Earthy

Connections

Bright Ideas to infuse Earth Science into your curriculum

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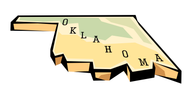


Pass Connections

Discipline: Objective	**Related labs**
Physical Science	
Matter is made up of minute particles called atoms, and atoms are composed of even smaller components (i.e., protons, neutrons, and electrons).	✓ ***Weather Me Down*** ✓ ***Solar Constant Challenge*** ✓ ***The Dating Game***
Matter has characteristic properties, such as boiling points, melting points, and density, which distinguish pure substances and can be used to separate one substance from another.	✓ ***Mineral Groups*** ✓ ***Mineral Ice***
All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.	✓ ***I'm All Shook Up*** ✓ ***Whole Lot of Shaking Going On*** ✓ ***How Well Do I Radiate*** ✓ ***Solar Constant Challenge*** ✓ ***Where UV***

Waves, including sounds and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter (such as used in telescopes, solar power, and telecommunication technology).	✓ **I'm All Shook Up** ✓ **Whole Lot of Shakin Going On** ✓ **Solar Constant Challenge** ✓ **How Well Do I Radiate** ✓ **Where UV**
Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations	✓ **Modeling Oklahoma's Geologic Past** ✓ **Fossil Inferences** ✓ **Walking With Dinosaurs** ✓ **Interpreting a Fossil Find** ✓ **Adaptive Ovali** ✓ **The Dating Game**
All stars have a life cycle including birth, development, and death. Fusion reactions in stars release great amounts of energy and matter over millions of years.	✓ **A Star is Born**
Biology	
Different species might look dissimilar, but the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry (e.g., homologous and analogous structures).	✓ **Adaptive Ovali** ✓ **Fossil Inferences**
Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology, which may enhance or limit the survival and reproductive success in a particular environment.	✓ **Adaptive Ovali** ✓ **Fossil Inferences**
As matter and energy flow through different levels of organization of living systems and between living systems and the physical environment, chemical elements are recombined in different ways by different structures. Matter and energy are conserved in each change (i.e., water cycle, carbon cycle, nitrogen cycle, food webs, and energy pyramids).	✓ **Weather Me Down** ✓ **Forming Minerals** ✓ **Where's the Ozone** ✓ **Your Calories or Mine?**
Chemistry	
Matter is made of atoms and atoms are composed of even smaller components (i.e., protons, neutrons and electrons).	✓ ***Weather Me Down*** ✓ ***Solar Constant Challenge*** ✓ ***The Dating Game*** ✓ ***Which Atmosphere?***
Atoms interact with one another by transferring or sharing outer electrons that are farthest from the nucleus. These outer electrons govern the chemical properties of the element	✓ **Mineral Light** ✓ **A Light Challenge** ✓ **Solar Constant Challenge**
An element is composed of a single type of atom. When elements are listed in order according to the number of protons, repeating patterns of physical and chemical properties identify families of elements with similar properties	✓ **Weather Me Down**
A compound is formed when two or more kinds of atoms bind together chemically. Each compound has unique chemical and physical properties.	✓ **A Concrete Challenge** ✓ **Weather Me Down** ✓ **A Star is Born** ✓ **Mineral Groups**

Solids, liquids, and gases differ in the energy that binds them together.	✓ **Mineral Ice** ✓ **Forming Minerals**
The rate of chemical reactions is affected by the concentration and temperature of the reacting materials. Catalysts accelerate chemical reactions	✓ **Light Challenge** ✓ **A Concrete Challenge**
Physics	
Energy can be transferred but never destroyed. As these transfers occur, the matter involved becomes steadily less ordered	✓ **How Well Do I Radiate?** ✓ **Your Calories or Mine** ✓ **Solar Constant Challenge** ✓ **Whole Lot of Shakin Going On**
All energy can be considered to be kinetic energy, potential energy, or energy contained by a field.	✓ **I'm All Shook Up** ✓ **Your Calories or Mine**
Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.	✓ **Forming Minerals** ✓ **Mineral Ice** ✓ **Your Calories or Mine** ✓ **Solar Constant Challenge**
Waves have energy and can transfer energy when they interact with matter. Sound waves and electromagnetic waves are fundamentally different	✓ **Solar Constant Challenge** ✓ **I'm All Shook Up** ✓ **How Well Do I radiate?**
Electromagnetic waves result when a charged object is accelerated or decelerated.	✓ **Solar Constant Challenge** ✓ **Where UV** ✓ **How Well Do I Radiate**

Mystery Planet:
Teacher Instructions

Adapted from: http://quilt.jpl.nasa.gov/docs/mysteryplanet_508FC.pdf

Objective: To provide students with an opportunity to make both qualitative and quantitative observations in order to formulate a hypothesis

Time Required: 1 class periods

Materials:

Materials Needed:

- Hand lens
- Toothpicks and/or tweezers
- Small magnets
- Sample "mystery" planet crustal material. Prepare a sample mixture of "typical" crustal material from a rocky planet. The exact composition is not critical, but include as many of the following as possible:
  - Coarse and fine sand from a playground, garden store, river, or beach
  - Small rounded pea-gravel from garden center, stream, or gravel pit
  - Small flat "skipper" type rounded pebbles from a rocky lake or ocean beach (the flattening is caused by the motion of the waves at or near the shore)
  - Angular crushed stone from a rural road, driveway, or garden center
  - Table salt
  - Coarse rock salt (sidewalk melting salt or crushed water softener pellets)
  - Crushed clinkers from a coal furnace or crushed charcoal briquettes
  - Vermiculite or perlite from gardening center
  - Small fossil fragments or simulate by breaking shells into ~1-cm fragments
  - Small fragments of man-made materials such as plastic or metals (optional)
- Any other rocky planet materials that you can obtain easily
- Metric graph paper to be used as a measuring device (mm or cm grid, as appropriate for the measurement skills of the students
- Large container, pail, or pan, about 1 – 3 liter capacity (1 – 4 quart)

Procedures:

1. Give each team of two students a sheet of graph paper and a sample of crustal material. Be sure to include both large and small pieces.
2. Have the teams explore and observe as many properties of each kind of substance in the sample as they can, using tweezers, graph paper measurements, magnifying lenses, and magnets. Remind them that they do NOT need to know what each substance is. Instead, lead them to describe the CHARACTERISTICS of the pieces, such as color, shape, size, luster, density, layered, magnetic, etc.
3. Have teams share and discuss their observations.
4. Have students infer the causes for the observed characteristics of the various materials. They might suggest water erosion, life forms, sedimentation and many other processes that cause the observed properties of components in the sample.

Name: ______________________ Date: ________________ Class: ________

Mystery Planet

Objective: You have been given an important job: to analyze material from a mystery planet in order to evaluate what kind of habitat is present and if life could exist there.

Procedure:

1. **Pour your mystery planet material into the blue container and use the hand lens, tweezers and other tools provided to sort through its contents.**
2. **Explore and observe the properties of the materials and record them in your data table under the headings qualitative observations. Use as much detail as possible**
3. **Quantify your findings: Example: 3 smooth stones, 100 grams of sandy mixture, etc**
5. **Answer the evaluation questions based on your findings.**
6. **Create a poster of what you think the area that your materials came from looks like.**
7. **Be prepared to communicate your findings with others.**

Data:

Type of material	Qualitative Observations

Type of material	Quantitative Observations

Mystery Planet Evaluations

Hypothesize: From what kind of landscape do the materials in your sample originate?

Support for your hypothesis:

Evaluate: Could life exist in your landscape? WHY OR WHY NOT?

Modeling Oklahoma's Geologic History:
Teacher Instructions and Background Information

Objective: To provide students with an opportunity to interpret information, use measurements, and create a model that communicates the geologic history of our great state.

Time Required: 2-3 class periods

Materials Needed:
Procedure page, Oklahoma's Geologic Events Table, Geologic Time Scale, adding machine tape, meter stick, plain paper, colored pencils, scissors, and glue.

Teacher Preparation:
Run off procedure pages and Oklahoma Geologic History Table, get out other materials

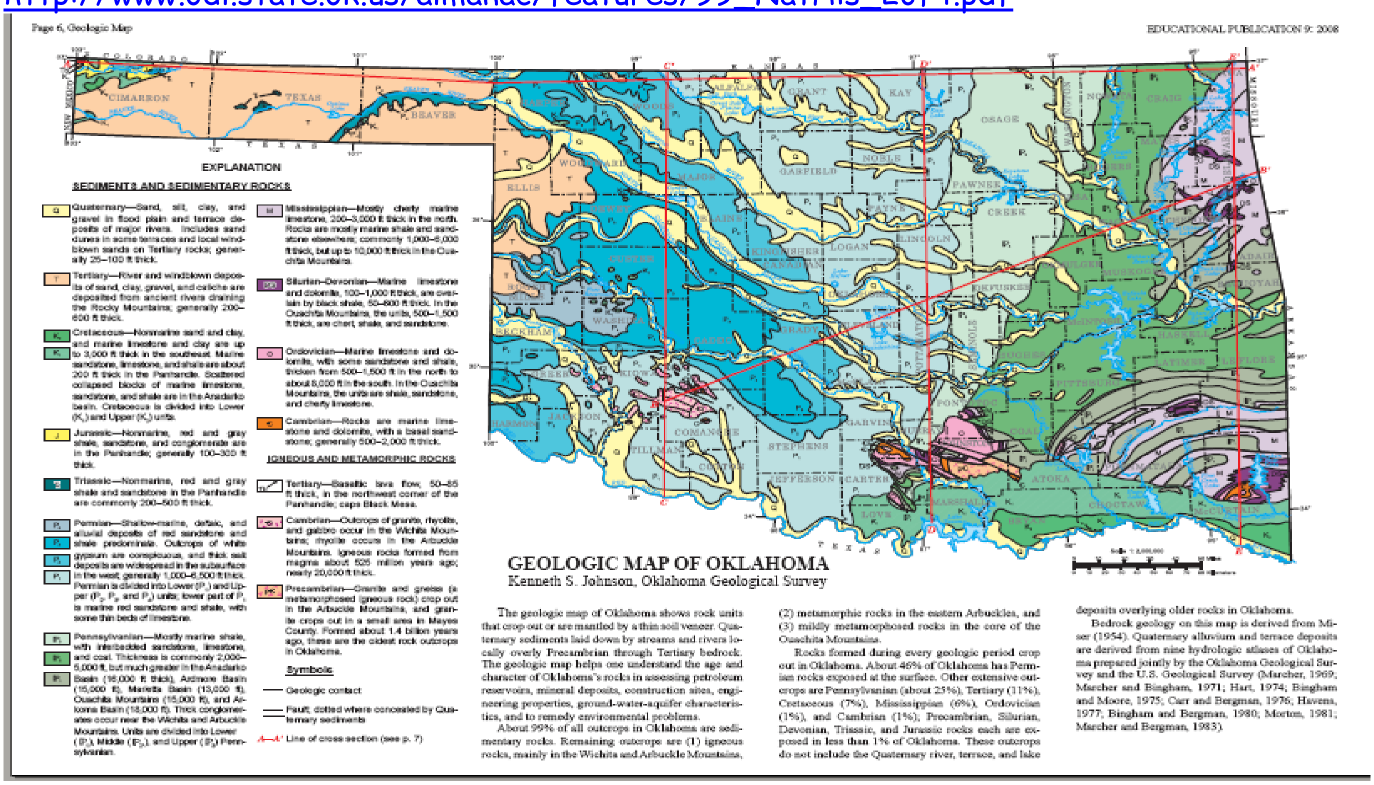
Useful Websites

http://www.ogs.ou.edu/pubsscanned/EP9_2-8geol.pdf

http://www.snomnh.ou.edu/collections-research/cr-sub/invertpaleo/common_fossils_of_ok/index.shtm

http://www.odl.state.ok.us/almanac/features/99_NatHis_1of4.pdf

http://www.odl.state.ok.us/almanac/features/99_NatHis_2of4.pdf



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EXPLANATION

SEDIMENTS AND SEDIMENTARY ROCKS

Quaternary—Sand, silt, clay, and gravel in flood plain and terrace deposits of major rivers. Includes sand dunes in some terraces and local windblown sands on Tertiary rocks; generally 25–100 ft thick.

Tertiary—River and windblown deposits of sand, clay, gravel, and caliche are deposited from ancient rivers draining the Rocky Mountains; generally 200–600 ft thick.

Cretaceous—Nonmarine sand and clay, and marine limestone and clay are up to 3,000 ft thick in the southeast. Marine sandstone, limestone, and shale are about 200 ft thick in the Panhandle. Scattered collapsed blocks of marine limestone, sandstone, and shale are in the Anadarko basin. Cretaceous is divided into Lower (K_1) and Upper (K_2) units.

Jurassic—Nonmarine, red and gray shale, sandstone, and conglomerate are in the Panhandle; generally 100–300 ft thick.

Triassic—Nonmarine, red and gray shale and sandstone in the Panhandle are commonly 200–500 ft thick.

Permian—Shallow-marine, deltaic, and alluvial deposits of red sandstone and shale predominate. Outcrops of white gypsum are conspicuous, and thick salt deposits are widespread in the subsurface in the west; generally 1,000–6,500 ft thick. Permian is divided into Lower (P_1) and Upper (P_2, P_3, and P_4) units; lower part of P_1 is marine red sandstone and shale, with some thin beds of limestone.

Pennsylvanian—Mostly marine shale, with interbedded sandstone, limestone, and coal. Thickness is commonly 2,000–5,000 ft, but much greater in the Anadarko Basin (16,000 ft thick), Ardmore Basin (15,000 ft), Marietta Basin (13,000 ft), Ouachita Mountains (15,000 ft), and Arkoma Basin (18,000 ft). Thick conglomerates occur near the Wichita and Arbuckle Mountains. Units are divided into Lower (IP_1), Middle (IP_2), and Upper (IP_3) Pennsylvanian.

Mississippian—Mostly cherty marine limestone, 200–3,000 ft thick in the north. Rocks are mostly marine shale and sandstone elsewhere; commonly 1,000–6,000 ft thick, but up to 10,000 ft thick in the Ouachita Mountains.

Silurian–Devonian—Marine limestone and dolomite, 100–1,000 ft thick, are overlain by black shale, 50–600 ft thick. In the Ouachita Mountains, the units, 500–1,500 ft thick, are chert, shale, and sandstone.

Ordovician—Marine limestone and dolomite, with some sandstone and shale, thicken from 500–1,500 ft in the north to about 8,000 ft in the south. In the Ouachita Mountains, the units are shale, sandstone, and cherty limestone.

Cambrian—Rocks are marine limestone and dolomite, with a basal sandstone; generally 500–2,000 ft thick.

IGNEOUS AND METAMORPHIC ROCKS

Tertiary—Basaltic lava flow, 50–65 ft thick, in the northwest corner of the Panhandle; caps Black Mesa.

Cambrian—Outcrops of granite, rhyolite, and gabbro occur in the Wichita Mountains; rhyolite occurs in the Arbuckle Mountains. Igneous rocks formed from magma about 525 million years ago; nearly 20,000 ft thick.

Precambrian—Granite and gneiss (a metamorphosed igneous rock) crop out in the Arbuckle Mountains, and granite crops out in a small area in Mayes County. Formed about 1.4 billion years ago, these are the oldest rock outcrops in Oklahoma.

Symbols

Geologic contact

Fault; dotted where concealed by Quaternary sediments

A—A' Line of cross section (see p. 7)

GEOLOGIC MAP OF OKLAHOMA
Kenneth S. Johnson, Oklahoma Geological Survey

The geologic map of Oklahoma shows rock units that crop out or are mantled by a thin soil veneer. Quaternary sediments laid down by streams and rivers locally overly Precambrian through Tertiary bedrock. The geologic map helps one understand the age and character of Oklahoma's rocks in assessing petroleum reservoirs, mineral deposits, construction sites, engineering properties, ground-water-aquifer characteristics, and to remedy environmental problems.

About 99% of all outcrops in Oklahoma are sedimentary rocks. Remaining outcrops are (1) igneous rocks, mainly in the Wichita and Arbuckle Mountains, (2) metamorphic rocks in the eastern Arbuckles, and (3) mildly metamorphosed rocks in the core of the Ouachita Mountains.

Rocks formed during every geologic period crop out in Oklahoma. About 46% of Oklahoma has Permian rocks exposed at the surface. Other extensive outcrops are Pennsylvanian (about 25%), Tertiary (11%), Cretaceous (7%), Mississippian (6%), Ordovician (1%), and Cambrian (1%); Precambrian, Silurian, Devonian, Triassic, and Jurassic rocks each are exposed in less than 1% of Oklahoma. These outcrops do not include the Quaternary river, terrace, and lake deposits overlying older rocks in Oklahoma.

Bedrock geology on this map is derived from Miser (1954). Quaternary alluvium and terrace deposits are derived from nine hydrologic atlases of Oklahoma prepared jointly by the Oklahoma Geological Survey and the U.S. Geological Survey (Marcher, 1969; Marcher and Bingham, 1971; Hart, 1974; Bingham and Moore, 1975; Carr and Bergman, 1976; Havens, 1977; Bingham and Bergman, 1980; Morton, 1981; Marcher and Bergman, 1983).

Helpful Background:

Teaching geologic time from an Oklahoma prospective allows students to better understand the changes our state has gone through and why we have our resources. It also connects to the Biology objectives allowing students to build a bridge between the two disciplines.

HOW OLD IS THE EARTH?

The Earth is about 4,600,000,000 years old (4,600 million or 4.6 billion years old). Assuming that Earth formed at about the same time as the rest of solar system, scientists have dated meteorites and samples of Moon rocks (because they have not been re-melted and re-formed as most rocks on Earth have). Meteorites and Moon rocks are about 4.6 billion years old and so Earth is estimated to be that old too.

IMAGINE: A Billion is a difficult number to comprehend,

A Billion Seconds ago – is equal to 31 years

A Billion Minutes ago – The Roman Empire was in full swing

A Billion Hours ago -- our ancestors were living in the Stone Age.

A Billion Days ago -- No-One walked on two feet on earth.

http://video.aol.com/video-detail/how-much-is-a-billion-dollars/455990892

Nice You-Tube video to introduce a billion

GEOLOGIC TIMESCALE

Paleontologists divide Earth's 4,600,000,000 year history into smaller blocks of time. Each block has a name and a beginning age and ending age. Together these blocks of time make a sort of calendar of Earth's history. We call this calendar the "Geologic Timescale."

In the 1700s and 1800's, paleontologists collected fossils from rocks across Europe. They found that certain groups of rocks always had nearly the same types of fossils, and that other groups of rocks had different types of fossils. In time, paleontologists gave each group of rocks a different name, like Cambrian rocks or Silurian rocks or Cretaceous rocks, to show that different fossils were found in them. As paleontologists continued to study rocks, they found that the groups of rocks always occurred in the same order. For example, Cretaceous rocks always were found on top of Silurian rocks, and both always were found on top of Cambrian rocks.

IMAGINE: Think about the dirty clothes in the hamper or in your closet. The clothes that you wore on Monday are on the bottom of the pile. The clothes that you wore on Tuesday are on top of Monday's clothes, and your Wednesday clothes are on top of everything. The oldest clothes are on the bottom and the most recent clothes are on the top.

Just like your dirty clothes, rocks are found in the same order. The oldest rocks are on the bottom and most recent rocks are on the top. This "rule" known as *The Principal of Superposition* , is why Cretaceous rocks always were found on top of Silurian rocks, and both always were found on top of Cambrian rocks. This rule allowed the paleontologists to put the different groups of rocks they found in order from oldest to most recent. They had created the first Geologic Timescale.

As more and more rocks were studied, and as more powerful ways of finding out the ages of rocks have been developed (for example radiometric dating), the Geologic Timescale has changed and become more accurate. However, finding fossils is still the first, fastest way to tell how old a rock is

Oklahoma is rich in fossils. They can be found in many parts of the state and common fossils can be fun to collect and study.

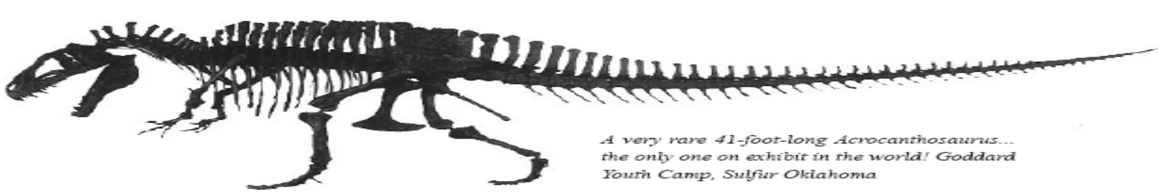
WHAT IS A FOSSIL?

Fossils are the remains of ancient life. They are most common in rocks called limestone and shale. Limestone is mostly made of the shells of invertebrate animals whereas shale is made of layered mud pressed into thin sheets.

WHERE FOSSILS OCCUR IN OKLAHOMA

Fossils are found in most counties of Oklahoma, but are most common in eastern and southern counties in the state. Fossils from these areas of Oklahoma range in age from about 500 million years ago to about 85 million years ago.

During the early Cretaceous Period, between 140 and 100 *mya*, an enormous meat-eating dinosaur called *Acrocanthosaurus atokensis* roamed coastal areas in what is now southeastern Oklahoma. Found in 1940 in the Antlers Formation of Atoka County, *Acrocanthosaurus* was one of the largest carnivores that lived during the Cretaceous Period. The largest known *Acrocanthosaurus* fossil is an individual that was 18 feet tall and 43 feet from head to tail. *Acrocanthosaurus* belonged to the Carnosauria, a group of meat-eating dinosaurs with large bodies and extremely large heads, and may have preyed mainly upon a plant-eating dinosaur called *Tenontosaurus*, whose fossil remains have been found in the same area and geological formations in south-eastern Oklahoma. *Acrocanthosaurus* specimens have been found in Atoka and McCurtain counties.



A very rare 41-foot-long Acrocanthosaurus... the only one on exhibit in the world! Goddard Youth Camp, Sulfur Oklahoma

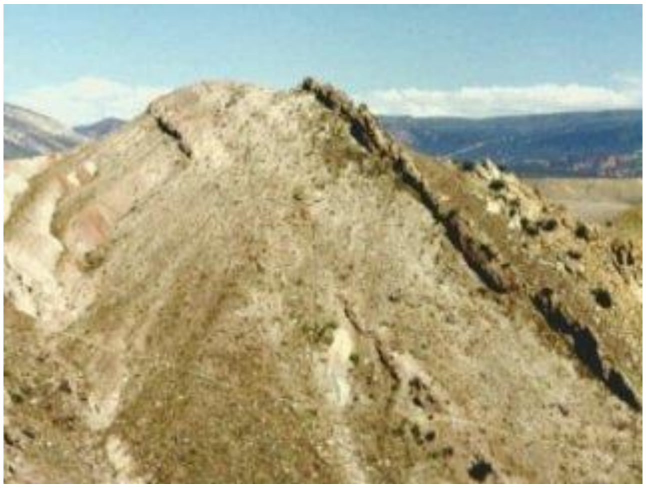
Oklahoma’s first residents (Related Article)

By Christian Price, News9.com INsite Team

NORMAN, Okla. -- From the highest point of our state, to the woodlands that haven't been explored, dinosaurs can be found in every part of Oklahoma.

Thousands of fossils fill the Sam Noble Museum of Natural History's collection.

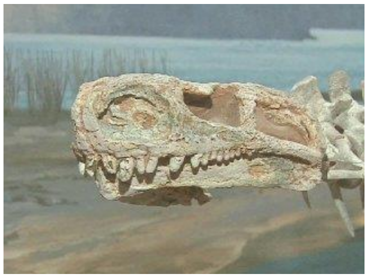
Dr. Richard Cifelli, a Paleontologist with The Sam Nobel Oklahoma Museum of Natural History, says Oklahomans don't realize what really lies beneath their feet.



The Morrison formation, which is found in Oklahoma's panhandle, yields countless fossils.

"Oklahoma is fossils from the grass roots down; there are fossils everywhere," Dr. Cifelli said. "It's truly a remarkable state because of the diversity of the kinds of things we have. People get this idea that dinosaurs are only found in really exotic places like Mongolia or Patagonia."

Some of the dinosaur material from Oklahoma is the oldest ever found.



Cotylorhynchus is Norman's first resident.

"The oldest material that's from Oklahoma, the oldest vertebrate material, is about 450 million-years-old," Cifelli said. "It's some of the earliest vertebrate material known in the whole world, and it comes from a site in the median of Interstate 35 as you're going over the Arbuckle's."

Our official state dinosaur, the Saurophaganax, is only found in the state panhandle. "We do feature a very large meat eating dinosaur out there," Dr. Cifelli said. "This thing goes by a kind of complicated moniker, Saurophaganax, but it's basically an Allosaurs on steroids. It's a real big bad Allosaurs. It's got three big claws on the hands and big jaws, so a very impressive one. It's only been found for certain in Oklahoma."

Even the animal with the longest neck in the world has been discovered in our red dirt.

"The other really cool thing we got from south eastern Oklahoma is this thing we named Sauroposeidon," Dr. Cifelli said. "It's a long necked dinosaur and it's actually related to the

Brachiosaurs, but it's about a third larger. It's got the longest neck of any animal known in the world at 39 feet." According to Dr. Cifelli, many of the most recent discoveries have all been found in the same area.

"Most of our discoveries through the 1990's and on into this century have been made actually at a state prison property down in south eastern Oklahoma," Dr. Cifelli said.

The person who found the dinosaur bones has a unique tie to the prison as well.

"That material was discovered by a guy who trains the prisons canine unit," Dr Cifelli said.

"His job is to basically run these dogs all over the whole property and he's a backwoodsman and he knows bone when he sees it."

Discovery of dinosaur remains still occur in Oklahoma, most of which are found by locals.

This dinosaur is on display at the Sam Noble Museum in Norman

Modeling Oklahoma's Geologic History

Student Procedure Sheet

Background Information: Geologic time is used to measure the history of the Earth. The Earth is theorized to be about 4.6 billion years old. A billion is one thousand million. To put this in perspective humans have a lifespan of 2 billion seconds and it would take 39 years of that lifespan to count to count out one (1,000,000,000) Billion nonstop without eating or sleeping. So how do scientists divide something so large into something that we can comprehend? They look to the fossil record and mark where evidence of major changes occurred. The history of the Earth can be divided into four large blocks of time known as eras. We live in the Cenozoic Era. Each era is further divided into periods that mark a specific transition. The earth's geologic time is often compared to the stages of human development wherein there are four major divisions: embryonic, child, adolescent, and adult. Each of the stages is further punctuated by unique transitions: infant, toddler, preschooler, and elementary age. In this activity we will use several tables to create a scale model of the changes that occurred here in Oklahoma over the last 600 million years.

Research Question: What geological events have shaped Oklahoma since the beginning of the Paleozoic Era?

Materials: Procedure page, Oklahoma's Geologic Events Table, Geologic Time Scale, adding machine tape, meter stick, plain paper, colored pencils, scissors, and glue.

Procedure:

1. Calculate the amount of adding machine tape to be used by completing the calculating geologic periods table
2. Use the meter stick to measure out the 1.3m (130 centimeters) of paper needed.
3. Beginning at the left end of the paper measure over 200 mm (20 cm) and make a vertical line. Label this period the Cambrian Period.
3. Place a heavy line at the beginning of the Tape and Label it **Paleozoic Era**
3. Use your calculations to mark out and **label** the remaining periods of geologic time. Do Not forget to make heavy lines and label the remaining Eras
4. Use the Geologic History of Oklahoma and Geologic Time Scale to communicate the major events that occurred here in Oklahoma during each period in terms of:
   - ✓ Rock and mineral formations that were laid down
   - ✓ Flora and Fauna that lived in the state
   - ✓ Important events that occurred
   - ✓ Existence or absence of sea water
   - ✓ Other information of interest
5. Use the plain paper to draw illustrations that can be cut out and glued to the time-tape.

Make sure that all members of the group have a job and are accountable for the finished product

Tapes will be judged for accuracy, neatness, and creativity. Winning tapes will receive a prize

Calculating Geologic Periods

Procedure: Use the table titled "Geologic History of Oklahoma" to determine how many years each of the periods and eras lasted. Record the data in the correct place and then use the scale 1 my = 2mm to calculate the amount of tape needed.
To calculate the lengths of time that Eras lasted use the formula shown below:

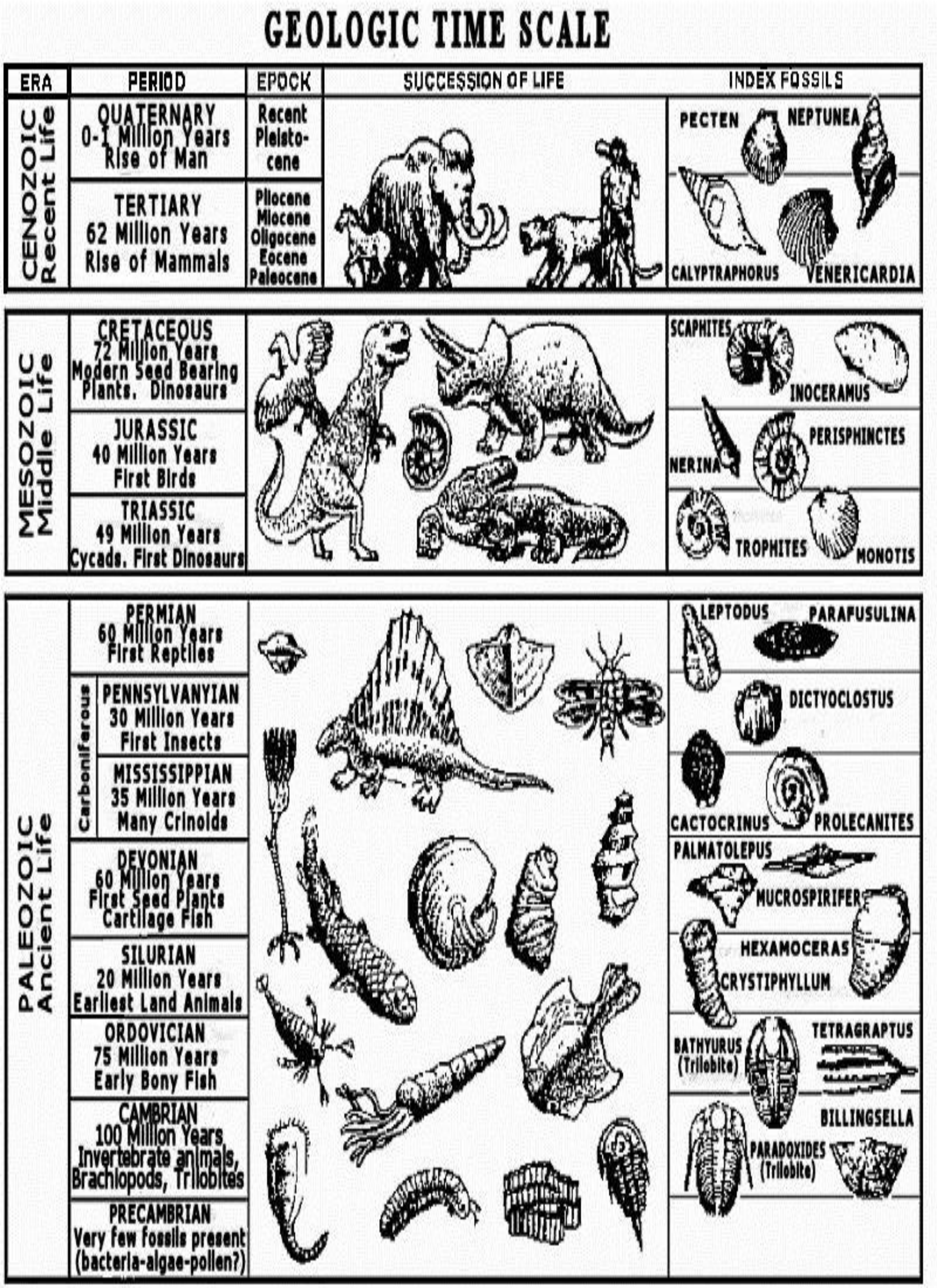
Total of all periods within Era = Length of Era

Period/Era	Time Lasted (millions of years)	X 2 mm/my	**Conversion factor** 10 mm = 1 cm	= centimeters needed
Cambrian				
Ordovician				
Silurian				
Devonian				
Carboniferous				
Permian				
Paleozoic Era				
Triassic				
Jurassic				
Cretaceous				
Mesozoic Era				
Tertiary				
Quaternary				
Cenozoic Era				
Total Needed				

Geologic History of Oklahoma

	Period	Year Began	Length	Major Events
Cenozoic Era	Quaternary	2.5 mya	To present	▪ 10,000 years ago humans appear ▪ Modern animals appear: Bisons, deer, and horses ▪ Deciduous forests replace Spruce forests ▪ Grasslands cover most of Oklahoma ▪ Melting glaciers in Kansas widen existing rivers and create new rivers ▪ At early part of period Spruce forests covers much of NE Oklahoma and Pine forests exist in SE Oklahoma ▪ 40,000 years ago an asteroid hits causing Great Ice Age, but Oklahoma is not covered with ice
	Tertiary	70 mya	67.5 my	▪ Bisons, small horses, Mammoths, and giant beavers inhabit Oklahoma ▪ Flora includes Flowering plants and trees ▪ Thick blankets of sane, clay, and gravel eroded from the Rocky Mountains are spread across the High Plains in the Panhandle ▪ In early part of period, Southeastern corner of Oklahoma is the shoreline of the Gulf of Mexico
Mesozoic Era	Cretaceous	135 mya	65my	➢ Mammals and birds survive and a new ERA begins ➢ Asteroid hits Earth in Gulf of Mexico causing extreme climate change and a mass extinction wherein 65% of life disappears ➢ Most of Oklahoma is covered by an inland sea ➢ Fist appearance of flowering plants ➢ Hardwood trees appear ➢ Large meat-eating dinosaur and plant-eating dinosaur roam coastal area of SE Oklahoma ➢ Shale, sandstone, and limestone beds are laid down in the Panhandle and Coastal Plains of the SE
	Jurassic	180 mya	45 my	➢ Many large dinosaurs roam Oklahoma ➢ Large feathered birds and flying reptiles fill Oklahoma skies ➢ Oklahoma lies above sea level ➢ One-bearing trees and fern-like Cycad plants dominate the landscape ➢ Sandstones and shales are deposited in the Panhandle from draining Colorado hills
	Triassic	230 mya	50 my	➢ First small dinosaurs appear ➢ Cone-bearing trees and fern-like Cycad plants dominate flora ➢ Oklahoma lies above sea level

Era	Period	Year Began	Length	Major Events
Paleozoic Era	Permian	285 mya	55 my	➢ Marine life dies out and new era is born ➢ Red-colored rock is laid down over most of the state ➢ Gypsum and salt beds form as sea water evaporates ➢ In early part of period shallow inland sea covers western Oklahoma ➢ Amphibian and reptiles roam the state
	Carboniferous	350 mya	65 my	➢ First reptiles appear ➢ Giant insects fill the air ➢ Fern trees become more like palm trees ➢ Swamps in lower elevations around Tulsa will become major coal beds as they decay over time ➢ Wichita, Arbuckle, and Ouchita Mountains push up to become major mountain ranges ➢ During first part of period, shallow seas still cover all of Oklahoma ➢ Marine animals such as sharks are prolific
	Devonian	410 mya	60 my	➢ Most of Oklahoma is covered by a shallow sea ➢ Many types of fishes and marine animals fill the sea ➢ Armored fishes become extinct ➢ Brachiopods, pelycypods and other shelled marine life fill the shallow seas ➢ First forest begin to emerge in areas where sea water is receding ➢ Limestone deposits are laid down
	Silurian	430 mya	20 my	➢ Most of Oklahoma is covered by shallow sea ➢ First amphibians begin to emerge ➢ Seas are filled with trilobites and armored fishes ➢ Scale trees develop ➢ Peak development of Eurypterids: A giant shrimp like animal that dominated the sea ➢ Gastropods, Brachiopods, and pelycypods thrive in the shallow seas
	Ordovician	500 mya	70 my	➢ Asteroid hits in NE Oklahoma ➢ Earliest jawless fish swim in the seas ➢ Graptolites, brachiopods, trilobites, and corals are present ➢ Algae begins to form ➢ All of Oklahoma is covered by a sea
	Cambrain	600 mya	100 my	➢ All of Oklahoma is covered by a sea ➢ Trilobites and marine plants are abundant ➢ Giant clams, snails, and seaweed develop ➢ Wichita Mountains and western section of Arbuckles are formed from Granites and rhyolitic lava packs
Archaeozoic Era	Precambrian	4.6 bya	4 by (billion years)	➢ Arbuckle Mountains begin to form ➢ Most of Oklahoma is covered with volcanoes


GEOLOGIC TIME SCALE
ERA
PERIOD
EPOCK
SUCCESSION OF LIFE
INDEX FOSSILS
CENOZOIC Recent Life
QUATERNARY 0-1 Million Years Rise of Man
Recent Pleisto-cene
TERTIARY 62 Million Years Rise of Mammals
Pliocene Miocene Oligocene Eocene Paleocene
PECTEN
NEPTUNEA
CALYPTRAPHORUS
VENERICARDIA
MESOZOIC Middle Life
CRETACEOUS 72 Million Years Modern Seed Bearing Plants. Dinosaurs
JURASSIC 40 Million Years First Birds
TRIASSIC 49 Million Years Cycads. First Dinosaurs
SCAPHITES
INOCERAMUS
NERINA
PERISPHINCTES
TROPHITES
MONOTIS
PALEOZOIC Ancient Life
PERMIAN 60 Million Years First Reptiles
Carboniferous
PENNSYLVANIAN 30 Million Years First Insects
MISSISSIPPIAN 35 Million Years Many Crinoids
DEVONIAN 60 Million Years First Seed Plants Cartilage Fish
SILURIAN 20 Million Years Earliest Land Animals
ORDOVICIAN 75 Million Years Early Bony Fish
CAMBRIAN 100 Million Years Invertebrate animals, Brachiopods, Trilobites
PRECAMBRIAN Very few fossils present (bacteria-algae-pollen?)
LEPTODUS
PARAFUSULINA
DICTYOCLOSTUS
CACTOCRINUS
PROLECANITES
PALMATOLEPUS
MUCROSPIRIFER
HEXAMOCERAS
CRYSTIPHYLLUM
BATHYURUS (Trilobite)
TETRAGRAPTUS
BILLINGSELLA
PARADOXIDES (Trilobite)

Name: ___________________________ Date: __________________ Class: _____

Modeling Oklahoma's Geologic History

Post Activity Questions

Procedure: Use your finished tape and background information to answer the following questions related to Oklahoma's geologic history:

1. Evaluate: During which period do you feel Oklahoma went through the most change? SUPPORT YOUR ANSWER

2. Compare: How is a period like an era?

3. Contrast: How does a period differ from an era?

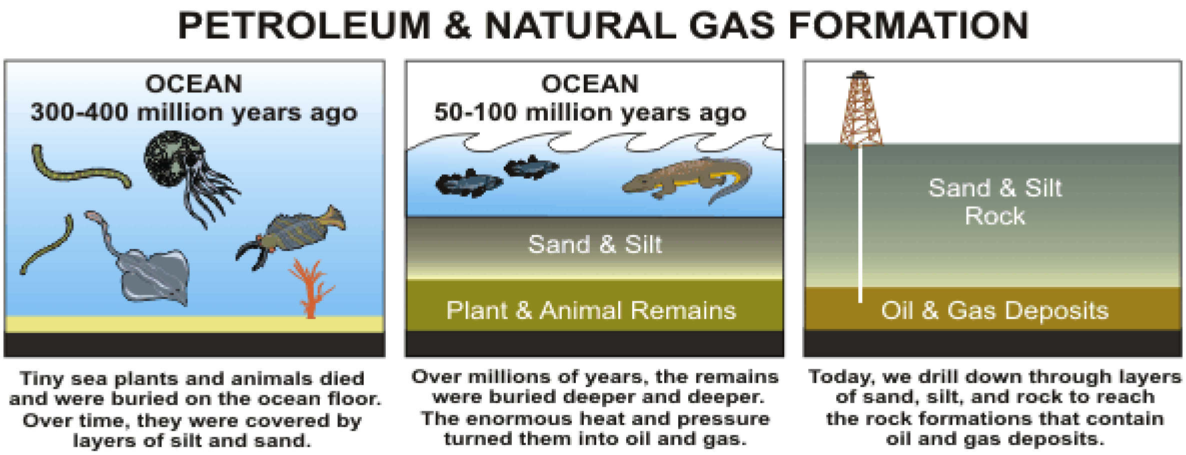
4. Evaluate: Is the fossil record complete? SUPPORT YOUR ANSWER

5. Calculate: If it would take ~ 31 years to count a billion seconds, how many seconds ago did the Earth form? SHOW YOUR WORK

6. Analyze: Oklahoma has a lot of gypsum. Gypsum is formed as an evaporative mineral, Based on this, during which period do you think our gypsum formed? SUPPORT YOUR ANSWER

   Where would you expect to find it in our state? SUPPORT YOUR ANSWER

Analyze: Use the figure below to answer the questions that follow



7. During which Era did the tiny sea plants and animals live that formed our Oil and Gas?

   Which Period?

8. Where in Oklahoma would you expect to find Oil and Natural Gas? SUPPORT YOUR ANSWER

9. Why are Oil and Natural Gas classified as non-renewable natural resources?

10. Evaluate: What have you learned about Oklahoma's Geologic History through this activity?

Fossil Inferences:
Teacher Instructions and background Information

Objective: To provide students with an opportunity to make inferences and observations related to how we analyze and interpret the fossil record using different types of fossils

Time Required: 1 class period

Materials Needed:

Fossil Tracks Slides, Fossil Bones cut and put into envelopes, large pieces of paper, glue, and student pages

Teacher Preparation:
Copy Bone pages and then cut them apart. Provide each group with an envelope containing ½ of the bones: Sheets may be cut apart and students can cut individual bones out to save time: Prepare your power-point slides or sun off the Trace Fossil Page and cut it into sections if you do not have PowerPoint. May wish to begin with article related to Dinosaur Tracks in Oklahoma and have students read article and then do a 5-minute Free-Write on what they learned

Useful Websites:
http://video.aol.com/video-detail/paintjam-dan-dunn/1271848983
To be used for 1st Section as a way to introduce Observations and Inferences

http://www.teachersdomain.org/asset/ess05_int_fossilintro/
Graphic for how fossils form

http://www.howcomyoucom.com/selfnews/viewnews.cgi?newsid1019139764,7609,.shtml
Article about how new discoveries challenge old interpretations

Teacher Background:

Students often have a difficult time discerning between observations and inferences. Fossils provide a great opportunity to help them understand the difference between these two important scientific terms. An observation can be defined as taking notice of the properties of an object or event through use of your senses and/or measurements. An inference is a logical explanation of an observation. When interpreting the fossil record, scientists rely on both to evaluate what the Earth's past looked like in terms of geographic features and flora and fauna.

Fossils reveal a great deal about earlier life forms. Paleontologists use them to reconstruct body shapes, which provide information about evolutionary processes and trends. Most prominent animal fossils, including those displayed in museums, are mineralized bones. From these skeletons, researchers can often learn about an animal's gender, physical capabilities, growth patterns, life expectancies, and pathologies. These are revealed through clues preserved in the fossils, as well as through comparisons to present-day life forms, which help scientists imagine what an ancient creature may have looked like.

In addition to bones, shells and teeth, also made primarily of inorganic compounds, are frequently preserved as fossils. In rare cases, soft parts such as muscles, skin, and other organs leave some kind of trace. Muscles, for example, leave marks where they attached to bones. Although completing a skeleton with missing components may be more straightforward than interpreting fossilized soft parts, the latter also provide useful information. For example, by studying the muscle attachment points on bone fossils, paleontologists can make inferences about the size and shape of muscles. This information helps them reconstruct the animal.

Scientists generally search for models on which to base reconstructions of complex organisms. The models may be modern living things with bones or other structures similar to the fossil or fossils in question, or they may be previously discovered fossils that bear some resemblance to the fossil. Using these models, scientists make inferences that allow them to manufacture a more or less complete physical interpretation of a plant or animal, even if many or most of the hard and soft parts are missing. For instance, based on their models, paleontologists might make an educated guess that an animal skull was covered in skin and hair or fur, even if evidence for these is lacking in the fossil itself. Or, if a scientist recognizes tell-tale holes in a skull that suggest it is that of a reptile, the scientist would assume that the skin covering the head and body was scaly or bumpy and without fur or feathers.

Of course, sometimes paleontologists get it wrong. For many years, *Tyrannosaurus rex* reconstructions showed the dinosaur standing erect the way a human does. But recently, scientists concluded that the creature's posture was more horizontal, like that of a bird. Many museums have since changed their displays to reflect this new understanding.

Fossil Identification: Fossils are identified according to the process by which it was formed.

- **Petrification**
- **Molds and Casts**
- **Imprints**
- **Preservation of Entire Organism**
- **Trace Fossils**

Petrification

- **Petrification means turning into stone. When the dinosaurs died, the soft parts of their bodies decayed quickly. Only the hard parts, the bones, were left. Many of these bones were buried in sediments of mud and wet sand. The water dissolved minerals in the mud and as the water flowed through pore in the bones, minerals were deposited. The water evaporated and the bones were turned to stone.**

Molds and Casts

- **Two types of fossils are formed when an animal or plant is buried in sediments that harden into rock. If the soft parts of the organism decay and the hard parts are dissolved by chemicals an empty space will be left in the rock. The empty space, called a mold, has the same shape as the organism. Sometime minerals fill in the mold and they harden to form a cast in the same shape as the organism.**

Imprints

- **Sometimes a fossil is formed before the sediments harden into rock. Thin objects, such as leaves and feathers, leave imprints or impressions in soft sediments such as med. When the sediments harden into rock, the imprints are preserved as fossils.**

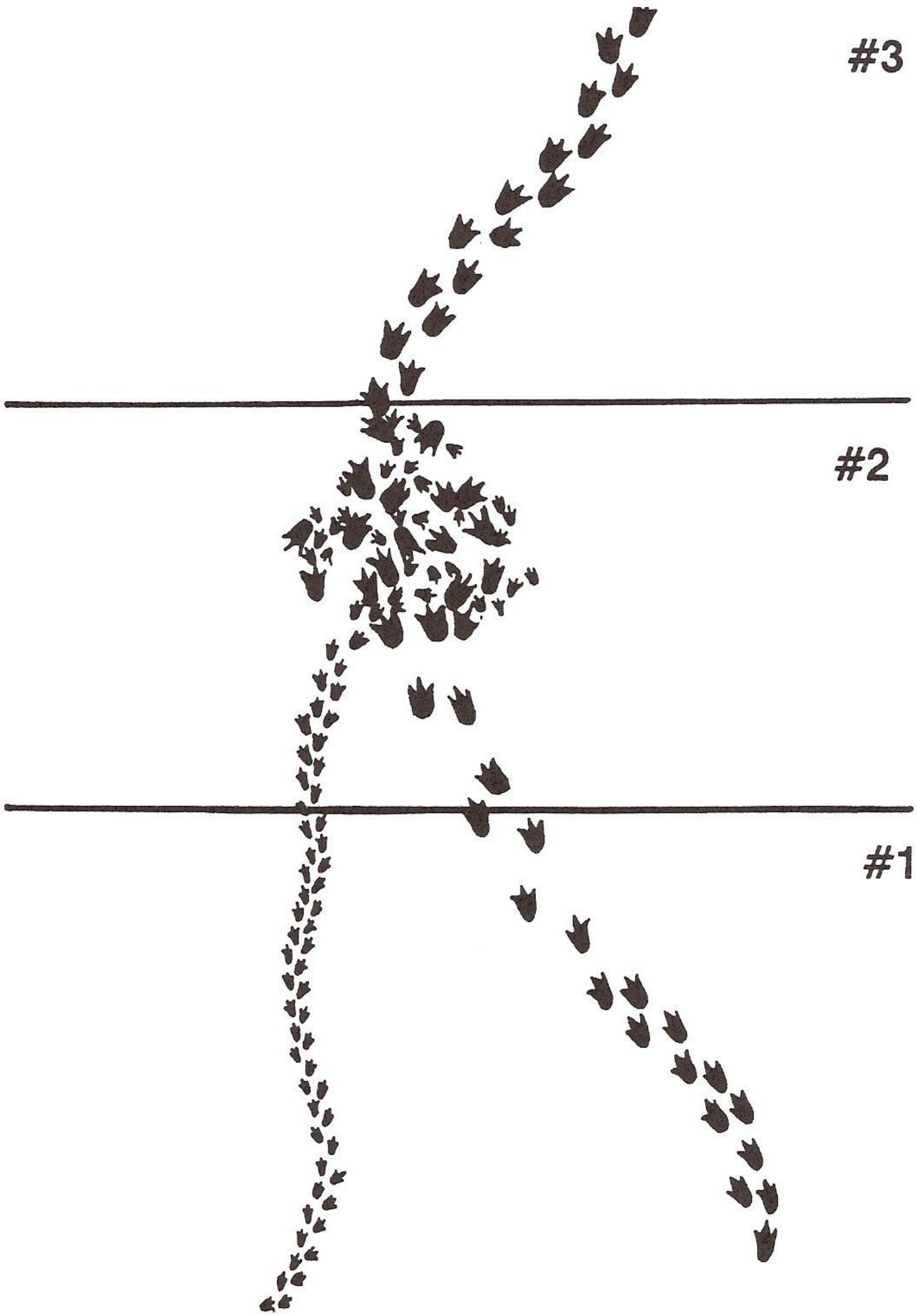
Preservation of Entire Organism

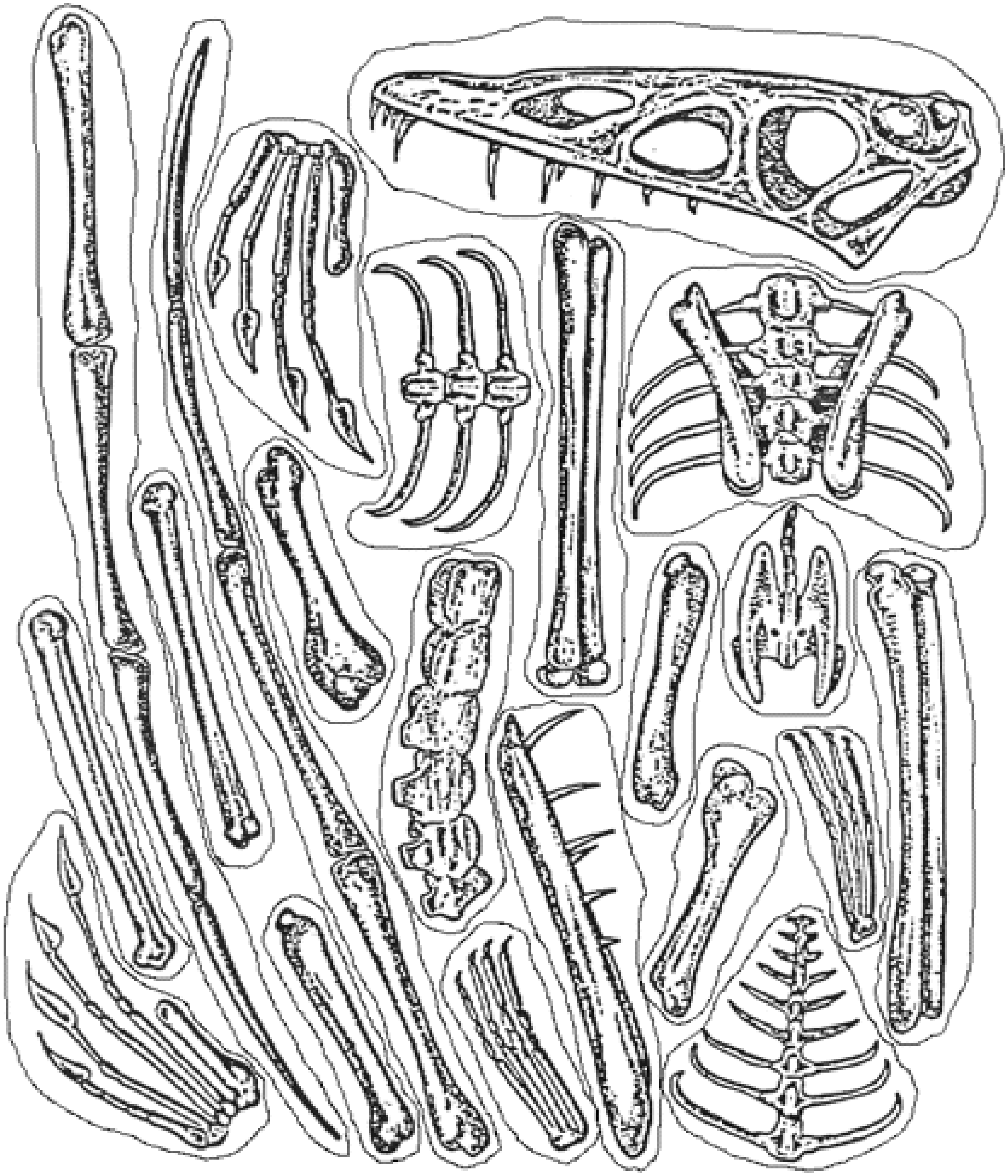
- **Freezing prevents substances from decaying. Freezing has preserved some animals. Wooly mammoths have been found in large blocks of ice. A furry rhinoceros was found in the loose frozen soil in the arctic. When the resin form evergreen trees hardens it forms amber. Insects have been trapped and preserved in amber. Some animals have been found in tar pits.**

Trace Fossils

- **Trace fossils are fossils that reveal much about an animal's appearance without showing any part of the animal. Trace fossils area the marks or evidence of animal activities. Tracks, trails, footprints, and burrows are trace fossils.**

Trace Fossils: for part 2: May Be cut apart or put into a Power Point





Petrifaction Fossils for part 3:

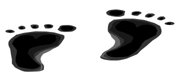
Name: ______________________________________ Date: _________________ Block: ________

Fossil Inferences

Background: Fossils provide evidence of events that happened long ago. Unfortunately they often provide an incomplete picture of what occurred. Scientists are often left to hypothesize the missing pieces based on observations and inferences. An inference is a logical explanation of an observation. As new evidence becomes available, scientists often change their inferences. In this investigation you will be given 3 opportunities to use your ability to observe and infer.

Paint Jam: As you watch the video clip, make observations and inferences as to what you think the picture will look like.

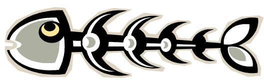
Observations	Inferences



Observation Set 2: Fossil Footprints: AT LEAST 3

	Observations	Inferences
Slide 1:		
Slide 2:		
Slide 3:		

Evaluate: How does new information change our inferences as to what life on Earth looked like in its past?



Boney Observations: **You and your partner have just been sent a package containing bones found at a dig site located in Mc Curtain County. Your job is to put the bones together based on what you know about**

- **Choose 8 bones from the envelope and then infer how they go together: Draw a sketch in the space provided:**

Observations to support your decision:

- **Find a pair of students with the Opposite set of bones that you and your partner have and join them to make a group of 4: Revise your boney reconstruction to include all 16 bones: and then glue them to the paper provided: Infer where the animal lived, what it ate, and other characteristics it may have possessed. Write them on the paper. Give your species a name and be prepared to share your results with the class**

Additional observations to support your decision:

Evaluate: How does an inference differ from an observation?

Analyze: How did your group's species compare to other groups species?

Infer: WHY DO YOU THINK THIS IS?

Evaluate: What information does a paleontologist rely on when reconstructing a partial fossil find?

Walking With Dinosaurs:
Teacher Instructions and Background:

Objective: To provide students with an opportunity to use a formula, collect and analyze data to evaluate what we can learn from fossil footprints using what we know today

Time Required: 2 class periods

Materials Needed:
Procedure page, measuring tape, metric ruler, calculators, large open space, article titled "*Dinosaur Tracks*," graph paper or access to computers, and

Teacher Preparation:
Run off procedure pages and get other materials. Measuring tapes work best for this activity as they are flexible

Useful Websites

http://www.enchantedlearning.com/subjects/dinosaurs/anatomy/Locomotion.shtml
Informative background from enchanted learning

http://www.beg.utexas.edu/UTopia/dinosaur/dino_faq.html
Informative website about dinosaur footprints in Texas

http://www.sorbygeology.group.shef.ac.uk/DINOC01/dinocal1.html
Dinosaur Speed Calculator

http://www.paleo.cc/paluxy/ovrdino.htm
Overview of dinosaur tracking

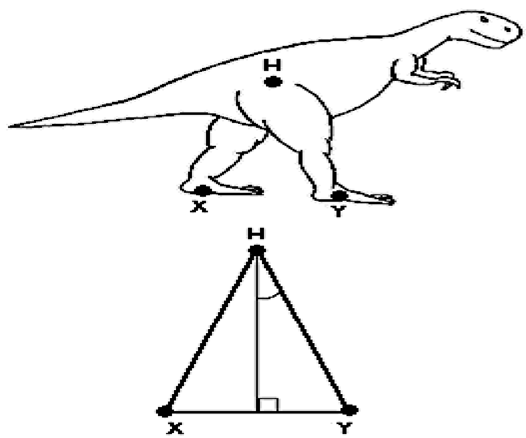
Teacher Background:

This lab focuses on what we can learn from fossils by connecting them to patterns observed today. It also allows students an opportunity to collect, analyze, and evaluate real data. The formula used is based on bipedal morphology.

As trace fossils, tracks and trackways represent preserved activities of animals in the past. Trackways provide direct data in the form of foot length/size and stride length. These data can provide information about the animals' physiology, speed, and behavior. However, interpretation of the data is dependent on several factors, including whether the animal was bipedal or quadrupedal, the size and weight of the animal, how the foot was placed, how the animal stood, the number of digits, the surface on which the animal was moving, and the preservation of the tracks.

By studying the tracks and trackways made by living animals, scientists have found sufficient consistency in the data to provide accurate correlations between the trackway data and the size and speed of the trackmaker. These same correlations can be applied to the tracks and trackways of extinct animals, such as dinosaurs.

The basic measurement of a dinosaur footprint is its length, represented as FL. The ratio of footprint length and hip height (h) is different for different groups of dinosaurs, but generally the hip height of a bipedal dinosaur is roughly four times the footprint length. The speed can then be determined as relative speed, which is stride length (SL), divided by hip height (h). Generally speaking, if the SL/h <2.0, then the animal was walking; >2.9, the animal was running; and between 2.0 and 2.9, the animal was trottingHip height can be estimated using a number of methods; two are described below.



Geometric Method

Drawing by M McLeod **after Avnimelech (1966) in Thulborn (1989)**

Using the **geometric method** illustrated above, suceeding footprints ('X' and 'Y') are assumed to be the base of an isosceles triangle. 'H' represents hip height.

The **morphometric method** was suggested by Alexander (1976). Alexander assumed from estimates of foot joint features that hip height was four times the length of the hind footprint for dinosaurs, whether bipedal or quadrupedal. This can be regarded as a crude, but useful ratio. **Hip Height Conversion Factors** Several workers have pointed out that different types of dinosaur had slightly different relationships between foot length and hip height and Thulborn (1990) has suggested that the following approximations could be used for bipedal dinosaurs

FL less than 0.25m		**FL greater than 0.25m**	
small theropods	h=4.5*FL	large theropods	h=4.9*FL
small ornithopods	h=4.8*FL	large ornithopods	h=5.9*FL
small bipedal dinosaurs in general	h=4.6*FL	large bipedal dinosaurs in general	h=5.7*FL

Recommendations for quadrupedal dinosaurs are less clear because in many groups the hind foot or pes has a large padded area. For sauropods Thulborn (1990) has suggested that h=5.9*FL while Lockley et al. (1986) used h=4*the foot width (FW) but a better general estimate may be h=4.6*FL. Published reconstructions and other lines of evidence also suggest the following conversion factors for other groups Ceratopsians h=4.2*FW Ankylosaurs h=3.7*FW Stegosaurs h=6.0*FW or h=5.0*FL

In the stegosaurs there is a very large difference between the height at the hips and the height at the shoulder and the latter, which may be more important in determining speed of movement, can be estimated from the width of the front foot or manus as 3.5*FW.

http://palaeo.gly.bris.ac.uk/Palaeofiles/Tracks/Report7/Speed.html

How Dinosaur Tracks are Formed

Unlike body fossils, which often are best preserved when they are buried rapidly, tracks are more likely to be well preserved when they are buried in a relatively slow, calm manner. For this reason, tracks and bones are seldom found in close association.

There are two main ways in which tracks can be formed and preserved. The classic scenario is as follows. First, a trackmaker walks along a moist but firm, fine-grained sediment. Then the tracks remain exposed for a short while, allowing them to become drier and harder (and thus able to resist damage during subsequent burial). A short time later the prints are gently buried with additional sediment, preferably of a contrasting type (which would allow the layers to separate when later reexposed). While buried for millions of years, the original sediment lithofies (turns into rock). Finally, the tracks are reexposed in modern times by erosion or other forces. Of course, the tracks also must be found and studied before they are destroyed by weathering, quarry workers, or other dangers. Tracks formed under less ideal conditions tend to be distorted or indistinct, if preserved at all.

