<u>ECOLOGY</u>

UNDERSTANDING ECOLOGY, THE DISCIPLINE

The subject of **ecology** will help us explore the 'living world' that exists on the earth. Let us first understand as to what this term 'ecology' means? The word '**ecology**' is derived from the Greek words *oikos*, meaning household, and *logos*, meaning study. Literally then, ecology is the study of 'life at home'. In other words, ecology is the study of the interconnections and interdependences of plants, animals and their environment.

Scientists use the word ecosystem to describe a particular environment and all the living things that are supported by it. An ecosystem can be as small as a pond or as large as a desert. What is important in an ecosystem is how the living parts of the ecosystem relate to the nonliving parts.

The essence of ecology lies in the study of the togetherness of everything— plants, animals, microorganisms and their environment.

Ecosystems: An ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. Such interactions sustain the system and allow it to respond to changing conditions. Thus an ecosystem includes the community, the nonliving components and their interactions.

The sum total of all the ecosystems on planet Earth is called the **biosphere**, which includes all the earth's living organisms interacting with the physical environment as a whole to maintain a steady-state ecosystem.

5. <u>Ecosystems:</u>

An ecosystem is the combination of an area's <u>abiotic</u> and <u>biotic</u> factors.

<u>Abiotic Features:</u>

- air
- water
- rainfall
- temperature
- soil
- rocks
- elevation
- humidity

<u>Biotic Features:</u>

ANYTHING LIVING!!!

Now let's think of your house like an ecosystem! What are the abiotic factors of your home and the biotic ones?

Definitions:

Biomass	Refers to the total mass of living plants, animals, fungi, and bacteria in a given area
Energy Flow	Flow of energy from an ecosystem to an organism and from organism to organism
Producers	Produce food in the form of carbs during photosynthesis
Consumers	Eat food produced by consumers. Consumers can become energy for other consumers if they are eaten
Decomposition	Breaking down of organic wastes and dead organisms
Biodegradation	The action of living organisms such as bacteria to break down dead organism.
Decomposers	Changes waste and dead organisms into useable nutrients.
Autotrophs	Use energy from the environment to fuel the assembly of simple inorganic compounds to complex organic compounds.
Herbivores	Eat Plants only
Carnivores	Eat meat only
Omnivores	Eat both
Detrivores	Feed on plant and animal remains and other dead material (Earthworms, snails, crabs)
Decomposers	Break down organic matter (Bacteria or Fungus)

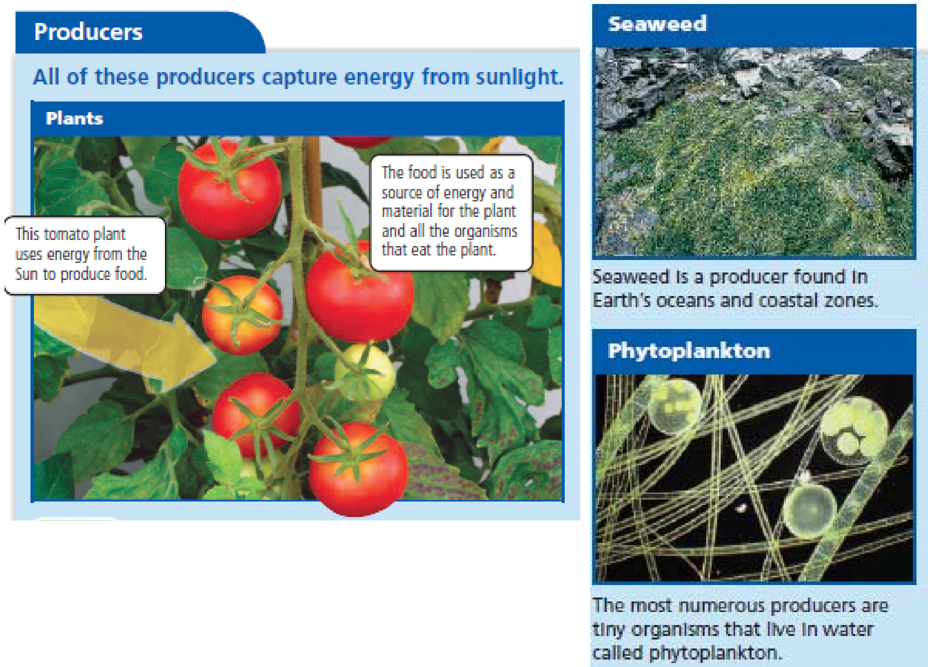
Producers

A producer is an organism that captures energy and stores it in food as chemical energy. The producers of an ecosystem make energy available to all the other living parts of an ecosystem. Most energy enters ecosystems through photosynthesis. Plants, and other photosynthetic organisms, take water and carbon dioxide from their environment and use energy from the Sun to produce sugars. The chemical energy stored in sugars can be released when sugars are broken down.

Plants are the most common producers found in land ecosystems. In water ecosystems, most food is produced by photosynthetic bacteria and algae. A few examples of producers that use photosynthesis are shown in the photographs above.

The Sun provides most of the energy that is stored in food. One exception is the unusual case of a type of bacteria that lives in the deep ocean, where there is no sunlight. These bacteria produce food using heated chemicals released from underwater vents. This process is called chemosynthesis.

In the absence of light, organisms can use chemical energy to produce carbohydrates, which is called chemosynthesis. This happens in deep ocean plant, which cannot get sunlight from the sun!

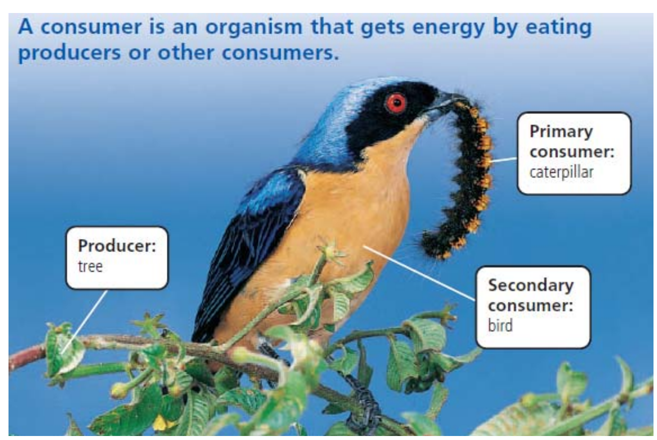


Consumers

Organisms that cannot produce their own food must get their food from other sources. Consumers are organisms that get their energy by eating, or consuming, other organisms. To understand how energy flows through an ecosystem, you have to study feeding relationships. A feeding relationship starts with a producer, followed by one and often many more consumers.

Consumers are classified by their position in a feeding relationship. Ecosystems also have special consumers called scavengers, like the vulture, which is a consumer that feeds on dead animals.

In the photograph (RHS), energy enters the ecosystem through the tree, which is the producer. The caterpillar that gets its energy by feeding on the leaves is the first, or primary, consumer. The bird that gets its energy by feeding on the caterpillar is a secondary consumer.

