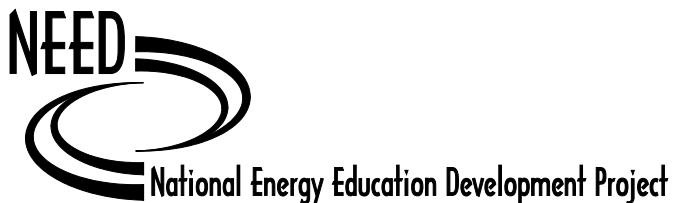
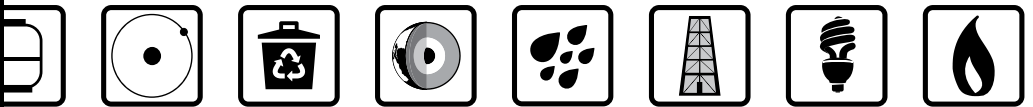


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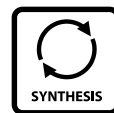
Exploring Climate Change

A comprehensive Teacher and Student Guide for students to learn about climate change through hands-on critical thinking activities.



Grade Level:

- Secondary



Subject Areas:

- Science
- Social Studies
- Language Arts
- Technology



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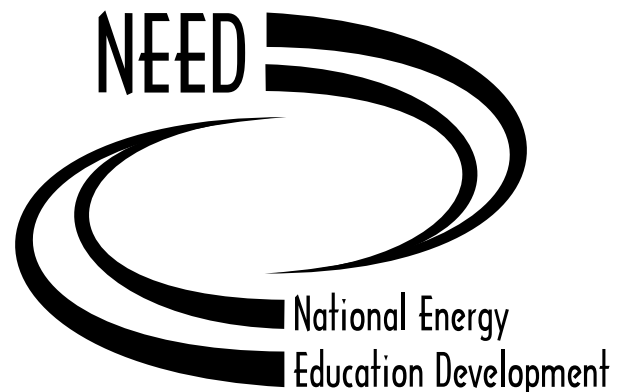
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Activity 5: Carbon Cycle Simulation

Objective

- Students will deepen their understanding of how carbon cycles throughout the Earth's systems.
- Students will be able to compare how carbon cycled through the Earth's systems prior to the Industrial Revolution and after the Industrial Revolution.

Materials

- *Reservoir Posters* (pages 12-15)
- *Reservoir Instruction Sheets* (pages 16-24)
- Two decks of playing cards, divided by suit
- 2 copies of *Carbon Tracking Sheet* for each student (page 50)
- *Carbon Reservoir Comparison* charts (page 49)

Pre-Industrial Round Preparation

1. Hang up the reservoir posters and *Pre-Industrial Round Instruction* sheets around the classroom (as shown in the diagram on page 10).
2. Place a full suit of cards at each of the eight reservoirs.

Pre-Industrial Round Procedure

1. Pass out the *Carbon Reservoir Comparison* chart and have students use the *Exploring Climate Change Student Backgrounder* to compare the four major carbon reservoirs. Review the information as a class.
2. Explain that in this activity students will become carbon atoms, and model the different forms carbon takes as it travels between these reservoirs.
3. Use the chart on page 11 to divide your students among the reservoirs. The natural exchange of carbon between the lithosphere and atmosphere pre-Industrial Revolution was negligible, so the lithosphere is not used in this round.
4. Pass out one *Carbon Tracking Sheet* to each student. Students will record which reservoirs they travel to in this round.
5. Assign students to their first reservoir. They should count how many people are at the reservoir and record the number on the sheet. Remind students that they should not pull cards until instructed. Students should not change reservoirs until given a signal to move. At that time, everyone who is changing reservoirs (based on the card they pulled) will move.
6. Students record the necessary information about their reservoir and carbon form on their *Carbon Tracking Sheet*.
7. Instruct students to each choose a card and use the directions on the sheet to determine who leaves the reservoir and who stays. Students return the cards to the original pile.
8. Signal students to change reservoirs. Once everyone has arrived where they need to be, the group counts how many people are at the reservoir and students write down the necessary information about the reservoir and carbon form on their worksheet.
9. Repeat steps seven and eight until you have completed 10 cycles in the Pre-Industrial Round.
10. Bring the students together and discuss what they noticed about carbon movement, the forms carbon comes in, and about the amount of carbon in each reservoir.

