Tropical Forests & Climate Change

Levels: Ages 15 -18

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Standards

- Common Core Standards for English Language Arts/Literacy and Mathematics
- Next Generation Science Standards for HS Earth's Systems: HS Weather and Climate: HS Human Sustainability

Concepts

- Students will learn about, and gain a comprehensive overview of climate change and the vital role tropical rainforests play in fighting climate change by storing carbon. Additionally, students

will learn how the impacts of climate change affect different ecosystems and processes across our planet through a human character.

- How are tropical rainforests threatened by climate change and what are the consequences to tropical ecosystems, local people and to us?

Part I: Making Connections

Idea – **Climate Change is a global phenomenon.** It affects all parts of the Earth and all parts of our lives differently, often in subtle and incremental ways. Understanding the science, human role and global impacts of this global issue can feel overwhelming.

Students will watch the Emmy award winning documentary television series, ***Years of Living Dangerously*** (2014), produced by James Cameron. "This groundbreaking documentary series explores the human impact of climate change. From the damage wrought by Hurricane Sandy to the upheaval caused by drought in the Middle East, YEARS OF LIVING DANGEROUSLY combines the blockbuster storytelling styles of top Hollywood movie makers with the reporting expertise of Hollywood's brightest stars and today's most respected journalists."

Materials – *Years of Living Dangerously* Series. 9-part series available through DVD or digital download on the Years of Living Dangerously website. http://yearsoflivingdangerously.com/

Procedure –

1. As a class watch the first episode: Dry Season, available for free on the Years of Living Dangerously Website.
2. Develop a series of questions that connects the relationships between climate and other issues throughout the world through a human perspective.
    a. What is the connection between extreme weather and climate change through the example of severe drought to farmers in the Southwestern United States?
    b. How does the world's appetite for products containing palm oil and the global demand for paper contribute to the cutting down of rainforests in Indonesia? What is the connection between deforestation and carbon emissions?
    c. How does severe drought related to climate change contribute to increased tensions and conflicts for resources in places like Syria and other parts of the Middle East?
3. Consider purchasing the remaining episodes for your school and watching them together as a class. Create similar questions to answer and discuss for each episode.
4. For each episode draw relationships between local and global connections, and between individual characters and the challenges they face due to climate change.
5. Have students think critically of ways climate change impacts their local area and impacts their lives locally and globally. Discuss together.

Part II: Reading and Discussion

Idea – **Forests store more carbon than any other ecosystem on land**. Tropical rainforests, such as the Amazon or the rainforests of Borneo can store even more.

Trees store carbon from the atmosphere in their trunks, branches and roots as they grow. It is estimated that forests store close to 300 million metric tons of carbon in the form of trees and plants. Combined with other plants, deadwood, leaf litter and soil, forests store an enormous amount of carbon, greater even than all the carbon in the atmosphere. **Because of their ability to store more carbon than they release back into the atmosphere, forests are sometimes referred to as carbon "sinks".** In fact, within the global carbon cycle more carbon is stored up in the world's forests than in the world's remaining oil stocks.

Storage of carbon by forests slows the rate of carbon dioxide accumulating in the atmosphere that contributes to climate change. Thereby **one way to reduce the effects of climate change or reverse the buildup of carbon in the atmosphere is to protect forests and their abilities to act as carbon sinks.**

In tropical rainforests trees benefit from a continuous growing season and sunlight that allows them to grow more rapidly than in other types of forests. Rainforests like the Amazon can lock in as much as 15 metric tons of carbon per hectare a year. **Planting trees and reforesting tropical rainforests therefore can remove large amounts of carbon from the atmosphere within a relatively short time and help in the fight against climate change.**

The amount of carbon each individual tree can store depends on the species of tree, its age and size. Generally though, **the larger the tree, the more carbon it can store and the faster it grows the more quickly it will store carbon.**

