Climate Change

Student Objective
The student:
- will be able to explain how human activity, especially the burning of fossil fuels, is increasing the amount of carbon dioxide in the atmosphere
- will be able to explain how high levels of carbon dioxide in the atmosphere would lead to a super greenhouse world
- will be able to describe a super greenhouse world and an anoxic ocean
- understands the difference between climate and weather

Key Words:
anoxic
Anthropocene
carbon dioxide
climate
feedback loop
greenhouse gases
negative feedback
positive feedback
super greenhouse
threshold
tipping point
weather

Time:
1 class for video & discussion

Materials:
- *Crude: The Incredible Journey of Oil* internet download (see Internet Sites below)
- Laboratory Manual

Background Information

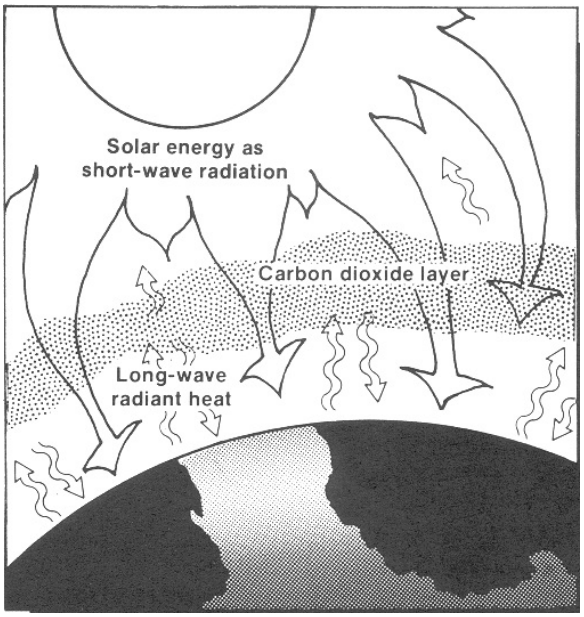
Climate, as defined by the U.S. Global Change Research Program, is the long-term average of conditions in the atmosphere, ocean, ice sheets and sea ice as described by statistics such as means and extremes. **Climate Change** refers to changes in the Earth's global climate over long periods of time–from decades to millions of years. These changes can be caused by forces inside the Earth (for example volcanos), forces from outside of the Earth (meteors, or differences in the intensity of sunlight), forces on the Earth (biology of living organisms), or the interaction of two or more of these. The Ice Ages are a well known example of climate change, although the forces that caused the Ice Ages are still not fully understood. More recent changes, especially those changes thought to be caused by human activity, have been dubbed **global warming**, although the term 'climate change' is a more accurate, less politicized term.

In order to understand the **climate change** that we are currently experiencing, we first need to understand how "sunshine" works and how it plays its part in creating the **greenhouse effect**. The sun, a medium-sized yellow star, gives off energy. The energy that is emitted from the sun is called the **electromagnetic spectrum**, which is made up of varying wavelengths of energy.

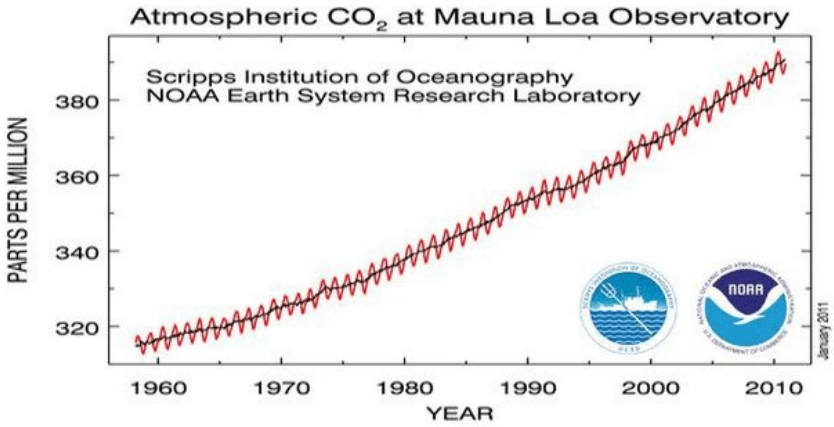
Longest ***(Rainbow)*** ***Shortest***

Radio – Radar & Microwave – Infrared – Visible light – UV – X-Rays – Gamma rays

The sun's shortwave radiation, including visible light is unstopped by molecules in the Earth's atmosphere. However, re-radiated longwave heat rays are reabsorbed and re-radiated by molecules of gases, mostly water vapor and carbon dioxide. These gases radiate heat energy so that half of it returns to Earth where it is absorbed before being re-radiated back into the atmosphere. This results in the build-up of heat energy. This is similar to what happens when your car's interior heats up on a sunny day. The sun's shortwave energy passes through the window glass. However, the re-radiated longwave, heat-producing (infrared) energy is trapped by that same window glass and the metal structure of the vehicle, turning your car into a solar thermal collector.



