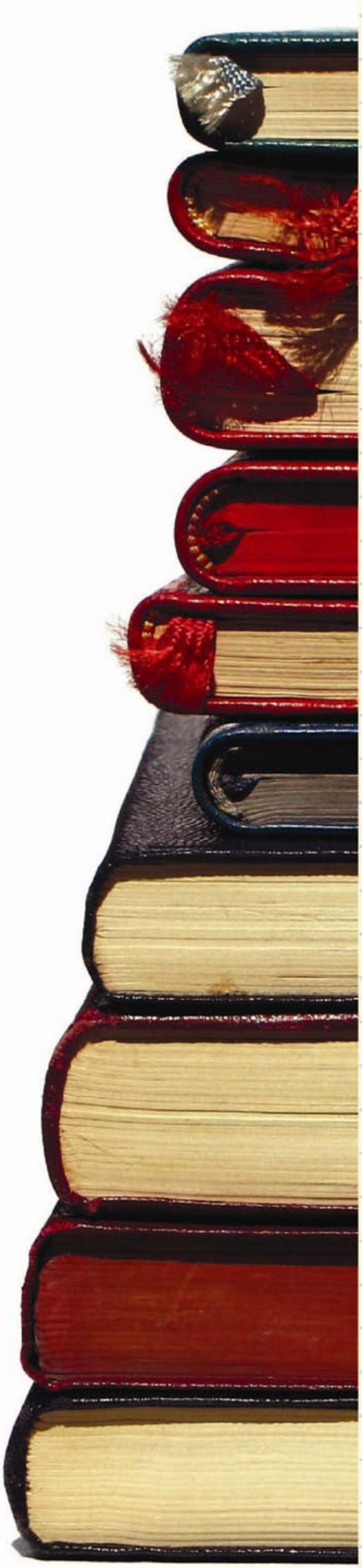

Comprehensive Curriculum

Revised 2008

Earth Science

Louisiana Department of
EDUCATION

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Earth Science

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Louisiana Comprehensive Curriculum, Revised 2008
Course Introduction

The Louisiana Department of Education issued the *Comprehensive Curriculum* in 2005. The curriculum has been revised based on teacher feedback, an external review by a team of content experts from outside the state, and input from course writers. As in the first edition, the *Louisiana Comprehensive Curriculum*, revised 2008 is aligned with state content standards, as defined by Grade-Level Expectations (GLEs), and organized into coherent, time-bound units with sample activities and classroom assessments to guide teaching and learning. The order of the units ensures that all GLEs to be tested are addressed prior to the administration of *i*LEAP assessments.

District Implementation Guidelines
Local districts are responsible for implementation and monitoring of the *Louisiana Comprehensive Curriculum* and have been delegated the responsibility to decide if

- units are to be taught in the order presented
- substitutions of equivalent activities are allowed
- GLES can be adequately addressed using fewer activities than presented
- permitted changes are to be made at the district, school, or teacher level

Districts have been requested to inform teachers of decisions made.

Implementation of Activities in the Classroom

Incorporation of activities into lesson plans is critical to the successful implementation of the Louisiana Comprehensive Curriculum. Lesson plans should be designed to introduce students to one or more of the activities, to provide background information and follow-up, and to prepare students for success in mastering the Grade-Level Expectations associated with the activities. Lesson plans should address individual needs of students and should include processes for re-teaching concepts or skills for students who need additional instruction. Appropriate accommodations must be made for students with disabilities.

New Features

Content Area Literacy Strategies are an integral part of approximately one-third of the activities. Strategy names are italicized. The link (view literacy strategy descriptions) opens a document containing detailed descriptions and examples of the literacy strategies. This document can also be accessed directly at http://www.louisianaschools.net/lde/uploads/11056.doc.

A *Materials List* is provided for each activity and *Blackline Masters (BLMs)* are provided to assist in the delivery of activities or to assess student learning. A separate Blackline Master document is provided for each course.

The *Access Guide to the Comprehensive Curriculum* is an online database of suggested strategies, accommodations, assistive technology, and assessment options that may provide greater access to the curriculum activities**.** The *Access Guide* will be piloted during the 2008-2009 school year in Grades 4 and 8, with other grades to be added over time. Click on the *Access Guide* icon found on the first page of each unit or by going directly to the url http://mconn.doe.state.la.us/accessguide/default.aspx.

Earth Science
Unit 1: Properties of Earth's Materials

Time Frame: 5 weeks

Unit Description

The focus of this unit is on the physical and chemical properties of planet Earth, including components of Earth's lithosphere, hydrosphere, and atmosphere, cryosphere, and limited aspects of the biosphere, with special emphasis on the lithosphere. The structure of molecules, minerals, rocks, mountains, and water and is explored and students are engaged in activities that emphasize the "interconnectedness" of the many aspects of Earth's materials.

Student Understandings

Students will be able to explain that physical properties of Earth's materials are determined by the kind and arrangement of the atoms that comprise them. They will be able to relate common rock and mineral properties to their environments of formation. Students will be able to discuss the relative importance of certain chemical elements, particularly oxygen, in each of the spheres. They should be able to summarize how these elements move and are cycled through Earth's processes over time. Students will also gain experience in using physical rock and mineral properties to make informed consumer decisions.

