Climate change is happening, humans are causing it, and I think this is perhaps the most serious environmental issue facing us. - - - - - Bill Nye
Climate Change across the Secondary School Curriculum.

Climate change is a complex global issue that spans many disciplines. The curriculum spans several subject areas and cuts across national standards.

The Clark team will focus on creating lesson plans to cover a span of two weeks; i.e. one unit on Climate Change.

The SAME concepts will be taught in the SAME week to the SAME 9\textsuperscript{th} and 12\textsuperscript{th} grade students; with a focus on those concepts:

- Science
- Social Studies
- English
- Mathematics
- Technology
Teaching Strategies

- Teacher lecture
- Student research, reading and writing assignments.
- Students analyze geospatial data climate information
- Hands on activities
- Guest speakers/ expert presentations
- Science fair project submission
### DAY 4 – The Size of Our Footprints, it All Adds Up

<table>
<thead>
<tr>
<th></th>
<th>Science</th>
<th>Social Studies</th>
<th>Reading/Writing</th>
<th>Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade level (9 to 12)</td>
<td>9 to 12</td>
<td>9 to 12</td>
<td>9 to 12</td>
<td>9 to 12</td>
</tr>
<tr>
<td>Summary of lesson plan</td>
<td>Students learn that a carbon footprint is measured in pounds of carbon dioxide (CO2) emissions and that it is one way to measure one’s impact on the climate. Students discuss some things they can do to shrink their carbon footprints; focusing on the things they will do and use every day at home and at school. They create a plan on “How to Live Green”</td>
<td>Students compare carbon footprints of countries around the world. They compare high-income and low-income countries, i.e. higher counties having a higher per capita footprint due to CO2 from fossil fuels; and likewise why low-income countries tend to have much smaller carbon footprints.</td>
<td>Students will be involved in an activity which encourages them to use the reading and writing process to generate reactions to articles on global warming and carbon footprint to advance students’ point of view.</td>
<td>Students analyze the energy consumption of a hypothetical household to determine the amount of carbon dioxide they are adding to the atmosphere each year.</td>
</tr>
</tbody>
</table>
Climate Change

• Brief introduction to Climate Change
• Thermal Expansion and Sea Level Rise
• CO2 – Sources and Sinks
• Looking into Surface Albedo
• Glaciers: Then and Now
• CO2: How Much do you Spew?
What controls the climate?

The Sun & Earth’s orbit

Clouds

Volcanic eruptions

Reflective snow & ice

And the amount of greenhouse gases...
The global ocean conveyor belt is a constantly moving system of deep-ocean circulation driven by temperature and salinity.
Earth is warming...

Line plot of global mean land-ocean temperature index, 1880 to present, with the base period 1951-1980. The dotted black line is the annual mean and the solid red line is the five-year mean. The green bars show uncertainty estimates. Hansen et al., 2010-02-18, http://data.giss.nasa.gov/gistemp/graphs/, NASA GISS.
The rise has been relentless and shows a remarkably constant relationship with fossil-fuel burning, and can be well accounted for based on the simple premise that 57% of fossil-fuel emissions remain airborne. Here the number 57% was selected to fit the curve at the ends of the record, but what is significant is how well this link with fossil-fuel burning also fits the curvature in the record, sloping upwards less rapidly at the beginning, and more rapidly at the end.

http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons_3.html
CO₂ Over Past 420 Thousand Years

Years before 2007

CO₂ Concentration (ppm)

2007 Level
383 ppm

*
During the 20th century, Earth’s average temperature rose 0.6°C.

- Some effects:
  - Arctic warming twice as fast
  - Changing precipitation patterns
  - Changing extreme weather events (droughts, heat waves, hurricanes)
  - Melting snow and ice
  - Longer growing season
  - Ocean acidity increasing
  - Sea level rise

During the 21st century, models predict Earth’s average temperature will rise between 1.8 and 4.0°C.  

