Nitrogen cycle

The nitrogen cycle is the process by which [nitrogen](https://en.wikipedia.org/wiki/Nitrogen) is converted between its various chemical forms. This transformation can be carried out through both biological and physical processes. Important processes in the nitrogen cycle include [fixation](https://en.wikipedia.org/wiki/Nitrogen_fixation), [ammonification](https://en.wikipedia.org/wiki/Ammonification), [nitrification](https://en.wikipedia.org/wiki/Nitrification), and [denitrification](https://en.wikipedia.org/wiki/Denitrification). The majority of [Earth's atmosphere](https://en.wikipedia.org/wiki/Earth%27s_atmosphere) (78%) is [nitrogen](https://en.wikipedia.org/wiki/Nitrogen), making it the largest pool of nitrogen. However, atmospheric nitrogen has limited availability for biological use, leading to a scarcity of usable nitrogen in many types of ecosystems. The nitrogen cycle is of particular interest to [ecologists](https://en.wikipedia.org/wiki/Ecologist) because nitrogen availability can affect the rate of key ecosystem processes, including [primary production](https://en.wikipedia.org/wiki/Primary_production) and [decomposition](https://en.wikipedia.org/wiki/Decomposition). Human activities such as fossil fuel combustion, use of artificial nitrogen fertilizers, and release of nitrogen in wastewater have dramatically [altered the global nitrogen cycle](https://en.wikipedia.org/wiki/Human_impact_on_the_nitrogen_cycle). but this form is relatively nonreactive and unusable by plants. Chemical processing or natural

**Ecological function :** Nitrogen is necessary for all known forms of life on Earth. It is a component in all [amino acids](https://en.wikipedia.org/wiki/Amino_acids), as it is incorporated into [proteins](https://en.wikipedia.org/wiki/Proteins), and is present in the bases that make up [nucleic acids](https://en.wikipedia.org/wiki/Nucleic_acids) such as [RNA](https://en.wikipedia.org/wiki/RNA) and [DNA](https://en.wikipedia.org/wiki/DNA). Nitrogen gas (N2) is the largest constituent of the [Earth's atmosphere](https://en.wikipedia.org/wiki/Atmosphere_of_Earth)[fixation](https://en.wikipedia.org/wiki/Nitrogen_fixation) (through processes such as bacterial conversion—see [rhizobium](https://en.wikipedia.org/wiki/Rhizobium)) are necessary to convert gaseous nitrogen into compounds such as nitrate or ammonia which can be used by plants. The abundance or scarcity of this "fixed" nitrogen (also known as reactive nitrogen) frequently limits plant growth in both managed and wild environments. The nitrogen cycle, like the carbon cycle, is an important part of every ecosystem.

**The processes of the nitrogen cycle :** Nitrogen is present in the environment in a wide variety of chemical forms including organic nitrogen,[ammonium](https://en.wikipedia.org/wiki/Ammonium) (NH4+), [nitrite](https://en.wikipedia.org/wiki/Nitrite) (NO2−), [nitrate](https://en.wikipedia.org/wiki/Nitrate) (NO3−), [nitrous oxide](https://en.wikipedia.org/wiki/Nitrous_oxide) (N2O), [nitric oxide](https://en.wikipedia.org/wiki/Nitric_oxide) (NO) or inorganic nitrogen gas (N2). Organic nitrogen may be in the form of a living organism, [humus](https://en.wikipedia.org/wiki/Humus) or in the intermediate products of organic matter decomposition. The processes of the nitrogen cycle transform nitrogen from one form to another. Many of those processes are carried out by [microbes](https://en.wikipedia.org/wiki/Microbes), either in their effort to harvest energy or to accumulate nitrogen in a form needed for their growth.

