Carbon Sequestration Investigation
How do trees store carbon from the atmosphere?

Trees take up carbon dioxide (CO_2) from the atmosphere for their growth and life. The amount taken up depends on the type of tree and its age. You will:

1. Measure the age of a tree.
2. Calculate the amount of carbon sequestered (taken up) by that tree during its life.
3. Compare the amount of carbon sequestered (taken up) by the tree to a typical American monthly carbon emission.

Step 1: Measure the age of a tree

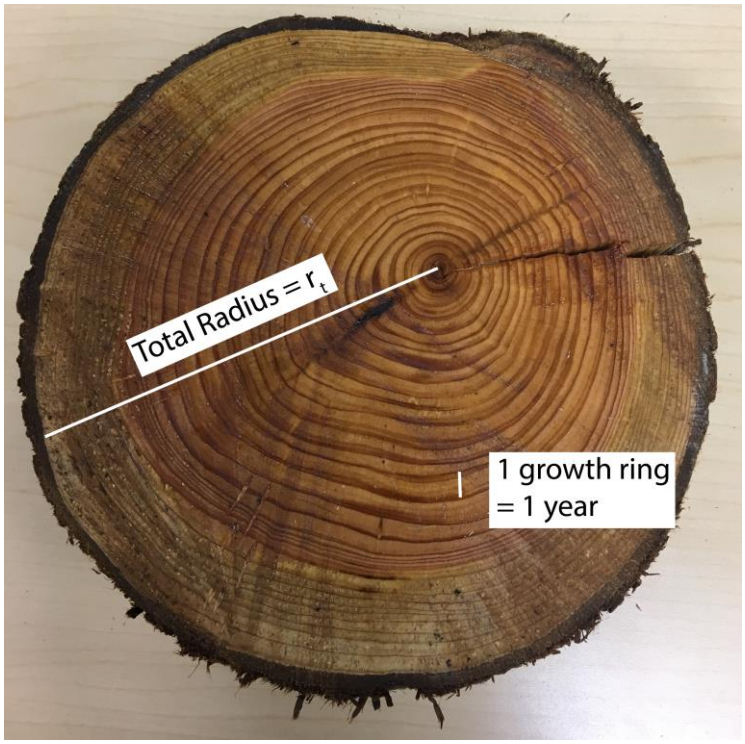
a. You will be given a tree "cookie" (slice) which is a cross section of a tree trunk. This tree was cut down in Summer 2017 by PPL to keep power lines clear.

b. Count the rings in your tree cookie (slice) to determine the age of your tree. Each year is made up of a thin and thick part of the ring. The thick part (light color) is during the growing season (spring-fall) and the thin part (dark ring) is growth during the winter.

Helpful Hint: Start counting from the center of the cookie to the bark. Count years from dark ring to dark ring.
The bark is not a ring.

Helpful Hint: Your cookie might be asymmetrical. For Step 1 you may use any radius you want, but we suggest you use a longer radius to make counting easier.

c. Answer **questions #1-3** below



1. a. How many rings did you count?

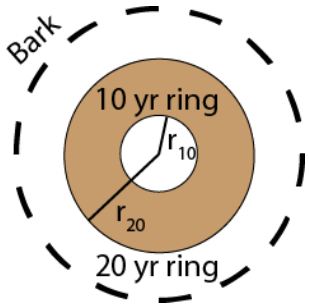
b. When was this tree planted? (**Hint**: Subtract the number of rings you counted from the year the tree was cut down - **2017**.)

2. Find the thickest tree ring (**summer AND winter**) in your cookie (slice). What year was this tree ring created?

3. Find the **ring for the 10th year** of the tree's life and **the ring for 20th year** of the tree's life. How much wood was added during these 10 years? (See image below for how to calculate area of wood added)

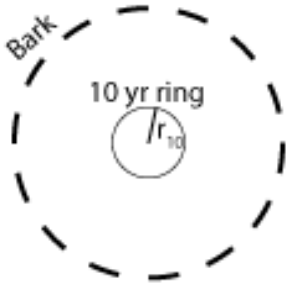
To calculate the amount of wood added during these 10 years you need to **measure the radius of ring #10 and ring #20 from the center**.

