THE INCREDIBLE CARBON JOURNEY

Has the carbon cycle changed since we started burning fossil fuels? Students become carbon atoms on a journey through the pre- and post-industrial carbon cycle. This activity is based on The Incredible Journey from Project WET.

LEARNING OBJECTIVE

Students will:

- Develop a better understanding of the carbon cycle.
- Compare pre-industrial and post-industrial carbon cycles.

VOCABULARY

Lithosphere: The ground and underground up to 60 miles below the Earth's surface.

Atmosphere: The envelope of air that surrounds the Earth.

Hydrosphere: All water on the Earth including in the air, oceans, rivers, streams and underground.

Biosphere: All life on Earth.

MATERIALS

1. Regular size (8/0) pony beads in the following colors: green (biosphere), blue (hydrosphere), clear (atmosphere) and black (lithosphere). For a class of 25 students, you'll need approximately 150 of each color. Place each color of beads in an empty 8 oz plastic bottle or other reusable plastic container to prevent spillage during the activity.

2. Signs for four stations (lithosphere, atmosphere, hydrosphere, and biosphere).

Instructor Tip: If playing outdoors, mount signs on stakes or heavy cardboard to protect them from blowing away.

3. Use the Dice Templates to create five large dice from boxes measuring approximately 4 inches square. Each die goes with a specific station and represents the different pathways carbon may take from that station. The Carbon Cycle Table tells you what labels to put on each face of the dice.

4. White pipe cleaners, two per student.

5. Copies of the Student Page.

BACKGROUND

The element carbon is one of the most basic building blocks of life on earth. It is found virtually everywhere -- from plants and animals to pencils, diamonds, soil, and even soda pop. Carbon's essential nature allows it to grab onto other atoms readily (including other carbon atoms); this is why carbon exists in so many forms. Carbon can dissolve in water (carbonic acid), form chains to create sugars, and form solid materials like graphite and limestone. Carbon in living things can be released or absorbed through respiration, consumed as food, or transformed into fossil fuels over millions of years. In the atmosphere, carbon exists primarily as carbon dioxide. Carbon dioxide is known as a *greenhouse gas* due to its ability to trap the sun's heat in the atmosphere. Without carbon dioxide's natural ability to trap heat in the atmosphere like a blanket, life as we know it could not exist.

When fossil fuels are burned, the bonds that hold carbon together inside those fossil fuels are broken and carbon is released into the atmosphere. Scientists have noted that the global atmospheric concentration of carbon dioxide has increased nearly 35% since the dawn of the industrial age; methane, another carbon-containing compound, has increased by 150%. Earth's average global temperature has also increased by more than one degree Fahrenheit over this time period – a seemingly small change, but one with significant ramifications for earth's climate and living things. A majority of climate scientists agree with the hypothesis that earth's rising temperature is largely due to the increase in carbon dioxide and other greenhouse gases in the atmosphere resulting from the burning of fossil fuels.

This activity allows students to model the "natural" or pre-industrial carbon cycle, and then compare it to the carbon cycle in the post-industrial age of fossil fuels. The exercise provides an excellent introduction to a lesson on climate science and the carbon cycle.

PROCEDURE

1. Each student will begin at one station as chosen by the student or teacher. There can be more than one student at each station.

2. Each student will be given one pipe cleaner. Have the student twist a knot or small loop onto one end of the pipe cleaner.

3. Tell the students they will represent carbon atoms in the carbon cycle. They will travel around the Earth following the journey of a carbon atom in the pre-industrial world – before we began burning lots of fossil fuels.

4. When given the signal by the teacher, each student will place one bead from their station on the pipe cleaner.

5. Each student rolls the cube at their station. This will tell the student where they need to go. The student will then move to the next station. In some cases, they may stay where they are. If the cube says "STAY", the student should go to the back of the line for that cube and wait to roll it again. While they are waiting to roll the cube, they should take a bead from that station and put it on their pipe cleaner.

6. Each time the student moves to another station, they do the same thing: Roll the cube, take a bead, and move to the next station (or go to the end of the line and repeat).

7. Students will move from station to station for at least 10 minutes or long enough for students to begin stacking up in the lithosphere line. This may take up to 15 minutes.

8. When most students have visited the lithosphere several times, ask them to stop. Wherever students are in line, they should take a bead from that line without rolling the cube and then sit down. This is the end of round one.

Ask students to record their journeys on their student pages. Ask the students what color beads they have on their pipe cleaner and what happened to them during their trip. Did they see any patterns? For instance did they stay at any place more than once? Did anyone go back and forth between two stations (for example, biosphere and atmosphere)? What may explain this?

Instruct students to make a bracelet out of their pipe cleaner by twisting the end through the loop on the other end.

Instructor Tip:

After round one, many students will have a high portion of black beads on their pipe cleaners. This represents coal, natural gas, oil -- all carbon molecules in the lithosphere.

Deposits of carbon have accumulated over time from the remains of plants and animals. Over millions of years, these deposits have become transformed into fossil fuels.

9. Announce to the students that we are moving into the Industrial Age. This is the beginning of Round 2. Give each student a new pipe cleaner. Remind them to twist a loop into the end of the pipe cleaner before proceeding.

10. Exchange the Pre-industrial Lithosphere (L1) cube for the Post-Industrial Lithosphere cube (L2).

11. Have students pick a station at which to begin their journey.

12. Again, students pick up a bead from their station and roll the cube. They will move around the room again for at least 10 minutes or long enough for students to begin stacking up in the atmosphere line. This may take up to 15 minutes.

13. When most students have visited the atmosphere several times, stop round 2. Wherever students are in line, they should take a bead from that line without rolling the cube and then sit down.

Ask students to record their journeys on their student pages. Ask the students what kinds of beads they have on their pipe cleaner and what happened to them in their trip/journey. How did this second round compare with their first journey through the carbon cycle? Did anyone find themselves "stuck" in one place? What may explain this?

Instructor Tip:

Although the amount of carbon in the atmosphere has increased significantly over the last 150 years, it's important to emphasize to students that the amount of carbon on the earth has not changed. Carbon has simply moved from one place to another.

Although you cannot predict exactly what combinations of beads your students will put on their pipe cleaners, you can be fairly certain that after the second round, more of the beads will be from the atmosphere. This represents the build-up of carbon dioxide in the atmosphere that is a direct result of the burning of fossil fuels.

*This activity works best if, for the longest lines, you facilitate students taking their beads in line **before** they arrive at the cube. If you have volunteers, station them along the longest lines of students and have them distribute the beads while the students wait their turn to roll the cube. It may also help to have two cubes for each station to minimize the wait time.*

Follow Up:

Have students create a storyboard, poster, or cartoon about their journeys through the carbon cycle. Encourage them to research and record the processes involved in getting them from one place to the next in the carbon cycle. Did they notice any patterns? For example, an alternating green-clear bead pattern could represent the cycling of carbon between plants and the atmosphere.

