3 BIOGEOCHEMICAL CYCLES

Biogeochemical cycle, any of the natural circulation pathways of the essential elements of living matter. These elements in various forms flow from the nonliving (abiotic) to the living (biotic) components of the biosphere and back to the nonliving again. In order for the living components of a major ecosystem (e.g., a lake or forest) to survive, all the chemical elements that make up living cells must be recycled continuously.

Each cycle can be considered as having a reservoir (nutrient) pool—a larger, slow-moving, usually abiotic portion—and an exchange (cycling) pool—a smaller but more active portion concerned with the rapid exchange between the biotic and abiotic aspects of an ecosystem.

Biogeochemical cycles can be classed as gaseous, in which the reservoir is the air or the oceans (via evaporation), and sedimentary, in which the reservoir is the Earth's crust. Gaseous cycles include those of nitrogen, oxygen, carbon, and water; sedimentary cycles include those of iron, calcium, phosphorus, and other more earthbound elements.

Gaseous cycles tend to move more rapidly than do the sedimentary ones and to adjust more readily to changes in the biosphere because of the large atmospheric reservoir. Local accumulations of carbon dioxide, for example, are soon dissipated by winds or taken up by plants. Extraordinary and more frequent local disturbances can, however, seriously affect the capacity for self-adjustment.

Sedimentary cycles vary from one element to another, but each cycle consists fundamentally of a solution phase and a rock (or sediment) phase. Weathering releases minerals from the Earth's crust in the form of salts, some of which dissolve in water, pass through a series of organisms, and ultimately reach the deep seas, where they settle out of circulation indefinitely. Other salts deposit out as sediment and rock in shallow seas, eventually to be weathered and recycled.

The cycling of chemical elements required by life between the living and nonliving parts of the environment. Some examples of these chemical elements are H2O, P, S, N2, O2 and C.

These elements cycle in either a gas cycle or a sedimentary cycle; some cycle as both a gas and sediment.

In a gas cycle elements move through the atmosphere. Main reservoirs are the atmosphere and the ocean.

In a sedimentary cycle elements move from land to water to sediment. Main reservoirs are the soil and sedimentary rocks.

Gas Cycles:	*Sedimentary Cycles:*
Carbon	Phosphorus
Nitrogen	Sulfur
Oxygen.	

CARBON CYCLE

The movement of carbon, in its many forms, between the biosphere, atmosphere, oceans, and geosphere is described by the carbon cycle, illustrated in the adjacent diagram. The carbon cycle is one of the biogeochemical cycles. In the cycle there are various sinks, or stores, of carbon (represented by the boxes) and processes by which the various sinks exchange carbon (the arrows).

We are all familiar with how the atmosphere and vegetation exchange carbon. Plants absorb CO2 from the atmosphere during photosynthesis, also called primary production, and release CO2 back in to the atmosphere during respiration. Another major exchange of CO2 occurs between the oceans and the atmosphere. The dissolved CO2 in the oceans is used by marine biota in photosynthesis.

Two other important processes are fossil fuel burning and changing land use. In fossil fuel burning, coal, oil, natural gas, and gasoline are consumed by industry, power plants, and automobiles. Notice that the arrow goes only one way: from industry to the atmosphere. Changing land use is a broad term which encompasses a host of essentially human activities. They include agriculture, deforestation, and reforestation.

