Carbon Travels Game

(Adapted from: STEM Earth Central 2006
- *modified version of activity produced by New England Aquarium)*

Purpose

- To learn that carbon is one of the most important, and abundant elements on Earth and can be found everywhere.
- To experience the concept of residence time by remaining in a carbon pool for several time periods (dice rolls).

Overview

This activity provides an introduction to the carbon cycle and, more broadly, to biogeochemical cycling, the greenhouse effect and climate change. During the activity, students research one carbon pool in depth, share their knowledge with peers and then see how carbon pools are connected by fluxes as they roll game dice to move from station to station around the classroom. Students keep track of the carbon pools they visit, and the process that takes them to the next carbon pool.

Student Outcomes

Students will be able to:
- Research a carbon pool and present the key points to their peers
- List all the major pools and fluxes in the global carbon cycle
- Define residence time and provide one example from the carbon cycle
- Compare and contrast the carbon cycle pre and post 1700

Content Questions

- What are the major pools and fluxes of the global carbon cycle?
- What is residence time and how does it play a role in the carbon cycle?
- How does today's carbon cycle differ from the carbon cycle prior to 1700?

Time

60 to 120 minutes.

Level

Secondary (Middle & High School)

Science Concepts

Grades 5-8

Science in Personal and Social Perspectives
- Human activities can induce hazards. Such activities can accelerate natural changes.

Grades 9-12

Physical Science
- Chemical reactions can take on both very short and very long time scales.

Life Science
- The atoms and molecules on the earth cycle among living and non-living components of the biosphere.
- Human beings live within the world's ecosystems and modify them in multiple ways.

Science in Personal and Social Perspectives
- Materials from human societies affect physical and chemical cycles of the Earth.

Materials and Tools

- Materials about the carbon cycle (*Carbon Cycle Adventure Story*, *Carbon Background*, & other resources)
- Poster materials (enough for 8 posters)
- *Carbon Cycle Station Instructions & Signs*
- *Journey Table* (1 set per student)
- 1 die per student

Prerequisites

Systems concepts – pools and fluxes, box and arrow diagrams. (*Paperclip Simulation* and/or *Carbon Cycle Adventure Story*).

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Background

See the *GLOBE Carbon Cycle Teacher Background*.

Preparation

- Print/copy *Carbon Travels Journey Tables* & *Carbon Cycle Adventure Story Booklets*
- Make a classroom example of the *Carbon Travels Journey Table* (on overhead, white or blackboard)
- Write essential, unit and content questions somewhere visible in the classroom

What To Do and How To Do It

ENGAGE **Student Grouping:** Whole Class **Time:** 10 minutes

*Note: Students may have completed this engagement exercise if they participated in the *Carbon Cycle Adventure Story.* If so, move on to Explore.

- Tell students that you want to begin teaching about carbon today, but you cannot seem to find it. Ask students if anyone saw carbon today on their way into class.
  - Record the ideas of where carbon is found on the board.
- Solicit additional ideas about the carbon cycle. What is carbon? Where is it found? How does carbon move from one place to another (the processes)? What forms does it take (C, CO_2, CH_4, $CaCO_3$, glucose)?
- Differentially highlight/circle the pools and fluxes.
- Group student's ideas into the major global carbon pools. (Atmosphere, Terrestrial Life, Soil, Surface Ocean, Marine Life, Deep Ocean, Fossil Fuels, Ocean Sediment/Earth's Crust).

EXPLORE **Student Grouping:** Small Groups **Time:** 40 minutes

- Groups of students should prepare a poster about one of the major global carbon pools (e.g. atmosphere, soil), using information from the *Carbon Cycle Adventure Story* and/or other age appropriate resources.
  - Posters should include a description of where and how carbon is stored in the pool and how it moves into and out of the pool (e.g. photosynthesis, ocean uptake).
  - It may also include the forms carbon moves in such as the compounds and state of matter.

EXPLAIN **Student Grouping:** Whole Class **Time:** 15 minutes

- Hang the *Carbon Cycle Station Instructions & Signs* for the game around the room. (Spread them out so there is room for at least 3 students at a station.)
- Student groups hang their poster next to the appropriate station instructions and present their research through a poster session or gallery walk.
- Help answer any additional questions students may have about carbon pools and fluxes.

