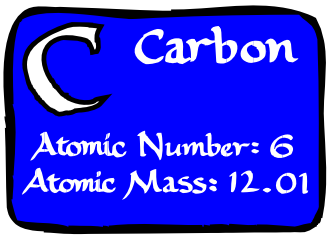



# The Carbon Cycle Game

(Adapted by Jennifer Ceven from "The Incredible Journey," *Project Wet*)



**Summary:**

By rolling a die, students will simulate a molecule of carbon's movement throughout various locations within the carbon cycle.

**Objective:**

- Students will describe the movement of carbon within the carbon cycle.
- Students will evaluate the relative timing of movement through various locations in the carbon cycle.

**Materials:**

- 7 Dice
- 7 Station Signs
- 7 Station Movement Directions
- Data record sheets for each student

**Background**:

The movement of carbon through various aspects of the natural environment is the focus of much scientific research. Global warming and climate change can be attributed to the increased amount of heat-trapping gases, such as carbon dioxide. Students must develop an understanding of how carbon moves through the environment in order to appreciate the complexity of developing solutions to address problems associated with climate change. In addition, since anthropogenic influences impact how much carbon is reintroduced to the active carbon cycle, students should recognize that human actions negatively affect the environment.

**Warm-Up:**

- Review what carbon is (an element, the stuff of life)
- Discuss where carbon can be found on Earth.
- Discuss the role of carbon in each of the places identified.
- Review the processes that move carbon around in the carbon cycle
    1. Physical processes
        - Water currents
        - Settling to the ocean floor or to the ground
    2. Chemical and Biological processes
        - Respiration – Exchange of gases through breathing
        - Photosynthesis - The synthesis of complex organic materials, esp. carbohydrates, from carbon dioxide, water, and inorganic salts, using sunlight as the source of energy and with the aid of chlorophyll and associated pigments.
        - Combustion – The act or process of burning

- Dissolving gaseous carbon dioxide into water, where it takes the form of carbonic acid
- Coming out of solution of carbonic acid to become carbon dioxide in the air (same process that occurs when you open a soda )
- Death and Decomposition - breakdown or decay of organic matter

**The Activity:**

1. Tell students that they are going to be carbon atoms moving through the carbon cycle.
2. Categorize the places carbon can be found into these stations: Atmosphere, Plants, Animals, Soil, Ocean, Deep Ocean, and Fossil Fuels. Point out the areas of the room that are labeled with each station and contain the directions for movement from that station.
3. Assign students to each station randomly and evenly. Have students identify the different places carbon could go from that given station. Discuss the processes that allow for the transfer of carbon between stations. Students should make a line and roll the die individually to follow the directions for movement from (or retention at) each station. Remind them that they are representing atoms of carbon moving through the carbon cycle and that they should record their movements on the data sheet.
4. Students will realize the routine movements (or non-movements) in the carbon cycle.
5. Once the carbon atoms (students) have had a chance to roll the die ten times, have each student create a bar graph using the data they collected. The bar graph should represent the number of times the carbon atom (student) was at each station.
6. Using graph paper, create a large bar graph recording the number of carbon atoms (students) at each station.

**Wrap-Up and Action Plan:**

- Ask a few students to tell the story of how their carbon atom moved through the cycle.
- Discuss the results – using the bar graph have the students explain where the most/least amount of carbon was in the cycle?

**Assessment:**

- Rate students' understanding on their responses from class or group discussions.
- Assign a follow-up activity:
  - Role-play the motion of carbon throughout the carbon cycle.
  - Write a story about your carbon atom as it moved through the carbon cycle.

**The Carbon Cycle**

# REFERENCE PAGE

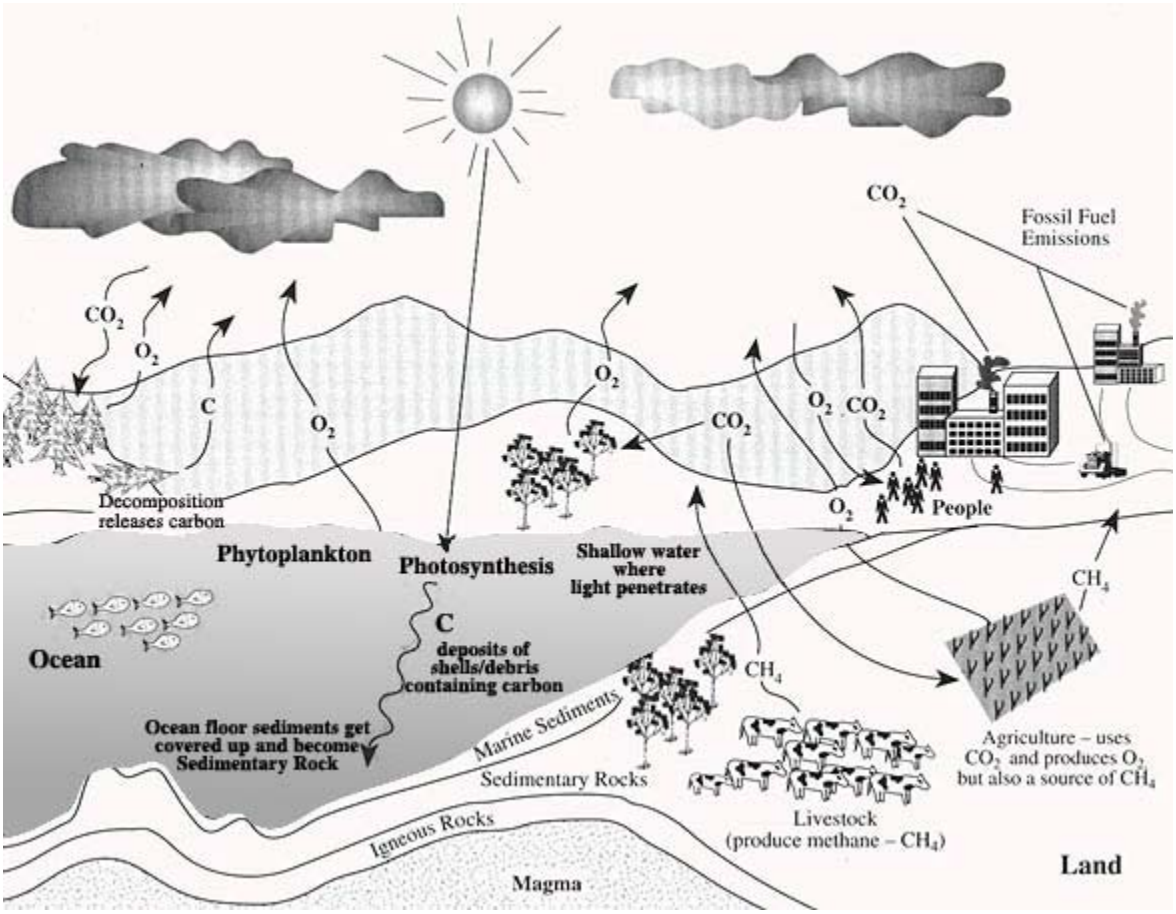



Image Source: http://www.bigelow.org/foodweb/carbon_cycle.jpg

**The Carbon Cycle**

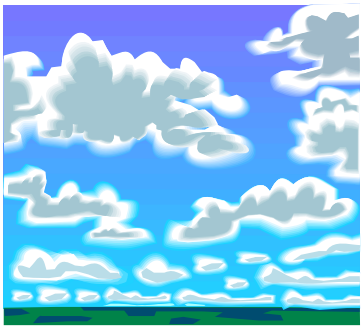
# DATA RECORD SHEET

Record the places you have traveled as a carbon molecule.
Student's Name: _____

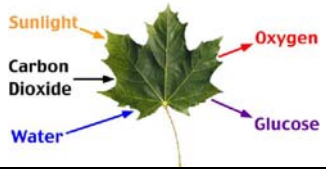
| Station Stop | What Happens | Destination |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |

**The Carbon Cycle**

# THE ATMOSPHERE

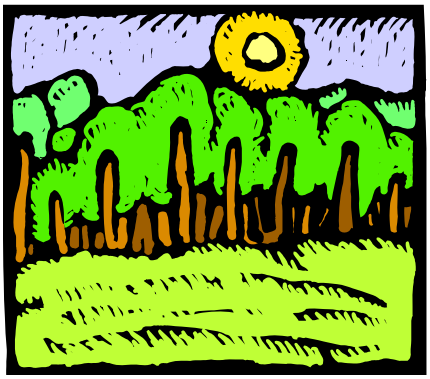


You are currently a molecule of carbon dioxide in the atmosphere.

| If you roll… | Then you … |
|---|---|
| 1 | Stay in the atmosphere. Much of the carbon dioxide in the atmosphere moves through the atmosphere. |
| 2 | Go to plant. You are used by a plant in photosynthesis.   |
| 3 | Stay in the atmosphere. Much of the carbon dioxide in the atmosphere moves through the atmosphere. |
| 4 | Stay in the atmosphere. Much of the carbon dioxide in the atmosphere circulates through the atmosphere. |
| 5 | Go to surface ocean. |
| 6 | Go to plant. You are used by a plant in photosynthesis. |

