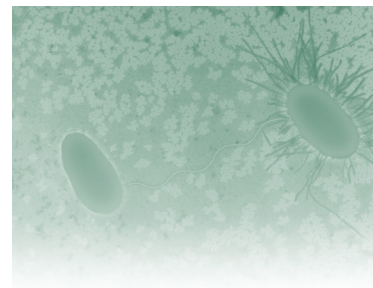


GLOSSARY



abiogenesis: The concept of spontaneous generation whereby it is held that living organisms or their essential components can emerge from non-living materials.

abiotic: Processes, conditions, or factors that do not require the involvement of biological organisms.

acetylene reduction assay: The enzymatic conversion of acetylene to ethylene, a process used to measure the rate of nitrogen fixation by microbial producers of nitrogenase.

acclimatization (acclimation): Process describing the capacity of organisms to adapt phenotypically to variable and usually unfavorable environmental conditions.

accretion: Term used in sedimentology or planetology to denote the increase in size by the addition of new materials from sources outside the system.

acid mine drainage: Ecosystem pollution resulting from mineral mining facilities where iron- and sulfur-oxidizing bacteria generate sulfuric acid through the leaching of sulfurylated ores. In addition to the acid, the drainage contains various combinations of toxic metals that may pose substantial hazards to ecosystem health.

acidophiles: Microorganisms that prefer to live in extremely acidic environments. For example, *Thiobacillus thiooxidans* grows at the minimum, optimum, and maximum pH values of 0.5, 2.0–2.8, and 4.0–6.0, respectively.

acrasin: 3', 5'-cyclic adenosine monophosphate, which is produced by slime molds during the initiation of fruiting body formation.

actinobiology (actinology; radiology): The field of research focused on the effects of radiation on living organisms.

actinomycetes: Bacteria that sometimes resemble fungi because they form branching filaments.

adaptation: The process by which an organism copes with environmental stress. It can occur through evolutionary modification of physiological, morphological, or behavioral characteristics, resulting in the enhanced survival of the organism.

adaptive radiation: The evolutionary emergence of a wide variety of species that have adapted to distinct niches from a narrower spectrum of primitive species.

adhesins: Adhesion factors or chemical substances synthesized by biofilm-forming microorganisms to aid their attachment to solid surfaces.

aerobic: A term used to denote processes, conditions, or organisms that are associated with, or function best in the presence of, molecular oxygen.

aerosol: Small particulate materials dispersed in a gaseous medium,

usually the atmosphere. Aerosolized particles are typically characterized by particle size (e.g. PM_{2.5} refers to particulate matter less than or equal to 2.5 micrometers in diameter) and settling rate. Many microorganisms are dispersed in the environment as aerosols. Abiotic aerosols include smoke from natural fires and haze.

AFLP (amplified fragment length polymorphism): A technique for detecting small sequence differences among DNA fragments from different organisms. The “fingerprinting” technique detects DNA restriction fragments through PCR analysis according to the following steps: Restriction of the DNA with two restriction enzymes, preferably a hexa-cutter and a tetra-cutter recognizing unique 6- and 4-nucleotide sequences, respectively; ligation of double-stranded adapters to the ends of the restriction fragments; amplification of a subset of the restriction fragments using two primers complementary to the adapter and restriction site sequences, and extended at their 3' ends by selective nucleotides; electrophoresis of the amplified restriction fragments on denatured polyacrylamide gels; visualization and comparative assessment of the DNA fingerprints.

algae: Photosynthetic and eukaryotic protocists, some of which are microscopic and unicellular. Others have few cells (protists) but many more are large multicellular organisms. Algae are typically aquatic, contributing substantially to biogeochemical cycling in freshwater and marine ecosystems.

alkaliphiles: Microorganisms that prefer to live in extremely alkaline environments. For example, *Nitrobacter* species grow at the minimum, optimum, and maximum pH values of 6.6, 7.6–8.6, and 10.0, respectively.

allochthonous: Not indigenous. Term used to describe opportunistic microorganisms that are either not normally present, or not major contributors to the ecology of a habitat, but are capable of rapidly proliferating following a major change in local environmental conditions, including the episodic introduction of nutrients.

amensalism: A form of ecological interaction in which the growth and activity of one organism is inhibited by another organism.

ammonification: The enzymatic formation of ammonium from nitrogen compounds carried out mostly by specialized bacteria.

anaerobic: Process, condition, or organism defined by the absence of oxygen. Anaerobic respiration is the metabolic process analogous to aerobic respiration, but where electrons are transferred from a reduced compound to an inorganic molecule that is different from oxygen. Sometimes used interchangeably with **anoxic**.

anagenesis: A theory of speciation that proposes the generation of higher levels of specialization through progressive evolution.