Guiding Questions

1. Can students describe each of the spheres of Earth?
2. Can students identify the common elements that are present in each of the spheres of Earth?
3. Can students provide examples of places where the spheres interact and elements are exchanged?
4. Can students explain the properties of water that make it unique and how that uniqueness chemically affects other substances like salt, for example?
5. Can students relate the presence of oxygen in each of the spheres of Earth to the abundance of silicate minerals in Earth's crust?
6. Can students trace the movement of carbon atoms through the spheres of Earth?
7. Can students relate the atomic arrangement of selected minerals to their crystal forms?
8. Can students interpret Bowen's Reaction Series and classify a group of igneous rocks by environment of formation?

9. Can students describe the relationships among color, texture and cooling rate of igneous rocks?
10. Can students compare the structure and formation of clastic and nonclastic sedimentary rocks?
11. Can students distinguish between foliated and nonfoliated metamorphic rocks and relate them to their mineral composition?
12. Can students trace the changes a rock would undergo as it experienced the processes in the rock cycle?
13. Can students use what they have learned about the composition and physical properties of rocks and minerals in a real-life decision-making scenario?

Unit 1 Grade-Level Expectations

GLE #	GLE Text and Benchmarks
Science as Inquiry	
The Abilities Necessary to Do Scientific Inquiry	
2.	Describe how investigations can be observation, description, literature survey, classification, or experimentation (SI-H-A2)
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H- A6) (SI-H-A2)
10.	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
16.	Use the following rules of evidence to examine experimental results: (a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability? (b) Has the technique or theory been subjected to peer review and publication? (c) What is the known or potential rate of error of the technique or theory when applied? (d) Were standards and controls applied and maintained? (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)

GLE #	GLE Text and Benchmarks
Earth Science	
13.	Explain how stable elements and atoms are recycled during natural geologic processes (ESS-H-B1)
14.	Compare the conditions of mineral formation with weathering resistance at Earth's surface (ESS-H-B1)
22.	Analyze data related to a variety of natural processes to determine the time frame of the changes involved (e.g., formation of sedimentary rock layers, deposition of ash layers, fossilization of plant or animal species) (ESS-H-C5)

Sample Activities

Opening Safety Exercise: Using Equipment Safely

Materials List: samples of equipment used in course, including safety eyewear, poster paper, reference materials, laboratory safety contract such as the Sample Laboratory Safety Contract BLM (one per student)

Students will observe and become acquainted with selected equipment that will be used in laboratory activities during the year. After this introduction, small cooperative groups will each choose one piece of critical equipment such as rock hammer, cold chisel, Bunsen burner, HCl, or other equipment and materials, and develop a safety plan for use of that equipment. The project should include all aspects of safe use, including appropriate uses, safe handling, storage, and other safety devices necessary in conjunction with its use. (For example, safe use of a rock hammer requires wearing protective eyewear.) Groups will present their plans to the class upon completion. The project should include a poster suitable for display in the classroom as a component of a yearlong safety focus. In addition to other elements of the project, groups should submit five multiple-choice assessment items derived from the content of their presentation. Each group will submit a copy of their list of five assessment items and the text of their presentation on their due date. During the presentations, remaining students should use *split-page note-taking* (view literacy strategy descriptions). In this note-taking strategy students fold a sheet of lined paper down the center to create two columns. The name of each piece of equipment should be written in the left column and the key information related to that item should be written alongside it in the right column. A whole-class assessment constructed from the student-developed items can be administered at a convenient time after all groups have made their presentations. Students should be given a copy of a safety contract such as the Sample Laboratory Safety Contract BLM included in this unit, to sign, take home for parental signature, return, and keep as a record of their having received safety instruction before hands-on activities begin.

Activity 1: The Dynamic Nature of Earth Materials-A First Look (SI GLEs: 5,6; ESS GLEs: 13 14)

Materials List: Earth material such as soil, sand, water, etc. in sufficient quantity for all students to receive a small sample and a container such as film canister, student-provided equipment and technology, as appropriate

Each student should be given a small quantity of a common Earth material, such as a small rock, a small pile of soil or sand, and a small container (film canister) of water. All students should receive the same kind of sample. Students will take their sample home and change it safely in several different ways. It will be necessary for the teacher to discuss examples of what kinds of changes would be considered reasonably safe in a home environment, The students should be instructed to record the procedures they used, the technology or equipment involved, and what safety precautions were taken. Their record should include a description of changes they caused, how they were caused, and what the material looked like after each change. Students can be instructed to use a *graphic organizer* (view literacy strategy descriptions) chart to represent their findings.

A *graphic organizer* is a communication tool that uses visual symbols to express ideas and concepts, illustrating the relationships between facts, terms, and or ideas within a learning task. The *graphic organizer* for this activity can take the shape of a table, flow chart, diagram, or illustration, but it should in some way record the students' procedures and the changes that resulted. They are to record any other ways in which they think the earth material might have changed that were not so obvious.