**The Carbon Cycle**

# PLANTS

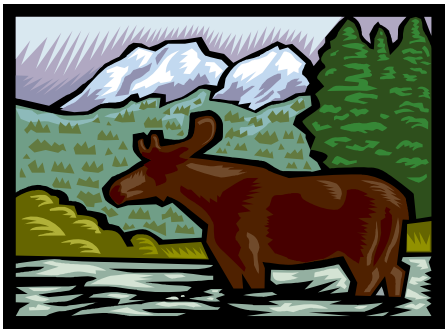


You are currently a carbon molecule in the structure of the plant.

| If you roll… | Then you … |
|---|---|
| 1 | Go to soil. The tree shed its leaves.  |
| 2 | Stay in plant. You are a carbon molecule in the tree's trunk. |
| 3 | Go to animal. The leaves and berries that the plant produced contain your carbon molecule and were eaten.  |
| 4 | Stay in plant. You are a carbon molecule in the tree's roots. |
| 5 | Stay in plant. You are a carbon molecule in the tree's branches. |
| 6 | Stay in plant. You are a carbon molecule in the tree's trunk. |

**The Carbon Cycle**

# ANIMALS

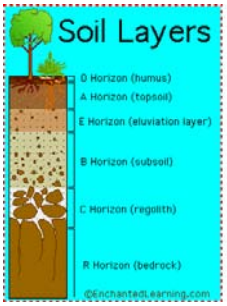


You are currently a molecule of carbon in an animal.

| If you roll… | Then you … |
|---|---|
| 1 | Stay in animal. The carbon molecule is stored as fat in the animal. |
| 2 | Go to soil. The animal that consumed you died and your carbon molecule is returned to the soil.  |
| 3 | Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide. |
| 4 | Stay in animal. You are eaten by a predator.  |
| 5 | Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide. |
| 6 | Go to atmosphere. The animal that consumed you respired (breathed) you out as carbon dioxide. |

**The Carbon Cycle**

# SOIL

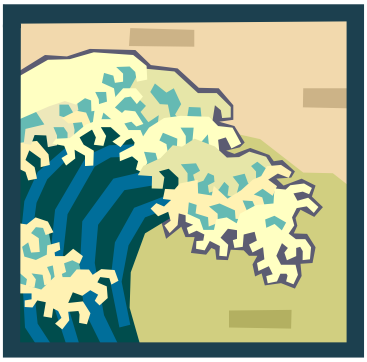



You are currently a molecule of carbon dioxide in the soil.

| If you roll… | Then you … |
|---|---|
| 1 | Stay in the soil. Much of the carbon in the soil is stored there. |
| 2 | Go to plant. You are used by a plant in photosynthesis. |
| 3 | Go to fossil fuels. Your carbon molecule has been in the soil so long it turns into fossil fuels.  |
| 4 | Go to the atmosphere. |
| 5 | Stay in the soil. |
| 6 | Go to fossil fuels. Your carbon molecule has been in the soil so long that it turns into fossil fuels.  |

**The Carbon Cycle**

# SURFACE OCEAN

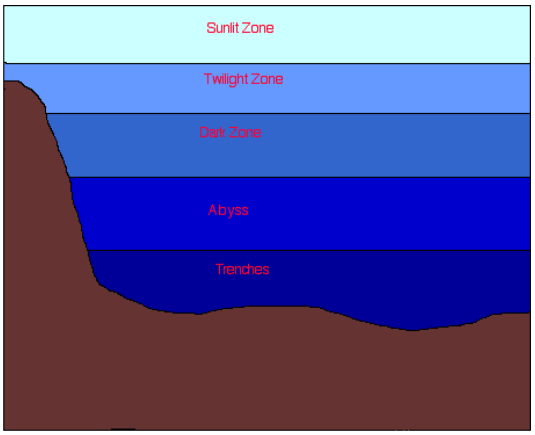


You are currently a molecule of carbon dioxide in the surface ocean.

| If you roll… | Then you … |
|---|---|
| 1 | Go to deep ocean. |
| 2 | Stay in the surface ocean. |
| 3 | Go to deep ocean. Your carbon atom was part of an ocean organism that has died and has sunk to the bottom of the ocean.  |
| 4 | Stay in the surface ocean. |
| 5 | Go to the atmosphere. |
| 6 | Go to the atmosphere. |

**The Carbon Cycle**

# DEEP OCEAN

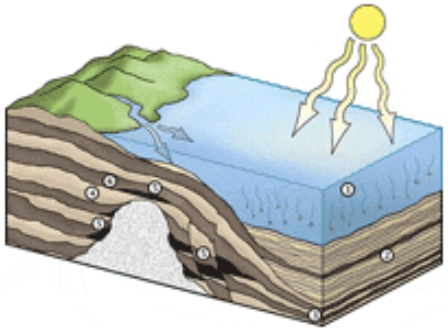



You are currently a molecule of carbon in the deep ocean.

| If you roll… | Then you … |
|---|---|
| 1 | Stay in the deep ocean. |
| 2 | Stay in the deep ocean. |
| 3 | Go to surface ocean. |
| 4 | Go to surface ocean. |
| 5 | Go to surface ocean. |
| 6 | Go to animal. An organism in the water has taken you up as food in the deep ocean. |

**The Carbon Cycle**

# FOSSIL FUELS



Fossil fuels are a rich source of energy that has been created from carbon that has been stored for many millions of years.

| If you roll… | Then you … |
|---|---|
| 1 | Stay in the fossil fuels. |
| 2 | Stay in the fossil fuels. |
| 3 | Stay in the fossil fuels. |
| 4 | Stay in the fossil fuels. |
| 5 | Go to the atmosphere. Humans have pumped the fuel that you are part of out of the ground and have used it to power their cars. |
| 6 | Go to the atmosphere. |

**AP ENVIRONMENTAL SCIENCE**
The Carbon Cycle Game

PROCEDURE

1. Groups should have 3 students. Each student chooses a playing piece. This playing piece represents a carbon atom. Each group needs 2 coins and a playing board. Each person requires a question sheet and a copy of the playing board. The group needs some colored pencils.

2. Place your playing pieces on space #1. Flip the coins as instructed on the following pages. Flip your coins at the start of the turn following instructions as you go. Do not follow the sequence of the numbers, follow the chance moves that the coins present. Two or more players can occupy the same place. When your carbon atom is returned to the atmosphere, you have completed one cycle. Continue playing until told to stop.

3. On your individual game board, use the colored pencils to keep track of your cycles with each color representing a single cycle. Label the cycles 1st, 2nd, etc. Everyone who travels through the cycle and understands the process is a winner.....BUT, for "fun"
   1) Who visited the most organisms
   2) Who completed the most cycles
   3) who completed the longest cycle? the shortest?
   4) Who spends the most time in the atmosphere?

4. Have fun .... then answer the questions in your lab book. Be sure to tape this sheet in as well.

## DISCUSSION QUESTIONS

1. For the sake of time and space, some important pathways have been left out of the game. Note these pathways and describe how carbon atoms might enter into and cycle through these pathways. In particular, note the aquatic and fossil fuel pathways.

2. In the course of the carbon cycle, are carbon atoms themselves ever created? Ever destroyed? Ever changed into other kinds of atoms? Ever changed into other compounds? Explain.

3. What changes do occur in the state of carbon atoms in the course of the cycle? Describe the organic and inorganic states of carbon and the changes that occur between these states.

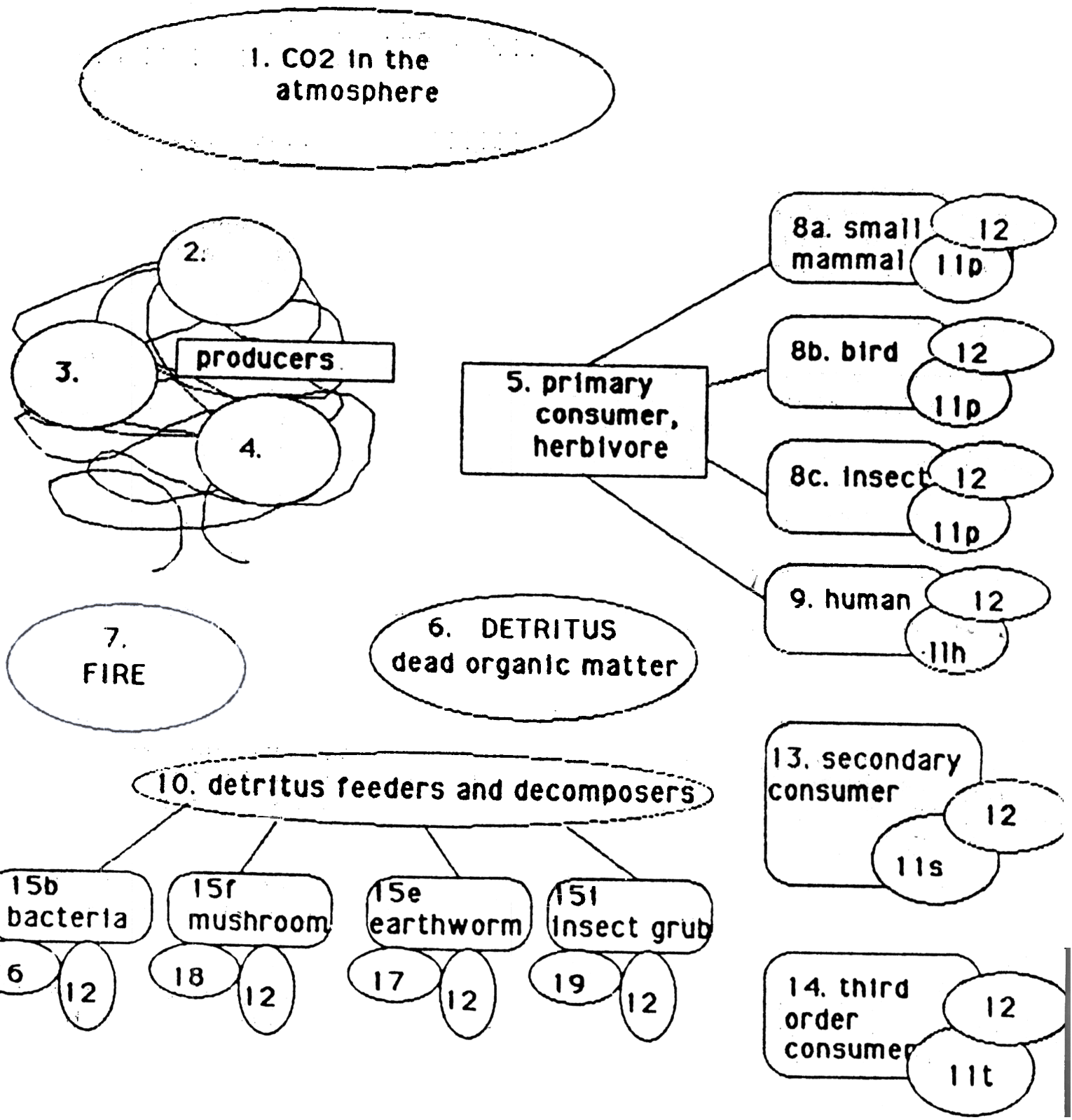
4. Why are some carbon atoms from Carbon Dioxide not incorporated into sugar molecules in darkness? Start by answering: What is the potential energy of carbon dioxide? Of sugar? What is necessary for them to go to a higher phase?

