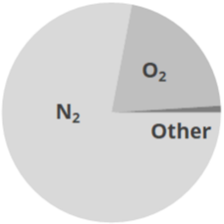
Today I Learned About Removing CO_2 from the Atmosphere

"For every million tons of CO_2 that you want to recover from the atmosphere … you have to physically move between 5 and 7 billion - with a B - tons of air, and a ton of air is as heavy as a ton of rock."
Niall Mac Dowell, Imperial College London
TILclimate podcast: Today I Learned About Removing CO_2 from the Atmosphere

Earth's Atmosphere



Earth's atmosphere contains about 78% Nitrogen (N_2) and 21% Oxygen (O_2). The remaining 1% is a mix of non-reactive gases (Argon, Neon, Helium, etc.) and gases that change over time and location, such as carbon dioxide (CO_2), water vapor (H_2O), methane (CH_4), sulfur dioxide (SO_2), and ozone (O_3).

Carbon Dioxide

As we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide into the atmosphere. This carbon dioxide acts like a blanket around Earth, trapping heat and warming our ocean and air. Warmer ocean and air temperatures lead to more extreme weather, sea level rise, and other impacts.

Even at extremely low concentrations, carbon dioxide has a huge impact on Earth's climate. We measure carbon dioxide at parts per million (ppm) instead of percent (%.)
In 2013, CO_2 reached 400ppm for the first time in millions of years.

400ppm
= 0.04%

Check Your Model

Today we will be modeling the atmosphere with beads. The actual concentration of CO_2 in the atmosphere is very low, so your model will have more "carbon dioxide" beads than the actual atmosphere. Make sure you know which color of bead is representing carbon dioxide in your model.

If you have time, you can calculate how many carbon dioxide beads would be accurate in your model. If you know how many beads you have total, multiply

____________ x ____________ = ____________

number of beads total x 400 parts per million = carbon dioxide beads

If you do not know how many beads you have total, there is a chart to help on page 3.

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Setup

Make sure to read through all instructions before you begin.

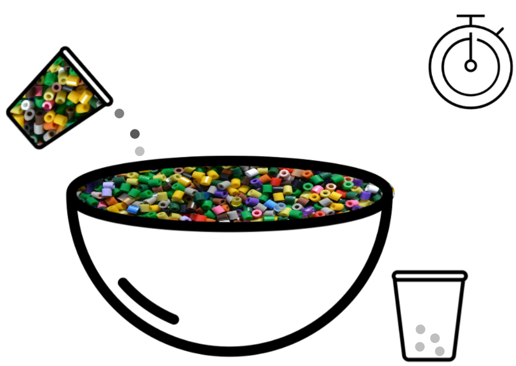
Materials:

- One larger container mixed-color beads
- One cup mixed-color beads
- One empty cup
- One timer

Before You Begin:

1. If there are no beads in the cup, scoop some out of the larger container.
2. Choose roles: 1 Timer, 1-2 Input, everyone else is Carbon Capture.
3. Make sure everyone in the Carbon Capture group agrees on which color bead represents carbon dioxide.

Do The Activity



All these steps happen at the same time:

1. Timer begins 1 minute countdown.
2. Input team steadily adds beads to the large container a few at a time.
3. Carbon Capture team digs through beads, finding and removing carbon dioxide beads and adding them to the empty cup.
4. When 1 minute is up, everyone stops.
5. Reset the activity by pouring all beads into the bowl, mixing, and scooping out one cup.

Discuss

- How many carbon dioxide beads did you get?
- Do you think you were able to get them all?
- Was it easy to find the right beads in among all the others?
- How many new carbon dioxide beads do you think were added during the activity?

Cup by Ahargun Ahduy, bowl by priiyanka from the Noun Project. Beads by Innviertlerin from Pixabay.

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Discussion

- Was this an accurate model of carbon capture technology? Why or why not?
- We measure carbon dioxide at very low levels, hundreds of parts per million. What are some other important things that might be measured at this level? (Think about testing drinking water, medicines, or other places that might affect human health.)
- Do you think engineers and inventors should keep developing carbon capture technology? Why or why not?
- What other ways do we know of to reduce the carbon dioxide in the atmosphere?

Math Extension

According to NASA[a], Earth's atmosphere weighs 5.1×10^{15} metric tons (MT).

As of June 2021[b], carbon dioxide measured 417ppm in the atmosphere.

For most of human history, we have had between 250-350ppm CO_2 in the atmosphere[c].

1. How many metric tons (MT) of CO_2 is in the atmosphere now? (417 ppm is .000417)
2. If we wanted to lower CO_2 to 350ppm, how many MT CO_2 would we have to remove?
3. Mount Everest is estimated to weigh 1.619×10^{11} metric tons[d]. How many Mount Everests would it take to make up the number of metric tons of CO_2 we would have to remove to get back to 350ppm?