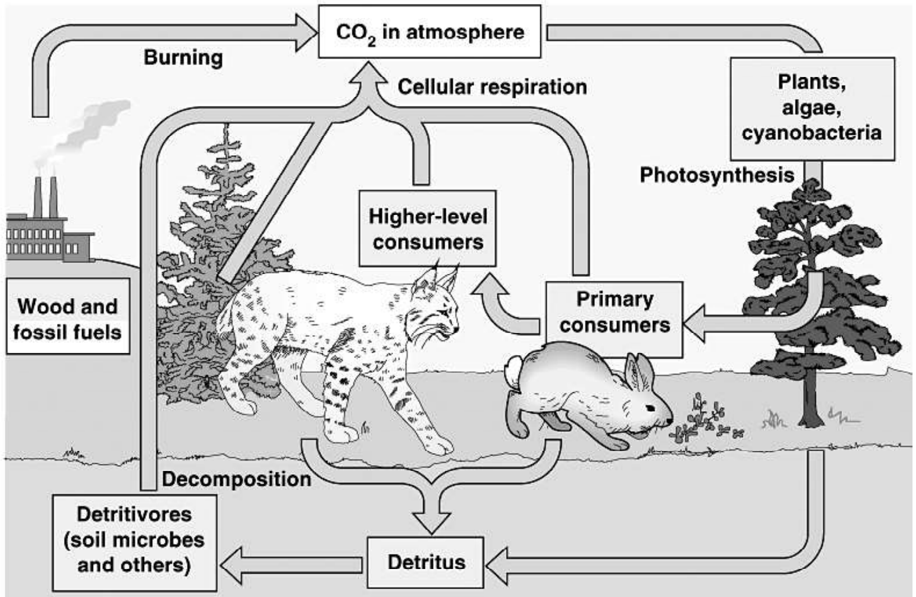


Image of a diagram which shows the carbon cycle with a mass of carbon. This image links to a more detailed image.The adjacent diagram shows the carbon cycle with the mass of carbon, in gigatons of carbon (Gt C), in each sink and for each process, if known. The amount of carbon being exchanged in each process determines whether the specific sink is growing or shrinking. For instance, the ocean absorbs 2.5 Gt C more from the atmosphere than it gives off to the atmosphere. All other things being equal, the ocean sink is growing at a rate of 2.5 Gt C per year and the atmospheric sink is decreasing at an equal rate. But other things are not equal. Fossil fuel burning is increasing the atmosphere's store of carbon by 6.1 Gt C each year, and the atmosphere is also interacting with vegetation and soil. Furthermore, there is changing land use.

The carbon cycle is obviously very complex, and each process has an impact on the other processes. If primary production drops, then decay to the soil drops. But does this mean that decay from the soil to the atmosphere will also drop and thus balance out the cycle so that the store of carbon in the atmosphere will remain constant? Not necessarily; it could continue at its current rate for a number of years, and thus the atmosphere would have to absorb the excess carbon being released from the soil. But this increase of atmospheric carbon (in the form of CO_2) may stimulate the ocean to increase its uptake of CO_2 .

What is known is that the carbon cycle must be a closed system; in other words, there is a fixed amount of carbon in the world and it must be somewhere. Scientists are actively investigating the carbon cycle to see if their data does indeed indicate a balancing of the cycle. These types of investigations have led many scientists to believe that the forests of the Northern Hemisphere are, in fact, absorbing 3.5 Gt C per year, and so changing land use is actually removing carbon from the atmosphere (~2 Gt C/year), not increasing it as the diagram shows. Experiments are ongoing to confirm this information.

NITROGEN CYCLE

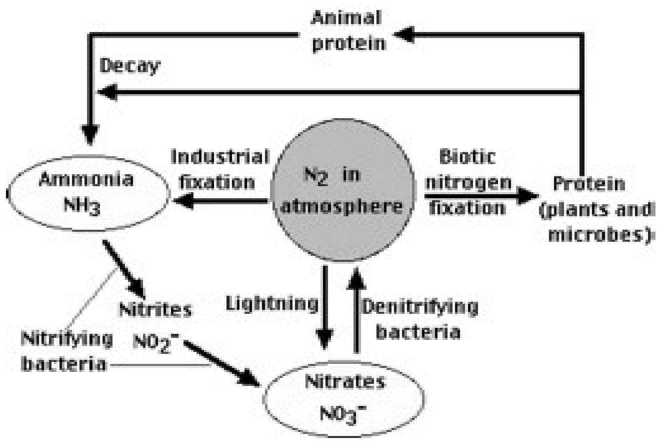
All life requires nitrogen-compounds, e.g., proteins and nucleic acids.

Air, which is 79% nitrogen gas (N_2), is the major reservoir of nitrogen.

But most organisms cannot use nitrogen in this form. Plants must secure their nitrogen in "fixed" form, i.e., incorporated in compounds such as:

- nitrate ions (NO_3^-)
- ammonium ions (NH_4^+)
- urea $(NH_2)_2CO$

Animals secure their nitrogen (and all other) compounds from plants (or animals that have fed on plants).



