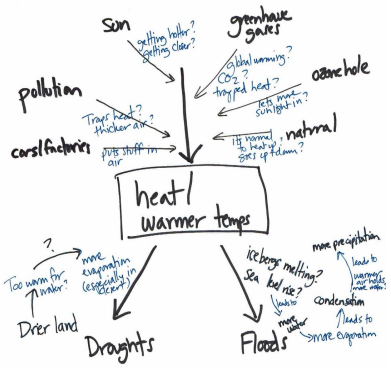
UNIT STORYLINE

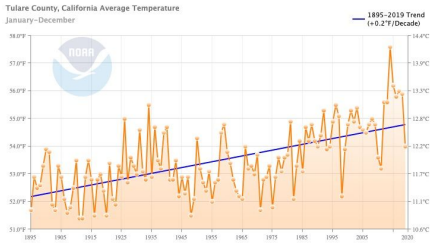
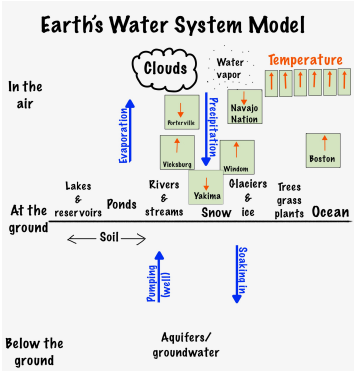
How students will engage with each of the phenomena

HANDS-ON/ LAB ACTIVITIES | VIDEOS OR IMAGES | DATA SETS | READINGS | COMPUTER INTERACTIVES

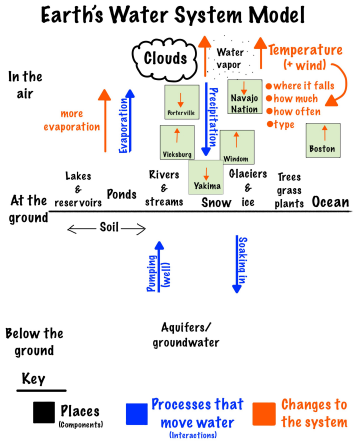
Unit Question: How do changes in Earth's system impact our communities and what can we do about it?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 3 days **Why are floods and droughts happening more often?** Anchoring Phenomenon	 *Floods and droughts are increasing across the US and there is a pattern of rising temperatures associated with both.*	We observe two news clips of extreme flood and drought events and share our own water stories. We examine headlines that show a "new normal" of increased floods and droughts and notice a pattern of rising temperatures. We develop an initial model explaining what could be causing warmer temperatures and how warmer temperatures could lead to both droughts and floods. We develop a Driving Question Board (DQB) and brainstorm investigations and sources of data that could help us figure out answers to our questions. We figure out: • Floods and droughts are increasing. • Floods and droughts are linked to a change in precipitation. • Heat waves and warmer temperatures are linked to the increase in floods and droughts.	

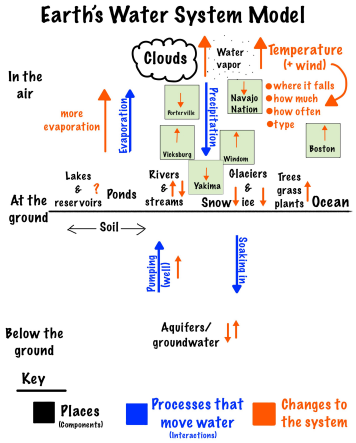
⇓ **Navigation to Next Lesson:** We figured out that increased temperatures seem to be linked to increases in floods and droughts, but we have a lot of questions about what is causing this and where all of the water is coming from or going to. We want to look at more places than just the two places in the videos to help figure out what is happening.

LESSON 2 3 days **What would we normally expect for these places and how do we know it's really changing?** Investigation	 *Long-term measurements show that changes in temperature and precipitation are not normal for these places.*	We develop a systems model to describe Earth's water system. We analyze data to determine what is normal and not normal about temperature and precipitation as it relates to floods and droughts. We do this with our community and six case sites in the United States. We figure out: • Earth's freshwater is distributed in the air, at the ground, and below the ground and moves in between these spaces. • Year-to-year variability in precipitation and temperature is a normal pattern. • Data averaged over long periods of time can give us the trends for an area. • Precipitation or heavy storm events show increasing trends in flood areas. • Precipitation, groundwater, and snowpack show decreasing trends in drought areas. • Temperatures are increasing for all of the places we investigated.	