Samples should be returned, earth materials and recorded findings examined by everyone, and the changes discussed. Students should be encouraged to think about any stable elements and/or atoms that were recycled during their experiment and be prompted to suggest natural processes that could have caused similar changes. This activity provides a common experience with an earth material that can be referenced during subsequent lessons related to earth materials and processes. The teacher should accept the questions that may arise without attempting to answer all of them. At this time the students should be generating questions to which they may be able to discover their own answers at a later date. This activity should be the starting point for students to create and maintain an "Earth Journal" as a *learning log* (view literacy strategy descriptions). The "Earth Journal" *learning log* is an ongoing, written document, possibly in a notebook format, that allows students to record what they are learning about rocks, minerals, other earth materials, and the processes that change them in their own words and with their own diagrams. Students should be given time to make entries in their *learning logs* after every activity. The teacher should review and comment upon these entries on a regular basis.

Activity 2: Spheres of Earth and their Common Elements (SI GLEs: 5, 7; ESS GLE: 13)

Materials List: photos, images, or pictures (enough for each small group to have one); Earth Spheres BLM **(**one per group)

As an introduction to the concept of "spheres" of Earth, interfaces between spheres, and elements that are exchanged between spheres, students should examine a variety of photos, images, or pictures that illustrate any of the zones of contact (interfaces) among lithosphere, hydrosphere, atmosphere, cryosphere, and biosphere. In a "think-pair-share" arrangement, the students should select an image, identify each interface they observe, describe each of the two spheres the interface separates, and suggest some elements that could be exchanged between the two spheres. Once groups of three to four students have shared and combined their observations, they can transfer their information to the *graphic organizer* (view literacy strategy descriptions), included with this activity, see Earth Spheres BLM. Each circle represents one of the spheres, and an arrow drawn between two circles indicates an interface between those two spheres. The names of elements, molecules, or chemicals exchanged at the interface should be written on the arrow line connecting the two circles**.** An example can be found on the diagram. Groups present their diagrams and discuss them with the class. This activity could begin with a single image used with the whole class participation as guided practice and then move on to the use of several images by smaller groups. The completed diagram is the product of this activity and can be graded using the Earth Spheres Activity Assessment Rubric BLM. Reference to the previous earth material activity can provide additional practice or reinforcement.

Activity 3: Unique Properties of Water (SI GLE: 7; ESS GLE: 13)

Materials List: rock salt or salt grains, large beaker, tap water to fill beaker almost full

Students are engaged by showing them a small pile of unknown white crystals (salt) and asking them to suggest ways the pile could be made to disappear before their eyes. Use of "rock salt" like that used in ice cream machines instead of table salt may heighten student curiosity as it is less likely that they will immediately recognize the substance as salt. After discussing and (if practical) trying several of their suggestions, the teacher takes out a large beaker of water, pours in the salt and stirs the water. The salt will dissolve and disappear. A discussion should follow as to what really happened to the salt crystals and why. The water molecule should be diagrammed and the dipolar nature of this universal solvent emphasized. Then, as students locate sodium and chlorine on the periodic table and discuss how the ionic bond is formed between them to produce sodium chloride, they should be able to understand how the water actually dissolves the salt.

Students will draw the water molecules on small index cards, identifying their positive and negative ends with + and - signs. Students will also draw the ionic bonds of sodium chloride, identifying its positive and negative ends. A role-playing activity can allow students to act out physically the pulling apart (dissolving) of the salt crystals by the water molecules.

Activity 4: Oxygen as A Common Element (SI GLEs: 5, 6, 9; ESS GLE: 13)

Materials List: print and electronic resources

Before beginning this DR-TA (*Directed Reading Thinking Activity)* (view literacy strategy descriptions) students should be engaged in a discussion and prediction of which is the most common element found in earth's lithosphere, hydrosphere, cryosphere, and atmosphere. A *DR-TA* activity invites students to make predictions and check the accuracy of their predictions during subsequent reading. All predictions can be combined in a master list and kept for comparison after the activity. Students should be encouraged to share the reasoning behind their predictions.

The activity: Groups of students will use all available print and electronic resources (Internet, textbook, and library) to identify and chart the most common elements (such as oxygen, carbon, silicon, nitrogen) in Earth's lithosphere, cryosphere, hydrosphere, and atmosphere. Using the information they have collected, students should be able to write a brief explanation of why minerals containing oxygen (silicates) are the most common by volume and weight in the Earth's crust. They can also be encouraged to make further predictions about the presence of oxygen in Earth's interior layers.