- annealing temperature:** The highest temperature at which two complementary strands of nucleic acid will form a stable double stranded structure. The annealing temperature is directly proportional to the proportion of guanine and cytosine residues, and indirectly proportional to the percentage of sequence mismatch.
- anoxyphotobacteria:** Photosynthetic bacteria in possession of photosystem I. These organisms conduct photosynthesis in anaerobic environments. Oxygen is not a product of this kind of photosynthesis.
- antagonism (antibiosis or allelopathy):** A form of ecological interaction in which one organism produces chemical substances that inhibit the growth and/or activities of one or more other organisms.
- antibody:** A proteinous immunoglobulin molecule produced by plasma cells in response to a foreign chemical or microbiological substance (antigen). A population of antibody molecules may be homogenous (monoclonal) or heterogeneous (polyclonal). Antibodies function as part of the disease prevention strategy of organisms to eliminate invading antigens from the body of vertebrates and certain marine animals. In the assessment of microbial diversity, the specificity of antibody–antigen reactions has been used to detect organisms in various environments and to distinguish among closely related varieties of organisms.
- antigen:** A substance that can elicit an immune response when introduced into the body of vertebrates or marine animals capable of synthesizing immunoglobulin molecules (antibodies). Haptens are molecules that need to be combined with other substances to become true antigens. Antigens may be soluble as in the case of several microbial toxins, or particulate as in the case of viruses. Proteins and polysaccharides are the most potent antigens. Antigens represented by specific molecules on the surface of microorganisms have been used extensively for taxonomic purposes. For example, the Kauffmann–White classification scheme for *Salmonella* species involves the notation of specific serotypes which are defined by the organism's "O", "H", and "Vi" antigens.
- apoprotein:** Polypeptide molecules isolated from non-polypeptide moieties with which they naturally associate to form functional protein complexes. For examples, ferritin without its ferric hydroxide core may be referred to as apoferritin, and apohemoglobin is the protein of hemoglobin without its heme group.
- aquifer:** Subsurface water systems (groundwater). Typically contains a diverse array of autochthonous microbial populations, but subject to the introduction of non-native microorganisms and chemical contaminants through pollution events.
- Archaea:** Prokaryotic unicellular microorganisms lacking murein in their cell walls, with ether bonds in their membrane phospholipids. According to a widely accepted view, one of three major phylogenetic domains of life, the other two being Bacteria and Eukarya.
- Archaean:** Geological time period from the formation of the Earth (approximately 4.5 billion years ago) to 2.4 billion years ago, during the Precambrian era.
- ascomycetes:** Filamentous fungi defined by the use of an ascus sac to contain ascospores.
- assimilation:** The metabolic integration of nutrient chemicals into organism biomass.
- asthenosphere:** The upper mantle of the Earth, or the layer beneath the lithosphere.
- atmosphere:** The gaseous layer that forms the interphase between the solid components of planets and outer Space. The chemical composition of atmospheres is influenced by the biogeochemical cycling of elements and is important for the maintenance of biodiversity. On Earth, the atmosphere consists of 79% nitrogen, 20% oxygen, 1% argon, approximately 0.03% carbon dioxide, and trace quantities of other gases including methane, nitrogen oxides, and ozone. Small changes in the concentration of the trace components such as methane and ozone can have strong influences on living organisms. Atmosphere is also the unit of air pressure. One atmospheric pressure is the pressure of air at sea level and it is equivalent to a force of approximately 10^5 Pascals (Newtons per square meter) or 14.7 pounds per square inch. Hyperbarophilic microorganisms thrive in the deep oceans at pressures of 400 atmospheres.
- autochthonous:** Indigenous inhabitants of a microbial ecosystem. The organisms are resilient in the sense that they maintain routine population densities and ecological functions despite variable environmental conditions.
- autopoiesis:** "Self-making" or the ability of organisms (cells) to independently maintain their own metabolism and reproduction.
- autotrophs:** Organisms that have the capacity to produce (fix) organic carbon compounds from carbon dioxide.
- Bacteria:** According to a widely accepted view, one of three major phylogenetic domains of life, the other two being Archaea and Eukarya. Bacteria are distinguished by unicellularity, lack of a nucleus, and cell walls containing murein.
- bacteriochlorophyll:** The light-gathering pigment found in green and purple anaerobic photosynthetic bacteria.
- bacteriophage:** Virus particles specialized in the infection of bacteria.
- banded iron formation:** A sedimentary rock with alternating iron-rich (Fe_2O_3) and iron-deficient bands. Banded iron formations (BIF) are typical of Precambrian rocks, and they are considered to be evidence for the emergence of oxygen-evolving photosynthesis approximately 3.5 billion years ago. BIF presumably resulted from the oxidation of Fe^{2+} by oxygen, and the resulting Fe_2O_3 was deposited in the primitive ocean. BIF deposits reached a peak occurrence in rocks dated from 2.5–3.0 billion years ago. Contemporary mining of iron ore taps ancient BIF deposits in Australia, South Africa, and the United States.
- barophiles:** Microorganisms typically found in deep seas, which grow best under conditions of high pressure.
- benthos:** Term used to describe organisms inhabiting the bottom section of aquatic environments.
- biodegradation:** Enzymatic conversion of complex chemical compounds into simpler compounds.
- biogas:** Primarily methane with traces of hydrogen sulfide and carbon dioxide produced by anaerobic microorganisms during the degradation of organic matter.
- bioluminescence:** The enzymatic action of luciferase to produce oxyluciferin from luciferin proteins. The reaction is associated with light production.
- biomass:** The total mass of living (micro) organisms in a particular habitat.
- biome:** A large geographical region characterized by a dominant climax ecological community. A biome typically has several communities at different successional stages.
- biosensor:** An artificial device based on genetic, immunological, or other biochemical process used for the detection of specific types of microorganisms, or the occurrence of specific microbial processes in complex environmental systems.
- biotype:** A variety of organisms distinguished by metabolic and/or physiological properties.

