The series of processes by which nitrogen and its differentforms are circulated and interconverted in nature with the help of livingorganisms is called the nitrogen cycle. It shows the path that nitrogen followsthrough the biogeochemical cycle using its storage reservoirs, such as theatmosphere, living organisms, and soil. Nitrogen Cycle Diagram The entire process of the Nitrogen Cycle, one of the importantbiogeochemical cycle takes place in five stages: 1) Nitrogen Fixation by Bacteria Convertinginert atmospheric nitrogen (N2)into biologicallyavailable forms such as ammonia (NH3), nitrates, or nitrites 2) Nitrification by Bacteria Converting ammoniato nitrite and then to nitrate 3) Assimilation by Plants Absorbingnitrogen from the soil and incorporating them in the plant and animal bodies 4) Ammonification by Decomposers Converting the deadorganicnitrogen of plants or animals back into ammonia 5) Denitrification by Denitrifiers Reducingnitratesor nitrites and releasing gaseous nitrogen Whatrole do bacteria play in the nitrogen cycle? Nitrogen fixation Performed by two different groups of bacteria a) symbioticnitrogen fixers like Rhizobium, which keep a close association with the hostleguminous plant, andb) free-living,non-symbiotic bacteria like Azotobacter. Both these group of bacteria use specific enzymes to completethe biological nitrogen fixation process by the following reaction N2+ 8 H++ 8 e 2 NH3+H2 Nitrification Performed by nitrifying bacteria in two steps i) Ammonia-oxidizing bacteria such as Nitrosomonas species perform oxidationof ammonia to nitrite by the following reaction 2NH4++ 3O2+ 8 e2 NO2+ 4H2 + 2H2O ii) Nitrite-oxidizing bacteria such as Nitrobacter species perform oxidationof nitrite (NO2) to nitrate (NO3)by the following reaction 2 NO3+ O2 2 NO3 Plants help in the assimilation of nitrogen when they absorb it from the soil in the form of ammonia, nitrite ions, nitrate ions or ammonium ionsto form plant and animal proteins. In leguminous plants such as pea and bean, the symbiotic association with Rhizobium helps to assimilate nitrogen directly in the form of ammonium ions. Detritus feeders or decomposers such as fungi and bacteria present in the soil convert the dead organicmatter of plants or animals back into ammonia (NH3) or ammonium ions (NH4+). Denitrifiers such as Clostridium and Pseudomonas helps in the reduction ofnitrates (NO3)or nitrites (NO2),resulting in the escape of gaseous nitrogen which again returns to the cycle. Lightning with thunderstorm serves as an important source of fixing nitrogen in the atmosphere apart from bacteria mediated nitrogen fixation. Here the energy of lightning breaks atmospheric nitrogen into nitrogen oxideswhich can then be utilized by plants for assimilation. Allowing plants and animals to use nitrogen by converting atmospheric nitrogen to a more chemically available form such as ammonium (NH4+), nitrate (NO3), ororganic nitrogen Enriching the soil through the formation of Nitrates and nitrites which are essential for the cultivationHelping in the synthesis of some biomolecules such as amino acids, nucleic acids, and chlorophyll, the building blocks of lifeDecomposing dead plant and animal matter by decomposers which cleans up the environment Humanactivities release excess nitrogen into the environment, eventually disturbingthe balance of nitrogen in its different reservoirs in two possible ways: Burning of Fossil FuelsUse of Nitrogen-Containing Fertilizers Burning fossil fuels like coal, petroleum, and natural gas releases excess nitrogen into the environment that accumulates over time. An increase in the concentration of nitrogen is found to affect the climate of the earth by gradually increasing its temperature, causing greenhouse effect and global warming. When artificial fertilizers containing nitrogen as one of the components are washed away from the agricultural fields, it contaminates the nearby water bodies and also the groundwater making it more difficult for the plants to absorb thenitrogen both for the terrestrial and aquatic plants. Since nitrogen fixation by plants is affected, it affects the nitrogen cycle. Article was last reviewed on Tuesday, February 25, 2020 The nitrogen cycle is the system by which nitrogen is converted into different chemical forms, some usable to humans and animals and some not, as it circulates among the atmosphere, the land and the oceans. Encyclopaedia Britannica/Getty Images/HowStuffWorks Living things require nitrogen for their cells to function and, furthermore, we are virtually steeping in the stuff since our atmosphere is made up of 78 percent nitrogen gas. Although nitrogen's lurking basically everywhere, it's not abundant in the Earth's crust, and it's difficult for living things to capture atmospheric nitrogen and use it for their purposes. The nitrogen cycle steps are kind of like a currency exchange, converting nitrogen into different forms, some of which plants and animals can use, and some of which they cant. "Nitrogen is a major part of amino acids, which are the building blocks of proteins and nucleic acids such as DNA," says Jessie Motes, a Ph.D. candidate in the Odum School of Ecology at the University of Georgia, in an email. "In addition to needing nitrogen for proteins in plants, it is a main component of chlorophyll, which makes it crucial for photosynthesis." Since nitrogen is a limited resource on this planet, a nitrogen atom doesn't spend much time doing nothing when it's in a form living things can use scientists call this nitrogen "fixed." Fixed nitrogen is taken up by plants, which are eaten by animals, which eat other animals, which die and decompose and release nitrogen back into the ecosystem to be worked on by bacteria or plants. This is the cycle of a nitrogen atom on Earth, and its journey starts either very quietly or with a humongous bang. Believe it or not, lightning and bacteria are primarily responsible for turning atmospheric nitrogen into nitrogen living things can use, in a process called nitrogen fixation. Atmospheric nitrogen (N2) is very stable, so it takes an incredible amount of energy to convert it to a different form. Lightning Strikes If you've ever wondered why your outdoor plants seem happier after a rain than they do when you turn a sprinkler on them, there's a reason for that: Lightning electrifies atmospheric nitrogen (N2) and water (H2O) to reconfigure them into ammonia (NH3) and nitrates (NO3). This falls to the ground as rain, where plants slurp it up and use it for their biological processes. Nitrogen-fixing Bacteria On the other end of the spectrum, the most common way nitrogen is made available to organisms is when atmospheric nitrogen is fixed by bacteria, some of which live free in the soil and others of which enjoy a symbiotic relationship with certain plant species. Legumes like peas, clover and peanuts have little nodules on their roots that attract bacteria that convert stubborn atmospheric nitrogen into ammonia or ammonium, which can then be used to power the plant. This process is known as biological nitrogen fixation, and it turns organic nitrogen gas into inorganic nitrogen compounds like ammonia and ammonium. Ammonia in the soil can be used directly by plants, but it's also the first step in the process of nitrification, through which specialized bacteria and archaea convert ammonia into nitrite (NO2), and then pass it off to an entirely different set of prokaryotes that further oxidize the nitrite into nitrate (NO3-). This process is slow, but it's the way that nitrogen is built as a nutrient in soil and aquatic and marine environments terrestrial plants, for instance, can absorb ammonium and nitrate through their root hairs. The organisms that specialize in nitrification are also important in treating municipal wastewater. Everything living eventually dies, and the nitrogen a particular organism was using when it croaked is taken to hand by bacteria that turn the nitrogen-rich corpse into ammonium, which can be picked back up by plants and used again. It's possible to convert bioavailable nitrogen into atmospheric nitrogen again, and that process is called denitrification. Nitrification is performed by bacteria and archaea that can tolerate oxygen not all prokaryotes can. In the case of denitrification, certain anaerobic bacteria that don't need oxygen convert nitrate to nitrogen gas, which floats up into the atmosphere and plays hard-to-get until some lightning or a crafty nitrogen-fixing bacterium comes along and ropes the gaseous nitrogen into the nitrogen cycle yet again. "Like most natural processes, anthropogenic activities are disrupting the nitrogen cycle through nitrogen deposition," says Motes. "Too much nitrogen can lead to increased emissions of the greenhouse gas nitrous oxide, as well as eutrophication, which is nitrogen pollution of water sources." Some of the human activities contributing to nitrogen deposition include: Burning fossil fuelsUsing synthetic fertilizers, which results in nitrogen-rich agricultural runoff entering aquatic systemsCultivating legumes, which fix nitrogen The nitrogen cycle is a biogeochemical process where nitrogen is converted into various chemical forms as it circulates through the atmosphere, land, and marine ecosystems.Despite nitrogen making up about 78% of Earths atmosphere, most of it is not easily accessible for biological use, causing a shortage of usable nitrogen in many ecosystems.In the environment, nitrogen appears in several chemical forms, including organic nitrogen, ammonium (NH4+), nitrite (NO2), nitrate (NO3), nitrous oxide (N2O), nitric oxide (NO), and inorganic nitrogen gas (N2).Organic nitrogen is present in living organisms, humus, or as intermediate products of organic matter decomposition. The nitrogen cycle involves the transformation of nitrogen from one form to another, a process largely driven by microbes either for energy production or nitrogen storage for growth.Nitrogen conversion occurs through both biological and physical processes. Key steps involve during nitrogen cycle are;Nitrogen FixationNitrogen AssimilationAmmonificationNitrificationDenitrificationFig: Flowchart showing steps in Nitrogen CycleThe transformation of N2 into nitrogen that can be used biologically is known as nitrogen fixation. N2 gas is highly stable because of the strong triple bond between its nitrogen atoms, and breaking this bond demands a significant amount of energy which at least sixteen ATP molecules.As a result, only a select group of prokaryotes are able to carry out this energetically demanding process.Most of the nitrogen fixation during the cycle, is carried out by prokaryotes, whereas some nitrogen can also be fixed physically by lightning or by certain industrial processes.Nitrogen can be fixed by lightning, which converts nitrogen and oxygen in the atmosphere into nitrogen oxides. These oxides may react with water or rain to form nitrous acid or nitric acid, which then seeps into the soil, creating nitrates that plants can utilize.Nitrogen in the atmosphere is highly stable and unreactive due to the strong triple bond between atoms in the N2 molecule. However, lightning generates enough energy and heat to break this bond, allowing nitrogen atoms to react with oxygen.Although the initial compounds formed cannot be used by plants, as these molecules cool, they react with oxygen to form NO2. This NO2 then reacts with water to produce HNO3 (nitric acid) or its ion NO3 (nitrate), which is usable by plants.Biological nitrogen fixation was first discovered by German agronomist Hermann Hellriegel and Dutch microbiologist Martinus Beijerinck. This process occurs when atmospheric nitrogen is converted into ammonia by the enzyme nitrogenase.Biological nitrogen fixation (BNF) serves as a valuable alternative to nitrogen fertilizers. It is naturally carried out in soil by microorganisms known as diazotrophs, which include bacteria like Azotobacter and certain archaea.All forms of biological nitrogen fixation are facilitated by nitrogenase enzymes, which contain iron and often another metal, usually molybdenum, though sometimes vanadium.Biological nitrogen fixation can be categorized into three types:Soil contains various free-living nitrogen-fixing organisms, including several aerobic and anaerobic bacteria, as well as blue-green algae.Biological nitrogen fixation by microorganisms that live freely or outside of plant cells is known as non-symbiotic Biological Nitrogen Fixation.The asymbiotic nitrogen fixers can be free-living aerobic nitrogen-fixing bacteria (Chlorobium, Chromatium, Azotobacter, Azomonas), Free-living anaerobic nitrogen-fixing bacteria (Rhodospirillum), Blue-Green Algae (Nostoc, Anabaena), Free-living Fungi (Yeasts)These organisms are more active in fixing nitrogen under low oxygen conditions, as long as no hydrogen gas is produced.Certain bacteria that live in close contact with the roots of cereals and grasses are capable of fixing nitrogen. This relationship, known as associative symbiosis, is a form of loose mutualism.Examples of this association include: Azospirillum brasilense with cereal roots. Beijerinckia with the roots of sugarcane. Azotobacter paspali with the roots of the tropical grass Paspalum notatum.Symbiotic nitrogen fixation occurs within a mutualistic relationship where plants provide a habitat and fixed carbon to bacteria in exchange for fixed nitrogen.This ecological association between bacteria and their host is long-term and beneficial for both parties, with the microbial partner responsible for fixing atmospheric nitrogen.Examples of symbiotic biological nitrogen fixation are Bradyrhizobium japonicum is a slow-growing symbiont of soybeans, Frankia, which forms root nodules in association with Alnus, Nostoc, forms association with Anthoceros, a bryophyte.Fig: Schematic Diagram of Nitrogen CyclePlants take up nitrate or ammonium from the soil through their root hairs. Nitrate is initially converted to nitrite ions and then further reduced to ammonium ions, which are used to synthesize amino acids, nucleic acids, and chlorophyll.In plants with a symbiotic relationship with rhizobia, some nitrogen is directly assimilated from the nodules as ammonium ions.It has been discovered that there is a more complex exchange of amino acids between Rhizobia bacteroids and plants. The plant supplies amino acids to the bacteroids, eliminating the need for ammonia assimilation, and in return, the bacteroids provide amino acids containing newly fixed nitrogen back to the plant, creating a mutually dependent relationship.While many animals, fungi, and other heterotrophic organisms obtain nitrogen by consuming amino acids, nucleotides, and other small organic molecules, some heterotrophs, including many bacteria, can use inorganic compounds like ammonium as a nitrogen source.Ammonia is a form of nitrogen that can be utilized by living organisms. Organic nitrogen, present in materials like proteins, amines, amides, and urea, is converted into ammonia by microbial populations.The extent of decomposition depends on the type of microbes acting on the organic matter. Proteins are broken down by proteolytic enzymes, which are extracellular.Microorganisms involved in ammonification include bacteria such as Pseudomonas, Bacillus, Clostridium, and Serratia, and fungi like Alternaria, Aspergillus, Penicillium, and Mucor.The aerobic decomposition of proteins results in carbon dioxide, ammonia, water, and sulfates, while anaerobic decomposition (putrefaction) produces hydrogen sulfide, mercaptans, and other compounds.Ammonia production from urea involves microbes like Bacillus, Proteus, Micrococcus, and Sarcina. Amines are processed by Pseudomonas, Protoaminobacter, with the help of amino oxidases, and amides are converted to ammonia by the enzyme amidase.Ammonia, being a volatile and positively charged compound, can disperse or bind to negatively charged clay particles in the soil. This ammonia may then be readily oxidized, leading to the next step in the cycle, which is nitrification.Nitrification is the process that transforms ammonia into nitrite and then into nitrate, and it is a crucial step in the global nitrogen cycle. Most nitrification occurs aerobically and is performed solely by prokaryotes, involving two distinct phases carried out by different microorganisms.The first phase involves the oxidation of ammonia to nitrite, which is carried out by ammonia-oxidizing microbes, such as Nitrosomonas. These aerobic ammonia oxidizers convert ammonia to nitrite through an intermediate hydroxylamine, using two enzymes: ammonia monooxygenase and hydroxylamine oxidoreductase.This process produces only a small amount of energy compared to other metabolic processes, which makes these bacteria slow growers.Additionally, aerobic ammonia oxidizers are autotrophs, fixing carbon dioxide to produce organic carbon, similar to photosynthetic organisms, but using ammonia as their energy source instead of light. While many microbes perform nitrogen fixation, ammonia oxidation is less widespread among prokaryotes.It was previously believed that only a few bacterial genera, such as Nitrosomonas, Nitrosospira, and Nitrosococcus, were responsible for ammonia oxidation. However, in 2005, an archaeon capable of ammonia oxidation was discovered.The second phase of nitrification is the oxidation of nitrite (NO2) to nitrate (NO3), carried out by a different group of prokaryotes known as nitrite-oxidizing bacteria.Nitrospira, Nitrobacter, Nitrococcus, and Nitrospina involve in oxidation of nitrate. Similar to ammonia oxidizers, the energy produced from nitrite oxidation is minimal, resulting in low growth yields.Both ammonia- and nitrite-oxidizers must process many molecules of ammonia or nitrite to fix a single molecule of CO2. Complete nitrification requires both ammonia oxidation and nitrite oxidation.These microorganisms are found in various aerobic environments, including soils, estuaries, lakes, and open-ocean environments. They also play a vital role in wastewater treatment facilities by removing excess ammonium that could otherwise pollute receiving waters.Denitrification is the process that converts nitrate into nitrogen gas, effectively removing bioavailable nitrogen and