The Carbon Cycle

Real World Ecosystems
Backgrounder

Carbon is the basis of all life on Planet Earth, Carbon atoms are found in almost every chemical in a living organism. If all of the water were removed from your body, what would remain is approximately 50% carbon. Carbon atoms form the physical structures of most living things and are involved in transporting energy in ecosystems. For these reasons, scientists are very interested in studying the carbon cycle, and what carbon does in ecosystems.

How the Carbon Cycle Works

In ecosystems, it is said, energy flows and matter cycles. Carbon is a form of matter, and it is continuously cycled and re-used in ecosystems. The carbon cycle is one of the most important ecological cycles on Earth. The atmosphere, rocks, and oceans store huge amounts of carbon in different forms. In the atmosphere, most of the carbon is in the form of carbon dioxide, a gas. In water, it forms a weak acid. In rocks, most of it is stored in the form of calcium carbonate, a hard mineral. Ecosystems move carbon around in the form of carbon dioxide or in food molecules, such as sugars, fats, and proteins.

By now, you know that plants start the cycling process by trapping carbon dioxide in the air and turning it into sugar, with the help of sunlight. Green plants are the only organisms that can capture carbon dioxide and turn it into other forms. Once the carbon gets into the food chain, it is distributed through the whole ecosystem, as organisms kill, eat, digest, graze, decompose, or whatever they do to get their food. Organisms also eventually return most of the carbon to the atmosphere through respiration in the form of carbon dioxide and the cycle is completed.

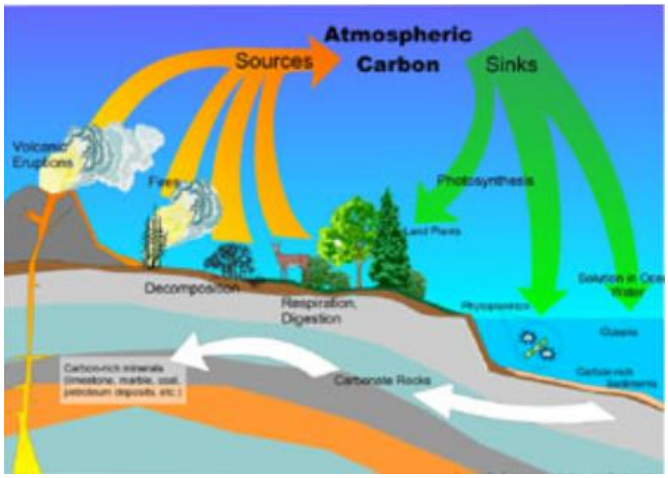

Illustration: Pembina Institute

Much of Earth's total supply of carbon is stored deep in the rocks of the Earth's crust. Millions of years ago, most of this carbon was in the atmosphere. Over time, plants and other organisms helped convert the carbon into solid forms that were buried along with other kinds of sediments. Heat and pressure transformed the sediments into minerals and petroleum deposits, such as oil and gas. Humans now extract and use of some of this stored carbon as a burnable fuel.

The job of capturing carbon from the atmosphere falls to photosynthetic plants.

Plants on land and in the oceans produce billions of tons of carbon-rich molecules by withdrawing carbon dioxide gas from the atmosphere. Plants produce an energy-rich food molecule called glucose. Glucose has many uses in ecosystems. Two important uses are that it carries energy to cells and is a building block for structures such as plant stems. wood, skeletons, and tissues. Glucose is the basis of cellulose, the fibrous material that stiffens plant stems. Wood is composed mostly of tightly-bound cellulose fibres.

Transferring Carbon in Ecosystems

Once atmospheric carbon is captured and used to make food molecules and cellulose, it gets shuffled around ecosystems by organisms. This happens in a **food web** (A diagram that represents the feeding relationships between organisms in an ecosystem) and food chains. As animals digest their food, they extract glucose and other molecules for use, in their cells. Some of this may be used immediately, and some may be stored as fat for use later. Inside the cells of all organisms, glucose is broken down. Its energy is freed up so that life processes such as growth, muscle movement, sending and receiving nerve impulses, etc., can take place. This process is called respiration.

In ecosystems, food molecules containing carbon may take complicated paths. For example, grass and other plants make up the food of most **herbivores**. Herbivores, in turn, provide the food supply for a variety of **carnivores.** Each time a predator kills and eats another animal, it is feeding itself carbon that was originally captured from the atmosphere by plants. The carbon may move through five or six different organisms on its trip through the ecosystem. The final stop is usually a **decomposer** organism, such as **bacteria** or **fungi.** These organisms use the dead remains of other creatures as their food, extracting most of the remaining useable food molecules and using the to power their own life processes.

Completing the cycle

When cells break down glucose and release its energy, water and carbon dioxide are produced as by-products. The carbon dioxide leaves the tissues of organisms and goes back into the atmosphere. For example, your breath contains carbon dioxide, the results of respiration in your body's cells.

Some plant and animal matter containing carbon may not be broken down, but becomes part of the carbon-rich sediment on land, or in the sea floor. It may remain there, unchanged, for centuries. In some situations, and over a period of millions of years, these sediments become deeply buried. At depth of a hundred metres or more, pressure and heat transform carbon-rich sediments into fossil fuels (coal, petroleum and natural gas) or carbon-rick rocks. In the oceans, carbon dioxide dissolves in sweater.

Although most carbon dioxide remains in solution, some will react with other elements to form the calcium carbonate found in shells and skeletons of many marine organisms. As these organisms die, they sink to the bottom of the ocean to form carbonate sediments such as limestone.

The Greenhouse Effect

The greenhouse effect is the rise in Earth's temperature because greenhouse gases trap heat from the sun in the atmosphere. Greenhouse gases are able to absorb the invisible energy given off by warm objects, or infrared radiation, from the Earth's surface. This causes warming of the atmosphere. Greenhouse gases include carbon dioxide, methane, water vapour, nitrous oxide, and ozone. Scientists are interested in carbon dioxide because it is the most important of the greenhouse gases. Greenhouse gases make up less than one-tenth of 1% of the composition of the atmosphere. Despite this, they have a profound impact on the Earth's climate. Without greenhouse gases, the average climate on Earth would be as much as 33° colder than it is. In other words, without greenhouse gases, the Earth would be a frozen wasteland, similar to Mars.

Trees Store Carbon

Changing the landscaping around your house is not just a way of producing a nicer-looking space in which to enjoy yourself. By carefully positioning trees around your house you could save up to 25% on your household heating and cooling bills. This, in turn,

reduces the amount of energy your home needs and results in lower overall greenhouse gas emissions. Trees also withdraw carbon dioxide gas from the atmosphere, offsetting some of the carbon dioxide released into the atmosphere by other human activities.

Carbon and Climate change

Humans all around the world depend heavily on fossil fuels for transportation, heat, and many other things. Burning coal, oil and gas releases large amounts of carbon dioxide into the atmosphere, measured in the billions of tonnes each year. This appears to be upsetting the natural balance in the carbo cycle, so that carbon dioxide concentrations are increasing in the atmosphere. Because of the greenhouse effect, scientists have believed for decades that this would have the effect of resetting the Earth's thermostat, pushing average temperatures higher than normal. Scientists have been studying this problem for the past 20 years or more. They agree that fossil fuel burning is, in face, changing Earth's climate. While there are some uncertainties as to how large an effect humans have on the Earth's climate, very few scientists doubt that the warming we are observing is, at least, partly caused by humans.

Think About...

- What is the difference between a carbon sink and a carbon source?
- What are some examples of carbon sinks and carbon sources?
- Carbon is a natural part of the carbon cycle, why is there concern about depleting the world's fossil fuels?