BROWN
Institute at Brown for Environment & Society

CLIMATE HISTORIES: ARCHIVES, SEASONALITY, AND THE TROPICS

LESSON PLAN

Keywords: seasonality, temperate and tropical climates, natural archives, tree rings, and climate literacy

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Practiced and co-designed with the fifth graders of SouthSide Elementary School in Providence, RI

Lesson Objectives: Promote and practice climate literacy, or the ability to read climatic change over time (history) and space (geography), through interactive plant learning activities. Climate literacy is a skill and a science; it helps foster "an understanding of your influence on climate and climate's influence on you and society" (climate.gov).

Primary Questions: What is seasonality, how does seasonality create plant-based archives, and how can we use seasonality and plant archives to read the climate of the near and distant pasts?

Lesson Argument: In much of the Mid-Atlantic United States, temperate climates with four seasons produce tree rings that can show us that climate history. Geography, or the study of the physical features of the earth and atmosphere, helps us understand differences in seasonal patterns in temperate and tropical regions. Tree rings are archives of information that help us read seasonal patterns in the past. In temperate regions, those patterns are caused by changes in temperature across spring, summer, autumn, and winter – but tree rings in tropical regions (if they form) show wet versus dry seasons. Like tree rings in temperate zones, tropical zones have other archives that scientists used to read climate in the past, but only in recent decades have such archives begun to be explored.

Exercise 1

Introduction to Seasons, Archives, & Climate Literacy with Tree Rings (1 hour)

Lesson materials: Provided slideshow presentation (slides 3-7)

Argument and objectives: Have students explore tree rings as the result of seasonal change and as natural archives that we can read to decipher how seasons changed in the past. Understanding the concept of seasonality, latitudes, and the tilt of the Earth.

Part One: Seeing seasons activity, group activity (20 minutes)

- In small groups of three to five, have your students sort through a bank of emojis to find the ones they believe represent different seasons in Rhode Island.

- Once they have their emojis divided into groups by season, have them write down key words for each group and write a sentence for one group of their choice. Have them write their answers on a single piece of paper and get prepared to share. Indicate a group leader to share the keywords and one or two willing students to share their sentences.

- Back in a large group, have the students share their key words and selected sentences group by group. Write down the student responses on the board, so they can continue to draw on a new bank of their own ideas, themes, and differences.

- In slide 4 you will find a video of the Earth and how it is tilted when it spins. Explain that the reason why we have seasons in mid and high latitudes is due to the tilt of the Earth when spinning around the sun. Play the video in the slide or look at the link in the notes of the slides if you encounter any issues. You can point out where Rhode Island is while the animation is playing and describe how the tropics receive a constant amount of sun throughout the year. This is why these regions don’t have seasons like Rhode Island does.

Part Two: Tree rings as historical archives of seasons, slideshow (20 minutes)

- What is history? Ask the students if they know what history is and, if so, how would they define it?
  - Define archives as sites where we can read history and see change across time.
  - Clarify that many historians work in archives that resemble libraries, but environmental historians and paleoclimatologists use natural archives like tree rings, coral samples, and bacterial lipids. These archives increase our climate literacy, or ability to read climate change.

- Trees as archives for reading seasonal patterns. Use the slides (5 and 6) to show that trees have all kinds of history and that tree histories teach scientists many things about the past.
  - Tree rings show the history of the seasonal change that trees have experienced as they've gotten older.
  - Clarify that tree rings occur in temperate regions and show when trees go dormant during the winter. Tropical trees do not store the same information (slide 7).

Part Three: Object lesson (20 minutes)

- Pass out a few different tree ring samples or visuals to your students in small groups of three to five. Have them spend a few minutes with each sample trying to read and count the number of seasons they see for each one. Have the students record their answers for each sample and have them prepare to share. If you don't have tree ring samples, you can print page 2 of the printouts document.

- Have the students compare and contrast their findings and share their thinking processes. Have the students take notes on their observations.