returning it to the atmosphere.The final product of denitrification is dinitrogen gas (N2), though intermediate gaseous forms like nitrous oxide (N2O) also occur. Nitrous oxide is a greenhouse gas that can react with ozone and contribute to air pollution.In contrast to nitrification, denitrification is an anaerobic process, taking place primarily in soils, sediments, and anoxic zones in lakes and oceans. Similar to nitrogen fixation, denitrification is carried out by a variety of prokaryotes, including bacteria from genera such as Bacillus, Paracoccus, and Pseudomonas. These denitrifying bacteria are chemoorganotrophs and require organic carbon for their growth. Denitrification is crucial for removing fixed nitrogen, such as nitrate, from ecosystems and converting it into a biologically inert form (N2).This process is especially significant in agriculture, where nitrate loss from fertilizers can be both costly and damaging. Conversely, denitrification in wastewater treatment is beneficial as it helps remove excess nitrates from wastewater, reducing the risk of adverse effects like algal blooms in the discharged water.Nitrogen cycle does have significant ecological and economic roles, which can be summarized as follows;Nitrogen cycle help inert nitrogen gas to get converted into usable form for plants and other organisms.Since, Nitrogen is crucial part of cell, as it is an component in the formation of various biomolecules.The photosynthetic process in plants need chlorophyll, Nitrogen is one of the major components in the formation of chlorophyll.This process involves in the process of ammonification, during which several decomposers converts animals and plant platter, through decomposition.During this cycle, nitrates and nitrites are released in soil, which will enhance the fertility of soil and increases the productivity.It involves in the process of denitrification, inwater treatment facilities it convert the excess nitrate into nitrogen gas which is then released into the atmosphere.The nitrogen cycle is a biogeochemical process where nitrogen is converted into various chemical forms as it circulates through the atmosphere, land, and marine ecosystems.Nitrogen conversion occurs through both biological and physical processes. Key steps involve during nitrogen cycle are;1. Nitrogen fixation2. Assimilation3. Ammonification4. Nitrification5. Denitrification. The nitrogen cycle is an ecological process that recycles nitrogen through the atmosphere, soil, and living organisms. The nitrogen cycle stages include nitrogen fixation, nitrification, assimilation, ammonification, and denitrification. All of them ensure that nitrogen is available for essential biological functions.In this article, we will cover in detail the nitrogen cycle definition and stages.What is Nitrogen Cycle?The nitrogen cycle is a natural process that recycles nitrogen through the environment. This cycle ensures its availability for all living organisms. The nitrogen cycle involves several key stages: nitrogen fixation, where atmospheric nitrogen is converted into ammonia by bacteria; nitrification which transforms ammonia into nitrites and then nitrates; assimilation, where plants absorb nitrates to build proteins; ammonification, where decomposers convert organic nitrogen back into ammonia; and denitrification, where bacteria return nitrogen to the atmosphere as gas. This cycle maintains the balance of nitrogen in the ecosystem, essential for the growth and survival of plants and animals.Stages of Nitrogen CycleThe various stages of nitrogen cycle are given below: Stage 1: Nitrogen FixationNitrogen fixation is the process where nitrogen gas (N) from the atmosphere is converted into ammonia (NH) or related compounds. This conversion is important because most organisms cannot use atmospheric nitrogen directly. Nitrogen fixation can occur in two primary ways:Biological Nitrogen Fixation: This is carried out by certain bacteria and archaea, known as diazotrophs. These microorganisms possess an enzyme called nitrogenase that can break the strong triple bond in nitrogen gas. Examples include Rhizobium, which forms symbiotic relationships with leguminous plants (like peas and beans), and free-living bacteria like Azotobacter.Non-biological Nitrogen Fixation: This includes processes like lightning, which provides enough energy to convert nitrogen gas and oxygen into nitrogen oxides (NO and NO). These oxides then dissolve in rainwater to form nitrates (NO), which plants can absorb.Stage 2: NitrificationNitrification is a two-step process that converts ammonia into nitrates, which plants can readily use. This process is carried out by specialized bacteria in the soil:Ammonia Oxidation: Ammonia (NH) is converted into nitrite (NO) by bacteria such as Nitrosomonas.Nitrite Oxidation: Nitrite is then converted into nitrate (NO) by bacteria such as Nitrobacter.These nitrifying bacteria play a crucial role in making nitrogen available to plants in a form they can absorb through their roots.Stage 3: Assimilation Assimilation is the process where plants absorb nitrates (NO) and ammonium ions (NH) from the soil through their roots. Once absorbed, these compounds are used to build plant proteins, nucleic acids, and chlorophyll. When animals eat plants, they assimilate nitrogen into their own bodies to form proteins and other essential compounds.Stage 4: AmmonificationAmmonification, also known as mineralization, occurs when organisms die or excrete waste products. Decomposers, such as bacteria and fungi, break down the organic nitrogen compounds (like proteins and nucleic acids) into ammonia (NH) or ammonium ions (NH). This process returns nitrogen to the soil, making it available for uptake by plants again.Stage 5: DenitrificationDenitrification is the process where nitrates (NO) in the soil are converted back into nitrogen gas (N) or nitrous oxide (NO) by anaerobic bacteria (bacteria that do not require oxygen). These bacteria, including species like Pseudomonas and Clostridium, thrive in waterlogged soils where oxygen is limited. Denitrification completes the nitrogen cycle by returning nitrogen to the atmosphere.Nitrogen Cycle Steps with DiagramThe diagram of nitrogen cycle with labelled steps are given below: Nitrogen Cycle Stages Explained with DiagramConclusion - Stages of Nitrogen Cycle In conclusion, the nitrogen cycle is a natural process that facilitates the recycling of nitrogen throughout the environment, ensuring its availability to all living organisms. Through its key stages of nitrogen fixation, nitrification, assimilation, ammonification, and denitrification, this cycle maintains the equilibrium of nitrogen in ecosystems, supporting the growth and survival of plants and animals. Understanding the intricacies of the nitrogen cycle underscores its importance in sustaining life on Earth and emphasizes the need for its conservation and management to preserve environmental balance.Also Read: The nitrogen cycle refers to the cycle of nitrogen atoms through the living and non-living systems of Earth. The nitrogen cycle is vital for life on Earth. Through the cycle, atmospheric nitrogen is converted to a form which plants can incorporate into new proteins. Nitrogen was originally formed in the hearts of stars through the process of nuclear fusion. When ancient stars exploded, they flung nitrogen-containing gases across the Universe. When the Earth was formed, nitrogen gas was the main ingredient in its atmosphere. Today, the Earths atmosphere is about 78% nitrogen, about 21% oxygen, and about 1% other gases. This is an ideal balance because too much oxygen can actually be toxic to cells. In addition, oxygen is flammable. Nitrogen, on the other hand, is inert and harmless in its gaseous form. However, nitrogen gas is not accessible to plants and animals for use in their cells.Here we will discuss how nitrogen plays a vital role in the chemistry of life and how it gets from the atmosphere, into living things, and back again. The basic steps of the nitrogen cycle are illustrated here:Nitrogen Cycle StepsWell discuss each part of the process below. In the process of nitrogen fixation, bacteria turn nitrogen gas from the atmosphere into ammonia.These nitrogen-fixing bacteria, often called diazotrophs, have an enzyme called nitrogenase which combines nitrogen atoms with hydrogen atoms. Ammonia is a nitrogen compound that can dissolve in water, and is easier for other organisms enzymes to interact with. Interestingly, the enzyme nitrogenase can only function when oxygen isnt present. As a result, organisms that use it have had to develop oxygen-free compartments in which to perform their nitrogen fixation!Common examples of such nitrogen-free compartment sare the Rhizobium nodules found in the roots of nitrogen-fixing legume plants. The hard casing of these nodules keeps oxygen out of the pockets where Rhizobium bacteria do their valuable work of converting nitrogen gas into ammonia.You can see the oxygen-free Rhizobium nodules, visible as big round lumps, on the roots of this cowpea plant:Rhizobia nodules on Vigna unguiculata In nitrification, a host of soil bacteria participate in turning ammonia into nitrate the form of nitrogen that can be used by plants and animals. This requires two steps, performed by two different types of bacteria.First, soil bacteria such as Nitrosomonas or Nitrococcus convert ammonia into nitrogen dioxide. Then another type of soil bacterium, called Nitrobacter, adds a third oxygen atom to create nitrate. These bacteria dont convert ammonia for plants and animals out of the goodness of their hearts. Rather, they are chemotrophs who obtain their energy from volatile chemicals. By metabolizing nitrogen along with oxygen, they obtain energy to power their own life processes.The process can be thought of as a rough (and much less efficient) analog to the cellular respiration performed by animals, which extract energy from carbon-hydrogen bonds and use oxygen as the electron acceptor, yielding carbon dioxide at the end of the process.Nitrates the end product of this vital string of bacterial reactions can be made artificially, and are the main ingredient in many soil fertilizers. You may actually hear such fertilizer referred to as nitrate fertilizer. By pumping the soil full of nitrates, such fertilizers allow plants to grow large quickly, without being dependent on the rate at which nitrogen-fixing bacteria do their jobs!Interestingly, high-energy environments such as lightning strikes and volcanic eruptions can convert nitrogen gas directly into nitrates but this doesnt happen nearly enough to keep modern ecosystems healthy on its own! In nitrogen assimilation, plants finally consume the nitrates made by soil bacteria and use them to make nucleotides, amino acids, and other vital chemicals for life.Plants take up nitrates through their roots and use them to make amino acids and nucleic acids from scratch. Animals that eat the plants are then able to use these amino acids and nucleic acids in their own cells. Now we have moved nitrogen from the atmosphere into the cells of plants and animals.Because there is so much nitrogen in the atmosphere, it may seem that the process could stop there but the atmospheres supply is not infinite, and keeping nitrogen inside plant and animal cells would eventually result in big changes to our soil, our atmosphere, and our ecosystems!Fortunately, thats not what happens. In a robust ecosystem like ours, anywhere that energy has been put into creating an organic chemical, there is another form of life that is waiting to extract that energy by breaking those chemical bonds.A process called ammonification is performed by soil bacteria which decompose dead plants and animals. During the process, these decomposers break down amino acids and nucleic acids into nitrates and ammonia and release those compounds back into the soil.There, the ammonia may be taken up again by plants and nitrifying bacteria. Alternatively, the ammonia may be converted back into atmospheric nitrogen through the process of denitrification. In the final step of the nitrogen cycle, anaerobic bacteria can turn nitrates back into nitrogen gas.This process, like the process of turning nitrogen gas into ammonia, must happen in the absence of oxygen. As such it often occurs deep in the soil, or in wet environments where mud and muck keep oxygen at bay.In some ecosystems, this denitrification is a valuable process to prevent nitrogen compounds in the soil from building up to dangerous levels. Nitrogen is an essential ingredient for life as we know it. Its unique chemical bonding properties allow it to create structures such as DNA and RNA nucleotides, and the amino acids from which proteins are built. Without nitrogen, these molecules would not be able to exist.Its thought that the first nucleotides and amino acids formed naturally under the volatile conditions of early Earth, where energy sources like lightning strikes could cause nitrogen and other atoms to react and form complex structuresThis process might have naturally produced self-replicating organic chemicals but in order to reproduce and evolve, life needed to figure out how to make these nitrogen compounds on demand.Today, nitrogen fixers are organisms that can turn nitrogen gas from the atmosphere into nitrogen compounds that other organisms can use to produce nucleic acids, amino acids, and more. These nitrogen fixers are such a vital part of the ecosystem that agriculture cannot occur without them.Ancient peoples learned that if they did not alternate growing nitrogen-consuming crops with nitrogen-fixing crops, their farms would become fallow and unable to support growth. Today, most artificial fertilizers contain life-giving nitrogen compounds as their main ingredient to make the soil more fertile. While the importance of nitrogen to plant and animal life might make it sound like theres no such thing as too much, there are actually some dangers that can arise from putting too many nitrates in the soil.Like anything else, nitrogen compounds can be toxic in high concentrations. Just like too much oxygen is toxic to air-breathers, plants can suffer harmful effects from nitrogen overdose. Nitrates can also be directly toxic to humans when consumed in large quantities in food or water, nitrates can increase cancer risks and interfere with blood chemistry, leaving blood unable to properly carry oxygen.Blue baby syndrome is one side effect seen in humans who consume high levels of nitrates in their food or water. Another acute worry is the danger of throwing ecosystems out of balance. Some organisms can use nitrogen compounds to grow faster than others and that means that when theres lots of nitrogen around, these organisms can grow so fast that they cause harm to other organisms.One concern that has been raised about the use of artificial nitrate fertilizer is that when it gets into rivers, lakes, and even the ocean, it can cause runaway growth of plant life there.More plant life might sound like a good thing but not when aquatic plants include algae that can block sun and oxygen from getting to other aquatic organisms, and even produce toxins that make humans and other animals sick!Nitrate fertilizer in water supplies has been blamed for some blooms of red tides, brown tides, and Pfiesteria bacteria all of which produce toxins that can sicken or kill humans and other animals.The question of how to keep farmlands fertile without using nitrate fertilizers is still being investigated by scientists. It is hoped that someday, sustainable practices using natural or genetically engineered nitrogen-fixing plants may allow farmers to produce high crop yields without adding high concentrations of artificial nitrates to the soil. The Story of ThanksgivingThe story of the first Thanksgiving goes that the pilgrims feasted with the Indians to celebrate their first harvest in the New World. But why was this harvest a big enough deal to throw a feast over? And why, exactly, was it important that the Indians and the European settlers ate together?When the European settlers came to the Americas, they had very little idea of how to survive here. Having worked farms in back in England for generations, the pilgrims assumed that farming here would be very much the same. That turned out not to be the case. The pilgrims had a difficult time growing or finding enough food to last them through the winter.One of the reasons for that was that there was not much nitrogen in the soil where the pilgrims landed. Their crops were not nitrogen-fixing, and they hadnt brought any large livestock. This was a major problem, as manure had been a common source of fertilizer in the old world. After trying in frustration to grow crops in the American soil, the Europeans were shown how to solve their problems by the American Indians.By burying dead fish in their crop fields, the pilgrims restored nitrogen from the fishs proteins and nucleotides to the ground. As a result, their crops flourished and the first European settlers learned from the American Indians how to survive in the New World. Some tribes of Native Americans traditionally grow three crops together corn, beans, and squash.Often referred to as the three sisters, this crop combination is ingenious for several reasons. For one, eating these three plants in combination provides humans with proteins containing all the essential amino acids.For another, it includes a nitrogen-fixing plant beans.The beans contain Rhizobium nodules in their roots, which contain bacteria that can convert atmospheric nitrogen into a form thats usable by soil bacteria and, ultimately, plants.Just like burying fish in the fields, growing beans alongside corn and squash assures that the soil does not become too depleted to grow new plants. Even a single crop of corn or squash may grow better alongside nitrogen-fixing beans, as their Rhizobium bacteria nurtures the surrounding soil! Humans first began fertilizing their crops using natural nitrogen-containing substances such, such as dead fish and animal manure. These waste products of animal life contained proteins, amino acids, and nucleotides which soil bacteria and plants could use to grow.Today, humans have discovered