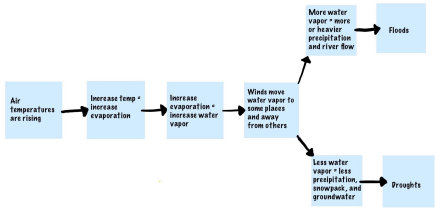
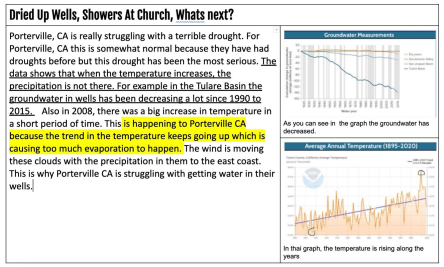
⇓ **Navigation to Next Lesson:** We are wondering if the rise in temperature is related to some places being drier and some places being wetter.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 3 2 days **How would increased temperatures affect evaporation?** Investigation	 *When we warm wet and dry soil at the surface we observe an increase in evaporation. This increases the overall water vapor in the air which does not move around the atmosphere evenly.*	We create bottle setups to test how increased temperatures affect evaporation rates. We also view visualizations of water vapor movement across the US and ocean temperatures in an open system. We figure out: • Increased temperatures lead to increased evaporation rates and more water vapor in the atmosphere. • Evaporation happened in all cases, but more moist conditions had higher evaporation rates than drier conditions. • The amount of water vapor is not the same for every location and winds move the water vapor to different locations. • Drought areas may be getting drier when water vapor moves away from the location, while flood areas may be getting wetter when more water vapor moves toward the location. • Cooler ocean water and landforms may affect how much water vapor gets to a location.	

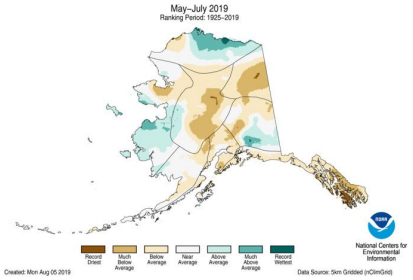
⇓ **Navigation to Next Lesson:** We observe that increased temperatures cause an increase in evaporation and water vapor in the air. Winds and ocean temperatures affect the movement of water vapor in the atmosphere explaining more about the location of droughts and floods. We wonder how increased temperatures may be affecting other parts of Earth's water system.

LESSON 4 1 day **Are rising temperatures affecting anything else in Earth's water system?** Investigation	 *Snow, ice, glaciers, and groundwater are decreasing in many areas, while sea level is rising. Earth's water system is changing.*	We obtain additional scientific and technical information about other components of Earth's water system and how those components are changing as temperatures increase. We conclude that all components and processes in the system have been affected by a temperature rise. We update our model and add an entry to our Progress Tracker. We figure out: • Changes to sources of water affect communities in different ways. • A small change in temperature in the atmosphere can have big changes in Earth's water system.	

⇓ **Navigation to Next Lesson:** We figure out that a small increase in temperature is having big impacts on all parts of the water system creating different problems for communities. We think we can explain how rising temperatures have led to droughts and floods in our communities.

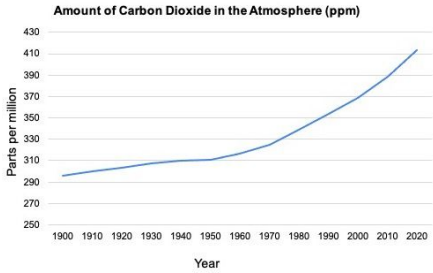
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 2 days **How are rising temperatures changing water stories in these communities?** Putting Pieces Together, Problematizing	 *Changes in community water sources can be explained through data and evidence.*	We use our key model ideas from previous lessons to construct explanations, using evidence, about how changes in temperature are having impacts on the water stories in our case site communities. We peer review our explanations and revise them using the feedback from our peers. We figure out: • Small changes in one part of Earth's system can have big impacts on another part. • An increase in temperatures can be used to explain the cause for multiple climate-related phenomena.	

