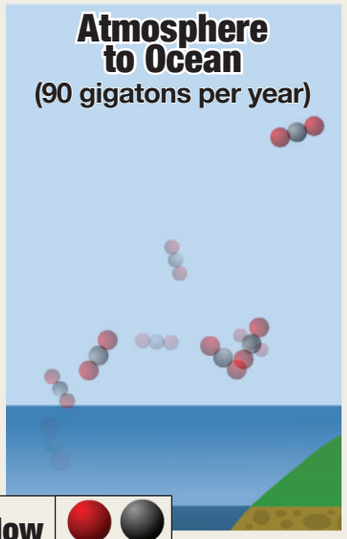
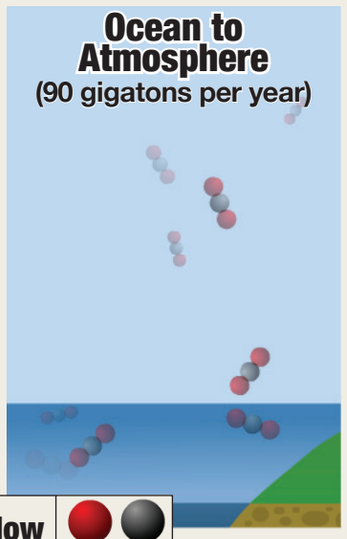
Atmosphere to Ocean
(90 gigatons per year)



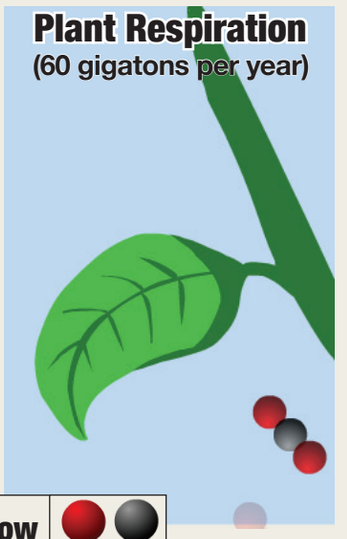
Flow — Oxygen, Carbon

Ocean to Atmosphere
(90 gigatons per year)



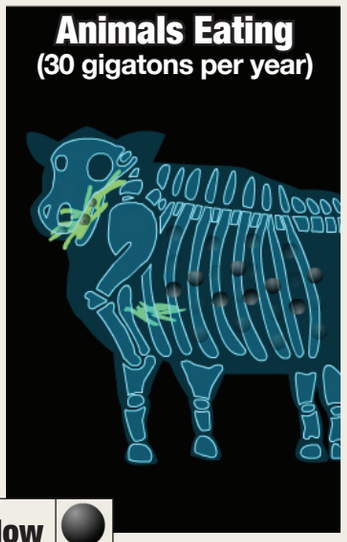
Flow — Oxygen, Carbon

Plant Respiration
(60 gigatons per year)



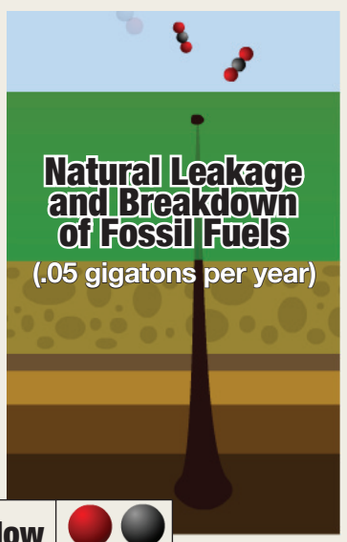
Flow — Oxygen, Carbon

Animals Eating
(30 gigatons per year)



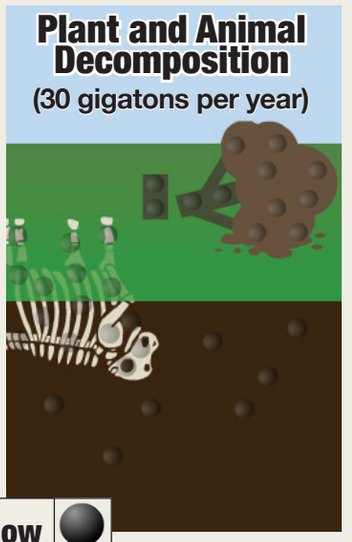
Flow — Carbon

Natural Leakage and Breakdown of Fossil Fuels
(.05 gigatons per year)



