MS.Earth's Interior Systems

MS.Earth's Interior Systems

Students who demonstrate understanding can:

MS-ESS3-f. Analyze and interpret data sets that indicate the location and frequency of earthquake, volcanic eruption, and tsunami hazards in a region and identify patterns that allow for forecasts of the likelihood and locations of future events.* [Clarification Statement: Data sets could be maps of the sizes and locations of earthquakes, animations of ocean tsunami propagation from earthquakes in different regions, or historical records of the timing and explosivity of past volcanic eruptions.]

MS-ESS2-e. Develop and use models of past plate motions to support explanations of existing patterns in the fossil record, rock record, continental shapes, and seafloor structures. [Clarification Statement: The evidence for past motions of tectonic plates is based on similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures such as ridges, fracture zones, and trenches.] [Assessment Boundary: Understanding of paleomagnetic anomalies in oceanic and continental crust is not assessed.]

MS-ESS2-f. Read critically using scientific knowledge and reasoning to evaluate data, hypotheses, and conclusions that appear in scientific texts about the way new evidence for geologic activity at plate boundaries and the movements of Earth's surface has led to continual refinements of the theory of plate tectonics. [Clarification Statement: Geologic activity at plate boundaries includes volcanoes and the folding and faulting of rocks; plate motion evidence comes from satellites (such as GPS) and seismic imaging of the earth.]

MS-ESS2-a. Use plate tectonic models to support the explanation that, due to convection, matter cycles between Earth's surface and deep mantle. [Clarification Statement: Patterns of mantle convection and its surface expression (plate tectonics) result in the destruction of sea floor rock at subduction zones and the formation of ocean trenches. Earth materials come to the surface via volcanism at continental and oceanic rift zones, above subduction zones, and at intraplate volcanoes, some of which are associated with rising mantle plumes that appear to be largely independent of plate tectonics. Explanations should account for the formation of mid-ocean ridges and features at subduction zones such as ocean trenches.] [Assessment Boundary: Details of the various processes and forces that drive mantle convection are not assessed.]

MS-ESS2-g. Collect data and generate evidence to answer scientific questions about the chemical and physical processes that form rocks and minerals and cycle Earth materials. [Clarification Statement: Investigations can use various materials to simulate the processes of melting, crystallization, weathering, deformation, and sedimentation. These processes act together to cycle and recycle Earth materials.]

MS-ESS3-a. Construct explanations based on evidence from multiple sources for how the uneven distribution of Earth's mineral and energy resources, which are limited and typically non-renewable, is a result of past and current geologic processes often associated with plate tectonics.* [Clarification Statement: For example, the global distribution of coal is a result of the burial and lithification of ancient swamp matter; the global distribution of petroleum is the result of the burial of organic marine sediments and subsequent development of petroleum traps; and the global distribution of many precious metals (e.g., gold, copper) correlates with past volcanic and hydrothermal activity associated with subduction zones.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to support explanations, describe, test, and predict more abstract phenomena and design systems.

- Use and/or develop models to predict, describe, support explanations, and/or collect data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales. (MS-ESS2-e),(MS-ESS2-a)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Collect data and generate evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-g)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Use graphical displays (e.g., maps) of large data sets to identify temporal and spatial relationships. (MS-ESS3-f)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Base explanations on evidence obtained from sources (including their own experiments) and the assumption that natural laws operate today as they did in the past and will continue to do so in the future. (MS-ESS3-a)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.

- Read critically using scientific knowledge and reasoning to evaluate data, hypotheses, conclusions that appear in

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth

- *Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE)* (MS-ESS2-e),(MS-ESS2-f),(MS-ESS2-a)

ESS2.A: Earth Materials and Systems

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles of produces chemical and physical changes in Earth's materials and living organisms. (*Interior processes are addressed here. Surface processes are addressed in MS.ESS-ESS.*) (MS-ESS2-a)
- *The top part of the mantle, along with the crust, forms structures known as tectonic plates. (HS.ESS2.A GBE)* (MS-ESS2-e),(MS-ESS2-f),(MS-ESS2-a)
- *Solid rocks can be formed by the cooling of molten rock, the accumulation and consolidation of sediments, or the alteration of older rocks by heat, pressure, and fluids. (NRC Framework, p. 180)* (MS-ESS2-g)

ESS2.B: Plate Tectonics and Large-Scale System Interactions

- Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-e)

ESS3.A: Natural Resources

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (*Interior resources are addressed here. Surface resources are addressed in MS.ESS-ESS.*) (MS-ESS3-a)

ESS3.B: Natural Hazards

- Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. However, mapping the history of natural hazards in a region combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (*Interior hazards are addressed here. Surface hazards are addressed in MS.ESS-ESP.*) (MS-ESS3-f)

Crosscutting Concepts

Patterns

- Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. (MS-ESS2-e),(MS-ESS2-f)

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-f)

Energy and Matter

- Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-a)

Stability and Change

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and *processes* at different scales, including the atomic scale. (MS-ESS2-g)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology, on Society and the Natural World

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Technology use varies over time and from region to region. (MS-

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice, Disciplinary Core Idea, or Crosscutting Concept.

scientific and technical texts in light of competing information or accounts; provide an accurate summary of the text distinct from prior knowledge or opinions. (MS-ESS2-f) --- ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** ▪ Scientific explanations are subject to revision and improvement in light of new evidence. (MS-ESS2-f) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ▪ Theories are explanations for observable phenomena. (MS-ESS2-f) ▪ Science theories are based on a body of evidence developed over time. (MS-ESS2-f) ▪ The term "theory," as used in science is very different from the common use outside of science. (MS-ESS2-f)	**PS4.A: Wave Properties** ▪ Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. (MS-ESS3-f) **ETS1.A: Defining and Delimiting an Engineering Problem** ▪ Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (MS-ESS3-f)	ESS3-a)

Connections to other DCIs in this grade-level: will be added in future version.

Articulation to DCIs across grade-levels: will be added in future version.

Common Core State Standards Connections: [Note: these connections will be made available soon.]
ELA/Literacy –
Mathematics –

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice, Disciplinary Core Idea, or Crosscutting Concept.

Molecular Motion
Are You Current on Convection?

Convection is the transport of energy due to density differences. As a liquid or gas is heated it expands and becomes less dense and therefore lighter. If a cooler material with greater density is above the warmer layer of fluid the warmer fluid material will be displaced and "rise" through the cooler material to the surface. The rising material will dissipate its heat (energy) into the surrounding environment, become more dense as it cools, and will sink to start the process over.

PURPOSE
In this activity you will explore the effect heat energy has on the speed of water molecules.

MATERIALS
2 beakers, 400 mL
blue, red or green food coloring
ice
safety goggles

SAFETY ALERT!

Make sure you and your group members are wearing safety goggles.

PROCEDURE
Part I

1. Obtain two 400 mL beakers and fill them with 200 mL of tap water.
2. In one beaker, add 100 mL of ice. In the second beaker your teacher will add 100 mL of hot water. Do not touch the beaker containing hot water.
3. Allow both beakers to settle for one minute.
4. While the beakers are settling, predict which beaker will have the most molecular movement. Write your answer under Predictions on your student answer page.
5. After waiting one minute, add one drop of food coloring to each beaker. Observe each beaker and draw what you see in the Observations section of your student answer page.
6. Answer the conclusion questions for Part I.

Part II

1. Answer the first five conclusion questions from Part II based on what you observed in Part I.
2. For question number 6, make a prediction about what will happen in the described demonstration. Draw your prediction on the student answer page.
3. Watch the demonstration. Draw what you saw happen, and describe it in words below your drawing.

Molecular Motion
Are You Current on Convection?

PREDICTIONS

OBSERVATIONS

Draw both beakers and write a description of each one below your drawing.

