Name: ______________________________

Proxy Data: Tree Rings and Ice Cores

Proxy data is gathered by paleoclimatologists from natural recorders of climate variability, e.g., tree rings, ice cores, fossil pollen, ocean sediments, coral and historical **data**. "Proxy" = an intermediary, or representation of a "true" value or figure.

I. Tree Rings

A tree ring is simply a layer of wood produced during one tree's growing season. A cross-section of a tree often shows a distinct pattern of concentric tree rings. You can see such rings on a stump or on a fallen tree truck that has been sawn through to clear a trail. Each tree ring marks a line between the dark *late wood* that grew at the end of the previous year and the relatively pale *early wood* that grew at the start of this year. One annual ring is composed of a ring of early wood and a ring of late wood. The growth occurs in the *cambium* (the thin, continuous sheath of cells between bark and wood). In spring, the cambium begins dividing. This creates new tissue and increases the diameter of the tree.

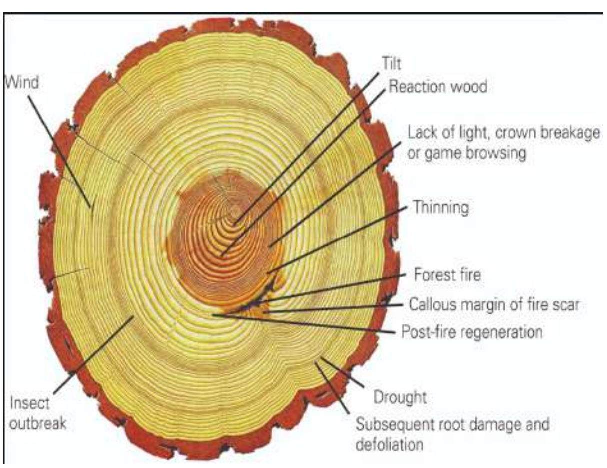
- When a tree grows quickly, the xylem (water-bearing) cells are large with thin walls. This early wood or springwood is the lighter-colored part of a tree ring.
- In late summer, growth slows; the walls of the xylem cells are thicker. This late wood or summerwood is the darker-colored part of a tree ring.

Other features of tree rings include:

- Trees growing in California add one annual ring per year. Trees in tropical regions may have more than one growth ring per year, or may appear to grow continuously and have no rings.
- Tree rings are easily seen in conifers (e.g., pine, spruce) and hardwoods (e.g., oak, ash).

When conditions encourage growth, a tree adds extra tissue and produces a thick ring. In a discouraging year, growth is slowed and the tree produces a thin ring. Much of the variation in tree rings is due to variations year-to-year.

Environmental Condition	Ring appearance
Higher springtime temperature	Wider ring
Abundant rainfall	Wider Ring
Crowding	Series of more than three narrow rings
Crowding on one side, or growth on a slope	Narrower rings on one side
Dark scars	Forest fires
More circular/narrow scars	Insect infestations



The science of studying the past by looking at tree rings is called **dendrochronology**.

What can be learned through dendrochronology?

1. ***The year that a building was constructed*** can be estimated if wood used in its construction has bark still intact. The tree ring next to the bark is the the ring created in the last growth-year of the tree. Tree ring dates from different sections should cluster within a short period. This would indicate that the trees were cut specifically for the construction, rather than being miscellaneous sections of re-used wood.
2. Reconstruction of ***past climate variations***, such as precipitation. In North America, climate changes may have triggered certain ***migrations*** in cultures before the European arrival.
3. Not only ***frequency of fire***, but also ***intensity of fire*** can be estimated.
4. For example, if a tree had a growth spurt after a fire, the fire probably:
   - Removed competition

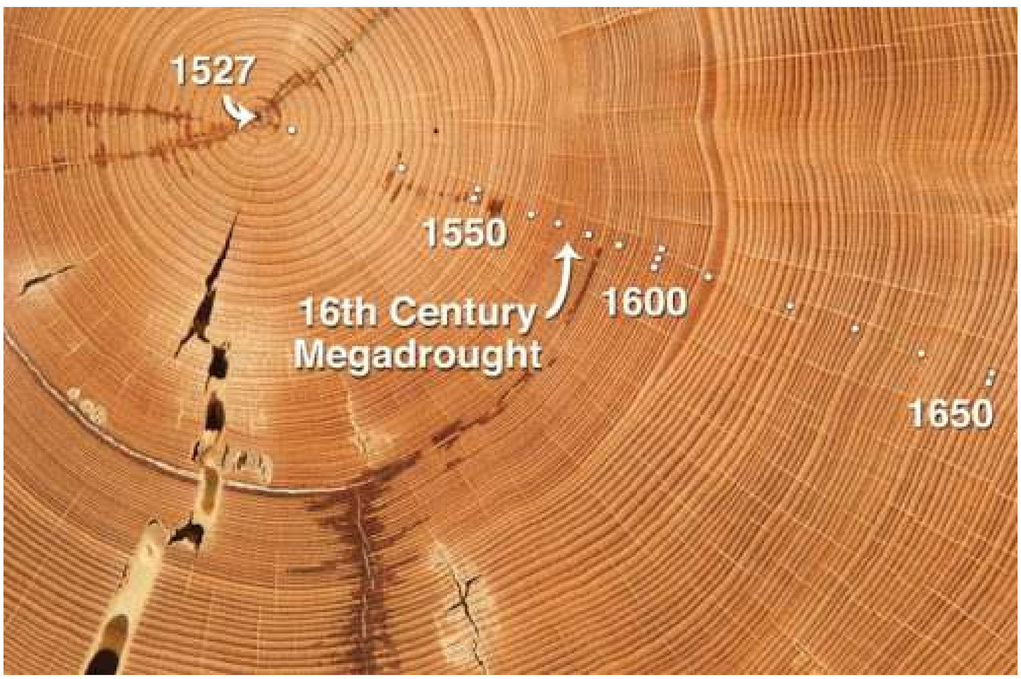
- Was not fierce enough to damage this tree permanently. An intense fire usually burns off the foliage of a tree. If the tree survives, growth rate is reduced for years until foliage regrows, restoring photosynthesis.

