GOVERNOR'S OFFICE OF ENERGY DEVELOPMENT

Advancing Utah's Energy Future

Carbon Cycle

Grade/Subject: Earth Space Science

Strand/Standard ESS.3.5 Develop and use a quantitative **model** to describe the cycling of carbon among Earth's systems. Emphasize each of Earth's systems (hydrosphere, atmosphere, geosphere, and biosphere) and how the movement of carbon from one system to another can result in changes to the system(s). Examples could include more carbon absorbed in the oceans leading to ocean acidification or more carbon present in the atmosphere leading to a stronger greenhouse effect. (LS2.B, ESS2.D, ESS3.D)

Lesson Performance Expectations:

- Students will complete a model of the carbon cycle including quantitative data.
- Students will look at the balance of carbon among the systems and construct an explanation of how the movement of carbon can result in changes to the system.

Materials:

- Student Sheet
- Digital device for research

Time: 1 - 60 minute period

Teacher Background Information:

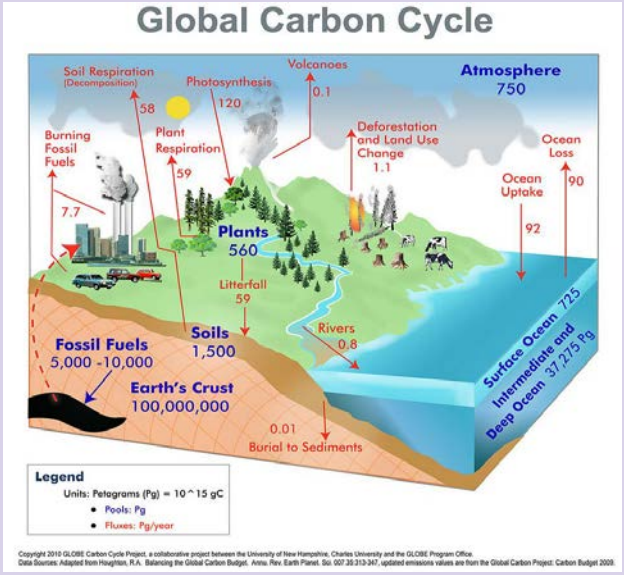
- We use hydrocarbons (fossil fuels) to perform everyday functions, and reliable fuels have created the standard of living we enjoy today. Carbon is stored when plants and animals decay and are buried for millions of years. As they burn, they produce carbon dioxide (CO_2), a natural component of our atmosphere. Hydrocarbons is a term for organic compounds containing only carbon and hydrogen atoms. Hydrocarbons are the primary constituents in petroleum, natural gas, and coal. Hydrocarbons form deep underground, where the Earth's inner forces (heat and pressure) are exerted on the remains of ancient sea plants and animals over millions of years. Over time, hydrocarbons can migrate through natural pores found in different rock layers or along faults until they reach the surface (oil seeps), or become trapped in the subsurface by an impermeable (zero to no pore space) rock layer such as shale or granite.