Take your best guess for this **radius in centimeters**.
Be sure to measure both radii in the same direction.



Key:
π=3.14
r_{20} = radius of ring #20
r_{10} = radius of ring #10

******Use the equation below******



$\pi \cdot r_{20}^2 \quad - \quad \pi \cdot r_{10}^2 \quad = \quad$ **Wood added**

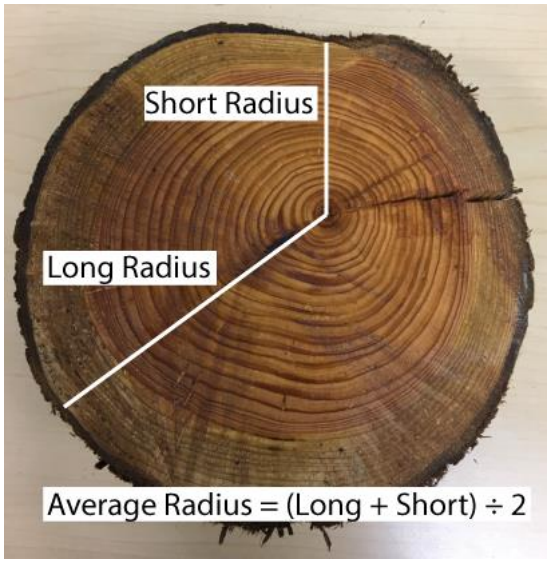
r_{20} = _____ cm r_{10} = _____cm

Show work here:

Wood material added between year 10 and year 20 : _____cm^2

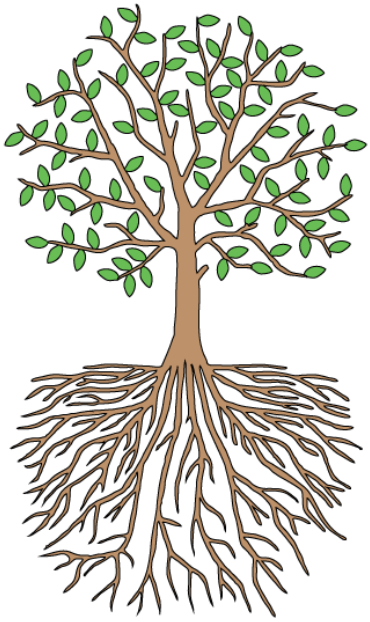
Step 2: Calculate the carbon sequestered by the tree during its life.

a. Now that you know the age of your tree you can calculate the amount of carbon sequestered (taken up) in its life. b. Use the equations on the right to calculate the amount of biomass and carbon for an Eastern Red Cedar: c. Answer **questions #4-7** below	$Total\ Biomass = 33{,}811{,}800{,}000\ \frac{kg}{cm^2} \bullet radius\ of\ cookie\ (cm)^2$ $Total\ Carbon = Total\ Biomass\ /\ 2$ **Please Note**: The total biomass includes the biomass from the trunk and leaves (above ground) and from roots (below ground). **Helpful Hint**: If your cookie has different radii (plural of radius), use an "average" radius measure of your cookie. You can calculate the diameter and divide by two. Or, you can find a radius that looks like the average radius of your cookie.



Short radius = ____cm

Long radius = ____cm



4. What are the total biomass and total carbon values for your specific tree cookie (slice)?

$Total\ Biomass = 33811.8\ \frac{kg}{m^2} \bullet radius\ of\ cookie\ (m)^2$

$Total\ Carbon = Total\ Biomass\ /\ 2$

Show Work Here:

Total Biomass: _____ kg

Total Carbon: _____ kg

Note: About one-half of a tree's biomass is stored in the root system below the ground. Much of the carbon sequestered by a tree is not at the surface.

5. Using your answer from Question # 1a how much carbon (**in kg**) does your Eastern Red Cedar tree sequester (take up) each year of its life (Assume it sequesters the same amount every year).

Helpful Hint: Use this equation: Total carbon / Age of the tree

_____kg

6. An Eastern Red Cedar can live up to 150 years. How much carbon would this tree sequester (taken up) over its lifetime if it was not cut down? (Assume the tree sequesters the same amount every year.)