HOT H_2O COLD H_2O

CONCLUSION QUESTIONS

Part I

1. In which beaker did the food coloring spread out faster?

2. What caused the molecules to move faster? How could you tell which beaker had faster molecules?

3. How does temperature change the speed of molecules?

Part II

1. Define "heat" in terms of molecular motion.

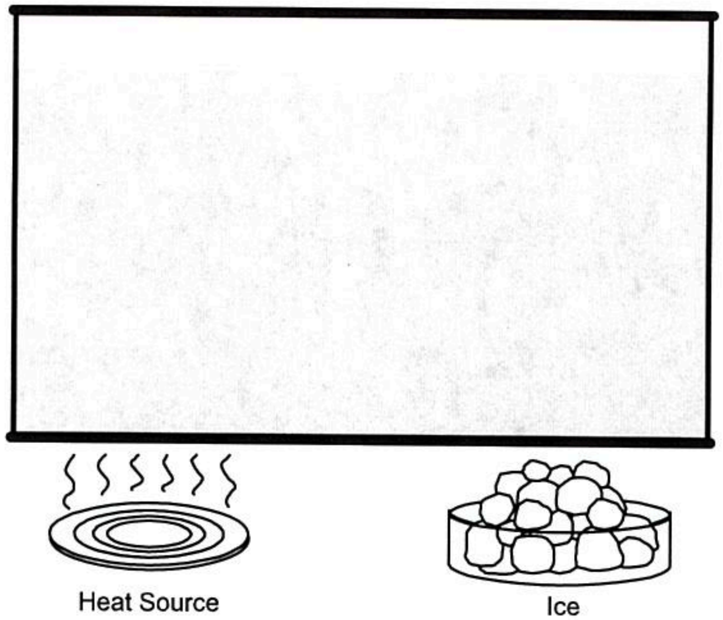
2. If the temperature of a liquid is raised, will its molecules collide with more or less force?

3. If the temperature of a liquid is raised, will it tend to take up more or less space?

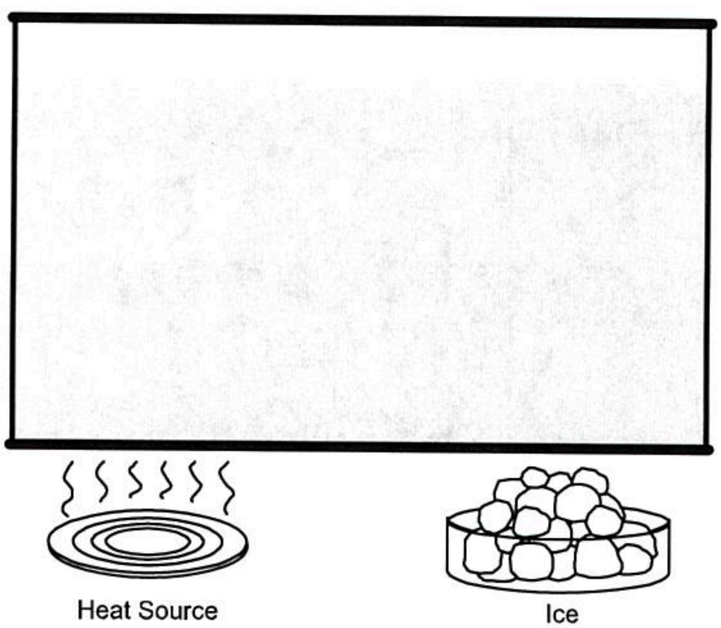
4. If the mass of a substance remains the same and its volume increases (see previous question), how is the density of a substance affected?

5. Which floats better….low density substances or high density substances?

6. Based on your answers to the previous questions, predict the movement of water (if any) in the unevenly heated container drawn below.



7. Watch the demonstration. Draw what actually happened to the water molecules during the demonstration and describe what happened in words below your drawing.



Molecular Motion
Are You Current on Convection?

OBJECTIVE
Students will be able to describe the effect that heat has on the speed of water molecules and then connect that learning to density and convection.

LEVEL
Middle Grades: Earth Science

NATIONAL STANDARDS
UCP.2, UCP.3, A.1, A.2, B.5, B.6, D.1

CONNECTIONS TO AP
AP Environmental Science:

I. Interdependence of Earth's Systems: Fundamental Principles and Concepts A. The Flow of Energy

TIME FRAME
60 minutes

MATERIALS
(For a class of 28 working in pairs)

14 beakers, 400 mL
ice, small cooler full
red, green, or blue food coloring
10 gallon aquarium
hot plate or tea kettle
small bucket or bowl for ice
electric heating pad
safety goggles

TEACHER NOTES

Molecular Motion: Are You Current on Convection is an introductory activity that explains how adding heat changes the speed of molecules. This is a fundamental concept for students and serves as the basis for explaining what happens in the atmosphere as a result of solar heating. Weather, winds, ocean currents and hurricanes all start with this basic concept.

Part I of the lesson requires ice and hot water. One small cooler of ice should be plenty for one class. An electric teapot makes heating and transporting the water from table to table very easy and safe. It is also possible to use a hot plate and pot or large beaker to heat the water. Have students wear goggles while you distribute the hot water. Any color of food coloring will work, but yellow is the least effective. Red, blue and green are all very visible.

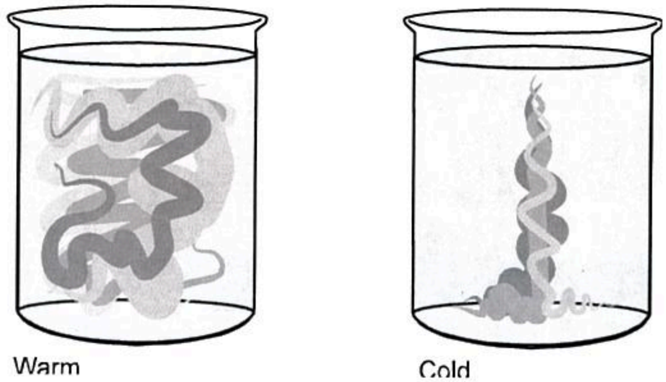
Part II of the lesson will demonstrate the movement of food coloring through a tank of water that has different temperature regions. The demonstration needs an aquarium with water set on top of both a heat source and a cooling source. A dual-temperature base can be created by using a stack of books and a wide bowl that are the same height. A hot pad laid over the stack of books creates the heated side and a bowl of ice creates the cooling side. Place the aquarium atop this base and fill it with some water. Set this up just prior to the demonstration.

When it is time for the demonstration, ask the students where they want you to drop the food coloring. Again, red, blue and green work well. Add several drops of the food coloring and allow students to observe what happens. A perfect little convection cell should develop after a minute or so.

Once students have completed and handed in their answer pages, review the concepts of heat (energy), density, volume, and convection.

POSSIBLE ANSWERS TO THE CONCLUSION QUESTION AND SAMPLE DATA
PART I

Observations: Draw both beakers and write a description of each one below.



CONCLUSION QUESTIONS

PART I

1. In which beaker did the food coloring spread out faster?
   - The food coloring spread out much faster in the beaker containing hot water.

2. What caused the molecules to move faster? How could you tell which beaker had faster molecules?
   - The hot water had more energy than the cold water. The heating of the water sped up the water molecules. The food coloring acted as an indicator and showed us the behavior of the water molecules moving.

3. How does temperature change the speed of molecules?
   - Increasing the temperature of the water increases the speed of the molecules. Decreasing the temperature of water decreases the speed of molecules.

TEACHER

PART II

1. Define "heat" in terms of molecular motion.
   - As you add thermal energy and heat up the water, you increase the temperature and increase the average molecular motion.