Materials – Read online or print copies of the New York Times article, *Restored Forests Breathe Life Into Efforts Against Climate Change*. By Justin Gillis (2014)
http://www.nytimes.com/2014/12/24/science/earth/restored-forests-are-making-inroads-against-climate-change-.html?_r=1

Procedure –

1. Read the article.
2. Have students answer the following questions in groups, go over as a class or create your own:
    a. Describe the carbon cycle. Illustrate the carbon cycle in a tropical forest on the board.
    b. How are the issues of climate change and tropical deforestation related? Explain.
    c. What is remarkable about the Costa Rica study site example? EX: the forest regenerated so quickly. Big implications that rainforests can come back through reforestation.
    d. According to scientists what percentage of carbon is being absorbed by trees and other plants across our planet?
    e. How did Brazil backslide from its previous success in protecting their rainforests?
    f. In what ways did environmental groups like Greenpeace put pressure on corporations to clean up their act? What are some ways you could do the same?
    g. Why are the rainforests being cut down so rapidly now across Indonesia?

h. Are there any lessons from Costa Rica or Brazil that could be useful in understanding or solving the current deforestation problems in Indonesia?
i. Create a chart to compare and contrast each rainforest country including percentage of forest loss, reasons for deforestation, solution or alternatives, percentage of reforestation.
j. Focus on the take away message – In addition to protecting rainforest from deforestation, how can large scale reforestation of rainforest areas be a win-win for protecting biodiversity and curbing the impacts of climate change?

Part III: Math and Geography

Idea – **Students will learn more about the important role of forests as carbon sinks at a local level and global level.** By measuring length and diameter at breast height (DBH) of a tree outside their schoolyard, students will learn how scientists measure trees and begin to estimate their carbon storage. Then students will learn about forest carbon storage at a global level by comparing figures of forest gain and loss in Brazil and Indonesia on NASA's Global Climate Change page.

Materials –

- Internet access to explore *Global Climate Change: Vital Signs of the Planet* created by NASA. http://climate.nasa.gov/
- Pencil, paper, writing materials for questionnaire
- DBH measuring tape, string, rulers
- Calculator or other materials for calculations

Procedure –

<u>Part I: Estimating Carbon</u>

1. Explain how foresters and scientists measure trees to calculate carbon. The standard method to measure the sizes of trees is called Diameter at Breast Height (DBH) and is always measured at about 1.4 meters above the ground, hence Diameter at Breast Height (DBH). By measuring at this roughly standard height it ensures consistency over time, across forest plots and between data collections. DBH measurements can be used to estimate volume, biomass and carbon storage for trees
2. Explain to students that today's exercise will involve us measuring the DBH of trees in our own school yards or backyards to understand how scientists measure trees and do basic calculations of how to measure carbon.
3. Take students outside to measure trees. Have them bring measuring and writing materials.
4. Choose your trees and have students first estimate the circumference of the tree (how big around it is) using centimeters, recording their estimates.
5. Divide the class up into pairs and ask each pair to calculate the DBH of the trees in their area recording results in their notebooks.
6. Next have each pair calculate the height of their trees by the following method:

a. Student A stands at the base of the tree
b. Student B stands holding a pencil or ruler at arm length pointing some distance away from the tree.
c. Using the pencil or ruler as a reference Student B lines up the bottom part of the pencil or ruler with Student A. This height represents the height of Student A.
d. Now, Student B moves the ruler or pencil to see how many scaled heights of Student A it takes to reach the top of the tree. In this way a rough estimate of student height and tree height can be made, standardized and compared.
e. Finally, have Student B measure Student A's actual height and multiply by the scaled height of the tree. As an example, if Student A's height is 150 cm and it takes eight scaled heights to reach the top of the tree, then the height of the tree would be 150 cm x 8 = 1200. Convert 1200 centimeters to meters = 12 meter tall tree.

