigen-antibody complexes precipitate and form a ring.

radiative forcing The increase in warming of Earth's atmosphere (in watts per square meter) associated with a particular climate factor, which is calculated as the difference between the sunlight energy absorbed by Earth and the energy radiated out to space.

radiolarian A member of the eukaryotic group Radiolaria—amebas with a silicate shell penetrated by filamentous pseudopods.

rancidity Food spoilage due to the oxidation of fats; it may or may not involve microbial activity.

rare biosphere Species that are present on Earth in such low abundance that metagenomic screens may not pick them up.

rarefaction curve A graph representing the number of different operational taxonomic units (species) found in a metagenome, as a function of increasing sample size.

RC See **reaction center** .

reaction center (RC) The complex containing a chlorophyll molecule that donates its excited electron to an electron transport system.

read A short DNA sequence that is generated by shotgun or next-generation sequencing methods.

real-time PCR See **quantitative PCR** .

reassortment The packaging of viral chromosome segments from two different viruses into one progeny virion. Refers to separate segments from a segmented genome, without helix recombination.

receptor-binding domain The part of a secreted protein (e.g., exotoxin) that binds to a target cell membrane receptor.

recombination See also *homologous recombination* . The process by which two DNA molecules exchange arms by cutting and splicing their helix backbones.

recombination signal sequence (RSS) A DNA region downstream of antibody heavy- and light-chain genes that allows recombination between widely separated gene segments.

recombinational repair A DNA repair mechanism that relies on recombination between an undamaged chromosome and a gap that occurred during replication of damaged DNA.

red alga Also called *rhodophyte* . An alga of the eukaryotic group Rhodophyta, which contain chloroplasts as primary algae, with red accessory photopigments.

redox couple The oxidized and reduced states of a compound. For example, NAD^+ and NADH form a redox couple.

redox reaction A chemical reaction in which one molecule or functional group becomes reduced and another becomes oxidized.

reducing agent See **electron donor** .

reductive acetyl-CoA pathway A carbon assimilation pathway in which two CO_2 molecules are condensed and reduced by two H_2 molecules to form an acetyl group.

reductive evolution Also called *degenerative evolution* . The loss or mutation of DNA encoding unselected traits.

reductive pentose phosphate cycle See **Calvin cycle** .

reductive TCA cycle Also called *reverse TCA cycle* . A CO_2 fixation pathway that generates acetyl-CoA through reversal of TCA cycle reactions. It requires ATP and NADPH.

reflection The deflecting of an incident light ray by an object, at an angle equal to the incident angle.

refraction The bending and slowing of light as it passes through a substance.

refractive index The degree to which a substance causes the refraction of light; a ratio of the speed of light in a vacuum to its speed in another medium.

regulatory protein A protein that can bind DNA and modulate transcription in response to a metabolite.

regulatory T cell (Treg) A T cell that regulates the activity of another T cell, usually by suppressing its activity.

regulon A group of genes and operons located at different positions in a genome that are coordinately regulated and share a common function.

rehydration therapy A medical treatment for dehydration, in which a liquid solution of salts and glucose is delivered orally. Also called **oral rehydration therapy (ORT)** .

relative fitness The ability of one strain of an organism to yield more progeny than a competitor does.

release factor A molecule that enters a ribosome A site containing an mRNA stop codon and initiates protein cleavage from the tRNA.

replication complex See **viral factory** .

replication fork During DNA synthesis, the region of the chromosome that is being unwound.

replicon A nucleic acid molecule such as a chromosome or plasmid that is replicated autonomously, with its own origin of replication.

replisome A complex of DNA polymerase and other accessory molecules that performs DNA replication.

reporter gene A gene whose protein product can be easily quantified; commonly used in gene fusions. Two examples are *lacZ* (beta-galactosidase) and *gfp* (green fluorescent protein).

repression The down-regulation of gene transcription.

repressor A regulatory protein that can bind to a specific DNA sequence and inhibit transcription of genes.

reservoir 1. The major part of the biosphere that contains a significant amount of an element needed for life. 2. An organism that maintains a virus or bacterial pathogen in an area by serving as a high-titer host.

resistance island A genomic island that contributes genes involved in antibiotic resistance.

resistome The collection of antibiotic resistance genes present in all pathogenic and nonpathogenic microbes that inhabit humans, animals, or the environment.

resolution The smallest distance that two objects can be separated and still be distinguished as separate objects.

resource colimitation A situation in which a population size is limited by the lack of two different resources, such as nitrogen and phosphorus.

respiration The oxidation of reduced organic electron donors through a series of membrane-embedded electron carriers to a final electron acceptor. The energy derived from the redox reactions is stored as an electrochemical gradient across the membrane, which may be harnessed to produce ATP.

response regulator A cytoplasmic protein that is phosphorylated by a sensor kinase and modulates gene transcription depending on its phosphorylation state.

restricted transduction See **specialized transduction** .