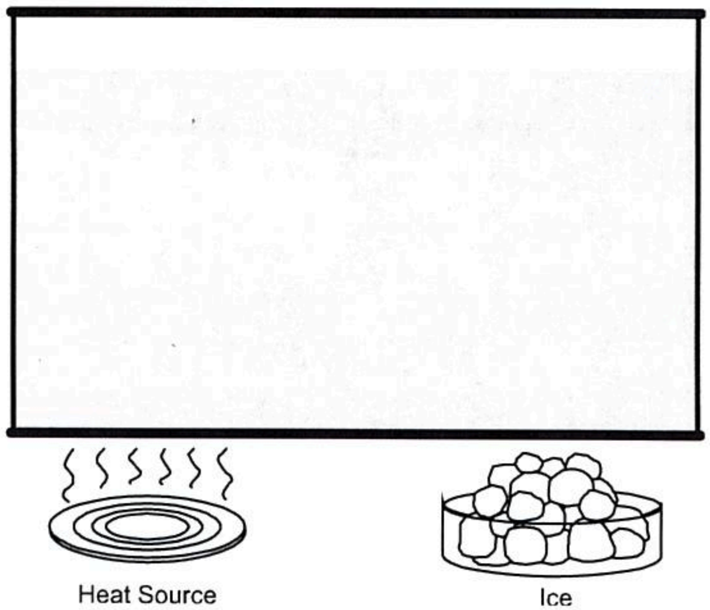
2. If the temperature of a liquid is raised, will the molecules within the sample collide with more or less force?
   - As the temperature of a liquid rises, its molecules will collide with more force because they are moving faster and have more energy.

3. If the temperature of a liquid is raised, predict whether the liquid sample will tend to take up more or less space?
   - Answers will vary, but most students will say that as the temperature of a liquid rises it will take up more space since it expands. Don't miss this opportunity to combat a common misconception — expansion occurs due to an increased distance *between* molecules, not that the molecules themselves become enlarged.

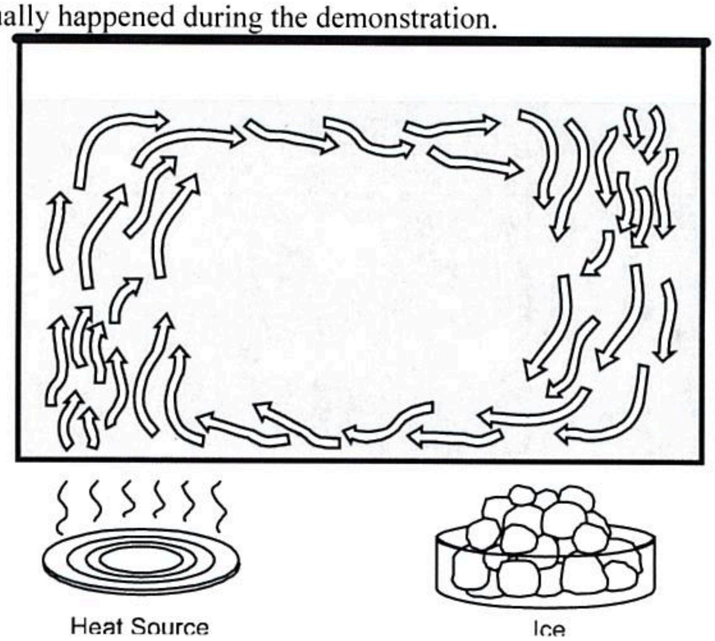
4. If the mass of a substance stays the same and its volume increases (see previous question), how is the density of a substance affected?
   - Density is the ratio of mass to volume, so if volume goes up density will go down.

5. Which floats better….low density substances or high density substances?
   - The lower the density the better something will float. One way to test if an object is less dense than water is to toss it into water and see if it floats. If it floats, then the object is less dense than water.

6. Based on your answers to the previous questions, predict the movement of water (if any) in the unevenly heated container drawn below.
   - Drawings of predictions will vary.



7. Draw what actually happened during the demonstration.

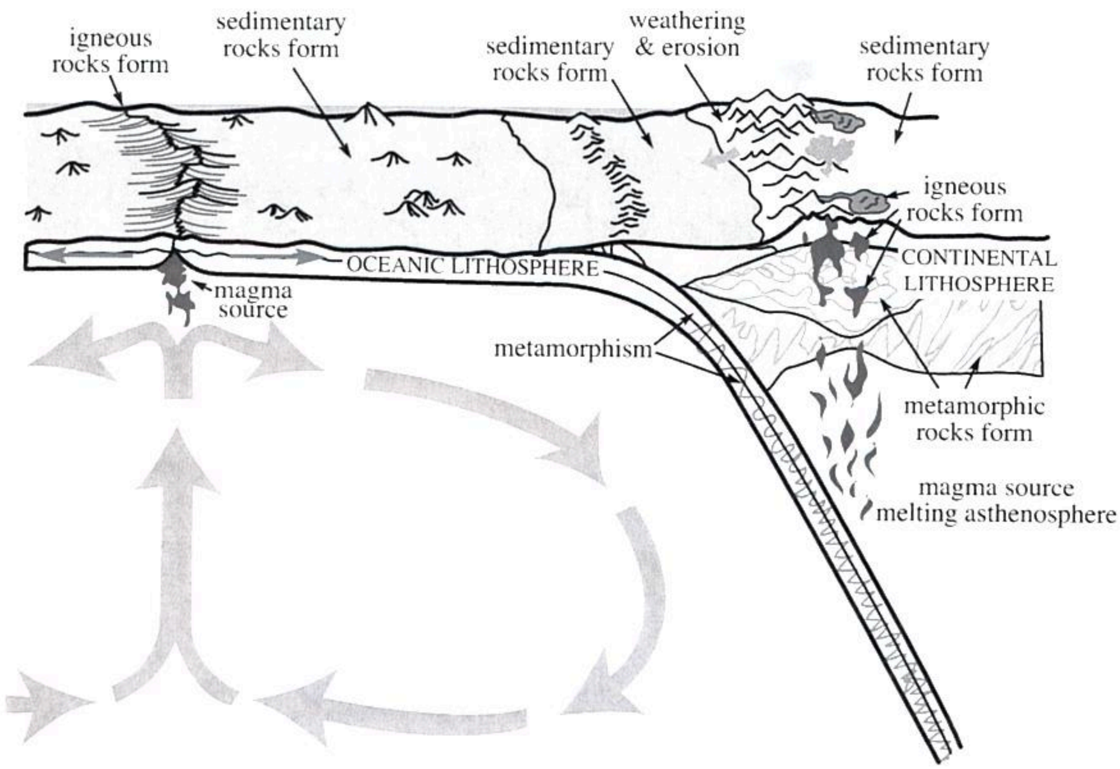


TEACHER

They Will Rock You!
Observing and Classifying Rocks

Rocks on Earth are formed from a combination of minerals. Because there are thousands of possible combinations of those minerals, there are many different kinds of rocks. Igneous rocks form when molten rock from Earth's interior cools. The cooling of igneous rocks can take place on the surface of Earth, in the interior of Earth, or a combination of both methods. Sedimentary rocks form when the sediments of older pieces of rocks, plants, and other loose material get pressed or cemented together. Sedimentary rocks, such as coal, form from plant remains and fossils. Metamorphic rocks need heat and pressure to form. Igneous and sedimentary rocks that are subjected to the forces of heat and pressure over millions of years, can transform into a metamorphic rock. Rocks change in time due to natural processes that occur on and in Earth. The rocks hold evidence about changes that have occurred on our planet.

The Rock Cycle



PURPOSE

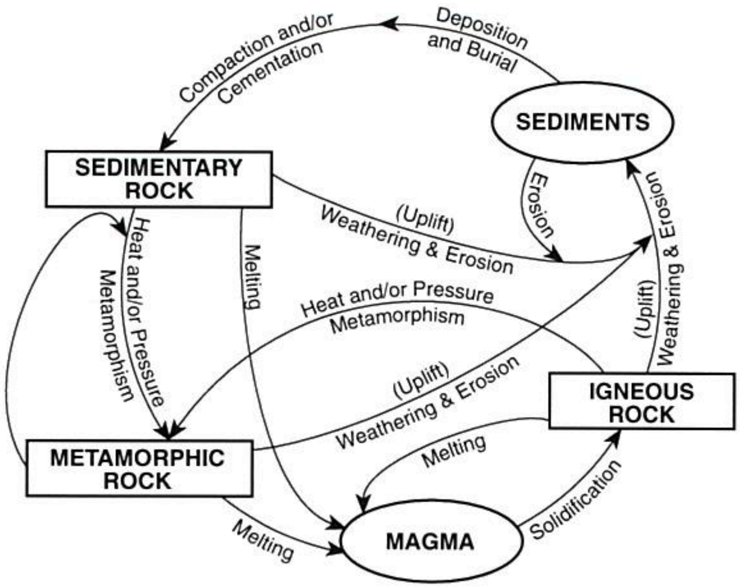
In this lesson you will classify rocks and describe the rock cycle.