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ELABORATE/INVESTIGATE

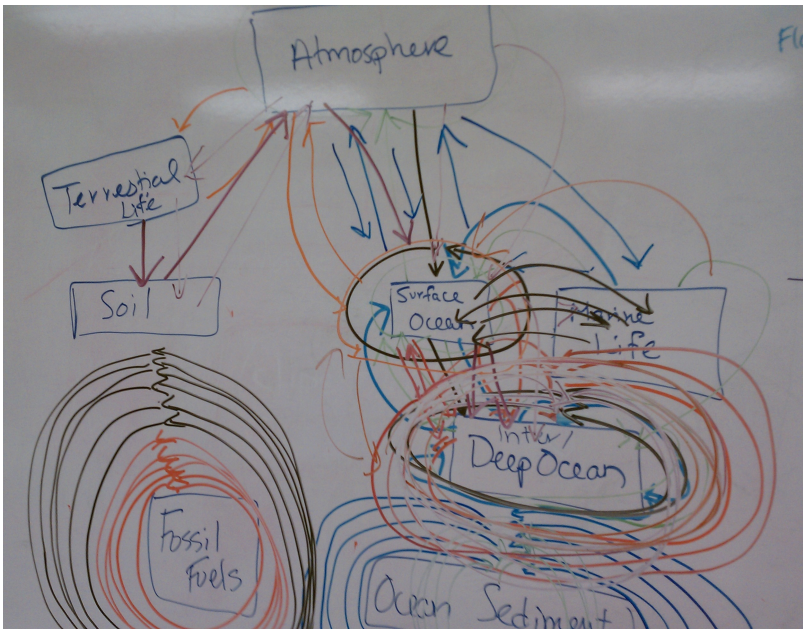
Student Grouping: Whole Class **Time:** 15 minutes

- Hand out copies of the *Journey Table* and tell students the game will begin pre-1700 (before the industrial revolution), and they may start anywhere in the cycle. **Model** how to use the *Journey Table* and emphasize the importance of including all the results even if they remain at the same pool repeatedly. Also remind them to take turns rolling the die per station.
- Students follow the instructions, move around the room at their own pace and record results in their tables. After 10 turns they stand to the side to indicate they are done.
- Flip over the instructions to begin the post-1700 simulation.
- Students complete another 10 turns under the new conditions.

EVALUATE/WRAP UP

Student Grouping: Individual **Time:** 15 minutes

- Students work independently on synthesizing the information they compiled. They complete "What's Your Carbon Story".
- Each student adds the path of his/her journey on the board (see sample), for both the pre and post-1700 scenarios.
    - Each time a student moved from one pool to another they should draw an arrow
    - Each time a student remained in a pool until the next turn they should circle the pool
- Referring to the students' data displayed on the board, discuss:
    - What was different before and after 1700?
    - List the major pools and fluxes before and after 1700 and compare and contrast.
    - What do the differences reflect? (Burning of fossil fuels & land use change)



- Discuss – Using their *Journey Table results*, ask students to observe the amount of time they stayed in each pool. Introduce the definition of residence time. (Add this term to your word wall if you have one in your classroom). How did residence time vary between pools? Why? (Use the **Mini-Activity** *Turnover Rate & Residence Time* to dig deeper into the topic – the *Getting to Know Global Carbon* activity will also provide depth to the discussion of residence time.)

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Assessment

- Students write a story or comic strip to describe their journey through the global carbon cycle. They should include information they learned from other student's presentations, creatively deal with pre vs. post 1700, and address residence time.

Adaptations

- To enhance the concept of residence time, place colored beads or paper slips at each station. Students should collect a new item (keeping them in order) each time they roll the dice. At the endof 10 rounds ask students to examine their own color pattern and the pattern of other students. What do they observe?
- To emphasize states of matter (carbon) add a state of matter column to the data table.
- Options for larger classes: 1) include multiple dice at each station, 2) half the class follows the pre-1700 cycle, then the other half the class follows the post-1700 cycle

Resources

STEM Earth Central 2006 – modified version of Carbon Travels activity produced by New England Aquarium

EPA Climate Change Kids Page – Flash Animations: http://epa.gov/climatechange/kids/animations.html

