Supplemental Science Unit

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For use with 9th – 11th Grade

May be used as a Science Supplement for Summer School or a Summer Homeschool Learning Unit.

Table of Contents

Unit 1 – Energy and the Earth's Climate

Instructions and expectations for this course.

This course is an independent study used to meet one of your credits for your high school record. This semester credit may be used to 'cushion' any lower-graded course work in other science courses throughout your high school career. This course will have a grading system and it will be YOUR responsibility to do the work. The reading required is minimal, however, you will need a strong discipline to complete this course successfully.

Materials

Your teacher will supply you with one spiral notebook, one folder/portfolio, and two grade trackers for your personal use. The grade trackers are to help YOU know where you are at any point in the course by simply adding together all of your scores and dividing by the total number of items added. The portfolio will be collected for participation points as well as ensuring that you are completing all of your assignments. Your notebook is part of your portfolio, and I advise that you take excellent care of your notes, questions, etc. You will be provided with a list of items that should be in your portfolio and notebook. NOTE: Since there are no pop quizzes for this class, I may collect your items at any time and award bonus points for a well-kept notebook/portfolio containing all items up to that point. Likewise, missing items will result in fewer to no bonus points and may result in deducting from your participation grade.

Items for your Notebook

1. All Lesson Questions (LQ) and Content Questions (CQ) with answers (Questions are in red & located on this schedule)
2. Notes from readings
3. Vocabulary Lists and definitions for each chapter
4. Reflection page after each lesson identifying what you have learned during the lesson

Items for your Portfolio

1. All handouts
2. All Homework Assignments and worksheets
3. Rough-sketches of visuals for this course
4. Grade Records with up-to-date recordings of grades
5. Concept Questions and Answers

Instructions for accessing the Modules and Tests

- You will log in to the has.portal.concord.org website.
- Your user name is ***kb1*** (your initials and the number 1)
- Your password is ***education.***
- Pretests are graded for participation
- Lessons follow the pretest and are geared in expanding the concepts you will learn from this course.
- Posttests are graded for the gradebook.

Unit 1 – Energy and The Earth's Climate

Chapter 1 – What are our Energy Choices

Lesson Overview and Schedule – 225 Minutes Module Total

Chapter 1 - **Vocabulary**

Term	Part of Speech	Definition
Biomass	Noun	living organisms, and the energy contained within them.
Casing	Noun	Material on the outside of a substance, usually there to protect the material inside.
Conservation	Noun	Management of a natural resource to prevent exploitation, destruction, or neglect.
Consumption	Noun	Process of using goods and services.
Efficient	Adjective	performing a task with skill and minimal waste.
Electricity	Noun	Set of physical phenomena associated with the presence and flow of electric charge.
Energy consumption	Noun	Use of power, usually defined as power produced by human beings in plants run on electricity, fossil fuels, or nuclear fission.
Energy resource	Noun	source of energy found in nature that has not been subject to any human-induced energy transfers or transformations; for example, oil, coal, gas, wind, or sunlight.
Fossil fuel	Noun	Coal, oil, or natural gas. Fossil fuels formed from the remains of ancient plants and animals.
Global warming	Noun	Increase in the average temperature of the Earth's air and oceans.
Greenhouse gas	Noun	Gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
Habitat	Noun	Environment where an organism lives throughout the year or for shorter periods of time.
Hydraulic fracturing	Noun	Process usually used to extract oil and natural gas in which rocks are fractured by injecting water, chemicals, and sand at high pressure. Also called fracking.
Hydroelectric energy	Noun	Energy generated by moving water converted to electricity. Also known as hydroelectricity.
Kilowatt-hour	Noun	(KWh) unit of energy equal to 1,000 watt hours.
Megawatt hour	Noun	Equal to 1,000 kilowatt hours (Kwh), or 1,000 kilowatts of electricity used continuously for one hour. One megawatt-hour equals one million (1,000,000) watt-hours or 3,600,000,000 joules.
Methane	Noun	Chemical compound that is the basic ingredient of natural gas.
Model, computational	Noun	A mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
Natural gas	Noun	Type of fossil fuel made up mostly of the gas methane.
Non-renewable energy	Noun	Energy resources that are exhaustible relative to the human life span, such as gas, coal, or petroleum.
Permeable	Adjective	Allowing liquid and gases to pass through.
Porosity	Noun	The ratio of the volume of all the pores, or holes, in an object and the object's total mass.
Renewable energy	Noun	Energy obtained from sources that are virtually inexhaustible and replenish naturally over small time scales relative to the human life span.
Renewable resource	Noun	Resource that can replenish itself at a similar rate to its use by people.
Shale	Noun	Type of sedimentary rock.

Background Information

Electricity is generated from many different sources. Most methods of generating electricity involve water. Coal, natural gas, biomass, and oil are burned to generate heat. The chemical energy stored in the bonds is turned into heat energy. Nuclear power heats water as a result of atomic decay. The heat energy is used to heat water, which is turned to steam, which turns turbines. Thus, the heat energy is turned into mechanical energy. The mechanical energy spins the turbines, and the spinning action of the copper wire generates electricity. Thus, the chemical energy in the bonds of coal, natural gas, biomass, and oil and the nuclear energy in uranium is turned into heat energy, mechanical energy, and finally electrical energy that can flow through power wires into houses to do work. In the house, the electrical energy is transformed again to power electrical devices.

In hydropower and wind operations, the water and wind turn the turbine directly—a transformation of mechanical energy into electrical energy as the spinning turbine generates electricity. Solar energy can be used to generate electricity in two different ways. One way involves heating water to spin a turbine. The other way, commonly seen on rooftops, involves direct generation of electricity. The solar energy moves electrons on a silicon panel, turning light energy into electrical energy in a single step.

The demand for electricity has increased. More people around the world are gaining access to electricity. The energy sources for electricity generation in the United States changed between 2001 and 2011. The amount of natural gas used to generate electricity has increased, while coal use has declined. More renewable energy sources are being used.

Geologists find oil and natural gas deposits by reading the history in the rocks. Oil and natural gas are formed when organic material is compacted and heated over long periods of time. Water provides a lot of pressure to pack organic materials into formations that can eventually produce oil and gas. Therefore, geologists look for areas that were once covered by water.

Sedimentary rocks are formed when many layers of sediments are compacted together; sedimentary rocks form under large bodies of water. Since Earth's continents are continually moving and areas that were once covered by water may no longer be covered by water, geologists look for sedimentary rocks with high organic matter content.

Shale is a tightly packed sedimentary rock. The shale is very porous, but it is not very permeable. This allows the shale to hold a lot of oil/natural gas but makes it difficult to remove the oil/natural gas from the shale. Recent technologies have made it possible to extract the oil and natural gas trapped in deep shale formations.

