**MODULE 3, Lesson 1: What's Your Carbon Number: Introduction to Carbon EPI**

Grades: 6-12

Duration: 4 class periods: 2 (45-50 minutes) lessons and 1 (90-100 minutes) lesson

Objective:

- Students will be able to make sense of embodied carbon costs in every day choices
- Students will be able to practice mathematic and scientific conversion skills
- Students will be able to use data to analyze the carbon output generated by different lifestyles
- Students will be able to use models to visualize the scale and magnitude of $CO_2$ that results from our lifestyle choices

Materials: Activity 1- index cards or matching worksheet, calculator (optional); Activity 2- chart paper or white board, student laptops; Activity 3- construction paper, rulers, scissors, tape (alternatives: clay and popsicle sticks), calculator (optional), stopwatches

**Suggested Standards:**

**NYS Content Standards:**

Grade 6-8 Science Standards:
Standard 1—Analysis, Inquiry, and Design
M2.1; M3.1; S1.1; S1.3; S2.1
Standard 2—Information Systems: 1.5 .
Standard 6—Interconnectedness: Common Themes
2.1 ; 2.2
Standard 7—Interdisciplinary Problem Solving
1.1; 1.2; 2.1 .

6-8 Life Science Standards
Standard 4:
7.1e ; 7.2a; 7.2c; 7.2d

Grades 6-8 Physical Setting Standards
Standard 4: 2.1a

Grades 9-12 Science Standards:
Standard 1:
1.1c ; 1.2a; 1.2b; M1.1; M2.1
Information Systems Key Idea 1
Standard 6—Interconnectedness: Common Themes
2.1; 3.1
Standard 7—Interdisciplinary Problem Solving: 1.2

Grades 9-12 Living Environment Standards
Standard 4:
6.1c ; 6.3c; 7.1b; 7.1c; 7.2a

Grades 9-12 Earth Science Standards
Standard 4: 2.2d

Grades 6-12 Technology Standards:
Standard 5 – Technology
Computer Technology 3

**Next Generation Science Standards:**

Grades 6-8 Life Science Standards:
MS-LS2-4

Grades 6-8 Earth and Space Science Standards:
MS-ESS3-3; MS-ESS3-4; MS-ESS3-5

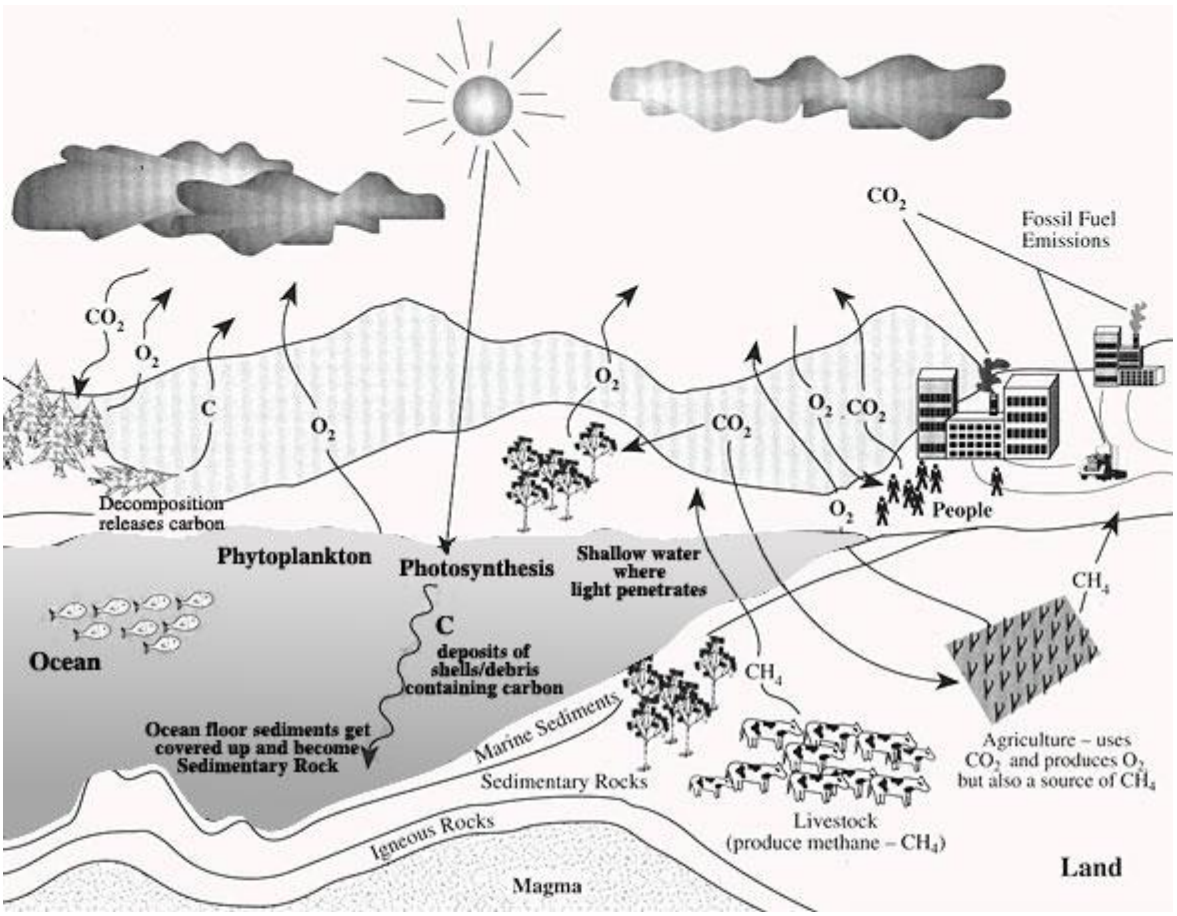
Grades 9-12 Life Science Standards:
HS-LS2-7