Windows to the Universe – The Carbon Cycle Game (Flash): http://www.windows2universe.org/earth/climate/carbon_cycle.html

Dr. Art's Guide to Planet Earth – The Carbon Cycle: http://www.planetguide.net/cool/carboncycle_activity.html

Environmental Literacy Council – Carbon Cycle: http://www.enviroliteracy.org/article.php/478.html

Northeast Science Center Collaborative – Climate Change Backpack: http://sciencecentercollaborative.org/backpack.php

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Name: _____ *Date:* _____

Carbon Travels Journey Table

Instructions: Pick a station/pool to start in- Atmosphere, Fossil Fuels, Soil/Detritus, Surface Ocean, Intermediate/Deep Ocean, Terrestrial Life, Marine Life or Ocean Sediments. Read the instructions, roll the die to see where you go to next. Keep taking turns by rolling the dice and moving between stations. **Record the results of every roll** in the table, even if you do not change stations! (To help you out, the flux is underlined on each station sheet.)

Pool you are starting from: _____

Pre-1700

Dice Roll	**Number Rolled**	**Where is carbon now? (Pool)**	**How did carbon leave? The process. (Flux)**	**Where did carbon arrive? (Pool)**
Ex.	*2*	*(Starting Pool) Terrestrial Life*	*Respiration*	*Atmosphere*
		Atmosphere		
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Turn your sheet over when instructor indicates time has shifted to post-1700.

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Starting from: _____

Post-1700

Dice Roll	Number Rolled	Where is carbon now? (Pool)	How did carbon leave? The process. (Flux)	Where did carbon arrive? (Pool)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

What's Your Carbon Story?

On separate paper answer the following questions. What happened to you on your journey? Where did you go, and how did you get there? Did you notice any patterns? Did you stay anywhere for a long time? How do your pre- and post-1700 journeys compare? Highlight some reasons why the two journeys were different. (You may draw pictures to help illustrate your thoughts.)

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Atmosphere Pre-1700

You are paired with two oxygen – you are in carbon dioxide, or CO_2!

Roll the Dice

If you roll a:

1: Stay in the **Atmosphere** 1 turn, then roll again.

2 or 3: A plant has taken you up as part of photosynthesis and synthesized you into sugar or a longer carbon chain. Become part of **Terrestrial Life**.

4, 5 or 6: You have dissolved in the waters of the **Surface Ocean**.

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Atmosphere Post-1700

You are paired with two oxygen – you are in carbon dioxide, or CO_2!

Roll the Dice

If you roll a:

1: Stay in the **Atmosphere** 1 turn, then roll again.

2 or 3: A plant has taken you up as part of photosynthesis and synthesized you into sugar or a longer carbon chain. Become part of **Terrestrial Life**.

4, 5 or 6: You have dissolved in the waters of the **Surface Ocean**.

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Terrestrial Life Pre-1700

You are part of a carbon chain – cellulose in a tree trunk, sugar in fruit, or muscle in an animal.

Roll the Dice

If you roll a:

1 or 2: You've been converted by respiration into carbon dioxide (CO_2), go to the **Atmosphere**.

3, 4, 5, or 6: The organism you were a part of died, and now the carbon that made it up has fallen to the ground where it will soon decay. Go into the **Soil**, because carbon never dies!

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Terrestrial Life Post-1700

You are part of a carbon chain – cellulose in a tree trunk, sugar in fruit, or muscle in an animal.

Roll the Dice

If you roll a:

1 or 2: You've been converted by respiration into carbon dioxide (CO_2), go to the **Atmosphere**.

3: You're wood or other material that has been burned (combustion) by humans as part of changing land use. Go to the **Atmosphere**.

4, 5, or 6: The organism you were a part of died, and now the carbon that made it up has fallen to the ground where it will soon decay. Go into the **Soil**, because carbon never dies!

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Soil/Detritus Pre-1700

You are part of a carbon chain, such as cellulose in a fallen leaf.

Roll the Dice

If you roll a:

1*, 2, 3, 4**: Stay in the **Soil** 1 turn, then roll again.

**If you roll 1 twice in a row, you are carried down to the Surface Ocean by a stream.*

***If you roll 4 five times in a row, you become a fossil fuel*

5, 6: The chain you are a part of decayed and became carbon dioxide. Go into the **Atmosphere**.