5. Much of the food ingested into each organism is metabolized in cell respiration. Why is this so? What does the organism need and get out of this process and how does it get it?

6. What happens to carbon atoms as a result of respiration?

7. (SUMMARY) Why is a natural ecosystem not polluted by wastes from the various organisms? In chart form, discuss waste, from what organism and used by.

# CARBON CYCLE GAME BOARD



# THE CARBON CYCLE GAME

NOTE: H=heads T = Tails Flip 2 coins unless you are told otherwise

**START AT NUMBER 1**

1. **YOUR CARBON ATOM IS NOW A MOLECULE OF $CO_2$ IN THE ATMOSPHERE.**
   Flip two coins
   **TT** Not absorbed; your carbon atom remains in the atmosphere for another turn.
   **TH or HH** your carbon atom is absorbed into a leaf of a plant. Go to number 2

2. **THE MOLECULE OF CO2 WITH YOUR CARBON ATOM IS NOW IN A LEAF OF A PLANT.**
   Flip two coins
   **TT** NO SUNLIGHT! NO photosynthesis. the CO2 molecule with your carbon atom returns to the atmosphere. Go back to #1.
   **TH or HH** SUNLIGHT! Photosynthesis. Tour carbon atom is incorporated into a sugar molecule by photosynthesis. Go to number 3.

3. **YOUR CARBON ATOM IS NOW IN A MOLECULE OF SUGAR IN A PLANT**
   Flip two coins
   **TT** the sugar molecule with your carbon atom is oxidized in cell respiration to provide energy for plant growth. your carbon atom is released in a molecule of CO2. Go back to number 1.
   **TH or HH** the sugar molecule with your carbon atom is incorporated into a molecule making up the tissue of a plant. Go to space Number 4.

4. **YOUR CARBON ATOM IS NOW IN A MOLECULE OF SUGAR IN A PLANT.**
   Flip two coins
   **TT** The plant is eaten by an animal. go to Number 5 and take another turn to determine what kind of animal.
   **TH or HH** plant part dies. its organic matter is detritus. Go to Number 6.

5. **THE PLANT TISSUE WITH YOUR CARBON ATOM IS EATEN BY A PRIMARY CONSUMER.**
   Flip one coin twice.
   **T & T** mammal herbivore -- go to 8A
   **T & H** bird -- go to 8B
   **H & T** insect -- go to 8C
   **H & H** human, perhaps yourself -- go to 9

6. **YOUR CARBON ATOM IS NOW IN A MOLECULE OF DEAD ORGANIC MATTER OR DETRITUS.**
   Flip two coins
   **TT or TH** consumed by a detritus feeder or decomposer. Go to 10 and take another turn to determine which one.
   **HH** FIRE! go to 7.

7. **THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING OXIDIZED (BURNED) IN A FIRE. OXYGEN IS COMBING WITH YOUR CARBON ATOM AND IT IS BEING RELEASED IN A MOLECULE OF CARBON DIOXIDE. GO IMMEDIATELY BACK TO NUMBER 1 WITHOUT TAKING A TURN.**

**8A, 8B AND 8C THE PLANT TISSUE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY A PRIMARY CONSUMER AS PART OF ITS FOOD.**

Flip two coins

**TT** the molecule with your carbon atom is metabolized into a molecule making a tissue of the consumer's body. go to 11P

**TH** CELL RESPIRATION! Go to 12.

**HH** the molecule with your carbon atom is not digested. it passes through the intestinal tract as fecal waste. -- go to 6.

**9. THE PLANT TISSUE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY A HUMAN -- PERHAPS YOURSELF, AS A PART OF FOOD.**

Flip two coins

**TT** the molecule with your carbon atom is metabolized into a molecule making up a tissue in your body. Go to 11H

**TH** CELL RESPIRATION! Go to 12

**HH** the molecule with your carbon atom is not digested, It passes through the intestinal tract and out as fecal waste. Go to number 6.

**THE MOLECULE CONTAINING YOUR CARBON ATOM IS NOW BEING INGESTED BY A PRIMARY DETRITUS FEEDER OR DECOMPOSER.**

Flip one coin twice.

**TT** earthworm go to 15E

**TH** decomposer -- fungus (mushroom) Go to 15F

**HT** decomposer -- bacteria Do to 15B

**HH** insect -- go to 15I

**11H. YOUR CARBON ATOM IS NOW IN A MOLECULE MAKING UP A TISSUE OF YOUR OR ANOTHER HUMAN'S BODY.**

Flip one coin

**T** the molecule is broken down and metabolized in cell respiration, -- go to 12

**H** when the human dies of injury and/or disease and if the body is cremated, the carbon atom will go to number 7.

**YOUR CARBON ATOM IS NOW IN A MOLECULE MAKING UP A TISSUE OF A PRIMARY CONSUMER OR HERBIVORE.**

Flip two coins

**TT** the molecule is broken down and metabolized in cell respiration -- go to 12.

**TH** the primary consumer is eaten by a secondary consumer. Go to 13

**HH** the primary consumer dies of injuries and/or disease. go to 6.

**11S YOUR CARBON ATOM IS NOW IN A MOLECULE MAKING UP A TISSUE OF A SECONDARY CONSUMER OR A CARNIVORE.**

Flip two coins

**TT** the molecule is broken down and metabolized in cell respiration -- go to 12.

**TH** the secondary consumer is eaten by a third order consumer. Go to 14

**HH** the secondary consumer dies of injuries and/or disease. Go to 6.

**11T YOUR CARBON ATOM IS NOW IN A MOLECULE MAKING UP A TISSUE OF A THIRD ORDER CONSUMER OR A CARNIVORE.**

Flip two coins

**TT** the molecule is broken down and metabolized in cell respiration -- go to 12.

**TH** the third order consumer is eaten by another third order consumer. Go to 14

**HH** the third order consumer dies of injuries and/or disease. Go to 6.

**12. THE MOLECULE CONTAINING THE CARBON ATOM IS NOW BEING BROKEN DOWN IN CELL RESPIRATION TO PROVIDE ENERGY FOR THE CONSUMER'S MOVEMENTS AND FUNCTIONS. IN THIS PROCESS, YOUR CARBON ATOM IS COMBINED WITH OXYGEN ATOMS AND IS RELEASED BACK INTO THE AIR AS CARBON DIOXIDE.** Go immediately back to number 1 without taking another turn.

**13. THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY A SECONDARY CONSUMER.**

Flip two coins

**TT** the molecule is metabolized into a molecule making up a tissues of the consumer's body. Go to 11S

**TH** CELL RESPIRATION!. Go to 12.

**HH** the molecule with your carbon atom is not digested. it passes through the intestinal tract and out as fecal matter. Go to 6

**14. THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY A COW -- A CONSUMER.**

Flip two coins

**TT** the molecule is metabolized into a molecule making up a tissues of the consumer's body. Go to 11T

**TH** CELL RESPIRATION!. Go to 12.

**HH** the molecule with your carbon atom is not digested. it passes through the intestinal tract and out as fecal matter. Go to 6.

**15B THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING ABSORBED BY A BACTERIA.**

Flip one coin

**T** it gets incorporated into a molecule of the bacteria - go to 16

**H** it gets broken down and metabolized in cell respiration -- go to 12.

**15E THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY AN EARTHWORM.**

Flip two coins

**TT** it gets incorporated into a molecule of the worm's body. Go to 17.

**TH** it gets broken down and metabolized in cell respiration. Go to 12.

**HH** it is not digested; it passes through the intestinal tract and out as fecal matter. Go to number 6

**15F THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING ABSORBED BY A FUNGUS (MUSHROOM).**

Flip one coin

T it gets incorporated into a molecule of the fungus. -- go to 18.