**Nitrogen fixation ;** Atmospheric nitrogen must be processed, or ["fixed"](https://en.wikipedia.org/wiki/Nitrogen_fixation), in a usable form to be taken up by plants. Between 10x1012 and 5x1012 g are fixed by [lightning](https://en.wikipedia.org/wiki/Lightning) strikes, but most fixation is done by free-living or [symbiotic](https://en.wikipedia.org/wiki/Symbiosis) [bacteria](https://en.wikipedia.org/wiki/Bacterium) known as [diazotrophs](https://en.wikipedia.org/wiki/Diazotrophs" \o "Diazotrophs). These bacteria have the nitrogen  [enzyme](https://en.wikipedia.org/wiki/Enzyme" \o "Enzyme) that combines gaseous nitrogen with [hydrogen](https://en.wikipedia.org/wiki/Hydrogen) to produce [ammonia](https://en.wikipedia.org/wiki/Ammonia), which is converted by the bacteria into other [organic compounds](https://en.wikipedia.org/wiki/Organic_compound). Most biological nitrogen fixation occurs by the activity of Mo-nitrogen, found in a wide variety of bacteria and some [Archaea](https://en.wikipedia.org/wiki/Archaea" \o "Archaea). Mo-nitrogen is a complex two component [enzyme](https://en.wikipedia.org/wiki/Enzyme) that has multiple metal-containing prosthetic groups .An example of the free-living bacteria is *[Azotobacter](https://en.wikipedia.org/wiki/Azotobacter" \o "Azotobacter)*. Symbiotic nitrogen-fixing bacteria such as [*Rhizobium*](https://en.wikipedia.org/wiki/Rhizobium) usually live in the root nodules of [legumes](https://en.wikipedia.org/wiki/Legumes) (such as peas, alfalfa, and locust trees). Here they form a [mutualistic](https://en.wikipedia.org/wiki/Mutualism_(biology)) relationship with the plant, producing ammonia in exchange for [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate). Because of this relationship, legumes will often increase the nitrogen content of nitrogen-poor soils. A few non-legumes can also form such [symbioses](https://en.wikipedia.org/wiki/Symbiosis). Today, about 30% of the total fixed nitrogen is produced industrially using the [Haber-Bosch](https://en.wikipedia.org/wiki/Haber-Bosch) process ,which uses high temperatures and pressures to convert nitrogen gas and a hydrogen source (natural gas or petroleum) into ammonia.

**Assimilation :** Plants take nitrogen from the soil by absorption through their roots as amino acids, nitrate [ions](https://en.wikipedia.org/wiki/Ion), [nitrite](https://en.wikipedia.org/wiki/Nitrite) [ions](https://en.wikipedia.org/wiki/Ion), or [ammonium](https://en.wikipedia.org/wiki/Ammonium) [ions](https://en.wikipedia.org/wiki/Ion). Most nitrogen obtained by terrestrial animals can be traced back to the eating of plants at some stage of the [food chain](https://en.wikipedia.org/wiki/Food_chain). Plants can absorb nitrate or ammonium from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporation into amino acids, nucleic acids, and chlorophyll.[[3]](https://en.wikipedia.org/wiki/Nitrogen_cycle#cite_note-Smil-3) In plants that have a symbiotic relationship with rhizobia, some nitrogen is assimilated in the form of ammonium ions directly from the nodules. It is now known that there is a more complex cycling of amino acids between *Rhizobia* bacteroids and plants. The plant provides amino acids to the bacteroids so ammonia assimilation is not required and the bacteroides pass amino acids (with the newly fixed nitrogen) back to the plant, thus forming an interdependent relationship.[[8]](https://en.wikipedia.org/wiki/Nitrogen_cycle#cite_note-8) While many animals, fungi, and other [heterotrophic](https://en.wikipedia.org/wiki/Heterotrophic) organisms obtain nitrogen by ingestion of [amino acids](https://en.wikipedia.org/wiki/Amino_acid),[nucleotides](https://en.wikipedia.org/wiki/Nucleotide) and other small organic molecules, other heterotrophs (including many [bacteria](https://en.wikipedia.org/wiki/Bacteria)) are able to utilize inorganic compounds, such as ammonium as sole N sources. Utilization of various N sources is carefully regulated in all organisms.

**Ammonification :** When a plant or animal dies or an animal expels waste, the initial form of nitrogen is organic. Bacteria or fungi convert the organic nitrogen within the remains back into ammonium (NH4+), a process called ammonification or mineralization. The conversion of ammonia to nitrate is performed primarily by soil-living bacteria and other nitrifying bacteria. In the primary stage of nitrification, the oxidation of ammonium (NH4+) is performed by bacteria such as the Nitrosomonas species, which converts ammonia to nitrites (NO2−). Other bacterial species such as Nitro bacteria, are responsible for the oxidation of the nitrites into nitrates (NO3−).[3] It is important for the ammonia to be converted to nitrates or nitrites because ammonia gas is toxic to plants. Due to their very high solubility and because soils are largely unable to retain anions, nitrates can enter groundwater. Elevated nitrate in groundwater is a concern for drinking water use because nitrate can interfere with blood-oxygen levels in infants and cause methemoglobinemia or blue-baby syndrome.[9][10] Where groundwater recharges stream flow, nitrate-enriched groundwater can contribute to eutrophication, a process that leads to high algal population and growth, especially blue-green algal populations. While not directly toxic to fish life, like ammonia, nitrate can have indirect effects on fish if it contributes to this eutrophication. Nitrogen has contributed to severe eutrophication problems in some water bodies. Since 2006, the application of nitrogen fertilizer has been increasingly controlled in Britain and the United States. This is occurring along the same lines as control of phosphorus fertilizer, restriction of which is normally considered essential to the recovery of eutrophied water bodies.