industrial processes which can turn ammonia into nitrates just like those produced by soil bacteria. Plants can use these nitrates directly, and human industry can produce them in large quantities.Unfortunately, the human impact on the nitrogen cycle makes changes to the environment, which can have unintended consequences. Just as artificial nitrates promote the growth of good plants like crops, they can also promote the growth of bad plants and algae that produce toxins and outcompete other life forms.This can be especially problematic when artificial fertilizers are carried by rainwater from farmlands and lawns into rivers and lakes. The result can be the growth of toxic algae that can strangle wetlands and even get into human drinking water. Galloway, J. N. et al. Year 2020: Consequences of population growth and development on deposition of oxidized nitrogen. Ambio 23, 120123 (1994). Howarth, R. W. Coastal nitrogen pollution: a review of sources and trends globally and regionally. Harmful Algae 8, 1420. (2008). Johnson, P. T. J. et al. Linking environmental nutrient enrichment and disease emergence in humans and wildlife. Ecological Applications 20, 1629 (2010). Koenneke, M. et al. Isolation of an autotrophic ammonia-oxidizing marine archaeon. Nature 437, 543546 (2005). Kuypers, M. M. M. et al. Massive nitrogen loss from the Benguela upwelling system through anaerobic ammonium oxidation. Proceedings of the National Academy of Sciences of the United States of America 102, 64786483 (2005). Risgaard-Petersen, N. et al. Evidence for complete denitrification in a benthic foraminifer. Nature 443, 9396 (2006). Strous, M. et al. Missing lithotroph identified as new planctomycete. Nature 400, 446449 (1999). Vitousek, P. M. et al. Human alteration of the global nitrogen cycle: sources and consequences. Ecological Applications 7, 737750 (1997). Vitousek, P. M. et al. Towards an ecological understanding of biological nitrogen fixation. Biogeochemistry 57, 145 (2002). Ward, B. B. et al. Denitrification as the dominant nitrogen loss process in the Arabian Sea. Nature 460, 7881 (2009). Zehr, J. P. et al. Nitrogenase gene diversity and microbial community structure: a cross-system comparison. Environmental Microbiology 5, 539554 (2003).The nitrogen cycle is a biogeochemical cycle that converts nitrogen into different forms in atmospheric, terrestrial, and marine ecosystems.The nitrogen cycle is a biogeochemical cycle that converts nitrogen into various forms throughout the ecosystem. Nitrogen is an essential element for life that organisms use in the synthesis of amino acids, proteins, and nucleic acids. Yet, while the atmosphere is rich in nitrogen (about 78%), this nitrogen (N2) is largely inaccessible to cells in its gaseous form. Through the nitrogen cycle, atmospheric nitrogen undergoes various transformations. Living organisms use nitrogen and ultimately return it back to the atmosphere.Several processes play a role in the nitrogen cycle, including both biotic (living) and abiotic (non-living) factors. These processes include nitrogen fixation, assimilation, ammonification, nitrification, and denitrification.Nitrogen fixation is the initial step of the nitrogen cycle, converting inert atmospheric nitrogen (N2) into a bio-available form, ammonia (NH3).Biological Fixation: Some types of bacteria convert nitrogen gas into ammonia. In symbiotic associations, bacteria like Rhizobium colonize the root nodules of legumes, converting atmospheric nitrogen into ammonia. Similarly, non-symbiotic bacteria like Azotobacter and cyanobacteria, especially those in aquatic systems, perform nitrogen fixation. The enzyme central to this process is nitrogenase, which facilitates the reduction of N2.Physical Fixation: Atmospheric processes, such as lightning, also convert atmospheric nitrogen into nitrogen oxides (NOx). These oxides subsequently react with water, forming nitrates that can be absorbed by plants.In assimilation, plants take up ammonia and incorporate nitrogen into amino acids, nucleic acids, and other vital organic molecules. Plants predominantly assimilate nitrogen through their roots in the form of nitrates (NO3) and ammonium ions (NH4+).As organisms die and waste products accumulate, decomposersspecifically fungi and certain types of bacteriabreak down the organic nitrogen within these materials and convert it back into ammonia. This process ensures that nitrogen trapped within organic matter returns to the soil in a form that plants can reuse.This aerobic process involves the stepwise oxidation of ammonia to nitrite and then to nitrate.First, bacteria like Nitrosomonas oxidize ammonia to nitrite (NO2).Following this, Nitrobacter takes over, oxidizing the nitrite to nitrate (NO3). Nitrification is a critical step of the nitrogen cycle because most plants predominantly utilize nitrates for their nitrogen needs.Denitrification is essentially the reverse of nitrogen fixation. Here, the nitrates in the soil transform back into atmospheric nitrogen. Anaerobic bacteria, such as Pseudomonas and Clostridium, reduce nitrates and nitrites to gaseous nitrogen, releasing it back into the atmosphere. This process prevents the accumulation of excess nitrates in terrestrial systems.Unlike denitrification, this process doesnt return nitrogen to the atmosphere. Instead, certain bacteria reduce nitrates to nitrites or ammonia for energy, especially under anaerobic conditions. However, the nitrogen remains in the ecosystem.In an anaerobic environment, specialized bacteria like Brocadia oxidize ammonia using nitrite as the electron acceptor, producing nitrogen gas. Anammox is particularly relevant in aquatic systems, contributing significantly to the removal of fixed nitrogen from the oceans.The marine environment offers unique niches for nitrogen transformation. While many processes mirror their terrestrial counterparts, the deep-sea regions offer unique conditions, such as oxygen minimum zones (OMZs) where processes like anammox and denitrification are prevalent. The ocean floor acts as a nitrogen sink in that organic debris falls and deposits as sediments. Over time, compression converts these particles into sedimentary rock. Geological uplifting eventually returns these rocks to the surface, where weathering releases the nitrogen compounds back into the cycle.Human activities significantly impact the nitrogen cycle. From agriculture to industry, anthropogenic nitrogen dramatically increases the flux of reactive nitrogen in the environment.Agriculture: The synthesis and widespread use of nitrogen-based fertilizers increase crop yields, but at the cost of nitrogen runoff that causes eutrophication and acidification in aquatic systems. Inorganic nitrogen in water systems also poses toxicity issues for humans and other animals.Burning of Fossil Fuels: Burning fossil fuels releases NOx into the atmosphere, which returns to the earths surface as acid rain or contribute to smog and greenhouse gas accumulation.Deforestation and Land Use Changes: Deforestation alters the natural nitrogen balance, leading to soil degradation and other ecological shifts.The repercussions of these impacts are multi-fold, affecting air and water quality, disrupting natural ecosystems, and posing direct and indirect health risks to humans.Camargoa, Julio A.; Alonso, lvaro (2006). Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment. Environment International. 32 (6): 831849. doi:10.1016/j.envint.2006.05.002Erisman, J. W.; Galloway, J. N.; et al. (2013). Consequences of human modification of the global nitrogen cycle. Philosophical Transactions of the Royal Society B: Biological Sciences. 368 (1621): 20130116. doi:10.1098/rstb.2013.0116Fowler, David; Coyle, Mhairi; et al. (2013). The global nitrogen cycle in the twenty-first century. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. 368 (1621): 20130164. doi:10.1098/rstb.2013.0164Galloway, J. N.; Townsend, A. R.; et al. (2008). Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions. Science. 320 (5878): 889892. doi:10.1126/science.1136674Voss, M.; Bange, H. W.; et al. (2013). The marine nitrogen cycle: recent discoveries, uncertainties and the potential relevance of climate change. Philosophical Transactions of the Royal Society B: Biological Sciences. 368 (1621): 20130121. doi:10.1098/rstb.2013.0121Related Posts Home Microbiology Environmental Microbiology Biogeochemical Cycling The nitrogen cycle is a fundamental biogeochemical process that facilitates the conversion of atmospheric nitrogen, which is chemically inert and inaccessible to most living organisms, into forms that can be readily assimilated. This cycle plays a pivotal role in the ecosystem, ensuring the availability of essential nitrogen compounds for various biological functions.Atmospheric nitrogen (N2), which constitutes approximately 78% of Earths atmosphere, is the primary reservoir of nitrogen. However, this form of nitrogen is not directly usable by most plants and animals. To bridge this gap, a series of interconnected processes within the nitrogen cycle transform this inert gas into biologically available compounds.The first step in this cycle is nitrogen fixation. Specialized bacteria, known as nitrogen-fixing bacteria, have the unique ability to convert atmospheric nitrogen into ammonia (NH3) or ammonium ions (NH4+). This process provides plants with an initial source of usable nitrogen.Following fixation, ammonification occurs. During this phase, decomposing bacteria break down organic matter, releasing ammonium ions back into the soil. This ammonium then undergoes nitrification, a two-step bacterial process. Initially, ammonium is converted into nitrite (NO2-), and subsequently, into nitrate (NO3-), a compound that plants can efficiently absorb and utilize.Once absorbed by plants, nitrogen compounds are incorporated into amino acids and proteins. As plants are consumed by herbivores, and herbivores by carnivores, these essential nitrogenous compounds are transferred along the food chain, ensuring nitrogen availability to higher trophic levels.The final step in the nitrogen cycle is denitrification. In this process, specific bacteria in oxygen-deprived environments transform nitrates back into gaseous nitrogen, releasing it into the atmosphere and completing the cycle.Its crucial to note that human activities, such as the combustion of fossil fuels, extensive use of nitrogen-based fertilizers, and wastewater discharge, have significantly impacted the natural balance of the nitrogen cycle. Such alterations can have detrimental effects on both the environment and human health.In conclusion, the nitrogen cycle is a sophisticated and vital process that ensures the continuous availability of an essential element for life on Earth. Through a series of biological and physical transformations, atmospheric nitrogen is converted into forms that can be assimilated by living organisms, supporting biodiversity and ecosystem functionality.Nitrogen CycleThe nitrogen cycle is a biogeochemical process that transforms atmospheric nitrogen into usable forms for living organisms and then returns it to the atmosphere through a series of biological and chemical reactions.GLOBAL NITROGEN CYCLEStages of Nitrogen CycleNitrogen fixation, nitrification, assimilation, ammonification, and denitrification are the steps in the Nitrogen Cycle. These processes occur in stages and are described in detail below:STAGES OF NITROGEN CYCLE1. Nitrogen FixationNitrogen fixation represents the primary step in the nitrogen cycle, where the inert atmospheric nitrogen (N2) is transformed into a biologically usable form, specifically ammonia (NH3). This pivotal process is facilitated by a select group of microorganisms known as diazotrophs. These organisms possess a specialized enzyme, nitrogenase, which facilitates the combination of nitrogen atoms with hydrogen to produce ammonia.Among the diazotrophs, certain free-living soil bacteria, including Azotobacter and Klebsiella, as well as cyanobacteria or blue-green algae, play a significant role in this process. Additionally, symbiotic bacteria, predominantly Rhizobium, collaborate with plant roots to facilitate nitrogen fixation. Its noteworthy that diazotrophic microorganisms contribute to approximately 60% of the Earths newly fixed nitrogen, estimated to be around 1011 kg annually. Other natural phenomena, such as lightning and ultraviolet radiation, account for an additional 15% of nitrogen fixation, with the residual portion attributed to industrial activities.The chemical reaction underpinning nitrogen fixation can be represented as: N2+3H22NH3 This reaction is mediated by the nitrogenase complex, which comprises a reductase and an ironmolybdenum-containing nitrogenase enzyme. The process is energy-intensive, necessitating the hydrolysis of at least 16 ATP molecules to produce two ammonia molecules. In symbiotic relationships, leghemoglobin acts as a protective agent, shielding the nitrogenase in Rhizobium from deactivation by oxygen.Furthermore, anthropogenic activities, including industrial combustion and agricultural fertilization, introduce additional fixed nitrogen into the environment. While industrial sources primarily release oxidized nitrogen gases like nitric oxide (NO) and nitrogen dioxide (NO2), agricultural activities contribute nitric oxide, nitrate (NO3), and ammonia (NH3).In essence, nitrogen fixation serves as the gateway, ensuring the continuous replenishment of usable nitrogen in ecosystems, thereby sustaining life on Earth.Nitrogen FixationNitrogen Fixation Steps/ProcessNitrogen fixation is a fundamental biochemical process that transforms the inert atmospheric nitrogen (N2) into forms that are biologically accessible to plants and other organisms. This conversion is pivotal for the sustenance of life, as nitrogen is a key component of amino acids, proteins, and nucleic acids. The process of nitrogen fixation can be categorized into several distinct pathways:Atmospheric Nitrogen Fixation: This process is predominantly driven by lightning. The intense heat generated during lightning strikes facilitates the conversion of atmospheric nitrogen into various nitrogen oxides, including nitrous oxide, nitrogen peroxide, and nitric oxide. These compounds, upon dissolution in rain, form diluted nitric acid. When this acidified rainwater reaches the terrestrial surface, it reacts with alkaline substances, producing nitrates that plants can readily assimilate.Biological Nitrogen Fixation: Certain specialized bacteria possess the capability to transform atmospheric nitrogen into ammonia. This biological conversion is mediated by the enzyme nitrogenase.Free-Living Bacteria: Organisms such as Azotobacter, Beijernickia, and Rhodospirillum, along with cyanobacteria, are examples of free-living bacteria that facilitate nitrogen fixation.Symbiotic Bacteria: Rhizobium, a symbiotic bacterium, forms associations with the roots of leguminous plants. Through a symbiotic relationship, it aids in the conversion of atmospheric nitrogen into forms that plants can utilize. The practice of crop rotation, where leguminous crops are alternated with other species, serves to naturally enrich soil nitrogen content.Industrial Nitrogen Fixation: The Haber process stands out as a pivotal industrial technique that transforms atmospheric nitrogen into ammonia. This synthesized ammonia is subsequently converted into various nitrates, which find extensive use in fertilizers to augment soil nutrient content.Nitrogen Fixation by Lightning: Beyond the primary atmospheric fixation process, lightning also plays a role, albeit minor, in nitrogen fixation. The energy from lightning strikes aids in the conversion of nitrogen into bioavailable forms, ensuring that plants have a consistent supply of this crucial nutrient.Furthermore, anthropogenic activities, encompassing industrial processes, vehicular emissions, power generation, and even forest fires, release nitrogen oxides. These compounds, while not directly involved in the primary nitrogen fixation process, influence the overall nitrogen balance in the environment.Nitrogen fixation is a pivotal process that facilitates the conversion of atmospheric nitrogen into forms that are biologically accessible. This transformation is essential for the sustenance of life on Earth, as nitrogen is a fundamental component of proteins, nucleic acids, and other vital biomolecules. The process of nitrogen fixation can be classified into three primary types:Atmospheric Fixation: This is a natural process wherein the immense energy from lightning strikes dissociates atmospheric nitrogen molecules, converting them into nitrogen oxides. These oxides subsequently dissolve in rainwater and are assimilated by plants. Through this mechanism, the ecosystem benefits from a direct influx of nitrogen, ensuring that terrestrial flora has access to this essential nutrient.Industrial Nitrogen Fixation: This method is anthropogenic in nature and involves the synthesis of ammonia through the direct combination of nitrogen and hydrogen gases. The resultant ammonia is a precursor for various nitrogenous fertilizers, such as urea. These fertilizers are then applied to agricultural lands, enhancing the nitrogen content of the soil and promoting plant growth.Biological Nitrogen Fixation: Contrary to popular belief, plants cannot directly assimilate atmospheric nitrogen. Instead, they rely on a symbiotic relationship with specific bacteria, such as Rhizobium and cyanobacteria (blue-green algae). These microorganisms possess the unique ability to convert atmospheric nitrogen into compounds that are readily usable by plants. Through this biological process, nitrogen is fixed in the soil in a form that plants can absorb and utilize for their growth and development.2. NitrificationNitrification is a fundamental biochemical process in the nitrogen cycle, characterized by the sequential conversion of ammonia (NH3) or ammonium ions (NH4+) into nitrate (NO3). This transformation is facilitated by specific soil bacteria in a two-tiered mechanism:Ammonia to Nitrite Conversion: In the initial phase, specialized bacteria, primarily Nitrosomonas and Nitrococcus, oxidize ammonia to form nitrite (NO2). These bacteria are