restriction endonuclease *or* restriction enzyme A bacterial enzyme that cleaves double-stranded DNA within a specific short sequence, usually a palindrome.

restriction-modification (RM) An antiphage defense system usually composed of a methyltransferase enzyme that methylates

DNA and a restriction endonuclease that cleaves unmethylated DNA.

restriction site A DNA sequence recognized and cleaved by a restriction endonuclease.

reticulate body The metabolically and reproductively active form of chlamydias.

reticuloendothelial system A collection of cells that can phagocytose and sequester extracellular material.

retinal A vitamin A–related cofactor in opsin proteins; it undergoes a conformational change upon absorbing a photon.

retrotransposon A retroelement that contains only partial retroviral sequences but may encode reverse transcriptase to allow further movement into the host genome.

retrovirus Also called *RNA reverse-transcribing virus* . A single-stranded RNA virus that uses reverse transcriptase to generate a double-stranded DNA.

reverse electron flow An enzyme-catalyzed redox reaction that couples an electron transfer with a positive ΔG (such as NAD^+ reduction to NADH) to a source of energy with a larger negative ΔG (such as a proton potential generated by an electron transport system).

reverse gyrase An enzyme that adds positive superturns to DNA in addition to the fundamental twist of the DNA helix. Found mainly in archaea, reverse gyrase differs from the gyrase of bacteria and eukaryotes, which adds negative superturns, against the twist.

reverse TCA cycle See **reductive TCA cycle** .

reverse transcriptase (RT) An enzyme that produces a double-stranded DNA molecule from a single-stranded RNA template.

reversion A mutation that changes a previous mutation back to its original state.

rhamnolipid A surfactant molecule composed of a rhamnose head group and a fatty acid tail.

Rhizaria A clade of eukaryotic microbes that have filamentous pseudopods.

rhizobium *pl.* rhizobia A bacterial species of the order Rhizobiales that forms highly specific mutualistic associations with plants in which the bacteria develop into intracellular bacteroids that fix nitrogen for the plant.

rhizosphere The soil environment surrounding plant roots.

Rho factor A bacterial protein involved in terminating transcription.

rhodophyte See **red alga** .

ribosomal RNA (rRNA) An RNA molecule that includes the scaffolding and catalytic components of ribosomes.

ribosome A large enzyme, composed of RNA and protein subunits, that translates mRNA into protein.

ribosome-binding site Also called *Shine-Dalgarno sequence* . In bacteria, a stretch of nucleotides upstream of the start codon in an mRNA that hybridizes to the 16S rRNA of the ribosome, correctly positioning the mRNA for translation.

riboswitch A secondary structure (hairpin) within some mRNA transcripts that can interact with metabolites or antisense RNA molecules, change structure, and affect the production or translation of the mRNA.

ribozyme See **catalytic RNA** .

ribulose 5-phosphate The five-carbon sugar ribulose, phosphorylated at carbon 5.

rich medium See **complex medium** .

ripening Ripening or aging is a process by which cheese undergoes drying and slow microbial conversion over a period of

weeks or months.

rise period The period of time in the viral life cycle when cells lyse and viral progeny are liberated.

RM See **restriction-modification** .

RNA-dependent RNA polymerase An enzyme that produces an RNA complementary to a template RNA strand.

RNA polymerase Also called *DNA-dependent RNA polymerase* . An enzyme that produces an RNA complementary to a template DNA strand.

RNA reverse-transcribing virus See **retrovirus** .

RNA world A model of early life in which RNA performed all the informational and catalytic roles of today's DNA and proteins.

rolling-circle replication A form of DNA replication that proceeds in one direction around a circular template, making tandem copies in a linear array (concatemer). The copies are later cleaved and circularized.

root In a phylogenetic tree, the earliest common ancestor of all members shown.

rotavirus One of a group of nonenveloped dsRNA viruses that cause severe diarrhea in children.

rRNA See **ribosomal RNA** .

RSS See **recombination signal sequence** .

RT See **reverse transcriptase** .

Rubisco Ribulose 1,5-bisphosphate carboxylase/oxygenase, the enzyme that catalyzes the carbon fixation step in the Calvin cycle.

rumen The first chamber of the digestive tract of ruminant animals such as cattle; the main site for microbial digestion of feed.

S

S-layer A surface layer of crystalline protein subunits, either replacing the cell wall or external to it in many species of archaea and bacteria.

sacculus *pl.* sacculi The bacterial cell wall, consisting of a single covalent molecule.

SALT See **skin-associated lymphoid tissue** .

sample In ecology, a small, defined portion of a population or ecosystem that represents the whole.