7. Have students record their measurements by creating a chart or print one to pass out making recording easier. Have student pairs compare their calculations for the tree height. Ask how similar or different are they? What are some factors that may account for their differences? (age, species of tree, soil type, location to sun).
8. Assume larger trees store more carbon. How does your tree or trees measure up to others? How might it compare to other trees in your area? How might it compare to trees in other areas like the tropics where trees grow year round and can get much bigger?

Part II: Comparing Tropical Forest Loss

1. Access NASA's figure, Forest Cover Vital Signs http://climate.nasa.gov/vital-signs/forest-cover/. Observe the two figures of annual forest loss-gain for Brazil and Indonesia for the years 2000 – 2012. Which country lost forest, which gained?
2. Globally forest loss between the years 2000 and 2012 was 888,000 square miles (2.3 million square kilometers). Can you figure out roughly how big an area that would be on a map? Try to find a region, city, state or country at the approximate same area size for comparison.
3. According to these figures 309,000 square miles (800,000 square kilometers) regrew during that period also. Now, try to figure out roughly how big an area that would be on a map.
4. Between forest loss and forest gain between 2000 and 2012 how much is that? How much area wise on a map?
5. How much do you think that amount of forest cover or loss translates to in terms of carbon? Review the carbon cycle.

Part V: Debate

Idea – As we have learned both climate change and the destruction of the rainforest are interconnected through the carbon cycle. Both climate change and the destruction of the rainforest are also connected through ongoing debates that have been going on for years. Despite overwhelming scientific evidence, there are many points of view as to whether humans are causing climate change and whether rainforests should be cut down in such large numbers. However all people are directly affected by any decisions made. One of the best ways to understand complex environmental issues is to take an in-debt

look at all sides of it. In this debate activity the student will be asked to take on the role of an individual who is directly affected by the destruction of the rainforest in South America. Students will be asked to gather information that supports their point of view arguing in favor of the benefits of keeping rainforests intact (carbon storage, biodiversity, medicine, water, ecosystem services) versus developing them (natural resources extraction, money, development, jobs).

Debate Groups

George – The CEO of a Large International Forestry Company

He says, "World population is expected to reach ten billion by 2040 with numbers expected to grow most in developing countries. To meet the growing demand for forestry products we must use and develop tropical forests for our ever growing population."

Vanessa – A scientist who studies the tropical rainforests of South America and their role as carbon sinks

She says, "Rainforests are the lungs of the Earth, filtering the air and sequestering huge amounts of carbon that help in the fight against climate change. They serve as a refuge for innumerable species of plants and animals, as well as peoples. While rainforests once covered 16% of the Earth's land surface, today they harbor only 6%.

Alejandro – An indigenous person from the rainforest

He says, "The rainforest is my home. The rainforest gives me shelter, provides me food to eat and is the resting place of my ancestors. I miss the sounds of singing birds, the deep booming voices of the howler monkey and the still, expectant silences. Now all I hear is the sound of chainsaws and bulldozers. The forest is dying …

Juan – An indigenous person from the rainforest who has been employed by an oil company

He says, "Working for the oil company has allowed me to save money to build a house and feed my wife and four kids. In the past there was no work, only trees. Now there are jobs and progress is being made. Soon there will a paved road into town and we will be able to buy goods we need like a new stove and a TV."

Materials – Access to the internet to research the different points of view for your debate.

Procedure –

1. Introduce competing narratives and perspectives on the rainforests to students. The central question should be a debate for or against developing the rainforest with a focus on tropical forest's role in reducing climate change versus being utilized for development.
2. Divide the students up into one of the four debate groups. Have each group research their character's perspective and argue for their viewpoint to develop or conserve the rainforest. Encourage students to get into their role playing, even if their characters view may not

necessarily reflect their own views. The better they can understand a different perspective the better they will be at understanding and arguing the issue from multiple perspectives.

