FCS Science Curriculum
Grade 6

Earth's Structure, Processes and History – Part A

Adapted from
Oakland Schools Science Scope

Grade 6
Earth’s Structure, Processes and History– Part A

About Our Scope Unit/Lesson Template

This template is designed to serve several teaching and learning principles considered as staples of state of the art science instruction. Here are the key principles in summary:

- It’s critical to **elicit prior knowledge** as a unit or lesson begins.
- **Key questions** should drive student explorations and investigations.
- **Activity Before Concept** – Student inquiry-based explorations which give personal experience with phenomena and ideas should precede a presentation of science ideas.
- **Evidence is the heart of the scientific enterprise.** Students generate evidence and analyze patterns in data that help to construct scientific explanations around key questions.
- **Concept Before Vocabulary** – Attaching science vocabulary to concepts developed by student investigations yields more success than beginning a unit or lesson with a list of science vocabulary.
- **Talk, argument and writing** are central to scientific practice and are among the most important activities that develop understanding.
- **Application** of the ideas provides review, extends understanding, and reveals relevance of important ideas.
- **Assessment** of knowledge, skill, and reasoning should involve students throughout the learning process and be well aligned to the main objectives and activities of the unit.

The Scope Science template is designed to put these principles into practice through the design of the ***SCOPE LEARNING CYCLE FOR SCIENCE***. Each unit has at least one cycle. The components are listed below:

The Key Question for the Unit	Each unit has one open-ended Focus Question that relates to all the content and skills of the unit. The Key Question is presented at the opening of the unit and revisited at the unit's conclusion.
Engage and Elicit	Each unit begins with an activity designed to elicit and reveal student understanding and skill prior to instruction. Teachers are to probe students for detailed and specific information while maintaining a non-evaluative stance. They also can record and manage student understanding, which may change as instruction proceeds.
Explore	A sequence of activities provides opportunities to explore phenomena and relationships related to the Key Question of the unit. Students will develop their ideas about the topic of the unit and the Key Question as they proceed through the Explore stage of the learning cycle. Each of the activities may have its own Key Question or central task that will be more focused than the unit question. The heart of these activities will be scientific investigations of various sorts. The results, data and patterns will be the topic of classroom discourse and/or student writing. A key goal of the teacher is to reference the Key Question of the unit, the Explore and Elicit of the students, and to build a consensus especially on the results of the investigations.
Explain	Each unit has at least one activity in the Explain portion of the unit when students reconcile ideas with the consensus ideas of science. Teachers ensure that students have had ample opportunity to fully express their ideas and then to make sure accurate and comprehensible representations of the scientific explanations are presented. A teacher lecture, reading of science text, or video would be appropriate ways to convey the consensus ideas of science. Relevant vocabulary, formal definitions and explanations are provided. It's critical that the activity and supporting assessments develop a consensus around the Key Questions and concepts central to the unit.
Elaborate	Each unit cycle has at least one activity or project where students discover the power of scientific ideas. Knowledge and skill in science are put to use in a variety of types of applications. They can be used to understand other scientific concepts or in societal applications of technology, engineering or problem solving. Some units may have a modest Elaborate stage where students explore the application of ideas by studying a research project over the course of a day or two. Other units may have more robust projects that take a few weeks.
Evaluation	While assessSummative assessments are posted in a separate document.

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Contents

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Unit Introduction

This unit attends to the Michigan Grade Level Content Expectations as they are gathered in Unit 3 of the Michigan Department of Education Science Companion Document. Topically, the unit addresses concepts related to earth materials (rocks, minerals, soil) and landforms which are produced from erosion and deposition of earth materials. This includes activities related to the structure, processes and history of these materials. To organize the content of this unit, the Oakland Schools Science Scope has established two learning cycles:

Cycle 1: Understanding Rocks and Minerals

Cycle 2: Changing Landscapes

Part A of this unit is followed by additional geology learning in Part B that focuses on plate tectonic theory and related earth history which is where SCoPE addresses Earth's magnetic field. Together they provide a strong overview of the science of geology.

The resources and opportunities to address these topics are of such abundance and quality that the unit has the tremendous potential to be a highly relevant, real world and investigation rich experience for students. As teachers look for ways to have students use real world data, apply interactive technology to real world questions, and foster meaningful tasks for reading, writing, argumentation and mathematics, and framed by the Common Core Curriculum Standards, the issues here provide abundant opportunity. The main limitation is the class time available given other content demands. It is highly recommended that teachers practice the activities and simulations throughout the whole unit in advance of teaching it to recognize potential misconceptions or struggles that may occur.

On the Common Core State Standards for English Language Arts and Literacy in Science

All science teachers will find the Common Core State Standards of ELA a tremendous asset for reaching learning objectives in science education. Reading, writing, argumentation and discourse are central proficiencies necessary for success in science. All teachers should become fluent with the document and will likely find it validating.

http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf

These standards are best reached with science instruction that connects content to real world problems and experiments, complimented with scientific writing, challenging questions, processes for classroom discussion and debate, and use of scientific text.

It is recommended that teachers require students to use an interactive science notebook to support learning in this unit. Here are some features and policies to consider:

- Use a bound notebook – cut and paste some other materials into it.
- The right-facing page is for teacher content, the left is for student reflection.
- Leave four pages for a table of contents.
- Leave the notebooks in the room.
- Consider using an online, web-based notebook tool (Google Docs, Weebly, Blogger) so students have the option of reviewing and updating their notebooks anytime, anyplace.

6th Grade - Earth Science Pre-Assessment

This assessment will help your teacher understand what you already know about Earth Science. Think about each question carefully and choose the responses you think best answer the questions.

* Required

1. *

....

Example: December 15, 2012

1. **First and Last Name:** *

....

2. **Class or Teacher Name:** *

....

3. **1. Choose all appropriate responses. The wearing away of rock and soil by the actions of wind, moving water and glaciers is called:** *
Check all that apply.
   - [ ] a. erosion
   - [ ] b. deposition
   - [ ] c. transportation
   - [ ] d. weathering

(1) **2. Choose all that apply. Naturally generated molten rock created and found within in the Earth is called:** *
Check all that apply.
   - [ ] a. extrusive igneous rock
   - [ ] b. magma
   - [ ] c. lava
   - [ ] d. intrusive igneous rock

(10) **3. Choose all that apply. Rock formed when lava above the Earth's surface cools and hardens is called:** *
Check all that apply.
   - [ ] a. intrusive igneous rock
   - [ ] b. extrusive igneous rock
   - [ ] c. metamorphic rock
   - [ ] d. sedimentary rock

7. **4. Choose all that apply. What causes igneous or sedimentary rock to change into metamorphic rock?** *
Check all that apply.

- [ ] a. weathering and compaction
- [ ] b. heat alone
- [ ] c. pressure alone d.
- [ ] heat and pressure
- [ ] e. weathering and cementing

8. **5. Rocks that formed from lava that cooled super fast like obsidian and pumice are called:** *
Mark only one oval.

- ◯ a. intrusive igneous rocks
- ◯ b. glassy extrusive igneous rocks
- ◯ c. sedimentary rocks
- ◯ d. coarse grained igneous rocks

9. **6. True or False: Any rock can become any other kind of rock.** *
Mark only one oval.

- ◯ True
- ◯ False

10. **7. True or False: The rock cycle flows in one direction.** *
Mark only one oval.

- ◯ True
- ◯ False

11. **8. True or False: Molten rock can only be found close to the surface.** *
Mark only one oval.

- ◯ True
- ◯ False

12. **9. True or False: Compaction and cementing are key processes in the formation of sedimentary rocks.** *
Mark only one oval.

- ◯ True
- ◯ False

13. **10. Type as many vocabulary words that you can think of that relate to rocks or the rock cycle** *

(Separate your vocabulary words with commas.)

Learning Cycle 1: Understanding Rocks and Minerals

Introduction

In Cycle 1, Understanding Rocks and Minerals, students develop competence identifying common rock forming minerals and selections of important rocks. They relate the rock classifications systems to rock forming processes as depicted by the rock cycle. They relate key rocks to three areas of the lithosphere: granite representing continent crust, basalt representing ocean crust, peridotite representing the mantle.

Learning Objectives

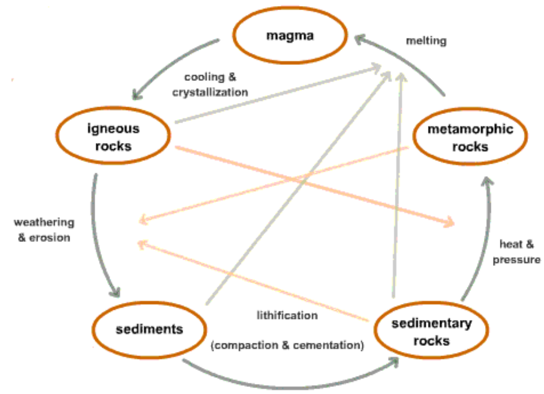
Students will be able to:

- Identify key set of rocks and minerals.
- Explain relationship of rock composition, texture, rock formation and relative age.
- Relate the rock classifications systems for igneous, sedimentary and metamorphic rocks to the rock cycle.
- Understand the importance of minerals to the global economy and our way of life.
- Soil…..

Key Question: What information does the analysis of a rock's properties allow us to infer about the history of that rock?

Engage and Elicit

Activity 1 – Our Personal History with Rocks



Purpose
To elicit student understanding of rocks, minerals and rock forming processes.

Activity Description
In any class of students, many are enthused to tell stories about some interesting interaction with rocks. With some structure and support, a teacher can learn a great deal about how students understand the topic. It is common to find that they have a lot of enthusiasm and some experience with rocks and minerals, without much accurate scientific understanding. We know that this combination can interfere with learning unless teachers 'make student thinking visible' and integrate student insights and views into conversations related to lessons.

Prior to beginning this learning cycle and activity, students should be asked to bring in rock samples from their environment and/or neighborhood. Additionally, in this activity, student groups are given a small set of rocks and minerals and a placemat-sized rock cycle.

While looking over the rocks and rock cycle, each student records some personal experience with rocks. Some may have collected an interesting rock while traveling. Others may have a relative with an extensive rock collection. They can also describe where in their environment that they found the rocks they brought to school and why they find them interesting. Students are prompted to relate their story to the samples and the rock cycle, or make some conjectures about their meaning. After some group sharing and visits from their teacher, a whole group discussion occurs where teachers catalog student understanding on a number of key concepts relevant to this unit. (Note: This activity is meant to be a pre-assessment of prior knowledge and current understanding. It can be used to determine student misconceptions that should be addressed during follow-up activities.)

Focus Question
What do I understand about rocks and minerals?

Duration
One class session

Materials
- Rock samples (such as these): granite, basalt, scoria, limestone (Petoskey Stone), sandstone, shale, gneiss
- Student rock samples: Students will gather unique rock samples from their neighborhoods or environments.
- Mineral samples (such as these): quartz, calcite, biotite, native copper, pyrite
- Student handout: "My Personal History with Rocks and Minerals"
  FCS Adapted Version: [My Personal History with Rocks and Minerals.docx] (Attached below).

Atlas URL:
http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/My%20Personal%20History%20with%20Rocks%20and%20Minerals.docx

- ActivInspire Flipchart: FCS Rocks and Minerals (download this flipchart by clicking on the following link:
https://drive.google.com/file/d/0B9Nh_z4RdgdKZl9fcmIxSGZwcjA/edit?usp=sharing

Teacher Preparation

1. Instruct students to bring samples of rocks from their outdoor environment or a collection they may have at home (with permission from parents).
2. Gather and organize rock and minerals samples for each group.
3. Print and copy "My Personal History with Rocks and Minerals."
4. Prepare questions to probe student thinking on their understanding of the rock cycle, rock versus minerals, rock classification, and origin.
5. Download multimedia files that will be used (Promethean flipcharts, videos, etc.) and set up any digital learning systems the class will be using (Weebly, google drive, Edmodo)

Classroom Procedure

1. Prompt students to follow the questions on the student handout.
2. Allow 5 or 10 minutes for them to explore and discuss the rocks, but then call for quiet so they can write their experiences down on the student handout.
3. Prompt students to share their stories while walking the room to listen in. Prompt them through each step of the handout.
4. Draw the whole group together to share two or three of the stories, but direct the conversation so that it emphasizes student thought about the rock cycle. **Rather than correcting their thoughts, allow students to debate with one another.**
5. Record some of the students' notions on a class whiteboard.
6. If possible share student responses to the rock cycle (via a document camera or other technology) and ask for student thoughts on their ideas. Again, rather than correcting their thoughts, allow students to debate with one another.
7. The "FCS – Rocks and Minerals" Promethean Flipchart should be used to introduce and guide the learning of Rocks and the Rock Cycle.

Explore

Activity 2 – Understanding Petrology

Purpose
To categorize and identify a set of common rocks and to understand how rock classification systems relate to the origins of rock.

Activity Description
The main objective is to know a select group of common rock types, the three rock classification systems (igneous, sedimentary and metamorphic) and to understand the reasons for the rock characteristics (texture and composition). The activity is meant to require a minimum amount of time so students can use “Every Pebble Tells a Story” (in Unit 4), which emphasizes interpretation of earth history from hand samples. The rock samples have been selected because their occurrences tell us fundamental information about earth history.