classified as chemotrophs, deriving their energy from chemical reactions rather than light or organic matter. The conversion of ammonia to nitrite is an energy-yielding process, and it predominantly occurs under aerobic conditions.Reaction: NH4+ (Ammonium) NO2- (Nitrite) Catalyzed by: Nitrosomonas (Optimal pH range: 4 10)Nitrite to Nitrate Conversion: In the subsequent phase, the nitrite produced is further oxidized to nitrate (NO3) by another group of bacteria, notably Nitrobacter. This reaction, too, is an aerobic process and is essential for the bacterias energy metabolism.Reaction: NO2- (Nitrite) NO3- (Nitrate) Catalyzed by: Nitrobacter (Optimal pH range: 6 9)Optimal Conditions for Nitrification:Aeration: Efficient oxygen supply is crucial as nitrification is an aerobic process.Temperature: The process is most efficient at temperatures ranging from 25C to 35C.Soil Moisture: Adequate moisture ensures the mobility of ions and facilitates bacterial activity.Exchangeable Bases: The presence of bases, especially calcium (Ca), enhances the nitrification process.Nutrient Availability: The presence of essential nutrients like NPK (Nitrogen, Phosphorus, and Potassium) supports bacterial growth and activity.Carbon to Nitrogen (C/N) Ratio: A lower C/N ratio is conducive for nitrification as it ensures adequate nitrogen availability.Nitrification Steps/ProcessNitrification is a pivotal microbiological process in the nitrogen cycle, orchestrated by specific bacteria, including Nitrosomonas, Nitrosococcus, and Nitrosospira. This process encompasses the systematic oxidation of nitrogen compounds, transitioning from ammonia to nitrite and subsequently to nitrate.Step 1: Conversion of Ammonia to Nitrite In the primary phase of nitrification, ammonia-oxidizing bacteria facilitate the transformation of ammonia (NH3) into nitrite (NO2-). The chemical reaction underpinning this conversion is delineated as: Ammonia(NH3)+Oxygen(O2)Nitrite(NO2-)+3Hydrogenions(3H+)+2electronsAmmonia(NH3)+Oxygen(O2)Nitrite(NO2-)+3Hydrogenions(3H+)+2electronsStep 2: Transition from Nitrite to Nitrate Following the initial conversion, the nitrite produced undergoes a subsequent oxidation to form nitrate (NO3-). This reaction is mediated by nitrite-oxidizing bacteria. The chemical equation representing this transformation is: Nitrite(NO2-)+Water(H2O)Nitrate(NO3-)+2Hydrogenions(2H+)+2electronsNitrite(NO2-)+Water(H2O)Nitrate(NO3-)+2Hydrogenions(2H+)+2electronsThe genus Nitrobacter is instrumental in this secondary phase of nitrification. Furthermore, other bacterial genera, such as Nitrospina, Nitrospira, and Nitrococcus, also partake in autotrophic nitrite oxidation, reinforcing the conversion process from nitrite to nitrate.To encapsulate, nitrification is a two-tiered process wherein autotrophic bacteria expedite the oxidation of ammonia first to nitrite and subsequently to nitrate. These sequential transformations are paramount in the nitrogen cycle, producing forms of nitrogen that are biologically assimilable. Through nitrification, the ecosystem is endowed with nitrates, an indispensable nutrient for flora and various ecological entities.Factors Affecting the Nitrification ProcessThe nitrification process, carried out by specialized bacteria, is influenced by various environmental conditions that play a significant role in its rate and efficiency. Several key factors affect the nitrification process, including:pH: The pH level of the environment has a considerable impact on nitrification. Nitrifying bacteria function optimally within a specific pH range. Generally, a slightly acidic to neutral pH is preferred for efficient nitrification. Extreme pH levels can hinder the activity of nitrifying bacteria, leading to a slowdown or even inhibition of the process.Temperature: Temperature is a crucial factor affecting the rate of nitrification. Nitrification is a temperature-dependent process, with the activity of nitrifying bacteria increasing as the temperature rises within a suitable range. However, very high or low temperatures can disrupt the activity of these bacteria, affecting the overall nitrification process.Transfer Rate: Efficient nitrification also relies on the transfer rate of substrates, such as ammonia and nitrite, to the nitrifying bacterial colonies. A sufficient transfer rate ensures a steady supply of these substrates to the bacteria, promoting continuous nitrification.Type of Media: The type of media used in nitrification systems can influence the surface area available for bacterial colonization. A larger surface area allows more nitrifying bacteria to establish themselves, enhancing the overall nitrification capacity.Level of the Filter: In wastewater treatment systems, the level of the filter bed can affect nitrification. Properly designed filter systems ensure adequate contact time between the wastewater and nitrifying bacteria, facilitating efficient ammonia removal.Dissolved Oxygen: Nitrifying bacteria are aerobic microorganisms, meaning they require oxygen to carry out the nitrification process. Sufficient dissolved oxygen levels in the environment are essential for optimal nitrification rates. Inadequate oxygen levels can hamper the activity of nitrifying bacteria and lead to incomplete nitrification.Presence of Inhibiting Agents: Certain substances or chemicals can act as inhibiting agents for nitrifying bacteria. For example, high concentrations of toxic substances like heavy metals, chlorine, or specific organic compounds can negatively impact the nitrification process, reducing the effectiveness of nitrifying bacteria.Wastewater BOD (Biochemical Oxygen Demand): High levels of Biochemical Oxygen Demand (BOD) in wastewater can indicate the presence of organic matter that consumes oxygen during decomposition. This can reduce the available oxygen for nitrifying bacteria, affecting the nitrification process.3. Nitrogen AssimilationNitrogen assimilation is a cardinal step in the nitrogen cycle, where inorganic nitrogen forms are integrated into organic nitrogenous compounds. This process is pivotal for both flora and fauna, enabling them to absorb and utilize the nitrate (NO3) and ammonia produced through prior stages of nitrogen fixation and nitrification.Mechanisms of Nitrogen Assimilation:Glutamate Dehydrogenase Pathway: Glutamate dehydrogenase is an enzyme that facilitates the reductive amination of -ketoglutarate, an intermediate of the citric acid cycle. This reaction, although reversible, predominantly utilizes NADPH as the reductant in the biosynthetic direction. Apart from its role in nitrogen assimilation, this enzyme also plays a part in amino acid catabolism.Glutamine Synthetase Pathway: Glutamine synthetase is responsible for the assimilation of ammonia into glutamine. This reaction is driven by the energy derived from ATP hydrolysis. The nomenclature synthetase is attributed to this enzyme due to its ATP-dependent reaction mechanism, distinguishing it from synthases that operate without ATP.Incorporation into Amino Acids: The nitrogen assimilated in the form of glutamate and glutamine serves as a precursor for the synthesis of other amino acids. These amino acids are then integrated into proteins and nucleic acids within the organism.Uptake and Reduction: Plants and certain microorganisms absorb nitrogen in the forms of nitrate, ammonium, and dissolved ammonia. These nitrogen sources are predominantly present in soils, marine sediments, or are procured from nitrogen-fixing bacteria. Nitrate undergoes a two-step reduction: initially to nitrite, catalyzed by nitrate reductase, and subsequently to ammonium, facilitated by nitrite reductase. The resultant ammonium is then incorporated into amino acids.Central Enzymatic Players: The enzymes glutamine synthetase (GS) and glutamate synthase, also termed glutamine oxoglutarate aminotransferase (GOGAT), are central to nitrogen assimilation. GS mediates the integration of an amino group into glutamate, yielding glutamine. Concurrently, GOGAT reverses glutamine synthesis, which acts as a substrate for synthesizing other amino acids. This process also involves the intermediate -ketoglutarate, a key component of the Krebs cycle.Nitrogen assimilation in plants is a pivotal biochemical mechanism that facilitates the absorption and utilization of nitrogen, a vital element for plant growth and metabolism. This intricate process encompasses a series of enzymatic reactions that transform inorganic nitrogen sources from the soil into organic nitrogen compounds, which are integral to the synthesis of essential plant biomolecules.Mechanism of Nitrogen Uptake: Plants predominantly acquire nitrogen from the soil in two primary forms: nitrates (NO3-) and ammonium ions (NH4+). The plant root system is equipped with specialized transport proteins that facilitate the efficient uptake of these nitrogenous compounds, ensuring a consistent nitrogen supply for various metabolic activities.Nitrate Reduction Pathway: Upon absorption, nitrates are channeled to the plant leaves, where they undergo a sequential reduction process. The enzyme nitrate reductase, located in the cytoplasm, catalyzes the initial conversion of nitrate to nitrite (NO2-). Subsequently, within the chloroplasts, nitrite reductase facilitates the reduction of nitrite to ammonia (NH3). Notably, this reduction can also transpire in the root plastids.Ammonia Assimilation and Amino Acid Synthesis: The generated ammonia interacts with the amino acid glutamate, resulting in the formation of glutamine. This reaction is orchestrated by the enzyme glutamine synthetase. The glutamine synthetase-glutamate synthase (GS-GOGAT) pathway further enables the transamination of ammonia, leading to the production of other vital amino acids, including asparagine. Given the alkaline nature of plant cellular pH, the synthesized ammonia undergoes protonation, transforming into ammonium ions. However, elevated concentrations of ammonium ions can be detrimental to plant cells. To circumvent this, plants swiftly convert ammonium ions into amino acids, thereby integrating the nitrogen into proteins and other indispensable biomolecules.Significance of Nitrogen Assimilation: The process of nitrogen assimilation is of paramount importance for plants. It not only ensures the synthesis of crucial amino acids and proteins but also underpins various metabolic pathways. By efficiently converting inorganic nitrogen sources into organic forms, plants bolster their growth, development, and vitality. This mechanism underscores the role of plants in maintaining the nitrogen balance within ecosystems, contributing to ecological stability and sustainability.Synthesis of amino acids from ammonium ion (NH4+) in plantsIn plants, the assimilation of ammonium ion (NH4+) into amino acids is a fundamental biochemical process that underpins the synthesis of proteins and other vital biomolecules. This intricate mechanism encompasses two primary pathways: reductive amination and transamination, both of which play pivotal roles in nitrogen metabolism.1. Reductive Amination:Reductive amination stands as a cornerstone in the synthesis of amino acids from ammonium ions. In this process, NH4+ reacts with -ketoglutaric acid, culminating in the formation of the amino acid glutamate. The enzyme glutamate dehydrogenase (GDH) orchestrates this reaction. The chemical representation of this reaction is as follows:-ketoglutaric acid + NH4+ + NADPH glutamate + H2O + NADP+Glutamate, in this context, is not merely an end product but a central hub in nitrogen metabolism. It paves the way for the generation of other amino acids through a myriad of enzymatic transformations.2. Transamination:Transamination is a subsequent pathway integral to amino acid synthesis. Here, an amino group is shuttled from one amino acid (typically glutamic acid) to a keto acid, thereby synthesizing a new amino acid. The enzyme spearheading these reactions is termed transaminase.This transamination process is versatile, facilitating the synthesis of a diverse array of amino acids by shuttling the amino group between different keto acids. Such a mechanism ensures a rich repertoire of amino acids, each serving distinct roles in plant physiology.Moreover, specific amino acids, namely aspartic acid and glutamic acid, undergo further modifications. An additional amino group is appended to them, resulting in the formation of asparagine and glutamine, respectively. These compounds, termed amides, are pivotal for nitrogen storage and conveyance in plants, disseminating to various plant tissues via the xylem.In certain plants, like the soybean, nitrogen fixation in nodules yields ureides. These compounds also ascend with the sap due to transpiration and are instrumental in the plants internal nitrogen transport mechanism.The conversion of ammonium ions into amino acids in plants is a meticulously orchestrated process, encompassing the pathways of reductive amination and transamination. These pathways are indispensable for the seamless integration of nitrogen into amino acids, which subsequently form the foundation for proteins and other quintessential biomolecules. Through a well-regulated nitrogen metabolism, plants ensure the optimal utilization and distribution of nitrogen, underpinning their growth, development, and overall vitality.3. AmmonificationAmmonification, also referred to as mineralization, is a pivotal biochemical process in the nitrogen cycle. It encompasses the transformation of organic nitrogen compounds, such as proteins, amino acids, and nucleic acids, into inorganic ammonia or ammonium (NH4+).Mechanism of Ammonification: The genesis of ammonification lies in the decomposition of organic matter. As plants, fungi, and animals die and decompose, the nitrogenous compounds within them, including proteins and genetic materials, undergo breakdown. This degradation is facilitated by proteolytic enzymes, which hydrolyze these compounds, releasing ammonia into the surrounding soil or water.Role of Soil Organisms: A myriad of soil-dwelling organisms, including bacteria and fungi, play a central role in ammonification. These microorganisms metabolize organic matter, harnessing the carbon and energy it provides. However, in this metabolic process, nitrogen is extricated and released in the form of ammonia. This ammonia, once liberated, stands ready for subsequent processes in the nitrogen cycle, such as nitrification or direct assimilation.Ecological Implications: Ammonification is ubiquitous, occurring in both terrestrial and marine ecosystems. In terrestrial realms, it is predominantly executed by plants, fungi, and small fauna. Conversely, in marine ecosystems, the baton is passed to non-photosynthetic microorganisms. The ammonia produced through ammonification can be assimilated to synthesize nitrogenous compounds, thereby augmenting biomass. Alternatively, it can embark on the path of nitrification, where it is oxidized to nitrate.Specialized Processes: In environments devoid of oxygen (anoxic conditions), a specialized process known as dissimilative nitrate/nitrite reduction to ammonia (DNRA) can transpire. Here, ammonia is derived from nitrate or nitrite. This process is a hallmark of certain nitrate-reducing bacteria and fungi found in diverse habitats, ranging from ocean sediments and the human gastrointestinal tracts and wastewater treatment plants.Ammonification stands as a linchpin in the nitrogen cycle, bridging the gap between organic and inorganic nitrogen forms. By converting complex nitrogenous compounds into a more accessible form, ammonification ensures the perpetuation of the nitrogen cycle, sustaining life across ecosystems. This intricate process underscores the interconnectedness of life and the environment, highlighting the importance of each cog in the vast machinery of ecological processes.Implications of AmmonificationAmmonification, the process of converting organic nitrogen into inorganic ammonia or ammonium ions, has several implications that are crucial for the cycling and availability of nitrogen in ecosystems.Recycling of Nitrogen: Ammonification plays a key role in the recycling of nitrogen. When plants or animals die and their organic matter decomposes, the nitrogen contained in their tissues is released back into the soil in the form of ammonium ions. This recycling process ensures that nitrogen is continually available for uptake by plants and other organisms, supporting their growth and development.Nitrogen Utilization: Living organisms require nitrogen in various forms, such as ions, proteins, vitamins, and urea. Ammonification provides a pathway for converting organic nitrogen present in the remains of living organisms into inorganic forms that can be easily utilized by plants and other organisms. This availability of nitrogen is crucial for various biological processes, including protein synthesis and other essential cellular functions.Nutrient Cycling: Ammonification is an essential part of nutrient cycling in ecosystems. The release of ammonium into the soil makes nitrogen accessible to plants, which then take up this nitrogen and incorporate it into their tissues. As animals consume plants, they obtain nitrogen-containing compounds, and when these organisms die or excrete waste, the cycle continues through ammonification, completing the loop of nutrient cycling.Soil Fertility: Ammonification contributes to soil fertility by providing a continuous supply of nitrogen in an easily utilizable form. In ecosystems with decomposers that efficiently carry out ammonification, the soil becomes enriched with ammonium ions, promoting the growth of plants and supporting a diverse range of organisms within the ecosystem.Plant Adaptations: Certain plant species that thrive in acidic soils are particularly adapted to receive nitrogen most effectively through ammonification. The presence of ammonium ions in acidic soils favors the growth and development of these specialized plant species, allowing them to thrive in their specific environmental niches.Environmental Concerns: While ammonification is essential for nitrogen cycling, excessive levels of ammonia in the soil can have negative implications for ecosystems. For instance, when fertilizers are added to the soil to increase