Hydraulic fracturing increases the permeability of the shale by forcing open the natural cracks in the shale. Water or other fluids, such as propane, are pumped into wells, cracking open the natural fissures in the rock. The fractures are kept open by use of proppants, such as sand. Propane-based fracturing is still in experimental stages, but it offers several advantages over water-based fracturing. Natural gas and associated oil is soluble in propane, so well production can be greater with a propane-based fracturing. Propane can also be more completely recovered from the well so that it can be used to fracture other wells. The major downside is cost, as propane is more expensive than water. But in areas where water is scarce, propane may become relatively cheaper than water.

Every electricity-generating resource has costs and benefits. All electricity-generating sources have negative effects on the environment. Each electricity-generating source also has some benefits. Resources can be compared based on their geographical abundance, energy density, effects on water quality, effects on air quality, and the amount of land needed for extraction and generation.

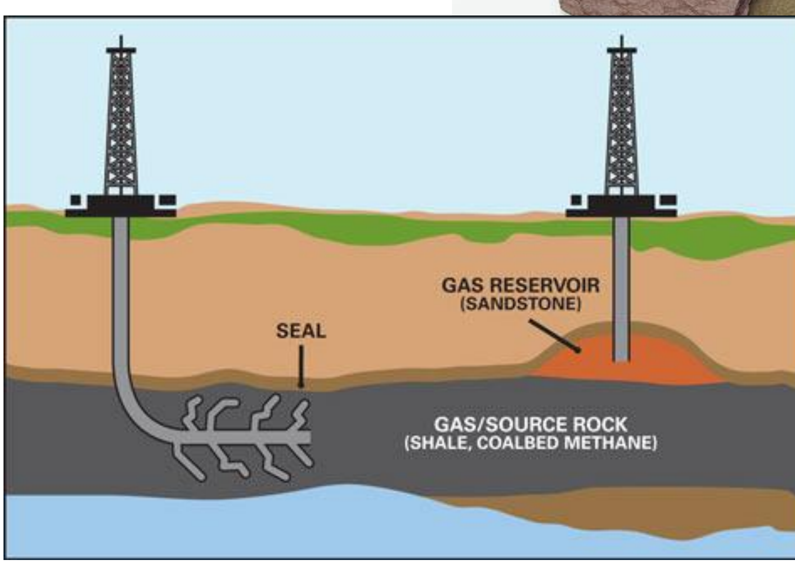
The extraction of natural gas from shale has the potential to contaminate groundwater. The casings around the pipe could leak, releasing methane into the aquifer. The pool of waste fracking fluid could leak, releasing contaminated water into the aquifer. Beyond the effects on groundwater quality, using water to hydraulically fracture natural gas wells could lead to a shortage of water, depending on the area’s climate. There are other negative environmental effects involved with extracting shale gas—from releasing greenhouse gases into the atmosphere to releasing volatile organic compounds that can result in smog and poor air quality.

Much of the generated electricity is lost before it can ever do any useful work. These losses are called conversion losses. In addition to the losses inherent in converting between different forms of energy, much of the energy is lost during transmission. Generating electricity closer to where it will be used reduces the amount of transmission losses.

But there are also benefits to using natural gas for generating electricity. Natural gas is abundant and inexpensive, and it releases fewer greenhouse gases into the atmosphere than burning coal. Extracting natural gas has less impact on human health than mining for coal or nuclear fuels.

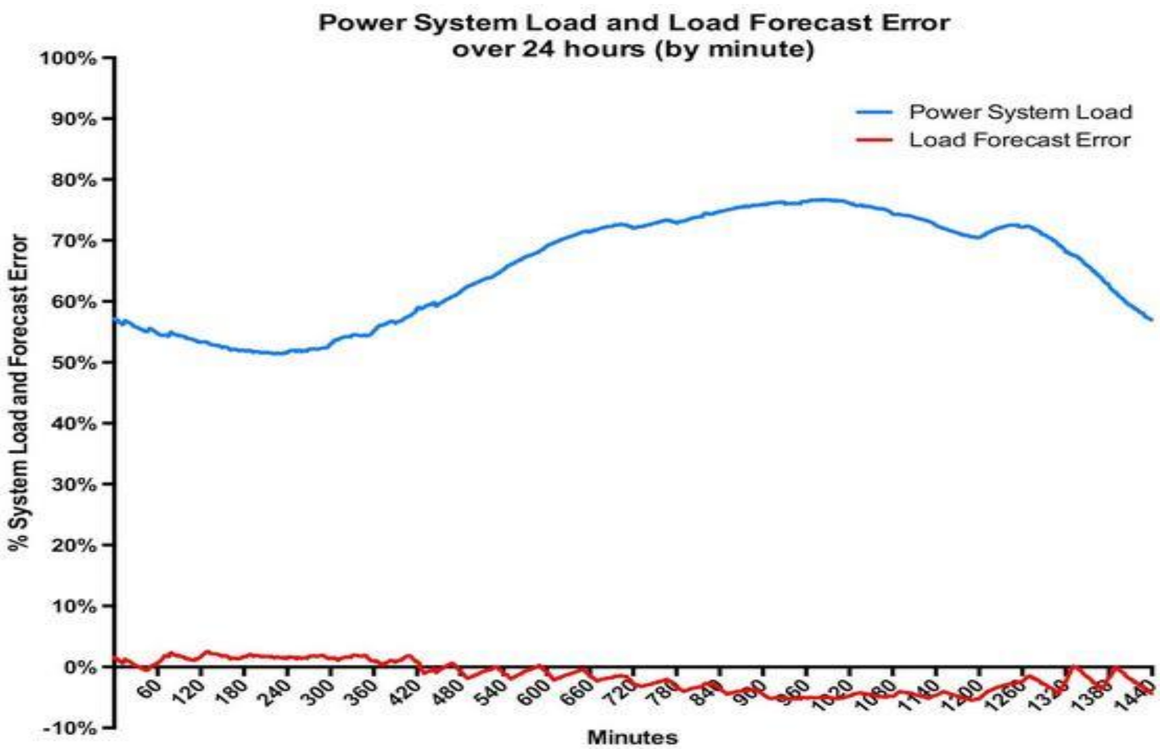
The demand for electricity has increased. Using less electricity and using electricity more efficiently can minimize the negative effects of resource extraction and generation on the environment and human health. Using more efficient electrical devices ensures that more of the electricity is used for useful purposes, rather than being lost as waste heat. One notable example is in lighting; incandescent bulbs get very hot when they are on. LED lighting remains cool to the touch. This is because the LEDs are more efficient at providing light. The incandescent bulbs provide light, but a large amount of the electricity used to operate them is "lost" as heat energy—electricity that was not able to be used for the primary purpose of providing light.