Global temperatures today are averaging .74º C (1.33º F) higher than 150 years ago. Most scientists agree that the cause is the increase in atmospheric CO^2 and the greenhouse effect that this gas causes. Measurements of atmospheric CO_2 taken in locations that are far away from fossil fuel sources have shown that carbon dioxide in the atmosphere is steadily increasing. Below is the graph of CO^2 concentration collected by the National Oceanic and Atmospheric Administration (NOAA) at the observatory on the top of Mauna Loa on the big island of Hawaii. The jagged line is the monthly averages showing the seasonal variations, and the smoother line is the yearly average. In both lines, a clear trend is obvious.



Vehicle exhausts, coal burning power plants, factories and other human activity vent about 23 billion tons of carbon dioxide into the atmosphere each year. In fact there is over 30% more CO_2 in the atmosphere now than there was in 1750 before the Industrial Revolution. Three quarters of the CO_2 that is released into the atmosphere comes from fossil fuels; the rest comes from factors such as cutting down and burning trees.

As the Earth's average temperature rises, ice at the caps will melt, and sea level will rise (from the increased water from the poles as well as the expansion of the warmer water). Weather patterns will change, probably affecting where and when food crops can be grown. Other effects are not as easily predicted; however most scientists agree that there will be extremes in the weather leading to larger storms, flooding, and droughts.

Although it seems clear that the burning of fossil fuels is altering the Earth's climate, so far governments and policy makers are unable to agree on what to do. The Intergovernmental Panel on Climate Change (IPCC), an international group founded by the United Nations and made up of hundreds of scientists, put out a report in 2014 that stated unequivocally that humans are behind the warming of the Earth's average temperature. Rajendra Pachauri, the chairman of the IPCC stated, "...no one on this planet is going to be untouched by climate change."

Procedure

1. **Engage:** Ask the students to explain the difference between climate and weather (Make sure that students understand that weather is the current state and that climate is a long term average. Even though winter is usually cold, a warm weather day can occur during the winter months.)
2. **Explore:** Show part 3 of the video, *Crude: The Incredible Journey of Oil* (listed in Internet Sites below). If you use the direct link, the video is already broken into three parts, if you are using the mirror sites (YouTube), start the video at the 59 minute, 4 second point.
3. Allow 10 - 15 minutes for the students to complete their Laboratory Manual pages.
4. **Explain:** Lead a class discussion about the video. Some topics to discuss might include:
   - Climate change is an 'issue' (and a theory), and therefore causes a lot of discussion and debate.
   - Scientists have analyzed data and concluded that we are living in a world with increasing levels of carbon dioxide in the atmosphere (this is a fact).

- Scientists are analyzing data that shows that the major cause of the increased carbon dioxide in the atmosphere we see today is the burning of fossil fuels (versus volcanos in Mesozoic times).
- Scientists are compiling and analyzing data in rock and ice samples from Earth's distant past to find times when the carbon dioxide level in the atmosphere was high. They are using what they know about the climate on Earth at those times to figure out what could happen to Earth's plants, animals, climate (and us) as carbon dioxide continues to increase in our atmosphere.
- Scientists are using computers and large programs to model the Earth's climate. With these modeling programs they can then run simulations to see what effects different variables (such as increased CO_2 or particulate matter from a volcano) could have on the climate.
- Scientists see the possibility of a problem *in the future*, and are warning us now so that we can take action. It is up to all of us to be responsible stewards of our Earth.
- There are many things each of us, *at any age*, can do to help.

Note: It is very important to make sure that the students see this issue as a call to action for all of us; it is important that students do not feel hopeless.