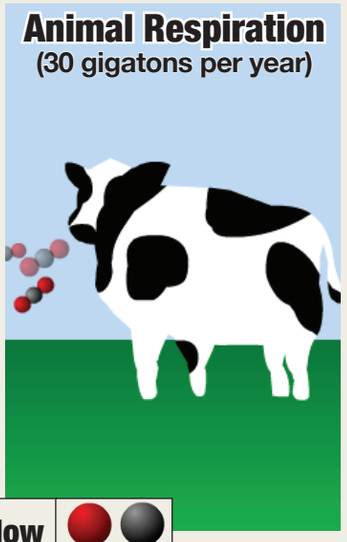
Flow — Oxygen, Carbon

Plant and Animal Decomposition
(30 gigatons per year)



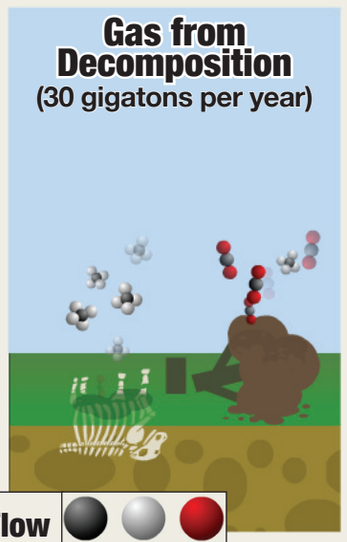
Flow — Carbon

Animal Respiration
(30 gigatons per year)



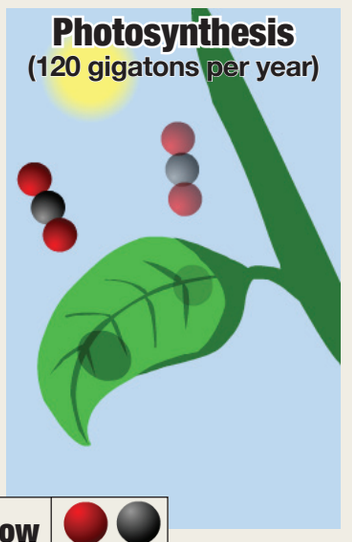
Flow — Oxygen, Carbon

Gas from Decomposition
(30 gigatons per year)



Flow — Carbon, Hydrogen, Oxygen

Photosynthesis
(120 gigatons per year)



Flow — Oxygen, Carbon

Flow

Atmosphere to Ocean

CO_2 from the atmosphere dissolves in ocean water.

Flow

Animals Eating

Animals eat plants and/or other animals. All cells of every plant and animal contain carbon.

Flow

Animal Respiration

When animals break down the food they eat, they breathe out CO_2 into the atmosphere.

Flow

Ocean to Atmosphere

CO_2 moves out of ocean water and into the atmosphere.

Flow

Natural Leakage and Breakdown of Fossil Fuels

Small amounts of fossil fuels (natural gas, crude oil, or coal) leak from underground to the surface. At the surface, the fossil fuels naturally break down into CO_2, which flows into the atmosphere.

Flow

Gas from Decomposition

Decomposers, such as bacteria and fungi, give off carbon to the atmosphere as CO_2 or CH_4 when they break down carbon from dead animals and plants into their different nutrients.

Flow

Plant Respiration

Plants need to use up some of their sugars to survive. Plants give off CO_2 into the atmosphere as they break down their own sugars for life processes. This happens during the day and at night.

Flow

Plant and Animal Decomposition

After plants and animals die, decomposers break them down into their different nutrients, which enter the soil. This is a way carbon flows into the soil reservoir.

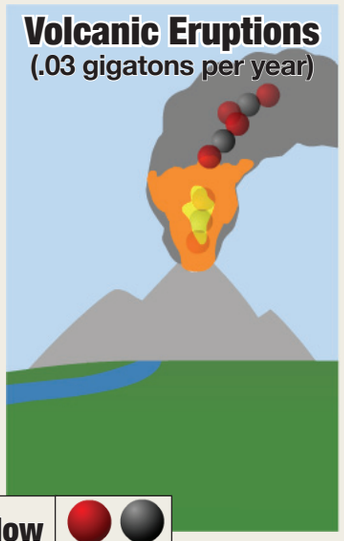
Flow

Photosynthesis

Land plants take in CO_2 from the atmosphere and H_2O from the soil to make sugars.