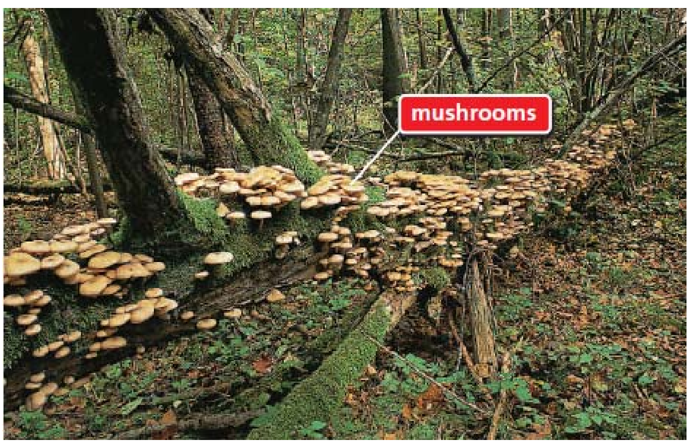


Decomposers

If you've been for a hike through a forest, or a walk through a park, you have seen the interaction of producers and consumers. Tall trees and leafy shrubs are home to many insects and the birds that feed upon the insects. Also important to the maintenance of an ecosystem are decomposers, a group of organisms that often go unseen. Decomposers are organisms that break down dead plant and animal matter into simpler compounds.

You can think of decomposers as the clean-up crew of an ecosystem. In a forest, consumers such as deer and insects eat a tiny fraction of the leaves on trees and shrubs. The leaves that are left on the forest floor, as well as dead roots and branches, are eventually digested by fungi and bacteria living in the soil. Decomposers also break down animal remains, including waste materials. A pinch of soil may contain almost half a million fungi and billions of bacteria.

The energy within an ecosystem gets used up as it flows from organism to organism. Decomposers are the organisms that release the last bit of energy from once-living matter. Decomposers also return matter to soil or water where it may be used again and again.



Models help explain feeding relationships

You have learned how energy is captured by producers and moved through ecosystems by consumers and decomposers. Scientists use two different models to show the feeding relationships that transfer energy from organism to organism. These models are food chains and food webs.

FOOD CHAINS

In an ecosystem, the sequential chain of eating and being eaten is called a **food chain**. It is this process which determines how energy moves from one organism to another within the system. In a food chain, energy (organic form) is transferred from one organism to another. Ideally, this transfer or flow of energy from the sun to green plants to herbivores to carnivores should be 100 per cent efficient. But in reality this does not happen, because at each link in a food chain, 80 to 90 per cent of the energy transferred is lost as heat (second law of thermodynamics). It is because of this loss that fewer individuals are found at each successive level of the food chain (e.g. fewer carnivores than herbivores). This also limits the number of levels in a food chain. All organisms are part of a food chain, and may be part of more than one.

Food chains usually consist of producers, primary consumers, secondary consumers, tertiary consumers and decomposers. Every organism in an ecosystem can be assigned a feeding level, referred to as the **trophic level**. A trophic level consists of those organisms in food chains that are the same number of steps away from the original source of energy. Green plants would be grouped in the first trophic level (producers), herbivores in the second trophic level (primary consumers), and carnivores in the third (secondary consumers) and so on.

A grasshopper eats the grass, a frog eats the grasshopper, and a snake eats the frog and is in turn eaten by a peacock. When these creatures die they are all consumed by decomposers (bacteria, fungi, etc.).

Grass →	Grasshopper →	Toad →	Snake →	Hawk →	Nothing may be here
Simplified Below					
Autotrophs (Producers)	**Herbivores** (Primary Consumers	**Carnivores** (2^{nd}, 3^{rd}, 4^{th}, order consumers)			No more than 5 levels in a chain.

Bacteria feed at EVERY trophic level!

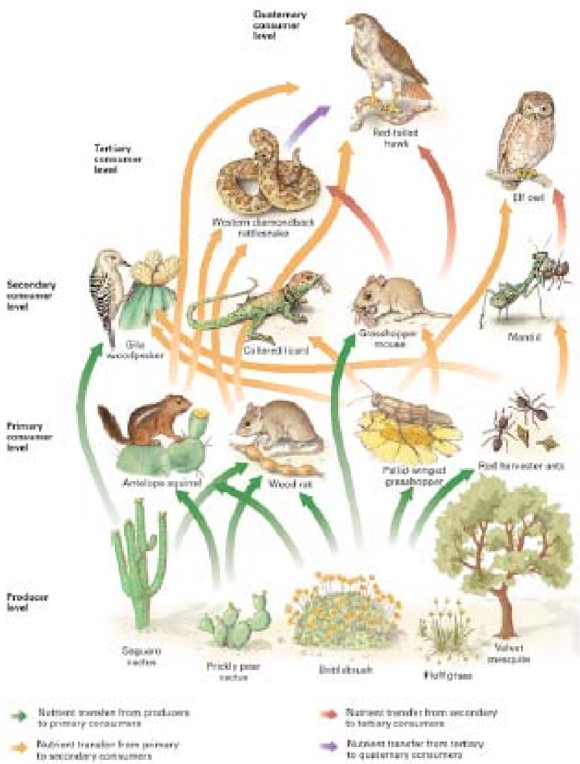
Types of Food Chains

Though all food chains comprise of a series of living organisms which are interdependent on each other for food and hence energy, they may not always be similar. In nature there are two major types of food chains: the first starts from a base of green plants and goes on to herbivores and finally to carnivores. This is called the grazing food chain. The other starts from a base of dead organic matter, proceeding to a variety of other organisms, including scavengers, insects and microorganisms, and is called the detritus food chain. Grazing food chains and detritus food chains are linked, as dead organisms from the grazing food chain form the base for the detritus food chain. This in turn provides nutrients vital to green plants. One could not exist without the other.

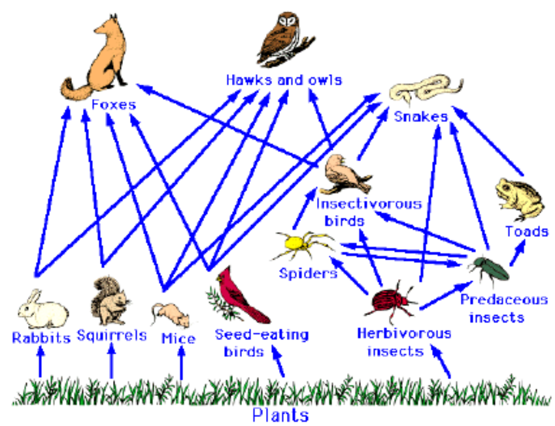
FOOD WEBS

A food web is a model of the feeding relationships between many different consumers and producers in an ecosystem. A food web is more like a spider web, with many overlapping and interconnected food chains. A number of food chains interwoven with one another give rise to a structure similar to the delicate web of a spider. These interlocking patterns formed by several food chains that are linked together are called **food webs**. It is a better model for the complex feeding relationships in an ecosystem, which usually has many different producers, with many primary and secondary consumers.

A food web shows how one consumer can play several roles in an ecosystem. Both food chains and food webs show how different organisms receive their energy. They also show how different organisms depend on one another. If one organism is removed from the food web or food chain, it may affect many other organisms in the ecosystem.



NOTE: **Carnivores:** Usually eat at least 2 different herbivores. Why?



LIVING THINGS CAPTURE AND RELEASE ENERGY

All living things need a source of energy to stay alive and grow. Everything you do—running, reading, and working—requires energy. The energy you use is chemical energy, which comes from the food you eat. When you go for a run, you use up energy. Some of that energy is released to the environment as heat, as you sweat. Eventually, you will need to replace the energy you've used.

Energy is vital to all living things. Most of that energy comes either directly or indirectly from the Sun. To use the Sun's energy, living things must first capture that energy and store it in some usable form. Because energy is continuously used by the activities of living things, it must be continuously replaced in the ecosystem.

Temperature, light, soil, and water are important nonliving factors in ecosystems. The student knows that the interactions of organisms with each other and with the non-living parts of their environments result in the flow of energy and the cycling of matter throughout the system.