Key Words & Definitions

- **anoxic** - lacking oxygen
- **Anthropocene** – the term for the geological age that we are in currently. Refers to an age where human activity has been the dominant influence on the environment.
- **carbon dioxide** (CO_2) – a colorless, odorless, incombustible gas composed of one carbon and two oxygen atoms. CO_2 acts as a greenhouse gas in the atmosphere and is the main evidence that indicates human activity is causing climate change.
- **climate** – the long term prevalent weather conditions in the atmosphere, ocean, ice sheets, and sea ice
- **feedback loop** - the path by which some of the output of a circuit, system, or device is return to the input
- **greenhouse gases** – any atmospheric gas that contributes to the greenhouse effect. Too many greenhouse gases can lead to the over-warming of the planet, resulting in climate change.
- **negative feedback** – an effect that diminishes the overall effects of climate change. For example in the climate change models, the increased carbon dioxide in the atmosphere increases plant growth through photosynthesis and allows plants to absorb more carbon dioxide.
- **positive feedback** – an effect that amplifies the output of a system. For instance, increased temperatures from carbon dioxide results in decreased ice mass which means decreased heat reflection surface, allowing the earth to absorb more heat and contributing to the warming effect.
- **super greenhouse** - a term used to refer to the climate present in the later Jurassic and Cretaceous periods

- **threshold** - the magnitude or intensity that must be exceeded for a certain event to happen
- **tipping point** – the point at which a series of small changes or incidents becomes significant enough to cause a larger, more important change
- **weather** – the current state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc

Related Research

1. Greg Johnson, one of the scientists who was part of the Intergovernmental Panel on Climate Change (IPCC), realized that it can be difficult to communicate scientific facts and numbers in a way that all people can understand. He worked with his artist daughter to create haiku paired with watercolor illustrations to distill the 27 page 'summary' of the IPCC's 2013 climate change report into a form that is easily understood. View his haiku **http://daily.sightline.org/2013/12/16/the-entire-ipcc-report-in-19-illustrated-haiku/** then using art, poetry or both, distill the facts from the third part of *Crude: The Incredible Journey of Oil* into something easier for younger students to understand.
2. Research a climate change issue directly related to Florida such as: how sea level rise will affect Miami, how citrus and other crops in Florida will be affected by changing temperature and rainfall patterns, how freshwater supplies will be affected by rising temperatures and increased saltwater intrusion by rising sea levels, etc.
3. Start a school environmental club and work on one initiative (recycling, energy conservation, reducing food waste, etc) that is most important to the group.
4. Schedule a school (or community) screening of the documentary film *Chasing Ice* and invite local decision makers to attend and discuss the film.
5. Have students complete the Global Warming crossword in the Learning Network of the New York Times **http://www.nytimes.com/learning/teachers/xwords/20060501.html**.

Related Reading

- ***365 Ways to Live Green: Your Everyday Guide to Saving the Environment*** by Diane Gow McDilda (F+W Publications, 2008)
  A lifestyle guide to going green. Some are small changes that can be made fairly easily, and others are lifestyle changes. Good for the students to think about and prepare for some decisions in the future (becoming responsible eco-citizens).
- ***A Short Introduction to Climate Change*** by Professor Tony Eggleton (Cambridge University Press, 2013)
  An introduction to climate change and the many issues surrounding it. Includes developments in climate science over the past 250 years, the difference between weather and climate, consequences of our extensive use of fossil fuels, and what actions we can take to halt further global warming.
- ***Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change*** by George Marshall (Bloomsbury USA, 2014)
  Why do many of us recognize that climate change is real, yet do nothing about it? Why are some people blatantly ignoring scientific facts? George Marshall explores the

psychological parameters around human responses to climate change. He argues that our brains have been wired in a certain way, which makes it difficult to accept the problem of climate change. Marshall also discusses how we can grow as a species and rise to the challenge of climate change.

- ***Goodbye, Miami*** by Jeff Goodell (Rolling Stone, 20 June 2013)
  "By century's end, rising sea levels will turn the nation's urban fantasyland into an American Atlantis." This article starts off with a detailed, shocking description of a potential future scenario of a hurricane passing through Miami. Hotels are flooded, billions of dollars of real estate is damaged, roads are submerged, raw sewage is overtaking the beaches, etc. Goodell discusses the multitude of problems that Miami residents face in the upcoming decades due to climate change, and how our political leaders are politically 'blind' to the threat.
- ***Miami, the Great World City, is Drowning While the Powers That Be Look Away*** by Robin McKie (The Observer, Friday 11 July 2014)
  This article in The Observer discusses the drastic effects that climate change has already had on Miami, and the many climate change deniers, including building developers and senior politicians, who are refusing to accept that the Miami coastline is rapidly becoming submerged. This article demonstrates the importance of electing informed, open-minded officials.