Recent research suggests another mechanism of print formation, which involves a dinosaur walking on a very soft surface. In such a case, the animal's feet may push into firmer layers below the surface. The soupy surface material may then rush back over the upper depressions, simultaneously covering the prints made in the lower layers. The subsurface prints are known as underprints, undertracks, or ghost tracks

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Extensions:

Students could make models of actual dinosaur trackways using data in teacher background.

http://www.beg.utexas.edu/UTopia/dinosaur/dino_activities/dino_activ01.html
Lab activity from University of Texas in Austin

Dinosaur Tracks (Related Article)

A series of dinosaur tracks in a strata of solid rock may be seen in the bed of a creek near the Black Mesa. The area where the tracks are found was at one time a swamp and forest area. At times, following flood conditions the tracks are covered with several feet of silt. At other times, gushing torrents along the waterway uncover the tracks completely. Immediately before the Boise City annual Trail Daze event, the tracks are swept clear of debris.

There are three sets of tracks in the creek bed - the main set, a shallower but similar set about 50 yards upstream, and a smaller and much more eroded set downstream. These tracks are in Jurassic formation - sandstone - 150 millions years old. These tracks were probably made by plant-eaters because of the large size of the tracks and the webbed toes. (Meat-eaters left smaller tracks [except for the Tyrannosaurus] and were pointy-toed.) You can tell the size of one of these dinosaurs by measuring across the tracks (18") and multiply by four, giving you the hip-height . . . in this case about 6 feet. Therefore this dinosaur, from head to tail, was about 25 - 30 feet long, walked on hind legs (since no front leg prints are visible) and did not drag a tail. Tracks close together indicate walking slowly along a beach or pool, maybe foraging for food. If you look closely you can actually see how the dinosaur's weight pushed the mud up to one side on each step. Almost all tracks found worldwide are so eroded you can no longer see the mud pushes.

Why did the dinosaur come here and nowhere else in Oklahoma? What did the land look like 150 million years ago? Most of the United States was underwater . . . there was an eastern ocean and a shallow, brackish western one. A long peninsula ran from the southwest through Kansas, Cimarron County, and into New Mexico. That's why Jurassic tracks are found here but nowhere else in Oklahoma. This was the beach where it was hot and muggy with lots of huge cypress trees. . .all the dinosaurs came here for vacation!

Were the tracks made the same day? The two larger track ways were probably made about the same time. . . but the smaller set downstream may be several million years older! There were LOTS of dinosaurs in this area for many years. From bones found in this area it is known that there were brontosaurus, stegosaurus, allosaurus, as well as iquanodon/camptosaurus, and also much smaller dinosaurs, some about the size of a chicken! There were also phytosaurs, which were huge alligator-looking critters up to 50 feet long. Their teeth have been found in quarries near here.

During the early 1930's, several dinosaur quarries were opened and excavated. More than 18 tons of fossilized prehistoric animal bones have been taken from Cimarron County quarries. A reassembled brontosaurus skeleton measuring 80 feet in length, 40 feet in height, and 85% complete is now on display in the Smithsonian Institute in Washington, D.C. This dinosaur weighed 80 tons and was at least 80 feet in length, 24 inches across the base, and 21 inches across the upper end. The bones weigh 425 pounds. Five distinct species of dinosaur were found in the same quarry. Other quarries in the same general area have given up parts of the remains of giant mammoths in the form of tusks, skull and other parts.

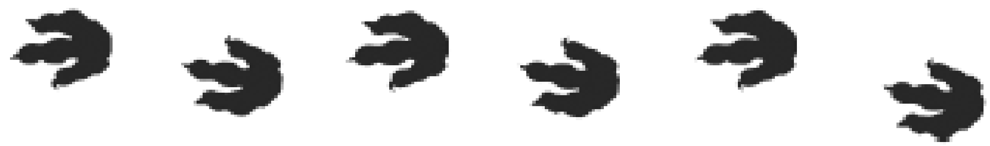
Walking With Dinosaurs

Name: ______________________ **Date:** ____________

Directions: Determine whether the dinosaurs are walking, trotting, or running by measuring their foot length (straight line from the tip of longest toe to the back of the foot) and stride length (distance between two successive placements (two steps) of the same foot, measuring between equal points), and using the formula below.

A

B

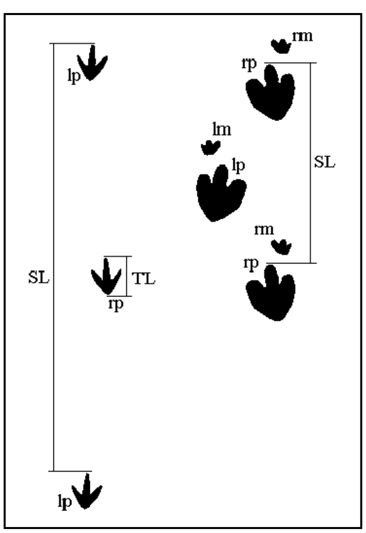


C

Trackway	FP Footprint length (cm)	HH Hip height (cm) HH = 4 x FP	LS Length of stride (cm)	LS/HH ratio	Walking Trotting Running

To find the LS/HH Ratio: Divide the Length of Stride by the hip height: Round your answer to the nearest 10th

If the LS/HH ratio is less than 1.0, the dinosaur was WALKING
If the LS/HH ratio is between 1.0 and 1.9, the dinosaur was TROTTING
If the LS/HH ration is greater than 1.9, the dinosaur was RUNNING



<u>Questions to Consider:</u>

Evaluate: What are four things that we can learn by studying dinosaur tracks?

Analyze: What is the relationship between footprint length and hip height? **BE SURE TO INCLUDE DATA!**

Infer: What inferences can you make about the dinosaur tracks to the left in figure 1?

Background Information: Dinosaur remains have been discovered on every continent. Some of the most common dinosaur fossils are footprints and trackways. Trackways give scientists some of the only direct evidence of dinosaur behavior. Based on trackways and track morphology, inferences about dinosaur size, gait, activity and speed of movement can be made. To interpret these trackways, however, modern organisms must be studied to determine what behavior leads to the formation of certain kinds of tracks. Imagine the different kinds of tracks you could make in various substrates (soft mud, wet sand, dry sand and so forth) or in various activities (running, walking, or jumping). Each behavior in each kind of substrate will leave a different kind of track.

The morphology and general behavior of an organism can also be determined by the trackway. The number and pairing of tracks indicate whether the creature was bipedal (walked on two feet) or quadruped (walked on four feet). In addition, the shape of the foot is an indication of behavior. Relatively narrow feet that have pointed toes are typical of carnivorous dinosaurs - all of which were bipedal. Broad feet with rounded toes are typical of herbivores - typically larger animals that require greater areas for support. Some ornithopods had smaller feet with a hoof-like pad. Inferring that most dinosaur trackways represent normal movement (typical gait) the size of the dinosaur and its speed can be estimated by the tracks and the length of its stride. In our investigation we will be using human data to analyze and evaluate the relationship between footprint size, hip height, and stride length. To get started we will need to collect some data from all of the members in the class and then record it in the data table provided.

Procedure:

Step1: Remove your shoe and have your partner measure your footrpint size: Write the measurement in the space below. Be ready to give your data when called on

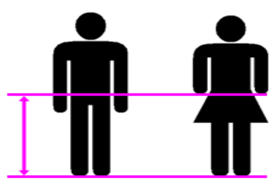
- **My footprint size is** ____________________

Calculate your leg length by multiplying your footprint size by 4:

- **Calculated hip height** = ________________

Step 2: Calculate the hip height for each member of the class: Round your answer to the nearest 10th

Step 3: Have your partner measure your hip height and write the measurement in the space below: Be ready to give your data when called on



Measure your hip height from the

- **Measured hip height:** ___________________________________
- **Difference from calculated**: SHOW WORK
- **Percent of Difference: Difference/actual x 100**

Step 4: Measuring Stride Length: Go into the atrium and begin at the starting line. Take ten steps walking at your regular rate. Have your partner measure the distance that you traveled and record the distance in the space below: Be prepared to give your data when called on:

- **Distance traveled in 10 steps**: ______________________

Step 5: Use the formula shown below to calculate the stride length for each member of the Class. Round your answer to the nearest 10th

Stride Length= Distance walked/ number of steps taken

Hypothesis: If ____

then: ____

because____

Walking With Dinosaurs Data Table

Student's Name	**Footprint Length**	**Calculated Hip Height**	**Actual Hip Height**	**Distance of 10 steps**	**Stride Length**

Name: ________________________________ Date: ______________Class: ______

Hip Height vs Stride Length UNRAVELS

U: Uncover the research question:

Does ____ affect ___________________

____

N: Name the independent and dependent variable:

IV: ___________________________________DV: ____________________________________

R: Reveal the hypothesis using an if, then, and because statement:

A: Analyze the experiment to explain what hip height and stride length measure and how scientists the relationship between these two measurements to make inferences about dinosaur tracks. <u>BE SURE TO USE COMPLETE SENTENCES</u>

V: Verify the experiment to explain how the data was collected. <u>Be sure to include the materials</u>

Materials:

Steps of the procedure:
1.

E: Evaluate the experiment to list the constants

L: **Link the data by ordering the hip heights from least to greatest**

Hip Height	Stride Length

Graph your data using the appropriate graph: Scatter Plot or Double Line

S: **Support or Disprove your hypothesis: Restate you hypothesis and then use the data in your graph to evaluate whether it supports or disproved your hypothesis.**
BE SURE TO USE COMPLETE SENTENCES

Interpreting a Fossil Find:
Teacher Instructions and background Information

Objective: To provide students with an opportunity to understand and evaluate how fossils are dated using relative age dating by analyzing a diagram and making a model to interpret data.

Time Required: 1 class period

Materials Needed:

Student pages, blue colored pencil

Teacher Preparation:
Copy Student pages

Useful Websites:

http://www.geosociety.org/educate/LessonPlans/Relative_Age.pdf
More advanced relative age dating activity

http://www.paleoportal.org/index.php?globalnav=time_space&sectionnav=state&name=Oklahoma
Great site for index fossils of different periods

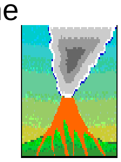
Teacher Background:

This lab allows students the opportunity to evaluate one of the methods used to determine the age of a rock layer and its fossils to better understand geologic time.

DATING FOSSILS
(http://www.enchantedlearning.com/subjects/dinosaurs/dinofossils/Fossildating.html)

DATING INDIVIDUAL FOSSILS
Paleontologists use many ways of dating individual fossils in geologic time.

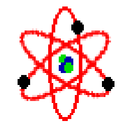
1. The oldest method is stratigraphy, studying how deeply a fossil is buried. Dinosaur fossils are usually found in sedimentary rock. Sedimentary rock layers (strata) are formed episodically as earth is deposited horizontally over time. Newer layers are formed on top of older layers, pressurizing them into rocks. Paleontologists can estimate the amount of time that has passed since the stratum containing the fossil was formed. Generally, deeper rocks and fossils are older than those found above them.
2. Observations of the fluctuations of the Earth's magnetic field, which leaves different magnetic fields in rocks from different geological eras.



3. Dating a fossil in terms of approximately how many years old it is can be possible using radioisotope-dating of igneous rocks found near the fossil. Unstable radioactive isotopes of elements, such as Uranium-235, decay at constant, known rates over time (its half-life, which is over 700 million years). An accurate estimate of the rock's age can be determined by examining the ratios of the remaining radioactive element and its daughters. For example, when lava cools, it has no lead content but it does contain some radioactive Uranium (U-235). Over time, the unstable radioactive Uranium decays into its daughter, Lead-207, at a constant, known rate (its half-life). By comparing the relative proportion of

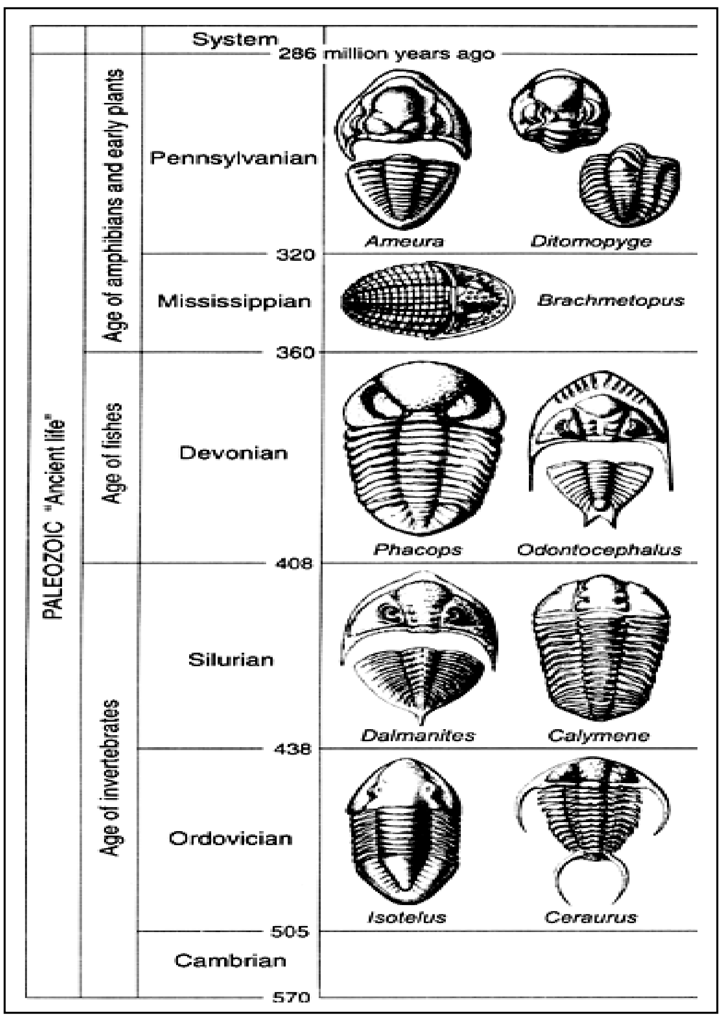
Uranium-235 and Lead-207, the age of the igneous rock can be determined. Potassium-40 (which decays to argon-40) is also used to date fossils.

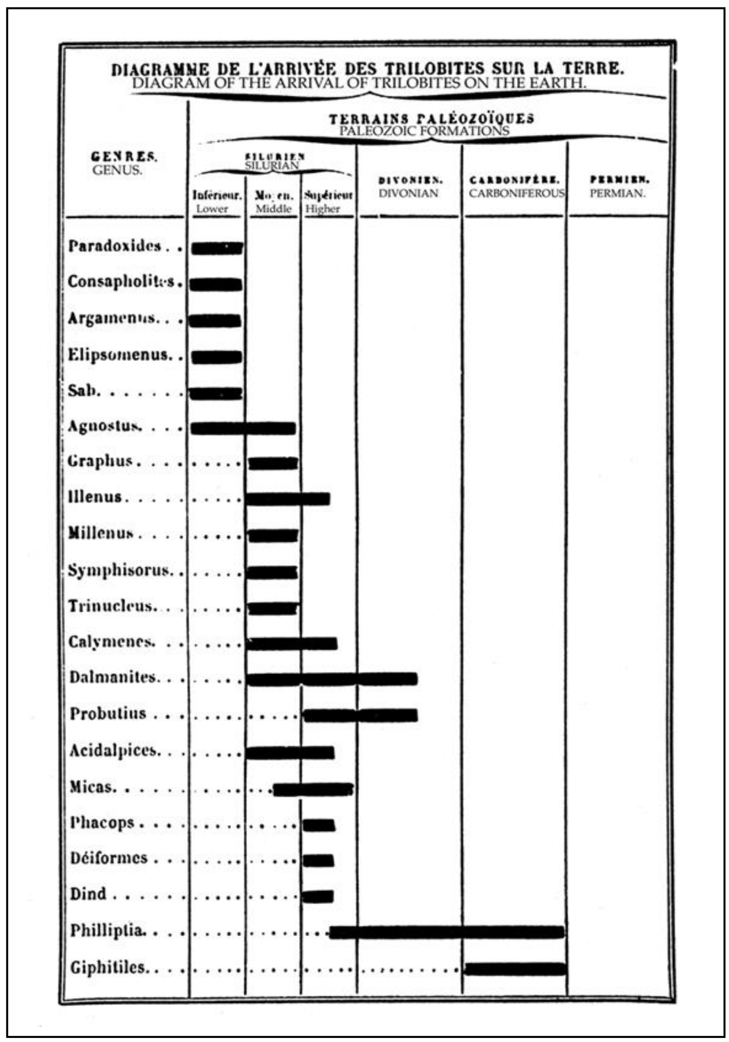
The half-life of carbon-14 is 5,568 years. That means that half of the C-14 decays (into nitrogen-14) in 5,568 years. Half of the remaining C-14 decays in the next 5,568 years, etc. This is too short a half-life to date dinosaurs; C-14 dating is useful for dating items up to about 50,000 - 60,000 years ago (useful for dating organisms like Neanderthal man and ice age animals).



Radioisotope dating cannot be used directly on fossils since they don't contain the unstable radioactive isotopes used in the dating process. To determine a fossil's age, igneous layers (volcanic rock) beneath the fossil (predating the fossil) and above it (representing a time after the dinosaur's existence) are dated, resulting in a time-range for the dinosaur's life. Thus, dinosaurs are dated with respect to volcanic eruptions.

4. Looking for index fossils - Certain common fossils are important in determining ancient biological history. These fossil are widely distributed around the Earth but limited in time span. Examples of index fossils include brachiopods (which appeared in the Cambrian period), trilobites (which probably originated in the pre-Cambrian or early Paleozoic and are common throughout the Paleozoic layer - about half of Paleozoic fossils are trilobites), ammonites (from the Triassic and Jurassic periods, and went extinct during the K-T extinction), many nanofossils (microscopic fossils from various eras which are widely distributed, abundant, and time-specific), etc.





Name: ____________________________ **Date:** ____________________ **Class:** ______

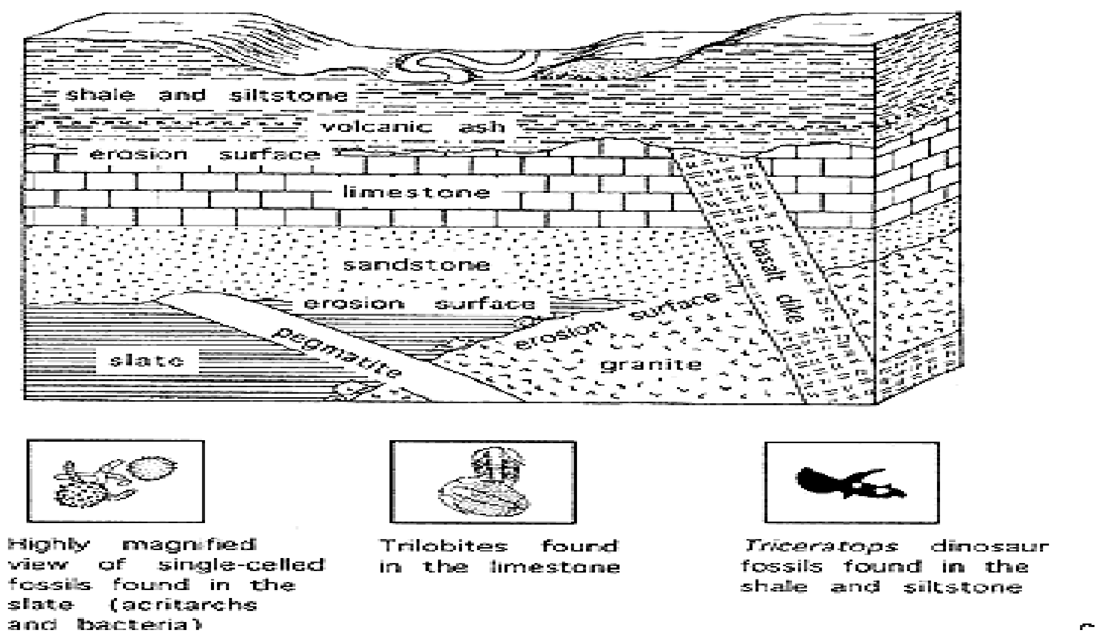
INTERPRETING FOSSIL FINDS

Background: To determine how old a fossil is, paleontologists use two basic methods. The first is called relative dating. The second technique is called **radiometric dating or radioisotope dating**. By **relative dating**, we mean that we determine the age of a fossil by looking at its relative position in the stratigraphic or rock layers. This technique is often called stratigraphic dating. To use relative dating, we look at the sediments above and below a fossil; this allows the paleontologist to infer that an animal lived after one species based on where it is found. Relative age dating relies on 2 important principles:

- **Principle of superposition:** States that younger sedimentary rocks are deposited on top of older sedimentary rocks.
- **Principle of cross-cutting relations:** States that any geologic feature is younger than anything else that it cuts across.

Part 1: Use the figure shown below to Prove (P) or Disprove (D) each statement. Be sure to write your support for your decision in the space below the statement:

Figure 1. Block diagram



1. ______ **The Trilobite fossils are older than the bacteria fossils.**

2. ______ **The Pegmatite Intrusion occurred before the sandstone layer was formed.**

3. ______ **The fossil record held in the rock layers show that there was an ocean before there was land.**

Part 2: Interpreting a Fossil Find:

Background: At a site in Southern Oklahoma, a paleontologist found fossils in two layers of sedimentary rock. In addition to identifying each fossil, she recorded its location by using map coordinates consisting of a letter and a number. She also notes whether the fossil was found in the upper or lower rock layer. The data she collected are show in Table 1.

Table 1: Locations of Fossils Uncovered at Site			
Rock Layer	**Shark (S)**	**Brachiopods (B)**	**Fern (F)**
Upper Layer	A4, B1, C2, C5, D3, E1	A5, B6, C6, D4, F1, F3	B9, E8, H5, H9, I2, J7
Lower Layer	A1, B4, D2, D7, E5, E10, G3, G6, I2, J5	G7, G9, H10, I6, J7	I8, J9, J10

- ✓ Your job is to create a table of the location of fossils in the upper rock layer and lower rock layer. For each fossil, mark a letter in the square that corresponds to the coordinates listed in Table 1. Use 'S' for shark, 'B' for Brachipod and 'F' for fern.

Table 2: Location of Fossils in the Upper Rock Layer										
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
1										
2										
3										
4	**S**									
5										
6										
7										
8										
9										
10										

Table 3: Location of Fossils in the Lower Rock Layer										
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

B. Examine Table 2. Which part was probably underwater when these organisms died?
Color this area blue.

C. Examine Table 3. Which part was probably underwater when these organisms died?
Color this area blue.

Conclusions:

1. **Compare**: How is the upper layer like the lower layer?

2. **Contrast**: How does the upper layer differ from the lower layer?

3. **Analyze**: How do paleontologists use relative age dating to determine the age of a fossil?

   What 2 Principles is it based on?

4. **Analyze:** Which animal/s became extinct?

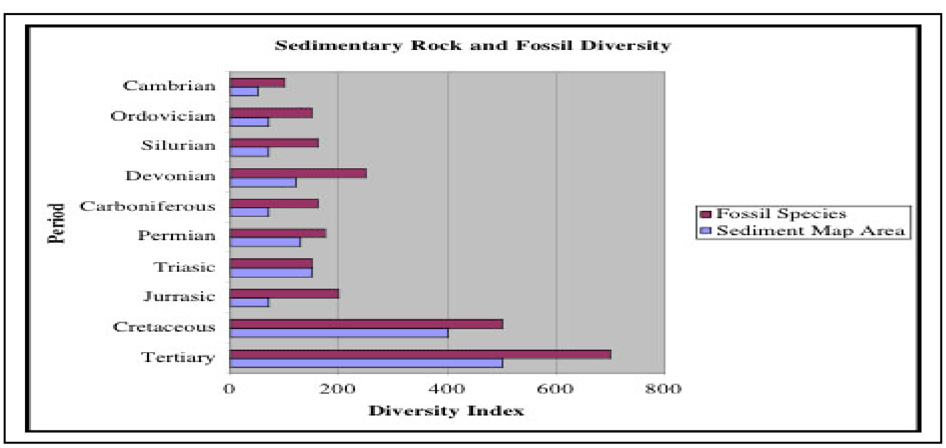
   Infer: Why do you think this is?

5. Looking back at Your "***Geologic History of Oklahoma Table"***, how old are the fossils in the upper layer? SUPPORT YOUR ANSWER.

   How old are the fossils in the lower layer? SUPPORT YOUR ANSWER.

6. **Evaluate:** Would you expect to Trilobite Fossils in the lower layer? SUPPORT YOUR ANSWER.

7. What other method could scientist use to date the fossils found in your site?



8. According to the graph, which period had the greatest diversity of fossil species?

   Infer: Why do you think this is?

Adaptive Ovali
Teacher Information and Background:

Objective: To provide students with an opportunity to use common traits to build a phylogenetic tree based on cladistic analysis for an unknown species using morphology and clues as to how the earth has changed throughout its geologic history.

Time Needed: 1 class period

Materials: scissors, glue or glue sticks, large paper, and lab sheets, and Oklahoma Geologic Time Table

Teacher preparation: get materials and run off lab pages

Useful Websites:

http://evolution.berkeley.edu/evolibrary/article/phylogenetics_01
Background on Cladistics

http://anthro.palomar.edu/time/time_1.htm
Interesting background on interpreting the fossil record

http://www.fossilnews.com/1996/cladistics.html
Nice background on Cladistics

http://www.geo.utexas.edu/courses/302m/cladistics/Clad%20proj/cladistics%20terms.htm
Cladisitcs terms

http://www.tellapallet.com/TreeOfLife.jpg
Great poster cladogram

Teacher Background:

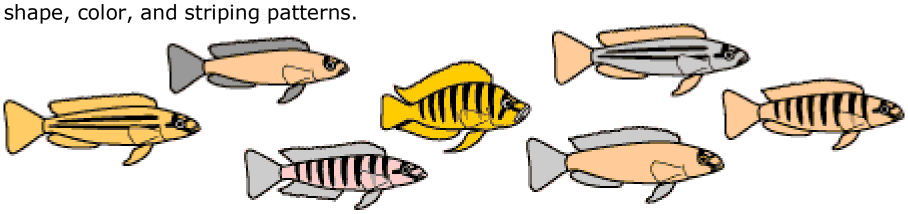
This is an open inquiry lab wherein students develop a phylogenetic tree for a fictitious species named ovalus. There is no right or wrong answer as long as students can support their decisions.

Further Background:
Columbia Encyclopedia: Cladistics is an approach to the classification of living things in which organisms are defined and grouped by the possession of one or more shared characteristics (called characters) that are derived from a common ancestor and that were not present in any ancestral group (as envisioned by Charles Darwin's idea of descent with modification). Developed by Willi Hennig, a German entomologist, in the 1950s, it is a method of reconstructing evolutionary relationships that emphasizes the importance of descent and common ancestry rather than chronology.

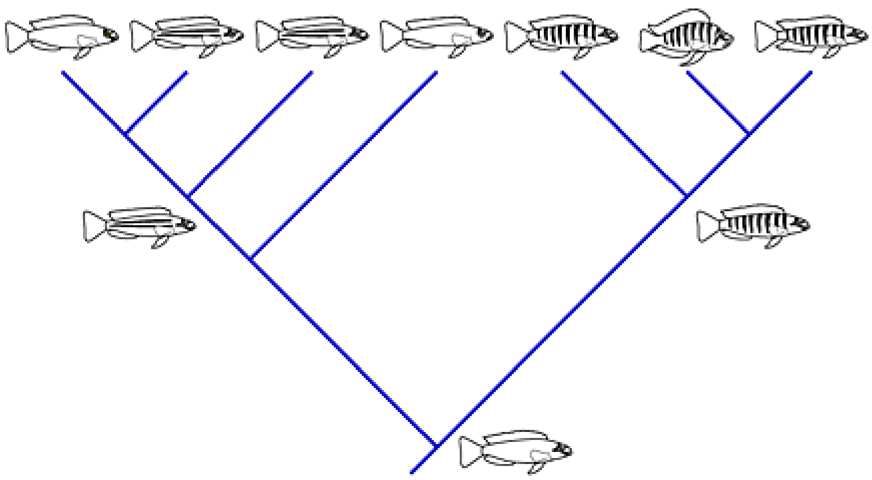
Cladistics places species in a group, or clade, based on a shared character. Within a clade, species that share other characters unique to them are grouped together, and so on, until a cladogram (a branching diagram that resembles a family tree) is assembled. For example, all vertebrates make up a clade; all tetrapods (vertebrates that have four limbs with wrists, ankles, toes, and fingers) form their own clade within the vertebrate clade. In this example the vertebrate clade would be considered primitive and the tetrapod clade derived or advanced. In living creatures genetic characters or behaviors as well as more obvious anatomical features might be considered in assembling a cladogram. In paleontology the characters are necessarily skeletal. Cladistics is especially significant in paleontology, as it points out gaps in the fossil evidence. It is also felt to be more objective than fossil study, which of necessity extrapolates from a limited number of finds that may or may not be representative of the whole.

Using trees to learn about the evolution of complex features: The striped cichlid

Reconstructing ancestral characters can help us understand how a complex feature evolved. For example, the cichlid fish shown above and represented below vary in shape, color, and striping patterns.



Researchers reconstructed the phylogeny of these fish based on molecular data, then mapped striping patterns onto the phylogeny. Scientists used parsimony to infer the probable pattern of the ancestral fish. The resulting phylogeny shows how these complex patterns evolved in different lineages.



Reconstructing trees: Cladistics

Cladistics is a method of hypothesizing relationships among organisms — in other words, a method of reconstructing evolutionary trees. The basis of a cladistic analysis is data on the characters, or traits, of the organisms in which we are interested. These characters could be anatomical and physiological characteristics, behaviors, or genetic sequences.

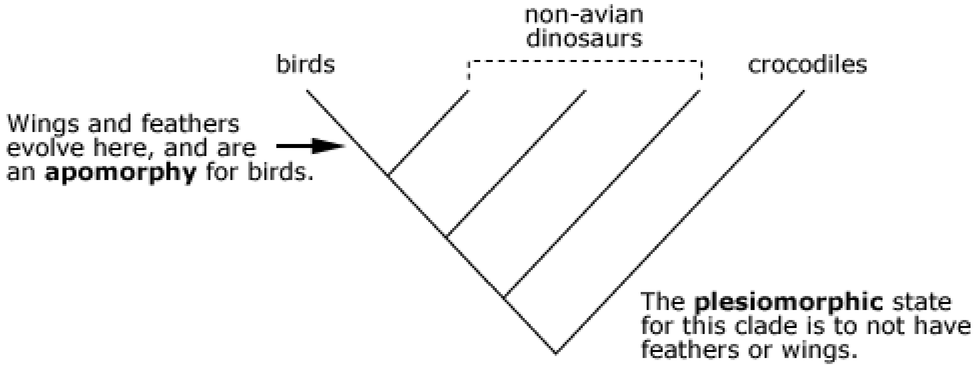
The result of a cladistic analysis is a tree, which represents a supported hypothesis about the relationships among the organisms. However, it is important to keep in mind that the trees that come out of cladistic analyses are only as good as the data that go into them. New and better data could change the outcome of a cladistic analysis, supporting a different hypothesis about the way that the organisms are related.

Assumptions

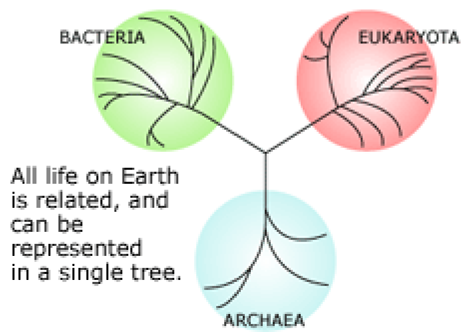
There are three basic assumptions in cladistics:

1. Change in characteristics occurs in lineages over time.

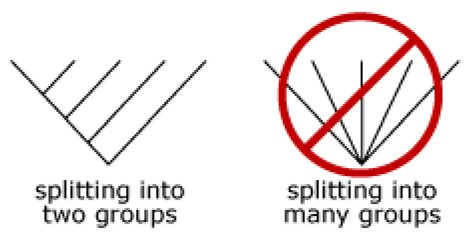
The assumption that characteristics of organisms change over time is the most important one in cladistics. It is only when characteristics change that we are able to recognize different lineages or groups. We call the "original" state of the characteristic *plesiomorphic* and the "changed" state *apomorphic*.



2. Any group of organisms is related by descent from a common ancestor.
This assumption is supported by many lines of evidence and essentially means that all life on Earth today is related and shares a common ancestor. Because of this, we can take any collection of organisms and hypothesize a meaningful pattern of relationships, provided we have the right kind of information.

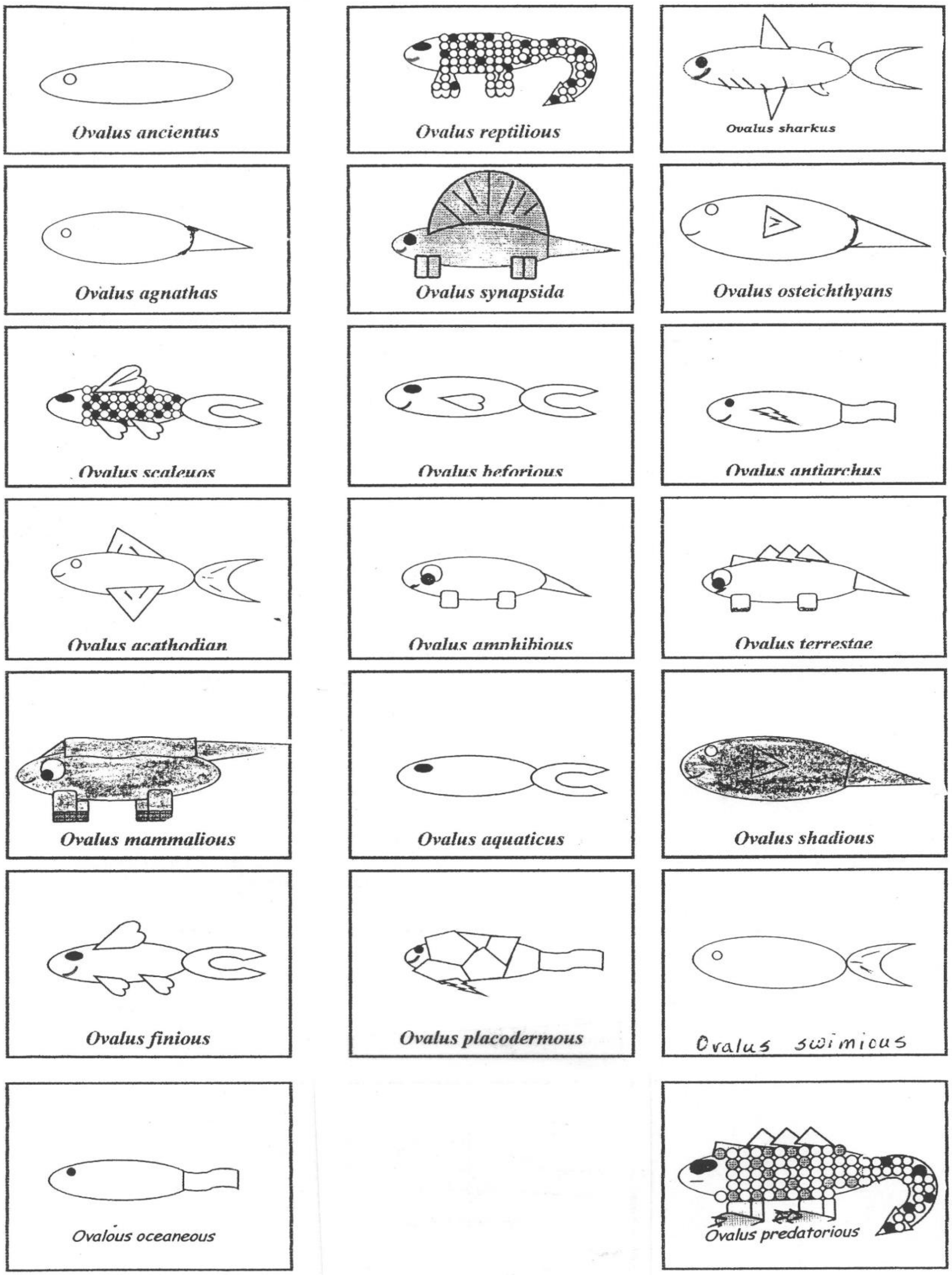


3. There is a bifurcating, or branching, pattern of lineage-splitting.
This assumption suggests that when a lineage splits, it divides into exactly two groups. There are some situations that violate this assumption. For example, many biologists accept the idea that multiple new lineages have arisen from a single originating population at the same time, or near enough in time to be indistinguishable from such an event (as in the case of the cichlid fish described previously). The other objection raised against this assumption is the possibility of interbreeding between distinct groups, which occurs at least occasionally in some groups (like plants). While such exceptions may exist, for many groups they are relatively rare and so this assumption often holds true.



http://evolution.berkeley.edu/evolibrary/article/phylogenetics_01

Adaptive Ovali



Adaptive Ovali
Student Background and Procedure

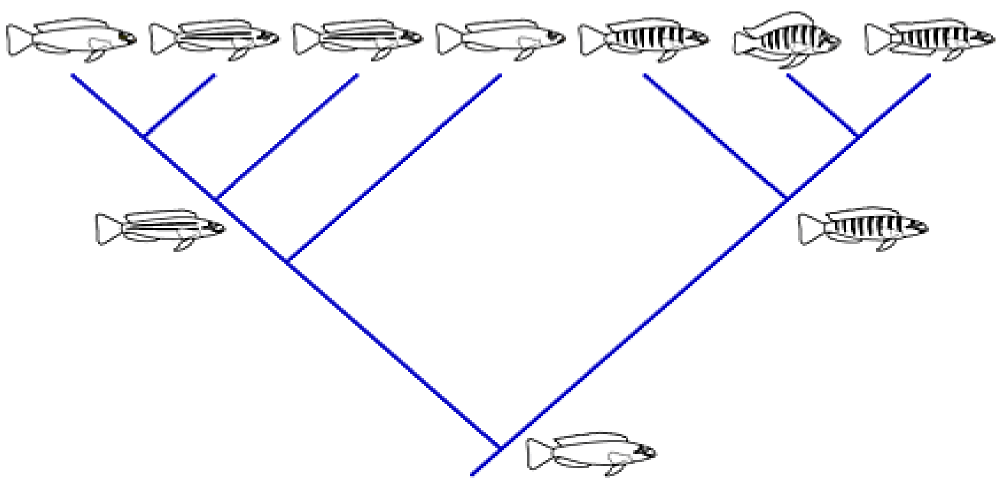
Background Information: Scientists estimate that over 99.9% of all living things are now extinct. This means that less than 1/10 of a 10th of one percent is extant, still living. When you consider that there are currently millions of different species inhabiting different environments this equates to an unfathomable number. We know from the fossil record that dinosaurs were a very successful group of reptiles that dominated the Earth for 160 million years before their mass extinction about 65 million years ago. We also know that there are many extant species of animals that share many of the same traits that made the dinosaurs so successful. How is this possible? The answer lies in genes. A gene is a unit of genetic material that determines a trait. Genes are passed from parents to their offspring through either sexual or asexual reproduction. Adaptive traits, such as sharp tearing teeth found in most predators, allow the species that carries them to be more successful in their environment. As a result, we see the same adaptive traits in many different species of living things. So instead of a species becoming completely extinct what we see throughout the geologic history of life is that life changes in response to a changing earth in a process known as adaptive radiation. Adaptive radiation is defined as the diversification of a species as it adapts to different ecological niches. These changes can be shown using a phylogenetic tree based on cladistic analysis: A phylogenetic tree is a family tree that shows a **hypothesis** about the evolutionary relationships thought to exist among groups of organisms. Phylogenetic trees are usually based on a combination of these lines of evidence:

- The fossil record
- Morphology
- Embryological patterns of development
- Chromosomes and DNA

A phylogenetic tree based on a cladistic analysis is called a cladogram. Cladistics is based on three principles:

1) Groups of organisms are descended from a common ancestor.
2) At each node (divergence of a population), there are two branching lines of descendants.
3) Evolution results in modifications of characteristics over time.

A cladogram from a genus of cichlid fish is shown below:



In this investigation you will develop a phylogenetic tree based on cladistic analysis for a fictitious genus to evaluate how it changed over time and which traits were most adaptive to its survival.

Research Question: How can I construct a phlyogenetic tree based on cladistic analysis to evaluate to analyze and evaluate how a genus adapted to earth's changes over time.

Materials: a legal-sized sheet of paper, scissors, glue, Oklahoma Geologic Time Table, and student pages

Procedure:
1. Cut the individual species of Ovalus apart.
2. Use the family clues provided to construct your phylogenetic tree.
3. You may add missing links by drawing other Ovali.
4. When you feel that it is correct, glue your family tree on the sheet of legal-sized paper that you were provided. Add a title and the branches that link each species to its ancestor.
5. Be prepared to present your finished tree and be ready to support your decisions
6. Use your completed family tree and the background information to answer the conclusion questions.

Family Clues:

- The oldest Ovalus produced four separate branches of Ovali
- Each branch of Ovali share similar characteristics: eyes, tail shape, and skin.
- Branches can also show a vertical relationship between two different species:
- Since life began on Earth, the earth has changed dramatically going from an almost completely aquatic environment to an environment with a single land mass which then split apart to form the continents shown on maps today.
- Adaptations result from changes in the environment.
- The long line of animals leading to the mammals include:
    - Jawless Fish- Cambrian to mid-Ordovician periods
    - Bony Fish- mid Ordovician to late Devonian periods
    - Amphibians- late Devonian to early Carboniferous periods
    - Reptiles- late Carboniferous
    - Synapsids- mammal-like reptiles- late Carboniferous to early Triassic
    - Mammals- mid Triassic period to today

Name: ___________________________ Date: _____________________ Hour: ___________

Adaptive Ovali
Student Conclusion Page

1. What lines of evidence did your group use to construct your Ovali phylogenetic tree?

Evaluate: Could the ovali have lived in Oklahoma? SUPPORT YOUR ANSWER

2. What evidence do scientists use to build a phylogentic tree?

3. Contrast: How does a cladogram differ from a phylogenteic tree?

4. What evidence is used to construct a cladogram?

5. According to the background information, how many species of living things do scientists

   estimate are now extinct? ______________ how many are extant? ___________

   What percentage of your Ovali became extinct? ____________ are extant? _____________

6. According to the background information, how did the oldest Ovali pass its traits on to other species of Ovali?

7. Which Ovali trait/s was passed on to all species of Ovali?

8. According to the background information, what is adaptive radiation?

9. Which trait was used to construct the cladogram in the background?

10. Evaluate: What purpose do cladograms and phylogenetic trees have to our understanding of the fossil record?

The Dating Game:
Teacher Instructions and Background:

Objective: To provide students with an opportunity to model how atoms change from parent atoms to daughter atoms to determine half-lives when using radiometric dating to determine the age of a rock or fossil

Time Required: 2 class periods

Materials Needed:
Individual packages of M & M's, alternate candy such as Smarties or plain Pennies and Painted pennies or another daughter atom model may be used

Teacher Preparation:
Run off procedure pages and get materials

Useful Websites
http://science.discovery.com/videos/100-greatest-discoveries-shorts-radiometric-dating.html
(video clip that explains radiometric dating)

http://facstaff.gpc.edu/~pgore/geology/geo102/radio.htm
Nice background

Teacher Background:
This lab connects atomic structure with geologic time and can be used as a bridge between the two seemingly unrelated objectives.

Dating a Fossil (http://science.howstuffworks.com/carbon-142.htm)

As soon as a living organism dies, it stops taking in new carbon. The ratio of carbon-12 to carbon-14 at the moment of death is the same as every other living thing, but the carbon-14 decays and is not replaced. The carbon-14 decays with its half-life of 5,700 years, while the amount of carbon-12 remains constant in the sample. By looking at the ratio of carbon-12 to carbon-14 in the sample and comparing it to the ratio in a living organism, it is possible to determine the age of a formerly living thing fairly precisely.

A formula to calculate how old a sample is by carbon-14 dating is:

$$\mathbf{t = [\ \ln (N_f/N_o) / (-0.693)\ ] \times t_{1/2}}$$

where ln is the natural logarithm, N_f/N_o is the percent of carbon-14 in the sample compared to the amount in living tissue, and $t_{1/2}$ is the half-life of carbon-14 (5,700 years).

So, if you had a fossil that had 10 percent carbon-14 compared to a living sample, then that fossil would be:

$$t = [\ \ln (0.10) / (-0.693)\ ] \times 5{,}700 \text{ years}$$

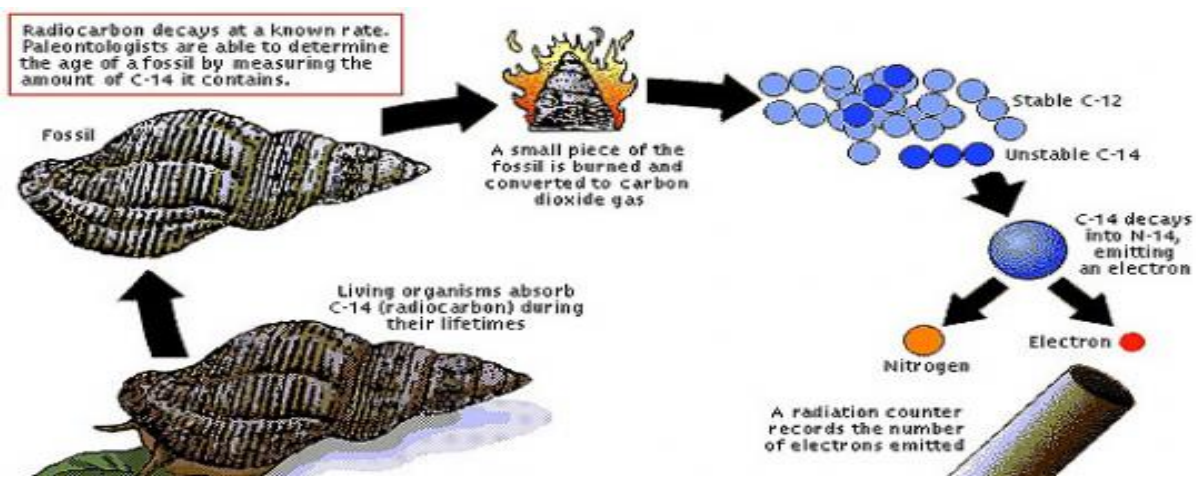
$$t = [\ (-2.303) / (-0.693)\ ] \times 5{,}700 \text{ years}$$

$$t = [\ 3.323\ ] \times 5{,}700 \text{ years}$$

t = 18,940 years old

Because the half-life of carbon-14 is 5,700 years, it is only reliable for dating objects up to about 60,000 years old. However, the principle of carbon-14 dating applies to other isotopes as well. Potassium-40 is another radioactive element naturally found in your body and has a half-life of 1.3 billion years. Other useful radioisotopes for radioactive dating include Uranium -235 (half-life = 704 million years), Uranium -238 (half-life = 4.5 billion years), Thorium-232 (half-life = 14 billion years) and Rubidium-87 (half-life = 49 billion years).

The use of various radioisotopes allows the dating of biological and geological samples with a high degree of accuracy. However, radioisotope dating may not work so well in the future. Anything that dies after the 1940s, when Nuclear bombs, nuclear reactors and open-air nuclear tests started changing things, will be harder to date precisely.



American chemist Bertram Boltwood (1870 - 1927) calculated the age of rocks by measuring the rate of its radioactive decay from uranium to lead. The result of his calculations placed the age of the Earth at 2.2 billion years. Much older rocks or minerals have recently been discovered and have been dated at 4.4 billion years old, an age that is very close to the best estimate of the age of the Earth determined by radiometric dating of lunar samples. His method has been found to be compatible with other radioactive elements, including carbon-14, which is used extensively by geologist, paleontologist and archeologist to date historical artifacts. (http://www.scienceray.com/Earth-Sciences/Great-Discoveries-in-the-Field-of-Earth-Sciences.274185)

Carbon-14 dating

http://higheredbcs.wiley.com/legacy/college/levin/0471697435/chap_tut/chaps/chapter03-05.html

Basic process:

a. Cosmic rays from the sun strike nitrogen-14 atoms in the atmosphere and cause them to turn into radioactive carbon-14, which combines with oxygen to form radioactive carbon dioxide.

b. Living things are in equilibrium with the atmosphere, and the radioactive carbon dioxide is absorbed and used by plants. The radioactive carbon dioxide gets into the food chain and the carbon cycle.
c. All living things contain a constant ratio of carbon-14 to carbon-12. (1 in a trillion.)
d. At death, carbon-14 exchange ceases and any carbon-14 in the tissues of the organism begins to decay to nitrogen-14, and is not replenished by new C-14.
e. The change in the carbon-14 to carbon-12 ratio is the basis for dating.
f. The half-life is so short (5,730 years) that this method can only be used on materials less than 70,000 years old. (Archaeological dating uses this method.) Also useful for dating the Pleistocene Epoch (Ice Ages).
g. Assumes that the rate of carbon-14 production (and hence the amount of cosmic rays striking the Earth) has been constant (through the past 70,000 years).

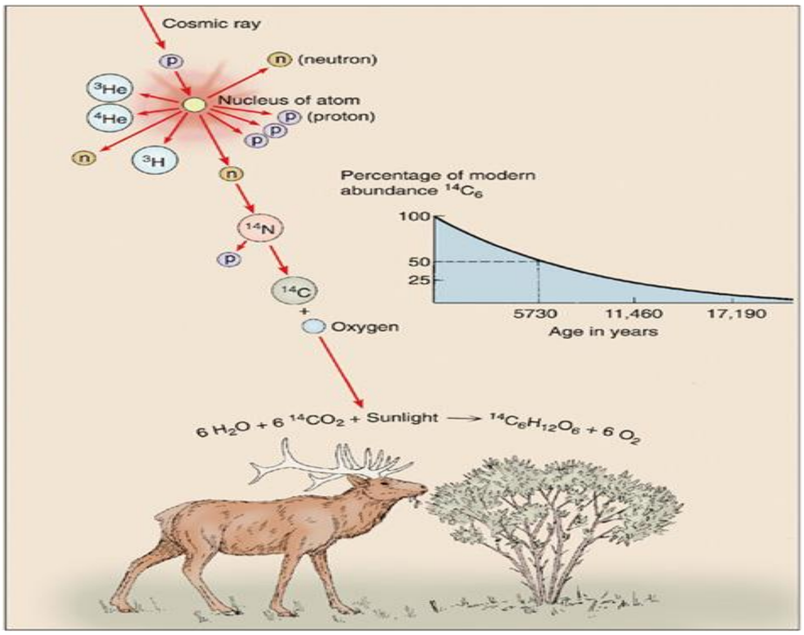
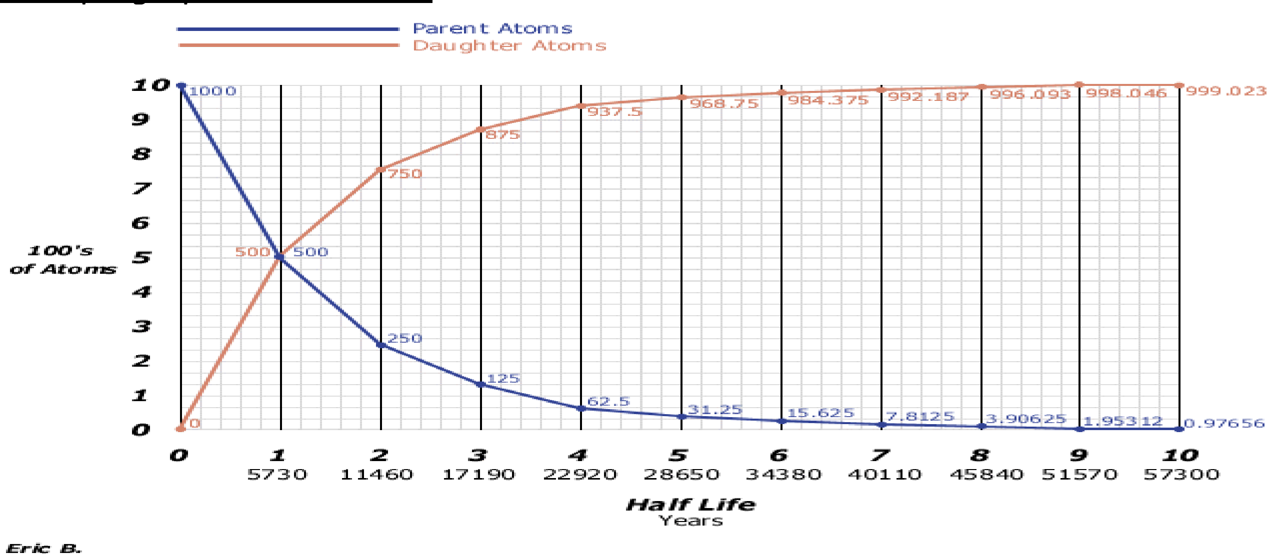


Diagram showing how carbon-14 dating works.

Example graph for Carbon 14

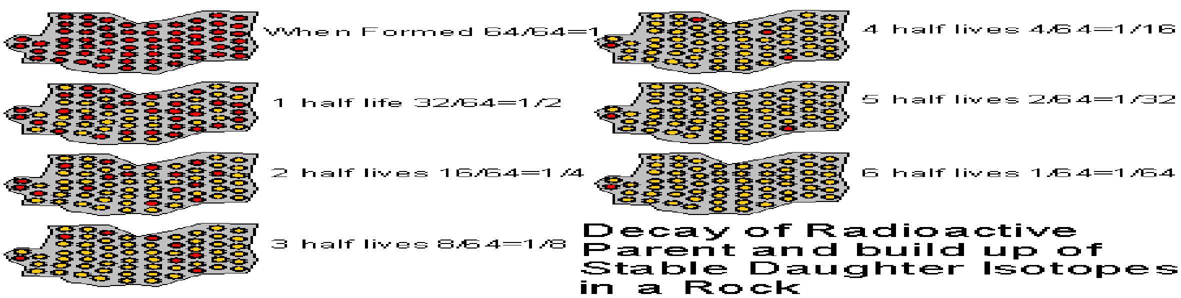


Name; ________________________date: ___________________ Class: ___________

The Dating Game

<u>Background Information:</u> In radiometric dating, different isotopes are used depending on the predicted age of the rocks. Samarium-deodymium dating is used for very old rocks since these elements have a half-life of 108 billion years. Potassium/Argon dating is good for rocks 100,000 years old since Potassium 40 has a half-life of 1.3 billion years! And finally, Uranium/Lead dating since U-238 has a half-life of 4.47 billion years. It is used for dating zircon crystals in igneous rocks.

By comparing the percentage of an original element (parent atom) to the percentage of the decay element (daughter atom), the age of a rock can be calculated. The ratio of the two atom types is a direct function of its age because when the rock was formed, it had all parent atoms and no daughters.



Radiocarbon dating uses Carbon-14 which has a half-life of 5730 years. This is used for organic things such as wood, human artifacts made from once living organisms, and modern bone. Modern isotopic counting techniques (accelerator mass spectrometer) can date things as old as 70,000 years. This is done by counting individual C-14 atoms (the parents) remaining in the once living organism. A very accurate age can be determined. The daughter atoms (Nitrogen-14) are lost to the atmosphere as elemental nitrogen.

Pre-Lab questions:

1. What is radiometric dating?

2. Compare: How does radiometric dating compare to relative age dating?

   Contrast: How does radiometric dating differ from relative age dating?

3. Evaluate: Why are different elements used to date the fossil found in different rocks?

4. What is radiocarbon dating?

5. If you found a fossil that contained 25% parent atoms and 75% daughter atoms, how many half lives would it have gone through?

6. What is a half-life?

Materials:

- **Gallon Ziplock bags, M&M's, Smarties, Paper, 2 colored Pencils**

Procedure:

1. Place the M&M's in the ziplock bag and seal it. These candy pieces represent the ______________________. Count the number and record in the data table
2. Shake the bag for several seconds and pour its contents out onto the table. Remove only the candy pieces with the "M" showing. These are the Parent Atoms which transmute (decay) to a new element, the Daughter element.
3. Count the removed Parent Atoms. Record the numbers in the data table below. Do not put the removed Parent Atoms back in the bag. (DO NOT EAT THEM YET!)
4. Replace the removed Parent Atoms with an equal number of Smarties. These new candy pieces are the Daughter Atoms.
5. Record the number of Daughter Atoms added in the table below. Check your progress. The total number of M&M's and Smarties in your bag must be the same as the number of M&M's you started with.
6. Seal the bag and shake it for several seconds. Open it and pour the contents onto the paper toweling. Count and remove only the Parent Atoms with the "M" showing. Fill in your data table. Do not put the removed Parent Atoms back in the bag. (DO NOT EAT THEM YET!)
7. Replace the Parent Atoms you removed with the same number of Daughter Atoms.
8. Repeat the above procedure until all of the Parent Atoms have changed into Daughter atoms. This process is called transmutation.

Data Table: Label your data table as you decide:

Draw a diagram of your results for each trial to show the relationship between the number of parent atoms and daughter atoms using 2 colored pencils: Be sure to include a key

Beg **Trial 1** **Trial 2** **Trial 3** **Trial 4** **Trial 5**

Key: ☐ **Parent Atom** ☐ **Daughter Atom**

Conclusion: Write a conclusion statement that communicates what happened to the number of parent atoms and daughter atoms over the number of trials that you conducted. Be sure to include the numbers.