Activity 5: Recycling of Carbon (SI GLEs: 2, 5, 9; ESS GLEs: 13, 22)

Materials List: *Anticipation Guide*: What Do You Know About Carbon? BLM (copies for each student), print and electronic resources, poster paper, markers for small groups

The teacher will engage students by creating an *anticipation guide* (view literacy strategy descriptions) such as *Anticipation Guide*: What Do You Know About Carbon? BLM. An anticipation guide is a type of *opinionnaire* that can be used with fact-based content material. This *anticipation guide* requires students to predict where carbon is found in Earth's five spheres, either in pure form or in chemical compounds, and use their own reasoning to defend their predictions. As the activity progresses, students should have several opportunities to return to their initial predictions to correct misconceptions and add factual information. Upon completion of the *anticipation guides*, small groups of students will use print and electronic resources to gather information related to one example of carbon cycling and present it to the class as a flow chart to illustrate how the carbon moves from one sphere to another. Groups should be encouraged to choose examples from different spheres so a more complete and detailed carbon cycle can be illustrated after all groups have shared their findings. Students can compare their diagrams to more sophisticated Carbon Cycle diagrams such as those found in the references listed at the end of this unit. Students should include in their discussions both the long and short time frames for partial and completed cycling of carbon through and between the spheres. Students should refer to their initial *anticipation guide* at the end of the activity to be sure they have identified and corrected misconceptions and incorrect information.

Activity 6: Atomic Arrangement and Crystal Form (SI GLEs: 2, 5, 7, ESS GLE: 13)

Materials List: diagrams or models of the six crystal systems; unlined paper; modeling materials such as pretzels, marshmallow, toothpicks, small polystyrene balls, cotton balls, etc.; protractors; mineral crystal samples such as quartz, halite, calcite, pyrite

This activity should follow an introduction to the formation of mineral crystals during rock cycling processes and the six mineral crystal systems used as one means of mineral classification. If possible, students should construct paper models of the six basic shapes during the introduction. They can then readily recognize the cubic crystals of halite or pyrite and the hexagonal crystals of quartz. Students can use simple materials such as marshmallows and pretzel sticks or toothpicks and foam balls to construct silica tetrahedral and arrange them into chains, double chains, sheets, and even basic networks to create visual representations of several crystalline forms. Then, given several appropriate silicate mineral samples of halite, pyrite, muscovite, and quartz, they should be able to recognize the appropriate model for each mineral. The muscovite will be the easiest to recognize, and a discussion of the strong bonds within the sheets and weak bonds between the sheets is important.

Students should have an opportunity to share the thinking they used in identification and explain and defend their answers. A follow up activity in which students use protractors to measure the angles between faces of crystals such as quartz, calcite, and pyrite or halite and then use those measurements to identify the crystal system of each sample will reinforce the relationship between atomic structure and physical form of minerals. Special attention must be give to help students avoid the confusion between crystal faces and cleavage planes. Students should understand that cleavage planes are zones of weakness in atomic bonds, and extend through the entire sample, while crystal faces are only surface features.

Activity 7: Bowen's Reaction Series (SI GLEs: 7, 9; ESS GLE: 14)

Materials List: copy of Bowen's Reaction Series chart (see online references at the end of this unit for choices); igneous rock samples such as basalt, dunite, diorite, granite, gabbro

In the activity students will be given a labeled group of several igneous rocks (e.g., dunite, basalt, diorite, and granite—or any combination available), the chemical formula for each mineral, and a copy of a Bowen's Reaction Series chart. Small group discussion should follow and students should arrange the rocks (or names on the list) in order, from those solidifying at highest temperatures to those that solidify last at the lowest temperatures based upon mineral position on the Bowen's chart. Student groups should be able to provide reasonable explanations for their arrangement when shared with the class. Open discussion of differences in arrangement and reasoning among groups should be included in the activity. They should compare the environment of mineral formation with the environment at the earth's surface, and, when given the fact that igneous minerals weather in the same general order in which they crystallize (meaning those that crystallize out first, at highest temperatures also weather out first when exposed at the surface), students should be able to predict which of the igneous rocks would be most (and least) resistant to weathering.

Activity 8: The Student as Scientist Scenario (SI GLEs: 7, 9; ESS GLEs: 13, 14)

Materials List: available print and electronic resources, Bowen's Reaction Series chart (see online references for choices), hand lens (two or three per group), clean, quartz sand (see teacher preparation), crushed basalt, crushed olivine (enough for each group to have a small sample), mortar and pestle or other appropriate items which will allow the teacher to crush the basalt sample and the olivine sample before the activity begins (one or two student samples of basalt and olivine, crushed, should be enough for 6-8 groups of students)

Teacher preparation:

- "play" sand is available at most home improvement centers and appropriate for this activity, as it is almost exclusively quartz
- a small chunk of basalt rock can be crushed to sand-grain size to simulate natural basalt sand
- a small chunk of olivine mineral can be crushed to sand-grain size to simulate natural olivine sand

This activity can be introduced as a *RAFT* (view literacy strategy descriptions), activity. A *RAFT*ed writing assignment enables students to apply their content knowledge from a perspective other than their own, to an audience other than the teacher, and in a form other than the usual theme. Students connect creativity and imagination to the knowledge they have learned. In this activity the students are given the *RAFT* assignment:

*R*ole: geologist or mineralogist
*A*udience: Island Government Director of Natural Resources
*F*orm: a letter
*T*heme: mineral composition of beach materials

The Scenario:
A small island nation faces difficult decisions about which of its local beaches to protect from natural erosion and unlawful human removal of their beautiful sand. Resident and tourist populations use the beaches on the island so the government fears significant loss of tourist revenue without visitor access to the beach areas. Three beaches have been identified as being the most heavily impacted, and the island's department of natural resources has indicated that only one can be fully protected with the available funding.

