Glossary

Acid deposition—the fallout of acidic substances, primarily of nitrogen and sulfur, from the atmosphere on to the earth’s surface in rain, snow, or other forms. Acid rain has a pH generally less than 5 (averaged over a year).

Aerosol—the suspension of very fine, generally micrometer-sized, solid and liquid particles in the atmosphere.

Albedo—the amount of incident radiation that is reflected by a surface and thus does not contribute to the heating of the surface. The albedo of the whole earth is approximately 30%. The albedo of clean snow is about 90% and that of water is about 10%.

Anaerobic—an organism that does not need oxygen to carry on its metabolism or an environment without oxygen.

Anoxic—without oxygen.

 Anthropogenic—of, relating to, or influenced by the impact of humans on nature.

Atom—the smallest component of an element having the chemical properties of the element. An atom consists of a nucleus of neutrons and protons and one or more electrons bound to the nucleus by electrical attraction.

Autotrophy—the biochemical pathway by which an organism uses carbon dioxide as a source of carbon and simple nutrient compounds for synthesis of organic matter.

Autotrophic system—an environment in which the difference between gross photosynthesis and gross respiration is positive. In such a terrestrial or aquatic environment, the net transfer of carbon dioxide is into the system.

Bacteria—one-celled organisms having a spherical, spiral, or rod shape belonging to the Kingdom Monera.

Benthic—of, relating to, or occurring at the bottom of a body of water.

Bioessential—required by virtually all living organisms. The major bioessential elements are oxygen, carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium. Minor or trace quantities of iron, manganese, copper, zinc, boron, silicon, molybdenum, chlorine, vanadium, cobalt, and sodium are also required by organisms.

Biogenic gas—a gas whose production or consumption on earth is accomplished by biological reactions.

Biogeochemical cycle—representation of biological, geological, and chemical processes that involve the movement of an element or compound about the surface of the earth.

Biogeochemical system—the interactive system of biogeochemical processes and cycles of elements and compounds.

Biogeochemistry—the discipline that links various aspects of biology, geology, and chemistry to investigate the surface environment of the earth.
Biological productivity—the rate of production per unit area of organic matter by producer organisms. For example, the rate may be given as grams of carbon per square meter per year for a marine grass community. There are several kinds of productivity. Gross primary production (GPP) refers to the total amount of plant material produced by photosynthesis in a defined area in an interval of time. Net primary production (NPP) is the net amount of plant material produced per unit area per unit time and is the difference between GPP and cell respiration. Net ecosystem production (NEP) is the difference between GPP and cell respiration plus heterotrophic processes of decay.

Biological pump—the set of processes by which organic carbon is exported from the surface ocean to the deep sea.

Biomass—the amount of living matter in a unit area or volume of habitat. For example, the total biomass of the world’s tropical rain forests is 42 kilograms of dry matter per square meter of forest, or a total of 420 billion tons of dry matter (equivalent to approximately 170 billion tons of carbon).

Biosphere—the living and dead organic components of the earth. Sometimes this term is used in the same way as the term ecosystems in this module, and sometimes for only the living animals and plants.

Climate—the characteristic long-term environmental conditions of temperature, precipitation, winds, etc., in a region or for the globe at present or in the past (paleoclimate).

Cloud condensation nuclei—airborne particles of very small size, generally less than one micrometer in diameter, that serve as sites on which liquid cloud droplets condense when an air mass is supersaturated with water vapor. The particles are commonly composed of water-soluble material.

Coccolithophoridae—a family of planktonic algae that build skeletons of micrometer-sized disc-shaped plates of calcite, called coccoliths.

Concentration—the fraction of the total of a substance made up of one component. For example, seawater contains 400 parts per million by weight of calcium. Concentration is also expressed in moles per liter or kilogram or in percent (that is, parts per hundred), parts per thousand (°/°°), per million (ppm), per billion (ppb), and so forth, either by weight or by volume.

Coupled—the condition in which information from one part of the system is provided to, and influences the behavior of, other parts. The biogeochemical cycles of the elements necessary for life are coupled through processes that are essential for life, e.g., photosynthesis and respiration.

Crust—the outer layer of the earth, enriched in silicon, sodium, and potassium and having a thickness of 35 kilometers beneath the continents and 10 kilometers beneath the oceans.