⇓ **Navigation to Next Lesson:** Now that we understand what is causing droughts and floods, we are wondering if we can apply these ideas to another headline we read about in Lesson 1.

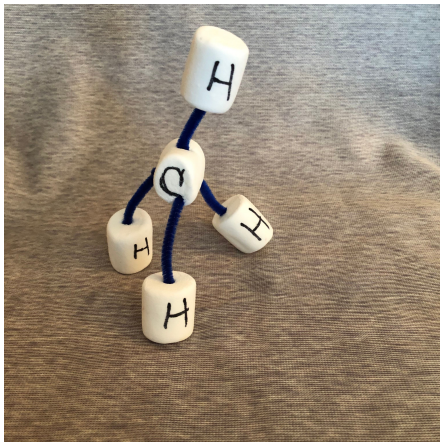
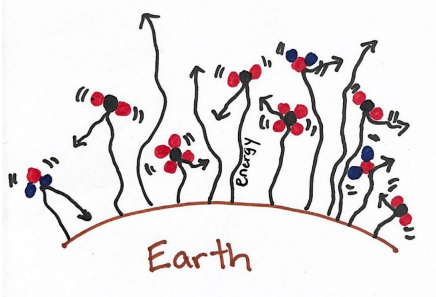
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 6 2 days **How are rising temperatures connected to two seemingly different phenomena?** Putting Pieces Together, Problematizing	 *Changes reported by headlines and by an Alaskan whaler can be explained through the increasing temperatures in Alaska.*	We revisit our Alaskan headlines about wildfires and also learn about another community in Alaska that is experiencing multi-year sea ice loss. We apply our key model ideas in a transfer task to explain how an increase in temperatures is causing both phenomena to occur. We figure out: • An increase in temperatures can cause an increase in both wildfires and a decrease in multi-year sea ice.	**Claims** / **Data we might need** Alaska is experiencing bad wildfires It is dry and hot in the Arctic — Wildfire data Temperature data Precipitation data Drought data The amount of old, multi-year sea ice is decreasing There is less sea ice than there was in the past There is more water where sea ice should be — Sea ice data over time - age of sea ice - amount of sea ice Temperature data over time

⇓ **Navigation to Next Lesson:** We figured out that the Alaskan claims are caused by rising temperatures. We also believe that the temperatures may continue to rise in the future. After visiting the class model and the Driving Question Board, we realized we still have questions about why the temperatures are increasing, along with what is causing that increase.

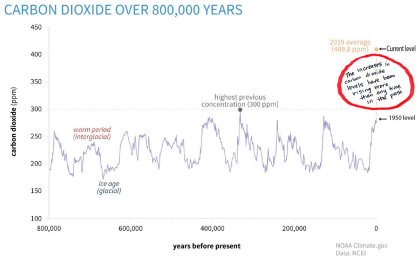
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 7 1 day **Are there any changes in the air that could be related to rising temperatures?** Investigation	 *The concentration of some atmospheric gases have stayed relatively stable over time, while other gases have increased at an unusual rate.*	We wonder if changes in the air are related to the rise in temperatures. By looking at data, we build our understanding of the meaning of parts per million and figure out how to find the percent change in the quantity of these gases over time. We notice that, while some gases have not changed at all, some have changed very little, and other gases show an unusual increase over the 100-year period. We figure out: • The atmosphere is made from different concentrations of gases. • Some gases have not really changed over time, but some show an unusual increase. • Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate.	**Model Ideas List** • Some gases have not really changed over time, but some show an unusual increase. • Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate.