CONTINUED ON NEXT PAGE

Online Resources

Samples of the Reservoir Posters and Instructions sheets are on pages 12-24. To download full size color copies of the posters visit www.NEED.org.

Note

If you do not have enough students to make up the minimum number in either the Pre-Industrial or Present Day Rounds, you can create “proxy carbons” to fill up the needed spots. Assign one or two students to be “proxy managers” who will be responsible for drawing the cards for the proxy carbons, and moving them where they need to go.

Activity 5: Carbon Cycle Simulation *(continued from previous page)*

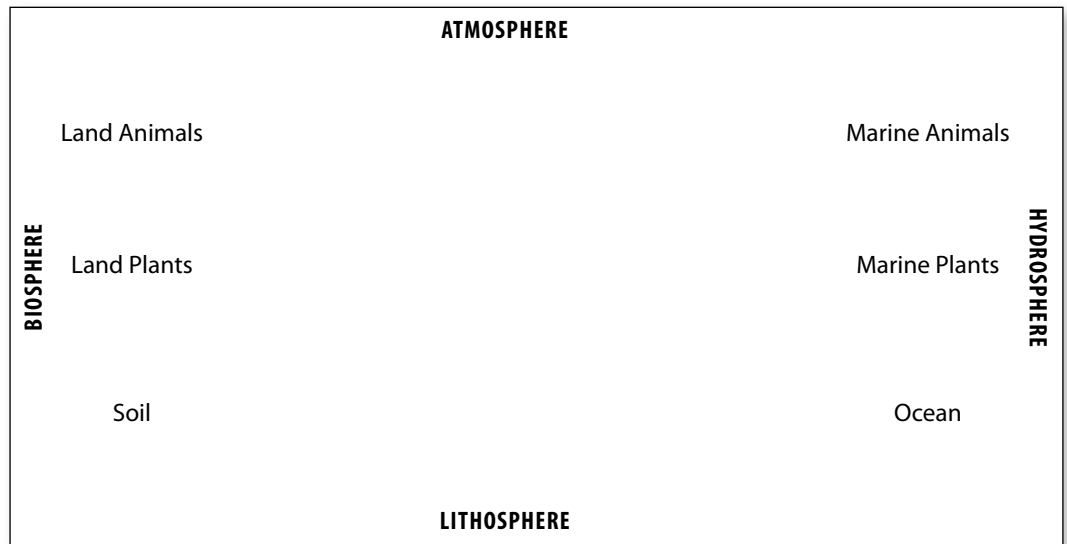
Present-Day Round Preparation

1. Hang up the Atmosphere and Lithosphere Present-Day Round instruction posters, pages 17 and 24.
2. Make sure each reservoir has a full suite of cards.

Present-Day Round Procedure

1. Pass out a new *Carbon Tracking Sheet* to each student.
2. Assign students reservoirs using the Present-Day Round table on the following page.
3. Follow the same direction as the Pre-Industrial Round and complete 10 cycles in the Present-Day Round.
4. When complete, discuss with the students the differences between the Pre-Industrial Round and the Present-Day Round. Use the data collected on the posters to graph the movement between the reservoirs. What conclusions can students make about carbon cycling based on the data?

Suggested Placement of Reservoir Posters



Number of Students in Each Reservoir

TOTAL NUMBER OF STUDENTS	PRE-INDUSTRIAL ROUND							
	ATMOSPHERE CO ₂ GAS	BIOSPHERE LAND PLANT	BIOSPHERE LAND ANIMAL	BIOSPHERE SOIL	LITHOSPHERE FOSSIL FUEL	HYDROSPHERE OCEAN	HYDROSPHERE MARINE PLANT	HYDROSPHERE MARINE ANIMAL
18	5	3	2	1	0	4	2	1
19	5	3	2	1	0	5	2	1
20	5	4	2	1	0	5	2	1
21	6	4	2	1	0	5	2	1
22	6	4	2	1	0	5	3	1
23	6	4	3	1	0	5	3	1
24	7	4	3	1	0	5	3	1
25	7	4	3	1	0	5	3	2
26	7	4	3	2	0	5	3	2
27	8	4	3	2	0	5	3	2
28	8	4	3	2	0	6	3	2
29	8	5	3	2	0	6	3	2
30	9	5	3	2	0	6	3	2
31	9	5	3	2	0	6	4	2
32	9	5	4	2	0	6	4	2