Rather than keying out each sample, students group samples based on common characteristics. A rock placemat, text material and rock classifications are provided, as well as directives by teachers.

Focus Question
How can we use observable characteristics of rocks to classify them?

Duration
Two class sessions

Materials
- Understanding Petrology
  - Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Understanding%20Petrology.doc
  - There is an updated FCS version of “Understanding Petrology” that is very similar attached at the end of this document.
- Rock Identification Flowcharts
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Rock%20Identification%20Flow%20Charts.docx
- Rock Placemats
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Rock%20Placemat.doc
- USGS Rock Explanations with Rock Key Flow Chart (at end of document)
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/USGS%20Rock%20Explanations.docx
- Managing HCl (for teacher use)
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Managing%20HCL.doc

- Minerals: The best place for Michigan teachers is from the Michigan Earth Science Teachers Association (MESTA). Their rock shop is open at the MESTA Conference and the annual MSTA Conference. They offer ample supplies of very inexpensive samples that can be purchased by the dozens.

- Rock Samples
  - Igneous: (granite, basalt, andesite, obsidian, pumice, peridotite)
  - Sedimentary: (shale, sandstone, conglomerate, limestone, chert)
  - Metamorphic: (slate, schist, gneiss, marble, quartzite)
- Tools
  - hand lens or magnifying glass
  - hardness tools: a penny, nail, glass plate (best to purchase those with glazed edges from Wards),
  - 1 M hydrochloric acid, dilute HCl (1 Molar solution) - (read "Managing HCl")
  - streak plate
  - magnet
- ActivInspire Flipchart: FCS Rocks and Minerals (download this flipchart by clicking on the following link: https://drive.google.com/file/d/0B9Nh_z4RdgdKZl9fcmIxSGZwcjA/edit?usp=sharing
- ClaimEvidenceReasoning – Graphic Organizer and Rubric (attached) Also available online at the following links: http://flintsciencesource.weebly.com/1st-mk-period-soil-earths-magnetic-field-rock-formation.html , or https://drive.google.com/file/d/0B9Nh_z4RdgdKMGRWQVZ4b0plQm8/edit?usp=sharing

Teacher Preparation

1. Group the rock sets as igneous, sedimentary or metamorphic, and put into separate, unlabeled Ziploc bags or pouches. Place them in medium-sized plastic bins with lids. Provide one kit for each team of two.
2. Put the tool sets in a pouch or Ziploc bag and place them in the tubs with the rocks.
3. DO NOT use concentrated HCl. Prepare the HCl with care so it is safely diluted. It works well to get a half liter or so from a high school chemistry class that can make a 1-Molar solution in their lab. Some teachers use vinegar, but acetic acid is much weaker and may not fizz when HCl would.
4. Print and copy sets of student materials:
   - Each student receives their own copy of the USGS Rock Explanation document and a fresh rock placemat for each category of rock.
   - Each team receives one working copy of the placemats and Understanding Petrology document.
   - Each team receives 6 copies of the Claim-Evidence-Reasoning Statement page from ClaimEvidenceReasoning – Graphic Organizer and Rubric. This could be distributed and documented electronically if iPads or computers are available.
   - ***NOTE:*** print out pages 5 and 6 from the USGS Rock Explanations as separate sheets. The other pages can be gathered as a single document. You may also want to laminate the flowchart pages so they could be used with dry erase markers.

Classroom Procedure

1. Introduce the activity with a brief overview and explanation:

- ActivInspire Flipchart: FCS Rocks and Minerals (download this flipchart by clicking on the following link: https://drive.google.com/file/d/0B9Nh_z4RdgdKZl9fcmIxSGZwcjA/edit?usp=sharing

- Explain the difference between rocks and minerals.
- Briefly define the three general types of rocks: igneous, sedimentary and metamorphic.
    - Option: 3 types of rock- a science song: https://www.youtube.com/watch?v=jPgE74Vltdc
- Explain that each group has a classification system that students will use.

2. Prompt each team to take out one rock sample from each of the three bags (one igneous, one sedimentary, one metamorphic) and gather as a group. It is fine (in fact, preferable) if the teams select different types of rocks. They may also use their own rock samples that they have brought in from their own environments.
3. Distribute the document "Understanding Petrology." The process follows the steps listed in the document.
4. Distribute the first flowchart from Rock Identification Flowcharts document titled: "Simplified Rock Identification and Origin Flow Chart."
5. Prompt the students to attempt to categorize the rock types using the flowchart. **The main thing here is that they make careful observations and use the logic of the flowchart.**
6. Walk the room to ensure students understand the flowchart and are making good observations. **Student will need help recognizing and describing grains, layers and luster (shiny, dull, etc.).** Challenge them to describe the rock with their own words, but ask them what may be meant by terms like 'fine grained,' 'wavy layers,' etc. Be clear on the kind of support needed at this point:
    - Understand the logic of the flowchart.
    - Refine students' language so observations can be discussed with standard terms (fine grain, coarse grain, sugary, layers, etc.).
    - **Refrain from naming the rocks or even correcting students' mistaken conclusions at this point (it's memorable for students to correct their own mistakes).**
7. Mentally note the kinds of useful student insights and critical confusions. (If you have a mobile device or tablet for your own use, you can document your notes there for reference.)
8. Have students complete a Claim-Evidence-Reasoning Statement page for each rock. The focus question should be, "Is this a metamorphic, igneous or sedimentary rock?"
9. Initiate a whole group discussion where groups can describe one or more of their conclusions in a "Claims," "Evidence," "Reasoning" format. Example:

Claim: This is an igneous rock.

Evidence (observations): There are no visible crystals or layers, and there are rounded holes.

Reasoning (relates claims to evidence using science content and logic): When you follow the flowchart from no layers to no visible crystals with holes like gas bubbles, it leads you to the conclusion that this is an igneous, volcanic rock.

10. Return the sedimentary and metamorphic rocks to their bags and follow the process in "Understanding Petrology." Students will place their rocks on the igneous placemats.
11. Have students complete a Claim-Evidence-Reasoning Statement page for one of the igneous rocks. The focus question should be, "What type of igneous rock is this?"
12. Walk the room, but this time help students make clear observations and sound conclusions.
13. Before proceeding to Part 3 (Sedimentary Rocks), host an interactive lecture on igneous rocks. Use this process:

- Have each student silently read the section on Igneous Rocks from the USGS Rock Explanation document.
- Prompt students to use the "Talking to the Text" strategy for reading comprehension. In doing so, students write notes in the margin that show their thinking during reading. Teachers will need to model this if students aren't familiar with the process. They might include:
  - Paraphrasing of content, sketches
  - Questions about comprehension
  - Questions that extend the content to other notions
  - Statements of other ideas.
- Present an explanation of some basic concepts about igneous rocks and the classification system while students label the placemat with the categories of rocks.

14. Repeat the general process for sedimentary and metamorphic rocks.

Claim, Evidence and Reasoning Statement

- Claim: statement or conclusion about a problem or question
- Evidence: scientific data that supports the claim
- Reasoning: justification that links the claim and the evidence together, showing why the data count as evidence to support the claim by using the appropriate scientific ideas or principals

Model and Practice Scientific Explanation

- Model the behaviors of a scientist and model how to analyze the data using the framework
- Create opportunities for students to practice via the daily sponge by providing relevant practice data sets for students to analyze, make a claim and support with evidence OR by providing a claim and evidence statement and students describe the data set that the evidence would require
- Make connections between everyday discourse and science discourse

Adapted for Flint Community Schools from JCPS Analytical and Applied Science:
http://www.indps.k12.wi.us/cms_files/resources/Notebooking%20ideas_including%20claim%20evidence%20reasoning.pdf

Claim-Evidence-Reasoning Statement

Focus Question

CLAIM: A statement that answers the original focus question or problem.
What conclusion can you make about your original focus question or problem?

EVIDENCE: Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.
What data or observations do you have to support your claim?

REASONING: A justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.
How does the data you used for evidence support your claim?

Adapted for Flint Community Schools from JCPS Analytical and Applied Science:
http://www.indps.k12.wi.us/cms_files/resources/Notebooking%20ideas_including%20claim%20evidence%20reasoning.pdf

Claim-Evidence-Reasoning Statement

An Example from Chemical Interactions

Following Investigation 3

Focus Question

Does air always take up the same amount of space?

CLAIM: A statement that answers the original focus question or problem.
What conclusion can you make about your original focus question or problem?

Air does not always take up the same amount of space. Air can be compressed into a smaller space or can expand into a larger space. .

EVIDENCE: Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.
What data or observations do you have to support your claim?

When our group trapped air in a syringe with a clamp we could press down on the plunger to make the amount of space that the air took up smaller. We were also able to pull the plunger back up to allow the air to take up more space.

REASONING: A justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.

How does the data you used for evidence support your claim?

The air in the syringe is made of particles that have nothing in between them. Since the air is trapped in the syringe the number of particles stays the same and can't change. The space between the air particles gets closer together when the plunger compresses the air. When the plunger is pulled out, the space between the air particles increases and the space the air takes up expands.

Adapted for Flint Community Schools from JCPS Analytical and Applied Science:
http://www.indps.k12.wi.us/cms_files/resources/Notebooking%20ideas_including%20claim%20evidence%20reasoning.pdf

Claim, Reasoning and Evidence Statement Rubric

Component		Level	
	0	1	2
Claim – statement or conclusion that answers the original question/problem.	Does not make a claim, or makes an inaccurate claim.	Makes an accurate but incomplete claim.	Makes an accurate and complete claim.
Evidence – scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence, or only provides inappropriate evidence (Evidence that does not support the claim.).	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning – justification that links the claim and evidence and includes appropriate and sufficient scientific principals to defend the claim and evidence.	Does not provide reasoning, or only provides recording that does not link evidence to claim.	Repeats evidence and links it to some scientific principles, but not sufficient.	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles.

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http://www.indps.k12.wi.us/cms_files/resources/Notebooking%20ideas_including%20claim%20evidence%20reasoning.pdf

Explore

Activity 3 – Simulating Rock Forming Processes

Purpose
To manipulate materials in ways which simulate igneous, sedimentary and metamorphic rock forming processes.

Activity Description
There are many examples of activities where students can simulate rock forming processes such as crystallization, erosion and sedimentation, and metamorphism. Using the "expert groups" collaborative process, give small student teams instructions to simulate rock forming and changing processes that they are to master and demonstrate for other students. Teachers can link to activity documents which describe these simulations:

- The Crayon Rock Cycle (Jelly Bean Rock Cycle (https://www.youtube.com/watch?v=pm6cCg_Do6k) or link to video included in the Promethean Flipchart titled: "FCS Rock Cycle" available for download using the following link: https://drive.google.com/file/d/0B9Nh_z4RdgdKOTFoM2xrc05rTUk/edit?usp=sharing)
- Growing crystals
- Rock erosion
- Sedimentary layering processes.

Given the amount of time it takes for all students to demonstrate their activity, it is recommended that at least two teams of students do the same activity. It also is an efficient use of time to hold a "gallery walk" where one half of the class sets up and hosts their demonstration as the other half visits those students as "museum goers."

Focus Question
How can rock forming processes be investigated using simulations?

Duration
Three class sessions

Materials
- Crayon Rock Cycle –see below or available online with the following links: http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf or http://flintsciencesource.weebly.com/1st-mk-period-soil-earths-magnetic-field-rock-formation.html
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/The%20Crayon%20Rock%20Cycle.pdf
  The FCS Adapted version of this file is included at the end of this document: Crayon-Rock-Cycle.pdf
- Document "Rock Activates" (growing crystals) simulations – see below or available online at the following link:
  Atlas URL: http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Simulate%20Rock%20Forming%20Processes.docx
  See below for the "FCS Simulate Rock Forming Processes – Growing Crystals."
- Goggles and gloves if using Salol for crystal growth

- Online Rock Cycle Quiz: (Have students complete the following activity either independently or with a partner on a computer or mobile device. They can print their result or take a screenshot and email it to the teacher. Medium skill level.) http://www.four-h.purdue.edu/kids/games/rock%20cycle.html

Teacher Preparation

1. Determine the simulations the class will perform. To add to the inquiry nature of this EXPLORE activity, teachers should allow students an opportunity to design their own model of the rock cycle or rock formation using other materials.
2. Another important decision is how crystal growth will be handled. If a teacher is uncomfortable with students using Salol, the process can be demonstrated with the crystal growth team.
3. It's most critical to decide how to simulate crystal growth. The "Rock Activities" explains that some means of crystal growth use precipitation while others use cooling of a melt. The latter accurately simulates igneous rock formation, while the former simulates sedimentary rock through evaporate formation (halite, gypsum) or chemical rock formation (limestone).
4. Become familiar with each of the activities. Take time to practice the simulations on your own prior to attempting them with students in order to identify potential misconceptions and areas that will be challenging in your class environment.
5. Gather and organize the materials for each of the activities.