H it gets broken down and metabolized in cell respiration -- go to 12.

**15I THE MOLECULE WITH YOUR CARBON ATOM IS NOW BEING INGESTED BY AN INSECT GRUB.**

Flip two coins

TT it gets incorporated into a molecule of the insects body. Go to 19.

TH CELL RESPIRATION!. Go to 12.

HH it is not digested. it passes through the intestinal tract and out as fecal waste. Go back to 6

**16 YOUR CARBON MOLECULE IS NOW A MOLECULE MAKING UP THE BACTERIA'S BODY.**

Flip two coins

TT the molecule is broken down and metabolized in cell respiration -- go back to 12.

TH the bacteria is eaten by an earthworm -- go to 15E

HH the bacteria dies, -- Go to 6.

**17 YOUR CARBON MOLECULE IS NOW A MOLECULE MAKING UP THE EARTHWORM'S BODY.**

Flip two coins

TT the molecule is broken down and metabolized in cell respiration -- go back to 12.

TH the worm is eaten by an bird -- go to 15E

HH the worm dies of injury or disease -- go to 6.

**18 YOUR CARBON MOLECULE IS NOW A MOLECULE MAKING UP A MUSHROOM.**

Flip two coins

TT the molecule is broken down and metabolized in cell respiration -- go back to 12.

TH the mushroom is eaten by an insect -- go to 15I

HH the mushroom matures and dies -- Go to 6

**19 YOUR CARBON MOLECULE IS NOW A MOLECULE MAKING UP THE BODY OF AN INSECT.**

Flip two coins

TT the molecule is broken down and metabolized in cell respiration -- go back to 12.

TH the insect is eaten by a small mammal. -- go to 8A

HH the insect dies of injury or disease -- go to 6.

Carbon, Climate, and Laser Technology

# The Carbon Cycle Pursuit Game

## Teacher's Guide

- *www.atd.ucar.edu/apol/biocomplexity*
- *www.eo.ucar.edu*

**Subject Focus:**
Earth Science
Biology
Chemistry

**Materials & Preparations**

**Time:**

**Preparation:** 30 minutes to make one game, although the process can be greatly expedited by involving students

**Introduction:** 10 minutes

**Playing time:** 30 minutes

**Materials:**
- game board
- game instructions (can be affixed to back side of game board)
- 7 dice, one color-coded to correspond to a specific carbon reservoir
- 7 color-coded sets of ten question cards corresponding to a specific carbon reservoir
- 1 game piece token/marker per team

**Teacher Materials:**
*See Assembly Instructions that follow*

**National Science Content Standards Addressed:**
Standards C, D, and F

**Learning Objectives:**
- Learn the biological carbon cycle as each team moves as carbon through the atmosphere, oceans, biosphere, and lithosphere
- Correctly identify and use the terms carbon source, sink, and reservoir
- Learn about human's role today in impacting the carbon cycle
- Understand that the carbon cycle is a dynamic system that plays a significant role in Earth's atmospheric composition
- Understand that changes in Earth's atmospheric composition impact climate and life on Earth

**Objective of Game:**
Small groups of 2-3 students work together to correctly answer questions about the carbon cycle and advance through all seven carbon reservoirs on the game board before their opposing team.

**Procedure:**
1. Assemble game pieces as instructed on the Assembly page at least one day prior to play. For a class of 30 students, five games should be constructed. It takes approximately 30 minutes to assemble one game setup.

**Game Day Directions:** Have competing teams read and disucss the Carbon Cycle Pursuit Directions page together before beginning play. Ask the class as a whole if there are any questions pertaining to how to play the game. After all questions are answered, begin play.

**Extensions and Assessment:**
Ask teams to develop new sets of questions for the game. Assign them a particular reservoir or have them determine a set number of questions for each. Make sure that students list their sources for their questions' content. Some excellent sources can be found in the appendix to ***Carbon, Climate and Laser Technology.***

The Carbon Cycle Pursuit game is intended as a review or to expand student knowledge following class content on the carbon cycle and/or climate change. Teachers can create their own question cards on the blank question card template provided to emphasize specific learning objectives. Students' ease in correctly answering the question cards will be indicative of their understanding of the carbon cycle and its connection to Earth's climate.

# Carbon Cycle Pursuit · Game Directions

**LEARNING OBJECTIVE:** To increase students' knowledge of the carbon cycle and humans' impact on it.

**GAME OBJECTIVE:** To be the first team to cycle through all carbon reservoirs on the game board. To win, one must correctly answering a carbon card question while in each reservoir, then roll the appropriate dice to advance to another location within the carbon cycle.

## MATERIALS:

- Game board
- 7 carbon cycle dice
- 7 sets of question cards
- Token for each team
- Minute glass for keeping time (optional)

## HOW TO PLAY THE GAME:

1. Have students form competing teams, each with two or three players.
2. Distribute items listed under "Materials" to each pair of competing teams.
3. Set out the game board, place each color-coded die near its matching carbon reservoir, and place the seven stacks of carbon question cards along side the game board, image-side up.
4. Present the game's objective and rules to the class as a whole, or have competing teams review them independently.

## RULES OF THE GAME:

1. The team with a member possessing a birthdate closest to the day's date goes first. (It does not matter if the birth date has recently past or is upcoming.) The team going first is referred to as Team A; the team going second, Team B.
2. Each team puts their marker in the *Fossil Fuel* resevoir to begin. Each carbon reservoir is image- and color-coded (e.g. "orange" with a traffic image for the *Fossil Fuel* reservoir; "green" with a plant image for the *Vegetation* reservoir).
3. Team B pulls the first question card from the *Fossil Fuel* stack and reads the carbon question to Team A, whose players have one minute to discuss and decide on their answer. (The answer is specified on the card.)
4. If Team A players do not answer the question correctly, their turn is over and the question card goes to the bottom of the stack. However, if they do answer correctly, they receive the question card and a roll of the *Fossil Fuel* resevoir die to attempt to advance.
5. If Team A rolls the die and it lands showing another reservoir, Team A may advance their token to it, and their turn ends. If they roll the die and it lands on the reservoir they are currently in, they must remain there, and their turn ends. They will have an opportunity to advance after answering another carbon card question correctly on their next turn.
6. Team B now repeats the same process.
7. After a team's players correctly answer a carbon card question in the same reservoir three times but fail to advance to a new reservoir, or if all questions in the resevoir have been exhausted, they may move their token to another carbon resevoior shown on their die.
8. To win, a team must be first to successfully cycle through all seven reservoirs on the game board and receive a carbon question card from each by correctly answering its question.

# Carbon Cycle Pursuit

## Game Assembly Teacher Instructions

### Materials needed for Game Assemblance:

- Copy of Carbon Cycle Pursuit Directions
- Copy of game board, preferrably in color
- A color copy of each reservoir die (7 total)
- 7 Manila folders or 7 pages of firm paper stock (20 lb. weight)
- Two-sided Question Cards printed and laminated (8.5”x11”pages)
- Container to hold game contents
- Envelope or rubber band for question cards
- Two game piece tokens, one for each team, preferrably representing a component of the carbon cycle
- Use of a laminator machine, printer, and copier
- Clear tape or stapler

### Advanced Preparation:

For a class of 30 students, with three students per team, you will need to prepare five Carbon Cycle Pursuit games. To make the process easier, solicit student assistance. Instructions for making one game follow:

Step 1: Print the following on a color printer: game board, 2-sided question cards (7 double-sided pages), and the 7 color-coded reservoir dice *(materials follow on attached pages)*

Step 2: On the backside of the game board page, copy the game directions.

Step 3: Laminate the game board and directions page as well as the question card pages.

Step 4: Cut out the question cards and organize them by reservoir. Each of the 7 reservoirs will have a set of 10 game card questions that are color-coded to match the reservoir and the reservoir die.

Step 5: Cut out the 7 die along each die’s outline and staple or glue each to one side of a manila folder or heavier paper stock. Cut out each die with its new backing, and fold into a cube along dotted lines. Secure fold with tape to maintain each die’s cube shape. *(See illustrations that follow.)*

Step 6: Add two markers/game pieces of your choosing -- one for each team -- to complete the advanced preparation of the Carbon Cycle Pursuit game. You may wish to choose markers that reflect some component of the carbon cycle (e.g. a leaf, pumas rock) or have each team do so for homework prior to playing the game.