ammonia levels, it can lead to an overgrowth of algae in water bodies, causing eutrophication and disrupting aquatic ecosystems. Therefore, proper management of nitrogen-based fertilizers is essential to prevent environmental imbalances.4. DenitrificationDenitrification is a microbial-driven process that facilitates the conversion of nitrate (NO3) into gaseous nitrogen forms, primarily nitrogen gas (N2) and, to a lesser extent, nitrous oxide (N2O). This transformation, predominantly orchestrated by denitrifying bacteria, plays a pivotal role in the nitrogen cycle, ensuring the return of nitrogen to the atmosphere.1. Environmental Context:Denitrification predominantly occurs in environments characterized by limited oxygen availability, such as the deeper strata of soils proximate to the water table. Wetlands, with their saturated conditions, emerge as significant arenas for denitrification, aiding in the mitigation of surplus nitrogen levels.2. Mechanistic Insights:In the absence of sufficient oxygen, denitrifying bacteria employ nitrate as the terminal electron acceptor during cellular respiration. This initiates a cascade of enzymatic reactions, leading to the sequential reduction of nitrate to dinitrogen:NO3 NO2 NO N2O N2This progression involves a suite of enzymes, including nitrate reductase, nitrite reductase, nitric oxide reductase, and nitrous oxide reductase. However, not all denitrifying bacteria possess the complete set of these enzymes. As a result, some bacteria halt the reduction process prematurely, releasing intermediates like nitric oxide (NO) and nitrous oxide (N2O) into the atmosphere.3. Conditions Favoring Denitrification: Oxygen scarcityPresence of oxidizable organic matter as an energy sourceWarm soil temperaturesSlightly acidic soil pH4. ANAMMOX: An Alternative Pathway:Apart from denitrification, the nitrogen cycle also encompasses the anaerobic ammonium oxidation (ANAMMOX) process. Here, ammonium (NH4+) undergoes oxidation to yield dinitrogen gas (N2) in tandem with the reduction of nitrite (NO2):NH4+ + NO2 N2 + 2H2OThis autotrophic process is executed by specific Planctomycetes species, predominantly located in marine sediments and wastewater treatment plant sludge.Denitrification stands as a cornerstone in the nitrogen cycle, ensuring the cyclic return of nitrogen to the atmosphere. By transforming nitrates into gaseous nitrogen forms, it aids in maintaining the equilibrium of nitrogen compounds in terrestrial and aquatic ecosystems. This process, in conjunction with ANAMMOX, underscores the intricate web of microbial interactions that underpin the sustainability of our planets nitrogen balance.Denitrification Half Reactions in DenitrificationDenitrification often occurs by a mixture of the following half-reactions, with the enzyme involved being listed in brackets:NO3 + 2 H+ + 2 e NO2 + H2O (Enzyme involved: Nitrate reductase)NO2 + 2 H+ + e NO + H2O (Enzyme involved: Nitrite reductase)2 NO + 2 H+ + 2 e N2O + H2O (Enzyme involved: Nitric oxide reductase)N2O + 2 H+ + 2 e N2 + H2O (Enzyme involved: Nitrous oxide reductase)A net balanced redox reaction where nitrate (NO3) is completely reduced to dinitrogen (N2) can be expressed as follows:2 NO3 + 10 e + 12 H+ N2 + 6 H2OFactors affecting the denitrification processThe denitrification process, a crucial part of the nitrogen cycle, is influenced by various factors that affect the activity and efficiency of denitrifying microorganisms in the soil. These factors play a significant role in regulating the rate and extent of denitrification, thereby impacting nitrogen dynamics in ecosystems. The main factors affecting the denitrification process are as follows:Soil Organic Matter: Soil organic matter is one of the most influential factors in the denitrification process. Denitrifying bacteria depend on organic matter present in the soil as their primary source of sustenance. This organic matter can originate from plant residues, decaying organic materials, or other sources within the soil. The availability of readily decomposable organic matter enhances denitrification rates, as it provides the necessary carbon sources for the denitrifying microorganisms.Soil pH: Soil pH plays a significant role in denitrification. Denitrification is favored in neutral to slightly acidic soils (pH 6-7), as extreme pH levels can inhibit the activity of denitrifying bacteria. Acidic conditions can suppress denitrification, while alkaline conditions may limit the availability of nitrogen sources for denitrification to occur effectively.Soil Texture: Soil texture, referring to the proportions of sand, silt, and clay in the soil, can impact denitrification. Sandy soils with larger particle sizes tend to have better aeration and drainage, providing suitable conditions for denitrification to occur. In contrast, clayey soils with smaller particle sizes may have lower oxygen availability, which can affect denitrification rates.Temperature: Temperature is a crucial factor affecting denitrification rates. Denitrification is a microbial process, and the activity of denitrifying bacteria is influenced by temperature. Warmer temperatures generally enhance microbial activity, including denitrification, leading to higher rates of nitrogen loss as nitrogen gas.Soil Oxygen Concentration: Denitrification is an anaerobic process, meaning it occurs in the absence of oxygen. Therefore, the availability of oxygen in the soil can influence denitrification. Oxygenated soils tend to suppress denitrification, as the presence of oxygen competes with the denitrification process for microbial respiration.Soil Moisture Content: Soil moisture content is a critical factor affecting denitrification. Adequate soil moisture is required to support microbial activity, including denitrification. Waterlogged or excessively wet soils can promote anaerobic conditions, favoring denitrification.Nitrate Concentration in the Soil: The availability of nitrate (NO3-) in the soil is essential for denitrification to occur. Higher nitrate concentrations can support more denitrification activity. However, extremely high nitrate levels may lead to excessive denitrification, resulting in the loss of valuable nitrogen from the soil and negatively impacting nutrient availability for plants.BACTERIA IN THE NITROGEN CYCLENitrogen Cycle in Marine EcosystemMARINE NITROGEN CYCLEThe nitrogen cycle in marine ecosystems shares many similarities with the nitrogen cycle in terrestrial ecosystems but also exhibits some unique features due to the presence of marine microorganisms. Lets explore how the nitrogen cycle operates in marine environments:Nitrogen Input: Nitrogen enters marine ecosystems through various pathways, including precipitation, surface runoff, and atmospheric deposition. Atmospheric nitrogen, in the form of dinitrogen (N2), constitutes the largest portion of nitrogen in the atmosphere, and some of it dissolves in the water during rainfall and enters the ocean.Nitrogen Fixation: Nitrogen fixation is a crucial process in the marine nitrogen cycle, and it is primarily carried out by certain bacteria, also known as blue-green algae. These specialized marine microorganisms can convert atmospheric dinitrogen into a usable form, such as ammonia (NH3) or nitrate (NO3-). Some marine bacteria, like Trichodesmium, play a significant role in fixing nitrogen in open ocean waters.Phytoplankton Consumption: Phytoplankton, microscopic marine algae, play a vital role in the marine nitrogen cycle. They consume the nitrogen-rich cyanobacteria and utilize the nitrogen-containing compounds obtained from them for their growth and metabolic processes.Ammonia and Urea Excretion: As phytoplankton consume cyanobacteria, they excrete ammonia (NH3) and urea (CO(NH2)2) into the water. These nitrogenous waste products are released into the marine environment, contributing to the pool of available nitrogen compounds.Ammonia Transport: Due to processes like water mixing and sinking, the ammonia excreted by phytoplankton can be transported to lower depths in the ocean. This vertical transport helps to distribute nitrogen throughout different layers of the marine ecosystem.Nitrification: Bacteria in the marine environment convert ammonia into nitrites (NO2-) and nitrates (NO3-) through the process of nitrification. These nitrifying bacteria play a crucial role in converting ammonia, which is toxic at high concentrations, into less harmful nitrate forms.Phytoplankton Uptake: Nitrates are essential nutrients for marine organisms, especially phytoplankton. Nitrates in the water column are absorbed by phytoplankton, which use them to support their growth and photosynthetic activity.Denitrification: In some regions of the ocean, denitrifying bacteria perform denitrification, converting nitrate back into gaseous nitrogen (N2). This process releases dinitrogen into the atmosphere, completing the nitrogen cycle in the marine ecosystem.NITROGEN CYCLE IN MARINE ECOSYSTEMNitrogen as a limiting nutrientMany activities in natural ecosystems, including primary production and breakdown, are constrained by the availability of nitrogen. In other words, nitrogen is frequently the limiting nutrient, i.e., the nutrient that is in the smallest supply and so restricts the growth of organisms or populations.How do we determine if a nutrient is scarce? This is frequently evaluated as follows:Adding more of a limiting nutrient will increase plant growth; for instance, it will lead plants to grow taller than if nothing were supplied.If a non-limiting nutrient is added, it will have no effect; for example, plants will grow to the same height regardless of the presence or absence of the nutrient.Adding nitrogen to half of the bean plants in a garden and observing that they grow higher than untreated plants would indicate that nitrogen was limiting. If, however, we did not observe a difference in growth in our experiment, it would indicate that a nutrient other than nitrogen is limiting.Nitrogen and phosphorus are the two most prevalent limiting elements in both natural and agricultural ecosystems. If you examine a bag of fertiliser, you will notice that it includes a great deal of nitrogen and phosphorus.Human activity affects cycling of nitrogenHuman activities have a significant impact on the nitrogen cycle in the environment, leading to both positive and negative consequences. While humans cannot fix nitrogen organically, we do so industrially through the Haber-Bosch process, which converts atmospheric nitrogen (N2) into fixed nitrogen compounds, such as ammonia (NH3). This process is essential for the production of nitrogen-based fertilizers, which play a crucial role in modern agricultural food production.Industrial Nitrogen Fixation: Approximately 450 million metric tons of fixed nitrogen are produced annually through the industrial nitrogen fixation process. The majority of this fixed nitrogen is used to manufacture fertilizers that are widely used in agriculture to enhance crop yields. While this process has significantly contributed to global food production, it has also led to environmental concerns.Atmospheric Nitrogen Emissions: Human activities, such as the combustion of fossil fuels and the use of nitrogen-containing fertilizers, release nitrogen into the atmosphere. These emissions increase the concentrations of nitrogen-containing molecules in the atmosphere, such as nitric oxide (NO) and nitrous oxide (N2O). Nitric oxide can react with other atmospheric components to produce nitric acid (HNO3), contributing to the formation of acid rain, which can have detrimental effects on ecosystems and human infrastructure.Fertilizer Runoff and Eutrophication: One of the major environmental impacts of human nitrogen use is excessive fertilizer runoff. When nitrogen- and phosphorus-containing fertilizers are applied to agricultural fields, excess nutrients can be washed away by rainwater and enter nearby water bodies through surface runoff. This nutrient-rich runoff leads to eutrophication, a process where excessive nutrients cause algal blooms in lakes, rivers, and coastal waters.Algal Blooms and Dead Zones: Algal blooms occur when the excess nutrients from fertilizers stimulate the rapid growth of algae and other microorganisms in water bodies. As these organisms die and decompose, they consume large amounts of oxygen, leading to hypoxic or anoxic conditions in the water, known as dead zones. Dead zones can cause mass mortality of fish and other marine organisms, severely disrupting aquatic ecosystems.Greenhouse Gas Emissions: Nitrous oxide (N2O), a potent greenhouse gas, is released into the atmosphere as a byproduct of human activities like agricultural practices and industrial processes. It contributes to global warming and climate change.Bacteria play a key role in the nitrogen cycle.Bacteria play a crucial role in the nitrogen cycle, a biogeochemical process that regulates the flow of nitrogen through different ecosystems. Through various metabolic pathways, bacteria and other unicellular prokaryotes transform atmospheric nitrogen (N2) into physiologically useful forms, enabling the incorporation of nitrogen into living organisms.Nitrogen Fixation: Some bacteria have the remarkable ability to fix atmospheric nitrogen into a usable form. Nitrogen-fixing bacteria convert atmospheric nitrogen gas (N2) into ammonia (NH3), a physiologically useful form of nitrogen. These bacteria are either free-living in soil or water or form symbiotic relationships with plants. Rhizobium and Bradyrhizobium are examples of symbiotic bacteria that form nodules on the roots of leguminous plants, providing them with fixed nitrogen.Plant-Microbe Symbiosis: Nitrogen-fixing bacteria form a mutually beneficial relationship with plants. In plant roots, these bacteria reside in specialized structures called nodules, where they convert atmospheric nitrogen into ammonia for the plants use. In return, the plant provides the bacteria with carbohydrates and other nutrients.Nitrogen Assimilation: Once fixed by nitrogen-fixing bacteria, ammonia (NH3) is utilized by plants to produce organic molecules, including amino acids, proteins, and nucleic acids. When animals consume plants, they obtain these nitrogen-containing molecules, incorporating them into their bodies.Nitrogen Recycling: Nitrogen does not persist indefinitely in living organisms. When plants and animals die or excrete waste, organic nitrogen is returned to the environment. This is where bacteria play another vital role in the nitrogen cycle. Decomposers, mainly bacteria, break down organic nitrogen compounds from dead organisms and waste materials.Ammonification: In the process of ammonification, bacteria convert nitrogenous substances from dead organisms and waste into ammonia (NH3). This ammonia can then be used by other microorganisms or taken up by plants, continuing the nitrogen cycle.Nitrification: Bacteria further convert ammonia (NH3) into nitrites (NO2-) and nitrates (NO3-). This step in the nitrogen cycle is called nitrification and is essential for making nitrogen available to plants and other organisms in a form they can utilize.Denitrification: Denitrifying bacteria complete the nitrogen cycle by converting nitrates (NO3-) back into atmospheric nitrogen (N2) gas. This process occurs mainly in anaerobic conditions where oxygen is limited, such as waterlogged soils or sediments.The Danger of Too Much NitrogenWhile nitrogen is essential for plant and animal life, too much nitrogen can pose significant dangers to both human health and ecosystems. Excessive nitrates in the soil, water, and food can lead to various adverse effects, highlighting the importance of managing nitrogen use sustainably.Toxicity in Humans: High levels of nitrates in food or water can be directly toxic to humans. When consumed in large quantities, nitrates can increase the risk of cancer and interfere with blood chemistry, hindering the proper oxygen-carrying capacity of blood. Blue baby syndrome is a known side effect of excessive nitrate consumption in infants, where nitrates interfere with the bloods ability to carry oxygen, leading to cyanosis or bluish skin discoloration.Ecosystem Imbalance: Excessive nitrogen can disrupt natural ecosystems. Some organisms, like certain algae and plants, can thrive and grow rapidly when there is an abundance of nitrogen. This rapid growth can outcompete other organisms, leading to imbalances within ecosystems. For example, excessive nitrogen in water bodies can trigger the overgrowth of algae, resulting in algal blooms. These blooms can block sunlight and oxygen from reaching other aquatic organisms, leading to habitat degradation and harmful consequences for aquatic life.Red Tide and Harmful Algal Blooms: Nitrate fertilizer runoff into water bodies has been linked to the occurrence of harmful algal blooms, such as red tides and brown tides. These blooms are caused by toxin-producing algae, such as Pfiesteria bacteria. These toxins can sicken or kill marine organisms and pose health risks to humans and other animals that consume contaminated seafood.Disrupting Aquatic Food Webs: The excessive growth of certain algae and plants in response to high nitrogen levels can disrupt aquatic food webs. Some organisms may thrive, while others, like fish and other aquatic animals, may suffer due to habitat degradation or loss of food sources.Soil Degradation: Prolonged use of artificial nitrate fertilizers can lead to soil degradation and reduced fertility over time. The excessive application of nitrates can alter soil pH and nutrient balance, affecting the growth of crops and native plants.Finding Sustainable Solutions: Scientists are actively researching and developing sustainable agricultural practices to reduce reliance on artificial nitrate fertilizers. Natural or genetically engineered nitrogen-fixing plants are being explored as potential alternatives to traditional fertilizers. These practices aim to maintain soil fertility and crop yields without causing excessive nitrogen accumulation in the environment.Examples of the Nitrogen CycleExamples of the nitrogen cycle can be found in various real-life scenarios, showing the interconnectedness of nitrogen's movement in the environment. Here are