Name: ______________________________ Date: _______________ Block: __________

Graphic Decay

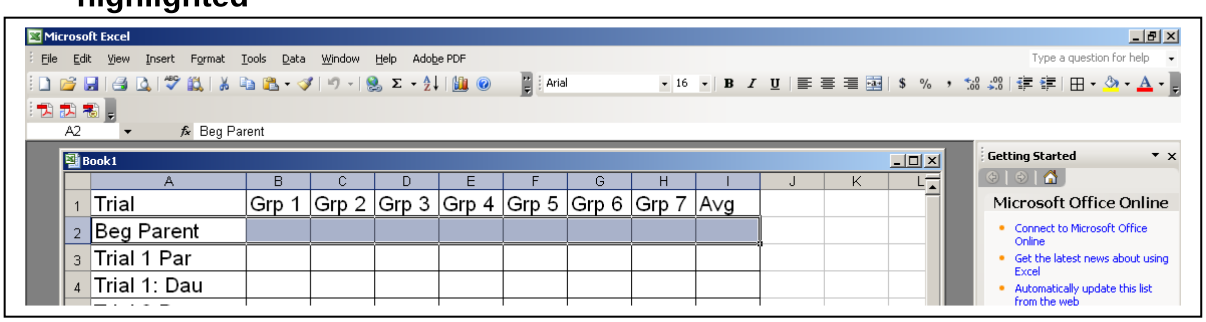
Procedure: Complete the table to communicate each group's data

Trial	Grp 1	Grp 2	Grp 3	Grp 4	Grp 5	Grp 6	Grp 7	Avg
Beg Parent								
Trial 1: Par								
Trial 1: Dau								
Trial 2: Par								
Trial 2: Dau								
Trial 3: Par								
Trial 3:Dau								
Trial 4: Par								
Trial 4:Dau								
Trial 5: Par								
Trial 5: Dau								
Trial 6: Par								
Trial 6:Dau								
Trial 7: Par								
Trial 7:Dau								
Trial 8 Par								
Trial 8:Dau								

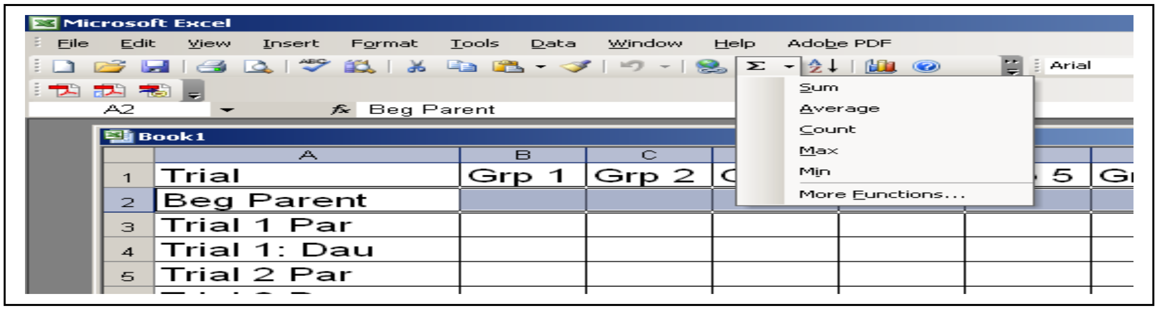
Step 1: Open an excel spreadsheet by choosing the icon shown

Step 2: Crate a spreadsheet the looks exactly like the table above including the data:

Step 3: Scroll across the fist set of data labeled beg Parent, notice that it is now highlighted



Step 4: Find the ∑ symbol located on the toolbar and click on the arrow beside it, scroll down to and click average; this should average the data in your row



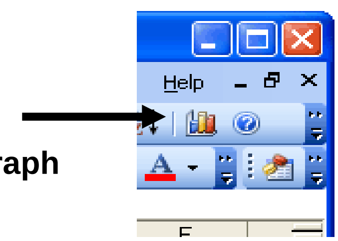
Step 5: Repeat step 4 to average all the data from each trial

Step 6: Create a new spreadsheet as shown below and then insert your data

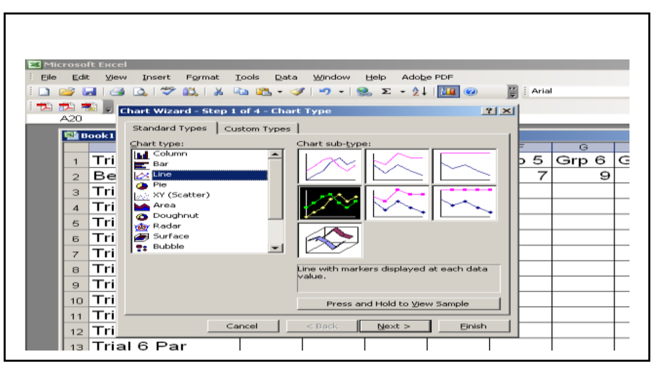
Trial	Avg Par	Avg Dau
beg		
T1		
T2		
T3		
T4		
T5		
T6		
T7		
T8		

Step 7: Highlight the data table by scrolling across all of the rows and columns:

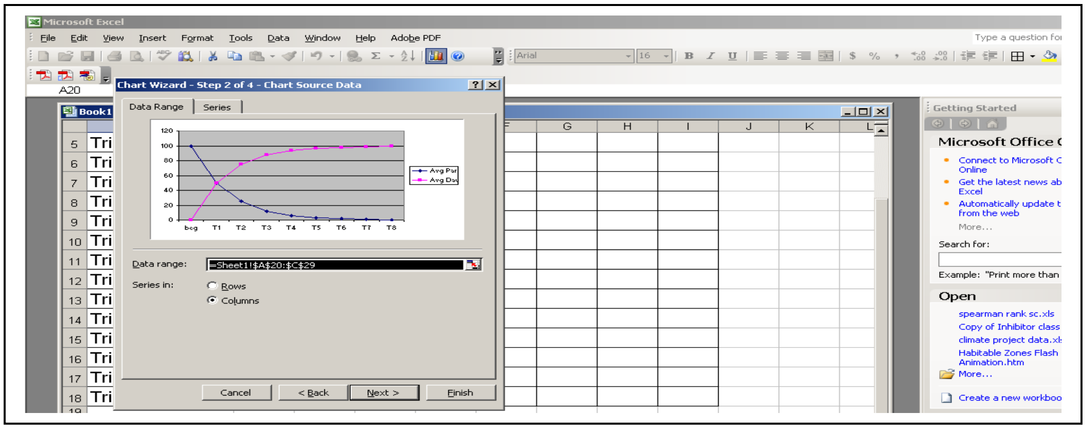
Step 8: Go up to the toolbar and find the graphing icon



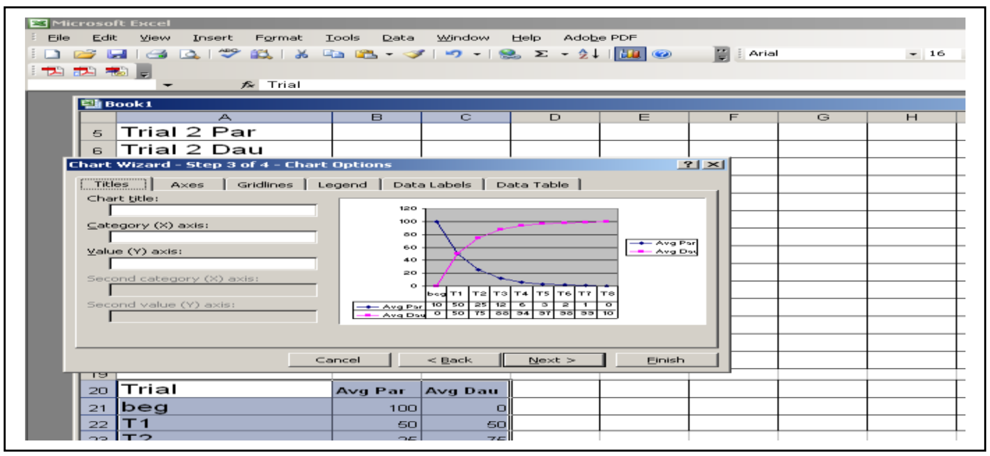
Step 9: Click on the icon and then scroll down to line graph Choose the graph that is highlighted below:



Step 10: Click next. You should see a graph of your data

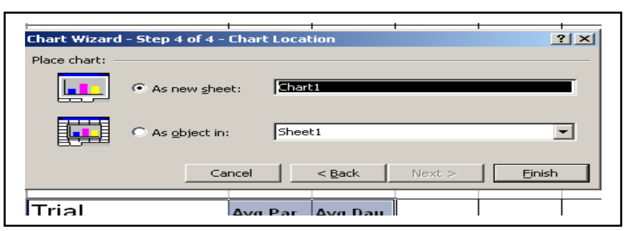


Step 11: Click the next button to title your graph and give it labels

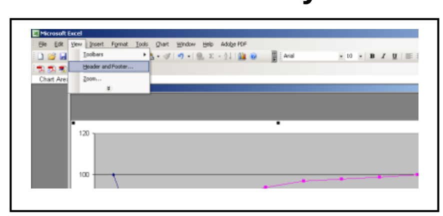


Step 12: Click on the tab labeled “Data Table” and then check show data table

Step 13: Click Next and finish your graph as a new sheet



Step 14: Go to the toolbar and find View: Click on the footer and header and add your name to your graph. Print your graph



Step 14: Write a conclusion statement on the back of the graph that defines the terms radiometric dating and half life, and then explains what happened to the number of parent and daughter atoms over time. BE SURE TO INCLUDE DATA and then explain how radiometric dating can be used to determine the age of a fossil or rock.

Mineral Groups:
Teacher Instructions and Background:

Objective: To provide students with an opportunity to use a formula, collect and analyze data to evaluate how elements join to form a special group of compounds known as minerals

Time Required: class periods

Materials Needed:
Individual packages of M & M's or tube of Mini M& M's per group

Teacher Preparation:
Run off procedure pages and get materials

Useful Websites
http://www.minsocam.org/MSA/K12/groups/groups.html
Mineral Group basics

http://www.dlese.org/library/query.do?q=mineral%20group&s=0
Comprehensive link to mineral group resources

Teacher Background:
The Earth is comprised of many elements. As shown in the table below

Elements in the Earth's Crust: physical geography.net

Element	Chemical Symbol	Atomic Number	Common Atomic Mass Number	Percent in Continental Crust	Required for all Life	Required for Some Lifeforms	Element Type	Moderately Toxic	Extremely Toxic
Aluminum	Al	13	27	8.2300	-	X	**Metalloid**	-	-
Antimony	Sb	51	122	0.00002	-	-	**Metalloid**	-	-
Arsenic	As	33	75	0.00018	-	-	**Metalloid**	-	X
Barium	Ba	56	137	0.0425	-	-	**Metal**	-	-
Beryllium	Be	4	10	0.00028	-	-	**Metal**	-	X
Bismuth	Bi	83	209	0.000017	-	-	**Metal**	-	-
Boron	B	5	11	0.0010	-	-	**Metalloid**	-	-
Bromine	Br	35	80	0.00025	-	-	**Nonmetal**	-	-
Cadmium	Cd	48	112	0.00002	-	-	**Metal**	-	X
Calcium	Ca	20	40	4.1000	X	-	**Metal**	-	-
Carbon	C	6	12	0.0200	X	-	**Nonmetal**	-	-
Chlorine	Cl	17	35.5	0.0130	-	X	**Nonmetal**	X	-
Chromium	Cr	24	52	0.0100	-	-	**Metal**	X	-

Cobalt	Co	27	59	0.0025	-	X	**Metal**	-	-
Copper	Cu	29	63.5	0.0055	X	-	**Metal**	X	-
Fluorine	F	9	19	0.0625	-	X	**Nonmetal**	X	-
Gallium	Ga	31	70	0.0015	-	-	**Metal**	-	-
Germanium	Ge	32	73	0.00015	-	-	**Metalloid**	-	-
Gold	Au	79	197	0.0000004	-	-	**Metal**	-	-
Hydrogen	H	1	1	1.4000	X	-	**Nonmetal**	-	-
Iodine	I	53	127	0.00005	-	X	**Nonmetal**	-	-
Iron	Fe	26	56	5.6000	X	-	**Metal**	-	-
Lead	Pb	82	207	0.00125	-	-	**Metal**	-	X
Lithium	Li	3	6	0.0020	-	-	**Metal**	-	-
Magnesium	Mg	12	24	2.3000	X	-	**Metal**	-	-
Manganese	Mn	25	55	0.0950	X	-	**Metal**	-	-
Mercury	Hg	80	201	0.000008	-	-	**Metal**	-	X
Molybdenum	Mo	42	96	0.00015	X	-	**Metal**	-	-
Nickel	Ni	28	59	0.0075	-	-	**Metal**	-	X
Nitrogen	N	7	14	0.0020	X	-	**Nonmetal**	-	-
Oxygen	O	8	16	46.4000	X	-	**Nonmetal**	-	-
Palladium	Pd	46	106	0.000001	-	-	**Metal**	X	-
Phosphorus	P	15	31	0.1050	X	-	**Nonmetal**	-	-
Platinum	Pt	78	195	0.0000005	-	-	**Metal**	-	-
Potassium	K	19	39	2.1000	X	-	**Metal**	-	-
Rubidium	Rb	37	85.5	0.0090	-	-	**Metal**	-	-
Selenium	Se	34	79	0.000005	-	X	**Nonmetal**	X	-
Silicon	Si	14	28	28.2000	-	-	**Metalloid**	-	-
Silver	Ag	47	108	0.000007	-	-	**Metal**	-	X
Sodium	Na	11	23	2.4000	-	X	**Metal**	-	-
Sulfur	S	16	32	0.0260	X	-	**Nonmetal**	-	-
Thorium	Th	90	232	0.00096	-	-	-	-	-
Tin	Sn	50	119	0.00020	-	-	**Metal**	X	-
Titanium	Ti	22	48	0.5700	-	-	**Metal**	-	-
Tungsten	W	74	184	0.00015	-	-	**Metal**	-	-
Uranium	U	92	238	0.00027	-	-	-	-	-
Vanadium	V	23	51	0.0135	-	X	**Metal**	X	-
Zinc	Zn	30	65	0.0070	X	-	**Metal**	-	-

Metals are elements that usually conduct heat and electricity and are shiny. ***Nonmetals*** do not conduct electricity that well and are normally not shiny. ***Metalloids*** have characteristics that are in between metals and nonmetals.

Unlike rocks, minerals are pure substances that can be identified based on their characteristic properties. Minerals are made of networks of bonded ions to form crystals. Minerals are classified according to chemical composition. There are seven major chemical groups as shown in the table below:

Mineral Group	Major Minerals	Chemical Formula
Carbonates	Calcite Dolomite	$CaCO_3$ $Ca\ Mg\ (CO_3)_2$
Silicates	Quartz Potassium Feldspar Biotite Pyroxene Amphibole Olivine	SiO_2 $KalSi_3O_8$ $K(MgFe)_3AlSi_3O_{10}\ (OH_2)$ $(Mg,\ Fe)_2Si_2O_6$ Variable $(Mg,\ Fe)_2\ SiO_4$
Sulfides	Galena Pyrite Sphalerite	PbS FeS_2 ZnS
Oxides	Hematite Magnetite Corundum	Fe_2O_3 Fe_3O_4 Al_2O_3
Sulfates	Gypsum Anhydrite	$CaSO_4 \cdot H_2O$ $CaSO_4$
Halides	Halite Fluorite	NaCl CaF_2
Native Elements	Silver Gold Graphite/Diamond	Ag Au C

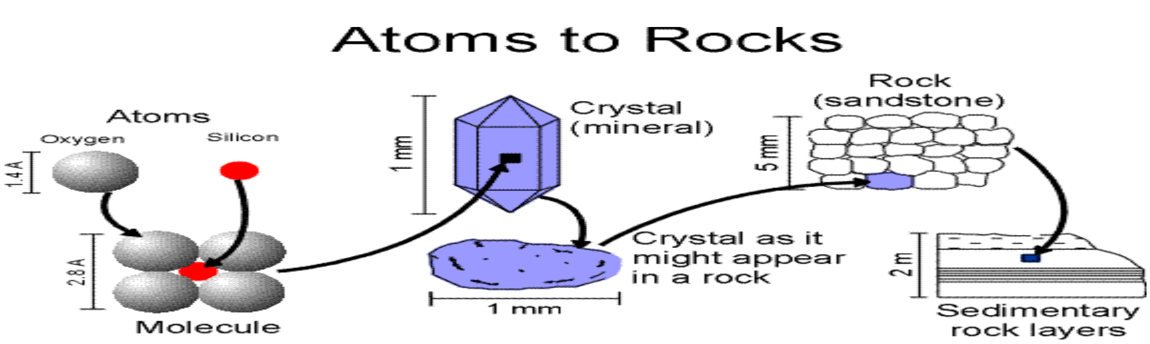
A mineral's properties depend on THE INTERNAL ARRANGEMENT OF ATOMS!!!

Unlike Rocks which are mixtures of minerals, a mineral is a compound that must meet all five of the criterion listed:

1. Inorganic
2. Found in nature (not man-made)
3. Solid
4. Have a definite crystalline structure

1. Have a definite composition (elements)

Minerals can be classified as either renewable or non-renewable natural resources depending on their availability.



Since most minerals exist in rocks, it is important to discern between the two

Minerals	Rocks
Made up of one or more **Elements**	Made up of one or more **Minerals**
Exist as a **Compound** or an **Element**	Exist as a **Mixture**
Must be **inorganic**	May be either **organic or inorganic**
Form with a definite crystal structure	**Contain** mineral crystals
Formed by **nature**	Formed by **nature**
May be a useful resource	May be or contain a useful resource
Formed from cooling magma or precipitation	Formed from cooling magma, heat and pressure, or cementation
Formed through **Physical changes**	Formed through **physical/ and or/ chemical** changes
Classified based on the **elements they contain**	Classified based on **how they form**
May contain one ore more **elements**	May contain one or more **minerals**
Exist as a **Solid**	Exist as a **Solid**
Exist in the Earth's crust	**Makeup** the Earth's crust
Can be identified through **physical** properties	Can be identified through **physical** properties
Has a definite chemical makeup	**Does not have** a definite chemical makeup

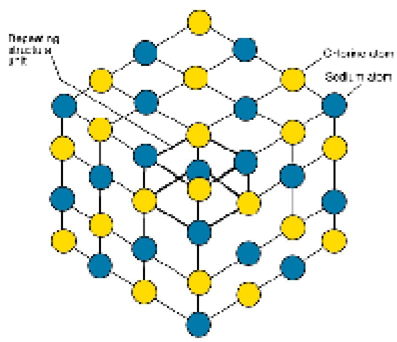
http://incompetech.com/graphpaper/polar/

You can generate a pie graph with gradients using the free website shown above. Use the same defaults, but choose 0 for the # of concentric, 0 for primary spokes and 36 for secondary spokes so that the graph will be divided into 10° sections for easier use

Mineral Groups

Student Background and Procedure Page

Background Information: Minerals are the constituents of rocks, and hence of the Earth (at least the crust and mantle). Minerals consist of molecules and atoms arranged in an orderly manner and are therefore classified as *crystalline* solids. There are hundreds, if not thousands, of different minerals. There are dozens of groups of minerals, each with its own type of structure. Every mineral is made of atoms, just like every other material. Minerals are naturally occurring homogeneous inorganic solids that have a definite chemical composition and have an orderly internal structure called a crystal lattice illustrated below:



Mineral have several characteristics:

- **They are naturally occurring, not artificial.**
- **They are homogeneous, that is, they all have the same chemical composition**
- **They naturally exist as solids**
- **They are inorganic:**
- **Minerals have a defined chemical composition**
- **Minerals exist in an ordered structure called a crystal lattice**

Minerals form either as a single element or a compound of several elements chemically bonded together by nature forming a solid whose atoms or molecules always form the same structure. Minerals like gold, silver, and zinc only contain one element in their chemical makeup. However, most minerals exist as a compound of several elements whose chemical makeup is shown using a chemical formula. Examples of some common minerals and their chemical composition are shown in the table below:

Mineral Name	Chemical Makeup	Uses
Quartz	SiO_2	Used in manufacturing glass, paints, abrasives, and pressure instruments
Feldspar	$AlSi_3O_8$	Flux for glass and ceramic manufacture, abrasives, and fillers in paint and plastics
Calcite	$CaCO_3$	construction materials, abrasives, agricultural soil treatments, construction aggregates, pigments, pharmaceuticals and more.
Hematite	Fe_2O_3	Iron ore and pigments in paint
Corundum	Al_2O_3	corundum highly desirable as a refractory (a substance capable of withstanding very high temperatures) and as an abrasive (a material used for cutting, grinding, and polishing other materials). One of the more common uses of corundum is in the preparation of toothpastes. Its abrasive properties help to keep teeth clean and white.
Halite	NaCl	Salt, used in human and animal diets for seasoning and preservation, soap manufacturing, home water softeners, and ice melt
Fluorite	CaF_2	Flux for steel and aluminum, glass, and enamels
Galena	PbS	Batteries, antiknock additive for gasoline, sound barriers, radiation shields, and ammunition
Sphalerite	ZnS	Galvanizing paints, automobile parts, pennies, processing rubber
Gypsum	$CaSO_4$	Sheetrock, plaster, and soil conditioning

Barite	$BaSO_4$	Drilling mud, fillers, and is also used as an aggregate to make a stronger type of cement. Barite can be ground and used as a filler or extender in industrial products. Such as paper, cosmetics, paint, linoleum or a weighting agent in petroleum. Barite is also used to line the intestines when conducting X-rays and is commonly used to enhance brilliance in glass products.

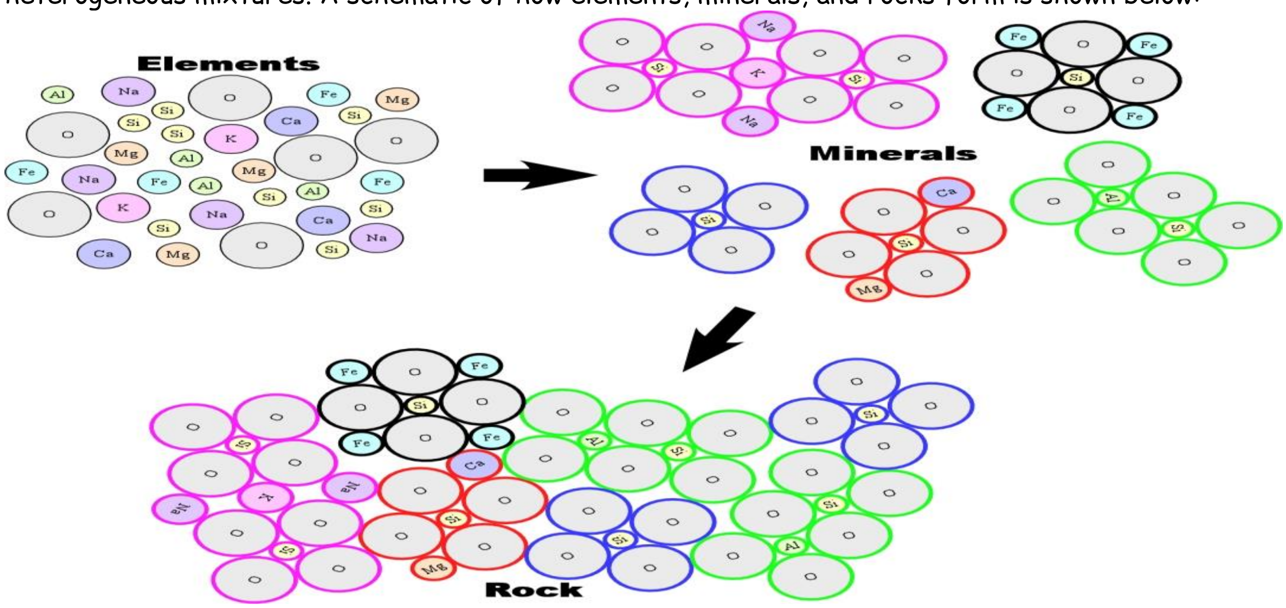
Evaluating the minerals in the table reveals that there are similarities in the chemical composition of most minerals. Example: both quartz and feldspar contain the elements silicon and oxygen in their chemical compositions. Most of the other 2,998 minerals also have similarities in their chemical composition enabling geologists to group or classify them together into one of six major mineral groups based on the non-metal elements that they contain as shown in the table on the next page:

Major Mineral Groups

Mineral Group's Name	**Chemical Composition**
• Silicates	Silicon (Si) + Oxygen (O) + one or more metals
• Carbonates	1 molecule of CO_3 + one or more metals
• Oxides	Oxygen (O) + one or more metals
• Sulfates	1 molecule of SO_4 + one or more metals
• Sulfides	Sulfur (S) + one or more metals
• Halides	Chlorine (CL) or Fluorine (F) + a metal

- **When writing a chemical formula the metal is shown first: Example: Magnesite, a carbonate, has 1 atom of Magnesium chemically bonded with one molecule of CO_3 whose chemical formula is $MgCO_3$**

Most mineral are found as a part of a rock. In simple terms minerals are the building blocks of rocks. A rock is a solid made up of minerals and other rock pieces. Because a rock does not have a homogenous makeup (always the same elements and crystal structure) they are classified as heterogeneous mixtures. A schematic of how elements, minerals, and rocks form is shown below:



Classifying minerals into smaller groups makes studying them easier. In today's investigation we will use colored candies to model the 6 different mineral groups in an effort to discover which one is the most abundant in our sample.

Research Question: Which mineral group makes up most of the Earth's crust?

Materials: 1 package of M & M's, 6-sorting cups, a calculator, and student investigation page.

Procedure:

1. Open your bag of M & M's and sort based on the property of color.
2. Count and record the number of each color in the data table under the label Number of Color in Sample.
3. Count the total # of M & M's in your bag and record this number in the table under the label Total Number in Sample
4. Calculate the percent of each color in your sample using the formula:
   Number of Color in Sample/ Total number in Sample x 100
5. Record the calculation made in step 4 in the data table under the label
   % of Color in Sample.
6. Identify and record the symbols of the elements that makeup each mineral group using the table titled "Major Mineral Groups"
7. Use the table that shows some common minerals to identify at least one mineral that belongs to each group.
8. Communicate your data in a graph as directed.
9. Enjoy your candies as you use your findings and the background information to answer the conclusion questions.

Name: ______________________________ Date: ______________ Hour: ___

Mineral Groups: Student Investigation

Color of M & M/ Mineral Group	Number of Color in Sample	Total Number in Sample	% of Color in Sample	Example of Mineral in Group from Table on the Front of the Background Sheet **(Name and chemical formula)**	Elements in 1 molecule of Mineral from table on the back of the background sheet	Uses
Brown/ Silicates						
Red/ Carbonates						
Orange/ Oxides						
Green/ Sulfates						
Yellow/ Sulfides						
Blue/ Halides						

Class Average: Find the average by adding each group's data and dividing by the number of groups

Group	Silicates	Carbonates	Oxides	Sulfides	Sulfates	Halides
1						
2						
3						
4						
5						
6						
7						
8						
Total						
# of groups						
Avg %						
X 360						
° needed						

Based on your class average, which mineral group is most common? ________________

Which mineral group is least common? ____

From the Background Information:

1. What is a mineral?

2. What characteristics does a mineral possess?

3. What are the two types of matter that a mineral can exist as? ___________________

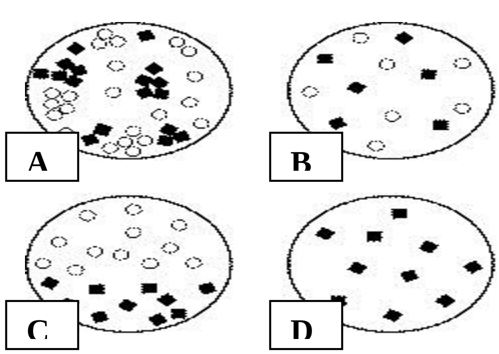
   ______________________How do most minerals exist? ____________________

4. Minerals are put into one of six major mineral groups based on____________________

5. Silicon and Oxygen makeup 95% of the Earth's crust. Based on this, which mineral group

   do you think makes up most of the Earth's crust? ______________________________

7. Explain the relationship between elements, minerals, and rocks:



8. Which of the illustrations to the left is a mineral? SUPPORT YOUR ANSWER:

9. Which of the illustrations to the left is a rock? SUPPORT YOUR ANSWER:

Forming Minerals
Teacher Information and Background

Objective: To provide students with an opportunity to follow a written procedure, use the scientific method, collect and analyze data to evaluate how minerals form and connect this process to making a solution, reading a solubility curve, and understanding how physical changes occur in nature

Time Required: 2 class periods

Materials Needed:

Materials: Graduated cylinder, balance, hot-water bath, 3 Erlenmeyer flasks, thermometer, sodium chloride, ice, tree forms, scissors, stirring rods, string, paperclips, and craft sticks

Teacher Preparation:

Run off procedure pages and get materials. If hot water bath is not available, bowls of hot water may be used

Useful Websites

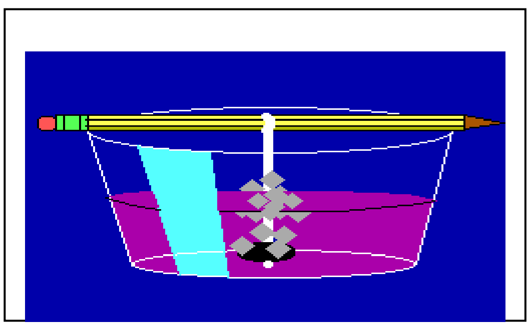
http://www.visionlearning.com/library/module_viewer.php?mid=119
Great background on minerals

http://www.dlese.org/library/query.do?q=how%20minerals%20form&s=0
Comprehensive link to forming minerals background and activities

http://earthsci.org/education/teacher/basicgeol/resource/resource.html
In-depth background on minerals

www.mariemontschools.org/juran/Power%20Point%207th/HO
PowerPoint on how minerals form

Teacher Background:



This lab may be done using the trees copied onto blotting paper available at an art store or using cotton stranded string or yarn. The porous blotting paper or string allows for capillary action and evaporation. The solution rises through the blotting paper and the solvent slowly evaporates leaving behind the mineral crystals. The bluing solution contains 2 forms of Prussian blue. The soluble $KFe^{III}Fe^{II}(CN)_6$ is actually a stable colloidal suspension, while the insoluble $Fe^{III}_4\{Fe^{II}(CN)_6]_3$ settles out of the solution upon standing. When combined with the ammonia solution: NH_3 and the saturated solution of Sodium Chloride (NaCL), the fluffy white crystals that form are believed to be ammonium chloride (NH_4Cl) and two forms of ferrous ferrocyanide, $KNa\,Fe^{III}Fe^{II}(CN)_6$ and $Na_4\,Fe^{III}_4\{Fe^{II}(CN)_6]_3$. produced from the reduction of the Prussian blue by ammonia in solution: Equations break down as follows:

Eqation 1: $\mathbf{KFe^{III}Fe^{II}(CN)_6 + e^- + Na \longrightarrow KNa\,Fe^{III}Fe^{II}(CN)_6}$

Equation 2: $\mathbf{Fe^{III}_4\{Fe^{II}(CN)_6]_3 + 4e^- + 4\,Na \longrightarrow Na_4\,Fe^{III}_4\{Fe^{II}(CN)_6]_3}$

Equation 3: $\mathbf{2NH_3 + 6OH^- \longrightarrow N_2 + 6H_2O + 6e^-}$

Food coloring may also be added to either the string or the tips of the tree branches.

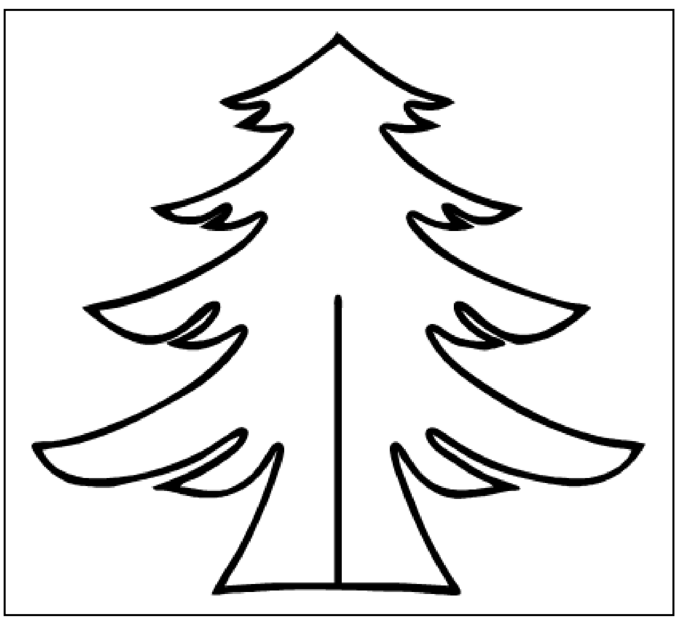
How do Minerals Form? http://www.museums.udel.edu/mineral/mineral_site/education/formation.html

Minerals form from solutions, melts and vapors. When as substances is in liquid or gaseous form the atoms are randomly arranged with no internal structure. What is happening internally when the substance changes phase from liquid or gas to solid is the atoms are becoming more and more organized and structured. This phase change can be precipitated by changes in the surrounding environment.

The easiest way to form a crystal is by evaporation of water. There is a limit to the number of atoms that can be contained by a volume of water. As the volume decreases, the atoms are forced closer and closer together finally bonding together to form solid crystals when enough of the water has been removed. The size of the resultant crystal is dependent on the rate of evaporation over time. Slow evaporation yields few large crystals while quick evaporation yields many smaller crystals.

Crystals can also form if the solution or vapor is cooled or subjected to a decrease in pressure. In general, hot solutions are able to accommodate more atoms per unit of solution. As the solution cools, the atoms have less and less room to move and when the solution has cooled sufficiently, the atoms link together precipitating the mineral. This is the same for changes in pressure. High pressures allow more atoms per unit volume. If the pressure is lowered, the atoms bond together forming the solid mineral.

Tree Cut Out patterns



How Minerals Form Background and Procedure:

RQ: What are the processes by which minerals form

The minerals that people use today have been forming deep in Earth's crust or on the surface for since the Earth began. In general, minerals can form in two ways: through crystallization of melted materials and through crystallization of materials dissolved in water. Crystallization is the process by which atoms are arranged to form a material with a crystal shape.

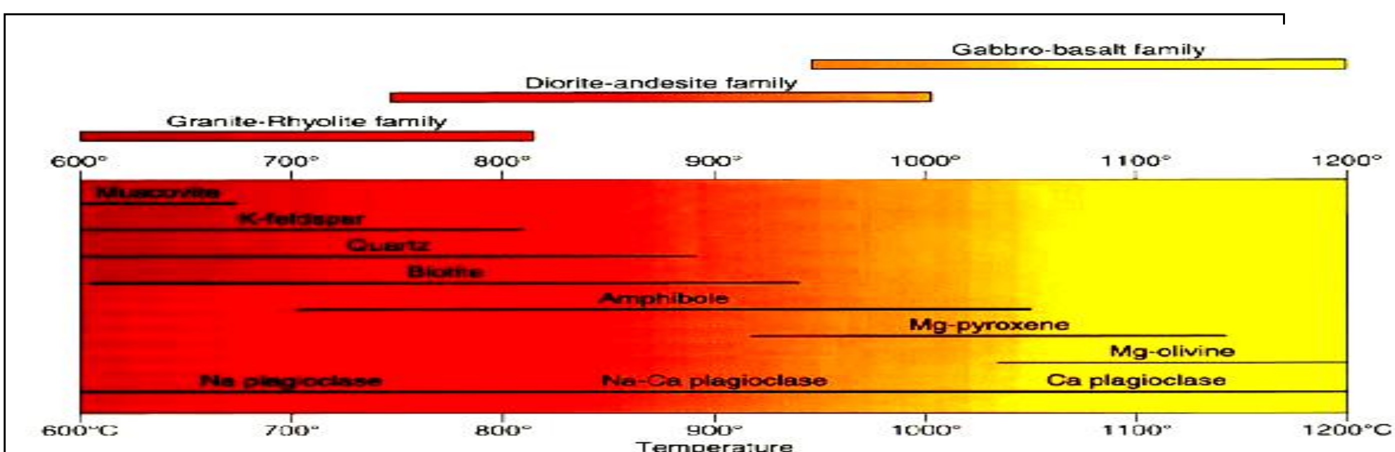
Minerals can form as hot magma cools deep inside the crust, or as lava hardens on the surface. When these liquids cool to the solid state, they form mineral crystals. The size of these crystals depends on several factors. The rate at which magma cools, the amount of gas magma contains, and the chemical composition of magma all affects crystal size. Slow cooling leads to the formation of minerals with large crystals. If the crystals remain undisturbed while cooling deep below the surface, they grow according to a regular pattern. Magma closer to the surface loses heat energy much faster than magma that hardens deep below ground. With rapid cooling, there is no time for magma to form large crystals. If magma erupts to the surface, the lava will also cool quickly and form minerals with small crystals.

Sometimes, the elements that form a mineral dissolve in hot water. These dissolved minerals form solutions. A **solution** is a mixture in which one substance dissolves in another during a physical change. When a hot water solution begins to cool, the elements and compounds leave the solution and crystallize as minerals. Pure metals that crystallize underground from hot water solutions often form veins. A vein is a narrow channel or slab of a mineral that is sharply different from the surrounding rock. Deep underground, solutions of hot water and metals often follow fractures, or cracks, within the rock. Then the metals crystallize into veins. Many minerals form from solutions at places where tectonic plates spread apart along the mid-ocean ridge. The hot magma heats ocean water that seeps underground. The heated water dissolves minerals. When the solution billows out of vents called "chimneys," minerals crystallize in the cold sea.

Minerals can also form when solutions evaporate. For example, thick deposits of the mineral halite, or table salt, formed over millions of years when ancient seas slowly evaporated. In addition to halite, other useful minerals form by the evaporation of seawater, including gypsum, calcite crystals, and minerals containing potassium.

Earth's crust is made up mostly of the common rock-forming minerals combined in various types of rock. Less common and rare minerals, however, are not distributed evenly throughout the crust. Instead, there are several processes that concentrate minerals in deposits. Many valuable minerals are found in or near areas of volcanic activity and mountain building.

The graph below shows the relationship between temperature and some common rock-forming minerals.



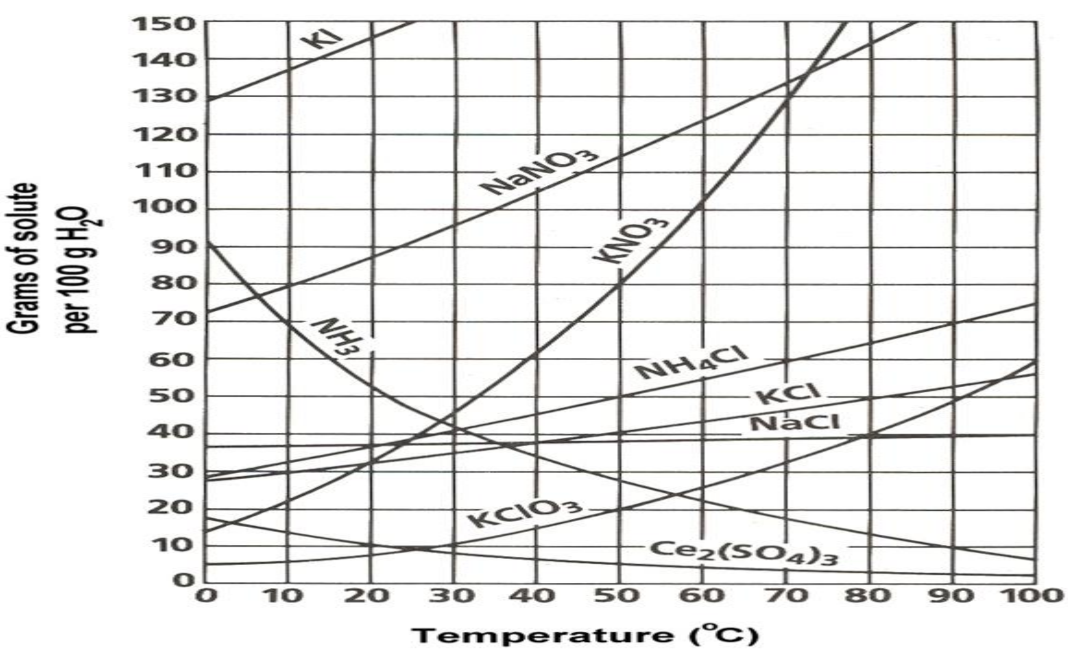
ORDER OF CRYSTALLISATION OF COMMON ROCK-FORMING MINERALS

Materials: Graduated cylinder, balance, hot-water bath, 3 Erlenmeyer flasks, thermometer, sodium chloride, ice, tree forms, scissors, and stirring rods, string, solo cups, paper clips, and craft sticks

Lab Procedure:

1. Cut the tree silhouettes out and then slide them together to form a tree
2. Find the mass of the tree and record it in the table
3. Measure out 100 ml of distilled water and pour it into the first Erlenmeyer flask.
4. Place the flask in the hot water bath to increase its temperature to 80 degrees
5. Measure out 100 ml of distilled water and pour it into the 2nd flask
6. Mass out 50 grams of sodium chloride using the first cup
7. Find the temperature of the water in the flask and then add a couple of cubes of ice to decrease the temperature to 10 degrees Celsius
8. Add a small amount of sodium chloride using the stirring rod to help it dissolve
9. Continue adding until it no longer dissolves.
10. Find the mass of the remaining sodium chloride and record it in your table
11. Add 10 ml of the bluing solution the flask and swirl to mix
12. Add 5 drops of the household ammonia to the flask and swirl to mix
13. Pour 30 ml of the solution into the first plastic boat
14. Label the first plastic dish with the temperature and then place the tree into the solution. Set this in a place where it will not be disturbed
15. Repeat steps 4-13 for room temperature water (22 degrees Celsius)
16. Check your water in the hot water bath and remove when it reaches a temperature of 80 degrees. Repeat steps 4-13 for this temperature

Solubility Curve



Name: ______________________________ date: ______________________ Class: __________

Forming Minerals UNRAVELS

U: Uncover the research question: ____

____

N: Name the independent and dependent variables and formulate a hypothesis:

IV: ____________________________________DV: ________________________________

Hypothesis: ____

____

R: Research section: Write a paragraph that includes the following information: Be sure to include an introduction sentence and a conclusion sentence

- Definition of a mineral
- Explanation of the two ways that minerals form, where it occurs, and what type of change it is
- Definition of a solution, what type of matter it is, and how it relates to minerals
- Connection between atoms, minerals, and rocks

A: Analyze the experiment to identity the constants

V: Verify the experiment by summarizing the procedure

L: Link the data in a data table:

Temperature of water	Beginning Mass of salt (NaCl)	Mass of salt left in cup	Mass of salt in solution	Rank: 1-3 wherein 1 is most crystals and 3 is least	Observations

S: Summarize the results by writing a conclusion statement that communicates the following using a complete paragraph: ***Begin by restating your hypothesis:***

- Identify and quantify the relationship between the temperature of the water and the amount of salt that was dissolved in our experiment
- Use the solubility curve to identify and quantify the amount of salt (NaCl) that should have dissolved at each temperature
- Identify and quantify the temperature of water that created the most crystals
- Identify and quantify the temperature of water that created the least crystals
- Infer why the experiment came out as it did

E: Extend: Use the information in the graph on the background page to compete the table and then answer the questions that follow:

Rock-Forming Mineral	Lowest temp for formation	Highest temp for formation
K-Feldspar		
Quartz		
Amphibloe		
Mg- Pyroxene		

1. Which rock-forming mineral would you expect to find at the greatest depth? **SUPPORT YOUR ANSWER**

2. Which family of rock would you expect to find closest to the surface? **SUPPORT YOUR ANSWER**

Mineral Ice?
Teacher Information and Background

Objective: To provide students with an opportunity to evaluate whether or not ice is a mineral and to model how mineral ice forms on the surface of our planet.

Time Required:
A class period

Materials Needed:
Crushed ice (Sonic ice), 400-600 ml beaker or battery jar, salt, water, thermometer, stirring rods, a large test tube, and distilled water

Useful websites:

http://webmineral.com/data/Ice.shtml
Mineral database for ice

http://www.its.caltech.edu/~atomic/snowcrystals/photos/photos.htm
Beautiful graphics of snowflake crystals

http://video.aol.com/video-detail/glaciers/1845415438
Video clip on glacier formation

http://video.aol.com/video-detail/fried-ice/307933820
Phase change for water

Teacher Background:

Lab: Minerals can form in one of two ways, the previous lab focused on precipitating minerals from a mineral forming solution. This lab focuses on crystallizing mineral by changing the temperature of a solution; in this case, students will use a super cooled solution to crystallize ice. Ice is now always classified as a mineral because by definition a mineral must occur naturally. This means that the ice you make in the freezer is not a mineral, but the ice that exists in the cryosphere meets the qualifications. This lab provides an excellent opportunity to discuss the diminishing crysophere and its consequences due to climate change. It also links to kinetic motion and energy exchange during a phase change.

The legal definition of "mineral," according to *Black's Law Dictionary* (1968, p. 1146) is **"any valuable inert or lifeless substance formed or deposited in its present position through natural agencies alone, and which is found either in or upon the soil of the earth or in the rocks beneath the soil."**

The federal government defines minerals in its section on national mining and minerals policy (U.S. Code: Title 30, Section 21a) as including **all minerals and mineral fuels including some non-solid substances such as petroleum and natural gas.** This definition is problematic, in that it uses the word "minerals" in the definition of the word "mineral." It also includes petroleum and natural gas, which are not considered minerals if the earth science definition is used. As in the legal definition, water could be considered a mineral in some areas, depending on the statute and legal issue being considered.

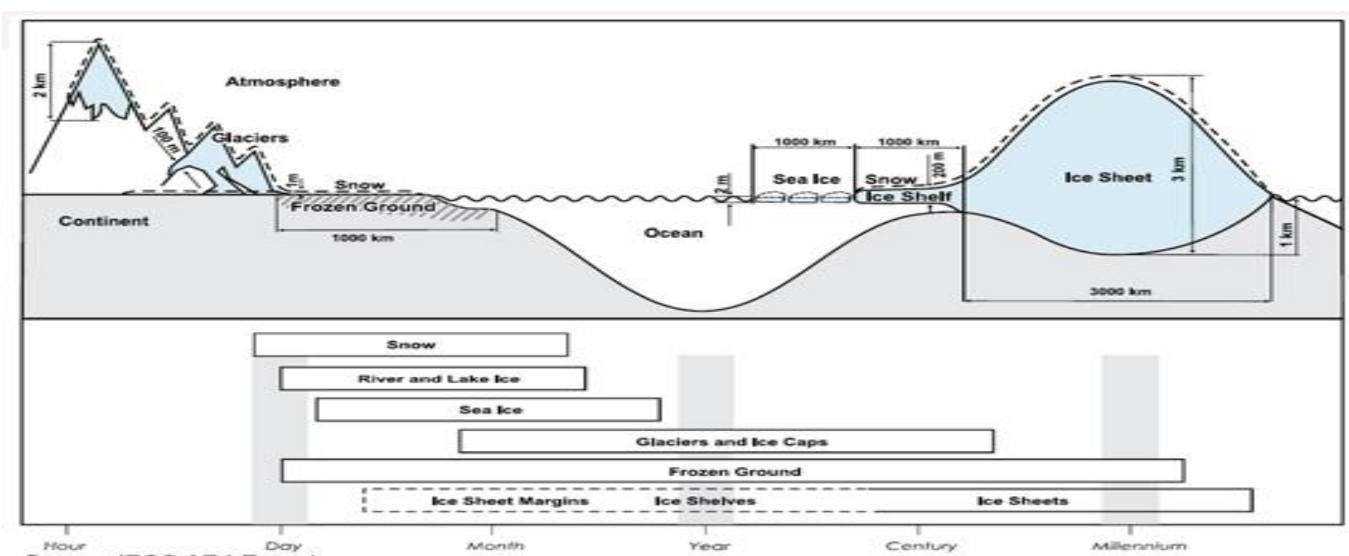
Water resources could become more and more valuable as a result of climate change, meaning that legally water could someday be classified as a mineral, but for now, we are going to focus on ice.

Introductionhttp://www.emporia.edu/earthsci/amber/go336/merhoff/index.htm

Ice is a mineral that affects us everyday. Yet many of us do not know that ice is actually a mineral. This frozen state of water actually has crystals and all the physical properties of a mineral. Ice has several important attributes and uses that helps make the living earth what it is today. The different types of ice such as glaciers, ice caps, and snowflakes have a definite affect on the climate of all the geographic regions around the world. Naturally, the more natural ice there is in a given region, the colder it will be.

Physical Properties of Ice

Chemical Composition	H_2O; 11.19% hydrogen, 88.81% oxygen; molecular weight=18.02 g
Cleavage	none
Crystal System	hexagonal; 6/m2/m2/m
Color	colorless, white, can be gray or brown
Density	0.99
Fracture	conchoidal
Habits	massive-granular, crystalline-course, dendritic
Hardness	1 1/2
Luster	vitreous
Melting Point	32 degrees F (0 degrees C)
Specific Gravity	0.9
Streak	none
Tenacity	brittle
Transparency	transparent to translucent



COMPONENTS OF THE CRYOSPHERE AND THEIR TIME SCALES

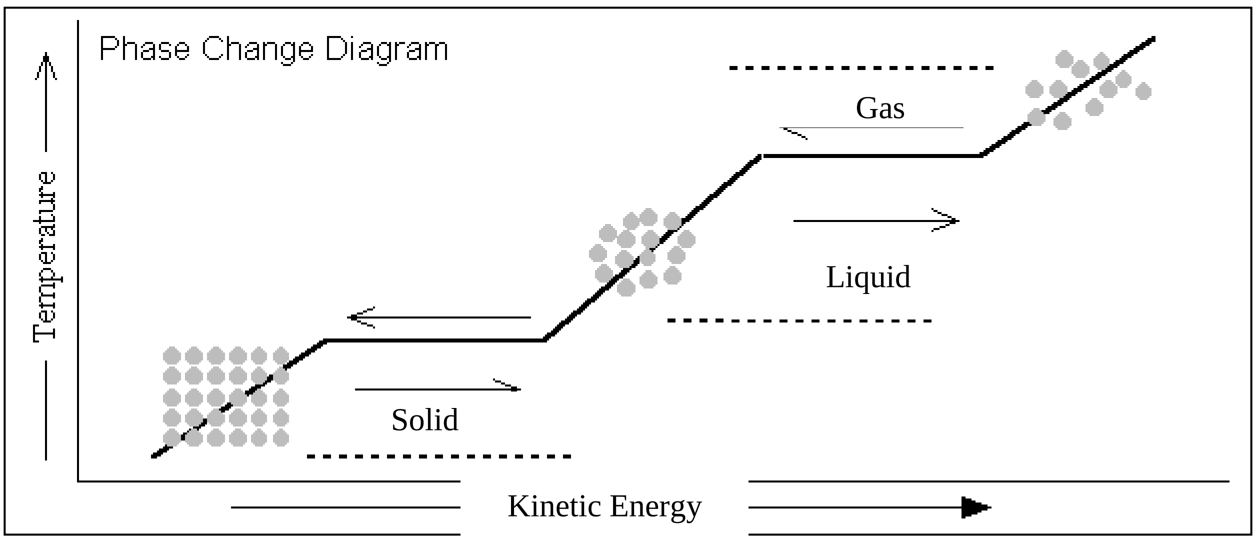
http://www.grid.unep.ch/glaciers/graphics.php

Name: _______________________________ Date: _____________ Class: ________

Mineral Ice?

Research Question: How can we crystallize ice to evaluate its classification as a mineral?

Background: To get started let's review. You have to remember that what one person calls a mineral isn't what someone else calls a mineral. The true definition of minerals is a naturally occurring, homogeneous inorganic solid substance having a definite chemical composition and characteristic crystalline structure, color, and hardness. Because minerals cannot be organic, coal and petroleum are not minerals from a geologist's point of view. However, lawmakers needed a place to put them into the law books so they were called minerals to simplify the rules and regulations. Legally, a mineral is **"**any valuable inert or lifeless substance formed or deposited in its present position through natural agencies alone, and which is found either in or upon the soil of the earth or in the rocks beneath the soil." From either standpoint, mineral formations almost always involve a change of states from a liquid to a solid. This phase change requires a change in energy as shown in the diagram below:



The atoms and molecules of minerals forming from cooling magma deep within the Earth slow down to form the beautiful crystalline solids that make up quartz. If pushed deeper into the Earth, they speed up and change back into magma. In this way, temperature plays a key role in how we classify the minerals in magma. In today's investigation we will be forming a mineral by changing its temperature and supplying a seed crystal on which it can grow to evaluate whether or not it can be classified as a true mineral.

Materials:
400-600 ml beaker or battery jar, crushed ice, large clean test tube, distilled water, salt, stirring rod, thermometer, and time

Procedure:

1. Fill the beaker ¼-full with cold water. Fill the remainder with ice.
2. Pour in enough salt so that even after stirring, you can still see salt on the bottom of the beaker
3. Wash the test tube, making sure that no dust or dirt remains inside it. Fill the test tube with distilled water so that the level of the water inside the test is level with the level of water in the beaker.
4. Gently place the thermometer in the beaker and then put the test tube in the beaker as shown in Figure 1.

5. Allow these to sit for 10 minutes or until the temperature is well below 0°C, stirring the inside of the beaker occasionally with a stirring rod. Stir gently to avoid breaking the thermometer.
6. At the end of 10 minutes, remove the thermometer and record the temperature in the data table.
7. Remove the test tube and immediately drop a small piece of crushed ice into it. Record your observations in the data table.
8. Empty the test tube and repeat
9. Clean your area as directed
10. Use your experiences and the background information to answer the conclusion questions

Name: ______________________________________ **Date:** _________________ **Class:** __________

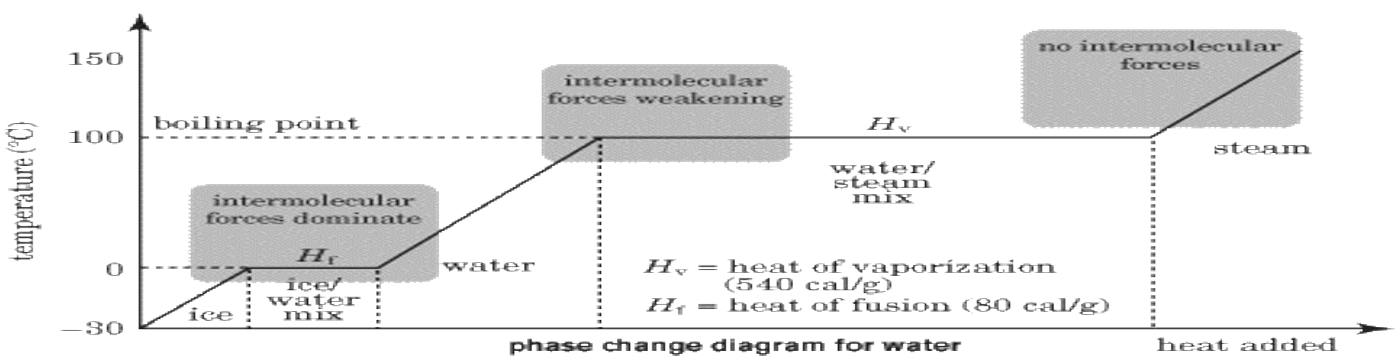
Mineral Ice: Data and Conclusions

- **My data Table: Construct a data table as outlined in the procedure: Do not forget to include observations:**

Conclusions:

1. **Infer**: what was the purpose of the salt?

2. **Analyze**: What happened to the kinetic energy of the water in the test tube? SUPPORT YOUR ANSWER.



3. **Analyze**: Does it require more or less energy for the water to change to ice? SUPPORT YOUR ANSWER WITH DATA FROM THE DIAGRAM.

4. **Analyze:** Would the phase change diagram for salt look like the one shown? WHY OR WHY NOT?

5. **Evaluate**: Would the ice you formed today be classified as a mineral? WHY OR WHY NOT?

Weather Me Down
Teacher Instructions and Background:

Objective: To provide students with an opportunity analyze and evaluate the effect of acid rain on building materials in order to relate chemical changes, chemical composition, and atomic structures to a real-world event

Time Required: 2 class periods

Materials Needed:
Procedure page, rock samples, vinegar, balance, squat 100 ml graduated cylinder, water, pH meter or pH paper, Clear solo cups,

Teacher Preparation:
Run off procedure pages and collect materials. Rock samples can be obtained from the

Useful Websites

http://www.gly.uga.edu/railsback/FundamentalsIndex.html
Fundamentals of geochemistry with great diagrams

http://www.physicalgeography.net/fundamentals/10r.html
Basics on weathering

Teacher Background:

The carbonates are an important mineral group. The carbonate rocks make up 10 to 15% of sedimentary rocks. They largely consist of two types of rocks.

1. Limestones which are composed mostly of calcite ($CaCO_3$) or high Mg calcite [$(Ca,Mg)CO_3$], and
2. Dolostones which are composed mostly of dolomite [$CaMg(CO_3)_2$]

Limestones and Dolomites are the constituents of cement and concrete. Because they are generally soluble in slightly acidic waters they provide an opportunity to connect real-world problems with chemical reactions as discussed in the article "*Chemical Weathering in Washington D.C.*" Although the vinegar used in this lab is a stronger acid (pH of 2.4 as opposed to 5.6) than the carbonic acid that occurs in nature it does provide an opportunity to explore this important environmental issue. Soda Water contains carbonic acid but quickly breaks down into water and carbon dioxide when opened. This lab focuses on the process of chemical weathering through the dissolution of Calcium Carbonate (found in the marble, cement, and limestone) when exposed to acetic acid. The chemical equation for this lab is:

$$2\ CH_3COOH + CaCO_3 \rightarrow (CH_3COO)_2Ca + CO_2 + H_2O$$

This is a neutralization reaction as used by many antacids

Calcium carbonate shares the typical properties of other carbonates. Notably:

- it reacts with strong acids, releasing carbon dioxide:

  $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$
- it releases carbon dioxide on heating (to above 840 °C in the case of $CaCO_3$), to form calcium oxide, commonly called quicklime, with reaction enthalpy 178 kJ / mole:
  $CaCO_3 \rightarrow CaO + CO_2$
- Calcium carbonate will react with water that is saturated with carbon dioxide to form the soluble calcium bicarbonate.
  $CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

This reaction is important in the erosion of carbonate rocks, forming caverns, and leads to hard water in many regions. As CO_2 is released through the dissolution of Carbonates, it is also a concern to scientists studying climate change.

Mechanical and Chemical Weathering www.ux1.eiu.edu/~cfjps/1300/weathering.html

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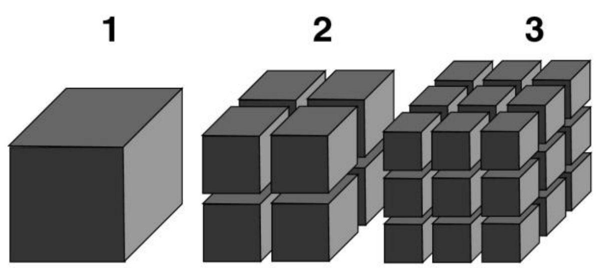
Since igneous rocks form at high temperatures, and under pressure conditions ranging from one to several atmospheres. However, the conditions at the Earth's surface are somewhat different than the conditions at which most rocks and minerals form. Therefore, the materials are no longer at equilibrium when they are exposed to surface conditions. Under these conditions, there is a tendency for all ordered systems to seek lower levels of energy or order. This is all done through weathering.

Weathering - the disintegration and decomposition of rock at or near the surface of the earth. It affects the rocks in place and no transport is involved. This distinguishes weathering from erosion.

Mechanical/physical weathering - physical disintegration of a rock into smaller fragments, each with the same properties as the original. Occurs mainly by temperature and pressure changes.

Chemical weathering - process by which the internal structure of a mineral is altered by the addition or removal of elements. Change in phase (mineral type) and composition are due to the action of chemical agents. Chemical weathering is dependent on available surface for reaction temperature and presence of chemically active fluids. Smaller particle sizes weather by chemical means more rapidly than large particles due to an increase of surface area. Look at the diagram below and you will see that as the particles get smaller, the total surface area available for chemical weathering increases.



SA (surface area) = # blocks x SA of each block

1. area of each face = l x w = 3" x 3" = 9 in^2
   total SA = 6 faces x 9 in^2 = 54 in^2
2. area of each face = l x w = 1.5" x 1.5" = 2.25 in^2
   total SA = 6 faces x 8 blocks x 2.25 in^2 = 108 in^2
3. area of each face = l x w = 1" x 1" = 1 in^2
   total SA = 6 faces x 27 blocks x 1 in^2 = 162 in^2

Erosion - the incorporation and transportation of weathering products by a mobile agent such as wind, water, ice.

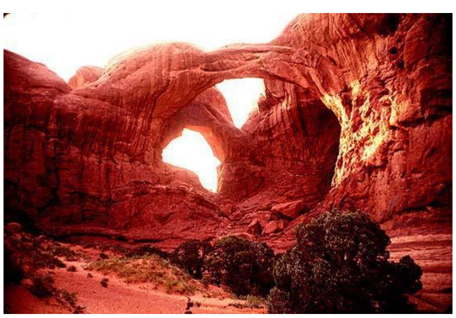
All three processes may act independently, but will more often than not, occur simultaneously. Different circumstance will have one weathering process more important than another. The processes may also act in concert with one another.

Types of Mechanical Weathering:

Frost Wedging - water expands when it freezes. This photograph shows the individual layers within the sedimentary rock breaking apart through repeated cycles of freeze-thaw. A similar process happens when the rock is repeatedly wetted and dried as salt crystals dissolve from the rock then grow when it is dried. Both processes can result in the rocks being heaved - so what was once a nice regular pattern of bricks set in a pavement will eventually become a chaotic jumble of bricks oriented every which way.
Thermal Expansion and Contraction - heating causes rock to expand, cooling results in contraction; different minerals expand and contract at different rates. This phenomena will look very similar to frost wedging and salt crystal growth, but will typically happen in climates that undergo extreme diurnal temperature changes.

Mechanical Exfoliation - rock breaks apart in layers that are parallel to the earth's surface; as rock is uncovered, it expands (due to the lower confining pressure) resulting in exfoliation. The photograph is from G. K. Gilbert (1903) in Sequoia National Park. The granite boulder is shaped by exfoliation; the boulder is about 40 feet in diameter, and the separated fragment resting on it is about 10 feet thick. Exfoliation is very common whenever plutonic igneous rocks are exposed. Since the plutonic rocks cool at depth under great pressure, they essentially de-pressurizes once the overburden is removed. This causes sheets of rock to peel off subparallel to the earth's surface, or whatever is the least pressurized surface.

Abrasion - physical grinding of rock fragments. Here, the photo shows some pits that have been eroded into the rock by sandblasting. Along with the physical weathering (the sandblasting), chemical weathering has taken place as the rock shows some signs of solution weathering as well.



Another photograph which shows the powerful effect of wind generated abrasion is the Double Arch from Arches National Park. The edges of the arches have weathered along joints, preexisting tectonically controlled vertical surfaces in the rock. Then mechanical abrasion took over and carved out the arches.

Types of Chemical Weathering:

Dissolution

$H_2O + CO_2 + CaCO_3$ --> $Ca^{+2} + 2HCO_3^-$
water + carbon dioxide + calcite dissolve into calcium ion and bicarbonate ion
Dissolution is very common in areas that have a great deal of limestone. Acidic waters (from pollution or natural) dissolve limestone allowing for additional water to gain entrance. Can cause sinkholes and karst features as well as dissolution of statutes and grave stones.

Oxidation (rust)

$4Fe^{+2} + 3O_2$ --> $2Fe_2O_3$
ferrous iron + oxygen combine to form ferric iron oxide (hematite)

Will happen to all iron-bearing silicates to varying degrees. Common reaction minerals are hematite, limonite, and goethite.

Hydrolysis
$2KAlSi_3O_8 + 3H_20$ --> $Al_2Si_2O_5(OH)_4 + 4SiO_2 + 2K(OH)$
potassium feldspar in acidic water hydrolyses to kaolinite + quartz + potassium hydroxide

Silicate minerals (unstable at the earth's surface) weather to form clay minerals such as kaolinite (stable at the earth's surface). Feldspars typically weather to produce clay minerals.