Nutrient cycles are the link between abiotic and biotic components of ecosystems. By the process of nutrient cycling, the nutrients from their pool (mainly in the soil, in some cases the atmosphere), fuelled by the energy from the sun, get converted into organic substances, then enter into a chain of biotic elements through food chains (more on food chains in the next unit). From there herbivores eat the plant and carnivores eat the herbivores. It is a simple interaction that passes energy up the food chain. Again, as the biotic components finish their life-cycles and die, the nutrients come back to their pool.

UNDERSTANDING ENERGY FLOW

It is a fact that any kind of 'work process' will either require or release energy. Thus if we want to study the functioning or the working of an ecosystem, we must understand the basic principles and laws of thermodynamics, in an ecological context as energy flow in ecosystems is governed by the two laws of thermodynamics:

(i) The first law of thermodynamics states that energy may be transformed from one type into another but is neither created nor destroyed. The ecological implication of these laws is that energy cannot be produced in ecosystems from nowhere.

(ii) The second law states that no energy transformations are hundred per cent efficient, i.e. energy is always being transformed from a more useful to a less useful form. Transfer of energy from one organism to the other, is never hundred per cent efficient, i.e. all energy transformations always involve energy loss in the form of heat energy that is not available to the organism. The amount of loss may vary from one transformation process to the other, but it invariably occurs.

(iii) Under natural conditions, energy tends to flow from higher level to the lower one. This is a derivation from the second law of thermodynamics. Energy movement is always unidirectional (from a higher end to a lower end) and hence this movement is called 'energy flow'.

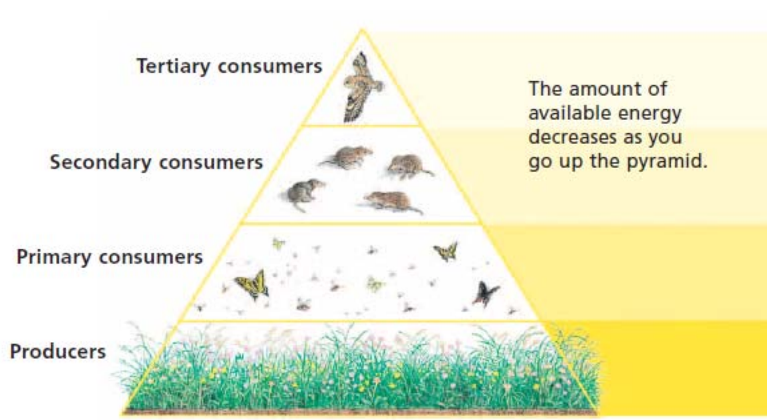
The energy (from sun) that enters the earth's atmosphere as heat and light is balanced by the energy that is absorbed by the biosphere, plus the amount that leaves the earth's surface as invisible heat radiation (first law of thermodynamics). When solar energy strikes the earth, it tends to be degraded into heat energy. Only a very small part (about 10 per cent) of this energy gets absorbed by the green plants, and is subsequently transformed into food energy. The food energy then flows through a series of organisms in ecosystems. All organisms, dead or alive, are potential sources of food for other organisms.

Rule of 10

• This is the concept that only 10% of the available energy at ANY trophic level gets transferred to the next highest level.

3rd order consumers (10 kilocalories)
2nd order consumers (100 kilocalories)
1st order consumers (1,000 kilocalories)
Producers (10,000 kilocalories)

Another way to picture the flow of energy in an ecosystem is to use an energy pyramid. An energy pyramid is a model that shows the amount of energy available at each feeding level of an ecosystem. The first level includes the producers, the second level the primary consumers, and so on. Because usable energy decreases as it moves from producers to consumers, the bottom level is the largest. The available energy gets smaller and smaller the farther up the pyramid you go.



All ecosystems need certain materials.

Living things depend on their environment to meet their needs. You can think of those needs in terms of the material, or matter, required by all living things. For example, all organisms take in water and food in order to survive. All of the materials an organism takes in are returned to the ecosystem, while the organism lives or after it dies.

Nutrient cycling : linking the biotic and abiotic

In nature, the nutrient elements and their compounds continuously move from nonliving environment to the living organisms and back to the nonliving environment. The cyclic movement of minerals from their reservoirs (air, water and soil), to the living components, and back to the reservoirs is called nutrient cycling or biogeochemical cycles. These complex series of invisible, delicately balanced, and interrelated biochemical reactions fuel life on earth. These nutrient cycles, driven directly or indirectly by incoming solar energy and gravity, include the carbon, oxygen, nitrogen, phosphorous, sulphur and hydrologic (water) cycles. Nutrients are available on the earth in fixed quantities. In nature, the nutrient cycles operate in a balanced manner.

(i): You know that the interactions of organisms with each other and with the non-living parts of their environments result in the flow of energy and the cycling of matter throughout the system.

(ii): You also know that all biotic and abiotic factors are interrelated and that if one factor is changed or removed, it impacts the availability of other resources within the system.

Human activities have impacted these cycles leading to disbalance in nature. For example, humans have intervened in earth's phosphorous cycle in three ways.

a) By mining large quantities of phosphate rock mainly for use in inorganic fertilizers and detergents; b) A lot of available phosphate is removed by humans in the process of cutting large numbers of trees in the rainforests (where once the trees are cut, the soil nutrient gets washed away very rapidly in the rains, making the forest land unproductive); c) adding excess phosphate to aquatic ecosystems in runoff of animal wastes (from livestock), runoff of fertilizers from cropland, and also discharge of sewage (detergents have very high level of phosphates). We have already looked at the impacts of too much nutrients in water bodies (refer to eutrophication). Scientists estimate that human activities have increased the natural rate of phosphorous release into the environment by over 3 folds. This is just one example of human interference into the natural cycling of nutrients. Such changes in turn have influenced both abiotic as well as the biotic components of nature.

Each nutrient e.g. carbon, oxygen, phosphorous, magnesium and so on, follows a unique cycle. Some elements like oxygen and nitrogen, cycle quickly and so are readily available for use by organisms. Others, such as phosphorous, magnesium, etc., take time for cycling, as they are released slowly. It is usually such slow cycling nutrients that become the limiting factors for plant growth. It is for this reason that such nutrients are supplied to crop species through synthetic fertilizers.

Water Cycle

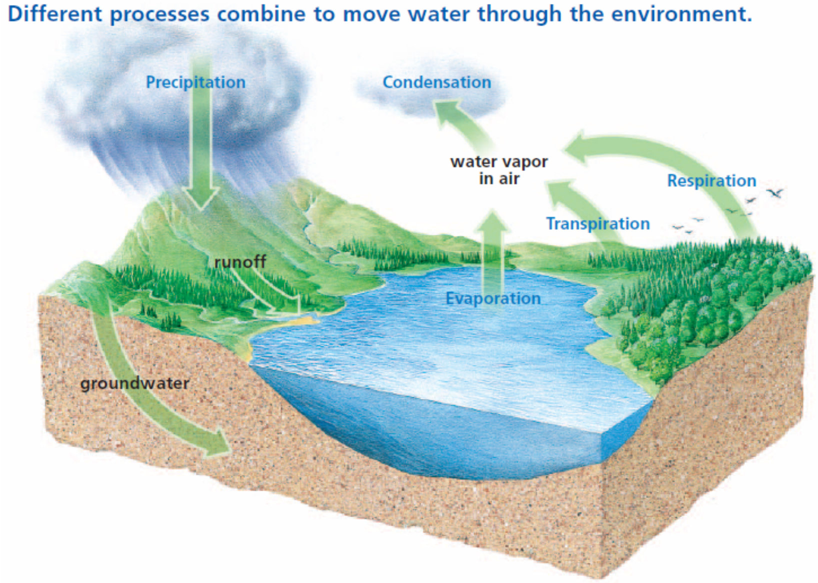
Water is stored on Earth's surface in lakes, rivers, and oceans. Water is found underground, filling the spaces between soil particles and cracks in rocks. Large amounts of water are stored in glaciers and polar ice sheets. Water is also part of the bodies of living things. But water is not just stored, it is constantly moving. The movement of water through the environment is called the water cycle.