Four processes participate in the cycling of nitrogen through the biosphere:

- nitrogen fixation
- decay
- nitrification
- dfenitrification

Microorganisms play major roles in all four of these.

Nitrogen Fixation

The nitrogen molecule (N_2) is quite inert. To break it apart so that its atoms can combine with other atoms requires the input of substantial amounts of energy.

OXYGEN CYCLE

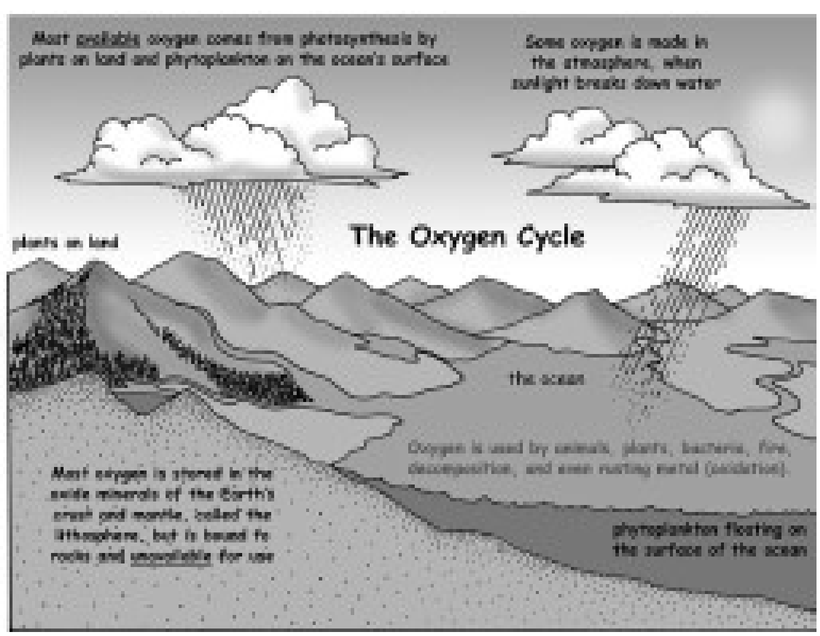
The oxygen cycle is the cycle that helps move oxygen through the three main regions of the Earth, the Atmosphere, the Biosphere, and the Lithosphere. The Atmosphere is of course the region of gases that lies above the Earth's surface and it is one of the largest reservoirs of free oxygen on earth. The Biosphere is the sum of all the Earth's ecosystems. This also has some free oxygen produced from photosynthesis and other life processes. The largest reservoir of oxygen is the lithosphere. Most of this oxygen is not on its own or free moving but part of chemical compounds such as silicates and oxides.

The atmosphere is actually the smallest source of oxygen on Earth comprising only 0.35% of the Earth's total oxygen. The smallest comes from biospheres. The largest is as mentioned before in the Earth's crust. The Oxygen cycle is how oxygen is fixed for freed in each of these major regions.

In the atmosphere Oxygen is freed by the process called photolysis. This is when high energy sunlight breaks apart oxygen bearing molecules to produce free oxygen. One of the most well known photolysis it the ozone cycle. O2 oxygen molecule is broken down to atomic oxygen by the ultra violet radiation of sunlight. This free oxygen then recombines with existing O2 molecules to make O3 or ozone. This cycle is important because it helps to shield the Earth from the majority of harmful ultra violet radiation turning it to harmless heat before it reaches the Earth's surface.

In the biosphere the main cycles are respiration and photosynthesis. Respiration is when animals and humans breathe consuming oxygen to be used in metabolic process and exhaling carbon dioxide. Photosynthesis is the reverse of this process and is mainly done by plants and plankton.

The lithosphere mostly fixes oxygen in minerals such as silicates and oxides. Most of the time the process is automatic all it takes is a pure form of an element coming in contact with



oxygen such as what happens when iron rusts. A portion of oxygen is freed by chemical weathering. When a oxygen bearing mineral is exposed to the elements a chemical reaction occurs that wears it down and in the process produces free oxygen.