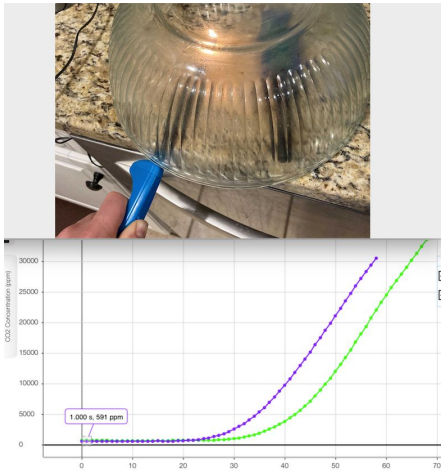
⇓ **Navigation to Next Lesson:** We figure out that carbon dioxide and methane, which make up a small percent of the atmosphere, are increasing at a high rate. Based on these new findings, we wonder if the gases that are rising are related to or causing the temperatures going up.

LESSON 8 2 days **Are changes in carbon dioxide and methane related to or causing temperatures to increase?** Investigation	 *Greenhouse gases absorb and release energy in the atmosphere regulating Earth's temperature.*	We use molecular models to investigate the way molecules move in response to energy transfer. We investigate this idea further using an interactive showing how molecules move when energy is absorbed. Using these ideas and the ideas from a reading, we figure out that because greenhouse gases absorb, vibrate, and release energy, they keep our atmosphere warm. We apply these ideas to what we learned about GHGs increasing in our atmosphere to figure out that increasing GHGs are why temperatures are currently increasing. We figure out: • GHGs are gas molecules in the atmosphere that absorb, vibrate, and release energy back into the atmosphere. This keeps Earth at a livable temperature. • As the amount of GHGs increases in our atmosphere, they cause the atmosphere to get warmer.	

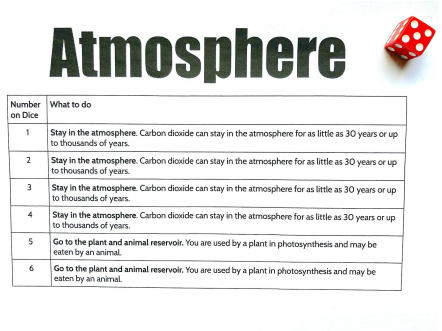
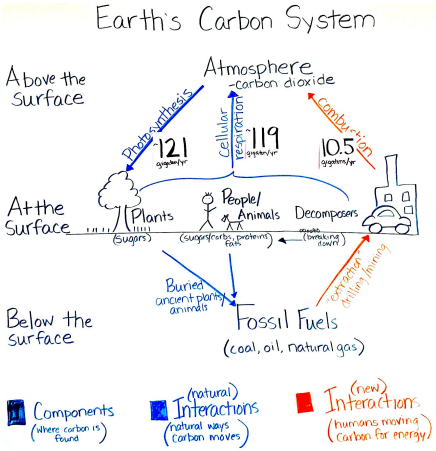
⇓ **Navigation to Next Lesson:** We figure out that increasing GHGs are causing the temperatures to rise, and we wonder if this rise in GHGs is normal.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 1 day **Are the changes in the amount of CO2 in the atmosphere part of normal cycles that Earth goes through?** Investigation	 *Ice core samples contain trapped bubbles of gases.*	We carry out an investigation to determine if gas can be trapped in ice. When we figure out it can, we find out more about how scientists use ice core samples from locations on Earth that have very old ice to determine the amounts of carbon dioxide in the air over time. We focus on carbon dioxide because we know that recently it has been rising the most. We figure out: • Levels of CO_2 are increasing at a faster rate than the normal cycles, which means the new levels are out of the normal range. • CO_2 levels over the last 100 years have been rising consistently. • We look back at data from hundreds of thousands of years through analyzing ice core data and find there are cycles, but the last 100 years are not following the normal cycle.	 *Climate.gov*

⇓ **Navigation to Next Lesson:** We figured out that CO2 levels are increasing at a faster rate than normal cycles. Now we want to know what is different today than in the past that is causing more CO2 to be in the air?