Cryosphere—the icy part of the earth; its continental and mountain glaciers, ice sheets, and ice shelves; a reservoir in the earth’s surface system.

Decay—the oxidative process of conversion of organic tissue to simpler organic and inorganic compounds. The oxidizing agent may be diatomic oxygen (O₂), nitrate (NO₃⁻), or other chemical compounds.

Denitrification—the conversion, principally by bacteria, of compounds of nitrogen in soils and aquatic systems to nitrogen gas (N₂) and nitrous oxide gas (N₂O) and the eventual release of these gases to the atmosphere.

Diagenesis—the collection of physical, chemical, and biological processes that operate on a sediment after deposition.

Diatom—planktonic and benthic freshwater and marine algae that commonly use silicon to build a skeleton of opal.
Dry deposition—the deposition of materials from the atmosphere onto the earth’s surface in the form of solid particles. Such particles also may be “washed out” of the atmosphere by rain.

Ecosphere—the system that includes the biosphere and its interactions with the air, water, and soils and sediments of the earth.

Ecosystem—complex of a community or group of communities and the environment that functions as an ecological unit in nature.

Electromagnetic spectrum—the entire range of radiation. The wavelengths (distances between adjacent peaks) of the electromagnetic waves within the spectrum range from kilometers for radio waves to billionths of a meter (nanometers) for X rays.

Entropy—a scientific measure of the degree of disorder in a system. The greater the disorder the greater is the entropy of the system. The Second Law of Thermodynamics states that entropy is always increasing.

Equilibrium—stable, balanced state in which all influences on a system are countered by others.

Erosion—the set of processes by which the surface of the earth is worn away by the action of water, wind, glacial ice, etc.

Euphotic zone—the upper, lighted zone of the ocean or a lake in which most of the productivity of plants occurs. In the ocean, the euphotic zone extends from the surface to a depth where the light intensity is reduced to about 0.1–1.0% of that available at the surface. The depth of the euphotic zone depends on season and latitude.

Eutrophication—the set of processes leading to overnourishment of an aquatic system in nutrients, rapid plant growth and death, and oxygen consumption and deficiency in the system. These processes occur naturally in some aquatic systems but may be speeded up by additions of nutrients from human activities (e.g., fertilizer application) to the systems. Human-induced eutrophication is often called cultural eutrophication.

Evaporation—the physical process by which water is converted from liquid to vapor and is transported into the atmosphere.

Evapotranspiration—the combined processes of evaporation and transpiration.

Evasion—the escape or release of a gas from the surface of the ocean or land to the atmosphere.

Evolution—the pattern of development and change in a variable from one state to another. Biological evolution describes the pattern of emergence, development, and extinction of organic species through geologic time.

Feedback—a process or mechanism in which some fraction of the output is returned or “fed back” to the input. Feedback loops may either stabilize (negative feedback) or destabilize (positive feedback) a system undergoing a perturbation. These feedback loops exist in both the biogeochemical cycles and the climate system.

Fermentation—the bacterial process of conversion of sugars to carbon dioxide.

Fixation—see Nitrogen fixation.

Flux—the movement of a variable or a substance into or out of a reservoir.

Foraminifera—animal plankton (zooplankton) in the ocean belonging to the Phylum Protozoa that commonly have a shell of calcium carbonate.
Forcing—the ability of a variable, like the concentration of a greenhouse gas in the atmosphere, to induce a change in a system. A forcing function controls the behavior of a system and often makes it regular and predictable.

General circulation model (GCM)—a simulation, usually performed on a large computer, of the largescale, or general, wind and ocean systems on earth to calculate climate and its changes.

Geologic time scale—a calendar of earth history. The time scale is divided into variable time units of eon, era, period, and epoch (see Figure 5).

Glacial stage—an extended cold interval of time within the Pleistocene Epoch in which continental glaciers covered much of the Northern Hemisphere continents, atmospheric CO₂ concentrations were low, and sea level was low.

Greenhouse effect—the warming of the earth’s atmosphere and surface by the atmospheric greenhouse gases. These gases absorb and reradiate longwave radiation from the earth, keeping it in the atmosphere and thus warming the global temperature. Without the natural greenhouse effect, the planet would be about 33°C cooler than its global mean annual temperature of 15°C, that is, −18°C. Because of inputs from human activities, these gases are increasing in concentration in the atmosphere. This may lead to an enhanced greenhouse effect and warming of the planet.