- blight:** A plant disease resulting in plant death or withering without producing rot.
- bloom:** Visible microbial biomass in aquatic systems produced by large numbers of cyanobacteria. Blooms are also attributable to excessive algal growth resulting from eutrophication.
- $C_0t_{1/2}$:** The amount of time required for half the concentration of single-stranded nucleic acids in a reaction to form stable double-stranded structures. It is usually taken as an index of diversity in a microbial community gene pool.
- carrying capacity:** The ability of an ecosystem to sustain its biological population.
- chemoautotroph (chemolithotroph):** Microorganisms capable of growing on carbon dioxide or carbonates as the sole source of carbon while deriving energy through the oxidation of reduced inorganic compounds.
- chemocline:** In aquatic systems, the layer formed by a sharp gradient in chemical composition. For example, salt concentrations may change sharply with depth in lakes that periodically receive freshwater input.
- chemoorganotroph (heterotroph):** A microorganism capable of growing on organic compounds as the source of energy and carbon.
- chemotaxis:** The movement of microorganisms towards or away from a chemical gradient, which is either desirable or toxic, respectively.
- chlorosis:** Discoloration or yellowing of plant tissue due to loss of the photosynthetic pigment chlorophyll. Chlorosis may result from microbial infection of plants.
- circadian rhythm:** Organism's intrinsic daily physiological rhythms independent of fluctuating environmental conditions.
- cladogenesis:** A theory of speciation that proposes the divergence of populations through progressive branching and splitting of early lineages.
- cladogram:** Also known as a "phylogenetic tree." Branching line diagrams of evolutionary relationships among species, strains, or molecular sequences. Independent lineages are represented by line segments. Branching points represent major periods of departure from the ancestral lineage, such as in the case of speciation events.
- climax community:** A microbial community in which all possible niches are occupied. The phrase is used to signify the terminal development stage of ecological succession.
- co-metabolism:** The enzymatic conversion of a chemical substrate into products by a microorganism that does not derive carbon, energy, or other forms of nutrients from the process. Typically, this is a fortuitous process as the enzyme is synthesized by the microorganism for a different purpose.
- consortium:** A community of two or more microbial species capable of combined metabolic activities that would otherwise proceed slowly or not at all without the presence of any one member.
- Crenarchaeota:** A kingdom within the Archaea domain characterized by extremely thermophilic members.
- crown gall:** Plant tumor, which is a symptom of infection by *Agrobacterium tumefaciens*. Many broad-leaved plants are susceptible to the disease.
- cyanobacteria:** Photosynthetic prokaryotes. They live mostly in aquatic environments and microbial mats where they generate oxygen by enzymatic cleavage of water.
- dendrogram:** A diagram representing the relatedness among different microbial strains or species according to phylogenetic analysis.
- denitrification:** Enzymatic reduction of nitrate or nitrite to nitrogen or other more reduced forms of nitrogen oxides. In anaerobic or micro-aerobic respiration, nitrogen oxides are used as terminal electron acceptors.
- desulfurization:** The enzymatic cleavage of sulfur, usually as hydrogen sulfide, from organic sulfur compounds.
- detritivores:** Organisms characterized by consumption of detritus or the degradation of waste materials and dead organisms. They are important in global geochemical cycling.
- DGGE (denaturing gradient gel electrophoresis):** A genetic analysis technique suitable for detecting single base changes and polymorphisms in whole genomes or DNA fragments. Under a concentration gradient of denaturing agent, the mobilities of DNA fragments of the same length but different nucleotide sequence are different. The technique can also be used to determine DNA fragment melting points.
- diazotroph:** Organisms that are capable of fixing molecular nitrogen by enzymatic reduction of N_2 to the equivalent of ammonia.
- diel:** Occurring daily; 24-hour periods.
- diversity:** A qualitative or quantitative measure of the types of species present in a microbial community. Measures of diversity assess differences among organisms with respect to a given trait at the molecular, physiological, or anatomic levels. Microbial diversity is subsumed under the general term biodiversity, which defines the total of all species in any habitat.
- dormancy:** The viable state of metabolic inactivity in which many kinds of microorganisms reside to cope with adverse environmental conditions. For example, bacteria and fungi form spores. The viable-but-non-culturable state that characterizes several microorganisms present in the environment can be considered a state of dormancy.
- dysphotic zone:** The zone in a body of water that does not receive sufficient light to support photosynthetic activity by plants, but with sufficient light to support other types of phototrophism carried out by microorganisms.
- dystrophic:** Fresh water systems that have low concentrations of dissolved nutrients, and high amounts of suspended colloids and fragments from plant material.
- ELISA (enzyme-linked immunosorbent assay):** ELISA is an antigen-detection strategy where antibodies are tagged with a quantifiable marker that is expressed following attachment to a specific antigen. ELISA has been used extensively for detecting the presence of many microorganisms, including viruses in complex environmental systems.
- epilimnion:** The layer above the thermocline in an aquatic ecosystem.
- epiterranean:** Organisms inhabiting the interface between soil and air.
- estuary:** An intermediary ecosystem defined by the mixing of freshwater from a river outlet and marine water from ocean tidal activity.
- Eubacteria:** Now renamed simply bacteria, refers to the first proposed name for non-archaea prokaryotes.
- Eukarya:** According to one view, the third major phylogenetic domain of life, the other two being Bacteria and Archaea. Eukaryotes are traditionally defined by possession of a membrane-bound nucleus containing the genetic material organized as tightly packaged chromosomes. Microscopic eukaryotes include some species of algae, protozoa, and fungi.
- euphotic zone:** In aquatic ecosystems, the depth of water receiving light, and consequently, the zone that supports the growth of photosynthetic organisms.
- eutrophication:** The process of "self-feeding" by which ecosystems sustain sufficient nutrients to support the growth of inhabiting organisms. In aquatic environments, excessive input of nutrients has