Exercise 2

Introduction to Seasons, Archives, & Climate Literacy with Tree Rings (1 hour)

Lesson materials: Skittles, color-coded sticky notes, paper plates, lake sediment core prototype A (pages 3-5 of the printouts document) and bacterial lipids prototype B (also pages 3-5, so print these pages twice).

Argument and objectives: Like tree rings in temperate zones, tropical zones have other natural archives that scientists can use to read climate in the past. Bacteria change the structure of their cell membranes in order to be able to adapt to the temperature of the medium they live in. The changes in cell membrane structures can tell us about past temperatures in the tropics. These bacteria are found in the sediment samples of lakebeds, which also allows scientists to see which ones are oldest and track changes in temperature through time.

Part One: Slideshow presentation and discussion (30 minutes)

- Briefly overview the highlights of Exercise 1 by asking the students what they remember about seasonal change, tree rings, and reading climate in temperate zones. Be sure to remind the students that tree rings only help scientists read climate in temperate zones where there is more seasonal change.

- Do tropical archives for reading climate exist? Yes. With the provided slides, introduce your students to another natural archive for reading climate in tropical zones: bacterial lipids in lakebed cores.

- Ask the students what they know about bacteria. Anticipate many responses. Without discrediting their thoughts, provide the working definition of bacteria, cell membrane, and bacteria lipids on slides 9 and 10.

- With the subsequent slides (11-13), introduce your students to the bacteria lipids that remain in the sediment of lakebeds in tropical zones for hundreds to thousands and even millions of years. Next, explain to your students how these bacteria's cell membranes fluctuate with temperature changes (like clothing, slide 13) and scientists can measure these membranes to show how climate changed over time.

Part Two: Reconstruct temperature in a lake sediment core activity (30 minutes)

- Give students a plate and a small bag of Skittles. Make sure each student has an assigned number in a consecutive order starting with one. Make sure each student writes the assigned number on the plate.

- Have each student separate the Skittles by color. When they are ready, they will exchange Skittles for color-coded sticky notes (see slide 14). Remember that they are not going to exchange all of the Skittles and this is part of doing science: Not everything you get in each layer can tell you something about temperature.
- After each student has their color-coded sticky notes, have them put the notes on the prototype core A from the uploaded printouts material. Make sure you print as many squares as there are students in the classroom (the prototype has two squares per page).

- When all of the color-coded sticky notes are on the core, the students can proceed to do some math. Use slide 15 to help them add the colors they each have (i.e. three blue sticky notes + one orange + two yellow = 26 °C).

- After each student has their temperature number, they can write it on a sticky note and put it on the core prototype B. Don't forget to print this out and put it next to the core prototype A.

- After collecting all the temperature numbers, you can connect the dots and, with the help of the students, trace a line along the core (prototype B) to show how climate could vary through time. Keep in mind that the bottom of the core is the oldest sediment and the top of the core is the youngest sediment in a lakebed.

Exercise 3

Optional Outdoors Activity: Climate Literacy with Tropical Plants (1 hour)

Lesson materials: A notebook for sketching, pencil, and printouts of leaf trees and name tags (pages 6-13).

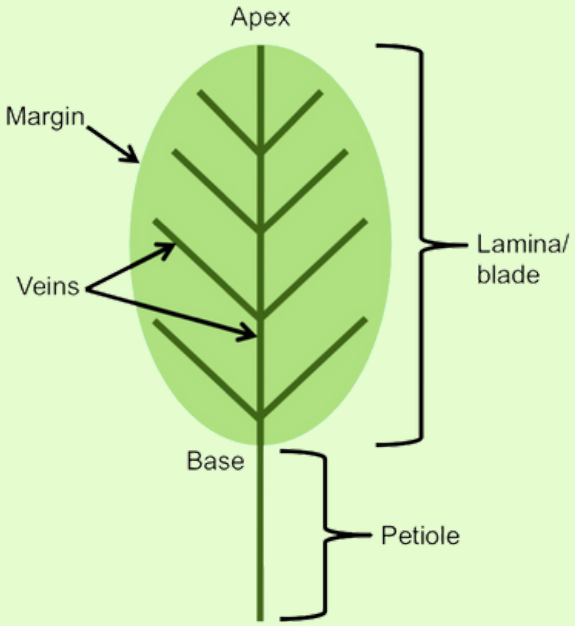
Location: A greenhouse in your neighborhood or city.