Greenhouse gas—an atmospheric gas that absorbs and radiates energy in the infrared part of the electromagnetic spectrum. Such gases include water vapor, carbon dioxide, methane, nitrous oxide, tropospheric ozone, and the synthetic chlorofluorocarbon gases. These gases warm the atmosphere and the earth’s surface below.

Groundwater—the water beneath the ground, largely formed by the seepage of surface water downward.

Heterotrophic system—an environment in which the difference between gross photosynthesis and gross respiration is negative. In such a terrestrial or aquatic environment, the net transfer of carbon dioxide is out of the system.

Heterotrophy—a biochemical pathway in which organic substrates are used by organisms to make organic matter.

Hothouse—an extended period of geologic time during which the earth was warm.

Hydrosphere—the watery envelope surrounding the earth; a reservoir in the earth’s surface system.

Hydrothermal reaction—a chemical reaction involving hot water and minerals in a rock.

Hydroxyl radical (OH*)—the excited chemical compound of hydrogen and oxygen in the atmosphere with an imbalance of electric charge. The hydroxyl radical is responsible for the oxidation of many chemically reduced gases emitted from the surface of the earth.

Ice age—a glacial stage, especially within the Pleistocene Epoch, beginning about 1.8 million years ago.

Ice house—an extended period of geologic time in which the earth was cool.

Infrared radiation—the region of the electromagnetic spectrum with wavelengths longer than visible light (about 1 micrometer) but shorter than microwaves (about 1 millimeter). Commonly known as heat. Radiation emitted from the earth back to space is predominantly infrared radiation.

Interglacial stage—an extended warm interval of time within the Pleistocene Epoch in which the continental glaciers retreated and atmospheric CO₂ concentrations and sea level were low.

Ion—an electrically charged atom or group of atoms formed by the loss or gain of one or more electrons. A positive ion, the cation, is created by an electron loss, and a negative ion, the anion, is created by an electron gain.
Irreversible process—a process in which the entropy change is greater than zero. After the process is complete, the system is more disordered than and different from its initial state.

Kerogen—fossil organic matter dispersed throughout a rock.

Leaching—the selective removal of substances from a substrate, usually with water. For example, rainwater percolating through a soil can dissolve nitrogen and transport it to the groundwater. This is leaching.

Lifetime—a measure of the reactivity of an atmospheric chemical compound. The more reactive the compound, the shorter its atmospheric lifetime. Analogous to residence time.

Limestone—a sedimentary rock consisting predominantly of calcium carbonate minerals.

Limiting nutrient—the chemical compound, generally inorganic, that limits productivity in a terrestrial or aquatic environment. Examples are nitrate, phosphate, and iron.

Lithosphere—the dynamic subdivision of earth on the order of 100 kilometers in thickness forming the outer, rigid part of the planet. Also, the solid portion of the earth, composed of minerals, rocks, and soils; a reservoir in the earth’s surface system.

Mantle—the portion of earth between its crust and its innermost zone (the core). The mantle is enriched in magnesium and iron and has a thickness of about 2,900 kilometers.

Metamorphism—the set of processes that lead to a change in the structure or composition of a rock due to pressure and temperature. A metamorphic rock is formed from a preexisting rock by an increase in pressure and temperature.

Methanogenesis—the conversion of organic material to methane, principally by bacteria.

Methanotrophy—the conversion of methane to carbon dioxide, principally by bacteria.

Mid-ocean ridge—any of several seismically active, submarine mountain ranges that are found in the Atlantic, Indian, and Pacific Oceans. These ridges are regions where the seafloor originates and are the source of the lithospheric plates.

Mixotrophy—the use of both organic and inorganic materials to make organic matter.

Mole—one gram atomic weight of an element or one gram molecular weight of a compound. One gram atomic weight of an element is its atomic weight expressed in grams (i.e., the atomic weight of oxygen is 16; its gram atomic weight is 16 grams). One gram molecular weight of a compound is its molecular weight expressed in grams (i.e., the molecular weight of carbon dioxide is 44; its gram molecular weight is 44 grams).

Molecule—the smallest physical unit of an atom or compound, consisting of one or more similar atoms in an element and two or more different atoms in a compound.

Negative feedback—a process or mechanism that relieves or subtracts from an initial perturbation to a system.

Net primary production—see Biological productivity.