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Soil/Detritus Post-1700

You are part of a carbon chain, such as cellulose in a fallen leaf.

Roll the Dice

If you roll a:

1: Human disturbance of the land causes you to be carried away in a rainstorm, as runoff, to streams and rivers, eventually arriving at the **Surface Ocean**.

2, 3, 4**: Stay in the **Soil** 1 turn, then roll again.

If you roll 4 five times in a row, you are buried to where no oxygen is available and become a **Fossil Fuel

5, 6: The chain you are a part of decayed and became carbon dioxide. Go into the **Atmosphere**.

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Surface Ocean Pre-1700

You are carbon dioxide dissolved in the surface waters of the ocean.

Roll the Dice

If you roll a:

1: Stay where you are in the **Surface Ocean** one turn, then roll again.

2 or 3: Through wave action you have come out of solution as carbon dioxide gas. Go to the **Atmosphere**.

4 or 5: The processes of water currents and ocean mixing sends you to the **Intermediate/Deep Ocean** layers.

6: Algae has taken you up out of the water through photosynthesis, and synthesizes you into a carbon chain. Become part of the **Marine Life** cycle.

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Surface Ocean Post-1700

You are carbon dioxide dissolved in the surface waters of the ocean.

Roll the Dice

If you roll a:

1: Stay where you are in the **Surface Ocean** 1 turn, then roll again.

2 or 3: Through wave action you have come out of solution as carbon dioxide gas. Go to the **Atmosphere**.

4 or 5: The processes of water currents and ocean mixing sends you to the **Intermediate/Deep Ocean** layers.

6: Algae has taken you up out of the water through photosynthesis, and synthesizes you into a carbon chain. Become part of the **Marine Life** cycle.

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Intermediate/Deep Ocean

Pre-1700

You are carbon dioxide dissolved in the deeper waters of the ocean.

Roll the Dice

If you roll a:

1*, 2, 3, or 4: Stay where you are 1 turn, then roll again.

If you roll 1 twice in a row you settle to the bottom of the ocean and become part of **Ocean Sediment.*

5 or 6: The processes of water currents and ocean mixing sends you up to the **Surface Ocean**.

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Intermediate/Deep Ocean

Post-1700

You are carbon dioxide dissolved in the deeper waters of the ocean.

Roll the Dice

If you roll a:

1*, 2, 3, or 4: Stay where you are 1 turn, then roll again.

If you roll 1 twice in a row you settle to the bottom of the ocean and become part of **Ocean Sediment.*

5 or 6: The processes of water currents and ocean mixing sends you up to the **Surface Ocean**.

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Marine Life Pre-1700

You are part of a carbon chain in an algae, or a marine mammal!

Roll the Dice

If you roll a:

1, 2, 3, 4, or 5: You've been exhaled/respired by marine life and converted to carbon dioxide gas. Go to **Surface Ocean**.

6: The organism you were a part of died, and the carbon that made it up is now drifting downwards in the ocean. Carbon never dies! Go to the **Intermediate/Deep Ocean**.

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Marine Life Post-1700

You are part of a carbon chain in an algae, or a marine mammal!

Roll the Dice

If you roll a:

1, 2, 3, 4, or 5: You've been exhaled/respired by marine life and converted to carbon dioxide gas. Go to **Surface Ocean**.

6: The organism you were a part of died, and the carbon that made it up is now drifting downwards in the ocean. Carbon never dies! Go to the **Intermediate/Deep Ocean**.

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Ocean Sediment Pre-1700

You can roll the die, but you're not going anywhere anytime soon! You are **Ocean Sediment**, and will become sedimentary rock.

Roll the Dice

Stay unless:

You roll a 1 five times in a row, after 10 million years you are compressed under conditions of great temperature and pressure to become **Fossil Fuel**.

If you roll a 6 five times in a row, after 10 million years you are released by a volcano as carbon dioxide gas. Go to the **Atmosphere**.

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Ocean Sediment Post-1700

You can roll the die, but you're not going anywhere anytime soon! You are **Ocean Sediment**, and will become sedimentary rock.

Roll the Dice

Stay unless:

You roll a 1 five times in a row, after 10 million years you are compressed under conditions of great temperature and pressure to become **Fossil Fuel Deposits**.