Classroom Procedure

1. Present the activity and process. Be sure to define what a simulation is, and present it as a simple type of scientific modeling.
2. Divide the class in half, and then into teams of three (four or five for each half).
3. Assign activities so two teams are doing each activity. They can work together, but during the gallery walk they will take on the role of either a presenter or a museum attendee.
4. Provide clear and simple instructions and all necessary materials. Provide one day for the teams to master their simulations.
5. IMPORTANT: Coach each group on connections to rock forming processes. Guide groups to integrate such ideas into their explanations. Consider using the Claim-Evidence-Reasoning format for explaining how each step of their simulation represents the rock cycle or rock formation.
6. Set up the room for a gallery walk. This is an event where students visit a number of demonstrations that are explained by other student teams. The demonstrations must be spread around the room so students can move freely and safely.
7. Hold the gallery walks twice, switching presenters so all students can view all presentations.
8. Debrief the gallery walk as a whole class. Emphasize the "take-away idea" of each demonstration and relate it to the rock cycle and rock forming processes.
9. During the whole class discussion, students should describe the demonstration and the take-away idea in their interactive notebooks.

Team #1: The Crayon Rock Cycle
Purpose: To demonstrate rock forming processes of the rock cycle.
Materials:

- Crayons – at least two different colors of wax crayons, at least one stick per student
- Source of very hot water
- Aluminum foil and/or foil cupcake cups
- Container to hold hot water
- Simple scraping device (popsicle stick, plastic knifes).

Procedure: See descriptions at http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf (or with Atlas URL should the original website every change). The FCS Adapted version of this file is included at the end of this document: Crayon-Rock-Cycle.pdf

Teams #2 & 3: Fast and Slow Grow Growth Crystals
Purpose: To demonstrate the differences between fast and slow growing crystals.
Materials: Determined by chosen activity.
Procedure: See "FCS Simulate Rock Forming Processes" document.

Teams #4 & 5: Additional rock cycle or rock formation modeling activities designed by students.
Purpose: To demonstrate rock forming processes and/or the rock cycle.
Materials: TBD based on the activity design.
Procedure: Students should write their procedure out in a similar format of the above procedures.

Explore and/or Explain

Activity 4 – Where Rock Types Occur

Purpose
To make some generalizations about where in the country rock types occur.

Activity Description
As an interactive lecture and reading assignment, the class uses the National Atlas and Tapestry of Time websites to explore where in North America various rock types occur.

Focus Question
What generalizations can be made about the distribution of igneous, sedimentary and igneous rocks in North America?

Duration
Two class sessions

Materials
- The National Atlas Website: http://nationalatlas.gov/articles/geology/a_timeterrain.html
- Distribution of Rock Types (from National Atlas)
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Distribution%20of%20Rock%20Types.docx
- The Paleontology Portal (click on Exploring Time and Space):
  http://www.paleoportal.org/index.php

Teacher Preparation
1. Practice navigating the websites.
2. Pre-read the National Atlas document. **If printing, a colored printer is required**. If iPads or laptops are available, consider using an annotation App such as "Type on PDF" or "
3. Choose some areas of interest, and pre-read the description of those regions from the Paleontology Portal.

Classroom Procedure
1. Distribute the National Atlas document to students.
2. Prompt students to look at the four maps. Review the difference between volcanic (fine grain, extrusive from fast cooling as a result of being erupted onto the surface) versus plutonic (coarse grain from slow cooling deep underground, intrusive).
3. Prompt students to write some generalizations about the distribution of the three types of rocks. They can use an interactive journal or write in the margins of the text.
4. Have pairs discuss their generalizations for three or four minutes, then call on some students to gather some ideas for the whole group. Some things to notice:
   - Most surface rocks are sedimentary.
   - Volcanic igneous are the second most plentiful, and are concentrated in mountain ranges.
   - Plutonic igneous and metamorphic rocks are concentrated in Canada and in mountain ranges. They are also closely associated in space.
5. Ask some challenging questions:

- Why would sedimentary rocks be the most abundant on the surface? (Because they form on the surface through deposition.)
- Why would volcanic rocks be in greater abundance than plutonic igneous or metamorphic rocks? (Because they, too, form at the surface.)
- Why would plutonic igneous and metamorphic rocks be associated with one another? (Because they are the material that makes up deep mountain ranges. Where high pressure and temperature from deep burial occurs, it creates the conditions where metamorphism and melting occur.)
- What would be underneath the sedimentary and volcanic rocks? (In many places it would be the rock types exposed in Canada – plutonic igneous and metamorphic rocks.)

6. Assign an in-class reading of the section on sedimentary rocks.
7. When students are finished reading, use the Paleontology Portal to look deeper into a section of the country, reading the description to the class. Here the conversation integrates geologic time and paleontology, the topics of the next cycle.
8. Repeat steps 6 and 7 for the igneous and metamorphic sections.

Explain
Activity 5 – The Rock Cycle Game

Purpose
To model the dynamics of the rock cycle in an interactive whole class activity.

Activity Description
Using the teacher guide provided by the Illinois State Museum, the room is set up with stations that represent positions in the rock cycle. At each station, a paper dice is available to direct students through the rock cycle. After students play the game and make notes, they create a narrate cartoons to show the paths they took. In a debrief, it would be interesting to hear some of the narrations and discuss places on the continent where such scenarios could have, or will realistically play out.

Focus Question
What are some possible pathways around the rock cycle?

Duration
One class session

Materials
- Online simulator of a simple rock cycle game
  http://www.four-h.purdue.edu/kids/games/rock%20cycle.html
- Main rock cycle game of this activity (from Illinois State Museum)
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Rock%20Cycle%20Game.pdf
- Rock Cycle Animation (click on Rock Cycle Animation link)
  http://ees.as.uky.edu/educational-materials (The animations at this site require Macromedia Flash so cannot be used on the iPad without a browser app such as Puffin Free or Photon ($). These would be great for students to be able to explore these individually or with a partner for a deeper understanding.)

Teacher Preparation
1. Review the animation websites.
2. Print a master copy of the teacher guide and make the dice out of the last few pages of the "Rock Cycle Game.pdf" (attached). Also available to view or download by clicking on the following links: https://drive.google.com/file/d/0B9Nh_z4RdgdKeVpHdEJsaWhJems/edit?usp=sharing , or http://flintsciencesource.weebly.com/1st-mk-period-soil-earths-magnetic-field-rock-formation.html It may work well to cut some tabs for easy gluing.
3. Set up the stations in the classroom.
4. Reproduce the introduction and Journal for student use.

Classroom Procedure
1. Open the activity by reviewing the rock cycle by playing the online simulator with the whole class.
2. Follow the suggested process in the teacher guide.
3. During a debrief, challenge students to discuss places on the continent where such scenarios could have, or will realistically play out.
4. Include the following point to review and discuss the Key Question of the cycle: "What information does the analysis of a rock's properties allow us to infer about the history of that rock?" or "How do rock classifications systems reflect rock forming processes?" For example, students may comment that igneous rocks are categorized by grain size which results from their cooling history (fast or slow).

Ride the Rock Cycle

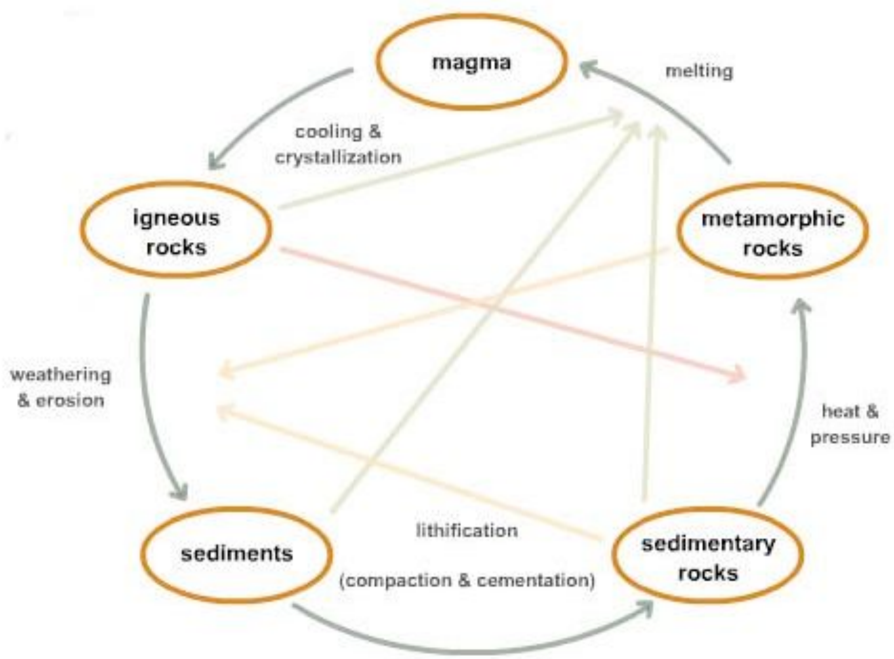
Grade Level: 5 – 6

Purpose: To teach students that the rock cycle, like the water cycle, has various stages and does not necessarily move linearly through those stages.

Suggested Goals: Students will gain an understanding of how a rock can move through the different stages of the rock cycle.

Targeted Objectives: As a result of this lesson, students will be able to:

4. Describe the rock cycle
5. Identify the various stages of the rock cycle



Background: A useful aid in visualizing the **rock cycle** is shown above. The three major rock types, igneous, metamorphic, and sedimentary, are shown. As you see, each may form at the expense of another if it is forced out of equilibrium with its physical or climatic environment by either internal or surficial forces.

Magma is molten rock. *Igneous* rocks form when magma solidifies. If the magma is brought to the surface by a volcanic eruption, it may solidify into an *extrusive* igneous rock. Magma may also solidify very slowly beneath the surface. The resulting *intrusive* igneous rock may be exposed later after uplift and erosion remove the overlying rock.
The igneous rock, being out of equilibrium, may then undergo *weathering* and *erosion,*

and the debris produced is transported and ultimately deposited (usually on a sea floor) as *sediment.* If the unconsolidated sediment becomes lithified (cemented or otherwise consolidated into rock), it becomes a *sedimentary rock.* As the rock is buried the additional layers of sediment and sedimentary rock, heat and pressure increase. Tectonic forces may also increase the temperature and pressure. If the temperature and pressure become high enough, usually at depths greater than several kilometers below the surface, the original sedimentary rock is no longer in equilibrium and recrystallizes. The new rock that forms is called a *metamorphic rock*. If the temperature gets very high the rock melts and becomes magma again, completing the cycle.

The cycle can be repeated, as implied by the arrows. However, there is no reason to expect all rocks to go through each step in the cycle. For instance, sedimentary rocks might be uplifted and exposed to weathering, creating new sediment.

Materials/Preparation: Create the dice and posters for the different stations of the rock cycle game. [See attached patterns.]

Procedure:
Part I: Play the Rock cycle game. Set up your classroom with 8 areas at which a change in the rock cycle occurs. Each student starts at one area. At each area is a die that the student should role to determine what path they should take. It is possible for the student to remain at the same station for a long time. To make the game more interesting, my rule is that you can only stay at one station for 3 turns. Then you must go to another station. While at each station and while moving to the different stations, students must record what is happening on their journey chart. [See attached log.] After the game is over they will have a record of what happened.

Part II: Cartoons
After their journey is complete, students must create a cartoon of how their adventures in the rock cycle occurred. Points are given for use of correct terms. Each cartoon page should be divided so there are 12 boxes—room for 12 drawings. Students should turn in their adventure log and cartoon together so you can see what has occurred in their adventure.

Questions: What happened while you were on the rock cycle?

Extensions: Have students create a story or a travel brochure about their time on the rock cycle.

Assessment: Evaluate the students' journey logs and cartoons.

Lesson Specifics:
Skills: Students will need to use observation, inference, data collection skills to complete the activity.

Duration: 1 day

Group size: Project should be completed individually

Setting: Classroom

Illinois State Board of Education Goals and Standards:

12.E.3b: Describe interactions between solid earth, oceans, atmosphere and organisms that have resulted in ongoing changes of Earth.

17.B.3a: Explain how physical processes including climate, plate tectonics, erosion, soil formation, water cycle, and circulation patterns in the ocean shape patterns in the environment and influence availability and quality of natural resources.

Web Resources:

ISM Geology Online Rock Cycle
http://geologyonline.museum.state.il.us

Earth and Ocean Sciences Department of the University of British Columbia. Introduction to Petrology; Rock Cycle
http://www.science.ubc.ca/~geol202/rock_cycle/rockcycle.html

Rock Cycle Burgess Shale Project
http://www.scienceweb.org/burgess/geology/cycle1.html

Rock Cycle Song
http://www.chariho.k12.ri.us/curriculum/MISmart/ocean/rocksong.htm

Rock Cycle
http://www.washington.edu/uwired/outreach/teched/projects/web/rockteam/WebSite/rockcycle.htm.htm

Journey on the Rock Cycle Name ___________________________

This sheet is to help you write about your experiences as a rock during your journey on the rock cycle. You will need to describe your adventures at each spot and tell about what kind of rock you feel that you were.

(2) I began my adventure at _________________________.

(3) The first thing that happened was ____, then I went to __________________________.