- detrimental impacts when oxygen is depleted through respiration to sustain growth. Run-off containing nitrogen and phosphorus fertilizers can lead to the eutrophication of water systems.
- evenness:** A quantitative measure of the distribution of individual microorganisms or species within a microbial community.
- exoenzymes (abiotic enzymes):** Enzymes that are active outside the cell. They are either secreted by living cells into their environment or leaked out of the cell following cell lyses.
- facultative:** Microorganisms that have the metabolic flexibility to conduct either one of two mutually exclusive metabolic processes such as anaerobic and aerobic respiration.
- FAME analysis:** Fatty acid methyl ester analysis is a technique for identifying microorganisms through unique combinations of fatty acids in their cells.
- fastidious:** A term used to describe microorganisms with extremely stringent growth requirements.
- feedback mechanism:** The process by which the production of a biochemical material leads to the enhancement (positive feedback) or inhibition (negative feedback) of the same production process. Feedback mechanisms contribute to the overall economy of metabolism where, for example, after reaching a certain concentration, the end product of a metabolic pathway inhibits an enzyme within the pathway. Similarly, accumulation of a substrate can induce the production of catabolic enzymes. Feedback mechanisms may also act on large scales to regulate major biogeochemical cycles, but this requires further research to elucidate the contributions of many different organisms involved in most element cycles.
- FISH (fluorescent *in situ* hybridization):** A technique for identifying phylogenetic groups of microorganisms in natural microbial communities without prior isolation or cultivation. The technique relies on genomic hybridization to nucleotide probes labeled with fluorescent molecules. FISH is typically combined with microscopy.
- flagellum (plural flagella):** An extracellular proteinous appendage of some prokaryotes responsible for cell motility. The flagellum may occur singly (monotrichous) or in multiple forms distributed evenly over the cell surface (peritrichous) or in a polar region (amphitrichous). Flagella in most bacteria project from the cell surface except in the members of the phylogenetic order *Spirochaetales*, where the flagella occur between layers of the cell envelope.
- fossil:** The preserved remains of an organism, typically in rock. Body fossils represent transformations of bones, shells, or other structures, whereas trace fossils refer to imprints, tracks, or burrows.
- gene:** The basic unit of heredity. Genes are made up of nucleic acid sequences. Structural genes (DNA) are either transcribed into messenger RNA, and subsequently translated into protein molecules, or they are transcribed into ribosomal RNA or transfer RNA and used directly in cells. Regulatory genes function to mediate the transcription and translation of structural genes. All the genes in an organism are collectively referred to as the genome. A major distinction between prokaryotes and eukaryotes is the organization of the genome. The genome of prokaryotes exists as a covalently closed chromosome(s) and occasional plasmid(s) in the cytoplasm. The genome of eukaryotes is organized in a special compartment—the nucleus.
- genomics:** The structural and functional investigation of the entire genetic material of organisms. Genomics has been facilitated by the invention of rapid DNA and RNA sequencing techniques.