Your team of geologists and mineralogists has been contracted to assist the island government in making the wisest choice of which beach to immediately protect as well as to offer recommendations for future protection should funding become available.

Student team tasks:

1. Examine the rock and/or beach material and other information for each location.
2. Use Bowen's Reaction Series chart and other available resources to determine which beach material is least stable at the surface and therefore would be least resistant to weathering, and least abundant.
3. Rank order the beach sands from 1-3, least abundant to most abundant, and explain your ranking choices.
4. Draft a letter to the island government's director of natural resources with your recommendation of which beach location has the greatest need for immediate protection. Be sure to include scientific reasoning to support your decision and recommendations for future protection of the other areas.

Descriptions of the three beaches under consideration:

A. close to mouth of a river; whitish, sugary sand; heavy wave activity along beach; no rock material nearby
B. near foot of volcanic mountain; black, glassy sand; basaltic rock nearby; heavy wave activity along beach
C. near foot of volcanic mountain; green, glassy, and translucent sand; basaltic rock nearby; heavy wave activity along beach

Information for the teacher:
Before beginning the activity students should be given the opportunity to use available resources to read about the jobs of geologist and the mineralogist and their contribution to society as well as their career potential.

When students examine each sample to determine its composition and consult the Bowen's chart, they should discover that the river sand, composed of mostly quartz is the most abundant and long-lived beach material. The sand made of basalt, a magnesium silicate, is somewhat less abundant, and more vulnerable to chemical breakdown into iron-bearing clays when exposed to ocean waters and atmospheric moisture. The clays, in turn become a resource of stable atoms and elements available for, among other things, soil formation. The rarest of the sand materials, and therefore the one in greatest need of protection, is the green olivine sand that is composed of the mineral olivine. Having crystallized out at high temperatures below the surface, olivine breaks down into its component elements relatively quickly when exposed to surface conditions. Upon exposure to even slightly acidic ground or rain waters, the iron and magnesium held in olivine's crystal lattice are released and carried away in solution, making them readily available for natural geological recycling.

Activity 9: Properties of Igneous Rocks (SI GLEs: 3, 5, 7; ESS GLEs: 13, 22)

Materials List: samples of coarse-grained, fine-grained, amorphous, and porphyrytic igneous rocks such as granite, gabbro, diorite, basalt, rhyolite, andesite, obsidian, pumice, and pegmatitie for each student group

After an introduction to igneous rock formation, students should have an opportunity to examine both intrusive and extrusive samples. Using color, texture, and cooling rate, small groups of students should work cooperatively to construct a *graphic organizer concept map* (view literacy strategy descriptions) that could be used to classify igneous rocks. A *concept map* is a special form of *graphic organizer* that consists of nodes or cells that contain a concept, item or question and links. The links are labeled and denote direction with an arrow symbol. The labeled links explain the relationship between the nodes. The arrow describes the direction of the relationship and reads like a sentence. The finished map should be large enough so samples can be placed in their appropriate positions on the page. Students should write a set of directions for using their map. Upon completion of the map and instructions, groups should swap maps, directions, and samples to test one another's products. Discussions of placement should include information about stable atoms and elements that are recycled during the natural geologic processes which produce igneous rocks. The map and directions may be assessed based on their usefulness to the testing group as they work to correctly place the samples on the page.

Activity 10: Structure and Formation of Sedimentary Rocks (SI GLEs: 3, 7, 10; ESS GLEs: 13, 22)

Materials List: Teacher-demonstration-sized piece of concrete; selection of sedimentary rocks which include detrital, chemical, and organic samples; selection of natural materials such as shell fragments, sand, small pebbles, salt, water, crushed chalk, powdered clay; science learning logs

A chunk of concrete used as a *SPAWN prompt* (view literacy strategy descriptions) creates an interesting opening to a study of sedimentary rocks. A *SPAWN* prompt is a teacher-generated statement or question about content material that requires a written student response. Asking students if the concrete sample is or is not a rock can focus their attention on both the materials and the processes necessary to make a material that is so much a part of students' lives. The teacher should allow students to write their responses within a reasonable time, probably about 5 minutes. Students should be asked to copy the prompt in their science *learning log* (view literacy strategy descriptions) before writing their responses and record the date. No definitive answers are needed at this time, just the opportunity for students to offer their opinions and share their reasoning with each other. The question can be revisited on a number of occasions.

Following an introduction to sedimentary rocks and an opportunity to examine samples of both detrital and chemical sedimentary rocks (including organic samples), students should be given the task of creating their own sedimentary rock. Choosing from natural substances such as shell fragments, sand, small pebbles, salt, water, crushed chalk, and powdered clay and selecting appropriate (and available) scientific equipment needed in the process, they will both develop and test their procedure for producing a sedimentary sample. Their work should include a description of the rock, a list of materials and equipment, detailed steps in the process of forming the rock, and a list of the safety measures identified as appropriate for the task. Upon completion of the written document, and with approval of the teacher, students will produce their rocks. They should be given time to share their products and their procedures with other members of the class. After the student-made rocks are complete, and the viewing of all samples has been accomplished, the teacher should revisit the question about the concrete once again to see if students' views on what the definition of a rock should include. Students' concepts of what rocks are and how stable elements and atoms are recycled during the natural geologic processes that produce rocks should grow as each family of rocks is studied.