(4) The next thing that happened was ____, then I went to ____.

(5) The next thing that happened was ____, then I went to ____.

(6) The next thing that happened was ____, then I went to ____.

(7) The next thing that happened was ____, then I went to ____.

(8) The next thing that happened was ____, then I went to ____.

(9) The next thing that happened was ____, then I went to ____.

(10) The next thing that happened was ____, then I went to ____.

(2) The next thing that happened was ____, then I went to ____.

(11) The next thing that happened was ____, then I went to ____.

(12) The next thing that happened was ____, then I went to ____.

(13) The next thing that happened was ____, then I went to ____.

Challenge

Create a comic strip story of your experiences from the journey through the rock cycle!

Tectonic plates move

Go to volcano

Station: Earth's Interior

	Tectonic plates move Go to volcano		
Magma is forced up Go to volcano	Pressure occurs More layers Remain here	Pressure occurs Remain here	Pressure occurs Remain here
	Tectonic plates push upward Go to mountains		

Station: Soil

		Pressure occurs Go to earth's interior	
Pressure occurs Go to earth's interior	Rocks break down Remain here	Pressure occurs Go to earth's interior	Rocks break down Remain here
		Sediment being formed Remain here	

Journey Through the Rock Cycle

Cut out each die pattern and the signs for each station. Assemble dice by folding along lines and taping the edges together.

As the students travel through the rock cycle, they must roll the die at the station and follow the written directions.

S. Baker 2001

Station: River

Flood water causes redeposit of silt to flood plain

Go to soil

Sediments form

Go to soil

Water washes away layers

Go to mountains

Silt washed into ocean

Go to ocean

Sediments under pressure

Go to earth's interior

Ice melts carrying rocks

Go to river

Station: Ocean

Sand washes up onto shore

Go to soil

Ocean floor being subducted

Go to earth's interior

Sand washes up onto shore

Go to soil

Dust evaporates with water

Go to clouds

Ocean floor being subducted

Go to earth's interior

Sand washes up onto shore

Go to soil

Rain

Go to ocean

Station: Clouds

Snow

Go to mountains

Rain

Go to soil

Snow

Go to mountains

Rain

Go to soil

Rain

Go to ocean

Station: Mountains

Wind erosion occurs

Go to soil

Wind erosion occurs

Go to soil

Ice melts carrying rocks

Go to river

Glacier or avalanche occurs

Go to ocean

Ice melts carrying rocks

Go to river

Wind erosion occurs

Go to soil

Station: Volcano

	Volcano erupts spewing forth lava Go to mountain		
Tectonic plates push upwards Go to mountains	Magma crystallizes Remain here	Volcanic ash and dust are pushed into atmosphere Go to clouds	Crystallized magma pushes up to surface Go to soil
	Magma flows into the ocean Go to ocean		

Explain

Activity 6 – Sedimentary Stories

Purpose
To interpret and infer from a model of a sedimentary rock sequence.

Activity Description
This activity requires the use of a flipchart file. As a whole group you will review the different types of sedimentary rocks and the ways these rocks are formed. Then there are 4 models of layers of sedimentary rocks showing the types of rocks as well as how many years are represented that the rocks date back in geologic time. With each model is an assessment question about what that sequence of rocks shows about the environment based on the order of the layers. This topic will be covered further in weathering and erosion as well.

Focus Question
What details about geologic history can be inferred from the layers of sedimentary rock from the Earth's crust?

Duration
One class session

Materials
- The ActivInspire flipchart "FCS Sedimentary Stories." Available for download using the following link: https://drive.google.com/file/d/0B9Nh_z4RdgdKVlNfU3QwdUh4ZDQ/edit?usp=sharing
- Printout or digital copy of the page with the different types of sedimentary rocks in the flipchart file.
- Samples of the following types of rocks for students to observe as the models are discussed: Conglomerate, sandstone, siltstone, shale, limestone, coal.
- Promethean Activote learning response devices (clickers).

Teacher Preparation
1. Download and review the "FCS Sedimentary Stories"
2. Print or electronically distribute copies of page 2 of the flipchart.
3. Make sure Activotes are ready to be used.

Classroom Procedure
1. Review the types of sedimentary rocks as well as the general process for how sedimentary rocks are formed in the rock cycle.
2. Go over the 4 models of the sedimentary layers and discuss their "stories."
3. Each of the models has a formative assessment question that goes along with it. After reviewing the model and what possibly happened to the Earth based on the layers, ask students to answer the questions using the Activote devices.
4. Include the following point to review and discuss the Key Question of the cycle: "What information does the analysis of a rock's properties allow us to infer about the history of that rock?"

Elaborate

Activity 7 – Advertising Rock and Mineral Resources

Purpose
To advertise the essential uses of minerals and rocks.

Activity Description
Students research a mineral or rock that has economic value. They create a poster, and the class participates in a poster session. While K-12 education justifiably tends to focus on environmental concerns related to mining, our economic dependence on minerals is often overlooked or underemphasized. Scores of minerals are consumed every day in all industries. Two current concerns are lithium (for use in batteries) and a collection of rare earth elements (for use in electronic circuits).

Focus Question
Why are mineral and rock resources essential to meet human needs?

Duration
Four class sessions

Materials
- Poster-making materials
- Websites on the uses of minerals, such as:
  - 40 Common Minerals and Their Uses
    http://www.nma.org/publications/common_minerals.asp
  - Rock and Mineral Uses
    http://www.rocksandminerals.com/uses.htm

Teacher Preparation
1. Design a process for student teams to determine what minerals they will research.
2. Set criteria for student posters. Some elements worth considering: Name and main uses of the minerals, geography of sources, how mineral forms in nature, price, concerns (environmental, scarcity?), images of the ore, and final products.
3. Schedule a computer lab or gather resources for the student research.
4. Gather poster-making material.
5. Determine a process for a class poster session. One good method is to hold two rounds where presenters stand by their posters while others visit in timed intervals. Presenters should have a script to present their poster in 2 or 3-minute intervals.

Classroom Procedure
1. Present the project by describing the product and processes.
2. Provide two class periods for students to decide on their mineral and conduct their research. Provide a day for students to assemble their posters, and another for the poster session presentations.

Elaborate

Activity 8: Soil Engineering with a Compost Pile (This activity should be introduced and started at the beginning of the unit and continued throughout the unit.)

Purpose

To compare the impacts on plant growth of soil that develops from organic material to other types of soil.

Activity Description

Students research the composting process and as a class build a 3 bin composting pile outside of the school. During Part A - Learning Cycle 2 for this unit, students will analyze the effects that soil has on plant growth. They will use soil from the compost pile to grow

Focus Question

How does organic material impact the creation of soil in a compost pile?

Duration

Four class sessions (including one that should occur at the beginning of the unit to introduce the project to the class and get it started).

Materials

- An area outside of the school building where 3 piles of compost could be set up. (This could be as simple as 3 piles or more sophisticated with bins or fencing.
- Materials for the compost piles: yard waste / grass clippings, fruit or vegetable scraps, cardboard, newspaper strips, egg shells, nut shells.
- A shovel to turn the compost.
- A water source for the compost if the weather does not allow for enough moisture.

Teacher Preparation

1. Review the following website for composting in schools: **http://compost.css.cornell.edu/schools.html and http://cwmi.css.cornell.edu/TrashGoesToSchool/Best.html**
2. Gather some material to start the compost. If possible get the process started a bit prior to introducing it to students.

Classroom Procedure

1. Review the composting process and reasons for composting as well as what can and cannot go in the compost pile.
2. Continue to add to the compost pile a few times a week.
3. Turn the compost pile with a shovel once a week.
4. The soil that is created from the organic composted materials will be used during Part A - Learning Cycle 2 of this unit when the impacts of soil are studied.

Evaluation:

Activity 9: Rock Cycle Quiz – See attached quiz at end of this document

Activity 10: Historical Fiction of a Rock's Life

Alternate assessment: Students write a fiction story that traces the path of a rock of student's choice. (This could be one that a rock the student found on their own or one from the teacher's materials.) Students should use the "claim, evidence, reasoning" structure within their story as they discuss the stages of the rock cycle that their rock "character" has experienced. Take pictures of rocks that the students have brought in or that you have provided and use them in their story. If computers/laptops or iPads are available, students can use a presentation application (Prezi, Adobe Voice, Haiku Deck, etc.) to document the story of their rock.

(Note: This is similar to an Elaborate Activity in Unit 1 – Part B. Teachers may want to consider beginning writing the story here, and encourage editing and re-writing once more information is learned during Part B of the unit.)

Learning Cycle 2: Changing Landscapes

Introduction

Part A – Learning Cycle 2 of Earth's Structure, Processes and History focuses on weathering, erosion, landscapes and soil. These topics lend themselves to broadening student interest and knowledge of global geography and the beauty of natural landscapes. Displaying images of landscapes can be very inspiring and should accompany the activities of this unit. Numerous landscapes are available to investigate, but because river systems are so relevant to society in many ways, this curriculum gives rivers extra focus. Some attention is given to glaciers as well because they have had the greatest influence on Michigan landscapes.

Learning Objectives

Students will be able to:

- Describe the relationship between weathering and erosion to the production of sediment and soil.
- Compare landforms that are products of deposition to those produced by erosion.
- Communicate the results of investigations that explore the variables that affect rates of sedimentation in a model of a stream.
- Define soil types based on composition, texture and grain size.
- Explain the importance and vulnerability of soil.

Key Question: How do earth materials relate to landforms?

Engage and Elicit

Activity 1 – What is Weathering?

Purpose
To create a concept map about the weathering of rocks.

Activity Description
A student volunteer helps his/her teacher perform a demonstration of mechanical weathering by shaking a jar of sandstone pieces. When using the common Michigan Sandstone, the sandstone will quickly break apart into sand grains. Students are asked individually to create a simple graphic organizer that depicts their understanding of how landscapes change over time. At the end of the unit, students will revise their map based on new understandings gained from the unit.

Focus Question
How does weathering relate to changes in the landscape over time?

Duration
Half a class period

Materials
- 1-2 inch pieces of Michigan Sandstone
- A plastic (or glass) jar. One-quart peanut butter jars work well
- Trays for pairs of students
- Magnifying glasses
- How Does Weathering Relate to Landscapes.doc
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/How%20Does%20Weathering%20Relate%20to%20Landscapes.docx
- Computer images of landscapes, rivers, waves, dunes, etc.

Teacher Preparation
1. Make the jar of rocks. Slabs of Michigan Sandstone are commonly available at local landscaping shops, or your neighbor's ledge-rock. A slab can be easily broken into small pieces with a hammer (Caution: use eye protection whenever striking rock).
2. Print and copy the document.
3. If iPads are available, consider having students use the "Connected Mind" App to complete their concept maps.

Classroom Procedure
1. Introduce the cycle by telling the students they will be investigating changing landscapes, and that they will begin by creating a graphic organizer that shows how they understand the ideas related to this topic.

2. To orient students to the topic, perform the demonstration. A student volunteer could actually perform the demonstration. Give the students the jar and ask them to vigorously shake the jar. In a minute or so, the rocks will mechanically break down into sand.
3. Distribute small samples of sand from the jar to each pair of students.
4. Ask students to analyze the sand and try to identify the types of grains (minerals: quarts, feldspar, mica, etc. / rock fragments: basalt, granite). See if they can sort the grains into color or size.
5. Provide each student with the document that instructs them to create a graphic organizer. The document provides terms and ideas they may want to use, but if students don't know how to incorporate them all into their map, that is fine.
6. If possible, start a computer slideshow with images of landscapes on the class screen.
7. As a facilitator, do not provide content information because the purpose is to see what students already know. If some students are stalled, prompt them with questions like: Where do you imagine the sand at the beach comes from, or the soil under your house? Do mountains last forever? If not, what happens to them?
8. If a document camera is available, show several concept maps for class discussion and comparisons. If not, host a gallery walk so students can present and see the ideas produced by the class. (If using iPads, if an AppleTV is available, use it to show student concept maps they created in Connected Mind.)

Collect, or have students store, the concept maps for later use.

Explore

Activity 2 – Breaking it Down

Purpose
To explore examples of mechanical and chemical weathering and their relationships to erosion.

Activity Description
This activity is hosted online by PBS. It offers a logical flow of concepts with a mixture of online content, class experiments, media (simple quizzes and games) and video of a real world situation in Hawaii. Because it is very well explained and sequenced, we are recommending its use even though it could be improved by a couple of simple changes. A few simple enhancements are recommended for the unit:

- Some main informational Internet links are broken and the activity offers worksheets that are specifically tailored to the sources of information. Therefore, other worksheets are provided below with suggestions for modification on the student task.
- The activity describes some good, simple experiments that can be conducted to simulate mechanical and chemical weathering. The activity misses an opportunity to involve students in some reflection on the design of the investigation and the strengths/limitation of the simulation as a model. Suggestions are offered below.
- The situation in Hawaii begs the question of whether public policy, informed by science, would have restricted development at the base of unstable, water-soaked cliffs. Many issues related to natural hazards lead to decisions humans can make to reduce risk and save money and lives.

Focus Question
In what ways can humans benefit from understanding the natural processes of weather and erosion?

