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Edvo-Kit #

930

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Invisible Footprints: Seeing CO_2 and Understanding Climate Change

Experiment Objective:

Sometimes the effect that our actions have on the environment can be hard to see. In this experiment, students use color changing atmospheres to explore carbon emissions and climate change solutions.

See page 3 for storage instructions.

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Safety Data Sheets can be found on our website: **www.edvotek.com/safety-data-sheets**

Experiment Components

Components		Storage	Check (✓)
A	Atmosphere Powder	Room Temp.	❑
B	CO_2e Powder	Room Temp.	❑
C	Color Change Solution	Room Temp.	❑
D	Mitigation Solution (concentrate)	Room Temp.	❑
•	Conical Tubes		❑
•	Microcentrifuge Tubes		❑
•	Transfer Pipettes		❑
•	Carbon Footprint Questions		❑
•	Carbon Handprint Actions		❑

This experiment is designed for 20 students.

All experiment components are intended for educational research only. They are not to be used for diagnostic or drug purposes, nor administered to or consumed by humans or animals.

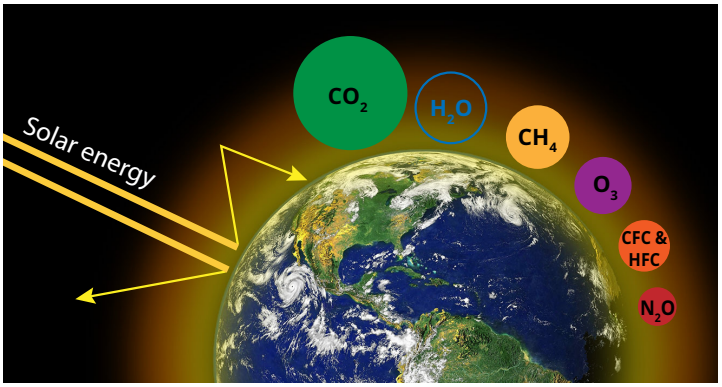
Requirements

- Distilled Water
- Three Beakers, Flasks, or Cups

Background Information

We inhabit a comfortable planet. Ocean currents, the water cycle, the survival of animals and ecosystems, and many elements of modern-day human life are all possible because Earth's temperatures stay within a certain range. Earth's current cozy temperatures are due to a group of gases called greenhouse gases (Figure 1). However, these gases - and in particular carbon dioxide - are increasing rapidly. This is causing higher temperatures and climate change. Because climate change is a major challenge to the environment and society, we need to limit carbon dioxide emissions by creating new energy habits and systems. This will require understanding, innovation, and action both at local and global levels. However, small changes add up! Begin today by reading this introduction and completing this lab!

Figure 1: Greenhouse gases trap energy in Earth's atmosphere. Carbon dioxide (CO_2) has contributed the most to recent temperature increases.



Carbon Dioxide 1.88 RFU
Water Vapor -0.55 RFU
Methane 0.49 RFU
Ozone 0.4 RFU
Halo-carbons 0.35 RFU
Nitrous Oxide 0.17 RFU

**Radiative forcing units (RFUs) are a measure of the net increase (or decrease) in energy reaching Earth's surface as a result of recent changes in greenhouse gas concentrations and are expressed as watts per square meter. RFU numbers are from IPCC 2007.*

OF CARBON, CYCLES, AND TEMPERATURE CHANGES

Carbon is an abundant and versatile chemical element. It can be found in the oceans, the air we breathe, rocks like limestone, the soil and in all living things. Importantly, carbon is dynamic and can easily move between these different places. A carbon atom can be part of a plant one day, an animal the next, and then travel downstream into the ocean or up into the air the next. The continuous movement of carbon is aptly called the carbon cycle (Figure 2) and is an essential part of life.

When carbon is in the air it is part of the atmosphere - a layer of gases that surround Earth. In the atmosphere, carbon is attached to oxygen as carbon dioxide (CO_2) or to hydrogen as methane (CH_4). These two molecules - along with a handful of other gases - have unique structures that enables them to trap heat that would otherwise escape into space. This heat-trapping process is called the greenhouse effect. Just like the glass panes in a greenhouse, these gases allow energy from the sun to enter Earth's atmosphere but block heat from escaping.

Greenhouse gases are essential to life. Without them, Earth's average temperature would be freezing (around 0°F or -18°C)! However, today the greenhouse effect is becoming too strong. A rapid increase in greenhouse gases is leading to higher temperatures worldwide and global climate change. Of all the greenhouse gases carbon dioxide receives the most attention, not because it is the most potent or abundant greenhouse gas, but because it is the one most responsible for current changes in global temperatures.

Carbon dioxide enters the atmosphere when plants and animals respire, volcanoes erupt, organic matter decays or is burnt, and when this gas is released by the ocean. It leaves the atmosphere when carbon dioxide is used by plants during photosynthesis or when this gas dissolves into the ocean. Because these processes are so dynamic, atmospheric carbon dioxide concentrations are constantly changing on a yearly, monthly, and even daily basis.

However, the overall trend of the last two hundred years is an unprecedented increase. In fact, today's carbon dioxide levels are higher than at any point in the past 800,000 years (Figure 3).

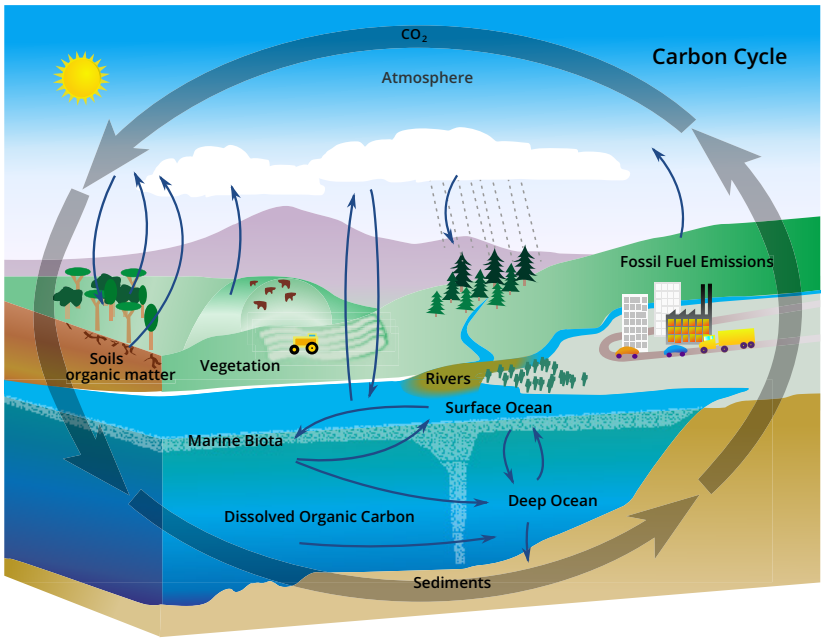


Figure 2: The Carbon Cycle.
Modified from Carbon_cycle-cute_diagram.jpeg Wikipedia Commons. [Public domain]

Two major drivers of the current increase in atmospheric carbon dioxide are the burning of fossil fuels and major land-use changes. Fossil fuels are the buried remains of plants and animals that lived thousands of years ago. They include petroleum, coal, and natural gas. Around 200 years ago we began digging these up and using them to power our factories, cars, and power plants. Our society is partially a result of having access to these powerful energy sources. However, using fossil fuels also moves carbon that was previously stored for millions of years underground into the atmosphere which has profoundly altered the carbon cycle. At the same time, we have also modified much of Earth's surface - about two-thirds of Earth's ice-free land is now used by humans to work, live, play, raise livestock, and grow crops. Compared to the original forest, wetlands, grasslands, etc. these new landscapes have a lower capacity to absorb carbon. This has also altered the carbon cycle.