Sanger sequencing A method of sequencing DNA based on the incorporation of chain-terminating dideoxynucleotides by a DNA polymerase.

sanitation The safe disposal of wastes hazardous to humans.

sarcina *pl.* sarcinae A cubical octad cluster of cells formed by septation at right angles to the previous cell division.

sargassum weed An unrooted secondary-endosymbiont form of algae that floats in marine water and forms kelp forests.

scaffold The assembly of contigs (regions of contiguous sequence) into a large segment of a draft genome.

scanning electron microscopy (SEM) Electron microscopy in which the electron beams scan across the specimen's surface to reveal the 3D topology of the specimen.

scanning probe microscopy (SPM) A type of microscopy in which a physical probe scans the surface of a specimen and maps the topography by detecting a property such as electron tunneling current (scanning tunneling microscopy) or atomic force (atomic force microscopy).

scattering Interaction of light with an object that results in propagation of spherical light waves at relatively low intensity.

schizogony Mitotic reproduction of parasitic cells to achieve a large population within a host tissue.

screen assay A genetic assay, used to identify mutants that have lost a particular function, in which all mutants can grow, but only the mutants involved in the function of interest show a phenotype different from the wild type.

second messenger A regulatory molecule such as cAMP that is produced in response to a primary signal. Second messengers typically affect the expression of numerous genes.

secondary algae Algae that evolved by engulfing primary algae in a second endosymbiotic event.

secondary antibody The second antibody added in an immunological assay, such as enzyme-linked immunosorbent assay (ELISA) or western blot. A secondary antibody carries a fluorescent or enzymatic tag and binds to the primary antibody in the assay.

secondary antibody response A memory B cell–mediated rapid increase in the production of antibodies in response to a repeat exposure to a particular antigen.

secondary chromosome A plasmid-like small chromosome that carries at least one essential gene.

secondary metabolite *or* secondary product An organic product of biosynthesis that does not have essential functions but enhances nutrient uptake under certain conditions or inhibits competing species (e.g., an antibiotic). Often produced during stationary phase.

secondary structure The second level of organization of polymers, consisting of regular patterns that repeat, such as the double helix in DNA or the beta sheet in proteins.

secondary syphilis A rash that may appear at some point after the primary latent stage of syphilis.

secondary tuberculosis A new round of serious disease that is caused by *Mycobacterium tuberculosis* in patients with latent tuberculosis who have become immunocompromised. Symptoms include severe cough, blood sputum, night sweats, and weight loss.

sedimentation rate The rate at which particles of a given size and shape travel to the bottom of a tube under centrifugal force. The rate depends on the particle's mass and cross-sectional area.

segmented genome A viral genome that consists of more than one nucleic acid molecule.

selectin One of a family of cell adhesion molecules.

selection assay A genetic assay, used to identify mutants that have lost a particular function, in which only the mutants involved in the function of interest can grow, while all other mutants and the wild-type parent die.

selective medium A medium that allows the growth of certain species or strains of organisms but not others.

selective toxicity The ability of a drug, at a given dose, to harm the pathogen and not the host.

selectively permeable membrane See **semipermeable membrane** .

SEM See **scanning electron microscopy** .

semiconservative Describing the mode of DNA replication whereby each new double helix contains one old, parental strand and one newly synthesized daughter strand.

semipermeable membrane Also called *selectively permeable membrane* . A membrane that is permeable to some substances but impermeable to other substances.

sensitivity In diagnostic testing, a measure of how often a test will be positive if a patient has a particular disease, reflecting how small a concentration of antigen the test can detect.

sensor kinase A transmembrane protein that phosphorylates itself in response to an extracellular signal and transfers the phosphoryl group to a receiver protein.

septation The formation of a septum, a new section of cell wall and envelope to separate two daughter cells.

septicemia An infection of the bloodstream.

septicemic plague Infection of the bloodstream by *Yersinia pestis* .

septum *pl.* septa A plate of cell wall and envelope that forms to separate two daughter cells.

sequela *pl.* sequelae A serious, harmful immunological consequence of bacterial and host antigen cross-reactivity that occurs after the infection itself is over. An example is rheumatic fever.

sequencing by synthesis A method of DNA sequence determination in which a template DNA strand is used for polymerization of the second strand. The incorporated nucleotides in the synthesized strand are identified by methods that depend on the instrument used. Illumina sequencing is one example.

serial endosymbiosis theory The theory that mitochondria and chloroplasts were originally free-living prokaryotes that formed an internal symbiosis with early eukaryotes.

serum The noncellular, liquid component of the blood.

sexual reproduction Reproduction involving the joining of gametes generated by meiosis.