Duration
Two or three class sessions

Materials
- Breaking it Down overview page:
  http://www.pbs.org/wnet/nature/lessons/breaking-it-down/lesson-overview/1682/
- Breaking it Down lesson page:
  http://www.pbs.org/wnet/nature/lessons/breaking-it-down/activities/1700/
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/PBS%20Activity-Breaking%20It%20Down.pdf
- Breaking it Down Video Page
  http://www.pbs.org/wnet/nature/lessons/breaking-it-down/video-segments/1702/
- Document on Mechanical Weathering:
  http://www.currtechintegrations.com/expressScience/ESMechanical%20Weathering.SG.pdf
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Mechanical%20Weathering%20Content.pdf

- Images of landscapes, particularly emotional landscapes http://images.google.com
- Promethean Flipchart "weathering" that includes Activote questions: http://www.prometheanplanet.com/en-us/Resources/Item/28676/weathering#.U9mrgONdWSo

Teacher Preparation

1. Thoroughly review the website and activity.
2. Review the student worksheets, but don't use them because they are based on content from broken links.
3. Review the links provided in SCoPE as a replacement.
4. Gather the materials listed on the overview page of the PBS website for the experiments.

Classroom Procedure

1. Follow the activity as it is laid out, but replace some of the content background, either with an age-appropriate earth science textbook or some of the resources suggested.
2. During investigations, direct class to evaluate the degree to which simulations of weathering represent weathering in the natural world.
3. Because this topic lends itself to touring amazing landscapes on earth, set up projected slideshows of beautiful and fascinating images.

Explore

Activity 3 – Weathering Simulations

Purpose
To model mechanical weathering and erosion with simulations.

Activity Description
Split the class into 5 equal groups so that each group is responsible for a simulation. Students present interactive demonstrations to model the earth processes of mechanical weathering and erosion with simulations. Student groups present their simulation to the whole class and communicate their thoughts on how the simulation relates to weathering or erosion.

Simulating Mechanical Weathering
Purpose: To demonstrate the process of mechanical weathering.
Materials:
- Plastic jar with a lid
- Small rock samples: sandstone (typical of landscaping rock), granite, shale, limestone.

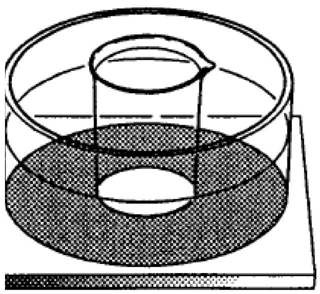
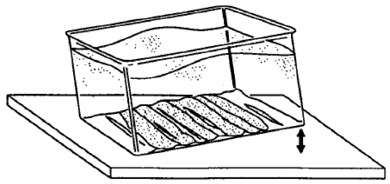
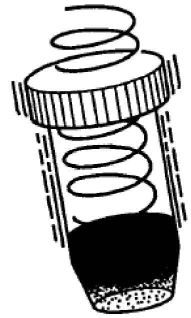
Procedure:

Group 1: Place the sandstone in the jar and shake vigorously. The sandstone of the Michigan formation, common in landscaping ledge rocks, is a perfect type to use. Notice it quickly turns into sand.

Group 2: Mix several rock types, some strong and some weak. Shake together. Notice the weaker rocks quickly turn to sediment while the stronger ones endure.

Simulating Sedimentary Types of Layers
Purpose: To demonstrate how the nature of hydraulic energy (flowing water) controls how sedimentary layers develop.
Materials:
- A round, flat-bottomed bowl – approximately 12 inches
- A beaker, small enough to fit inside the bowl, leaving a large enough track to conduct the simulation
- Aquarium
- Bottle with lid
- Beach sand
- Pea gravel
- Silt or clay.

Procedure:
Groups 3, 4 &5

		
ONE DIRECTION FLOW • Place a thin layer of the sand in the bottom of the bowl as configured. • Swirl the water in one direction. • Observe and sketch the sedimentary layers. • Notice ripple mark patterns.	OSCILATING FLOW • Place sand in the bottom of the aquarium and cover with water. • Gently lift an edge and rock the water back and forth. • Observe and sketch the sedimentary layers. • Notice ripple mark patterns.	GRAVITY SETTLING • Place the beach sand mixed with pea gravel and silt or clay. • Vigorously shake the bottle for 30 seconds. • Place on a table to let the sediment settle. • Observe and sketch the sedimentary layers. • Notice the graded bedding.
GEOLOGIC ENVIRONMENTS • Streams and rivers • Glacial outwash plains • River deltas, except near tidal environments	GEOLOGIC ENVIRONMENTS • Beaches – from wave action	GEOLOGIC ENVIRONMENTS • Beach to offshore settings where coarser material is near shore and finer material is offshore. • Off of continental slopes where shelf sediment pours down to ocean bottoms. • River deltas where fast rivers join lakes and quickly dump sediment.

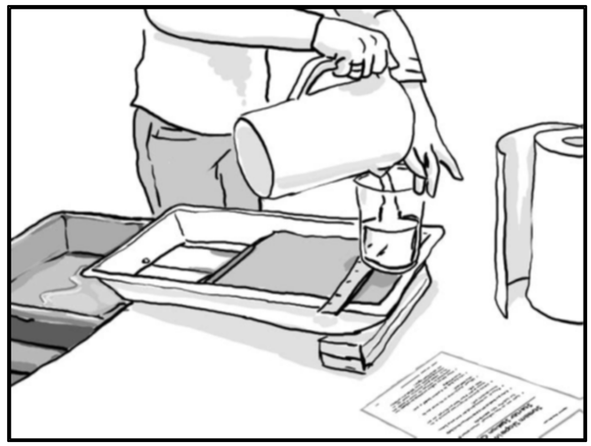
Explore

Activity 4 – Modeling Natural River Systems Using a Stream Table

Purpose

To explore and understand the effects of certain variables (flow rates, slope, sediment characteristics on erosion, and depositional features) of river systems.

Activity Description



This activity provides students the opportunity to explore an important set of landforms in depth, those associated with river systems. Students build a physical model of a landscape with a stream. They manipulate variables in order to conduct seven experiments. The stream table offers a great opportunity to emphasize the role of modeling in scientific investigations of natural systems.

Teachers will find a link to an elaborate guide that is adapted from a professional development program developed and implemented by the Institute for Inquiry, which is part of the famous Exploratorium, in San Francisco. The aim of that program was to promote teacher skill in constructing and facilitating student-directed inquiry. As a result, the guide is highly prescribed and scripted. We left much of the guidance intact because it is full of great facilitation strategies. After a few basic phenomena are shown to students, they are set onto the task of generating their own research question, which they pursue using the materials provided.

The experiments will demonstrate several main ideas, but teachers should provide students the opportunity to observe and describe these:

- When the flow of a stream increases, more erosion takes place.
- When the slope of a stream increases, more erosion takes place.
- Lighter particles (typically smaller or less dense) are deposited farther downstream than heavier particles.
- Stream flow is chaotic, yet regular patterns emerge. For example:
  - Certain shapes regularly form, including fans, streamlined [lens-shaped "( )"] islands, deltas, meanders, and canyons.
  - The main stream channel changes position, moving back and forth, especially on fans. This happens because as material is deposited, it builds up high ground in the channel, so another channel becomes the most direct downhill route.

Focus Question

How is deposition and erosion in a river system affected by changes in flow rate, slope and sediment size?

Duration

Three class sessions

Materials

- Stream Table Modeling Guide
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Stream%20Table%20Modeling%20Guide.docx
    - This is a detailed guide that may seem overwhelming at first. Plan ahead so there is ample time to prepare. To get the best results from the investigations, prepare the sediment as prescribed.
- Stream set-up materials as described in the Stream Table Modeling Guide document
- Sediment recipe as described in the Stream Table Modeling Guide document
- Other materials as described in guide
- A set of landscape photos of river systems from a variety of settings (arid, temperate/tropical moist, large, small, glacial, braided, meandering, deltaic)
- Videos from a River Modeling project. This includes stream dynamics from the field and a scaled physical model. http://serc.carleton.edu/NAGTWorkshops/geomoph/emriver/index.html

Teacher Preparation

1. Study the teacher guide carefully.
2. Follow the set-up procedures outlined in the teacher guide.
3. Practice running the experiments to understand how to run them well.
4. Create a plan to use the available class time, which may mean dividing the experiments between teams. It would be best if all students did the first two experiments, but after that it would be expedient if teams took on different questions.

Classroom Procedure

1. While the guide is very explicit, here are suggestions to help connect this activity to the main science ideas of this cycle and unit:
    - Start the activity by showing landscape photographs of river systems.
    - Ask students to note the differences and ask for ideas on what variables account for them. Point out that the causes students suggest are all part of a complicated system and that how they affect one another will take some research to better understand.
    - Tell students that streams are complex systems, which means that a number of processes are interacting in a complicated and dynamic way. Scientists build physical and mathematical models to study the cause and effect relationships in natural systems.
2. Present the model and procedure that the class will use to initiate their investigations.
3. Show the videos to give ideas to students about research questions.

Explain

Activity 5 – Michigan Glacial Geology

Purpose
To reinforce concepts of weathering, erosion, and deposition through an investigation of Michigan glacial geology.

Activity Description
As an Explain activity, this activity can use and reinforce student understanding of the concepts related to the previous activities. This activity is an interactive lecture where the teacher presents an image-rich slideshow, and students respond to question prompts for each slide. The most prominent form of weathering in glacial history is mechanical weathering due to the freeze-thaw cycle at the base of glaciers and the gravitational force that moved them away (southward) from the thickest regions. In many slides, this cycle can be recognized. Chemical weathering did not play as prominent a role as mechanical, but can be credited for weakening rocks at the surface. The glacial landscape of southern Michigan can be sorted into features of deposition (moraines, outwash plains, kames, eskers) and erosion (the Great Lakes, glacial striations, kettle lakes).

Focus Question
How can glacial deposits be explained through concepts of weathering and erosion?

Duration
One class period

Materials
- Michigan Geologic History – Cranbrook Institute of Science:
  http://www.oakgov.com/peds/assets/docs/es_docs/geo_overview.pdf
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Michigan%20Geologic%20History.pdf
- Oakland County Surface Geology and Hydrology Map:
  http://www.oakgov.com/peds/assets/docs/es_docs/geo_surface.pdf
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/oakland%20county%20geo%20map.pdf
- Geology Resource Guide – Cranbrook Institute of Science:
  http://www.oakgov.com/peds/assets/docs/es_docs/geo_resguide.pdf
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Oakland%20County%20Glacial%20Geology.pdf

Teacher Preparation
1. Review the slideshow (Michigan Geologic History – Cranbrook Institute of Science) and analyze each slide for examples of mechanical and chemical weathering.

2. Study the background content from the Geology Resource Guide.pdf.
3. Print and copy pages 6 – 21 of Cranbrook's Geology Resource Guide as text for student reading. During the interactive lecture students will use the 3-D sketches of glacial landforms in Figures 11a and 11b (pgs. 14 and 15). There may be better versions of these schematics in other sources such as school textbooks. One set per student.
4. Gather resources to explore Michigan beaches and dunes. There are online animations that show long shore drift, spit and bay mouth bar formation, as well as the consequences of human structures such as peers, groins and break walls. Dune blowouts and dune migration are also topics that are well described and animated.

Classroom Procedure

1. Distribute the text from pages 6 – 21 of Cranbrook's Geology Resource Guide and have students find the sketches in Figures 11a and 11b on pages 14 and 15.
2. Tell students that a slide show ("Michigan Geologic History.pdf") will be presented.
3. Explain that during the slideshow, pairs of students will discuss whether the content, primarily examples of glacial features, shows products of mechanical weathering, chemical weathering, erosion or deposition.
4. Begin the slideshow and pause at each slide to ask for examples of products of mechanical weathering, chemical weathering, erosion or deposition.
5. Allow for student conversation and listen for insight or confusion. Draw some of these into the open conversation.
6. With teacher insight, model how to recognize such features, correct misunderstandings, and elaborate on the glacial history of Michigan. For a very detailed look at glacial features display the Oakland County Surface Geology and Hydrology Map.
7. Michigan beaches and lakeshore dunes provide another interesting topic to apply student knowledge of erosion and deposition. Present and discuss short videos, animations or images.
8. This point in the unit would be a good place to revisit the Key Question of the cycle: "How do earth materials relate to landforms?"
9. With the help of Cranbrook's Geology Resource Guide provide a homework assignment have students write a one page essay that addresses this question:

   What is the evidence that a continental glacier covered Michigan?

   Their explanation should include examples of erosion and deposition.

Elaborate

Activity 6 – The Importance of Soil

Purpose
To investigate the nature and importance of soil.

Activity Description
Soil is an incredibly important topic that relates to and applies student knowledge of minerals, erosion and deposition, and river processes. Soils that took thousands of years to develop are degrading and eroding in a time frame comparable to human life spans, and human history is loaded with stories of societies that collapsed due to soil degradation.