MATERIALS

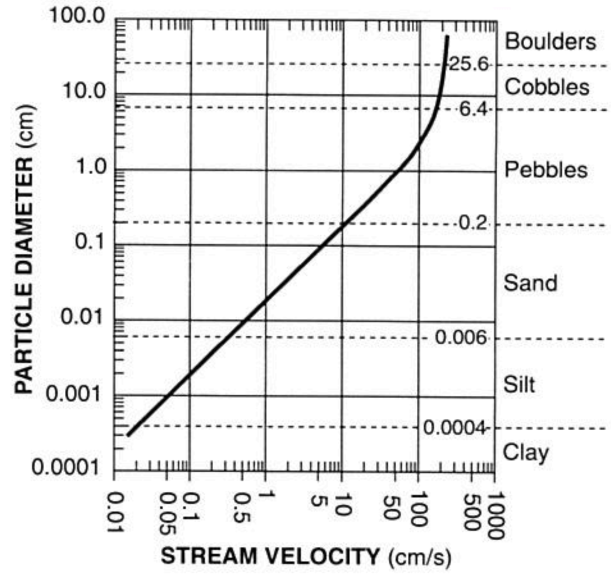
Each lab group will need the following:

magnifying glass
pencil, colored
rock samples

Rock Cycle in Earth's Crust

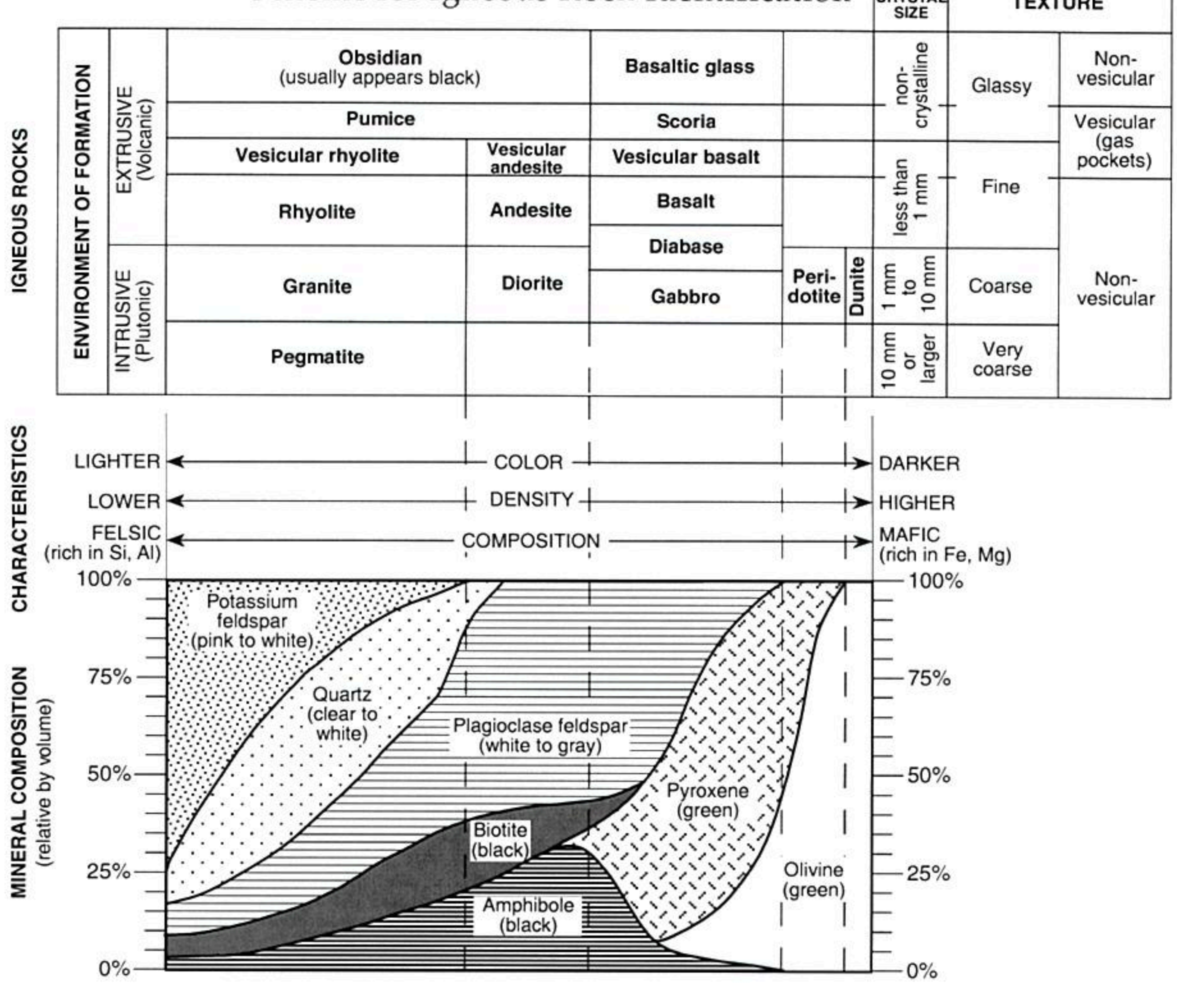


Relationship of Transported Particle Size to Water Velocity



This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

Scheme for Igneous Rock Identification



Scheme for Sedimentary Rock Identification

INORGANIC LAND-DERIVED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Clastic (fragmental)	Pebbles, cobbles, and/or boulders embedded in sand, silt, and/or clay	Mostly quartz, feldspar, and clay minerals; may contain fragments of other rocks and minerals	Rounded fragments	**Conglomerate**	
			Angular fragments	**Breccia**	
	Sand (0.006 to 0.2 cm)		Fine to coarse	**Sandstone**	
	Silt (0.0004 to 0.006 cm)		Very fine grain	**Siltstone**	
	Clay (less than 0.0004 cm)		Compact; may split easily	**Shale**	

CHEMICALLY AND/OR ORGANICALLY FORMED SEDIMENTARY ROCKS					
TEXTURE	**GRAIN SIZE**	**COMPOSITION**	**COMMENTS**	**ROCK NAME**	**MAP SYMBOL**
Crystalline	Fine to coarse crystals	Halite	Crystals from chemical precipitates and evaporites	**Rock salt**	
		Gypsum		**Rock gypsum**	
		Dolomite		**Dolostone**	
Crystalline or bioclastic	Microscopic to very coarse	Calcite	Precipitates of biologic origin or cemented shell fragments	**Limestone**	
Bioclastic		Carbon	Compacted plant remains	**Bituminous coal**	

Scheme for Metamorphic Rock Identification

TEXTURE		GRAIN SIZE	COMPOSITION	TYPE OF METAMORPHISM	COMMENTS	ROCK NAME	MAP SYMBOL
FOLIATED	MINERAL ALIGNMENT	Fine	MICA, QUARTZ, FELDSPAR, AMPHIBOLE, GARNET, PYROXENE	Regional (Heat and pressure increases)	Low-grade metamorphism of shale	**Slate**	
		Fine to medium			Foliation surfaces shiny from microscopic mica crystals	**Phyllite**	
					Platy mica crystals visible from metamorphism of clay or feldspars	**Schist**	
	BAND-ING	Medium to coarse			High-grade metamorphism; mineral types segregated into bands	**Gneiss**	
NONFOLIATED		Fine	Carbon	Regional	Metamorphism of bituminous coal	**Anthracite coal**	
		Fine	Various minerals	Contact (heat)	Various rocks changed by heat from nearby magma/lava	**Hornfels**	
		Fine to coarse	Quartz	Regional or contact	Metamorphism of quartz sandstone	**Quartzite**	
			Calcite and/or dolomite		Metamorphism of limestone or dolostone	**Marble**	
		Coarse	Various minerals		Pebbles may be distorted or stretched	**Metaconglomerate**	

PROCEDURE

PART I: ORGANIZING ROCKS INTO GROUPS

1. Use the hand lens or loupe to observe each rock.
2. Work with your lab partners to find similarities in the rocks. Sort the rocks into three groups.
3. List your three groups of rocks in Data Table 1 on your student answer page. Put each rock's number in the boxes containing either A, B, or C.
4. Describe your three groups of rocks in the second column in Data Table 1.
5. Justify your method of rock grouping by completing the last column of the table.
6. Complete the observation section on your student answer page.