Grades 9-12 Earth and Space Science Standards:
HS-ESS2-4

ACTIVITY 1:

**Ordering Lifestyle Activities Based on Carbon (45-50 minutes)**

To introduce the concept of the carbon cycle, students must have a basic understanding of what the urban carbon cycle looks like. Begin by familiarizing students with a basic image of the carbon cycle (see image below) to introduce basic carbon cycle concepts. Students should have an understanding of the fundamentals of this concept before engaging in the activities included in this lesson.




Original image: http://www.bigelow.org/foodweb/carbon_cycle.jpg

Begin this lesson by asking students to generate a list of activities that occur in urban settings that would increase carbon output. These activities should be ones that are potentially relatable to students' everyday lives or the lives of their families.

To reinforce these concepts and allow students to get an understanding on the scale of carbon usage, students will work in small groups to 'order' various activities based on their carbon output. The following six activities will be presented to students (options include printing the description of each activity on a separate index card or creating a "matching" worksheet) and their task will be to determine the order of activities from lowest amount of carbon output (in metric tons) to highest.

*For more information on these calculations, consult the corresponding references for how and/or why these activities generate the stated $CO_2$ outputs.*

- Doing a load of laundry (warm wash and tumble dry)[1]
  - 0.0024 metric tons of $CO_2$
- Drying your hands (using 3 paper towels after each wash)[2]
  - 0.00003 metric tons of $CO_2$
- Doing the dishes (by hand, with extravagant use of water)[3]
  - 0.008 metric tons of $CO_2$
- Taking a vacation (roundtrip flight from New York to London, economy class)[4]
  - 2 metric tons of $CO_2$
- Heating your home (per cubic foot with natural gas- annually- based on national average monthly consumption of 5,583 cubic feet of gas)[5]
  - 3.65 metric tons of $CO_2$
- Driving one mile (national average of tailpipe $CO_2$)[6]
  - 0.000411 metric tons of $CO_2$

After students have determined their guess, select a few student groups to share out their order and explain *why* they made those decisions. After several groups have shared their thoughts, reveal the correct order and facilitate a discussion about the scale of the carbon output across the activities. For example, what are the impacts of car-pooling on the reduction of $CO_2$ emission?

A potential extension activity could see students calculating relationships between activities.

---

[1] Mike Berners-Lee and Duncan Clark, "What is the Carbon Footprint of…A Load of Laundry?," *The Guardian*, November 25, 2010, https://www.theguardian.com/environment/green-living-blog/2010/nov/25/carbon-footprint-load-laundry.