Lesson A - Vocabulary and Topic Discussion.

- View the pie charts found in this lesson. Electricity is generated in the US by many different sources.
  - Discussion Questions: How did the US's usage of coal change between 2001 and 2011? How did the US's usage of nuclear power change between 2001 and 2011? How did the US's usage of natural gas change between 2001 and 2011? In this chapter, you will be exploring how electricity is produced in the 50 states.
    - Science is a process of learning how the world works and the scientists do not know the "right" answers when they start to investigate a question.
    - View the chart and answer the Lesson Questions.



      - LQ 1: Did the scientists forecast the power demand exactly?
      - LQ 2: Why do you think scientists did not accurately predict the forecast load?
    - Throughout this lesson, you will be asked questions about the certainty of your predictions. You should think about what scientific data are available as you assess your certainty. Identifying scientific data is a huge step in getting a more accurate prediction.
    - Pretest for Energy Lesson (make sure you log in)

Lesson B - Electricity Sources and Challenges

- Activity #1 - Electricity Sources and Challenges – Module 45 (Make sure you log in)
    - LQ 3: How is electricity generated from coal, natural gas, and biomass?
    - LQ 4: What energy transformations happen once electricity arrives at your home?
    - LQ 5: Why isn't electricity demand constant?
    - LQ 6: What sources are used to generate electricity in your state?
- Complete the Content Questions:
    - CQ 1: What energy conversion happen to generate electricity from coal?
    - CQ 2: What energy conversion happen in your home?
    - CQ 3: How did electricity generation change in the United States from 2001 to 2011?

Lesson C - Homework Assignment

- Remind me to print the page to complete the assignment.
- Use the Interactive Map to locate the sources in your state as well as another state of your choice. Be sure to describe the increase or decrease in sources over the years differences as shown on the map. Use the attached worksheet to complete this assignment.

State # **1** __**Arkansas**__. Year ________		State # **1** __**Arkansas**__. Year ________		State # 2 ______________ Year ______		State # 2 ______________ Year ______	
Source 1		Source 1		Source 1		Source 1	
Source 2		Source 2		Source 2		Source 2	
Source 3		Source 3		Source 3		Source 3	
Source 4		Source 4		Source 4		Source 4	

Written Analysis

In your own words, describe the change in primary and secondary energy sources for both states. How do you think the states' electricity generate might change in the future? Explain.

Questions to Answer

1. What was the primary source for each state in 2001?
2. According to the data, did the primary source change in 2011?
3. Opinion questions: Of the sources used, which one do you believe is least damaging to the earth's atmosphere? Explain.

Lesson D - Extracting Gas from Shale

The United States has produced natural gas commercially for over 100 years. View the following Graphic provided by National Geographic.

- Answer the following Lesson Questions
  - LQ 7: How has the production of natural gas changed since 1950?
  - LQ 8: From where has the most recent increase in natural gas come?

Recent technologies have made it possible to extract natural gas from deep underground shale formations. In this chapter, you will be using models to explore how natural gas is released from shale. View the following cross-sectional graphic to better understand how shale is located. Marcellus Shale contains natural gas. You can see examples of scientists uncertainly in knowing how deep or how thick the shale layers are in some areas.

- LQ 9: Is it possible to drill at the same depth to reach the Marcellus Shale?
- LQ 10: How do you think scientists know where to drill to reach the shale layer?

Lesson D - Extracting Gas from Shale (Cont.)

Scientists use computational models, such as weather forecasting, to predict the locations and quantities of natural gas deposits. You can get an idea of such models by viewing this link of the NOAA NWS map. Geophysicists use physical characteristics such as magnetic and gravitational properties to guess the type and shape of subsurface rocks. Scientists use technologies to model and visualize layers below the surface they cannot see. Scientists test their models by drilling and sampling.

- Activity # 2 – Extracting Gas from Shale – Module 45 (Make sure you log in)
  - LQ 11: How does natural-gas filled shale form?
- Use the Hydraulic Fracturing Model to answer the next questions
  - LQ 12: Why doesn't shale release its natural gas without being fractured?
  - LQ 13: What happens to the water that is used during the hydraulic fracturing process?
  - LQ 14: Can you predict the shape of a shale formation from a single point?
  - LQ 15: Why does the natural gas output of a well decline over time?
- Complete the content questions
  - CQ 4: How is shale formed?
  - CQ 5: Why does some shale contain oil and/or natural gas while other types of shale do not?
  - CQ 6: Why does shale have to be fractured to release the trapped natural gas?

Lesson E - Evaluating Natural Gas

All electricity generating sources have an effect on the environment. Discussion questions: What kinds of effects can the extraction and use of the energy resources have on the environment? In this lesson, you will explore the costs and benefits of using shale gas as an electricity-generating resource.

- Activity # 3 – Evaluating Natural Gas - Module 45
  - Answer the Lesson Questions
    - LQ 16: Is there an advantage for natural gas over coal?
    - LQ 17: How does drilling for natural gas affect the land?
  - For the next questions, use the Hydraulic Fracturing Model 3
    - LQ 18: How can drilling for natural gas affect the aquifer?
    - LQ 19: Is there a difference between using water and using propane to fracture the well?
    - LQ 20: Can you predict when a leak will happen in the casing or in the water storage pool?
  - Answer the Content Questions
    - CQ 7: How can the water table be contaminated by shale gas extraction?
    - CQ 8: What precautions can be taken to prevent ground water contamination?
    - CQ 9: What are some benefits of extracting shale gas for electricity generation?

Lesson F - Evaluating Other Sources of Energy

In this lesson, we will discuss the theory "tragedy of the commons", where "individuals, acting independently and rationally according to each one's self-interest, behave contrary to the whole group's long-term best interests by depleting some common resource." For example, a common area is used for grazing cow; each person grazes all of their cattle there, and eventually, the grass is all gone.

- Discussion Questions:
  - Could people have predicted that the cattle would eat all of the grass?
  - Do you think it is possible to know in advance how much of a resource there is?
  - Do you think it is possible to know in advance how human's use of a resource will affect the environment?
- Activity # 4 – Evaluating Other Energy Sources – Module 45
  - Answer the Lesson Questions
    - LQ 21: Which electricity-generating sources have the lowest effect on global warming?
    - LQ 22: Which electricity-generating sources have effects on the water supply?
    - LQ 23: What is the effect of renewable energy sources?
    - LQ 24: Which electricity generating source is most abundant in your area? You may review The Graphic of the US to recall your state electricity-generating sources
  - Answer the Content Questions
    - CQ 10: Why is the location of a resource important in its usefulness as an electricity-generating source?
    - CQ 11: Why is the abundance of a resource important to its usefulness as an electricity-generating source?
    - CQ 12: Which electricity-generating sources emit greenhouse gases?
    - CQ 13: What are the benefits of using renewable resources for electricity generation?
    - CQ 14: What effects do different electricity-generating sources have on water supply and quality?