IPCC (2007)
Commonly Accepted Definitions

**Weather**
refers to the current atmospheric conditions (including temperature, precipitation, wind, humidity, barometric pressure) at a particular time and place.

**Climate**
refers to the general weather patterns expected in a given area (sometimes based on the 30 year average weather). Climate may also be applied more generally to large-scale weather patterns in time or space (e.g., an Ice Age climate or a tropical climate).

*Or, in the words of a middle school student….*

"climate tells you what clothes to buy, but weather tells you what clothes to wear."
Carbon Dioxide – Sources and Sinks

Students investigate how carbon dioxide gets into and out of the atmosphere using a chemical indicator (BTB).

**Materials for each group:**

- Rack and 4 tubes
  - 1 – vinegar
  - 2 – BTB
  - 1 – foil covered
- Stopper with tubing
- Cotton balls
- Baking soda
- Aluminum foil
- Straws
Carbon Dioxide – Sources and Sinks Activity

Part 1: Detecting Carbon Dioxide Gas
(i.e., figuring out how this chemical indicator works)

1. Make a small "boat" out of foil and fill 1/2 full of baking soda.

2. Carefully slide the foil boat inside the vinegar test tube without spilling baking soda from the boat. Plug the test tube with the stopper and tubing.

3. Place the free end of the tubing into BTB. Place a cotton ball at the neck of the BTB tube. Mix the vinegar and soda gently.

What happened?
Carbon Dioxide – Sources and Sinks

Part 2: Are animals a source of CO2?
1. Place a straw in a test tube of BTB.
2. Place a cotton ball in the test tube opening.
4. What happened?

Part 3: Are plants a source of CO2?
1. Place a sprig of *Elodea* (or other water plant) into a test tube of BTB.
2. Wrap the tube in foil so that no light can get in.
3. Leave it for at least 24 hours.
4. Unwrap – what happened?

Part 4: Do plants take up CO2?

- Place unwrapped test tube with *Elodea* from Part 3 in light for a day.
Carbon Dioxide – Sources and Sinks Activity

Part 5: Are fossil fuels a source of CO2?

1. *Carefully* untwist the tie of the exhaust filled balloon while pinching the balloon neck.

2. Insert a straw into the neck of the balloon while still preventing the gas from escaping.

3. Insert the other end of the straw into blue BTB.

4. Insert a cotton ball at the top of the tube.

5. *Gently* release air from the balloon.
Albedo

The albedo is the reflectivity of a surface.

- Substances with a high albedo reflect light and stay cool
- Substances with a low albedo absorb light and warm up

Snow, ice, and clouds have high albedo
Dark soils, asphalt, water, and forests have lower albedo

What is the impact of global warming on albedo?
Looking into Surface Albedo

• Pick a photo
• Read the temperature on two small thermometers
• Tape the small thermometers below different colored parts of the photo
• What happens to the temperature below the lighter and darker parts of the image after 3 minutes?
Looking into Surface Albedo

• Activity shows that lighter surfaces, like the ice shown in the images, stay cooler than the darker parts of the image, where light is absorbed.

• Which regions do you think have a higher albedo? Forests? Glaciers? Ocean? Farm Land?

• What do you think will happen to temperature if ice is lost around the world?

• Feedback loops
  – Positive – reinforcing, move systems away from equilibrium
  – Negative – damping, tends to maintain equilibrium
Glacier mass balance

During the 20th century, glaciers and ice caps have experienced widespread mass losses and have contributed to sea level rise.

Further decline of mountain glaciers projected to reduce water availability in many regions.
Glaciers Then and Now

• These glacier pictures were taken from the same place, but years apart.
• Can you match up the pictures?
CO2: How Much Do You Spew?

Students analyze the energy consumption of a hypothetical household to determine the amount of carbon dioxide they are adding to the atmosphere each year.