- greenhouse effect:** The climatic phenomenon where average temperatures increase in response to the increased concentration of “greenhouse gases” such as carbon dioxide and methane in the atmosphere.
- halophiles:** Microorganisms that thrive in a high salt environment, up to 30% NaCl. For example, *Halococcus* species.
- hormesis:** The seemingly paradoxical observation that exposure of organisms to sub-toxic concentrations of a toxic substance can stimulate the organism’s growth.
- hot spring:** An aquatic ecosystem or thermal spring defined by temperatures exceeding 37°C.
- humic acids:** Abundant soil organic material characterized by irregular high molecular weight acidic polymers.
- hybridization:** The annealing of two complementary single strands of nucleic acids (DNA and/or RNA) to form double-stranded molecules whose stability depends on the extent of sequence similarity.
- hypolimnion:** In aquatic ecosystems, the deep, cold zone beneath the thermocline.
- k-strategists:** Species of microorganisms that maintain their population densities at the approximate carrying capacity of the environment. They are also known as the autochthonous organisms whose populations do not fluctuate to extremes in response to environmental changes.
- lichen:** A symbiotic association between fungi (mostly *Ascomycetes* or *Basidiomycetes*) and cyanobacteria. Most of the lichen tissue is made up of the fungal hyphae and cyanobacterial cells are distributed throughout the hyphal network. The cyanobacteria provide nutrients for the fungi, which protect the cyanobacteria from desiccation. Lichens grow in nutrient poor surfaces such as rocks and tree bark because of the photosynthetic activity of the cyanobacteria.
- lignin:** Abundant complex polymers that provide structural support for the woody part of plants.
- lithosphere:** The rigid crustal plates of the Earth, immediately above the asthenosphere, where most of the biological diversity resides.
- littoral zone:** The shore of a lake to a depth of 10 m or the shore of a continental shelf to a depth of 200 m.
- lysogeny:** The reversible latent condition in which a bacteriophage exists with its genome either integrated into the host chromosome or replicating autonomously in the host cytoplasm.
- magnetotaxis:** Locomotion of microorganisms towards a defined geomagnetic field. These kinds of organisms produce intracellular granules that aid their responses to magnetic fields.
- melting temperature (T_m):** The temperature at which double-stranded nucleic acid molecules dissociate (“melt”) into two single-stranded molecules. The T_m depends on the proportion of guanine and cytosine bonds (G + C ratio) in the double-stranded molecule and the extent of sequence mismatch.
- mesophiles:** Microorganisms that grow optimally within the temperature range of 15°C to 35°C. Most prokaryotes that have been described belong to this group.
- mesozoic:** Geological era from 245 to 66 million years ago.
- metabolism:** The combination of all enzymatic processes that sustain an organism’s physiology, including biochemical reactions resulting in the synthesis of new compounds (anabolism) and the degradation of compounds (catabolism).
- metagenomics:** A term coined to describe the analysis of genetic material extracted directly from environmental samples, in order to facilitate the characterization of microbial diversity that encompasses culturable and unculturable organisms. Metagenomics-based research involves the construction of composite libraries of microbial genomes that can be screened for particular functional traits, or