Lesson G - Energy Efficiency

View the following Flow Graph

Not all electricity that is generated makes it to homes and businesses. Discussion questions: How much of the electricity is lost? Where does the lost energy go? How do you think the amount of electricity losses can be minimized? Why are there transmission and delivery losses from the generated electricity?

- Activity # 5 – Energy Efficiency - Module 45 (Make sure you log in)
  - Answer the Lesson Questions
    - LQ 25: During what season is electricity usage the highest?
    - LQ 26: How could people use electricity more efficiently in the summer?
    - LQ 27: How can schools be made more efficient?
    - LQ 28: How does energy efficiency affect the electrical grid?
    - LQ 29: Is it better for the environment to put solar panels on your roof or be more energy efficient?
    - LQ 30: What do you think the energy mix for electricity generation will be in the future? Explain.
  - Answer the Content Questions:
    - CQ 15: How can electricity losses be minimized?
    - CQ 16: How can buildings be made more energy efficient?
    - CQ 17: What can you do to avoid needing to build new power plants in your state?

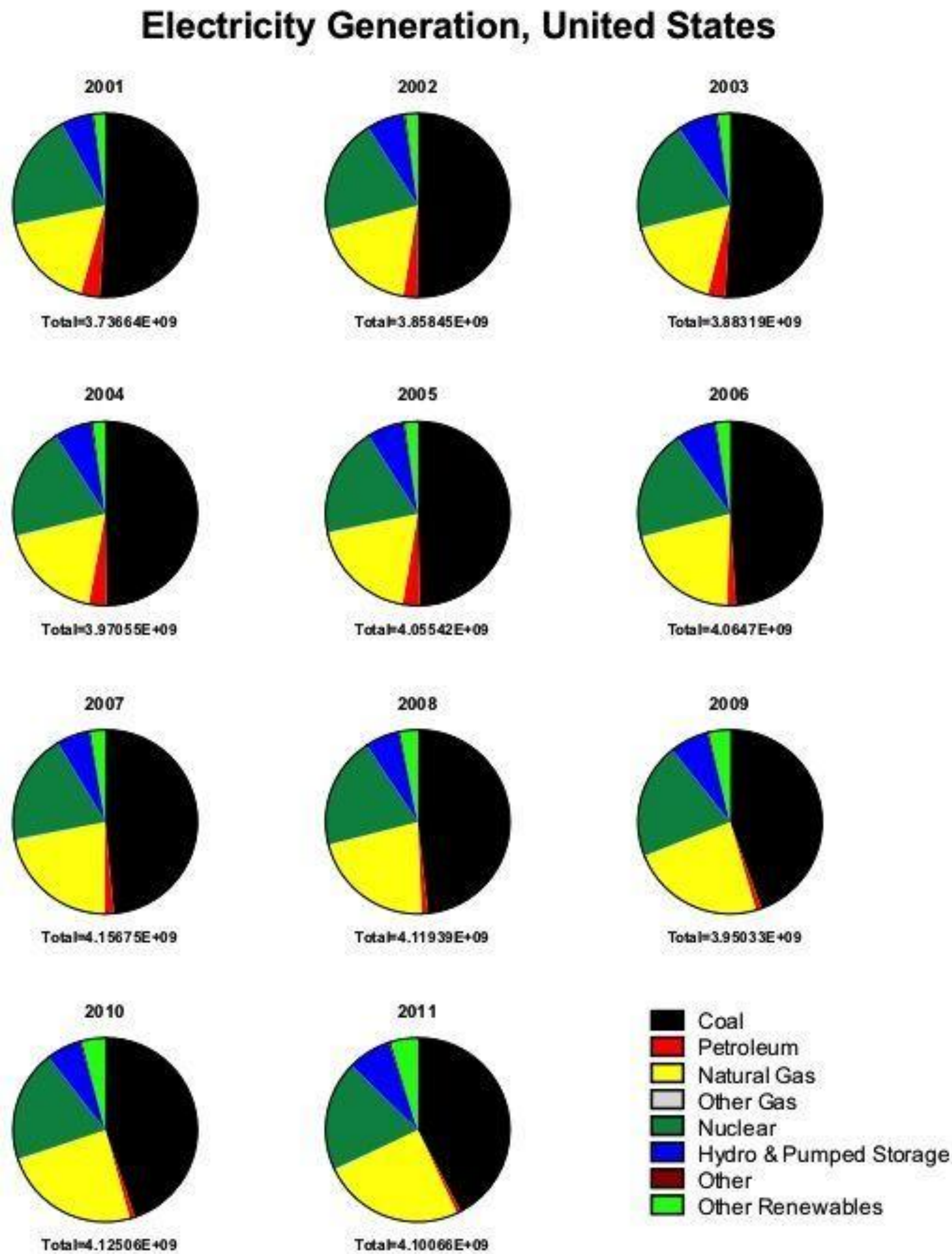
Lesson H – Post-Test for Energy Lesson

(Make sure you log in)

Watch this video about Fracking and Earthquakes in Arkansas

Between 1975 and 2008, Oklahoma only had an average of 6 earthquakes a year. In one year, they had over 200. Do you think fracking is the cause of the earthquakes?