Factors that influence chemical weathering
Climate
Living Organisms
  bioturbation
  acid production and mineral decomposition
Time
Mineral composition
  Goldich Dissolution Series
  (Bowen's Reaction Series)

Chemical Weathering Products
  Clays
  Metals ores
  Rounding of boulders (chemical exfoliation)

Soils and Soil Formation
Dependence of weathering type on the mean temperature and annual rainfall.
Weathering rates depend on the composition of the rock, temperature range and rainfall amount.
Weathering produces soils. Soils may or may not remain in place, and any soil may be a combination of residual and transported material.

Factors in Soil Formation

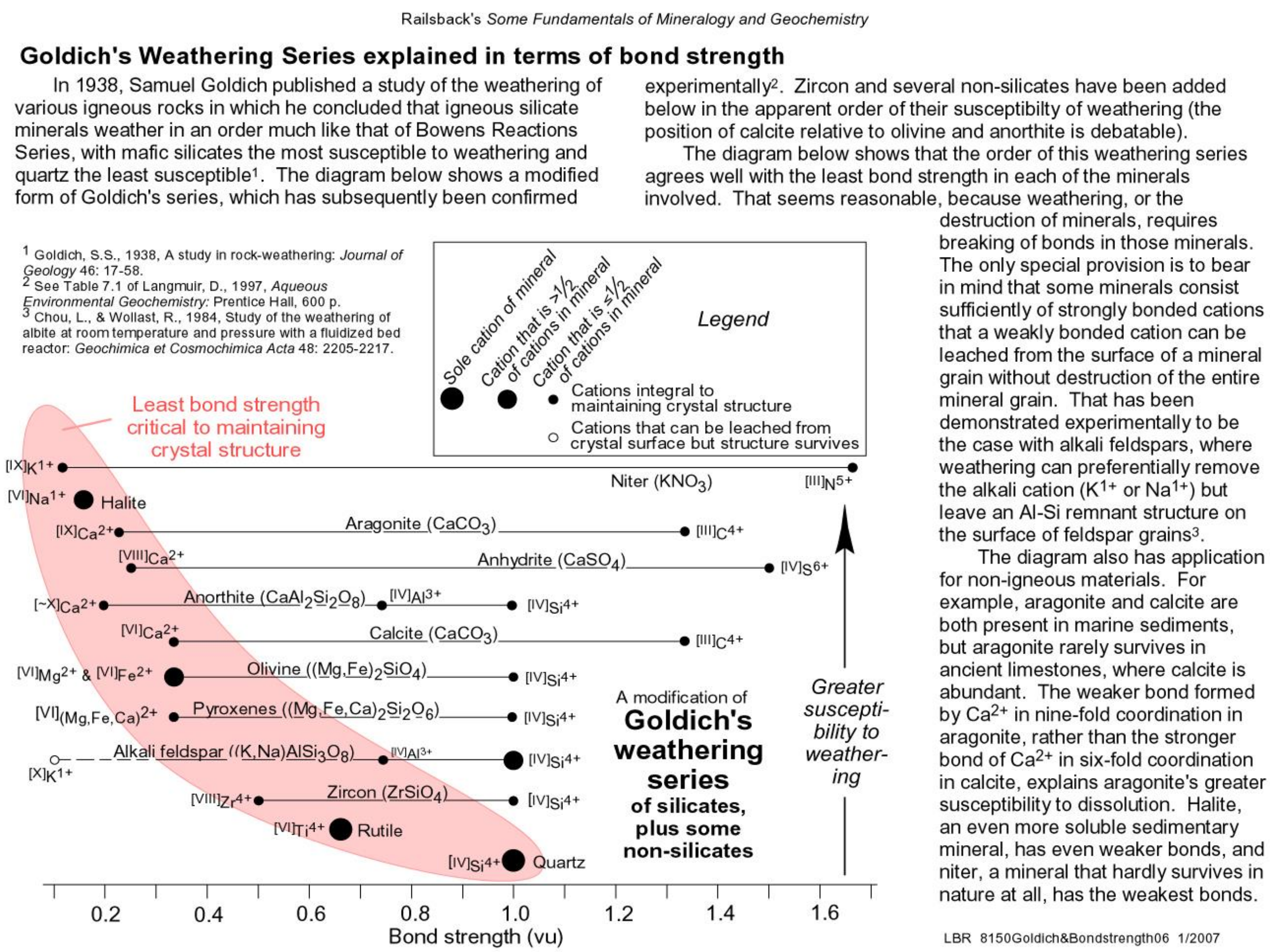
1. Climate: The greater the rainfall amount, the more rapid the rate of erosion and leaching. Laterites form in humid climates where only Al_2O_3 (Bauxite) and $Fe(OH)_3$ remain.
2. Topography: The steeper the surface slope, the more likely any eroded material is to be transported out of the system.
3. Parent Material: Granites are more resistant to weathering than gabbros. Sandstones are more resistant to weathering than limestones in humid climates, but limestones are more resistant than sandstones in arid climates.

4. Plant and Animal activity: Plant and animal activity produces humic acids that are powerful erosion agents. Plants can physically erode as well as chemically erode. Plants stabilize soil profiles, Animals (including man) tend to destabilize the soil profile, increasing erosion.
5. Time: Reaction rates are slow, the longer a rock unit has been exposed, the more likely it is to be weathered.

These factors can be remembered by the acronym ClORPT - Climate, Organic activity (plants and animals), Relief (topography), Parent material, and Time.

Mineral stability

Sediments are the by-product of weathering. Sediments are particles of minerals, some of them altered from the original rock, some simply reduced in sized, and some new minerals by reaction. The stability of minerals can be predicted using the Bowen's reaction series, however, in the case of the weathering series this is known as the Goldich Dissolution Series:



http://www.gly.uga.edu/railsback/Fundamentals/8150Goldich&BondStreng06LS.jpg

Minerals crystallize from a melt at different temperatures during the migration and emplacement of the magma. Those minerals that crystallize at higher temperatures will be the least stable at the surface. From this it is obvious that quartz will be the most stable mineral in the weathering environment, and will be a dominant constituent of sediments and sedimentary rocks.

Name: ___________________________ date: ______________Class:______

Weather Me Down

RQ: How does the type of building material used affect its rate of chemical weathering due to acid rain?

- Before we get started we need to do a bit of research and answer the pre-lab questions:

1. What is weathering?

2. In what way/s can a rock or mineral be weathered?

3. Which type of weathering results from a chemical reaction? SUPPORT YOUR ASNWER

4. Which kind/s of weathering are occurring in Washington D.C.? ____________________________
   SUPPORT YOUR ASNWER

5. What does mass measure?

   What does volume measure?

   What does density measure?

Procedure:

1. Use the rock key to identify your samples and then Use the hand lens and look at each building material: Draw a detailed sketch in the space provided and place its name below the diagram
2. Hypothesize which building material will be most affected by the acid and write your hypothesis in the space provided
3. Find the mass of each building material and record it in the table under beginning mass
   DO NOT FORGET YOUR UNITS
4. Use the water and graduated cylinder to find the volume of each building material
   DO NOT FORGET YOUR UNITS
5. Use the formula shown below to calculate the density of each building material
   Density = mass ÷ volume
6. Place each building material in a beaker, label the beaker with the identity of its contents
7. PUT YOUR SAFETY GOGGLES ON AND THEN Use the pH meter to find the pH of the acid that your group was given and record it in the table
8. Cover each building material sample with acid.
9. Record any observations that your have in the table
10. Write the names of the members of your group on the card and place it on the tray
11. Place your tray where directed and clean your area
12. Wait 6 days and remeasure your materials. Record your measurements in the 2nd table

Building Observations: Be sure to label each sketch

Hypothesis: If ____

then ____

because ____

IV: ____

DV: ____

Weather Me Down DATA For Acid pH tested: ___________________

Building Material	Initial Mass	Initial Volume	Initial Density	Observations
Sandstone				
Limestone				
Marble				
Granite				
Concrete				

Conclusion: Which building material feels heaviest? ______________________ is it also most dense? ________ INFER: Why do you think this is?

In addition to type of building material, what other variables could affect the rate of chemical weathering due to acid rain?

Acid Rain in Washington (Student Background)

Minerals and rocks can be broken down in a process known as weathering. Two important classifications of weathering processes exist. Mechanical or physical weathering involves the breakdown of rocks and soils through direct contact with atmospheric conditions such as heat, water, ice and pressure. The second classification, chemical weathering, involves the direct effect of atmospheric chemicals, or biologically produced chemicals (also known as biological weathering), in the breakdown of rocks, soils and minerals.

Chemical weathering involves the change in the composition of rocks, often leading to a 'break down' in its form. This is done through a combination of water and various chemicals to create an acid which directly breaks down the material causing a chemical change in its composition. This type of weathering happens over a period of time. Chemical weathering may alter a rocks chemical make up by changing the minerals in the rock or it adds some new minerals.

Chemical weathering has become an issue as the problem of urban pollution and acid precipitation (often called acid rain) has begun to take their toll on many historic landmarks in the Washington metropolitan area. Pure, distilled water has a neutral pH of 7. Normal, unpolluted rain is slightly acid, with a pH of 5.6, because the carbon dioxide in air combines with water to form small amounts of a weak acid called carbonic acid. Rainfall in the Washington area has an average pH of 4.2 to 4.4, more than 10 times as acid as unpolluted rain. The main source of pollution here is exhaust from automobiles, trucks, and other forms of transportation. Vehicle exhaust contains nitrogen oxides and sulfur dioxide, which combine with water to form strong acids.

The marble balustrade on the west side of the Capitol building shows damage from acid rain dissolving the mineral calcite.

Questions still remain about acid rain and building stone in the Washington area. Weathering (deterioration caused by exposure to the environment) is a natural part of the normal geologic cycle. For example, the process of weathering has turned the hard rocks of the Piedmont Plateau into the soft sediments washed downriver to form the Coastal Plain. Similar weathering processes affect the stones in buildings and monuments. Has this normal process been accelerated by human actions and urban pollution? Geologists at the U.S. Geological Survey are working with scientists at other Federal agencies, including the National Park Service, to learn more about the connections between acid rain and the deterioration of our buildings and monuments through laboratory experiments and studies of the building stones themselves. In order to protect our historically and culturally significant buildings, we need to understand how the various processes of weathering and deterioration can affect the stones from which they were built.

Rock ID and Information

LIMESTONE (lime'-stone)

What Type of Rock Is It? Sedimentary

What Does It Look Like? Limestone is usually white, gray, tan, or yellow. It may contain impurities to make it red or black. Fossils are often found in limestone. It may be very smooth or even sugary, fine grained, or medium grained. The powdered rock will usually fizz in white vinegar. Unlike marble, limestone is not composed of visible crystals.

Chemical Composition: mostly calcite ($CaCO_3$)

How Was It Formed? Most limestone is formed by a chemical reaction in sea water. The reaction makes a lime mud which sinks to the bottom to for the limestone. Some limestones are formed from buried coral reefs.

SANDSTONE (sand'-stone)

What Type of Rock Is It? Sedimentary

What Does It Look Like? Sandstone is often red to brown, light gray to nearly white. Sometimes it is yellow or green. It usually is composed of rounded grains that are all of the same size; and it is usually medium grained. Some sandstones show slight color variations in layering.

Chemical Composition: SiO2 93-94% Iron (Fe2O3) 1.5%-1.6% Alumina (Al2O3) 1.4 to 1.5% Soda (Na2O) & Potash (KrO) 1.0% to 1.2% Lime (CaO) 0.8% to 0.9% Magnesia (MgO) 0.2 to 0.25%

How Was It Formed? Quartz sand that is produced by the weathering of other rocks (such as granite, gneiss, and other sandstones) is deposited by rivers, waves, or wind. The sediment may have been a sand bar, an ocean beach, or desert sand dunes. The sand is buried under other sediments, compacted by the weight of those sediments, and cemented by material dissolved in water that seeps through it.

GRANITE (gran'-it)

What Type of Rock Is It? Igneous

What Does It Look Like? The feldspars give granite most of its color, which may be white to light gray, yellowish, or pink. The quartz is usually smoky gray or white. Black specks of biotite, or sometimes hornblende, are common. So is silvery to brownish muscovite. Granite is coarse grained to very coarse grained. The crystals are randomly arranged (unlike gneiss where they are in lines or layers).

Chemical Composition:

- SiO_2 — 72.04% Al_2O_3 — 14.42% K_2O — 4.12% Na_2O — 3.69% CaO — 1.82%.,FeO — 1.68%
- Fe_2O_3 — 1.22% MgO — 0.71% TiO_2 — 0.30% P_2O_5 — 0.12% MnO — 0.05%

How Was It Formed? Granite forms deep in the earth's crust from cooling magma. The magma contains a lot of silica (quartz). Slow cooling produces the large crystals in granite.

MARBLE (mar'-bul)
What Type of Rock Is It? Metamorphic
What Does It Look Like? Often pure white. It may be streaked or patchy gray, green, tan, or red. Marble is fine grained to very coarse grained and crystals are usually easy to see. The rock is soft; it will not scratch glass (quartzite may look like a fine grained marble, but easily scratches glass). The powdered marble will often fizz with white vinegar. If it does not fizz, it may be dolomitic marble.
Chemical Composition: Same as limestone
How Was It Formed? Marble forms from the metamorphism of limestones.

Because Concrete is man-made and is not formed by nature, it is not classified as an actual rock. However: it is made of rocks and is a very important building material;

Chemical Composition:

Chemical Composition: Concrete is made by the combination of cement, water, and aggregate of various sizes to make workable slurry that has the consistency of a thick milk shake.

Name	**Percent by Weight**	**Chemical Formula**
Tricalcium silicate	50%	3Ca0 SiO2
Dicalcium silicate	25%	2Ca0 SiO2
Tricalcium aluminate	10%	3Ca0 Al2 O3
Tetracalcium aluminoferrite	10%	4Ca0 Al2 Fe2 O3
Gypsum	5%	CaSO4 H2O

Name: ______________________________ Date: _______________ Class:___

Weather Me Down UNRAVEL

U: Uncover the Research Question:

N: Name the Variables:

IV: ______________________________ DV: _______________________

Constants:

____

Hypothesis:

R: Research: Compose two paragraphs that include the following information:

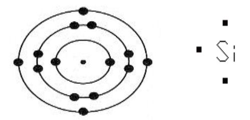
Paragraph 1:

- ✓ What an element is
- ✓ What a compound is
- ✓ What a mixture is
- ✓ Relationship between elements, compounds, and mixtures and rocks

Paragraph 2:

- ✓ What weathering is
- ✓ Types of weathering with examples
- ✓ How weathering affects us

Complete the chart to identify the Chemical Composition of rock used in lab: The first one has been done for you

Rock Found In (G,S,L,M,C)	Element	# of p+	# of n	**Classification**	Bohr and Lewis Dot
G,S, C	Si	14	14	metalloid	

Rock Found In	Element	# of p+	# of n	Classification	Bohr and Lewis Dot

Compare: How are the different rocks that we used alike?

Analyze: Which rock contained the most compounds? ______________________

Which rock contained the least compounds? ______________________

V: Verify the experiment by identifying the materials used and a composing a summary of the procedure that was followed

L: Link the data in a data table:

Type of building material	End Mass	End Volume	End Density	Initial Density	Difference	% of Change Diff/initial x 100

Weathered Observations: Be sure to label each sketch

Graph the data using a double bar graph to communicate the initial and end density

S: Summarize the results by writing a conclusion statement that communicates the following using a complete paragraph: ***Begin by restating your hypothesis:***

- Identity of the building material that changed most, INCLUDE HOW MUCH IT CHANGED and its chemical composition
- Identity of building material that changed the least, INCLUDE HOW MUCH IT CHANGED and its chemical composition
- Inference that explains why the experiment turned out as it did

A Concrete Challenge

Teacher Background and Information

Objective: To provide students with an opportunity to explore and examine the chemical processes that form concrete and evaluate what affect this has on our planet.

Time required: 1-2 class periods

Materials Needed: Choose the aggregates that you wish to supply, or have students bring in their own:

Aggregates may include: clay, crushed brick, old concrete, vermiculite, perlite, crushed granite, course sand, fine sand, screening material, sytrofoam beads, small gravel,

Bonding agent: pickling Lime (CaO) and diatomaceous earth (O_2Si)
disposable cups, and crafts sticks

All of the aggregates shown can be found at your local Home renovation store or a rock store. Many times a rock store will give you small samples. Vermiculite and perlite are often used as soil conditioners. Diatomaceous earth can also be bought at a home improvement store and Pickling Lime at the grocery store.

Safety: Both Quicklime and diatomaceous earth are hazardous to breath and get on your hands, Use of gloves, safety shield, and aprons is advised

MSDS Sheets:

http://www.apacapacas.com/msds.html Diatomaceous Earth

http://www.jtbaker.com/msds/englishhtml/c0407.htm Pickling Lime

Useful Websites:

http://clarkson.us/highschool/k12/pdf/productdesign/Lesson%203%20Research.pdf
Web-based research for Concrete

http://matse1.mse.uiuc.edu/concrete/prin.html
Scientific principles of Concrete

Teacher Background:
Much research is being delegated to the area of concrete manufacturing as part of the current processing and environmental weathering releases CO_2. This lab is an open inquiry lab wherein students are asked to develop a recipe to make concrete using Plaster of Paris in place of cement. Try and guide students to make paste before adding aggregates for better success. Concrete can also be left to harden for several days and then weathered with vinegar if you choose. Tensile strength can also be measured using the procedure at the website found below:

http://www.rsc.org/education/teachers/learnnet/inspirational/resources/4.3.3.pdf

Cement and Concrete about.com
If you think of bricks as artificial rocks, cement might be considered artificial lava—a liquid stone that is poured into place where it hardens into solidity.

Cement and Concrete
Many people talk about cement when they mean concrete.

- Cement is a fine-grained compound that turns into a solid when mixed with water. Cement is used to bind mixtures of materials into a composite solid.
- Concrete is a mixture of cement, sand and gravel. That is, cement is the glue of concrete.
- Now that we've made that clear, let's talk about cement. Cement begins with lime.

Lime, the First Cement

Lime is a substance used since ancient times to make useful things like plaster and mortar. Lime is made by burning, or calcining, limestone—and that's how limestone gets its name. Chemically, lime is calcium oxide (CaO) and is made by roasting calcite ($CaCO_3$) to drive off carbon dioxide (CO_2). That CO_2, a greenhouse gas, is produced in great quantities by the cement industry.

Lime is also called quicklime or calx (from Latin, where we also get the word calcium). In old murder mysteries, quicklime is sprinkled on victims to dissolve their bodies because it is very caustic.

Mixed with water, lime slowly turns into the mineral portlandite in the reaction $CaO + H_2O = Ca(OH)_2$. Lime is generally slaked, that is, mixed with an excess of water so it stays fluid. Slaked lime continues to harden over a period of weeks. Mixed with sand and other ingredients, slaked lime cement can be packed between stones or bricks in a wall (as mortar) or spread over the surface of a wall (as render or plaster). There, over the next several weeks or even years, it reacts with CO_2 in the air to form calcite again—artificial limestone!

Concrete made with lime cement is known from archaeological sites in both the New and Old World, some more than 5000 years old. It works extremely well in dry conditions. It has two drawbacks:

- Lime cement takes a long time to cure, and while the ancient world had lots of time, today time is money.
- Lime cement does not harden in water but stays soft, that is, it is not a hydraulic cement. So there are many situations where it cannot be used.

Ancient Hydraulic Cement

The Pyramids of Egypt are said to contain a hydraulic cement based on dissolved silica. If that 4500-year-old formula can be confirmed and revived, it would be a great thing. But today's cement has a different pedigree that is still quite ancient.

Around 1000 BCE, the ancient Greeks were the first to have a lucky accident, mixing lime with fine volcanic ash. Ash can be thought of as naturally calcined rock, leaving silicon in a chemically active state like the calcium in calcined limestone. When this lime-ash mixture is slaked, a whole new substance is formed: calcium silicate hydrate or what cement chemists call C-S-H (approximately $SiCa_2O_4 \cdot xH_2O$).

C-S-H is still a mysterious substance today, but we know it is an amorphous gel without any set crystalline structure. It hardens fast, even in water. And it is more durable than lime cement.

The ancient Greeks put this new cement to use in new and valuable ways, building concrete cisterns that survive to this day. But Roman engineers mastered the technology and constructed seaports, aqueducts and temples of concrete as well. Some of these structures are as good as ever today, two thousand years later. But the formula for Roman cement was lost with the fall of the Roman empire.

Modern Hydraulic Cement

While lime cement continued in use throughout the Dark and Middle Ages, true hydraulic cement was not rediscovered until the late 1700s. English and French experimenters learned that a calcined mixture of limestone and claystone could be made into hydraulic cement. One English version was dubbed "Portland cement" for its resemblance to the white limestone of the Isle of Portland, and the name soon extended to all cement made by this process.

Shortly thereafter, American makers found clay-bearing limestones that yielded excellent hydraulic cement with little or no processing. This cheap natural cement made up the bulk of American concrete for most of the 1800s, and most of it came from the town of Rosendale in southern New York. Rosendale was practically a generic name for natural cement, although other manufacturers were in Pennsylvania, Indiana and Kentucky. Rosendale cement is in the Brooklyn Bridge, the U.S. Capitol building, most 19th-century military buildings, the base of the Statue of Liberty and many other places. With the rising need to maintain historic structures using historically appropriate materials, Rosendale natural cement is being revived.

True portland cement slowly gained popularity in America as standards advanced and the pace of building quickened. Portland cement is more expensive, but it can be made anywhere the ingredients can be assembled instead of relying on a lucky rock formation. It also cures faster, an advantage when building skyscrapers a floor at a time. Today's default cement is some version of portland cement.

Modern Portland Cement

Today limestone and clay-containing rocks are sintered—roasted together at nearly melting temperature—at 1400° to 1500°C. The product is a lumpy mixture of stable compounds called clinker. Clinker contains iron (Fe) and aluminum (Al) as well as silicon and calcium, in four main compounds:

- Alite (Ca_3SiO_5)
- Belite (Ca_2SiO_4), known to geologists as larnite
- Aluminate ($Ca_3Al_2O_6$)
- Ferrite (Ca_2AlFeO_5)

Clinker is ground to powder and mixed with a small amount of gypsum, which slows down the hardening process. And that is Portland cement.

Making Concrete

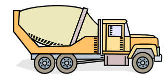
Cement is mixed with water, sand and gravel to make concrete. Pure cement is useless because it shrinks and cracks; it's also much more expensive than sand and gravel. As the mixture cures, four main substances are produced:

- C-S-H
- Portlandite
- Ettringite ($Ca_6Al_2(SO_4)_3(OH)_{12} \cdot 26H_2O$; includes some Fe)
- Monosulfate ($[Ca_2(Al,Fe)(OH)_6] \cdot (SO_4,OH,etc) \cdot xH_2O$)

The details of all this are an intricate specialty, making concrete as sophisticated a technology as anything in your computer. Yet basic concrete mix is practically stupidproof, simple enough for you and me to use.

Name: _________________________________ Date: ________________ Class: ________

A Concrete Challenge



Research Question: How can I use ratios to replicate ancient concrete used to build the pyramids?

Background Information: We drive our cars on it, we build skyscrapers with it. But concrete, one of the most common building materials in the world, has an ugly secret: It's a major source of carbon dioxide (CO2) emissions, which contribute to global warming. Roughly 5 to 10 percent of global CO2 emissions are related to the manufacture and transportation of cement, a major ingredient of concrete. With cement production expected to grow exponentially in coming decades, the industry is trying to address its environmental challenges. The answer may lie by looking back in time to the Romans.

Ancient Roman concrete has withstood the attack by elements for over 2,000 years. The basic construction techniques of the Romans must be better than those of modern practice as judged by comparing the products.

Solving the riddle of ancient concrete consisted of two studies: the first involved understanding the chemistry, and the other was determining the placement of ancient concrete. To understand its chemical composition, we must go back in time much before Moses. People of the Middle East made walls for their fortifications and homes by pounding moist clay between forms, often called pise work. To protect the surfaces of the clay from erosion, the ancients discovered that a moist coating of thin, white, burnt limestone would chemically combine with the gases in the air to give a hard protecting shied. A chemical reaction took place between the chemicals in the wall of volcanic ash (silica and small amounts of alumina and iron oxide) and the layer of lime (calcium hydroxide) applied to the wall. Later they found that mixing a little volcanic ash in a fine powder with the moist lime made a thicker coat, but it also produced a durable product that could be submerged in water- something that the plaster product of wet lime and plain sand could not match.

To explain this chemical difference we must examine the atomic structure. Common plaster is made with wet lime and plain sand. This sand has a crystalline atomic structure whereby the silica is so condensed there are no atom holes in the molecular network to allow the calcium hydroxide molecule from the lime to enter and react. The opposite is true with the wet lime-pozzolan contact. The pozzolan has an amorphous silica atomic structure with many holes in the molecular network. Pozzolans are present on earth's surface such as diatomaceous earth, volcanic ash, opaline shale, pumicite, and tuff. Upon mixing the wet lime with the pozzolan, the calcium hydroxide enters the atomic holes to make a concrete gel that expands, bonding pieces of rock together. The fine powder condition of the pozzolan provides a large surface area to enhance chemical reaction. We find parts of the complex chemistry of the ancient concrete bonding gel matching the same chemical formula of modern concrete bonding gel. So the pozzolan-wet lime gel gave permanence to the ancient concrete.

Explaining the placement of ancient concrete solved the second part of the riddle. Chemistry alone will not make good concrete. People make good concrete. Studies of the placement process are very important in making durable concrete. The ancients hand mixed their components (wet lime and volcanic ash) in a mortar box with very little water to give a nearly dry composition; carried it to the job site in baskets placing it over a previously prepared layer of rock pieces; and then proceeded to pound the mortar into the rock layer. Fortunately, we have proof. Vitruvius, the noted Roman architect (cir. 20 BC) mentioned this process in his history formulas for his concrete, plus the fact that special tamping tools were used to build a cistern wall. Is this important? Yes, for two reasons: close packing of the molecular structure by tamping reduced the need of excess water; which is a source of voids and weakness and it also allows for more bonding gel than might be normally expected. By studying ancient methods of making concrete, scientists can use what they learned to make more permanent concrete thus reducing its carbon footprint.

To get started we need to understand a bit about modern concrete production: In its simplest form, concrete is a mixture of paste and aggregates. The paste, composed of portland cement and water, coats the surface of the fine and coarse aggregates. Through a chemical reaction called hydration, the paste hardens and gains strength to form the rock-like mass known as concrete.

Modern Concrete consists of the following ratios:

% by volume in concrete

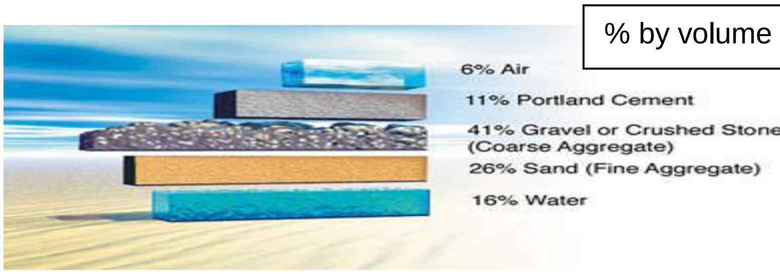
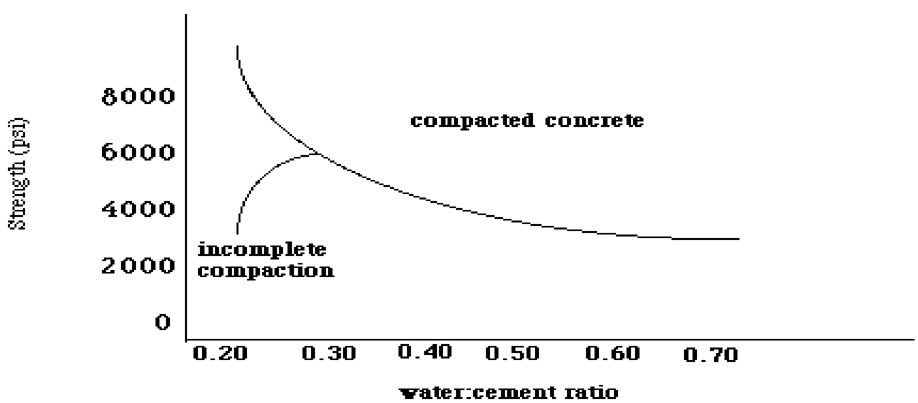


Table 1: Classes of Aggregates

class	examples of aggregates used	uses
ultra-lightweight	vermiculite ceramic spheres perlite	lightweight concrete which can be sawed or nailed, also for its insulating properties
lightweight	expanded clay shale or slate crushed brick	Used primarily for making lightweight concrete for structures, also used for its insulating properties.
normal weight	crushed limestone sand river gravel crushed recycled concrete	Used for normal concrete projects
heavyweight	steel or iron shot steel or iron pellets	used for making high density concrete for shielding against nuclear radiation

Figure 6: A plot of concrete strength as a function of the water to cement ratio.



Pre-Lab:

- ✓ What safety measures do you need to take in this lab?

- ✓ What were the key ingredients in ancient concrete?

- ✓ Why are we looking at new ways to make concrete?

- ✓ What are the key ingredients commonly used to make concrete today?

- ✓ How will you measure your ingredients to assure the proper ratios?

- ✓ How important is the amount of water that you use?

- ✓ What affect do you think the size of aggregates used will have on the strength of your concrete? WHY?

- ✓ How will you know if a chemical reaction takes place?

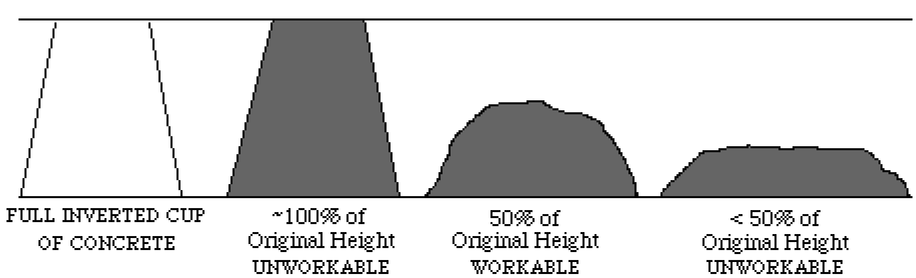
- ✓ Evaluate: Would concrete be classified as a mixture or a compound? SUPPORT YOUR ASNWER

A Concrete Plan: Materials our group plans to use:

A Concrete Process: List the steps of your process; be sure to include exact amounts and numbered steps

Results: Test your concrete using the accepted slump test by taking your concrete out of the cup and measuring the amount of slump using a ruler and the top of the cup.

Slump Test = _____________________________



Evaluate: What changes would you make if you were to repeat this challenge? WHY?

REMIXING CONCRETE RELATED ARTICLE

The New York Times has an article on efforts to produce concrete without emitting large volumes of CO2 - Concrete Is Remixed With Environment in Mind.

Concrete may seem an unlikely material for scientific advances. At its most basic, a block of concrete is something like a fruitcake, but even more leaden and often just as unloved. The fruit in the mix is coarse aggregate, usually crushed rock. Fine aggregate, usually sand, is a major component as well. Add water and something to help bind it all together — eggs in a fruitcake, Portland cement in concrete — mix well, pour into a form and let sit for decades.

Let a lot of it sit. Every year, about a cubic yard of concrete is produced for each of the six-billion-plus people on the planet. Think of it this way. The stretch of sidewalk in front of your house? That is you and your spouse's share. That concrete truck rumbling down the street? It holds a yard for each member of the New York Yankees' starting lineup. Add the Mets and the Red Sox, and you have enough for the typical house foundation and basement floor.

But those are small projects. The St. Anthony Falls Bridge used about 50,000 yards of concrete. Hoover Dam used more than three million. And the Three Gorges project in China contains more than a yard for every man, woman and child in Canada, population 33 million.

All that concrete may seem the same. And the basic product did remain relatively unchanged since the invention of Portland cement in the early 1800s. (The ancient Romans made concrete, too, but from volcanic ash.) Producers have always tinkered with the mix to find the right proportions of concrete's basic ingredients, but the recipe never varied much.

Now the experimentation is more elaborate, designed to tailor the concrete to the need. Increasingly, that need includes the environment. Aesthetic considerations aside, concrete is environmentally ugly. The manufacturing of Portland cement is responsible for about 5 percent of human-caused emissions of the greenhouse gas carbon dioxide.

"The new twist over the last 10 years has been to try to avoid materials that generate CO2," said Kevin A. MacDonald, vice president for engineering services of the Cemstone Products Company, the concrete supplier for the I-35W bridge.

In his mixes, Dr. MacDonald replaced much of the Portland cement with two industrial waste products — fly ash, left over from burning coal in power plants, and blast-furnace slag. Both are what are called pozzolans, reactive materials that help make the concrete stronger. Because the CO2 emissions associated with them are accounted for in electricity generation and steel making, they also help reduce the concrete's carbon footprint. Some engineers and scientists are going further, with the goal of developing concrete that can capture and permanently sequester CO2 from power plants or other sources, so it cannot contribute to the warming of the planet. ...

Some researchers want to eventually eliminate Portland cement entirely and replace it with other cements to produce zero-carbon, or even carbon-negative, concrete.

Portland cement is at the heart of concrete's environmental problems. About a ton of CO2 is emitted for every ton of cement produced. The basic manufacturing process involves burning limestone and other minerals at about 2,700 degrees Fahrenheit to create an intermediate product called clinker.

“Essentially, we’re trying to make the same minerals that they did in 1825,” said Mr. Stehly, who is head of a committee addressing sustainability issues at the American Concrete Institute.

The cement industry, particularly in the United States and Europe, has reduced CO_2 emissions through the use of more efficient kilns and processes, and is now allowed to add some ground unburned limestone to the clinker, reducing the actual cement in the mix. But about half of the CO_2 from cement cannot be eliminated — it is produced in the reaction, called calcination, that occurs as the limestone (which consists of calcium carbonate) is being burned.

So to reduce concrete’s carbon footprint to near zero or less, different approaches are needed. Novacem, a British startup, is developing a cement that does not use carbonates and can make concrete that absorbs carbon dioxide. Carbon Sense Solutions, in Halifax, Nova Scotia, wants to bubble CO_2 through wet cement, sequestering the gas through carbonation (a process that occurs naturally, though very slowly, under normal conditions).

At a site adjacent to a gas-fired electricity generation plant in Moss Landing, Calif., the Calera Corporation is developing a process to bubble power plant flue gases through seawater or other brackish water, using the CO_2 in the gases to precipitate carbonate minerals for use as cement or aggregates in concrete. The process mimics, to some extent, what corals and other calcifying marine organisms do.

Calera calculates that producing a ton of these minerals consumes half a ton of CO_2, so the resulting concrete could potentially be carbon negative — sequestering carbon dioxide permanently.

Brent R. Constantz, the company’s founder, has a background in cements, having made specialty products for use in orthopedic surgery. But he does not describe Calera as a cement company. “We’re primarily driven by the need to capture large amounts of CO_2 and sequester it,” he said.

The company probably will begin by making aggregate, because the barriers to making a commercially acceptable product are lower than with cement. Even with aggregate, any new product must meet standards and must be accepted by the concrete industry, which can be conservative. “Any time you introduce anything new,” Dr. Constantz said, “it’s a challenge.”

Mineral Lights:
Teacher Instructions and Background:

Objective: To provide students with an opportunity to use a formula, collect and analyze data to evaluate the two types of chemical bonds and their relationship to conductivity as seen in electrolytic solutions

Time Required: 1 class periods

Materials Needed:
steel wool, 2 steel nails: 0.1 Molar solution of $CuSO_4$, alligator clips, 1.5 volt led light, Battery pack, 2 double A batteries, Sodium Chloride, distilled water, Sodium Bicarbonate, sucrose, Potassium Chloride, clean 300 ml cup, unsweetened drink mix, 8 beakers or plastic Solo Cups, and a balance.

Teacher Preparation:
Run off procedure pages and get materials. 1,5 v LEDs are available at Radio Shack, if battery packs are not available, two batteries can be taped together

Useful Websites

http://health.howstuffworks.com/electrolyte.htm/printable
Useful background on electrolytes

http://www.files.chem.vt.edu/RVGS/ACT/notes/Notes-Chapter_10.html
More Comprehensive background for ionic and covalent bonding and electrolytes

http://www.mhhe.com/physsci/chemistry/animations/chang_7e_esp/bom1s2_11.swf
Flash animation for ionic and covalent bonding

http://www.youtube.com/watch?v=EBfGcTAJF4o
You-tube that shows dissociation of salt in water

http://www.youtube.com/watch?v=yjge1WdCFPs&feature=related
You-Tube that shows ionic and covalent bonding

Teacher Background:
This lab provides an opportunity to explore several learning objectives: types of chemical bonds, evidence of chemical reactions, how a battery works, and the biological role of minerals. Gatorade and other sports drinks have flooded the market and are advertised as replacing needed electrolytes. In this lab students investigate the components of a sports drink to determine which parts provide the electrolytes needed to conduct the electrical processes that occur in their bodies. This could also be used to test minerals in soil or bottled drinking water as the voltage required is so small.

Information Background:

How can common solid salt crystals dissolve in water to make an electrolyte? Salt crystals are composed of a sodium atom and a chloride atom. Under the right conditions, these atoms combine as a result of an electrostatic force between the atoms. The sodium atom (11 protons and 11 electrons) has one electron that is loosely bound to the atom compared to the remaining 10 electrons. This means that it may be willing to share this electron with another element such as chloride under the right conditions. Chloride (17 protons and 17 electrons) has 17 tightly bound electrons with room to share one more electron in a loose manner. A field of study called quantum mechanics states that electrons in atoms are located in discrete energy levels. That is right, an electron cannot have an energy value midway between two energy levels. The nuclei (central portion of the atom containing protons and neutrons) of atoms are surrounded by electrons in a series of these energy levels sometimes called shells. These shells may be imagined as follows. Consider three spheres, a ping pong ball inside a baseball inside a basketball, all sharing the same center. The shell may be thought of as the surfaces of these three spheres. The closer the shell is to the nucleus, the stronger the attraction between the electrons (negative charge) and the protons (positive charge) in this atom, and the higher the energy level. Recall, that opposite charges attract (electromagnetic force) and this attractive force increases as the distance between charges decreases. The outer most energy level of chloride and sodium can potentially contain eight electrons. So, when chloride and sodium combine to become a molecule, the one electron in sodium and the seven electrons in chloride combines to fill their respective outer most energy levels. Both atoms share their outer most electrons and, of course, forms salt. When immersed in water, the electrostatic force binding the atoms together as a molecule is weakened because of the special electrical properties of the water molecule (dipole properties to be explained later). By stirring or slightly heating the salt water mixture (dissolving the salt), it is energetically favorable for the sodium chloride bond to split leaving behind the weakly bound electron in the outer most energy shell of the sodium atom attached to the chloride atom. The sodium atom minus an electron is a positive sodium ion and the chloride atom with an extra electron is a negative chloride ion. These ions floating freely in the water medium can be manipulated with the electromagnetic force and therefore forms what we call an electrolyte. Electrolytes provide a vehicle for electricity (current) to flow between two electrodes (two dissimilar metals immersed in the electrolyte) in the battery usually called the positive and negative terminals of the battery. For **batteries,** the **positive terminal** is call the **cathode,** and the **negative terminal** is call the **anode.** The **anode** is the electrode through which electrons are removed from the electrolytic liquid causing what chemist refer to as an **oxidation reaction**. The **cathode** is the electrode from which electrons enter the electrolytic solution which chemists have coined as a **reduction reaction.**

Name: ________________________________ Date: ____________________ Class: ___________

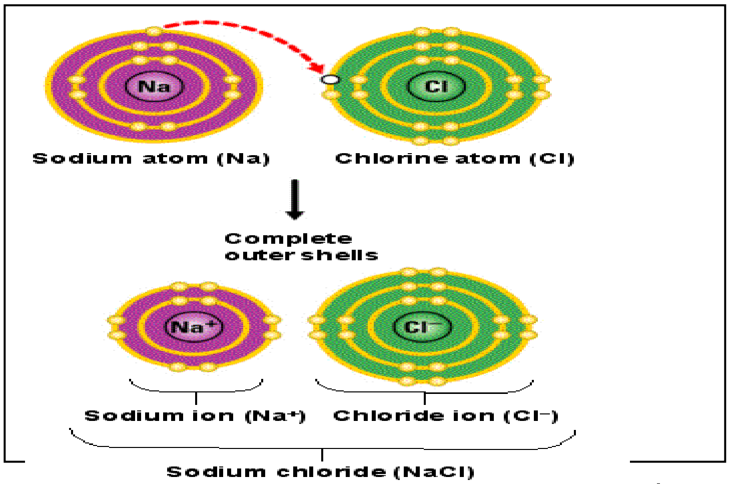
A Light Mineral

RQ: Which type of bond forms an electrolyte and why are they important to our health?

Background Information: Remember that elements join together to make compounds by forming chemical bonds. Chemical bonds are formed when the electrons in an atom interact with the electrons in another atom. This allows for the formation of more complex molecules. Properties of each type of bond are shown in the table below:

Property	Ionic Compounds	Covalent Compounds
Elements	metal - nonmetal	nonmetal - nonmetal
Phase (at STP)	solid (in crystal lattice)	solid, liquid or gas
Hardness	hard and brittle (salt)	brittle and weak or soft and waxy
Melting/Boiling Points	Generally Higher than 300°C	low
Solubility	mostly soluble in water	solubility varies widely
Electrical Conductivity	solid - nonconductor, liquid or aqueous solution - conductor	insulators
Bonding	Ionic bonds due to a transfer of valence electrons.	Covalent bonding due to the sharing of valence electrons

Chemically, electrolytes are ionic compounds. Electrolytes work by dissociating in a solution to form ions that have the ability to conduct electricity. An Ion is an atom or a group of atoms that has acquired a net electric charge by gaining or losing one or more electrons. Normally the number of electrons is the same as the number of protons and the atom is neutral. However it is possible to add or remove an electron from an atom. When this occurs the atom becomes a charged ion.



Notice that the sodium atom has transferred one of its negatively charged electrons to the atom of chlorine

Result: The sodium atom becomes a positively charged sodium ion known as an anion

The chlorine atom gained a negatively charged electron

The result: A negatively charged chlorine ion known as a cation

Batteries rely on electrolytes to transform chemical energy into electrical energy. The electrolyte used in a battery depends on the battery's type and purpose. Batteries are composed of three main parts, the anode, the cathode, and an electrolyte. Without the electrolyte to conduct the electricity, the battery cannot work.

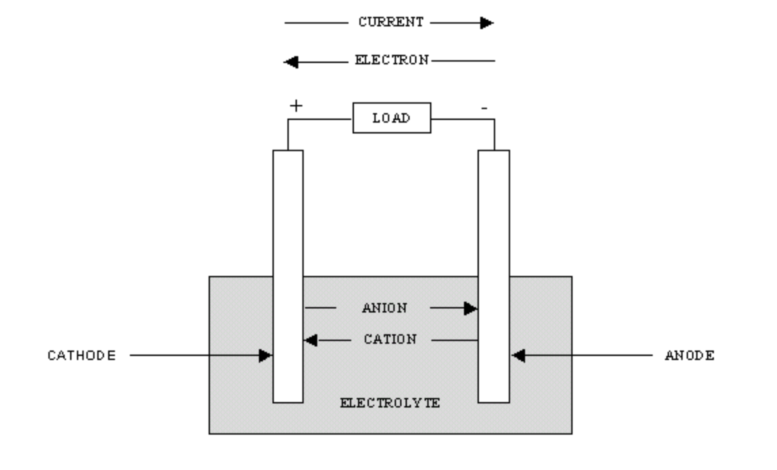


Figure 2: Cell in Operation (Discharge)

Cathode: negative side of the battery that receives electrons

Anode: positive side of the battery that gives up electrons

Electrolyte: solution that conducts an electrical current

Anion: positively charged metallic ion that loses electrons

Cation: negatively charged non-metallic ion that gains electrons

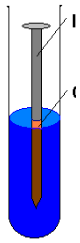
Interestingly, humans are like batteries in this regard, we need to electrolytes to work at our maximum efficiency. Electrolytes are important because they are what your cells (especially nerve, heart, muscle) use to maintain voltages across their cell membranes and to carry electrical impulses (nerve impulses, muscle contractions) across themselves and to other cells. Your kidneys work to keep the electrolyte concentrations in your blood constant despite changes in your body. The primary electrolytes required in the body fluid are cations (of calcium, potassium, sodium, and magnesium) known as macrominerals and anions (of chloride, carbonates, amino acetates, phosphates, and iodide). When you exercise heavily, you lose electrolytes in your sweat, particularly sodium and potassium. These electrolytes must be replaced to keep the electrolyte concentrations of your body fluids constant. So, many sports drinks have sodium chloride or potassium chloride added to them. They also have sugar and flavorings to provide your body with extra energy and to make the drink taste better. In this investigation we will be evaluating the different ingredients found in a homemade sports drink to determine which are able to conduct electricity using a conductivity tester.

Materials: steel wool, 2 steel nails: 0.1 Molar solution of $CuSO_4$, alligator clips, 1.5 volt led light, Battery pack, 2 double A batteries, Sodium Chloride, distilled water, Sodium Bicarbonate, sucrose, Potassium Chloride, clean 300 ml cup, unsweetened drink mix, 6 beakers or plastic Solo Cups, and a balance.

Recipe for Homemade Sports Drink

- Measure all ingredients precisely. Small variations can make the drink less effective or even harmful. Mix the following in a clean 300 ml cup.
  - 250 ml distilled water
  - 0.75 g sodium bicarbonate ($NaHCO_3$)
  - 0.75 g table Soidum Chloride (NaCl)
  - 0.3 g Potassium Chloride KCl aka "Lite Salt" or Morton Salt Substitute
  - 7.5 g sucrose ($C_{12}H_{22}O_{11}$)
  - 0.3 g package unsweetened drink mix (Contains citric acid $C_6H_8O_7$)

Mineral Light Procedure: Part 1



1. Fill 2 test tubes ¾ full of the Copper sulfate solution and then place them in the test tube rack
2. Use the steel wool to clean your 2 nails and then dip them in the Copper Sulfate Solution for 20 seconds. Use caution as copper sulfate is poisonous.
3. Take the nails out of the solution and lay them on a paper towel to dry.
4. Record what happened in the space provided
5. Return your copper sulfate to the designated area and then get materials for part 2

➢ **Observations:**

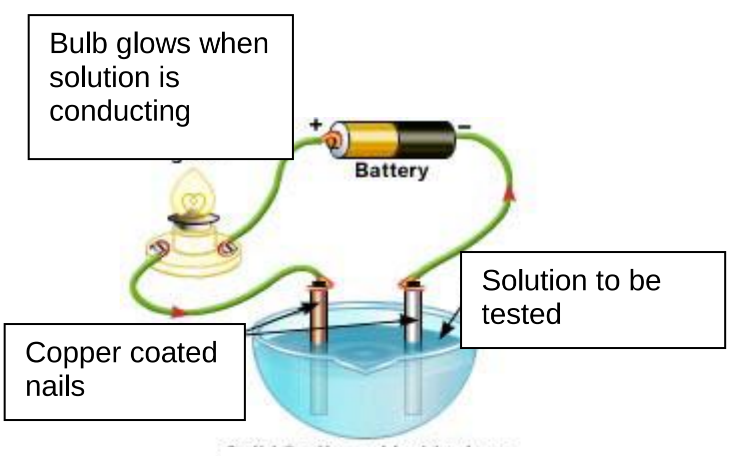
The chemical equation for this reaction is shown below:

$$Fe_{(s)} + CuSO_{4(aq)} \longrightarrow FeSO_{4(aq)} + Cu_{(s)}$$

➢ **Does this reaction adhere to the Law of Conservation of Mass? SUPPORT YOUR ANSWER**

Part 2:

1. Follow the recipe to make the home made sports drink
2. Construct your conductivity tester as outlined below:
    a. Place 2 double A batteries in your battery pack as shown in the pack
    b. Attach an alligator clip to the red wire
    c. Attach another alligator clip to the black wire
    d. Attach the alligator clip connected to the red wire to one side of the led light
    e. Attach the alligator clip connected to the black wire to one of your copper coated nails
    f. Attach an additional alligator clip to the other side of the led light
    g. Attach the other end to the 2nd copper coated nail
    h. Touch the nails together to make sure that your light works
    i. If it does not, switch connections



3. Test each of the solutions shown in the table and record your results
4. Use the background and your experiences to answer the conclusion questions

How Well Do I Conduct

Solution Tested	Electrolyte Y or N	Other Observations
Homemade Sports Drink		
250 ml Distilled Water		
250 ml Distilled Water + 0.75 g NaCl		
250 ml Distilled Water + 0.75 g $NaHCO_3$		
250 ml Distilled Water + 0.3 g KCl		
250 ml Distilled Water + 7.5 g $C_{12}H_{22}O_{11}$		
250 ml Distilled Water + 7.5 g		
250 ml Distilled Water + 0.3 g $C_6H_8O_7$		
250 ml Tap Water		

Conclusions:

1. **Infer**: Why were the Solids put into water?
2. What is an electrolyte?
3. Why are electrolytes important to our health?
4. **Analyze**: How do electrolytes work to conduct electricity? BE SPECIFIC
5. What are the two types of chemical bonds?
6. Compare: How are the two types of chemical bonds alike?
7. Contrast: How do the two types of chemical bonds differ?
8. **Compare:** How are the electrical processes that occur in our body like those of a battery?
9. **Evaluate:** Why are sports drink so popular?

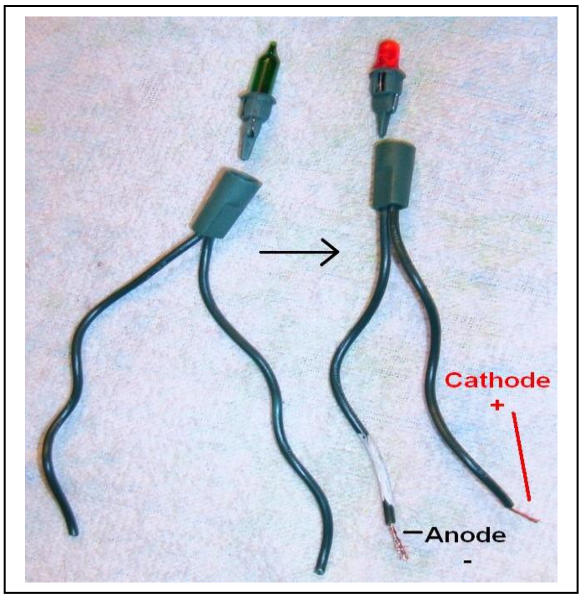
Light Challenge
Teacher Information Page

Objective: To provide students with an opportunity to problem solve and use previous knowledge to develop a system that lights a 2.4 v Christmas Light.

Time Needed: 1 Class Period

Materials: Battery pack, 2 Double A batteries, alligator clips, various metals: aluminum foil, zinc coated nails, iron nails, pennies, dimes, nickels, pencils, salt, distilled water, vinegar, heating source, potassium chloride, and other electrolytic solutes and solutions

Teacher Preparation:
Run off student pages, assemble materials, and cut Christmas lights apart as shown below



Teacher Background:
In the previous lab, students were given an opportunity to evaluate how ionic solutions found in sports drinks can be used to conduct electricity to light a 1.5 v led bulb. In this investigation students will be challenged to light a 2.4 v Christmas light using what they know about electrolytes, metal reactivity and changing the rate of a chemical reaction. You may wish to review the factors that affect the rate of chemical reactions as a starting point and then have the materials listed available for them to experiment with. The goal is that they design their own experiment and write their own procedure.

What factors influence the rate of a chemical reaction?

- Temperature
- Concentration of reactants
- Catalysts
- Surface Area of Solid Reactants
- Pressure of gaseous reactants or products

How does temperature affect the rate of a chemical reaction?
When two chemicals react, their molecules have to collide with each other with sufficient energy for the reaction to take place. This is collision theory. The two molecules will only react if they have enough energy. By heating the mixture, you will raise the energy levels of the molecules involved in the reaction. Increasing temperature means the molecules move faster. This is kinetic theory. If your reaction is between atoms rather than molecules you just substitute "atom" for "molecule" in your explanation.

How do catalysts affect the rate of a reaction?
Catalysts speed up chemical reactions. Only very minute quantities of the catalyst are required to produce a dramatic change in the rate of the reaction. This is really because the reaction proceeds by a different pathway when the catalyst is present. Adding extra catalyst will make absolutely no difference.
How does concentration affect the rate of a reaction?
Increasing the concentration of the reactants will increase the frequency of collisions between the two reactants. So this is collision theory again. You also need to discuss kinetic theory in an experiment where you vary the concentration. Although you keep the temperature constant, kinetic theory is relevant. This is because the molecules in the reaction mixture have a range of energy levels. When collisions occur, they do not always result in a reaction. If the two colliding molecules have sufficient energy they will react.

How does surface area affect a chemical reaction?
If one of the reactants is a solid, the surface area of the solid will affect how fast the reaction goes. This is because the two types of molecule can only bump into each other at the liquid solid interface, i.e. on the surface of the solid. So the larger the surface area of the solid, the faster the reaction will be.

What affect does pressure have on the reaction between two gasses?
You should already know that the atoms or molecules in a gas are very spread out. For the two chemicals to react there must be collisions between their molecules. By increasing the pressure, you squeeze the molecules together so you will increase the frequency of collisions between them.

Name: ________________________________ Date: _______________ Class: _________

Light Challenge

Challenge: To design a system that is capable of lighting a 2.4 v light bulb.

Before you begin, identify and explain the 5 factors that can affect the rate of a chemical reaction:

1.

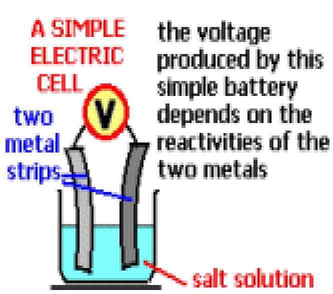
2.

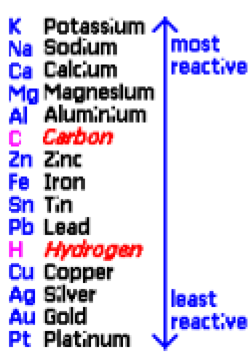
3.

4.

5.

Evaluate: Which of the factors identified do you feel would have the greatest affect on a battery? WHY?





- ✓ **Use the materials provided to create a system that lights the 2.4 v bulb. Draw a <u>detailed labeled</u> diagram of your assemblage below:**

- ✓ **Write a step-by-step procedure so that your experiment could be replicated**

Holey Rocks: A Pore Investigation
Teacher Information and Background

Objective: To provide students with a hands-on opportunity to discover how oil and natural gas are found within the earth.

Time Required: 1-2 class periods

Materials: per group

1 sample of cellulose sponge
1 sample of synthetic sponge
1 sample of sandstone
1 sample of shale
bottle of water with eyedropper
4-petri dishes
Student pages

Key Terms:

Porosity- the amount of pore space that a rock contains
Permeability- how connected the pore spaces in a rock are.
Source Rock- a metamorphic rock, usually shale, where oil and natural gas formed.
Reservoir rock- a sedimentary rock, usually sandstone, where oil and gas are held.
Fossil Fuel- an energy-rich substance formed from the remains of plants and microscopic organisms.

Teacher Preparation:
Assemble materials, run off student pages, and prepare demonstration

Useful Websites:
http://www.geomore.com/Oil%20and%20Gas%20Traps.htm
Nice background on formation and trapping

http://www.fas.org/irp/imint/docs/rst/Sect5/Sect5_5.html
Great resource on finding oil and natural gas from space here in Oklahoma

http://www.science.duq.edu/esm/Course_Material/ESM551/Notes_Only/Nonrenewable/nonrenewable.html
Background on mineral resources

http://hyperphysics.phy-astr.gsu.edu/hbase/organic/hydrocarbon.html
Background on hydrocarbons

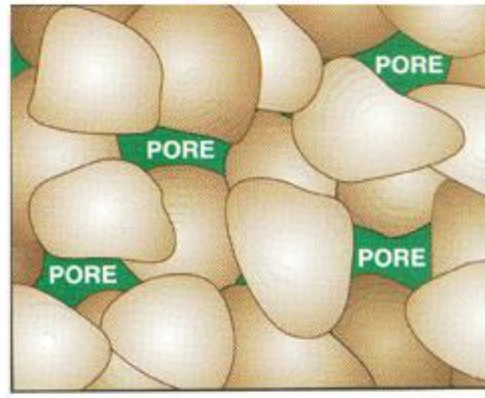
Teacher Information:

Hydrocarbons are another group of compounds. Unlike minerals, they are formed from organic matter and usually exist as liquids or gases. There is a common myth that oil and natural gas forms from the remains of dead dinosaurs and is found in large lakes or pools under the surface of the earth. This lab seeks to dispel these common myths by allowing students to actually investigate how oil and natural gas form and where they are held.

Students should notice that the pore spaces in the synthetic sponge are very small and the water does absorb into them very well until there is increased pressure put on it. On the other hand, the cellulose sponge quickly absorbs all of the water that is put on it. The synthetic sponge acts to model the source rock whose pore spaces are very small and unconnected. The cellulose sponge acts to model the reservoir rock whose pore spaces are connected. When the rock samples are introduced students should be able to easily identify which one is which based on the results of their investigation with the sponges.

Oil and Gas: Characteristics and Occurrence

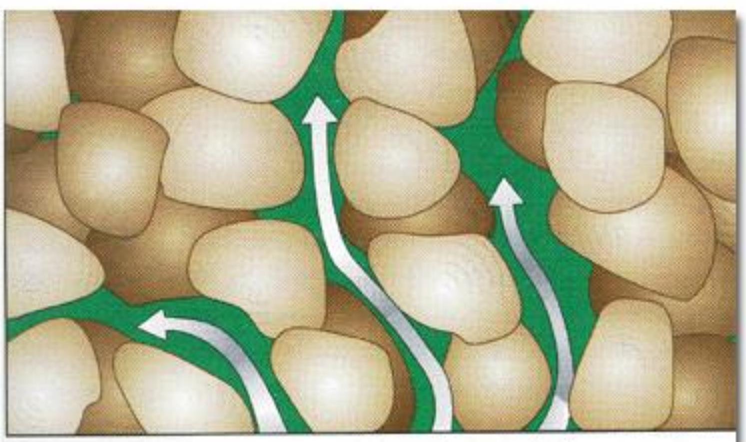
OIL AND GAS RESERVOIRS Hydrocarbons and their associated impurities occur in rock formations that are usually buried thousands of feet or metres below the surface. Scientists and engineers often call rock formations that hold hydrocarbons "reservoirs." Oil does not flow in underground rivers or pool up in subterranean lakes, contrary to what some people think. And, as you've learned, gasoline and other refined hydrocarbons do not naturally occur in pockets under the ground, just waiting to be drilled for. Instead, crude oil and natural gas occur in buried rocks and, once produced from a well, companies have to refine the crude oil and process the natural gas into useful products. Further, not every rock can hold hydrocarbons. To serve as an oil and gas reservoir, rocks have to meet several criteria.



A pore is a small open space

Characteristics of Reservoir Rocks: Nothing looks more solid than a rock. Yet, choose the right rock-say, a piece of sandstone or limestone-and look at it under a microscope. You see many tiny openings or voids. Geologists call these tiny openings "pores". A rock with pores is "porous" and a porous rock has "porosity." Reservoir rocks must be porous, because hydrocarbons can occur only in pores.

A reservoir rock is also permeable-that is, its pores are connected. If hydrocarbons are in the pores of a rock, they must be able to move out of them. Unless hydrocarbons can move from pore to pore, they remain locked in place, unable to flow into a well. A suitable reservoir rock must therefore be porous, permeable, and contain enough hydrocarbons to make it economically feasible for the operating company to drill for and produce them.


Connected pores give a rock permeability.

Origin and Accumulation of Oil and Gas To understand how hydrocarbons get into buried rocks, visualize an ancient sea teeming with vast numbers of living organisms. Some are fishes and other large swimming beasts; others, however, are so small that you cannot see them without a strong magnifying glass or a microscope. Although they are small, they are very abundant. Millions and millions of them live and die daily. It is these tiny and plentiful organisms that many scientists believe gave rise to oil and gas.

When these tiny organisms died millions of years ago, their remains settled to the bottom. Though very small, as thousands of years went by, enormous quantities of this organic sediment accumulated in thick deposits on the seafloor. The organic material mixed with the mud and sand on the bottom. Ultimately, many layers of sediments built up until they became hundreds or thousands of feet (meters) thick.