Activity 11: Metamorphic Rock Formation (SI GLE: 9; ESS GLEs: 13, 22)

Materials List: modeling clay in several colors (enough for each small group to have a fist-sized chunk in each color), paper towels, text books

Prior to this activity, students should discuss the processes involved in metamorphism. Many students will put the word *metamorphism* into the context of the kinds of change that caterpillars undergo to become butterflies, or the changes that occur in animated movie characters. Their previous experiences can be used as a launching point. Sharing available photographs or textbook illustrations of rock outcrops that show the folding of country rock during regional metamorphism gives students some idea of the scope and enormity of the forces involved in metamorphism. The teacher should prompt a discussion of what forces could cause such dramatic changes, including thermal/contact metamorphism that takes place when magma intrudes into existing country rock and regional metamorphism occurring during mountain building episodes and lithospheric plate movements.

The activity: Students should be given fist-sized chunks of modeling clay in several different colors. They should use the clay to form a layered clay sedimentary rock or they may choose to break off small pieces of different colors and stick them together to form a crystalline igneous rock. Then they should be given an equivalent amount of clay, but all in a single color, and the same instructions. They should set the two clay rocks side-by-side, but not touching, and cover them with a paper towel. Next, they should place a book on top of the two clay rocks and press down on both of them with equal pressure. Remove the book and paper towel and examine the rocks. Ask how they are alike and how they are different. Then give students samples of foliated and nonfoliated metamorphic rocks. They should discuss how stable atoms and elements have been recycled during the natural geologic processes that produce metamorphic rocks. Have the students complete a written explanation of how they are alike and how they are different, based upon what they learned with the clay models.

Activity 12: The Rock Cycle (SI GLE: 9; ESS GLEs: 13, 22)

Materials List: a selection of rock samples (one per student), hand lens for each student

After students have studied all three families of rocks and have some familiarity with examples of each family, this activity can be used to bring closure to the unit. Every student is assigned or may choose a favorite rock. If this activity is described at the beginning of the unit, students can think about their choice for this activity as they study the families of rock. Once students have chosen a favorite rock, their task will be to use what they have learned plus all available resources to trace the changes in form and chemical composition that a rock would experience as it undergoes the processes in the rock cycle. There should be an explanation of the recycling of stable atoms and elements that occurs in rock cycle processes and the part it plays in determining their rock's resistance to weathering at the surface. Students may tell the story as a narrative life story or complete a flow chart, or draw and label diagrams. The method of representation might be left to them to choose according to their preferred learning style. Final projects should be displayed, shared, and enjoyed by other members of the class, and if possible, actual samples of the rock should be available. Science *Learning Logs* (view literacy strategy descriptions), chronicling the journey toward their final product, should be a part of the display. The assessment of the project should focus on how accurately the information describes changes in the original rock.

Activity 13: The Student as Scientist (SI GLEs: 11, 16; ESS GLEs: 14)

Materials List: samples of selected minerals such as quartz, limestone, orthoclase and plagioclase feldspars, and others as available (set for each small group); field test equipment such as penny, streak plate, glass plate, steel file, 5% HCl in dropper bottle for each small group (Safety rules should be reviewed before testing; safety eyewear for every student is mandatory.)

This activity should follow a thorough review of the physical properties of minerals and the tests used in the identification of minerals, including an opportunity to conduct the tests needed to identify selected minerals such as quartz, limestone, feldspars, and others as available. Special attention needs to be paid to the safety guidelines for using chemicals with students and mandatory use of safety eyewear must be reinforced.

The Scenario:
A family with three young children is remodeling their kitchen. After deciding to use natural stone for the kitchen countertops, they found their budget would allow them to choose from granite or marble as the countertop material. The sales associate used a

computer program, combined with relevant information about their family and its needs, to recommend marble over granite as the most practical choice for their kitchen. Using all you know about rocks and minerals, evaluate this recommendation of which stone material is best for their kitchen countertops. Your evaluation is to be written in paragraph form, and should include an explanation of whatever scientific evidence you have to defend your position.

Teacher assessment of the student document should focus on the composition and physical properties of marble vs. granite, and the durability of each stone relative to substances and materials typically used in a kitchen.

Sample Assessments

General Guidelines

- Student participation should be monitored throughout all activities with the use of predetermined teacher observation checklist, and student journal entries.
- Student-developed products should be evaluated as the unit progresses and feedback delivered in a timely manner.
- Where a rubric is used for evaluation, students should participate in developing the criteria for the rubric.

General Assessments

- The student will engage in problem-solving and performance-based assessments including construction and use of models, presentations, product development, discussions, and group participation/cooperation.
- The student will participate in reflective assessments including journal entries, explanations of choices made during activities, report writing, group discussions and consensus, and defense of position taken.
- The student will complete traditional assessments such as quizzes and pencil and paper tests containing multiple-choice items and constructed response items.