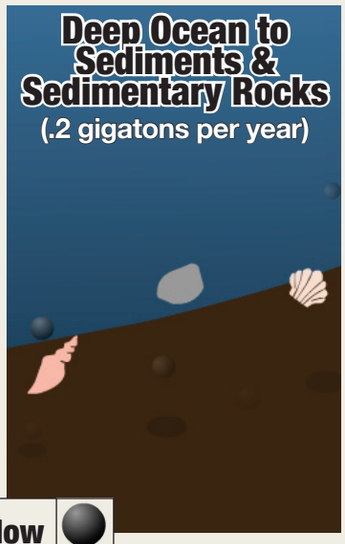
Photosynthetic organisms in the ocean take in dissolved CO_2 from the water to make sugars.

Volcanic Eruptions
(.03 gigatons per year)



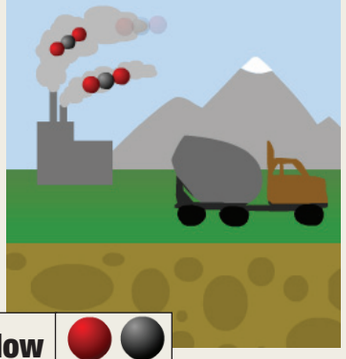
Flow — Oxygen, Carbon

Deep Ocean to Sediments & Sedimentary Rocks
(.2 gigatons per year)



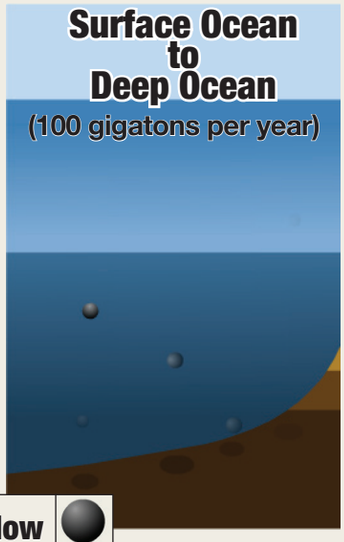
Flow — Carbon

Human Industry: Making Cement
(.3 gigatons per year)



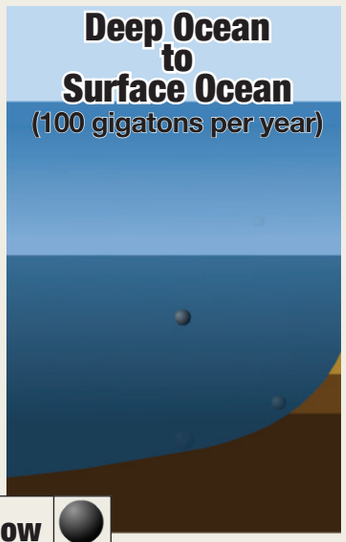
Flow — Oxygen, Carbon

Surface Ocean to Deep Ocean
(100 gigatons per year)



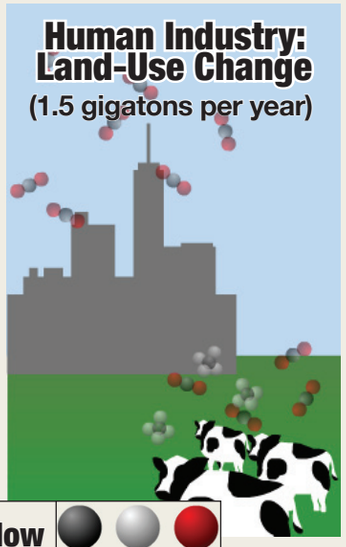
Flow — Carbon

Deep Ocean to Surface Ocean
(100 gigatons per year)



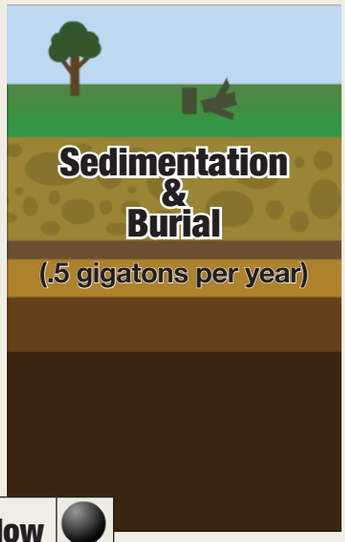
Flow — Carbon

Human Industry: Land-Use Change
(1.5 gigatons per year)



