Cycles, Sinks, and Solutions

Ideas for a Global Climate Change Unit

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Presentation available for download at
https://mi01000971.schoolwires.net/Domain/650

Cycles, Sinks, and Solutions

A Global Climate Change Unit

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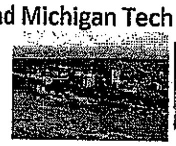
This unit was created in conjunction with funding and training provided by the National Science Foundation and Michigan Technological University (2014)

Michigan and Michigan Tech



Michigan Technological University

Michigan Tech Teacher Institutes and MiSTAR Project

MichiganTech

Mi-STAR
Michigan Science Teaching and Assessment Reform

http://wupcenter.mtu.edu/summer_institutes.html

http://mi-star.mtu.edu/about-mi-star/mi-star-leadership/

NGSS PE for Global Climate Change – Middle School

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.]

Designing a 5E/NGSX aligned unit:

Engage	• Phenomenon: Weird recent local weather/climate event (heat wave, drought, flooding, polar vortex...) • Storyline: You are a researcher at a local university writing a grant to study the effects of global climate change on some aspect of the local economy
Explore/ Explain	• Lake Mendota Ice Dates Graphing • Dancing Molecules • Phenomenon: Candle in a jar (NGSX modeling opportunity - may do as part of Carbon Cycle lessons) • Carbon Cycle Game and Model (embedded assessment)
Extend	• How Much Carbon Is In My Tree? • Wind Turbine Engineering (meets Engineering PEs)
Evaluate	• Local Research Question project (embedded assessment)

Engage

- Begin with a local incident of unusual climate (abnormally hot, cold, rainy/flooding, drought...)
- Discuss:
  - What could cause this?
  - Is there a pattern?
  - What testable questions could we generate to research?
    - What are the attributes of a testable question?
    - How do we evaluate research sources? (C.A.R.S, CER)
  - How should we react?
    - Adapt (farming, tourism)
    - Change behavior (energy generation)

Practice Evaluating Information

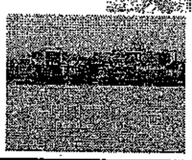
Provide groups of students with different articles about local effects of climate change in your area.

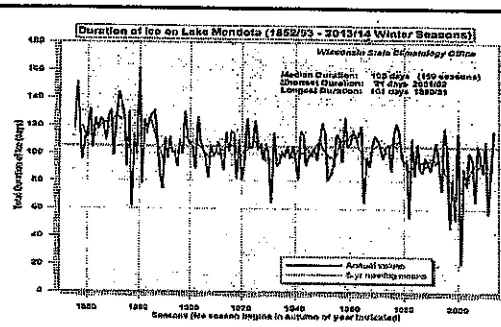
Using C.A.R.S. checklist, have students evaluate reliability of the source.

Using C.E.R., have students evaluate the content of the article.

Explore: How do we know the climate is changing? (Argue from Evidence)

- One example: Lake Mendota, Madison, WI
- Records of ice coverage (in days) from 1855 to present





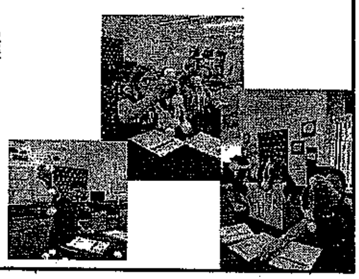
Student Activity: Graph the Ice Duration Data (Math and Technology)

- https://www.youtube.com/watch?v=8dPAWIzD(u) Lake Mendota Ice Out video
- Lake Mendota data set: https://lter.limnology.wisc.edu/about/lakes/mendota_ice_cover



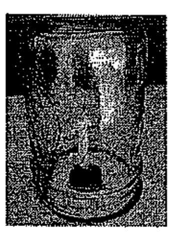
Explain: Greenhouse Effect - Dancing Molecules (Modeling)

- https://www.youtube.com/watch?v=AlBk0pGV_BQ
  - Scott Denning, professor at Colorado State, explains how greenhouse gases dance.
- Dancing Molecules student activity (created by Dr. Janet Vail, Grand Valley State University, Michigan)



