ST[EMpower]

GREENHOUSE GASES

VOLUME 8, ISSUE 4, APRIL 2019

THIS MONTH

POWER WORDS

- **compound**: comprised of two or more elements
- **element**: atoms of the same kind (all oxygen or all carbon); the primary building blocks of all matter; each is distinguished by an atomic number
- **molecule**: atoms held together by chemical bonds

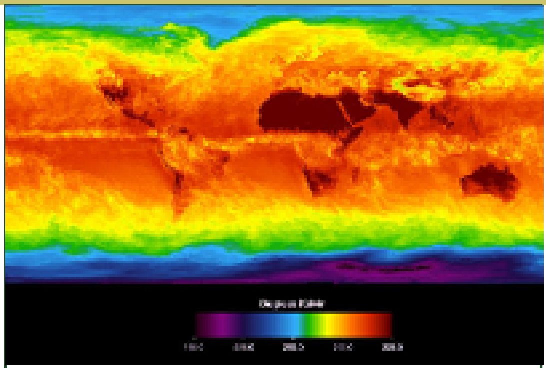
CAREERS

CLIMATE CHANGE

Greenhouse gases are getting a bad rap right now. Without these gases, the average temperature for Earth would be around 0°F (-18°C). There could be life on Earth, but it would probably be archaebacteria (similar to bacteria) and bacteria. Because we do have greenhouse gases, the average temperature for Earth is 59°F (15°C) instead.

The coldest recorded temperature was Vostok Station in Antarctica of -128.6°F (-89.2°C) on July 21, 1983 (July is during Antarctica's winter). The hottest recorded temperature was Furnace Creek in Death Valley of 134°F (56.7°C) on July 10, 1913.

Our atmosphere is comprised of 78% nitrogen, 21% oxygen, and .93% argon gases. The remaining .07% are carbon dioxide, neon, helium, methane, water vapor, and a few other trace gases. Nitrogen gas is made from two nitrogen atoms triple bonded together. This is an extremely stable molecule. Oxygen is made from two oxygen atoms double bonded. It, however, is a necessary component for fire. At the 21% of the atmospheric gases, this provides ample oxygen for life, but will not cause massive firestorms, as happened in our planet's history.



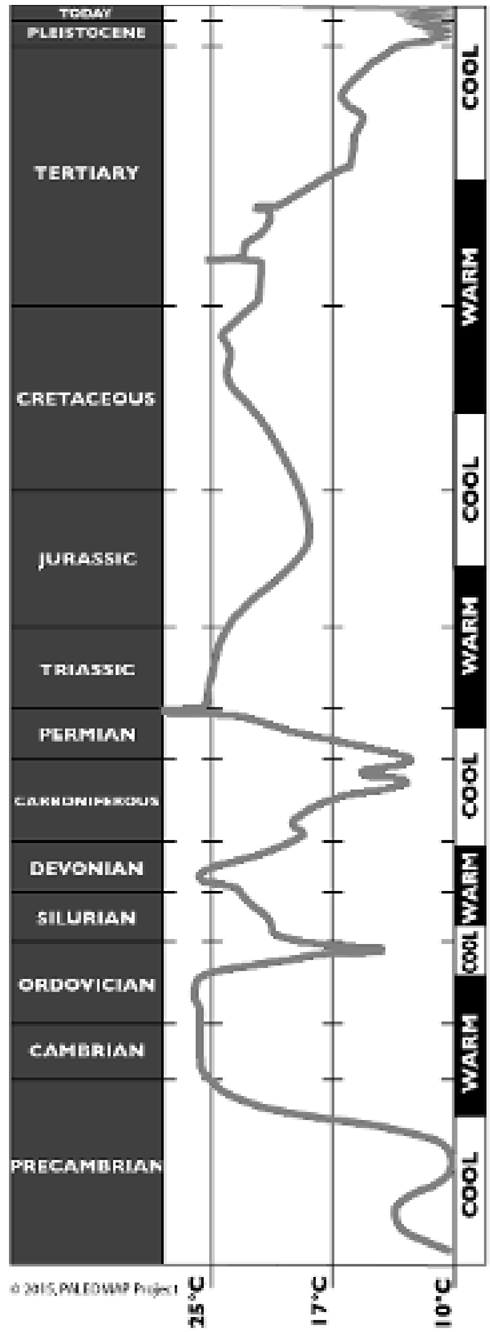
Temperature world map
Temperature range is (dark red) 115°F to -(purple) 115°F.

The greenhouse gases are composed of at least two different elements, e.g. carbon dioxide (1 carbon atom and 2 oxygen atoms) or methane (1 carbon and 4 hydrogen atoms). That is an important aspect of how greenhouse gases work.

The Earth's climate history includes many times that our world was much warmer, and other times it was much cooler. If that is the case, they why are we concerned? Isn't this the normal swings of long-term climate? Why are scientists so concerned?

Scientists cannot use direct measurements to evaluate the climate of our Earth through time. They, instead, use several natural methods, which are indirect measurements. These are called proxy measurements. Some are:

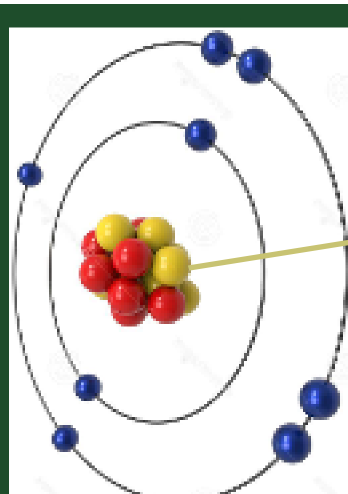
- **Coral** is extremely sensitive to temperature change and to the ocean acidity. They also have growth rings similar to trees. Coral grow on top of older members of the coral, leaving a record of ancient coral intact. Scientists interpret the ancient coral at the bottom of the colonies to interpret the oceans warming and cooling trends.
- **Atmospheric gas isotopes** trapped in glaciers indicate a warm or cool planet. An atom is determined by the number of protons. A neutral atom has an equal number of electrons. The neutrons are usually the same as the protons, but there can be more neutrons than protons, which make the atom heavier. Example: oxygen in water vapor. When the planet is very cold, lighter oxygen atoms sublimate more than heavier oxygen atoms, leaving the heavier isotopes trapped in the glacier. When the planet is warm, the glacier melts, removing the enriched heavy oxygen isotopes. Scientists use mass spectrometry to determine the ratio of light to heavy oxygen isotopes.
- **Rocks deposited by glaciers** from other places do not fit the geology of rock formed in place. By studying these



POWER WORDS

- **isotope**: two or more forms of the same element that contain equal numbers of protons, but different number of neutrons in their nuclei
- **mass spectrometry**: identifying chemical composition of a sample by separating it according to the mass and charge
- **proxy**: a figure that can be used to represent the value of something in a calculation
- **sublimate**: phase change from a solid to a gas, skipping the liquid phase

Ice House or Hot House Graph displays the variation in our Earth's temperature over the past 2 billion years.