Have students graph the numbers of visits for each of the four spheres in the pre-industrial and post-industrial cycles. Create a class graph that incorporates the data from everyone's journeys in the pre-industrial and post-industrial cycles.

STUDENT PAGE

Record your journey through the carbon cycle on this page. Beginning at one end of your pipe cleaner, write the "sphere" you visited for each bead on the pipe cleaner.

Blue beads = Hydrosphere
Black beads = Lithosphere
Clear beads = Atmosphere
Green beads = Biosphere

ROUND 1

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____

ROUND 2

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____

Station	Die Side Labels	Explanation
Biosphere	one side ***stay***	Carbon is used by plants and animals and remains in the cells.
	two sides ***lithosphere***	Carbon enters the soil when plants and animals die.
	three sides ***atmosphere***	Carbon is released through decomposition, fire, and respiration.
Hydrosphere	three sides ***stay***	Carbon remains in oceans and other bodies of water.
	one side ***lithosphere***	Carbon precipitates as sediment and settles to the bottom of the ocean.
	one side ***biosphere***	Carbon is absorbed by marine plants during photosynthesis. Marine animals absorb carbon by eating the plants.
	one side ***atmosphere***	Carbon is released into the atmosphere from the ocean and other bodies of water.
Atmosphere	two sides ***stay***	Carbon remains in the atmosphere.
	two sides ***hydrosphere***	Carbon is absorbed by the ocean and other bodies of water. Cool water abosorbs carbon faster than warm water.
	two sides ***biosphere***	Carbon is absorbed by plants during photosynthesis.
Pre-Industrial Lithosphere	five sides ***stay***	Carbon remains in the soil as organic matter and in sediments containing fossil fuels.
	one side ***atmosphere***	Carbon is released through decomposition of dead organic matter in the soil, and through the metabolic processes of soil microbes.*
Post-Industrial Lithosphere	two sides ***stay***	Carbon remains in the soil as organic matter and in sediments containing fossil fuels.
	four sides ***atmosphere***	**Burning fossil fuels releases carbon dioxide.** Carbon is also released through decomposition of dead organic matter in the soil, and through the metabolic processes of soil microbes.*

* Although decomposition and soil microbial processes are biological, because they happen in the soil they are considered part of the lithosphere.

The Carbon Cycle

101.5 Pg/year = 101.5 Pg/year

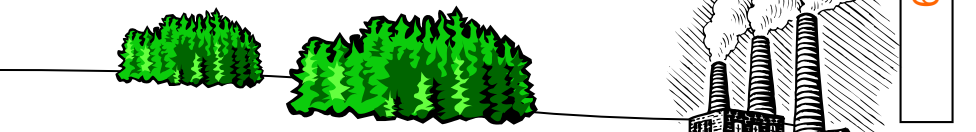
\+ 6 Pg/year

Fossil Fuel Combustion and Industrial Releases:

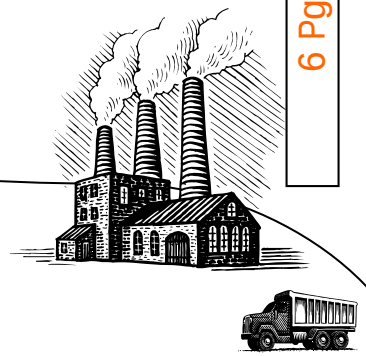
Upsetting the Balance

Released but not stored/ sequestered

92 Pg/year - 90 Pg/year



Terrestrial Carbon:
Equally released and stored by plants and animals



Photosynthesis absorbs CO_2 that is generated through respiration

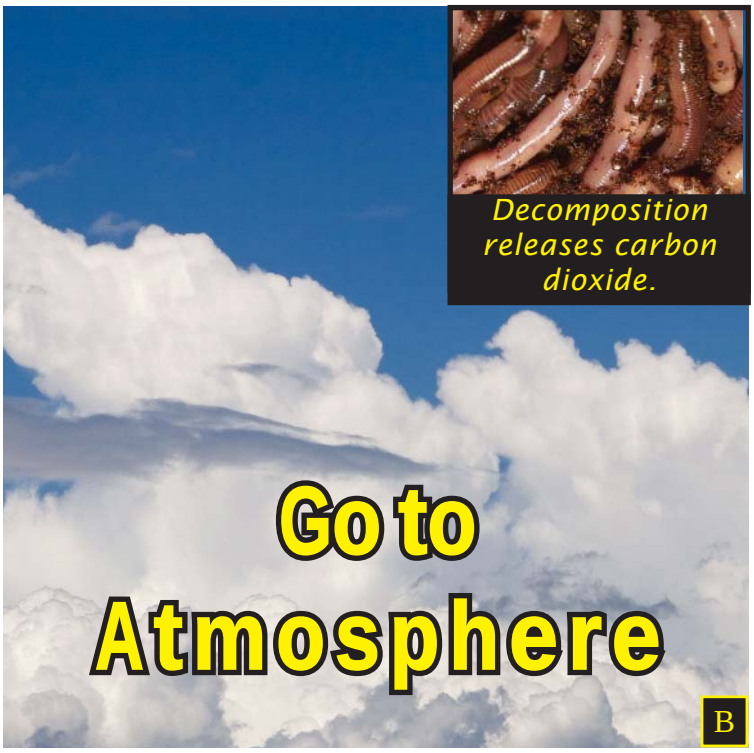
=

Human Respiration releases CO_2:
.000000002 Pg/year

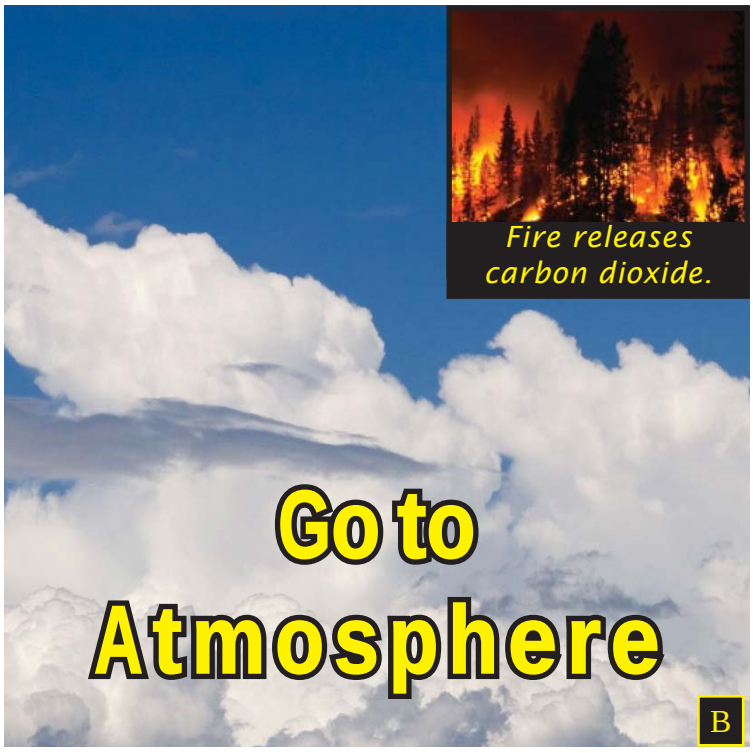
Oceanic Carbon:
Oceans hold more carbon than they release; warming oceans are less able to absorb carbon