**Denitrification :** Denitrification is the reduction of nitrates back into the largely inert nitrogen gas (N2), completing the nitrogen cycle. This process is performed by bacterial species such as [*Pseudomonas*](https://en.wikipedia.org/wiki/Pseudomonas) and [*Clostridium*](https://en.wikipedia.org/wiki/Clostridium) in anaerobic conditions.[[3]](https://en.wikipedia.org/wiki/Nitrogen_cycle#cite_note-Smil-3) They use the nitrate as an electron acceptor in the place of oxygen during respiration. These facultatively anaerobic bacteria can also live in aerobic conditions. Denitrification happens in anaerobic conditions e.g. waterlogged soils. The denitrifying bacteria use nitrates in the soil to carry out respiration and consequently produce nitrogen gas, which is inert and unavailable to plants.

**New vs. regenerated nitrogen :** Nitrogen entering the euphotic zone is referred to as new nitrogen because it is newly arrived from outside the productive layer. The new nitrogen can come from below the euphotic zone or from outside sources. Outside sources are upwelling from deep water and nitrogen fixation. If the organic matter is eaten, respired, delivered to the water as ammonia, and re-incorporated into organic matter by phytoplankton it is considered recycled/regenerated production.  
New production is an important component of the marine environment. One reason is that only continual input of new nitrogen can determine the total capacity of the ocean to produce a sustainable fish harvest. Harvesting fish from regenerated nitrogen areas will lead to a decrease in nitrogen and therefore a decrease in primary production. This will have a negative effect on the system. However, if fish are harvested from areas of new nitrogen the nitrogen will be replenished.

**Human influences on the nitrogen cycle :**As a result of extensive cultivation of legumes (particularly [soy](https://en.wikipedia.org/wiki/Soy), [alfalfa](https://en.wikipedia.org/wiki/Alfalfa), and [clover](https://en.wikipedia.org/wiki/Clover)), growing use of the [Haber–Bosch process](https://en.wikipedia.org/wiki/Haber%E2%80%93Bosch_process) in the creation of chemical fertilizers, and pollution emitted by vehicles and industrial plants, human beings have more than doubled the annual transfer of nitrogen into biologically available forms. In addition, humans have significantly contributed to the transfer of nitrogen trace gases from Earth to the atmosphere and from the land to aquatic systems. Human alterations to the global nitrogen cycle are most intense in developed countries and in Asia, where vehicle emissions and [industrial agriculture](https://en.wikipedia.org/wiki/Industrial_agriculture) are highest.

[Nitrous oxide](https://en.wikipedia.org/wiki/Nitrous_oxide) (N2O) has risen in the atmosphere as a result of agricultural fertilization, biomass burning, cattle and feedlots, and industrial sources. N2O has deleterious effects in the [stratosphere](https://en.wikipedia.org/wiki/Stratosphere), where it breaks down and acts as a [catalyst](https://en.wikipedia.org/wiki/Catalyst) in the destruction of atmospheric [ozone](https://en.wikipedia.org/wiki/Ozone). Nitrous oxide is also a [greenhouse gas](https://en.wikipedia.org/wiki/Greenhouse_gas)and is currently the third largest contributor to [global warming](https://en.wikipedia.org/wiki/Global_warming), after [carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide) and [methane](https://en.wikipedia.org/wiki/Methane). While not as abundant in the atmosphere as carbon dioxide, it is, for an equivalent mass, nearly 300 times more potent in its ability to warm the planet.