[2] Mike Berners-Lee, "What is the Carbon Footprint of…Drying your Hands?," *The Guardian*, August 5, 2010, https://www.theguardian.com/environment/green-living-blog/2010/aug/05/carbon-footprint-drying-hands.

[3] Mike Berners-Lee and Duncan Clark, "What is the Carbon Footprint of…Doing the Dishes?," *The Guardian*, August 19, 2010, https://www.theguardian.com/environment/green-living-blog/2010/aug/19/carbon-footprints-dishwasher-washing-up.

[4] Mike Berners-Lee, "What is the Carbon Footprint of…Using a Mobile Phone?," *The Guardian*, June 9, 2010, https://www.theguardian.com/environment/green-living-blog/2010/jun/09/carbon-footprint-mobile-phone.

[5] US Environmental Protection Agency, "Household Emissions Calculator Assumptions and References," *Greenhouse Gas Emissions*, EPA, last modified August 9, 2016, https://www.epa.gov/ghgemissions/household-emissions-calculator-assumptions-and-references.

[6] US Environmental Protection Agency, "Greenhouse Gas Emissions from a Typical Passenger Vehicle," *Green Vehicle Guide*, EPA, last modified March 25, 2016, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle-0.

EXAMPLE: Students will be provided with the carbon output of two different activities in each scenario. They will work in small groups to determine the extent to which each activity would have to be completed in order to result in equivalent amounts of carbon output.

<u>Sample Question:</u> How many loads of laundry (assuming a household does 2 loads of laundry a week) would you have to do in a year to equate to driving 15 miles per day for a year?

<u>Sample Procedure:</u>

**Step 1: Calculate how much $CO_2$ is produced annually from washing 2 loads of laundry per week.**

- Calculation:
  - Doing 1 load of laundry = 0.0024 metric tons x 2 (loads) = 0.0048 metric tons per week
  - 0.0048 x 52 (weeks in a year) = 0.2496 metric tons of $CO_2$ per year

**Step 2: Calculate how much $CO_2$ is produced annually from driving 15 miles a day.**

- Calculation:
  - Driving 1 mile = 0.000411 metric tons x 15 (miles) = 0.006165 metric tons per day
  - 0.006165 x 365 (days in a year) = 2.25 metric tons of $CO_2$ per year

**Step 3**: **Determine the difference in the rate of carbon output between both activities.**

Divide the ‘driving’ number by the “laundry” number to determine how much greater the former is than the latter:

- Calculation: 2.25 metric tons ÷ 0.2496 metric tons = 9 (rounded to the nearest whole number)

**Step 4**

Multiply the number of loads of laundry a household does per week (2) by 9 in order to determine how many loads of laundry you would have to do per week on an annual basis to generate the same carbon output as driving 15 miles per day for a year.
2 x 9 = 18 loads of laundry per week.
Multiply that number by 52 (weeks in a year) to determine the number of total loads.
18 x 52 = 936 loads of laundry

**Sample Answer:**
You would have to do 936 loads of laundry a year to generate the same carbon output as driving 15 miles daily for a year.

ACTIVITY 2:

**Calculating Carbon Output across Lifestyles (45-50 minutes)**

Now that students have an understanding of the carbon cycle, they will explore carbon output across different lifestyles on Visionmaker.

As a class, you should collectively create a vision that encompasses the surrounding area of your school. Once the specific block(s) is selected, students should start off by exploring the *Lifestyle Selectors* by clicking the information button to see the parameters and lifestyle choices that influence ecosystem cycles of population, carbon, water, and biodiversity. Students will once again look at the different parameters and determine which ones they think have an impact on carbon. Each student should provide a short written explanation to support their rationale and justify their argument (they can refer back to the image from Activity 1 for assistance).