3. Have each debate group be clearly FOR or AGAINST developing the rainforest.
4. Discuss with the groups the format of a debate and expectations for a positive team experience and persuasive debate.
5. Have each debate group nominate a CAPTAIN. The captain acts as a leader maintaining group focus, being fair and unbiased and delegating responsibilities.
6. Discuss how teams will nominate a captain fairly and responsibly by consensus or randomly.
7. Once teams have nominated a captain and brainstormed research topics, team members should assume responsibility for researching their supporting topics using all available resources via the internet, literature and other sources.
8. Once resources have been collected, it is important that each group member has an opportunity to present their research and materials for the discussion.
9. Together each group should formulate an argument in favor for or against developing the rainforest. Topics to include in their argument are the role of carbon storage and climate change, development, creating jobs, biodiversity conservation, traditional livelihoods, and ecosystem services, feeding or supporting growing populations. The list is long and diverse, so encourages students to be creative in their arguments and focus on the strongest points.
10. Also encourage each group to conjecture and guess what the other teams' arguments and responses may be so that they are prepared to respond to them.
11. Hold your debate. The teacher's role is that of the facilitator, monitoring each group.
12. At the end of the debate bring everyone together and ask them what they learned about tropical rainforests, climate change and about debating.
13. Were any of the arguments used in the debate able to shift student's opinions or viewpoint into a different direction, or did research enforce your view more? Did there seem to be a clear winning argument for or against developing the rainforest? How large a role did climate change play in the debate? Would understanding competing viewpoints like this be positive for more people in society to understand and discuss these issues? Why or why not?

Part IV: Service Learning

Idea – Raise awareness about climate change and protect tropical rainforest! **Put your lessons into action by organizing a fundraising campaign to protect tropical rainforest with Rainforest Trust.** For over 25 years Rainforest Trust has protected nearly 8 million acres. We have a long history of working with school clubs, student groups, and everyone who cares about saving the rainforest. To date many teachers, students, parents and youth groups have made meaningful contributions to the environment through Rainforest Trust by organizing rainforest fundraising events to help purchase and protect real acres in real places.

Materials – as necessary for your event

Procedure –

1. Choose a Rainforest Trust project to support.
2. Organize a fundraising event or activity with your class, school or community to raise awareness of the importance of tropical forests in combatting climate change.
3. Once you have decided on a fundraiser event plan it and put it into action with the support of your community.
4. Use the funds you raised to purchase critical rainforest acres with the help of Rainforest Trust. All proceeds will be used to protect tropical forests and crucial habitat for wildlife.
5. Tell us about your event and be featured on our Rainforest Ambassadors webpage and receive a certificate to commemorate the acres you saved.
6. Spread the word and help us protect rainforests!

Visit Rainforest Ambassadors for examples, success stories and inspiration from a network of young people around the world helping us save rainforests. https://www.rainforesttrust.org/get-involved/youth-programs/

Appendix: Additional Resources & Activities

I. Understanding Climate

Idea – The Earth's climate is changing. **Over the past century the Earth's average temperature has risen by 1.4 °F and is projected to rise another 2 to 11.5 °F over the next hundred years.** Though these changes may seem small, any change to the average temperature of the planet can translate into large and potentially dangerous shifts in climate and weather.

What is the difference between climate and weather though? **Weather** is what is happening outside at any given moment in time. This includes things like temperature, rainfall, cloud cover and humidity to create the variables of the weather you see daily ranging from sun and warmth to a cold winter snowstorm.

In contrast, **climate** is what you might expect weather patterns to be over a longer term. An area's climate is calculated using averages over a period of decades to create a general picture of predictable weather patterns and average temperatures for an area.

The evidence is clear, the climate is changing. Rising global temperatures have been accompanied by changes in both weather and climate. In many places throughout the world, changes in rainfall have resulted in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. Meanwhile the planet's oceans and glaciers have also experienced some big changes. The oceans are warming making them more acidic, ice caps are melting and sea levels are rising. As these changes to our global climate become more obvious in the coming decades, they will present severe challenges to our society and environment.