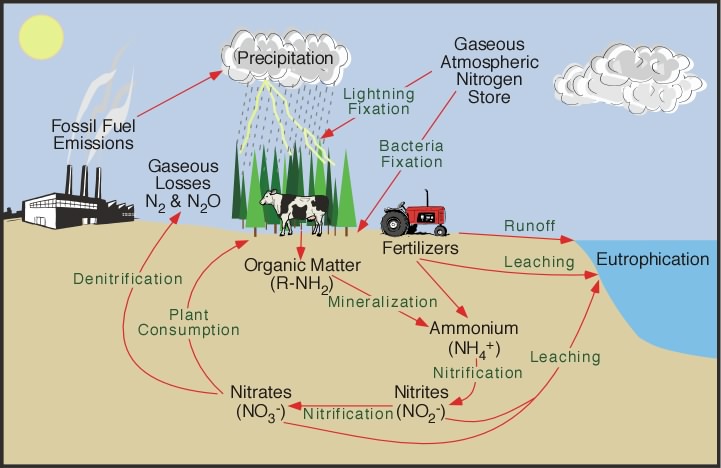
[Ammonia](https://en.wikipedia.org/wiki/Ammonia) (NH3) in the atmosphere has tripled as the result of human activities. It is a reactant in the atmosphere, where it acts as an [aerosol](https://en.wikipedia.org/wiki/Aerosol), decreasing air quality and clinging to water droplets, eventually resulting in [nitric acid](https://en.wikipedia.org/wiki/Nitric_acid) ([H](https://en.wikipedia.org/wiki/Hydrogen)[NO3](https://en.wikipedia.org/wiki/Nitrate)) that produces [acid rain](https://en.wikipedia.org/wiki/Acid_rain). Atmospheric ammonia and nitric acid also damage respiratory systems.

The very-high temperature of lightning naturally produces small amounts of NOx, NH3, and HNO3, but high-temperature [combustion](https://en.wikipedia.org/wiki/Combustion) has contributed to a 6 or 7 fold increase in the flux of NOx to the atmosphere. Its production is a function of combustion temperature - the higher the temperature, the more NOx is produced. [Fossil fuel](https://en.wikipedia.org/wiki/Fossil_fuel) combustion is a primary contributor, but so are biofuels and even the burning of hydrogen. The higher combustion temperature of hydrogen produces more NOxthan natural gas combustion.

Ammonia and nitrous oxides actively alter [atmospheric chemistry](https://en.wikipedia.org/wiki/Atmospheric_chemistry). They are precursors of [tropospheric](https://en.wikipedia.org/wiki/Troposphere) (lower atmosphere) ozone production, which contributes to[smog](https://en.wikipedia.org/wiki/Smog) and [acid rain](https://en.wikipedia.org/wiki/Acid_rain), damages [plants](https://en.wikipedia.org/wiki/Plant) and increases nitrogen inputs to ecosystems. [Ecosystem](https://en.wikipedia.org/wiki/Ecosystem) processes can increase with [nitrogen fertilization](https://en.wikipedia.org/wiki/Nitrogen_fertilization), but[anthropogenic](https://en.wikipedia.org/wiki/Human_impact_on_the_environment) input can also result in nitrogen saturation, which weakens productivity and can damage the health of plants, animals, fish, and humans.

Decreases in [biodiversity](https://en.wikipedia.org/wiki/Biodiversity) can also result if higher nitrogen availability increases nitrogen-demanding grasses, causing a degradation of nitrogen-poor, species diverse [heathlands](https://en.wikipedia.org/wiki/Heath_(habitat)).

**Environmental impacts :** Additional risks posed by increased availability of inorganic nitrogen in aquatic ecosystems include water acidification; [eutrophication](https://en.wikipedia.org/wiki/Eutrophication) of fresh and saltwater systems; and toxicity issues for animals, including humans. Eutrophication often leads to lower dissolved oxygen levels in the water column, including hypoxic and anoxic conditions, which can cause death of aquatic fauna. Relatively sessile benthos, or bottom-dwelling creatures, are particularly vulnerable because of their lack of mobility, though large fish kills are not uncommon. Oceanic [dead zones](https://en.wikipedia.org/wiki/Dead_zone_(ecology)) near the mouth of the Mississippi in the Gulf of Mexico are a well-known example of algal bloom-induced [hypoxia](https://en.wikipedia.org/wiki/Hypoxia_(environmental)). The New York Adirondack Lakes, [Catskills](https://en.wikipedia.org/wiki/Catskills), Hudson Highlands, Rensselaer Plateau and parts of Long Island display the impact of nitric acid rain deposition, resulting in the killing of fish and many other aquatic species. Ammonia (NH3) is highly toxic to fish and the level of ammonia discharged from wastewater treatment facilities must be closely monitored. To prevent fish deaths, nitrification via [aeration](https://en.wikipedia.org/wiki/Aeration) prior to discharge is often desirable. Land application can be an attractive alternative to the aeration.



**The Oxygen Cycle**Almost all living things need oxygen.  They use this oxygen during the process of creating energy in living cells.