Shine-Dalgarno sequence See **ribosome-binding site** .

siderophore A high-affinity iron-binding protein used to scavenge iron from the environment and deliver it to a siderophore-producing organism.

sigma factor A protein needed to bind RNA polymerase for the initiation of transcription in bacteria.

signal recognition particle (SRP) A receptor that recognizes the signal sequence of peptides undergoing translation. The complex attaches to the cell membrane of prokaryotes (or the rough endoplasmic reticulum of eukaryotes), where it docks the

protein-ribosome complex to the membrane for protein membrane insertion or secretion.

signal sequence A specific amino acid sequence on the amino terminus of proteins that directs them to the endoplasmic reticulum (of a eukaryote) or the cell membrane (of a prokaryote).

silent mutation A mutation that does not change the amino acid sequence encoded by an open reading frame. The changed codon encodes the same amino acid as the original codon.

simple stain A stain that makes an object more opaque, increasing its contrast with the external medium or surrounding tissue.

single-cell genomics The study of the genome of a single cell.

single-celled protein An edible microbe of high food value, such as *Spirulina* or some yeasts.

single-molecule sequencing A method of nucleic acid sequence determination that can be applied to single nucleic acid molecules. The method does not require a prior PCR amplification step.

sink A part of the biosphere that can receive or assimilate significant quantities of an element; may be biotic (as in plants fixing carbon) or abiotic (as in the ocean absorbing carbon dioxide).

site-directed mutagenesis A molecular biology technique that intentionally alters a specific sequence in a DNA molecule.

site-specific recombination Recombination between DNA molecules that do not share long regions of homology but do contain short regions of homology specifically recognized by the recombination enzyme.

skin-associated lymphoid tissue (SALT) Immune cells, such as dendritic cells, located under the skin that help eliminate bacteria that have breached the skin surface.

sliding clamp A protein that keeps DNA polymerase affixed to DNA during replication.

sludge The solid products of wastewater treatment.

small RNA (sRNA) A non-protein-coding regulatory RNA molecule that modulates translation or mRNA stability.

small-subunit ribosomal RNA (SSU rRNA) In bacteria and archaea, 16S rRNA; in eukaryotes, 18S rRNA. A ribosomal RNA found in the small subunit of the ribosome. Its gene is often sequenced for phylogenetic comparisons.

SOS response A coordinated cellular response to extensive DNA damage. It includes error-prone repair.

source A part of the biosphere that stores a significant quantity of a given element; may be biotic (as in tree biomass, a source of carbon) or abiotic (as in carbonate rock).

sourdough An undefined yeast population, derived from a previous batch of dough, that is used in bread production.

Southern blot A technique (named for its inventor, Edwin M. Southern) to detect specific DNA sequences. Sample DNA segments are separated by gel electrophoresis, transferred to a blot, and probed with a labeled DNA that will hybridize to complementary DNA sequences.

space-filling model A molecular model that represents the volume of the electron orbitals of the atoms, usually to the limit of the van der Waals radii.

specialized transduction Also called *restricted transduction* . Transduction in which the phage can transfer only a short DNA sequence adjacent to a prophage (integrated phage genome) from a donor cell to the recipient cell.

species A single, specific type of organism, designated by a genus and species name.

specificity In diagnostic testing, a measure of how often a test will be negative if a patient does not have a particular disease, reflecting how well a test can distinguish between two closely related antigens.

spectrum of activity The range of pathogens for which an antimicrobial agent is effective.

spheroplast A cell whose peptidoglycan is degraded by lysozyme; thus the cell loses its shape, forming a sphere.

spike protein A viral glycoprotein that connects the membrane to the capsid or the matrix and may be involved in viral binding to host cell receptors.

spirillum *pl.* spirilla A rigid, corkscrew-shaped bacterial cell such as *Rhodospirillum* sp.

spirochete A bacterium with a tight, flexible spiral shape; a species of the phylum Spirochetes (Spirochaetota).

Spirochetes *or* Spirochaetota A phylum of bacteria with a unique morphology: a flexible, extended spiral that twists via intracellular flagella.

SPM See **scanning probe microscopy** .

spongiform encephalopathy A brain-wasting disease caused by a prion.

spontaneous generation The theory, much debated in the eighteenth century, that under current Earth conditions life can arise spontaneously from nonliving matter.

sporangiospore A haploid spore of a fungus that can germinate to form a haploid mycelium.

sporangium *pl.* sporangia A fungal organ that releases nonmotile spores.

spore stain A type of differential stain that is specific for the endospore coat of various bacteria, typically a firmicute species.

spread plate A method to grow separate bacterial colonies by plating serial dilutions of a liquid culture.

sRNA See **small RNA** .

SRP See **signal recognition particle** .

SSU rRNA See **small-subunit ribosomal RNA** .

staining The process of treating microscopic specimens with a stain to enhance their detection or to visualize specific cell components.

stalk An extension of the cytoplasm and envelope that attaches a microbe to a substrate.

stalked ciliate A ciliate that adheres to a substrate and uses its cilia to obtain prey.

standard reduction potential ($E°$) The reduction potential (tendency of a chemical to gain electrons and thereby become reduced) under standard conditions of 1 M concentration, 25°C temperature, and 1 atm pressure.

staphylococcus A hexagonal arrangement of cells formed by septation in random orientations.

starch A glucose polymer in which an acetal (O–COH) of each glucose has condensed with a hydroxyl group of the next glucose, releasing H_2O.

start codon A codon (usually AUG, encoding methionine) that signals the first amino acid of a protein.

starter culture A mixture of fermenting microbes added to a food substrate to generate a fermented product.

stationary phase A period of cell culture, following exponential phase, during which there is no net increase in replication.

sterilization The destruction of all cells, spores, and viruses on an object.

stick model A molecular model in which stick lengths represent the distances between bonded pairs of atomic nuclei.