Moving forward:

1. Students will work in small groups that will be representative of each lifestyle (Lenape, Average New Yorker, Average American, Eco-conscious, and Average Earthling).
2. The climate and precipitation event dropdowns should be uniform for the entire class. The independent variable that they are exploring is lifestyle.
3. In their groups, within the vision extent, students will examine how their assigned lifestyle impacts the carbon EPI for both greenhouse gases ($CO_2$) and solid waste under the *Environmental Performance* tab.
4. Without making any modifications to the current vision, students should monitor the change in carbon outputs as they change the lifestyles (recording worksheet provided as an attachment).
5. One representative from each group will chart their greenhouse gases ($CO_2$) and solid waste data into a single graph that will display the entire class's data (the teacher should provide a pre-made double-y axis bar graph template that includes a proper title, identification of the x and y axes, units, and scale for the students)
    a. Title: The effect of lifestyle on $CO_2$ emissions and solid waste
    b. Y axis
        i. $CO_2$ emissions (unit = kg $CO_2$ / year)
        ii. Solid waste (unit = kg solid waste/year)
    c. X axis: Lifestyle
    d. Scale: teacher to determine
6. What significant differences do they notice? Were the trends and patterns what they would expect? Why, or why not?

Extension Activity

As an extension each group could further examine the specific inputs and outputs of carbon to see how the various lifestyles differ under the "data summary" or "inputs and outputs" tabs. It is important to open the various subcategory arrows to see values that impact the totals. Discussion around the specific values for each lifestyle could ensue (*impacts of lifestyle will be explored in further detail in Module 4*).

*Examples of subcategories to further explore for extension activity:*

Carbon Inputs

- *Foods eaten*
- *Fuels consumed*
    - *Biomass fuels consumed*
        - *Wood and other biomass*
        - *Municipal solid waste*
            - *using grid electricity*
    - *Fossil fuels consumed*
        - *Gasoline*
            - *Transporting people*

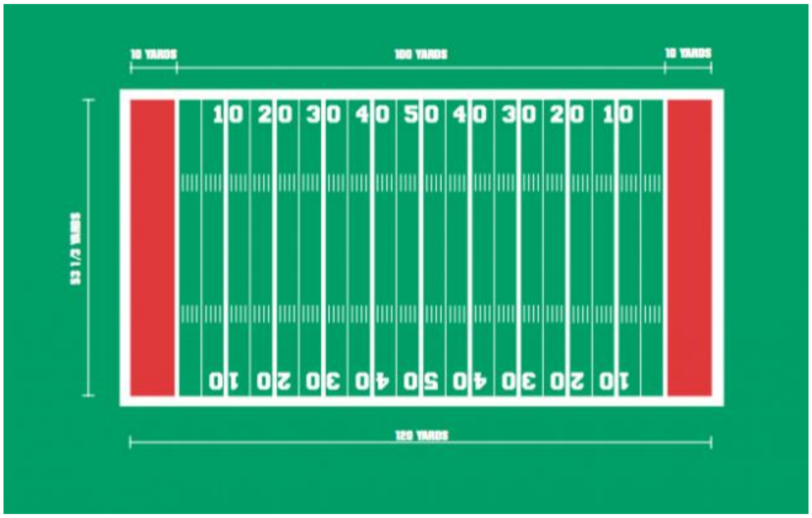
Carbon Outputs

- *Greenhouse gases*
    - *Carbon dioxide*
        - *Fuel combustion ($CO_2$) output*
            - *Coal*
            - *Gasoline*
            - *Natural gas*
            - *Wood and other biomass*
- *Wastes*
    - *Solid waste*
        - *Non-biodegradable solid waste*
            - *Residential use*
            - *Restaurant use*
            - *Transportation use*

ACTIVITY 3:

**Measuring the weight of lifestyle choice on $CO_2$ (90-100 minutes)**

Building on Activity 2, each lifestyle group will make physical, to-scale models of an NFL football field. The purpose of Activity 3 is to give students a visual with which they can contextualize the magnitude of $CO_2$ that each lifestyle creates per year.




Orginial image: http://www.stack.com/a/the-dimensions-of-a-football-field

The dimensions of a standard football field are as follows: 120 yards long (the playing field is 100 yards long, and each end zone is 10 yards deep) and 53 1/3 yards wide. **For the sake of this activity, we will extend the width of the field to 60 yards to make scaling of the model easier.** Teachers should have students create models that are 4 ft long x 2 ft wide. Students will be expected to use proper measurement tools to scale and convert numbers to appropriate units of measurement as needed.