Directions:
• Each group has the a different family/individual described on their card. All these people live in different situations and use energy in different ways.
• Read the information about the family’s energy use.
• Use the worksheet to calculate their CO2 emissions.
• Then, let’s discuss!
## CO2: How Much Do You Spew?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Calculation</th>
<th>CO2 Emissions (in pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Driving:</strong></td>
<td>Miles driven per year by the vehicle [ \frac{\text{Miles per gallon (mpg)}}{\text{Miles per gallon (mpg)}} ] for the vehicle (average) Divide: miles driven by miles per gallon = gallons used per year Multiply: gallons used per year by 22 pounds of CO2 Do the above calculations for each car or truck that the family drives. Add the pounds of CO2 for all cars and trucks</td>
<td>Pounds of CO2 from driving</td>
</tr>
<tr>
<td><strong>2. Flying:</strong></td>
<td>[ \text{total miles of air travel per year for all people} ] Multiply: total miles traveled by 0.9 pounds of CO2 Note: Total the miles travelled by each family member. (For example, if four people take a 1000 mile flight, the total is 4000 miles.)</td>
<td>Pounds of CO2 from air travel</td>
</tr>
<tr>
<td><strong>3. Mass Transit:</strong></td>
<td>[ \text{miles on mass transit per year by all people} ] Multiply: mass transit miles by 0.5 pounds CO2</td>
<td>Pounds of CO2 from mass transit</td>
</tr>
<tr>
<td><strong>4. Taxis and Limos:</strong></td>
<td>[ \text{miles by taxi/limo per year by all people} ] Multiply: taxi and limo miles by 1.5 pounds CO2</td>
<td>Pounds of CO2 from taxi/limo</td>
</tr>
<tr>
<td><strong>5. Electricity:</strong></td>
<td>[ \text{Kilowatt hours (kWh)} \text{ per year per household} ] Multiply: Kilowatt hours by 1.5 pounds CO2 per kWh</td>
<td>Pounds of CO2 from electricity</td>
</tr>
<tr>
<td><strong>6. Heating Oil:</strong></td>
<td>[ \text{gallons per year per household} ] Multiply: gallons of oil by 22 pounds of CO2 per gallon</td>
<td>Pounds of CO2 from heating oil</td>
</tr>
<tr>
<td><strong>7. Natural Gas:</strong></td>
<td>[ \text{therms per year per household} ] Multiply: therms of natural gas by 11 pounds of CO2</td>
<td>Pounds of CO2 from natural gas</td>
</tr>
<tr>
<td><strong>8. Bottled gas or Propane:</strong></td>
<td>[ \text{gallons per year per household} ] Multiply: gallons per year by 13 pounds of CO2</td>
<td>Pounds of CO2 from gas/propane</td>
</tr>
</tbody>
</table>

### What does this mean?
The total pounds of CO2 you just calculated is only one third of the emissions for which this family is responsible. The other two thirds come from the businesses that provide the family with services such as stores and factories.

If you just calculated less than 11,000 pounds per person, then the family you are analyzing is to be congratulated. They are using less energy than 1990 levels, which is compliant with Kyoto Protocol recommendations (CO-OP America Quarterly).

### Think about it! How could they reduce their emissions?
How could the family you analyzed reduce the amount of CO2 they produce? What would you change about the way they live to decrease emissions?

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Adapted from measurements developed by the National Audubon Society.
The Frank and Fannie Farmer Family

Who are they?
The Farmer family has lived on their 500-acre Illinois property for four generations. The whole family - two parents and ten children - work together to grow soybean and wheat, tend a herd of dairy cows, raise chickens for egg production, and maintain the farm machinery. Every penny seems to be stretched to the limit with so many children to feed and clothe. The long cold winter months demand costly heating oil for their drafty home, and the cost of fuel for the tractors is always going up. Holidays are unheard of. The parents expect the kids to come right from the bus to the barn to do the chores. In spite of the hardships, they all pride themselves in their self-sufficiency and they enjoy many good times with neighbors and local school sports events in the community.