Stickland reaction An energy-yielding reaction between two amino acids in which one oxidizes the other. The reaction typically produces short organic acids plus $2NH_4^+$; it may also produce CO_2 and H_2.

stop codon One of three codons (UAA, UAG, UGA) that do not encode an amino acid, and thus trigger the end of translation.

Stramenopiles Also called *Heterokonta*. A superphylum of eukaryotic microbes that usually possess a pair of differently shaped flagella.

streptogramin An antibiotic that binds 23S rRNA and blocks elongation of protein synthesis in bacteria.

strict aerobe An organism that performs aerobic respiration and can grow only in the presence of oxygen.

strict anaerobe An organism that cannot grow in the presence of oxygen.

stringent response A cellular response to idle ribosomes (often indicating low carbon and energy stores) that includes a decrease in rRNA and tRNA production.

stromatolite A mass of sedimentary layers of limestone produced by a marine microbial community over many years.

structural formula A representation of molecular structure in which each covalent bond is shown as a line between atoms.

structural isomer A molecule with the same molecular formula as a different molecule but a different arrangement of atoms.

substrate-level phosphorylation The formation of ATP by the enzymatic transfer of a phosphoryl group from a substrate molecule onto ADP.

succession Change of species composition over time in a community or microbiome.

sulfa drug An antibiotic that inhibits folic acid synthesis and, thus, nucleotide synthesis.

Sulfolobales A phylum of thermophilic archaea in the TACK superphylum that includes sulfur oxidizers.

superantigen A molecule that directly stimulates T cells without undergoing antigen-presenting-cell processing and surface presentation.

supercoiled DNA A physical state of circular DNA where the number of twists of the two strands around each other is either less than or greater than the number found in the relaxed state of the double-stranded helix. The resulting tension generates a higher-order helix that compacts the DNA double-stranded helix.

super-resolution imaging Techniques of microscopy that pinpoint the location of an object with a precision greater than the resolution of ordinary optical or fluorescence microscopy.

Svedberg coefficient A measure of particle size that is based on the particle's sedimentation rate in a tube subjected to a high *g* force.

swarming *or* swarming motility A behavior in which some microbial cells differentiate into large swarmer cells and swim together as a unit.

switch region A repeating DNA sequence interspersed between antibody constant-region genes that serves as a recombination site during isotype, or class, switching.

symbiont An organism that lives in a close association with another organism.

symbiosis *pl.* symbioses The intimate association of two different species.

symbiosis island A type of genomic island in which the stretch of DNA expresses proteins that enable a symbiotic relationship with another organism.

symport Coupled transport in which the molecules being transported move in the same direction across the membrane.

syndromic surveillance See **systemic surveillance** .

synergism Cooperation between species in which both species benefit but can grow independently. The cooperation is less intimate than symbiosis.

synthetic biology The genetic construction of novel organisms with useful functions.

Syntrophoarchaeota See **Anaerobic Methane-Oxidizing Euryarchaeota** .

syntrophy Metabolic cooperation between two different species; usually one member releases a product whose removal by the second species enables the pair to metabolize with a negative value of ΔG .

systemic surveillance Also called *syndromic surveillance* . The policy, established by central health organizations such as the U.S. Centers for Disease Control and Prevention or the World Health Organization, whereby physicians are required to report instances of diseases that have particularly high levels of severity and transmissibility, and thus are known as notifiable diseases.

T

T cell An adaptive immune cell, developed in the thymus, that can give rise to antigen-specific helper cells and cytotoxic T cells.

T-cell receptor (TCR) A surface receptor on T cells that binds MHC-bound antigen on antigen-presenting cells.

T3SS See **type III secretion system** .

T4SS See **type IV secretion system** .

tailed phage A phage such as T4 that contains a genome delivery device called the tail.

tandem repeat A stretch of directly repeating DNA sequence (direct repeats) without any intervening DNA.

TaqMan A real-time PCR technique in which Taq polymerase, in the process of synthesizing DNA along a template, degrades a downstream fluorescent oligonucleotide probe. The increase in fluorescence indicates the production of an amplified DNA product.

tardigrade A microscopic segmented animal with eight legs, miniaturized by evolution; possesses few-celled forms of all major organ systems.

target community A community whose genomes are sequenced for metagenomic analysis.

taxon *pl.* taxa A category of organisms with a shared genetic ancestor.

taxonomy The description of distinct life forms and their organization into different categories on the basis of genetic relatedness.

T_C cell See **cytotoxic T cell** .

TCA cycle See **tricarboxylic acid cycle** .

TCR See **T-cell receptor** .

tegument The contents of a virion between the capsid and the envelope.

teichoic acid A chain of phosphodiester-linked glycerol or ribitol that threads through and reinforces the cell wall in Gram-positive bacteria.

telomerase A reverse transcriptase enzyme complex that reads RNA as a template to synthesize DNA.

telomere The DNA segment at either end of a eukaryotic chromosome.