Chapter Graphics



Chapter 2 – What is the Future of Earth's Climate

Lesson Overview and Schedule – Module Total 225 minutes

Chapter 2 - Vocabulary

Term	Part of Speech	Definition
Absorb	Verb	to soak up.
Albedo	Noun	scientific measurement of the amount of sunlight that is reflected by a surface.
Annual	Adjective	yearly.
Atmosphere	Noun	layers of gases surrounding a planet or other celestial body.
Carbon dioxide	Noun	greenhouse gas produced by animals during respiration and used by plants during photosynthesis. Carbon dioxide is also the byproduct of burning fossil fuels.
Climate	Noun	all weather conditions for a given location over a period of time.
Emit	Verb	to give off or send out.
Error bar	Noun	visual representation used in graphs to indicate the uncertainty in a measurement.
Glacier	Noun	mass of ice that moves slowly over land.
Greenhouse effect	Noun	phenomenon where gases allow sunlight to enter Earth's atmosphere but make it difficult for heat to escape.
Greenhouse gas	Noun	gas in the atmosphere, such as carbon dioxide, methane, water vapor, and ozone, that absorbs solar heat reflected by the surface of the Earth, warming the atmosphere.
Ice age	Noun	long period of cold climate where glaciers cover large parts of the Earth. The last ice age peaked about 20,000 years ago. Also called glacial age.
Ice core	Noun	sample of ice taken to demonstrate changes in climate over many years.
Infrared radiation	Noun	part of the electromagnetic spectrum with wavelengths longer than visible light but shorter than microwaves.
Model, computational	Noun	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
Parts per million (ppm)	Plural Noun	A unit of measure of the amount of dissolved solids in a solution in terms of a ratio between the number of parts of solids to a million parts of total volume.
Radiation	Noun	energy, emitted as waves or particles, radiating outward from a source.
Running mean	Noun	calculation that analyzes data by creating a series of averages of different groups of a whole data set. Also called a moving mean, rolling mean, or moving average.
Sink	Noun	part of a physical system that absorbs some form of matter or energy.
Solubility	Noun	ability of a substance to be dissolved or liquified.
Source	Noun	any place or thing or place from which something comes, arises, or is obtained.
System	Noun	collection of items or organisms that are linked and related, functioning as a whole.
Temperature	Noun	degree of hotness or coldness measured by a thermometer with a numerical scale.
Variable	Noun	piece of data that can change.
Water vapor	Noun	molecules of liquid water suspended in the air.

Background

Earth's climate is continually changing. Earth has been covered in ice (snowball Earth) at some points during its existence, while at other times Earth has been ice-free. Earth is in a warming period now, due in part to enhance human emissions of greenhouse gasses. (Greenhouse gases, such as carbon dioxide, methane, and water, trap heat in the atmosphere by absorbing heat energy emitted from the surface.)

Scientists use past and current temperature data to develop climate models to predict how warm the planet might get. Scientists use ancient sediments and ice cores to measure past temperatures. They put these data into sophisticated computational models to make predictions about the future.

When scientists can accurately predict past climates with their inputs and algorithms, they can be surer that their models will be able to correctly predict future climates. There are many different factors that can affect Earth's atmosphere and temperature, and scientists continually update their models to reflect as many of these interactions as they can.

Computational models are used to explore phenomena that are too large, too small, too quick, or too slow to observe otherwise. The computational models with which you may be familiar are used for forecasting weather events such as hurricanes. Scientists are more confident in the output of their models when they can input a lot of data. Other scientists check their models against what happens in reality; when the model accurately reflects what happens in reality, scientists can be more confident in their models.

Greenhouse gases warm the atmosphere by trapping outgoing heat (infrared) radiation. Sunlight brings visible (and ultraviolet and infrared) light to Earth. The radiation can be absorbed by Earth's surface, or it can be reflected back into space. The radiation that is absorbed heats molecules in Earth's surfaces. This heat energy, or infrared radiation, is radiated back out towards space. The infrared energy can be absorbed and re-emitted by greenhouse gases in the atmosphere. This absorption and re-emission keeps heat trapped in the atmosphere for longer periods of time, leading to an increased atmospheric temperature.

Like all matter, carbon cycles throughout the Earth system. Carbon dioxide is released into the atmosphere from rocks as they weather. It is taken up by plants and incorporated into proteins, carbohydrates, and fats. It is released when organisms respire, and it is released when fossil fuels are burned. Carbon dioxide is removed from the atmosphere when it dissolves into the ocean.

The oceanic uptake of carbon dioxide is temperature-dependent. Carbon dioxide, like all gasses, is less soluble in water as the water temperature warms. So as Earth warms, the oceans are less able to remove carbon dioxide from the atmosphere. At the same time, the increased temperature resulting from increased levels of atmospheric carbon dioxide causes water to evaporate from the ocean surface. Water vapor is a powerful greenhouse gas. With increased water vapor in the atmosphere, the temperature increases ever more. The relationship between atmospheric carbon dioxide and water vapor is a type of positive feedback–an increase in one leads to an increase in the other, leading to a continual increase in temperature.

Solar radiation consists of visible light, infrared radiation (heat), and ultraviolet radiation. When solar radiation encounters Earth's atmosphere and surface, it can be reflected (sent back into space) or absorbed. Energy that is absorbed becomes heat in Earth's surface. This heat can be re-radiated into space. Light-colored surfaces reflect more solar energy than dark-colored surfaces. Infrared radiation is emitted by Earth's surface. Instead of the infrared radiation being allowed to exit Earth's atmosphere into space, greenhouse gases absorb it and re-emit it, keeping more heat in the atmosphere. Greenhouse gases include carbon dioxide, methane, and water.

Clouds can have a cooling effect or a warming effect, depending on their makeup and position in the atmosphere. High-level clouds have a net cooling effect as they block incoming solar radiation. Low-level clouds have a net warming effect as they prevent infrared radiation from escaping into space

Lesson I – Vocabulary words and Topic Discussion

- LQ 1: What are some examples of climates?
- LQ 2: What factors determine a region's climate?
- LQ 3: Has Earth always had the same climates as it has today?

Lesson J – Pretest

(Be sure to log in)

The Role of Uncertainty in the scientific process.

Science is a process of learning how the world works and that scientists do not know the "right" answers when they start to investigate a question. The graphs below will show you examples of scientists' uncertainties in their predictions. The following graph shows several different models of forecast temperature changes. View the Graph and answer the following Question