Internet Sites

Video for this lesson

http://www.abc.net.au/science/crude/

Crude: The Incredible Journey of Oil, ABC Television (Australia), Science Series.

https://www.youtube.com/watch?v=IC40mZHu2ZQ

Mirror site - same video as above

Related sites - The Problem

http://learning.blogs.nytimes.com/2014/04/02/teaching-about-climate-change-with-the-new-york-times/

New York Times, Learning Network. Resources for instructors teaching about climate change.

http://climatekids.nasa.gov/

NASA's interactive student website on weather and environmental issues.

http://sealevel.climatecentral.org/

Climate Central interactive map showing Sea level rise graphically for coastal areas of the U.S.

http://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change

Ted Talk, *The Emergent Patterns of Climate Change* by Gavin Schmidt, discusses the hows and whys of climate change modeling

http://ed.ted.com/lessons/climate-change-earth-s-giant-game-of-tetris-joss-fong

Ted Ed lesson, *Climate Change: Earth's Giant Game of Tetris* by Joss Fong, includes video, discussion questions and lesson ideas.

http://ed.ted.com/lessons/how-quantum-mechanics-explains-global-warming-lieven-scheire

Ted Ed lesson, *How Quantum Mechanics Explains Global Warming* by Lieven Scheire explains in an atomic view how CO2 heats the earth.

http://ed.ted.com/lessons/why-i-must-speak-out-about-climate-change-james-hansen

Ted Ed lesson, *Why I must speak Out About Climate Change*, by James Hansen, includes video, discussion questions and lesson ideas.

https://www.youtube.com/watch?v=2Jp1D1dzxj8

What's The Deal With Carbon? Animated video describes the carbon cycle and how it is affected by human activity.

Related sites - Solutions

https://www.nwf.org/Eco-Schools-USA/Become-an-Eco-School/Pathways/Climate-Change/Tips.aspx

National Wildlife Federation, Top Ten Tips to Tackle Climate Change, written with students and schools in mind, includes actions that classes and school environmental groups can take.

http://www.ucsusa.org/what-can-i-do-about-climate-change

Union of Concerned Scientists lists online petitions related to climate change.

http://www.youngvoicesonclimatechange.com/

Young Voices for the Planet, a site started by author Lynne Cherry, includes videos of students talking about their successful environmental initiatives.

http://www.greenpeace.org/international/en/campaigns/climate-change/Solutions/What-you-can-do/

Greenpeace lists actions that individuals can take to save energy, live 'green' and choose climate-friendly transportation.

Climate Change

Florida NGSS Standards & Related Subject Common Core

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Nature of Science																					
Standard 1	**SC.912.N.1.**	X		X	X																
Standard 2	**SC.912.N.2**				X																
Standard 3	**SC.912.N.3.**	X	X			X															
Standard 4	**SC.912.N.4**	X																			
Earth and Space																					
Standard 5	**SC.912.E.5.**				X																
Standard 6	**SC.912.E.6.**						X														
Standard 7	**SC.912.E.7.**			X			X	X	X	X											
Life Science																					
Standard 17	**SC.912.L.17.**											X		X		X	X				X
Social Studies Standards		SS.912.G.3.3, SS.912.G.S.1, SS.912.G.S.4, SS.912.G.6.1, SS.912.C.2.10																			

Standard 1: The Practice of Science

- SC.912.N.1.1 – Define a problem based on a specific body of knowledge, and do the following: 3) examine books and other sources of information to see what is already known, 4) review what is known in light of empirical evidence, 8) generate explanations that explicate or describe natural phenomena, 9) use appropriate evidence and reasoning to justify these explanations to others, 10) communicate results of scientific investigations, and 11) evaluate the merits of the explanations produced by others.
- SC.912.N.1.3 – Recognize that the strength or usefulness of a scientific claim is evaluated through scientific argumentation, which depends on critical and logical thinking, and the active consideration of alternative scientific explanations to explain the data presented
- SC.912.N.1.4 – Identify sources of information and assess their reliability according to the strict standards of scientific investigation.