This activity prepares student to create a community "soil walk" by informing them about the nature of soil and its importance. First, students explore local soil in the schoolyard or community. Then they explore the relationship between water and soil with an in-class model and online content. Then they study other fundamentals of soil and strategies for soil sustainability. After hours, student document soil near their homes and communities and work in teams to present a community "Soil Walk" modeled after those presented by "Soil-Net.com."

Focus Question
How can our understanding of soil help us protect it so it is sustainable for food production and other needs?

Duration
Five class sessions

Materials
- For describing and sampling soil:
  http://soil.gsfc.nasa.gov/pvg/chartoc.htm
- Smithsonian's Soil Exhibit – Dig It! – Watch the New Curator-Led Tour Video / Interactive online content and video
  http://forces.si.edu/soils/index.html
- For comprehensive background and lab activities:
  http://www.soil-net.com/
- For great microscopic photographs of soil organics (bacteria, nematodes, amoebae and more)
  http://school.discoveryeducation.com/schooladventures/soil/index.html
- For grade-leveled investigations for soils:
  http://forces.si.edu/educators_2.html
- Smithsonian Soil Activity – Just Passing Through
  http://forces.si.edu/main/pdf/6-8-JustPassingThrough.pdf
  Atlas URL:
  http://oaklandk12.rubiconatlas.org/links/Science_6/Science_Gr_6_Earth_Materials/Smithsonain%20Soil%20Activity%20-%20JustPassingThrough.pdf

Teacher Preparation

1. Determine the best location and method for sampling local soil. It would be a good idea to use the school ground with an easy-to-access road cut. If there is no road cut, a trench or auger method may be necessary. Teachers should review the methods described on the NASA website (http://soil.gsfc.nasa.gov/pvg/chartoc.htm) to determine what is best for the school situation.
2. Of the resources provided, Soil-Net.com is worth exploring for other resources, content, and activities a teacher may want to incorporate. Teachers will need to prepare for any activities they use from this site. Three are recommended here:
   - On Rivers and Soil Formation From Case Studies, click on Soils and Water, then click on Rivers and Soil because it relates to the previous activity on rivers.
   - Activities and Downloads: "What is a Soil Walk"? For this activity, students may need to use their own home tools, or they could describe soil that is exposed on roadways or rivers.
   - Materials on Threats to Soil: http://www.soil-net.com/dev/page.cfm?pageid=secondary_threats.
3. Gather materials for the "Just Passing Through" activity from the Smithsonian Institute.

Classroom Procedure

1. Describe the "Soil Walk Project" and provide students with a calendar and process to follow.
2. Explore and describe the local soil, ideally on the school grounds. Before presenting information on the soil horizons, challenge students to observe and describe the differences from the top layer to those below. Ask student teams to determine what makes up the soil (minerals, organics, air, water). Ask them to describe the texture and structure (layers) of the soil.
3. Show the "new curator" video from the Smithsonian display "Dig It," and use the interactive tools to convey some basic information about soil (e.g., layers or zones).
4. Conduct the "Just Passing Through" activity from the Smithsonian Institute.
5. Provide class time for students to create and present their Soil Walking Tours.
6. Close the activity by providing students with the short article on threats to soil: http://www.soil-net.com/dev/page.cfm?pageid=secondary_threats
7. Discuss strategies that help make soil sustainable.

Elaborate

Activity 7 – Soil Engineer: Compare the effect of different types of soil on plant growth. (This is a follow-up to the composting activity that was started in the Part A, Learning Cycle 1. Soil from the composting pile(s) should be used as one of the soil samples.)

Purpose

To determine the effect of compost on plant germination and growth.

Activity Description

Students will design experiments for planting seeds in compost-generated soil versus other types of soil. They will observe, analyze and compare the results of germination and growth of the seeds/plants in different types of soil mixtures.

Focus Question

What is the impact of organic materials in soil on the growth of plants?

Duration

2-3 full class sessions plus a few minutes of several other class sessions to record data from the plants.

Materials

- pots or planting trays
- compost
- soil
- seeds (e.g. beans, radishes, mustard greens, cress, melons all germinate in about five to six days)
- light source (sunlight or artificial lighting)

Teacher Preparation

1. Review the website: http://compost.css.cornell.edu/plantgrowth.html for instructions on class procedures for the study / experiment.
2. Choose and procure the seeds to be used.
3. Gather materials for students and sort for group use.

Classroom Procedure

1. Follow the procedures on the website: http://compost.css.cornell.edu/plantgrowth.html.

Elaborate

Activity 8 – Student Publishing by EarthCaching

Purpose
To investigate and publish scientific documents as an EarthCache.

Activity Description
EarthCaching is a way for students to explore and document a local feature in an international online project. The EarthCaching Project is organized and operated by the Geological Society of America (GSA). Student writing and photography can be uploaded for as an EarthCache that people from around the world can visit. The EarthCaching Project will evaluate the submission and inform authors if they are accepted, or what improvements would allow it to meet their standards. Student could use maps and field visits to document local glacial features (e.g., kames, moraines outwash planes) or their own local soils. Teachers will need to prepare by gathering resources that would be necessary for students to write up and document their investigations.

Focus Question
What can be learned from local features in our community?

Duration
Three class periods

Materials
- EarthCaching homepage (Click on "listings" to see examples)
  http://www.earthcache.org/
- EarthCaching Teacher's Sites
  http://www.geosociety.org/Earthcache_Lessons/
- EarthCache Teacer's Guide (PDF)
  http://www.geosociety.org/Earthcache/teacherGuide.htm
- Michigan Quaternary Geology Maps by County
  http://mnfi.anr.msu.edu/data/quatgeo.cfm
- Michigan Quaternary Geology Map from DNR
  http://www.dnr.state.mi.us/spatialdatalibrary/PDF_Maps/Geology/Quaternary_Geology_Map.pdf

Teacher Preparation
1. Review the materials at the EarthCache website to understand the project. Note the link to Submittal Guidelines.
2. Read through the Teachers Guide, especially Chapter 3 on student created EarthCache's.
3. Determine the local feature to be investigated as an Earth Cache and gather necessary resources so students can understand the science. Here are some suggestions:
   - Local glacial feature: use Cranbrooks Oakland County map (if your school is in Oakland County, or a state geology map if not).
   - Soils study – relate the local soil to agriculture

- Watershed study – describe the watershed of the community.

4. Determine a means to divide the tasks among student teams.
5. Determine logistics of a field trip is necessary.

Classroom Procedure

1. Present the project to the students and involve them in the logistics of the planning.

Appendix – Lesson Resources

My Personal History with Rocks and Minerals NAME: ____________________________

1. Look over the samples on the table. Think of a time when you have seen other interesting rocks or minerals. Describe your experience and describe the scientific characteristics of what you saw.
2. Share your stories with others in your group. Try to emphasize the science of the rocks or minerals. (Think like a scientist!)
3. Work with others in your group to try to sort the samples as either a rock or a mineral. Ask your teacher to check your work.
4. Choose one of the rock samples and think about how it may have been formed. Draw the rock you chose in the space to the left below. Then, propose a realistic history by tracing along the arrows on the rock cycle below. Add written descriptions of the things that may have happened to the rock. Drawing

Understanding Petrology

Overview: The study of rocks is called "Petrology." In this exploration you will become familiar with 16 common rocks and the classification of the three major rock types (igneous, sedimentary, metamorphic).

Part 1: Categorizing Rocks – Igneous, Sedimentary, Metamorphic
(one of each type of rock)

1. From the rock samples that are provided to you, select one of each type of rock (igneous, sedimentary, metamorphic).
15. Using careful observations and the "Simplified Rock Identification and Origin Flow Chart" categorize them as igneous, sedimentary or metamorphic.
2. Participate in a whole group discussion by describing you conclusion in a "claim," "evidence," "reasoning" format.
3. Learn about other types of observations from the other groups in your class.

Part 2: Igneous Rocks
(granite, basalt, andesite, obsidian, pumice, peridotite)

1. Place the group of igneous rocks on your workspace.
2. Sort them into groups based on physical characteristics that you find distinguishes each from one another. This is ***your*** classification system.
3. Share your observations and reasoning of your classification system with other groups nearby or to the whole class during a whole group discussion.
4. Use the rock identification flow chart to name each sample.
5. Place each sample on the Igneous Rock Placemat.
6. Complete some of the labels on the placemat.

Part 3: Sedimentary Rocks
(shale, sandstone, conglomerate, limestone, chert)

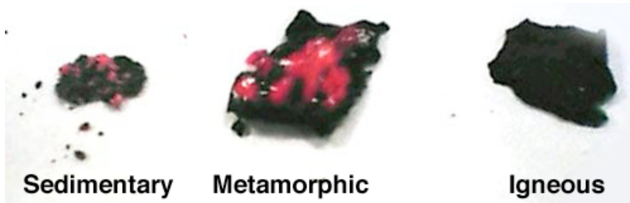
1. Place the group of sedimentary rocks on your workspace.
2. Sort them into groups based on physical characteristics that you find distinguishes each from one another. This is ***your*** classification system.
3. Share your observations and reasoning of your classification system with other groups nearby or to the whole class during a whole group discussion.
4. Use the rock identification flow chart to name each sample.
5. Place each sample on the Sedimentary Rock Placemat.
6. Complete some of the labels on the placemat.

Part 4: Metamorphic Rocks
(slate, schist, gneiss, marble, quartzite)

1. Place the group of metamorphic rocks on your workspace.
2. Sort them into groups based on physical characteristics that you find distinguishes each from one another. This is ***your*** classification system.
3. Share your observations and reasoning of your classification system with other groups nearby or to the whole class during a whole group discussion.
4. Use the rock identification flow chart to name each sample.
5. Place each sample on the Metamorphic Rock Placemat.
6. Complete some of the labels on the placemat.

The Crayon Rock Cycle

Drawing conclusions about rocks with colored wax.



Introduction:

This activity is an introduction to the rock cycle by using wax crayons. Crayons have the ability to be ground into small particles (weathered), heated, cooled and compressed just like rocks. However, unlike rocks, all these processes can be done safely and at reasonable temperatures. Using crayons students can create sedimentary, metamorphic and igneous crayons.

Materials:

- Crayons – at least two different colors of wax crayons, at least one stick per student
- Source of very hot water
- Aluminum Foil and/or foil cupcake cups[1]
- Container to hold hot water
- Simple scraping device (popsicle stick[2], plastic knifes….)

To do and notice:

To make a Sedimentary Crayon:

1. You need to make small, particles sized sediments out of your crayons. These can be scraped from new crayons (which can also be considered an igneous crayon), a sedimentary block of crayon, a metamorphic block of crayon or an igneous block of crayon. Scrape crayons with Popsicle sticks, plastic knives or other safe grating tools.

2. Gather a pile of sediments collected from various scraped crayons.
3. Pressing down on this pile will allow the particles to stick together.
   a. Encasing the sediments between sheets of paper, foil, etc will help keep the sediments together.
   b. Using a utensil or stepping on your encase pile will help this process along too.
4. Your coherent bunch of crayon sediments is now equivalent to a model of a sedimentary rock.

To make a Metamorphic Crayon:

1. Place a small pile of sedimentary, metamorphic or igneous

crayons into piece of aluminum foil or foil cupcake cup.

2. Float this foil on hot water.
3. Watch as the heat from the water transfers to the foil and to the crayons. The crayons should start to melt.
4. Remove the foil when the crayon wax is soft to the touch (don't use your finger, use a probe such as a Popsicle stick).
5. Let your crayons cool.
6. Your partially melted and cooled crayons are now equivalent to a model for metamorphic rocks.