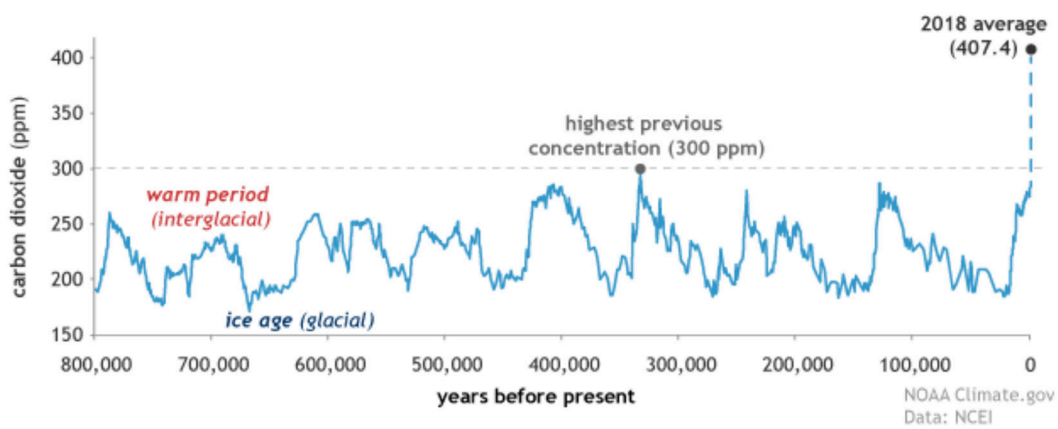


Figure 3: Atmospheric carbon dioxide concentrations in parts per million for the past 800,000 years based on ice core data. From Luthi et al. 2008.

CLIMATE CHANGE AND HUMANS

As more carbon enters into - and is stored by - the atmosphere the greenhouse effect is becoming stronger. This causes many environmental changes including:

- An increase in average yearly temperatures and larger temperature extremes.
- Changing precipitation patterns.
- Changes to where different plants and animals live.
- More extreme weather (i.e. hurricanes, heat waves, blizzards, droughts).
- Melting ice.
- Rising sea levels.
- Ocean acidification.

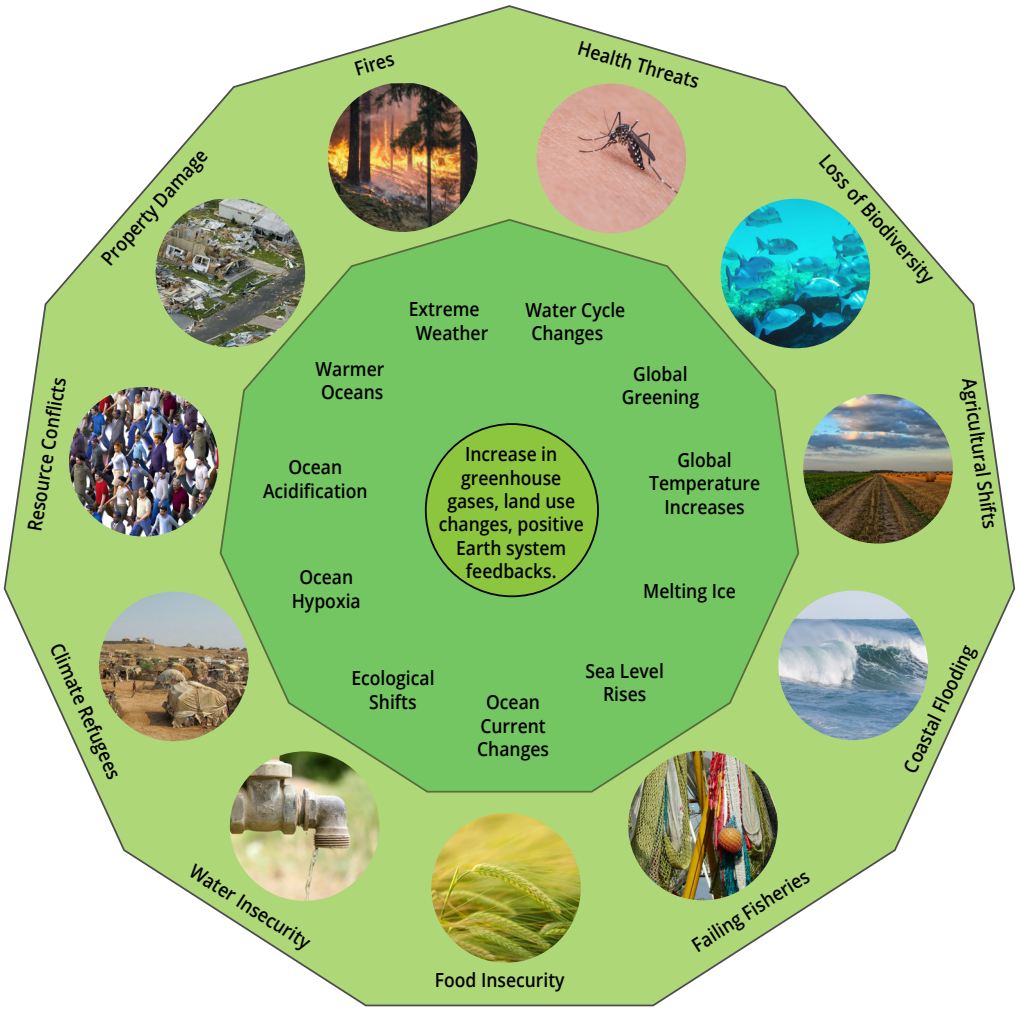


Figure 4: Effects of Climate Change.

These changes, in turn, affect everything living in the environment - including us (Figure 4). Examples of how humans are affected by climate change are:

- Rising sea levels and events like hurricanes, forest fires, and droughts are life-threatening. They also can damage property and/or force people to move.
- Important food production industries like farms and fisheries need to relocate, change, or shut down because of ocean acidification, warming temperatures, and changing rain patterns.
- Some crops - such as grains - are growing faster due to higher temperatures and CO_2 concentrations leading to better harvests.
- Heat waves, the expanded range of ticks and mosquitos, and the growth of toxic algae and cyanobacteria are making more people sick.
- Deaths from winter weather in cold climates are decreasing.

The social consequences of climate change are complex and varied. Some changes are life-threatening, others are inconvenient, and still others are positive. Moreover, climate change will affect different people in different places in different ways. Currently, individuals who live in the arctic, coastal nations, and in drought or fire-prone areas are experiencing climate change much more directly. However, as the effects of global warming continue to intensify, the costs to society are likely to grow and affect everyone.

To live and thrive on Earth humans need to address climate change. Climate change solutions can be divided into the two areas of mitigation and adaptation. Mitigation measures are actions that reduce greenhouse gas emissions. These actions aim to limit the speed and severity of climate change. However, some change is inescapable. Adaptation measures are actions that will help us effectively response to these changes. They include planting more drought-tolerant crops, helping threatened species migrate, creating flood defenses in low lying coastal areas, and designing buildings that can handle extreme weather events.

CARBON FOOTPRINTS & HANDPRINTS

In discussions about climate change you may have heard the term carbon footprint. In this context, "footprint" is a metaphor for the total impact that something has and "carbon" is shorthand for all greenhouse gas emissions that are causing climate change. (Remember that CO_2 leads this list in terms of recent impact, Figure 1). Carbon footprint calculations are a tool used by individuals, groups, companies, and even nations to examine and better understand their climate impact. These calculations address questions like: how much carbon dioxide do I/we release into the atmosphere? What actions are responsible for these emissions? And what can be changed?

Carbon dioxide equivalent (CO_2e) is a metric measure used to describe greenhouse gas emissions by converting other gas emissions to the CO_2 amounts that would have the same global warming impact. It is typically expressed as tons of carbon dioxide in the atmosphere for 100 years. Trying to visualize a carbon dioxide ton? Check out the UN's CO_2 Cube art instillation online.

Most carbon footprints are expressed as tons of carbon dioxide equivalent (CO_2e) produced per year as a result of a person's or group's actions and needs. Some actions are easy to connect to emissions such as driving or heating a building. Others are harder. For example, the electricity that most people purchase is from local suppliers who can use different methods - with different emissions - to create this energy. Even more complicated is incorporating items that we buy like groceries, clothing, and cars into a footprint. Every stage of such an item's production releases carbon dioxide (Figure 5) but tracking all the carbon released and then deciding how much to assign to the end-user is complex.