These are the main oxygen cycles and each play an important role in helping to protect and maintain life on the Earth.

HYDROLOGIC CYCLE

Hydrologic cycle, cycle that involves the continuous circulation of water in the Earth-atmosphere system. Of the many processes involved in the hydrologic cycle, the most important are evaporation, transpiration, condensation, precipitation, and runoff. Although the total amount of water within the cycle remains essentially constant, its distribution among the various processes is continually changing.

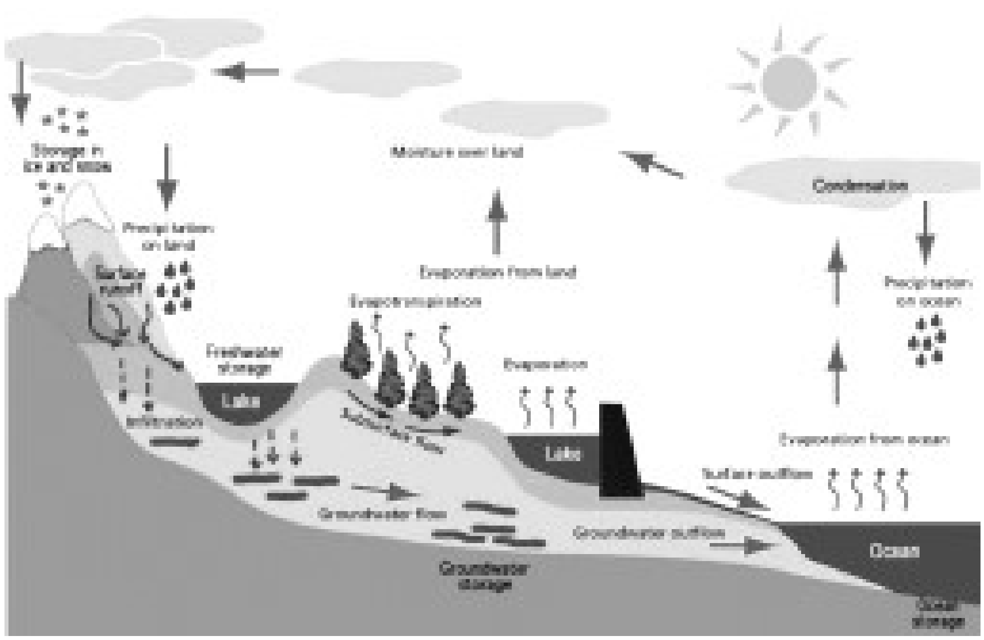
A brief treatment of the hydrologic cycle follows. For full treatment, see hydrosphere: The hydrologic cycle.

Evaporation, one of the major processes in the cycle, is the transfer of water from the surface of the Earth to the atmosphere. By evaporation, water in the liquid state is transferred to the gaseous, or vapour, state. This transfer occurs when some molecules in a water mass have attained sufficient kinetic energy to eject themselves from the water surface. The main factors affecting evaporation are temperature, humidity, wind speed, and solar radiation. The direct measurement of evaporation, though desirable, is difficult and possible only at point locations. The principal source of water vapour is the oceans, but evaporation also occurs in soils, snow, and ice. Evaporation from snow and ice, the direct conversion from solid to vapour, is known as sublimation. Transpiration is the evaporation of water through minute pores, or stomata, in the leaves of plants. For practical purposes, transpiration and the evaporation from all water, soils, snow, ice, vegetation, and other surfaces are lumped together and called evapotranspiration, or total evaporation.

Water vapour is the primary form of atmospheric moisture. Although its storage in the atmosphere is comparatively small, water vapour is extremely important in forming the moisture supply for dew, frost, fog, clouds, and precipitation. Practically all water vapour in the atmosphere is confined to the troposphere (the region below 6 to 8 miles [10 to 13 km] altitude).

The transition process from the vapour state to the liquid state is called condensation. Condensation may take place as soon as the air contains more water vapour than it can receive from a free water surface through evaporation at the prevailing temperature. This condition occurs as the consequence of either cooling or the mixing of air masses of different temperatures. By condensation, water vapour in the atmosphere is released to form precipitation.