Oxygen isotopes:

- 99.7% of all oxygen isotopes - $_{16}O$ has 8 protons, 8 electrons, and 8 neutrons
- $_{17}O$ has 8 protons, 8 electrons, and 9 neutrons
- $_{18}O$ has 8 protons, 8 electrons, and 10 neutrons

rocks, scientists can determine approximate areas where the rocks originated. These data are then used to determine glacial advances and retreats.

- **Patterns of sedimentary rocks formed by glaciers** differ than sedimentary rocks formed in oceans and lakes. Scientists can then determine glaciers from the past.
- **Ocean sediment cores** contain plankton, that die and drift to the bottom of the ocean. Some species, like *Calanus finmarchicus* (pictured below) thrive in cold water, while other species, like *Calanus helgolandicus,* thrive in warm water. Analyzing the layers, identifying which species is present in more abundance gives scientists clues to when the world was colder and when it was warmer.
- **Fossils** also indicate climate. What animals and plants do you find at the equator? What about the poles?
- **Tree rings** (the next activity)

Dendrochronology is the scientific word for studying tree rings. Dendro means tree ring, chron means time, and ology means the study of.

Trees do not grow like animals. They grow from the tip of the stems out (new leaves and stems), from the tip of the roots down, and from the trunk outwards.

Steamboat Springs has carvings on Aspen made by shepherds over the past century. The carvings do not move upward as the tree grows, but remain at the same level. Trees grow at the tree tops up, the roots down, and the trunk broader. The image below is one of these carvings.

If you look at a tree that has been cut down, you will see tree rings. This is because we have seasons. The tree grows during spring and summer. It prepares in the fall, for winter, and then is dormant until spring. The tropical trees to not have rings. Why do you think that is?

POWER WORDS

- **dendrochronology**: dating events, environmental change, and archaeological artifacts by using the characteristic patters of annual growth rings in timber and tree trunks
- **phloem**: cells in a plant that carry sugar products made in photosynthesis to the roots for storage
- **transpiration**: water carried through a plant to the leaves
- **xylem**: cells in the tree that support transpiration

Calanus finmarchicus is a cold water species of plankton about 1" long. When they die, they sink to the ocean bottom, leaving a layer of their remains. Ratios between cold and warm plankton are proxy measurement to ocean temperatures.

INFORMATION:

Curious about these techniques? Check out these websites:

- About the Ice Core Lab in Denver:
  https://icecores.org/about-ice-cores
- About Coral as Proxy Measurements:
  https://www.ncdc.noaa.gov/news/picture-climate-how-we-can-learn-corals
- NOAA and NASA Paleoclimatology
  https://www.ncdc.noaa.gov/data-access/paleoclimatology-data

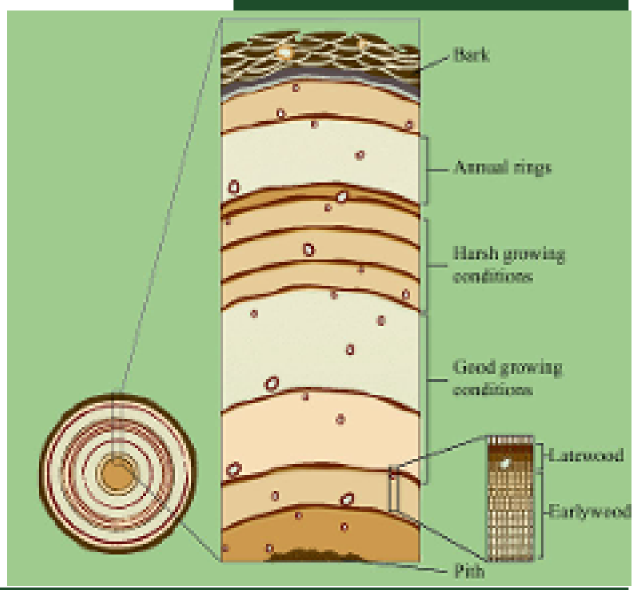
Scientists who study tree rings do not have to chop down a tree to read the rings. Instead, they core the tree. They use a hollow tube to cut into the tree to the center, and then withdraw the sample. Sounds easy, but it is hard work!

Directions:

- The first video is from the US Forestry Service explaining how trees grow. On your computer, copy/past the "How Trees Grow" website listed in the green box below. The video is 3 minutes.
- The second video is from Extension in Wyoming explaining why we see tree rings. On your computer, copy/paste "Tree Rings" listed in the green box below. The video is 2½ minutes.
- *Apply what you learned*: On page 5, use the image of the tree cross section to answer the questions on the bottom of that page. The pith represents the tree as a seedling to a sapling. Depending on the species of tree, that can last between 1-3 years. Count the pith as 1 year for this activity.
- Dr. Laci Gehart-Barley of the Paleoenvironmental Laboratory at Kansas State University has a really nice YouTube video on how to core a tree. On your computer, go to the "Dr. Laci Gerhart-Barley" website listed in the green box below. It is not linked, so you will need to copy/paste the address. The video is 6½ minutes, a how-to video, and interesting.
- For more information about tree rings, and how they are used as proxy measurements, Rocky Mountain Tree Ring Research as an excellent website: http://www.rmtrr.org/basics.html
- The image below shows the orientation of a cross section and a tree ring core.
- Page 6 has a simulated tree ring core from a tree that was a seedling in 1402. The directions on that page will lead you to draw conclusions about this proxy measurement for the past climate.
- While this tree was alive, there was a time known as "The Little Ice Age." On the other hand, the Twentieth Century has been much warmer.
- Can you figure out the answers to the questions below the "cores"?