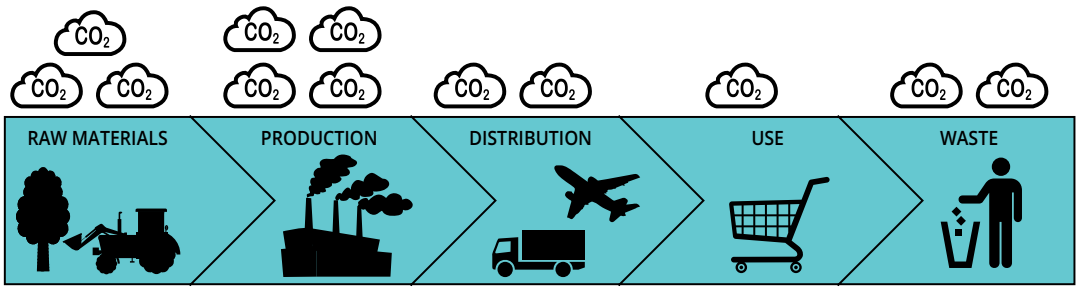


Figure 5: Indirect carbon emissions during an item's life cycle.

Even though carbon dioxide is constantly being released into the atmosphere it's hard to see. One reason for this is that the gas is invisible, odorless, and tasteless. Another reason is that the gas often gets released many miles away from the pollution-causing activity. For example, when you turn on your air conditioning the energy used to cool your home or school comes from a power plant miles away. Because carbon emissions are part of a global carbon cycle their effects are also hard to see! This is true spatially - instead of staying near to where they are emitted, greenhouse gases quickly disperse into Earth's atmosphere. It's also true temporally. For many years, the oceans have been able to absorb most of the extra carbon dioxide that was being released by humans. Consequently, we are just beginning to experience the effects of the last two hundred years of changes to the carbon cycle and the effects of current CO_2 emissions may not be fully experienced until many years from now.

One weakness of carbon footprint calculations are that they focus entirely on the negative impacts of an individual or group. However, this is only half of the picture! Every day, people are positively addressing climate change through changing habits, innovation, and cooperation. Carbon handprints are a way to describe and quantify actions that lead to climate change mitigation. Similar to footprints, every individual, group, business, and nation has a handprint. The major ways that an individual can grow their carbon handprint are by (1) reducing and modeling energy conservation, (2) educating other people about the causes and consequences of climate change, (3) inventing and finding new energy solutions efficient energy use and (4) promoting climate change solutions at the local, national, and even global level.

References:
IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, D. Raynaud, J. Jouzel, H. Fischer, K. Kawamura, and T.F. Stocker. (2008). High-resolution carbon dioxide concentration record 650,000-800,000 years before present. Nature, Vol. 453, pp. 379-382. doi:10.1038/nature06949.

Experiment Overview

EXPERIMENT OBJECTIVE

Sometimes the effect that our actions have on the environment can be hard to see. In this experiment, students use color changing atmospheres to explore carbon emissions and climate change solutions.

LABORATORY SAFETY

Gloves and goggles should be worn routinely as good laboratory practice when handling liquids.

Wear gloves and safety goggles

LABORATORY NOTEBOOKS

Scientists document everything that happens during an experiment, including experimental conditions, thoughts and observations while conducting the experiment, and, of course, any data collected. Today, you'll be documenting your experiment in a laboratory notebook or on a separate worksheet.

Before starting the Experiment:

- Carefully read the introduction and the protocol. Use this information to form a hypothesis for this experiment.
- Predict the results of your experiment.

During the Experiment:

- Record your observations.

After the Experiment:

- Interpret the results – does your data support or contradict your hypothesis?
- If you repeated this experiment, what would you change? Revise your hypothesis to reflect this change.

Module I
Calculating Your Carbon Footprint
10 minutes

↓

Module II
Seeing Your Carbon Footprint
30 minutes

↓

Module III
Your Positive Impact
10 minutes (plus at home work)

↓

Module IV
Seeing Carbon Handprints
20 minutes

NOTE: Experimental times are approximate.

Module I: Calculating Your Carbon Footprint

In this module you will determine your carbon footprint by looking at four key areas of daily life: transportation, home energy use, diet, and purchases.

1. **READ** through the questions and **CIRCLE** the answer that best applies to you or your family. Remember that carbon footprint calculations are approximations so make a best guess when you can.

2. **STAR** any questions that you don't know the answer to.

3. **INVESTIGATE** the answer to any starred questions for homework. (E.g. if you don't know how long you shower - time yourself, if you don't know how many of your appliances are energy star - check at home, if you don't know what temperature your clothing is washed at - ask the person who does this for you.) If you still cannot find the answer to a question, use the middle most value or - for yes/no questions - circle both.

Carbon Footprint Questions

– TRANSPORTATION –

1. How do you get to school? *If you use more than one option (e.g. you walk and then catch a bus) or if it varies by day (e.g. some days you drive and some days you carpool) then average the two numbers.*
   a. Carpool
   b. Car
   c. Bus or other public transport
   d. Bike
   e. Walk

2. *Answer only if you circled a or b above*: Do you wait for the person picking you up or do they wait for you?
   a. They wait for me and they keep the engine idling.
   b. They wait for me and they turn the engine off.
   c. I wait for them.

3. On average when driving in your family's car how many empty seats are there?
   a. 3 or more
   b. 1 or 2
   c. None

4. If a destination (friend's house, store, restaurant etc.) is under two miles do you or your family ever walk or bike there?
   a. Often
   b. Sometimes
   c. Never

5. In the last 6 months how many round trip airplane flights have you taken?
   a. Zero
   b. One
   c. Two
   d. Three
   e. Four or more

– HOME ENERGY USE –

6. Describe your house.
   a. Free standing/detached
   b. Townhouse
   c. Apartment or condo

7. What type of light bulbs are used in your home?
   a. Incandescent light bulbs (left)
   b. Compact fluorescent light bulbs (center)
   c. LED light bulbs (right)

8. How many of your home appliances are Energy Star? *(Most ES appliances will have a symbol on them. The ES status of many products can also be looked up at www.energystar.gov).*
   a. Most
   b. Some
   c. None

9. How often do you and your family heat or cool the house?
   a. Always (e.g. 12 months and everyday)
   b. Most of the year (e.g. 8-11 months and everyday)
   c. Some of the year (e.g. 4-7 months and/or most days)
   d. Rarely (e.g. <3 months and/or some days)
   e. Never

10. Do you turn off lights when you leave a room?
    a. Always
    b. Sometimes
    c. Never

11. Do you turn off computers, TVs, and game systems when you're not using them?
    a. Always
    b. Sometimes
    c. Never

12. Do you unplug your phone charger, other chargers, or other appliances when not in use?
    a. Always
    b. Sometimes
    c. Never

13. What water temperature do you or your family use to wash your clothes?
    a. Hot (>104°F)
    b. Warm (86-104°F)
    c. Cold (<68°F)

14. How do you or your family dry clothes?
    a. Hang to dry
    b. Dryer
    c. Both/Varies

15. Do you turn off the water when brushing your teeth?
    a. Always
    b. Sometimes
    c. Never

16. How long is a typical shower for you?
    a. Less than 5 minutes
    b. 6-10 minutes
    c. 11-15 minutes
    d. More than 15 minutes
    e. A bath

Carbon Footprint Questions, continued

***USE FOR QUESTIONS 17-23:**

Average Servings

- Red meat - 4 card deck size portions per week.
- White meat - 4 card deck sized portions per week.
- Fish - 2 card deck sized portions per week.
- Eggs - 12 eggs per week.
- Dairy - 5 cups a day.
- Grains - 5 cups a day.
- Fruits & Vegetables - 4 cups a day.

– DIET –

17. How many servings of red meat do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

18. How many servings of white meat do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

19. How many servings of fish do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

20. How many servings of eggs do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

21. How many servings of dairy do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

22. How many servings of grains do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

23. How many servings of fruits and vegetables do you eat?*
    a. Much more than average
    b. Just above average
    c. Average
    d. Below average
    e. Never

24. Do you eat leftovers?
    a. As much as possible to cut down on food waste.
    b. Sometimes, if they taste good.
    c. Never

25. Do you or your family grow any of your own vegetables/fruits or buy some produce that is locally grown?
    a. Yes
    b. No

26. How do you stay hydrated?
    a. I drink several bottles of water, disposable cups of coffee and tea, or cans of soda, etc. a day.
    b. I drink mainly from reusable bottles/glasses/mugs but have one disposable drink (bottled water/take out cup of coffee/ can of soda etc.) each day.
    c. I drink only from the fountain or from reusable bottles, glasses, and cups.