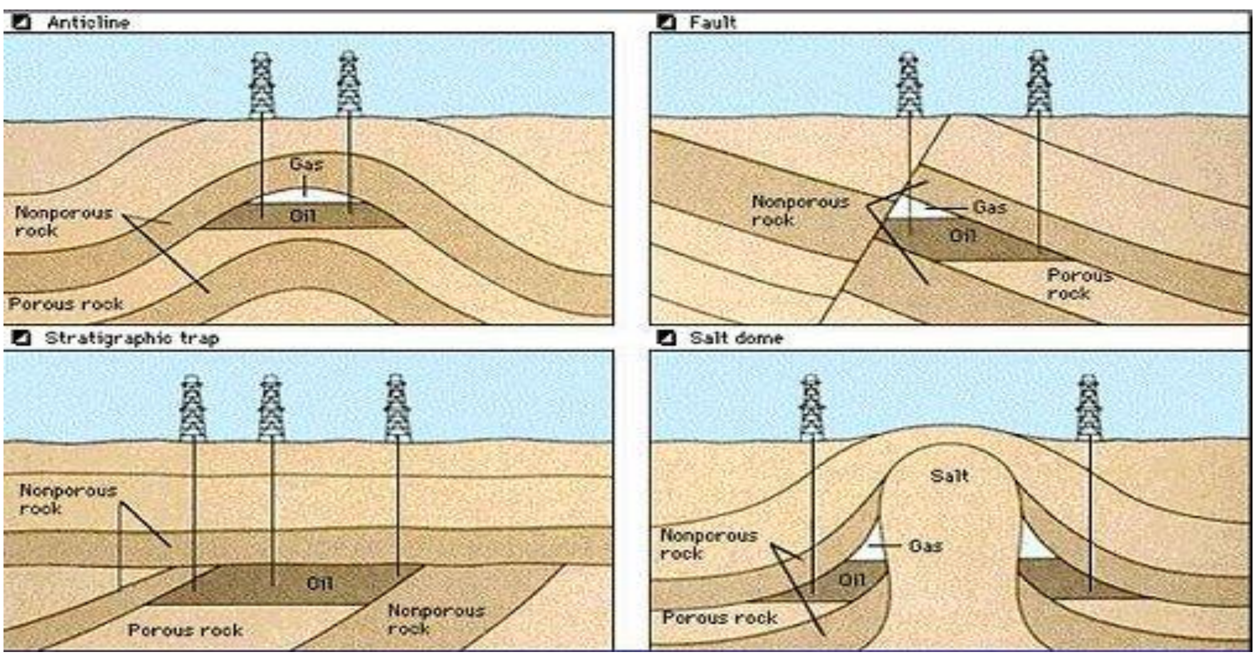
The tremendous weight of the overlying sediments created great pressure and heat on the deep layers. The heat and pressure changed the deep layers into rock. At the same time, heat, pressure, and other forces changed the dead organic material in the layers into hydrocarbons: crude oil and natural gas.

Meanwhile, geological action created cracks, or faults, in the earth's crust. Earth movement folded layers of rock upward and downward. Molten rock thrusted upward, altering the shape of the surrounding beds. Disturbances in the earth shoved great blocks of land upward, dropped them downward, and moved them sideways. Wind and water eroded formations, earthquakes buried them, and new sediments fell onto them. Land blocked a bay's access to open water, and the resulting inland sea evaporated. Great rivers carried tons of sediment; then dried up and became buried by other rocks. In short, geological forces slowly but constantly altered the very shape of the earth. These alterations in the layers of rock are important because, under the right circumstances, they can trap and store hydrocarbons.

Even while the earth changed, the weight of overlying rocks continued to push downward, forcing hydrocarbons out of their source rocks. Seeping through subsurface cracks and fissures, oozing through small connections between rock grains, the hydrocarbons moved upward. They moved until a subsurface barrier stopped them or until they reached the earth's surface. Most of the hydrocarbons, however, did not reach the surface. Instead, they became trapped and stored in a layer of subsurface rock. Today, the oil industry seeks petroleum that was formed and trapped millions of years ago.

Petroleum Traps A hydrocarbon reservoir has a distinctive shape, or configuration, that prevents the escape of hydrocarbons that migrate into it. Geologists classify reservoir shapes, or traps, into two types: structural traps and stratigraphic traps.

Structural Traps Structural traps form because of a deformation in the rock layer that contains the hydrocarbons. Two examples of structural traps are fault traps and anticlinal traps

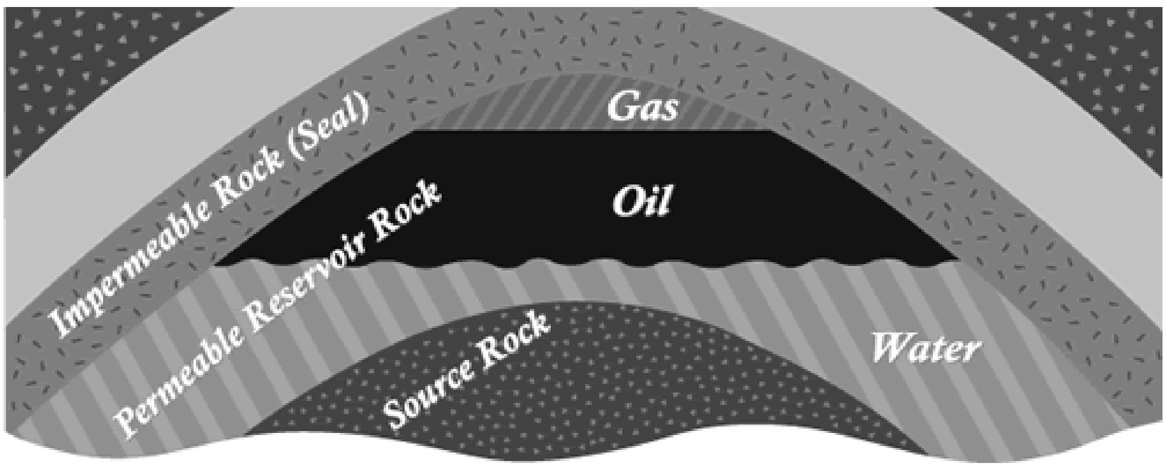


This demonstration can be used prior to the lab to introduce new vocabulary and the process that forms oil and/or natural gas:

1) Fill a large clear container with about 4-cm of water.
2) Add blue food coloring to model the ocean
3) Add colored sugar crystals to model the plankton.
4) Have students observe where the sugar crystals go as they model dying.
5) Have several synthetic sponges cut into small cubes and fill the bottom with them to model sediments.
6) Put pressure on the sponges until the have soaked up the water to model how the water and plankton are held in the pore spaces.

7) Have the inner layer of a disposable diaper that contains the super-absorber crystals in it accessible and use it to cover the layer of sponges that now contain water and sugar crystals.
8) Exert more pressure on the layer of disposable diaper and point out to students that the liquid in the sponges is being forced into the layer of disposable diaper. This models migration.
9) Add several more layers of sponge and exert pressure. The liquid will not move out of the diaper. It is held there in much the same way the pore spaces in a sedimentary rock hold oil and natural gas.

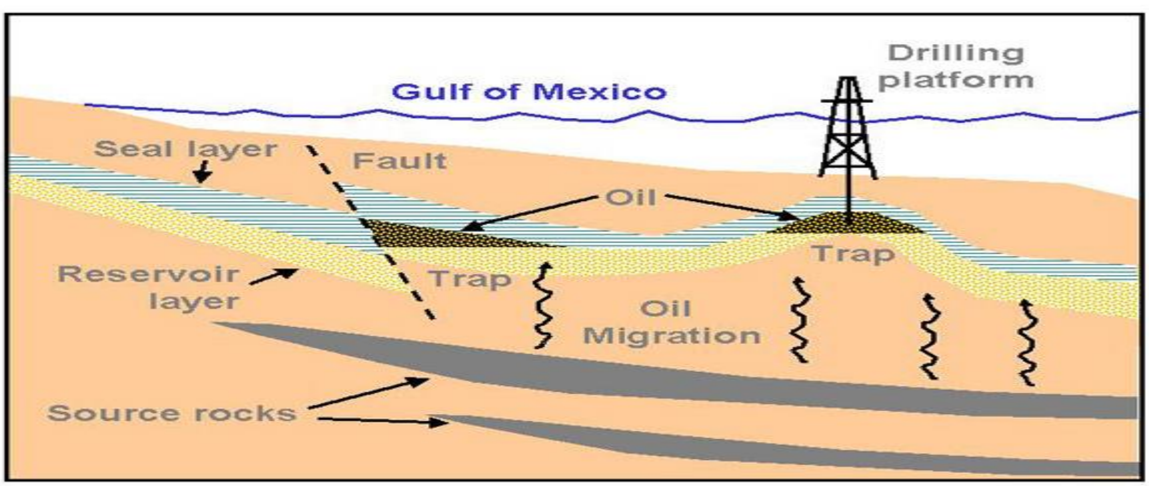
When the demonstration is complete question students as to the path that the water and sugar crystals took. Then introduce the vocabulary stating that the layer of sediments that the oil and natural gas formed in is known as the source rock. Because additional sediments cover it the oil is squeezed upwards into the reservoir rock where it is held until we locate it and drill it out of the ground. The processes that allowed plankton to become oil and natural gas are not very common so that all plankton did not become a fossil fuel. The diagram below also can be used to illustrate where oil and natural gas are found.



The source rock is the place where, millions of years ago, tiny sea plants and animals—called phytoplankton and zooplankton—lived, died, and were preserved. Source rock contains the source of the hydrocarbon. Shale is a common source rock.

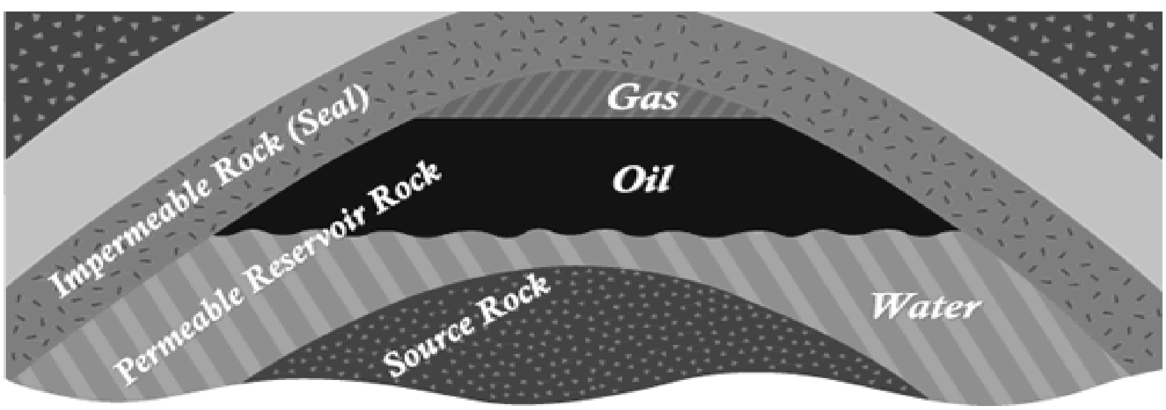
The reservoir rock is a layer of permeable sedimentary rock, usually sandstone or limestone. The gas migrates into the pores of the reservoir rock.

The seal is a dome-shaped layer of impermeable rock, often made of granite, above the reservoir rock that traps the gas and keeps it from moving upward. The seal is also called a cap rock.



Holey Rocks, A Pore Investigation
Student Background and Procedure

Background Information: Some extinct life forms become fossils, some leave no evidence to mark their presence, and some become the fuels that we use to heat our homes and drive our cars. It is this last group that we will focus on today. They are known as *fossil fuels*. Fossil fuels are energy-rich substances formed from the remains of plants and microscopic organisms, such as plankton, that inhabited ancient seas or swamps over 200 million years ago. Because there was little oxygen in the atmosphere at this time as these life forms died they went through chemical changes transforming them into fossil fuels instead of decomposing or fossilizing them. The three most common fossil fuels are coal, oil, and natural gas. Coal formed as dead organic material found in swamps formed layers, was put under pressure, was compacted and cemented together to make a sedimentary rock. Because oil and natural gas do not exist as solids the processes that formed them are different. However; most oil and natural gas deposits are found in underground layers of sedimentary rock. You might questions how oil and natural gas can be part of a rock. It is because sedimentary rock is made up of many different shaped particles that when cemented together do not fit together tightly creating tiny spaces between their individual sediments. These spaces are known as *pores*. Pores can be filled with air, water, and in some cases, oil or natural gas. The amount of pore space a rock contains is known as its *porosity*. Very porous sedimentary rocks, such as sandstone, make an excellent home for oil and natural gas. This rock that holds the oil or natural gas is known as the *reservoir rock*. The reservoir rock also possesses another characteristic: it is *permeable.* The *permeability* of a rock is determined by how well connected the pore spaces in the rock are. Because reservoir rock contains pore spaces that are well connected we can retrieve the valuable resource in much the same way as you retrieve the soda from a cup using a straw. As you put you mouth onto a straw you change the amount of pressure exerted by the air on the soda; as a result, the soda is forced upwards into your mouth. When we drill for oil or natural gas we insert a hollow tube with a drill bit on its end into the earth allowing the oil or natural gas to flow to the surface through the well connected pore spaces in the rock.



How the oil and natural gas formed is another story that began over 200 million years when the earth was young and consisted mostly of shallow seas. These ancient seas were teeming with different species of aquatic life including microscopic plankton. As the plankton died it sank to the bottom. In areas where the water was deep or sheltered by basins the dead plankton accumulated in layers, and a lack of oxygen prevented them from decomposing. Other sediments gradually buried the plankton, piling up at a rate of perhaps 1/10 of an inch per year. Once there was about 1,000 feet of overlying sediments, the organic material in the plankton began to transform into a waxy compound known as kerogen. The inorganic sediments compacted and cemented together to form layers of sedimentary rock which were then driven further into the earth as new sediments put pressure on them. Next, the extreme heat and increased pressure within the earth cooked the kerogen transforming it into the fossil fuels we use today.

Because fossil fuels are made up of the elements hydrogen and carbon, they are also known as *hydrocarbons***.** The rock where the hydrocarbons form from kerogen is known as the *source rock* as it is the origin of the fossil fuel. A very common source rock is shale. Shale is a metamorphic rock made up of very fine sediments that have been squeezed very tightly together eliminating most of it pore spaces. Earlier you were informed that fossil fuels are found in the pore spaces of a reservoir rock that is sedimentary. Now you read that the rock it forms is metamorphic. Which is right? Remember that sedimentary rock becomes metamorphic rock as it is buried deeper within the earth where it is subjected to much greater temperatures and pressure. So, as the source rock is buried deeper within the earth, the oil and/or natural gas it contains is squeezed upwards as its pore spaces are eliminated into the next layer of rock. Because this layer is not under as much pressure its pore spaces are still open allowing it to become reservoir of the oil and natural gas. This process that forces the oil and natural gas upwards is known as *migration*. Migration stops when it hits a layer of impermeable rock, such as igneous, that has no pore spaces and acts to *trap* or *seal* the oil within the ground until engineers reveal its location. Because this process takes millions of years, fossil fuels are classified as non-renewable resources. In today's investigation we will evaluate the porosity and permeability of two different types of sponges to determine which would models a source rock and which models a reservoir rock.

Research Question: How can I model the two types of rock that are the source and reservoir of oil and natural gas?

Materials: 2 sponge samples, 2 rock samples, water, and eyedropper, a hand lens, 4 petri dishes, a clock, student procedure and investigation

Procedure:

1. Use the background information to answer the pre-lab questions.
2. Examine both samples of sponge and predict which one will model the reservoir rock and which will model the source rock.
3. Record your predictions in the table beside the label Predicted Model.
4. Use the dropper and drop 15 drops of water into the middle of the orange or red sponge sample.
5. Let sample with water stand for 1 minute and record your observations in the table beside the label 1- Minute.
6. Add 15 more drops of water and let stand 1 minute. Record your observations in the table beside the label 2- minutes.
7. Add 15 more drops of water to the sample and let it stand for 1 minute. Record your observations in the table beside the label 3- minutes.
8. Add 15 more drops of water to the sample and record your observations in the table beside the label 4- minutes.
9. Repeat steps 4 - 8 for the yellow sponge.
10. Based on your investigation answer the Post-Investigation Conclusions.
11. Raise your hand to acquire your rock samples from your teacher.
12. Examine them closely and predict which one is the reservoir rock and which is the source rock. Record your predictions in the space provided.
13. Test your predictions by adding 5 drops of water to each one.
14. Use your experiences and the background information to answer the conclusion questions regarding this investigation.

Name: _____________________________ Date: ________________ Hour: _______

Holey Rocks, A Pore Investigation Student Lab Page

Pre-Lab Questions:

1. Where are most oil deposits found? _______________________________________
2. What is porosity? ____
3. What is permeability? ____
4. What is a reservoir rock? ____
5. What is a source rock? ____
6. How does the oil go from the source rock to the reservoir rock? ____
7. Does the source or reservoir rock contain larger pore spaces? ______________

Observing Sponges

Sample A-	**Sample B-**
Predicted model-	Predicted model-
Observations	**Observations**
1 min:	1 min:
2 min:	2 min:
3 min	3 min:
4 min:	4 min:

Post- Investigation Conclusions:

1. Which sponge held the most water? _______________________________________
2. Does it model the source or reservoir rock? ________________________________
3. Put pressure on the sponge that did not absorb as much water. What

   happened?____

4. Does it model the source or reservoir rock? ________________________________

Observing Rocks: Identify each sample as a source or reservoir rock

Rock Sample A	**Rock Sample B**
Predicted Type:	Predicted Type:
Concluded Type:	Concluded type:

Conclusion Questions:

1. What is a fossil fuel? ____

2. What are fossil fuels formed from? ____

3. What are the three main types of fossil fuels? _____________, ______________,

   and __________________________________

4. Which elements are they made of? ____

5. What type of process formed them? ____

6. Why didn't they become fossils or decompose? ___________________________________

7. How does coal form? ____

8. Based on the background information, sequence the following steps that transformed ancient sea life into fossil fuels.

Step	Process
	As the plankton died it accumulated in layers in areas where the water was very deep or protected by basins which prevented them from decomposing.
	Kerogen is transformed into oil and/ or natural gas through a chemical process and
	1,000 feet of sediment cover the layer of dead plankton pushing it further into the earth.
	More than 200 million years ago shallow seas covered most of the earth. These shallow seas were teeming with many different living organisms including microscopic plankton.
	The organic material in the plankton began to transform into kerogen while the layers of inorganic sediment became sedimentary rock.
	The source rock is changed into metamorphic rock as it is put under extreme heat and pressure within the earth causing the fossil fuel to migrate upwards into the reservoir rock.
	Other layers of sediment cover the sedimentary rock and kerogen deeper into the earth
	Oil and/ or natural gas are held in the pore spaces of the reservoir rock until found.

9. How do we get oil and natural gas out of the ground?

10. Why are Oil and natural gas are commonly found together?

    If you were drilling, which would you hit first? WHY?

11. A standard barrel of oil has a capacity of 205 liters which when processed yields 95.5 liters of gasoline. If a car uses 4 liters of gasoline everyday for a year, how many liters would that car use in one year?

    How many barrels of oil would be it take to produce that much gasoline? (SHOW WORK)

12. Which type of resource are fossil fuels considered to be? SUPPORT YOUR ASNWER

Web-Based activity:

Name: ______________________________ date: __________________ Block: ________

Oklahoma's Mineral Resources

Procedure: Go to the website shown below:

http://www.odl.state.ok.us/almanac/2005/17-wildlfe.pdf

Find the page/s that talk about Oklahoma's Minerals and Mineral Resources and then list the names of all the minerals that can be found in Oklahoma in the table: You will need to use additional websites to find the uses for these resources:

Name of Resource	Type of Mineral Product	What it is used for

Just the facts: Find the name of the any mineral resources that we rank in the production of and write them here:

Write down any other interesting information you found related to Oklahoma's mineral resources:

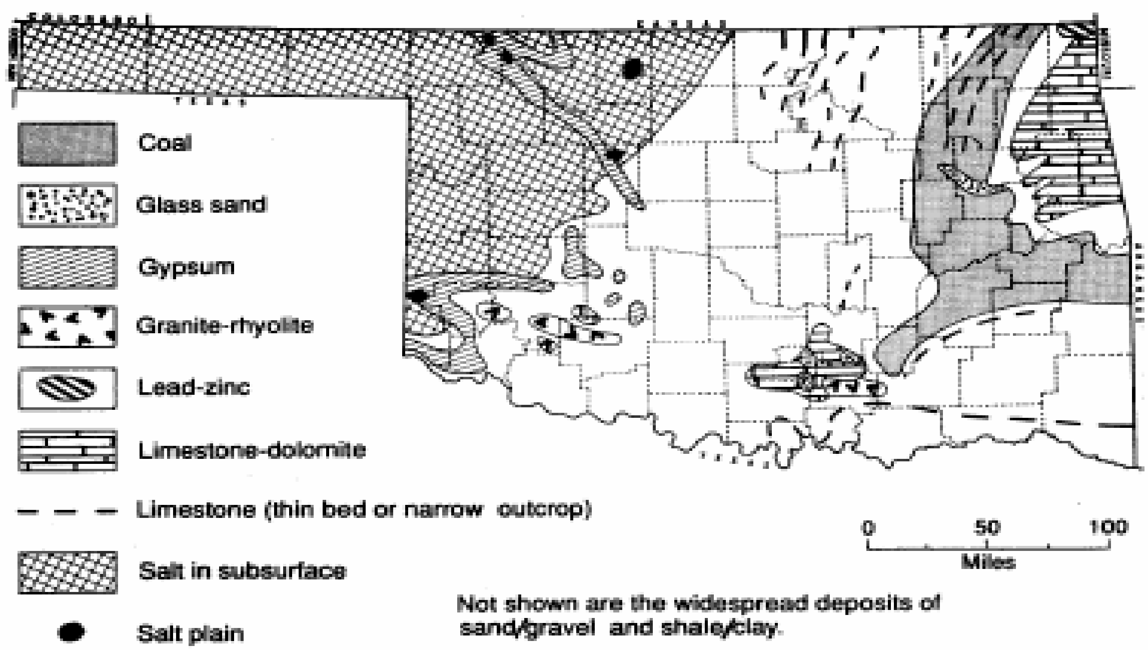


Figure 1. Selected nonpetroleum-mineral resources of Oklahoma.

Analyze: Which mineral resources are found near you?

Infer: Where did our mineral resources come from?

Fossil Fuel Poster

Teacher Information

Objective: To provide students with an opportunity to compile, evaluate, and communicate information related to fossil fuels

Time Required: 1 Class Period

Teacher Preparation:
Run off student pages and decide what criteria your posters should contain

Useful Websites:

http://reenergizekc.org/wp-content/uploads/2007/05/petroleumproductslist.pdf
petrochemical information

http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html
Energy page for kids

http://www.ogs.ou.edu/fossilfuels/pdf/EP-9O&Gpdf.pdf
Information on Oklahoma's Oil and Natural Gas resources with map

Teacher Background: and Resources
Most textbook have a section on hydrocarbons or organic chemistry, if not, there are a plethora of web resources and books in the library. Since the oil and natural gas industry are vital to our state, providing students with an opportunity to research and educate others through a poster presentation is a optimal learning opportunity.

Hydrocarbon basics:

How hydrocarbons Convert Energy

$$C_nH_{2n+2} + \frac{3n+1}{2}O_2 \longrightarrow nCO_2 + (n+1)H_2O + \text{Energy}$$

Hydrocarbon Oxygen Carbon Dioxide Water

Petroleum (oil and natural gas) consists of many different such hydrocarbons, but the most important of these are a group known as the paraffins. ***Paraffins*** have the general chemical formula:

$$C_nH_{2n+2}$$

As the value of n in the formula increases, the following compounds are produced:

n	Formula	Compound	Use
1	CH_4	methane	Natural Gas
2	C_2H_6	ethane	
3	C_3H_8	propane	
4	C_4H_{10}	butane	
5	C_5H_{12}	pentane	Gasoline
6	C_6H_{14}	hexane	
7	C_7H_{16}	heptane	
8	C_8H_{18}	octane	
9	C_9H_{20}	nonane	
>9	various	various	Lubricating Oils, Plastics

When we extract petroleum containing these compounds and add oxygen to it, either in furnaces, stoves, or carburetors the following reaction takes place:

Comparing and Contrasting Fossil Fuels To use in a Venn Diagram

Characteristic	Coal	Oil	Natural Gas
Made up of the elements hydrogen and carbon			
Exists as a solid			
Exists as a liquid			
Exists as a gas			
Is a compound			
Formed from the remains of plants that lived in ancient swamps			
Formed from the remains of ancient protists, algae and other small animals that lived in oceans and shallow seas			
Found in the pore spaces of sedimentary rocks like sandstone and limestone			
Forms as a sedimentary rock			
Contributes to the greenhouse effect through CO_2 emissions			
Is found using sound waves			
Most plentiful fossil fuel in the United States			
Made from organic materials			
Classified as a nonrenewable resource			
Found in Oklahoma			

A partial list of products made from Petroleum (144 of 6000 items)

One 42-gallon barrel of oil creates 19.4 gallons of gasoline. The rest (over half) is used to make things like: http://www.ranken-energy.com/Products%20from%20Petroleum.htm

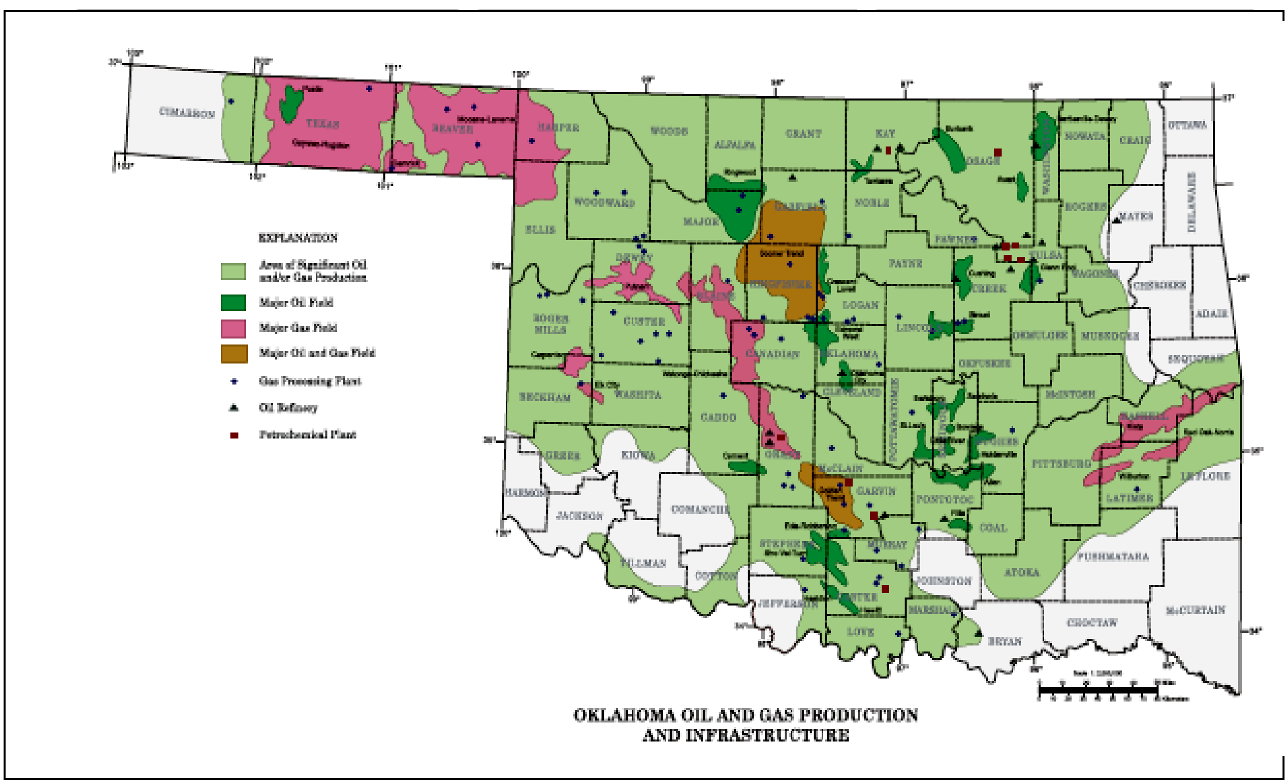
Solvents	Diesel	Motor Oil	Bearing Grease
Ink	Floor Wax	Ballpoint Pens	Football Cleats
Upholstery	Sweaters	Boats	Insecticides
Bicycle Tires	Sports Car Bodies	Nail Polish	Fishing lures
Dresses	Tires	Golf Bags	Perfumes
Cassettes	Dishwasher	Tool Boxes	Shoe Polish
Motorcycle Helmet	Caulking	Petroleum Jelly	Transparent Tape
CD Player	Faucet Washers	Antiseptics	Clothesline
Curtains	Food Preservatives	Basketballs	Soap
Vitamin Capsules	Antihistamines	Purses	Shoes
Dashboards	Cortisone	Deodorant	Footballs
Putty	Dyes	Panty Hose	Refrigerant
Percolators	Life Jackets	Rubbing Alcohol	Linings
Skis	TV Cabinets	Shag Rugs	Electrician's Tape
Tool Racks	Car Battery Cases	Epoxy	Paint
Mops	Slacks	Insect Repellent	Oil Filters
Umbrellas	Yarn	Fertilizers	Hair Coloring
Roofing	Toilet Seats	Fishing Rods	Lipstick
Denture Adhesive	Linoleum	Ice Cube Trays	Synthetic Rubber
Speakers	Plastic Wood	Electric Blankets	Glycerin
Tennis Rackets	Rubber Cement	Fishing Boots	Dice
Nylon Rope	Candles	Trash Bags	House Paint
Water Pipes	Hand Lotion	Roller Skates	Surf Boards
Shampoo	Wheels	Paint Rollers	Shower Curtains
Guitar Strings	Luggage	Aspirin	Safety Glasses
Antifreeze	Football Helmets	Awnings	Eyeglasses
Clothes	Toothbrushes	Ice Chests	Footballs
Combs	CD's	Paint Brushes	Detergents
Vaporizers	Balloons	Sun Glasses	Tents
Heart Valves	Crayons	Parachutes	Telephones
Enamel	Pillows	Dishes	Cameras
Anesthetics	Artificial Turf	Artificial limbs	Bandages
Dentures	Model Cars	Folding Doors	Hair Curlers
Cold cream	Movie film	Soft Contact lenses	Drinking Cups
Fan Belts	Car Enamel	Shaving Cream	Ammonia
Refrigerators	Golf Balls	Toothpaste	Gasoline

Americans consume petroleum products at a rate of three-and-a-half gallons of oil and more than 250 cubic feet of natural gas per day each! But, as shown here petroleum is not just used for fuel.

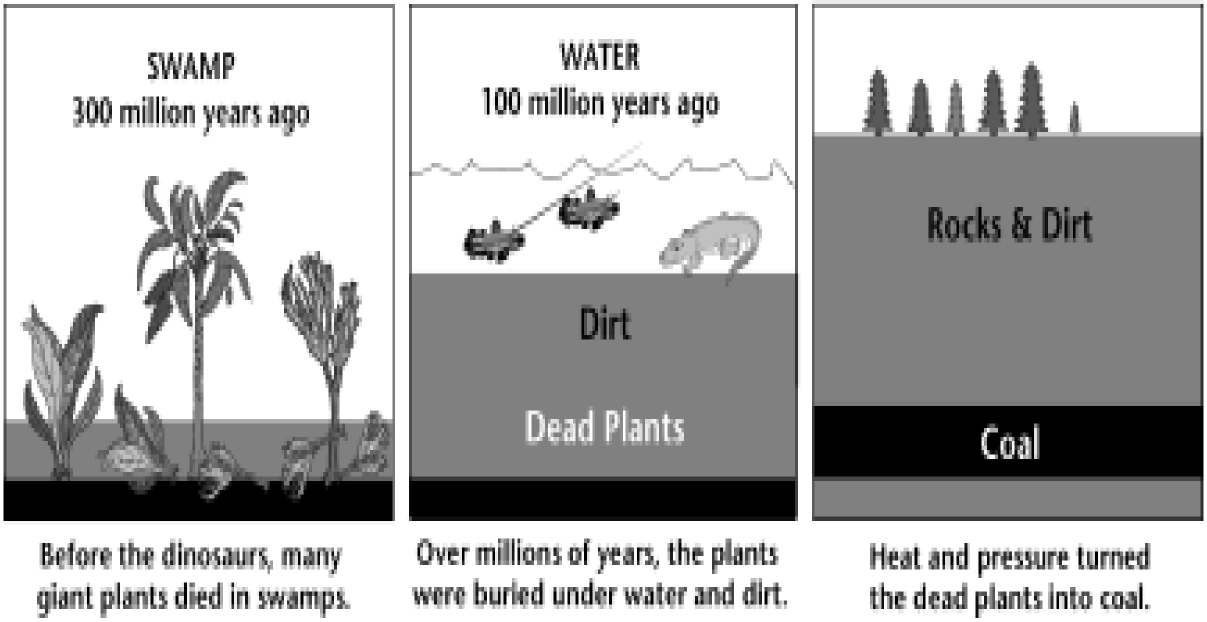
Energy Content of Fuels (in Joules)

Energy Unit	Joules Equivalent (S.I.)
gallon of gasoline	1.3×10^{8}
AA battery	10^{3}
standard cubic foot of natural gas (SCF)	1.1×10^{6}
candy bar	10^{6}
barrel of crude oil (contains 42 gallons)	6.1×10^{9}
pound of coal	1.6×10^{7}
pound of gasoline	2.2×10^{7}
pound of oil	2.4×10^{7}
pound of Uranium-235	3.7×10^{13}
ton of coal	3.2×10^{10}
ton of Uranium-235	7.4×10^{16}

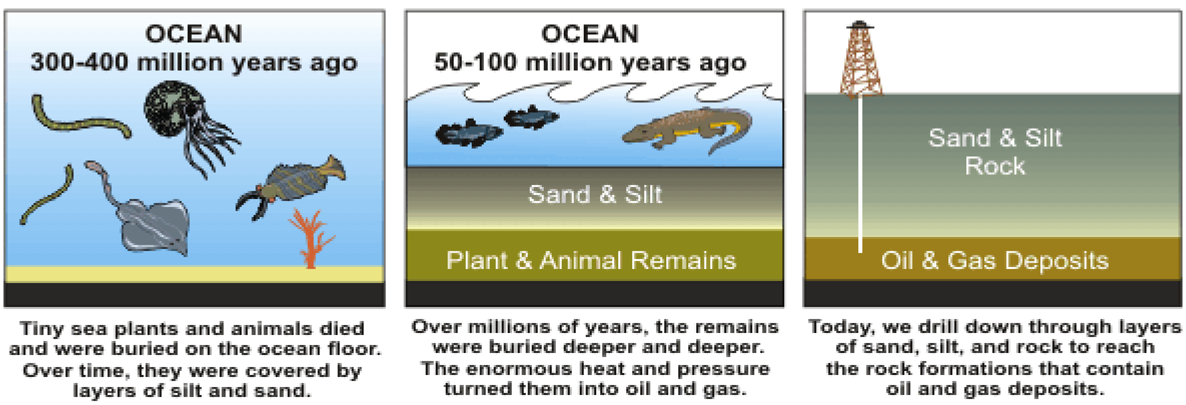
PETROLEUM & NATURAL GAS FORMATION



HOW COAL WAS FORMED



PETROLEUM & NATURAL GAS FORMATION



What are minerals used for? (Related article)

by Carl Ege

The importance of minerals in everyday life is hardly recognized by the vast majority of people. According to the U.S. Bureau of Mines, the average person consumes or uses 40,000 pounds of minerals every year. Over the course of a lifetime, an individual will use more than 1,050 pounds of lead, 1,050 pounds of zinc, 1,750 pounds of copper, 4,550 pounds of aluminum, 91,000 pounds of iron and steel, 360,500 pounds of coal, and one million pounds of industrial minerals such as limestone, clay, and gravel.

To help illustrate how important minerals are to us, perhaps a trip through a normal working day of a geologist will better explain our reliance on minerals.

Morning

As we wake up in the morning from a restless night of sleep - dreaming of piles of paperwork at the office, we turn off our alarm clock (manufactured from limestone, mica, talc, silica, and clays). After getting out of bed (bed frame and bed springs made from iron and nickel), we make our way into the kitchen. We turn on the electric light switch (copper, aluminum, and petroleum products) and the coffee pot, which is made of glass or ceramics (silica sand, limestone, talc, and feldspar). While waiting for the coffee (coffee beans fertilized with phosphate) to brew, we sit down on a chair (aluminum and petroleum products) and read the local newspaper (kaolin clay, limestone, sodium sulfate, and soda ash). As usual, we don't find any interesting articles concerning geology so we daydream of the time when we can finally try out our new pair of skis (graphite) and boots (limestone, talc, clay, mica, and petroleum products).

Thinking about what happened to our previous pair of skis (broken in half after they fell out of the ski rack and were run over by a truck on the freeway), we develop an upset stomach. We decide to take Milk of Magnesia (magnesium and dolomite) or Kaopectate (kaolin clay) for relief of our upset stomach.

We look up at the clock (silica sand, steel, and petroleum products) and hurry upstairs on the bright neon green carpeted floor (limestone, selenium, and petroleum products). We jump in the shower (made of ceramic tiles that are composed of silica sand, limestone, talc, and feldspar) and turn on the water (softened by halite). We adjust the shower head and turn the water faucets (iron, nickel, chromium) for warm water. Remembering that this house has no warm water, we take a quick cold shower, using soap (talc) and shampoo (coal tar, lithium clays, and selenium) to clean ourselves.We get out of the shower and brush our teeth with a toothbrush (limestone, mica, talc, clays, and petroleum products) and toothpaste (limestone, phosphate, gypsum, selenite, fluorite, and dolomite).

On the way to work

The truck we drive is composed of many different components that were manufactured from minerals. The tires are made from limestone and clay. All of the glass in the truck is made from silica sand and feldspar. The rusted body of the truck (including the bumper) is made from iron, limestone, mica, talc, silica, clays and petroleum products. The automobile engine and other components under the hood are made out of iron, lead, molybdenum, chromium, nickel, aluminum, and zinc. The red paint flaking off of our truck is made of titanium, kaolin clays, mica, talc, gypsum, sulfur, silica, and limestone.

At work in the field

First, we decide to use our laptop computer (gold, silica, nickel, aluminum, zinc, iron, petroleum products, and thirty other minerals) and digital topographic map software on CD-ROM (aluminum and petroleum products) to help guide us to the correct field location. Once we get to the field area, we begin by pulling out a field notebook (kaolin clay, limestone, and soda ash). We begin writing preliminary information, such as latitude/ longitude coordinates we obtained from our Global Positioning System (silica, mica, clay, limestone, and talc) with our pencil (graphite and clays) or pen (limestone, mica, clays, silica, talc, and petroleum products).

We see an interesting rock and decide to use our hammer (iron and nickel) and break off a chunk for analysis. For safety, we put on our safety goggles (silica, talc, clays, and mica). We get out our hand lens (iron ore and silica) and view the mineral content of the rock closely. Next, we find our hydrochloric acid (halite) to test for the calcium carbonate content of the minerals. We also pull out our ceramic scratch plate (silica sand, limestone, talc, lithium, and feldspar) to check the streak of the mineral.

Finally, we decide to use our camera (silica and petroleum products) and film (silver and petroleum products) and take several pictures of the rock outcrop. When we feel like we have analyzed the outcrop thoroughly, we load up the truck and head for home.

Evening

When we get home at night, we decide to warm up a meal in the microwave oven (silica, copper, gold, iron, and nickel) and enjoy some refreshments (filtered through perlite or diatomite). These refreshments are served in a glass or ceramic mug (silica, limestone, and feldspar). Our day ends with us falling asleep in front of the television (silica, iron, copper, aluminum, and nickel).

In summary

A day in the life of a geologist may seem a little strange to some, but there are similarities among all of us in other professions or fields. Everyone relies heavily on minerals to do their job and in their daily life. So, the next time you drive a car or work on the computer at the office, think about how important minerals are to us. What would we do without them?

I'm All Shook UP
Teacher Information and Background

Objective: To provide students with an opportunity to use data to make a model that communicates earthquake frequency here on Oklahoma in order to evaluate and analyze why we have them.

Time Needed: 1 class period

Materials: Colored pencils and student pages

Useful Websites:

http://earthquake.usgs.gov/regional/states/?region=Oklahoma
Links to many data sheets, maps, and background

http://www.okgeosurvey1.gov/
Oklahoma Geologic Survey

http://www.ogs.ou.edu/pdf/okearthquakes2005.pdf
Everything you need to know about earthquakes in Oklahoma

http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/15/c5/13.pdf
Seismic Sleuths a 326 page curriculum developed by FEMA> Great activities. I especially like the Wattsville quakes activity on page 162

Teacher Background:

Before the recent onslaught of earthquakes, most students were unaware that they occurred in our home state. This lab provides them an opportunity to use data to discern where and why we have earthquakes and whether or not we should get ready for a big one.

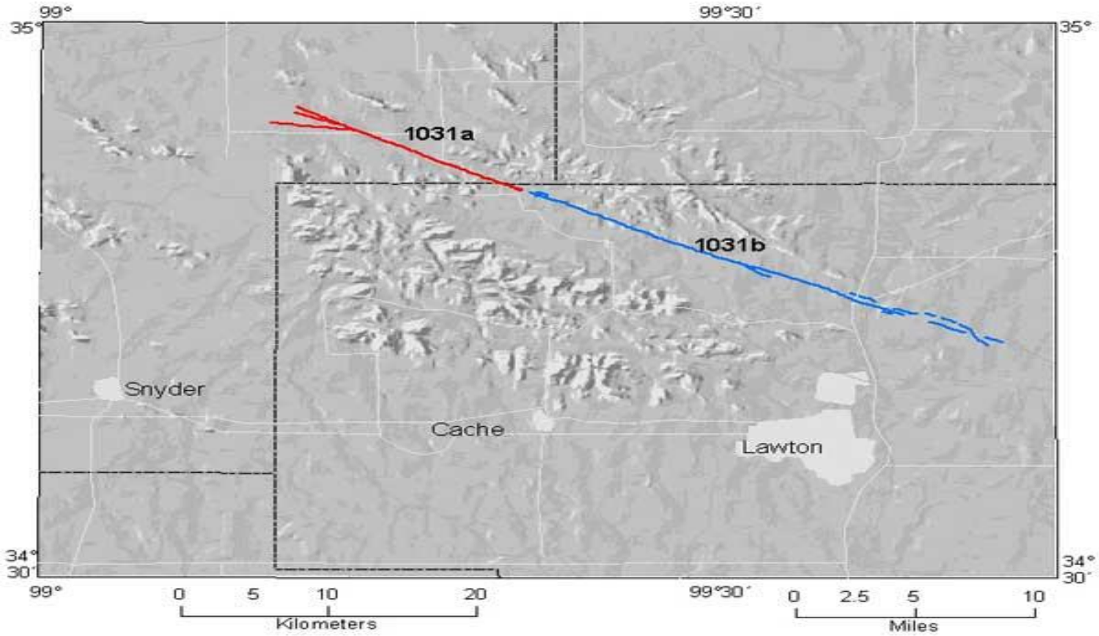
http://www.museumgreatplains.org/lawtoncentennial/meersfault.html

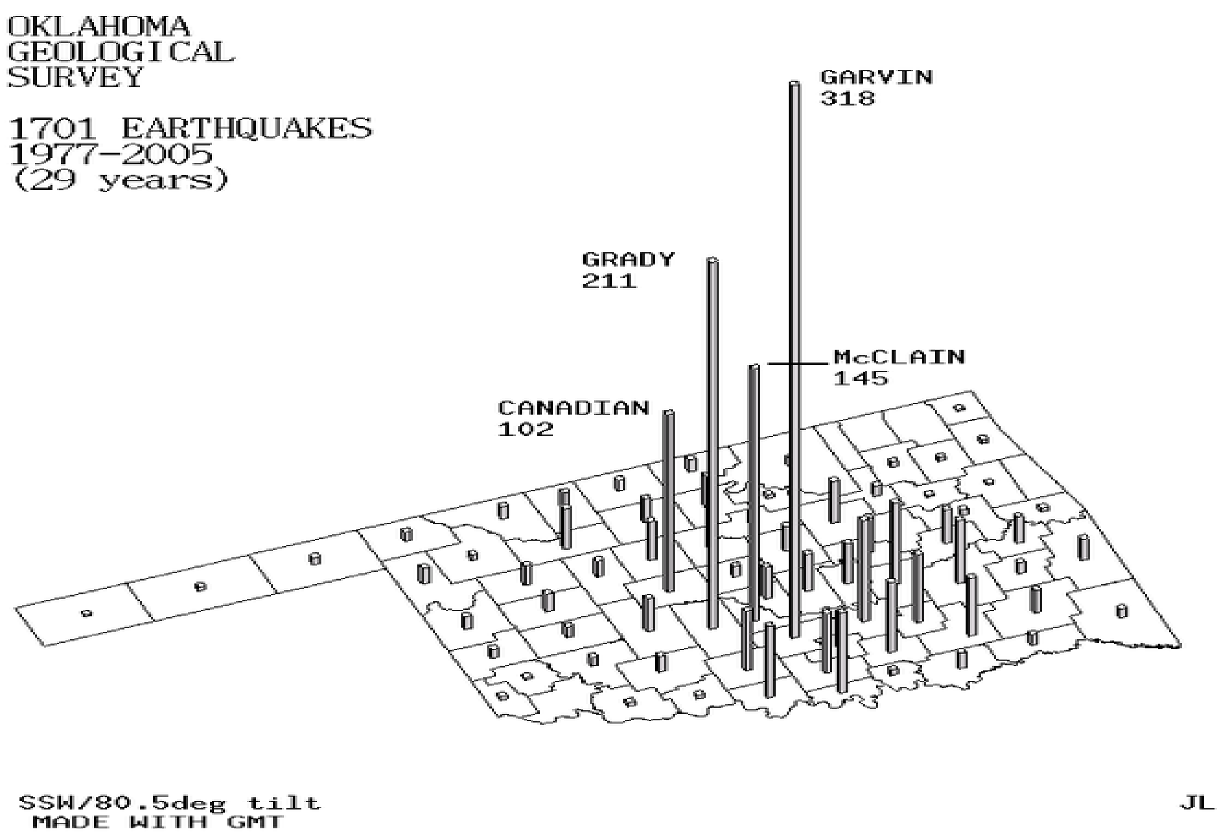
California has earthquakes! Alaska has earthquakes! Oklahoma has earthquakes, too! They come in different sizes. The power of a quake is called the magnitude of the quake. How much the ground shakes determines the power of a quake. Earthquakes are often caused when energy deep inside the Earth is suddenly released. The sudden release of energy happens along fault lines. Faults are fractures in the crust of the Earth.

The Meers fault is a crack in the earth's crust. The 15-mile-long fault can be seen from the air. This fault is special. It is the only fault that breaks the surface of the Earth east of the Rocky Mountains. The fault is a part of the Wichita Mountains, the oldest mountains in North America. Once they were higher than the Rocky Mountains. But as the wind blew and the rain fell for millions of years, they were worn down.

The Oklahoman Geological Survey put a seismograph in the Meers Store in May, 1985. The seismograph records what is happening in the Meers Fault. The seismograph is able to feel movement in the Earth from far away. It one of the best seismographs in the country. It has recorded earthquakes in the Indian Ocean, more than 10,300 miles away from Meers. The seismograph has recorded Russian nuclear tests, a natural gas explosion in Texas, and a mine accident in Michigan

Meers Fault

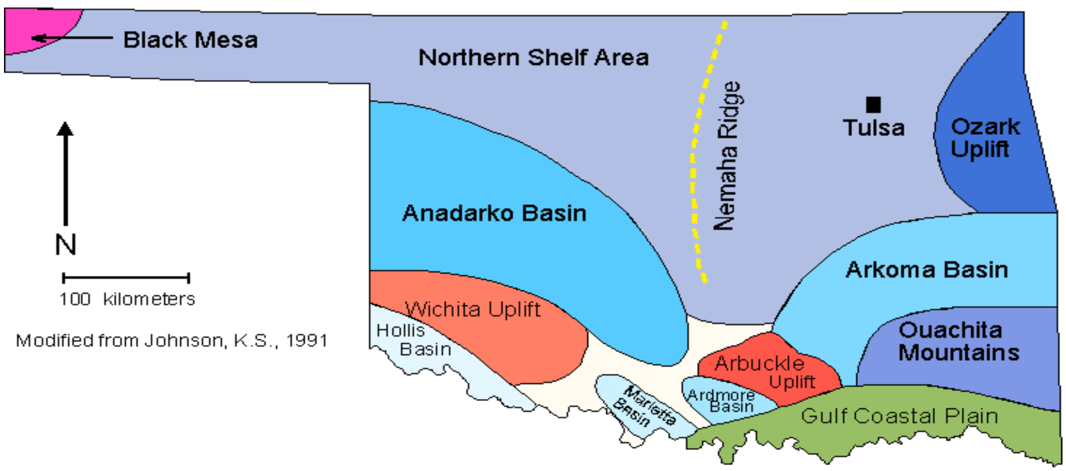




I'm All Shook Up

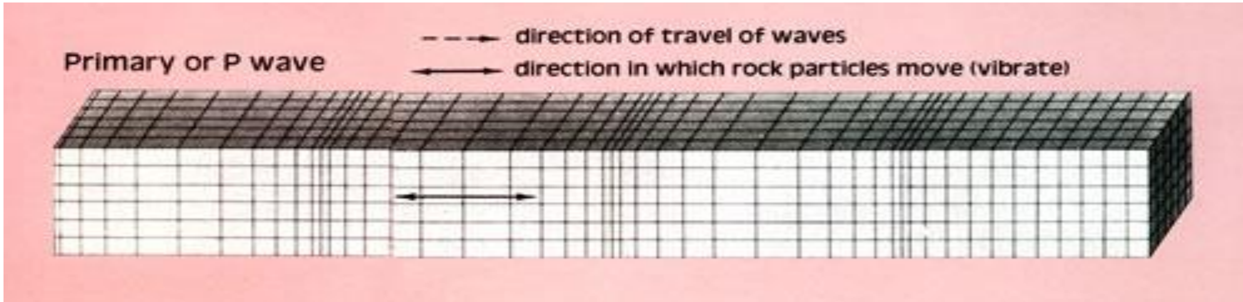
Background Information: Few things come close to matching the kinetic energy released during an earthquake. Earthquakes provide an example of what happens when forces put the earth's tectonic plates into motion. It may seem odd to talk about earthquakes here in Oklahoma until you realize that Oklahoma lies in the middle of one of the three most active earthquake zones east of the Rockies. In fact, Oklahoma averages between 50 and 100 recorded locatable earthquakes each year. An **earthquake** is a movement of the earth's crust wherein stored potential energy is converted into kinetic energy due to a force. Remember that a **force** is a push or a pull that causes a body to move. Earthquakes in Oklahoma occur as a result of crustal movement along inter-crustal fault zones as the crust is pushed up along the Nemaha and Wichita uplifts.

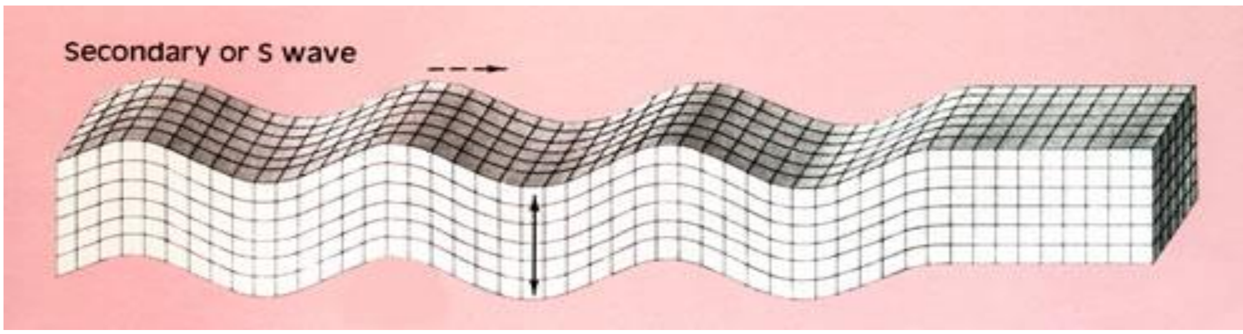
Generalized geologic provinces of Oklahoma



A **fault** is a crack in the earth's crust caused by movement. Because the crust is made of rock, it cannot move very much without breaking, when it breaks we call this a fracture or a fault. Oklahoma has thousands of faults. So what causes the faults? We often think of the earth's crust as a solid layer of rock; however, the earth's crust is broken into pieces called tectonic plates. According to **Newton's 1st Law**, these plates would like to stay still, in a state of inertia. They do not get this opportunity due to unbalanced forces that act upon them and put them in motion. Movement of these plates creates geologic features such as mountains, faults, islands, and deep ocean trenches. Geologists theorize that the same plate movement that built our mountains also caused our fault zones. Mountains are built as two tectonic plates collide and uplift occurs. As you might expect the area where this occurs gets broken in the process. Although Oklahoma is no longer located in an area of active plate movement (like Califiornia), intracrustal movements occur all of the time. When this occurs faults and fault zones are able to release their stored kinetic energy, the result is an earthquake.

Although we cannot feel most of the earthquakes that occur we can still detect them using an instrument known as a seismograph. Seismographs measure the amount of kinetic energy that an earthquake sends out from its epicenter (area where the earthquake originates). The amount of energy an earthquake sends varies, but the way that the energy is sent remains the same. All earthquakes release kinetic energy in the form of **seismic waves**. A **wave** is a traveling disturbance that carries energy from one place to another. There are two main types of earthquake waves: Primary waves and Secondary waves. **Primary** waves, also known as compression waves cause the earth to move back and forth in the same direction much like the motion of a slinky. **Secondary** waves also known as transverse waves are more destructive as they cause the earth's crust to move side by side at right angles. Look at the diagrams shown on the below to get a better picture of the two types of waves that carry the kinetic energy released through an earthquake.





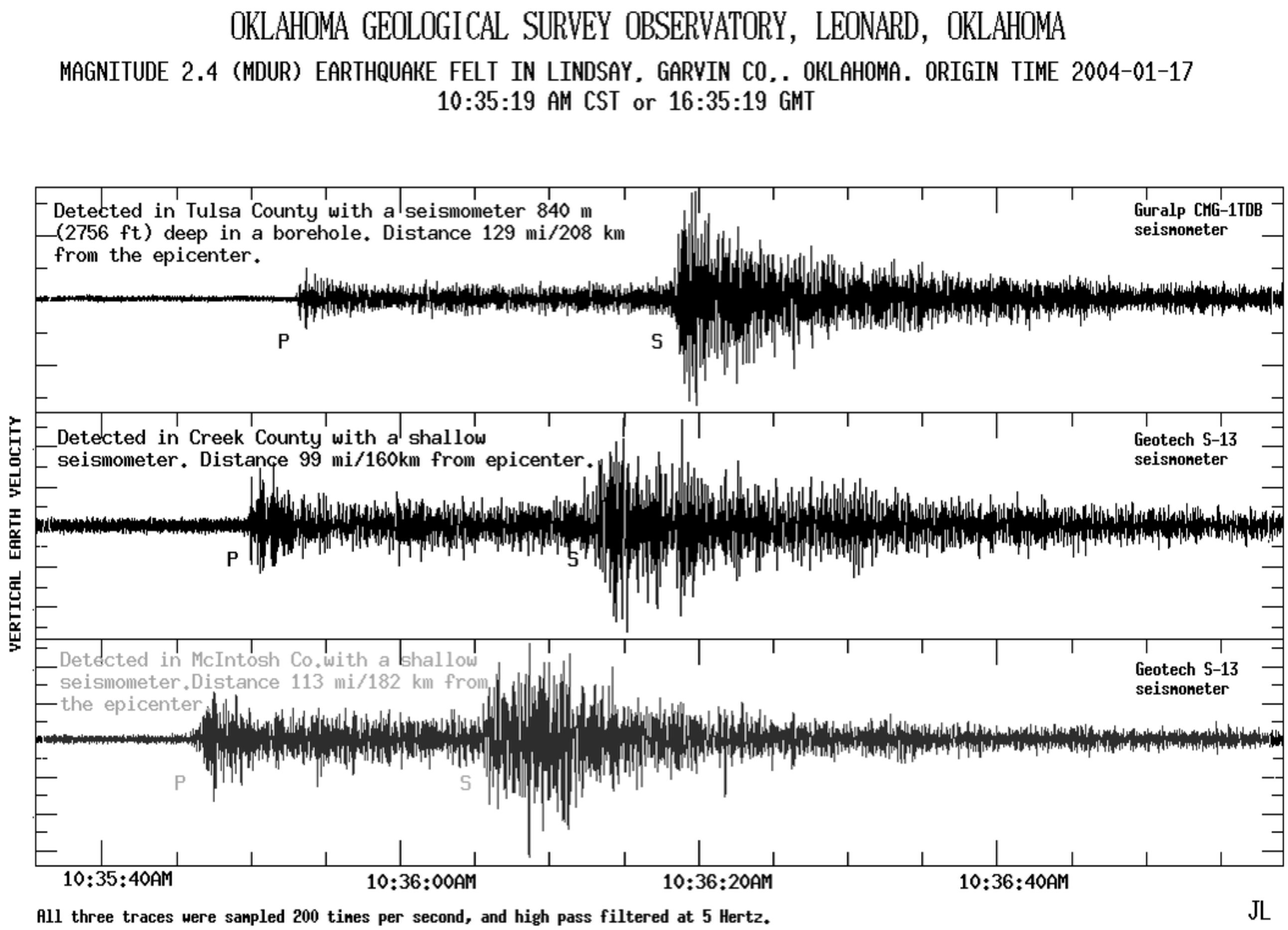
Although we have not experienced a large earthquake here in Oklahoma, scientists are concerned that we will. In this investigation you will be using data to gain a better understanding of where, when, and why we have earthquakes in Oklahoma.

Materials: This background and procedure page, colored pencils, student data page, and your brain.