Activity-Specific Assessments

- Activity **2**: The teacher can use the diagram included with this activity as a model. Students can recreate the diagram on poster board or even several sheets of copy paper taped together. They should work cooperatively/collaboratively to demonstrate an understanding of the concept of interfaces between the spheres. A rubric such as the Earth Spheres Activity Assessment Rubric provided in this unit can be used to assess the product and the participation. This rubric is scored on a five-point scale, but multiples of 5 points can be used and would allow more flexibility in scoring.

- Activity 9: Students will develop a concept map that can serve as a key for identifying unknown igneous rocks. Before they begin this performance assessment they should participate in the construction of a rubric to be used in evaluating their products. In the development of the rubric the teacher should guide students to include some or all of the following criteria.

    - Use of all three properties of igneous rocks (color, texture, cooling rate)
    - Logical arrangement and flow in the chart
    - Ease of use to identify unknown igneous rocks
    - Quality and clarity of directions for using the key
    - Neatness and overall quality of product
    - Group cooperation and collaboration

  Their rubric should be available to groups while they are developing their keys and while they are "testing" each other's products. The combined scoring of both the teacher and the testing groups should be used to establish scores for the project.

- Activity 12: If this is an ongoing assessment, begun when the study of minerals is undertaken, a series of smaller point values can be assigned to entries in the student's science *learning log*, and the completed logs can be submitted at the conclusion of the unit. At each juncture where students have learned something new about minerals and rocks, they should have an opportunity to observe their "favorite rock" and enter new information into their logs. Then when the final evaluation comes, they will use the collected information in their logs, together with researched material to tell the life story of their rock as it goes through the rock cycle. Each rock sample is unique and therefore each product will be as well. Allowing students to choose the means of representation according to their preferred learning style will result in a wide variety of products to be assessed individually. Some points to consider when establishing criteria for the project are
    - Is the product understandable? Can one distinguish the rock cycle changes in the rock? (suggest 25%)
    - Is the product complete? Does it take the original rock through all stages in the rock cycle appropriately? (suggest 25%)
    - Does the product accurately trace the changes in physical form and chemical composition that would occur as the rock cycle changes occurred? (suggest 25%)
    - If the product is a visual representation such as a flow chart or diagram, is it neat and attractive? (suggest 10%)
    - If the product is a narrative, is it neat and has attention been paid to grammar and spelling? (suggest 10%

- Did the student science learning log contain all of the assigned entries over the course of the project? (suggest 15%)

Resources

- Spheres of Earth
  http://www.classzone.com/books/earth_science/terc/content/investigations/es0103/es0103page01.cfm?chapter_no=investigation

- Properties of water
  http://ga.water.usgs.gov/edu/waterproperties.html

- States and characteristics of water
  http://www.uni.edu/~iowawet/H2OProperties.html

- Introduction to oxygen
  http://www.atlanticeurope.com/Elements/Oxygen.html

- The Carbon Cycle
  http://www.ucar.edu/learn/1_4_2_15t.htm

- Background information on crystalline structure for teacher
  http://www.emporia.edu/earthsci/amber/go340/crystal.htm
  http://serc.carleton.edu/research_education/crystallography/xldatabases.html

- Bowen’s Reaction Series
  http://hyperphysics.phy-astr.gsu.edu/hbase/geophys/bowen.html
  http://jersey.uoregon.edu/~mstrick/AskGeoMan/geoQuerry32.html
  http://csmres.jmu.edu/geollab/Fichter/RockMin/RockMin.html

- Rock formation and the rock cycle
  http://www.cotf.edu/ete/modules/msese/earthsysflr/rock.html
  http://www.rocksandminerals.com/rockcycle.htm

Earth Science
Unit 2: Earth's Place In The Universe

Time Frame: 6 Weeks

Unit Description

This unit addresses the scientific evidence for our current understanding of the structure and organization of the known universe and its component parts. It includes the laws governing the motion of planetary bodies, the history of our solar system, and an overview of the current knowledge regarding our planetary neighbors. Properties of stars, their life cycles, and how they compare to our own star the Sun are studied in this unit. Evidence that supports the big bang theory is identified, as well as the kinds of technologies that have expanded our knowledge of the universe and all that it contains.

Student Understandings

At the conclusion of this unit, students will be able to describe the overall organizational structure of the known universe. They will be able to relate the laws of motion for orbiting bodies to the movement of Earth around our Sun, model the Nebular Hypothesis of our solar system's origin, and discuss current findings related to the other bodies in our solar system.

They will be able to compare selected properties of stars using observable data and the Hertzsprung-Russell Diagram, use spectrograms of known elements to identify elements present in selected stars (such as our Sun), and summarize the stages in the life of an average star. Students will also be able to outline evidence that supports the big bang theory and discuss the technologies that have enabled development of our current models of the known universe and all it contains.