TEM See **transmission electron microscopy** .

tempeh A mold-fermented soy product, popular as a food in parts of Asia.

temperate phage A phage capable of lysogeny.

template strand A DNA strand (or an RNA strand in some viruses) that is used as a template for the synthesis of mRNA.

Tenericutes See *Mollicutes* .

terminal electron acceptor The final electron acceptor at the end of an electron transport system.

termination (*ter*) site A bacterial sequence of DNA that halts replication of DNA by DNA polymerases elongating from both directions around the circular genome.

terminator stem loop See **attenuator stem loop** .

terpenoid A branched lipid derived from isoprene that is found in hydrocarbon chains of archaeal membranes.

terraforming The idea of transforming the environment of another planet to make it suitable for life from Earth.

tertiary structure The third level of organization of polymers; the unique 3D shape of a polymer.

tertiary syphilis A final stage of syphilis, manifested by cardiovascular and nervous system symptoms.

tetanospasmin The tetanus-causing potent exotoxin produced by *Clostridium tetani* .

tetraether A molecule containing four ether links. An example is found in archaeal membranes, when two lipid side chains form ether linkages with a pair of side chains from the other side of the bilayer.

T_H cell See **helper T cell** .

T_H 17 cell A class of helper T cell that secretes the inflammatory cytokine IL-17.

Thaumarchaeota A phylum of archaea in the TACK superphylum that includes ammonia oxidizers and symbionts of marine invertebrates

thermal vent See **hydrothermal vent** .

thermocline A region of the ocean where temperature decreases steeply with depth, and water density increases.

thermophile An organism adapted for optimal growth at high temperatures, usually 50°C or higher.

Thermoplasmatales An order of extreme thermoacidophiles in the Euryarchaeota superphylum.

Thermoproteales A clade of the phylum Thermoproteota, thermophilic archaea including hyperthermoacidophiles, in the TACK superphylum.

Thermotogae (Thermotogota) A phylum of thermophilic bacteria; in some species, the cell is enclosed by a toga-shaped outer covering.

threshold dose The concentration of antigen needed to elicit adequate antibody production.

thylakoid An intracellular chlorophyll-containing membrane folded within a phototrophic bacterium or a chloroplast.

Ti plasmid A plasmid found in tumorigenic strains of *Agrobacterium tumefaciens* that can be used as a vector to introduce DNA into plant cells.

tight junction A type of junction between the membranes of two adjacent vertebrate cells that form an impermeable barrier.

TLR See **Toll-like receptor** .

tmRNA See **transfer messenger RNA** .

TNF See **tumor necrosis factor** .

TNF-alpha See **tumor necrosis factor alpha** .

Toll-like receptor (TLR) A member of a eukaryotic transmembrane glycoprotein family that recognizes a particular microbe-associated molecular pattern (MAMP) present on pathogenic microorganisms.

tomography The acquisition of projected images of a transparent specimen from different angles that are digitally combined to visualize the entire specimen.

topoisomerase An enzyme that can change the supercoiling of DNA.

total magnification The magnification of the ocular lens multiplied by the magnification of the objective lens.

transamination The transfer of an ammonium ion between two metabolites.

transcript An RNA copy of a DNA template.

transcription The synthesis of RNA complementary to a DNA template.

transcriptional attenuation A regulatory mechanism that terminates transcription in progress, before it even reaches the first gene.

transcriptional fusion A technique to monitor transcriptional regulation by fusing a reporter gene containing its own ribosome-binding site to the 3′ end of an operon. Unlike the translational fusion technique, only the promoter of the target gene directs expression of the reporter.

transcriptome The set of transcribed genes in a cell at a given time. The "complete transcriptome" includes all the possible RNA transcription products from a given genome. The "expressed transcriptome" is the set of RNAs present during a given condition.

transcytosis The movement of a cell or substance from one side of a polarized cell to the other side, using an intracellular route.

transduction The transfer of host genes between bacterial cells via a phage head coat.

transfection In biotechnology, the transfer of DNA (usually viral) into cells.

transfer messenger RNA (tmRNA) A molecule resembling both tRNA and mRNA that rescues ribosomes stalled on damaged mRNAs lacking a stop codon.

transfer RNA (tRNA) An RNA that carries an amino acid to the ribosome. The anticodon on the tRNA base-pairs with the codon on the mRNA.

transform To cause bacteria to take up exogenous DNA. In eukaryotes, to convert cultured cells into cancer cells.

transformation The internalization of free DNA from the environment into bacterial cells.

transgene A gene that has been transferred by genetic engineering techniques from one organism to another.

transglycosylase An enzyme that condenses *N*-acetylglucosamine and *N*-acetylmuramic acid into chains during bacterial cell wall synthesis.