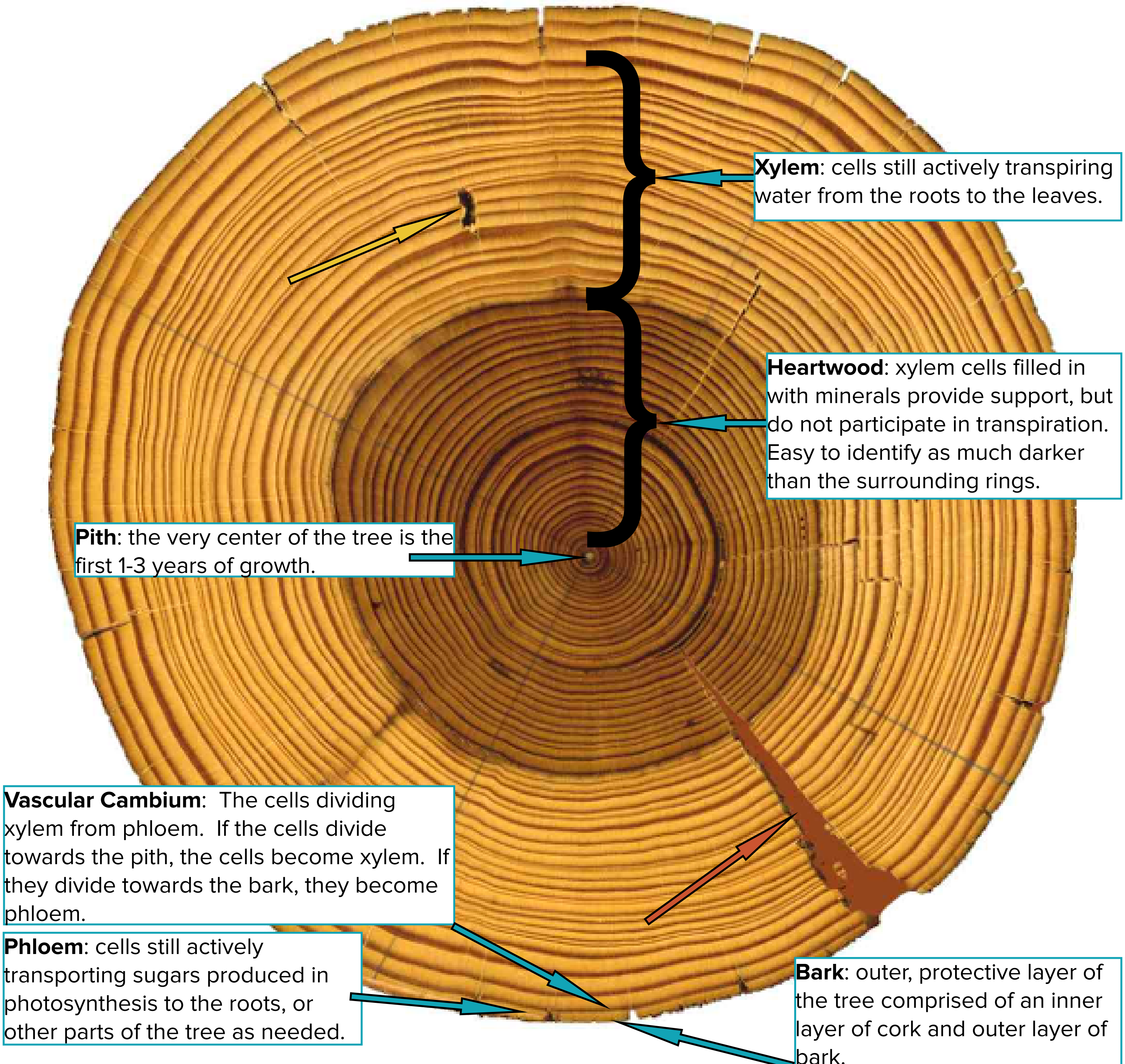
POWER WORDS

- **axis**: an imaginary line about which an object could rotate; a point on which something is centered
- **cross section**: a surface that is exposed by making a straight cut at a right angle to the axis
- **right angle**: 90° as in the corner of a square



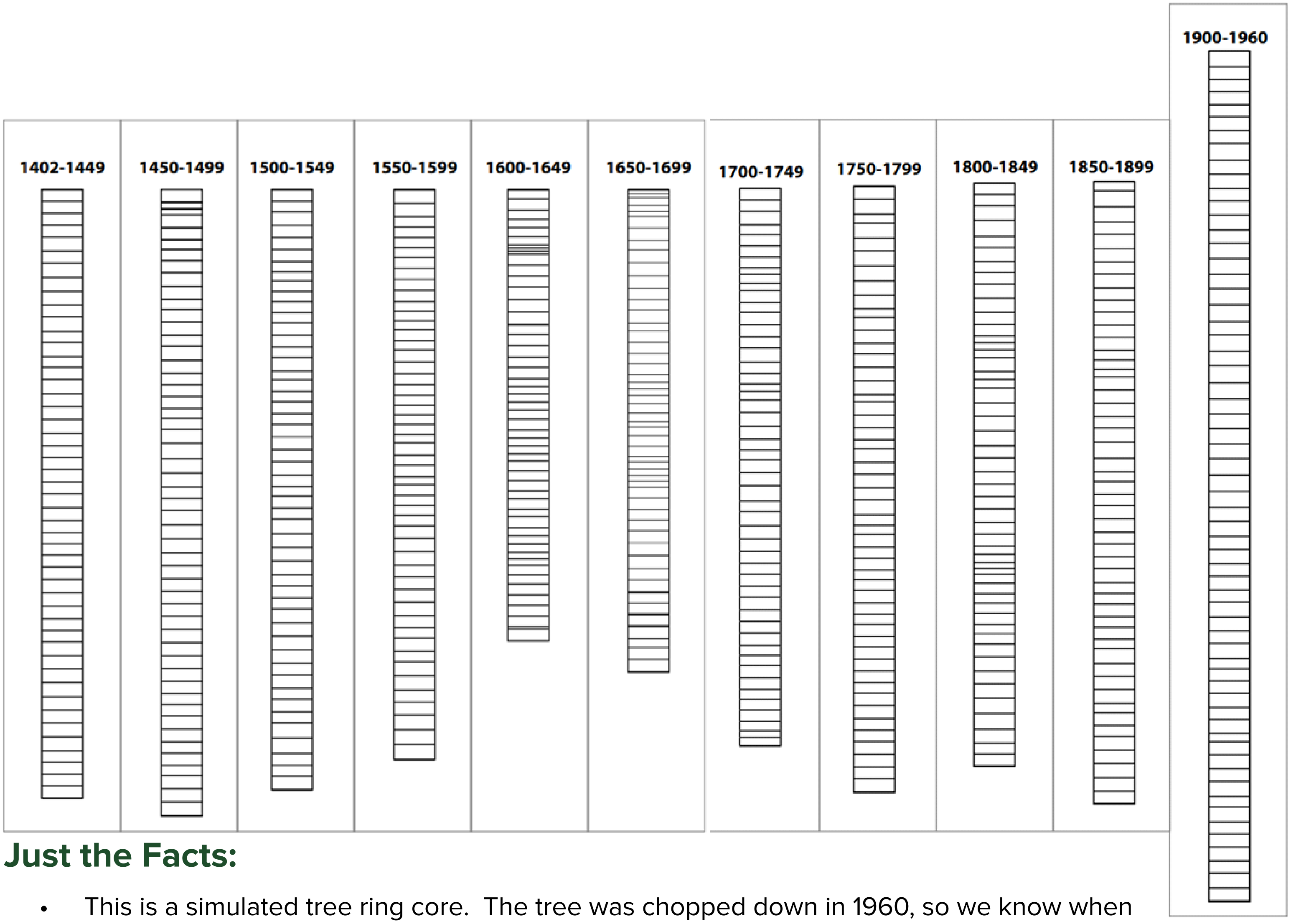
MATERIALS:

- computer with internet access
- How Trees Grow https://www.youtube.com/watch?v=0lDH7HDfVmM
- Tree Rings https://www.youtube.com/watch?v=XSTn2SMRYTg
- Dr. Laci Gehart-Barley https://www.youtube.com/watch?v=jPJUewNcvao
- sharp pencil
- copy pages 5 and 6



The number of years the tree was alive is represented by the center pith (year one) to the vascular cambium. During years of drought and/or cold, the tree does not produce as many xylem cells, so the ring is narrow. During years when there is plenty of rain and/or warmth, the rings are wider. (Answers on page 16)

1. How old is this tree?
2. How old was the tree during the five worst droughts?
3. The red arrow points to part of the tree. What is this?
4. The yellow arrow points to part of the tree. What is this?



Just the Facts:

- This is a simulated tree ring core. The tree was chopped down in 1960, so we know when the tree died. Scientists counted the rings, and the tree was a seedling in 1402.
- The first core represents 48 years, and the last core represents 61 years. All the other pieces represent 50 years.
- During optimum growing conditions, there is plenty of rain and sun. The temperatures are generally warmer. The tree rings are wider, representing these optimum growing conditions.
- During minimal growing conditions, either there is a drought or the temperatures are much colder. The growing conditions are minimal, and the tree rings are much thinner.

What do you think?:

- How old is this tree?
- Why does the tree ring core support that the 20th Century is warmer than prior 5 centuries?
- When was the Little Ice Age?
- During each core segment of 50 years, can you identify which year had the greatest optimum growth?
- During each core segment of 50 years, can you identify which year had the greatest minimal growth?
- What would the core look like if the scientist had taken the core through insect damage?
- What would the core look like if the scientist had taken the core through a year that the tree survived a forest fire?
- Proxy measurements give us strong indications of climate change. Scientists check other proxy measurements (i.e. coral, ice core, and fossil) for similar results to understand paleoclimates.

Greenhouse gases are those compounds that help to warm our planet. If our planet did not have these gases, life would be very different here. What exactly are these gases, and why are they different than the nitrogen and oxygen that represent about 99% of our atmospheric gases?

Chemical models are used to help visualize the best theory of how atoms, compounds, and molecules are bonded.

In this activity, you will build the models for some atmospheric gases: nitrogen, oxygen, carbon dioxide, water vapor, and methane. It should help to explain why greenhouse gases are able to absorb solar radiation to keep our planet warm.

Directions:

- Marshmallows represents individual atoms; toothpicks represent the bonds.
- To differentiate the different elements, dye the regular marshmallows different colors.
- Work on a large piece of wax paper. On one side, set out the paper towel.
- Add water half full in each cup. You need enough liquid to dip the regular marshmallow completely into the solution. Place the cups in the center of the wax paper.
- Add enough food coloring to the water in each cup to get a rich, deep color:
    - blue in the first cup
    - red in the second cup
    - green in the third cup
- You need 2 green (carbon) marshmallows. In the top center of the marshmallow, push a toothpick in about halfway. Hold the toothpick and dip the marshmallow into the green dye. Remove, and blot excess liquid with the paper towel. Set on the wax paper to dry. Repeat with the other marshmallow.
- You need a total of 5 red (oxygen) atoms. Set out five regular marshmallows, and insert the toothpick. Hold the toothpick and dip the marshmallow into the red dye. Remove, and blot excess liquid with the paper towel. Set on the wax paper to dry. Repeat with the other 4 marshmallows.
- You need 2 blue (nitrogen) atoms. Set out 2 regular marshmallows, and insert the toothpick in the top center. Holding the toothpick, dip the marshmallow into the red dye. Remove, and blot excess liquid with the paper towel. Set on the wax paper to dry. Repeat with the other marshmallow.