LESSON 10 2 days **What is happening in the world to cause the sharp rise in CO2?** Investigation	 *Data shows a rapid increase in fossil fuel use, CO2 emissions, and human population in the last two centuries.*	We zoom into the last 200 years of Earth's history to understand what led to a rapid increase in CO_2 emissions. We watch a visualization and read about key innovations in human history that transformed the types of energy used to power our communities. We figure out: • Large deposits of mineral resources (such as "fossil fuels") are used to power our communities and transportation networks, and this use has increased over time. • Population growth increases consumption of resources (per-capita consumption). • A growing population that consumes large amounts of mineral resources is correlated with the rapid increases in CO_2 in Earth's atmosphere.	**Model Ideas List** • Some gases have not really changed over time, but some show an unusual increase. • Carbon dioxide and methane are a small percent of the atmosphere but are increasing at a high rate. • GHGs absorb, vibrate, and release energy back into the atmosphere. • As the amount of GHGs increase in our atmosphere, they cause the atmosphere to get warmer. • CO_2 levels are higher than any time in the past and seem to be increasing really fast outside the normal range. • ↑ population + ↑ mineral resource use = ↑ CO_2 in atmosphere • CO_2 and H_2O (greenhouse gases) are products of the combustion of fossil fuels.

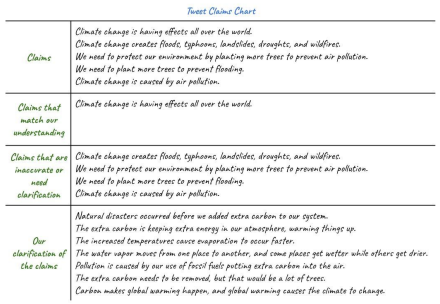
⇓ **Navigation to Next Lesson:** We are wondering what fossil fuels, which provide us with energy, are made of?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 11 1 day **Why could burning fossil fuels create a problem for CO2 in the atmosphere?** Investigation	 *Burning fossil fuels adds CO2 to the atmosphere at a faster rate than is taken out by photosynthesis.*	We modify an Earth's Carbon System model to represent the locations of carbon and processes that move carbon around. We simulate these processes using a kinesthetic activity. We figure out that photosynthesis cannot take up CO_2 at the same rate that burning fuels puts CO_2 in the atmosphere and that this is creating a buildup of CO_2 in the atmosphere. We figure out: • Photosynthesis is a way to get CO_2 out of the atmosphere, but the rate of photosynthesis is not enough to take up CO_2 from combustion of fossil fuels and cellular respiration combined. • Combustion of fossil fuels is creating a carbon imbalance in the atmosphere.	

Atmosphere

Number on Dice	What to do
1	**Stay in the atmosphere.** Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
2	**Stay in the atmosphere.** Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
3	**Stay in the atmosphere.** Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
4	**Stay in the atmosphere.** Carbon dioxide can stay in the atmosphere for as little as 30 years or up to thousands of years.
5	**Go to the plant and animal reservoir.** You are used by a plant in photosynthesis and may be eaten by an animal.
6	**Go to the plant and animal reservoir.** You are used by a plant in photosynthesis and may be eaten by an animal.

⇓ **Navigation to Next Lesson:** We figured out that CO2 entering the atmosphere is not balanced by CO2 taken out of the atmosphere. We think we can explain what is causing the temperatures to rise.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 12 2 days **How are changes to Earth's carbon system impacting Earth's water system?** Putting Pieces Together	 *Some social media posts need additional clarification to reflect accurate science ideas.*	We model the causal relationship between fossil fuel use and changing water resources. We review a tweet regarding climate change and its impacts, break the tweet down into claims, and clarify the information as a class. We take an assessment identifying claims made in another tweet and refute any inaccurate claims by providing an explanation of the causal relationships between human activities and climate change. We figure out: • Changes in the carbon system have an effect on Earth's water system. • We can use our scientific understanding to clarify claims about the connection between the carbon system and Earth's water system.	