transition A point mutation in which a purine is replaced by a different purine or a pyrimidine is replaced by a different pyrimidine.

translation The ribosomal synthesis of proteins based on triplet codons present in mRNA.

translational control A regulatory mechanism that modulates protein production by influencing the translation of mRNA.

translational fusion A technique to measure control of gene transcription or translation by inserting a reporter gene into a target gene. Expression of the reporter relies on both the promoter and the ribosome-binding site of the target gene.

translocation The energy-dependent movement of a ribosome to the next triplet codon along an mRNA.

transmembrane domain The membrane-spanning amino acid sequence within a membrane protein that connects intracellular and extracellular parts of the membrane protein.

transmembrane protein Also called *integral protein* . A protein with a membrane-spanning region.

transmission electron microscopy (TEM) Electron microscopy in which electron beams are transmitted through a thin specimen to reveal internal structure.

transovarial transmission The transfer of a pathogen from parent to offspring by infection of the egg cell. Typically seen in insects.

transpeptidase An enzyme that cross-links the side chains from adjacent peptidoglycan strands during bacterial cell wall synthesis.

transport protein *or* transporter A membrane protein that moves specific molecules across a membrane.

transplacental transmission The process by which certain pathogens in maternal blood can pass through the placenta to infect the fetus.

transposable element Also called *jumping gene* . A segment of DNA that can move from one DNA region to another.

transposase A transposable element–encoded enzyme that catalyzes the transfer of the transposable element from one DNA region to another.

transposition The process of moving a transposable element from one DNA region to another.

transposon A transposable DNA element that contains genes in addition to those required for transposition. Examples of additional genes include those that encode resistance to antibiotics.

transversion A point mutation in which a purine is replaced by a pyrimidine or vice versa.

Treg See **regulatory T cell** .

tricarboxylic acid (TCA) cycle Also called *Krebs cycle* . A metabolic cycle that catabolizes the acetyl group from acetyl-CoA to $2CO_2$ with the concomitant production of NADH, $FADH_2$, and ATP.

tRNA See **transfer RNA** .

trophic level A level of a food web representing the consumption of biomass of organisms from another level, usually closer to producers.

tropism The ability of a virus to infect a particular tissue type.

true fungi See **Eumycota** .

trypanosomatid A parasitic excavate protist that has a cortical skeleton of microtubules culminating in a long flagellum.

trypanosome A member of the parasitic genus *Trypanosoma* , such as the cause of sleeping sickness, *Trypanosoma brucei* .

tumor necrosis factor (TNF) A cytokine released by several cell types (e.g., macrophages) in response to cell damage.

tumor necrosis factor alpha (TNF-alpha) A cytokine involved in systemic inflammation.

turgor pressure See **osmotic pressure** .

twitching motility A type of bacterial movement on solid surfaces in which a specific pilus extends and retracts.

two-component signal transduction system A message relay system composed of a sensor kinase protein and a response regulator protein that regulates gene expression in response to a signal (usually an extracellular signal).

two-hybrid analysis An in vivo technique to determine protein-protein interactions in which DNA sequences encoding proteins of interest are fused separately to the DNA-binding and activation

domains of a transcription factor. The recombinant organism is then tested for expression of a reporter gene.

type I hypersensitivity Also called *immediate hypersensitivity* . An IgE-mediated allergic reaction that causes degranulation of mast cells within minutes of exposure to the antigen. The severe reaction known as anaphylaxis is triggered by type I hypersensitivity.

type II hypersensitivity An immune response in which antibodies bind to the patient's own cell-surface antigens or to foreign antigens adsorbed onto the patient's cells. Antibody binding triggers cell-mediated cytotoxicity or activation of the complement cascade.

type II secretion system A bacterial protein secretion system that uses a type IV pilus–like extraction/retraction mechanism to push proteins out of the cell.

type III hypersensitivity Also called *immune complex disease* . An immune reaction triggered when IgG antibody binds to an excess of soluble foreign antigen in the blood. The immune complexes deposit in small blood vessels, where they interact with complement to initiate an inflammatory response.

type III secretion system (T3SS) A bacterial protein secretion system that uses a molecular syringe to inject bacterial proteins into the host cytoplasm.

type IV hypersensitivity Also called *delayed-type hypersensitivity (DTH)* . An immune response that develops 24–72 hours after exposure to an antigen that the immune system recognizes as foreign. The response is triggered by antigen-specific T cells. It is delayed because the T cells need time to proliferate after being activated by the allergen.

type IV pili Retractable appendages used for surface attachment and twitching motility along the surface.

type IV secretion system (T4SS) Protein secretion system of Gram-negative bacteria whose components exhibit sequence

homology with the components of conjugation systems.

type VI secretion system (T6SS) A protein secretion system (derived from the tail components of a T4 bacteriophage) that propels a rod tipped with a toxin protein into adjacent bacterial or eukaryotic target cells.