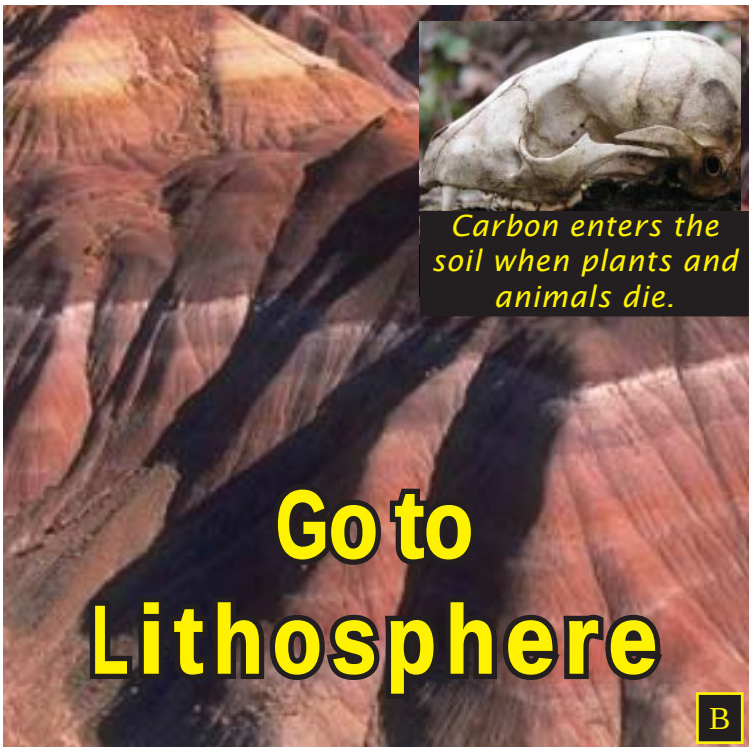
Sources: United Nations Environment Program, Carbon Dioxide Information Analysis Center, U.S. Environmental Protection Agency, KY Division for Air Quality