Tweet Claims Chart

Claims	*Climate change is having effects all over the world.* *Climate change creates floods, typhoons, landslides, droughts, and wildfires.* *We need to protect our environment by planting more trees to prevent air pollution.* *We need to plant more trees to prevent flooding.* *Climate change is caused by air pollution.*
Claims that match our understanding	*Climate change is having effects all over the world.*
Claims that are inaccurate or need clarification	*Climate change creates floods, typhoons, landslides, droughts, and wildfires.* *We need to protect our environment by planting more trees to prevent air pollution.* *We need to plant more trees to prevent flooding.* *Climate change is caused by air pollution.*
Our clarification of the claims	*Natural disasters occurred before we added extra carbon to our system.* *The extra carbon is keeping extra energy in our atmosphere, warming things up.* *The increased temperatures cause evaporation to occur faster.* *The water vapor moves from one place to another, and some places get wetter while others get drier.* *Pollution is caused by our use of fossil fuels putting extra carbon into the air.* *The extra carbon needs to be removed, but that would be a lot of trees.* *Carbon makes global warming happen, and global warming causes the climate to change.*

⇓ **Navigation to Next Lesson:** While we now understand the connection between the changing carbon system and our changing water system, we still have questions about what we can do to help fix the problem of our changing climate.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

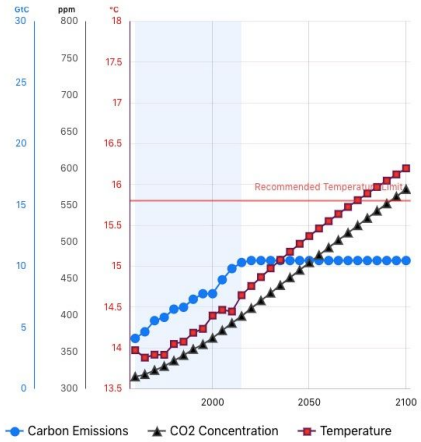
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 13

1 day

Why is solving the climate change problem so challenging?

Problematizing



As CO2 emissions increase, so do global temperatures. To reach equilibrium, emissions need to be cut by 9 gigatons per year.

We determine that the problem of increasing temperatures is due to the CO_2 imbalance in the atmosphere caused by human combustion. We use a simulation to determine what cuts are needed to emissions rates to reach equilibrium. We figure out:

- Our carbon imbalance in our atmosphere is due to human combustion.
- We release an estimated 10.5 gigatons of CO_2 from human combustion.
- Simply cutting emissions in half will not halve temperature increases.
- To reach CO_2 emissions equilibrium, emissions would need to be cut by 9 gigatons.
- Any reduction in emissions helps to slow the global temperature increase.

Change to emissions rate	Gigatons of carbon	Prediction of the effects on temperature and CO_2 concentration	Observations of Temperature and CO2 between now and 2100
Eliminate all carbon emissions.	0	*Temperatures and CO2 will go down quickly*	*Both went down but not that much (only .5 change in temperature)*
Cut emissions in half.	5.2	*Temperatures and CO2 will go down -but not as fast*	*Temperature and CO2 kept climbing! Temp increased faster than CO2 levels*
Cut it to 1/3	3.5	*Temperatures and CO2 will go down after going up for a while*	*Temperature and CO2 kept climbing! Didn't climb as fast or as much as with 5.2*
Cut it to 1/4	2.6	*Temperatures and CO2 will go down after going up for a while*	*Temperature and CO2 still went up but not as much (lines were flatter)*
Cut it to 1/8	1.3	*Temperatures and CO2 will go down*	*Temperature and CO2 still went down (a little bit)*

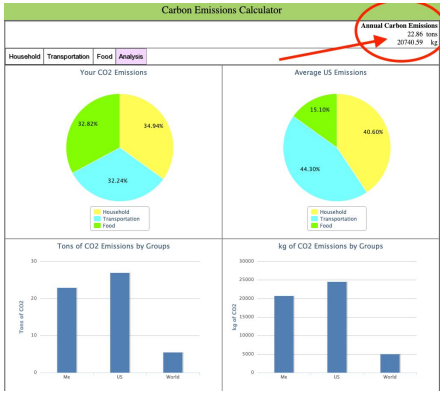
⇓ **Navigation to Next Lesson:** We think we've heard of things we can do to solve this, like turning off lights, changing out bulbs, driving less, eating less meat. But how much do our daily actions impact the CO2 levels in the atmosphere?

LESSON 14

1 day

What things can people do to reduce carbon dioxide going into the atmosphere?