Just as water moves from the sky to the earth and back in the hydrologic cycle, oxygen is also cycled through the environment.  Plants mark the beginning of the oxygen cycle.  Plants are able to use the energy of sunlight to convert carbon dioxide and water into carbohydrates and oxygen in a process called photosynthesis.   
 **http://water.me.vccs.edu/concepts/oxycle_eq.gif**

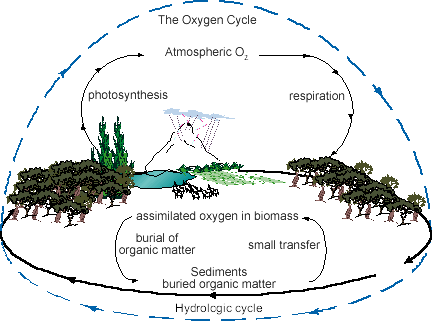
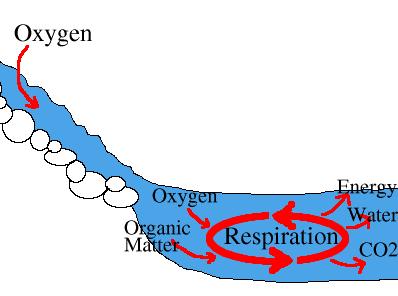
This means that plants "breathe" in carbon dioxide and "breathe" out oxygen.     
  
Animals form the other half of the oxygen cycle.  We breathe in oxygen which we use to break carbohydrates down into energy in a process called respiration.

http://water.me.vccs.edu/concepts/oxycle_eq2.gif

Carbon dioxide produced during respiration is breathed out by animals into the air.     
  
So oxygen is created in plants and used up by animals, as is shown in the picture above.  But the oxygen cycle is not actually quite that simple.  Plants must break carbohydrates down into energy just as animals do.  During the day, plants hold onto a bit of the oxygen which they produced in photosynthesis and use that oxygen to break down carbohydrates.  But in order to maintain their metabolism and continue respiration at night, the plants must absorb oxygen from the air and give off carbon dioxide just as animals do.  Even though plants produce approximately ten times as much oxygen during the day as they consume at night, the night-time consumption of oxygen by plants can create low oxygen conditions in some water habitats.

**Oxygen in Water :** Oxygen in water is known as dissolved oxygenor DO.  In nature, oxygen enters water when water runs over rocks and creates tremendous amounts of surface area.  The high surface area allows oxygen to transfer from the air into the water very quickly. When the water in a stream enters a pond, microorganisms in the pond begin to metabolize (break down) organic matter, consuming oxygen in the process.  This is another form of oxygen cycle - oxygen enters water in rapids and leaves water in pools.

Oxygen uptake rate (O.U.R.) is the rate at which oxygen is consumed by living organisms in the water.  Since organisms are constantly using up oxygen in the water and oxygen is constantly reentering the water from the air, the amount of oxygen in water remains relatively constant.  In a healthy ecosystem, the rates of oxygen transfer (being used up) and oxygen uptake are balanced in the water.



# Carbon cycle

The carbon cycle is the [biogeochemical cycle](https://en.wikipedia.org/wiki/Biogeochemical_cycle) by which [carbon](https://en.wikipedia.org/wiki/Carbon) is exchanged among the [biosphere](https://en.wikipedia.org/wiki/Biosphere), [pedosphere](https://en.wikipedia.org/wiki/Pedosphere), [geosphere](https://en.wikipedia.org/wiki/Geosphere), [hydrosphere](https://en.wikipedia.org/wiki/Hydrosphere), and [atmosphere](https://en.wikipedia.org/wiki/Earth%27s_atmosphere) of the Earth. Along with the [nitrogen cycle](https://en.wikipedia.org/wiki/Nitrogen_cycle) and the [water cycle](https://en.wikipedia.org/wiki/Water_cycle), the carbon cycle comprises a sequence of events that are key to making the Earth capable of sustaining life; it describes the movement of carbon as it is recycled and reused throughout the[biosphere](https://en.wikipedia.org/wiki/Biosphere), including [carbon sinks](https://en.wikipedia.org/wiki/Carbon_sinks).

The *global carbon budget* is the balance of the exchanges (incomes and losses) of carbon between the carbon reservoirs or between one specific loop (e.g., atmosphere <-> biosphere) of the carbon cycle. An examination of the carbon budget of a pool or reservoir can provide information about whether the pool or reservoir is functioning as a source or sink for carbon dioxide. The carbon cycle was initially discovered by[Joseph Priestley](https://en.wikipedia.org/wiki/Joseph_Priestley) and [Antoine Lavoisier](https://en.wikipedia.org/wiki/Antoine_Lavoisier), and popularized by [Humphry Davy](https://en.wikipedia.org/wiki/Humphry_Davy" \o "Humphry Davy).