In one year...

<table>
<thead>
<tr>
<th>Miles driven</th>
<th>Frank drives his truck (which gets 12 mpg) 2000 miles and a tractor (which gets 5 mpg) 10,000 miles. Fannie drives her 1982 Chevrolet (10 mpg) 4000 miles and two of the teenage kids have cars that get 21 mpg. Each drives 8000 miles per year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles flown</td>
<td>0</td>
</tr>
<tr>
<td>Miles traveled by mass transit</td>
<td>Are you kidding?</td>
</tr>
<tr>
<td>Miles traveled by taxi or limo</td>
<td>0</td>
</tr>
<tr>
<td>Kilowatt hours of electricity (kWh)</td>
<td>Each month, the house uses 900 kWh, the barn uses 600 kWh, and the chicken coop uses 400 kWh (chickens need light all night.) That’s 22,800 kWh per year.</td>
</tr>
<tr>
<td>Gallons of heating oil</td>
<td>800</td>
</tr>
<tr>
<td>Thersms of natural gas</td>
<td>0</td>
</tr>
<tr>
<td>Gallons of bottled gas or propane</td>
<td>0</td>
</tr>
</tbody>
</table>

The Sam and Sally Snow Family

Who are they?
Life in Snowdon, northern Saskatchewan, is lonely for some, but a joy for the Snows. They love living in their four-room log cabin, which is "off the grid," deep in the taiga forest not far from the arctic tundra. The long, dark, winter days are perfect for Sam and Sally, who work at home as writers of children’s books. They have home school their five-year-old twin sons, Saul and Sean. Thank goodness, the cabin’s thick walls offer good insulation. The propane tank in the backyard is so large that when filled in the fall, it gets them through the winter with adequate fuel for the cook stove fuel, a small heater in the kids’ bedroom, and the lanterns. They could never get by without the two snowmobiles which they use to drive 20 miles into Snowdon once a week for supplies. Their gasoline storage tank is enough to last them a whole year.

In one year...

<table>
<thead>
<tr>
<th>Miles driven</th>
<th>2100 miles traveled by each of the two snowmobiles. Each snowmobile gets 10 mpg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miles flown</td>
<td>Sam and Sally fly to see their book publisher in Montreal twice per year for a total of 4000 miles</td>
</tr>
<tr>
<td>Miles traveled by mass transit</td>
<td>0</td>
</tr>
<tr>
<td>Miles traveled by taxi or limo</td>
<td>50 miles for each trip to Montreal, sharing the ride</td>
</tr>
<tr>
<td>Kilowatt hours of electricity (kWh)</td>
<td>0</td>
</tr>
<tr>
<td>Gallons of heating oil</td>
<td>0 (The Snows heat their home with a wood stove and propane.)</td>
</tr>
<tr>
<td>Thersms of natural gas</td>
<td>0</td>
</tr>
<tr>
<td>Gallons of bottled gas or propane</td>
<td>2000 gallons</td>
</tr>
</tbody>
</table>
Thermal Expansion and Sea Level Rise

Materials:
Conical flask
Rubber stopper - 2 holes
Glass or plastic tube
Thermometer
Lamp
100-150 Watt bulb
Water with food coloring

We’ll set this up, and see what happens!
What’s happened to the Thermal Expansion Demo?

What happens to sea level as ocean waters warm?
Sea Level Rise

• The heat lamp heats the water in the flask, causing the water to expand slightly.

• As the water expands, the level of the water goes up in the small tube, visually showing the expansion of the water.

• As the Earth warms, its waters will also expand slightly.

• As Earth’s atmospheric temperature rises from global warming, the oceans will warm and sea levels will rise from the expansion of the water, as well as from the addition of water from melted land-based glaciers.
Additional activities can be found on:
http://www.windows2universe.org/