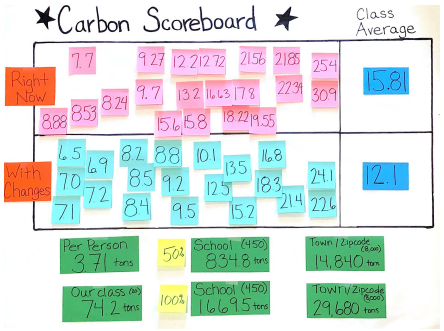
Investigation



Everyday actions and behaviors emit CO2, and changes to those behaviors can reduce emissions.

We calculate our daily carbon footprint and create a class Carbon Scoreboard. We calculate the average carbon footprint for someone in our class and compare it to the average American's footprint. We revisit our footprint and choose carbon reduction activities and behaviors we are willing to make that would reduce our carbon emissions and would benefit our family in other ways. We compound the effects of these changes if everyone in our classroom, school, and community are willing to make changes. We figure out:

- Changes to daily activities and behaviors can reduce atmospheric CO_2.
- If more people do these things, we will have further reduction in CO_2.
- Changes to behaviors are limited by other constraints, so each person may have different options available to them.



⇓ **Navigation to Next Lesson:** We are wondering not only how to engage more people in these kinds of behaviors, but also what other solutions could we consider on a larger scale?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it

LESSON 15

3 days

How can large-scale solutions work to reduce carbon in the atmosphere?

Investigation

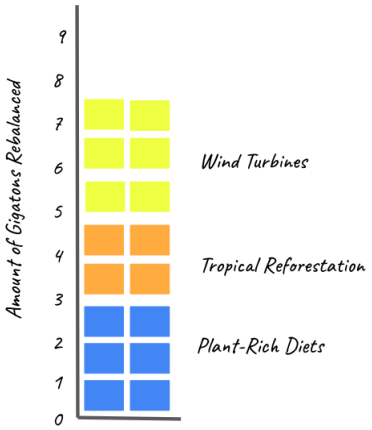
Evaluating the solution against our criteria and constraints:

Solution	Criteria: Ability to reduce CO_2 in the atmosphere	Constraint 1	Constraint 2	Constraint 3	Constraint 4	Constraint 5	Constraint 6
Plant Rich Diets	●●●						
Reducing Food Waste	●						
Wind Turbines	●						
LED Lighting	●						
Recycling	●						
Reducing Plastic	●						
Reforestation	●●●						

Solutions have differing effects towards the reduction of atmospheric CO2. Implementing multiple solutions can compound the reduction in CO2 emissions.

We use a Design Matrix to organize the different solutions for reducing CO_2 in the atmosphere that we evaluated last class. From our evaluations we determine our constraints for the solutions in trying to meet the criteria of reducing the imbalance of carbon in the air. We reevaluate each solution using our constraints and decide that multiple solutions would need to be implemented to meet our criteria. We figure out:

- There are many different solutions that can be implemented to reduce the amount of CO_2 being emitted into the atmosphere.
- There are some solutions that help take CO_2 out of the atmosphere, though there are very few of these.
- Implementing only one solution will not lead to a decrease of CO_2 in the air. Multiple solutions need to be done together in order for any reduction to occur to help decrease the imbalance of CO_2 in the air.



⇓ **Navigation to Next Lesson:** We figure out some likely solutions that are accessible for many people. Now we want to know who is responsible for implementing the solutions and what people are already doing.

LESSON 16

1 day

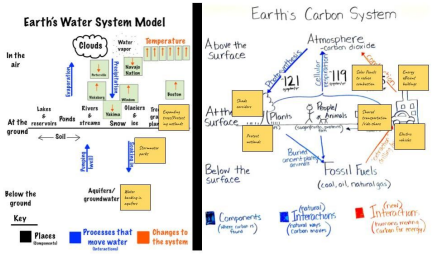
How are these solutions working in our communities?