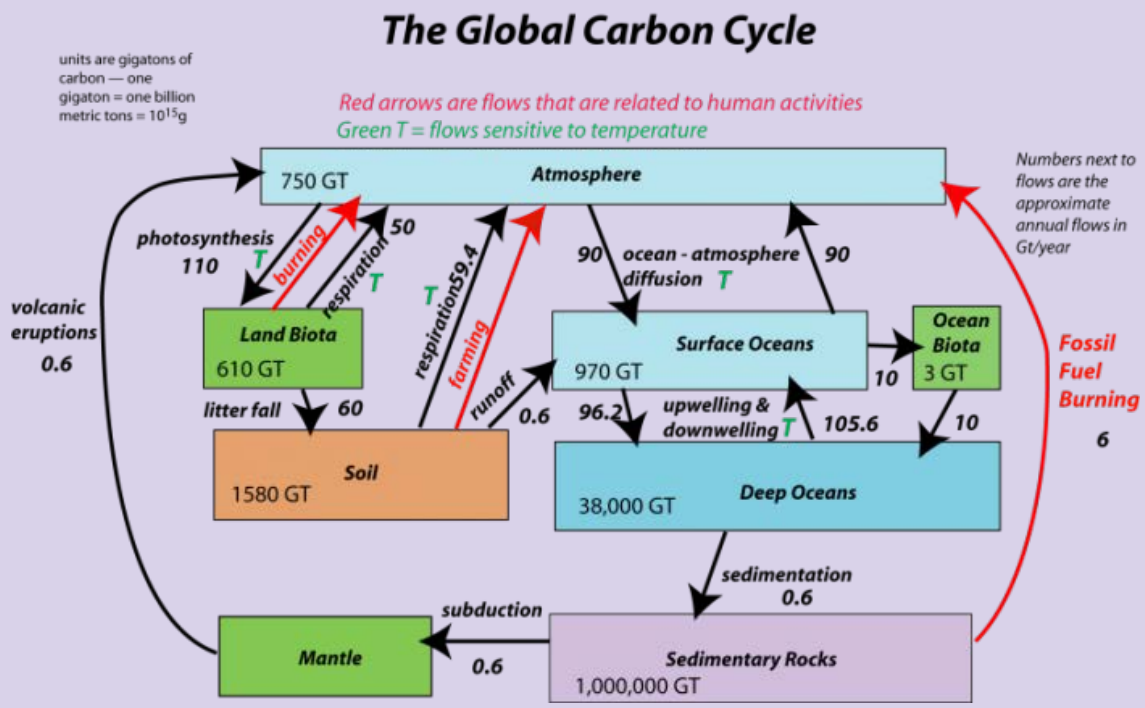
- Recovering and refining hydrocarbons provides us with the fuels necessary for generating electricity and powering our vehicles, as well as providing materials for plastics and polymers found medical supplies, clothing, as inputs for industrial applications, and much more.

- Extracting energy from hydrocarbons occurs by breaking the hydrogen-carbon bonds through a combustion reaction, producing energy, water, and carbon dioxide (CO_2). Carbon dioxide is a naturally occurring gas critical to the carbon cycle. The carbon cycle is the natural exchange of CO_2 between the atmosphere and terrestrial and marine biomes. Plants, soil, and the ocean act as carbon sinks in this process, meaning they take in CO_2. The use of hydrocarbons contributes CO_2 to the atmosphere, increasing the burden on these sinks to exchange more gas. Terrestrial biomes are doubly affected. Models have indicated that rising CO_2 levels in the atmosphere increase temperatures, which increases the rate that organic matter in the soil begins to decompose. This

creates even more CO2 in the soil and the atmosphere. This challenge has led to innovations in alternative fuel technologies, energy efficiency and renewable energy. Utah is leading out on innovative energy development, from tier 3 fuels, carbon capture, cutting edge geothermal research, strategic energy efficiency projects, and much more.

- The Carbon Cycle is a model of the flow of carbon through Earth's systems. There are many ways to illustrate that flow and the diagrams below are examples of carbon cycle models.





Student Background Knowledge:

- Students know that hydrocarbons have supported our standard of living today.
- Students know carbon dioxide is a greenhouse gas and that it is released when fossil fuels are burned.
- Students know that plants use carbon dioxide.

Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce *Phenomenon:***
    a. Show students the following images. We use fossil fuels to perform everyday functions like driving cars, warming our homes and powering our schools, hospitals and business's. While this contributes to our mobility, economy and high quality of life, it also produces emissions. How are the photos related in terms of the carbon cycle?

    b. Show students the above photos of a city and a decaying forest.Ask them what questions they have