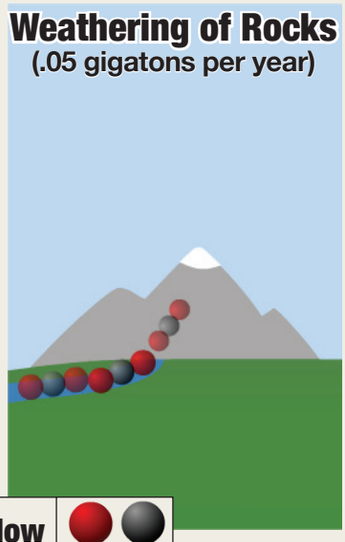
Flow — Carbon, Hydrogen, Oxygen

Sedimentation & Burial
(.5 gigatons per year)



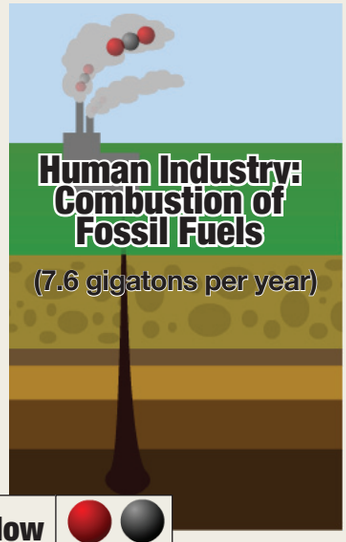
Flow — Carbon

Weathering of Rocks
(.05 gigatons per year)



Flow — Oxygen, Carbon

Human Industry: Combustion of Fossil Fuels
(7.6 gigatons per year)



Flow — Oxygen, Carbon

Flow

Volcanic Eruptions

Volcanoes release CO_2 into the atmosphere from rocks that are deep in Earth's crust.

Flow

Surface Ocean to Deep Ocean

Dead organisms, shells, and the carbon they contain, sink to deep ocean water.

Flow

Sedimentation & Burial

Carbon in the ground (originally from dead organisms), which is not consumed, can be buried under layers of earth. Under high pressures and temperatures and over millions of years, the material is changed into fossil fuels.

Flow

Deep Ocean to Sediments & Sedimentary Rocks

Dead organisms and shells settle to the seafloor. As layers build up over time, these materials may be changed into sedimentary rocks or fossil fuels.

Flow

Deep Ocean to Surface Ocean

Carbon can remain in the deep ocean for hundreds of years. However, mixing can bring deep water with carbon back to the surface.

Flow

Weathering of Rocks

Carbon from CO_2 is removed from the atmosphere when it combines with rainwater and reacts with the chemicals in rocks. The products from the reactions, such as carbonate (CO_3^{2-}), can be used by plankton or can settle on the seafloor and are eventually buried.

Flow

Human Industry: Making Cement

Limestone is heated to make cement, and this releases limestone's carbon (as CO_2) into the atmosphere. In the last ~100 years, more and more cement has been made, releasing more and more carbon as CO_2 into the atmosphere.

Flow

Human Industry: Land-Use Change

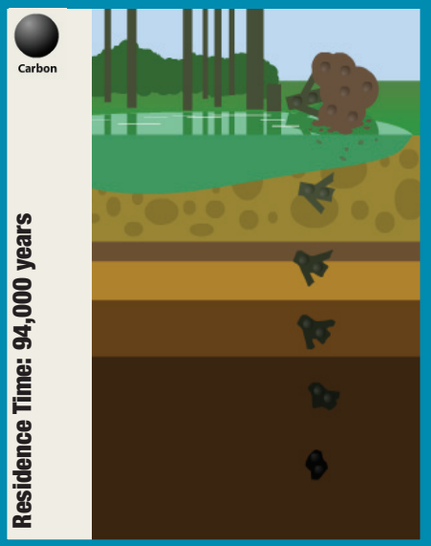
When forests are cut down or burned so the land can be used another way, such as building cities and roads or raising cows and crops, there are fewer trees to absorb carbon through the process of photosynthesis. The overall result is that more carbon ends up in the atmosphere.