TOTAL NUMBER OF STUDENTS	PRESENT-DAY ROUND							
	ATMOSPHERE CO ₂ GAS	BIOSPHERE LAND PLANT	BIOSPHERE LAND ANIMAL	BIOSPHERE SOIL	LITHOSPHERE FOSSIL FUEL	HYDROSPHERE OCEAN	HYDROSPHERE MARINE PLANT	HYDROSPHERE MARINE ANIMAL
28	5	3	2	1	10	4	2	1
29	5	3	2	1	10	5	2	1
30	5	4	2	1	10	5	2	1
31	6	4	2	1	10	5	2	1
32	6	4	2	1	10	5	3	1



CARBON CYCLE SIMULATION

The Atmosphere: CO₂ Gas Pre-Industrial Round

You are now part of a carbon dioxide molecule in the atmosphere.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the "I arrived here by the process of ..." and "What I am now" columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the "Next I am going to the..." column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE LAND PLANT RESERVOIR	GO TO THE OCEAN RESERVOIR	STAY IN THE ATMOSPHERE RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start				
1	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
2	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
3	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
4	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
5	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
6	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
7	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
8	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
9	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
10	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	



CARBON CYCLE SIMULATION

The Atmosphere: CO₂ Gas Present-Day Round

You are now part of a carbon dioxide molecule in the atmosphere.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the “I arrived here by the process of ...” and “What I am now” columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the “Next I am going to the...” column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE LAND PLANT RESERVOIR	GO TO THE OCEAN RESERVOIR	STAY IN THE ATMOSPHERE RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start				
1	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
2	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
3	<u>Two</u> Highest Cards	Next <u>Four</u> Highest Cards	All Others	
4	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
5	<u>Two</u> Highest Cards	Next <u>Four</u> Highest Cards	All Others	
6	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	
7	<u>Two</u> Highest Cards	Next <u>Four</u> Highest Cards	All Others	
8	<u>Two</u> Highest Cards	Next <u>Four</u> Highest Cards	All Others	
9	<u>Two</u> Highest Cards	Next <u>Four</u> Highest Cards	All Others	
10	<u>Two</u> Highest Cards	Next <u>Three</u> Highest Cards	All Others	



CARBON CYCLE SIMULATION

The Biosphere: Land Plant All Rounds

You are now part of a glucose molecule in a carrot.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the “I arrived here by the process of ...” column and “What I am now” columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the “Next I am going to the...” column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE LAND ANIMAL RESERVOIR	GO TO THE SOIL RESERVOIR	STAY IN THE LAND PLANT RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start				
1	High Card	Low Card	All Others	
2	<u>Two</u> Highest Cards		All Others	
3	High Card	Low Card	All Others	
4	<u>Two</u> Highest Cards		All Others	
5	High Card	Low Card	All Others	
6	<u>Two</u> Highest Cards		All Others	
7	High Card	Low Card	All Others	
8	<u>Two</u> Highest Cards		All Others	
9	High Card	Low Card	All Others	
10	<u>Two</u> Highest Cards		All Others	



CARBON CYCLE SIMULATION

The Biosphere: Land Animal All Rounds

You are now part of a protein molecule in a rabbit.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the "I arrived here by the process of ..." and "What I am now" columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the "Next I am going to the..." column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE ATMOSPHERE	GO TO THE SOIL RESERVOIR	STAY IN THE LAND ANIMAL RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start				
1	High Card		All Others	
2	High Card	Low Card	All Others	
3	High Card		All Others	
4	High Card	Low Card	All Others	
5	High Card		All Others	
6	High Card	Low Card	All Others	
7	High Card		All Others	
8	High Card	Low Card	All Others	
9	High Card		All Others	
10	High Card	Low Card	All Others	