U

ubiquitin (Ub) In eukaryotes, a 76-amino-acid peptide that tags proteins, marking them for degradation by the proteasome.

ultracentrifuge A machine that subjects samples to high centrifugal forces and can be used to separate subcellular components.

uncoating The release of a viral genome from its capsid, following entry of the virion into a host cell.

uncoupler A molecule that makes a membrane permeable to protons, dissipating the proton motive force and uncoupling electron transport from ATP synthesis.

uncultured Describing an organism whose requirements for culture remain unknown.

upstream processing The culturing of industrial microbes to produce large quantities of a desired product.

V

vaccination Exposure of an individual to a weakened version of a microbe or a microbial antigen to provoke immunity and prevent development of disease upon reexposure.

van der Waals force A weak, temporary electrostatic attraction between molecules caused by shifting electron clouds.

vancomycin A glycopeptide antibiotic that binds the D-Ala-D-Ala end of the cell-wall peptide, thus inhibiting the transpeptidase enzyme and preventing crossbridge formation in the cell wall.

variable region The amino-terminal portions of antibody light and heavy chains that confer specificity to antigen binding and define the antibody idiotype.

vasoactive factor A cell signaling molecule that increases capillary permeability.

vector 1. An organism (e.g., insect) that can carry infectious agents from one animal to another. 2. In molecular biology, a molecule of DNA into which exogenous DNA can be inserted to be cloned; or an engineered virus that can clone a gene in its DNA or RNA genome.

vegetative cell A metabolically active, replicating bacterial cell.

vegetative mycelium A mass of hyphae (branched filaments) produced by vegetative cells that expand into the substrate.

vehicle transmission In disease, the transfer of a pathogen when an infected person deposits it on a surface or in food or drink that another person touches or consumes.

ventilation In building maintenance, the exchange of indoor air with fresh outdoor air.

Verrucomicrobia (Verrucomicrobiota) A phylum of free-living aquatic bacteria with wart-like, protruding structures containing tubulin.

vertical gene transfer The generational movement of genes from parent to offspring through reproduction.

vertical transmission In disease, the transfer of a pathogen from parent to offspring. See also **transovarial transmission** .

vesicle A small, membrane-enclosed sphere found within a cell.

vesicular-arbuscular mycorrhizae See **arbuscular mycorrhizae** .

viability PCR A form of PCR that amplifies DNA only from viable cells.

viable Capable of replicating; for instance, by forming a colony on an agar plate.

viral factory Also called *replication complex* . An intracellular membrane compartment with viral proteins that synthesize progeny virions.

viral shunt The release by viral lysis of cell contents as organic material available for microbial consumers in the upper region of the ocean.

viremia The presence of large numbers of virions in the bloodstream.

virion A virus particle.

virocell A cell infected by a virus that reprograms it to maximize production of virus particles.

viroid An infectious naked nucleic acid.

virome The genomes of all the viruses that inhabit a particular organism or environment.

virulence A measure of the severity of a disease caused by a pathogenic agent.

virulence factor A trait of a pathogen that enhances the pathogen's disease-producing capability.

virus A noncellular particle containing a genome that can replicate only inside a cell.

W

wastewater treatment A series of wastewater transformations designed to lower biological oxygen demand and eliminate human pathogens before water is returned to local rivers.

water activity A measure of the water that is not bound to solutes and is available for use by organisms.

water cycle See **hydrologic cycle** .

water molds See **Oomycetes** .

water table The layer of soil that is permanently saturated with water.

western blot A technique to detect specific proteins. Proteins are subjected to gel electrophoresis, transferred to a blot, and probed with enzyme-linked or fluorescently tagged antibodies that specifically bind the protein of interest.

wet mount A technique to view living microbes with a microscope by placing the microbes in water on a slide under a coverslip.

wetland A region of land that undergoes seasonal fluctuations in water level and aeration.

whey The liquid portion of milk after proteins have precipitated out of solution, usually during cheese production.

Winogradsky column A glass tube containing a stratified environment that causes specific microbes to grow at particular levels; a type of enrichment culture for the growth of microbes from wetland environments.

X

X-ray crystallography *or* X-ray diffraction analysis A technique to determine the positions of atoms (atomic coordinates) within an array of identical molecules or molecular complexes on the basis of the diffraction of X-rays by the molecule.

Y

yeast A unicellular fungus.

yogurt A semisolid food produced through acidification of milk by lactic acid–producing bacteria.

Z

Z pathway See **oxygenic Z pathway** .

zone of hypoxia See **dead zone** .

zone of inhibition A region of no bacterial growth on an agar plate that is due to the diffusion of a test antibiotic. Correlates to the minimal inhibitory concentration.

zoonotic disease An infection that normally affects animals but can be transmitted to humans.

zoospore A flagellated reproductive cell produced by chytridiomycete fungi.

zygomycete A member of the eukaryotic group Zygomycota—fungi forming nonmotile haploid gametes that grow toward each other, fusing to form the zygospore.

zygospore In zygomycetes, the diploid structure formed by the fusion of two gamete-bearing hyphae.