Did you know it takes one water molecule about 4000 years to make it through the cycle!

As water moves through an ecosystem, it changes in physical form, moving back and forth between gas, liquid, and solid. Water in the atmosphere is usually in gaseous form—water vapor. Water that falls to Earth's surface is referred to as precipitation. For precipitation to occur, water vapor must condense—it must change into a liquid or solid. This water can fall as rain, snow, sleet, mist, or hail.

Water returns to the atmosphere when heated, changing back into vapor, a process called evaporation. Living things also release water vapor. Animals release water vapor when they breathe, or respire. Plants release water vapor through a process called transpiration.

Different processes combine to move water through the environment.

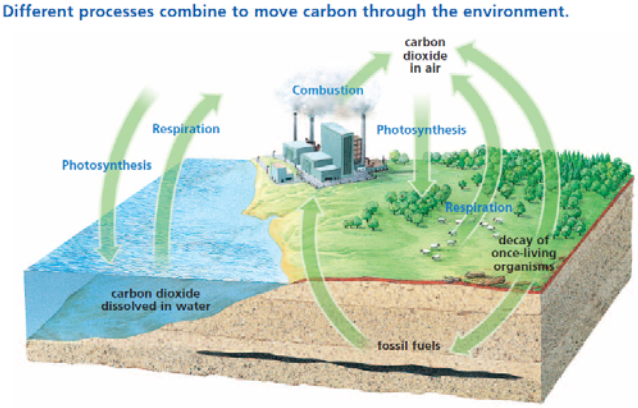


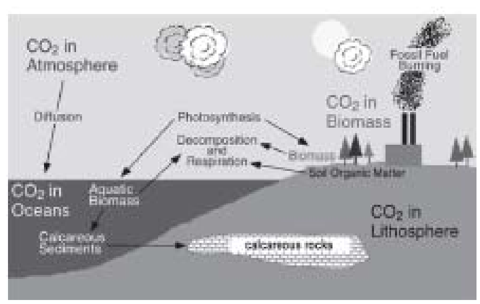
Carbon cycles through ecosystems.

Carbon is an element found in all living things. Carbon moves through Earth's ecosystems in a cycle referred to as the carbon cycle. It is through carbon dioxide gas found in Earth's atmosphere that carbon enters the living parts of an ecosystem.

Plants use carbon dioxide to produce sugar—a process called photosynthesis. Sugars are carbon compounds that are important building blocks in food and all living matter. Food supplies the energy and materials living things need to live and grow. To release the energy in food, organisms break down the carbon compounds—a process called respiration. Carbon is released and cycled back into the atmosphere as carbon dioxide. When living things die and decay, the rest of the carbon that makes up living matter is released.

Different processes combine to move carbon through the environment.





Carbon Cycle

The oceans also play a major role in regulating the level of carbon-di-oxide in the atmosphere. Earth's oceans contain far more carbon than the air does. In water ecosystems—lakes, rivers, and oceans—carbon dioxide is dissolved in water. Algae and certain types of bacteria are the photosynthetic organisms that produce food in these ecosystems. Marine organisms, too, release carbon dioxide during respiration. Also, in these ecosystems, some organisms use carbon-di-oxide or other forms of carbon to build shells and skeletons. When these organisms die and as their bodies settle down at the bottom of the oceans, the carbon contained in them gets stored in the ocean floor. In fact most of the earth's carbon is stored in the ocean floor sediments and on the continents. This carbon enters the cycle at a very slow pace as the sediments dissolve. This carbon then becomes dissolved in the water and then enters the atmosphere.

Large amounts of carbon are stored underground. The remains of plants and animals buried for millions of years decay slowly and change into fossil fuels, such as coal and oil. The carbon in fossil fuels returns to ecosystems in a process called combustion. As humans burn fossil fuels to release energy, dust particles and gases containing carbon are also released into the environment.

Estimated major stores of carbon on the Earth.

Sink	Amount in Billions of Metric Tons
Atmosphere	578 (as of 1700) - 766 (as of 1999)
Soil Organic Matter	1500 to 1600
Ocean	38,000 to 40,000
Marine Sediments and Sedimentary Rocks	66,000,000 to 100,000,000
Terrestrial Plants	540 to 610
Fossil Fuel Deposits	4000

At this point it is important to understand that Carbon plays a key role in the temperature regulation mechanism of our earth (refer 'Green House Effect')—If too much carbon is removed, the earth will cool; if too much Carbon is generated, the earth will get hotter.

NITROGEN CYCLES THROUGH ECOSYSTEMS

Nitrogen is another element important to life that cycles through Earth in the nitrogen cycle. Almost four-fifths of the air you breathe is clear, colorless nitrogen gas. Yet, you cannot get the nitrogen you need to live from the air. All animals must get nitrogen from plants. Plants cannot use pure nitrogen gas either. However, plants can absorb certain compounds of nitrogen. Plants take in these nitrogen compounds through their roots, along with water and other nutrients.

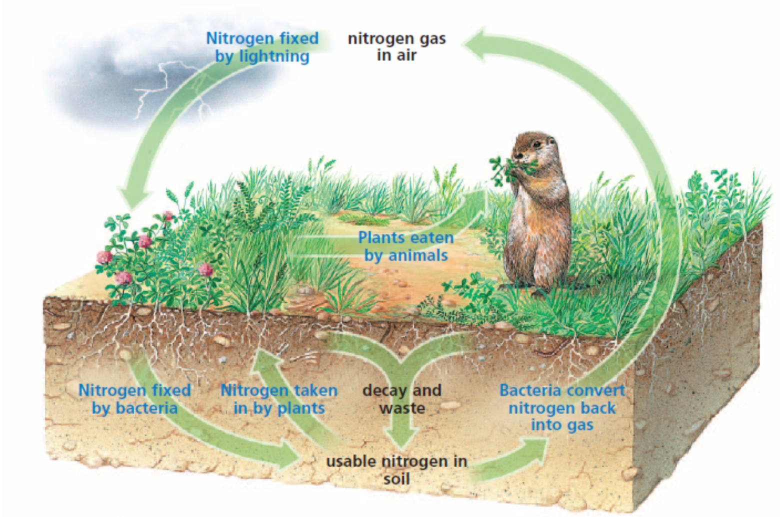
So how does the nitrogen from the atmosphere get into the soil?

(i) One source is lightning. Every lightning strike breaks apart, or fixes, pure nitrogen, changing it into a form that plants can use. This form of nitrogen falls to the ground when it rains.

(ii) A far greater source of nitrogen is nitrogen-fixing bacteria. These bacteria live in the oceans as well as the soil. Some even attach themselves to the roots of certain plants, like alfalfa or soybeans.

When organisms die, decomposers in the ocean or soil break them down. Nitrogen in the soil or water is used again by living things. A small amount is returned to the atmosphere by certain bacteria that can break down nitrogen compounds into nitrogen gas.