## Carbon Pursuit Game Board


## Carbon Pursuit Game Dice (7)

## Carbon Pursuit Questions

# Carbon Cycle Pursuit


Diffusion

Photosynthesis

Diffusion

Respiration


Photosynthesis

Burning of Fossil Fuels

Land Use


Decomposition


Circulation

Circulation

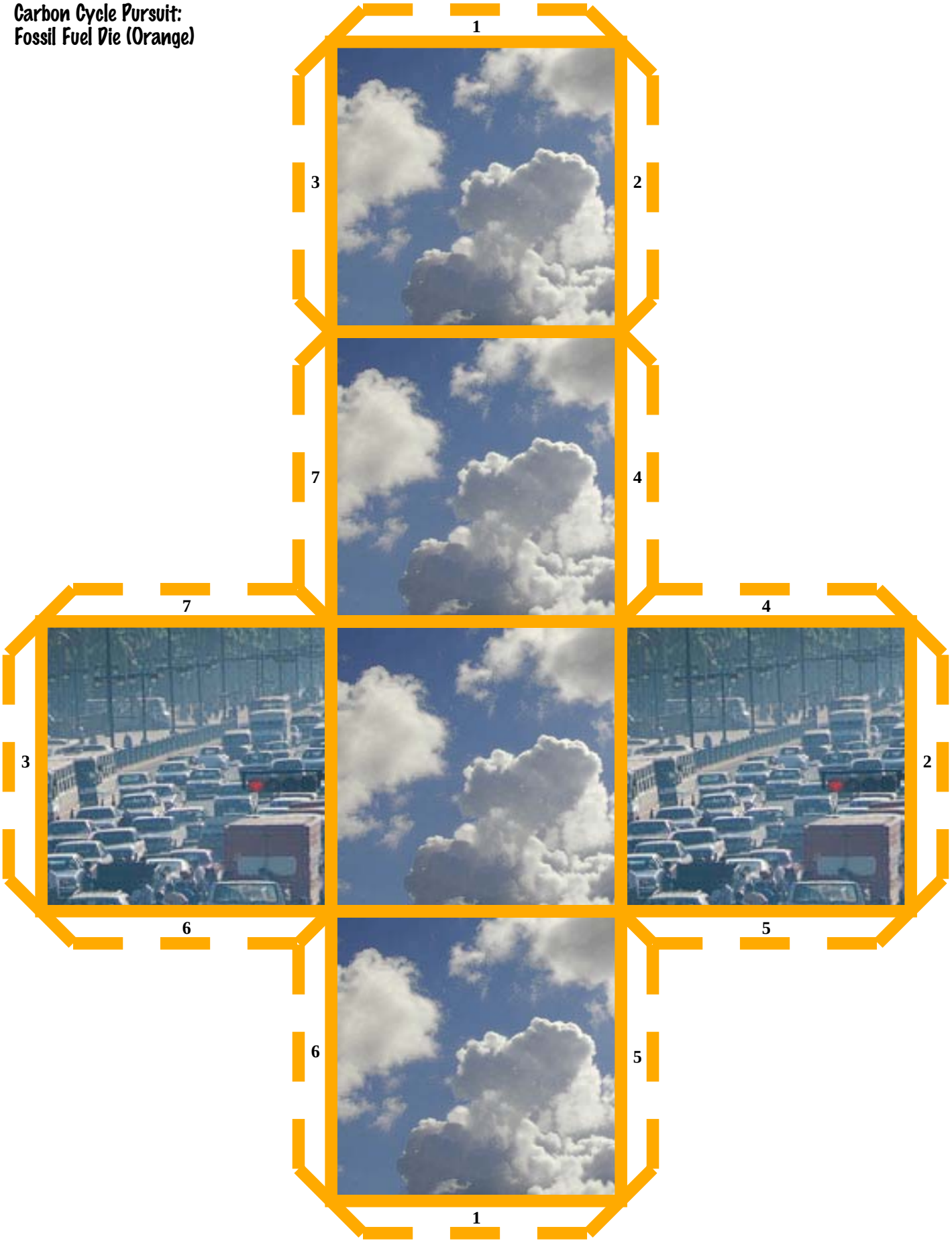
Decomposition



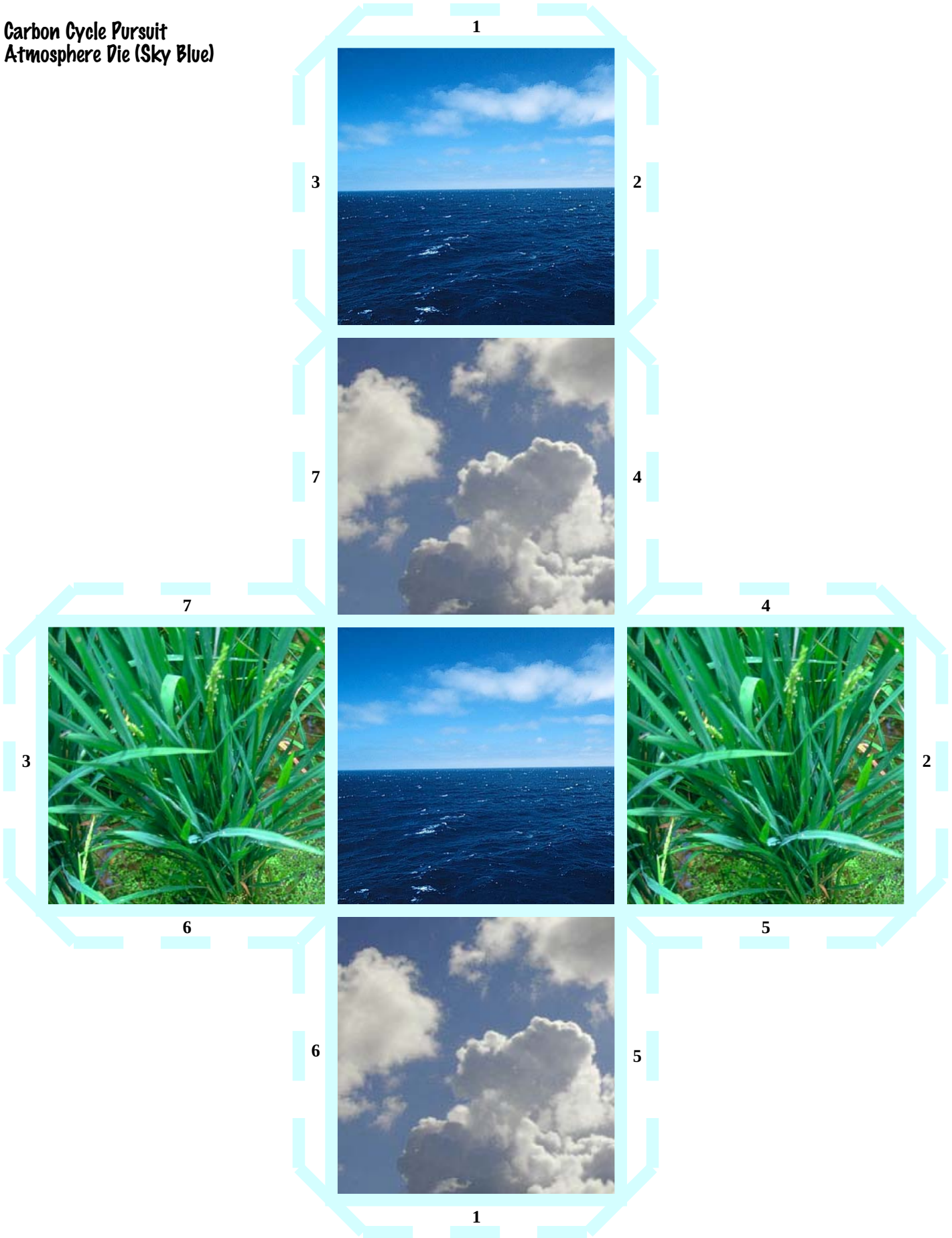

Carbon Cycle Pursuit

www.atd.ucar.edu/apol/biocomplexity

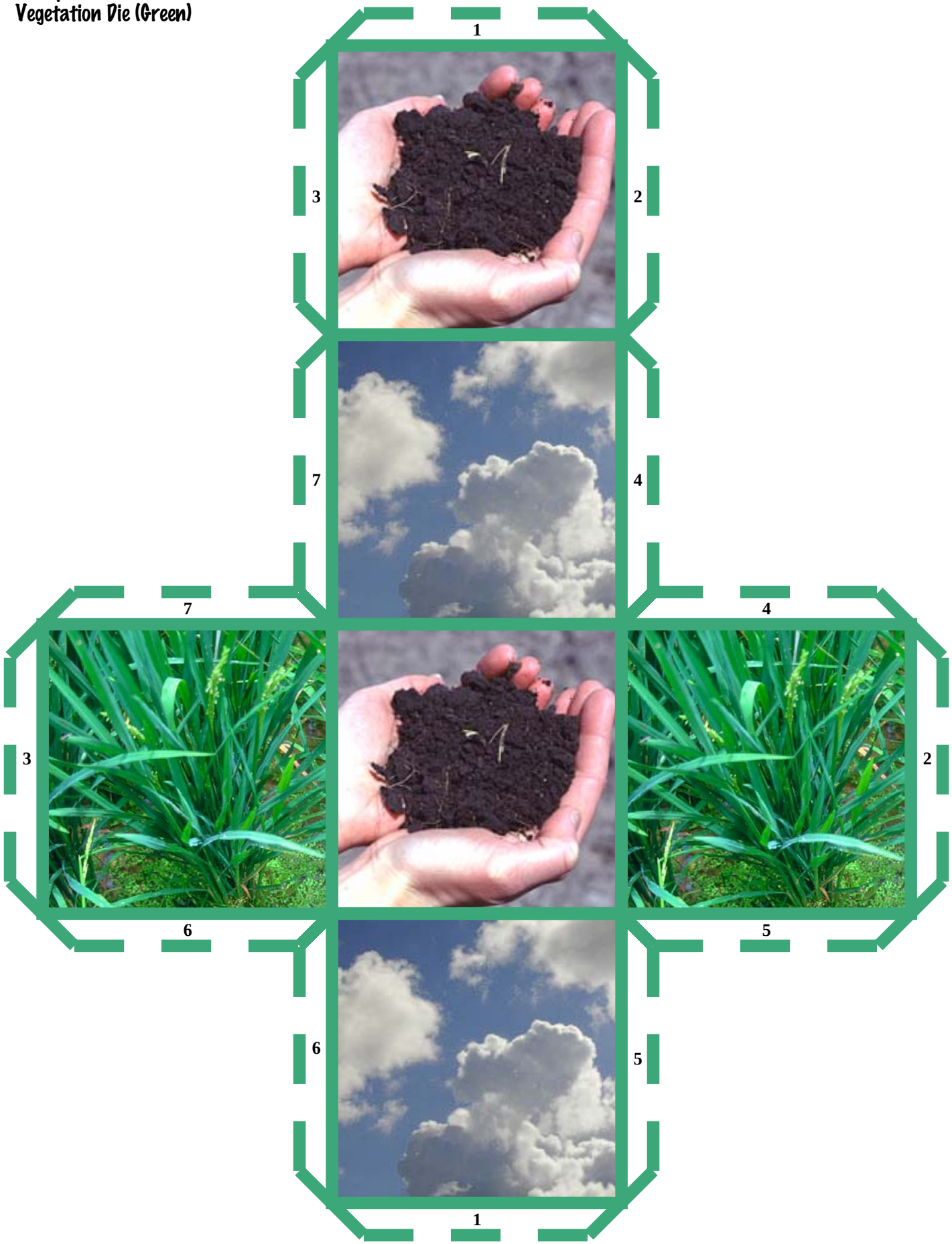
# Carbon Cycle Pursuit: Fossil Fuel Die (Orange)