5. Reconstruction of ***past insect infestations.*** Insects are an integral component of forest ecosystems. They can cause mass tree mortality, leading to increased wildfire hazard. Or they can devour leaves, reducing growth.
6. Reconstruction of ***past glacial activity*** *and* ***volcanic events***.
7. Reconstruction of ***past rainfall.*** The width of a tree ring usually depends on how much rain fell during the year the ring was formed.
8. Assessment of the ***"age structure"*** (distribution of tree ages) of a forest. Forest managers need this.
9. ***Climate and wildfire predictions.*** Based on the past found from tree rings, it is becoming possible to predict future climate behavior over a period of years, and to predict seasonal conditions that lead to severe wildfire.

Procedure:

Use the image below to analyze a tree cookie. The year the tree was planted is already given for you. Analyze the rings of the trees and label the following significant events:

- year with the most precipitation
- Other than the 16th century megadrought, where else did the tree show dry conditions?
- Possible fire damage



Analysis:

1. Describe in a few sentences what you see as the history of this tree?

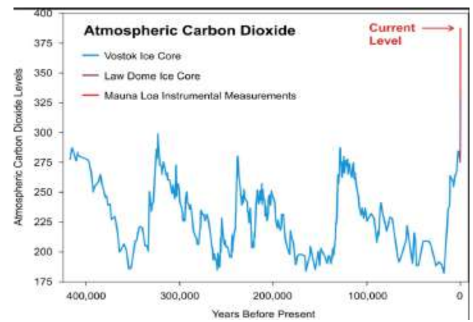
2. This particular tree cookie image only shows you up to 1650 - but if you could look at the rings after the industrial revolution (where there is increase CO_2) what might you see in the rings?

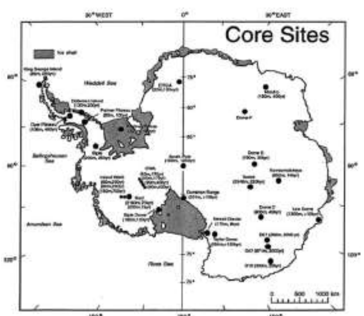
II. *Ice Cores Pre Lab*

Glaciers form as layers of snow accumulate on top of each other. Each layer of snow is different in chemistry and texture, summer snow differing from winter snow. Over time, the buried snow compresses under the weight of the snow above it, forming ice. The icy layers also hold particles—aerosols such as dust, ash, pollen, trace elements and sea salts--- that were in the atmosphere at that time. These particles remain in the ice thousands of years later, providing physical evidence of past global events, such as major volcanic eruptions. As the ice compacts over time, tiny air bubbles of the atmosphere—including greenhouse gases like carbon dioxide and methane—press inside the ice. The oldest ice cores are

from East Antarctica and provide an 800,000-year-old record of Earth's climate. How do we know that they are that old? Each season's snowfall has slightly different properties than the last. These differences create annual layers in the ice that can be used to count the age of that ice, just like the rings inside of a tree.

Ice cores, cylinders of ice drilled from ice sheets and glaciers, are essentially frozen time capsules that allow scientists to reconstruct climate far into the past. Layers in ice cores correspond to years and seasons, with the youngest ice at the top and the oldest ice at the bottom of the core. By drilling down into the ice sheet or glacier and recovering ice from ancient times, scientists are able to determine the past composition and behavior of the atmosphere, what the climate was like when the snow fell, and how the size of ice sheets and glaciers have changed in the past in response to different climate conditions. Ice cores have provided climate and ice dynamics information over many hundred thousand years in very high, sometimes seasonal, resolution. This information allows scientists to determine how and why climate changed in the past. By understanding how and why climate changed in the past, scientists are able to improve predictions of how climate will change in the future. Because of their high time-resolution, the physical nature of their proxy records, and their ability to archive actual greenhouse (and non-greenhouse) gas concentrations from the past, ice cores have become one of the golden standards in paleoclimate research.