Flow

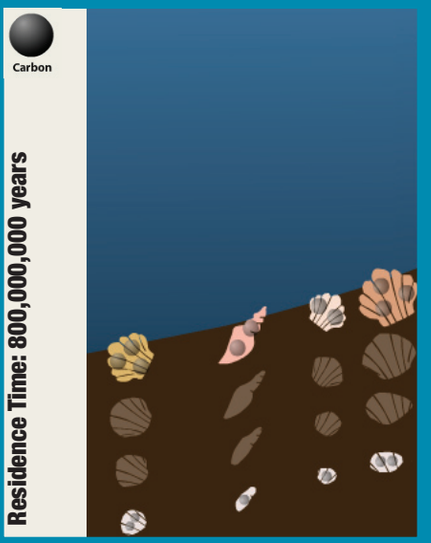
Human Industry: Combustion of Fossil Fuels

In the last ~100 years, humans have taken more and more crude oil and other fossil fuels from underground and used them to power cars, machines, and more. The fossil fuels are burned, and carbon is released into the atmosphere as CO_2.

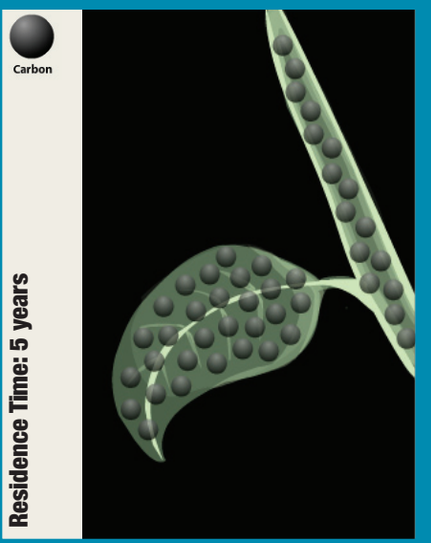
Fossil Fuels: Coal
(3,800 gigatons)



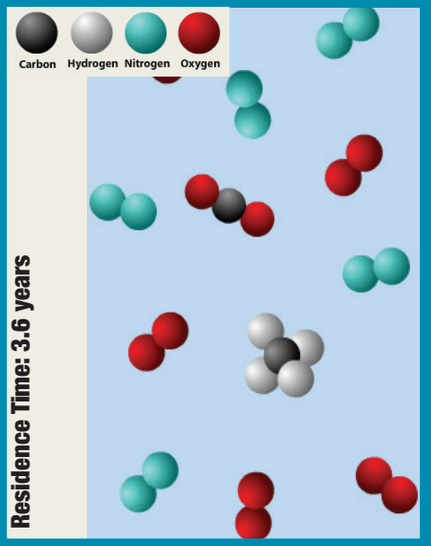
Limestone & Other Rocks
(40,000,000 gigatons)



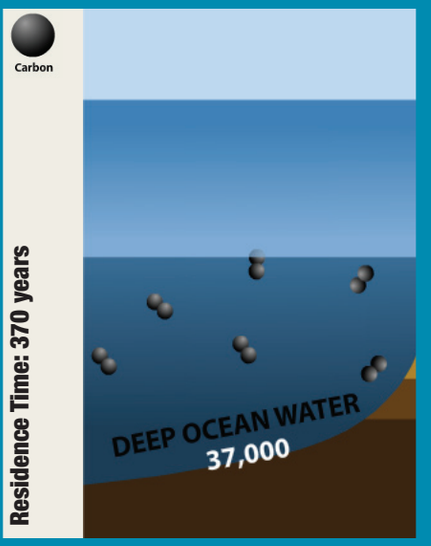
Plants
(600 gigatons)



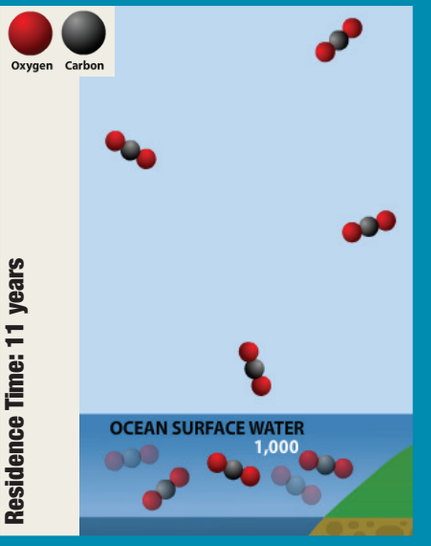
Atmosphere
(800 gigatons)