PART II: CLASS NOTES

1. Complete Data Table 2 as your teacher describes the three types of rocks.
2. Record several different examples of each rock type.

PART III: CLASSIFYING ROCKS

1. Use the hand lens and loupes to observe each rock.
2. Record data about texture, color, rock type, and overall description for each rock in Data Table 2.
   a. Subtype should be indicated as: intrusive, extrusive, foliated, non-foliated, clastic, chemical, or organic
   b. Type of rock: igneous, metamorphic, and sedimentary
3. Answer the Conclusion Questions.

They Will Rock You!
Observing and Classifying Rocks

DATA AND OBSERVATIONS

PART I: ORGANIZING ROCKS INTO GROUPS

Data Table 1		
Rock Numbers Included in Group	**Description of Rock Group**	**What are the Similarities of the Rocks in this Group?**
A.		
B.		
C.		

OBSERVATIONS

1. Which rocks did not seem to fit in the three categories?

2. Write three questions you have about rocks.

PART II: CLASS NOTES

Data Table 2

Type	Formation	General Characteristics	Examples	Additional Notes
Igneous				
Sedimentary				
Metamorphic				

PART III: CLASSIFYING ROCKS

Data Table 3					
Rock Number	**Color**	**Description of Rock**	**Type of Rock**	**Subtype**	**Rock Name**
1					
2					
3					
4					
5					
6					
7					
8					
9					

Rock Number	Color	Description of Rock	Type of Rock	Subtype	Rock Name
10					
11					
12					
13					
14					
15					

CONCLUSION QUESTIONS

1. Give three characteristics each for sedimentary, metamorphic, and igneous rocks that could be used to distinguish each type of rock.

2. Why do some igneous rocks have coarse grains while others are fine-grained?

3. How are clastic and chemical sedimentary rocks different?

4. Would you expect to find sedimentary rocks on the moon? Why or why not?

5. Would you choose sandstone or slate for a statue in your yard? Explain.

They Will Rock You!
Observing and Classifying Rocks

About this Lesson
In this lesson, students will determine how rocks form and change by natural processes. Students will identify samples of rocks as sedimentary, igneous, or metamorphic and describe the processes responsible for their unique characteristics

This lesson is included in the LTF Middle Grades Module 12.

Objectives
Students will:

- Use the graphic organizer to classify rocks into three categories based on their own observations and group discussions
- Take notes during the teacher led discussion
- Observe the rock sample kit and record data about each rock's texture, color, type, and overall description
- Identify the subtype and rock name of each sample

Level
Middle Grades: Earth Science

Common Core State Standards for Science Content

LTF Science lessons will be aligned with the next generation of multi-state science standards that are currently in development. These standards are said to be developed around the anchor document, *A Framework for K–12 Science Education*, which was produced by the National Research Council. Where applicable, the LTF Science lessons are also aligned to the Common Core Standards for Mathematical Content as well as the Common Core Literacy Standards for Science and Technical Subjects.

Code	Standard	Level of Thinking	Depth of Knowledge
(LITERACY) RST.9-10.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	Apply	II

Connections to AP*
AP Environmental Science
I. Interdependence of Earth's Systems: Fundamental Principles and Concepts C. The Solid Earth 2. Earth dynamics: plate tectonics, volcanism, and the rock cycle and soil formation.

Materials

Each lab group will need the following:

magnifying glass
pencil, colored
rock samples

Assessments

The following types of formative assessments are embedded in this lesson:

- Visual assessment of student data tables

The following assessments are located on the LTF website

- Middle Grades Earth: Rocks and Minerals Assessment

Teaching Suggestions

Part I: Organizing Rocks into Groups
Students will begin with an inquiry and observation activity in Part I of this lesson. The students will use the rock sample kit to observe similarities and differences in the rocks. They will use the graphic organizer (Data Table 1) to classify rocks into three categories based on their own observations and group discussions. Students will describe the three groups and justify their method of classification in Data Table 1.

Part II: Class Notes
After students have initially explored the rocks, you should give a lesson about igneous, sedimentary, and metamorphic rocks (See Lecture Notes). Images of rocks may be obtained from the internet to enhance the lecture. One suggested site for images of rocks is www.geology.com. Data Table 2 has been provided for students to take notes during your lecture.

Part III: Classifying Rocks

Students will use the same rock sample kit to complete Part III of the lesson. They will observe the rocks and record data about each rock's texture, color, type, and overall description in Data Table 3. Students should complete all parts of the table except for the rock name. After students have completed the data table, lead a discussion identifying the characteristics and names of each of the samples. At this time, students should correct the information in Data Table 3, if needed, and add the name of each sample.

LECTURE NOTES

I. Introduction
- Millions of years to complete the cycle
- Multiple paths a rock can take during the cycle
- Three broad categories based on the way the rocks are formed:
    - Igneous
    - Metamorphic
    - Sedimentary

II. Igneous Rocks
- Make up over 70% of continental crust and 90% of oceanic crust
- Formed when molten rock cools and solidifies
- Two types of igneous rocks:

  (1) Intrusive (plutonic)
    - Magma cools within Earth as opposed to on surface of Earth
    - Cooling rate is slower resulting in coarser grained rocks
    - Minerals are visible to naked eye
    - Examples: granite, gabbro, peridotite

  (2) Extrusive
    - Magma cools on Earth's surface, usually from volcanic eruptions
    - Cooling rate is faster resulting in finer grained rocks
    - Minerals are too fine to be seen with naked eye – petrographic microscope
    - Examples: rhyolite, basalt, and pumice
- Some igneous rocks have both intrusive and extrusive features
    - Result of two step process – some cooling within Earth; some on surface
    - Porphyritic texture – combination of coarse and fine crystals
- Identifying igneous rocks
    - Texture is important, but not the only consideration
    - Mineral composition, especially silica content
        - * Light colored rocks typically have high silica content (granite, rhyolite)
        - * Dark colored rocks typically have lower silica content (gabbro, basalt)

III. Sedimentary Rocks
- Formed by contributions from wind, oceans, rivers, rain runoff and gravity
- Typical process includes:
    - Weathering and erosion breaks down rocks (of any kind) and moves the pieces to other locations on Earth's surface
    - Water currents naturally sort out the minerals by their size and weight (coarse, medium, fine)

- Particles settle and are deposited
- Compaction and cementation press the particles into a new rock

- Classified based on texture, chemical composition, and mineralogy
- Major categories:
  - Clastic
    * made from other rock pieces
    * subdivided by grain size (fine sand vs. boulders)
    * further grouped by mineral content
    * examples include: conglomerates, sandstones, and shales
  - Chemical
    * Precipitated material
    * Examples include: limestone and dolomite
  - Organic (biogenic)
    * Formed from organic (or once living) material
    * Example: coal

IV. Metamorphic rock

- Has undergone a structural and mineralogical change
- Degree of change depends on the amount of heat and pressure and length of time
- Classified based on texture
  - Foliated -- aligned sheet or plate-like layered structure (gneiss and schist)
  - Non-foliated – non aligned layers (marble and slate)

V. Rock Cycle

- Rocks of all three types can be changed into another type
- A very long process (millions of years)
- Involves erosion, sedimentation, uplift, deep burial, and recrystallization
- Moving tectonic plates create heat, pressure and chemical reactions
- Examples of transformations:
  - Sedimentary rocks are transformed into metamorphic rocks, such as Limestone turning into marble and mudstone to slate, after thousands to millions of years of heat and pressure.
  - An igneous rock that reaches Earth's surface through the uplifting of mountains is destined to break and weather into sediments, thereby becoming part of the sedimentary class of rocks.
  - Magma from Earth's interior adds new igneous rocks through volcanic eruptions and at mid-ocean ridges.