You roll a 6 five times in a row, after 10 million years you are released by a volcano as carbon dioxide gas. Go to the **Atmosphere**.

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Fossil Fuel Deposits

Pre-1700

You are part of a carbon chain in oil or natural gas.

Roll the Dice

You can roll the die, but you're not going anywhere! You are ancient plants compressed and transformed into **Fossil Fuel Deposits**, and you are stuck under many layers of rock on land and in the oceans.

Stay in the **Fossil Fuel** pool for 10 turns.

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Fossil Fuel Deposits

Post-1700

You are part of a carbon chain in oil or natural gas.

Roll the Dice

If you roll a:

1, 2, 3, or 4: Stay where you are in **Fossil Fuel Deposits** for 1 turn. You have not been extracted from underneath the rocks. Roll again.

5 or 6: You've been extracted and then burned in a car or power plant and converted into carbon dioxide gas. Go to the **Atmosphere**.

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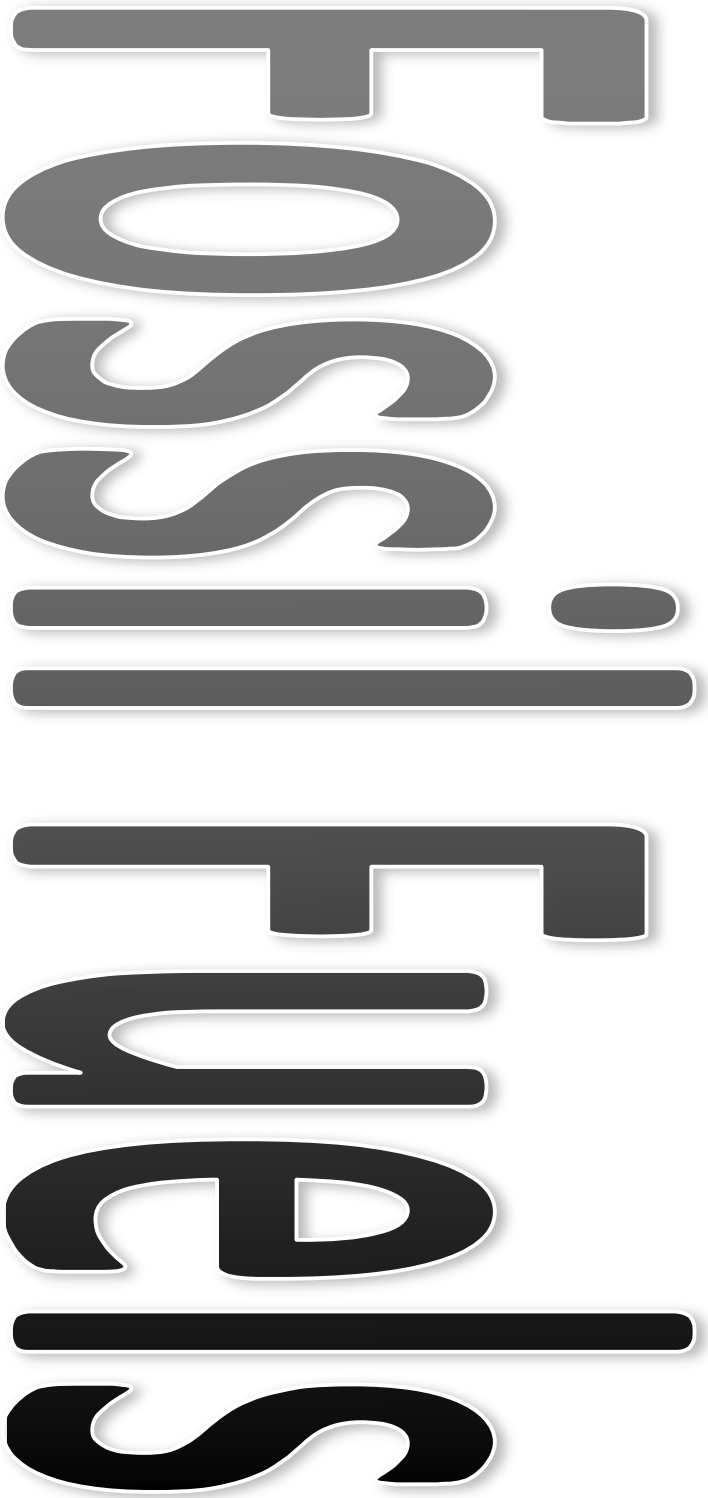