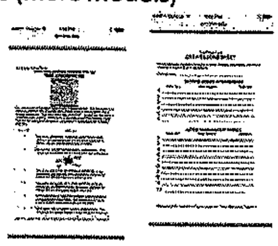
Explain: The Carbon Cycle (Develop Models)

- Begin with Candle in a Jar phenomenon
  - Use NGSX "talk moves" to discuss student-generated models that explain what they've observed.
- http://learndbir.org/resources/4-Goals_and_Moves-Checklist.pdf



Explain: Carbon Cycle (More Models)

Carbon Cycle Game (adapted from the Incredible Journey, Project Wet, by Jennifer Ceven and further adapted by Michigan Tech MiTEP program teachers)
http://www.geo.mtu.edu/~raman/SilverI/MiTEP_ESI-1/Day_7_Core_and_the_subsurface_files/Carbon%20Cycle%20Game_JCevensCredited.pdf



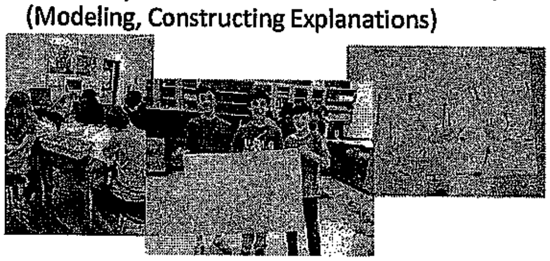
Extend: Trees are Carbon Sinks (Math)

- Calculate how much carbon is in a tree…and how many trees you'd need to plant every year just to balance the carbon produced by your family car.

  Adapted from Kristen Schmitz, "Carbon Sequestration in Forests," Global Change Teacher Institute, Michigan Technological University, Houghton MI.

- This published paper lists carbon content for many other tree species from around the world:
  - Zianis, Dimitris, and Maurizio Mencuccini. "On Simplifying Allometric Analyses of Forest Biomass." Forest Ecology and Management 187.2-3 (2004): 311-32.

Carbon Cycle Model Embedded Assessment (Modeling, Constructing Explanations)



Evaluate: Getting to the primary SEP (Asking questions to clarify evidence)

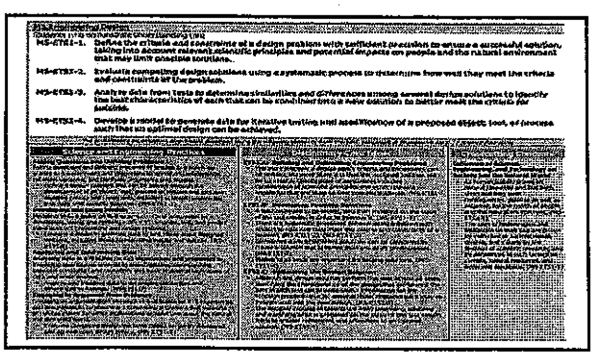
- Students prepare a research grant proposal on the effects of climate change on a local industry or economy (agriculture, tourism, etc.)
  - The proposal must include:
    - A testable question
    - At least three reliable research sources related to your question.
    - A logical hypothesis
    - An argument for the hypothesis using evidence from the three sources.

Skills involve using checklists to evaluate reliability of sources and C. E. R. formats to evaluate article content.

Engineering a Solution

"Scientists dream about doing great things. Engineers do them."

James A. Michner


MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

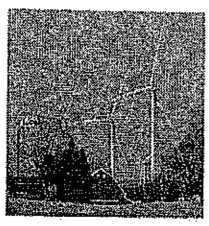
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Disciplinary Core Ideas

Middle School Engineering Design

Wind Turbines

- https://www.youtube.com/watch?v=sLXZkn2W-lk
- https://www.youtube.com/watch?v=8lWTQdHEazg&feature=youtu.be



Engineering Challenge

- Students build wind turbine models to find the design that rotates longest, using card stock, straws, and pins
- Record work in Engineering Journal




Your turn!

- Try out the Dancing Molecules activity
- Play the Carbon Cycle game
- Design and test a "wind turbine"

This PowerPoint is available on my school website:
http://apschools.schoolwires.net/Domain/650

Checklist

Goals for Productive Discussions and Nine Talk Moves

Talk Science
in the Inquiry Project

Goal One Help Individual Students Share, Expand and Clarify Their Own Thinking — Notes/Frequency of Use

☐ **1. Time to Think**
- Partner Talk
- Writing as Think Time
- Wait Time

☐ **2. Say More:**
"Can you say more about that?"
"What do you mean by that?"
"Can you give an example?"