But why is it called climate change? The rising average world temperature is often called global warming, but scientists prefer to use the term climate change. This is because its impacts will be different in every region of the world and will involve changes in rainfall and other aspects of climate, not just temperature. How has climate changed in your area?

Materials –

- Internet access to explore *Global Climate Change: Vital Signs of the Planet* created by NASA. http://climate.nasa.gov/
- Pencil, paper, writing materials for questionnaire

Procedure – Students will learn about climate change by exploring a series of scientific graphs, data collections and educational information provided by NASA, the National Atmospheric and Space Association and one of the world's biggest Earth science research organizations.

Students will explore the relationship between carbon dioxide and global temperature from the past to the present to better understand the scientific basis behind global climate change. Then students will design a questionnaire to ask a parent or grandparent how these scientific observations of changes in the global climate may or may not match up with daily observations over a person's life time.

1. Review some of the basic information you have just learned with students. Ask students if they have heard of the term “global climate change”? Is climate the same as weather? What change does “climate change” refer to? How is climate change different than “global warming”?
2. Have students log onto computers to explore *Global Climate Change: Vital Signs of the Planet* created by NASA.
3. As a class together click on the **Carbon Dioxide** graphic on the bottom left of the site. Explore the graph together. What is carbon dioxide? Explain that it is one of several gases in our atmosphere that are known as “greenhouse gases” because they trap heat, like a greenhouse. How much have carbon dioxide levels gone up between 2006 and today? Have students observe and understand the graph and time series showing changes in carbon dioxide over the past decade.
4. If carbon dioxide (CO2) is a “greenhouse” or heat trapping gas, wouldn’t that suggest if there is more carbon dioxide in the atmosphere it would make the climate on average warmer? Next look at the **Global Temperature** graphic on the bottom left. Have students observe and understand the graph and time series showing changes in global average surface temperature between the late 1800’s and today.
5. Finally, have students explore the **Science** tab at the top right of the webpage. Let students read and explore these pages. When they are finished go over the Evidence, Causes, Effects and Consensus provided. **Give students a short quiz to test their knowledge.** Ask questions: What is the strongest evidence of climate change? How are human activities contributing to climate change? Which are some of the activities? What is the “greenhouse effect”? What are some ways plants, animals and the environment will be affected by climate change in the future? What are some ways we will be affected in the future? How much consensus is there by scientists around the world on climate change? Can you think of any reasons why some people would be resistant to the idea that our activities and way of life are changing the climate and negatively affecting the Earth?
6. Lastly, ask students whether their parents, grandparents or neighbors have ever mentioned any changes they have noticed in the climate. Invite students to interview someone in the community about changes they may have observed over their life. Design a short questionnaire together as a class (5 or 6 questions).
7. When students have finished with their questionnaires ask what they have learned from the interview. What changes have people noticed in the past 10 – 30 years? What do they think might be causing these changes? How do they view these changes in terms of the future?

II. Understanding the Carbon Cycle

Idea – **Carbon dioxide is one of many gases found in Earth’s atmosphere.** Each carbon molecule is made up of one part carbon (C) and two parts oxygen (O), therefore it is often written CO2.

So what does carbon have to do with climate change? An important component of climate change is the amount of greenhouse gases in the atmosphere. These gases help trap heat and include carbon, nitrous oxide, methane and water vapor. Greenhouse gases like carbon are a natural part of the

atmosphere and are necessary for life on Earth to exist. Despite making up only a small percentage of the Earth's atmosphere, they play an immensely important role.

As the sun's radiation enters the atmosphere and warms up the Earth, greenhouse gases prevent some of this heat from escaping back into space, in the same way that glass panels in a greenhouse trap heat. **Without this "greenhouse effect", Earth's atmosphere would be vastly different and too cold to support life as we know it.**

Why is the level of carbon in the atmosphere a concern to us? For the past several thousand years the levels of carbon in the Earth's atmosphere have been fairly stable at about 280 parts per million (ppm). The decay of material in forests and grasslands naturally emit carbon into the atmosphere. In the past these sources were balanced by natural processes such as plant growth and the dissolving of carbon in seawater to remove carbon from the atmosphere.