three examples:Thanksgiving Story: The story of the first Thanksgiving highlights the significance of nitrogen in agriculture. When European settlers arrived in the Americas, they faced challenges in growing crops due to the lack of nitrogen in the soil. Without nitrogen-fixing crops or manure, which served as a common fertilizer in the old world, their crops struggled. However, they learned from the Native American Indians to bury dead fish in their crop fields. This practice restored nitrogen from the fishs proteins and nucleotides back to the soil, enriching it with essential nutrients. As a result, their crops flourished, and they learned valuable agricultural practices from the Native Americans, demonstrating the role of nitrogen in promoting plant growth.The Three Sisters: Native American tribes traditionally grew three crops together corn, beans, and squash known as the three sisters. This combination is ingenious for multiple reasons. Firstly, it provides a balanced diet with proteins containing all essential amino acids when these three plants are consumed together. Secondly, it includes a nitrogen-fixing plant beans. Beans have Rhizobium nodules in their roots, which contain bacteria capable of converting atmospheric nitrogen into a usable form for soil bacteria and plants. The nitrogen-fixing capability of beans benefits the surrounding soil, ensuring that it remains fertile for the growth of new plants, including corn and squash.Artificial Fertilizer: Modern agriculture heavily relies on artificial fertilizers, which are industrially produced nitrates that plants can directly utilize for growth. These fertilizers have revolutionized agriculture by providing an easily accessible source of nitrogen for crops, leading to increased food production. However, the use of artificial fertilizers also poses environmental challenges. Excessive application of fertilizers can lead to nutrient runoff into water bodies, causing algal blooms and eutrophication. The growth of toxic algae can have detrimental effects on ecosystems and even human health when it contaminates drinking water sources.Importance of Nitrogen CycleThe nitrogen cycle plays a vital role in maintaining the balance and sustainability of ecosystems. Its importance can be seen in various aspects of the natural world and human activities:Plant Growth and Chlorophyll Synthesis: Nitrogen is a crucial element required for the synthesis of chlorophyll, the green pigment responsible for photosynthesis in plants. Through the nitrogen cycle, nitrogen compounds are transformed into usable forms like nitrate and ammonium, which are essential for plant growth and development.Nitrogen Fixation: The nitrogen cycle involves nitrogen fixation, where specialized bacteria convert atmospheric nitrogen (N2) into ammonia (NH3), which can be utilized by plants. This process provides a renewable source of nitrogen for plants and contributes to maintaining soil fertility.Decomposition and Environmental Cleanup: Ammonification, a part of the nitrogen cycle, involves the breakdown of organic matter by bacteria. This decomposition helps in nutrient recycling and contributes to cleaning up the environment by breaking down dead plant and animal materials.Enriching Soil Nutrients: The conversion of nitrogen to nitrates and nitrites enriches the soil with essential nutrients required for plant growth. Plants take up these nitrogen compounds from the soil, which supports healthy plant growth and sustains diverse ecosystems.Formation of Biomolecules: Nitrogen is a crucial component of various biomolecules, including amino acids, proteins, and nucleic acids (DNA and RNA). These biomolecules are essential for the structure and function of living organisms, making nitrogen a fundamental element of life.Human Activities: The nitrogen cycle is impacted by human activities, such as the combustion of fossil fuels and the use of nitrogen-based fertilizers in agriculture. These activities increase the levels of nitrogen-containing compounds in the atmosphere, contributing to air pollution and affecting global nitrogen levels.Eutrophication: Excessive use of nitrogen-based fertilizers and wastewater runoff can lead to eutrophication in aquatic ecosystems. Elevated levels of nitrates and nitrites in water bodies promote the rapid growth of algae and other aquatic plants, leading to imbalances in the ecosystem and detrimental effects on other organisms.Quiz FAQDenitrification is a microbiological process that removes beneficial nitrogen from soil and releases the greenhouse gas nitrous oxide (N2O) and tropospheric pollutant nitric oxide (NO). The biological cycle of denitrification involves an enzyme cascade that converts nitrate to dinitrogen.When the soils oxygen (O2) supply becomes depleted, a variety of microorganisms use oxygen for respiration instead of nitrate. Denitrification happens most frequently in wet, moist, or flooded soil when the oxygen supply for respiration is limited or restricted. Some fungi are capable of denitrification, however they are regarded insignificant.Denitrification is more active in locations where the percentage of water-filled soil pores reaches 60 percent. The end-product gas is contingent on the conditions of the soil and the microbial community. As the oxygen deficiency grows, bacteria fulfil their jobs by converting an increasing amount of nitrate to dinitrogen (N2) gas. Denitrification occurs in the loss of valuable nitrogen (N) for the purposes of nutrient management, but the effects on the atmosphere will vary.The process by which bacteria convert atmospheric nitrogen into nitrites and nitrates is known as nitrogen fixation. It is utilised by plants, which then incorporates it into the food chain.Microorganisms that denitrify include Thiobacillus denitrificans and Micrococcus denitrificans.Denitrification decreases the quantity of soil nitrogen that is fixed.Nitrogen constitutes several cellular components and is vital in many biological functions. For instance, the amino acids include nitrogen and serve as the building blocks for hair, tissues, and muscles, among other components of the human body.Nitrogen is required by plants since it is an essential component of chlorophyll. As a result, chlorophyll is essential for photosynthesis, and a lack of nitrogen can result in deficiency illnesses such stunted growth and other abnormalities.Nitrogen FixationAssimilationAmmonificationNitrificationDenitrificationDuring the degradation of organic matter, ammonifying bacteria convert organic nitrogen into inorganic compounds such as ammonia and ammonium ions.Nitrification is the process by which bacteria convert ammonia to nitrate. The bacteria Nitrosomonas, Nitrococcus, etc., convert ammonia to nitrite (NO2), which is then transformed to nitrate (NO3) by Nitrobacter.Denitrification is the process by which bacteria such as Pseudomonas, Thiobacillus, Bacillus subtilis, etc. transform nitrate into molecular nitrogen.Nitrifying bacteria are a tiny category of aerobic bacteria primarily responsible for the transformation of ammonia into nitrates.Nitrogen fixation occurs spontaneously in the root nodules of the plant in the soil.ReferencesBurt, T. P. (2013). Nitrogen Cycle. Reference Module in Earth Systems and Environmental Sciences. doi:10.1016/b978-0-12-409548-9.00944-1Holland, E. A., & Weitz, A. M. (2003). Nitrogen Cycle, Biological. Encyclopedia of Physical Science and Technology, 441448. doi:10.1016/b0-12-227410-5/00940-6Karl, D. M., & Michaels, A. F. (2001). Nitrogen Cycle. Encyclopedia of Ocean Sciences, 18761884. doi:10.1006/rwos.2001.0275Widdison, P. E., & Burt, T. P. (2008). Nitrogen Cycle. Encyclopedia of Ecology, 25262533. doi:10.1016/b978-008045405-4.00750-3Karl, D. M., & Michaels, A. F. (2001). Nitrogen Cycle. Encyclopedia of Ocean Sciences, 3239. doi:10.1016/b978-012374473-9.00275-7Burt, T. P. (2013). Nitrogen Cycle. Reference Module in Earth Systems and Environmental Sciences. doi:10.1016/b978-0-12-409548-9.00944-1Gruber, N. (2008). The Marine Nitrogen Cycle. Nitrogen in the Marine Environment, 150. doi:10.1016/b978-0-12-372522-6.00001-3Global Nitrogen Cycle: Critical Enzymes, Organisms, and Processes for Nitrogen Budgets and Dynamics Xinning Zhang, Bess B. Ward, and Daniel M. Sigman Chemical Reviews 2020 120 (12), 5308-5351 DOI: 10.1021/acs.chemrev.9b00613Takai K. The Nitrogen Cycle: A Large, Fast, and Mystifying Cycle. Microbes Environ. 2019;34(3):223-225. doi: 10.1264/jsme2.ME3403rh. PMID: 31554776; PMCID: PMC6759337. //kids.frontiersin.org/articles/10.3389/frym.2019.00041 //www.vedantu.com/biology/nitrogen-cycle //cceonondaga.org/resources/nitrogen-basics-the-nitrogen-cycle //www.lenntech.com/nitrogen-cycle.htm //www.nature.com/scitable/knowledge/library/the-nitrogen-cycle-processes-players-and-human-15644632/ //royalsocietypublishing.org/doi/10.1098/rstb.2013.0164 //biologydictionary.net/nitrogen-cycle/ //en.wikipedia.org/wiki/Nitrogen_cycle The nitrogen cycle refers to the cycle of nitrogen atoms through the living and non-living systems of Earth. The nitrogen cycle is vital for life on Earth. Through the cycle, atmospheric nitrogen is converted to a form which plants can incorporate into new proteins. Nitrogen was originally formed in the hearts of stars through the process of nuclear fusion. When ancient stars exploded, they flung nitrogen-containing gases across the Universe. When the Earth was formed, nitrogen gas was the main ingredient in its atmosphere. Today, the Earths atmosphere is about 78% nitrogen, about 21% oxygen, and about 1% other gases. This is an ideal balance because too much oxygen can actually be toxic to cells. In addition, oxygen is flammable. Nitrogen, on the other hand, is inert and harmless in its gaseous form. However, nitrogen gas is not accessible to plants and animals for use in their cells.Here we will discuss how nitrogen plays a vital role in the chemistry of life and how it gets from the atmosphere, into living things, and back again. The basic steps of the nitrogen cycle are illustrated here:Nitrogen Cycle StepsWell discuss each part of the process below. In the process of nitrogen fixation, bacteria turn nitrogen gas from the atmosphere into ammonia.These nitrogen-fixing bacteria, often called diazotrophs, have an enzyme called nitrogenase which combines nitrogen atoms with hydrogen atoms. Ammonia is a nitrogen compound that can dissolve in water, and is easier for other organisms enzymes to interact with. Interestingly, the enzyme nitrogenase can only function when oxygen isnt present. As a result, organisms that use it have had to develop oxygen-free compartments in which to perform their nitrogen fixation!Common examples of such nitrogen-free compartment sare the Rhizobium nodules found in the roots of nitrogen-fixing legume plants. The hard casing of these nodules keeps oxygen out of the pockets where Rhizobium bacteria do their valuable work of converting nitrogen gas into ammonia.You can see the oxygen-free Rhizobium nodules, visible as big round lumps, on the roots of this cowpea plant:Rhizobia nodules on Vigna unguiculata In nitrification, a host of soil bacteria participate in turning ammonia into nitrate the form of nitrogen that can be used by plants and animals. This requires two steps, performed by two different types of bacteria.First, soil bacteria such as Nitrosomonas or Nitrococcus convert ammonia into nitrogen dioxide. Then another type of soil bacterium, called Nitrobacter, adds a third oxygen atom to create nitrate. These bacteria dont convert ammonia for plants and animals out of the goodness of their hearts. Rather, they are chemotrophs who obtain their energy from volatile chemicals. By metabolizing nitrogen along with oxygen, they obtain energy to power their own life processes.The process can be thought of as a rough (and much less efficient) analog to the cellular respiration performed by animals, which extract energy from carbon-hydrogen bonds and use oxygen as the electron acceptor, yielding carbon dioxide at the end of the process.Nitrates the end product of this vital string of bacterial reactions can be made artificially, and are the main ingredient in many soil fertilizers. You may actually hear such fertilizer referred to as nitrate fertilizer. By pumping the soil full of nitrates, such fertilizers allow plants to grow large quickly, without being dependent on the rate at which nitrogen-fixing bacteria do their jobs!Interestingly, high-energy environments such as lightning strikes and volcanic eruptions can convert nitrogen gas directly into nitrates but this doesnt happen nearly enough to keep modern ecosystems healthy on its own! In nitrogen assimilation, plants finally consume the nitrates made by soil bacteria and use them to make nucleotides, amino acids, and other vital chemicals for life.Plants take up nitrates through their roots and use them to make amino acids and nucleic acids from scratch. Animals that eat the plants are then able to use these amino acids and nucleic acids in their own cells. Now we have moved nitrogen from the atmosphere into the cells of plants and animals.Because there is so much nitrogen in the atmosphere, it may seem that the process could stop there but the atmospheres supply is not infinite, and keeping nitrogen inside plant and animal cells would eventually result in big changes to our soil, our atmosphere, and our ecosystems!Fortunately, thats not what happens. In a robust ecosystem like ours, anywhere that energy has been put into creating an organic chemical, there is another form of life that is waiting to extract that energy by breaking those chemical bonds.A process called ammonification is performed by soil bacteria which decompose dead plants and animals. During the process, these decomposers break down amino acids and nucleic acids into nitrates and ammonia and release those compounds back into the soil.There, the ammonia may be taken up again by plants and nitrifying bacteria. Alternatively, the ammonia may be converted back into atmospheric nitrogen through the process of denitrification. In the final step of the nitrogen cycle, anaerobic bacteria can turn nitrates back into nitrogen gas.This process, like the process of turning nitrogen gas into ammonia, must happen in the absence of oxygen. As such it often occurs deep in the soil, or in wet environments where mud and muck keep oxygen at bay.In some ecosystems, this denitrification is a valuable process to prevent nitrogen compounds in the soil from building up to dangerous levels. Nitrogen is an essential ingredient for life as we know it. Its unique chemical bonding properties allow it to create structures such as DNA and RNA nucleotides, and the amino acids from which proteins are built. Without nitrogen, these molecules would not be able to exist.Its thought that the first nucleotides and amino acids formed naturally under the volatile conditions of early Earth, where energy sources like lightning strikes could cause nitrogen and other atoms to react and form complex structuresThis process might have naturally produced self-replicating organic chemicals but in order to reproduce and evolve, life needed to figure out how to make these nitrogen compounds on demand.Today, nitrogen fixers are organisms that can turn nitrogen gas from the atmosphere into nitrogen compounds that other organisms can use to produce nucleic acids, amino acids, and more. These nitrogen fixers are such a vital part of the ecosystem that agriculture cannot occur without them.Ancient peoples learned that if they did not alternate growing nitrogen-consuming crops with nitrogen-fixing crops, their farms would become fallow and unable to support growth. Today, most artificial fertilizers contain life-giving nitrogen compounds as their main ingredient to make the soil more fertile. While the importance of nitrogen to plant and animal life might make it sound like theres no such thing as too much, there are actually some dangers that can arise from putting too many nitrates in the soil.Like anything else, nitrogen compounds can be toxic in high concentrations. Just like too much oxygen is toxic to air-breathers, plants can suffer harmful effects from nitrogen overdose. Nitrates can also be directly toxic to humans when consumed in large quantities in food or water, nitrates can increase cancer risks and interfere with blood chemistry, leaving blood unable to properly carry oxygen.Blue baby syndrome is one side effect seen in humans who consume high levels of nitrates in their food or water. Another acute worry is the danger of throwing ecosystems out of balance. Some organisms can use nitrogen compounds to grow faster than others and that means that when theres lots of nitrogen around, these organisms can grow so fast that they cause harm to other organisms.One concern that has been raised about the use of artificial nitrate fertilizer is that when it gets into rivers, lakes, and even the ocean, it can cause runaway growth of plant life there.More plant life might sound like a good thing but not when aquatic plants include algae that can block sun and oxygen from getting to other aquatic organisms, and even produce toxins that make humans and other animals sick!Nitrate fertilizer in water supplies has been blamed for some blooms of red tides, brown tides, and Pfiesteria bacteria all of which produce toxins that can sicken or kill humans and other animals.The question of how to keep farmlands fertile without using nitrate fertilizers is still being investigated by scientists. It is hoped that someday, sustainable practices using natural or genetically engineered nitrogen-fixing plants may allow farmers to produce high crop yields without adding high concentrations of artificial nitrates to the soil. The Story of ThanksgivingThe story of the first Thanksgiving goes that the pilgrims feasted with the Indians to celebrate their first harvest in the New World. But why was this harvest a big enough deal to throw a feast over? And why, exactly, was it important that the Indians and the European settlers ate together?When the European settlers came to the Americas, they had very little idea of how to survive here. Having worked farms in back in England for generations, the pilgrims assumed