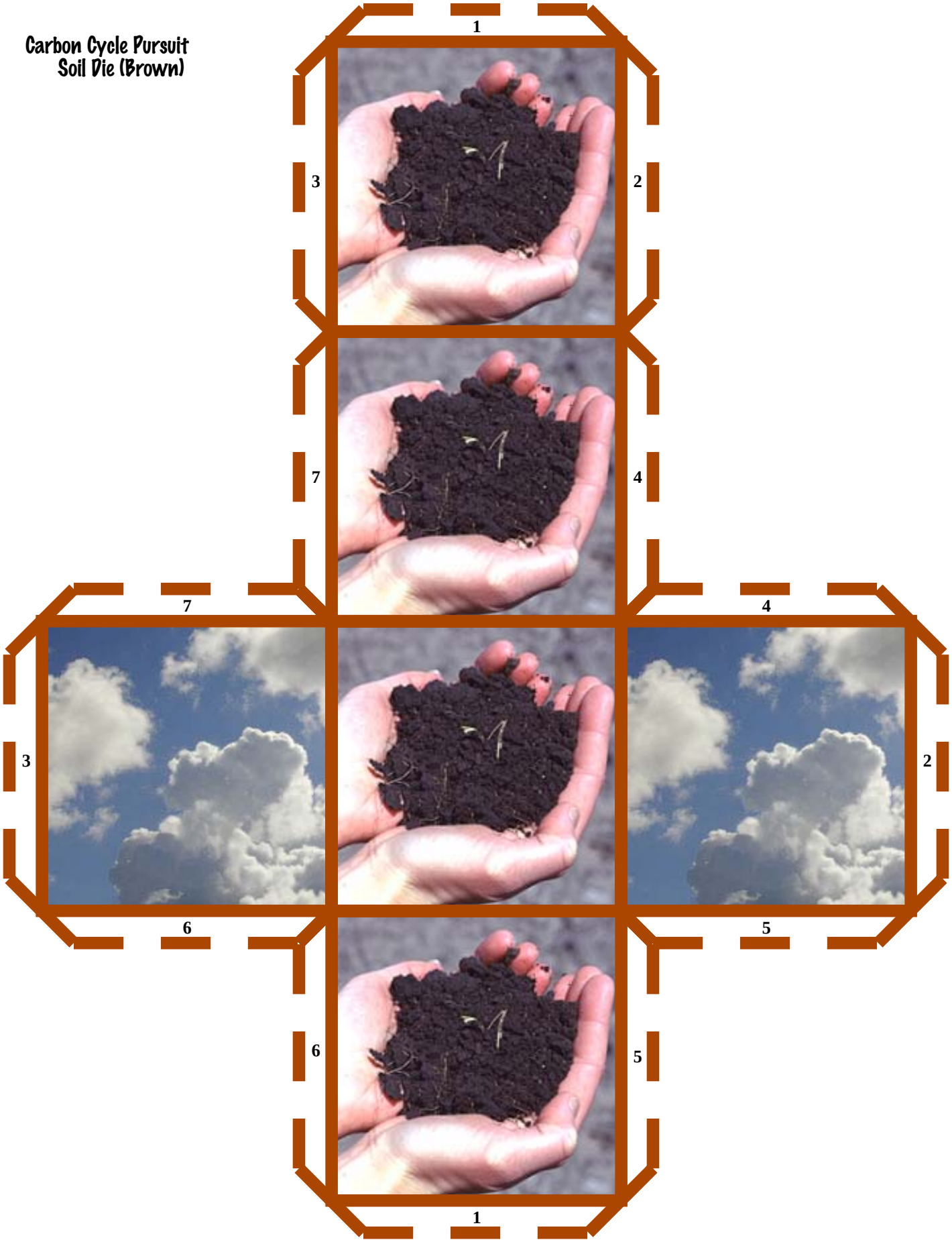
# Carbon Cycle Pursuit
## Atmosphere Die (Sky Blue)



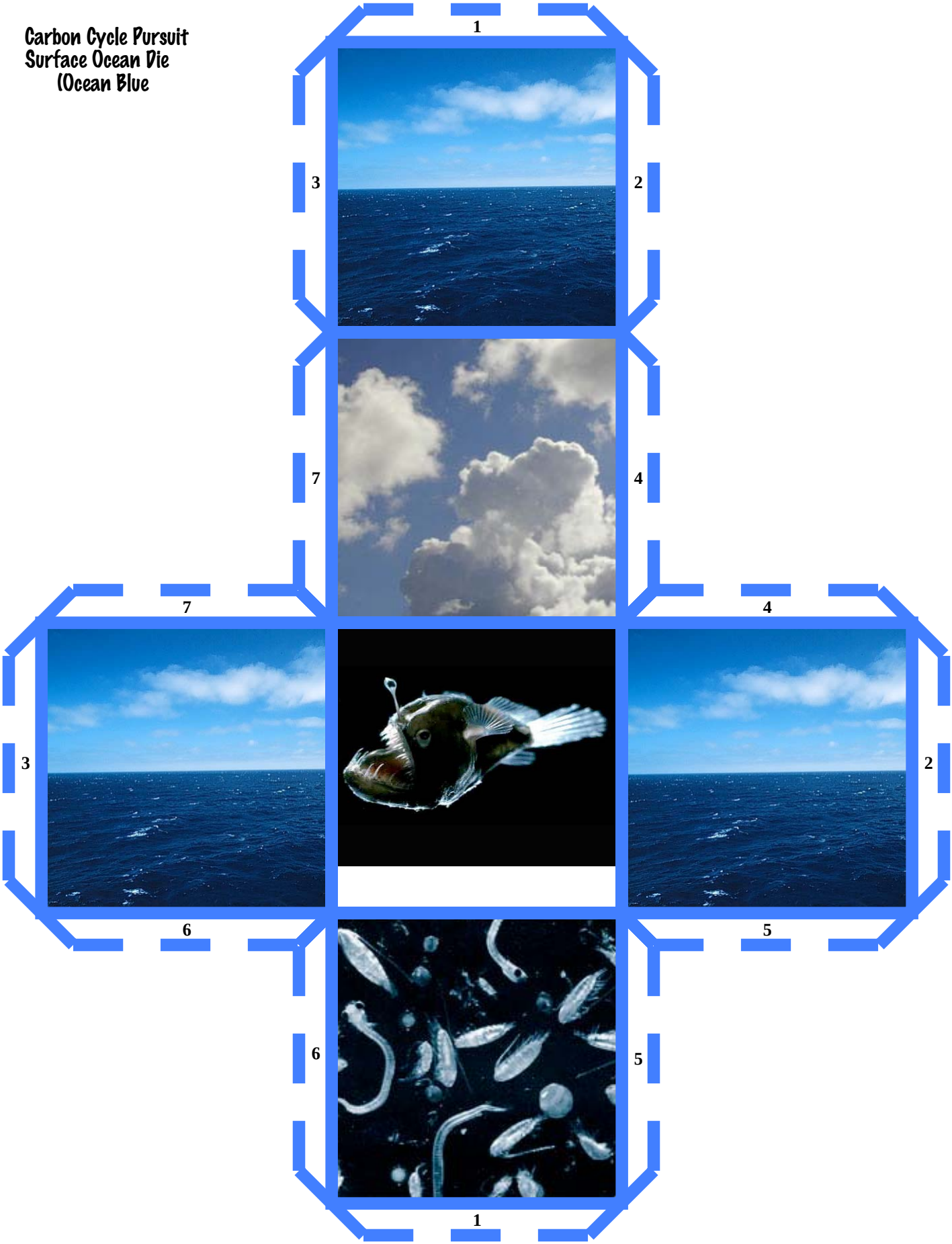
Carbon Cycle Pursuit
Vegetation Die (Green)