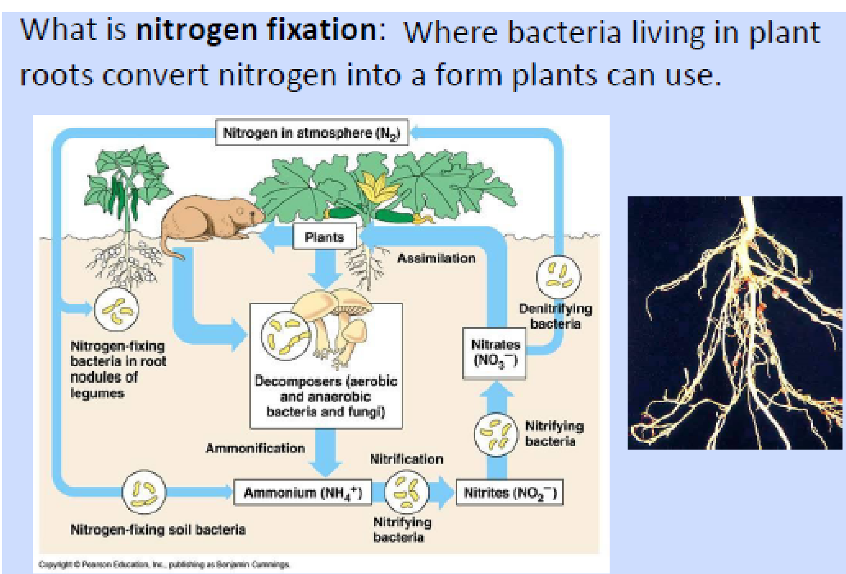
Different processes combine to move nitrogen through the environment.



When Nitrogen is circulating in nutrient subcycles, it undergoes a series of reversible oxi-red reactions. Nitrogeneous organic mols like proteins converted to NH_3, NO_2-, NO_3-

- $\text{Org N} \rightarrow NH_3 \xrightarrow{O2} NO_2^- \xrightarrow{O2} NO_3^-$

Plants take up NH_3, NOs dissolved in soil-pore water and convert them into proteins, DNA. Animals get their Nitrogen by eating plants or plant eating animals



Nitrogen Cycle

- Nitrogen Fixation
- Nitrification
- Ammonification/mineralization
- Denitrification

Bacteria involved in different steps:

- N2 fixation
- Nitrification
- Ammonification
- Denitrification

- Cyanobacteria and rhizobium
- Autotrophic bacteria: Nitrosomonas and nitrobacter
- Ammonifying bacteria
- Facultative heterotrophic bacteria like: Bacterium denitrificans :Pseudomonas anchromobacter

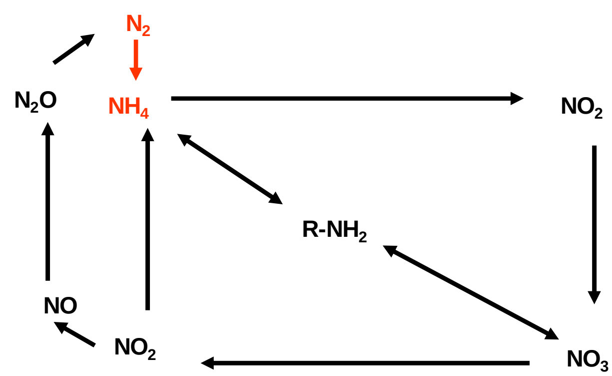
Nitrogen fixation

Conversion of atmospheric nitrogen to other chemical forms. There are two main ways nitrogen is '*fixed*':

Fixation by Lightning

The energy from lightning causes nitrogen (N_2) and water (H_2O) to combine to form ammonia (NH_3) and nitrates (NO_3). Precipitation carries the ammonia and nitrates to the ground, where they can be assimilated by plants.

Biological Fixation



About 90% of nitrogen fixation is done by bacteria present in water soil and root nodules of legumes alfalfa, beans. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$
Ammonia can be used by plants directly. Ammonia and ammonium ion may be further reacted in the nitrification process (*consider the red portion of the diagram*).

Energy intensive process :

$N_2 + 8H^+ + 8e^- + 16\ ATP = 2NH_3 + H_2 + 16ADP + 16\ Pi$

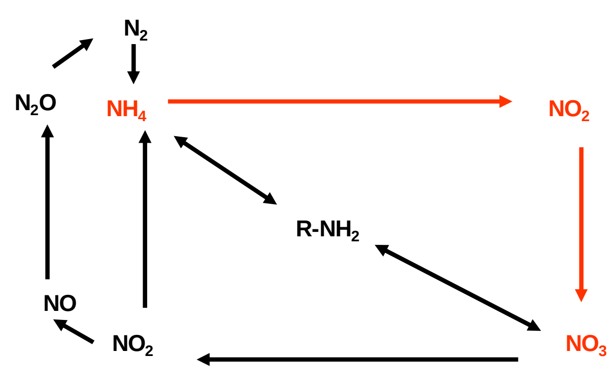
Performed only by selected bacteria and actinomycetes Performed in nitrogen fixing crops (ex: soybeans)

NITRIFICATION

Two step reactions (*consider the red portion only*) that occur together :

- 1^{rst} step catalyzed by *Nitrosomonas*

  $2\ NH_4^+ + 3\ O_2 \rightarrow 2\ NO_2^- + 2\ H_2O + 4\ H^+$
- 2^{nd} step catalyzed by *Nitrobacter*
- $2\ NO_2^- + O_2 \rightarrow 2\ NO_3^-$



Optimal pH is between 6.6-8.0

If $pH < 6.0 \rightarrow$ rate is slowed

If $pH < 4.5 \rightarrow$ reaction is inhibited

Ammonification or Mineralization

Plants die or bacterial cells lyse → release of organic nitrogen

Organic nitrogen is converted to inorganic nitrogen (NH_3)

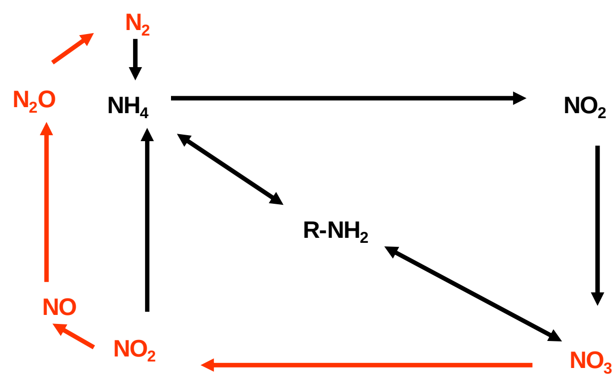
When pH<7.5, converted rapidly to NH_4^+

- Decomposers: earthworms, termites, slugs, snails, bacteria, and fungi
- Uses extracellular enzymes → initiate degradation of plant polymers
- Microorganisms uses:
- Proteases, lysozymes, nucleases to degrade nitrogen containing molecules

Denitrification

- Removes a limiting nutrient from the environment
- $4NO_3^- + C_6H_{12}O_6 \rightarrow 2N_2 + 6\ H_2O$

Through denitrification, oxidized forms of nitrogen such as nitrate and nitrite (NO_2-) are converted to dinitrogen (N_2) and, to a lesser extent, nitrous oxide gas (consider the red portion of the diagram).



Denitrification is an anaerobic process that is carried out by denitrifying bacteria, which convert nitrate to dinitrogen in the following sequence:

$NO_3\text{-} \rightarrow NO_2\text{-} \rightarrow NO \rightarrow N_2O \rightarrow N_2$.