☐ **3. So, Are You Saying...?:**
"So, let me see if I've got what you're saying. Are you saying...?"
(always leaving space for the original student to agree or disagree and say more)

Goal Two Help Students Listen Carefully to One Another

☐ **4. Who Can Rephrase or Repeat?**
"Who can repeat what Javon just said or put it into their own words?"
(After a partner talk) "What did your partner say?"

Goal Three Help Students Deepen Their Reasoning

☐ **5. Asking for Evidence or Reasoning**
"Why do you think that?"
"What's your evidence?"
"How did you arrive at that conclusion?"

☐ **6. Challenge or Counterexample**
"Does it always work that way?"
"How does that idea square with Sonia's example?"
"What if it had been a copper cube instead?

Goal Four Help Students Think With Others

☐ **7. Agree/Disagree and Why?**
"Do you agree/disagree? (And why?)"
"What do people think about what Ian said?"
"Does anyone want to respond to that idea?"

☐ **8. Add On:**
"Who can add onto the idea that Jamal is building?"
"Can anyone take that suggestion and push it a little further?"

☐ **9. Explaining What Someone Else Means**
"Who can explain what Aisha means when she says that?"
"Who thinks they could explain why Simon came up with that answer?"
"Why do you think he said that?"

The Inquiry Project: Bridging Research & Practice
Supported by the National Science Foundation

Adapted from: Chapin, S. O'Connor, C., & Anderson, N. (2009)

Article 1- The C.A.R.S. Checklist for Evaluating Internet Sources

Website Evaluation Checklist		
Title of the website: URL:		
Credibility: A source that is created by a person or organization who knows the subject and who cares about its quality. • Is there a publishing or sponsoring organization? • Does the individual or organization list all of their qualifications, or credentials? Are they experts in their field? • Does the website have an .edu, .org, or .gov ending in its URL?	Yes	No
Accuracy: A source with information that is current, complete, and correct. • Based on the reading you have already done on the subject does the information on the site seem accurate? • Is the website free of spelling errors, grammatical errors, dead links, or other problems that indicate lack of quality control?		
Reasonableness: a source that is truthful and unbiased • Does the website avoid advertising that may be in conflict with the content of the website? • If an issue is covered, are both sides presented? • Do you trust the author or organization that has created the website?		
Support: A source with verifiable sources of information? • Is factual information referenced in footnotes or a bibliography?		

Article 1: Claims Evidence Reasoning

Title:____

Source Citation:

Question:	
Claim: (The answer to the question.)	
Evidence: (List the scientific data that supports the claim.)	
Reasoning: (Explain how the evidence supports the claim.)	

Created by Christine Geerer, Grosse Pointe Public Schools

Lake Mendota Ice Graph
Directions

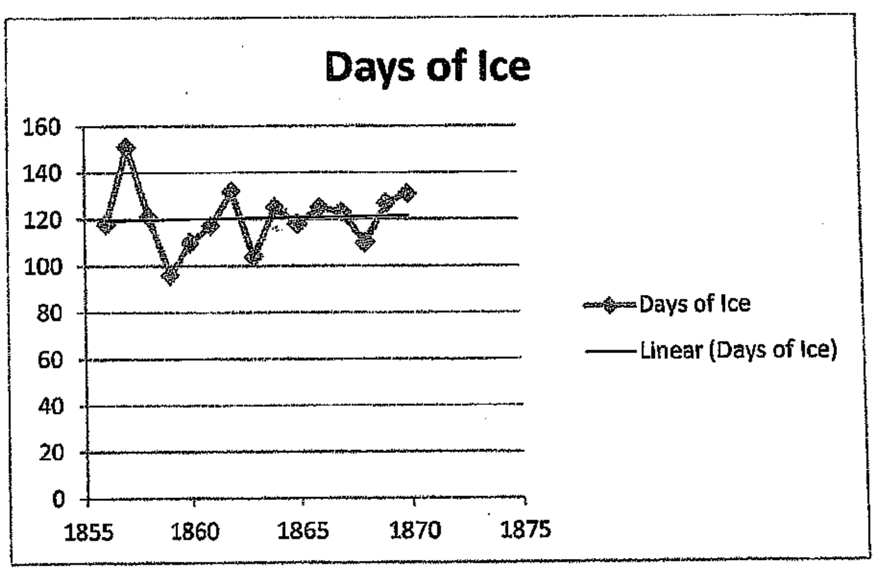
1. Open Microsoft Excel.
2. In Row 1 Column A (top left box) type End Year.
3. In Row 1 Column B type Days of Ice.
4. Fill in **YOUR** data set.