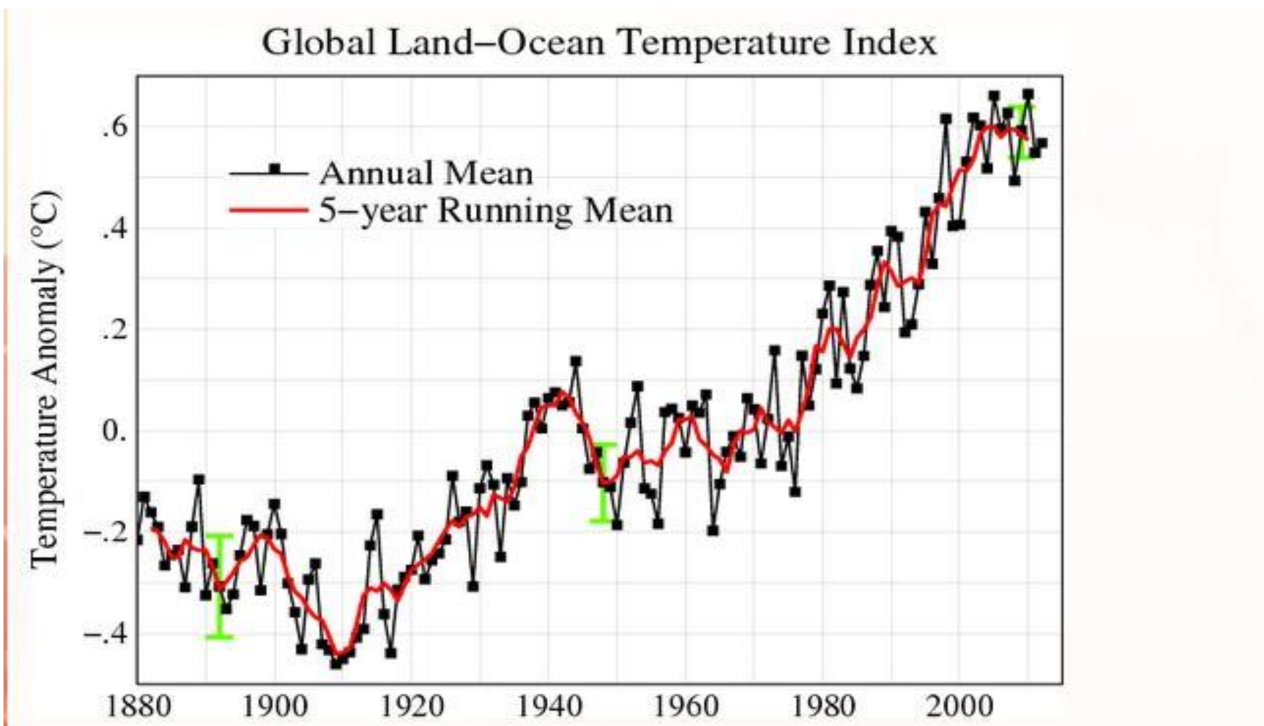
- LQ 4: Why is there more variation (a wider spread) between the models at later dates than at closer dates?

The ability to better predict near-term events occurs in hurricane and tropical storm forecasting as well. The cone in the following graph shows the scientists' uncertainty in the track of the storm, just as the climate models show the scientists' uncertainty in how much Earth's temperature will change in the future. View the Graph and answer the following Question

- LQ 5: When are scientists most confident in their predictions?

Lesson K – Earth's Changing Climate

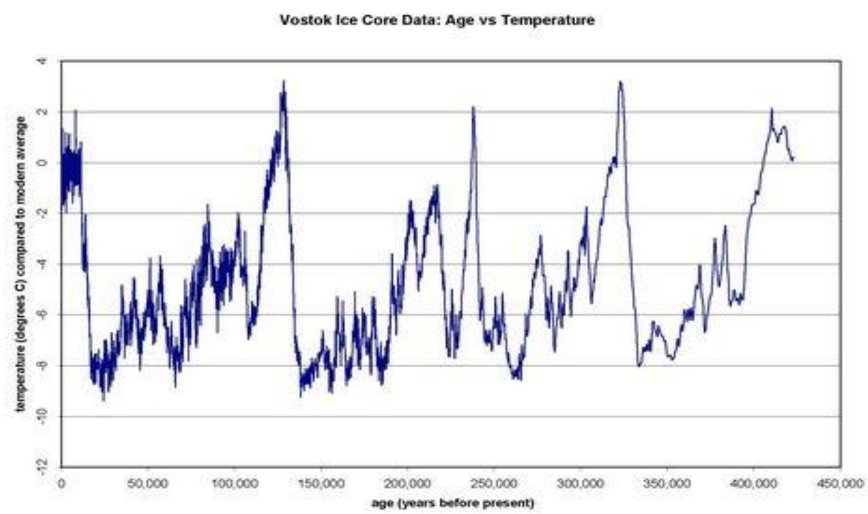
- Activity # 1 - Earth's Changing Climate –- Module 45 (be sure to log on)
- Greenhouse gases cause a warming of Earth's atmosphere.
    - LQ 6: List several greenhouse gases and hypothesize how they warm Earth's atmosphere.



Average temperature change, compared to 1950-1980 baseline, from 1880 to 2010

NASA Goddard Institute for Space Studies

- View the following graphs and discuss
  - LQ 7: Why don't you see the temperature trend from the first graph (1880-2010) represented on the second graph (Vostok ice core)?
  - LQ 8: How are ice ages represented on the Vostok ice core graph?
  - LQ 9: What is the average temperature difference between glacial and interglacial periods?
  - LQ 10: How long (in thousands of years) did it take to go from glacial periods to interglacial periods?
  - LQ 11: How do these changes compare to the time scale for the most recent (current) warming trend?



Temperature change, measured from dissolved gases. Vostok Ice Core.

- LQ 12: Why do you think scientists think the warming of the 20th century cannot be explained by the natural variability seen over geologic time?
- Concept Questions
- CQ 1: How has Earth's average temperature changed over the past 400,000 years?
- CQ 2: How do scientists determine what the temperature was 400,000 years ago?
- CQ 3: What makes scientists more confident in their predictions of future climates?

Watch this video which discusses "Ice Calving".

Watch this video about "Global Warming".

Lesson L – The Role of Systems in Climate Science

Forecasting what will happen in Earth's climate system is a complicated process because there are many different interacting parts. Scientists think about how one part of the system can affect other parts of the system. Read the following scenario for discussion: On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits.

- When there are a lot of rabbits, what will happen to the fox population?
- What happens to the fox population when they've eaten most of the rabbits?
- What happens to the amount of grass when the fox population is high?
- If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply.

- What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?
- These simple cause-effect relationships can expand into more complex system relationships. You will be exploring cause-effect and system feedback relationships between carbon dioxide and water vapor in this activity. Think about how each piece of the system affects other pieces of the system.

Interactions within Earth's Atmosphere Computational models are used by scientists all over the world to better predict weather patterns, climate changes and other weather-related phenomenon.

- Graph for Discussion
    - Understand that:
        - Scientists use information about the past to build their climate models.
        - Scientists test their climate models by using them to forecast past climates.
        - When scientists can accurately forecast past climates, they can be more confident about using their models to predict future climates.
- Interactive Items for Discussion - (Model 1) & (Model 2)
- Activity #2 – Interactions within the Atmosphere – Module 45 (be sure to log in)

Lesson L – The Role of Systems in Climate Science (cont.)

