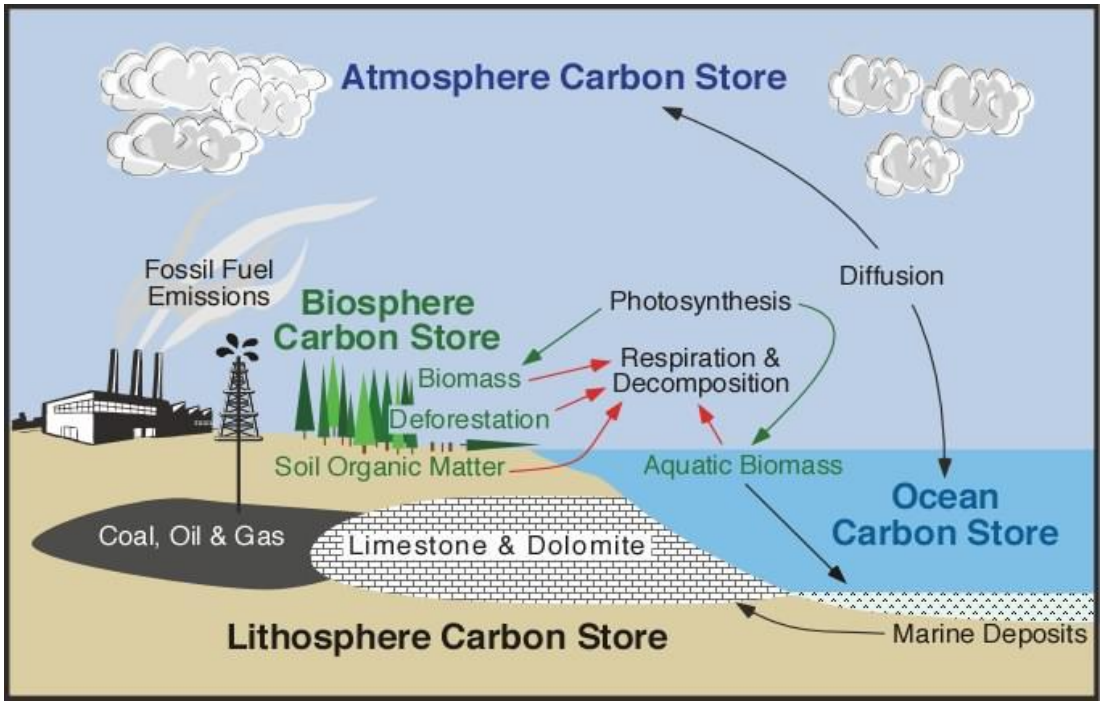
TEACHER BACKGROUND:
CARBON DIOXIDE AND THE CARBON CYCLE

All life is based on the element ***carbon***. Carbon is the major chemical constituent of most organic matter, from **fossil fuels** to the complex molecules (**DNA** and **RNA**) that control genetic reproduction in organisms. B By weight however, carbon is not one of the most abundant elements within the Earth's crust. In fact, the lithosphere is only 0.032% carbon by weight. In comparison, oxygen and silicon respectively make up 45.2% and 29.4% of the Earth's surface rocks.

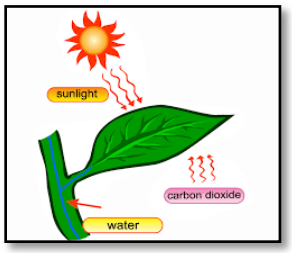
Carbon is stored on our planet in the following major sinks (1) as organic molecules in living and dead organisms found in the biosphere; (2) as the gas carbon dioxide in the atmosphere; (3) as organic matter in soils; (4) in the lithosphere as fossil fuels and sedimentary rock deposits such as limestone, dolomite and chalk; and (5) in the oceans as dissolved atmospheric carbon dioxide and as calcium carbonate shells in marine organisms.



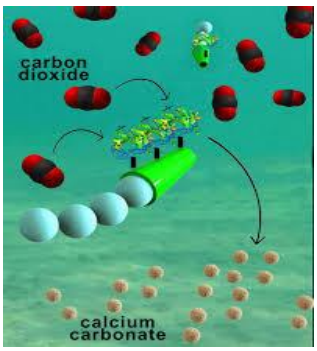
The Carbon Cycle.