Pg = Petagram
1 Pg = 1,000,000,000 metric tons

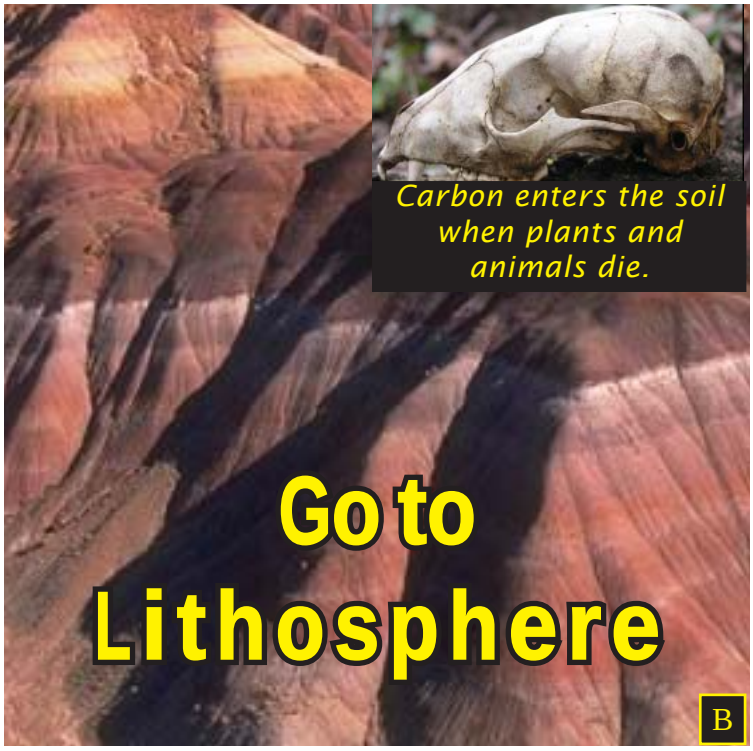

Decomposition releases carbon dioxide.
Go to Atmosphere
B

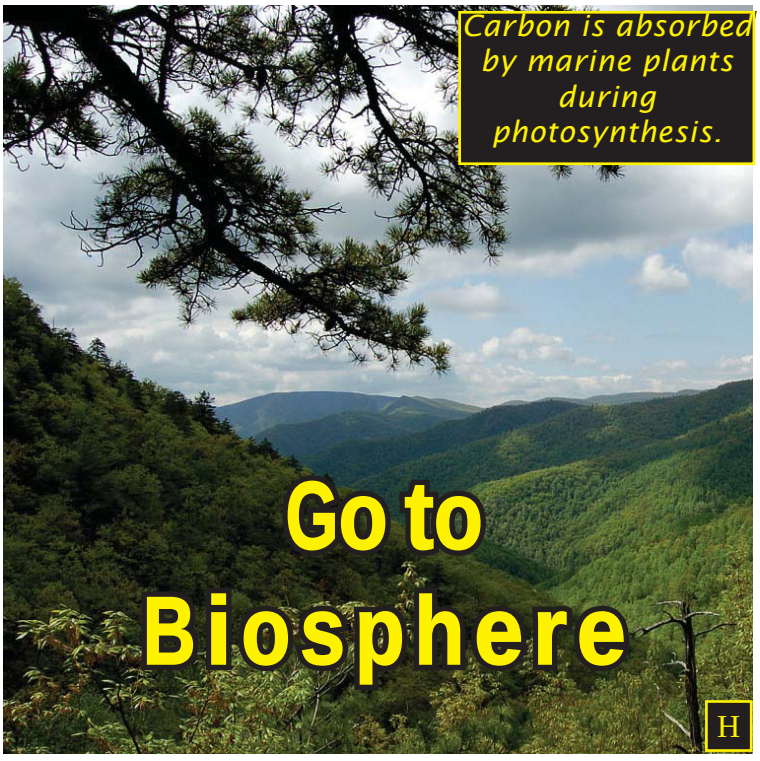

Respiration releases carbon dioxide.
Go to Atmosphere
B

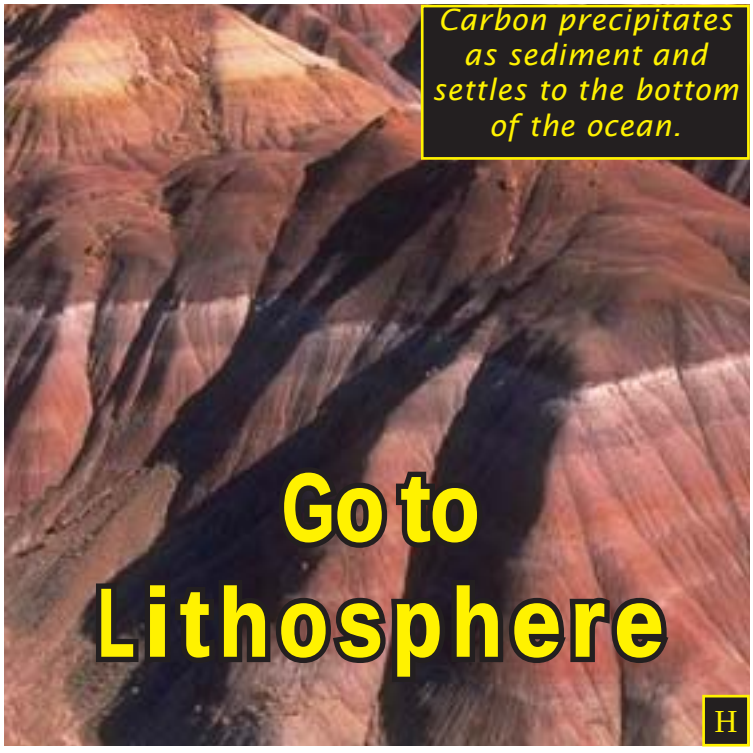

Fire releases carbon dioxide.
Go to Atmosphere
B


Carbon enters the soil when plants and animals die.
Go to Lithosphere
B


Carbon is used by plants & animals & remains in the cells.
STAY
B


Carbon enters the soil when plants and animals die.
Go to Lithosphere
B


Carbon is absorbed by marine plants during photosynthesis.
Go to Biosphere
H


Carbon precipitates as sediment and settles to the bottom of the ocean.
Go to Lithosphere
H


Carbon is released into the atmo-sphere from the ocean & other bodies of water.
Go to Atmosphere
H