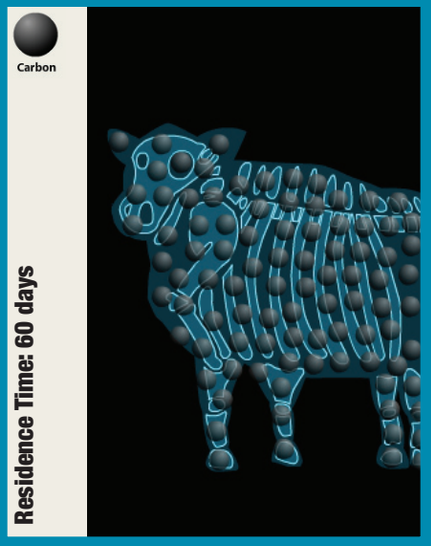
Deep Ocean Water
(37,000 gigatons)



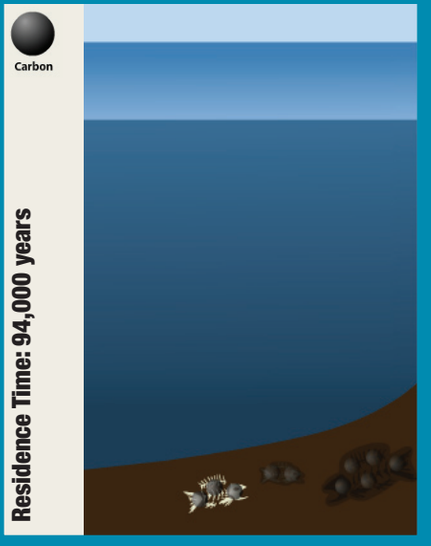
Ocean Surface Water
(1,000 gigatons)



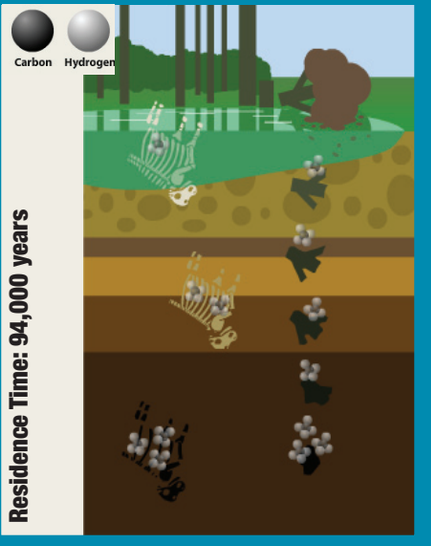
Animals
(5 gigatons)



Fossil Fuels: Crude Oil
(680 gigatons)



Fossil Fuels: Natural Gas
(570 gigatons)



Reservoir

Fossil Fuels: Coal

In watery environments on land, some dead plants get buried rather than decomposing right away. Under high pressures and temperatures and over millions of years, much of this old plant matter becomes coal.

Reservoir

Atmosphere

The atmosphere is a layer of gases surrounding the planet. The atmosphere is mostly nitrogen and oxygen gases, with less than 1% CO_2 (carbon dioxide), CH_4 (methane), and other gases.

Reservoir

Animals

Every cell in every animal has carbon in it. Animals get their carbon by eating plants or other animals.

Reservoir

Limestone and Other Rocks

Calcium carbonate ($CaCO_3$) shells from dead ocean organisms collect on the ocean floor. Over millions of years, they are buried and form limestone. Carbon in limestone may change into other rocks, such as marble.

Reservoir

Deep Ocean Water

Carbon in dead organisms slowly falls from the surface to the deep ocean (marine snow).

Reservoir

Fossil Fuels: Crude Oil

At the bottom of the ocean, some dead organisms get buried rather than decomposing. Under high pressures and temperatures and over millions of years, much of what remains of these dead organisms becomes crude oil.

Reservoir

Plants

Plants are built of sugars ($C_6H_{12}O_6$) that they make through photosynthesis, using CO_2 and H_2O. The sugars are then changed into cellulose and other materials to make different plant structures. Every cell of every plant contains carbon.