_____kg

Challenge question:
7a. In questions #5 and #6 we assumed that a tree sequesters the same amount of carbon every year. We can test this by comparing the **amount of wood** added in first 5 years to the **amount of wood** added in the last 5 years of the tree's life cycle.

Use the equation in question #3 to calculate the amount of wood added in the first and last 5 years of this tree's life.

Sample answer based on an 8cm radius cookie with 1.5 cm growth for first 5 years.

First 5 years wood growth: _____cm^2

Last 5 years wood growth = Total cookie wood growth area ____ (cm^2) -
Total cookie wood growth area not including the last 5 years ____ cm^2

= _____ cm^2

b. Use the equation in Step 2 to calculate the amount of carbon added in the first and last 5 years of this tree's life.

First 5 years of carbon sequestered: _____ kg

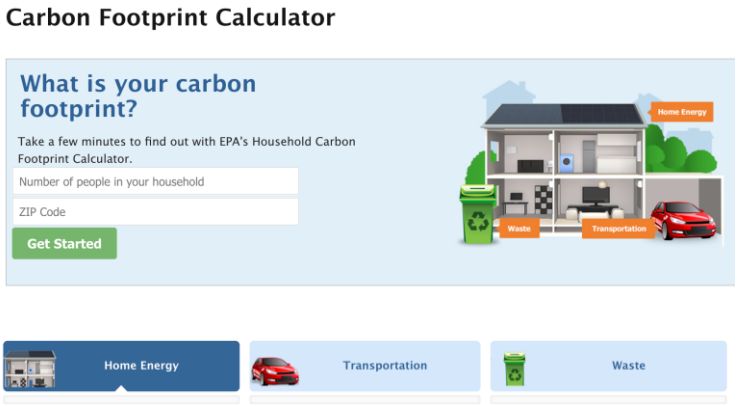
Last 5 years carbon sequestered: _____ kg

c. Why do you think the amount of wood added changes over the life of a tree?

Step 3: Compare the amount of carbon sequestered by a tree to your household's yearly emissions.

People in Allentown and across America generate CO_2 emissions when they travel, use electricity, heat or cool their home, in addition to other daily activities. Trees can take up this CO_2 to create biomass, but how many trees would you need to offset the typical yearly emissions by someone in Allentown?

Go to **https://www3.epa.gov/carbon-footprint-calculator/** and calculate the carbon emissions for your home based on your family's lifestyle.
Note: Instead of using your own home's energy values, your teacher might decide to give you a sample data set based on a specific type of energy source in a home and certain energy consumption behaviors. If this is the case, **enter your assigned Family #** _____

a. Enter then number of people in your household and your home's zip code. b. Follow the on-screen questions for your **simulated** home energy, transportation, and waste. Enter required information. c. After answering all questions, select **Continue to Report.**	

8a. What is your household **CO_2 emissions in lbs./year**? (**Hint:** This is what the Website displays)

Home Energy	Transportation	Waste	Total

b. What is your household **CO_2 emissions in kg**? **Show your calculations.**
Hint 1: The Website gives the emissions in pounds, not kg. 1 lb. = 0.454 kg
Hint 2: Convert lbs. -> kg
For example, if a household carbon footprint is 30,000 lbs. / year, the total household emissions would be calculated by 30,000 • 0.454 (lbs./kg) = 13620 kg

9a. The average household in Allentown emits 43000 kg of CO_2 per year. **How does your household compare to the average?**

b. How many **Eastern Red Cedar trees** would it take to sequester the annual (per year) CO_2 emissions from an average Allentown household? **Show your calculations.**
(**Hint: See answer to #5 to find out how much** CO_2 is sequestered by one Eastern Red Cedar tree.)