Example:

End Year	Days of Ice
1856	118
1857	151
1858	121
1859	96
1860	110

5. When you have all your years entered, highlight both columns from top to bottom.
6. Choose the Insert tab at the top of the page.
7. Choose Scatter. Choose the scatter plot with sharp lines.
8. Choose the Layout tab at the top of the page.
9. Click on Trendline.
10. Choose Linear.

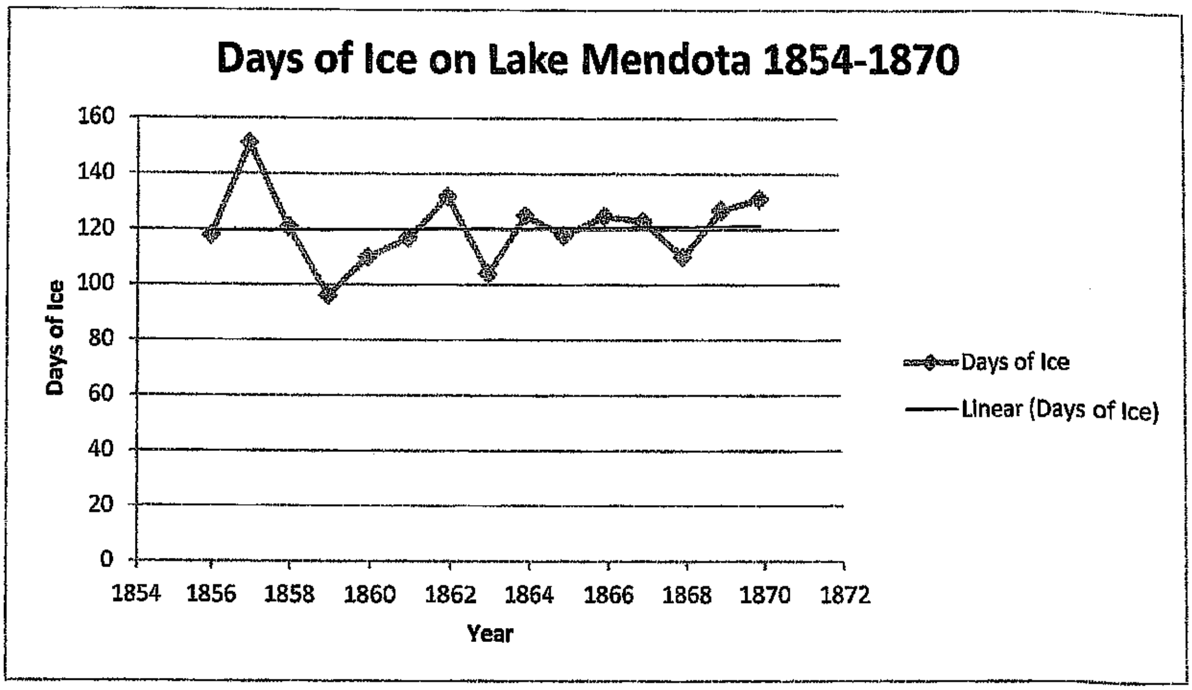
Your graph should look something like this:



11. Click directly on the chart title. Change your title to Days of Ice on Lake Mendota (fill in your years). Stretch the chart out if needed.

12. Using the Layout tab, choose Axis Titles. Choose Primary Horizontal Axis. Choose Title Below Axis. Click on the text box on the chart. Type in Year.

13. Using the Layout tab, choose Axis Titles. Choose Primary Vertical Axis. Choose Rotated Title. Click on the text box on the chart. Type Days of Ice.