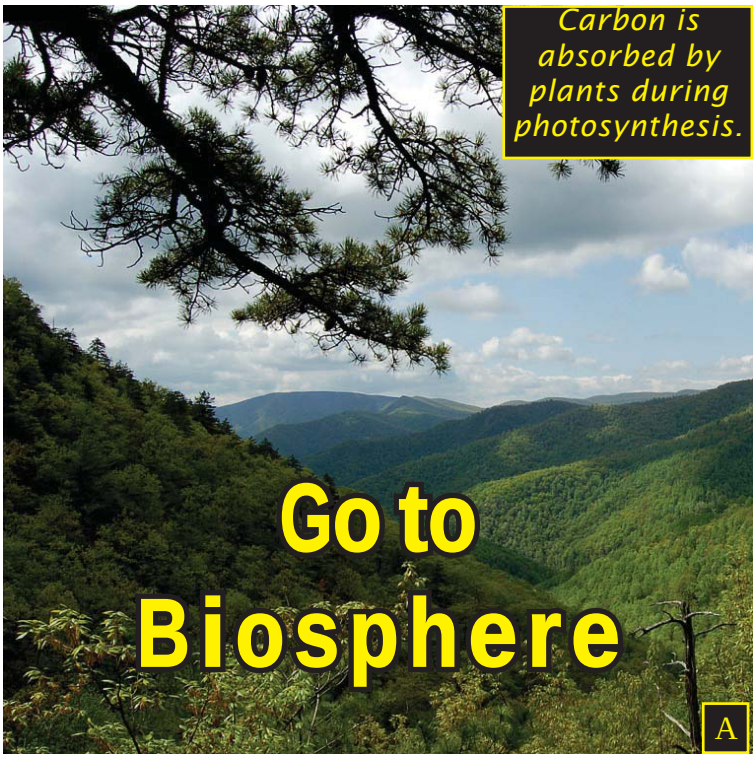

Carbon remains in oceans and other bodies of water.
STAY
H

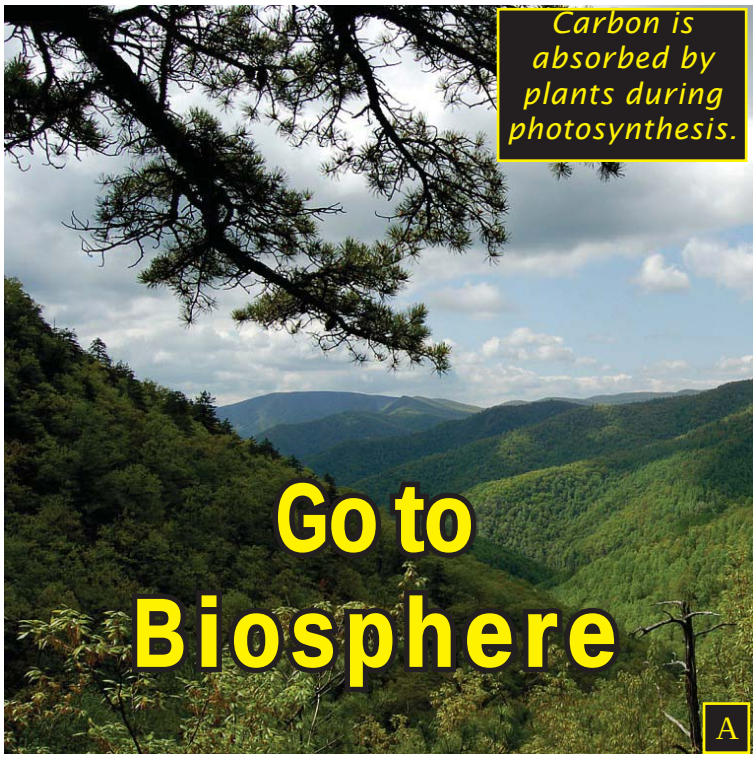

Carbon remains in oceans and other bodies of water.
STAY
H

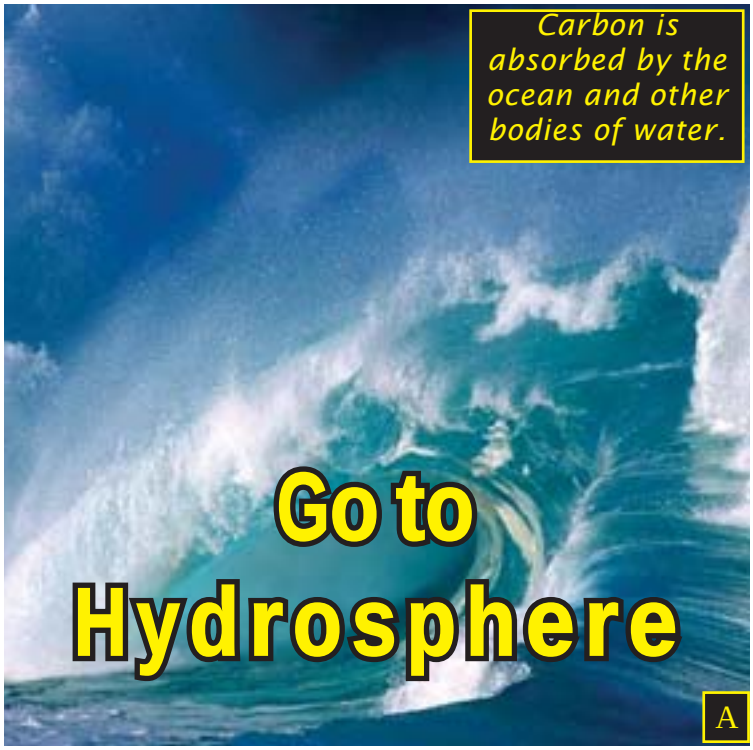

Carbon remains in oceans and other bodies of water.
STAY
H

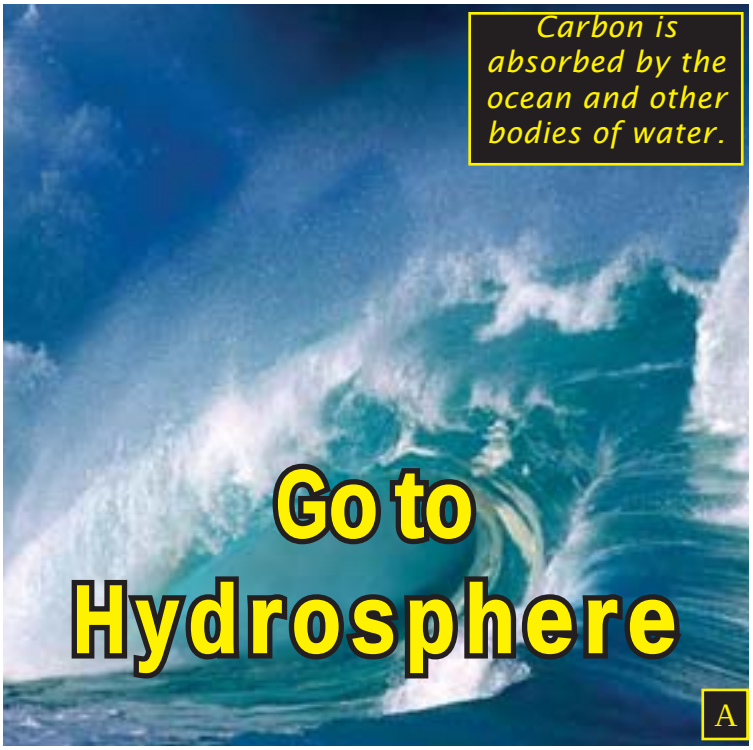

Carbon remains in the atmosphere.
STAY
A


Carbon remains in the atmosphere.
STAY
A


Carbon is absorbed by plants during photosynthesis.
Go to Biosphere
A


Carbon is absorbed by plants during photosynthesis.
Go to Biosphere
A


Carbon is absorbed by the ocean and other bodies of water.