Sink	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

Estimated major stores of carbon on the Earth

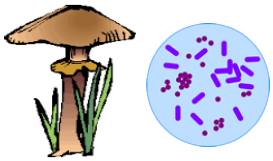


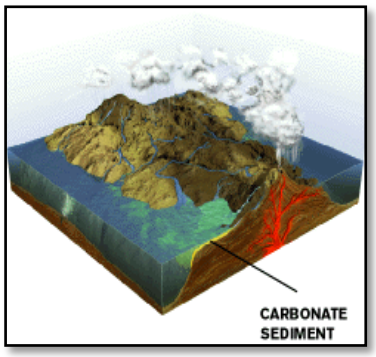
Ecosystems gain most of their carbon dioxide from the atmosphere. ***Producers*** (plants) have specialized systems that allow for absorption of this gas into their cells. With the addition of water and energy from solar radiation, these organisms use ***photosynthesis*** to chemically convert the carbon dioxide to carbon-based sugar molecules. These molecules can then be chemically modified by these organisms through the metabolic addition of other elements to produce more complex compounds like proteins, cellulose, and amino acids. Some of the organic matter produced in plants is passed down to ***consumers (animals)*** through consumption.



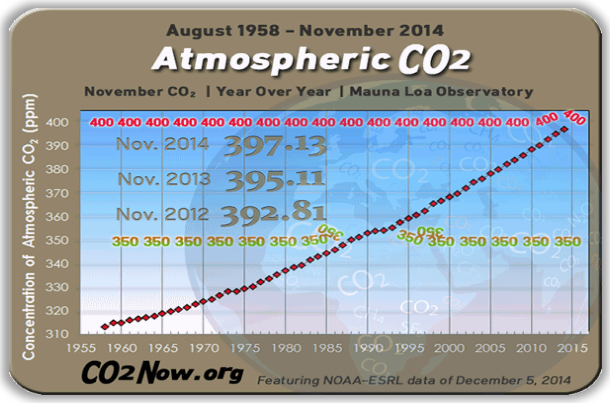
Carbon dioxide enters the waters of the ocean by simple ***diffusion***. Once dissolved in seawater, the carbon dioxide can remain as is or can be converted into ***carbonate*** (CO_3^{-2}) or ***bicarbonate*** (HCO_3^-). Certain forms of sea life biologically fix bicarbonate with calcium (Ca^{+2}) to produce ***calcium carbonate*** ($CaCO_3$). This substance is used to produce shells and other body parts by organisms such as coral, clams, oysters, some protozoa, and some algae. When these organisms die, their shells and body parts sink to the ocean floor where they accumulate as carbonate-rich deposits. After long periods of time, these deposits are physically and chemically altered into sedimentary rocks. Ocean deposits are by far the biggest sinks of carbon on the planet.

Carbon is released from ecosystems as ***carbon dioxide*** gas by the process of ***respiration***. Respiration takes place in both plants and animals and involves the breakdown of carbon-based organic molecules into carbon dioxide gas and some other by-products. The ***detritus food chain*** contains a number of ***decomposers (fungi and bacteria)*** whose primary ecological role is the ***decomposition*** of organic matter into its raw materials.





Carbon is stored in the ***lithosphere*** in both inorganic and organic forms. Inorganic deposits of carbon in the lithosphere include ***fossil fuels*** like coal, oil, and natural gas, oil shale, and carbonate based sedimentary deposits like limestone. Organic forms of carbon in the lithosphere include litter, organic matter, and humus (organic matter) found in soils. Some carbon dioxide is released from the interior of the lithosphere by volcanoes. Carbon dioxide released by volcanoes enters the lower lithosphere when carbon-rich sediments and sedimentary rocks are subducted and partially melted beneath tectonic boundary zones.



Since the **Industrial Revolution**, human activity has greatly increased the quantity of carbon dioxide found in the atmosphere and oceans. Atmospheric levels have increased by over 30%, from about 275 parts per million (ppm) in the early 1700s to just over 400 PPM today. Scientists estimate that future atmospheric levels of carbon dioxide could reach an amount between 450 to 600 PPM by the year 2100.

The major sources of this gas due to human activities include fossil fuel combustion and the modification of natural plant cover found in grassland, woodland, and forested ecosystems. Emissions from fossil fuel combustion account for about 65% of the additional carbon dioxide currently found in the Earth's atmosphere. The other 35% is derived from deforestation and the conversion of natural ecosystems into agricultural systems.