- for performing comparative assessments of genetic potential cross ecological systems.
- metalloproteins:** Protein molecules that require metal ions to function. Many microbial enzymes are metalloproteins, and the intracellular metal ion concentrations are under tight regulation to avoid potential toxicity.
- meteorite:** Fragments of asteroids that fall to Earth, surviving the disintegration by vaporization that usually occurs for materials passing through the atmosphere at great speed. Stony meteorites are most common, consisting of silicate minerals. Iron meteorites consist primarily of iron and some nickel. Carbonaceous chondrites are meteorites containing clay-type silicate materials and organic compounds that have been investigated as originating from biological sources, or as contributing materials to the origin of life on Earth.
- methanogens:** Microorganisms that produce methane through the enzymatic reduction of carbon dioxide or low molecular weight fatty acids. Most belong to the Archaea domain.
- microaerophiles:** Microorganisms that grow best under very low concentrations of oxygen. In aquatic environments, they are found beneath the water surface and above the sediment layer at a region where the diffusion gradient of oxygen reaches a sufficiently low concentration to support growth.
- microbial loop:** The concept that is used to explain the participation of microorganisms in nutrient cycling and food webs in marine ecosystems. The microbial loop is essentially a food chain that works within, or in parallel to, the classical food chain. In the microbial loop, heterotrophic bacteria obtain their carbon and energy sources directly from dissolved inorganic materials. These organisms, which are too small to be preyed on directly by copepods, are grazed by flagellates and ciliates. Ciliates are then consumed by copepods and the process continues up the classical food chain. The microbial loop concept is considered a major milestone in marine biology.
- microbial mat:** A densely structured heterogeneous microbial community in the benthos. Phototrophic bacteria are typically responsible for primary productivity in microbial mats. Stromatolites are fossilized microbial mats.
- mineralization:** The enzymatic transformation of an element from organic forms to its inorganic form. An example of mineralization is the total conversion of cellulose to carbon dioxide.
- mitochondrion (plural: mitochondria):** An organelle of eukaryotic cells occurring as a semi-autonomous structure with its own genome. Mitochondria function in cellular energy generation through respiration and the tri-carboxylic acid cycle. Mitochondria are absent from certain eukaryotes, including protozoa belonging to the phylogenetic orders *Pelobiontida* and *Diplomonadida*. The serial endosymbiotic theory posits that mitochondria originated through symbiotic interactions among ancestral prokaryotes. The prokaryotic origin of mitochondria is supported by nucleic acid sequence analysis.
- mixotrophism:** The capacity of some microorganisms (mixotrophs) to conduct both autotrophic and heterotrophic modes of metabolism.
- molecular marker:** Traceable genetic trait that can be used to identify specific microorganisms defined by phenotypic affiliation or ability to perform a certain ecological function in a complex heterogeneous community.
- mutagen:** A physical (e.g. electromagnetic radiation), chemical (e.g. nitrous acid and 5-bromo-deoxyuridine), or biological (e.g. transposable nucleic acid; transposons) agent that can cause mutations (nucleotide sequence alterations) in the genetic material.
- mycorrhiza:** Symbiotic interaction between filamentous fungi and plants in the rhizosphere.
- neutralism:** Used to define the absence of a relationship between two different species present in the same habitat. Neutralism is very difficult to prove.
- niche:** The concept used to define both the physical and functional situations of an organism relative to the biotic and abiotic components of its immediate environment. The niche concept encompasses all parameters that support or restrict the existence of species. Related concepts include **niche diversification**, or the total number of possible microhabitats and functions necessary to maintain ecosystem integrity; **niche breadth**, which defines the hyperspace in which organisms exist (upper and lower boundaries of physical and chemical parameters that support growth); **niche size**, which is an index of the number of species that can coexist in a community or habitat; and **niche overlap**, which defines direct competition between two or more species for the same ecological role, resources, or physical space.
- nitrification:** Part of the nitrogen cycle in which ammonium is enzymatically oxidized to nitrogen oxides, particularly nitrite and nitrate.
- nitrogen fixation:** The enzymatic conversion of molecular nitrogen to ammonia, which is then converted to organic nitrogen required by organisms for cellular metabolism. In nature, this is primarily a symbiotic process between plants and a selected group of microorganisms. Approximately 5–8% of the global amount of fixed nitrogen is attributed to lightning events which split molecular nitrogen, there enabling N atoms to combine with oxygen in the air to form nitrogen oxides. Industrially, nitrogen is fixed through Haber's process where under high pressure and temperature (600°C), atmospheric nitrogen and hydrogen are catalytically combined to form ammonia, which is either used directly or processed further to generate, for example, ammonium nitrate fertilizer.
- numerical taxonomy:** In microbial systematics, a strategy of positioning organisms in a phylogenetic tree by comparing large numbers of characteristics.
- oligonucleotide:** Short fragment of nucleic acid typically consisting of 30 or fewer nucleotides. Can be labeled and used as a hybridization probe.
- oligotrophic:** Limited supply of nutrients. Describes environments where the growth of organisms is retarded because of inadequate access to nutrients.
- organelle:** Small "organs" representing distinct intracellular features specialized in certain functions. For example, prokaryotic organelles include ribosomes, carboxysomes, and flagella. Examples of organelles for eukaryotes include the products of endosymbiosis, namely mitochondria and the plastids.
- osmophiles:** Organisms capable of living in environments with high concentrations of sugar.
- ozone layer:** The layer of ozone in the stratosphere. Ozone can be depleted by catalytic reactions involving halogenated compounds of industrial or biological origin.
- Pangaea:** The supercontinent which existed 200 million years ago.
- Paleozoic:** Geological era from 570 to 245 million years ago.
- parasitism:** Ecological interaction in which one organism depends entirely on another organism for nutrients and/or habitat.
- PCR (polymerase chain reaction):** A method originally developed by Kary Mullis for amplifying specific segments of DNA, through the

