STEAM Subject: Climate Science
Lab: Greenhouse Gases
Grades: 4-8

Learning Objective:
Students will be able to:

- identify greenhouse gases and describe their function on Earth's temperature
- identify human impacts on Earth and find solutions to reduce our impact.
- model greenhouse gases and compare and contrast their molecular structures.

ENGAGE:
Ask students the following questions:

- What is a greenhouse? *It is a structure that maintains the proper temperature for plants to grow inside.* Have you ever been inside one?
- What does it feel like inside? Is it warm or cold? *It is usually very warm!*
- This is what the atmosphere of the Earth is like. *It acts as a blanket that keeps the Earth warm at night and not too hot during the day.*

EXPLORE:
What are greenhouse gases?

- Greenhouse gases are gases that exist in the Earth's atmosphere that trap heat.
- They do this by having a *flexible molecular structure* (which we will observe in our models).

Mini Greenhouse Activity
Students will take the temperatures inside and outside a "greenhouse" to investigate the greenhouse effect.

Materials

- a small Ziplock bag
- two thermometers
- one clear plastic cup or glass jar
- 100 ml water

Directions:

1. Pick a sunny spot to set up your experiment.
2. Label each cup (1. Greenhouse 2. Earth)
3. Add 50 ml of water inside each clear glass jar or cup.
4. Put a thermometer inside each cup.
5. Put the cup of water "Greenhouse" inside the small "Ziplock" bag and seal the bag. Record the initial temperature.

6. Next to the Greenhouse, set up the cup label Earth with 50 mL of water and a thermometer inside, and record the initial temperature.
7. Record the temperature of each thermometer at 12 pm, 3 pm, and 5 pm.
8. Create a table to record the 4 temperatures on each cup and compare the temperatures of the "Earth" and "Greenhouse".
9. You can create a graph to show your results.

Guiding Questions:

- Did you find any changes in temperature? Which one was higher inside or outside the greenhouse?
- At what time the temperature was higher? How many degrees higher?
- Think of how it feels when you enter a greenhouse or when you sit in a room with lots of windows on a hot day—it's very hot. This is because sunlight passes through the windows creating heat which cannot escape.
    - ✓ The same happens in our atmosphere: sunlight passes through bringing with it heat which is trapped by greenhouse gases and can then not escape.

Image Credit: http://www.old-ib.bioninja.com.au/standard-level/topic-5-ecology-and-evoluti/52-the-greenhouse-effect.html

- What do greenhouse gases do for our Earth?
    - They keep the Earth warm enough for life to exist. Without them, the Earth would be too cold for any living thing to survive, including us.
    - Watch this video from *The Kids Should See This* "How Do Greenhouse Gases Actually Work?": https://thekidshouldseethis.com/post/how-do-greenhouse-gases-actually-work

- How they can be harmful?
    - An increase in greenhouse gases caused by human activity is responsible for the greenhouse effect and global warming.

- We add greenhouse gases to the atmosphere by burning fossil fuels and as a result of our over consuming lifestyle. Example: deforestation, transportation, electricity, agriculture, and other human related sources.
- More greenhouse gases trap more heat, and even a small temperature increase could have catastrophic effects on our planet.

Image Credit: https://www.nationalgeographic.com/environment/global-warming/greenhouse-gases/

Types of greenhouse gases

1. Methane
    - Chemical formula: CH_4
    - 1 carbon atom surrounded by 4 hydrogen atoms
    - Methane is often linked with cows (release gas *farts*). It is released from livestock, landfill sites, and when coal, oil, and natural gas are extracted from the Earth.
2. Ozone
    - Chemical formula: O_3
    - 3 oxygen atoms
    - It is blue and has a strong smell (the oxygen we breathe has 2 atoms of oxygen and has no color or smell).
    - The ozone layer blocks radiation from the sun.
3. Chlorofluorocarbons (CFC's)
    - CFCs are made up of chlorine, fluorine, carbon, and hydrogen
    - 1 carbon molecule in the center, surrounded by 2 chlorine molecules and 1 fluorine molecule

- This is the greenhouse gas responsible for the depletion of our ozone layer (they are manmade and not found in nature); they break down ozone gas, reducing the ozone layer's ability to protect us from the sun's harmful rays.
- CFCs were found in aerosols, fridges, and foam products.

4. Nitrous oxide
    - Chemical formula: N_2O
    - 1 nitrogen molecule attached to 2 oxygen molecules
    - Nitrous oxide is a natural part of the nitrogen cycle.
    - Too much of it though (from burning fossil fuels) can lead to smog and acid rain.
5. Water vapor
    - Chemical formula: H_2O
    - 1 hydrogen molecule with 2 oxygen molecules attached.
    - Water vapor is water in a gas form; it forms clouds and drops back to Earth as rain.
    - Water vapor is the largest contributor to the Earth's greenhouse effect, but this is directly related to the Earth's temperature (the increase in temperature has led to an increase in water vapor in the atmosphere).
6. Carbon dioxide
    - Chemical formula: CO_2
    - 1 carbon molecule with 2 oxygen molecules on opposing sides
    - Carbon dioxide is probably the most famous of the greenhouse gases.
    - It is released mainly through burning fossil fuels, carbon powered power plants, and transportation.