**Global climate :** Carbon-based molecules are crucial for life on Earth, because it is the main component of biological compounds. Carbon is also a major component of many minerals. Carbon also exists in various forms in the atmosphere. [Carbon dioxide](https://en.wikipedia.org/wiki/Carbon_dioxide) (CO2) is partly responsible for the [greenhouse effect](https://en.wikipedia.org/wiki/Greenhouse_effect) and is the most important human-contributed [greenhouse gas](https://en.wikipedia.org/wiki/Greenhouse_gas).[[2]](https://en.wikipedia.org/wiki/Carbon_cycle#cite_note-GlobalCarbonCycle-2)

In the past two centuries, human activities have seriously altered the global carbon cycle, most significantly in the atmosphere. Although carbon dioxide levels have changed naturally over the past several thousand years, human emissions of carbon dioxide into the atmosphere exceed natural fluctuations.[[2]](https://en.wikipedia.org/wiki/Carbon_cycle#cite_note-GlobalCarbonCycle-2) Changes in the amount of atmospheric CO2 are considerably altering weather patterns and indirectly influencing oceanic chemistry.. Current carbon dioxide levels in the atmosphere exceed measurements from the last 420,000 years and levels are rising faster than ever recorded,[[3]](https://en.wikipedia.org/wiki/Carbon_cycle#cite_note-Crowley2000-3) making it of critical importance to better understand how the carbon cycle works and what its effects are on the global climate.

# Main components :

|  |  |
| --- | --- |
| **Carbon pools in the major reservoirs on earth.**[[2]](https://en.wikipedia.org/wiki/Carbon_cycle#cite_note-GlobalCarbonCycle-2) | |
| **Pool** | **Quantity (gigatons)** |
| Atmosphere | 720 |
| Oceans (total) | 38,400 |
| Total inorganic | *37,400* |
| Total organic | 1,000 |
| Surface layer | 670 |
| Deep layer | 36,730 |
| [Lithosphere](https://en.wikipedia.org/wiki/Lithosphere) |  |
| Sedimentary carbonates | > 60,000,000 |
| [Kerogens](https://en.wikipedia.org/wiki/Kerogen) | 15,000,000 |
| Terrestrial biosphere (total) | 2,000 |
| Living biomass | 600 - 1,000 |
| Dead biomass | 1,200 |
| Aquatic biosphere | 1 - 2 |
| Fossil fuels (total) | 4,130 |
| Coal | 3,510 |
| Oil | 230 |
| Gas | 140 |
| Other ([peat](https://en.wikipedia.org/wiki/Peat)) | 250 |

The global carbon cycle is now usually divided into the following major reservoirs of carbon interconnected by pathways of exchange:

* The [atmosphere](https://en.wikipedia.org/wiki/Atmosphere)
* The terrestrial [biosphere](https://en.wikipedia.org/wiki/Biosphere)
* The [oceans](https://en.wikipedia.org/wiki/Ocean), including [dissolved inorganic carbon](https://en.wikipedia.org/wiki/Total_inorganic_carbon) and living and non-living marine biota
* The [sediments](https://en.wikipedia.org/wiki/Sediment), including [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuel), fresh water systems and non-living organic material.
* The Earth's interior, carbon from the Earth's [mantle](https://en.wikipedia.org/wiki/Mantle_(geology)) and [crust](https://en.wikipedia.org/wiki/Crust_(geology)). These carbon stores interact with the other components through geological processes

The carbon exchanges between reservoirs occur as the result of various chemical, physical, geological, and biological processes. The ocean contains the largest active pool of carbon near the surface of the Earth. The natural flows of carbon between the atmosphere, ocean, terrestrial ecosystems, and sediments is fairly balanced, so that carbon levels would be roughly stable without human influence.

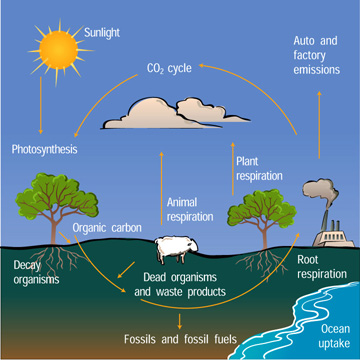
**Geological carbon cycle :** The geologic component of the carbon cycle operates slowly in comparison to the other parts of the global carbon cycle. It is one of the most important determinants of the amount of carbon in the atmosphere, and thus of global temperatures.