POWER WORDS

- **bond**: a lasting attraction between atoms, molecules, and/or ions
- **compound**: two or more atoms of different elements are bonded together (i.e. table salt NaCl)
- **ion**: an atom or molecule with a net electric charge due to loss or addition of an electron
- **molecule**: two or more of the same element bonded together (i.e. O_2)
- **radiation**: energy

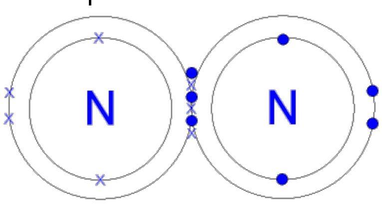
Atom Color Code

H - hydrogen	white	
C - carbon	green	
O - oxygen	red	
N - nitrogen	blue	

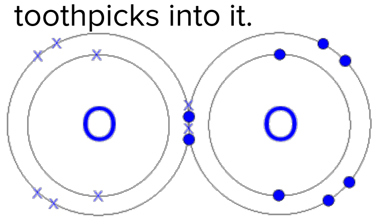
MATERIALS:

- regular sized marshmallows
- white mini marshmallows
- 4-pack food coloring (you need red, green, and blue)
- 3 plastic cups (the short, broad cups work best)
- wax paper
- paper towels
- water
- toothpicks
- copy of page 12
- pencil

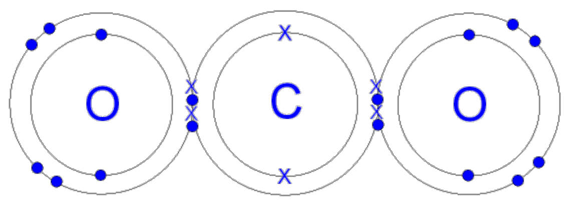
- Molecular models help us to better understand how compounds and molecules work. Atoms are too small to see, even using the most powerful microscopes. Chemists have developed this model with all the available evidence, and this theory is robustly supported.
- Nitrogen gas is 78% of our atmosphere is nitrogen gas. It is formed by two nitrogen atoms bonded together with three bonds. It is extremely stable. You need two blue marshmallows and 3 toothpicks. Insert the three toothpicks in a line along one side of the first marshmallow. Press the second marshmallow, pushing the three exposed ends of the toothpicks into it.



- Oxygen gas is 21% of our atmosphere is oxygen gas. Oxygen is necessary for multicellular organisms to live. Oxygen is poisonous to some bacteria! Crazy but true. You need two red marshmallows and two toothpicks. Insert the 2 toothpicks in a line along one side of the first marshmallow. Press the second marshmallow, pushing the two exposed ends of the toothpicks into it.



- Carbon Dioxide gas is only a trace of the atmosphere. This gas is causing concern. Humans are releasing sequestered carbon in fossil fuels and trees. It is formed by two oxygen atoms and one carbon atom. You need two red marshmallows, one green marshmallow, and four toothpicks. Insert two toothpicks on the green marshmallow on one side. On the opposite side, insert the other two toothpicks. These three atoms make a line. Push the first red marshmallow on the two toothpicks on once side. Insert the other red marshmallow on the other side.

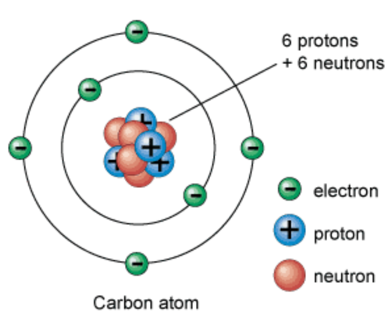


- Water vapor is a greenhouse gas, and the amount of this gas varies with weather conditions. It is also a polar molecule (like a weak magnet), and it is bent. It is comprised of one oxygen atom and two hydrogen atoms. You need one red and two white mini marshmallows.

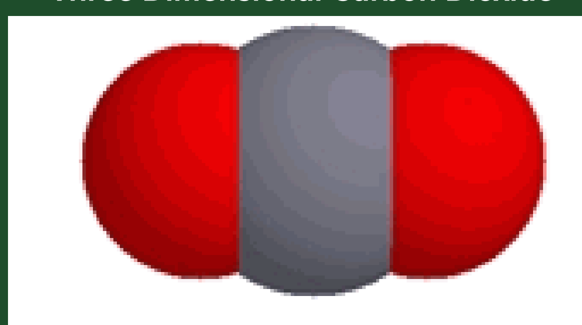
POWER WORDS

- **atom**: the smallest piece of matter can be and remain an element
- **electron**: subatomic particle with a negative charge
- **element**: a pure substance that is made from a single type of atom
- **polar**: having electrical or magnetic charge
- **proton**: subatomic particle with a positive charge
- **sequester**: isolate or hide away so that it is no longer available

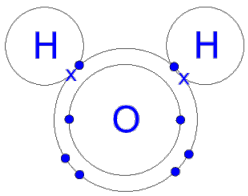
Diagram of an Atom



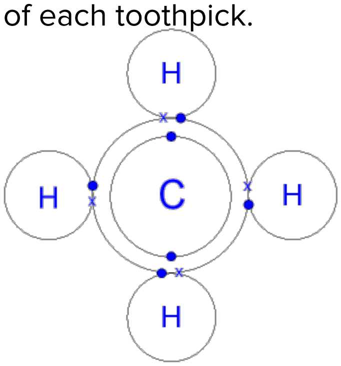
Three Dimensional Carbon Dioxide



Insert two toothpicks into the red oxygen marshmallow as if you were going to put Micky Mouse ears on the oxygen (see diagram below). Put one white mini marshmallow on the tip of each toothpick. Hydrogen atoms are the smallest. They usually only have one proton and one electron.

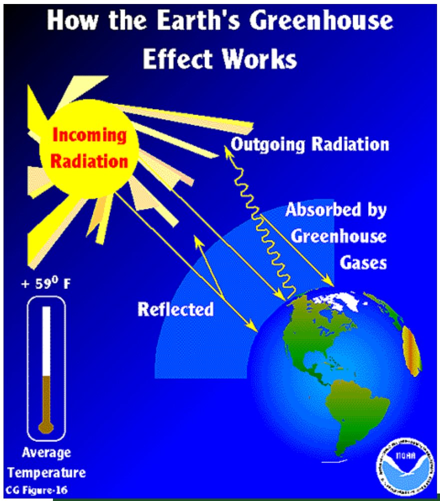


- Methane is a greenhouse gas, and much of it is produced by cows. You need 1 green marshmallow, 4 white mini marshmallows, and 4 toothpicks. Even though the diagram below looks like the molecule will lay flat, it will not. Each of they hydrogen atoms is as far from the other hydrogen atoms. The best way to make this atom is to start by making a tripod with the toothpicks. See the 3-D methane model in the green box (carbon is represented in gray and hydrogen atoms are green). Set the marshmallow on the tripod, and place the fourth toothpick on the top. Insert one white mini marshmallow at the other end of each toothpick.