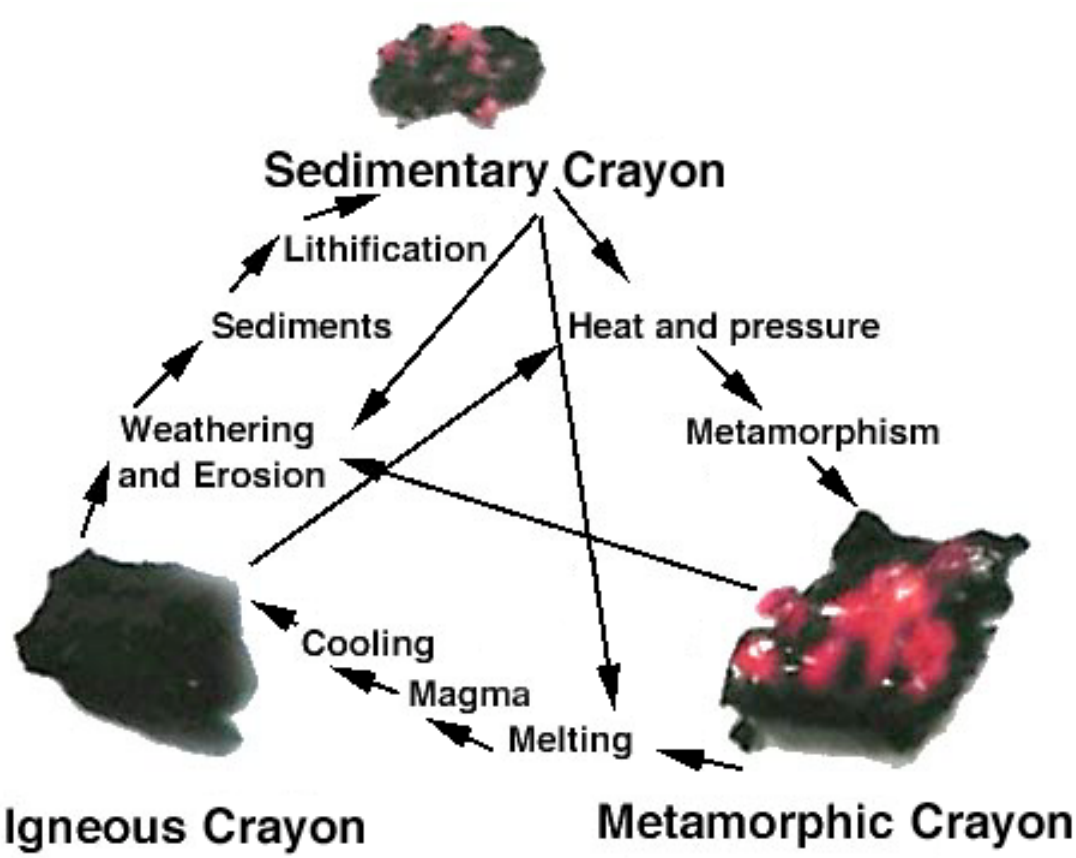
Adapted for Flint Community Schools from Eric Muller – Exploratorium 2004 DRAFT
http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf

To make an Igneous Crayon:

1. Place a small pile of sedimentary, metamorphic or igneous crayons into piece of aluminum foil or foil cupcake cup.
2. Float this crayon containing foil on hot water.
3. Watch as the heat from the water transfers to the foil and to the crayons. The crayons should start to melt.
4. The crayons should be allowed to melt **until a smooth liquid forms**.
5. Carefully remove molten crayon wax and let cool. Your totally melted and cooled crayons are now equivalent to a model for an igneous rocks.

What's going on?

This crayon cycle is designed to model the rock cycle. The rock cycle is a continuing process that has occurred throughout geologic time. One type of rock can become another rock type over time. This process can be thought of as a cycle and can be diagramed (see below). The particles that constitute an igneous rock held in one's hands today may become part of a sedimentary or metamorphic rock in the distant future. Very little rock on the surface of the earth has remained fixed in its original rock type. Most rocks have undergone several iterations of the rock cycle. [3]



[1] Aluminum foil cupcake molds work well for this step – idea from Coral Clark.
[2] Use of a popsicle sticks for younger children - idea from Coral Clark.
[3] The oldest known rocks on the surface of the earth are 3.8 billion years old (found in Greenland).

Adapted for Flint Community Schools from Eric Muller – Exploratorium 2004 DRAFT
[4] http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf

Activities to Simulate Rock Forming Processes.

In this document:

- Link to the Crayon Rock Cycle
- 2 crystal growing activities
- Sedimentary deposits

Online Resources:

- The Crayon Rock Cycle: http://www.exo.net/~emuller/activities/Crayon-Rock-Cycle.pdf

GROWING CRYSTALS

There are many activities for students to grow crystals. One consideration is what compound will be used. One would use a different compound to simulate igneous cooling than one that simulates precipitated crystals.

- Choose a compound to grow crystals:
  - **Salol** (Phenyl Salicylate) – this is best for modeling slow and fast growing crystals because it can be heated to a melt at 45 C (115 F). However, there may be more convenient compounds to obtain. Check with your friendly high school chemistry teacher.
  - **Alum** (in spice section of grocery store), – precipitates out of solution, so not like igneous processes.
  - **Salt or Sugar** – precipitates out of solution, so not like igneous processes
  - **Washing soda -** precipitates out of solution, so not like igneous processes

Activity 1: Growing Crystals by Cooling

from Illinois State Museum Geology Online -*http://geologyonline.museum.state.il.us*

Materials:

- Salol (Phenyl Salicylate) - fairly safe, but gloves and goggles are required due possibility of eye or skin irratation
- 10 metal teaspoons or 10 GLASS microscope slides
- Ice
- Magnifiers (hand lenses)
- Safety glasses
- Heat source such as a candle
- Matches
- Copies of the procedure sheet that follows (available in printable form in the PDF download version of this lesson)

Preparation:

Read the CAUTIONS on the bottle of salol. Salol is a very safe compound when used correctly but be sure to read the warnings before beginning class. Salol is a compound that grows crystals in minutes. It can be used to grow crystal repeatedly even in the limited time available in a class period. Give each group a pinch of the compound to use in their crystal growing activity. Groups of two or three students work best. Place the salol in a teaspoon or on a glass slide. I have found that the spoons work much better if they are available. If you are using glass slides be aware that there will be a carbon build-up on the bottom that should be removed between periods. It can easily be wiped off with a paper towel. Give each group a candle, an ice cube, a tiny quantity of salol other than that on the spoon/slide, and a magnifier. Have them wear their safety goggles.

Procedure:

NOTE: Teacher can perform this as a demonstration if they are not comfortable having students conduct the activity. If preferred there is a different crystal growing activity that uses salt, sugar or other safe compounds. However, they grow crystals by precipitation which does not accurately simulate igneous crystal growth.

Part 1: In this activity you are going to do an amazing thing, you are going to grow crystals. This process can take years to happen in nature but you will grow them quickly with a chemical called salol. If you touch the chemical be sure to wash your hands before leaving the classroom. Your teacher will give you a small amount of salol.

1. You will need to melt the salol over a candle. Do not hold it over the flame very long because it will get so hot that no crystals will grow for a long time.

2. Slide it over the flame and wait to see how much melts. Continue to do this until **almost** all of the salol has melted, then set it down on the table and do not disturb it. The crystals should begin forming in just a few seconds. If you melted ALL of it, the crystals will not be able to begin forming since they need something to attach to.
3. If all of the salol melted you will need to drop some solid grains of salol, called seed crystals, into the melted salol. If these melt, wait a few moments and try again until the crystals begin to grow.
4. Move the solid salol from side to side to let the light show the crystals better. One of the neat things about salol is that it can be melted over and over again to grow new crystals. If you do not like the ones you got the first time, try again.

Observations:

[Have students record their observations from Part 1.]

Part 2:

Now we are going to repeat the experiment, but once you see crystals beginning to form, place the spoon/slide on an ice cube to harden.

Observations:

[Have students record their observations from Part 2.]

Questions:

1. Which crystals were larger? No ice or ice? Why? [Students should notice that the crystals were largest in the salol with no ice. They are bigger because the molecules had more time to lock into place. Once the salol hardens all molecular migration ceases and no more molecules can increase the size of the seed crystals.]
2. If crystals formed underground where it is warm a very long time, would you expect large or small crystals to form? Why? [The largest crystals would form underground where the magma stays liquid longer and there is more time for the molecules to lock into place.]

Activity 2 – Growing Crystals by Precipitation

Background On Crystal Growth:

Minerals are considered crystalline. A crystalline structure is characterized by a certain internal arrangement of atoms and molecules. The external shape of a mineral may or may not reflect its internal structure. In the case of crystals, the external form reflects its internal structure.

Rocks are composed of mineral grains. Some sedimentary rocks are composed of or may contain minerals that crystallize from concentrated salt water, these include rock salt (halite), and gypsum. Igneous rocks include those that solidify from a molten material. The crystal size in igneous rocks is controlled by their rate of cooling. Slowly cooling molten material causes crystals to grow to a visible size and have a coarse grained texture while molten material that cools quickly will result in quite small crystals.

Materials Needed:

Alum (approx. 4 ounces) – Alum is available in the spice section of most grocery stores.
4 Tablespoons salt
4 glass containers – One pint mason jars or beakers work well.
3 feet of thread
A hot plate
Water
Magnifiers (microscope or magnifying glasses)
Samples of mineral crystals (quartz, halite, or calcite)
Samples of igneous rocks (granite or basalt)

Procedures:

<u>Part 1 – Crystal Shapes</u>

In this activity, you will grow crystals from both alum and salt. Have students observe each substance and note that they are similar in color. The alum will likely be granulated and finer than the salt. Have the students make predictions of whether crystals formed from these two substances will be similar or different from each other in color, size, and shape. Heat two cups of water (approx. 500 ml) and dissolve four ounces of alum in the water. When the alum is dissolved pour about one inch into a clean jar and set aside uncovered. In about an hour, small crystals should begin to form in the bottom of the jar. Pour the remainder of the solution into a jar and cover it. Now heat one cup of water and dissolve as much salt as possible in the water. There will probably be some salt that doesn't dissolve. Pour about one inch of the solution into a clean jar and set aside uncovered. In about an hour, very small crystals of salt should begin to form. Once the crystals have formed in both solutions, have the students examine them and compare the color, size, and shape of the crystals. After examining with a magnifying glass, have the students compare their predictions to the result.

<u>Part 2 – The Effect of Cooling on Growth of Crystals</u>

In this activity, you will grow alum crystals under various conditions. One jar will be cooled while the other will sit at room temperature. Have the students make predictions about what effect the cooling will have on the shape or size of the crystals. Remove two crystals from the alum solution that was made in part one to use as "seed crystals." Tie the seed crystals to separate pieces of thread, each about a foot long. This can be a bit tricky so it may be useful to notch the crystals on each side with a small knife.

Tie the free end of the thread to a pencil and prop the pencil across the top of the jar, do this with each crystal so it is hanging suspended near the bottom of the jar. Take your reserved alum solution from part one and divide it equally between the two jars. Make sure the solution is not too hot as it can dissolve the crystals. Place one of the jars in ice water, and set the other jar where it can cool at room temperature. The crystals will now need several hours to form completely. Once the crystals have formed, have the students observe and compare the shape and size of the crystals grown under the different conditions and compare their predictions with the result.

Results and Discussion:

Part 1:

Students should have observed that the shapes of the salt and alums crystals are quite different. The salt crystals are cubical while most of the alum crystals are variants of octahedrons. Students should have also noticed that the salt crystals are much smaller than the alum crystals. This is due to a function of the kinetics of crystallization. At this point, show the students some different mineral crystals if available, to demonstrate the variety of possible shapes.

Part 2:

This part of the exercise can have variable results but ideally the crystals grown at room temperature will be larger than the crystals grown while cooling on ice. Larger crystals result from having a greater time for the crystallization to occur. At this point, show students how igneous rocks formed from the cooling of magma such as granite have bigger crystals because they cool slowly, while crystals in rocks such as basalt are smaller because they cool rapidly.

Tips:

It is a good idea to experiment with this exercise before attempting it with students. You can also add another part to the experiment by mixing together the salt and alum in a water solution and having students observe what type of crystals form. It is also a great time to construct a lab sheet for students to fill out.

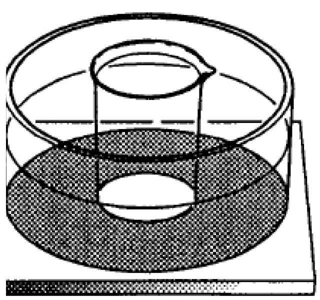
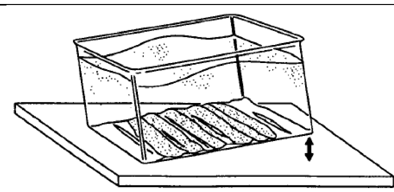
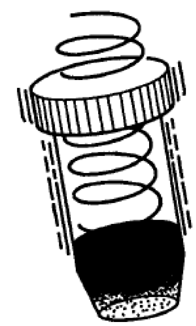
Simulating Sedimentary Types of Layers

Purpose: to demonstrate how nature of hydraulic energy (flowing water) controls how sedimentary layers develop.

Material:

- A round, flat bottomed bowl – approximately 12 inches
- A beaker, small enough to fit inside the bowl, leaving a large enough track to conduct the simulation
- Aquarium
- Bottle with lid
- Beach sand
- Pea gravel
- Silt or clay

Procedures:

		
ONE DIRECTION FLOW ● Place a thin layer of the sand in the bottom of the bowl as configured ● Swirl the water in one direction ● Observe and sketch the sedimentary layers. ● Notice ripple mark patterns	OSCILATING FLOW ● Place sand in the bottom of the aquarium and cover with water ● Gently lift an edge and rock the water back and forth ● Observe and sketch the sedimentary layers. ● Notice ripple mark patterns	GRAVITY SETTLING ● Place the beach sand mixed with pea gravel and silt or clay ● Vigorously shake the bottle for 30 seconds ● Place on a table to let the sediment settle ● Observe and sketch the sedimentary layers. ● Notice the graded bedding
GEOLOGIC ENVIRONMENTS ● Streams and rivers ● Glacial outwash plains ● River deltas, except near tidal environments	GEOLOGIC ENVIRONMENTS ● Beaches – from wave action ●	GEOLOGIC ENVIRONMENTS ● Beach to offshore settings where coarser materials is near shore and finer material is offshore ● Off of continental slopes where shelf sediment pours down to ocean bottoms ● River deltas where fast rivers join lakes and quickly dump

		sediment.