Nitrification—the conversion of ammonium to nitrite and nitrate by nitrifying bacteria.

Nitrogen fixation—the conversion of diatomic nitrogen gas (N₂) to ammonium by bacteria. Also, the industrial conversion of free nitrogen into combined forms used as starting materials for fertilizers and explosives.

Nutrient—a substance that supplies nutrition to a living organism, like phosphorus and nitrogen.

Organic—pertaining to a class of chemical compounds that include carbon as a component; characteristic of or derived from living organisms.
**Oxidation**—the removal of electrons from an atom or molecule. **Oxidizing capacity** is the intrinsic ability of a system to oxidize reduced substances.

**pH**—the negative logarithm of the effective hydrogen ion concentration, used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14, with 7 representing neutrality. Numbers less than 7 denote increasing acidity, and numbers greater than 7 increasing alkaline (basic) conditions.

**Photoautotrophy**—the conversion of inorganic carbon into organic matter in the presence of light.

**Photochemical**—pertaining to chemical reactions involving chemical compounds in the presence of light. Urban smog is the result of a complex series of photochemical reactions involving ozone, nitrogen and sulfur oxides, and hydrocarbons.

**Photolysis (photodissociation)**—pertaining to chemical reactions triggered by light that convert a complex compound to more simple products. The photolysis of ammonia is an example: \(2\text{NH}_3 \rightarrow \text{N}_2 + 3\text{H}_2\).

**Photosynthesis**—the synthesis of complex organic materials (e.g., carbohydrates) from carbon dioxide, water, and nutrients, using sunlight as a source of energy with the aid of chlorophyll and associated pigments.

**Phytoplankton**—minute plant life that passively floats in a body of water. The phytoplankton are at the base of the food chain in the ocean.

**Plankton**—minute plant and animal life of the ocean ranging in size from 5 micrometers to 3 centimeters. The plant plankton are the **phytoplankton**; the animal plankton are the **zooplankton**.

**Plate tectonics**—the theory of global tectonics in which the lithosphere is divided into a number of crustal plates that move on the underlying plastic asthenosphere. These plates may collide with adjacent plates, slide under or over them, or move past them in a nearly horizontal direction. The sources of the plates are the great midocean ridges of the world’s oceans, where hot molten material upwells from within the earth. The plates are destroyed at subduction zones, like that along the western margin of the Pacific Ocean, where they sink down into the underlying asthenosphere.

**Positive feedback**—a process or mechanism that reinforces or adds to an initial perturbation of a system.

**Precipitation**—the removal of water from the atmosphere and its deposition on the earth’s surface in the form of rain, ice, or snow.

**Prokaryote**—any cellular organism that has no membrane about its nucleus and no organelles in the cytoplasm except ribosomes. Prokaryotic genetic material is in the form of single, continuous strands forming coils or loops, characteristic of all organisms of the Kingdom Monera, such as bacteria or cyanobacteria.

**Protozoan**—eukaryotic organism of the Kingdom Prototista, Phylum Protozoa, with a membrane-bound nucleus and organelles within a mass of protoplasm. Planktonic foraminifera and radiolarians which secrete shells of calcium carbonate and opal, respectively, are members of the group.

**Radical**—an electronically excited compound with an imbalance of electric charge, which enables it to react rapidly with another molecule.

**Redfield ratio**—the relatively constant ratio of 106:16:1 of the bioessential elements carbon, nitrogen, and phosphorus in marine plankton. The concept of the Redfield ratio has been applied to the terrestrial realm as well as to organic matter in soils and sediments.

**Reduction**—the chemical process by which an atom or a molecule gains electrons.
Reservoir or stock—a part of a system that can store or accumulate and be a source of one of the substances that compose the system. For example, the atmosphere is a reservoir of the surface system of the earth (the ecosphere). It can store water vapor released to it from the land by evapotranspiration and from the ocean by evaporation, and return the water to the earth’s surface as precipitation.

Residence time—the total mass of a substance in a reservoir divided by its rate of inflow or outflow. The residence time is a measure of the reactivity of the substance in the reservoir. For example, the residence time of sodium in the ocean is very long (55 million years). Therefore, sodium does not enter into chemical or biochemical reactions that remove it very rapidly from the ocean. In contrast, the residence time of dissolved silica in the ocean is about 20,000 years. This compound is readily taken up by certain types of plankton to build their skeletons.