To print:

14. Click and drag your chart up to Row 2, Column C. Stretch it out into Column L and down into Row 19.

15. Highlight Column C to Column L, from Row 1 to 20.

16. Using the Page Layout tab, choose Print Area and Set Print Area.

17. Click on the Home button at the top left. Choose Print.

Lake Mendota Ice Cover Data Since 1852

https://lter.limnology.wisc.edu/about/lakes/mendota_ice_cover

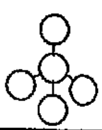
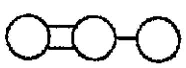
Start Year	End Year	Ice-On Date	Ice-Off Date	Ice Duration
1855	1856	1855-12-18	1856-04-14	118
1856	1857	1856-12-06	1857-05-06	151
1857	1858	1857-11-25	1858-03-26	121
1858	1859	1858-12-08	1859-03-14	96
1859	1860	1859-12-07	1860-03-26	110
1860	1861	1860-12-14	1861-04-10	117
1861	1862	1861-12-02	1862-04-13	132
1862	1863	1862-12-26	1863-04-09	104
1863	1864	1863-12-18	1864-04-21	125
1864	1865	1864-12-08	1865-04-05	118
1865	1866	1865-12-14	1866-04-18	125
1866	1867	1866-12-18	1867-04-20	123
1867	1868	1867-12-12	1868-03-31	110
1868	1869	1868-12-10	1869-04-16	127
1869	1870	1869-12-02	1870-04-12	131
1870	1871	1870-12-24	1871-04-02	99
1871	1872	1871-12-19	1872-04-23	126
1872	1873	1872-11-30	1873-04-23	144
1873	1874	1873-11-29	1874-04-14	136
1874	1875	1874-12-10	1875-04-15	126
1875	1876	1876-01-10	1876-04-10	91
1876	1877	1876-12-08	1877-04-17	130
1877	1878	1878-01-06	1878-03-09	62
1878	1879	1878-12-21	1879-04-12	112
1879	1880	1879-12-17	1880-03-25	99
1880	1881	1880-11-23	1881-05-03	161
1881	1882	1882-01-02	1882-03-21	78
1882	1883	1882-12-10	1883-04-13	124
1883	1884	1883-12-18	1884-04-15	119

This is one of four pages of data – go to the website to find/print the rest

Student Activity

Dancing Molecules

To illustrate absorption of energy by molecules that are greenhouse gases, you will be comparing the range of movement of the various molecules. Construct models of the molecules in the chart below by using pipe cleaners and sytrofoam or other materials as directed by your teacher. Each straight line on the molecule diagrams represents a chemical bond. Create the bond by curling a pipe cleaner around a pencil or pen. After you have construted the molecules, rank their relative movement as you hold them and move them around. Complete the chart by reading the *Greenhouse Gases* handout.

Molecule	Relative Movement	Is this a greenhouse gas?	Atmospheric Concentration, % by volume	Global Warming Potential (100 Yr)
 Nitrogen				
 Oxygen				
 Carbon Dioxide				
Methane 				
 Nitrous Oxide				

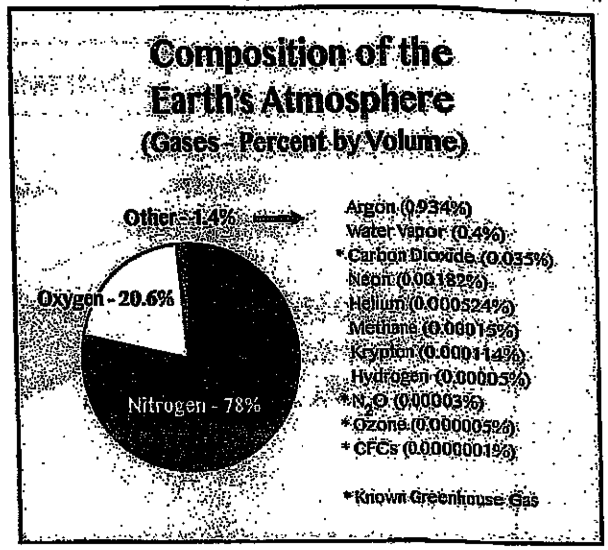
1. Which molecules moved the most? ____________________
2. Which molecules moved the least? ____________________
3. Which molecules are greenhouse gases? ____________________
4. Refer to the *Greenhouse Gases* reading and complete the columns in the table above. Other than water vapor, which greenhouse gas is the most abundant? __________
5. Which of the greenhouse gases in the chart above has the greatest Global Warming Potential but is the least abudundant in the atmosphere? ____________________