Modeling Oklahoma's Quakes: http://www.okgeosurvey1.gov/bar.1977.2005.html
Use the data shown below and the scale directed by your teacher to create a map that models how many earthquakes occur in each of our Oklahoma counties 1977-2005

306	GARVIN	18	POTTAWATOMIE	7	OKMULGEE	3	WOODWARD
197	GRADY	18	MURRAY	7	KAY	2	TILLMAN
126	MC CLAIN	17	NOBLE	7	COMANCHE	2	TEXAS
87	CANADIAN	17	MC INTOSH	6	WASHITA	2	SEQUOYAH
54	PONTOTOC	17	CLEVELAND	6	PAYNE	2	PAWNEE
43	LOVE	15	HASKELL	6	LATIMER	2	MUSKOGEE
42	HUGHES	14	JEFFERSON	6	TULSA	2	MAYES
36	JOHNSTON	13	GARFIELD	6	OKLAHOMA	2	HARMON
32	PITTSBURG	12	CADDO	5	OSAGE	2	COTTON
32	STEPHENS	11	LINCOLN	5	MC CURTAIN	2	DELAWARE
31	COAL	11	PUSHMATAHA	5	HARPER	1	OTTAWA
28	ATOKA	9	BLAINE	5	GRANT	1	GREER
25	LOGAN	9	ELLIS	5	CHOCTAW	1	WAGONER
24	CREEK	9	DEWEY	5	BECKHAM	1	CHEROKEE
24	CARTER	9	CUSTER	5	WOODS	0	WASHINGTON
23	MAJOR	9	ALFALFA	4	BEAVER	0	NOWATTA
21	SEMINOLE	8	BRYAN	4	KIOWA	0	JACKSON
20	OKFUSKEE	8	LE FLORE	3	MARSHALL	0	CRAIG
20	KINGFISHER	7	ROGER MILLS	3	ROGERS	0	CIMARRON
						0	ADAIR

Calculating Speed: Use the seismographs shown below and the formula s=d/t to complete the table



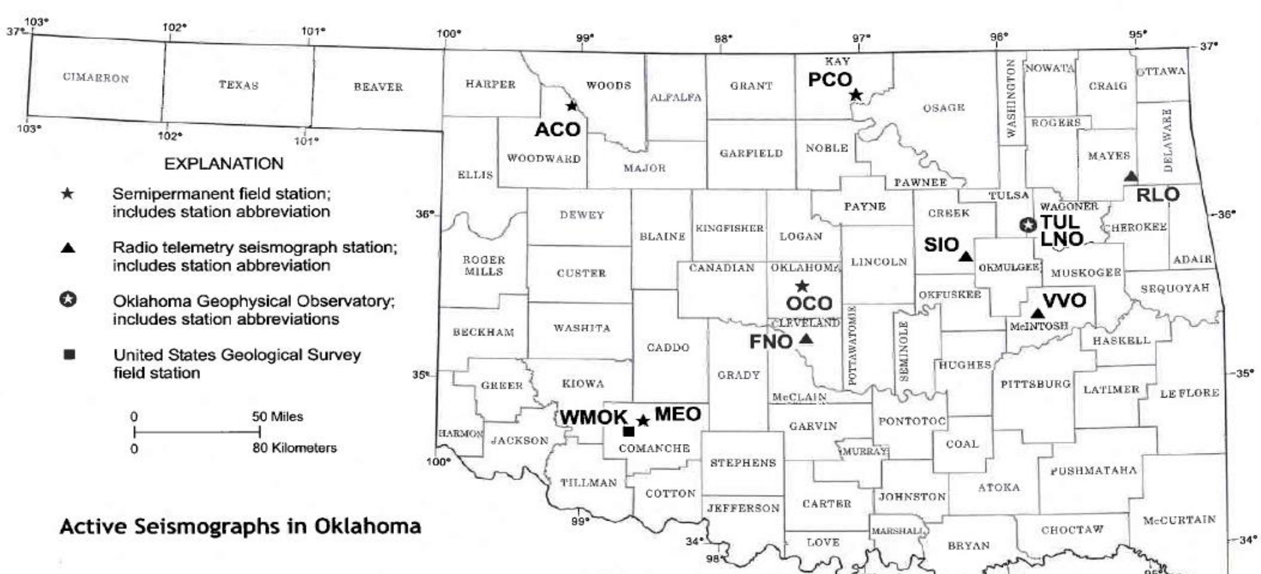
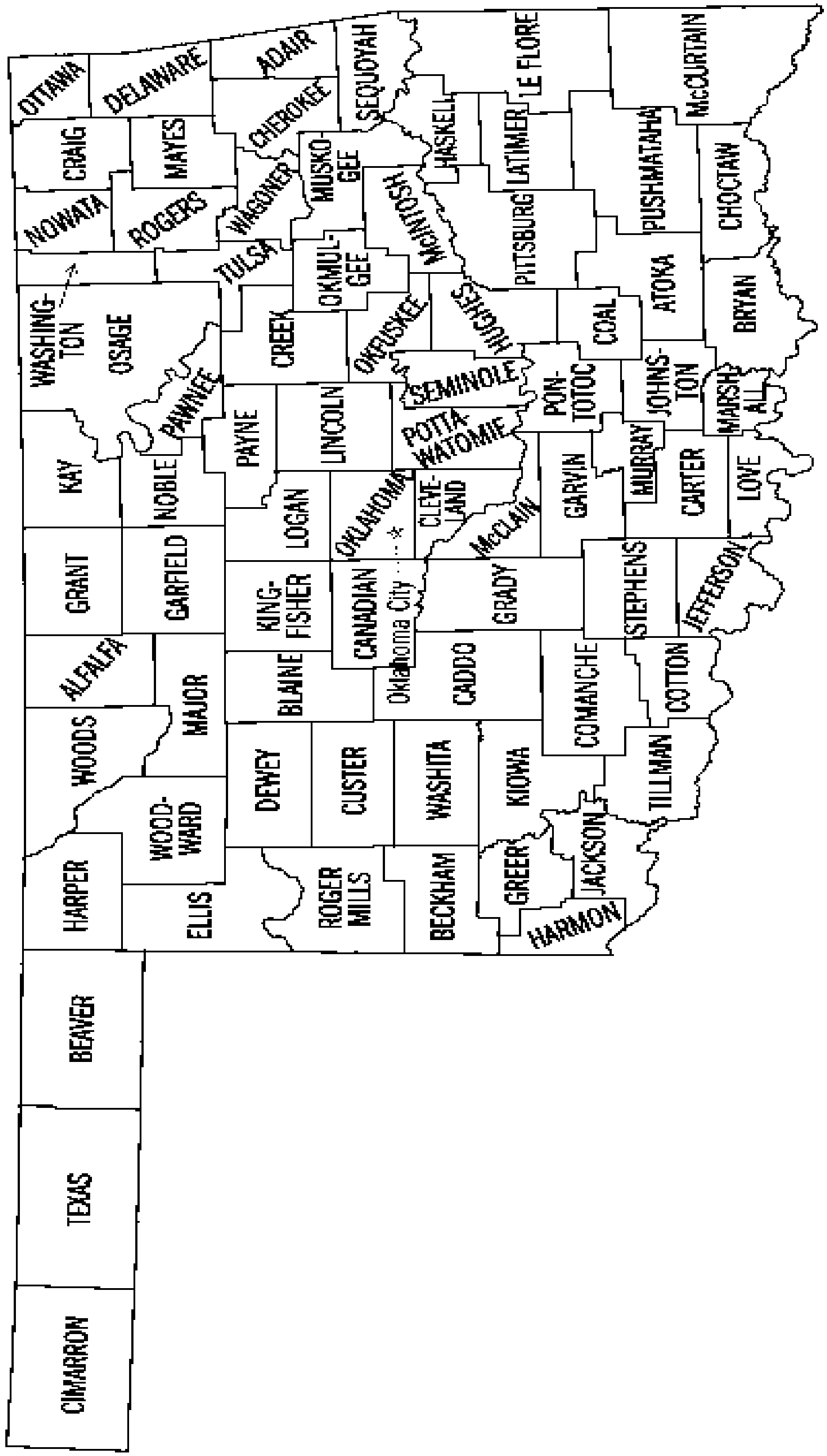


Figure 1. Active seismographs in Oklahoma.


OTTAWA
DELAWARE
ADAIR
SEQUOYAH
LE FLORE
McCURTAIN
CRAIG
MAYES
CHEROKEE
MUSKO-GEE
HASKELL
LATIMER
PUSHMATAHA
CHOCTAW
NOWATA
ROGERS
WAGONER
McINTOSH
PITTSBURG
TULSA
OKMUL-GEE
HUGHES
ATOKA
BRYAN
WASHING-TON
OSAGE
CREEK
OKFUSKEE
COAL
PAWNEE
SEMINOLE
PON-TOTOC
JOHNS-TON
MARSH-ALL
KAY
NOBLE
PAYNE
LINCOLN
POTTA-WATOMIE
MURRAY
CARTER
LOVE
GARVIN
LOGAN
OKLAHOMA
CLEVE-LAND
McCLAIN
GRANT
GARFIELD
KING-FISHER
CANADIAN
Oklahoma City
GRADY
STEPHENS
JEFFERSON
ALFALFA
MAJOR
BLAINE
CADDO
COMANCHE
COTTON
WOODS
DEWEY
CUSTER
WASHITA
KIOWA
TILLMAN
WOOD-WARD
ROGER MILLS
BECKHAM
GREER
JACKSON
HARMON
HARPER
ELLIS
BEAVER
TEXAS
CIMARRON

Name: ____ Date: ________________ Class: ___

I'm All Shook Up

Procedure: Use your map and the background information to answer the following questions:

1. What is an earthquake? ____

2. What force causes earthquakes here in Oklahoma?

3. According to the background information, how many earthquakes occur in Oklahoma each year?

4. Based on the map, which area/s of Oklahoma have had the most earthquakes? _______________

   Infer: Why do you think this is? ____

5. Which county/ies have not had any earthquakes here in Oklahoma? ______________________

   Were these counties located in the same area? ________ Infer: Why do you think this is? _______

   ____

6. What is a fault? ____

7. What is the relationship between Newton's 1^{st} Law and Oklahoma's earthquakes?

8. How do we detect earthquakes? ____

9. How does the energy released from an earthquake travel?

10. Why are secondary waves more destructive than primary waves? _________________________

11. Looking at the seismographs from the earthquake in Lindsey, which wave was detected at all 3 stations first? ___________ Why do you think this is?

12. Seismic Speed: Use the seismograph data formula given to complete the table

Station: Wave	Distance Wave Traveled (mi)	Origin Time	Arrival Time	Time Wave Traveled (s)	Speed (mi/s)
Tulsa County; P Wave					
Tulsa County: S Wave					
Creek County: P Wave					
Creek County: S Wave					
McIntosh County: P Wave					
McIntosh County: S Wave					

13. Did all of the P waves travel with the same velocity? ___________ Infer: Why do you think this is?

    ____

14. Was there a body of water between the earthquakes epicenter and the seismic station? _______

    How do you know? ____

15. Where was the epicenter of this earthquake? ____________________ What is an epicenter?

Whole Lot of Shakin Going On
Teacher Information and Background

Instructional Objective: To provide students with an open-ended opportunity to explore the problems associated with engineering

Time Required:**1 class period**

Materials: per group

- 20 gumdrops 20 marshmallows, 24 pieces of pasta, 1 ruler, lab sheets, 8 X 8 metal baking pan, sand, and water

Teacher Preparation:

- Read through the lab procedure, Buy needed materials, Sort materials for each group, prepare lab buckets, and run off lab sheets

Useful Websites:

http://dsc.discovery.com/guides/planetearth/earthquake/interactive/interactive.html
Earthquake simulation program

http://www.sciencecourseware.org/eec/earthquake/
Nice web-based investigation

http://www.mcvicker.com/twd/apa/eqguide/eqguid03.htm
Earthquake and Building Guide

Teacher Information:

Every building built has its own frequency. This is why you can feel a tall building sway when you are on the upper floor. In an earthquake energy is sent out in the form of waves. Each earthquake has its own frequency. If the frequency of the earthquake is close to the frequency of a building it causes the building to resonant and the wave amplitude to increase causing severe damage to the building. We cannot predict the frequency an earthquake will travel as. This causes engineering problems for multi-story buildings because they do not know which frequency to build the building to. In this lab, students are provided with an open-ended opportunity to explore some of the difficulties encountered by engineers on a daily basis.

Lab Information: Allow the students 30 minutes to build their towers according to the building codes provided. Students are to build their buildings in the cake pans filled ¾ full of sand and water. Add water to the sand so that the sand is full of water, but the water is not visible on top. Shake the buildings for approximately 30 seconds. And then wait 5 minutes and repeat to simulate aftershocks. Second shaking should not be as vigorous.

Suggested Challenge Guidelines:
Building must be at least 30 cm tall
Building must be at least 2 stories
Building must be freestanding in the base material
Building must be built with materials provided
Building must be built in allotted time in class

Name: _______________________________ Date: _____________ Block: ____

Whole Lot of Shakin Going On

Whole Lot of Shakin Going On

Objective: To evaluate what variables affect how much damage a building sustains during an earthquake.

- Identify the independent variable that you investigated:

- Identify the dependent variable that you investigated:

- Identify at least 2 controlled variables in this investigation:

Sketch a diagram of your building in the space below:

Summarize: Write a description of what happened to your building during the simulated earthquake:

Decide: If we did this investigation again what changes would you make?

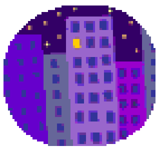
- Identify at least **3 variables** that could affect how much damage a building sustains during an earthquake:

  1. ____

  2. ____

  3. ____

- **You decide: Look at the variables shown below and decide which one would have the greatest affect on how much damage a building sustains during an earthquake and then complete the hypothesis statement:**



✓ **Ground**

1. Stable, solid ground
2. along a fault zone
3. loose, gravely soil
4. coastal ground

Hypothesis: If you build a building on ___________________________________

instead of ____,

then the building will ____.

✓ **Prevention**:

1. Reinforced building materials
2. Foundation anchoring
3. Base isolation that allows the foundation and ground to move together
4. Pile foundations anchored to bedrock

Hypothesis: If you use ____ as

prevention instead of ____

then the building will ____

✓ **Magnitude:**

1. Tremor: minor quake magnitude between 2-4.9
2. Quake: magnitude between 5-6.8, damage and injuries expected
3. Superquake: magnitude between 7.0-9.45

Hypothesis: If an earthquake measures _____________________________________

then ____ .

Predict: which variable do you think will have the most affect on how much damage a building sustains during an earthquake: the ground the building is constructed on, the prevention methods used during construction, or the magnitude of the earthquake?

____

WHY? ____

Go to : http://dsc.discovery.com/guides/planetearth/earthquake/interactive/interactive.html to test your hypothesize

Which Atmosphere?
Teacher Information and background

Objective: To provide students with an opportunity to model the gases in our atmosphere and then analyze and evaluate how they compare and contrast to other atmospheres in our solar system

Time Required: 1 class period

Materials: Reese's Confetti popcorn or colored beads, matrix such as kitty liter, Petri dishes or other sorting container, tweezers, calculators, and student pages

Teacher Preparation:
Sort popcorn and use the data in the student pages to prepare different planet atmospheres based on ratios presented. Use 150 as your total to make it a bit more challenging. Run off student pages and read over background

Useful Websites:

http://www.physicalgeography.net/fundamentals/7a.html
Introduction to the atmosphere from Physical Geography

http://www.indiana.edu/~geog109/topics/01_atmosphere/atmos.htm
Nice background on our atmosphere

http://www.c-f-c.com/charts/atmosph.htm
Complete table of atmospheric gases

http://www.kidsgeo.com/geography-for-kids/0040-introduction-to-our-atmosphere.php
Lower level guide to the atmosphere

http://www.visionlearning.com/library/module_viewer.php?mid=107
Informative guide to our atmosphere and how we measure its chemical composition

http://www.usoe.k12.ut.us/curr/Science/core/earth/sciber9/Stand_5/html/intro.htm
Web-based activities that illustrate how why our atmosphere is important and special to life on earth

http://www.ucar.edu/learn/1.htm
Great learning module from one of my favorite places

Teacher Background:

How do the atmosphere, solar energy and surface temperature found on Earth compare with what we find on other planets? Earth's atmosphere is significant for organisms that live here. Without this atmosphere, life as we know it would cease to exist. Earth's organisms interact with the atmosphere, often helping other organisms survive. Throughout history, the atmosphere has changed; some changes may have been less beneficial than others to life on Earth. Our atmosphere differs greatly from others in our solar system; many students do not understand the current composition of our atmosphere and its relationship to life on earth. This lab is designed to help them understand why maintaining our atmospheric composition is vital to life as we know it.

Composition of the Atmosphere: http://csep10.phys.utk.edu/astr161/lect/earth/atmosphere.html

The original atmosphere may have been similar to the composition of the solar nebula and close to the present composition of the Gas Giant planets, though this depends on the details of how the planets condensed from the solar nebula. That atmosphere was lost to space, and replaced by compounds outgassed from the crust or (in some more recent theories) much of the atmosphere may have come instead from the impacts of comets and other planetesimals rich in volatile materials. The oxygen so characteristic of our atmosphere was almost all produced by plants (cyanobacteria or, more colloquially, blue-green algae). A Comparison of the early atmosphere and the current atmosphere are shown in the table below:

Earth's Early Atmosphere	Earth's Current Atmosphere	Percent Abundance
Carbon Dioxide (CO_2)	Nitrogen (N_2)	78%
Water Vapor (H_20)	Oxygen (O_2)	21%
Nitrogen (N_2)	Argon (Ar)	0.93%
Methane (CH_4)	Carbon Dioxide (CO_2)	0.037%
Ammonia (NH_4)	Neon (Ne)	0.002%
Sulfur Dioxide (SO_2)	Helium (He)	0.0005%
Hydrochloric Acid (HCl)	Methane (CH_4)	0.0001%
	Ozone (O_3)	0.000007%

Primary Atmospheres:

The primary atmosphere for every terrestrial world was composed mostly of light gases that accreted during initial formation. These gases are similar to the primordial mixture of gases found in the Sun and Jupiter. That is 94.2% H, 5.7% He and everything else less that 0.1%.

However, this primary atmosphere was lost on the terrestrial planets. Why? a combination of surface temperature, mass of the atoms and escape velocity of the planet.

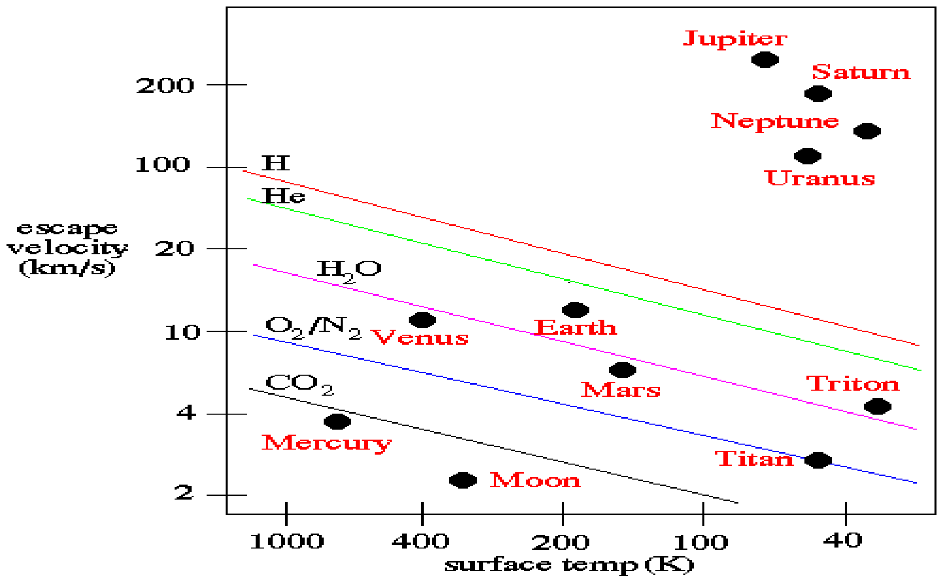
What determines if a particular atom is retained by a planet's gravitational field? if the atom is moving less than the escape velocity for the planet, it stays. If it moves faster than escape velocity, it escapes into outer space.

From the kinetic theory of gases, we know that the mean velocity of a bunch of atoms is set by the temperature of the planet's surface. Remember our microscopic description of macroscopic quantities such as pressure and temperature. Higher temperatures translate into higher velocities for the atoms.

Now consider of mix of elements in an atmosphere. Some atoms/molecules are low in mass (H, He) some are heavy (CO_2, H_2O, etc). The light elements are moving faster than the heavy elements and can reach escape velocity.

The second variable is the surface temperature of the planet. The inner worlds are closer to the Sun, therefore warmer. The opposite is true of the outer planets, farther from the Sun therefore cooler.

Combining the variables of escape velocity (mass, radius of planet) and surface temperature (distance from Sun plus effects of atmosphere heating) produces the following diagram. For key elements, lines are draw to show where the element escapes from the planet. If a planet is below that line, that element will escape.



So note that for the outer Jovian worlds, all the primary, initial atmosphere is held. But for the inner worlds, most of the original H and He has been lost. These inner worlds then will form a *secondary* atmosphere composed of the outgassing from tectonic activity.

Secondary Atmospheres:

For the warmer terrestrial worlds, the light, gaseous elements (H, He) are lost. The remaining elements are grouped into the rocky materials (iron, olivine, pyroxene) and the icy materials (H2O, CO2, CH4, NH3, SO2). The icy materials are more common in the outer Solar System, they are delivered to the inner Solar System in the form of comets.

The rocky and icy materials mix in the early crust and mantle. If the planet cools quickly, there is little to no tectonic activity and the icy materials are trapped in the mantle (see for example the Galilean moons). If the planet has a large mass (which means lots of trapped heat from formation), then there is a large amount of tectonic activity -> volcanos.

The icy materials are turned to gases in the warm mantle and returned to the planet surface in the form of outgassing to produce a secondary atmosphere. The atmospheres of Venus, Earth and Mars are secondary atmospheres. The composition of outgassing is similar for Venus, Earth and Mars and is composed of 58% H2O, 23% CO2, 13% SO2, 5% N2 and traces of noble gases (Ne, Ar, Kr). The latter evolution of this outgassing is driven primarily by the surface temperature and chemistry of the planet.

Evolution of TP atmosphere from secondary outgassing

secondary atmosphere (outgassing)		Venus (hot)		Earth (warm)		Mars (cold)	
H_2O	58%	H_2, oxides	<0.1%	oceans	<1%	ice	<0.1%
CO_2	23%	—	97%	carbonite rock life photochemical	<1%	—	95%
SO_2	13%	sulfuric acid	<1%	sulfur rocks	<0.1%	sulfur rocks	<0.1%
N_2	5%	—	2%	—	78%	—	3%
noble gases	1%	—	0.5%	—	1%	—	2%
mass		thick		thick		thin	

Note that H_2O is the key catalyst for the evolution of a secondary atmosphere. On the Earth, the temperature was just right for the formation of liquid water = oceans. The CO_2 released by outgassing was dissolved in the liquid water to produce carbonate rocks. Thus, the Earth had a *reducing* atmosphere.

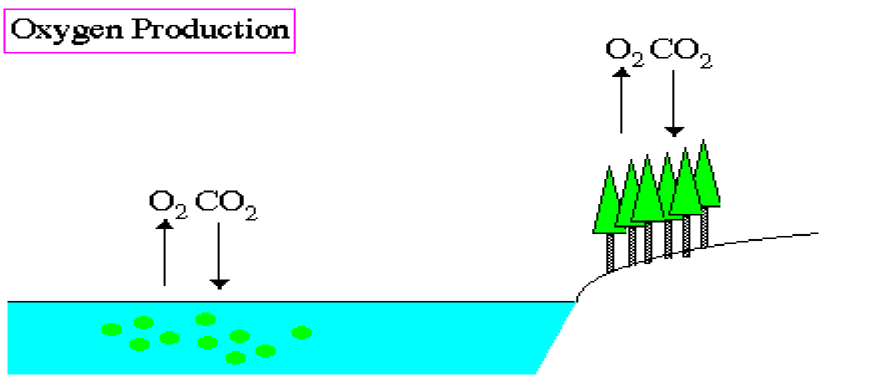
On both Venus there was no liquid water (too hot) and, therefore, no place for the CO2 to dissolve. If the atmosphere is reducing in CO2 than lower ranking elements become important once the CO2 is gone. For the Earth, this meant that the atmosphere became primarily N2 based, with later additions of O2 from lifeforms. On Venus, CO2 was not reduced and stayed as the primary component to their atmospheres.

On Mars there was a period of liquid water very soon after formation. But there was insufficient temperature for this water to remain as a liquid, so it froze out leaving CO2 as the primary component in the atmosphere.

Also note how the noble gases are good traces of the amount of evolution an atmosphere undergoes. Noble gases do not react with other elements (they are inert). An atmosphere that is thin and undergoes sharp changes in mass has a high percentage of noble gases. In this case, Mars has had most of its atmosphere frozen out in the form of H2O and CO2 ice, leaving a high amount of noble gases. Thick atmospheres, such as Venus, have small percentages of noble gases since most of the outgassing material remains on the planet surface.

Earth's Oxygen:

Note that most of the O2 released by outgassing is locked up in liquid H2O. Since O2 is highly reactive, it must constantly be replenished. Some is released by photodisintegration with H2O vapor in the upper atmosphere.



Both plankton in the oceans and plants on land contribute to convert CO_2 into O_2, the oceans are much larger contributors to this process.

But most of the O2 in today's atmosphere is from the photosynthesis process associated with lifeforms. This occurred about 1 billion years after the Earth formed. The original secondary atmosphere of the Earth was lacking large amounts of O2 and was rich in N2 and CO2.

Greenhouse changes:
The greenhouse effect is controlled by the amount (by mass) of greenhouse gases in an atmosphere. These gases are primarily H2O, CO2, CH4, NH3. For secondary atmospheres on Venus, Earth and Mars, only CO2 has a major contribution to the greenhouse effect (although note that the amount of CH4 is increasing on the Earth due to the waste products of animals and agriculture).
The greenhouse effect currently raises the temperature of Venus, Earth and Mars by the following amounts:

- Mars -> +5 degrees
- Earth -> +35 degrees
- Venus -> +500 degrees
    - ✓ Note that the greenhouse effect for the Earth is just enough to keep us out of a perpetual Ice Age (a little greenhouse effect is good for you). Whereas for Venus, a severe runaway greenhouse effect makes it the hottest place in the Solar System.
    - ✓ Also note that Mars probably had a stronger greenhouse effect in its distant past. But the large amounts of CO2 were converted to rocks in the early Mars oceans. The atmosphere thinned too fast stopping the greenhouse effect and the liquid H2O turned to ice (cold death).

The lesson to learn here is that Mars and Venus are exactly opposite in their evolution and the result of the greenhouse effect. The dynamics of planetary atmospheres are unstable and complex so that changes in Earth's atmosphere, even small, are a very serious matter for those of us who need a place to live.

Titan's atmosphere:
One of the thickest atmosphere's in the Solar System (2nd only to Venus) is Titan. Titan's current atmosphere is 90% N2 and 7% CH4 (methane). Since Titan formed in the outer Solar System where it is much cooler, and contains more icy materials such as NH3 (ammonia) and CH4. NH3 is easily separated into N2 and H2 by sunlight. The N2 is retained by Titan's gravity (see the chart above), but H2 escapes. Thus, over time, Titan has built up a N2 atmosphere like the Earth's from an original secondary atmosphere that was rich in NH3.

Note that the interaction of sunlight and CH4 induces chemical reactions that build hydrocarbons such as ethane, acetylene, propane; all of which have been detected in Titan's atmosphere. Hydrocarbons can join together to form long molecular chains called polymers.

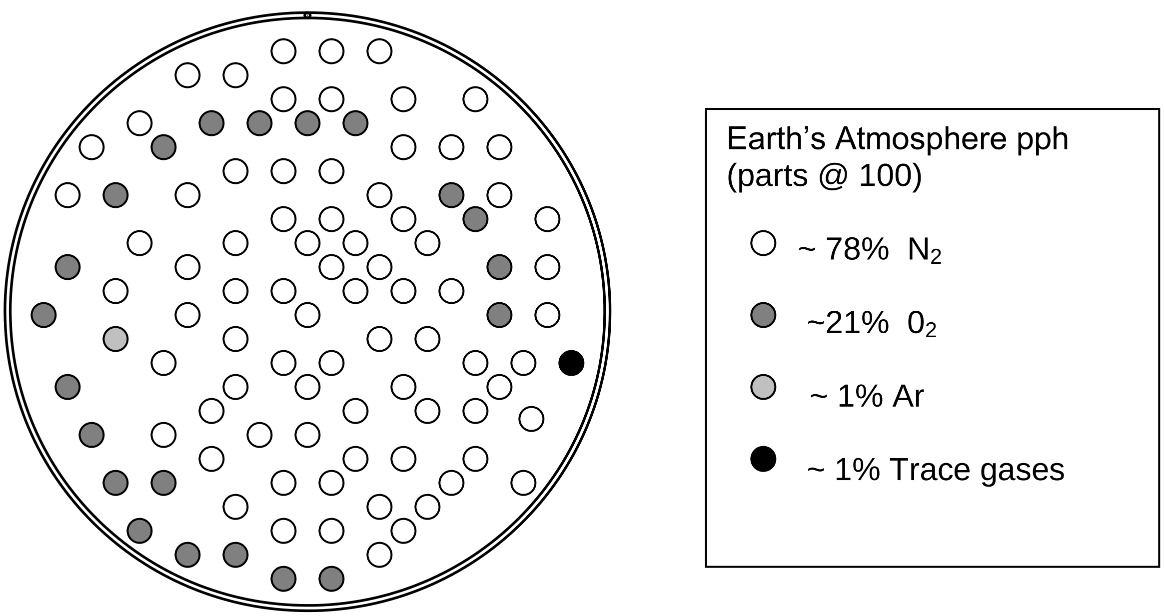
Droplets of polymers can remain suspended in an atmosphere to form an aerosol (heavy smog) whereas others will sink to form a thick layer of tar on the surface.

Composition of a Secondary Atmosphere:
In summary, the composition of an atmosphere on a terrestrial planet will be determined by the following:

- Distance from Sun (surface temperature of planet)
- Mass and radius of planet = surface gravity = escape velocity
- chemical reactions = different molecules are created and destroyed in various environments, higher temperatures mean faster reactions
- geological activity = amount of outgassing, more activity = more outgassing = thicker atmosphere
- living organisms = change the composition through their waste products

Why are Terrestrial Planets small and rocky? The primary atmosphere has boiled off leaving the rocky core. Why did this happen? Distance from the Sun for the primary worlds, distance from warm Jupiter or Saturn for the terrestrial moons.

Dot Diagram for Earth's Atmosphere



Name: ______________________________Date: __________________________ Class: _______

Which Atmosphere?

Procedure:

1. Use the tools provided to separate the gas molecules modeled by colored popcorn from the substrate material
2. Complete the data table to communicate your findings
3. Calculate the percentage of gas molecules in your sample using the formula shown below
   # of gas molecules of specific gas/ total # of gas molecules in sample x 100
4. Use your calculations and your research from yesterday to decide which planet your sample models
5. Answer the conclusion questions

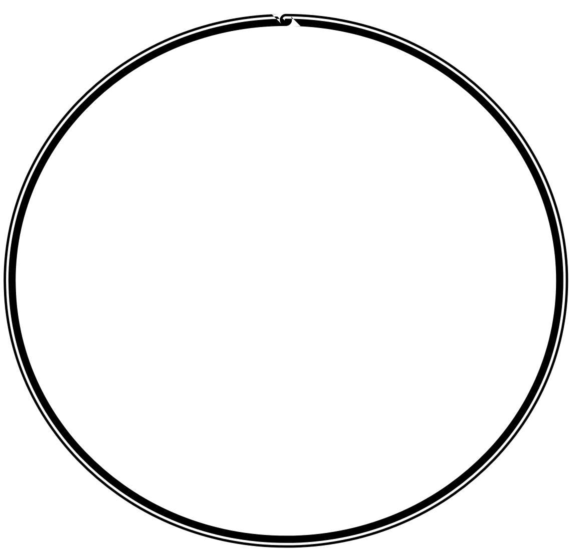
Gaseous Data:

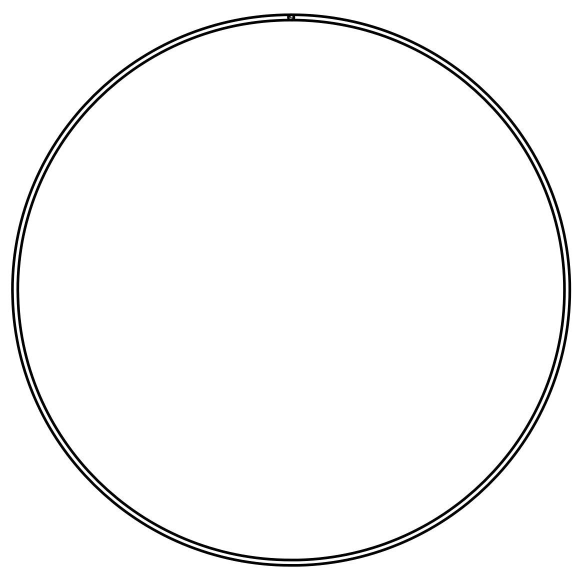
Gas	# of atoms or molecules	Total number of gas molecules	% of gas in sample

Evaluate: Which planet or moon does your sample represent:
<u>be sure to support your answer with data</u>:

What trace gases exist in addition to the main gases listed in the table?

Planet analysis: Use your colored pencils to make a representation of your findings for both your planet and earth in parts per hundred (pph): Be sure to include a KEY





Compare: How are the two atmosphere's alike?

Contrast: How do the two atmospheres differ?

Temperature: Compare the means surface temperatures using data

Evaluate: Is there a relationship between atmospheric components and mean surface temperature? SUPPORT YOUR ANSWER

Recall: What does albedo measure?

Analyze: Compare the albedo of your planet to earth's using data

Evaluate: Does there seem to be a relationship between the albedo and the mean surface temperature of the planet's in the table? SUPPORT YOUR ANSWER WITH DATA

Infer: Why do you think this is?

Analyze: Would life as we know it survive on your planet? SUPPORT YOUR ANSWER:

Evaluate: Could your planet be engineered to support life as we know it? WHY OR WHY NOT?

Evaluate: The inner planets are classified as terrestrial planets as they are rocky, the outer planets are known as Jovian planets. Is there a relationship between the classification of a planet and the chemical composition of its atmosphere? SUPPORT YOUR ANSWER.

Source: NASA Planet facts

Planets: Atmospheres

Planet	g ($\times g_E$)	v_{esc} (km/s)	distance (A.U.)	albedo (%)	temperature (K)	atm. press. (× Earth's)	atm. comp.
Mercury	0.378	4.3	0.387	5.6	100 night, 590–725 day	10^{-15}	98% He, 2% H_2
Venus	0.907	10.36	0.723	72	737	91	96.5% CO_2, 3.5% N_2, 0.015% SO_2
Earth	1.000	11.186	1.000	38.5	283–293 day	1.000	78.084% N_2, 20.946% O_2, 0.934% Ar, 0.035% CO_2, H_2O highly variable (<1%)
Mars	0.377	5.03	1.524	16	184–242 day	0.007–0.009	95.32% CO_2, 2.7% N_2, 1.6% Ar, 0.13% O_2, 0.08% CO, 0.021% H_2O, 0.01% NO
Jupiter	2.364	59.5	5.203	70	165	>>100	89% H_2, 11% He, 0.2% CH_4, 0.02% NH_3
Saturn	0.916	35.5	9.539	75	134	>>100	89% H_2, 11% He, 0.3% CH_4, 0.02% NH_3
Uranus	0.889	21.3	19.182	90	76	>>100	89% H_2, 11% He
Neptune	1.125	23.5	30.06	82	72	>>100	89% H_2, 11% He
Pluto	0.0675	1.1	39.53	14.5	50	0.003	CH_4, N_2

Notes: Surface gravity g is given in Earth gravities (1 g_E = 9.803 m/s^2); escape velocity is v_{esc}, albedo is the percent of ALL of the Sun's energy hitting the planet that is reflected (100% would be perfect reflection); temperature and surface gravity for Jupiter, Saturn, Uranus, Neptune are given at a depth where the atmospheric pressure = 1 Earth atmosphere; atmospheric pressure (atm. press.) is at the surface (>>100 for the jovian planets).

Gas Key:

Sample Color	Gas it Models
Crimson	Diatomic Nitrogen (N_2)
Lite Yellow	Diatomic Hydrogen (H_2)
Orange	Helium (He)
Green	Carbon Dioxide (CO_2)
Blue	Methane (CH_4
Red	Diatomic oxygen (O_2)
Bright yellow	Argon (Ar)
Black	Trace gases (Less than 1%)

Where's the Ozone
Teacher Information and Background

Objective: To provide students with an opportunity to use real data to make and interpret a graph to evaluate where the majority of ozone is located in our atmosphere and to use information found in a scientific reading to analyze its importance to life on earth.

Time Needed: 1-2 class periods

Materials: Copy of lab sheets and graphing paper

Useful Websites:
http://www.epa.gov/ozone/science/sc_fact.html
Article on Ozone Depletion

http://www.oar.noaa.gov/climate/t_ozonelayer.html
Discusses different types of Ozone and how we measure it as well as provides data on Ozone depletion

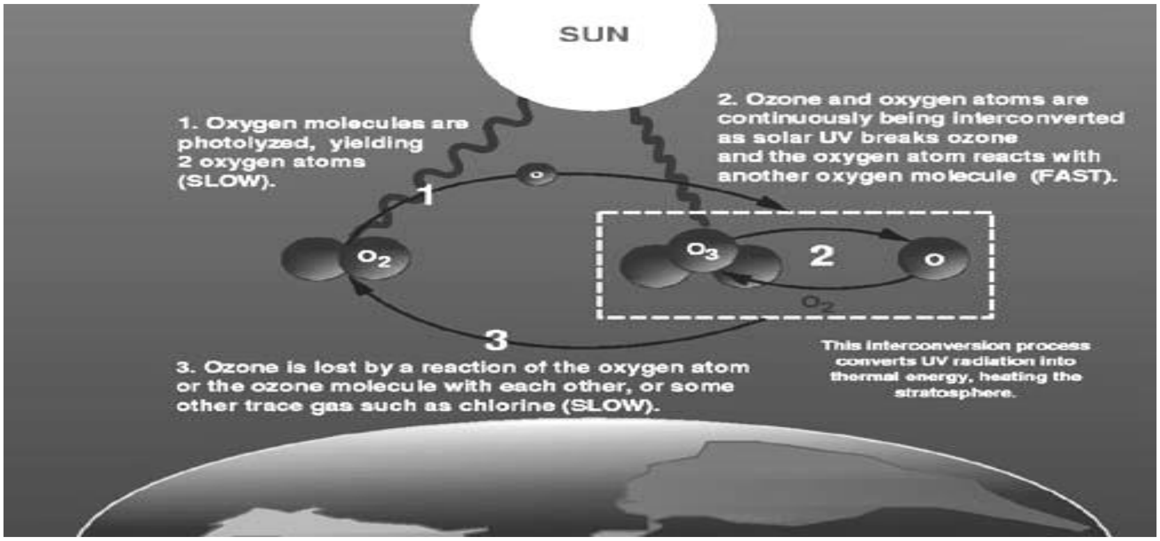
http://www.epa.gov/ozone/science/currentstate.html
Current data for the ozone layer

http://www.theozonehole.com/fact.htm
Ozone fact sheet

Teacher background:

Ozone depletion was once a very hot topic among environmental scientists. The understanding of what ozone is, how it affects our planet, where it is concentrated in our atmosphere, and how it forms are often topics that students misunderstand and confuse with global warming. They are two very significant, very different issues. This activity s designed to provide students with an opportunity to understand the issues so that they can make informed decisions.

The ozone layer is a deep layer in the stratosphere, encircling the Earth that has large amounts of ozone in it. The layer shields the entire Earth from much of the harmful ultraviolet radiation that comes from the sun. Interestingly, it is also this ultraviolet radiation that *forms* the ozone in the first place. Ozone is a special form of oxygen, made up of three oxygen atoms rather than the usual two oxygen atoms. It usually forms when some type of radiation or electrical discharge separates the two atoms in an oxygen molecule (O_2), which can then individually recombine with other oxygen molecules to form ozone (O_3). As shown in the graphic on the next page:



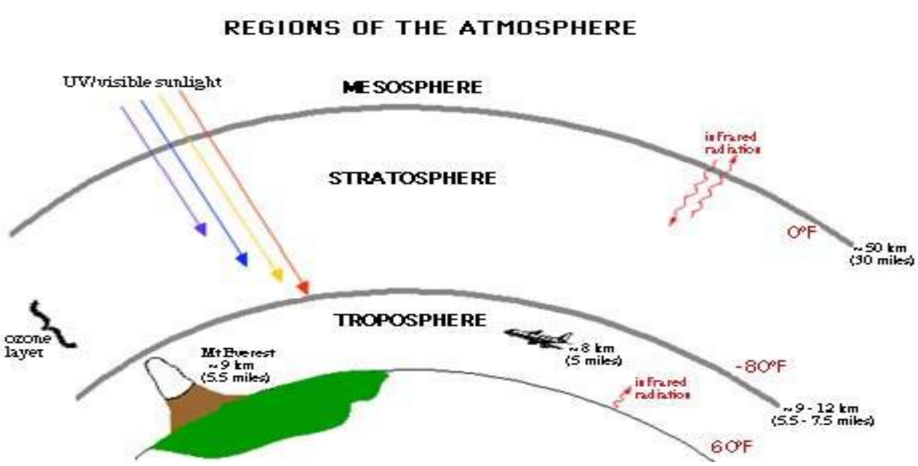
Ozone is produced everyday when UV radiation from sunlight hits a molecule of oxygen (O_2) and breaks it into two atoms of oxygen (O):

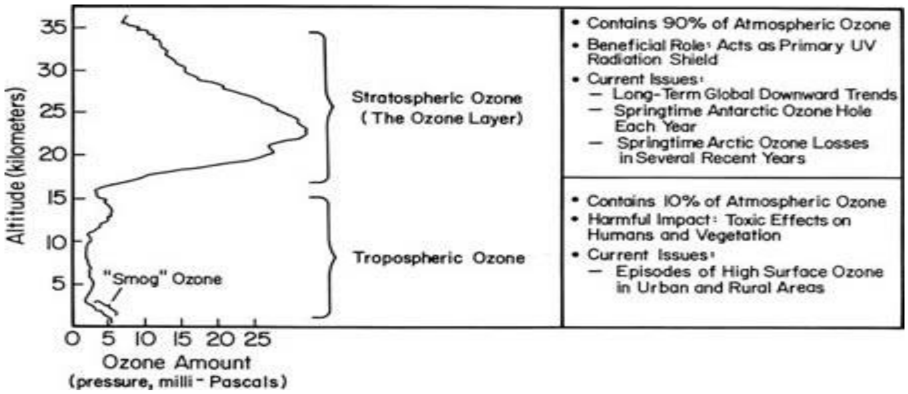
$$O_2 (g) \text{ ------> } 2 O (g)$$

One of the two atoms of oxygen (O) combine with a molecule of oxygen (O_2) to get one molecule of ozone (O_3):

$$O (g) + O_2 (g) \text{ ------> } O_3(g)$$

This stratospheric ozone, which protects us from the sun, is good. There is also ozone produced near the ground, from sunlight interacting with atmospheric pollution in cities that is bad. It causes breathing problems for some people, and usually occurs in the summertime when the pollution over a city builds up during stagnant air conditions associated with high pressure areas.





The ozone layer prevents most ultraviolet (UV) and other high-energy radiation from penetrating to the earth's surface but does allow through sufficient ultraviolet rays to support the activation of vitamin D in humans. The full radiation, if unhindered by this filtering effect, would destroy animal tissue. Higher levels of radiation resulting from the depletion of the ozone layer have been linked with increases in skin cancers and cataracts and have been implicated in the decline of certain amphibian species.

In 1974 scientists warned that certain industrial chemicals, e.g., chlorofluorocarbons (CFCs) and to a lesser extent, halons and carbon tetrachloride, could migrate to the stratosphere. There, sunlight could free the chlorine or bromine atoms to form chlorine monoxide or other chemicals, which would deplete upper-atmospheric ozone. A seasonal decrease, or hole, discovered in 1985 in the ozone layer above Antarctica was the first confirmation of a thinning of the layer. The hole occurs over Antarctica because the extreme cold helps the very high clouds characteristic of that area form tiny ice particles of water and nitric acid, which facilitate the chemical reactions involved. In addition, the polar winds, which follow a swirling pattern, create a confined vortex, trapping the chemicals. When the Antarctic spring sun rises in August or September and hits the trapped chemicals, a chain reaction begins in which chlorine, bromine (from the halons), and ice crystals react with the ozone and destroy it very quickly. The effect usually lasts through November. There is a corresponding hole over the Arctic that similarly appears in the spring, although in some years warmer winters there do not result in a major depletion of the ozone layer. A global thinning of the ozone layer results as ozone-rich air from the remaining ozone layer flows into the ozone-poor areas.

Minimum ozone levels in the Antarctic decreased steadily throughout the 1990s, and less dramatic decreases have been found above other areas of the world. In 2000 (and again in 2003 and 2006) the hole reached a record size, extending over more than 10.5 million sq mi (27 million sq km), an area greater than that of North America. In 1987 an international agreement, the Montreal Protocol, was reached on reducing the production of ozone-depleting compounds. Revisions in 1992 called for an end to the production of the worst of such compounds by 1996, and CFC emissions dropped dramatically by 1993. Recovery of the ozone layer, however, is expected to take 50 to 100 years. Damage to the ozone layer can also be caused by sulfuric acid droplets produced by volcanic eruptions.

Where's the Ozone
Background Information and Data

Background Information: Ozone is a triatomic form of oxygen meaning it contains three atoms of oxygen (O_3) held together in the shape of the letter "V." Ozone is not the same as the diatomic oxygen (O_2) that we breathe. There is little of this gas in the atmosphere. In fact if all of the ozone were brought down to the earth's surface it would form a layer only about 4 mm thick. Although ozone is all around us, it is rare as shown in the table below:

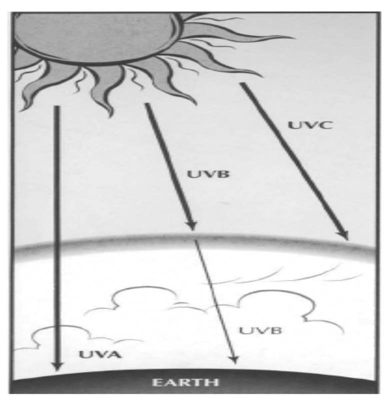
Temperature, Altitude, and Ozone
(Data collected at NOAA's Climate Monitoring and Diagnostics lab in Boulder, CO)

Altitude: Above Earth's surface (Km)	Temperature (C)	Ozone Concentration (* mPa)	Altitude: Above Earth's surface (Km)	Temperature (C)	Ozone Concentration (*mPa)
0	12	5	18	-59	10.53
2	5	3.98	20	-56.5	12.64
4	-9.5	2.49	22	-52.9	13.86
6	-25.7	1.75	24	-51.2	13.18
8	-41.5	1.65	26	-42.1	12.22
10	-49.7	2.39	28	-38.8	10.90
12	-53.8	1.83	30	-35.2	8.37
14	-67.9	1.57	32	-30.2	6.46
16	-70.2	2. 97	34	-21.3	4.50

* mPa stands for milliPascal. This unit of pressure is used to measure the amount of ozone in the atmosphere

Close to the earth's surface, ozone plays a destructive role. Classified as a secondary pollutant, ozone is one of the major components of petrochemical smog. The negative effects of ozone near the earth's surface are well documented. Short-term exposure to elevated levels causes eye and lung irritation, lowers crop yields, retards tree growth, and damages ornamental plants and shrubs. Because the reactions that create ozone are stimulated by strong sunlight, the formation of polluting ozone in the troposphere is limited to daylight hours. As expected, ozone levels are highest during hot afternoons in the summer months.

In contrast, stratospheric ozone plays quite a different role. Instead of harming plants and animals, the ozone in the stratosphere actually works to protect living things by absorbing large amounts of the sun's shorter-wave Ultraviolet Radiation. NASA has been monitoring the levels of ozone in the stratosphere for a number of years. Their findings reveal that this protective layer is thinning meaning that it no longer affords the protection that it once did. Ozone depletion in the stratosphere has been linked with a rise in skin cancer, damage to terrestrial crops and other terrestrial ecosystems, damage to certain marine organisms (phytoplankton and zooplankton), weakened immune systems, and genetic mutations. To understand how the ozone layer in the stratosphere is being damaged, we must first understand where ozone comes from. Ozone molecules in the stratosphere are constantly being created and destroyed, over and over. New ozone molecules are created in chemical reactions caused by the sun whose energy splits apart diatomic oxygen molecules making them very reactive. The oxygen atoms bond with oxygen molecules to form a triatomic oxygen molecule as shown in the schematic below.

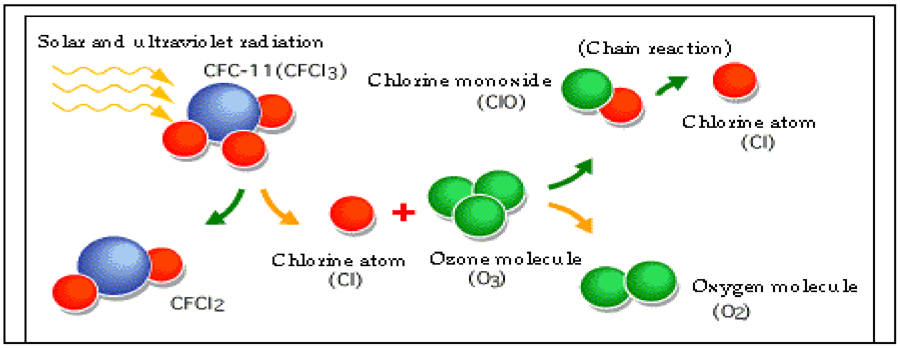


The stratospheric ozone layer [illegible] harmful UV radiation. Courtesy of the Environmental Protection [illegible]

$$O_2 + \text{photon} \longrightarrow 2\,O$$

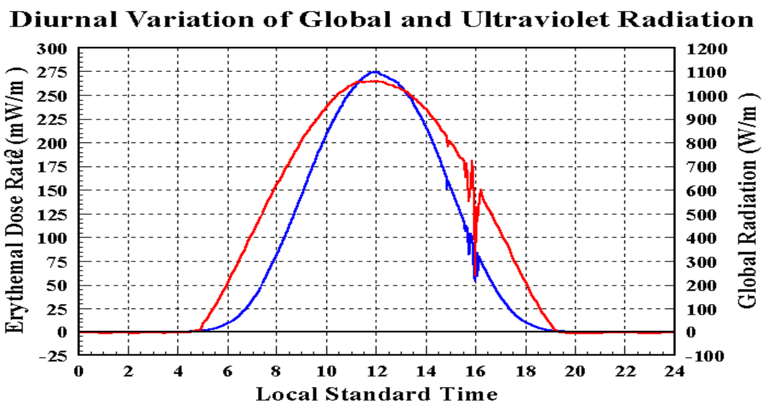
$$O + O_2 \longrightarrow O_3$$

The recycling of ozone molecules in the stratosphere is a natural process. Unfortunately, the introduction of a group of chemical compounds known as CFC's has changed the way that split oxygen molecules bond by providing other elements as shown in the graphic below



It is important to appreciate that there are several factors that affect the amount of UV radiation some of these factors are:

- **Latitude and Season: Changes in latitude and day of year alter the distance between the sun and a person on Earth.**
- **Time of Day:**



2

ınd sand

Co

- Grass reflects from 2.5 to 3 percent of UV rays hitting its surface.
- Sand reflects 20 to 30 percent of UV rays.
- Snow and ice can reflect 80 to 90 percent of UV rays.
- Depending on the angle of reflection, water can reflect up to a full 100 percent of UV rays striking the surface.

- **Cloud Conditions: Clouds also affect the amount of UV radiation that reaches the Earth's surface.**

- Clear skies allow 100 percent of UV rays to reach the surface.
- Scattered clouds allow 89 percent of UV rays to reach the surface.
- Overcast clouds allow 32 percent of UV rays to reach the surface

All the variables shown above are also impacted through human activity. Knowing what they are and what impact they have can help guide our decisions if we choose to consider them.

Name: ___________________________Date: _______________ Class: __________

Where's the Ozone?

Background Information and Map Questions:

1. What is ozone? ____

   How does it differ from the oxygen we breathe? ______________________________________

2. What affect does the ozone in the troposphere have on our planet? ________________________

   ____

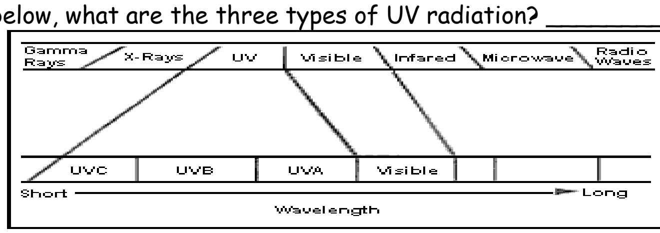
   Where does it come from? ____

3. How does the ozone in the stratosphere differ from the ozone found in the troposphere?

   ____

   Where does it come from? ____

4. Looking at the diagram below, what are the three types of UV radiation? ____________________



Evaluate: Which form/s do you think are harmful to living things? SUPPORT YOUR ANSWER!

5. Complete the table to identify and evaluate the different factors that affect the amount of UV radiation: Be sure to include data when it is available:

Cause	Effect

6. **Evaluate**: Which factor shown do you feel has the greatest impact on you and the amount of UV radiation that you receive here in Oklahoma? SUPPORT YOUR ASNWER

7. Based on the data shown on the 2 UV Index maps, which month of has the least variation?

Infer: Why do you think this is?

8. . Hypothesize what the map would look like for the month of May and then support your hypothesis:

Support for your hypothesis:

Graphing Procedure:

A. Using the data in the table, plot the points that communicate temperature. Connect your points using a colored pencil
B. Use another color to plot the points that relate to Ozone concentration. Connect your points using a different colored pencil.
C. Draw a horizontal line across the graph at the point where the temperature stops decreasing. Label the area below the line Troposphere and the area above the line Stratosphere.

Graph Conclusions:

9. According to your graph, how high does the troposphere go? ___________________________

What is the temperature at this altitude? __________ Does the temperature in the troposphere

increase or decrease as you go higher up ? ________________________

10. At what altitude in the **troposphere** did they find the highest concentration of Ozone?

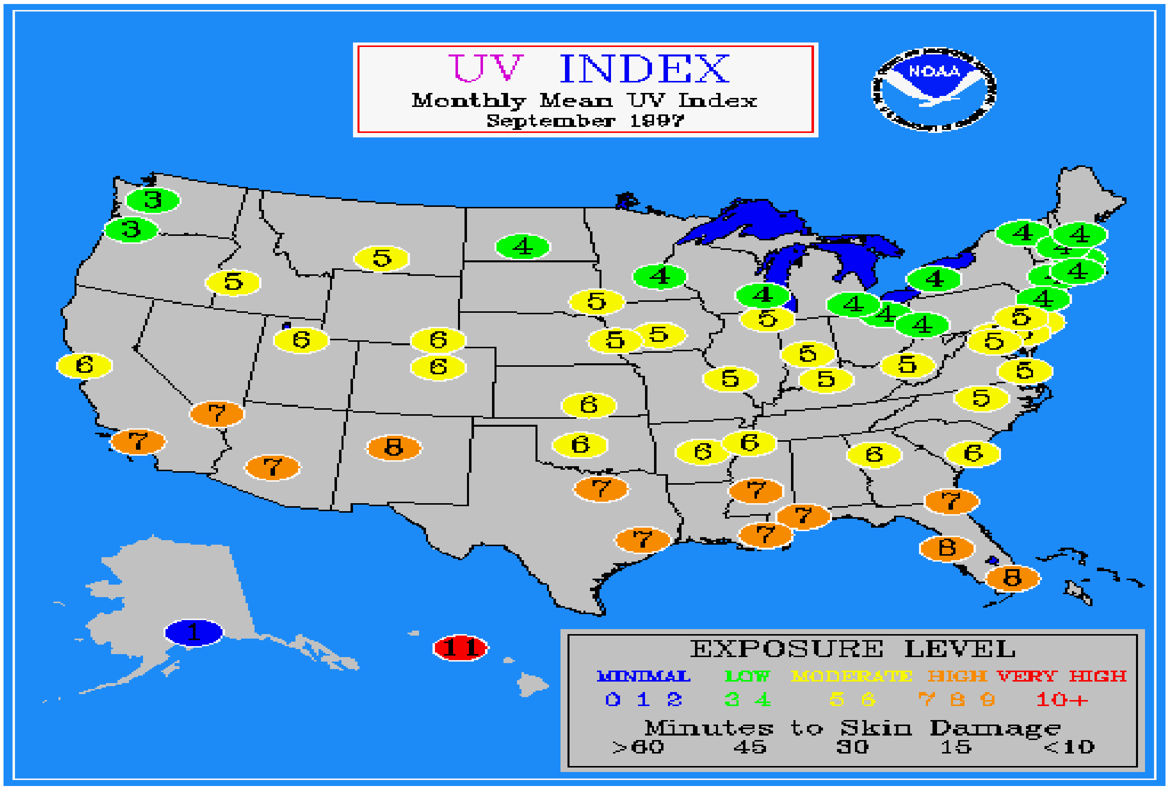
______________ What temperature? ________________ Evaluate: Is there a relationship between the amount of ozone and the temperature in the troposphere? SUPPORT YOUR ANSWER WITH DATA!!!!!

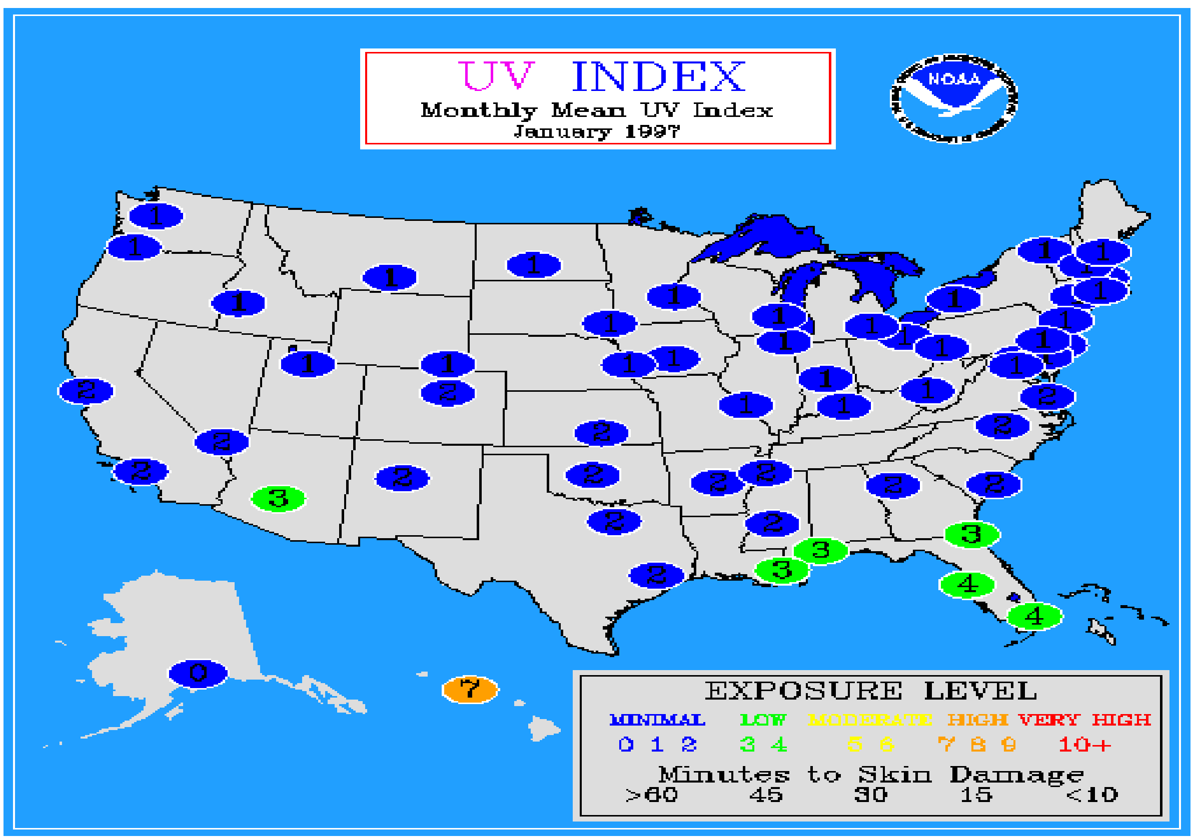
11. In which **layer of our atmosphere** did they find the highest concentration of ozone?

____________________________ How high up? ________________ What temperature? _______

12. Does the temperature in the stratosphere increase or decrease as you go higher up? __________

Evaluate: Is there a relationship between ozone concentration and temperature in the stratosphere? SUPPORT YOUR ANSWER WITH DATA

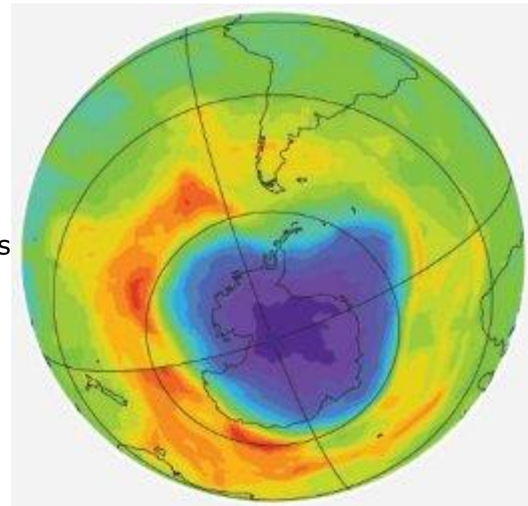

UV INDEX
Monthly Mean UV Index
September 1997
NOAA
EXPOSURE LEVEL
MINIMAL LOW MODERATE HIGH VERY HIGH
0 1 2 3 4 5 6 7 8 9 10+
Minutes to Skin Damage
>60 45 30 15 <10


UV INDEX
Monthly Mean UV Index
January 1997
NOAA
EXPOSURE LEVEL
MINIMAL LOW MODERATE HIGH VERY HIGH
0 1 2 3 4 5 6 7 8 9 10+
Minutes to Skin Damage
>60 45 30 15 <10

Earth's ozone layer appears to be on the road to recovery.

May 26, 2006: Think of the ozone layer as Earth's sunglasses, protecting life on the surface from the harmful glare of the sun's strongest ultraviolet rays, which can cause skin cancer and other maladies.

People were understandably alarmed, then, in the 1980s when scientists noticed that manmade chemicals in the atmosphere were destroying this layer. Governments quickly enacted an international treaty, called the Montreal Protocol, to ban ozone-destroying gases such as CFCs then found in aerosol cans and air conditioners.



Right: The Antarctic ozone hole.

Today, almost 20 years later, reports continue of large ozone holes opening over Antarctica, allowing dangerous UV rays through to Earth's surface. Indeed, the 2005 ozone hole was one of the biggest ever, spanning 24 million sq km in area, nearly the size of North America.

Listening to this news, you might suppose that little progress has been made. You'd be wrong. While the ozone hole over Antarctica continues to open wide, the ozone layer around the rest of the planet seems to be on the mend. For the last 9 years, worldwide ozone has remained roughly constant, halting the decline first noticed in the 1980s.