- Answer the following questions
    - LQ 13: What do models help you visualize?
    - LQ 14: What are the similarities and differences between the Earth System Model (Model 1) and the Molecular Model (Model 2)?
    - LQ 15: What are the limitations of the models in this activity?
    - LQ 16: Based on these models, what is the relationship between atmospheric carbon dioxide and temperature?
- View the Keeling Curve (Full Mauna Loa CO_2 Record)
    - LQ 17: Why do you think the carbon dioxide level fluctuates so regularly?
    - LQ 18: Based on the Keeling Curve, what do you expect the temperature of Earth to do?
- Concept Questions
    - CQ4: What two things can happen to solar radiation as it enters Earth's atmosphere?
    - CQ 5: Which type of solar radiation is absorbed by greenhouse gases?
    - CQ 6: What is the long-term trend of carbon dioxide concentration in the atmosphere and global temperature?

Lesson M - Homework Activity

Use the following graph to create your own records of the precipitation and temperature for our area. You will also select an area from another continent. (I will print these for you, just tell me when you need it). You will need to gather the data you will need for this assignment. Due TODAY!

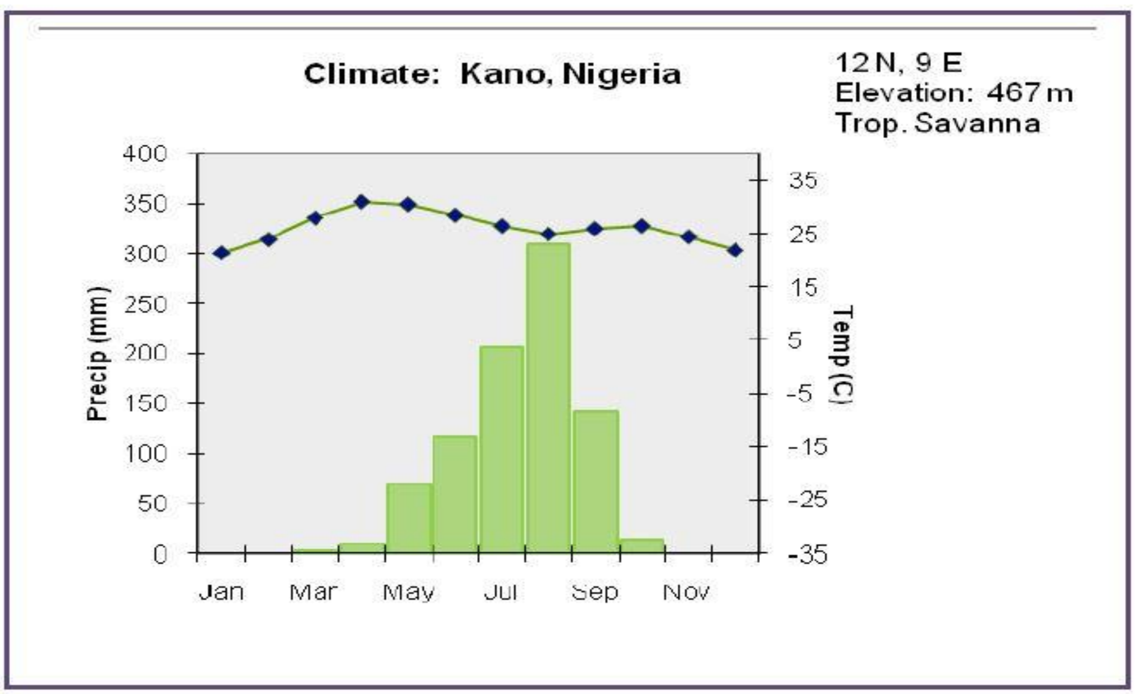
Information for HW Assignment

Earth's surface is a patchwork of climates, but the pattern is not random. There is an order to climate zones. Climate is not the same as weather. Weather is the day to day, even hour to hour conditions of Earth's lower atmosphere. Climate is the long-term average of atmospheric conditions at a particular place on Earth's surface.

Certain factors interact to determine the climate of a particular place: latitude, elevation, prevailing winds, ocean currents, landforms, and location relative to water.

Instructions:

1. Examine the graph below. Notice the left axis shows precipitation in millimeters and the right axis shows temperature in degrees Celsius; and the base identifies a column for each month of the year. Look at the sample graph. Notice that precipitation is represented by bars and temperature is represented by a points connected with a line. The color used relates to the climate zone in which the location is found.
2. Use the NOAA site to determine the color of Arkansas's climate zone for your graph. Use the same site for your second graph/location
3. Access the internet to locate data for our area as well as the second graph/location
4. After you have constructed your graph, be sure to label the climate station, absolute location, and elevation of the cities you have documented.
5. Answer the following questions on the back of your HW paper:
    a. What climate characteristics does each location have? How are they similar? How are they different?
    b. How do factors such as latitude, elevation, prevailing winds, ocean currents, landforms and location relative to water help explain these similarities?