Ice cores are drilled in glaciers and on ice sheets on all of Earth's continents. Most ice cores, however, come from Antarctica and Greenland, where the longest ice cores extend to 3 kilometers—over 2 miles—or more in depth. Ice cores from the cold interior regions of polar ice sheets provide exceptionally well-preserved and detailed climate records. This is because the lack of melt at these locations does not corrupt the record of trapped gases or blur the record of other impurities. The oldest continuous ice core records extend to 130,000 years in Greenland, and 800,000 years in Antarctica. Ice cores are typically drilled by means of either a mechanical or thermal drill. Both types of drills incise an annulus, or circle, around a central, vertical core.

Info from: https://icecores.org/about-ice-cores (National Science Foundation)

Video 1: Studying Ice Cores in Antarctica *(2:41) https://www.youtube.com/watch?v=VjTsj-fi-p0*
Video 2: Using Ice Cores to Model Climate Changes *(4:46)*
https://ca.pbslearningmedia.org/resource/ice13.sci.ess.icecore/using-ice-cores-to-model-climate-changes/
(Questions start at *2:20*)

1.	How do the scientists measure the CO_2 concentration?
2.	How do the scientists measure the age?
3.	How do the scientists measure the changes in temperature?
4.	What has been found to be the relationship between CO_2 and temperature?
5.	Why are scientists confident their models are highly accurate for future predictions?

Ice Core Data Analysis

Scroll through actual core data. http://www.ncdc.noaa.gov/paleo-search/study/17975

What government agencies funded this data? *(main website is fine)*

- *Open the **Excel Data File** from **EPICA Dome C***
- *Click on the "CO2 Composite" tab on the bottom of the spreadsheet*

Take a minute to scroll around on the data. Notice that there are different researchers' work being combined in this data sheet.

What does "kyr BP" mean? ___________________________________

Notice the most recent dates are given as negative numbers. This is because 1950 was designated as "Year Zero", so that all the data can be easily standardized when they are combined. The most recent year in the table is 2001, seen as "-51 cal yr"

- *Select Column B. This column shows CO2 concentrations. Highlight and sort from most to least (click yes for expand selection).*

What year BP is listed as having the highest CO2 concentration?

Year: ______________________ CO2: _______________________

How far do you have to scroll before you see a year that is not fairly recent (between -60 and 100 years ago)

Line #: ___________________ What was the CO2? ______________________

Keep scrolling down. Approximately (within 10,000 years) how long it has been since the CO2 concentration was at its highest? Is that measurement close to the modern measurements?

Write 1-2 sentences summarizing what you can see when you look at this data.

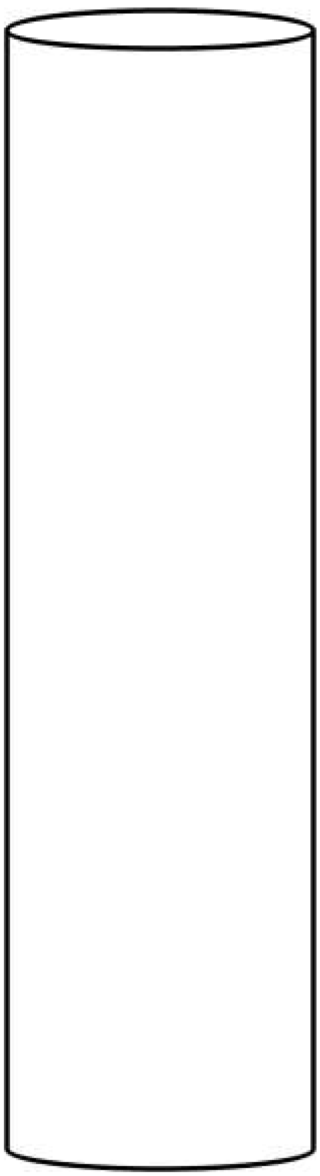
Ice Core Model

Procedure:

1. Use scissors to snip the top of the Pringles can. Once you have started the rip, you will be able to use your hands to tear the can off the ice in a spiral manner.
2. Place the ice in the holder and start to examine it. There are **8 layers** that each represent **25 years.** Our ice cores are representing 200 years from 1800-2000. Notice that the layers are not the same width.

What do the different widths represent? ____

Appearance	Simulates
Yellow food coloring	Acid rain
Sand/small pebbles	deposits from erosion
beads	CO_2 bubbles
Pink glitter	Pollen
Plastic Insects	Insects
dark color	Dust—emissions or volcanic



There are different examples of proxy data types embedded in the ice core layers. With your group, examine your ice core, measure and diagram it and then write a narrative describing what happened over the 200 years in that region. You should consider the time in the world's history as well as what has happened in nearby layers when writing your narrative.

Label, sketch contents, provide measurements of layer widths (cm)

A***nalysis (Narrative)***

Tell me what you think happened in each section of your ice core. What are the items in the section and what does that tell you about the climate in that region at that time?