Go to Hydrosphere
A


Carbon is absorbed by the ocean and other bodies of water.
Go to Hydrosphere
A

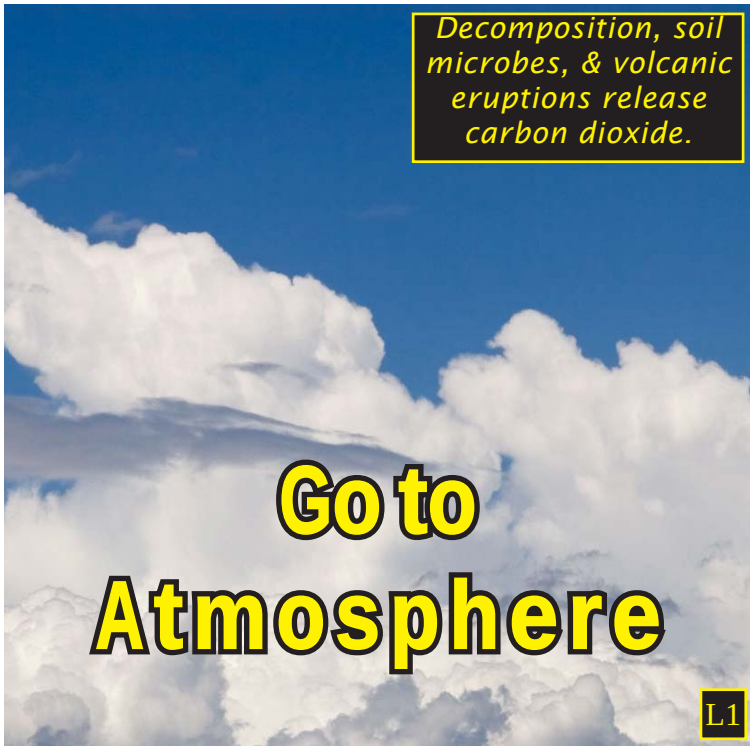

Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L1


Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L1


Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L1

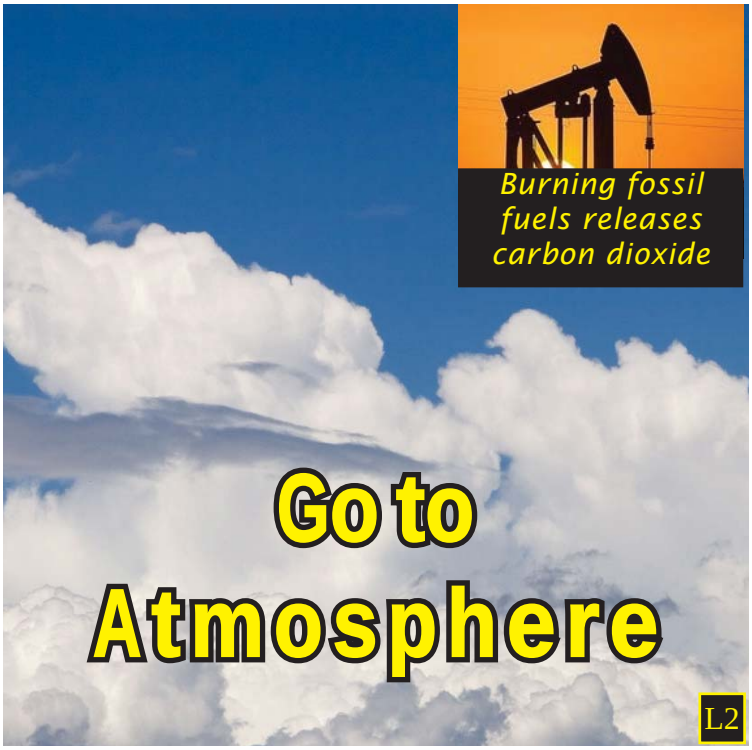

Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L1

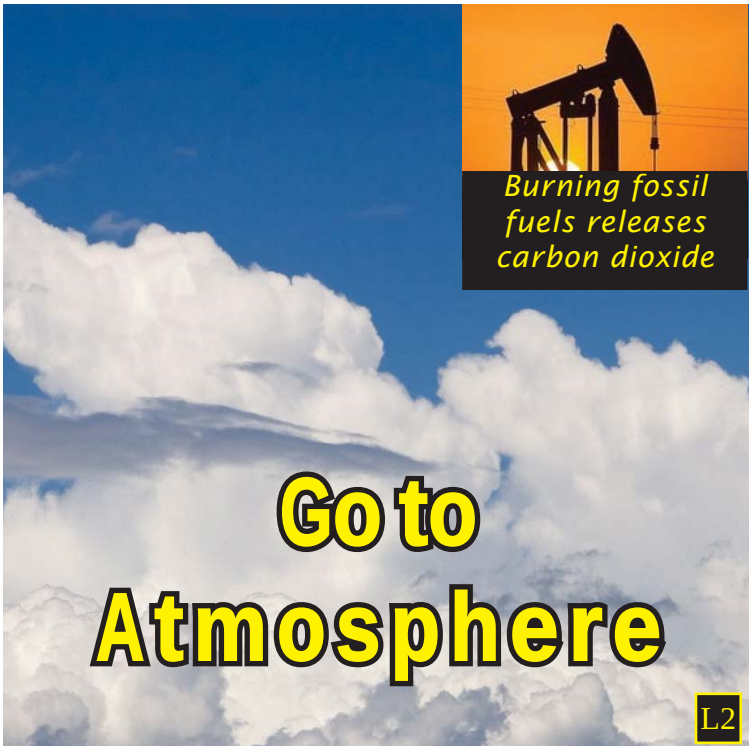

Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L1

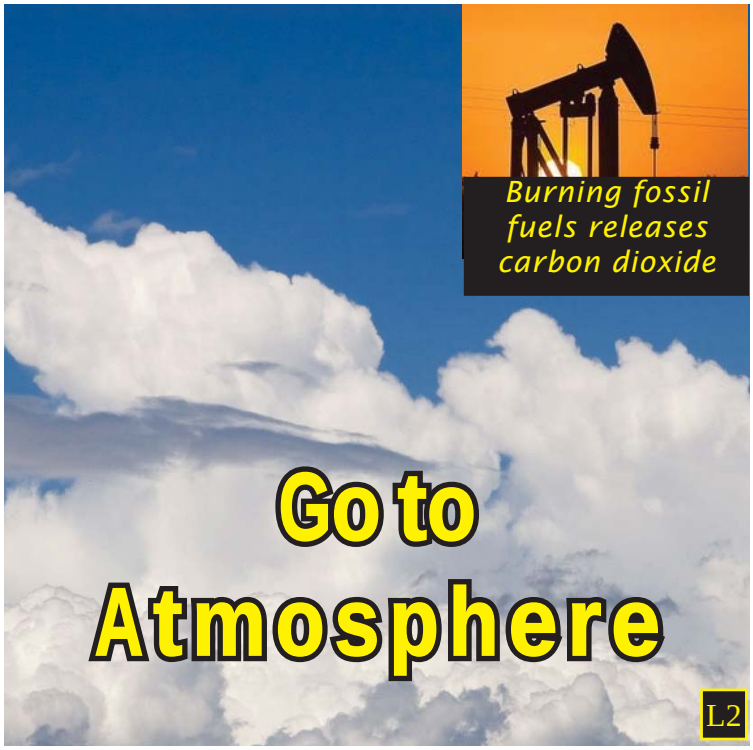

Decomposition, soil microbes, & volcanic eruptions release carbon dioxide.
Go to Atmosphere
L1