27. How many servings of wrapped food (bag of chips, granola bar, etc.) do you eat each day?
    a. None
    b. Between 1 and 3
    c. 4 or more

– PURCHASES –

28. In the past year, how many new electronics has your family purchased?
    a. None
    b. Between 1 and 3
    c. 4 or more

29. In the past month, how many new things have your family purchased for you? (Excluding food and electronics.)
    a. More than 15
    b. Between 11 and 15
    c. Between 6 and 10
    d. Between 1 and 5
    e. Under 5

30. How often do you or your family return items that you have recently purchased?
    a. Often
    b. Sometimes
    c. Never

31. Do you ever do any of the following: buy vintage or second hand clothing, participate in a clothing swaps, repair damaged clothing, donate or hand down clothing that no longer fits?
    a. Yes
    b. No

32. On average how many large garbage bags do you throw out a week?
    a. 1 bag
    b. 2, 3 or 4 bags
    c. 5, 6 or 7 bags
    d. 8, 9, or 10 bags
    e. More than 10 bags

33. Before you throw things away do you try to either give them away, recycle them, or repurpose them?
    a. Whenever I can
    b. Sometimes
    c. Never

34. Do you recycle magazines, newspapers, and other paper products?
    a. Yes
    b. No

35. Do you recycle glass and plastics?
    a. Yes
    b. No

36. Do you recycle aluminum and other metals?
    a. Yes
    b. No

Module II: Seeing Your Carbon Footprint

In this module, you'll receive a personal atmosphere to which you will add CO_2e solution based on your Carbon Footprint answers. Next, you'll add color change solution to instantly see how warm your modified atmosphere would make the planet.

1. **COLLECT** a 15 mL tube from your teacher. This is your personal atmosphere. **LABEL** it with your initials or group number. Also, **COLLECT** a CO_2e tube, empty 1.5 mL tube, and small transfer pipet. Finally, make sure you have your Carbon Footprint Questions from Module I.

2. For each Carbon Footprint Question, use Table 1 (right) to **DETERMINE** the number of CO_2e drops associated with your answer. **WRITE** this number next to each question. Finally, **ADD** the appropriate number of drops to your atmosphere tube. This is much easier to do one questions at a time!

   NOTE: If you are performing Module II as a group, either select a person to represent each area (transportation, diet, etc.) or calculate a group average for each question.

3. **TALLY** the total number of CO_2e drops added to the atmosphere and **RECORD** this number here:_____.

4. Using the small transfer pipet from step 3, **TRANSFER** 1 mL of your atmosphere to a 1.5 mL tube. (Use the side of either tube to measure 1 mL.) **LABEL** this tube with your group number and with the total CO_2e drop number.

5. Using a large transfer pipette, **ADD** 3 drops of the color change solution to your atmosphere and invert several times to mix. What color did it turn? _____.

6. **MATCH** your tube with the Color Change Key, Table 2.

In this simulation, one drop (or 15 µL) of "CO_2e" solution represents 0.1 tons of carbon dioxide.

TABLE 1: CARBON EMISSIONS KEY

Question	a	b	c	d	e
#1	40	20	5	0	0
#2	5	2	0	N/A	N/A
#3	20	10	0	N/A	N/A
#4	0	5	10	N/A	N/A
#5	0	15	30	45	60
#6	20	15	10	N/A	N/A
#7	6	3	2	N/A	N/A
#8	4	8	12	N/A	N/A
#9	40	30	20	10	0
#10	0	2	4	N/A	N/A
#11	0	3	6	N/A	N/A
#12	0	2	4	N/A	N/A
#13	6	3	1	N/A	N/A
#14	0	8	4	N/A	N/A
#15	1	2	3	N/A	N/A
#16	2	4	6	8	9
#17	30	20	10	5	0
#18	12	9	6	3	0
#19	5	4	3	2	0
#20	5	4	3	2	0
#21	6	5	4	3	0
#22	4	3	2	1	0
#23	4	3	2	1	0
#24	0	3	6	N/A	N/A
#25	0	10	N/A	N/A	N/A
#26	3	1	0	N/A	N/A
#27	0	2	4	N/A	N/A
#28	10	5	0	N/A	N/A
#29	20	15	10	5	1
#30	3	1	0	N/A	N/A
#31	0	5	N/A	N/A	N/A
#32	1	3	6	9	12
#33	0	2	4	N/A	N/A
#34	0	2	N/A	N/A	N/A
#35	0	1	N/A	N/A	N/A
#36	0	4	N/A	N/A	N/A

Module II: Seeing Your Carbon Footprint, continued

7. As a class, **CREATE** a common atmosphere.
   a. **TRANSFER** 500 µL of your atmosphere from step 2 to the classroom atmosphere tube.
   b. After everyone has added their samples, have one group or your teacher **SWIRL** the classroom tube to **MIX** and then **REMOVE** 1 mL of the solution to a 1.5 mL tube. (Save the remaining class atmosphere for Module IV.)
   c. Have one group or your teacher **ADD** 3 drops of the color change solution to this tube using the large transfer pipette. **INVERT** several times to **MIX**. What color did the class atmosphere turn? _____

8. (Optional) **TAKE** a picture of the colored 1.5 mL conical tubes representing the starting atmosphere (this has been prepared before class by your teacher), your atmosphere after the carbon footprint was added, and your class's combined atmosphere.

TABLE 2: COLOR CHANGE KEY

COLOR	G1	G2	G3	Y1	Y2	O1	R1
Drops	0-25	25-75	75-150	150-200	200-225	225-250	250+
2050 CO_2 Concentration	420 ppm	454 ppm	620 ppm	705 ppm	775 ppm	855 ppm	1255 ppm
Predicted Temperature Increase	1.5°C (2.7°F)	1.8°C (3.2°F)	2.6°C (4.7°F)	3°C (5.3°F)	3.2°C (5.8°F)	3.5°C (6.2°F)	4.5°C (8.1°F)

NOTE: Both the 2050 CO_2 atmospheric concentrations and predicted temperature increases are very general estimates.

Module III: Your Positive Impact

In this module you will consider things you can do to grow your carbon handprint. You will then focus on actions that can be practiced or accomplished during this upcoming week.

1. **READ** through the list of Carbon Handprint Actions and **SELECT ONE or MORE** actions that you would like to do and that you think you could successfully carry out during the next week.

2. **Act on these choices! PRACTICE** the new habit(s) during the week or **FINISH** the actions(s)/project(s) that you selected.

3. **WRITE DOWN** a few notes about the experience. (When did you complete the actions? Was anyone else involved? Were they easier or harder than you expected? Were there any challenges? Were there any unexpected rewards? etc.)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Carbon Handprint Actions

There are many things you can do to reduce your carbon footprint and climate impact! Read through this list and identify one or more actions that you can take in the next week.

— TRANSPORTATION —

Cut down on short car trips.

- **Action #1:** As a family, list the places that you will drive to this week. Identify one that you or your family could walk, bike, carpool, or take public transportation to.
- **Action #2:** For an even larger environmental impact, map a two mile circle around your home. For a whole week walk or bike to any destination within this zone.

Maximize miles per gallon.

- **Action #3:** Driving with properly inflated tires and a well maintained engine can increase fuel efficiency by 5-10%. Find out when your family car last had an oil change. If it's been over a year, offer to help make this happen over the weekend.
- **Action #4:** Check the gas cap of you family car. A loose or damaged gas cap wreaks havoc on the environment and wastes fuel, but can easily be tightened or replaced if necessary.
- **Action #5:** Do you know someone who is buying a car this year? Find time this week to ask them if they are factoring miles per gallon into their decision.

Advocate for transportation diversity.

- **Action #6:** This week find a nonprofit that promotes safe bicycle and pedestrian infrastructure projects. See if you can volunteer and help them for an hour.
- **Action #7:** Find a non profit that fixes old bikes and then gives them to communities in need. Donate your old bikes or - if you're good at bike repair - volunteer.
- **Action #8**: Write an email to your local government asking them what they are doing to improve public transportation and to promote transit-oriented development. Let them know that you care about the transportation and development choices they are making.

— HOME ENERGY USE —

Adjust your home's temperature.