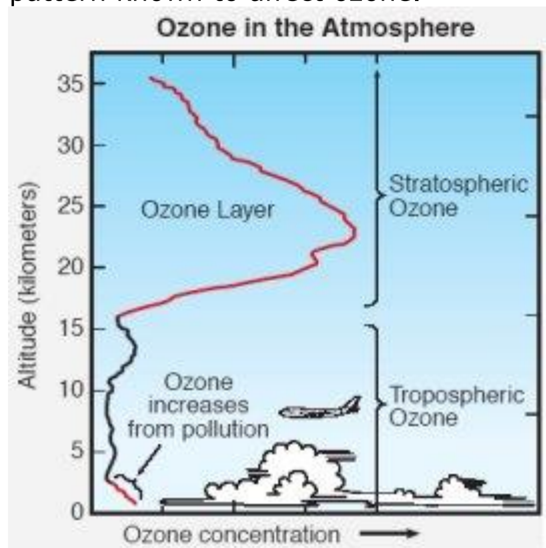
The question is *why?* Is the Montreal Protocol responsible? Or is some other process at work? It's a complicated question. CFCs are not the only things that can influence the ozone layer; sunspots, volcanoes and weather also play a role. Ultraviolet rays from sunspots boost the ozone layer, while sulfurous gases emitted by some volcanoes can weaken it. Cold air in the stratosphere can either weaken or boost the ozone layer, depending on altitude and latitude. These processes and others are laid out in a review just published in the May 4th issue of Nature: "The search for signs of recovery of the ozone layer" by Elizabeth Weatherhead and Signe Andersen.

Sorting out cause and effect is difficult, but a group of NASA and university researchers may have made some headway. Their new study, entitled "Attribution of recovery in lower-stratospheric ozone," was just accepted for publication in the Journal of Geophysical Research. It concludes that about half of the recent trend is due to CFC reductions.

Lead author Eun-Su Yang of the Georgia Institute of Technology explains: "We measured ozone concentrations at different altitudes using satellites, balloons and instruments on the ground. Then we compared our measurements with computer predictions of ozone recovery, [calculated from real, measured reductions in CFCs]." Their calculations took into account the known behavior of the sunspot cycle (which peaked in 2001), seasonal changes in the ozone layer, and Quasi-Biennial Oscillations, a type of stratospheric wind pattern known to affect ozone.

What they found is both good news and a puzzle.

The good news: In the upper stratosphere (above roughly 18 km), ozone recovery can be explained almost entirely by CFC reductions. "Up there, the Montreal Protocol seems to be working," says co-author Mike Newchurch of the Global Hydrology and Climate Center in Huntsville, Alabama.



Right: The ozone layer is located about 15+ km above Earth's surface. [More]

The puzzle: In the lower stratosphere (between 10 and 18 km) ozone has recovered *even better* than changes in CFCs alone would predict. Something else must be affecting the trend at these lower altitudes.

The "something else" could be atmospheric wind patterns. "Winds carry ozone from the equator where it is made to higher latitudes where it is destroyed. Changing wind patterns affect the balance of ozone and could be boosting the recovery below 18 km," says Newchurch. This explanation seems to offer the best fit to the computer model of Yang et al. The jury is still out, however; other sources of natural or manmade variability may yet prove to be the cause of the lower-stratosphere's bonus ozone.

Whatever the explanation, if the trend continues, the global ozone layer should be restored to 1980 levels sometime between 2030 and 2070. By then even the Antarctic ozone hole might close--for good.

Where UV?
Teacher Information and Background

Objective: To provide students with an opportunity to analyze and evaluate both qualitative and quantitative observations in order to draw conclusions and an understanding of Ultraviolet light.

Time Required: 1 Class period

Materials Needed: UV Beads, UV Detector, if possible, and student pages

Teacher Preparation: Get materials gathered and run off lab sheets

Useful Websites:
http://earthobservatory.nasa.gov/Features/UVB/uvb_radiation2.php
Effects of UV on the biosphere and how we measure at the surface

http://www.ec.gc.ca/ozone/docs/uo/UVHealth/EN/uvhealth.cfm
Health issues and UV Radiation

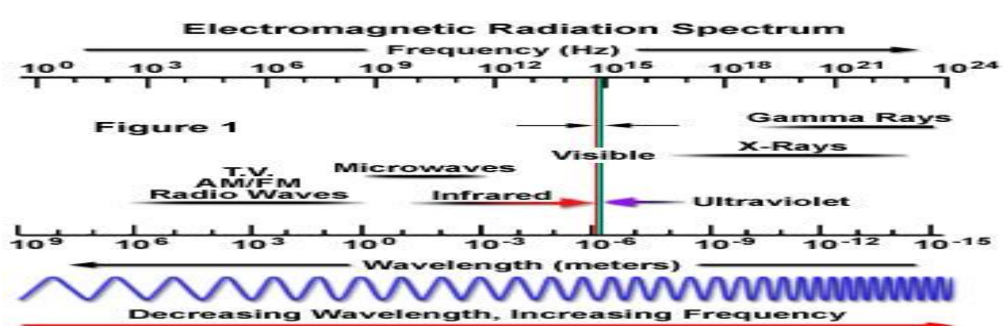
http://www.tufts.edu/as/wright_center/cosmic_evolution/docs/text/text_bio_1.html
Role of UV in cosmic evolution

http://www.utahweather.org/UWC/temperatures_sunshine/ultraviolet_radiation.html
Mentions tanning salons

Teacher Background:

This lab can be done without the UV Intensity meters, but is harder to quantify. Students are often surprised to learn that UV gets through clouds, the window in your car, and even the leaves on a tree. It is suggested that you do this lab a couple of times during the year if possible so that they can collect and analyze more data.

Background: The term **electromagnetic radiation**, coined by Sir James Clerk Maxwell, is derived from the characteristic electric and magnetic properties common to all forms of this wave-like energy, as manifested by the generation of both electrical and magnetic oscillating fields as the waves propagate through space. Visible light represents only a small portion of the entire spectrum of electromagnetic radiation (as categorized in Figure 1), which extends from high-frequency cosmic and gamma rays through X-rays, ultraviolet light, infrared radiation, and microwaves, down to very low frequency long-wavelength radio waves.

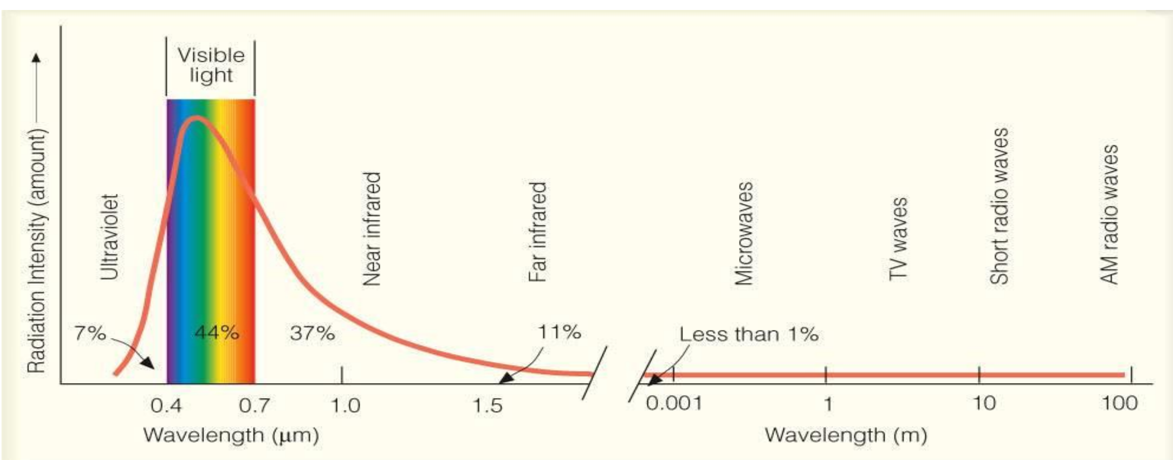


Listed below are the approximate wavelength, frequency, and energy limits of the various regions of the electromagnetic spectrum.

	Wavelength (m)	Frequency (Hz)	Energy (J)
Radio	> 1×10^{-1}	< 3×10^{9}	< 2×10^{-24}
Microwave	1×10^{-3} - 1×10^{-1}	3×10^{9} - 3×10^{11}	2×10^{-24}- 2×10^{-22}
Infrared	7×10^{-7} - 1×10^{-3}	3×10^{11} - 4×10^{14}	2×10^{-22} - 3×10^{-19}
Optical	4×10^{-7} - 7×10^{-7}	4×10^{14} - 7.5×10^{14}	3×10^{-19} - 5×10^{-19}
UV	1×10^{-8} - 4×10^{-7}	7.5×10^{14} - 3×10^{16}	5×10^{-19} - 2×10^{-17}
X-ray	1×10^{-11} - 1×10^{-8}	3×10^{16} - 3×10^{19}	2×10^{-17} - 2×10^{-14}
Gamma-ray	< 1×10^{-11}	> 3×10^{19}	> 2×10^{-14}

Ultraviolet radiation, at the other end of the visible spectrum, was discovered by Wilhelm Ritter, who was one of the first scientists to investigate the energy associated with visible light. By observing the rate at which various colors of light stimulate darkening of paper saturated with a solution of silver nitrate, Ritter discovered that another invisible form of light, beyond the blue end of the spectrum, yielded the fastest rates.

The wavelength at which a star emits most of its electromagnetic radiation is dependent on its temperature. Since our sun is ~5800 K, it emits most of its energy in the visible light range as shown in the diagram below:

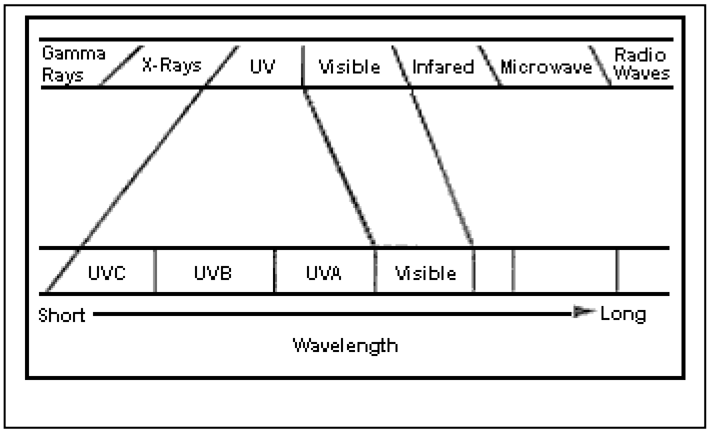


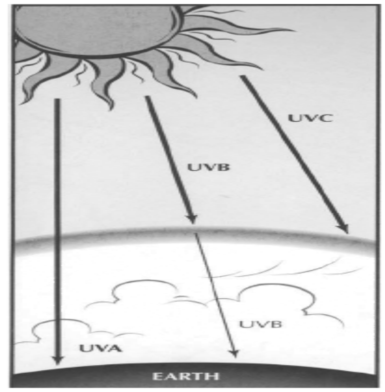
Note that 7% is in the Ultraviloet range. UV consists of several wavelengths:

UVA
UVA is ultraviolet radiation with wavelengths from 320-400 nm. It passes right through the Earth's ozone layer. UVA can cause early aging of the skin.

UVB
UVB is ultraviolet radiation with wavelengths of 280-320nm. It does not go as deeply into the skin as UVA does. UVB causes skin cancer. It might also be involved with cataracts. (Cataracts are a clouding of the lens of the eye that can lead to blindness.) The ozone layer absorbs most of the sun's UVB, but even then the small amount of UVB rays can do substantial damage. Also, with the possibility of the thinning of the ozone layer, more UVB rays might result in more damage.

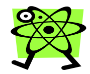
UVC
UVC is ultraviolet radiation with wavelengths shorter than 280 nm. It is also dangerous to people. But it is completely absorbed by the Earth's ozone layer.





The stratospheric ozone layer screens out much of the sun's harmful UV radiation. Courtesy of the Environmental Protection Agency's Sunwise Program.

Name: ______________________________ Date: ______________Class: ____

Where UV? 

Research question: How does location here at PC affect the amount of UV radiation we receive?

Materials: UV beads on a bracelet and in a plastic bag, UV intensity meter, piece of fabric, and electromagnetic radiation

Procedure:

1. Identify the variables and formulate a hypothesis
2. Take the UV beads and intensity meter to the different locations shown in the table and record your findings. (Remember that the more intense the bead's color, the more UV radiation) DO NOT FOREGET TO CHOOSE THREE MORE LOCATIONS!!!
3. Use the results of your investigation and your text to answer the conclusion questions

Independent Variable: ____

Dependent Variable: ____

Hypothesis: ____

____

ONCE YOU HAVE COMPLETED THE FIRST STEP, YOU MAY GO AND GET YOUR BEADS

Location Tested	Bead Observations: Be Specific and refer to color and intensity of color	UV Intensity Meter reading
Inside the classroom by the window		
Outside the classroom by the window		
Under a tree		
In a shady place		
On asphalt		
On a light colored car		
On a dark colored car		

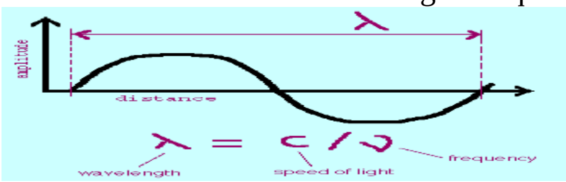
Compose a conclusion statement that communicates what you did and what you found out. Be specific and delineate which location had the highest UV reading and which had the lowest UV reading then infer why this might be.

Questions to consider:

1. What is electromagnetic radiation?

- **Use the formula shown below to find the wavelength:**

wavelength = equals the speed of light/ by the frequency



lambda = c / nu (Speed of light = 3.0 x 10^8)

Part of EMS	Frequency (Hz)	Beginning Wavelength (m)	End Wavelength (m)	Range of Wavelengths as whole numbers
Radio	3 x 10^3 3 x 10^9			
Microwave	3 x 10^9 3 x 10^{11}			
Infrared	3 x 10^{11} 4 x 10^{14}			
Optical	4 x 10^{14} 7.5 x 10^{14}			
UV	7.5 x 10^{14} 3 x 10^{16}			
X-ray	3 x 10^{16} 3 x 10^{19}			
Gamma-ray	3 x 10^{19} 3 x 10^{23}			

2. What does the wavelength measure?

3. What does frequency measure?

4. What is the relationship between wavelength and frequency? (Be specific and use data)

5. What is the relationship between a wave's frequency and energy or temperature? (Be specific and use data)

Infer: Why do you think this is?

Ultraviolet Radiation: How it Affects Life on Earth

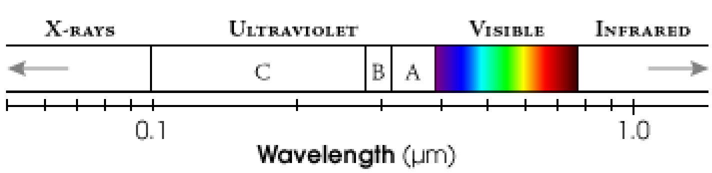
Related Article

By Jeannie Allen • September 6, 2001

The sun radiates energy in a wide range of wavelengths, most of which are invisible to human eyes. The shorter the wavelength, the more energetic the radiation, and the greater the potential for harm. Ultraviolet (UV) radiation that reaches the Earth's surface is in wavelengths between 290 and 400 nm (nanometers, or billionths of a meter). This is shorter than wavelengths of visible light, which are 400 to 700 nm.

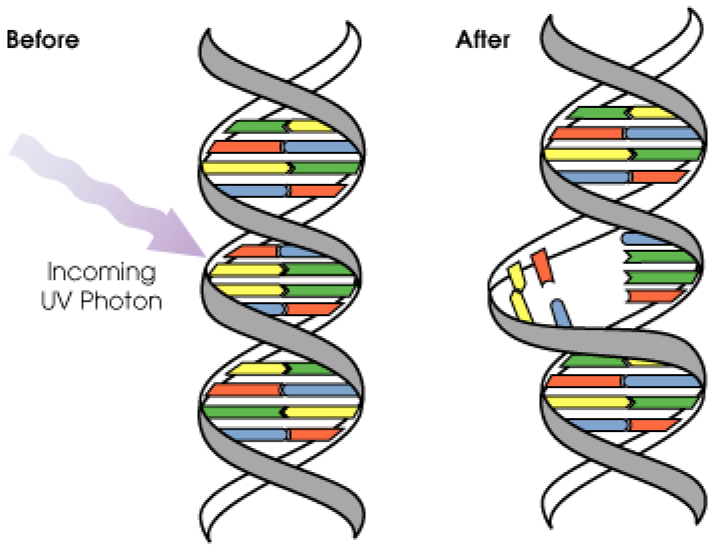
People and plants live with both helpful and harmful effects of ultraviolet (UV) radiation from the sun. (Photograph courtesy Jeannie Allen)

UV radiation from the sun has always played important roles in our environment, and affects nearly all living organisms. Biological actions of many kinds have evolved to deal with it. Yet UV radiation at different wavelengths differs in its effects, and we have to live with the harmful effects as well as the helpful ones. Radiation at the longer UV wavelengths of 320-400 nm, designated as UV-A, plays a helpful and essential role in formation of Vitamin D by the skin, and plays a harmful role in that it causes sunburn on human skin and cataracts in our eyes. Radiation at shorter wavelengths of 290-320 nm, designated as UV-B, causes damage at the molecular level to the fundamental building block of life— deoxyribonucleic acid (DNA).



Electromagnetic radiation exists in a range of wavelengths, which are delineated into major divisions for our convenience. Ultraviolet B radiation, harmful to living organisms, represents a small portion of the spectrum, from 290 to 320 nanometer wavelengths. (Illustration by Robert Simmon)

DNA readily absorbs UV-B radiation, which commonly changes the shape of the molecule in one of several ways. The illustration below illustrates one such change in shape due to exposure to UV-B radiation. Changes in the DNA molecule often mean that protein-building enzymes cannot "read" the DNA code at that point on the molecule. As a result, distorted proteins can be made, or cells can die.



Ultraviolet (UV) photons harm the DNA molecules of living organisms in different ways. In one common damage event, adjacent bases bond with each other, instead of across the "ladder." This makes a bulge, and the distorted DNA molecule does not function properly. (Illustration by David Herring)

But living cells are "smart." Over millions of years of evolving in the presence of UV-B radiation, cells have developed the ability to repair DNA. A special enzyme arrives at the damage site, removes the damaged section of DNA, and replaces it with the proper components (based on information elsewhere on the DNA molecule). This makes DNA somewhat resilient to damage by UV-B.

In addition to their own resiliency, living things and the cells they are made of are protected from excessive amounts of UV radiation by a chemical called ozone. A layer of ozone in the upper atmosphere absorbs UV radiation and prevents most of it from reaching the Earth. Yet since the mid-1970s, human activities have been changing the chemistry of the atmosphere in a way that reduces the amount of ozone in the stratosphere (the layer of atmosphere ranging from about 11 to 50 km in altitude). This means that more ultraviolet radiation can pass through the atmosphere to the Earth's surface, particularly at the poles and nearby regions during certain times of the year.

Without the layer of ozone in the stratosphere to protect us from excessive amounts of UV-B radiation, life as we know it would not exist. Scientific concern over ozone depletion in the upper atmosphere has prompted extensive efforts to assess the potential damage to life on Earth due to increased levels of UV-B radiation. Some effects have been studied, but much remains to be learned.

How Well Do I Radiate?
Teacher Background and Information

Objective: to provide students with an opportunity to collect and analyze data to evaluate what affect different building materials and surfaces have on how our earth is heated.

Time Needed: 1-2 class periods

Materials: 32 ounce insulated mugs or Styrofoam cups, foil or Mylar sheets, thermometer, and outdoor surfaces to check

Useful websites:

http://www.uwsp.edu/gEo/faculty/lemke/geog101/lecture_outlines/02_radiation_energy_balance.html
Nice background information with formulas

http://www.uwsp.edu/geo/faculty/ritter/geog101/uwsp_lectures/lecture_radiation_energy_balance.html
Energy radiation balance

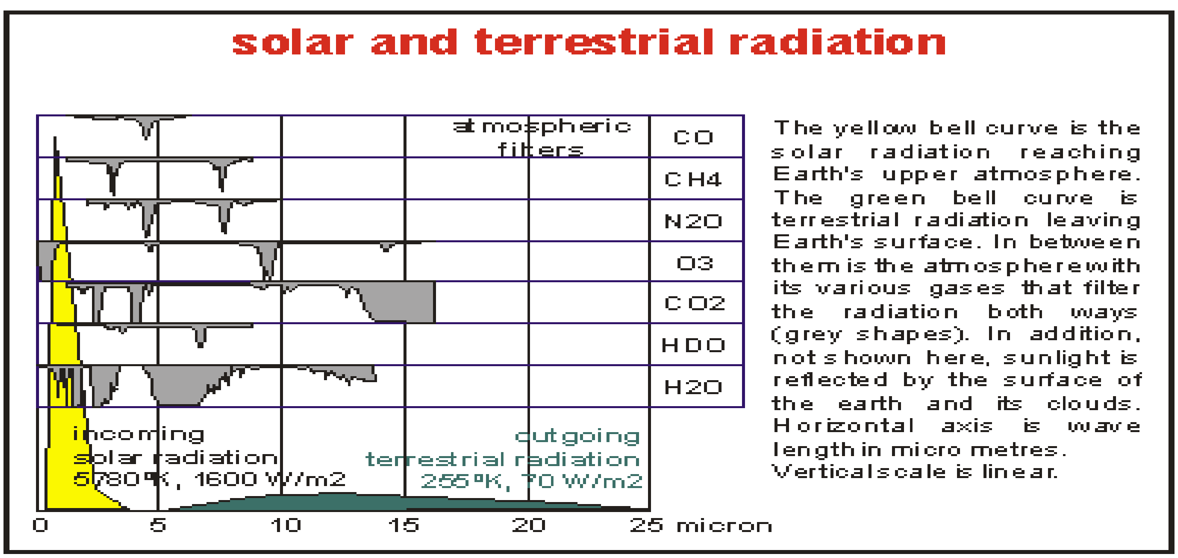
http://www.udel.edu/Geography/DeLiberty/Geog474/geog474_energy_interact.html
Energy Interactions with the atmosphere and at the surface

http://www.ldeo.columbia.edu/edu/dees/V1003/lectures/greenhouse_gas/
Great notes of radiative forcing and greenhouse effect. Also has table and graphs

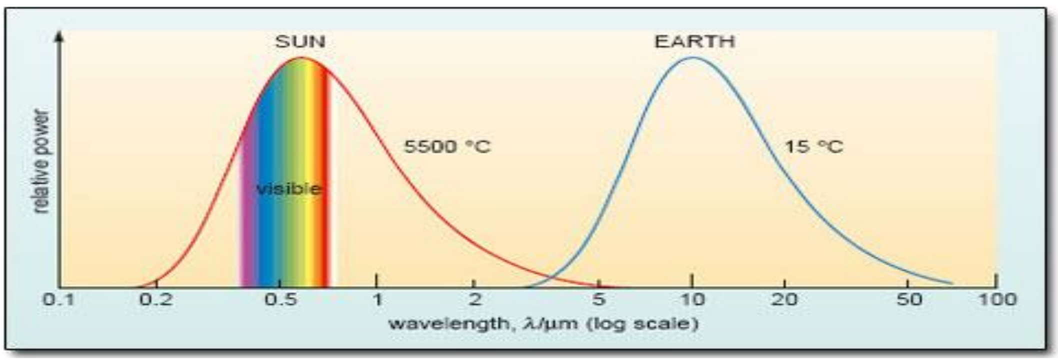
http://www.earth.rochester.edu/fehnlab/ees215/lect16.html
Nice background and great graphics

Teacher Background:

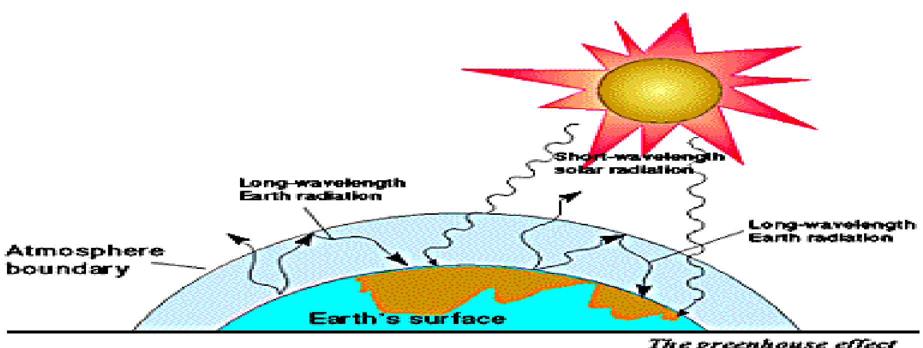
Most students do not fully understand the greenhouse effect and its relationship to global warming. Both of these are natural processes that make our Earth habitable. By measuring terrestrial radiation using an infrared telescope students are better able to evaluate what impact our choice in land usage has on our climate. The diagram shown below relates how the different components of our atmosphere interact to make our planet habitable through the greenhouse effect.

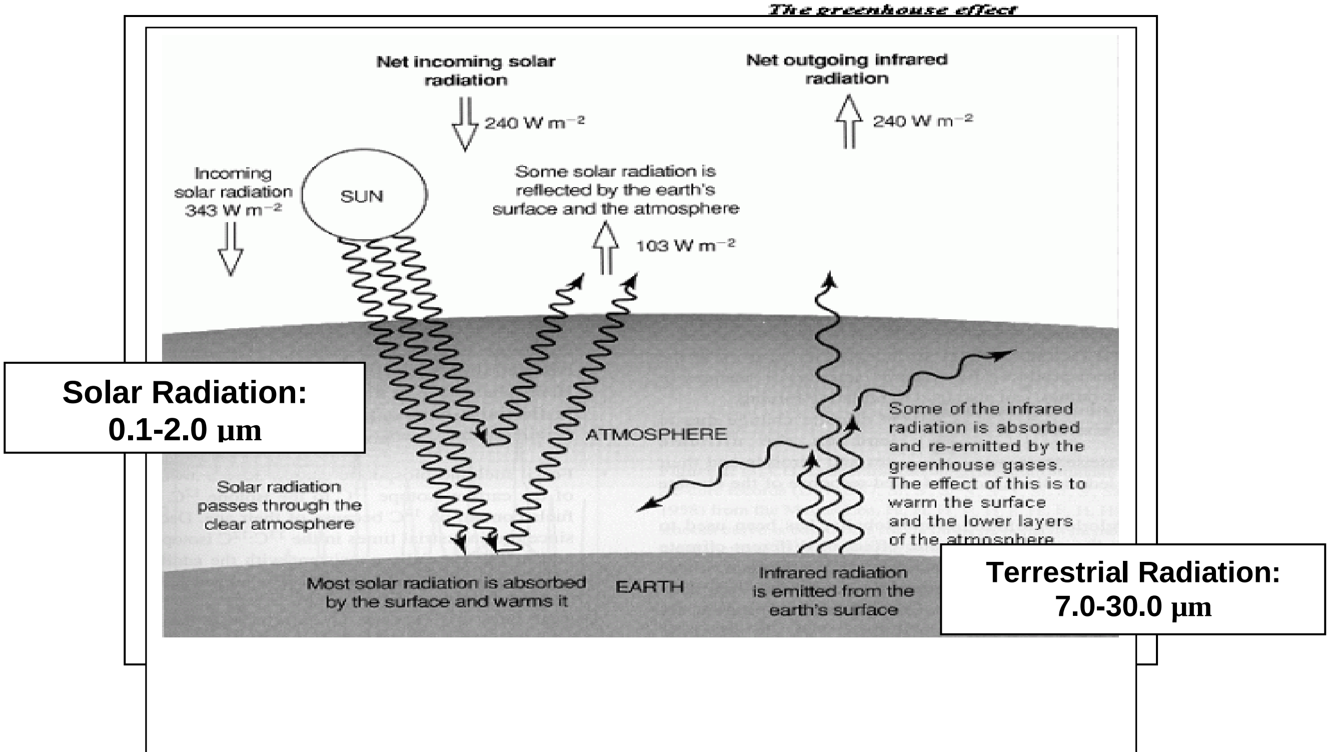


The greenhouse effect occurs because the earth's surface absorbs the sun's shortwave energy and re-emits it in a longer wavelength. Remember that the wavelength in which a blackbody radiates is dependent on temperature. A perfect radiating body emits energy in all possible wavelengths, but the wave energies are not emitted equally in all wavelengths; a spectrum will show a distinct maximum in energy at a particular wavelength depending upon the temperature of the radiating body. As the temperature increases, the maximum radiation occurs at shorter and shorter wavelengths. The hotter the radiating body, the shorter the wavelength of maximum radiation. For example, a very hot metal rod will emit visible radiation and produce a white glow. On cooling, it will emit more of its energy in longer wavelengths and will glow a reddish color. Eventually no light will be given off, but if you place your hand near the rod, the infrared radiation will be detectable as heat. A comparison of the blackbody spectrum for the earth and the sun are shown below:

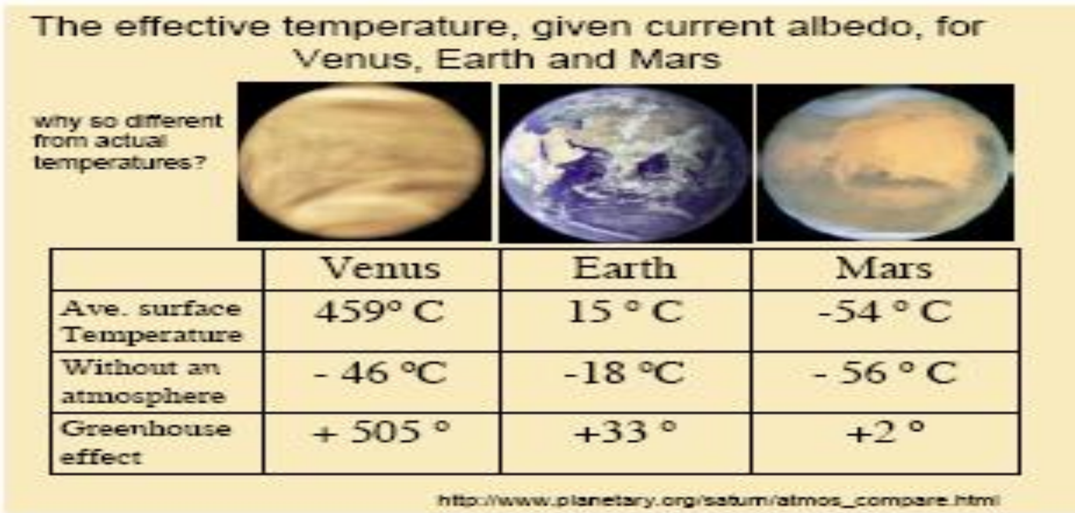


Notice that the terrestrial radiation be re-emitted by the earth is in the far infrared range. Infrared radiation is what they use to keep your burgers warm at many fast food places. It is also what the earth relies on to stay warm. Let's dissect the greenhouse effect





The infrared radiation emitted from Earth's surface is intercepted by greenhouse gases that comprise less than 1% of the total atmospheric gases: water vapor, carbon dioxide, and other trace gases (methane, nitrous oxide) in the troposphere creating a situation that has come to be known as the greenhouse effect. The greenhouse effect increases temperatures at Earth's surface by 33°C, ensuring that we have a livable planet. Earth would have an average surface temperature of –18°C rather than the present average of +15oC without the heat-trapping property of water vapor and other gases in our atmosphere. Venus, with a carbon dioxide atmosphere, has a runaway greenhouse effect with surface temperatures of over 200°C.



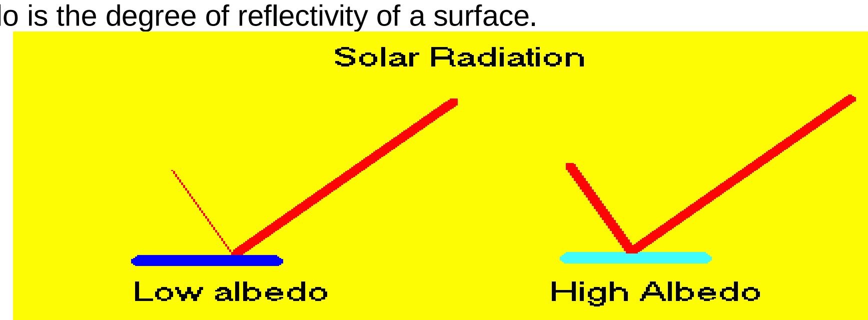
	Venus	Earth	Mars
Ave. surface Temperature	459° C	15 ° C	-54 ° C
Without an atmosphere	- 46 °C	-18 °C	- 56 ° C
Greenhouse effect	+ 505 °	+33 °	+2 °

Atmospheric scientists first used the term 'greenhouse effect' in the early 1800s. At that time, it was used to describe the naturally occurring functions of trace gases in the atmosphere and did not have any negative connotations. It was not until the mid-1950s that the term greenhouse effect was coupled with concern over climate change. And in recent decades, we often hear about the greenhouse effect in somewhat negative terms. The negative concerns are related to the possible impacts of an enhanced greenhouse effect. It is important to remember that without the greenhouse effect, life on earth as we know it would not be possible.

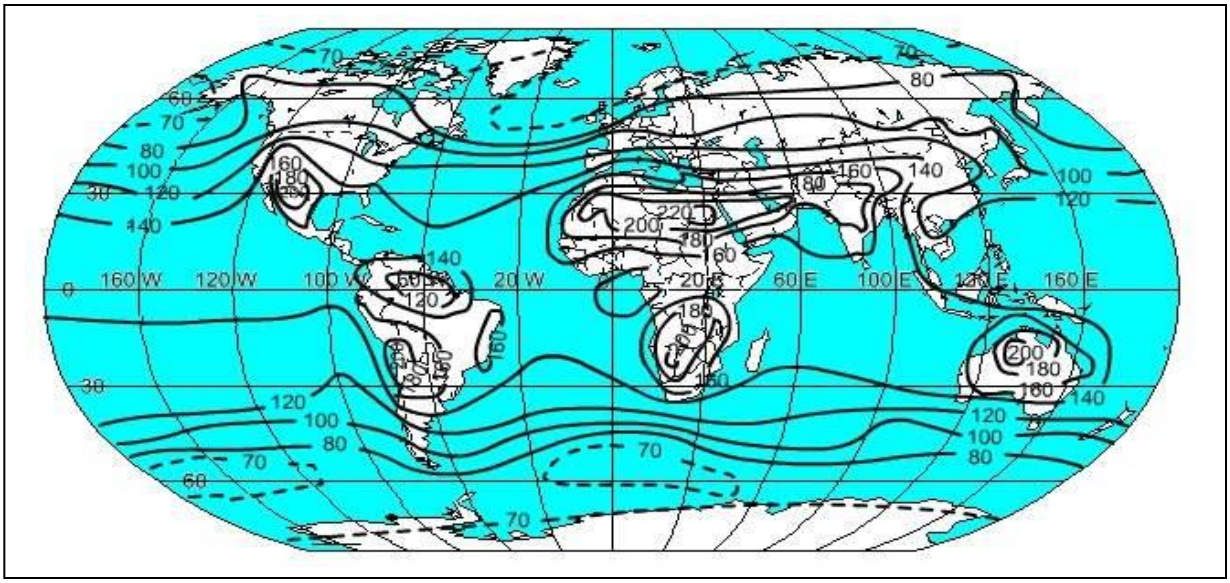
While the earth's temperature is dependent upon the greenhouse-like action of the atmosphere, the amount of heating and cooling are strongly influenced by several factors just as greenhouses are affected by various factors.

In the atmospheric greenhouse effect, the type of surface that sunlight first encounters is the most important factor. Forests, grasslands, ocean surfaces, ice caps, deserts, and cities all absorb, reflect, and radiate radiation differently. Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere. Sunlight falling on a dark desert soil is strongly absorbed, on the other hand, and contributes to significant heating of the surface and lower atmosphere. Cloud cover also affects greenhouse warming by both reducing the amount of solar radiation reaching the earth's surface and by reducing the amount of radiation energy emitted into space.

Scientists use the term albedo to define the percentage of solar energy reflected back by a surface. Albedo is the degree of reflectivity of a surface.



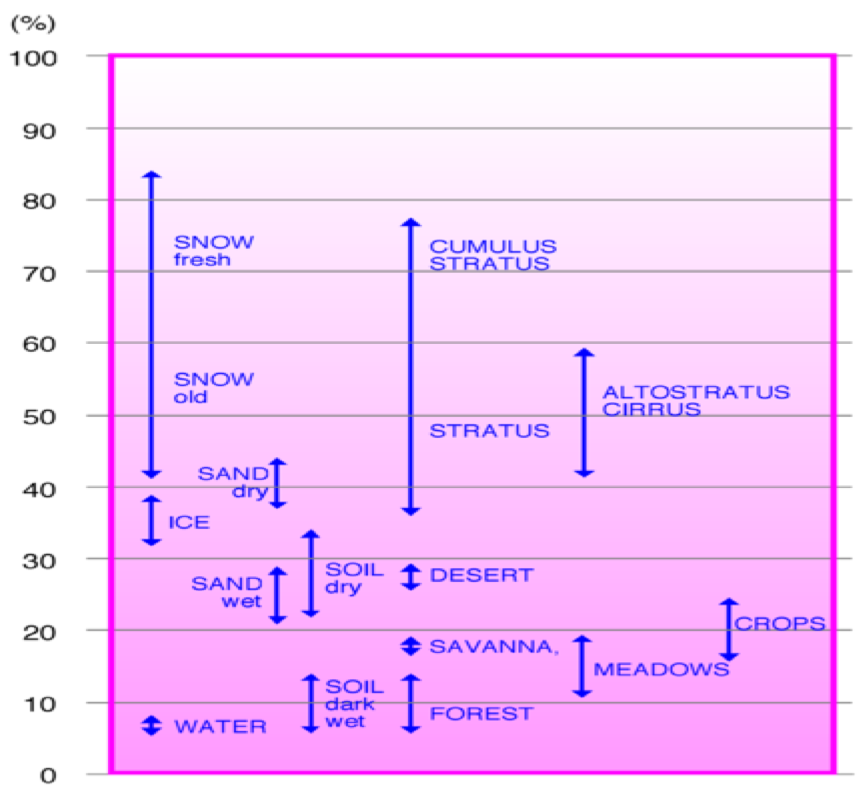
Surfaces with a higher albedo reflect more solar radiation than they absorb creating an uneven heating of the earth’s surface as shown on the map



In general, the amount of energy absorbed by an object depends upon the following:

- The object's absorptivity, which, in the visible range of wavelengths, is a function of its color
- The intensity of the radiation striking the object
- The angle at which the sun strikes (Law of reflection)
- Time of day
- Surface’s albedo

Albedo of Different surfaces



In a nut shell:

- Solar radiation occurs in a range of wavelengths represented by the electromagnetic spectrum
- Solar radiation reaching Earth's atmosphere is in the form of ultraviolet radiation, visible light, and infrared radiation
- Incoming short and intermediate wavelength radiation may be: absorbed by gases in the atmosphere, reflected back into space from the atmosphere or earth's surface, or absorbed by the earth's surface
- Incoming and outgoing long wavelength terrestrial radiation is absorbed by water vapor, carbon dioxide, and other greenhouse gases in the atmosphere to warm the planet
- The greenhouse effect occurs when long wavelength radiation is absorbed in the troposphere
- Radiation absorbed by the earth's surface is affected by the surface albedo, latitude, angle of incidence, and time of day

The interaction of solar radiation and the atmosphere provides the habitable planet we live on and contributes to the future potential for global warming. In addition, solar radiation supplies the energy necessary for cloud formation, precipitation, and local weather conditions.

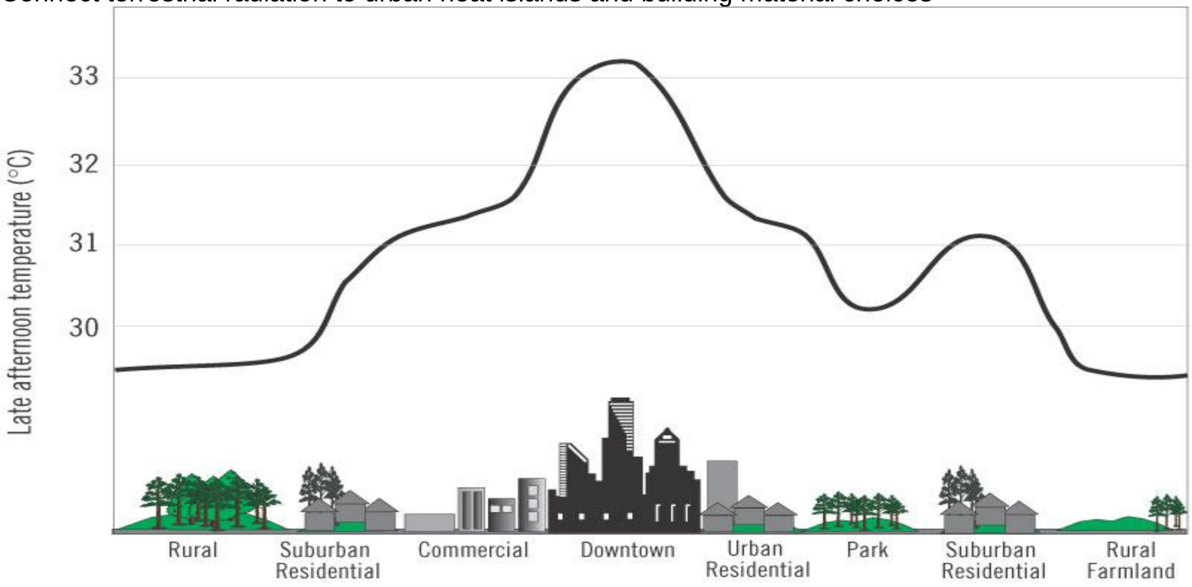
Making Your Infrared Telescope:

1. Get a 32 ounce insulated container: Styrofoam cup or insulated mug
2. Line the interior with a reflective surface such as mylar or aluminum foil
3. Make a hole in the bottom large enough for a thermometer
4. Place the telescope open side down over the surface being measured and record the temperature at which the body radiates

How it works:

Infrared radiation is emitted by a body that has a temperature. The infrared telescope essentially measures the heat that is coming off the surface being measured. As infrared radiation is also a form of light the telescope's reflective surface and insulating properties hold the radiation being emitted allowing students to measure it with a thermometer.

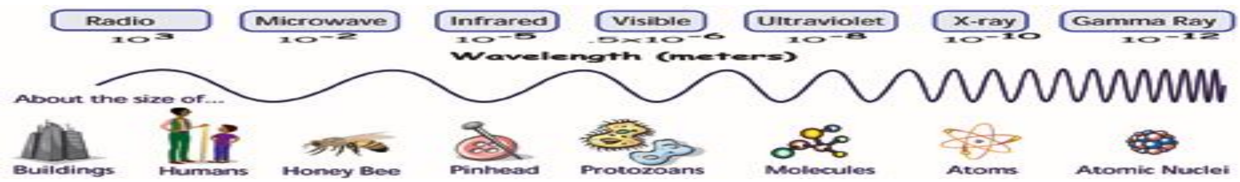
Extensions: http://www.urbanheatislands.com/
Connect terrestrial radiation to urban heat islands and building material choices



Name: ____________________________________ Date: _____________ Block: _________

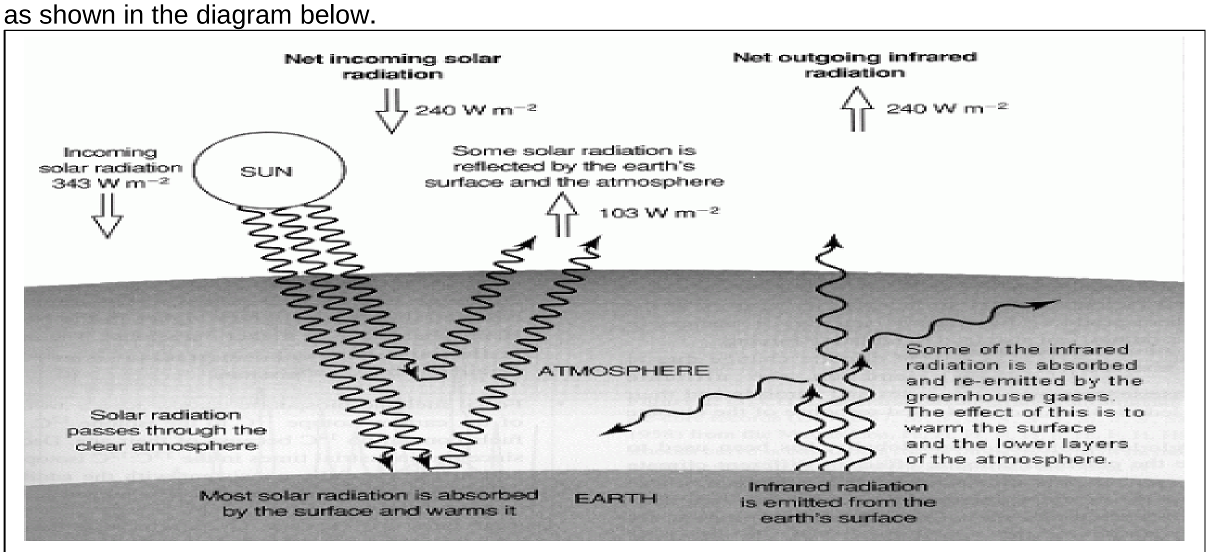
How Well Do I Radiate?

Background: Before we get into the greenhouse effect we need to understand a little more about where the energy that heats our planet comes from. One might be inclined to say the sun, but then the questions of how the sun produces energy arises. The sun's energy; often called electromagnetic radiation, is produced as excited electrons change energy levels to produce particles of light known as photons. Photons oscillate at different frequencies that result in a range of wavelengths as shown below;



Different wavelengths of light interact with our atmosphere to create a suitable climate allowing for life here to exist.

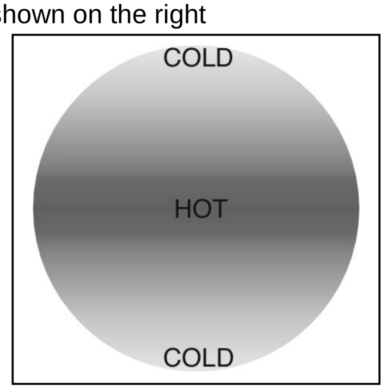
Conceptually, Earth's climate is pretty simple. The Sun emits solar radiation, some of which hits the Earth. The Earth absorbs a fraction of this and heats up. The radiation is then re-emitted by the earth's surface in a longer infrared wavelength warming the planet through a process called the greenhouse effect as shown in the diagram below.

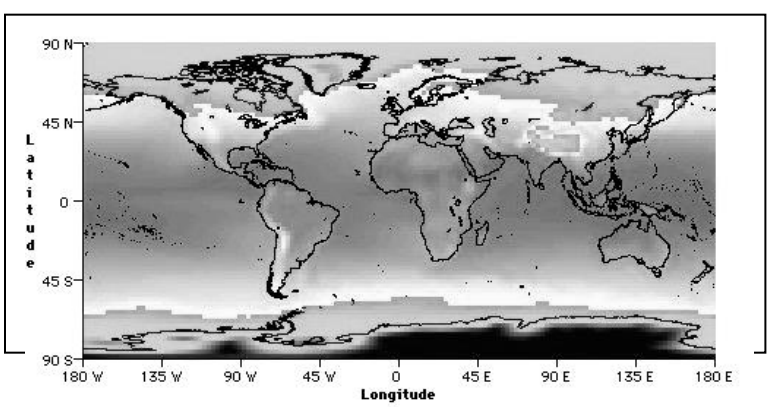


This means that our atmosphere is heated from the ground up through convective processes wherein long-wave terrestrial radiation is emitted and held in by the greenhouse gases.

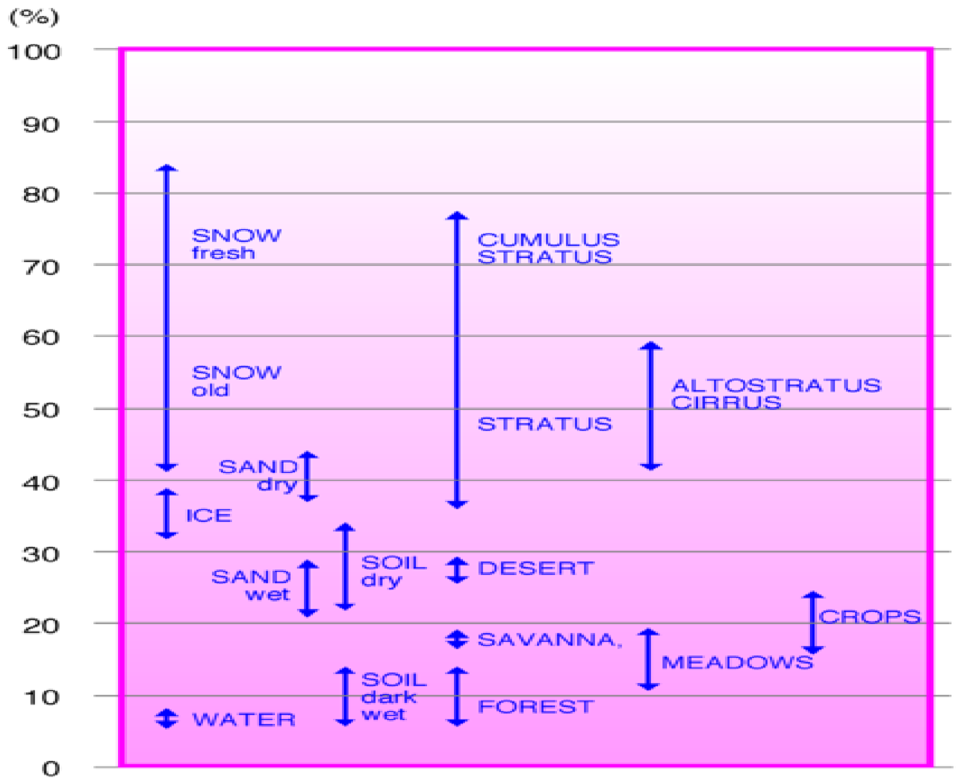
So the next question is what variables affect the amount of the sun's radiation that the Earth absorbs and is able to re-emit as heat? Please consider the following:

If the Earth were a homogeneous body its surface temperatures would be based solely on latitude creating a latitudinal distribution much like the one shown on the left as opposed to the actual annual distribution shown on the right





Recall that latitude determines how much solar radiation is received. The amount of solar radiation received along specific latitude is further influenced by the angle of incidence and the length of the day. Another important variable that affects the amount of solar radiation absorbed and re-emitted back as terrestrial radiation is related to the surface properties of the matter. Some solar radiation is reflected by a substance. This means that the electromagnetic waves simply bounce back into space. Earth reflects an average of 36 percent of the incoming solar radiation. The percent of reflectivity of all wavelengths on a surface is known as its ***ALBEDO.*** Earth's average albedo is from 36 to 43 percent. That is, Earth reflects 36 to 43 percent of solar radiation back into space. In calculating the albedo of Earth, the assumption is made that the average cloudiness over Earth is 52 percent. All surfaces do not have the same degree of reflectivity; consequently, they do not have the same albedo. Some examples are shown in the diagram:



In this investigation we will construct and use an infrared telescope to determine how much terrestrial radiation is emitted by different types of matter found on our surface.

Research Question: How does the matter a surface is made of affect the amount of terrestrial radiation it emits?

Procedure:

1. **Identify the variables and then formulate a testable hypothesis**
2. Construct your infrared telescope as instructed by your teacher.
3. **Choose one location outside and measure the temperature of the air at the altitudes indicated.**
4. Locate the surfaces requested in the table and use your infrared telescope as directed to find the radiating temperature being emitted as infrared radiation
5. Choose 5 additional surfaces to test and add them to your table
6. Collect the class data and then find the averages. Graph your data as directed
7. Use your data and the background information to answer the conclusion questions:

Independent Variable: ____

Dependent Variable: ____

Hypothesis: ____

____

Step 3:
Location air temperature measured at: ____

Temp of the air @ 2cm: ______ Temp of air @ 1 m: _______ Temp of air @ 2m: _______

Stop and think: What did you notice about the above measurements?

Infer: Why do you think this is?

Step 4: Radiating Data:

Surface Measured	Amt of infrared radiation being emitted	***Surface Measured***	Amt of infrared radiation being emitted
Asphalt			
Metal surface			
Green vegetation			
Dead vegetation			
Cement or concrete			
Shaded location			

Conclusions: Compose a conclusion statement that includes the following information:

- ✓ Restate your hypothesis and state whether the experiment proved or disproved it
- ✓ Explain what terrestrial radiation is, quantify its wavelengths, and then explain how it warms our planet (May use a diagram)
- ✓ Identify and quantity surface the emitted the most terrestrial radiation
- ✓ Identify and quantify surface that emitted the least terrestrial radiation
- ✓ Infer why this might be

Questions to consider from background:

1. Compare: How are solar and terrestrial radiation alike?

2. Contrast: how do solar and terrestrial radiation differ?

3. What does albedo measure?

   Infer: How does a surface’s albedo affect the amount of terrestrial radiation that it emits?

4. Analyze: How does latitude affect the amount of incoming solar radiation received?

   What variables can influence the amount of solar radiation received at specific latitude?

   Evaluate: Did latitude affect today’s data? _________________ Support your answer:

5. Evaluate: what effect do clouds have on our climate if they appear during the day? Use from the table and be specific.

6. Explain how the greenhouse effect works: *May use a labeled diagram that differs from the one in the background;

7. Evaluate: Why is the greenhouse effect important to life on earth?

Group Data: Radiating Data:

Surface Measured	Grp 1	Grp 2	Grp 3	Grp 4	Grp 5	Grp 6	Grp 7	Avg
Asphalt								
Metal surface								
Green vegetation								
Dead vegetation								
Cement or concrete								
Shaded location								

Measuring the Solar Constant
Teacher Information and Background:

Objective: To provide student with an inquiry based opportunity to design and build a photon collector in order to measure the solar constant.

Time required: 2-3 class periods

Materials needed: various containers: Styrofoam cups, clear plastic cups, cardboard cups, hand lenses, Petri dishes, plastic wrap, foil, chip bags, saran wrap, black plastic bag, white plastic bags, etc

Useful websites:

http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/science-briefs/ed-stickler/ed-irradiance.html
Great Background on what the solar constant is and how we measure it from NASA

http://www.schoolphysics.co.uk/age16-19/Nuclear%20physics/Nuclear%20energy/text/Solar_energy/index.html
Physics behind solar constant

http://www.dlese.org/library/query.do?q=calculating%20the%20solar%20constant&s=0
Plethora of resources

http://heasarc.gsfc.nasa.gov/docs/cosmic/earth.html
Cool site

http://earthstorm.mesonet.org/materials/les_ov_solar_rad.php
Nice background

http://science.nasa.gov/headlines/y2003/17jan_solcon.htm
Relationship between solar constant and sunspots

http://www.bruderheim-rea.ca/warming4.htm
Solar variation and climate change

http://www.swpc.noaa.gov/Curric_7-12/Activity_3.pdf
Less inquiry

http://www.saddleback.edu/faculty/csolem/solarradiationlab.htm
Different lab done inside

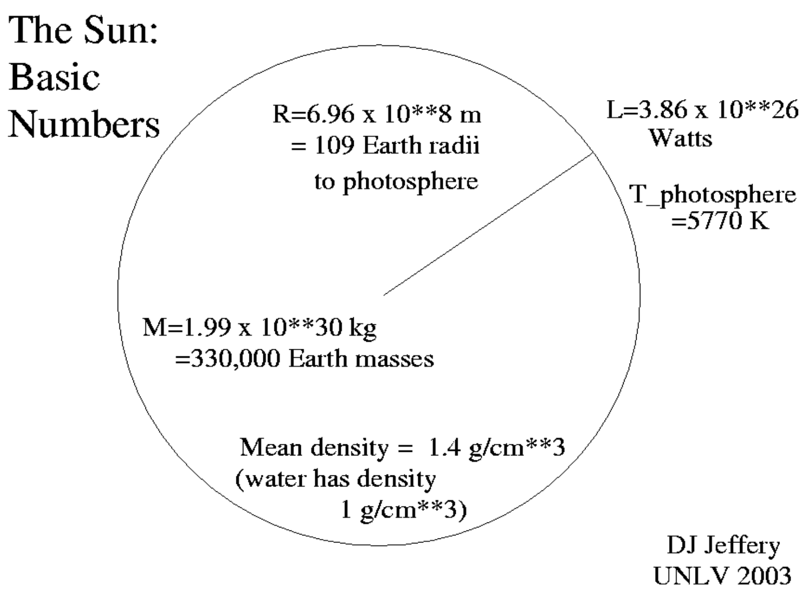
Teacher Background:

This lab provides students opportunity to design, construct, and test a photon collector to measure the amount of sunlight that they collect and compare it to the solar constant. The end result is not that they arrive at the exact calculation, but that they have the experience and are able to analyze and evaluate what variables could account for the difference in the accepted value and their experimental measurements. This lab is adapted from the website shown below from the University of Arizona:

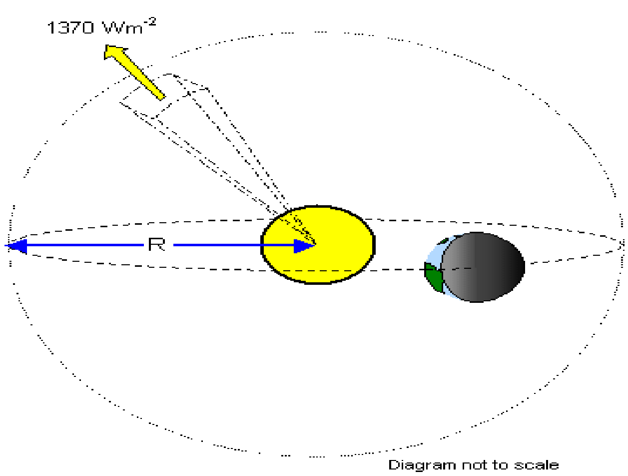
http://www.cerritos.edu/ladkins/a101l/Solar%20energy.pdf

THE SOLAR CONSTANT

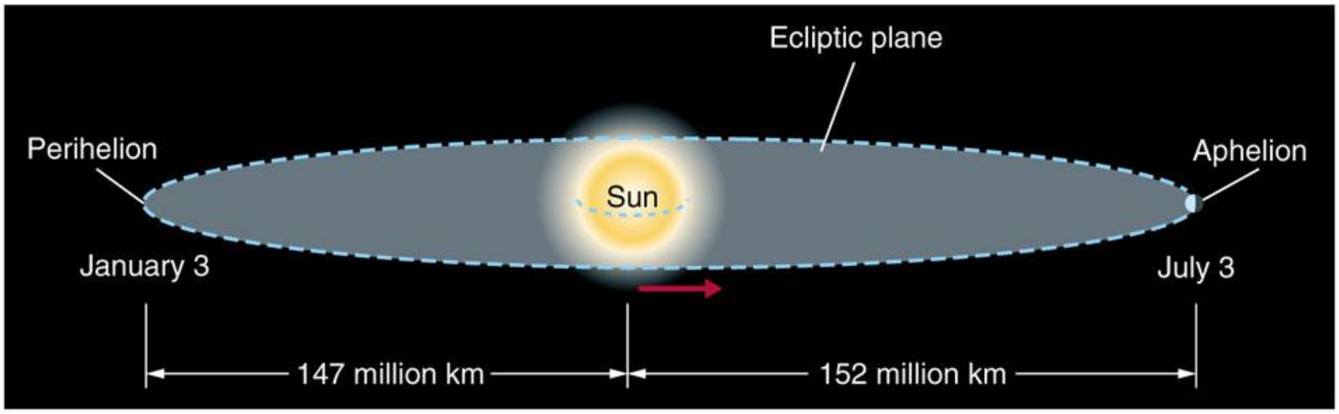
The luminosity of the Sun is about 3.86×10^{26} watts. This is the total power radiated out into space by the Sun. Most of this radiation is in the visible and infrared part of the electromagnetic spectrum, with less than 1 % emitted in the radio, UV and X-ray spectral bands. The sun's energy is radiated uniformly in all directions.