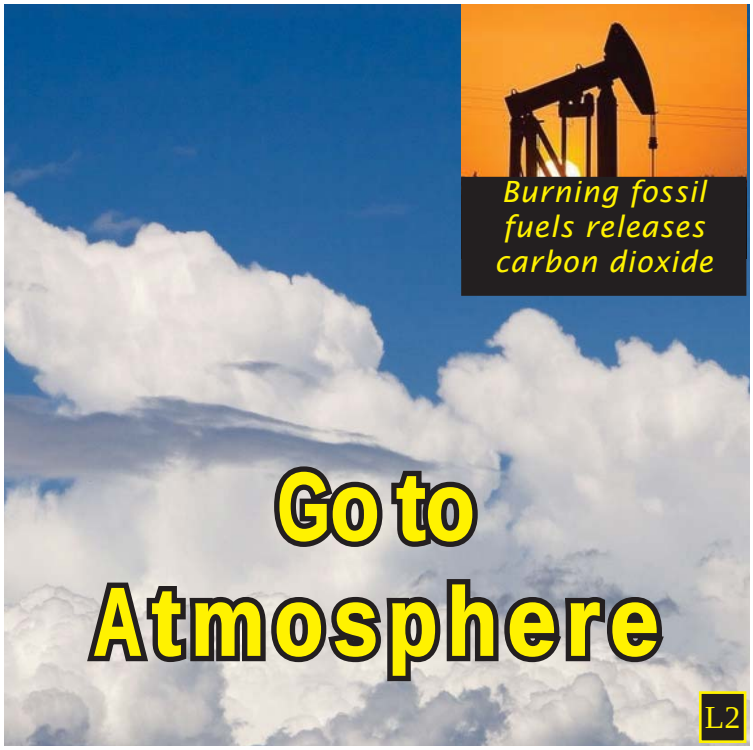

Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L2

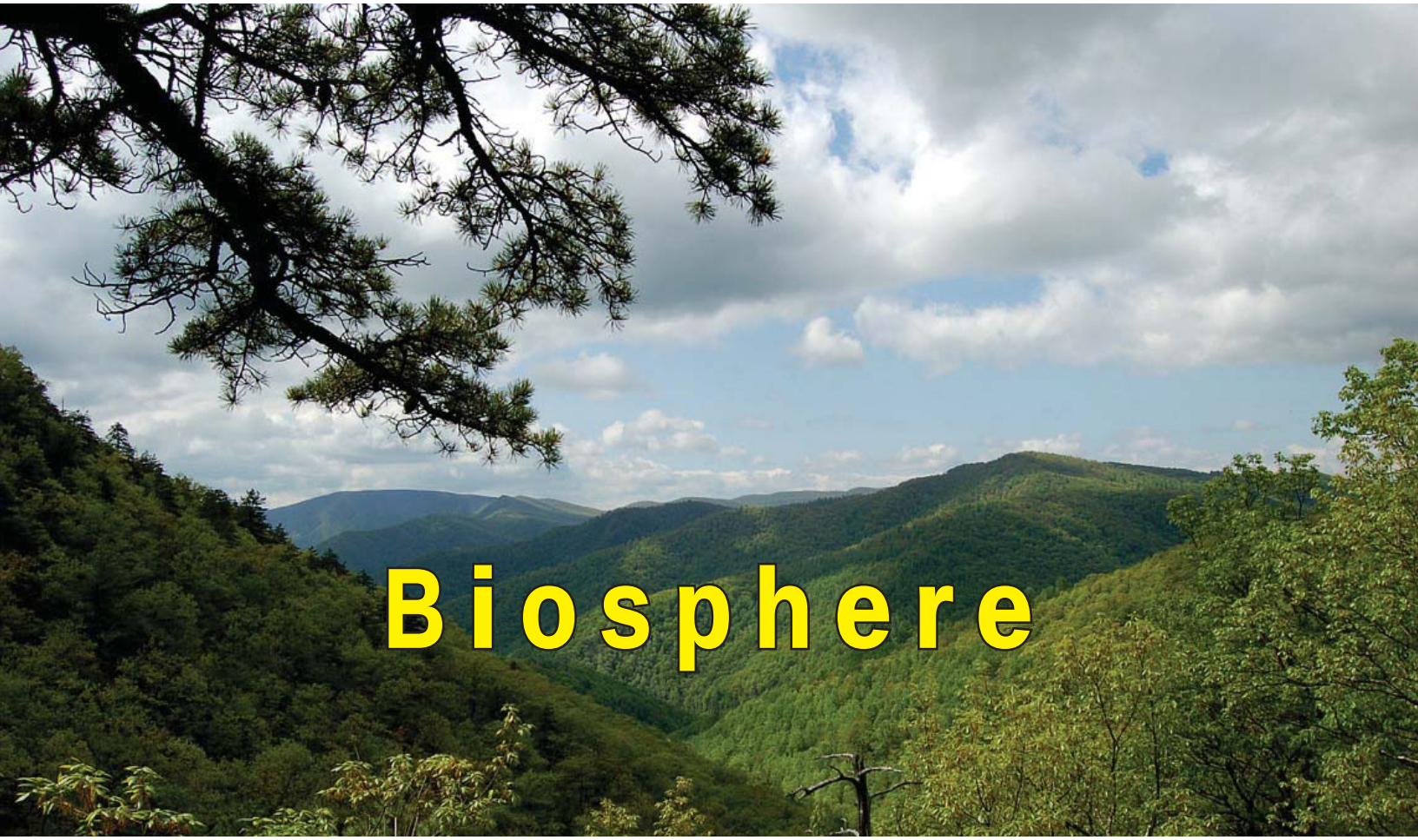

Carbon remains in the soil as organic matter & in sediments containing fossil fuels.
STAY
L2