- **Action #9:** If you are using your air conditioner, adjust your thermostat to run 2 degrees warmer this week. If you are using heat, adjust your thermostat to run 2 degrees cooler this week. Even though you likely won't notice much of a difference in temperature it is best to ask your family before doing this!
- **Action #10:** For a whole week play accomplice to your HVAC. If the air conditioner is running, close blinds/curtains during the day and find ways to skip using the oven, dishwasher, and clothes dryer during the day. If the heating is running, open the blinds/curtains during the day and close and (safely) seal vents in any unused rooms.
- **Action #11:** Give your HVAC system a spa day. Make sure floor registers are free of dust and debris, that outside evaporators and condensers are also unblocked, and that the filters are clean and/or have been replaced in the past three months.
- **Action #12:** Prepare a pitch to make a home energy saving investment such as a programmable thermostat, door and window whether strips, or home insulation. This pitch should include an estimate of the initial cost and the projected yearly savings.

Reduce electrical use.

- **Action #13**: Replace any incandescent light bulbs with CFL or LED lights.
- **Action #14:** Reduce computer, TV, or game console use by 30 minutes a day for the week.
- **Action #15:** Many large appliances have energy saving modes. Check your home for any appliances with this feature. If you have one, run a controlled experiment where you compare the appliances performance in both the default and energy efficient settings.
- **Action #16:** Ask your family to consider a home energy audit. Professional energy audits can be expensive but often pay for themselves with energy bill savings. Alternatively, the Department of Energy has a guide for doing your own energy audit (www.energy.gov/energysaver/home-energy-audits/do-it-yourself-home-energy-audits).

Reduce water (and especially hot water) use.

- **Action #17:** Reduce your shower time by one, five, ten etc. minutes. If you're competitive recruit friends or family to try the 5 minute shower challenge.

Carbon Handprint Actions, continued

- **Action #18:** Check all taps in your home for leaks.
- **Action #19:** Shock your parents by offering to do your laundry for a week and then use cold when possible.

Switch to renewable energies.

- **Action #20:** For a week take over drying the laundry and then hang it to dry. Clothes hung outside dry quickly but drying clothes over an indoor drying rack is also a good option.
- **Action #21:** Find out the sources of your electricity. How much of your electricity is coming from non-renewable sources? How much is coming from renewable sources? You may have to contact your utility company to do this.
- **Action #22:** Contact your utility company and ask them about any green pricing programs (programs where you play slightly more in exchange for electricity generated from clean, renewable power). How much would such a program cost your home? Would you be willing to fund your family's switch?
- **Action #23:** Use google's Project Sunroof to calculate the benefits of adding solar panels to your home, a friend or relative's home, or to a local business or organization. Before you start, ask your family/friend/organization if they would like you to do this!
- **Action #24:** This week research current jobs in the renewable energy field. Are there any that you think suit your interests and strengths? Make a list of skills that you would need to cultivate in order to be amazing at the job.

— DIET —

Eat lower in the food chain.

- **Action #25:** For at least two meals this week increase your portions of vegetables, fruits, grains, eggs or beans and lower the amount of meat that you eat.
- **Action #26:** For at least two snacks this week skip the meat or dairy option and go for a serving of vegetables, fruits, grains etc.
- **Action #27:** Offer to cook your family a vegetarian meal.
- **Action #28:** If your family has a go-to beef dinner on heavy rotation ask to substitute white meat, vegetarian meat, or mushrooms one time. Then compare notes - was the new dish something everyone could eat again or a one time experience.

Eat seasonal and local foods.

- **Action #29:** Research and make a list of what fruits and vegetables are in season where you live. Put this somewhere that the family's grocery shopper will see.
- **Action #30:** Plant a community garden. Meet neighbors and grow food at the same time by volunteering at or founding a public garden. Begin by going to the American Community Garden Association website and checking out their interactive map and resource page.
- **Action #31:** Plant your own vegetable garden or make plans to. This will take time and space so okay it with your family first and, if you can, recruit some help for the growing season.
- **Action #32:** Support a local farm by going to a roadside stand or farmers market or by investigating CSA (community supported agriculture) options in your area.
- **Action #33:** If you're in the city find a nearby rooftop farm, urban orchard, or vertical farm and see if they offer tours.

Reduce your food waste.

- **Action #34:** This week take smaller portions and ask for seconds (and thirds) rather than have uneaten food on your plate at the end of the meal.
- **Action #35:** Research if there is community composting site near you or ask other family members whether they have ever considered beginning a compost heap in the backyard.
- **Action #36:** Organizations around the country are findings ways to address food loss and food waste. See if there is one located near to you and consider volunteering or interning there.

Ditch the packaging.

- **Action #37:** Find a reusable water bottle or travel mug that you like and use it for the whole week.
- **Action #38:** As a family, brainstorm what items you can buy in bulk. Help this conversation by preparing a price per ounce comparison.

— PURCHASES —

Embrace "second hand goods" as good and "no goods" as great.

- **Action #39:** Go to a nearby vintage clothing store, consignment shop, or thrift store and see if there are any items you can give a second life.
- **Action #40:** Thinking of purchasing something new this week? Before you do, ask: How often will I use it? For how long will I use it? Do I really want it? Can I borrow it?

Carbon Handprint Actions, continued

Send your old items off in style.

- **Action #41:** This week make a list of nearby locations that allow you to either donate, sell, or simply recycle used clothing, games, and other household items. Then ask your family to schedule a weekend afternoon where everyone will pack up things they no longer need and can give to you to be donated, sold, or recycled.

- **Action #42:** Is your family looking into purchasing a new electronic device? This week come up with a plan to sell, donate, or recycle the older one.

- **Action #43a:** If you do not have recycling pick up services or if you have limited recycling pick up, find a recycling center near you and for one week expand your home's recycling program.

- **Action #43b:** If you do have recycling pick up services, assess whether your family is making full use of this service. Is there anything you can do to help your family better remember to recycle paper, plastics, glass, and especially cans/metals?

- **Action #44:** Artistic? Undertake an upcycling project. Upcycling is the process of converting old or discarded materials into something useful and often beautiful. Look online for examples or come up with your own.

Use your consumption powers for good.

- **Action #45:** Many manufacturers have begun publishing the carbon footprint of their products. Ask your family to help identify a purchase that you are planning to make in the next month. Next, research to see if the items you may buy have an estimated carbon footprint. If they do, try to factor this into your purchase decision. If they don't, let the company know that you would like this information.

- **Action #46:** Do you have a favorite company or brand that you buy repeatedly from? If so, research what they are doing to minimize their carbon footprint. Then write to them this week. You can thank them for what they are doing, ask them to do more, and let them know that their decisions in this area are important to you.

— CHANGING THE SYSTEM* —

Get people talking.

- **Action #47:** Write a letter to the editor about carbon footprints and climate change and send it to a school, local, or national newspaper.

- **Action #48:** Post about this activity on your favorite social media platform.

- **Action #49:** Listen to someone. Most people don't like to be told what to do but do like to be listened to. Pick a friend, family member, or family friend and ask them their thoughts on energy conservation and climate change. With any luck they may then ask you what you think.

Communicate with your representatives.

- **Action #50:** Contact the office of an elected official representing you (congressman, senator, state senator, governor, mayor etc.) and ask what their plans are for climate change.

- **Action #51:** Find an upcoming town hall near you and ask your representative about climate change in person.

Learn.

- **Action #52:** Read a newspaper or magazine article OR listen to a podcast OR watch a video about climate change and how youths and students are affecting the conversations around it.

- **Action #53:** Learn from others. Does your school have a climate club or is there a nearby chapter of a national student climate change organization? If so commit to going to their next meeting.

- **Action #54:** Find answers. Are there questions about climate change that you have? (How does climate change influence weather? What are biofuels? How do we know the climate is changing? How will my surroundings be affected 50 years from now? etc.) Write the questions down and then use online resources to find the best answers.

**Around one fourth of an individual's carbon footprint is unrelated to their personal energy and consumption choices. This systematic carbon load is part of the basic services offered to all citizens in a country - police, roads, libraries, military, courts, etc. It's one reason that carbon reductions need to occur at all levels. In addition, these higher system changes make climate conscious habits much easier for a large number of people to begin.*

Module IV: Seeing Carbon Handprints

In this module your class will incorporate the positive impacts of your carbon handprint actions into a combined classroom atmosphere. Then you'll again add the color change solution to instantly see how these actions would affect atmospheric greenhouse gas concentrations and Earth's temperature.