Reservoir

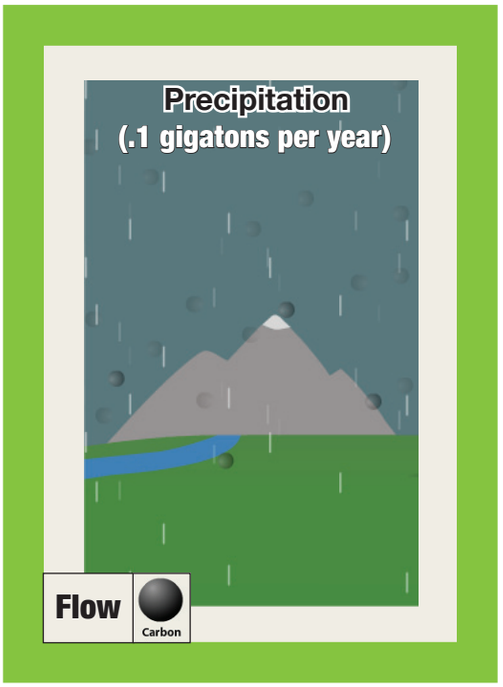
Ocean Surface Water

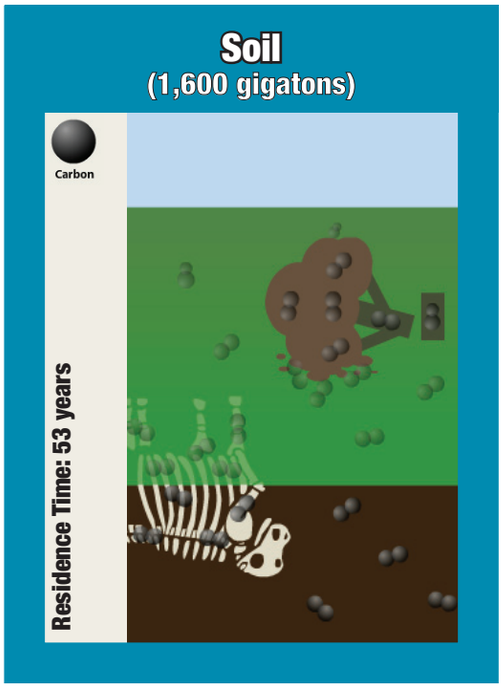
Carbon dioxide (CO_2) from the atmosphere dissolves into ocean water at the surface. Some of the carbon combines with calcium to form calcium carbonate ($CaCO_3$) in shells.

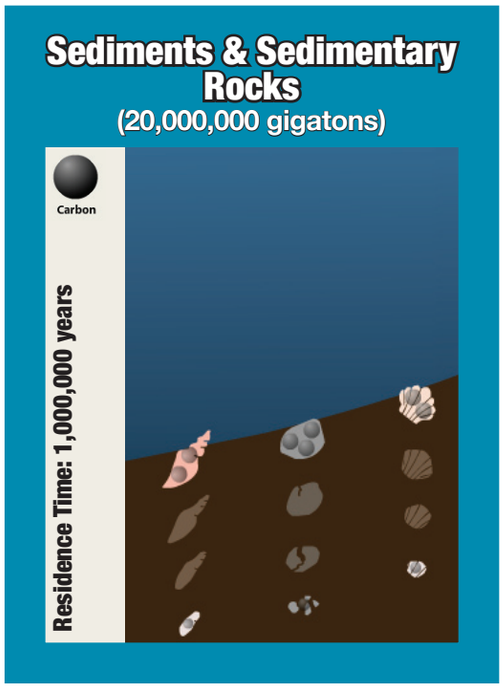
Reservoir

Fossil Fuels: Natural Gas

In watery environments on land and at the bottom of the ocean, some dead organisms get buried rather than decomposing. Under high pressures and temperatures and over millions of years, some of the buried material becomes natural gas, and the rest becomes coal or crude oil.


Precipitation
(.1 gigatons per year)
Flow
Carbon


Soil
(1,600 gigatons)
Carbon
Residence Time: 53 years


Sediments & Sedimentary Rocks
(20,000,000 gigatons)
Carbon
Residence Time: 1,000,000 years

Flow

Precipitation

As rainwater falls, it dissolves small amounts of atmospheric CO_2 to form carbonic acid (H_2CO_3). This weak acid can react with the chemicals in rocks and break them down. In some rocks, this can ultimately cause the release of carbonate (CO_3^{2-}) into the waterways.

Reservoir

Soil

Some carbon from decomposing organisms and decomposers ends up in the soil. This carbon stays in the soil for as little as a few weeks to as long as tens of thousands of years. Soil with more carbon in it is richer (more productive).

Reservoir

Sediments and Sedimentary Rocks

Sediments and sedimentary rocks are formed from the breakdown of rocks, such as granite and basalt, and from the buildup of dead organisms, including $CaCO_3$ shells.