Greenhouse Gas Activity*:*
Students will build the six different greenhouse gases and compare their molecular structures.

Materials Needed:

- 6 different colors of Play-Doh or other modeling clay
- Toothpicks
- Printed out images of the structures found here: https://climatekids.nasa.gov/greenhouse-cards/

Set up:
Separate Play-Doh based on colors and assign an element to each color. See the image below for molecular structures.

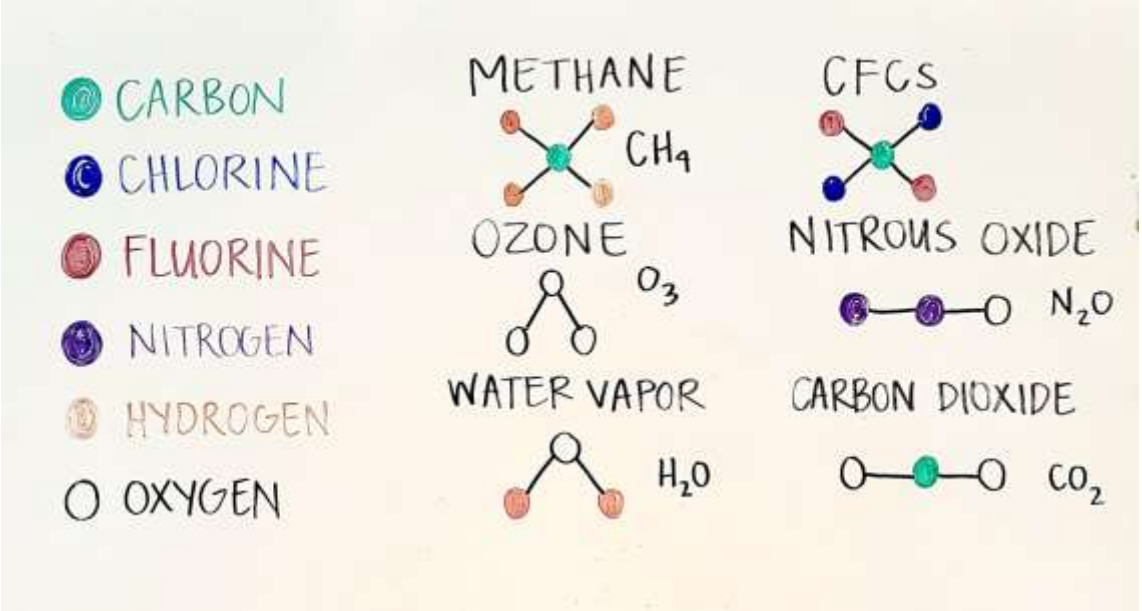

Image Credit: EIS Marine & Climate Science Instructor Leslie Gobel

Directions:
Using the images provided and the guide of colors/molecules, build each greenhouse gas using Play-Doh and toothpicks.
Observe the differences between structures and how flexible/complex they are.

Discussion:
As we learned, it is the structure of these molecules that allows them to absorb heat so well in our atmosphere. We can see the difference between all the molecules, and especially between the natural ones and the man-made ones (CFCs). CFCs are clearly much more complex and stable, making them much longer lasting in our atmosphere, which is bad!

EXPLAIN:

Greenhouse gases become harmful because humans are adding more into the atmosphere by burning fossil fuels and by our over consuming lifestyle.
Greenhouse gases have a structure that allows them to absorb heat, and many human-made gases tend to have more complex structures. Overall, these greenhouse gases (with the exception of CFCs) are not inherently bad for the environment. In fact, they actually help keep Earth habitable. It is when they exist in excess, due to human causes, that they start to be detrimental to the Earth and the things living here.

REVIEW SCIENCE VOCABULARY:

- **Greenhouse gases***:* a gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons. These gases keep the Earth warm enough for life to exist (otherwise, we would freeze!)
- **Atmosphere***:* the envelope of gases surrounding the earth or another planet.
- **Fossil fuels***:* a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms.
- **Molecule***:* a group of atoms bonded together, representing the smallest fundamental unit of a chemical compound that can take part in a chemical reaction.
- **Ozone layer***:* a region of Earth's stratosphere that absorbs most of the Sun's ultraviolet radiation.

EVALUATE:

Students will make a list of things we can do to help reduce greenhouse gas emissions. They can pick 3-5 things they are able to do with their families!

1. Reduce, Reuse, and then Recycle things like water bottles, bags, and others.
2. At home use energy-efficient products such as light bulbs and unplug electrical devices when not using them.
3. Walk or ride your bicycle.
4. Eat less meat, grow your own food, and don't WASTE food! Eat more vegetables, since growing veggies produces a lower carbon and water footprint than meat.
5. Use less heating and air conditioning less.
6. Use public transportation, carpool, or use an electric or hybrid car.

RESOURCES:https://www.science-sparks.com/know-your-greenhouse-gases/