Precipitation that falls to the Earth is distributed in four main ways: some is returned to the atmosphere by evaporation, some may be intercepted by vegetation and then evaporated from the surface of leaves, some percolates into



the soil by infiltration, and the remainder flows directly as surface runoff into the sea. Some of the infiltrated precipitation may later percolate into streams as groundwater runoff. Direct measurement of runoff is made by stream gauges and plotted against time on hydrographs.

Most groundwater is derived from precipitation that has percolated through the soil. Groundwater flow rates, compared with those of surface water, are very slow and variable, ranging from a few millimetres to a few metres a day. Groundwater movement is studied by tracer techniques and remote sensing.

Ice also plays a role in the hydrologic cycle. Ice and snow on the Earth's surface occur in various forms such as frost, sea ice, and glacier ice. When soil moisture freezes, ice also occurs beneath the Earth's surface, forming permafrost in tundra climates. About 18,000 years ago glaciers and ice caps covered approximately one-third of the Earth's land surface. Today about 12 percent of the land surface remains covered by ice masses.

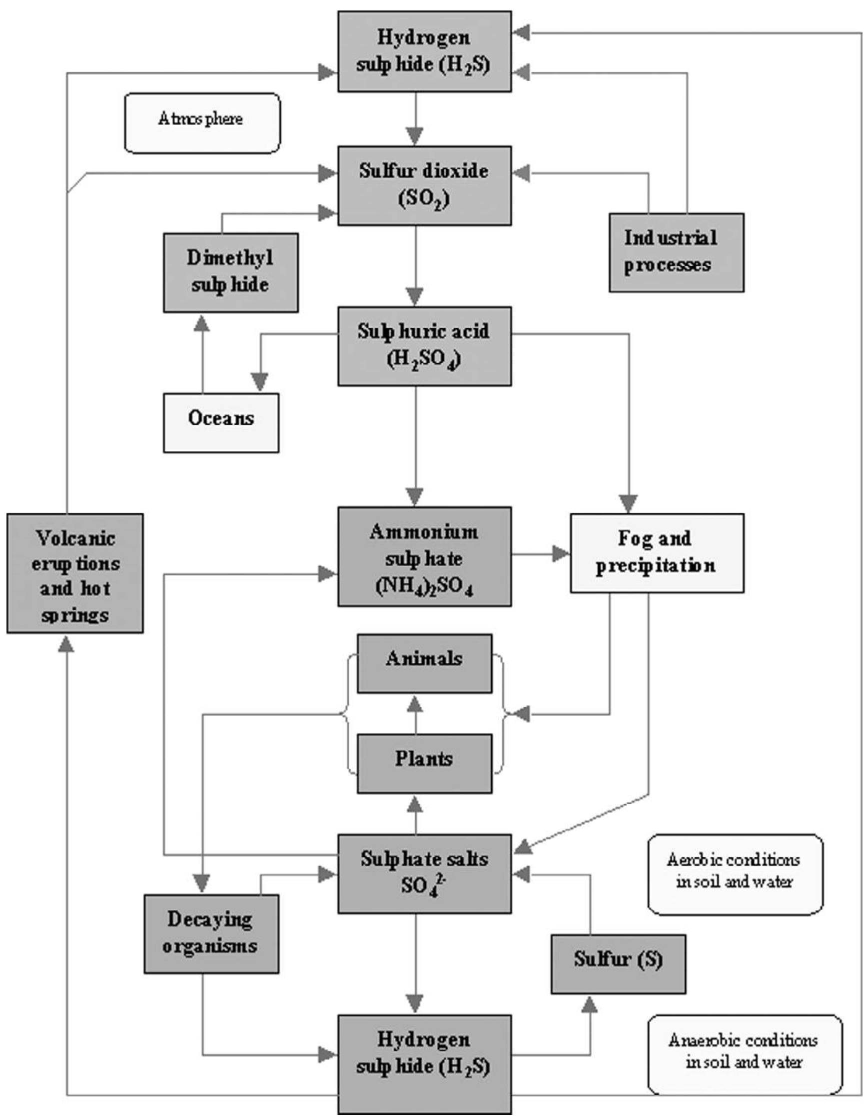
SULPHUR CYCLE

Sulphur is one of the components that make up proteins and vitamins. Proteins consist of amino acids that contain sulphur atoms. Sulphur is important for the functioning of proteins and enzymes in plants, and in animals that depend upon plants for sulphur. Plants absorb sulphur when it is dissolved in water. Animals consume these plants, so that they take up enough sulphur to maintain their health.