- Compare and contrast each of these molecules. What is the difference between the major atmospheric gases of nitrogen and oxygen compared and contrasted to the three representative greenhouse gases of carbon dioxide, water vapor, and methane?
- Try wiggling the molecules. Are some harder to wiggle? Think about how oxygen and nitrogen bond together with multiple bonds. Each bond strengthens the molecule.
- Use the data sheet on page 10 to record your thoughts about these greenhouse gases.

NOAA (National Oceanic and Atmospheric Administration) diagram how greenhouse gases work.



ATOMIC BONDS

Element are determined by the number of protons. The electrons equal the protons.

Hydrogen - 1 proton, 1 electron
Carbon - 6 protons, 6 electrons
Oxygen - 8 protons, 8 electrons

Lewis Dot Structures explain how atoms bond by sharing electrons with other atoms to fill their orbitals.

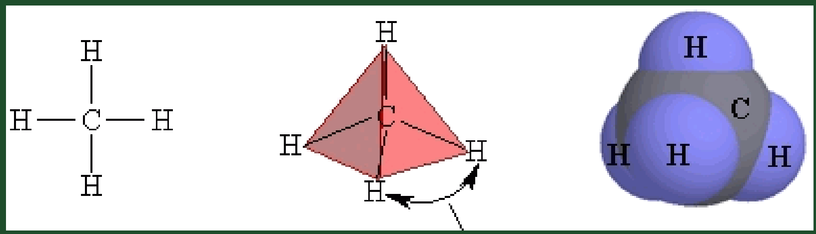
The water molecule diagram on the left has one orbital around hydrogen and two orbitals around oxygen. The first orbital is full with 2 electrons. The second orbital is full with 8 electrons. Think of the atom as "happy" when the orbital is full.

Hydrogen has 1 electron, and wants 2. By sharing with an electron in oxygen, it is happy.

Oxygen has 8 electrons, 2 in the first orbital and 6 in the second orbital. It wants 8 in the second orbital. By sharing 2 hydrogen electrons, it is happy. It can also share 2 electrons with another atom, called a double bond. Examples are carbon dioxide and oxygen gas.

Carbon has 6 electrons, 2 in the first orbital, and 4 in the second. It wants 4 more electrons to fill the second orbital. It bonds with 4 hydrogens in methane (below).

Nitrogen has 7 electrons, and it can triple bond.



Methane as a three dimensional molecule

Greenhouses trap solar radiation. It passes through the glass, but gets trapped inside. Greenhouse gases act like the glass in a greenhouse, trapping heat in our atmosphere rather than escaping into space.

This experiment will compare three scenarios (diagram below right):

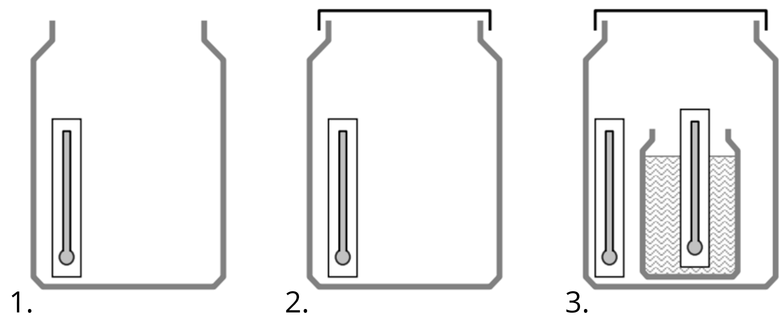
1. an open container (Earth with no greenhouse gases)
2. a closed container (Earth with greenhouse gases)
3. a closed container with water or sparkling water (Earth with greenhouse gases and an ocean)

Directions:

- Tape the thermometer for easy reading to the inside of each gallon jar, the front against the glass, and back to the insides.
- Place the thermometer in the pint jar, front by the glass. The jar will be filled about 3/4 full with water, so tape the thermometer above the estimated waterline.
- Add 350 ml (1.5 cups) of water (or sparking water) to the pint jar and insert it into gallon mason jar 3.
- Align the thermometers in the water and gallon jar so the scales are in the same direction.
- Find a spot that will remain sunny for the next three hours.
- Place each jar on top of a white piece of paper and screw the lids on jar 2 and 3.
- Turn each jar in the full sun, but so the direct light strikes the back of the thermometer, not the scale. When you read the thermometers, you will be facing the sun.
- What do you think will happen in each jar? Record your ideas.
- Use a timer to keep track of the time. Record the temperature for each jar every 5 minutes for the first 15 minutes.
- After the first 15 minutes, record the temperature for each jar every 15 minutes until you reach a total of 90 minutes (1.5 hours).
- Place a large cardboard box by your experiment to keep the jars in the shade for the remainder of the experiment. If windy, add weight to the box to keep from blowing over.
- Record the temperature for each jar every 5 minutes for the first 15 minutes.
- After the first 15 minutes, read and record the temperature for each jar every 15 minutes until you reach a total of 90 minutes (1.5 hours).

CLIMATE CHANGE

- Most scientist agree that our planet is warming. They use ocean temperature as the indicator.
- Warmer summers, regardless of how cold winter is, means our planet is warming.
- Carbon dioxide is stored in the Earth as oil and gas, in trees as part of the plant, and in the oceans.



MATERIALS:

- 3 mason jars, wide mouth, gallon sized and 2 lids
- 1 mason jar pint sized (must fit in the large container)
- 4 outdoor thermometers
- masking tape
- sparkling water
- copy of Global Warming data sheet (page 12)
- copy graph paper (page 13)
- color pencils
- 3 sheets white paper
- timer
- cardboard box larger than the 3 gallon jars

Scientists use graphs to analyze their data. The graph paper for you to analyze your global warming experiment on page 13.