- annealing of oligonucleotide primers, and the extension of the primers based on the template DNA present in the target genetic material. Heat-stable DNA polymerase is essential for PCR. The amplification of target RNA is possible through the action of reverse transcriptase (RT-PCR).
- pelagic zone:** In marine environments, the zone between the sea floor and the edge of the continental shelf.
- phanerozoic:** The period from 570 million years ago to the present.
- phosphobacteria:** Phosphatase-producing bacteria capable of producing orthophosphate from organic phosphate compounds.
- photolithotrophs:** Microorganisms that can grow using light energy and carbon dioxide (or carbonates) as the sole source of carbon.
- photosynthesis:** The process through which certain organisms grow using light energy captured by photosynthetic pigments (e.g. chlorophyll) to drive reactions that produce organic matter from carbon dioxide and an electron donor (e.g. hydrogen, water, hydrogen sulfide).
- photosystem I:** The photosynthesis system that does not require external electron donors and does not produce reduced coenzyme.
- photosystem II:** In contrast to photosystem I, photosystem II is a photosynthetic system that requires external electron donors and produces reduced coenzyme.
- phylogenetic:** The evolutionary relationships within and between taxonomic groups. The phylogeny or “family tree” of a group is represented by diagrams tracing the relationships between ancestors and descendants.
- phytoplankton:** An aquatic community of unicellular photosynthetically active organisms.
- plasmid:** An autonomously replicating satellite DNA carried by some bacteria in addition to the chromosome.
- population:** All individuals representing a group of organisms belonging to the same species and occupying the same geographical location at the same time. Populations sharing a common gene pool as a local interbreeding group are referred to as “demes”.
- P/R ratio:** A quantitative measure of the relationship between photosynthesis and respiration in an ecosystem.
- Precambrian:** The period from the formation of Earth to 570 million years ago.
- prions:** Causative agent of neurodegenerative diseases. Pathogenic prions are deformed versions of proteins that are normally required for cellular functioning.
- prokaryotes:** Unicellular microorganisms traditionally defined by their lack of a nucleus. Instead, the genetic material (chromosome) is loosely organized within the cell.
- proteome:** The total protein content of a cell or of a microbial community.
- Protocista:** A phylogenetic domain consisting of eukaryotic organisms defined by a multi-genomic nature and aquatic habitats, excepting true fungi, plants, and animals. Protocists include algae, amoebas, ciliates, foraminiferans, seaweeds, and water molds. Protists within this group are either unicellular or exhibit a small number of cells.
- protozoa:** Eukaryotic microorganisms without rigid cell walls. Protozoa are important in bacterial ecology because of their grazing activities.
- psychrophiles:** Microorganisms that thrive in cold environments. They are defined by the ability to proliferate at 0°C. Cold tolerance in psychrophilic bacteria is associated with plasma membranes which contain unsaturated fatty acids. Psychrophiles in the Antarctic contain polyunsaturated fatty acids, which were previously thought to be absent in prokaryotes.
- protocooperation:** A mutually beneficial but unnecessary interaction between two species.
- quorum sensing:** The ability of microorganisms to monitor and respond to population densities in complex microbial communities.
- recalcitrant chemicals:** Chemicals, usually anthropogenic, which are resistant to microbiological degradation.
- respiratory quotient:** An index of the efficiency of respiration defined as the number of carbon dioxide molecules produced from each molecule of oxygen.
- r-strategists:** Organisms which are optimized for maximizing growth rate under conditions in which exogenous nutrients become available, as opposed to organisms that keep growth rate in check while favoring maintaining population density around the environment’s carrying capacity (k-strategists). In environmental microbiology, r-strategists are also known as allochthonous or zymogenous microorganisms.
- RAPD (random amplification of polymorphic DNA):** The technique invented for identifying molecular level differences among organisms through the conduction of PCR using random primers. The primers anneal to different parts of the genome in different organisms, leading to differently sized amplification products. A comparative assessment of the amplification products can provide an index of diversity in a microbial community.
- redox potential (E_h in volts):** The quantitative index of the electron exchange tendency of a system. It is a relative index based on the assumption that the redox potential of a standard hydrogen electrode is zero.
- remote sensing:** The use of Earth-orbiting satellites to investigate physical structures, ecosystem boundaries, and changes in environmental parameters without direct contact sampling. Extensive data processing, photogrametric image analysis, and ground-level verification are usually required to correctly interpret data acquired through remote sensing.
- RFLP (restriction fragment length polymorphism):** A technique for determining the level of nucleotide sequence differences among different genomes. A restriction enzyme with a strict nucleotide sequence recognition profile is used against each genome. If the frequency of occurrence of the recognition sequence differs among the genomes being compared, the resulting restriction fragment profiles will be different.
- rRNA (ribosomal ribonucleic acid):** A component of ribosomes, the location of protein synthesis in all cells. Prokaryotic ribosomes contain three major kinds of rRNA molecules: 5S, 16S, and 23S rRNA. More than 10,000 16S and 16S-like rRNA and 1,000 23S and 23S-like rRNA genes have been sequenced by laboratories trying to understand the phylogenetic relationships among organisms.
- semaphoront:** The basic unit of biological systematics, representing an individual at a particular phase of the life cycle.
- serial endosymbiotic theory:** Explains the origin of eukaryotes from ancestral prokaryotic cells that engaged in a series of symbiotic interactions occurring in a specific sequence, leading to the establishment of organelles such as mitochondria, plastids, and undulipodia.
- serotype:** A microorganism that has antigens (protein molecules that can induce immune response in mammals) that distinguish the organism from other closely related varieties.
- siderophore:** A microbial product secreted by some organisms, notably pseudomonads, to form stable coordination compounds