Most of the earth's sulphur is tied up in rocks and salts or buried deep in the ocean in oceanic sediments. Sulphur can also be found in the atmosphere. It enters the atmosphere through both natural and human sources. Natural recourses can be for instance volcanic eruptions, bacterial processes, evaporation from water, or decaying organisms. When sulphur enters the atmosphere through human activity, this is mainly a consequence of industrial processes where sulphur dioxide (SO2) and hydrogen sulphide (H2S) gases are emitted on a wide scale.

When sulphur dioxide enters the atmosphere it will react with oxygen to produce sulphur trioxide gas (SO3), or with other chemicals in the atmosphere, to produce sulphur salts. Sulphur dioxide may also react with water to produce sulphuric acid (H2SO4). Sulphuric acid may also be produced from demethylsulphide, which is emitted to the atmosphere by plankton species.

All these particles will settle back onto earth, or react with rain and fall back onto earth

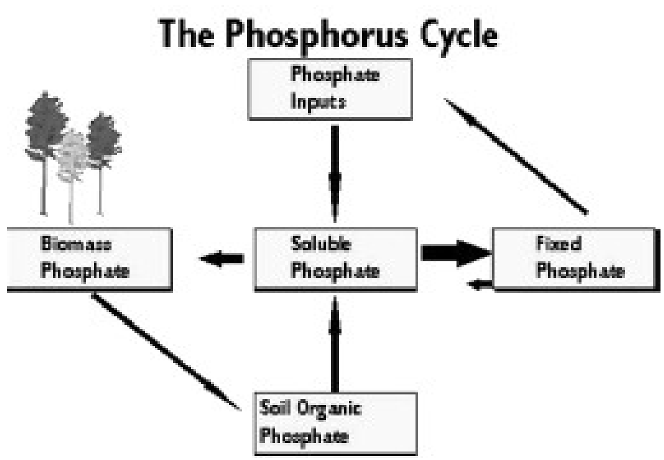


as acid deposition. The particles will than be absorbed by plants again and are released back into the atmosphere, so that the sulphur cycle will start over again.

PHOSPHORUS CYCLE

Phosphorus is an essential nutrient for plants and animals in the form of ions PO43- and HPO42-. It is a part of DNA-molecules, of molecules that store energy (ATP and ADP) and of fats of cell membranes. Phosphorus is also a building block of certain parts of the human and animal body, such as the bones and teeth.

Phosphorus can be found on earth in water, soil and sediments. Unlike the compounds of other matter cycles phosphorus cannot be found in air in the gaseous state. This is because phosphorus is usually liquid at normal temperatures and pressures. It is mainly cycling through water, soil and sediments. In the atmosphere phosphorus can mainly be found as very small dust particles.



Phosphorus moves slowly from deposits on land and in sediments, to living organisms, and than much more slowly back into the soil and water sediment. The phosphorus cycle is the slowest one of the matter cycles that are described here.

Phosphorus is most commonly found in rock formations and ocean sediments as phosphate salts. Phosphate salts that are released from rocks through weathering usually dissolve in soil water and will be absorbed by plants. Because the quantities of phosphorus in soil are generally small, it is often the limiting factor for plant growth. That is why humans often apply phosphate fertilizers on farmland. Phosphates are also limiting factors for plant-growth in marine ecosystems, because they are not very water-soluble. Animals absorb phosphates by eating plants or plant-eating animals.

Phosphorus cycles through plants and animals much faster than it does through rocks and sediments. When animals and plants die, phosphates will return to the soils or oceans again during decay. After that, phosphorus will end up in sediments or rock formations again, remaining there for millions of years. Eventually, phosphorus is released again through weathering and the cycle starts over.