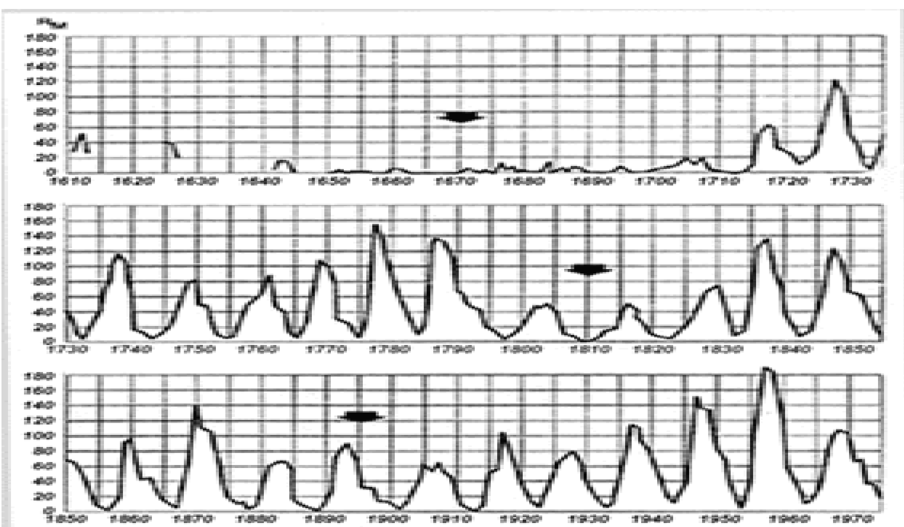
Because the Sun is about 150 million kilometers from the Earth, and because the Earth is about 6300 km in radius, only 0.000000045% of this power is intercepted by our planet. This still amounts to a massive 1.75 x 1017 watts. For the purposes of solar energy capture, we normally talk about the amount of power in sunlight passing through a single square meter face-on to the sun, at the Earth's distance from the Sun. The power of the sun at the earth, per square meter is called the solar constant and is approximately 1370 watts per square meter (W m-2).



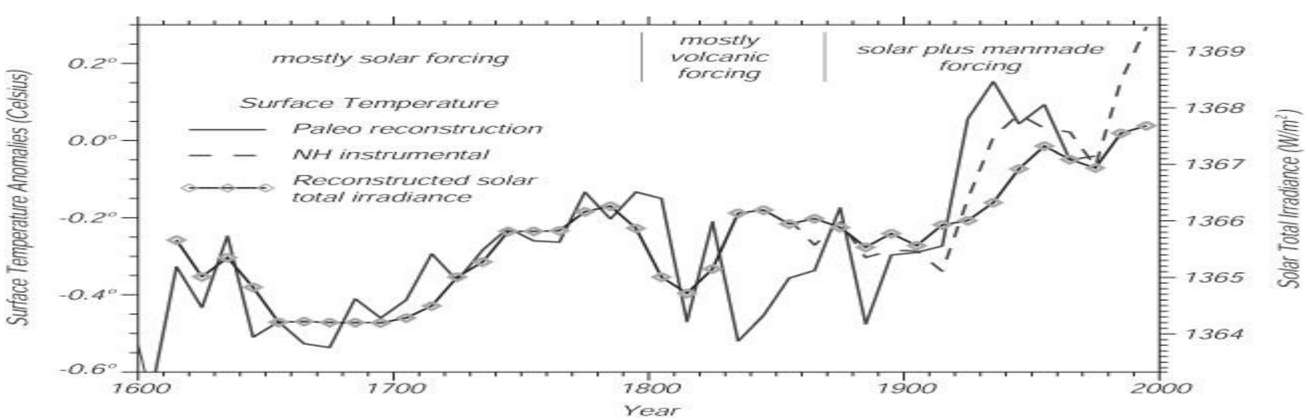
The solar constant actually varies by +/- 3% because of the Earth's slightly elliptical orbit around the Sun. The sun-earth distance is larger when the Earth is at perihelion (first week in January) and smaller when the Earth is at aphelion (first week in July). Some people, when talking about the solar constant, correct for this distance variation, and refer to the solar constant as the power per unit area received at the average Earth-solar distance of one “Astronomical Unit” or AU which is 149.59787066 million kilometers.



The total energy radiated by the sun has changed (when looked at a large timescale). In the very early years of the sun's life, the sun was radiating less energy than it does today. The solar constant has been measured by satellites since 1978: The data from these satellites shows that the average has indeed changed over the past 20 years ranging from 1363.1464 watts/m2 to 1368.0818 watts/m2. The measurements show that that the sun is a slightly variable star with a period on the order of 11 years.



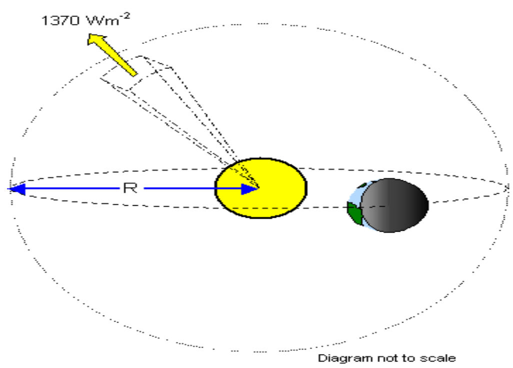
Connection between Solar variation and global temperature



Name: ________________________________ Date: ____________________ Class: ______

Measuring the Solar Constant Challenge

BACKGROUND: WHAT IS THE SOLAR CONSTANT?
The Sun contributes 99.98% of Earth's energy budget. The next largest heat source (< 0.02%) is the decay of ***long-lived radioisotopes*** in Earth's interior. Thanks to solar energy, Earth's surface is on average a balmy 18°C instead of -18°C. Solar energy keeps most of Earth's surface in the temperature range where liquid water is possible maintaining conditions necessary for life. The amount of solar energy reaching Earth is therefore one of the most important factors in understanding the habitability of this planet. Scientists have quantified the amount of solar energy the sun sends our planet and identified it as the ***solar constant***. The solar constant (SC) is the total amount of radiant energy emitted by the sun at all wavelengths, received at the top of Earth's atmosphere per unit time per unit area when Earth is at its mean distance (1 AU) from the sun. The solar constant is expressed either in units of energy received per unit area per unit time, such as calories per square centimeter per minute (cal/cm2·min), or in units of power per unit area, such as watts per square meter (W/m 2). *A calorie is the amount of energy required to raise the temperature of 1 gram of* H_20 *by 1 °C*. A Watt is a unit of energy equal to 1 Joule per second. Recall that a calorie is equal to 4.18 Joules. The solar constant is not actually a true constant because solar energy production varies by a few tenths of a percent over many years. There are several scientists looking for correlations between solar variations and their possible influence on global climate change.



At first it may appear that the solar constant, as defined above, can only be measured from a spacecraft outside Earth's atmosphere: however, it can also be done at the surface if correction factors are applied to account for specific conditions at a particular location. Similar steps will be taken by your team to normalize your data relevant to our campus. To get started you need to first design and build your photon collector. Keep in mid that we will be using water as our photon collecting medium due to its specific heat capacity and ability to store thermal energy. Thermal energy is a form of kinetic energy associated with the movement of particles. As your water molecules absorb the sun's electromagnetic radiation, their kinetic motion will increase and a rise in temperature can be observed and quantified. Although thermal energy cannot be lost or destroyed, it can be transferred through conduction, convection, and radiation. So you may want to relate your design to that of a Thermos.

Pre-Lab Questions:

1. What does the solar constant measure?

2. What are the 2 sources of energy for our planet? (Be sure to include percents)

3. What unit/s are used to express the solar constant?

4. What does a calorie measure?

5. Use complete sentences to provide a synopsis (summary) of the procedure we will use to find the solar constant here on our campus?

6. Evaluate: What variables might we have to normalize in our calculations?

THE APPARATUS

- To get started define the following terms in your own words:

Conduction

Convection:

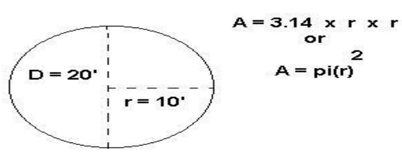
Radiation:

- Assemble your solar collector, designing it to minimize heat transfer to its surroundings. Be prepared to ***answer questions*** on why you used the materials you chose and why you assembled the photon collector in the way you did. Consider the properties of all materials in terms of how they conduct thermal energy. Solar Collector must be ready for use Thursday! Identify the materials that your group used and then write a very clear step-by-step procedure in the space below and then include a labeled diagram of your device on a separate sheet of paper.

Name: ________________________________ Date: ___________________ Block: _________

Measuring the Solar Constant

1: Measure the inside diameter of the cup at the water line using an improvised method of your choice. You should think about this before you put water in the cup. Use the diameter to calculate the surface area *A* of water exposed to sunlight. **SHOW YOUR CALCULATIONS**



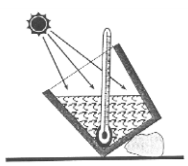
Diameter = ____________ cm Radius= ______________cm

Area =

2. Fill the photon collector about 1/2 to 3/4 full of water.
3. Use a graduated cylinder to measure the volume (*V*) of water used. ***The water should either be chilled with ice or warmed with hot water so that its temperature at the start of your measurements is 5 to 10 °C below the ambient outside air temperature***
4. Record the beginning temperature in your data table under 0 minutes
5. Calculate the mass of the water. The mass *m* of water in your photon collector is calculated from the measured volume *V* knowing that the density r = *m*/*V* of liquid water is 1 g/cm3 (1 cm3 = 1 ml).

Volume of water = ______________ ml ***Mass of water*** = ______________ g

6. Take your photon collector to the designated area and set it up in a location that will be fully exposed to the sun for the next 45 minutes.



Note: Prop the radiometer so that it points directly at the Sun. The rim of the cup must never cast a shadow on the surface of the water, so you may have to adjust the tilt during observations. Orient the thermometer so that it does not have to be removed to be .

6. Create a data table in the space provided below: Record time, temperature and atmospheric conditions throughout the lab
7. ***Take your first temperature reading and start the stopwatch.*** You will take the next reading in 2 minutes. Continue recording data for 45 minutes

SOLAR CONSTANT DATA

Time	Temp	Atm Cond	Time	Temp	Atm Cond
0			24		
2			26		
4			28		
6			30		
8			32		
10			34		
12			36		
14			38		
16			40		
18			42		
20			44		
22			45		

Beg Temp: _______________ End Temp: ___________ ∆T = _________

Calculating the Solar Constant:

Formula: Solar Constant = mc/ L_{Atm}· A {∆T/∆t}

Wherein:

m = mass of water **__________ g (Hint: 1 ml of water = 1 gram)**

A= surface area =**________________ cm^2 / 10,000cm^2/ m^2 = ________________ m^2**

C= specific heat capacity= **___________ cal/g · °C = ____________ J/g · °C**

L_{Atm} = conditions of the atmosphere and angle of the sun _________________________
(used to normalize our calculation as we are measuring our SC at the surface using the tables provided)

∆T/∆t = change in temp/ change in time ___________________________ °C/ min

∆T/∆t °C/ min / 60 sec/min = ___________________________ °C/ sec

Units, Conversions, and Constants

Energy (erg, Joule, calorie)

1 erg = 1 g cm^2/sec^2 = 10^{-7} Joules = 10^{-7} J
1 calorie = 4.186 J

Power (watts)

1 watt = 1 J/sec

Specific Heat Capacity of Water

c = 1 cal/g · °C

Plug your variables into the equation and then calculate your solar constant using the formula shown above.

Be sure to show each step:

Step 1: Multiply m · c

Step 2: Multiply L_{Atm} · A in meters

Step 3: Divide m · c / L_{Atm} · A (Product of step 1 divided by product of step 2)

Step 4: Multiply your answer to step 3 by ∆T/∆t. Your units should be expressed as W/m2

Step 5: The actual solar constant is 1367 W/m2. Calculate your percent of error using the formula shown below: <u>Be sure to show your calculation!!!!</u>

% of error = Difference in experimental value and actual value / actual value x 100

Evaluate: What variable/s could account for your difference?

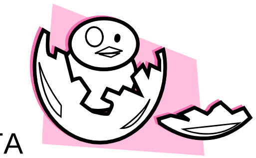
CORRECTION FOR LOSSES IN EARTH'S ATMOSPHERE (*LAtm*). Sunlight interacts in complex ways with atmospheric and surface materials the amount of solar energy reaching the ground is only 60-70% of the solar energy incident at the top of the atmosphere. Some solar photons are absorbed by molecules in the atmosphere, thereby warming it. Other photons are either reflected back to space or diffusely scattered within the atmosphere by molecules and dust. The direct component of sunlight reaching the ground is either absorbed by the surface or reflected upwards interacting again with the atmosphere. Consequently, there is a very complex relation between the amount of solar energy detected on the ground and that at the top of the atmosphere. To get around this complexity we will use the results of an ***atmospheric model*** which expresses these complex interactions by the dimensionless ***correction factor LAtm***. As found on the tables listed below: Note that there are 2 sets of tables: one for the Fall and one for the Spring. In addition there are tables for different atmospheric conditions:

Clear Atmosphere: Fall Table 1: L_{ATM} NORMALIZING DATA

Time	Solar Zenith	L_{atm}	Time	Solar Zenith	L_{atm}
7:00	4.2	**0.707**	12:00	46.0	**0.638**
7:30	10.0	**0.705**	12:30	46.0	**0.638**
8:00	15.7	**0.698**	1:00	44.9	**0.645**
8:30	21.2	**0.694**	1:30	42.8	**0.651**
9:00	26.4	**0.687**	2:00	39.7	**0.657**
9:30	31.3	**0.679**	2:30	35.9	**0.668**
10:00	35.7	**0.670**	3:00	31.5	**0.679**
10:30	39.5	**0.660**	3:30	26.7	**0.685**
11:00	42.6	**0.651**	4:00	21.5	**0.692**
11:30	44.8	**0.647**	4:30	16.0	**0.699**

Hazy Atmosphere: Fall Table 1: L_{ATM} NORMALIZING DATA

Time	Solar Zenith	L_{atm}	Time	Solar Zenith	L_{atm}
7:00	4.2	**0.569**	12:00	46.0	**0.470**
7:30	10.0	**0.566**	12:30	46.0	**0.470**
8:00	15.7	**0.560**	1:00	44.9	**0.479**
8:30	21.2	**0.552**	1:30	42.8	**0.486**
9:00	26.4	**0.540**	2:00	39.7	**0.505**
9:30	31.3	**0.529**	2:30	35.9	**0.512**
10:00	35.7	**0.517**	3:00	31.5	**0.528**
10:30	39.5	**0.505**	3:30	26.7	**0.538**
11:00	42.6	**0.489**	4:00	21.5	**0.550**
11:30	44.8	**0.480**	4:30	16.0	**0.559**



Clear Atmosphere: Spring Table 1: L_{ATM} NORMALIZING DATA

Time	Solar Zenith	L_{atm}	Time	Solar Zenith	L_{atm}
7:00	11.6	**0.703**	12:00	63.3	**0.535**
7:30	17.7	**0.699**	12:30	64.2	**0.527**
8:00	23.8	**0.695**	1:00	63.3	**0.535**
8:30	29.8	**0.681**	1:30	60.8	**0.568**
9:00	35.8	**0.672**	2:00	57.1	**0.578**
9:30	41.6	**0.650**	2:30	52.5	**0.614**
10:00	47.2	**0.633**	3:00	47.3	**0.634**
10:30	52.4	**0.613**	3:30	41.8	**0.652**
11:00	57.0	**0.577**	4:00	36.0	**0.665**
11:30	60.7	**0.567**	4:30	30.0	**0.682**

Hazy Atmosphere: Spring Table 1: L_{ATM} NORMALIZING DATA

Time	Solar Zenith	L_{atm}	Time	Solar Zenith	L_{atm}
7:00	11.6	**0.564**	12:00	63.3	**0.349**
7:30	17.7	**0.558**	12:30	64.2	**0.333**
8:00	23.8	**0.549**	1:00	63.3	**0.349**
8:30	29.8	**0.535**	1:30	60.8	**0.781**
9:00	35.8	**0.518**	2:00	57.1	**0.399**
9:30	41.6	**0.489**	2:30	52.5	**0.423**
10:00	47.2	**0.461**	3:00	47.3	**0.459**
10:30	52.4	**0.425**	3:30	41.8	**0.484**
11:00	57.0	**0.400**	4:00	36.0	**0.511**
11:30	60.7	**0.379**	4:30	30.0	**0.533**

Your Calories or Mine?
Teacher Background and Information

Objective: To provide students with an opportunity to use inquiry to collect data and relate it to the way energy is transferred through the hydrologic cycle.

Time Required: 1-2 Class periods

Materials Needed: Large test tubes with rubber stoppers, distilled water, graduated cylinders, and thermometers

Useful Websites:

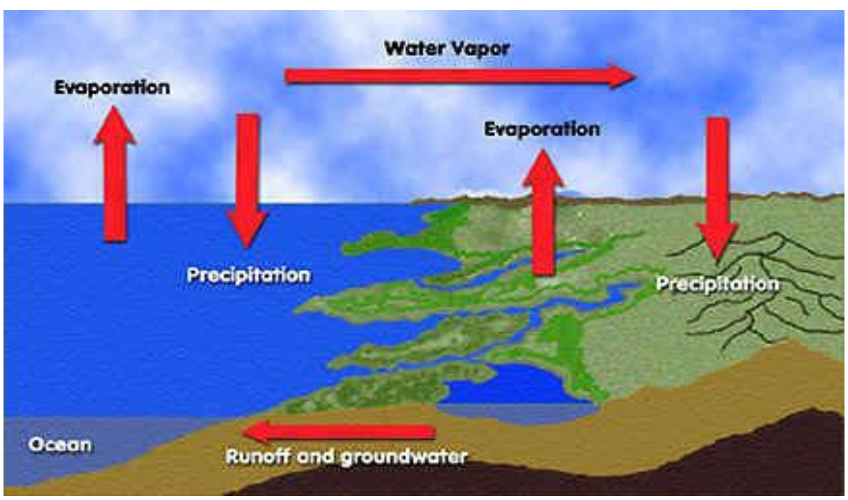
http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/atmospheric_moisture/hydrologic_cycle.html
Very thorough background on the hydrologic cycle

http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Watercycle.shtml
Simplified version form Enchanted Learning

http://physics.ship.edu/~mrc/astro/NASA_Space_Science/observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html
Web based unit from NASA

http://www.dlese.org/library/query.do?q=hydrologic%20cycle&s=0
Plethora of resources from DLESE

Teacher Background:
We live on a water planet, yet few of our students understand the importance and complexities of the hydrologic cycle. They have heard of and perhaps even studied the water cycle as it is shown below:



What's missing is the energy. Any change in state or phase requires energy. It is either absorbed to speed the molecule up or released into the atmosphere as the molecules molecular motion slows down. Either way it is transferred and still adheres to the laws of thermodynamics. This energy transfer may be responsible for the severe storms we experience here in Oklahoma.

Energy is added to storms when warm moist air rises, releases some of its latent energy to the atmosphere to condense onto a condensation nuclei to form a liquid cloud droplet. This results in a transfer to the atmosphere of 600 cal/ gram. Please consider the following:

How much does a cloud weigh? http://www.wrh.noaa.gov/fgz/science/cloud.php?wfo=fgz

To answer this question, we have to get our hands dirty and do a little bit of math. Lets take an example of where a fair weather cumulus cloud is about 1 km by 1 km by 1 km in dimension and located approximately 2 km above the ground. The mass of a differential volume element (such as our "cube" cloud), is simply the density times the volume of that element.

So, to figure this out, we need to first calculate the density of dry air and compare that to the density of the air in our "cube" cloud, which is made up of a small percent of water vapor along with a lot of air molecules. Water has an atomic weight of 18 while Nitrogen (N2) has an atomic weight of 28 and Oxygen (02) has an atomic weight of 32. Therefore we can already hypothesis that when water molecules displace Nitrogen or Oxygen molecules, the "weight" of the air mixture will decrease. Therefore, a cloud should "weigh" less than the air it is displacing.

The ideal gas law states that:

DENSITY = P / TR (pressure(P) divided by temperature(T) multiplied by a constant(R))

From the average values found in our atmosphere, we can use a temperature at about 2 km altitude of 275.15K (+2.15C) and a pressure at 2 km of 79.495KPa (795 mb). [Note: don't worry so much about the units given, just follow the general idea of the discussion.] For dry air, the constant(R) equals 287 J/K*kg. This gives us a density of 1.007 kg/m3 for dry air. For pure water vapor, we would use a constant(R) of 461 J/K*kg which ends up giving us a density for pure water vapor of 0.627 kg/m3. Because the cloud is made up of a small amount of water vapor and a large amount of air, we would need to calculate the partial pressure of the water vapor, which in this case comes out to around 7 mb, or 0.9% of the total pressure (795 mb).

So, [99.1 X (dry air density) + 0.9 X (moist air density)]/100 is approximately the density of the cloud itself. Calculating this gives a density in the cloud of 1.003 kg/m3, compared to 1.007 kg/m3 in the dry air surrounding the cloud. This shows that a cloud is less dense than the air around it, which is why it floats!

Now that density is taken care of, we only need to calculate the volume of the cloud. To make the example as easy as possible, we are assuming a 1 km by 1 km by 1 km cloud which gives us a volume of 1 cubic km (km3).

Finally, we can now calculate the mass of the cloud. Remember, the mass is density times the volume. So, we multiply 1 km^3 by the density which is 1.003 kg/m^3 and then multiply that by a factor of 1000 to get the units to be in kilograms(kg).

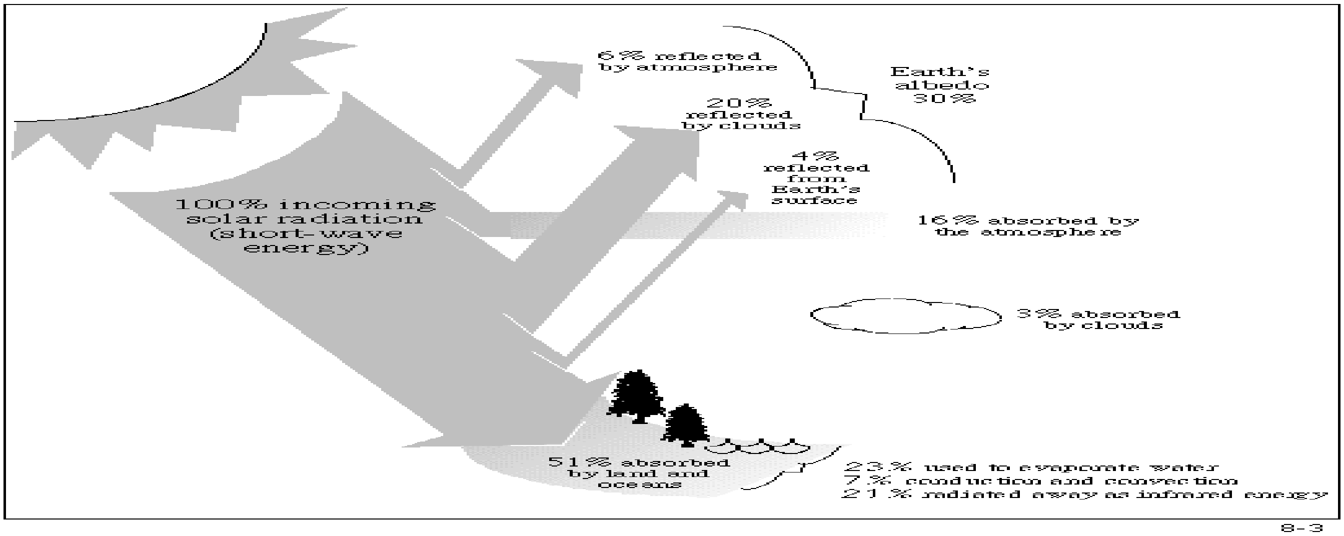
If you get out your calculators and do the math, you will see that our "cube" cloud weighs 1,003,000,000 kg or approximately 2,211,200,000 lbs. Thats almost 2.2 BILLION pounds!!! However, remember that air also has mass. By doing the same calculation, but this time using the density of dry air, we come out with a mass of 1,007,000,000 kg or approximately 2,220,000,000 lbs. So, dry air indeed weighs more than moist air, which is why clouds can exist where they do, seeming to 'float' across the skies.

In conclusion, a "typical" fair weather cumulus cloud (such as seen in the picture) "weighs" about over 2 billion pounds, or about 9 million pounds less than dry air of equal volume. The main point to get from this discussion is not that clouds weigh a lot, since in reality they cannot be weighed, but rather, that moist air is less dense than dry air. This is an important factor during the summer thunderstorm season when afternoon thunderstorms develop rapidly after a cloudless morning.

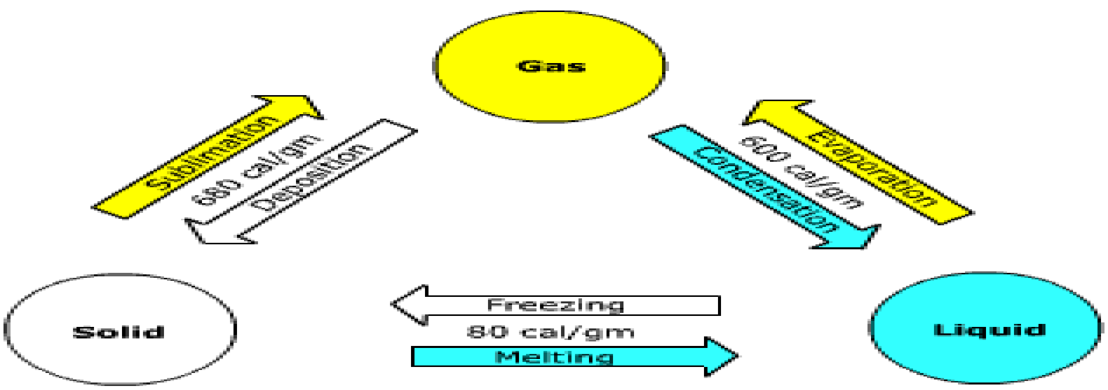
That's a lot of energy!

So where does the energy come from?

Earth's energy budget



Note that 23 % of the sun's energy that reaches the surface is used to evaporate water. That's almost ½ of the 51% absorbed at the earth's surface. How much energy does it take to evaporate a drop of water? Would you believe 600 cal/gram?



Change	Phases	Name	Amount of Energy Needed	What happens to energy
Rain changing into freezing rain	Liquid- solid	freezing	80 cal/g	Released into atmosphere
Water vapor changing into snow	Gas-solid	Deposition	680 cal/g	Released into atmosphere
Water changing into water vapor	Liquid-gas	Evaporation	600 cal/g	Energy is absorbed
Water vapor changing into a cloud	Gas-liquid	Condensation	600 cal/g	Released into atmosphere
Frost	Gas-solid	Deposition	680 cal/g	Released into atmosphere
Dew	Gas-liquid	Condensation	600 cal/g	Released into Atmosphere
Ice changing into water vapor	Solid-gas	Sublimation	680 cal/g	Released into atmosphere

CHIEF IDEAS:

1. **Water** plays a wide variety of roles in the global ecosystem. Water makes up the oceans and seas of the hydrosphere. Plants and animals in the biosphere consist of 65-90% water. Water vapor is the most important gas in the atmosphere for weather. Water has a high heat capacity and helps regulate the earth's temperature. Water is also a universal solvent and helps to shape the lithosphere.

2. The amount of water on earth is finite. However, water constantly moves from the hydrosphere to the atmosphere, the atmosphere to the lithosphere and biosphere, and then back to the atmosphere and hydrosphere. This is the **hydrologic cycle**. As water moves, it frequently changes state. Sometimes, water is a liquid, sometimes a solid (ice), and sometimes a gas (water vapor).

3. The driving force for the hydrologic cycle is **solar energy** assisted by **gravity**. Solar energy moves water in a **closed system** where it is regularly recycled.

4. Most of the world's supply of water is stored in the oceans (97.2%). Relatively small quantities of water are in the form of ice (2.15%) and groundwater (0.63%). Small but vital quantities of water are found in lakes and rivers (0.0001%), and in the atmosphere (0.001%).

5. Every time water changes its state, heat is either absorbed or released by water molecules. This heat energy is called **latent heat**. Heat is absorbed as liquid water changes to water vapor during **evaporation** and **transpiration**. **Condensation** releases latent heat when water vapor changes to tiny water droplets. When ice freezes (**sublimation**) it releases latent heat and when it melts, it absorbs heat.

6. These exchanges of energy take place constantly throughout the hydrologic cycle as water is evaporated over the oceans, transported over land areas in vaporized form, and then released by condensation as clouds and fog. **Precipitation** (rain, snow, hail, sleet, drizzle) is a by-product of condensation.

7. Precipitation is the most important source of fresh water for the earth's surface. When water falls on land:

    - It infiltrates the soil water belt
    - It percolates downward to join ground water
    - It runs off to rivers and eventually to the sea
    - It accumulates as glacier ice
    - But, **most** of the precipitation **evaporates** or **transpires** back into the atmosphere

Key points to consider:

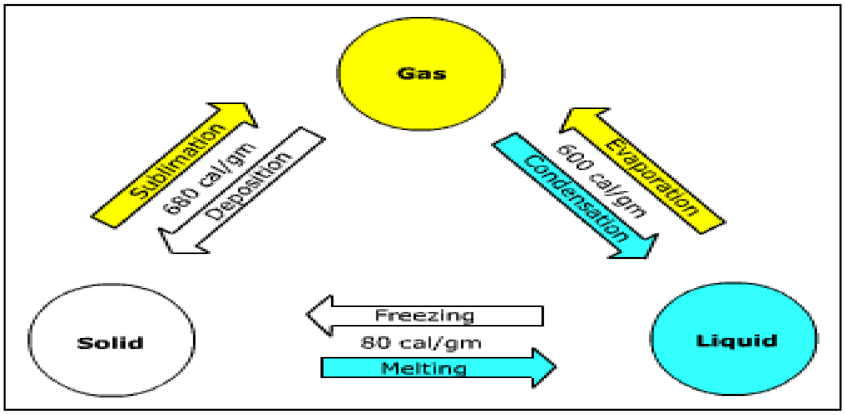
Evaporation is primarily dependent on the temperature of the water
Condensation is primarily dependent on the temperature of the air

- residence time = average time that one "package" of water remains in a reservoir (time)
    - Typical residence times:
        - **Oceans: 1000-10,000 years**
        - **Atmosphere: 10 days**
        - **Groundwater 100 to 100,000+ years**

Name: _______________________________ Date: _______________ Block:______

Your Calories or Mine?

Background Information: The conversation of energy is one of the very basic laws of nature. It says that energy cannot be created or destroyed, but it can change form. This means that when water molecules slow down enough to change from vapor to liquid or ice, the kinetic energy of their movement changes into another form of energy, heat. When water moves through the hydrologic cycle by evaporating from surface water to become water vapor in the atmosphere, the kinetic energy of their increased motion becomes heat or thermal energy. To see how this works, imagine being outdoors on a hot day. To make this thought experiment work even better, we will imagine that the humidity is low. As you exercise you begin to sweat, but the sweat quickly disappears. What's happening? The sweat, which is water, is evaporating and changing into water vapor in the air. Your body's heat is supplying the energy needed to speed up the molecular motion in the sweat to turn it into water vapor. This heat is latent heat, and the evaporated water is carrying it away from your body - it's cooling you off. When it's humid, sweat doesn't evaporate as easily and thus can't do as good a job of cooling you off. Perhaps some of the air that your sweat evaporated into is warmed by the latent heat released as your sweat evaporates. This causes it to rise and maybe feed into the bottom of a growing cumulus cloud. As the air rises it cools, which slows down the motion of the air's molecules. Eventually, some of the molecules of water that evaporated from your body slow down enough to join millions of others to make a drop of liquid water. When this happens, the kinetic energy just doesn't go away. It becomes heat - latent heat - that warms the air around it. The latent heat billions of molecules of water vapor release as they condense into water warms the air enough to make it rise faster. As the air rises, more air flows in, creating wind. The release of latent heat supplies most of the energy needed for rain showers, thunderstorms, and even hurricanes. The amount of energy needed to change the sweat on your body into water vapor is measured in calories. A calorie is the amount of thermal energy it takes to increase the kinetic energy of 1 gram of water enough to raise its temperature by 1° C. AS you might expect, the amount of energy needed to change water into its different phases is dependent on which phase change it is going through as shown both in your notes and below:



In this investigation you will be challenged to decide the best way to transfer your body's thermal energy to the water in a sealed test tube.

Caution: The water must remain in the test tube at all times.

To get started you need to identify your variables:

Independent variable: ____

Dependent variable: ____

Now do some brainstorming and come up with at least 3 ways that you could transfer the thermal energy from your body to the water in the test tube. Remember that the water must remain in the stoppered test tube at all times:

____
____
____

Now it's time to write your hypothesis by predicting which variable you chose will have the greatest amount of thermal energy transferred:

Hypothesis: ____

____

Now that you've formed your hypothesis, you can begin your experiment by following this procedure:

1. Write in the methods that you will use to transfer your thermal energy into the data table
2. Use the graduated cylinder to measure out 30 ml of distilled water
3. Carefully transfer the water into the test tube, and then use the thermometer to measure the temperature of the water.
4. Record your measurement in the data table
5. Put the rubber stopper into the test tube and make sure that it is secure and begin to transfer your thermal energy while your partner times 5 minutes.
6. When your five minutes is up, carefully remove the stopper and again measure the temperature of the water in the test tube. Record this measurement in the table.
7. Pour the water out and repeat steps 2-6 using the same method of transfer
8. Trade places with your partner and have them transfer their energy using a different method by repeating steps 2-6
9. Repeat steps 2-6 again using your third choice of energy transfer.

Way Energy Transferred	Starting Temp Trial 1 (°C)	End Temp Trial 1 (°C)	Dif in Temp (°C) Trial 1	Starting Temp Trial 2 (°C)	End Temp Trial 2 (°C)	Dif in Temp (°C) Trial 2

10. Find the average energy transferred (end temperature) and the average beginning water temperature and record both averages in the table.
11. Find the difference between the average beginning temperature and the average end temperature and record it in the table;
12. Use the formula shown below to convert your measurement to calories. Remember that each milliliter of water has a mass of 1 gram.

Amount of water changed (g) x Difference in temperature= calories

Way Energy Transferred	Avg Start Temp (°C)	Avg End Temp 1 (°C)	Avg Dif in Temp	Amount of Water Changed (G)	Calories of energy

Conclusions: ____

____

____

____

____

Inference: ____

____

____

Questions from Background:

1. What was the source of the thermal energy in this lab? ___________________________

How **much more** energy would have been needed to change all of the water in the test tube to water vapor? (Remember that 1 calorie is the amount of energy needed to change the temperature of 1 gram of water 1°C) Be sure to show your work:

____

2. What is the source of the energy needed to evaporate water in the hydrologic cycle?

____

3. How does water vapor get into the atmosphere? ________________________________

____

Complete the chart to show what happens during the hydrologic cycle:

Change	Phases	Name	Amount of Energy Needed	What happens to energy
Rain changing into freezing rain				
Water vapor changing into snow				
Water changing into water vapor				
Water vapor changing into a cloud				
Frost				
Dew				
Ice changing into water vapor				

4. If we had only used one gram of water, how many milliliters would this be? _____________

How would this have affected your data? ____

____

5. If the average hailstone has a mass of about 2.0 grams, how much energy was required to change it from the liquid water droplets in the cloud into the frozen water that could damage your car? (Show work)

6. How much energy is needed to change the hailstone back into water vapor so that it can return to the atmosphere? (SHOW YOUR WORK)

7. In the space provided, draw and label a diagram of the hydrologic cycle tracing a drop of water from the ocean to a cloud and back to earth as precipitation. Include labels that communicate which latent phase is represented and how much energy is required for each phase.

9. Evaluate: What affect do you think that this energy transfer through the hydrologic cycle has on our weather? BE SURE TO SUPPORT YOUR ANSWER!!!!!!! (Don't you just love these questions?

A Star Is Born
Teacher Background and Information

Objective: To provide students to model how stars in our universe form.

Time Needed: 1-2 class periods

Materials: Clean film canisters that have been sterilized, heavy whipping cream, Ziploc bags, bread, toaster, and jelly

Useful Websites:

http://rainman.astro.uiuc.edu/ddr/stellar/beginner.html
Digitial Simulator

http://cseligman.com/text/stars/starsummary.htm
Nicely written and very in depth

http://ircamera.as.arizona.edu/NatSci102/text/hydrostat.htm
Great graphics for hydrostatic equilibrium

http://cass.ucsd.edu/public/tutorial/StevI.html
Very thorough background

http://www.physics.howard.edu/students/beth/bh_stellar.html
In depth resource

http://universe-review.ca/F08-star.htm
Nice graphics and includes Wolf-Rayet stars

http://www.reciprocalsystem.com/isus/rec/rec27/earthcore.html
Connections between Stellar evolution and planetary formation

Teacher Background:

Stellar evolution can be as complicated or simple as you choose. This lab is designed to allow students an opportunity to model how stars form through accretion of heavier particles through centripetal forces by making butter. Just as the cream (the heavier particles) clump together whenever rotational motion is added by shaking, so to do protostars form from nebulous clouds that have had energy added causing them to spin; of course this is just the beginning. Stellar evolution is simply a star's battle to overcome the forces acting on it.

Nuclear Fusion Is NOT Why Stars Are Hot And Bright

http://cseligman.com/text/stars/starevol2c.htm

Suppose you were asked why is the Sun so hot and bright? The obvious answer is the fusion of hydrogen to helium in the core of the Sun. But *that is wrong*. The fusion of hydrogen to helium is what *keeps* the Sun hot and bright, but is not what *made* it that way. What made it that way was the heating of its gases by extreme compression -- its collapse and contraction from a cloud of interstellar gas hundreds of thousands of AUs in size, to a ball of plasma less than one two-hundredth of an AU in size. During that reduction of tens of millions of times in diameter, and thousands of millions of trillions (approximately 21 zeros) in volume, the gas inside the Sun became very, very hot -- more than ten million Kelvins hot -- and as a result, thermonuclear fusion began, which maintains the Sun's heat and brightness to this day, and will continue to do so for billions of years to come. But -- and this is a very important "but" -- *even before nuclear reactions began in the core of the Sun, it was nearly as hot and bright as it is, and if those reactions had never begun, it would have continued to contract, and would have become even hotter and brighter than it is*. It just wouldn't have lasted as long.

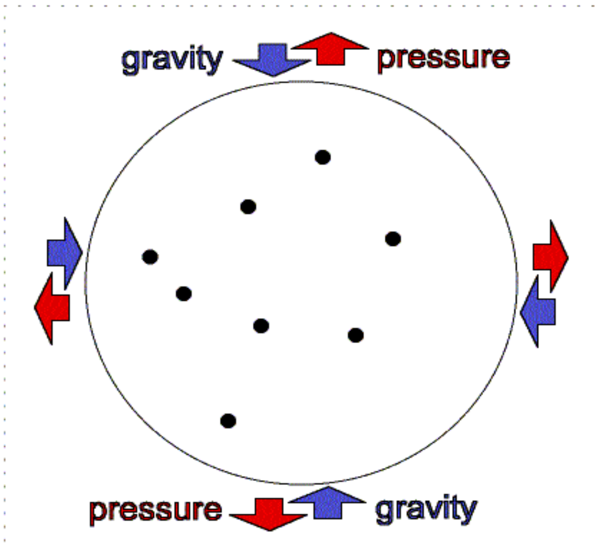
Stellar Evolution: The Life Cycle of Stars

Basic Idea:

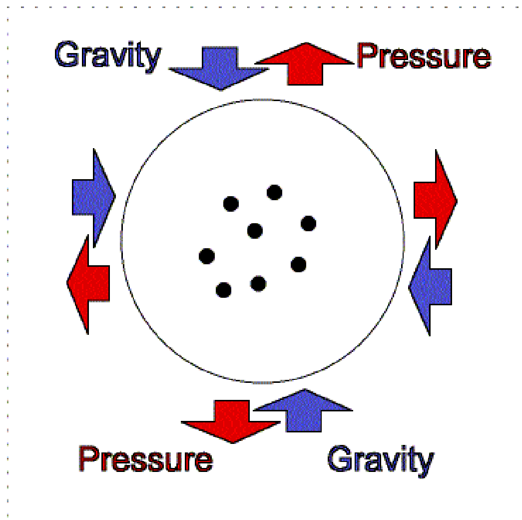
- Stars spend their lifetimes trying to maintain balance between the forces acting on them: hydrostatic forces and thermal equilibrium.
- When stars are unable to generate enough energy, they fall out of equilibrium and evolve
- Stellar evolution is simply a star's eternal battle with gravity

Gravity Holds a Star Together http://www.astronomynotes.com/starsun/s7.htm

Stars are held together by gravity. Gravity tries to compress everything to the center. What holds an ordinary star up and prevents total collapse is thermal and radiation pressure. The thermal and radiation pressure tries to expand the star layers outward to infinity.

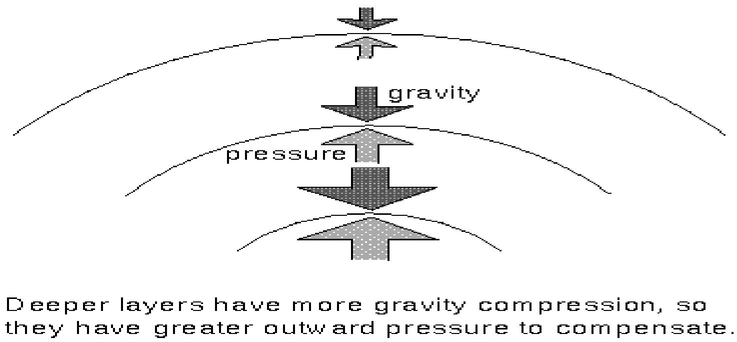


Hydrostatic equilibrium: gravity compression is balanced by pressure outward.



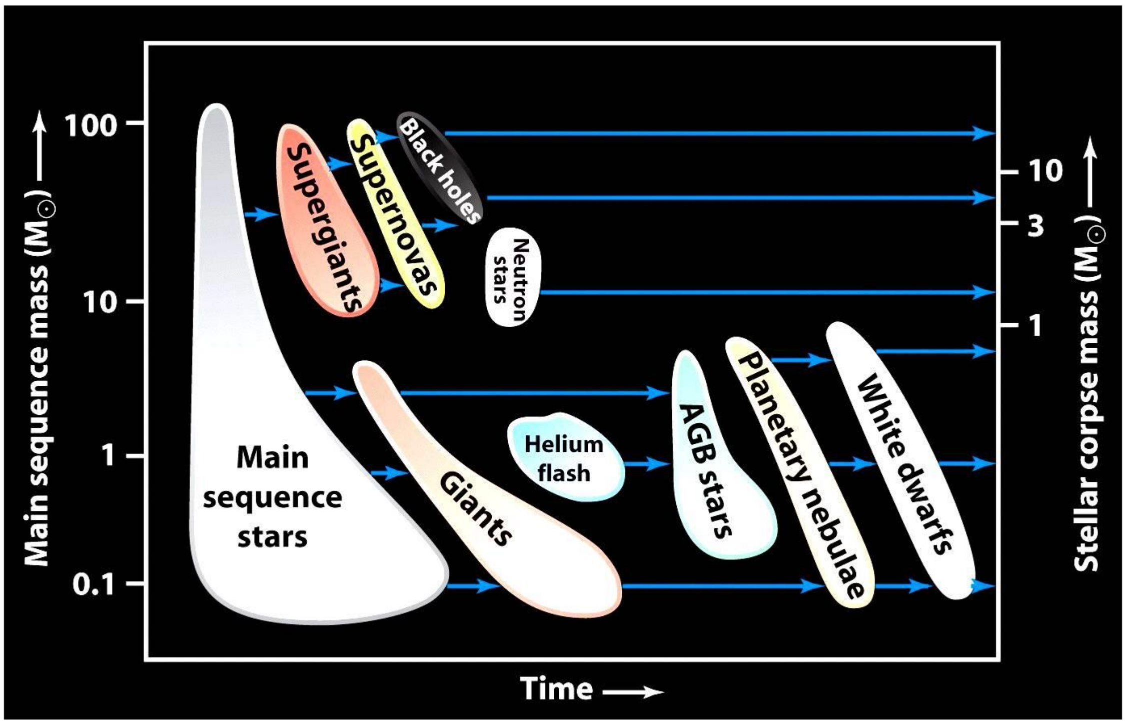
Greater gravity compresses the gas, making it denser and hotter, so the outward pressure increases.

In any given layer of a star, there is a balance between the thermal pressure (outward) and the weight of the material above pressing downward (inward). This balance is called hydrostatic equilibrium. A star is like a balloon. In a balloon the gas inside the balloon pushes outward and the elastic material supplies just enough inward compression to balance the gas pressure. In a star the star's internal gravity supplies the inward compression. Gravity compresses the star into the most compact shape possible: a sphere. Stars are round because gravity attracts everything in an object to the center. Hydrostatic equilibrium also explains why the Earth's atmosphere does not collapse to a very thin layer on the ground and how the tires on your car or bicycle are able to support the weight of your vehicle.



Life Cycles:

- The life cycle, or evolutionary path that a star takes is dependent on its mass
- Mass determines how long a star lives and how will end

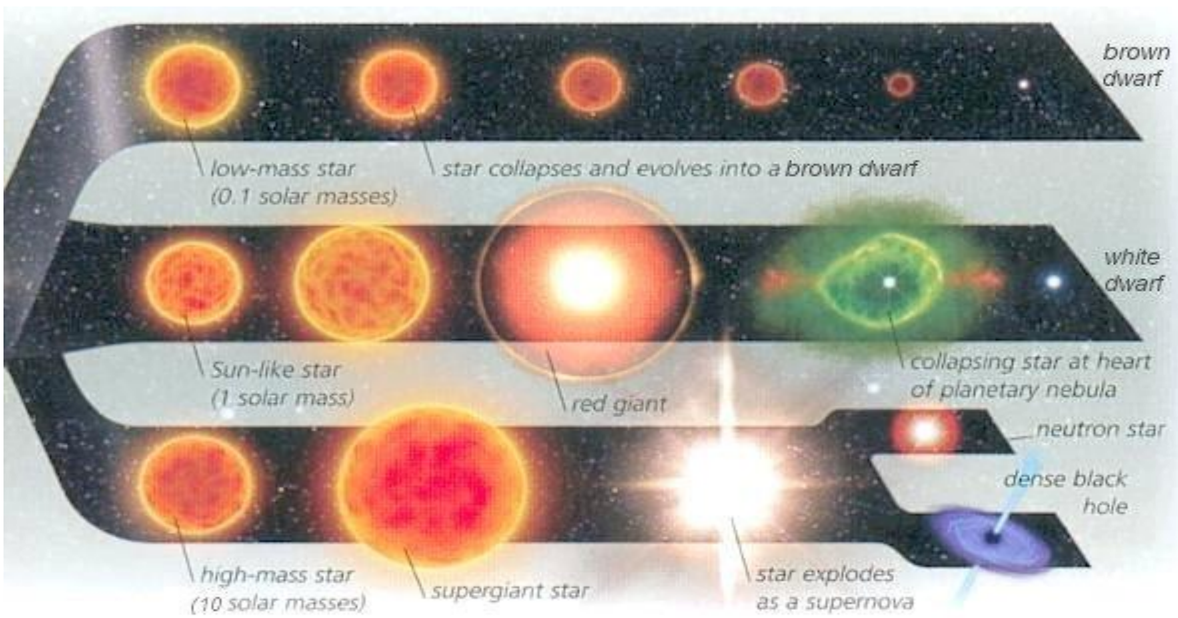


Stars spend the majority of their lifetime in the main sequence phase:

1. High-mass stars start off bright, and stay bright, despite shrinking, by getting hotter on the outside as well as on the inside. They take only a few tens of thousands or hundreds of thousands of years to form, because they throw away their energy so fast.
2. Low-mass stars start off faint, and get even fainter as they shrink, by getting hotter on the inside but staying cool on the outside. They take tens of millions of years to form, because they use their energy so slowly.
3. Medium-mass stars, like the Sun, start off with medium brightness, get fainter at first, like low-mass stars, then, as their central temperatures rise, begin to behave more like high-mass stars, and get hotter and brighter. They take a few millions of years to form, since they use their energy at middling rates.

Avg. Mass	spectral class	Avg. Luminosity	Avg Diameter	Main sequence lifetime
40 x Sol	O5	500 000 x Sol	18 x Sol	1 million years
17 x Sol	B0	20 000 x Sol	7.6 x Sol	10 million years
7 x Sol	B5	800 x Sol	4.0 x Sol	100 million years
3.6 x Sol	A0	80 x Sol	2.6 x Sol	500 million years
2.2 x Sol	A5	20 x Sol	1.8 x Sol	1000 million years
1.8 x Sol	F0	6 x Sol	1.3 x Sol	2000 million years
1.4 x Sol	F5	2.5 x Sol	1.2 x Sol	4000 million years
1.1 x Sol	G0	1.3 x Sol	1.04 x Sol	10 000 million years
1.0 x Sol	G2 (sun)	1.0 x Sol	1.00 x Sol	12 000 million years
0.9 x Sol	G5	0.8 x Sol	0.93 x Sol	15 000 million years
0.8 x Sol	K0	0.4 x Sol	0.85 x Sol	20 000 million years
0.7 x Sol	K5	0.2 x Sol	0.74 x Sol	30 000 million years
0.5 x Sol	M0	0.03 x Sol	0.63 x Sol	75 000 million years
0.2 x Sol	M5	0.008 x Sol	0.32 x Sol	200 000 million years

Not everyone agrees how mass affects the final evolutionary state as shown in the two examples below: However, everyone is in agreement that our sun will eventually burn out and become a black dwarf. It does not have the mass to go supernova, but watch out when it giants.



Fates of a Star is related to its Mass

Initial Mass (Compared to the Sun)	**Final Evolutionary state**
<0.01	planet
0.01<M<0.08	Brown Dwarf
0.08<M<0.25	Helium White Dwarf
0.25<M<9.0	C-O White Dwarf
8.0<M<12	O-Ne-Mg White Dwarf
12<M<40	Super Nova → Neutron Star
40<M	Super Nova → Black Hole

Name: ______________________________ Date: _____________ Block: _______

A Star Is Born

Background: Unlike humans and other mammals whose birth is due to biological processes, the birth of a star results from same rules of physics that apply to all of the matter in the universe. You start with a cool gas and a little cosmic dust to block starlight in a place called a Nebula. The cool gas atoms are attracted to the center due to gravity. Recall that every atom is attracted to every other atom. The closer the atoms are, the bigger the attraction. The cloud of gas gets smaller and denser and the cloud starts to contract and pull in on itself (again due to gravity.) At this time it starts to rotate due to the conservation of angular momentum. The outside forms a disk and the mass continues to contract. As the atoms are squeezed together tighter and tighter things heat up. Recall that when you compress a gas, it gets warm. This is energy conservation at work: gravitational potential energy becomes thermal energy. As the temperature goes up several thousand degrees, the protostar begins to radiate and emit thermal energy that can be detected with an infrared telescope. When the center of the protostar gets hot enough and the forces of attraction are great enough, the atoms of hydrogen begin to fuse together to form helium in a process known as nuclear fusion. The protostar is now emitting enough energy to move into its next stage of life: the main-sequence phase. The central heat source stabilizes the pressure, halting further contraction so that the energy being radiated is now supplied by the nuclear fusion occurring in the star's core instead of the compression of its gases. A star has been born. This main-sequence star will spend the greater part of its life in this main-sequence phase battling gravity to remain in equilibrium. Unfortunately, the physics dictates that this equilibrium cannot last forever and the star will lose its battle with gravity as it dies.

Research Question: How do stars evolve?

Materials: empty film canister, heavy cream, Ziploc bag, graduated cylinder, triple-beam balance, and some rotating bodies

Procedure:

1. Seal the canister and place it in the Ziploc bag. Seal the bag and compress the lid as you take turns rotating or shaking the canister
2. Continue rotating the canister until the heavier elements in the cream have condensed to form butter.
3. Remove the canister from the Ziploc bag and pour off the whey
4. Use your notes and the background information to answer the conclusion questions.
5. CLEAN YOUR AREA!

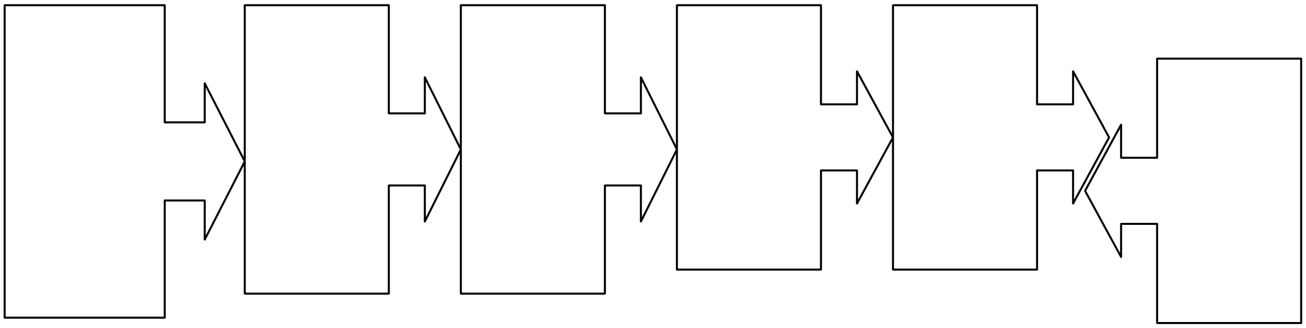
Conclusions:

1. What happened to the temperature of the cream as you rotated the canister?

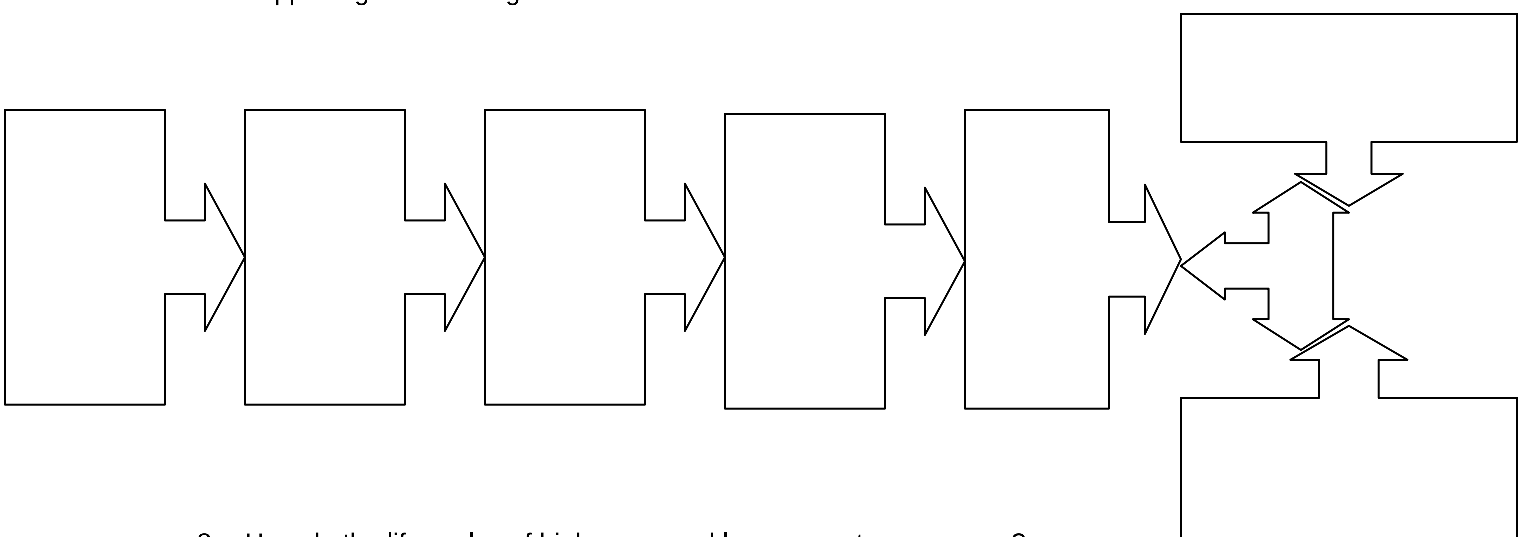
   WHY?

2. What force caused the heavier elements of the cream to come together?
3. Write a summary that describes the physics behind making butter using the information in the background: Be sure to include what happened to the kinetic energy, what caused the change, and how it changed.
4. What is hydrostatic equilibrium and how does it affect the evolutionary pathway of a stellar mass?
5. Where are the elements that makeup all of the matter in our universe theorized to come from?

6. Complete the concept map to track the evolutionary pathway of ***low-mass stars*** such as our sun and then include a time scales for each stage of development also include a **brief description** of what is occurring during each stage.



7. Complete the concept map to track the evolutionary pathway of ***high-mass stars*** such as Vega and then include a time scales for each stage of development and a brief description of what is happening in each stage



8. How do the life cycles of high-mass and low-mass stars compare?

9. How do the life cycles of high-mass and low-mass stars differ?

10. Complete the table to show the final evolutionary state for each star shown:

Initial Mass	Final Evolutionary State
40 < M	
8.0 <M < 12	
0.08 < M < 0.25	

11. During a supernova explosion, 90% of the star's mass is expelled into space to form a new nebula. Will our sun ever form a nebula? Support your answer:

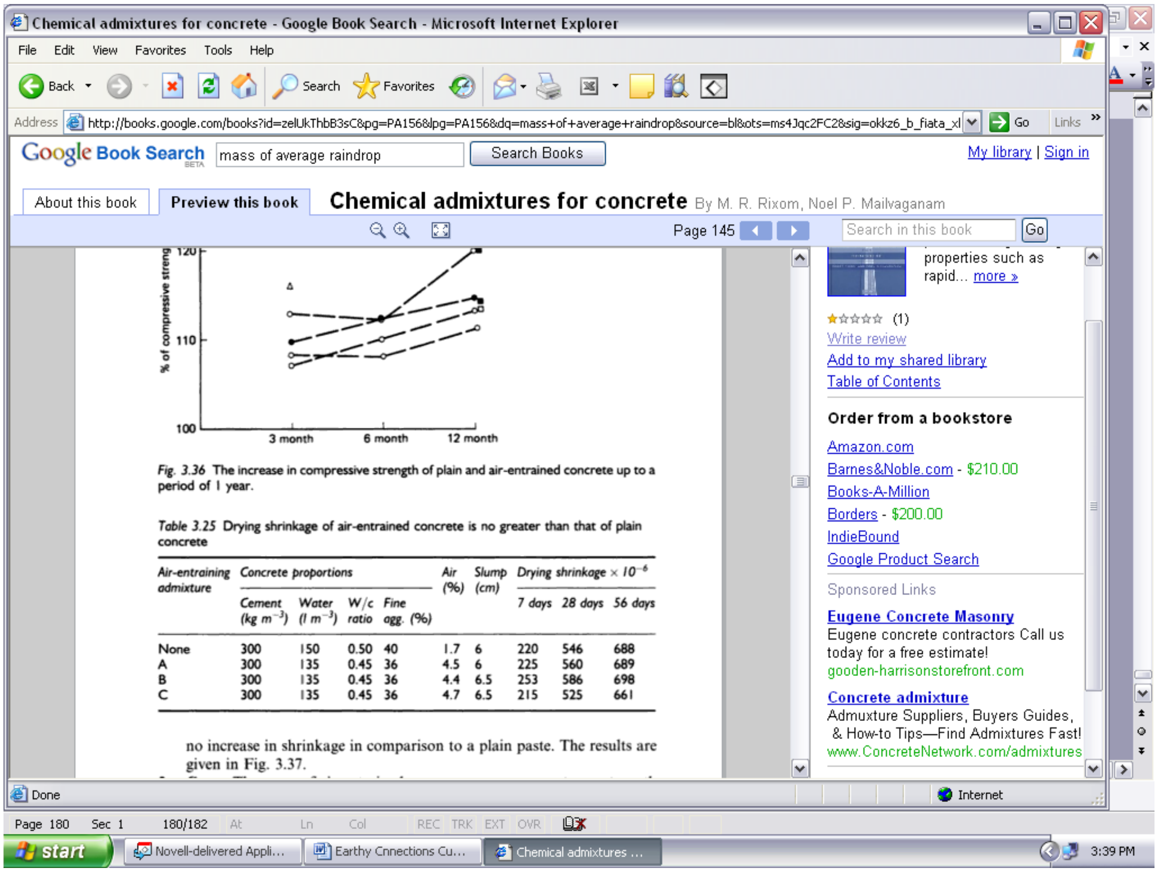
12. Identify the type of telescope used to detect and study the following stages of a star's life:

Protostar-

Main-sequence star-

Neutron Star-

Black hole-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Page 145
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Go
% of compressive streng
120
110
100
3 month
6 month
12 month
Fig. 3.36 The increase in compressive strength of plain and air-entrained concrete up to a period of 1 year.
Table 3.25 Drying shrinkage of air-entrained concrete is no greater than that of plain concrete
Air-entraining admixture | Concrete proportions | Air (%) | Slump (cm) | Drying shrinkage × 10⁻⁶
Cement (kg m⁻³) | Water (l m⁻³) | W/c ratio | Fine agg. (%) | 7 days | 28 days | 56 days
None 300 150 0.50 40 1.7 6 220 546 688
A 300 135 0.45 36 4.5 6 225 560 689
B 300 135 0.45 36 4.4 6.5 253 586 698
C 300 135 0.45 36 4.7 6.5 215 525 661
no increase in shrinkage in comparison to a plain paste. The results are given in Fig. 3.37.
properties such as rapid... more »
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