Investigation

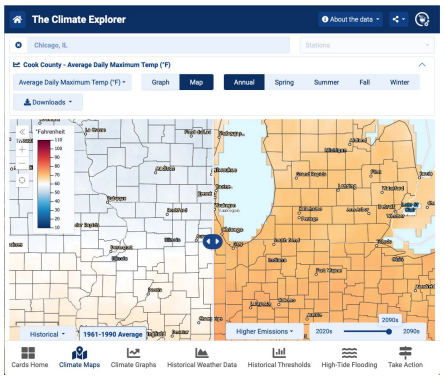
Community plans include ways to mitigate carbon or adapt to changes.

In this lesson, we obtain information from community plans to determine how the solutions are being used in the communities and how they rebalance carbon and/or help the community to become more resilient to changes already occurring in the community. We use these plans as examples to help motivate the need to evaluate and/or develop a plan for their own community. We figure out:

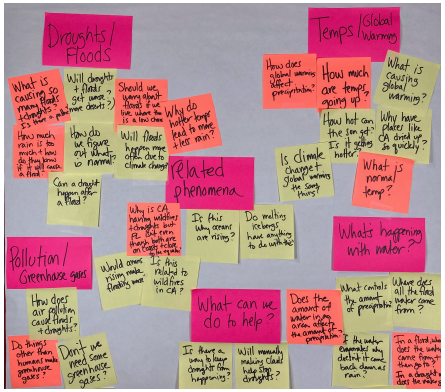
- Communities develop plans to rebalance CO_2 levels in the atmosphere while also building a more resilient community adapting to changes already occurring within the community.
- Plans include many solutions across different parts of the community and at different scales, from individual and family options to large-scale community solutions.



⇓ **Navigation to Next Lesson:** We are wondering if our community has a plan or if we should develop a plan for our community.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 17 4 days **What solutions work best for our school or community?** Investigation, Putting Pieces Together	 *Schools, communities, and businesses adopt new behaviors or technologies to contribute to rebalancing carbon and to build resilience to changes happening now.*	We create a checklist for what a resilience plan for our school and local community should include. We work in groups to design resilience plans that contribute to the long-term rebalancing of carbon and also prepare the community for change. We provide feedback to other groups and evaluate the plans by asking questions. We brainstorm how to communicate our plans to other audiences. We argue for the one best for our community. We figure out: • Communities can design plans to help rebalance carbon dioxide which will take awhile, but they can also do things to make the community resilient to changes happening now. • Communities design plans based on community member needs and characteristics of the community itself. • Some places and people may be more at risk for impacts in the community. • Solutions adopted at home and school can make the whole community more resilient.	*What an effective plan does* / *What we should include* *Tell people about the problem(s).* — ☐ *Our community will experience more drought or flood, or both.* ☐ *Some seasons might become drier or wetter than before.* ☐ *Some areas or some people in our community might be at more risk or more impacted.* *Teach people about what's causing the problem.* — ☐ *CO_2 is building up in the atmosphere.* ☐ *CO_2 traps energy in the atmosphere that causes temperatures to rise.* ☐ *Warmer temperatures means more evaporation and water vapor in the atmosphere, but it doesn't fall evenly.* ☐ *Photosynthesis is one way to take CO_2 out of the atmosphere but there are also ways to reduce putting it in the atmosphere. Some combination is necessary to solve the problem.* *Directs people to solutions.* — ☐ *Share solutions their community can take to:* ○ *Reduce CO_2 going into air* ○ *Pull CO_2 out of air* ○ *Be prepared for higher temperatures* ○ *Be prepared for more/less precipitation.* ☐ *Give people more than one way to help.* ☐ *Include different actions that different people can take in different situations.*

⇓ **Navigation to Next Lesson:** We will celebrate learning by answering questions from the DQB.

LESSON 18 1 day **What can we explain now, and what questions do we still have?** Putting Pieces Together	 *Asking questions about phenomena gives us a mission for our science learning.*	We identify the questions from our DQB that we can now answer. We celebrate all that we have learned in this unit and across the school year. We spend time identifying the questions that we did not answer and build a new DQB of these questions. We create a plan to answer some of them on our own and in school next year and beyond. We figure out: • Science learning is about asking questions and gathering evidence to answer those questions. • As some questions get answered, new questions come up.	

⇓ **Navigation to Next Lesson:** This is the last lesson in the unit.

LESSONS 1-18

33 days total