The carbon cycle began to become unbalanced starting around 1860, the beginning of the Industrial Revolution. As industry grew it converted the carbon stored in natural deposits of wood, coal and oil into energy releasing that carbon back into the atmosphere. By the middle of the 1900's, a hundred years later, carbon levels were up to 316 ppm from 280 ppm. By 2010, levels were at 390 ppm – a 39 percent increase since 1860, and rising. Scientists have given overwhelming evidence that changes in the carbon cycle and increase of carbon into the atmosphere are the main cause of rising global temperatures.

Most of the increase in carbon in the atmosphere is from burning **fossil fuels** for energy. These fossil fuels include petroleum products like coal, natural gas and kerosene. When they are burned they release carbon into the atmosphere. A second major source of carbon being released into the atmosphere is caused from **deforestation**. When forests are logged for lumber or fuel, and when forested land is cleared for farming or pastures, carbon is emitted into the atmosphere.

Although rainforests cover only about 6% of the Earth they account for between 30% and 50% of total primary productivity (photosynthesis) in terrestrial (land based) systems. That means that **rainforests store more carbon per unit area than any other type of ecosystem.** The rainforests of the Amazon contain between 14 and 40 kilograms of carbon per square meter, while the soils lying under rainforests contain huge stored carbon reserves in the form of roots, microorganisms, fungi and plants. In other words, rainforest ecosystems store a disproportionately high amount of carbon both above and below ground. Therefore in addition to protecting rainforest for their incredible biodiversity of plants and animals, healthy standing rainforests help in the fight against climate change by storing and trapping atmospheric carbon.

Students will learn about the carbon cycle by writing a brief story from the perspective of a carbon atom as it cycles through the rainforest.