that farming here would be very much the same. That turned out not to be the case. The pilgrims had a difficult time growing or finding enough food to last them through the winter.One of the reasons for that was that there was not much nitrogen in the soil where the pilgrims landed. Their crops were not nitrogen-fixing, and they hadnt brought any large livestock. This was a major problem, as manure had been a common source of fertilizer in the old world. After trying in frustration to grow crops in the American soil, the Europeans were shown how to solve their problems by the American Indians.By burying dead fish in their crop fields, the pilgrims restored nitrogen from the fishs proteins and nucleotides to the ground. As a result, their crops flourished and the first European settlers learned from the American Indians how to survive in the New World. Some tribes of Native Americans traditionally grow three crops together corn, beans, and squash.Often referred to as the three sisters, this crop combination is ingenious for several reasons. For one, eating these three plants in combination provides humans with proteins containing all the essential amino acids.For another, it includes a nitrogen-fixing plant beans.The beans contain Rhizobium nodules in their roots, which contain bacteria that can convert atmospheric nitrogen into a form thats usable by soil bacteria and, ultimately, plants.Just like burying fish in the fields, growing beans alongside corn and squash assures that the soil does not become too depleted to grow new plants. Even a single crop of corn or squash may grow better alongside nitrogen-fixing beans, as their Rhizobium bacteria nurtures the surrounding soil! Humans first began fertilizing their crops using natural nitrogen-containing substances such, such as dead fish and animal manure. These waste products of animal life contained proteins, amino acids, and nucleotides which soil bacteria and plants could use to grow.Today, humans have discovered industrial processes which can turn ammonia into nitrates just like those produced by soil bacteria. Plants can use these nitrates directly, and human industry can produce them in large quantities.Unfortunately, the human impact on the nitrogen cycle makes changes to the environment, which can have unintended consequences. Just as artificial nitrates promote the growth of good plants like crops, they can also promote the growth of bad plants and algae that produce toxins and outcompete other life forms.This can be especially problematic when artificial fertilizers are carried by rainwater from farmlands and lawns into rivers and lakes. The result can be the growth of toxic algae that can strangle wetlands and even get into human drinking water. The nitrogen cycle is an ecological process that recycles nitrogen through the atmosphere, soil, and living organisms. The nitrogen cycle stages include nitrogen fixation, nitrification, assimilation, ammonification, and denitrification. All of them ensure that nitrogen is available for essential biological functions.In this article, we will cover in detail the nitrogen cycle definition and stages.What is Nitrogen Cycle?The nitrogen cycle is a natural process that recycles nitrogen through the environment. This cycle ensures its availability for all living organisms. The nitrogen cycle involves several key stages: nitrogen fixation, where atmospheric nitrogen is converted into ammonia by bacteria; nitrification which transforms ammonia into nitrites and then nitrates; assimilation, where plants absorb nitrates to build proteins; ammonification, where decomposers convert organic nitrogen back into ammonia; and denitrification, where bacteria return nitrogen to the atmosphere as gas. This cycle maintains the balance of nitrogen in the ecosystem, essential for the growth and survival of plants and animals.Stages of Nitrogen CycleThe various stages of nitrogen cycle are given below: Stage 1: Nitrogen FixationNitrogen fixation is the process where nitrogen gas (N) from the atmosphere is converted into ammonia (NH) or related compounds. This conversion is important because most organisms cannot use atmospheric nitrogen directly. Nitrogen fixation can occur in two primary ways:Biological Nitrogen Fixation: This is carried out by certain bacteria and archaea, known as diazotrophs. These microorganisms possess an enzyme called nitrogenase that can break the strong triple bond in nitrogen gas. Examples include Rhizobium, which forms symbiotic relationships with leguminous plants (like peas and beans), and free-living bacteria like Azotobacter.Non-biological Nitrogen Fixation: This includes processes like lightning, which provides enough energy to convert nitrogen gas and oxygen into nitrogen oxides (NO and NO). These oxides then dissolve in rainwater to form nitrates (NO), which plants can absorb.Stage 2: NitrificationNitrification is a two-step process that converts ammonia into nitrates, which plants can readily use. This process is carried out by specialized bacteria in the soil:Ammonia Oxidation: Ammonia (NH) is converted into nitrite (NO) by bacteria such as Nitrosomonas.Nitrite Oxidation: Nitrite is then converted into nitrate (NO) by bacteria such as Nitrobacter.These nitrifying bacteria play a crucial role in making nitrogen available to plants in a form they can absorb through their roots.Stage 3: Assimilation Assimilation is the process where plants absorb nitrates (NO) and ammonium ions (NH) from the soil through their roots. Once absorbed, these compounds are used to build plant proteins, nucleic acids, and chlorophyll. When animals eat plants, they assimilate nitrogen into their own bodies to form proteins and other essential compounds.Stage 4: AmmonificationAmmonification, also known as mineralization, occurs when organisms die or excrete waste products. Decomposers, such as bacteria and fungi, break down the organic nitrogen compounds (like proteins and nucleic acids) into ammonia (NH) or ammonium ions (NH). This process returns nitrogen to the soil, making it available for uptake by plants again.Stage 5: DenitrificationDenitrification is the process where nitrates (NO) in the soil are converted back into nitrogen gas (N) or nitrous oxide (NO) by anaerobic bacteria (bacteria that do not require oxygen). These bacteria, including species like Pseudomonas and Clostridium, thrive in waterlogged soils where oxygen is limited. Denitrification completes the nitrogen cycle by returning nitrogen to the atmosphere.Nitrogen Cycle Steps with DiagramThe diagram of nitrogen cycle with labelled steps are given below: Nitrogen Cycle Stages Explained with DiagramConclusion - Stages of Nitrogen Cycle In conclusion, the nitrogen cycle is a natural process that facilitates the recycling of nitrogen throughout the environment, ensuring its availability to all living organisms. Through its key stages of nitrogen fixation, nitrification, assimilation, ammonification, and denitrification, this cycle maintains the equilibrium of nitrogen in ecosystems, supporting the growth and survival of plants and animals. Understanding the intricacies of the nitrogen cycle underscores its importance in sustaining life on Earth and emphasizes the need for its conservation and management to preserve environmental balance.Also Read: The nitrogen cycle is thebiogeochemical process by which nitrogen in the environment gets converted into different chemical forms that living organisms may utilize.This cycle, which comprises a sequence of biological, chemical, and physical transformations in soil, water, and air, is critical for the survival of the ecosystems on Earth.Understanding and managing the nitrogen cycle correctly is critical for sustainable agriculture and conservation of the environment.Steps of Nitrogen cycleThe nitrogen cycle consists of the following steps:Nitrogen cycleStep 1Nitrogen FixationNitrogen gas (N2) from the earths atmosphere is turned to ammonia (NH3) or ammonium (NH4+) by nitrogen-fixing bacteria present in soil, water, and the roots of some plants.N2 + 8H+ + 8e + energy2NH3This process is carried out by nitrogen-fixing bacteria, which use energy from diverse sources such as sunlight or chemical compounds to turn atmospheric nitrogen gas (N2) into ammonia (NH3) or ammonium ions (NH4+).Nitrogen fixing bacteriaRhizobium, Bradyrhizobium, Azotobacter, Frankia, CyanobacteriaStep 2NitrificationNitrifying bacteria transform ammonia to nitrite (NO2) and finally into nitrate (NO3). The steps of this processit takes take place in soil or water and requires oxygen.NH3 + 2O2NO2 + 3H+ + 2e NO2 + H2ONO3 + 2H+ + 2eThese processes are carried out by nitrifying bacteria, that utilize oxygen to convert ammonia into nitrite (NO2) and subsequently into nitrate (NO3), releasing electrons and protons in the process.Nitrosomonas (converts ammonia to nitrite)Nitrobacter (converts nitrite to nitrate)Step 3AssimilationPlants uptake nitrate, which is utilized to synthesise nucleic acids and proteins.NO3 + H+ + eNO2 + H2O NO2 + H+ + eNH3 + H2OPlants and other organisms carry out these processes by using nitrate or nitrite to produce amino acids and various nitrogen-containing compounds.Step 4AmmonificationOrganic matter (dead plants and animals) is broken down by decomposers like bacteria and fungus, which releases ammonia back into the soil.Organic nitrogen compoundsNH3Decomposers, including bacteria and fungus, carry out this activity by dissolving the organic nitrogen molecules in dead plants and animals and releasing the ammonia back into the soil.Bacillus, Clostridium, Actinomycetes, Proteus, Pseudomonas, Escherichia coliStep 5DenitrificationNitrate is reprocessed by certain bacteria into nitrogen gas, which is then discharged into the atmosphere. This process takes place in habitats with low oxygen levels, such as wet soils or silt at the bottom of lakes and rivers.NO3NO2NON2ON2Pseudomonas, Paracoccus, Alcaligenes, Bacillus, AchromobacterIn natural ecosystems, the various stages are interrelated and continuously take place. The nitrogen cycle may go out of balance due to human activity, including the usage of fertilizers and the combustion of fossil fuels, which can have detrimental effects on the ecosystem.Importance of Nitrogen cycleThe earths ecosystems cannot function and cannot survive without the nitrogen cycle. The nitrogen cycle is crucial for a number of reasons, some of which are listed below:Essential nutrient: The nitrogen cycle enables the conversion of nitrogen into a form that plants can use. Nitrogen is a necessary ingredient for plant development.Protein synthesis: Proteins and nucleic acids, which are necessary for the growth and reproduction of all living things, are made up mostly of nitrogen.Soil fertility: By replacing nutrients that plants deplete, the nitrogen cycle helps to maintain soil fertility.Environmental equilibrium: The nitrogen cycle contributes to the preservation of the nutrient balance in aquatic environments, limiting the accumulation of surplus nutrients that can result in algal blooms and other negative impacts.Climate control: By managing the quantity of nitrogen in the atmosphere, which can impact the amount of greenhouse gases there, the nitrogen cycle contributes to the regulation of the global climate.Nitrogen fixation is the process by which atmospheric nitrogen gas (N2) is converted into ammonia (NH3) or ammonium (NH4+) by certain microorganisms, such as bacteria or cyanobacteria. Nitrogen fixation is essential for life on earth, as nitrogen is an essential nutrient for plant growth, and plants form the base of the food chain.Most plants and animals cannot use atmospheric nitrogen gas directly, as the nitrogen molecule is very stable and requires a lot of energy to break apart. Nitrogen fixation is therefore a crucial step in the nitrogen cycle, as it provides a source of usable nitrogen for plants and other organisms.There are two main types of nitrogen fixation: biological and industrial.Biological nitrogen fixation occurs naturally in soil and water, where certain bacteria form symbiotic relationships with plants and convert atmospheric nitrogen gas into ammonia, which can be taken up by the plants.Industrial nitrogen fixation, on the other hand, involves the use of high-pressure and high-temperature conditions to convert atmospheric nitrogen into ammonia, which is used to produce fertilizers and other industrial chemicals.Overall, nitrogen fixation is a key process in the global nitrogen cycle and plays a critical role in maintaining the health and productivity of ecosystems on earth.How Nitrogen cycle works?Nitrogen-fixing bacteria are a group of bacteria that have the unique ability to convert atmospheric nitrogen gas (N2) into ammonia (NH3) or ammonium (NH4+), which can be used by plants to synthesize amino acids and other nitrogen-containing compounds. These bacteria are commonly found in soil, water, and the roots of certain plants.There are two main types of nitrogen-fixing bacteria:These bacteria are found in soil and water and can fix atmospheric nitrogen on their own without forming any symbiotic relationships with plants.Some examples of free-living nitrogen-fixing bacteria include Azotobacter and Clostridium.These bacteria form symbiotic relationships with plants, where they live inside nodules on the roots of leguminous plants such as peas, beans, and clover. The bacteria fix atmospheric nitrogen and provide it to the plant, while the plant provides the bacteria with nutrients and a protective environment.Examples of symbiotic nitrogen-fixing bacteria include Rhizobium and Bradyrhizobium. Home Biology The movement of nitrogen between theatmosphere,biosphere, andgeospherein different forms is called thenitrogen cycle and is one of the majorbiogeochemical cycles. It may also be considered as the movement of nitrogen through the food chain from simple inorganic compounds, mainly ammonia, to complex organic compounds. This complex cycle involves bacteria, plants, and animals. All organisms can convert ammonia (NH3) to organic nitrogen compounds that are compounds containing CN bonds. However, only a few microorganisms can synthesize ammonia from nitrogen gas (N2). Although N2 gas makes up about 80% of the earths atmosphere, it is a chemically unreactive compound and thus needs to be changed in order to be utilized by living beings. Within the biosphere, there is a balance between total inorganic and total organic forms of nitrogen. The conversion of organic to inorganic nitrogen comes about through catabolism, de-nitrification, and decay. Nitrogen Cycle Process The first stage in the nitrogen cycle is the reduction of N2 gas to ammonia, a process called nitrogen fixation. The process of converting atmospheric N2 gas into ammonia is carried out by only a few microorganisms, termed diazotrophs which have an enzyme called nitrogenase that combines nitrogen atoms with hydrogen atoms. These are some free-living soil bacteria such as Klebsiella and Azotobacter, cyanobacteria (blue-green algae), and the symbiotic bacteria (mainly Rhizobium). The amount of N2 fixed by these diazatrophic microorganisms has been estimated to be in the order of 1011 kg per year, about 60% of the earths newly fixed nitrogen. Lightning and ultraviolet radiation fix another 15%, with the remainder coming from industrial processes. Ammonia can also be obtained by the reduction of the nitrate ion (NO3) that is present in the soil. Nitrate reduction can be carried out by most plants and microorganisms. The ammonia resulting from these two processes can then be assimilated by all organisms. Reaction: N2 + 3 H2> < 2 NH3 This process is carried out by the nitrogenase complex, which consists of a reductase and an ironmolybdenum-containing nitrogenase. At least 16 ATP molecules are hydrolyzed to form two molecules of ammonia. Leghemoglobin is used to protect the nitrogenase in the Rhizobium from inactivation by O2.Nitrification is a two-step process in which NH3/ NH4+ is converted to NO3 . First, the soil bacteriaNitrosomonasandNitrococcusconvert NH3 to NO2, and then another soil bacterium,Nitrobacter, oxidizes NO2 to NO3. These bacteria are chemotrophs who obtain their energy from volatile chemicals.They gain energy through these conversions, both of which require oxygen to occur. Nitrosomonas Nitrobacter [NH4+] > NO2- -> NO3- Ammonium pH 4 10 nitrite pH 6 9 nitrate Optimum conditions for nitrification: Adequate aeration Optimum temperature 25 35oC Adequate soil moisture Adequate exchangeable bases particularly Calcium (Ca) NPK availability Requires a low C/N ratioThe next step in the nitrogen cycle is the assimilation of inorganic nitrogen, into organic nitrogen-containing compounds. It is the process by which plants and animals incorporate the NO3 and ammonia formed through nitrogen fixation and nitrification. All organisms assimilate ammonia via two main reactions catalyzed by glutamate dehydrogenase and glutamine synthetase giving rise to the amino acids glutamate (Glu) and glutamine (Gln), respectively. The amino nitrogen in Glu and the amide nitrogen in Gln are then used in further biosynthetic reactions to give rise to other compounds. Glutamate dehydrogenase Glutamate dehydrogenase catalyzes the reductive amination of the citric acid cycle intermediate -ketoglutarate. Although the reaction is reversible, the reductant used in the biosynthetic reaction is NADPH. This enzyme is also involved in the catabolism of amino acids. Glutamine synthetase Glutamine synthetase catalyzes the incorporation of ammonia into glutamine, deriving energy from the hydrolysis of ATP. This enzyme is named a synthetase, rather than a synthase because of the reaction couples bond formation with the hydrolysis of ATP. In contrast, a synthase does not require ATP. Plants take up these forms of nitrogen through their roots and incorporate them into plant proteins and nucleic acids. Animals are then able to utilize nitrogen from the plant tissues.Assimilation produces large quantities of organic nitrogen, including proteins, amino acids, and nucleic acids. Ammonificationis the conversion of organic nitrogen into ammonia. Here, organic nitrogen from dead plants and soil organisms is converted to ammonium (NH4+) by