## Lesson Summary
Students will learn about different carbon sources and sinks and the release and storage processes for each of them.

## Prior Knowledge & Skills
- Knowledge of the greenhouse effect and CO2
- Knowledge of carbon as the main constituent of living organisms

## AAAS Science Benchmarks
### The Physical Setting
- Processes that Shape the Earth

### The Living Environment
- Interdependence of Life
- Flow of Matter and Energy

## NSES Science Standards
### Physical Science
- Chemical Reactions

### Earth and Space Science
- Geochemical Cycles

### Science in Personal and Social Perspectives
- Natural and Human Induced Hazards

### Unifying Concepts and Processes
- Change, Constancy, and Measurement

## NCGE Geography Standards
### Physical Systems
- Standard 7

## Teaching Time
**Teaching Time:** ~1 hour

## Materials
- 1 copy of The Carbon Cycle (Figure 1)
- 1 copy of The Carbon Cycle A4 sheet for each student
- 1 set of A4 sheets of ‘products’
- 1 set of A4 sheets of ‘processes’
- 1 set of specimens of ‘products’ *
  - Carbon dioxide in the atmosphere
  - Carbon in green plants
  - Carbon in animals
  - Carbon in soil
  - Carbon in seawater
  - Carbon in marine animals and plants
  - Carbon in coal and natural gas
  - Carbon in oil
  - Carbon in limestone

## Advanced Planning
### Preparation Time: ~10 minutes
1. Review the instructions
2. Gather the necessary supplies.
3. Place ‘products’ sheets in a rough circle on desks around the classroom

### Recommended Reading: (attached)
- Various carbon cycle diagrams

*Editor’s note: Examples of the ‘products’ specimens can be found under the activities Apparatus and materials section.

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The Royal Society of Chemistry: JESEI
http://www.chemsoc.org/Networks/Learnnet/jesei/lab/home.htm
Carbon cycle in the lab: carbon products and the processes that link them (teacher’s notes)

Topic
This activity is one of five aimed to teach students about the nature of carbon, the different types of compounds it exists in (e.g., charcoal, glucose, carbon dioxide), the biochemical reactions it takes part in (photosynthesis and respiration), the range of processes that carbon and carbon compounds are involved in on Earth, and how these link together to form the carbon cycle.

Context
An understanding of the carbon cycle is essential to the debate about global warming, an environmental issue that most students will have heard about. Since the Earth’s atmosphere formed, it seems to have always contained carbon dioxide in varying amounts. Carbon dioxide is a ‘greenhouse gas’ through which light radiation can pass but which absorbs some of the heat radiation produced by light irradiating the Earth’s surface. This causes the Earth’s surface and atmosphere to be warmer than it would otherwise be and without the ‘greenhouse effect’ the Earth would probably be completely frozen. Humans, as all life on Earth, have always been part of the carbon cycle, but now (since the industrial revolution) the large scale burning of oil, coal and natural gas, along with deforestation, is leading to increasing atmospheric carbon dioxide levels. This in turn is related to an enhanced greenhouse effect and consequent climatic change. An understanding of the factors affecting global warming leads to an understanding of the measures required to reduce their impact. This can link into economic and political debates on the subject. Students should have already covered photosynthesis and respiration in order to do this set of activities effectively.

Teaching points
The carbon cycle is a “big idea” that can be difficult to understand because parts of it work at a microscopic scale while other parts affect the whole Earth. Also, some parts happen in milliseconds whilst others can take millions of years to have an effect. We can get a feel for how the whole carbon cycle works by turning the lab into a model of the carbon cycle and seeing how the different things that are produced in the cycle (the products) fit together with the way those products are made (the processes).
Apparatus and materials

The teacher will need:

An OHT showing the carbon cycle (Figure 1).

A copy of the carbon cycle A4 sheet for each pupil (Figure 1).

Either a copy of Carbon cycle in the lab: carbon products and the processes that link them (for pupils) worksheet for each pupil or an OHT version

1 set of A4 sheets of ‘products’, (Carbon dioxide in the atmosphere, Carbon in green plants; Carbon in soil; Carbon in marine animals and plants/ Carbon in soft parts/ Calcium carbonate in hard parts; Carbon in coal and natural gas/ Carbon in oil/ Carbon in limestone; Carbon dissolved in seawater)

1 set of A4 sheets of ‘processes’, (dissolved in rain/ soil water - carried to sea; absorption by organisms; burial and rock formation; burial and decomposition in rock sequence; burial and rock formation; weathering; combustion; photosynthesis; consumption; death; excretion and death; respiration)

Set of specimens of ‘products’:

- Carbon dioxide in the atmosphere – a stoppered test tube, labelled ‘Atmosphere’
- Carbon in green plants - grass or leaf (or a picture)
- Carbon in land animals - mirror
- Carbon in soil - bag of soil
- Carbon in seawater - test-tube of water labelled ‘seawater’
- Carbon in marine animals and plants- sea shells
- Carbon in coal and natural gas - coal
- Carbon in oil – a stoppered, labelled test tube of crude oil (molases could be used as a substitute if crude oil is not available)
- Carbon in limestone - limestone

To prepare:

A4 sheets of the ‘products’ of the cycle are put in a rough circle on desks around the room.

Keep the A4 sheets of the ‘processes’ for use later.

Safety

Be aware of the risk of breaking test-tubes.
**Activity**

Through discussion with the class, the teacher puts the specimens in the correct places on the carbon cycle product sheets laid out around the room.

Then, again through interactive discussion, the teacher puts the ‘processes’ sheets in the correct places between the products around the room.

Finally the pupils are shown an OHT version of the cycle and are given their own copies. They should write the examples of the ‘products’ they have been shown in the correct places on their version of the diagram. Faster pupils can then answer the questions on the worksheet.

**Questions**

Which products of the carbon cycle:

Q 1. can you see out of the window? = *Green plants, land animals, soil, limestone.*

Q 2. can you never see? = *Carbon dioxide in the atmosphere and dissolved in seawater, natural gas.*

Q 3. might you see in a quarry? = *Limestone, coal, soil, plants, land animals, the hard parts of marine animals.*

Q 4. are fluids (liquids or gases)? = *Carbon dioxide in the atmosphere, natural gas, oil, dissolved carbon dioxide in seawater.*

Q 5. last the longest? = *Limestone, coal, oil/natural gas trapped in rocks, carbon dioxide in the atmosphere.*

Q 6. might affect global warming? *(This is for the more able/interested and is a ‘warm up’ for activities to come!)* = *Greenhouse gases carbon dioxide and methane (natural gas); coal, oil, natural gas that will produce carbon dioxide when burned, green plants that remove CO$_2$ in photosynthesis, animals and plants that release CO$_2$ in respiration (all the other products may affect global warming too, eg weathering of limestone releases more CO$_2$, when there is more CO$_2$, plant life is more prolific and the animal life feeding on the plant life is more prolific, etc).*
Figure 1 The carbon cycle
Carbon dioxide in atmosphere
Carbon in green plants
Carbon in land animals
Carbon in soil
<table>
<thead>
<tr>
<th>Carbon in marine animals and plants</th>
<th>Calcium carbonate in hard parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon in soft parts</td>
<td></td>
</tr>
</tbody>
</table>
Carbon in coal and natural gas
Carbon in oil
Carbon in limestone
Carbon dissolved in seawater
dissolved in rain/soil water
- carried to sea
absorption by organisms
burial and rock formation
burial and decomposition in rock sequence
burial and rock formation
weathering
combustion
photosynthesis
consumption
death
excretion and death
respiration