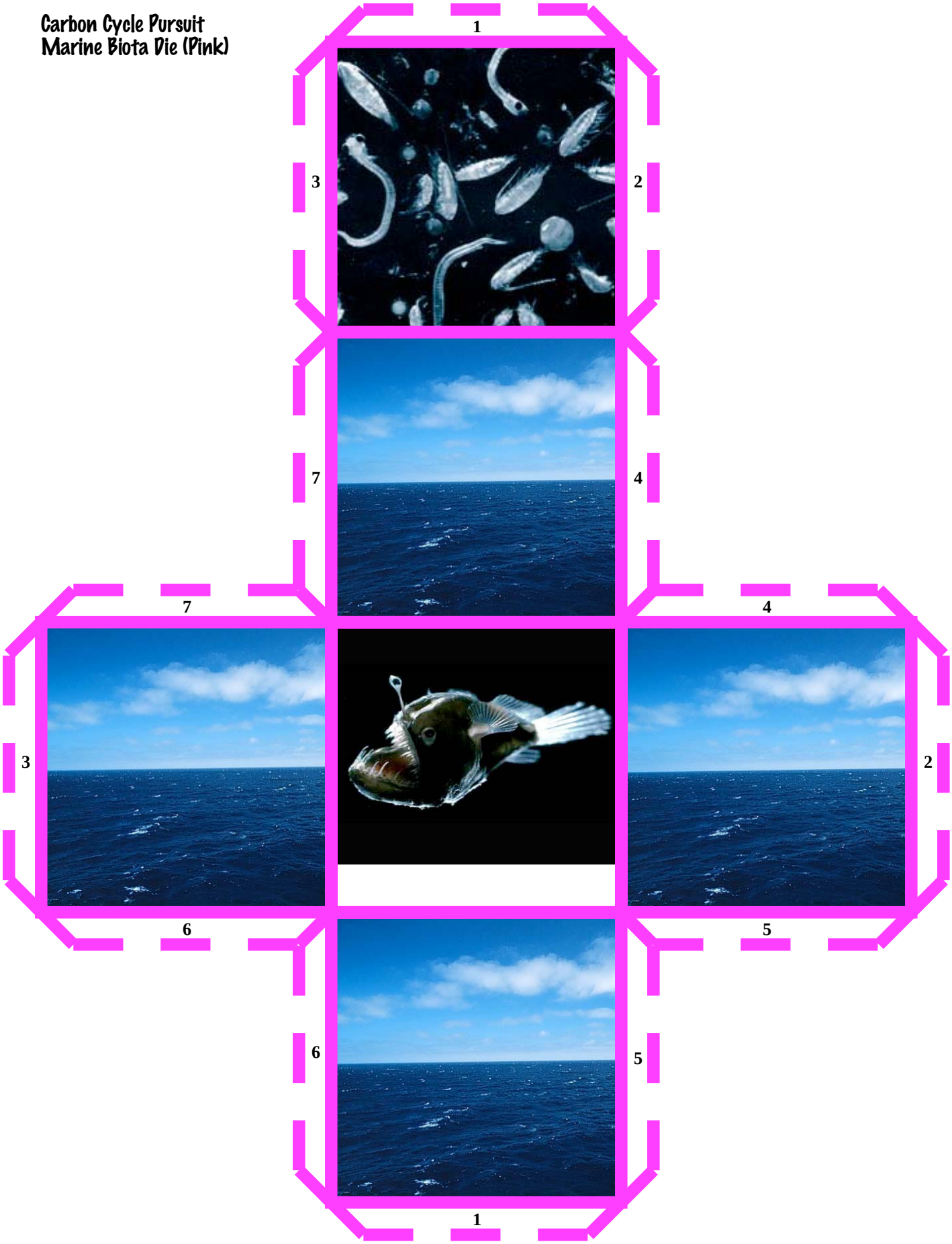
Carbon Cycle Pursuit
Soil Die (Brown)



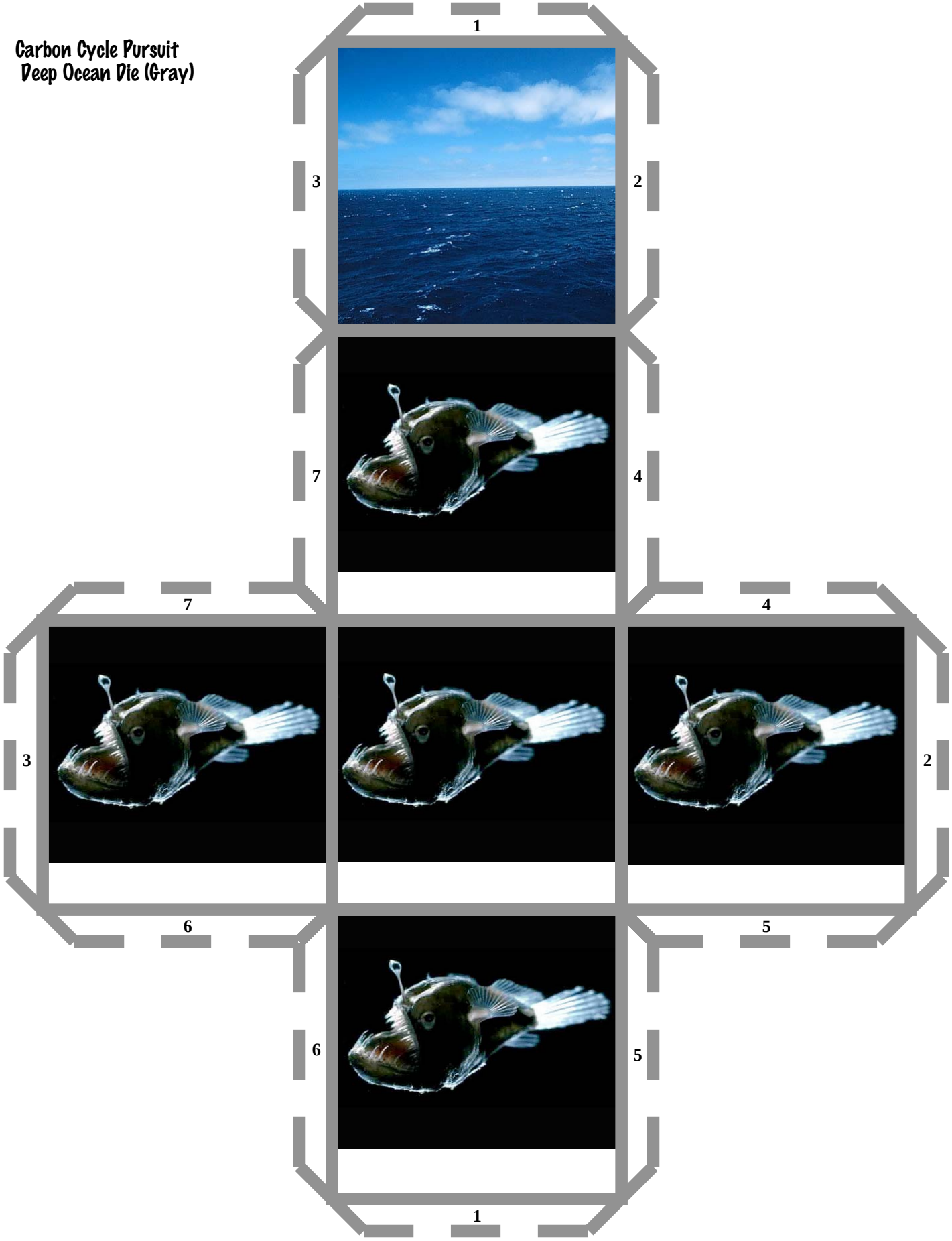
Carbon Cycle Pursuit
Surface Ocean Die
(Ocean Blue



Carbon Cycle Pursuit
Marine Biota Die (Pink)



Carbon Cycle Pursuit
Deep Ocean Die (Gray)



*Approximately how many Megatons of Carbon do humans produce by burning fossils fuels each year?*
(1 Megaton = one million tons)

*a. 5*
*b. 50*
*c. 500*
*d. 5,000*

***d***

*How does the US get the majority of its energy?*

*a. Petroleum*
*b. Natural Gas*
*c. Coal*
*d. Oil*

***a***

*What percent of our countries electricity comes from the burning of coal?*

*a. 10%*
*b. 20%*
*c. 40%*
*d. 60%*

***d***

*How many pounds of carbon is each person in the US responsible for producing per year?*

*a. 46*
*b. 460*
*c. 4600*
*d. 46000*

***c***

*How many pounds of carbon is each person in Japan responsible for producing per year?*

*a. 180*
*b. 1800*
*c. 18000*
*d. 180000*

***b***

*How many trees would each American have to plant to make up for how much $CO_2$ we release into the atmosphere each year?*

*a. 8*
*b. 80*
*c. 800*
*d. 8,000*

***c***

*Which state uses the most oil to produce electricity?*

*a. California*
*b. New York*
*c. Colorado*
*d. Florida*

***d***

*Coal power plants produce approximately ____ of $CO_2$ emissions from electric utilities in the US.*