1. Use the Handprint Actions Key below to **IDENTIFY** the impact points for each handprint activity that you practiced/accomplished last week. **RECORD** this number here:_____.

   NOTE: If you are working in groups, RECORD the average impact points of your group here:_____ and use this number in step 3.

   NOTE: The number of impact points assigned to an action reflect both the time investment and the possible impact. Small changes can have large impacts! For example, any new habit that you adopt will have a huge cumulative effect over your lifetime and involving others can have cascading effects.

TABLE 3: HANDPRINT ACTIONS KEY

Action #	Impact Points	Action #	Impact Points
#1	8	#28	12
#2	15	#29	8
#3	8	#30	8**
#4	3	#31	8**
#5	5	#32	5
#6	8*	#33	5
#7	8*	#34	3
#8	8	#35	4
#9	13	#36	5*
#10	6	#37	4
#11	5	#38	5
#12	8	#39	7
#13	3	#40	10
#14	4	#41	2
#15	5	#42	6
#16	10	#43	6
#17	3**	#44	4
#18	8	#45	9
#19	5	#46	8
#20	5	#47	9
#21	6	#48	9
#22	7	#49	9
#23	6	#50	9
#24	11	#51	5
#25	8	#52	8
#26	7	#53	9
#27	13	#54	10

**plus 5 for every hour volunteered*
***plus 5 for every person recruited*

Module IV: Seeing Carbon Handprints, continued

2. **SHARE** with your classmates your chosen action(s), how the week went, and the impact number(s).

3. For each impact point **ADD** one drop of Mitigation solution to the classroom atmosphere. Take turns adding these drops to your classroom atmosphere. The last student/group to add their drops should also **MIX** the solution by capping the tube and inverting it several times.

4. Have one group or your teacher **TRANSFER** 1 mL of this new atmosphere to a 1.5 mL tube. Using the large transfer pipette, **ADD** 3 drops of the color change solution to this tube. **INVERT** several times to **MIX**. **COMPARE** this tube to the original classroom atmosphere that your teacher made before class.

   What color did it turn? _____

5. (Optional) **TAKE** a picture comparing the color of your original classroom atmosphere and your class's atmosphere after the Mitigation drops were added.

Study Questions

PRELAB QUESTIONS

1. What is one way that carbon can enter the atmosphere? What is one way that it can exit the atmosphere?
2. What role(s) do human play in the carbon cycle?
3. How does the concentration of atmospheric greenhouse gases affect earth's temperature?
4. Choose one way that our climate is changing. Then brainstorm 2-3 ways this change will affect society or the natural environment.
5. Give an example of an adaptive solution to climate change and a mitigative solution to climate change.

POSTLAB QUESTIONS

1. Which of the four areas (transportation, home energy use, diet, purchases) contributed most to your carbon footprint? Which do you think would be easiest to change? Which do you think would be the hardest? Why?
2. Carbon dioxide is an invisible pollutant whose effects are best seen over long time frames and on a global scale. How do you think this has affected the ways that individuals, companies, and governments tackle this problem?
3. In module II was there any variation between different student's/group's atmospheric colors? What happened when you combined samples for the classroom atmosphere? How do you think this may effect the ways that individuals, companies, and governments tackle carbon emissions?
4. Which activity was more interesting – calculating and seeing your carbon footprint (Modules I and II) or completing a climate action and seeing the combined class effects of these actions (Modules III and IV)?
5. This experiment looked at individual carbon footprints and handprints. Pick a country and see if you can find out what the country's carbon footprint is and at what rate it is growing. Next, research any actions that the country is taking to reduce greenhouse gas emissions.

Instructor's Guide

NOTES TO THE INSTRUCTOR

This experiment starts with 36 lifestyle questions that can be used to calculate an individual's carbon emissions. We've kept these broad and simple to minimize the challenges of gathering energy use details. These questions should take students 10 minutes of class time to complete. If you decide to add additional student written questions **Module I** will take longer. Alternatively **Module I** can be assigned as a home activity.

In **Module II**, students will be adding a simulated carbon dioxide equivalent (CO_2e) solution. This activity is most meaningful if students add this solution one question at a time. However, to save time, students can tally their total emissions and use a micropipette to add the appropriate volume. One CO_2e drop is approximately 15 µL.

In **Module III**, students will examine the positive actions they can take. For the most part these actions will take place out of the classroom and so should be included as part of the week's homework. If you have multiple classes, this is a great place to introduce some friendly competition!

The cumulative effects of these positive actions will be observed in **Module IV** where students will add a Mitigation solution to a classroom atmosphere. This atmosphere can be saved from Module II or quickly remade before class.

OVERVIEW OF INSTRUCTORS PRELAB PREPARATIONS

Preparation For:	What to do:	When:	Time Required:
Module I: Calculating Your Carbon Footprint	(OPTIONAL) Modify Carbon Footprint Questions	Anytime before Module I.	(15 min.)
Module II: Seeing Your Carbon Footprint	Prepare and aliquot student atmospheres and CO_2e solutions. Prepare reveal station. Hand out plastics.	Day of or day before Module II.	15 min.
Module III: Your Positive Impact	(OPTIONAL) Modify Carbon Handprint Ideas	Anytime before Module III.	(15 min.)
Module IV: Seeing Carbon Handprints	Prepare classroom atmosphere. Aliquot Mitigation solution.	Day of or day before Module IV.	15 min.

Prelab Preparations

PREPARATIONS FOR MODULE I

If you are adding additional student written questions (Appendix A) or would like to modify these questions to better fit your class, download the open document versions of the footprint questions and make any desired changes. Print or electronically distribute the new questions to your class.

FOR MODULE I
Students will need:
- A copy or digital access to your class's Carbon Footprint Questions.

PREPARATIONS FOR MODULE II

FOR MODULE II
Students will need:
- One 15 mL tube with Atmosphere Solution
- One 15 mL tube with CO_2e Solution
- 1 empty 1.5 mL tube
- 1 small transfer pipet
- Completed Carbon Footprint Questions from Module I.
- Access to the Reveal Station

1. In a beaker, **COMBINE** all the atmosphere powder (Component A) and 300 mL of distilled water. **MIX** until the powder is completely dissolved. Label "Atmosphere".
2. **ALIQUOT** 10 mL of this solution into twenty 15 mL tubes labeled "Atmosphere".
3. **ALIQUOT** 1 mL of this solution into a 1.5 mL tube labeled "Original Atmosphere". Using a large transfer pipette, **ADD** 3 drops of color change solution (Component C) to this tube and **INVERT** several times to **MIX**.
4. **SAVE** the remaining solution from step 1 by covering the beaker and storing in a temperature stable place.
5. In a second beaker, **COMBINE** all the CO_2e powder (Component B) and 200 mL of distilled water. **MIX** until the powder is completely dissolved. **LABEL** "CO_2e".
6. **ALIQUOT** 5 mL of this solution into twenty 15 mL tubes labeled "CO_2e".
7. **SAVE** the remaining solution from step 5 by covering the beaker and storing in a temperature stable place.
8. **DISTRIBUTE** the atmosphere and CO_2e tubes to each group as well as an empty 1.5 mL tube and a small transfer pipette.
9. **LABEL** an empty 15 mL tube and 1.5 mL tube as "Classroom Atmosphere".
10. **SET UP** a reveal station with the color change solution, a large transfer pipette, and the starting atmosphere sample you created in step 3. A great way to do this is to put all three items in a ziplock bag that can easily be passed between students/groups.
11. AT THE END OF MODULE II:
    a. **SAVE** the 15 mL tube and 1.5 mL tube of "Classroom Atmosphere" for Module IV. These tubes can be saved at room temperature for a week. If module IV is more than a week away, **STORE** them in the freezer.
    b. **RECORD** the total number of CO_2e drops that each student/group added to their atmosphere and average this number.

Prelab Preparations, continued

PREPARATIONS FOR MODULE III

You may want to brainstorm with your students additional ways they can impact the climate or delete an action. Like with module I the handprint document is on our website in a modifiable form.