Bill Chameides, Ph.D., a science adviser to the Environmental Defense Fund and member of the National Academy of Sciences has helped people visualize what a single ton of $CO_2$ would look like; "Picture a football field, and then imagine a round balloon with one end lined up on the goal line and the other on the 10 yards line – that is, a balloon with a diameter of 10 yards. If that balloon were filled with $CO_2$, it would weigh about 1 ton; it would be a 1-ton $CO_2$ balloon."[7]

Students will be responsible for figuring out how to convert kilograms to tons in order to create appropriate sized balloon figures in their model to represent the carbon levels for their group's specific lifestyle (Lenape, Average New Yorker, Average American, Eco-conscious, and Average Earthling). How many balloon figures would they need in their football field to represent the kg $CO_2$/year for their lifestyle, and how many total lengths of the football field would they have to cover to represent the total number of balloons? *Note that some students' answers might be quite large so it may not be practical to have a representative balloon for each carbon ton. The bigger take away is for students to recognize the magnitude of $CO_2$ that each lifestyle creates per year.*

The fastest 40 yard dashes in NFL history have been achieved by cornerbacks Justin King, Tyvon Branch, and Jonathon Joseph in 4.31 seconds. Students should figure out how long it

---

[7] Bill Chameides, "Picturing a Ton of $CO_2$," *Climate 411*, Environmental Defense Fund, http://blogs.edf.org/climate411/2007/02/20/picturing-a-ton-of-co2/.

would take these men to run the total representative distance of their group's lifestyle carbon output.

*Example*

Eco-conscious lifestyle is 16,000,000 kg $CO_2$/year = 16,000 tons $CO_2$/year

1 ton of $CO_2$/year = 10yards

16,000 tons = 160,000 yards ÷ 40 yards (distance of the race) = 4000 races (each race is 40 yards)

4000 races x 4.31 sec = 17,240 sec = 4 hr: 47 min: 20 sec

If time allows, the students could then run a 40 yard dash race themselves. Find an appropriate area outside or in the gymnasium. Each group can elect one team member to represent their lifestyle group in the race. There should be 5 separate time keepers, one for each group. Once the race is over and the times are recorded, each group should then calculate the amount of time it would take to run the total representative distance of their group's lifestyle carbon output with their teammate's 40 yard dash time. *This segment of the activity is meant to target kinesthetic learners, giving students with different learning modalities the opportunity to engage and participate in the lesson. Student groups will not be able to compare their results with one another since they will likely have varying race times. However, the race section is intended to be a fun participatory segment of the activity that enables them to also continue practicing targeted conversion skills.*

To conclude this activity, each student should individually write their own reflection about the overall activity with the following prompts:

**WHAT**: What from this activity resonated with you?

**SO WHAT**: So what does this mean to you (make a connection to your everyday lifestyle choices)?

**NOW WHAT**: Now what does this mean for you in the future? What actions will you take to reduce your carbon output?

**Directions:**

Use the following worksheet to have students in small groups record how their particular lifestyle affects the Carbon EPI for both greenhouse gases and solid waste. Without making any modifications to the current vision, students should monitor the change in carbon outputs as they change the lifestyles.

| **Lenape Group** | | |
|---|---|---|
| Climate: (should be same for all groups) | Precipitation: (should be same for all groups) | |
| Greenhouse Gas: | | (kg $CO_2$/year) |
| Solid Waste: | | (kg solid waste/year) |

| **Average New Yorker Group** | | |
|---|---|---|
| Climate: (should be same for all groups) | Precipitation: (should be same for all groups) | |
| Greenhouse Gas: | | (kg $CO_2$/year) |
| Solid Waste: | | (kg solid waste/year) |

| **Average American Group** | | |
|---|---|---|
| Climate: (should be same for all groups) | Precipitation: (should be same for all groups) | |
| Greenhouse Gas: | | (kg $CO_2$/year) |
| Solid Waste: | | (kg solid waste/year) |

| Eco-Conscious Group | |
|---|---|
| Climate: (should be same for all groups) | Precipitation: (should be same for all groups) |
| Greenhouse Gas: | (kg $CO_2$/year) |
| Solid Waste: | (kg solid waste/year) |

| Average Earthling Group | |
|---|---|
| Climate: (should be same for all groups) | Precipitation: (should be same for all groups) |
| Greenhouse Gas: | (kg $CO_2$/year) |
| Solid Waste: | (kg solid waste/year) |