Respiration—the physical and chemical processes by which an organism supplies its cells and tissues with the oxygen needed for metabolism and releases carbon dioxide formed in the energy-producing reactions.

Reversible process—a process in which the change in entropy is zero. In general, after the process is complete, the state of the system is as it was initially.

Saturation—the degree to which a solution or a gas is at equilibrium with one of its components. It is measured in several different ways. For example, a humidity of 125% would be a supersaturation of 25% with respect to water vapor in the air. Saturation of seawater with respect to the mineral calcite (CaCO₃) of 50% would mean that the seawater was 50% undersaturated with respect to calcite. If a lake water contained exactly enough dissolved CO₂ to be in equilibrium with the atmosphere, it would have a saturation of 100% with respect to CO₂.

Sedimentary rock—a rock formed from the erosion of preexisting rocks and the deposition of the eroded materials as sediment. Sedimentary rocks are also formed by inorganic or biological precipitation of minerals from natural waters.

Shortwave radiation—generally, the region of the electromagnetic spectrum with wavelengths shorter than 0.5 micrometers. Solar radiation has an important component of shortwave radiation of varying intensity.

Solar radiation—the electromagnetic radiation emitted by the sun. It includes energy wavelengths from the very short ultraviolet (<0.2 micrometers) to about 3 micrometers.

Stratosphere—the region of the upper atmosphere extending upward from the troposphere to about 30 kilometers above the earth’s surface. This region is characterized by an increase in temperature as altitude increases.

Subduction zone—the juncture of two lithospheric plates where the collision of the plates results in one plate’s being drawn down or overridden by another plate. This region is the sink of the crustal plates of the earth.

System—a selected set of interactive components. An example of a simple system is an air conditioning unit. A biogeochemical system consists of reservoirs, processes and mechanisms, and associated fluxes involving material transport. The global climate system is very complex and involves all the physical, chemical, and biological interactions that control the long-term environmental conditions of the world.

Thermocline—the depth range in the ocean where the temperature decreases rapidly with increasing depth. The thermocline is about one kilometer thick and extends from the base of the surface layer of the ocean at a depth of 50–300 meters to a depth of about 800–1,000 meters.

Trace gas—a gas present in the atmosphere in a very low concentration (less than 1% of the composition of the atmosphere). For example, methane, nitrous oxide, and carbon monoxide are considered trace gases.
Transitional phenomenon—a feature of a system that changes from one state to another. Such a change may be relatively slow or more generally abrupt. In the boiling of water, the change from the state of little water motion to that of turbulence is a transitional phenomenon.

Transpiration—the process by which water in plants is excreted through a plant membrane as water vapor.

Troposphere—the lowest level of the atmosphere, up to 8–13 kilometers high, within which there is a steady drop in temperature with increasing altitude. It is the region where most cloud formations occur and weather conditions manifest themselves.

Ultraviolet radiation—the region of the electromagnetic spectrum with wavelengths longer than 0.5 nanometers but shorter than 0.5 micrometers. Solar radiation has an important component of ultraviolet radiation of varying intensity.

Uptake—generally, the incorporation of a substance into a solid or liquid. For example, the invasion of CO₂ into the ocean represents the uptake of CO₂ from the atmosphere.

Upwelling—the upward movement of water from depths of typically 50–150 meters at speeds of approximately 1–3 meters per day. The upwelling of water generally results from the lateral movement of surface water. Upwelling zones in the ocean are found along the western margins of the continents, in equatorial regions, and at high latitudes of the Southern Hemisphere.

Vascular plant—either a plant with seeds that are not enclosed in a fruit or seed case, such as pine, fir, spruce, and other cone-bearing trees or shrubs (gymnosperm), or a flowering plant that produces encased seeds, such as oak, maple, and eucalyptus trees (angiosperm).

Volatilization—the conversion of a substance into the gas or vapor state and its emission into the environment.

Washout—the scavenging of particles from the atmosphere by rainfall and their subsequent deposition on the surface of the earth.

Weathering—the set of chemical, physical, and biological processes that lead to the disintegration of minerals, kerogen, and rocks.

Wet deposition—the deposition on the earth’s surface of solid particles and dissolved chemical compounds in rain.

Zooplankton—minute animal life in a body of water that generally drift passively or swim very weakly.
Supplementary Reading


References