TEACHER

POSSIBLE ANSWERS TO CONCLUSTION QUESTIONS AND SAMPLE DATA

DATA AND OBSERVATIONS

PART I: ORGANIZING ROCKS INTO GROUPS

- Categories and observations for rocks will vary. Students may classify according to color, grain size, luster, or by other criteria. Encourage students to explain their reasons for the classifications that they chose. Use their questions about rocks to plan future lessons.

OBSERVATIONS

1. Which rocks did not seem to fit in the three categories?
   - Answers will vary.

2. Write three questions you have about rocks.
   - Answers will vary.

PART III: CLASSIFYING ROCKS

(Sample results based on Cynmar Corp. Rock Sample Kit # 500-14235).

Data Table 3

Rock Number	Color	Description of Rock	Type of Rock	Sub-type	Rock Name
1	Black or brown	Volcanic glass	Igneous	Extrusive	Obsidian
2	Multicolor	Medium or coarse-grained	Igneous	Intrusive	Granite
3	Dark	Microcrystalline	Igneous	Extrusive	Basalt
4	Dark red or brown	Porous	Igneous	Extrusive	Scoria
5	Light	Similar to granite	Igneous	Extrusive	Rhyolite
6	Brown or red	Clay, silt or mud sized particles	Sedimentary	Clastic	Shale
7	Light	Angular fragments of limestone or quartz	Sedimentary	Clastic	Breccia
8	Sand colored	Sand-sized particles	Sedimentary	Clastic	Sandstone
9	Multicolor	Coarse-grained	Sedimentary	Clastic	Conglome rate
10	Light	Mainly calcium carbonate	Sedimentary	Organic	Limestone
11	Dark	Metamorphosed shale	Metamorphic	Foliated	Slate
12	Multicolor	Recystallized limestone	Metamorphic	Non-foliated	Marble
13	White or light	Recrystallized sandstone	Metamorphic	Non-foliated	Quartzite
14	Multicolor	Banding of granular and flaky minerals	Metamorphic	Foliated	Gneiss
15	Multicolor Dark	Metamorphosed shale or siltstone often containing mica or garnets	Metamorphic	Foliated	Schist

CONCLUSION QUESTIONS

1. Give three characteristics each for sedimentary, metamorphic, and igneous rocks that could be used to distinguish each type of rock.
   - Sedimentary rocks are usually dull in luster. They may shed sand or fragments of rock when handled. Sedimentary rocks are usually formed in layers and some are cemented together with chemicals. Intrusive igneous rocks are characterized by grains that are large enough to view with the naked eye. Extrusive igneous rocks such as pumice are light and have many holes. Igneous rocks such as obsidian are glassy. Metamorphic rocks may be foliated such as in gneiss or non-foliated like marble.

2. Why do some igneous rocks have coarse grains while others are fine-grained?
   - Igneous rocks with coarse grains were cooled in Earth's interior. Because the cooling was slow, large crystals could grow. Fine-grained igneous rocks cooled on Earth's surface and, therefore, cooled too quickly for large crystal growth.

3. How are clastic and chemical sedimentary rocks different?
   - Clastic sedimentary rocks are formed when water and wind move solids such as pieces of rock and sediments from one place to another. The pieces become deposited into new areas which can become compacted or cemented into a sedimentary rock. Chemical sedimentary rocks form when material is dissolved in a solution and carried to bodies of water. The precipitates form rocks.

4. Would you expect to find sedimentary rocks on the moon? Why or why not?
   - You would not expect to find sedimentary rocks on the moon since there is no atmosphere on the Moon and, therefore, no wind or water to move rock fragments and sediments.

5. Would you choose sandstone or slate for a statue in your yard? Explain.
   - Since sandstone is most affected by the weathering of wind and water, it would be best to choose slate for the statue. Slate is a very strong rock that is used for roofing material because it weathers well.

Name ______________________________ Date ________________ Period _____ Score out of 25 _____

Corrected by ______________________________

The Rock Cycle Lab

The rock cycle is a never-ending process. Igneous rock forms from magma or lava. Weathering breaks igneous rock into sediments such as pebbles and sand. These small pieces are compacted and cemented under pressure into sedimentary rock. Under great heat and pressure inside the Earth's crust, igneous and sedimentary rocks are changed into metamorphic rocks. These rocks are brought to the earth's surface where they are weathered again into sediments to become sedimentary rocks.

Materials

- hot plate
- 10 milk chocolate chips
- 10 white chocolate chips
- 10 butterscotch or peanut butter chips
- plastic knife, paper plate
- sheet of aluminum foil
- heavy books

Safety Concern: The hot plate will cause burns. Use it carefully.

4 points for completing the lab correctly ________________

Part 1 Making Weathering Rocks Procedure

A. Pour one color of chips on the plate and cut them into little pieces and shavings with the plastic knife. (The smaller the pieces and shavings, the better)

B. Pour the little pieces and shavings on to the aluminum foil.

C. Take another color of chips and cut them up into little pieces.

D. Pour the little pieces and shavings on top of the other color on the foil.

E. Repeat with the last color.

1. Describe your observations.

____

____

____

2. Draw and color what you see from the top.

3. Draw and color what you see from the side.

Part 2 Making Sedimentary Rock Procedure

A. Fold the aluminum foil over your three layers of chips.

B. Place two –three heavy books over the aluminum foil and leave for 3 minutes.

C. Take off the books and observe the chips.

4. Describe your observations in the space below.

____

____

____

5. Draw and color what you see from the top.

6. Draw and color what you see from the side.

Part 3 Making Metamorphic Rock

A. Fold the aluminum foil over the chips again.
B. Have one member of the group press very hard on the foil with their hands for 30 seconds.
C. Have another member of the group do the same for another 30 seconds.
D. Continue doing this until all members of the group have done it twice.
E. Unwrap the aluminum foil and observe the chips.

7. Make some observations in the space below.

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____

____

8. Draw and color what you see from the top.

9. Draw and color what you see from the side.

Part 4 Making Igneous Rock

A. Wrap the aluminum foil over the chips again.
B. Take the foil package to a hot plate and lay it on the hot plate for 30-45 seconds.
C. Pick up the package by the sides and return it to your table.
D. Leave the package wrapped for at least **10 minutes.**
E. Gently unwrap the aluminum foil and observe.

10. Make some observations in the space below.

____

____

____

11. Draw and color what you see from the top.

12. Draw and color what you see from the side.

Name ________________________________ Date ___________________________ Period _____