- with iron. The major types of siderophores are catecholate and hydroxamate, and they play critical roles in maintaining homeostatic control of metal bioavailability.
- skotophiles:** Microorganisms that prefer growth in dark environments.
- species:** The smallest formal unit in the hierarchy of microbiological classification, representing a group of organisms formally recognized as distinct from other groups. Members of a single species may be recognized as different strains when they exhibit characteristics that are temporary or easily selected in a population.
- spores:** Reproductive cells produced by some prokaryotes in response to adverse environmental conditions. Spores are important in the survival and dispersal of microorganisms in the environment.
- SSCP (single-strand conformation polymorphism):** A technique for detecting genetic diversity through the observation of small differences in nucleotide sequences. The technique is facilitated by PCR, and it takes advantage of differences in the mobility of single-stranded DNA according to sequence information, which allows the formation of secondary structures with variable stability.
- strain:** Within a taxon, organisms or populations of organisms that are genetically similar, but distinguishable from other organisms or populations within that taxon.
- stratosphere:** The region of the atmosphere that extends from the tropopause to the stratopause, at about 50 km. The stratosphere features the ozone layer, which absorbs much of the solar electromagnetic radiation in the ultraviolet range.
- stromatolite:** Biogenic sedimentary structure of laminated silicate or carbonate rocks. Stromatolites are fossilized microbial communities consisting of cyanobacteria and other microorganisms typical of living microbial mats.
- symbiosis:** The ecological relationship in which two different species occupy the same microhabitat with extensive obligatory interactions, which may not necessarily be mutually beneficial.
- synergism:** The ecological relationship in which two species engage in non-obligatory mutually beneficial interactions.
- TGGE (temperature gradient gel electrophoresis):** Technique for screening a population of microorganisms for mutation in a particular genetic locus. When a temperature gradient is applied during the electrophoretic separation of nucleic acids (DNA or RNA), fragments of identical length but different sequence can be separated.
- thermocline:** In aquatic ecosystems, the zone defined by drastic change in water temperature.
- thermophiles:** Organisms that thrive in extremely hot environments. For example, the optimum growth temperature for *Pyrococcus furiosus* is around 100°C. *Methanopyrus* and *Pyrodictium* species can grow at maximum temperatures of 110°C and 113°C, respectively. Thermophilic bacteria have saturated fatty acids in their membranes. Hyperthermophilic Archaea do not have fatty acids in their membranes. Instead, they have repeating subunits of phytane, a branched, saturated, isoprenoid. Protein molecules in thermophiles undergo post-translational modification, including dehydration, to render them heat stable.
- tokogenetic:** A term used to describe the genetic relationship between individuals.
- transposon:** Mobile genetic element found in many phylogenetic groups. The mechanism of mobility involves non-homologous recombination.
- troposphere:** The region of the atmosphere that extends from the Earth's surface to the tropopause, approximately 10–16 km in altitude, depending on the latitude at which the measurement is taken. An important feature of the troposphere is that most of the biological influences on atmospheric composition are limited to this range, except for the impact on the tropospheric ozone layer, which should be recognized as distinct from the tropospheric ozone that results from urban air pollution.
- undulipodium (plural: undulipodia):** An organelle of eukaryotes, including cilia, that functions in motility associated with sensory or feeding activity. The serial endosymbiotic theory posits that undulipodia originated through symbiosis among prokaryotes.
- UV:** Ultraviolet light representing the 100–400 nm segment of the electromagnetic spectrum.
- viruses:** Particulate obligately infectious genetic entities consisting primarily of a protein coat and genome made up of DNA or RNA.
- visible light:** The 400–800 nm section of the electromagnetic spectrum. Visible light is required for most photosynthetic activity.
- xenobiotic:** A chemical compound that is not a product of biological metabolism, but of industrial manufacture. Many xenobiotic compounds are recalcitrant and/or toxic to living systems.
- xerophiles:** Microorganisms that live in extremely dry environments lacking easily available water.