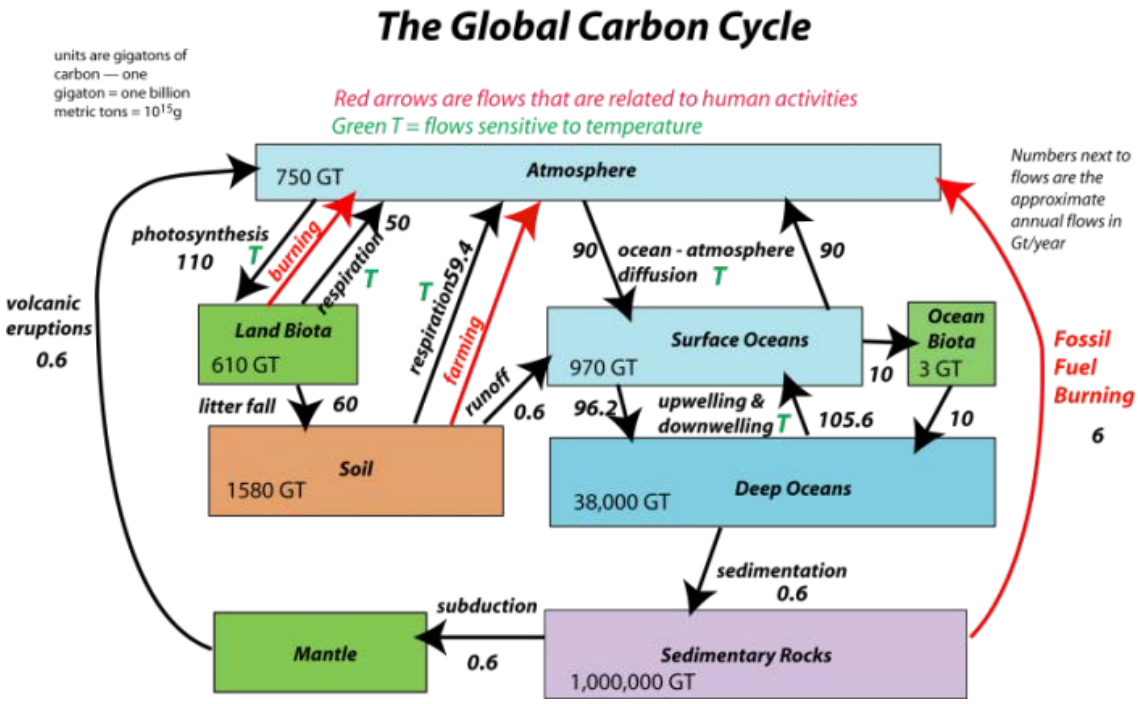
about the phenomenon. *In what ways is carbon added to the carbon cycle?*

2. **Obtain Information**
   a. Read the information on the student sheet with students. They should understand the process for each movement of CO2. For example, they may be unfamiliar with the idea that CO2 can be absorbed or released by ocean water or are stored in rock or fossil fuels.
   b. Have students use the data to create a model in the space on their student sheet. They can choose any format to design it (may be pictorial, may be boxes). Add quantitative data to show the flow of carbon in each of the systems on the model.
3. **Use the model and Construct an Explanation** Students will use the data to answer Question #1 and have materials to research an issue. Research how changes to the carbon cycle affect:
   a. air.
   b. water.
   c. living things.
   d. people Possible Video: It's Easy to be Epic (.30 min)

Assessment of Student Learning. Students will construct an explanation about how the movement of carbon can result in changes to one of the systems in their model. Students will use quantitative evidence from their model.

Standardized Test Preparation:

Carbon Cycle



1. How does this model help explain the carbon cycle? Choose all that apply.
   a. It provides a visual representation of something impossible to see.*
   b. It describes all the known sources and sinks of carbon on Earth.

c. It provides an analysis of the activities that are affecting the cycle.
d. It summarizes data that has been collected from a variety of sources.*

2. Plants and soil add and remove carbon from the atmosphere. What plant activity removes carbon?
   a. Respiration
   b. Photosynthesis*
   c. Deforestation
   d. Evaporation

3. According to the model, deforestation contributes between 1 billion metric tons of carbon per year. Select all of the options that show why deforestation contribute carbon to the atmosphere?
   a. Burning or the decay of harvested trees adds carbon dioxide to the air.*
   b. Forests are carbon sinks that allow carbon to flow in and out of the air.
   c. Fewer trees are available to absorb and incorporate carbon into their bodies.*
   d. The crops grown in the deforested areas do not pull as much carbon from the air.*

4. Based on this model, what is the net carbon flow in a year?
   a. 100 pentagrams of carbon are added to the atmosphere.
   b. 10 pentagrams of carbon are added to the atmosphere.*
   c. 10 pentagrams of carbon are removed from the atmosphere.
   d. 100 pentagrams of carbon are removed from the atmosphere.