FOR MODULE III
Students will need:
- A copy or digital access to your class's Carbon Handprint Actions. (And 1 week to complete actions.)

PREPARATIONS FOR MODULE IV

1. In a beaker, **COMBINE** all the mitigation solution concentrate (component D) with 10 mL of distilled water and **MIX**.
2. **ALIQUOT** 500 µL of the Mitigation solution to twenty 1.5 mL tubes.
3. **RETRIEVE** the 15 mL and 1.5 mL classroom atmospheres you created during Module II*. **POUR** the solution in the 15 mL tube into a 50 mL tube (you'll need the extra room if your class has a high impact number.) **LABEL** both of these as "Starting Classroom Atmosphere.
4. **SET UP** your reveal station with the 1.5 mL "Starting Classroom Atmosphere", the color change solution, and a large transfer pipette.

FOR MODULE IV
Students will need:
- One 1.5 mL tube with Mitigation Solution
- 1 small transfer pipet
- Access to the Classroom Atmosphere and to the Reveal Station

**NOTE: Enough reagents are provided to allow you to recreate your classroom atmosphere if needed. To do this:*

1. *Add 10 mL atmosphere solution to a new 50 mL tube and label "Starting Classroom Atmosphere."*
2. *Add CO_2e solutions to the atmosphere by either:*
   a. *Multiplying your classroom's carbon footprint average by 15 and then adding that many microliters (µL) of the CO_2e solution.*
   b. *Choosing a general starting atmosphere: for a red atmosphere add ~4 mL of CO_2e, for an orange atmosphere add ~3 mL of CO_2e, for a yellow atmosphere add ~2 mL of CO_2e, or for a light green atmosphere add ~1 mL of CO_2e.*
3. *Subsample 1 mL of this solution into a 1.5 mL tube and add 3 drops of color change solution. Label "Starting Classroom Atmosphere".*

CLEAN-UP

All solutions in this kit were made with classroom safe chemicals. However, gloves should be worn when handling all solutions and plastics. Solutions can be disposed of down the drain. If you wish to save and reuse any of the plastics in this kit, soak them in water and then air dry.

Frequently Asked Questions

(1) **My class is bigger than 20 students.**
Have students complete Modules I and III independently but work as a lab group for Modules II and IV.

(2) **My students don't know how their clothing is washed, what appliances are in their house etc.**
Assign completing module I as a homework assignment. Students may have to investigate items in their house or ask members of their family for certain answers. If students are still unable to figure out the answer use the middle most value or the average of both the yes and no answers.

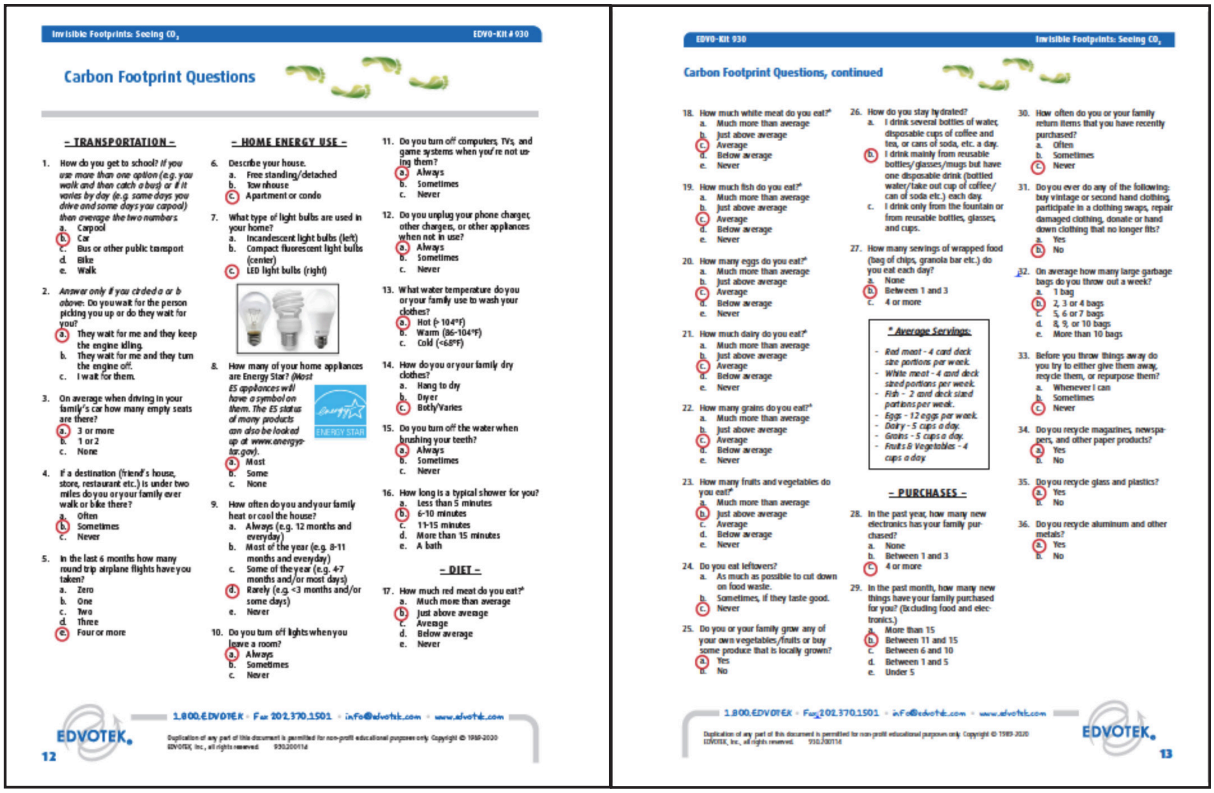
(3) **There are social/economical differences in my class that I worry a carbon footprint calculation will highlight.**
The questions in this exercise have been written to de-emphasize differences in status symbols. Look over and see which questions you are comfortable with and which ones you are not. Footprints questions are provided as modifiable word document so you can delete or modify any question before printing. ALTERNATIVELY, have each student or group fill out the questions as one of their favorite fictional characters. See the results section as an example of this.

(4) **Several students were unable to fully complete their a carbon handprint action.**
Decide beforehand whether to assign partial credit.

Experiment Results and Analysis

Below are example results based on the fictional character of James Bond.

MODULE I



Invisible Footprints: Seeing CO_2 EDVO-Kit #930

Carbon Footprint Questions

– TRANSPORTATION –

1. How do you get to school? *If you use more than one option (e.g. you walk and then catch a bus) or if it varies by day (e.g. some days you drive and some days you carpool) then average the two numbers.*
   a. Carpool
   (b.) Car
   c. Bus or other public transport
   d. Bike
   e. Walk
2. *Answer only if you circled a or b above:* Do you wait for the person picking you up or do they wait for you?
   (a.) They wait for me and they keep the engine idling.
   b. They wait for me and they turn the engine off.
   c. I wait for them.
3. On average when driving in your family's car how many empty seats are there?
   (a.) 3 or more
   b. 1 or 2
   c. None
4. If a destination (friend's house, store, restaurant etc.) is under two miles do you or your family ever walk or bike there?
   a. Often
   (b.) Sometimes
   c. Never
5. In the last 6 months how many round trip airplane flights have you taken?
   a. Zero
   b. One
   c. Two
   d. Three
   (e.) Four or more

– HOME ENERGY USE –

6. Describe your house.
   a. Free standing/detached
   b. Townhouse
   (c.) Apartment or condo
7. What type of light bulbs are used in your home?
   a. Incandescent light bulbs (left)
   b. Compact fluorescent light bulbs (center)
   (c.) LED light bulbs (right)
8. How many of your home appliances are Energy Star? *(Most ES appliances will have a symbol on them. The ES status of many products can also be looked up at www.energystar.gov).*
   (a.) Most
   b. Some
   c. None
9. How often do you and your family heat or cool the house?
   a. Always (e.g. 12 months and everyday)
   b. Most of the year (e.g. 8-11 months and everyday)
   c. Some of the year (e.g. 4-7 months and/or most days)
   (d.) Rarely (e.g. <3 months and/or some days)
   e. Never
10. Do you turn off lights when you leave a room?
    (a.) Always
    b. Sometimes
    c. Never
11. Do you turn off computers, TVs, and game systems when you're not using them?
    (a.) Always
    b. Sometimes
    c. Never
12. Do you unplug your phone charger, other chargers, or other appliances when not in use?
    (a.) Always
    b. Sometimes
    c. Never
13. What water temperature do you or your family use to wash your clothes?
    (a.) Hot (> 104°F)
    b. Warm (86-104°F)
    c. Cold (<86°F)
14. How do you or your family dry clothes?
    a. Hang to dry
    b. Dryer
    (c.) Both/Varies
15. Do you turn off the water when brushing your teeth?
    (a.) Always
    b. Sometimes
    c. Never
16. How long is a typical shower for you?
    a. Less than 5 minutes
    (b.) 6-10 minutes
    c. 11-15 minutes
    d. More than 15 minutes
    e. A bath