Standard 2: The Characteristics of Scientific Knowledge

- SC.912.N.2.4 – Explain that scientific knowledge is both durable and robust and open to change. Scientific knowledge can change because it is often examined and re-examined by new investigations and scientific augmentation. Because of these frequent

examinations, scientific knowledge becomes stronger, leading to its durability.

Standard 3: The Role of Theories, Laws, Hypotheses, and Models

- SC.912.N.3.1 – Explain that a scientific theory is the culmination of many scientific investigations drawing together all the current evidence concerning a substantial range of phenomena; thus, a scientific theory is the most powerful explanation scientists have to offer.
- SC.912.N.3.2 – Describe the role consensus plays in the historical development of a theory in any one of the disciplines of science.
- SC.912.N.3.5 – Describe the function of models in science, and identify the wide range of models used in science.

Standard 4: Science and Society

- SC.912.N.4.1 – Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

Standard 5: Earth in Space and Time

- SC.912.E.5.4 – Explain the physical properties of the sun and its dynamic nature and connect them to conditions and events on Earth.

Standard 6: Earth and Space Science

- SC.912.E.6.6 – Analyze past, present, and potential future consequences to the environment resulting from various energy production technologies.

Standard 7: Earth Systems and Patterns

- SC.912.E.7.3 – Differentiate and describe the various interactions among Earth systems, including: atmosphere, hydrosphere, cryosphere, geosphere, and biosphere.
- SC.912.E.7.6 – Relate the formation of severe weather to the various physical factors.
- SC.912.E.7.7 – Identify, analyze, and relate the internal (Earth system) and external (astronomical) conditions that contribute to global climate change.
- SC.912.E.7.8 – Explain how various atmospheric, oceanic, and hydrologic conditions in Florida have influenced and can influence human behavior, both individually and collectively.
- SC.912.E.7.9 – Cite evidence that the ocean has had a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water.

Standard 17: Interdependence

- SC.912.L.17.11 - Evaluate the costs and benefits of renewable and nonrenewable resources, such as water, energy, fossil fuels, wildlife, and forests.
- SC.912.L.17.13 – Discuss the need for adequate monitoring of environmental parameters when making policy decisions.
- SC.912.L.17.15 – Discuss the effects of technology on environmental quality.
- SC.912.L.17.16 – Discuss the large-scale environmental impacts resulting from human activity, including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.
- SC.912.L.17.20 – Predict the impact of individuals on environmental systems and examine how human lifestyles affect sustainability.

Social Studies Standards

Geography

- SS.912.G.3.3 – Use geographic terms and tools to explain differing perspectives on the use of renewable and non-renewable resources in Florida, the United States, and the

world.

- SS.912.G.5.1 – Analyze case studies of how the Earth's physical systems affect humans.
- SS.912.G.5.4 – Analyze case studies of how humans impact the diversity and productivity of ecosystems.
- SS.912.G.6.1 – Use appropriate maps and other graphic representations to analyze geographic problems and changes over time.

Civics and Government

- SS.912.C.2.10 - Monitor current public issues in Florida.

National Next Generation Science Standards

Ecosystems: Interactions, Energy, and Dynamics

- HS-LS2-3 - Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- HS-LS2-5 - Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
- HS-LS2-6 - Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-LS2-7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Biological Evolution: Unity and Diversity

- HS-LS4-5 - Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of the same species, (2) the emergence of new species over time, and (3) the extinction of other species.

Earth's Systems

- HS-ESS2-2 - Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems.
- HS-ESS2-4 - Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Earth and Human Activity

- HS-ESS3-5 - Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
- HS-ESS3-6 - Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Climate Change

1. How did the discovery of a band of dark organic rich shale in the limestone rock in Italy lead scientists to hypothesize that this band of rock was part of a global period of ocean stagnation (oceanic anoxic event) that was linked to a super greenhouse world?

2. What was the super greenhouse world like?

3. How are fossils of the ginko plant used to tell scientists how much carbon dioxide was in the atmosphere when the plant was alive?

4. What do scientists believe stopped the runaway greenhouse effect of the global anoxic events of the past?

5. Why is the current loss of ice at the poles worrying to climate scientists?

6. According to the video, will we run out of crude oil before we ruin our climate?

7. What can we do to decrease the amount of carbon dioxide that is getting put in the atmosphere from the burning of fossil fuels.....
(list at least three actions for each group below)

.....as an individual?

....in my family?

.....at our school?

....as a nation?