Nitric oxide and nitrous oxide are both environmentally important gases. Nitric oxide (NO) contributes to smog, and nitrous oxide (N_2O) is an important greenhouse gas, thereby contributing to global climate change.

Once converted to dinitrogen, nitrogen is unlikely to be reconverted to a biologically available form because it is a gas and is rapidly lost to the atmosphere. Denitrification is the only nitrogen transformation that removes nitrogen from ecosystems (essentially irreversibly), and it roughly balances the amount of nitrogen fixed by the nitrogen fixers described above.

PHOSPHORUS CYCLES THROUGH ECOSYSTEMS

• Phosphorus exists in several allotropic forms: white (or yellow), red, violet and black.

• Never found free in nature, it is widely distributed in combination with minerals. Phosphate rock, which contains the mineral apatite, an impure calcium phosphate, is an important source of the element.

Apatite
$[Ca_5(PO_4)_3(OH, F, Cl)]$

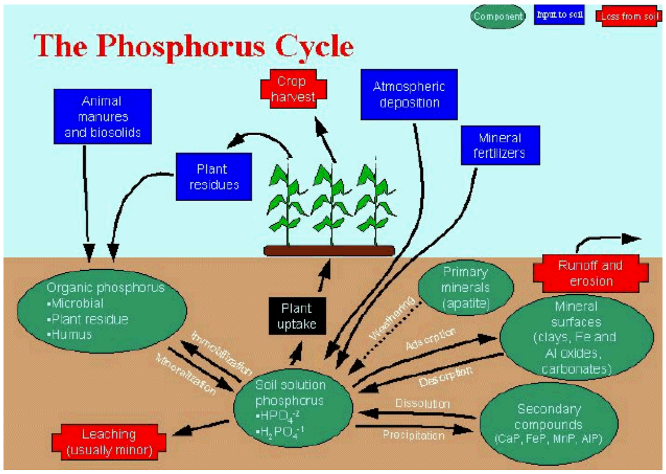
Phosphorus is the second most abundant mineral in the human body, surpassed only by calcium. It makes up more than 20 percent of the mineral ash in the body, about one percent of total body weight. Nearly 80 percent of the P in humans is found in bones and teeth. The remainder is widely distributed…in combination with proteins, fats, and salts. Mineral supplements containing P may be prescribed by doctors when a P deficiency is diagnosed. Strong teeth and bones depend on an adequate supply of P.

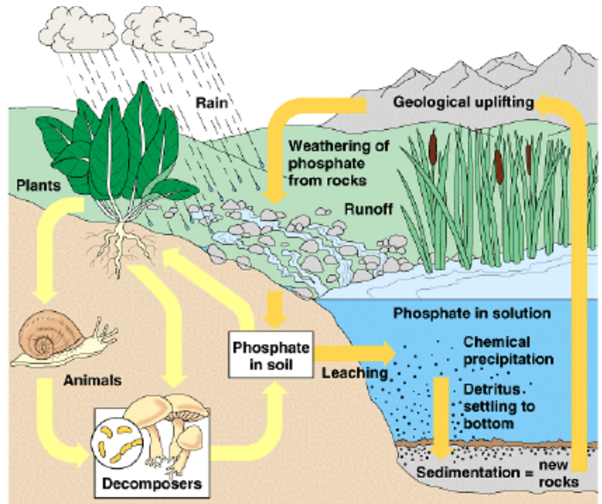
- The phosphorus cycle has no atmospheric component
- The phosphorous cycle is largely restricted to solid and liquid phases.
- Unlike N cycle, major source of reactive P is not through microbial reactions
- Only 10% of P from rivers to oceans is available to marine biota; rest tied to soil and deposited quickly
- The major sink is burial in marine sediments. Marine phosphorite deposits are mined and reintroduced to the cycle by man's activities.
- Unlike nitrogen, phosphorus cycling includes significant inorganic (mineral) reactions that make it much more difficult to study.
- A second major difference is that gaseous P (phosphine, PH3) is negligible in biogeochemical cycles and can be ignored.

Phosphorus pool

- The phosphorus cycle is a "sedimentary" cycle in which the earth's crust is the major reservoir. On land, phosphate rock deposits are the primary source of phosphorus. Through natural and human induced erosion processes, phosphates from these rock deposits are washed into rivers, and eventually to the oceans, where they form shallow and deep ocean phosphate rock deposits.
- Plants and animals play a role in the phosphorus cycle. As plant roots absorb phosphates from the soil, phosphorus is carried up through the food chain, eventually returning to the soil via animal waste and decay. However, these returns are small compared to the amount of phosphate which is continually eroding from the land to the oceans each year.

• Phosphorus, more than any other element, can become the limiting factor for agricultural plant growth. Many tonnes of phosphate rock are mined each year in the production of fertilizers to replace some of the phosphates lost from farmland through erosion, crop production exports and lawns, and to make phosphate Phosphorus Cycle





Trophic Levels

• This is a feeding step in a food chain or food web.

• Each trophic level contains a certain amount of energy available to the next level.

• The lower trophic level always has more energy stored than the level above…that's just the way energy moves

• All trophic levels begin with the producers

• Each trophic level can magnify the amount of toxins in tissues significantly, placing a heavy burden on the highest trophic levels.

2. Levels of Organization

Species→ Population→ Community→ Ecosystem→ Biome → Biosphere

The Biosphere is HUGE, which is why we usually study smaller divisions like biomes and ecosystems. Biomes can be subdivided into smaller divisions called ecosystems.

3. What is a biome?

Well biomes are environments that have characteristic climax communities (don't change too much over time). Some people think that there are over 30 different types of biomes in the world….. But here are a few

a. Aquatic:

- rivers
- streams
- lakes
- intertidal zone
- neritic zone
- open-sea zone
- deep-sea zone
- estuaries

b. <u>Terrestrial</u>

- Tundra
- Taiga
- Desert
- Grassland
- Temperate forest
- Tropical rainforest

<u>Regions of Earth are classified into biomes.</u>

If you could travel along the 30° latitude line, either north or south of the equator, you'd notice an interesting pattern. You would see deserts give way to grasslands and grasslands give way to forests. Across Earth, there are large geographic areas that are similar in climate and that have similar types of plants and animals. Each of these regions is classified as a biome (BY-OHM). There are six major land biomes on Earth, as shown on the map on page 517.

Climate is an important factor in land biomes. Climate describes the long-term weather patterns of a region, such as average yearly rainfall and temperature ranges. Climate also affects soil type. Available water, temperature, and soil are abiotic factors important in ecosystems. The fact that the abiotic factors of a particular biome are similar helps to explain why the ecosystems found in these biomes are similar. Biomes represent very large areas, which means that there will be many ecosystems within a biome.

Forest Biomes

- Taiga Forests (also called Boreal Forest)
- Temperate Forests
- Tropical Forests

<u>Taiga and Tundra</u>

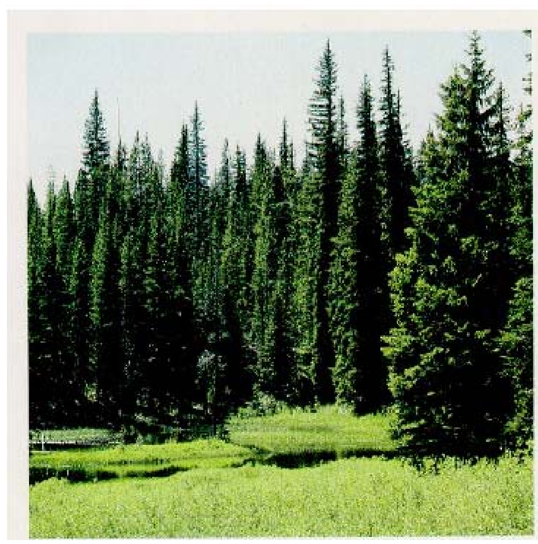
If you go to the northernmost regions of Earth, you will find two biomes—tundra and taiga—that are characterized by long cold winters and short cool summers. In the Arctic tundra, temperatures can go as low as –50°C, with a high of about 18°C.