– DIET –

17. How much red meat do you eat?*
    a. Much more than average
    (b.) Just above average
    c. Average
    d. Below average
    e. Never

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EDVO-Kit 930 Invisible Footprints: Seeing CO_2

Carbon Footprint Questions, continued

18. How much white meat do you eat?*
    a. Much more than average
    b. Just above average
    (c.) Average
    d. Below average
    e. Never
19. How much fish do you eat?*
    a. Much more than average
    b. Just above average
    (c.) Average
    d. Below average
    e. Never
20. How many eggs do you eat?*
    a. Much more than average
    b. Just above average
    (c.) Average
    d. Below average
    e. Never
21. How much dairy do you eat?*
    a. Much more than average
    b. Just above average
    (c.) Average
    d. Below average
    e. Never
22. How many grains do you eat?*
    a. Much more than average
    b. Just above average
    (c.) Average
    d. Below average
    e. Never
23. How many fruits and vegetables do you eat?*
    a. Much more than average
    (b.) Just above average
    c. Average
    d. Below average
    e. Never
24. Do you eat leftovers?
    a. As much as possible to cut down on food waste.
    b. Sometimes, if they taste good.
    (c.) Never
25. Do you or your family grow any of your own vegetables/fruits or buy some produce that is locally grown?
    (a.) Yes
    b. No
26. How do you stay hydrated?
    a. I drink several bottles of water, disposable cups of coffee and tea, or cans of soda, etc. a day.
    (b.) I drink mainly from reusable bottles/glasses/mugs but have one disposable drink (bottled water/take out cup of coffee/can of soda etc.) each day.
    c. I drink only from the fountain or from reusable bottles, glasses, and cups.
27. How many servings of wrapped food (bag of chips, granola bar etc.) do you eat each day?
    a. None
    (b.) Between 1 and 3
    c. 4 or more

Average Servings:

- *Red meat - 4 card deck size portions per week.*
- *White meat - 4 card deck sized portions per week.*
- *Fish - 2 card deck sized portions per week.*
- *Eggs - 12 eggs per week.*
- *Dairy - 5 cups a day.*
- *Grains - 5 cups a day.*
- *Fruits & Vegetables - 4 cups a day.*

– PURCHASES –

28. In the past year, how many new electronics has your family purchased?
    a. None
    b. Between 1 and 3
    (c.) 4 or more
29. In the past month, how many new things have your family purchased for you? (Excluding food and electronics.)
    (a.) More than 15
    (b.) Between 11 and 15
    c. Between 6 and 10
    d. Between 1 and 5
    e. Under 5
30. How often do you or your family return items that you have recently purchased?
    a. Often
    b. Sometimes
    (c.) Never
31. Do you ever do any of the following: buy vintage or second hand clothing, participate in a clothing swaps, repair damaged clothing, donate or hand down clothing that no longer fits?
    a. Yes
    (b.) No
32. On average how many large garbage bags do you throw out a week?
    a. 1 bag
    (b.) 2, 3 or 4 bags
    c. 5, 6 or 7 bags
    d. 8, 9, or 10 bags
    e. More than 10 bags
33. Before you throw things away do you try to either give them away, recycle them, or repurpose them?
    a. Whenever I can
    b. Sometimes
    (c.) Never
34. Do you recycle magazines, newspapers, and other paper products?
    (a.) Yes
    b. No
35. Do you recycle glass and plastics?
    (a.) Yes
    b. No
36. Do you recycle aluminum and other metals?
    (a.) Yes
    b. No

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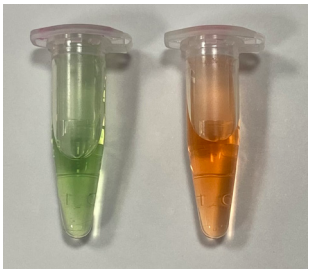
MODULE II

Total CO_2e Drops Added: 245
Color Change: Green to Orange



Picture of Starting Atmosphere (left) and Carbon Footprint Atmosphere (right).

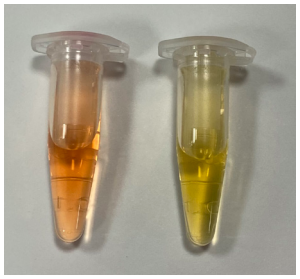
MODULE III

Selected Action #5 – "Do you know someone who is buying a car this year? Find time this week to ask them if they are factoring miles per gallon into their decision."

Talked to Q about my next assignment's car being electric. He said he would look into it. If the acceleration and max speeds are similar, he even said he would consider making it a division policy. I like the idea of not having to find a gas station to refill my car during working hours but think I would still like gas as a backup opinion. (Although truthfully most of my cars don't last long enough to need refueling /re-charging.) Perhaps I can also talk to Q about whether we have a good car/car part recycling program in place.

MODULE IV

Action #5:
9 impact points. Added 90 drops (9 impact points x 1 drop per point x 10 groups)



Picture of Classroom Carbon Footprint Atmosphere (left) and Classroom Carbon Handprint Atmosphere (right.)

Please refer to the kit insert for the Answers to Study Questions

Please refer to the kit insert for the Answers to Study Questions

Appendix A
Customizing Your Class's Carbon Footprint Questions or Carbon Handprint Actions

One size does not fit all. Both the Carbon Footprint Questions and Carbon Handprint Actions sheets associated with this experiment are available as open documents on our website so that you or your class can delete, add, or modify these questions and actions. Below are student instructions for a Module I or Module III extension activity that takes advantage of these documents.

FOR THE CARBON FOOTPRINT QUESTIONS

1. **BRAINSTORM** activities that you do daily that may release carbon pollution. **RECORD** ten in your notebook or below.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

2 **READ** through the "Carbon Footprint Questions" on pages 11 and 12.

3. Are there any important areas in your life that are not included in the current questions? If so **WRITE** a multiple choice question that describes this area as well as several potential answers. Record this in your notebook or below.

_____

_____

_____

_____

_____

_____

4. As a class **DECIDE** which additional questions should be added.

5. For added questions, **RESEARCH** and **ESTIMATE** approximately how many tons of carbon dioxide would be released by an individual or family in a year for each action choice (a, b, c, d, etc.). Then **MULTIPLY** these numbers by 10 to convert to CO_2e drops for Module II. These will need to be added to Table 1 on page 11 by hand.

6. Have your teacher or a group **UPDATE** the Carbon Footprint Questions and Key with your class's additions/modifications and then **DISTRIBUTE** the new version to everyone.

continued

Appendix A
Customizing Your Class's Carbon Footprint Questions or Carbon Handprint Actions, continued

FOR THE CARBON HANDPRINT ACTIONS

1. **READ** through the "Carbon Handprint Actions" on pages 16, 17, and 18.

2. **BRAINSTORM** additional actions that you could take that would reduce the size of your carbon footprint and **RECORD** them below.

_____

_____

_____

_____

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3. **SELECT** one or two of your favorite ideas and scale them into a projects or habit that could be accomplished or practiced within the next week.

_____

_____

_____

_____

_____

_____

4. As a class **DECIDE** which additional actions should be added.

5. For added actions, **CREATE** an impact number based on how much you think the action will reduce carbon emissions and how long the action will take. Actions that take less than an hour should get an impact number between 1 and 5, while actions that take more than an hour should get an impact number above 5.

6. Have your teacher or a group **UPDATE** the Carbon Handprint Actions with your class's additions/modifications and then **DISTRIBUTE** the new version to everyone.