Directions:

1. Use a different color for each treatment (for example green for open container, blue for closed container, and red for closed container with sparkling water).
2. The "X" axis is the horizontal line of your graph. The "X" axis is "Time." Start with 0 minutes in the bottom left corner of the graph. There are 38 cells total on the "X" axis. Each cell will represent 5 minutes. You conducted this experiment for 180 minutes, so you will need 36 cells in your graph. Label every three cells with a 15 minute increase (15, 30, 45, etc.), and continue until you reach 180 minutes.
3. The "Y" axis is the vertical line of your graph. The "Y" axis is "Temperature." Start with 0°C in the bottom left corner of the graph. There are 50 cells total on the "Y" axis. Each cell will represent 2°C. Label every 5 cells with a 10°C increase and continue until 100°C.
4. Pick a color pencil to represent treatment 1 (the control), and in the legend on the graph, color the small square on the right.
5. On your graph, make a dot at the intersection of lines for the time ("X" Axis) and Temperature for that time ("Y" Axis). When you have completed that treatment, connect the dots.
6. Repeat steps 4 and 5 for treatment 2, container with a lid (no sparkling water).
7. Repeat steps 4 and 5 for treatment 3, container with a lid and sparkling water.

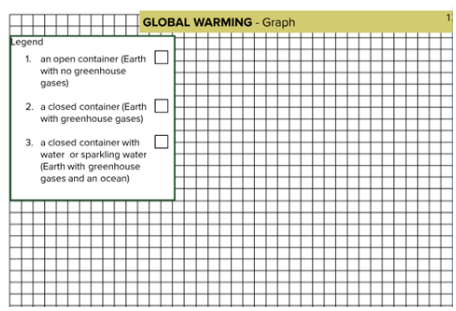
Before you start drawing conclusions about your data, why do you think the experiment used sparkling water rather than tap water? The ingredient label states "carbonated water" or "carbonated mineral water." In our experiment, you used two greenhouse gases in your closed container for treatment #3: water vapor and carbon dioxide. Do you think you have different results if you just used water? Why?

How does your experiment relate to greenhouse gases? What happened to the three containers? Were there any confounding variables? What were they? What does it mean? Why did this happen? How do you explain your results using the information yc learned in this newsletter? Do you need to look up more information?

Can you design an experiment to compare only water vs. carbonated water? Remember you will need a control (a container with no addition water or sparkling water added).

POWER WORDS

- **confounding variable**: extra variable that you didn't expect, for example, a cloud covering the sun
- **horizontal**: parallel to the plane of the horizon
- **treatment**: variable changed by the experimenter
- **variable**: an feature that is changed, for example, no lid, lid, and lid with water
- **vertical**: at a right angle to the horizon; the top is directly over the bottom



Greenhouse Gases - Compare and Contrast

Dominant Atmospheric Gases

Nitrogen N_2
Oxygen O_2

Trace Greenhouse Gases

Carbon Dioxide CO_2
Water Vapor H_2O
Methane CH_4

Global Warming Data Sheet

Record your hypothesis (what you think will happen)

Time (in minutes)		Air Temp Open Control	Air Temp Closed Container	Air Temp Closed with H_2O	Observations
In Full Sun	5 minutes				
	10 minutes				
	15 minutes				
	30 minutes				
	45 minutes				
	60 minutes				
	75 minutes				
	90 minutes				
In The Shade	5 minutes				
	10 minutes				
	15 minutes				
	30 minutes				
	45 minutes				
	60 minutes				
	75 minutes				
	90 minutes				

Legend

1. an open container (Earth with no greenhouse gases) ☐
2. a closed container (Earth with greenhouse gases) ☐
3. a closed container with water or sparkling water (Earth with greenhouse gases and an ocean) ☐

SOLUTIONS FOR THE 21ST CENTURY

It seems that politics and science are at great odds right now over climate change. As a scientist, I accept that the climate is warming. Scientists for decades have been modeling what will happen if we keep adding carbon dioxide that was isolated in oil, gas, trees, and other organic matter. We are seeing those models happen with devastating storms, shifting weather patterns, and other predictions.

The United Nation's Intergovernmental Panel on Climate Change (IPCC) are scientists all over the world bringing their research together to figure out what is happening. As best we can tell, the future will be a challenge for all people on our planet. Read more at their website listed in the green box.

This is not all bleak, doomsday predictions. Humans have the capacity to reason, and we do not know of any other species that can do this. You can make a difference right now for a better future.

- Citizen scientist programs are one way to help scientists collect data. This newsletter has promoted CoCoRaHS (Community Collaboration of Rain, Hail, and Snow Network) to gather precipitation levels all over the US, and now internationally. The website is listed in the green box.
- National Phenology Network collects data on changing seasons, to better observe the timing of each of them. As our climate warms, the seasons shift towards an earlier spring and a later fall. How do these changes impact the plants, animals, and other organisms? These data help scientists conduct research vital to targeting the interactions in an ecosystem. Check out this project on Nature's Notebook website in the green box.
- NASA regularly funds citizen scientist projects for everything from questions about our cosmos to exploring our Earth. Recently funded projects include climate change programs in their Explore Earth series. The link to these programs is in the green box below, and include:
    - Community Snow Observations
    - Global Kelp Cover
    - Animal Biodiversity
    - Low-cost Air Quality Sensors
    - Water Storage in Lakes
    - Air Quality Measurements Network
- NOAA funded Citizen Scientist project run by Cornell University has a series of projects recording the arrival and departure of different animals (e.g. frogs and birds) as well as examining vegetation. Website below.

You Can Make a Difference!

ONE PERSON

In 1955, Montgomery, AL had laws requiring African American people to ride the bus in the "Colored" section. This section could be changed if more white people got on the bus, forcing those sitting in their seats to move. Rosa Parks refused to give her seat, and she was arrested. This launched the Bus Boycott, a major Civil Rights victory, finally desegregating Alabama buses. Rosa Parks is known as the Mother of Civil Rights. One person can make a difference.

CITIZEN SCIENTISTS PROJECTS:

- IPCC: https://www.ipcc.ch/
- CoCoRaHS: https://www.cocorahs.org/
- NASA Citizen Scientist Projects: https://blogs.nasa.gov/educationsciencewow/tag/citizen-science-projects/
- Nature's Notebook: https://www.usanpn.org/natures_notebook
- NOAA and Cornell University http://www.birds.cornell.edu/citscitoolkit/climatechange/c3-sciencentral-videos

Hold on to those Mind Maps one more month. Exploring careers in Clean Energy fits so nicely with this issue, let's explore those first.