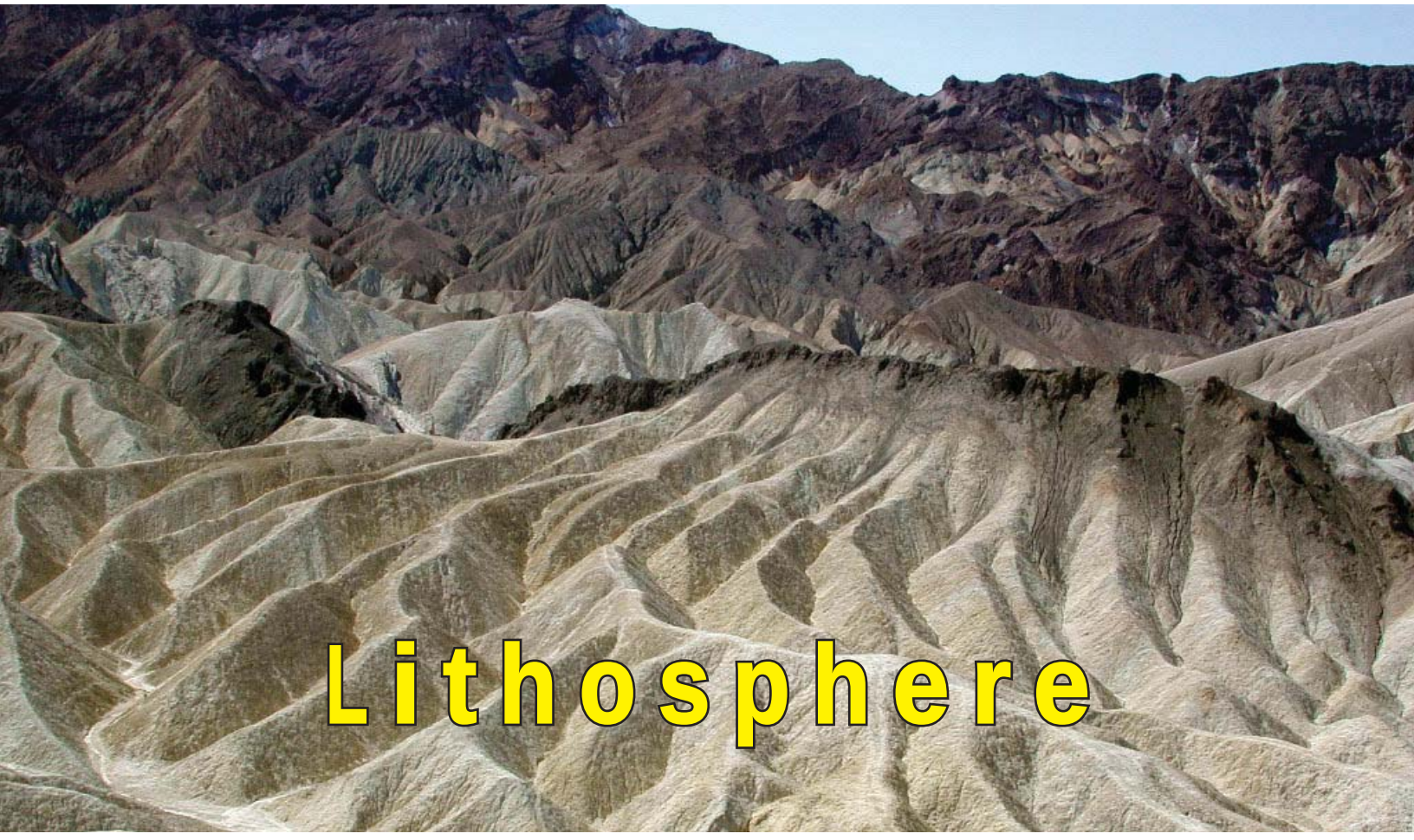

Burning fossil fuels releases carbon dioxide
Go to Atmosphere
L2

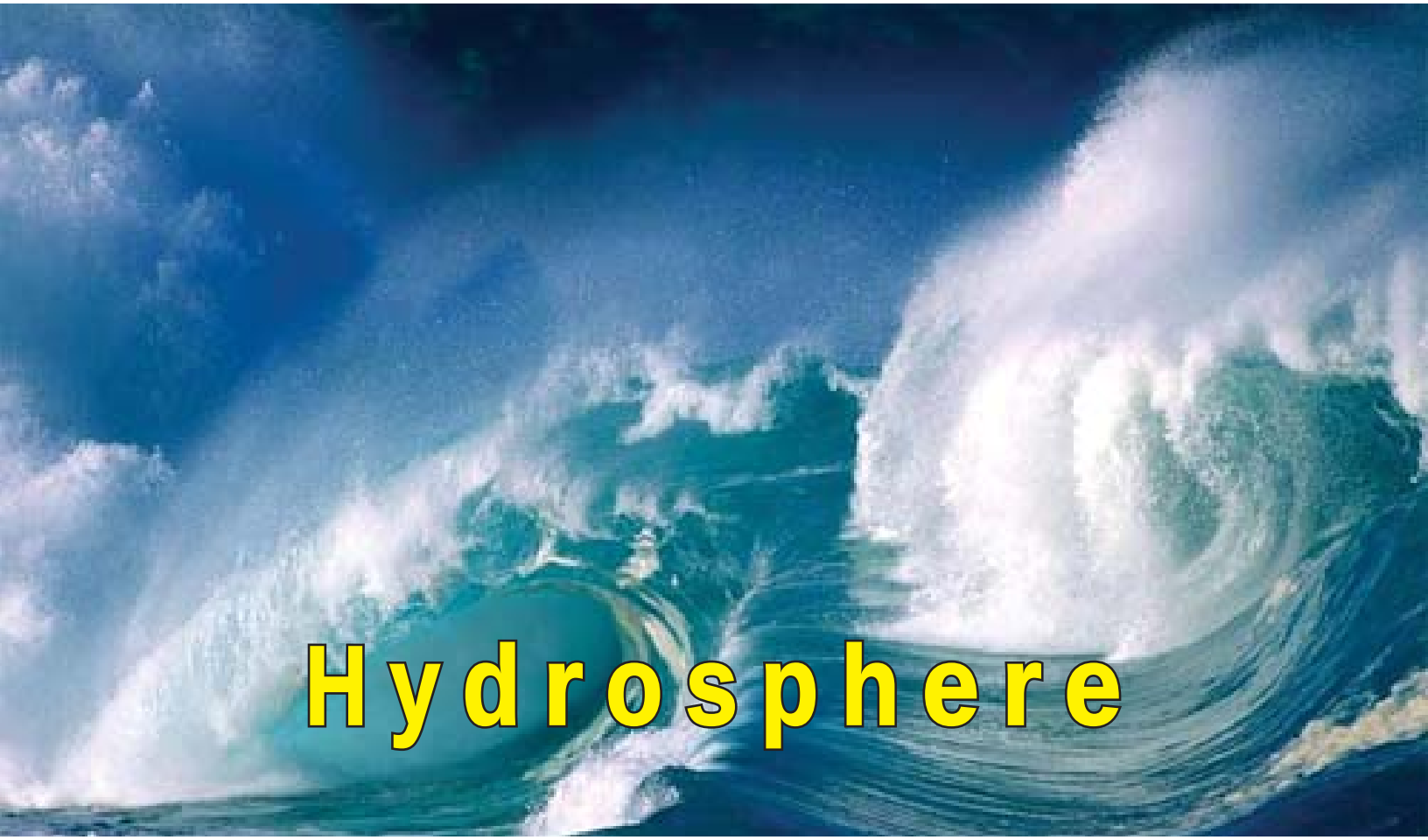

Burning fossil fuels releases carbon dioxide
Go to Atmosphere
L2


Burning fossil fuels releases carbon dioxide
Go to Atmosphere
L2

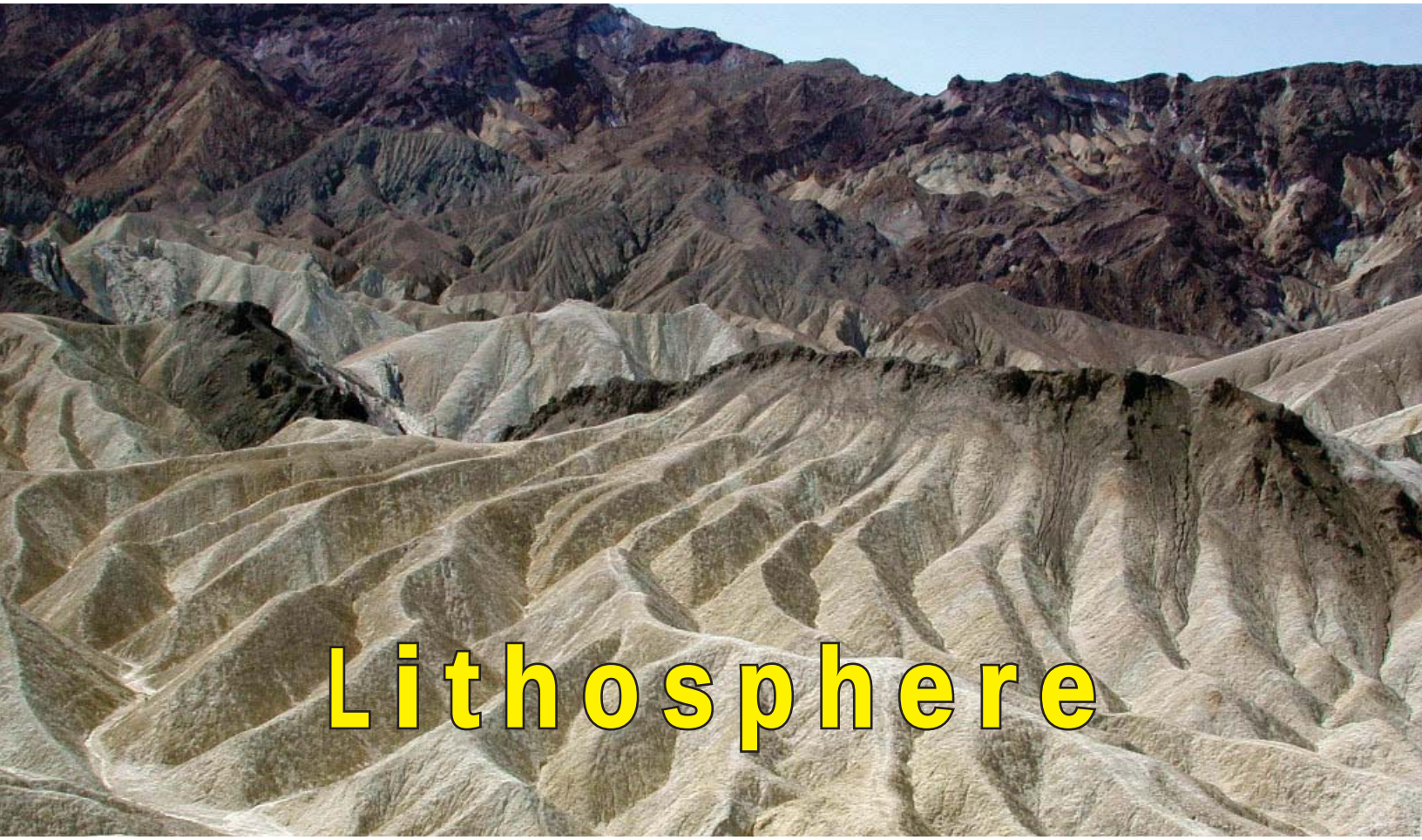

Burning fossil fuels releases carbon dioxide
Go to Atmosphere
L2


Biosphere


Lithosphere


Hydrosphere


Atmosphere


Lithosphere


Atmosphere