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Terrestrial

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Surface Ocean

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Intermediate/

Deep Ocean

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Ocean Sediment

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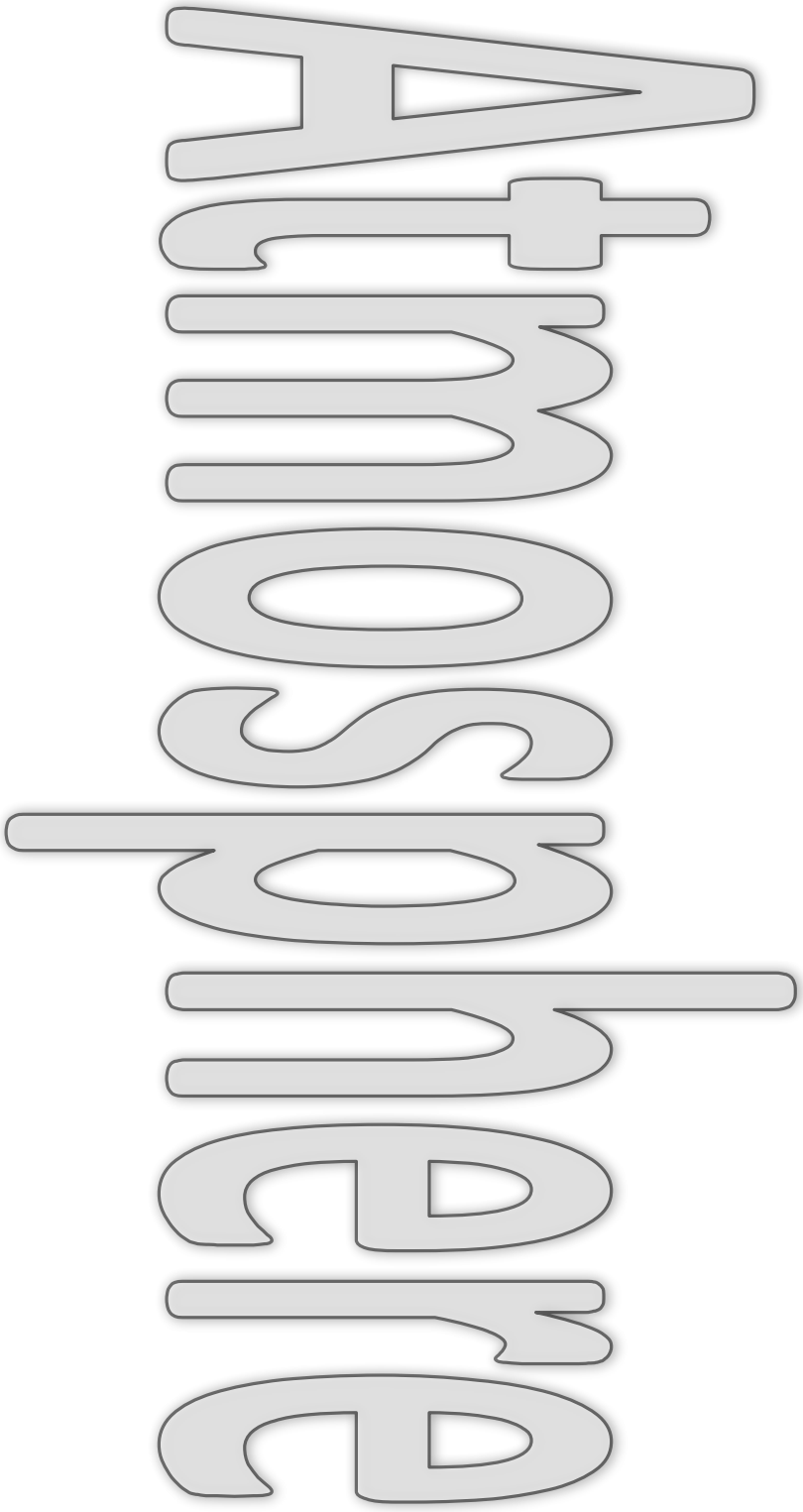

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