*a. 35%*
*b. 50%*
*c. 75%*
*d. 90%*

***d***

True or False: *Ccar engines exist that do not produce $CO_2$ as a byproduct.*

***True***

True or False: *Increased $CO_2$ levels in the atmosphere will be detrimental to ones health.*

***True***

FOSSIL FUELS










FOSSIL FUELS

*What percent of the atmosphere is carbon dioxide?*

a. *0.04%*
b. *0.4%*
c. *4%*
d. *40%*

***a***

*What percent of the atmosphere was carbon dioxide before the start of the industrial revolution?*

a. *0.0028%*
b. *0.028%*
c. *0.28%*
d. *2.8%*

***b***

True or False: *$CO_2$ is a very reactive molecule in the atmosphere.*

***False***

*How much of an increase of $CO_2$ in the atmosphere have we seen since the industrial revolution?*

a. *5% increase*
b. *15% increase*
c. *30% increase*
d. *50% increase*

***c***

*The radiative forcing due to $CO_2$ is at present slightly larger than _____ of the total greenhouse gas forcing.*

a. *50%*
b. *26%*
c. *12%*
d. *4%*

***a.***

*Geochemical measurements made on ancient ocean sediments suggest that atmospheric $CO_2$ levels over the past _____ years were never as high as they are today.*

a. *100,000*
b. *500,000*
c. *5,000,000*
d. *20,000,000*

***d***

*The average annual increase of $CO_2$ since 1958 has been ____ ppm (parts per million per year).*

a. *0.5*
b. *1.0*
c. *1.5*
d. *2.0*

***c***

*The increase of $CO_2$ in the atmosphere for years 2002 and 2003 were __ ppm and __ ppm,(parts per million) respectively.*

a. *0.5, 0.6*
b. *1.0, 1.1*
c. *1.7, 1.8*
d. *2.4, 2.3*

***d***

*$CO_2$ atmospheric concentrations increased by ____ ppm (parts per million) in 2004.*

a. *1.5*
b. *2.0*
c. *2.5*
d. *3.0*

***a***

True or False: Release of a carbon dioxide molecule affects the atmosphere for a very long time.

***True***

ATMOSPHERE

ATMOSPHERE

*Which of the following releases $CO_2$ into the atmosphere?*

a. *burning wood*
b. *harvesting wood*
c. *clearing of forest*
d. *all of the above*

***d***

True or False: *Forests that grow after being cut down by logging companies serve as large carbon sinks.* (Meaning they take up a lot of $CO_2$)

***True***

*Forest cover about __ of the land surface of the earth.*

a. *1/2*
b. *1/3*
c. *1/4*
d. *1/6*

***b***

True or False: *Plants both absorb $CO_2$ from the atmosphere and release it, and therefore serve as both a source and a sink in the carbon cycle.*

***True***

True or False: *Worldwide, forested land is being cleared at a rate of about one football field per second.*

***True***

*The process by which the plants give off $CO_2$ is called*

a. *regeneration*
b. *regurgitation*
c. *respiration*
d. *relaxation*

***c***

*A carbon sink is*

a. *something that stores carbon*
b. *something that gives off carbon*
c. *something that destroys carbon*
d. *can be any of the above*

***a***

*A carbon source is*

a. *something that stores carbon*
b. *something that gives off carbon*
c. *something that destroys carbon*
d. *can be any of the above*

***b***

*Plants and forests serve as*

a. *carbon sinks*
b. *carbon sources*
c. *both*
d. *neither*

***c***

True or False: *If atmospheric $CO_2$ levels continue to increase, plants will take in more $CO_2$ and grow faster.*

***True***

VEGETATION

VEGETATION










VEGETATION

*Which of the following take up $CO_2$ from the atmosphere?*

a. *soil*
b. *ocean*
c. *plants*
d. *all of the above*

***d***

True or False: *When plants die and deteriorate into the soil, they release $CO_2$.*

***True***

*The soil serves as a*

a. *carbon sink*
b. *carbon source*
c. *both*
d. *neither*

***b***

*Detritus is*

a. *small organisms living in the soil*
b. *dead plants and animals deteriorating in the soil*
c. *the scientific name for worms*
d. *another name for soil*

***b***

*Soils store about ___ of the earth's total $CO_2$.*

a. *3%*
b. *13%*
c. *30%*
d. *63%*

***a***

True or False: *Soils emit more $CO_2$ into the atmosphere than humans.*

***True***

*The erosion and weathering of rocks*

a. *release $CO_2$*
b. *store $CO_2$*
c. *both*
d. *neither*

***a***

True or False: *Carbon compounds in the soil react to form humus.*

***True***

*Currently the US farmlands are responsible for storing ___ metric tons of carbon.*

a. *2 million*
b. *20 million*
c. *100 million*
d. *200 million*

***b***

*If the US were to increase the carbon storage in its farmland tenfold over the next 40 years, this total uptake would account for ____ of the US yearly output in carbon.*

a. *12%*
b. *24%*
c. *48%*
d. *96%*

***a***

SOIL










SOIL

True or False: *The ocean absorbs more $CO_2$ than land.*

***False***

True or False: *The surface ocean stores more carbon than soils.*

***False***

*The surface ocean absorbs approximately ___ GtC per year. (GtC = Gigatons of Carbon)*

*a. 20*
*b. 50*
*c. 90*
*d. 140*

***c***

True or False: *The ocean helps regulate the amount of $CO_2$ in the atmosphere.*

***True***

True or False: *As carbon dioxide enters the surface water, much of it reacts and only a small fraction of it remains in $CO_2$ form.*

***True***

*Much of DIC (Dissolved Inorganic Carbon) in the surface water is*

*a. transported to the poles by ocean currents*
*b. sinks to the deep ocean*
*c. absorbed by fish*
*d. none of the above*

***a***

True or False: *More carbon can dissolve in cold water than in warm water.*

***True***

*The _____ is the process by which large biologically formed particles sink into the deep ocean.*

*a. oceanic pump*
*b. dissolution*
*c. oceanic decay*
*d. biological pump*

***d***

*The mechanism by which skeletal structures of sea life transfer carbon to the deep ocean by sinking is called*

*a. the skeletal pump*
*b. the carbonate pump*
*c. the carcass pump*
*d. the calcium pump*

***b***

True or False: *The surface ocean only absorbs $CO_2$ from the atmosphere.*

***False***

SURFACE WATER










SURFACE WATER

True or False: *Phytoplankton are a class of micro-organisms that take in $CO_2$ in the ocean.*

***True***

*Phytoplankton is eaten by*

a. *zooplantkton*
b. *fish*
c. *whales*
d. *all of the above*

***d***

*Microorganisms will die if*

a. *pH becomes too high or low*
b. *carbon to nitrogen ratios are changed*
c. *temperature significantly changes*
d. *all of the above*

***d***

*Marine Biota utilize ___ GtC annually. (Gigatons of carbon)*

a. *5*
b. *20*
c. *50*
d. *80*

***c***

True or False: *Shells in the ocean contain $CO_2$.*

***False***

True or False: *Ocean life can survive without carbon.*

***False***

True or False: *When carbon levels get too high, they prevent sea animals fromo undergoing the chemical processes that form their shells (calcium carbonate).*

***True***

*Which animals will be hurt by increased $CO_2$ levels?*

a. *algae*
b. *mollusk*
c. *coral*
d. *all of the above*

***d***

True or False: *The marine biota reservoir is the only reservoir where its yearly fluxes are much larger than the size of the reservoir itself.*

***True***

*The most dynamic reservoir in the carbon cycle is*

a. *plants*
b. *soils*
c. *ocean*
d. *marine biota*

***d***










*Carbon dioxide that enters the Deep Ocean is removed from the carbon cycle for ____ of years.*

a. *tens*
b. *hundreds*
c. *thousands*
d. *millions*

***b***

True or False: *Once the $CO_2$ enters the deep ocean, we don't have to worry about it for at least 100 years.*

***True***

True or False: *Once the $CO_2$ enters the deep ocean, it will never circulate up again and cause $CO_2$ levels to rise in the atmosphere.*

***False***

*At the poles*

a. *Cold dense water sinks to the ocean floor and fills the ocean basins*
b. *Much of the $CO_2$ freezes and is trapped in the polar ice*
c. *The $CO_2$ is released into the atmosphere*
d. *none of the above*

***a***

*The mechanism by which the ocean circulates $CO_2$ from the surface water to the deep oceans near the poles is called the*

a. *oceanic circulation*
b. *dissolution*
c. *oceanic transpiration*
d. *solubility pump*

***d***

True or False: *When cold water from the deep ocean heats up, it releases $CO_2$. while rising to the surface.*

***True***

*The deep ocean accounts for more than ___ of the earth's carbon.*

a. *5%*
b. *16%*
c. *50%*
d. *65%*

***d***

*The deep ocean gets carbon from*

a. *the surface ocean*
b. *marine biota*
c. *both*
d. *neither*

***c***

*Where are we likely to see a carbon buildup first?*

a. *at the poles*
b. *at the equator*
c. *everywhere*
d. *its random*

***a***

*Is the deep ocean a place where we can store extra carbon indefinitely?*

a. *yes*
b. *no*
c. *we don't know*
d. *it depends*

***b***

DEEP OCEAN










DEEP OCEAN

TEACHER QUESTIONS

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