CARBON CYCLE SIMULATION

The Biosphere: Soil All Rounds

You are now part of an organic molecule in the soil.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the “I arrived here by the process of ...” and “What I am now” columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the “Next I am going to the...” column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE ATMOSPHERE RESERVOIR	STAY IN THE SOIL RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start			
1	High Card	All Others	
2	High Card	All Others	
3	High Card	All Others	
4	High Card	All Others	
5	High Card	All Others	
6	High Card	All Others	
7	High Card	All Others	
8	High Card	All Others	
9	High Card	All Others	
10	High Card	All Others	



The Hydrosphere: Ocean All Rounds

You are now part of a carbon dioxide molecule dissolved in the ocean.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the "I arrived here by the process of ..." and "What I am now" columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the "Next I am going to the..." column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE ATMOSPHERE RESERVOIR	GO TO THE MARINE PLANT RESERVOIR	STAY IN THE OCEAN RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start				
1	<u>Three</u> Highest Cards	Low Card	All Others	
2	<u>Three</u> Highest Cards	Low Card	All Others	
3	<u>Three</u> Highest Cards	Low Card	All Others	
4	<u>Three</u> Highest Cards	Low Card	All Others	
5	<u>Three</u> Highest Cards	Low Card	All Others	
6	<u>Three</u> Highest Cards	Low Card	All Others	
7	<u>Three</u> Highest Cards	Low Card	All Others	
8	<u>Three</u> Highest Cards	Low Card	All Others	
9	<u>Three</u> Highest Cards	Low Card	All Others	
10	<u>Three</u> Highest Cards	Low Card	All Others	



CARBON CYCLE SIMULATION

The Hydrosphere: Marine Plant All Rounds

You are now part of a glucose molecule in a marine plant.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the “I arrived here by the process of ...” column, and “What I am now” columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the “Next I am going to the...” column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE MARINE ANIMAL RESERVOIR	STAY IN THE MARINE PLANT RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start			
1	High Card	All Others	
2	High Card	All Others	
3	High Card	All Others	
4	High Card	All Others	
5	High Card	All Others	
6	High Card	All Others	
7	High Card	All Others	
8	High Card	All Others	
9	High Card	All Others	
10	High Card	All Others	



The Hydrosphere: Marine Animal All Rounds

You are now part of a protein molecule in a marine animal.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the "I arrived here by the process of ..." and "What I am now" columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the "Next I am going to the..." column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE OCEAN RESERVOIR	STAY IN THE MARINE ANIMAL RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start			
1	High Card	All Others	
2	High Card	All Others	
3	High Card	All Others	
4	High Card	All Others	
5	High Card	All Others	
6	High Card	All Others	
7	High Card	All Others	
8	High Card	All Others	
9	High Card	All Others	
10	High Card	All Others	



CARBON CYCLE SIMULATION

The Lithosphere: Fossil Fuel Present-Day Round

You are now part of a hydrocarbon molecule in a coal deposit.

1. When you arrive, use the *Carbon Tracking Sheet* to fill in the “I arrived here by the process of ...” and “What I am now” columns of your worksheet.
2. Record the total number of carbons in this reservoir in the space provided below.
3. Each person draws a card. Use the chart below to figure out where each person goes next. Then each person fills in the “Next I am going to the...” column on their worksheet.
4. Return cards to a pile and shuffle.
5. WAIT UNTIL YOU ARE DIRECTED TO MOVE TO YOUR NEW RESERVOIR.

	GO TO THE ATMOSPHERE RESERVOIR	STAY IN THE LITHOSPHERE RESERVOIR	NUMBER OF CARBONS IN THIS RESERVOIR
Start			
1	High Card	All Others	
2	High Card	All Others	
3	High Card	All Others	
4	High Card	All Others	
5	High Card	All Others	
6	High Card	All Others	
7	High Card	All Others	
8	High Card	All Others	
9	High Card	All Others	
10	High Card	All Others	



Carbon Reservoir Comparison

Atmosphere

Biosphere

Hydrosphere

Lithosphere