Temperature ranges in the taiga are similar, –40°C to 20°C. The tundra doesn't get much precipitation, less than 25 centimeters each year. Yet the area is wet because cold temperatures keep the water from evaporating. One of the important characteristics of tundra is permafrost, a deep layer of permanently frozen soil that lies just below the surface soil. Permafrost prevents trees from taking root in the tundra. Plants of the tundra are small and include mosses, grasses, and woody shrubs. Organisms called lichens also do well in the tundra.

The producers of tundra ecosystems support rodents, caribou, and musk oxen. Grizzly bears, white fox, and snowy owls are predators found there. Migrating birds come to nest in the tundra, feeding on insects that mature in summer.

Even though the temperatures of the taiga are similar to those of the tundra, the taiga has more precipitation, 30 to 60 centimeters a year. The effect of this is that there is more snow on the ground, which insulates the soil below, keeping it from permanently freezing.

Taiga ecosystems are characterized by evergreen trees called coniferous (koh-NIHF-uhr-uhs) trees. These trees have needlelike leaves that produce food all year long. This is an advantage in taiga ecosystems because decomposers work slowly in the cold, so the soil is low in nutrients. The wood and leaves of these trees feed insects and their seeds feed birds and squirrels. Taiga ecosystems support deer, elk, snowshoe hares, and beavers. Predators include lynx, owls, bears, and wolves.



Taiga, or boreal forest.

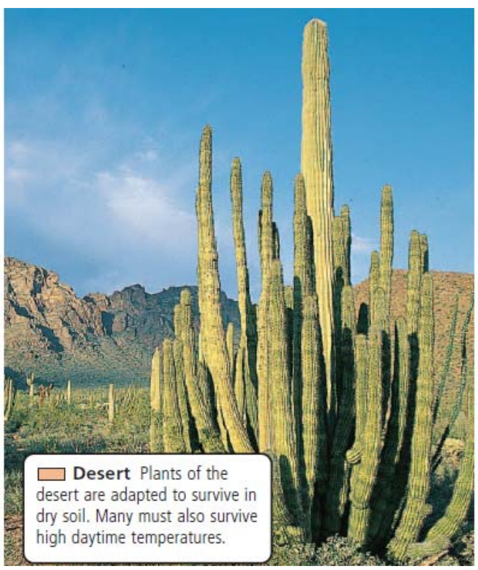
Desert and Grassland

Deserts and grasslands are biomes found toward the middle latitudes. You can see from the map on page 517 that a desert biome often leadsinto a grassland biome.What deserts and grasslands have in common is that they do not get enough precipitation to support trees.

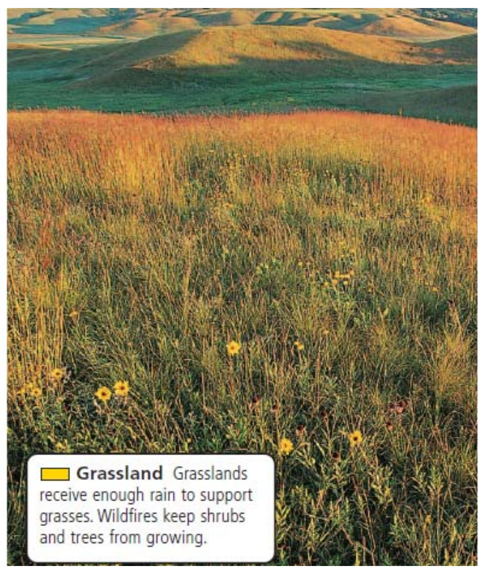
Some deserts are cold and some deserts are hot, but all deserts are characterized by their dry soil. Less than 25 centimeters of rain falls each year in a desert. Desert plants, like the cactus, and desert animals, like the collared lizard, can get by on very little water. Small burrowing animals like the kangaroo rat and ground squirrel are part of desert ecosystems. Desert predators include snakes, owls, and foxes.

Grassland ecosystems develop in areas of moderate rainfall, generally from 50 to 90 centimeters each year. There is enough rain to support grasses, but too little rain to support forests. Periodic wildfires and droughts keep smaller shrubs and tree seedlings from growing. Summers in grassland ecosystems are warm, up to 30°C, but winters are cold.

Grasses do well in large open areas. The more rain a grassland ecosystem gets, the higher the grasses grow. These ecosystems support seed-eating rodents that make their burrows in the grassland soil. There are also large grazing animals, like bison, wild horses, gazelle, and zebra. Predators include wolves, tigers, and lions.



Desert Plants of the desert are adapted to survive in dry soil. Many must also survive high daytime temperatures.



Grassland Grasslands receive enough rain to support grasses. Wildfires keep shrubs and trees from growing.

Grasslands

There are different types of grasslands, but they all have grasses are the dominant vegitation.

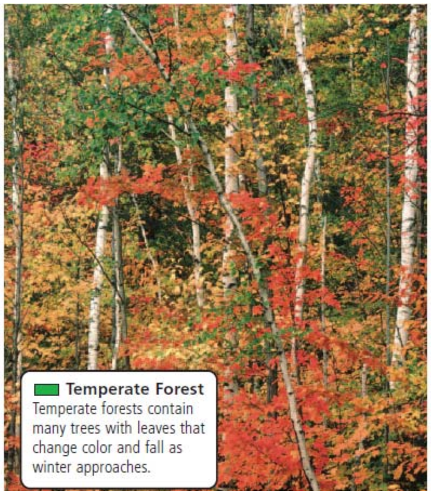
• Prairies • Pampas • Savanna • Steppe

Temperate Forest and Tropical Forest

Trees need more water than smaller plants, shrubs, and grasses. So forest biomes are usually located in regions where more water is available. The taiga is a forest biome. There the coniferous trees survive on smaller amounts of precipitation because the cold weather limits evaporation.

Across the middle latitudes, temperate forests grow where winters are short and 75 to 150 centimeters of precipitation fall each year. Near the equator, there are no winters. There, tropical forests grow where 200 to 450 centimeters of rain fall each year.

Most temperate forests are made up of deciduous trees, sometimes referred to as broadleaf trees. Deciduous trees drop their leaves as winter approaches and then grow new leaves in spring.



The most common broadleaf trees in North American deciduous forests are oak, birch, beech, and maple. Temperate forests support a wide variety of animals. Animals like mice, chipmunks, squirrels, raccoons, and deer live off seeds, fruit, and insects. Predators include wolves, bobcats, foxes, and mountain lions.

Most temperate forests in North America are deciduous. However, the wet winters and dry summers in the Pacific Northwest support forests made up mostly of coniferous trees—redwoods, spruce, and fir.

These forests are referred to as temperate rain forests. The largest trees in the United States are found in these temperate rain forests. Tropical forests are located near the equator, where the weather is warm all year, around 25°C. The tropical rain forest is the wettest land biome, with a rainfall of 250 to 400 centimeters each year. The trees tend to have leaves year round. This provides an advantage because the soil is poor in nutrients. High temperatures cause materials to break down quickly, but there are so many plants the nutrients get used up just as quickly.