Simulating Mechanical Weathering

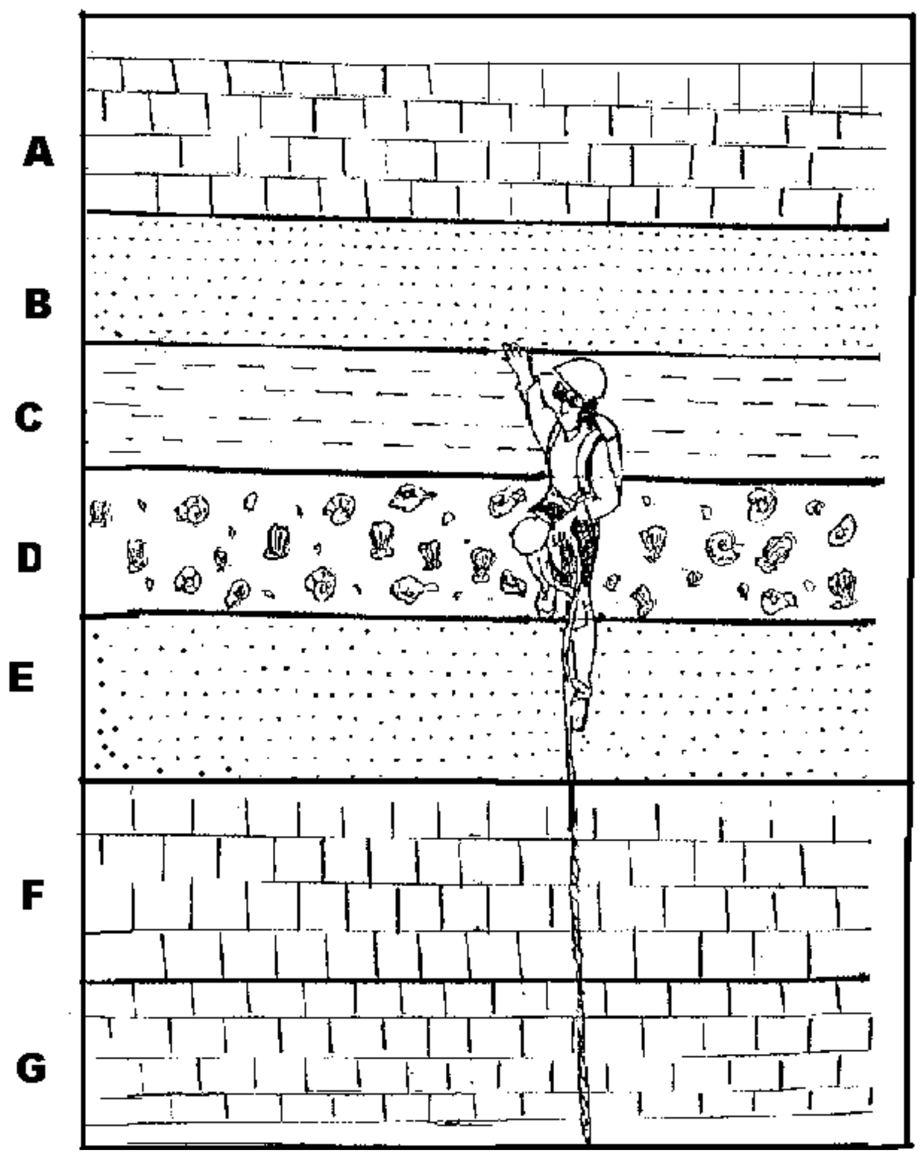
Purpose: to demonstrate the process of mechanical weathering.
Materials:
Plastic jar with a lid
Small rock samples
-sandstone, typical of landscaping rock
-granite
-shale
-limestone
Procedure:
Part 1: Place the sandstone in the jar and shake vigorously. The sandstone of the Michigan formation, common in landscaping ledge rocks is a perfect type to use. Notice that it quickly turns into sand.
Part 2: Mix several rock types, some strong and some weak. Shake together. Notice that the weaker ones quickly turn to sediment while the stronger ones endure.

Rock Cycle Quiz **Name_________________________**

Observe the sample labeled rocks provided by your teacher and use your observations when thinking about the answers to the following questions.

1. What information can a geologist infer by examining sedimentary rock?

A mountain climber is climbing up a cliff. On the way up, he notices seashell fossils in one of the rock layers.



Use the drawing on the previous page to answer questions 2–7.

2. Observe the limestone sample. What can you infer about the environment in which the limestone layer (D) was formed?

3. Why is the limestone layer (D) no longer on the top surface?

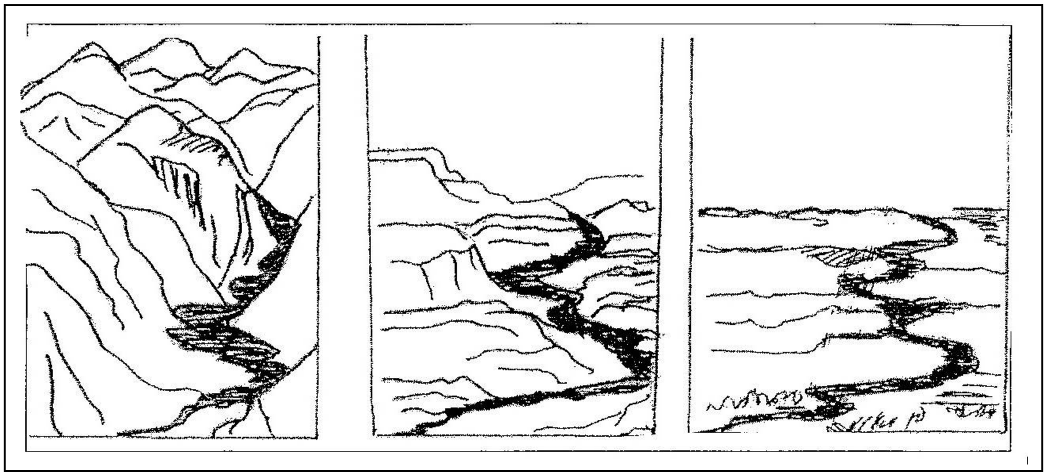
4. Which layer of the cliff is the oldest and which layer is the youngest? Explain why.

5. Observe the sandstone sample. What can you infer about the environment in which sandstone layers (B and E) were formed?

6. Observe the shale sample. What can you infer about the environment in which shale layer (C) was formed?

7. Observe layers D, C, and B. Layer D is limestone. Layer C is shale. Layer B is sandstone. This one location has three different rock types. What changes can you infer occurred to the environment during the time period when layers D, C, and B were deposited?

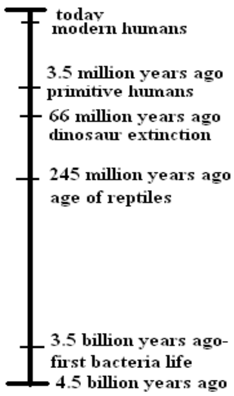
8.



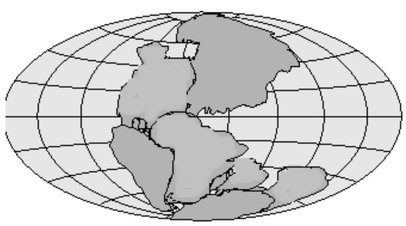
The three pictures above show the same land area over a period of time. Describe how weathering, erosion, and deposition changed the land surface over time.

9. The Delaware River begins in the mountains of New York and Pennsylvania. The river deposits sand sediments at the mouth of the Delaware Bay. Delaware beaches are covered by sand. Describe how the processes of weathering, erosion, and deposition are responsible for the sand.

10. Below is a geologic timeline. How do geologists know about Earth's past if humans were not present on the Earth at that time? Give an example.



12.a. Geologists believe that the continents are continually moving. About 225 million years ago, the continents were connected together, but today the continents are separated. Describe one piece of evidence that geologists use to support this theory.



12.b. Energy must be provided for things to move. Where does the energy come from for the continents to move?

Rock Cycle Quiz (25 total points)
Teacher Rubrics and Directions

1. What information can a geologist infer by examining sedimentary rock?

This item measures student understanding of the use of sedimentary rocks to infer Earth's past.
Criterion for a complete response:

1. Student indicates that sedimentary rocks provide information about Earth's past. This can include information on the environment, the relative layering of rock layers, or how the environment changed due to the changing rock layers. Examples: *The rocks tell what the environment was like. The rocks can tell which was deposited first, second, or third.*

Pts	Response
	Complete Response
5	Meets criterion.
4-5	Any other scientifically correct response.
	Partially Correct Response
3	Response refers to the properties of sedimentary rocks rather than the environment of deposition. Examples: *The rocks have fossils. The rocks react with acid.*
2-3	Any other partially correct response.
	Incorrect Response
1	Response only indicates rock type: limestone, shale, sandstone.
0-1	Any other incorrect response.
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret.
0	Blank.

2. Observe the limestone sample. What can you infer about the environment in which this limestone layer (D) was formed?

This item measures the student's knowledge that seashell fossils occur in a marine environment or aquatic environment.

Criterion for a complete response:

1. Infers that this layer formed in an aquatic or marine environment.

Pts	Response
	Complete Response
3	Response meets criterion.
2-3	Any other scientifically correct response.
	Incorrect Response
1	States seashells were deposited on a beach.
1	States rock layer formed at sea level.

0	States rock layer was formed on land.
0	Repeats the stem of the question.
0	Any other incorrect response.
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret.
0	Blank.

3. Why is this limestone layer (D) no longer on the top surface?

This item measures the students' understanding of the concept of sediment deposition in undisturbed layers.

Criterion for a complete response:

1. Includes the idea that more sediment (layers) has been deposited (formed) on top of the seashell layer.

Pts	Response
	Complete Response
3	Response meets criterion.
2-3	Any other scientifically correct response.
	Incorrect Response
1	States more layers grew on top of the seashell layer.
1	States the layer was eroded by various factors; for example, the water, the river, etc.
0	States the layer sank.
0	Repeats the stem of the question.
0-1	Any other incorrect response.
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret
0	Blank

4. Which layer of the cliff is the oldest and which layer is the youngest? Explain why.

This item measures the student's understanding of layering.

Criteria for a complete response:

1. Includes that layer A is the youngest and layer G is the oldest.

11. Includes that rock layers are generally successively deposited one on top of the other.

Pts	Response
	Complete Response
5	Response meets criteria one and two.
5	States layer A is the youngest and layer G is the oldest because of superpositioning.
4-5	Any other scientifically correct response.
	Partially Correct Response
3	Response meets criteria one.
3	Gives explanation but omits youngest and oldest.

2-4	Any other partially correct response.
	Incorrect Response
1	Names layer G as the youngest and layer A as the oldest.
0	Names other layers as oldest and youngest.
0	Repeats the stem of the question.
0-2	Any other incorrect response.
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret.
0	Blank.

5. Observe the sandstone sample. What can you infer about the environment in which sandstone layers (B and E) were formed?

This item measures the students' understanding that sandstone was deposited in a beach environment or at the edge of water.

Criterion for a complete response:

1. Infers that this layer formed in a beach environment or near the water's edge.

Pts	Response
	Complete Response
3	Response meets criterion.
2-3	Any other scientifically correct response.
	Incorrect Response
1	States sandstone formed under water.
0	Repeats the stem of the question.
0-2	Any other incorrect response.
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret.
0	Blank.

6. Observe the shale sample. What can you infer about the environment in which shale layer (C) was formed?

This item measures the students' understanding that shale was formed in a still water environment such as a marsh or pond.

Criterion for a complete response:

1. Infers that this layer formed in a still water environment or indicates pond, lake, or other still water environment.

Pts	Response
	Complete Response
3	Response meets criterion.
2-3	Any other scientifically correct response.
	Incorrect Response
1	States shale formed in the ocean.
0	Repeats the stem of the question.

0-2	Any other incorrect response.
	Non Response
0	Crossed out, erased, illegible, or impossible to interpret.
0	Blank.

7. Observe layers D, C, and B. Layer D is limestone. Layer C is shale. Layer B is sandstone. This one location has three different rock types. What changes can you infer occurred to the environment during the time period when layers D, C, and B were deposited?

This item measures the student's understanding that the different rock layers indicate that the environment changed (the area was under water when the limestone formed, then the water was calm for the shale to form, and then the area became a beach for the sandstone to form).

Criterion for a complete response:

1. Indicates that the environment changed from being under water to being above water.

Pts	Response
	Complete Response
3	Response meets criterion.
2-3	Any other scientifically correct response.
	Incorrect Response
1	Indicates that the environment went from being dry to under water.
0	Repeats the stem of the question
0-2	Any other incorrect response
	Non-Response
0	Crossed out, erased, illegible, or impossible to interpret
0	Blank

Rock Cycle Quiz – Teacher Rubrics and Directions
Adapted from
*https://www.doe.k12.de.us/infosuites/staff/sci_assess/middle68/sum68/earth.shtml*https://www.doe.k12.de.us/infosuites/staff/sci_assess/middle68/sum68/earth.shtml
https://www.doe.k12.de.us/infosuites/staff/sci_assess/middle68/sum68/earth.shtml

Adapted from:

Oakland Schools Scope on Atlas Rubicon
http://oaklandk12.rubiconatlas.org/public