1/9/2012

Created by Dr. Janet Vail
Grand Valley State University
Michigan

Greenhouse Gases

Gases that trap heat in the atmosphere are often called greenhouse gases. Some greenhouse gases such as carbon dioxide occur naturally and are emitted to the atmosphere through natural processes and human activities. Water vapor is a greenhouse gas that has a variable composition in the atmosphere. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities. The Global Warming Potential (GWP) value is used to compare the abilities of different greenhouse gases to trap heat in the atmosphere. GWPs are based on the heat-absorbing ability of each gas relative to that of carbon dioxide (CO_2), as well as the atmospheric lifetime of the gas (the amount removed from the atmosphere over a given number of years)



Source: http://www.esrl.noaa.gov/gsd/outreach/education/climgraph/

The principal greenhouse gases that enter the atmosphere because of human activities are:

- **Carbon Dioxide (CO_2):** Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle. GWP = 1
- **Methane (CH_4):** Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills. GWP = 25
- **Nitrous Oxide (N_2O):** Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. GWP = 298
- **Halocarbons:** Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in small quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases"). GWP = 1,430 - 22,800.

Greenhouse Gas Inventories

A greenhouse gas inventory is an accounting of the amount of greenhouse gases emitted to or removed from the atmosphere over a specific period of time (e.g., one year). A greenhouse gas inventory also provides information on the activities that cause emissions and removals, as well as background on the methods used to make the calculations. Policy makers use greenhouse gas inventories to track emission trends, develop strategies and policies and assess progress. Scientists use greenhouse gas inventories as inputs to atmospheric and economic models. Michigan (and many other states) has developed a greenhouse gas inventory.

Sources:
http://epa.gov/climatechange/emissions/index.html Michigan Greenhouse Gas Inventory http://www.michigan.gov/documents/deq/MI_Greenhouse_Gas_Inv_1990_2002_277467_7.pdf

The Carbon Cycle

DATA RECORD SHEET

Record the places you have traveled as a carbon molecule before human interference. You may or may not fill up all the spaces.

Student's Name: ______________________________

BEFORE HUMAN INTERFERENCE

Station Stop   What Happens   Destination

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

AFTER HUMAN INTERFERENCE

Station Stop   What Happens   Destination

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________

(Adapted by Jennifer Ceven, Grade 6 Science Teacher, from "The Incredible Journey," *Project Wet*)

Name:
Hour:

The Carbon in Trees

By Christine Geerer, Grosse Pointe Schools
Adapted from Carbon in Trees by K. Schmitt, Michigan Technological University, 2014

You are going to calculate an estimate of how much carbon is stored in trees around the school.
First, choose a tree that you can easily measure diameter at about 4.5 feet above the ground (standard measurement for forestry).

1. ***Find the diameter of your tree:***

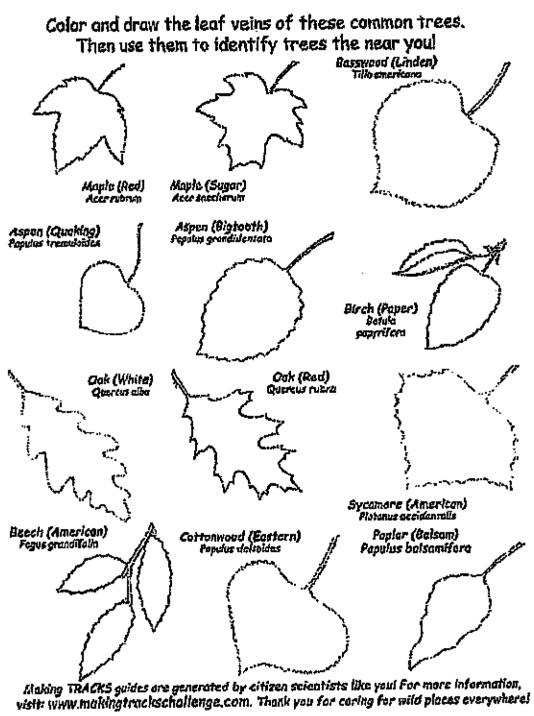
Using the Diameter Tape, find the diameter of your tree in centimeters at about 4.5 feet above the ground. (The Diameter Tape has already helped you calculate $c = \pi * d$.)