Extension of lesson and Career Connections:

- Have students research the Utah Geological Survey (UGS). How do they gather their data? Have students research jobs available in Utah's energy industry and what types of degrees would be required to have those jobs.
- Read this article about a new technology for emissions-free fossil fuel energy and research the process of chemical looping. Talk about ways to reduce emissions including: energy efficiency, renewable energy, and alternative fuels.

Carbon Cycle

Name_____

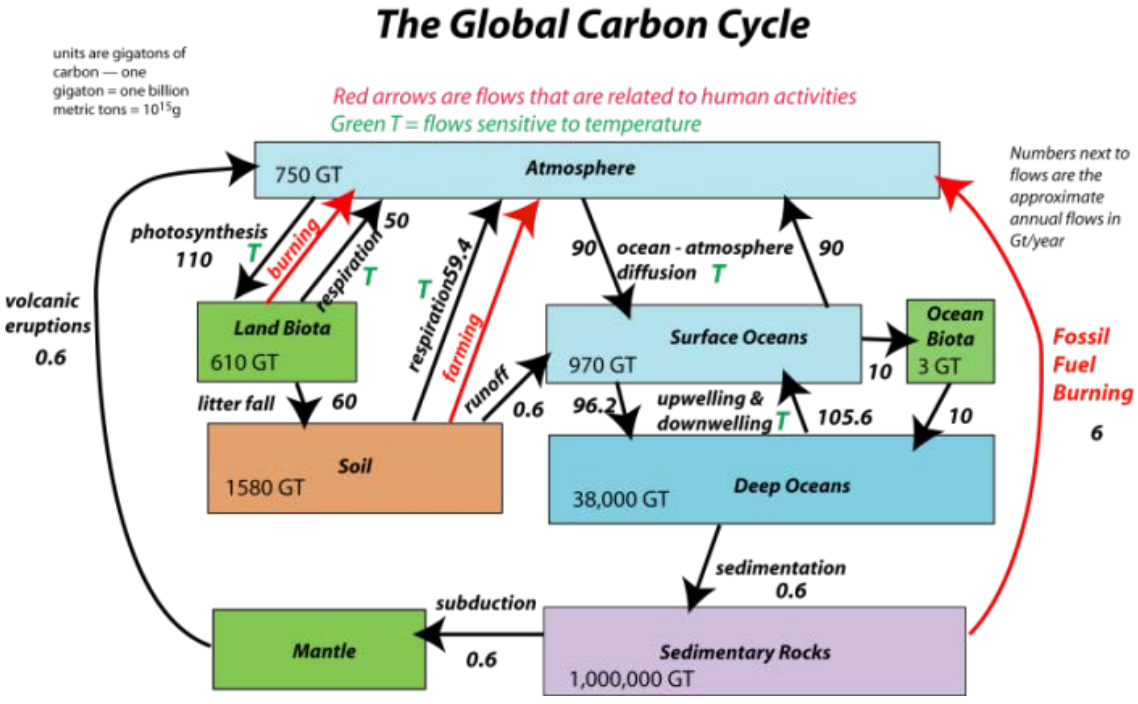
Phenomenon: Observe the phenomenon. Ask three questions about what you see.

1.

2.

3.

Scientists have measured (and estimated) the amount of carbon held in reservoirs on Earth. Some carbon is always moving from reservoir to reservoir. The atmosphere is a reservoir for 750 gigatonne (Gt) of carbon dioxide. 1 Gt is equal to 1,000,000,000 metric tons. A metric ton is exactly **1000 kilograms**. This makes 1 Gt equal to 1,000,000,000,000 kilograms. Natural and human activities add and subtract carbon dioxide from the atmosphere.



Data:

Source	Add (in Gt)	Reduce
Fossil Fuel Burning	6	
Ocean (ocean water absorbs CO2 and releases it)	90	90

Plants (photosynthesis absorbs, decay, respiration releases it)	50	110
Soil Decomposition	59.4	
Volcanoes	.6	
Farming	59.4	
Burning Land Biota	50	
Soil formation (plant decay)		59

Develop a model of the Carbon Cycle using the data from the table.

1. Based on this data, what is the net flow of carbon dioxide into the atmosphere?

2. Choose one of the following to state a **claim**. Research how changes to the carbon cycle affect:
    a. air.
    b. water.
    c. living things.
    d. people.

Support your claim with **evidence** from your research. Describe your **reasoning.**