Seth Potts is my son's best friend. Seth didn't do well in high school. In fact, he dropped out and earned his GED. While working at a low paying job, he attended a Wind Energy Trade School. He was hired by a Wind Farm in the Columbia Gorge near Goldendale, Washington as part of the maintenance crew. There, with his knowledge and work ethic, he quickly rose to managing a section of this immense farm.

Wind turbine technicians require knowledge in electricity, generators, circuits, as well as physical fitness. Seth is curious and intelligent. His career did not require a college degree. He found another way to a satisfying career.

STEM careers are the fastest growing job market, and they pay decent wages. People in these fields report high job satisfaction. In particular, the clean energy has some of the highest demand for a trained workforce, and this industry is expanding by 18% per year, according to an Environment and Energy Study. Careers in coal, oil, and gas are beginning to flat line.

To prepare for these careers, you need additional education after high school. Different positions require different levels of education, from training programs to a Ph.D.

The five fastest growing jobs are:

1. Wind Turbine Technician
2. Solar Installer
3. Clean Car Engineer
4. Sustainable Builder
5. Sustainability Professional

Mr. Seth Potts, manager of a wind farm in the Columbia Gorge, Oregon and Washington

If those jobs sound interesting, check out more at the US Government's Office of Energy Efficiency & Renewable Energy's website below.

The Office of Energy Efficiency & Renewable Energy also has career development information on their website, as well as how to find jobs in this industry. Perhaps your future career is here. Check the websites below.

INSPIRATIONAL WORDS

Choose a job you love, and you will never have to work a day in your life. (*Confucius*)

Work to become, not to acquire. (*Elbert Hubbard*)

The best way to predict the future is to create it. (*Abraham Lincoln*)

Anyone who has never made a mistake has never tried anything new. (*Albert Einstein*)

You can't build a reputation on what you're going to do. (*Confucius*)

CLEAN ENERGY CAREERS

- Office of Energy Efficiency and Renewable Energy Careers:
  https://www.energy.gov/eere/education/find-jobs
  https://www.energy.gov/eere/education/map-career-clean-energy
  https://www.energy.gov/eere/education/clean-energy-jobs-and-planning

ISSUE INFORMATION

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ACKNOWLEDGMENTS

Funding for this project provided by Colorado State University System Venture Capital Fund

CJ Mucklow, Colorado State University Extension Western Regional Director;

Dr. Joe Cannon and Marketing Strategies students: Berlyn Anderson, Jenna Balsley, Rachel Kassirer, Rachel Richman, Colorado State University, College of Business, for marketing strategies and ST[EMpower] graphics.

Doug Garcia, Colorado State University Creative Services Communication Coordinator/ Designer

ANSWERS

1. The tree is 53 years old if you count the pith as 1 year.
2. When it was 16, 18, 19, 40, and 44 years old.
3. Red arrow - a branch
4. Yellow arrow - probably insect damage

CITATIONS

Information:

- https://www.giss.nasa.gov/research/briefs/ma_01/
- https://www.space.com/17816-earth-temperature.html
- https://www.climate.gov/maps-data/primer/past-climate
- https://climate.nasa.gov/news/2540/tree-rings-provide-snapshots-of-earths-past-climate/
- https://www.ncdc.noaa.gov/data-access/paleoclimatology-data
- About the Ice Core Lab in Denver: https://icecores.org/about-ice-cores
- Dodd, Matthew S.; Papineau, Dominic; Grenne, Tor; slack, John F.; Rittner, Martin; Pirajno, Franco; O'Neil, Jonathan; Little, Crispin T. S. (2 March 2017). "Evidence for early life in Earth's oldest hydrothermal vent precipitates"(PDF). *Nature*. **543** (7643): 60–64.
- https://www.seas.harvard.edu/climate/eli/research/equable/isotope.html
- https://www.ncdc.noaa.gov/news/picture-climate-how-can-we-learn-tree-rings
- http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson5_9.28.05.pdf
- https://www.youtube.com/watch?v=jPJUewNcvao
- https://web.archive.org/web/20110215124039/http://www.steamboatmagazine.com/articles/40.php
- Rocky Mountain Tree Ring Reseaerch: http://www.rmtrr.org/basics.html
- Tree Ring core Activity: http://eo.ucar.edu/educators/ClimateDiscovery/LIA_lesson5_9.28.05.pdf
- Global Warming Experiment: http://peabody.yale.edu/sites/default/files/documents/education/Global%20Warming%20In%20A%20Jar.pdf
- Energy Careers: https://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-and-energy-efficiency-2017
- Inspirational Quotes: https://www.workitdaily.com/inspirational-career-quotes

Images:

- Temperature World Map: https://www.space.com/17816-earth-temperature.html
- Ice House or Hot house Graph: http://scotese.com/climate.htm
- Oxygen Atom model: https://www.dreamstime.com/bohr-model-oxygen-atom-proton-neutron-electron-bohr-model-oxygen-atom-proton-neutron-electron-science-image111148512
- Plankton: http://geographical.co.uk/nature/oceans/item/656-cold-water-plankton-not-adapting-to-warmer-oceans
- Aspen carving: https://web.archive.org/web/20110215124039/http://www.steamboatmagazine.com/articles/40.php
- Tree rings: https://www.ltrr.arizona.edu/introdendro/
- Tree ring core: http://www.earthsci.org/space/space/geotime/dendro/dendro.html
- Marshmallows: https://parade.com/127140/smccook/29-how-to-dye-marshmallows/
- Molecules: http://www.gcsescience.com/a26-covalent-bond-oxygen-gas-molecule.htm
- Three Dimensional Molecules: https://archives.library.illinois.edu/erec/University%20Archives/1505050/Rogers/Text7/Tx73/tx73.html
- Diagram of an Atom:https://www.universetoday.com/56469/atom-diagram/
- Greenhouse Gases Effect: https://www.esrl.noaa.gov/gmd/outreach/lesson_plans/
- Hope: https://www.smithsoniansecondopinion.org/climate-change/hope-180964428/
- Seth Potts (taken by a colleague at the top of a wind turbine)
- Wind Turbine: https://en.wikipedia.org/wiki/Wind_power_in_Oregon