mineralization. Mineralization is the decomposition of organic matter to NH4+ which is a useable nutrient ion. Many different soil organisms are involved in the ammonification process including bacteria and fungi. These soil organisms break down organic matter using the carbon and energy produced, but nitrogen is released. Ammonia is also released by the process of excretion into the environment and is then available for either nitrification or assimilation.Denitrification refers to the change (via denitrifying bacteria) of nitrate to gaseous forms of nitrogen such as nitrogen gas (N2) or nitrous oxide (N2O). The process is rapid and large amounts of N2 are lost from the soil system and end up in the atmosphere. This process only occurs where there is little to no oxygen, such as deep in the soil near the water table. Hence, areas such as wetlands provide a valuable place for reducing excess nitrogen levels via denitrification processes. Conditions favoring denitrification: Lack of adequate O2 Requires energy source of oxidizable organic matter for bacteria Warm, slightly acidic soils. The nitrogen cycle illustrates the relationship between different forms of nitrogen in the soil, water, air, and living organisms. It is considered to be a cycle since nitrogen moves around from place to place in different forms but is always present. It is important for the following reasons: Neither plants nor animals can obtain nitrogen directly from the atmosphere and thus depend on the nitrogen fixation process. Nitrogen (N) is an essential component ofDNA,RNA, andproteins, the building blocks of life. Allorganismsrequire nitrogen to live and grow. Nitrogen is a key part of amino and nucleic acids and also an important part ofATP, which is the basic energy molecule for living things.NITROGEN FIXATION: The process of nitrogen gas is converted into ammonia by lightning or bacteria. NITRIFICATION: The process of ammonia being converted into nitrates and nitrites. AMMONIFICATION: The process of dead organisms breaking down into ammonia. DENITRIFICATION: The process of nitrates and nitrites being converted into nitrogen gas or gaseous nitrogen.David Hames and Nigel Hooper (2005). Biochemistry. Third ed. Taylor & Francis Group: New York. About Author The nitrogen cycle refers to the cycle of nitrogen atoms through the living and non-living systems of Earth. The nitrogen cycle is vital for life on Earth. Through the cycle, atmospheric nitrogen is converted to a form which plants can incorporate into new proteins. Nitrogen was originally formed in the hearts of stars through the process of nuclear fusion. When ancient stars exploded, they flung nitrogen-containing gases across the Universe. When the Earth was formed, nitrogen gas was the main ingredient in its atmosphere. Today, the Earths atmosphere is about 78% nitrogen, about 21% oxygen, and about 1% other gases. This is an ideal balance because too much oxygen can actually be toxic to cells. In addition, oxygen is flammable. Nitrogen, on the other hand, is inert and harmless in its gaseous form. However, nitrogen gas is not accessible to plants and animals for use in their cells.Here we will discuss how nitrogen plays a vital role in the chemistry of life and how it gets from the atmosphere, into living things, and back again. The basic steps of the nitrogen cycle are illustrated here:Nitrogen Cycle StepsWell discuss each part of the process below. In the process of nitrogen fixation, bacteria turn nitrogen gas from the atmosphere into ammonia.These nitrogen-fixing bacteria, often called diazotrophs, have an enzyme called nitrogenase which combines nitrogen atoms with hydrogen atoms. Ammonia is a nitrogen compound that can dissolve in water, and is easier for other organisms enzymes to interact with. Interestingly, the enzyme nitrogenase can only function when oxygen isnt present. As a result, organisms that use it have had to develop oxygen-free compartments in which to perform their nitrogen fixation!Common examples of such nitrogen-free compartment sare the Rhizobium nodules found in the roots of nitrogen-fixing legume plants. The hard casing of these nodules keeps oxygen out of the pockets where Rhizobium bacteria do their valuable work of converting nitrogen gas into ammonia.You can see the oxygen-free Rhizobium nodules, visible as big round lumps, on the roots of this cowpea plant:Rhizobia nodules on Vigna unguiculata In nitrification, a host of soil bacteria participate in turning ammonia into nitrate the form of nitrogen that can be used by plants and animals. This requires two steps, performed by two different types of bacteria.First, soil bacteria such as Nitrosomonas or Nitrococcus convert ammonia into nitrogen dioxide. Then another type of soil bacterium, called Nitrobacter, adds a third oxygen atom to create nitrate. These bacteria dont convert ammonia for plants and animals out of the goodness of their hearts. Rather, they are chemotrophs who obtain their energy from volatile chemicals. By metabolizing nitrogen along with oxygen, they obtain energy to power their own life processes.The process can be thought of as a rough (and much less efficient) analog to the cellular respiration performed by animals, which extract energy from carbon-hydrogen bonds and use oxygen as the electron acceptor, yielding carbon dioxide at the end of the process.Nitrates the end product of this vital string of bacterial reactions can be made artificially, and are the main ingredient in many soil fertilizers. You may actually hear such fertilizer referred to as nitrate fertilizer. By pumping the soil full of nitrates, such fertilizers allow plants to grow large quickly, without being dependent on the rate at which nitrogen-fixing bacteria do their jobs!Interestingly, high-energy environments such as lightning strikes and volcanic eruptions can convert nitrogen gas directly into nitrates but this doesnt happen nearly enough to keep modern ecosystems healthy on its own! In nitrogen assimilation, plants finally consume the nitrates made by soil bacteria and use them to make nucleotides, amino acids, and other vital chemicals for life.Plants take up nitrates through their roots and use them to make amino acids and nucleic acids from scratch. Animals that eat the plants are then able to use these amino acids and nucleic acids in their own cells. Now we have moved nitrogen from the atmosphere into the cells of plants and animals.Because there is so much nitrogen in the atmosphere, it may seem that the process could stop there but the atmospheres supply is not infinite, and keeping nitrogen inside plant and animal cells would eventually result in big changes to our soil, our atmosphere, and our ecosystems!Fortunately, thats not what happens. In a robust ecosystem like ours, anywhere that energy has been put into creating an organic chemical, there is another form of life that is waiting to extract that energy by breaking those chemical bonds.A process called ammonification is performed by soil bacteria which decompose dead plants and animals. During the process, these decomposers break down amino acids and nucleic acids into nitrates and ammonia and release those compounds back into the soil.There, the ammonia may be taken up again by plants and nitrifying bacteria. Alternatively, the ammonia may be converted back into atmospheric nitrogen through the process of denitrification. In the final step of the nitrogen cycle, anaerobic bacteria can turn nitrates back into nitrogen gas.This process, like the process of turning nitrogen gas into ammonia, must happen in the absence of oxygen. As such it often occurs deep in the soil, or in wet environments where mud and muck keep oxygen at bay.In some ecosystems, this denitrification is a valuable process to prevent nitrogen compounds in the soil from building up to dangerous levels. Nitrogen is an essential ingredient for life as we know it. Its unique chemical bonding properties allow it to create structures such as DNA and RNA nucleotides, and the amino acids from which proteins are built. Without nitrogen, these molecules would not be able to exist.Its thought that the first nucleotides and amino acids formed naturally under the volatile conditions of early Earth, where energy sources like lightning strikes could cause nitrogen and other atoms to react and form complex structuresThis process might have naturally produced self-replicating organic chemicals but in order to reproduce and evolve, life needed to figure out how to make these nitrogen compounds on demand.Today, nitrogen fixers are organisms that can turn nitrogen gas from the atmosphere into nitrogen compounds that other organisms can use to produce nucleic acids, amino acids, and more. These nitrogen fixers are such a vital part of the ecosystem that agriculture cannot occur without them.Ancient peoples learned that if they did not alternate growing nitrogen-consuming crops with nitrogen-fixing crops, their farms would become fallow and unable to support growth. Today, most artificial fertilizers contain life-giving nitrogen compounds as their main ingredient to make the soil more fertile. While the importance of nitrogen to plant and animal life might make it sound like theres no such thing as too much, there are actually some dangers that can arise from putting too many nitrates in the soil.Like anything else, nitrogen compounds can be toxic in high concentrations. Just like too much oxygen is toxic to air-breathers, plants can suffer harmful effects from nitrogen overdose. Nitrates can also be directly toxic to humans when consumed in large quantities in food or water, nitrates can increase cancer risks and interfere with blood chemistry, leaving blood unable to properly carry oxygen.Blue baby syndrome is one side effect seen in humans who consume high levels of nitrates in their food or water. Another acute worry is the danger of throwing ecosystems out of balance. Some organisms can use nitrogen compounds to grow faster than others and that means that when theres lots of nitrogen around, these organisms can grow so fast that they cause harm to other organisms.One concern that has been raised about the use of artificial nitrate fertilizer is that when it gets into rivers, lakes, and even the ocean, it can cause runaway growth of plant life there.More plant life might sound like a good thing but not when aquatic plants include algae that can block sun and oxygen from getting to other aquatic organisms, and even produce toxins that make humans and other animals sick!Nitrate fertilizer in water supplies has been blamed for some blooms of red tides, brown tides, and Pfiesteria bacteria all of which produce toxins that can sicken or kill humans and other animals.The question of how to keep farmlands fertile without using nitrate fertilizers is still being investigated by scientists. 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The pilgrims had a difficult time growing or finding enough food to last them through the winter.One of the reasons for that was that there was not much nitrogen in the soil where the pilgrims landed. Their crops were not nitrogen-fixing, and they hadnt brought any large livestock. This was a major problem, as manure had been a common source of fertilizer in the old world. After trying in frustration to grow crops in the American soil, the Europeans were shown how to solve their problems by the American Indians.By burying dead fish in their crop fields, the pilgrims restored nitrogen from the fishs proteins and nucleotides to the ground. As a result, their crops flourished and the first European settlers learned from the American Indians how to survive in the New World. Some tribes of Native Americans traditionally grow three crops together corn, beans, and squash.Often referred to as the three sisters, this crop combination is ingenious for several reasons. For one, eating these three plants in combination provides humans with proteins containing all the essential amino acids.For another, it includes a nitrogen-fixing plant beans.The beans contain Rhizobium nodules in their roots, which contain bacteria that can convert atmospheric nitrogen into a form thats usable by soil bacteria and, ultimately, plants.Just like burying fish in the fields, growing beans alongside corn and squash assures that the soil does not become too depleted to grow new plants. Even a single crop of corn or squash may grow better alongside nitrogen-fixing beans, as their Rhizobium bacteria nurtures the surrounding soil! Humans first began fertilizing their crops using natural nitrogen-containing substances such, such as dead fish and animal manure. These waste products of animal life contained proteins, amino acids, and nucleotides which soil bacteria and plants could use to grow.Today, humans have discovered industrial processes which can turn ammonia into nitrates just like those produced by soil bacteria. Plants can use these nitrates directly, and human industry can produce them in large quantities.Unfortunately, the human impact on the nitrogen cycle makes changes to the environment, which can have unintended consequences. Just as artificial nitrates promote the growth of good plants like crops, they can also promote the growth of bad plants and algae that produce toxins and outcompete other life forms.This can be especially problematic when artificial fertilizers are carried by rainwater from farmlands and lawns into rivers and lakes. The result can be the growth of toxic algae that can strangle wetlands and even get into human drinking water. 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As a result, organisms that use it have had to develop oxygen-free compartments in which to perform their nitrogen fixation!Common examples of such nitrogen-free compartment sare the Rhizobium nodules found in the roots of nitrogen-fixing legume plants. The hard casing of these nodules keeps oxygen out of the pockets where Rhizobium bacteria do their valuable work of converting nitrogen gas into ammonia.You can see the oxygen-free Rhizobium nodules, visible as big round lumps, on the roots of this cowpea plant:Rhizobia nodules on Vigna unguiculata In nitrification, a host of soil bacteria participate in turning ammonia into nitrate the form of nitrogen that can be used by plants and animals. This requires two steps, performed by two different types of bacteria.First, soil bacteria such as Nitrosomonas or Nitrococcus convert ammonia into nitrogen dioxide. Then another type of soil bacterium, called Nitrobacter, adds a third oxygen atom to create nitrate. 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By pumping the soil full of nitrates, such fertilizers allow plants to grow large quickly, without being dependent on the rate at which nitrogen-fixing bacteria do their jobs!Interestingly, high-energy environments such as lightning strikes and volcanic eruptions can convert nitrogen gas directly into nitrates but this doesnt happen nearly enough to keep modern ecosystems healthy on its own! In nitrogen assimilation, plants finally consume the nitrates made by soil bacteria and use them to make nucleotides, amino acids, and other vital chemicals for life.Plants take up nitrates through their roots and use them to make amino acids and nucleic acids from scratch. Animals that eat the plants are then able to use these amino acids and nucleic acids in their own cells. Now we have moved nitrogen from the atmosphere into the cells of plants and animals.Because there is so much nitrogen in the atmosphere, it may seem that the process could stop there but the atmospheres supply is not infinite, and keeping nitrogen inside plant and animal cells would eventually result in big changes to our soil, our atmosphere, and our ecosystems!Fortunately, thats not what happens. In a robust ecosystem like ours, anywhere that energy has been put into creating an organic chemical, there is another form of life that is waiting to extract that energy by breaking those chemical bonds.A process called ammonification is performed by soil bacteria which decompose dead plants and animals. During the process, these decomposers break down amino acids and nucleic acids into nitrates and ammonia and release those compounds back into the soil.There, the ammonia may be taken up again by plants and nitrifying bacteria. Alternatively, the ammonia may be converted back into atmospheric nitrogen through the process of denitrification. In the final step of the nitrogen cycle, anaerobic bacteria can turn nitrates back into nitrogen gas.This process, like the process of turning nitrogen gas into ammonia, must happen in the absence of oxygen. As such it often occurs deep in the soil, or in wet environments where mud and muck keep oxygen at bay.In some ecosystems, this denitrification is a valuable process to prevent nitrogen compounds in the soil from building up to dangerous levels. Nitrogen is an essential ingredient for life as we know it. Its unique chemical bonding properties allow it to create structures such as DNA and RNA nucleotides, and the amino acids from which proteins are built. Without nitrogen, these molecules would not be able to exist.Its thought that the first nucleotides and amino acids formed naturally under the volatile conditions of early Earth, where energy sources like lightning strikes could cause nitrogen and other atoms to react and form complex structuresThis process might have naturally produced self-replicating organic chemicals but in order to reproduce and evolve, life needed to figure out how to make these nitrogen compounds on demand.Today, nitrogen fixers are organisms that can turn nitrogen gas from the atmosphere into nitrogen compounds that other organisms can use to produce nucleic acids, amino acids, and more. These nitrogen fixers are such a vital part of the ecosystem that agriculture cannot occur without them.Ancient peoples learned that if they did not alternate growing nitrogen-consuming crops with nitrogen-fixing crops, their farms would become fallow and unable to support growth. 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What are the 4 steps in nitrogen cycle. What is the steps of nitrogen cycle. List and describe the biological steps in the nitrogen cycle.