Questions

13. What did your group do to simulate weathering rocks?

____

14. What did your group do to make the sedimentary rocks stick together?

____

15. What did your group do to make the metamorphic rocks stick together?

____

16. What was the difference between what you did to the sedimentary rocks and what you did to the metamorphic rocks?

____

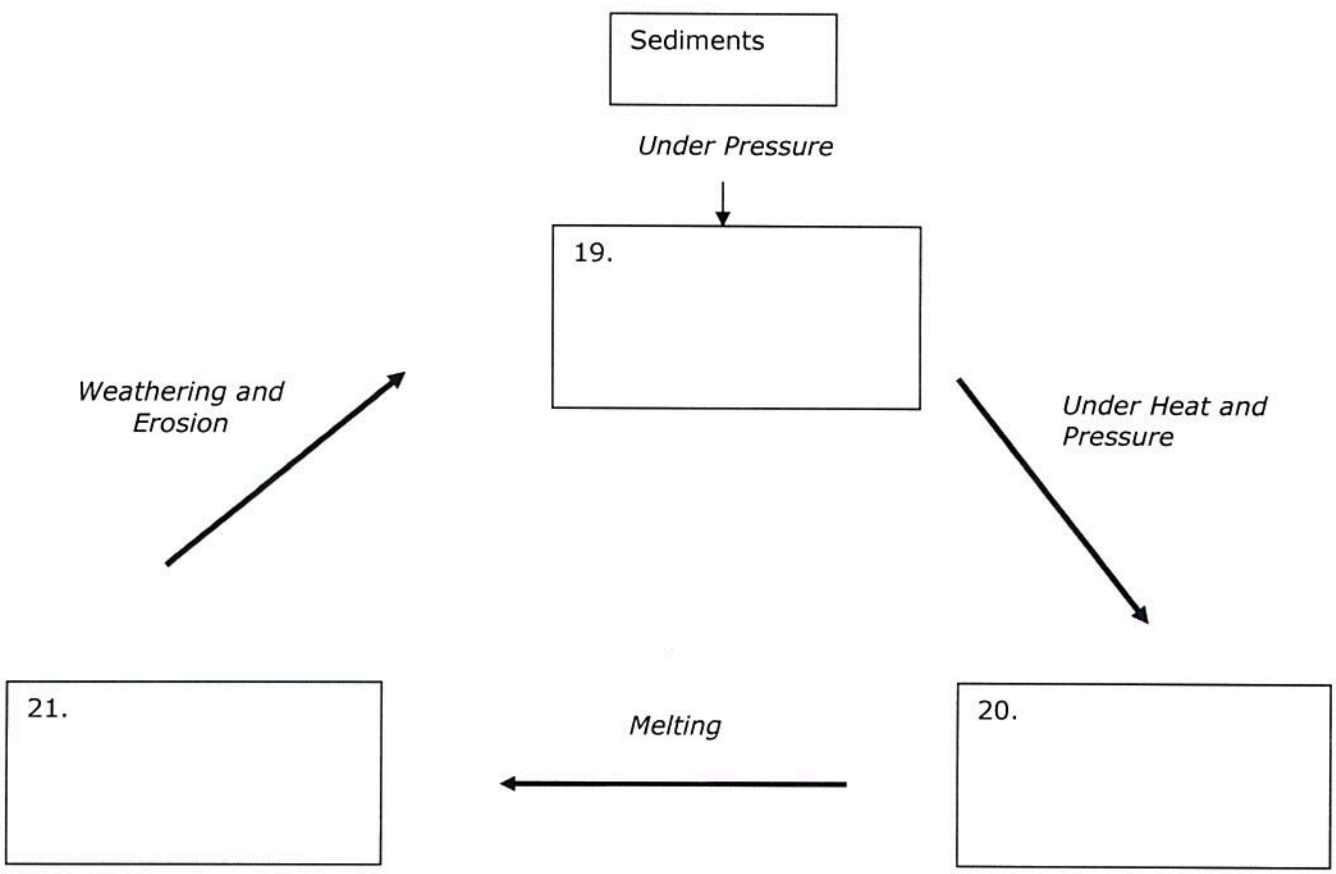
17. What did your group do to make the igneous rocks?

____

18. What was different between what you did to the metamorphic rocks and the igneous rocks?

____

Remembering the information you learned in this lab, fill in the following flow chart.
Use the following words: **Sedimentary Rocks, Metamorphic Rocks, Igneous Rocks**



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D. Pour the little pieces and shavings on top of the other color on the foil.

E. Repeat with the last color.

1. Describe your observations.

____

____

____

2. Draw and color what you see from the top.

3. Draw and color what you see from the side.

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4. Describe your observations in the space below.

____

____

____

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D. Continue doing this until all members of the group have done it twice.

E. Unwrap the aluminum foil and observe the chips.

7. Make some observations in the space below.

____

____

____

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9. Draw and color what you see from the side.

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____

____

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Name ______________________ Date ______________________ Period ______

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____

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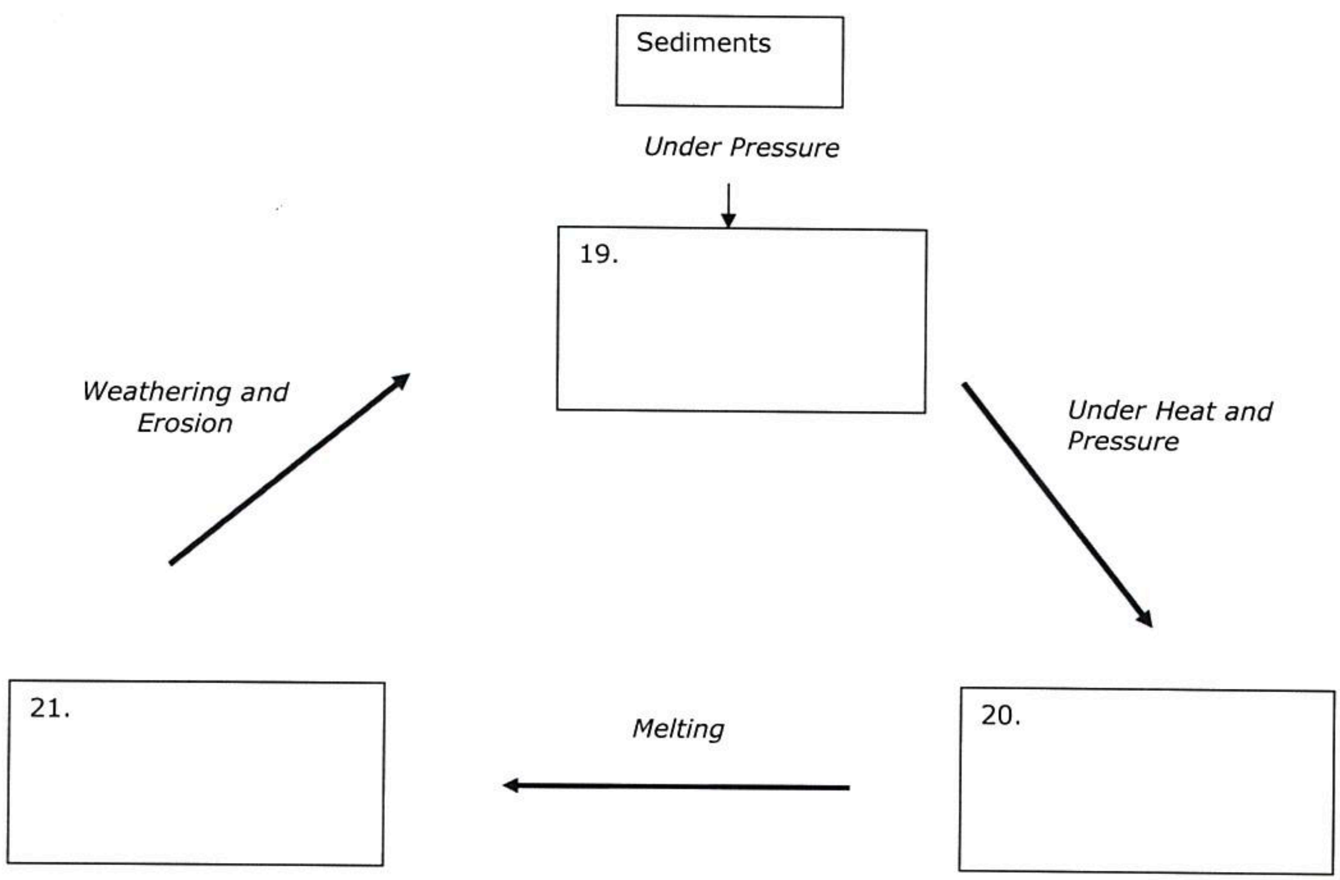
____

Remembering the information you learned in this lab, fill in the following flow chart.
Use the following words: **Sedimentary Rocks, Metamorphic Rocks, Igneous Rocks**



The Rock Cycle Game

Instructions: We will break up into 10 groups. Each group will go to one of the 10 stations here in the room? Each station is a type of rock or other material that is part of the rock cycle. When you get to your station:

- Read the station description below to find out what you are and where in the earth you are located.
- If you are a rock, look carefully at the rock samples and read their labels.
- Each person should roll the dice and follow the instructions. There is only one die at each station, so take turns if need be. Below is a list of numbers 1-6 for each station. Each number tells you what to do if you roll it. Go where you are instructed and repeat the process at the next station.
- You will trace your route from one station to another by doing the following:
    a. As you move from station to station document your journey on the rock cycle using the sheet labeled Journey on the Rock Cycle.