Most of the earth's carbon is stored inertly in the earth's [lithosphere](https://en.wikipedia.org/wiki/Lithosphere).Much of the carbon stored in the earth's mantle was stored there when the earth formed.Some of it was deposited in the form of organic carbon from the biosphere. Of the carbon stored in the geosphere, about 80% is [limestone](https://en.wikipedia.org/wiki/Limestone) and its derivatives, which form from the sedimentation of [calcium carbonate](https://en.wikipedia.org/wiki/Calcium_carbonate) stored in the shells of marine organisms. The remaining 20% is stored as [kerogens](https://en.wikipedia.org/wiki/Kerogen" \o "Kerogen) formed through the sedimentation and burial of terrestrial organisms under high heat and pressure. Organic carbon stored in the geosphere can remain there for millions of years.

Carbon can leave the geosphere in several ways. Carbon dioxide is released during the [metamorphosis](https://en.wikipedia.org/wiki/Metamorphism_(geology)) of carbonate rocks when they are [subducted](https://en.wikipedia.org/wiki/Subduction" \o "Subduction) into the earth's mantle. This carbon dioxide can be released into the atmosphere and ocean through [volcanoes](https://en.wikipedia.org/wiki/Volcanism) and [hotspots](https://en.wikipedia.org/wiki/Hotspot_(geology)). It can also be removed by humans through the direct extraction of kerogens in the form of [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuels). After extraction, fossil fuels are burned to release energy, thus emitting the carbon they store into the atmosphere.

**Human influence :** The largest and most direct human influence on the carbon cycle is through direct emissions from burning [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuels), which transfers carbon from the geosphere into the atmosphere. Humans also influence the carbon cycle indirectly by changing the terrestrial and oceanic biosphere. Other human-caused changes to the environment change ecosystems' productivity and their ability to remove carbon from the atmosphere. [Air pollution](https://en.wikipedia.org/wiki/Air_pollution), for example, damages plants and soils, while many agricultural and land use practices lead to higher [erosion](https://en.wikipedia.org/wiki/Erosion) rates, washing carbon out of soils and decreasing plant productivity.

Humans also affect the oceanic carbon cycle. Current trends in climate change lead to higher ocean temperatures, thus modifying ecosystems. Also, acid rain and polluted runoff from agriculture and industry change the ocean's chemical composition. Such changes can have dramatic effects on highly sensitive ecosystems such as [coral reefs](https://en.wikipedia.org/wiki/Coral_reef), thus limiting the ocean's ability to absorb carbon from the atmosphere on a regional scale and reducing oceanic biodiversity globally.



# The phosphorus cycle

[Phosphorus](http://sciencelearn.org.nz/About-this-site/Glossary/phosphorus) is a chemical [element](http://sciencelearn.org.nz/About-this-site/Glossary/element) found on Earth in numerous [compound](http://sciencelearn.org.nz/About-this-site/Glossary/compound) forms, such as the phosphate [ion](http://sciencelearn.org.nz/About-this-site/Glossary/ion) (PO43-), located in water, soil and [sediments](http://sciencelearn.org.nz/About-this-site/Glossary/sediments).  The quantities of phosphorus in soil are generally small, and this often limits plant growth. That is why people often apply phosphate [fertilisers](http://sciencelearn.org.nz/About-this-site/Glossary/fertiliser" \o "Compounds that are given to plants to promote growth.) on farmland. Animals absorb phosphates by eating plants or plant-eating animals.

### The role of phosphorus in animals and plants

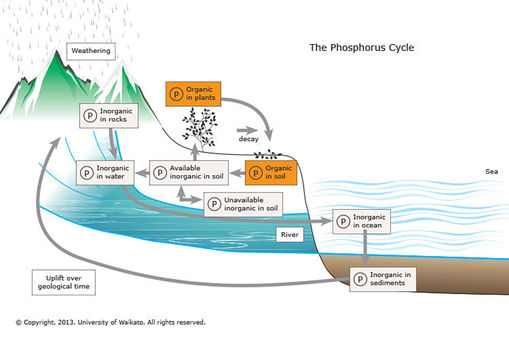
Phosphorus is an essential [nutrient](http://sciencelearn.org.nz/About-this-site/Glossary/nutrient) for animals and plants. It plays a critical role in [cell](http://sciencelearn.org.nz/About-this-site/Glossary/cell" \o "1. Building block of the body. A human is made of millions of cells, which are adapted for different functions and can reproduce themselves exactly. 2. A simple electrolytic device that enables chemical energy to be transformed into electrical energy.)development and is a key component of molecules that store energy, such as [ATP](http://sciencelearn.org.nz/About-this-site/Glossary/adenosine-triphosphate-ATP) (adenosine triphosphate), [DNA](http://sciencelearn.org.nz/About-this-site/Glossary/DNA) and lipids (fats and oils). Insufficient phosphorus in the soil can result in a decreased [crop](http://sciencelearn.org.nz/About-this-site/Glossary/crop) yield.

