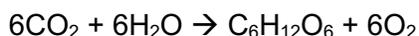


Assessing Trees Made of Air

Level 4 responses are in **bold blue italics** below. We also have suggestions based on our research about likely Level 2 and Level 3 responses. We would expect students' original responses to include a variety of Level 2 and Level 3 answers, but the revised class consensus responses to include more Level 4 responses.

This worksheet has "assessing" in the title because we do NOT recommend giving your students a grade based on the scientific accuracy of their responses at this point in the unit. It is designed to be used as a tool for formative assessment.

As we have seen, plants, including trees, take in carbon dioxide (CO₂) from the air and water (H₂O) and convert these molecules into sugar (C₆H₁₂O₆) and oxygen (O₂) molecules through the process of photosynthesis.



This means that trees can move CO₂ from the air into themselves.

- **How much CO₂ is sequestered (taken out of atmosphere) into a large tree?**
- **How does that compare with the amount of CO₂ we put into the air each year?**

These are the questions we will answer in this activity.

1. Explain how a solid tree can be produced from a gas (CO₂) and a liquid (H₂O).
Photosynthesis is a chemical reaction that combines and rearranges the atoms in the gas and liquid to make a solid substance, sugar. The tree builds the sugar into other molecules it needs. (The majority of dry mass of a tree is cellulose – a polymer of sugar.)
2. The amount of CO₂ a tree can sequester depends on its size and many other factors. We are going to do a rough calculation that depends only on the tree size, specifically the area covered by its canopy. The assumption is that the rate of photosynthesis, and therefore the rate of CO₂ uptake, depends on the amount of sunlight a tree captures. This, in turn, depends on the area of the canopy.

Pick a tree in your school yard or neighborhood.

- You will need a ball of string and a meter stick or measuring tape.
- One partner should stand holding one end of the string at the edge of tree's canopy.
- While unwinding the string, the other person should walk past the tree trunk to the edge of the canopy directly across from the first person.
- Mark the edge of the canopy on the string.
- Use the meter stick or measuring tape to measure the diameter of the canopy in centimeters.
- Diameter of the canopy ***for example, 1000*** cm
- Diameter of the canopy 10 m (diameter in cm x 0.01 m/cm)

3. Calculations

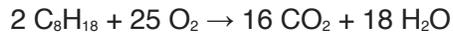
Area of the canopy = πr^2 . We want the area in m², so use the diameter in m.

Therefore, area of the canopy $A = 3.14 [d/2]^2 =$ 79 m²

The amount of carbon sequestered in the tree per year is:

$${}^1A \times 0.205 \text{ kg C yr}^{-1} = \underline{\quad 16 \quad} \text{ kg C yr}^{-1}$$

4. One of the ways we put CO₂ into the air is by driving. Through the process of combustion or burning, molecules of gasoline (composed of hydrocarbons such as C₈H₁₈) and oxygen (O₂) are converted into molecules of CO₂ and H₂O, both of which are emitted into the air and move into the atmosphere.



The Environmental Protection Agency (EPA) estimates **a typical passenger vehicle emits about 4.7 metric tons (1000 kg) of carbon dioxide per year. That is 1300 kg of carbon moving from gasoline to the atmosphere per year.** This assumes the average gasoline vehicle on the road today has a fuel economy of about 21.6 miles per gallon and drives around 11,400 miles per year. Every gallon of gasoline burned creates about 8.9 kg of CO₂.

Does your tree sequester 1300 kg of carbon per year? No

How many trees like yours would it take to sequester 1300 kg of carbon per year?

$$\frac{1300 \text{ kg C yr}^{-1}}{16 \text{ kg C tree}^{-1} \text{ yr}^{-1}} = \sim 81 \text{ trees}$$

Digging Deeper

1. Our calculation of the amount of carbon dioxide sequestered per year depended on the size of the canopy of the tree. However, in reality there many **other factors that affect the rate of photosynthesis**. Can you think of some of these?

Type of tree, overall climate, rainfall and temperature in a particular year, soil

The U.S. Department of Agriculture Forest Service has a calculator that takes into account type of tree and climate (CUFR Tree Carbon Calculator, <https://www.fs.usda.gov/ccrc/tools/tree-carbon-calculator-ctcc>). This calculator uses the diameter at chest height and the height of the tree as measures of tree size. **How does the estimate of CO₂ sequestered from this tool agree with your original calculation?** Note that your original calculation yielded kg of carbon and this calculator estimates kg of carbon dioxide. To compare the results, you need to know that carbon makes up a little more than a quarter (0.27) of the mass of carbon dioxide.

2. You calculated the amount of carbon your tree sequesters in a year. But **how much carbon does the tree sequester over its life time?** The Forest Service calculator also gives this information.

¹ Nowak, DJ, Greenfield, EJ, Hoehn, RE, & Lapoint, E. (2013). Environmental Pollution 178, 229-236.

total kg CO₂ sequestered x 0.27 = total kg carbon

What do you think will be the fate of that carbon? What happens to the carbon in each of the following scenarios?

- The tree is harvested and used for firewood.

When the wood is burned, the material in it which is mostly cellulose, a polymer of sugar, combines with oxygen to form carbon dioxide and water. So the carbon that was sequestered in the tree returns to the atmosphere.

- The tree is harvested and its wood is used to make a house.

When the wood is made into a house, it is kept dry and does not decompose. Therefore, the carbon that was sequestered remains in the wood.

- The tree dies and decomposes in the forest.

When the tree decomposes, it is because decomposing microbes are using it as food. They use it in the process of cellular respiration and other related decomposition processes. This produces carbon dioxide and water. Therefore the carbon that was sequestered in the tree returns to the atmosphere.