Diameter of your tree (d):

__________ in. x 2.54 = _________ cm

2. ***Identify your tree.***

Use the pictures below, the handout, or ask Mrs. Geerer.



3. ***Find the biomass for your whole tree:***

The formula is a $d^2 \times a$ = biomass (kg)

Find your "a" number on the chart below:

Tree Species	a
American Elm	0.08
Aspen or Cottonwood	0.05
Ash	0.16
Basswood	0.09
Beech	0.2
Dogwood	0.05
Cherry Tree	0.16
Hickory	0.08
Northern White Cedar	0.09
Red or Silver Maple	0.16
Red Oak	0.13
Red Pine	0.17
Sugar or Norway Maple	0.17
Tulip Tree	0.06
White birch	0.12
White pine	0.75
Willow	0.16

Calculate. Don't forget to "square" your diameter.

$\underline{\hspace{3cm}}^2$ x $\underline{\hspace{2cm}}$ = $\underline{\hspace{3cm}}$

diameter a biomass (kg)

4. ***Find the total carbon content for your tree:***

____________ ÷ 2 = _______________
biomass(kg) kg of carbon

5. ***Convert the amount of carbon from kilograms to pounds:***

____________ x 2.2 = __________________
kg of carbon lb of carbon

6. ***Convert carbon to carbon dioxide (CO^2):***

____________ x 3.67 = ____________________
lb of carbon lb of CO^2

My tree contains __________ pounds of CO^2!

Now solve the problem:

A car emits 19.6 lbs of CO^2 for each gallon of gas. If you use 400 gallons of gas a year, how much CO^2 would you emit?

Names:
Hour:

Carbon Cycle Poster

Christine Geerer, Grosse Pointe Schools

(50 points)

You will work with one or two partners to create a model describing the function of the carbon cycle and identify three things you could do to reduce atmospheric carbon.

Your poster must include:

a. A diagram or graphic of the carbon cycle that labels sources and sinks **and how they interact.** You should identify each source as natural or man-made.
b. A description of three ways you, as students, could reduce carbon sources or increase carbon sinks.

Requirement	2 points	6 points	8 points	10 points
Carbon cycle sinks	1 or fewer sinks identified	2-3 sinks identified	4 sinks identified	5 or more sinks identified
Carbon cycle sources	1 or fewer sources identified	2-3 sources identified	4 sources identified	5 or more sources identified and labeled man-made or natural
Carbon cycle graphic design includes identifying the interaction of the sources and sinks.	Most of the graphic is incorrect or missing.	Graphics are somewhat clear, correct. Some interactions labeled. Few illustrations.	Graphics are mostly clear, correct, and include some illustrations. Interactions are labeled.	Graphics are clear, correct, and include many illustrations. Interactions are labeled with detail.
Ways to decrease carbon sources or increase sinks are listed and labeled as "source" or "sink".	All suggestions are incorrect.	One way to increase sinks or decrease sources is correct and labeled.	Two ways to increase sinks or decrease sources are correct and labeled.	Three or more ways to increase sinks or decrease sources are correct and labeled.
Overall product quality	Little effort or creativity evident.	Some evidence of effort and creativity.	Mostly neat, creative, and colorful, shows effort.	Neat, colorful, creative, shows best effort.

Name____ Period______

Unit 8.5: Global Climate Change Final Project

You are a research scientist and desire to apply for a grant to fund further research concerning the impact of climate change in your state. Your challenge is to find good scientific evidence on your topic and develop a testable question. After evaluating this evidence you will develop a hypothesis for your grant request.

Requirements:

1) You will decide on a testable question. Example: Does climate change benefit agriculture in Michigan? (You are asking a question if climate change benefits or harms an environment or industry in Michigan.) Use www.goscienceseven.com/SciMethod/sciquestions.html as a reference for writing your question.