### The phosphorus cycle

Phosphorus moves in a cycle through rocks, water, soil and sediments and organisms.

Here are the key steps of the [phosphorus cycle](http://sciencelearn.org.nz/About-this-site/Glossary/phosphorus-cycle):

* Over time, rain and [weathering](http://sciencelearn.org.nz/About-this-site/Glossary/weathering) cause rocks to release phosphate ions and other minerals. This [inorganic](http://sciencelearn.org.nz/About-this-site/Glossary/inorganic) phosphate is then distributed in soils and water.
* Plants take up inorganic phosphate from the soil. The plants may then be consumed by animals. Once in the plant or animal, the phosphate is incorporated into [organic](http://sciencelearn.org.nz/About-this-site/Glossary/organic) molecules such as DNA. When the plant or animal dies, it decays, and the organic phosphate is returned to the soil.
* Within the soil, organic forms of phosphate can be made available to plants by [bacteria](http://sciencelearn.org.nz/About-this-site/Glossary/bacteria) that break down organic [matter](http://sciencelearn.org.nz/About-this-site/Glossary/matter) to inorganic forms of phosphorus. This process is known as [mineralisation](http://sciencelearn.org.nz/About-this-site/Glossary/phosphorus-mineralisation).
* Phosphorus in soil can end up in waterways and eventually oceans. Once there, it can be incorporated into sediments over time.

[](http://sciencelearn.org.nz/Contexts/Soil-Farming-and-Science/Sci-Media/Images/The-phosphorus-cycle)

### Most phosphorus is unavailable to plants

Since most of our phosphorus is locked up in sediments and rocks, it’s not available for plants to use. A lot of the phosphorus in soils is also unavailable to plants.

Soil phosphorus becomes unavailable to plants through several routes:

* **Bacteria**: Bacteria convert plant-available phosphate into organic forms that are then not available to plants. Although other bacteria make phosphate available by mineralization, the contribution of this is small.
* [**Adsorption**](http://sciencelearn.org.nz/About-this-site/Glossary/adsorption): Inorganic (and available) phosphorus can be chemically bound (adsorbed) to soil particles, making it unavailable to plants. [Desorption](http://sciencelearn.org.nz/About-this-site/Glossary/desorption) is the release of adsorbed phosphorus from its bound state into soil solution.
* [**pH**](http://sciencelearn.org.nz/About-this-site/Glossary/pH): Inorganic phosphorus compounds need to be soluble to be taken up by plants. This depends on the acidity (pH) of the soil. If soils are less than pH 4 or greater than pH 8, the phosphorus starts to become tied up with other compounds, making it less available to plants.
* Many plant crops need more phosphorus than is dissolved in the soil to grow optimally. In addition, crops are usually harvested and removed – leaving no decaying [vegetation](http://sciencelearn.org.nz/About-this-site/Glossary/vegetation) to replace phosphorus. Therefore, farmers replenish the phosphorus ‘pool’ by adding fertilizers or [effluent](http://sciencelearn.org.nz/About-this-site/Glossary/effluent) to replace the phosphorus taken up by plants.

### Phosphate fertilizers replenish soil phosphorus

Many farmers replenish phosphorus through the use of phosphate fertilizers. The phosphorus is obtained by mining deposits of rock phosphate. Locally produced sulfuric acid is used to convert the insoluble rock phosphate into a more soluble and usable form – a fertilizer product called [superphosphate](http://sciencelearn.org.nz/About-this-site/Glossary/superphosphate).

In New Zealand, superphosphate is made using rock imported mainly from Morocco.

Adjusting the pH of the soil for efficient plant uptake of phosphate should be done prior to [fertilization](http://sciencelearn.org.nz/About-this-site/Glossary/fertilisation). For example, adding [lime](http://sciencelearn.org.nz/About-this-site/Glossary/lime) reduces soil acidity, which provides an environment where phosphate becomes more available to plants.

### Water pollution by fertilizers

When fields are over fertilized (through commercial fertilizers or manure), phosphate not utilized by plants can be lost from the soil through [leaching](http://sciencelearn.org.nz/About-this-site/Glossary/leaching) and water [run-off](http://sciencelearn.org.nz/About-this-site/Glossary/run-off). This phosphate ends up in waterways, lakes and [estuaries](http://sciencelearn.org.nz/About-this-site/Glossary/estuary). Excess phosphate causes excessive growth of plants in waterways, lakes and estuaries leading to [eutrophication](http://sciencelearn.org.nz/About-this-site/Glossary/eutrophication).

Steps are being taken in agriculture to reduce phosphate losses in order to maximize the efficiency of fertilizer and effluent applications.