Materials – Student notebooks and writing materials

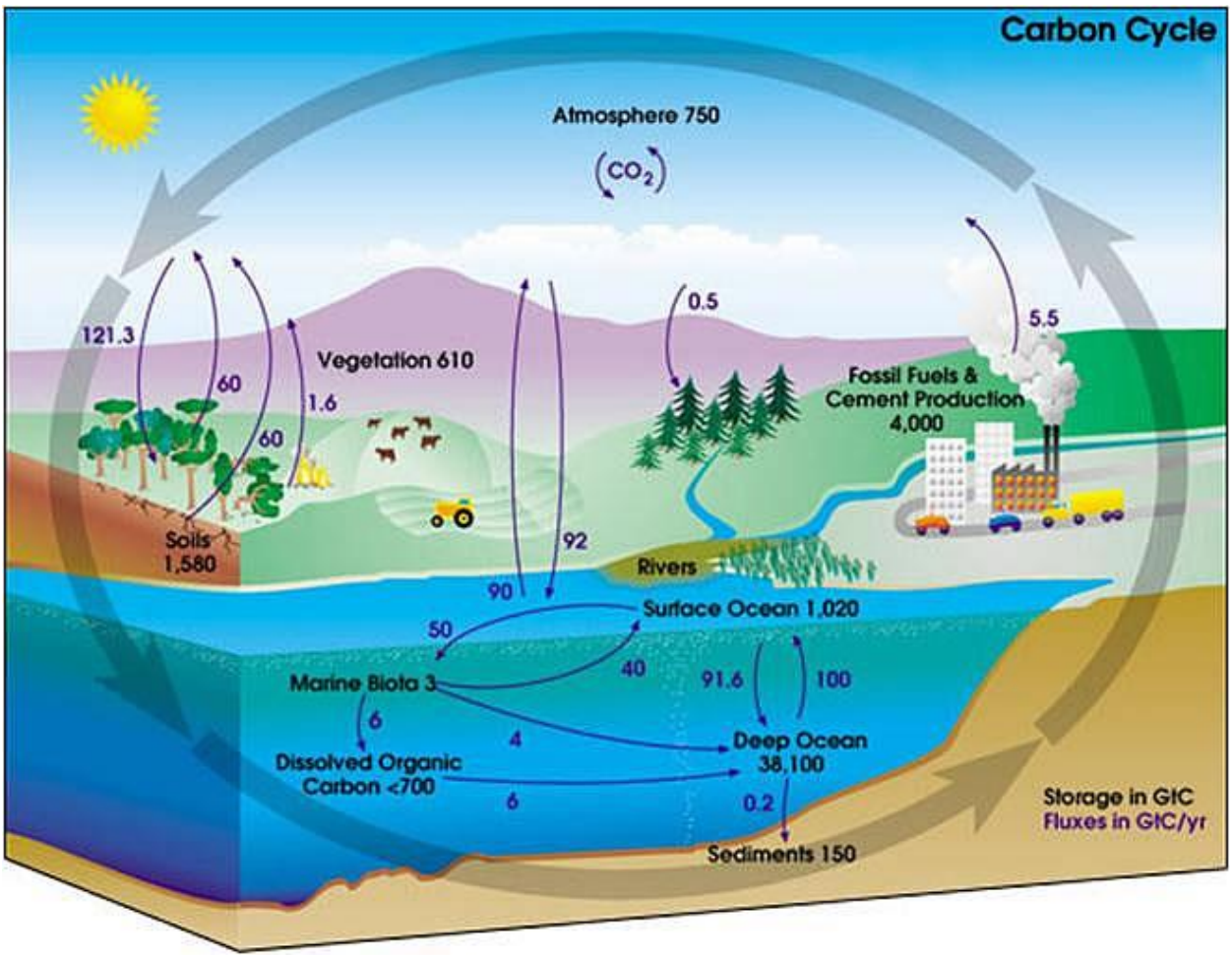

Diagram of the Carbon Cycle

Procedure –

1. Draw a rough map of a rainforest carbon cycle on the board. Make it as simple or elaborate as you wish but make sure to include at least the following three stations: **Atmosphere, Plants, and Animals.**
2. Using a rough diagram drawn on the board or printed out, explain how carbon in the air becomes part of plants through the process of photosynthesis. The chemical reaction of photosynthesis converts the carbon in the air into food (carbohydrates) for plants. When any animal eats plants it ingests these carbohydrates and thus the carbon stored in them. Through the process of respiration (breathing), carbon returns to the air and the cycle begins anew.
3. In any ecosystem, especially in a highly diverse tropical rainforest, this process is much more complex than our diagram. Walk through the basic carbon cycle on the board together, pointing out examples within each part like: a tree is chopped down for fuelwood, a tapir eats a plant, a tree sucks in carbon from the atmosphere and grows, a forest fire burns etc.

4. To better understand the rainforest carbon cycle, play a game with students. Each student will be a carbon atom cycling through the rainforest at one of three stations. Atmosphere, Soil, Tree, Plant, Animal, Lake.
5. Divide up between different stations to begin. Place one dice at each station and have each student roll the dice or choose a number between 1 and 6. Each number represents one of the six carbon stations.
6. At each station students should imagine a scenario for their carbon journey. Ex, they ~~are sucked~~ are converted into the leaves of a tropical water hyacinth plants. The hyacinths are eaten by a tapir. Etc.
7. Each time you call out "cycle", students should move to the next station directed on their card. If they stay at the same station, students should roll the dice again or choose a number between 1 and 6.
8. Repeat this until most students have cycled through the rainforest stations on their carbon journey.
9. When the exercise is over, have each student write a short story about their individual carbon journeys. Have them describe their journey in writing and address where they spent the most time. Which places they were locked up or stored, and which places they were released back into the atmosphere. Ask which path releases carbon quickly into the atmosphere and which stores it for a long period of time? How does the carbon cycle help us understand the relationship between tropical rainforests and global climate change?