Research question:

____

____

____

2) Find and evaluate three reputable sources (see the rubric for more details) that will help provide evidence to answer your research question.

3) Use the C.A.R.S Checklist for Evaluating Sources http://www.literacyta.com/sites/default/themes/literacyta/websiteevalchecklist.pdf)

4) If your research question needs to be modified re-write it here:

5) Once you have identified three reputable sources, complete the CER (Claim, Evidence Reasoning) Sheet for each article (attached).

6) Cite your three sources. Make sure to include the citation on the CER! (www.easybib.com)

7) **You will do this part last!!!**

Once you have evaluated the evidence in your articles, develop a hypothesis. This is a statement about what you believe based on your research. Use the format: if....then...because...

Example: If global climate change increases, then the jellyfish population will increase because...(here is where you would explain your evidence).

Your hypothesis:

Use the rubric below to ensure you have all components of this project:

Sample Rubric:

Points	5	4	3	2	1
Testable Question	Question is clear and testable	Question is clear and testable but not directly related to climate change	Question is clear but not testable	Question is unclear and not testable	Question is neither clear nor testable
Supporting Evidence (types of sources: books magazines internet videos pod casts tv documentary newscasts interviews)	3 pieces of evidence from at least 2 different types of sources	3 pieces of evidence from 1 type of source	2 pieces of evidence from at least 2 different types of sources	2 pieces of evidence from 1 type of sources	1 piece of evidence
Rationale for further investigation	Complete explanation (includes data) on why this should be investigated including support from 5 sources	Complete explanation (includes data) on why this should be investigated with support from less than 5 sources	Partial explanation with support from 4 - 5 sources	Partial explanation with support from less than 3 sources	Incomplete explanation with minimal support
Hypothesis	Clear, Concise and testable	Clear, concise and testable but written as a question	Clear and concise but not easily testable	Written as a question, but clear and concise, not easily testable	Not testable and not clear
Source Citations (If a source is not reputable it doesn't count)	3 reputable citations properly done		2 reputable citations properly done		1 reputable citation properly done

Created by Christine Geerer, Grosse Pointe Public Schools

Name:
Hour:

Wind Turbine Engineering Journal
(20 points)

Record your work on this document as you design your wind turbine.

1. Define the problem:

2. What are the limits you have to work with?

3. Sketch your first design. Label the parts of the diagram.

4. Build your design.

5. Using one full breath blowing through a straw, test your turbine by timing how long it turns. Repeat three times and find the mean.

Time (s)

Trial One	Trial Two	Trial Three	Mean

6. Note any uncontrolled variables here:

7. Note any construction problems:

8. What improvements could you make on your next wind turbine iteration? Write/sketch below plans for your second turbine design. Label the parts of your diagram.

9. Build your second design.

10. Using one full breath blowing through a straw, test your turbine by timing how long it turns. Repeat three times and find the mean.

Time (s)

Trial One	Trial Two	Trial Three	Mean

11. Note any uncontrolled variables here:

12. Note any construction problems:

13. What improvements could you make on your next wind turbine iteration? Write/sketch below plans for your third wind turbine design. Label the parts of your diagram.

14. Build your third design.

15. Using one full breath blowing through a straw, test your turbine by timing how long it turns. Repeat three times and find the mean.

Time (s)

Trial One	Trial Two	Trial Three	Mean

16. Note any uncontrolled variables here:

17. Note any construction problems:

18. Which turbine design worked the best?

19. Why do you think that design worked best?

20. Write a paragraph to a wind turbine engineer, describing what you learned about building wind turbines, to help him/her design them better:

Wind Turbine Journal Rubric
(20 points)

	0 points	3 points	4 points	5 points
Completion	Most questions are left blank	Some questions are left blank	No more than two questions are left blank	All questions have responses
Calculations	Most calculations are incorrect	Some calculations are correct	Most calculations are correct	All calculations are correct
Diagrams	Diagrams are unclear; lack labels/units	Some diagrams are clear and have labels/units	Most diagrams are clear and have labels/units	All diagrams are clear and have labels/units
Thought and effort	Most responses are brief and unclear	Some responses are brief and unclear	Most responses show thought and effort	Thought and effort are evident in all responses