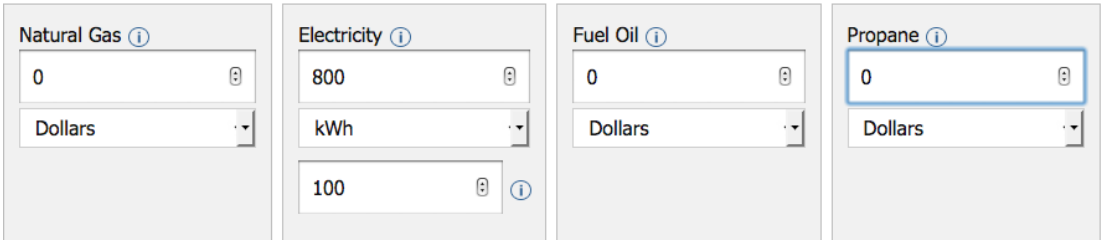
10a. Compare your household to **3** other kinds of households in your class. You will need to share information with other groups. **Use kgs for your units.**

Group Name	Home Energy	Transportation	Waste	Total
Your Group				
Group 1				
Group 2				
Group 3				

b. Which group had the lowest emissions?

11a. Go to **https://www3.epa.gov/carbon-footprint-calculator/**.
Change your electricity emissions by:

(1) Use **Electricity** as your energy source.
(2) Use 800 kWh per month.
(2) Use **100% of the electricity from green power** and not from fossil fuels. (See image below)



Complete the chart below:

Home Energy Source	Energy Behavior Change	CO_2 Emissions lbs./year	CO_2 Emissions kg /year
Starting Energy Source & Amount:	None		
Electricity, 800 kWh	100% renewables		

b. How much did this energy source **reduce** your carbon emissions **in kg / year**?

12a. Reduce your transportation emissions by not using a car.
- **Write your current emissions total in the chart below.**
- Go to the Transportation screen.
- Enter "0" for Vehicles.

Complete the chart below:

Transportation Source	Energy Behavior Change	CO_2 Emissions lbs/year	CO_2 Emissions kg /year
Starting Car Use	Car use		
None	Not using a car		

b. How much did not using a car **reduce** your carbon emissions **in kg / year?**

13. There are other ways to reduce your household carbon emissions. Examples include changing your thermostat, using EnergyStar lights and products, and drying clothes on a clothes line.
Go to the Home Energy screen.
Go to "Reduce Your Emissions".
Make one change and record that household change in the chart below and record the resulting CO_2 Emissions.
Repeat for 4 more household changes.

Complete the chart below:

Home Energy Source	Energy Behavior Change (Be specific)	Estimated Annual Savings ($)	CO_2 Emissions lbs./year	CO_2 Emissions kg /year
Starting Home Energy Source:	None	$0		
Household Energy Change 1				
Household Energy Change 2				
Household Energy Change 3				
Household Energy Change 4				
Household Energy Change 5				

b. Which household energy change reduced your annual (each year) CO_2 emissions the most?

c. Which household energy change saved you the most money?
HINT: Go to your **Household Carbon Footprint Report** screen. Look at the **Small Actions Add Up** section.

14. Take a few **screen shots of your Household Carbon Footprint Report that includes:**

a. **Your Household Carbon Footprint**.
b. **What your planned actions are equal to: gas savings, planting trees, or recycling waste**.
c. **All the new actions you have selected**.

Submit your screenshot images to Google Classroom as a new Google Doc called: "[***LastName]***_**CarbonOffsetPath**".

15. What changes made the biggest impact to your emissions (changing energy source, changing transportation, or household changes)?

Challenge Question:
16. a. Electricity sources have different CO_2 emissions and cost per kilowatt hour (kWh). Fill out the table below to calculate the amount of CO_2 emitted per $ for each type of power plant.

Type of Power Plant	grams of CO_2/kWh	Cost ($/kWh)	grams of CO_2/$
Coal	820 g	$0.095	
Natural Gas	490 g	$0.073	
Nuclear	12 g	$0.095	
Solar	45 g	$0.125	
Wind	11 g	$0.074	

b. What power source produces the **least CO_2 emissions**?

c. What power source produces the **most CO_2 emissions?**

d. What power source produces the **least CO_2 emissions per dollar**?

e. What power source produces the **most CO_2 emissions per dollar?**

f. Power sources such as Solar or Wind power do not directly produce CO_2 emissions during power generation. **What do you think is responsible for the emissions listed for these power sources?**