Station #1 - Intrusive Igneous Rock: You are now granite, diorite, etc. in the earth's crust.

1) Stay an intrusive igneous rock. Roll again.
2) Stay an intrusive igneous rock. Roll again.
3) Get uplifted, exposed, and eroded. Take the chemical weathering pathway and become ions dissolved in water. (salt, silicates, etc.) Go to hydrosphere/biosphere.
4) Get uplifted, exposed, and eroded. Take the mechanical weathering pathway and become sediment. Go to unconsolidated sediments.
5) Another magma body intrudes nearby. Experience high heat get re-melted. Go to magma.
6) Get pushed to great depths because mountains pile up on top of you. You experience high heat and get re-melted. Go to magma

Station #2 Extrusive (volcanic) Igneous Rock: You are now basalt, rhyolite, etc. on the earth's surface.

1) Stay a volcanic rock. Roll again.
2) Stay a volcanic rock. Roll again.
3) Get eroded. Take the chemical weathering pathway and become ions dissolved in water. Go to hydrosphere/biosphere.
4) Get eroded. Take the mechanical weathering pathway and become sediment. Go to unconsolidated sediments.
5) Get buried deeply by sediments. Another magma body intrudes nearby. Experience high heat and get re-melted. Go to magma.
6) Get buried deeply by sediments and get pushed to great depths as mountains pile up on top of you. You experience high heat and get re-melted. Go to magma.

Station #3 Clastic Sedimentary Rock: You are now sandstone, conglomerate, etc. in the upper part of the Earth's crust.

1) Stay a clastic sedimentary rock. Roll again.
2) Get uplifted, exposed, and eroded. Take the chemical weathering pathway and become ions dissolved in water. (salt, silicates, etc.) Go to hydrosphere/biosphere.
3) Get uplifted, exposed, and eroded. Take the mechanical weathering pathway and become sediment. Go to unconsolidated sediments.
4) A magma body intrudes nearby. Experience high heat and pressure - get metamorphosed. Go to metamorphic rock.
5) A magma body intrudes nearby. Experience extreme heat, melt and get incorporated into the magma. Go to magma.
6) Get pushed to great depths because mountains pile up on top of you. You experience high heat and pressure and get metamorphosed. Go to metamorphic rock.

Station # 4 - Metamorphic Rock: You are now gneiss, schist, etc., deep in the earth's crust.

1) Stay a metamorphic rock. Roll again
2) Stay a metamorphic rock. Roll again.
3) Stay a metamorphic rock. Roll again.
4) Get uplifted, exposed, and eroded. Take the chemical weathering pathway and become ions dissolved in water. (salt, silicates, etc.) Go to hydrosphere/biosphere.
5) Get uplifted, exposed, and eroded. Take the mechanical weathering pathway and become sediment. Go to unconsolidated sediments.
6) A magma body intrudes nearby. Experience extreme heat, melt, and get incorporated into the magma. Go to magma.

Station #5 - Unconsolidated Sediments: You are now silt, sand, clay, etc. at the Earth's surface.

1) Stay unconsolidated sediments. Roll again.
2) Stay unconsolidated sediments. Roll again.
3) Stay unconsolidated sediments. Roll again.
4) Get buried deeply by other sediments. Undergo compaction and cementation and become clastic sedimentary rocks. Go to clastic sedimentary rocks.
5) Get buried deeply by other sediments. Undergo compaction and cementation and become clastic sedimentary rocks. Go to clastic sedimentary rocks.
6) Get buried deeply by other sediments. Undergo compaction and cementation and become clastic sedimentary rocks. Go to clastic sedimentary rocks.

Station # 6 - Magma: You are now magma in the earth's crust.

1) Stay magma. Roll again.
2) Stay magma. Roll again.
3) Crystallize in the crust and become an intrusive igneous rock. Go to intrusive igneous rock.
4) Crystallize in the crust and become an intrusive igneous rock. Go to intrusive igneous rock.
5) Get erupted and crystallize on the earth's surface. Go to extrusive (volcanic) rock.
6) Get erupted and crystallize on the earth's surface. Go to extrusive (volcanic) rock.

Station # 7 - Nonclastic (Crystalline and Bioclastic): You are now limestone, rock salt, coal, etc. near the earth's surface.

1) Stay a nonclastic sedimentary rock. Roll again.
2) Get uplifted, exposed and eroded. Take the chemical weathering pathway and become ions dissolved in water. Go to hydrosphere/biosphere.
3) Get uplifted, exposed and eroded. Take the mechanical weathering pathway and become sediment. Go to unconsolidated sediments.
4) Get buried under other sedimentary rocks. A magma body intrudes nearby. Experience high heat and pressure - get metamorphosed. Go to metamorphic rock.
5) Get buried under other sedimentary rocks. A magma body intrudes nearby. Experience high heat and pressure and get metamorphosed. Go to metamorphic rock.
6) Get pushed to great depths because mountains pile up on top of you. You experience high heat and pressure and get metamorphosed. Go to metamorphic rock.

Station # 8 - Mantle Rock: You are peridotite, eclogite, etc. in the earth's upper mantle.

1) Stay mantle rocks. Roll again.
2) Stay mantle rocks. Roll again.
3) Stay mantle rocks. Roll again.
4) Stay mantle rocks. Roll again.
5) Stay mantle rocks. Roll again.
6) Get partially melted and become magma. Rise at the mid-ocean ridge and cool to form oceanic crust. Go to oceanic crust.

Station # 9 - Oceanic Crust: You are now basalt or gabbro in the oceanic crust drifting away from the mid-ocean ridge.

1) Stay oceanic crust. Roll again.
2) Get subducted and re-assimilated into upper mantle. Go back to mantle rocks.
3) Get subducted and re-assimilated into upper mantle. Go to mantle rocks.
4) Get subducted and re-assimilated into upper mantle. Go to mantle rocks.
5) Get subducted, experience extreme heat, and melt. Become magma that rises upward. Go to magma.
6) Get subducted, experience extreme heat, and melt. Become magma that rises upward. Go to magma.

Station # 10 - Hydrosphere/Biosphere: You are now dissolved ions in an ocean, river, plant, animal, etc.

1) Stay in the hydrosphere/biosphere. Roll again.
2) Say in the hydrosphere/biosphere. Roll again.
3) Get utilized by marine organisms and precipitate in the form of shells, coral, or other "hard part." Accumulate on the ocean floor and become limestone. Go to nonclastic sedimentary rock.
4) Get utilized by marine organisms and precipitate in the form of shells, coral, or other "hard part." Accumulate on the ocean floor and become limestone. Go to nonclastic sedimentary rock.
5) Precipitate in a saline lake or sea restricted in a desert climate and become evaporate. Go to nonclastic sedimentary rock.
6) Precipitate at a hot spring and become tufa. Go to nonclastic sedimentary rock.

Journey on the Rock Cycle

Roll	Station Number	Station Name	What happened when you were there?	Describe the environment that is forming you
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Draw a diagram of your rock's cycle in the space below.

1. Where did you spend the most time?

2. What stations had the largest number of people? Since all station started out with basically the same number of people, what does this say about the rock cycle and its different stages?

3. Why is the rock cycle, called a cycle?

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4. What are the possible directions that SEDIMENTARY ROCK can take in this cycle?

5. What processes can happen after materials are brought to the surface ?

6. Why didn't everyone follow the same path?

7. How much of the rock cycle can be observed, and how much is inferred (list specific steps in your answer)?

8. How might people be affected (in both the short and long term) by the movement of earth material through the rock cycle?

9. Assuming that each "roll" requires 200,000 years, determine the average time it takes for each of the following steps to occur:

INTRUSIVE IGNEOUS ROCK to UNCONSOLIDATED SEDIMENTS =

METAMORPHIC to NON CLASTIC SEDIMENTARY ROCK =

CLASTIC SEDIMENTARY ROCK to IGNEOUS ROCK =

10. Discuss the relative length of time rocks spend in different stages. Explain how this activity showed these differences.

11. In relation to the Earth's surface, explain where rocks spend most of their time.