More types of animals, plants, and other organisms live in the tropical rain forest than anywhere else on Earth. The trees grow close together and support many tree-dwelling animals like monkeys, birds, insects, and snakes. There are even plants, like orchids and vines, that grow on top of the trees.

Marine Biomes

Marine biomes are saltwater biomes. The three general marine biomes are coastal ocean, open ocean, and deep ocean. Beaches are part of the coastal ocean biome. Tidal pools also form along the coast as the tide comes in and goes out and the conditions constantly change.

Organisms like crabs and clams are able to survive the ever-changing conditions to thrive in coastal areas. Organisms in the open ocean receive less sunlight than in the coastal ocean, and the temperatures are colder. Many types of fish and other marine animals and floating seaweed live in the upper ocean.

There are no plants in the open ocean. The producers at the bottom of the food chain are different types of phytoplankton. The deep-ocean regions are much colder and darker than the upper ocean. In the deep ocean there is no sunlight available for photosynthesis.

The animals in the deep ocean either feed on each other or on material that falls down from upper levels of the ocean. Many organisms in deep ocean biomes can only be seen with a microscope.

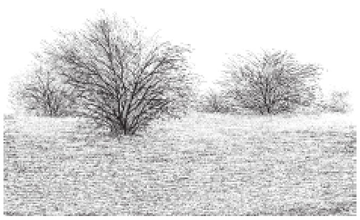
BIOGEOGRAPHIC REGIONS OF INDIA

Because of the influence which abiotic factors exert on organisms, different ecosystems develop differently. The major factors that determine the growth and type of ecosystem include temperature, rainfall, soil type and the location (the latitude and altitude). These factors, their interactions with each other and with the local biotic community have resulted in a variety of ecosystems. India, the seventh largest landmass in the world, possesses a variety of ecosystems. These include mountains, plateaus, rivers, wetlands, lakes, mangroves, forests and coastal ecosystems. This section looks at the ecological profile of India.

The Himalayan Region

Sparse vegetation and rare fauna that includes snow leopards, wild pigs and tigers, characterize the transHimalayan region. The Himalaya, the highest mountain range in the world, is one of the richest areas of India in terms of habitat and species diversity. Both altitudinal as well as longitudinal variations are seen in the Himalayan belt. Three distinct subzones, each with its characteristic species diversity, are recognized—Himalayan foothills from the eastern frontiers of Kashmir to Assam; Western Himalaya, which are the higher altitude region from Kashmir to Kumaun (in Uttaranchal); and the Eastern Himalaya (in the north-east part of the country).

The Gangetic plains with their rich alluvial soil make excellent crop fields. It is in this area that the floodplains are found, which makes this region important for flood control too.



The Desert

The desert regions of the northwest have large expanses of grasslands in patches. For kilometers together, one may not find any signs of vegetation in the desert. Water, or the lack of it, is the single-most significant feature in the desert. In this region, both plants and animals face the problem of maintaining the water balance of their bodies under extreme diurnal temperature variation. They show many adaptations to cope with this. For details on some such adaptations, refer the box on 'Adapting to the Desert' in Unit 2.

The North-East

In contrast to the northwest, the northeastern region has lush green rain forests. The forests consist of very dense and lofty trees with multitudes of species occurring in a given area. The unique plant species include mosses, ferns, epiphytes, orchids, lianas and vines. The rich plant diversity of these forests is home to an equally rich diversity of animals, including elephants, barking deer, hoolock gibbon, golden langur, macaque species and other primates.

The Western Ghats

While the Western Ghats with an evergreen forest cover make biodiversity-rich zones, the Nilgiris, an offshoot of Western Ghats, have extensive grassy areas interspersed with densely forested evergreen vegetation known as *Sholas*. They provide shelter to elephants, gaur and other large animals. Many of the trees and also some of the animals found in these high *Shola*s are also found in the high altitude forests of the northeastern region.

Islands and Wetlands

India also has two major groups of islands—Lakshwadeep islands in the Arabian Sea, and Andaman & Nicobar islands in the Bay of Bengal. These islands receive both the southwest and the northeast monsoons. Being tropical in climate, these islands are home to tropical rainforests.

India, with its varied terrain and climate, supports a rich diversity of in land and coastal wetlands. A total of 21 **wetlands** have been declared as National Wetlands. An important wetland of the country is the Keoladeo National Park in Bharatpur, Rajasthan, which is a human-made wetland. Among the various migratory species of birds that visit this Park almost every winter, is the endangered Siberian Crane (*Grus leucogeranus*). Another important wetland is Chilika (1,100 sq km), the largest brackish water lake in India, situated in Puri and Ganjam district of Orissa.

WETLANDS AND THEIR SIGNIFICANCE

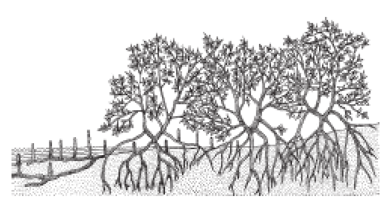
Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by shallow water. Wetlands are areas of great ecological and economic significance. In their natural condition, wetlands supply numerous ecological, economic, and cultural benefits to local communities, including water quality protection, flood control, erosion control, fish and wildlife habitat, aquatic productivity, and unique opportunities for education and recreation.

One of the most important functions of wetlands is the ability to maintain good surface water quality in rivers, streams, and reservoirs and to improve degraded surface waters. Wetlands do this several ways:
a) by removing and retaining nutrients.
b) by processing chemical and organic wastes.
c) by reducing sediment loads. Wetlands are particularly good water filters. Due to their landscape position between uplands and deep water, wetlands intercept surface water runoff before it reaches open water and filter out nutrients, wastes, and sediments from flood waters. This function is particularly important in urban and agricultural areas.

In some places, wetlands contribute to the recharge of groundwater sources of drinking water. During periods of heavy runoff, such as major storms or snowmelt in the spring, wetlands adjacent to streams and in depressions collect excess water. When the water table drops, the water held in the wetlands infiltrates slowly back through the soil into the aquifer to replenish groundwater. Also by temporarily storing and slowly releasing flood waters, wetlands help protect adjacent and downstream property owners from flood damage. Wetlands provide critical habitat for several species— many amphibians, fishes, variety of plants including grasses.

The Marine Wealth

India has the world's seventh largest coastline measuring over 7,500 km. The Indian coastline is broadly divided into the Western coast and the Eastern coast. The Western coast borders the Arabian Sea and the Eastern coast is along the Bay of Bengal. The Western coast is divided into three parts: the Saurashtra coasts along the northern part; the middle portion called the Konkan



coast; and the southern part known as the Malabar Coast. The Eastern coast extends from Kanyakumari to the delta of the Ganga in the Bay of Bengal. The southern half of the coast is called the Coromandel coast.

Oceans have great diversity of life forms as they provide a gradient of habitats in terms of varied light and pressure zones. With their rich cache of fish, minerals and potential energy, the marine ecosystems make an invaluable resource. It is due to the geographical location of the land masses within the Indian Ocean that the Indian subcontinent experiences a ***unique pattern*** of winds and rains. This phenomenon is known as '**monsoon**'. Oceans are also the reservoir of food and the resource for aquacultural practices.

THE INDIAN BIODIVERSITY

Group	Number of species in India (SI)	Number of species in the world (SW)	SI/SW (%)
Mammals	350	4,629	7.6
Birds	1228	9,702	12.6
Reptiles	428	6,550	6.2
Amphibians	197	4,522	4.4
Fishes	2546	21,730	11.7
Flowering Plants	15,000	250,000	6.0