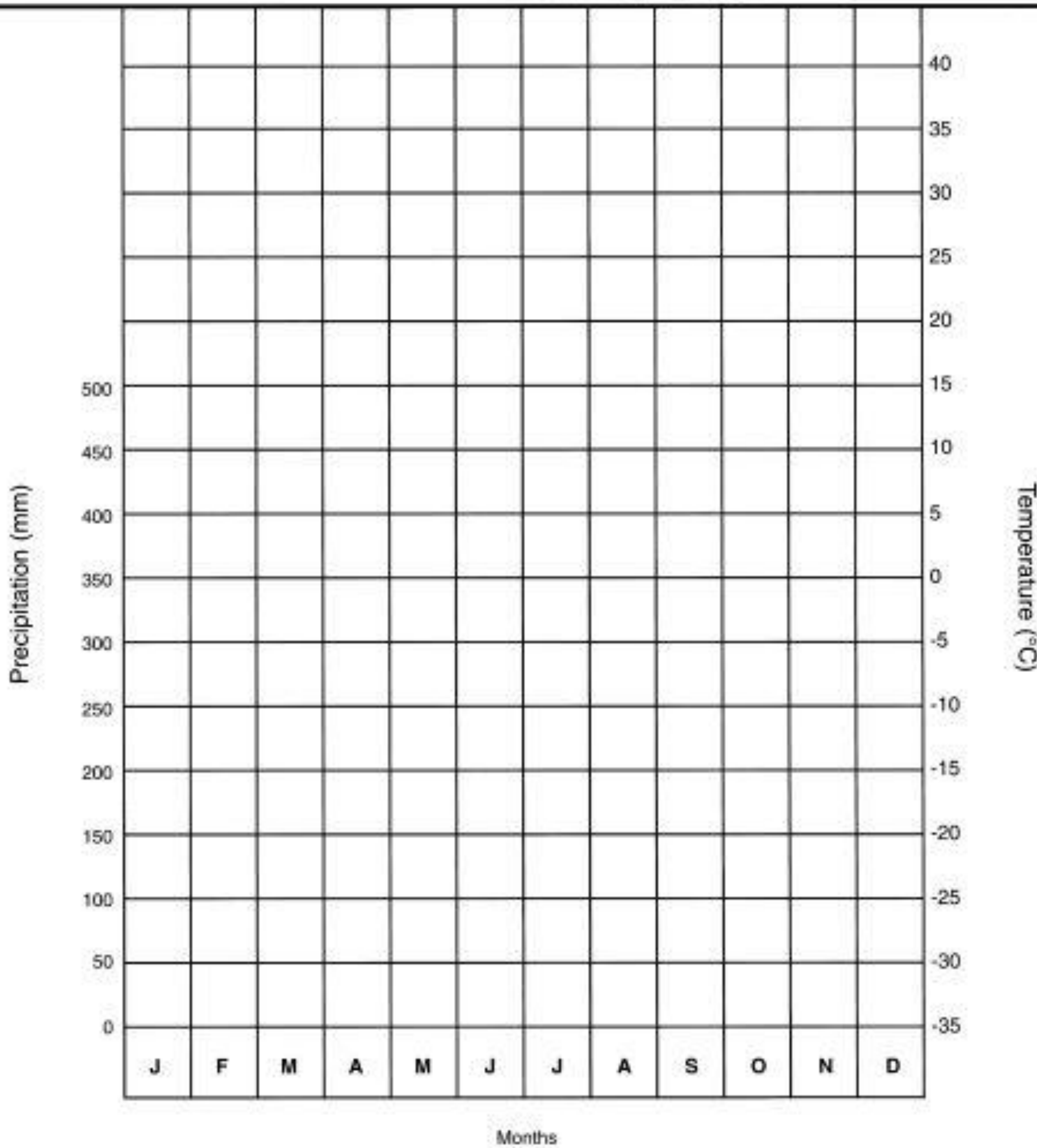


Station: ______________ Climate type: ____________

Latitude: ______________ Longitude: ______________

Elevation: ______________ Temperature Range: ______

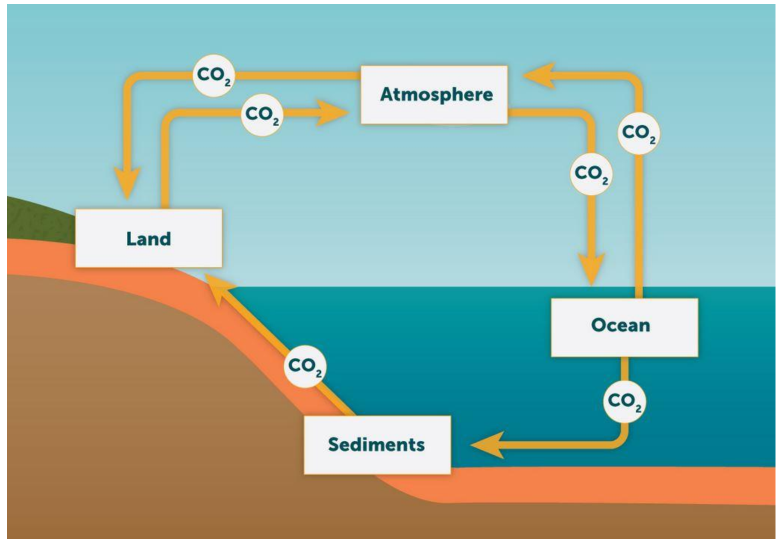
Total Precipitation: ________



Lesson N - Sources, Sinks and Feedback

Matter cycles throughout Earth's system and matter is not destroyed as it moves throughout the system.

- Discussion Questions: What are some sources of carbon dioxide? Where is carbon stored when it is not carbon dioxide? Where does carbon dioxide go after it's released into the atmosphere?
- Activity #3 – Sources, Sinks and Feedback – Module 45 (be sure to log in)
- Look at the chart to the left and answer the question.
  - LQ 19: Is there a source that does not act as a sink?
  - LQ 20: What is the effect of water vapor on temperature?
- Concept Questions
  - CQ 7: How is the solubility of carbon dioxide affected by temperature?
  - CQ 8: How do atmospheric carbon dioxide levels affect ocean temperature?
  - CQ 9: What is the effect of water vapor on temperature?
  - CQ 10: How does the relationship between carbon dioxide and water vapor become considered "positive feedback relationship?"



Lesson O – Feedbacks of Ice and Clouds

View these photos to compare Bear Glacier and glacial melting 1909 and 2005.

Some surfaces reflect light more than others and that more reflective surfaces have higher albedo.

Discussion Questions: Which photo shows surfaces with higher albedo? Which photo shows surfaces that would absorb the most solar radiation? Why does a dark-colored surface feel much hotter than a light-colored surface in the sunshine?

- Activity #4 – Feedbacks of Ice and Clouds – Module 45 (be sure to log in)
  - Answer the following questions:
    - LQ 21: What is the relationship between ice cover and temperature?
    - LQ 22: In the model of the Earth system with clouds (Model 7), how did clouds affect the temperature?
    - LQ 23: Is Model 7 realistic?
    - LQ 24: What would happen to ice cover if greenhouse gas concentrations increase?
    - LQ 25: Is the feedback of the relationship between clouds and temperature positive or negative? Explain.
  - Answer the Concept Questions
    - CQ 11: How do ice, snow, and clouds affect temperature?
    - CQ 12: Why is it colder on clear nights than on cloudy nights?
    - CQ 13: If the sea ice melts, how might that affect global temperature and the atmospheric concentrations of carbon dioxide and water vapor?

Lesson P - Using Models to make Predictions

Today, you will be investigating how much greenhouse gas concentrations need to be reduced to prevent major warming of Earth's atmosphere. Discussion questions: How do greenhouse gases cause atmospheric warming? How does the level of carbon dioxide in the atmosphere affect the level of water vapor in the atmosphere? How does the color of Earth's surfaces affect temperature? What is the relationship between water vapor and clouds?

- Activity #5 – Using Models to Make Predictions – Module 45 (be sure to log in)
- Answer the following questions:
  - LQ 26: Are models necessary to understand climate change?
  - LQ 27: How can you tell that the results from a climate model are valid?
  - LQ 28: In the Earth System Model (Model 8), how much of a decrease in greenhouse gas emissions was needed to keep the temperature from rising too much?
- Answer the following content questions:
  - CQ 14: What is the relationship between greenhouse gas emissions and Earth's temperatures?
  - CQ 15: Why does the temperature not decrease immediately after greenhouse gas emissions decline?
  - CQ 16: Why do scientists think the warming of the 20th century cannot be explained by natural variability?

Lesson Q - Posttest

(Be sure to log in)