- The Conservatory in Brown University's Plant Environmental Center (fourth floor of 85 Waterman St, Providence, RI 02912) is open to the public Monday–Friday from 8: 30 a.m. to 3 p.m. Entry is free.
- The Roger Williams Park Botanical Center (1 Floral Ave, Providence, RI 02905) has four year-round greenhouses open Tuesday–Sunday from 10 a.m. to 4 p.m. General tickets are $5 and child tickets (ages 6-12) are $2.

Argument and objectives: Compare plant morphology that corresponds to different types of climates/latitudes and understand how a landscape can change depending on the type of climate.

Part One: Greenhouse activity (30 minutes)

- This activity compares greenhouse plants with outdoor plants you see on the streets, in your local parks, or in a forest nearby. In the greenhouse, have students discuss the environmental variables of the place.
  - How does the temperature feel?
  - Is it more humid or more dry than outdoors? Are there bodies of water in the greenhouse?
  - What is the ceiling made of? How much sunlight can you see entering the room? Are there additional lights? Is this amount of sunlight what you expect to have inside the place you live?
- After they've answered the previous questions, have students go and find a plant with a leaf bigger than the palm of their hand. Have them use their notebooks to sketch the leaf and the plant, paying attention to the details.
  - What does the end of the leaf look like?
  - Is the margin of the leaf smooth or toothed?
  - Can you see the main vein in the leaf?
  - What do the secondary veins look like? Why do you think they are shaped this way?
  - Practice sketching: Draw a leaf and label the following parts: primary vein, secondary veins, margin, etc.



- Have you ever seen the plant you drew before? If so, where? Was it in the place you live? Discuss and analyze the plant you drew and where it lives with your team or by taking your own notes.

Part Two: Leaf margins across climates (30 minutes)

- Where do banana plants come from geographically? By analyzing their leaves carefully, briefly give an introduction to where bananas come from climatically (slide 17).
- Where do apple trees come from? Where have you seen an apple tree? Where do people around the world usually find apples? (slide 18)
- With the students in groups of two or three, give them the six leaf printouts and the six names of the fruits/food that the leaves come from.
- Help them match the leaf with the corresponding fruit/food label, and make sure they provide explanations (e.g. Why do you think apple leaves grow certain characteristics in their natural environments?)
- Emphasize the places they have seen the fruits outside the grocery store. Are berries known to be found nearby? Where do mangos usually come from? And bananas?
- Then bring all the students together and make them match the fruit and name as a collective activity.
- Discuss the difference in margin between the tropical fruits (banana, mango, and pineapple have a smooth margin) and the more temperate fruits/food (berries, apples, maple).
- Finish the activity by mentioning that smooth margins correspond to warmer climates today, typically from tropical regions, while toothed margins correspond to colder climates, such as places in the United States or Europe. Emphasize that what we tend to call tropical fruits (such as mangos, bananas, and pineapples) have those smooth margins and those fruits are mostly produced in tropical to subtropical regions. Meanwhile the berries, maple sugar, and apples come from plants that are produced in temperate regions and have toothed margins. We can find those trees in Rhode Island.

Next Generation Scientific Standards (NGSS): Disciplinary Core Ideas

- MS-ESS1-1: Earth's Place in the Universe: The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

- 2-LS4-1: Biological Evolution: Make observations of plants and animals to compare the diversity of life in different habitats.
- 4-LS1-1: From Molecules to Organisms, Structures and Processes: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

- K-ESS3-1. Earth and Human Activity: Use a model to represent the relationship between the needs of different plants or animals (including humans and the places they live).

- MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

- ESS1.B: Earth and the Solar System: Students are expected to learn that seasonal patterns of sunrise and sunset can be observed, described, and predicted.