Check Your Model

1. Count out and weigh 100 beads in grams.	A: ________ grams	Taking a sample is easier than counting all the beads.
2. Weigh all beads in grams.	B: ________ grams	Make sure to tare the weight of the container.
3. Divide B / A	C: _________	How many sets of 100 beads do you have?
4. Multiply C * 100	D: _________ beads	How many beads do you have?

a NASA Earth Fact Sheet https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html
b NASA Global Climate Change Vital Signs https://climate.nasa.gov/vital-signs/carbon-dioxide/
c Ask MIT Climate "What is the ideal level of carbon dioxide in the atmosphere for human life?" https://climate.mit.edu/ask-mit-climate
d How Much Does Mount Everest Weigh? https://weightofstuff.com/how-much-does-mount-everest-weigh/

ENVIRONMENTAL SOLUTIONS INITIATIVE

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> "We are at, I think, the very early days of developing direct air capture technology. You know, the basic science is sort of there, right? We know how to capture the CO_2. The problem is that what we need to do is be actively removing lots of CO_2 at the million tons per year scale minimum. It's a bit maybe like saying we need to be able to break the sound barrier and Orville and Wilbur Wright now just managed to get … the first plane flying for 10 meters.
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A Warming Planet

As we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide into the atmosphere. Carbon dioxide (CO_2) acts like a blanket, trapping heat. We need regular amounts of CO_2 for life on Earth. We are seeing rampant CO_2 now, and the blanket is trapping extra heat, warming our Earth and ocean. This leads to impacts such as extreme weather and sea level rise around the world.

How Do We Know?

The Mauna Loa Observatory in Hawai'i has been measuring CO_2 in the atmosphere since 1958[1]. This is one of the best sets of data showing direct measurement of carbon dioxide. For measurements before 1958, scientists use gas trapped in ice and other places.

What Does It Show Us?

1. Visit https://gml.noaa.gov/ccgg/trends/graph.html. Make sure **Mauna Loa, Hawaii** and **Interactive Plots** are selected.
2. The first measurements were taken in March 1958. What was the level of CO_2 in the atmosphere at that time? What is it now?
3. What do you notice about this graph?
4. What do you wonder?
5. There are two lines on the graph — CO_2 and trend. Why are both lines needed? What do they tell us?
6. At the bottom of the graph, there is a slider that allows you to focus on a section of time. Slide the bars to show just the decade 1960-1969, and then the decade 2010-2020. What do you notice about the shape of the CO_2 line?
7. What other questions could you ask and answer with this tool?

1 NOAA Global Monitoring Laboratory: Trends in Atmospheric Carbon Dioxide https://gml.noaa.gov/ccgg/trends/

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What Does It Show Us?

1. Visit https://gml.noaa.gov/ccgg/trends/data.html. Make sure **Mauna Loa, Hawaii** and **Data** are selected.
2. Download the data file **Mauna Loa CO_2 annual mean data**. Depending on how you will be graphing, you may want the .txt file or the CSV file, which is in parenthesis.
3. Graph Annual Mean CO_2 as a function of year.
4. The first measurements were taken in 1959. What was the level of CO_2 in the atmosphere at that time? What is it now?
5. What do you notice about this graph?
6. What do you wonder?
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What Does It Show Us?

1. Visit https://gml.noaa.gov/ccgg/trends/data.html. Make sure **Mauna Loa, Hawaii** and **Data** are selected.
2. Download the data file **Mauna Loa CO_2 monthly mean data**. Depending on how you will be graphing, you may want the .txt file or the CSV file, which is in parenthesis.
3. Graph Monthly Mean CO_2 and the Interpolated column as a function of decimal date.
4. The first measurements were taken in 1959. What was the level of CO_2 in the atmosphere at that time? What is it now?
5. What do you notice about this graph?
6. What do you wonder?
7. There are two lines on the graph – average and interpolated. Why are both lines needed? What do they tell us?
8. What other questions could you ask and answer with this tool?

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> "We will need everything. We need renewable energy. We need fuel switching. We need nuclear power. We need demand reduction. We need carbon capture and storage, and we will need all forms of greenhouse gas removal as and when they get going."
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We Need Everything

Carbon capture technology is very promising, but even its biggest supporters agree that it will not be ready for widespread use for years or even decades. In the meantime, we know that we need to be adding less carbon dioxide to the atmosphere. If a bathtub is about to overflow, the best thing to do is turn the faucet off before you start trying to empty the tub.

Each One, Teach One

1. Visit https://climate.mit.edu/explainers. Each member of your group will read a different one of the articles listed below.
2. Briefly describe what you learned to your teammates.
3. As a team, decide on three key messages you want to share with your classmates, friends, and family.
4. Create! How will you share what you have learned? You could create a podcast episode, a video, a painting or mural…

Keep In Mind:

- Talking about climate change can feel scary. This is OK – you don't need to be complete expert. If you don't know the answer to a question, you can give people resources to find out their own answers.
- Choose your key messages with your audience in mind. Does your audience need convincing about climate change, or do they just want to know what to do about it?
- Make it real. You don't need a lot of graphs and figures. People respond to metaphors, stories, and your passion for the topic.
- Think about solutions on a community scale. The biggest change happens when policies, laws, and programs make it easier for everyone to use renewable energy, switch fuel types, and reduce their energy use.

Suggested MIT Explainers:

- Renewable Energy, Greenhouse Gases, Carbon Capture, Soil-Based Carbon Sequestration, Forests and Climate Change, Concrete, Nuclear Energy, Food Systems and Agriculture, Energy Storage