Guiding Questions

1. Can students describe the overall organization of the known universe?
2. Can students list and describe the laws of motion governing orbiting bodies?
3. Can students describe Earth's elliptical orbit and demonstrate its effect on orbital velocity?
4. Can students construct a model of the Nebular Hypothesis?
5. Can students provide several pieces of current information about the other bodies in our solar system?
6. Can students describe the stages in the life of an average star?
7. Can students explain why the sun will never become a Black Hole?

8. Can students read and interpret spectrograms of known elements and use them to identify elements present in the spectra of selected stars?
9. Can students describe the big bang theory and list evidence to support it?
10. Can students list several examples of the technologies that have expanded our knowledge of the universe?

Unit 2 Grade-Level Expectations

GLE #	GLE Text and Benchmarks
Science as Inquiry	
The Abilities Necessary to Do Scientific Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
Understanding Scientific Inquiry	
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
13.	Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2)
Earth Science	
16.	Use the nebular hypothesis to explain the formation of a solar system (ESS-H-C1)
23.	Identify the evidence that supports the big bang theory (ESS-H-D1)
24.	Describe the organization of the known universe (ESS-H-D2)
25.	Using the surface temperature and absolute magnitude data of a selected star, locate its placement on the Hertzsprung-Russell diagram and infer its color, size, and life stage (ESS-H-D3)
26.	Identify the elements present in selected stars, given spectrograms of known elements and those of the selected stars (ESS-H-D4)
28.	Identify the relationship between orbital velocity and orbital diameter (ESS-H-D6) (PS-H-E2)
29.	Demonstrate the elliptical shape of Earth’s orbit and describe how the point of orbital focus changes during the year (ESS-H-D6)
30.	Summarize how current technology has directly affected our knowledge of the universe (ESS-H-D7)

Activity 1: Organization of the Universe (SI GLE: 7; ESS GLE: 24, 30)

Materials List: poster paper, markers

This activity begins with a "Think, Pair, Share" component in which individual students will use *brainstorming* (view literacy strategy descriptions) to generate a list of the levels of organization in the universe between the atom and the universe itself. Brainstorming encourages spontaneous thinking by students and the opportunity to generate possible ideas while deferring judgment. Each student will share his/her list with the student sitting nearest and they will merge their lists into one, removing repetitions. These two students will then share and merge information with two others. When there is one list for every three or four students the next task is for these small groups to organize their information into a flow chart *graphic organizer* (view literacy strategy descriptions) that illustrates the levels of organization they have identified. Identification of the kinds of technologies required to gather data about each level of organization should be included, and a master list of technologies that have expanded our knowledge of the universe should be maintained throughout the unit. A draft of the charts should be posted and students should take time for a gallery walk to view all of the draft copies. There may be differences in the information included by some of the groups. An opportunity for revision should be provided before the final charts are constructed. The chart should be drawn on poster board and each group should present its final report to the class. Should time permit, each group could choose or be assigned one level on the chart to research further and share that information with the whole group.

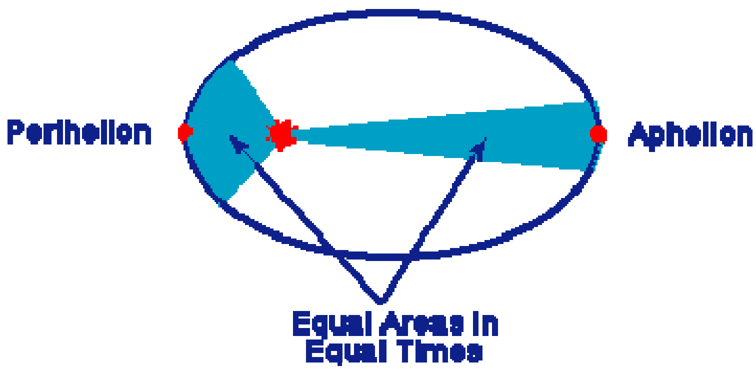
Activity 2: Laws of Motion for Orbiting Bodies (SI GLEs: 1, 5, 7, 9; ESS GLEs: 28, 29)

Materials List: unlined paper, graph paper, thumbtacks, pencils, string, corrugated cardboard, textbooks, online or print resources

A brief overview of Kepler's three laws governing planetary motion should preface this activity. Kepler's First Law of Planetary Motion can then be discussed as students practice drawing ellipses. Kepler's Second Law is demonstrated in the activity itself, and the Third Law of Planetary Motion can be calculated using planetary periods of revolution available in most Earth Science textbooks or online using one of the resources listed in this unit.

As an opening to this activity, students should use unlined paper, thumbtacks, string, and corrugated cardboard (under the paper) to practice drawing ellipses. They should be encouraged to place the thumbtacks side-by-side at different distances from one another, trying different configurations until they understand the relationship between the distance between the foci and the eccentricity of the ellipse: that the farther apart the foci, the more eccentric the ellipse and the closer the foci, the more nearly circular the ellipse.

The activity:
Working in small, cooperative groups, students will use string, thumbtacks, and a section of corrugated cardboard box material slightly larger than the graph paper to create an ellipse. The ellipse represents the orbital plane of a planet in a solar system. After marking and labeling the orbital foci they should choose one focus to represent the Sun and label it. Next, the students will draw a straight line (called the major axis) across the full length of the ellipse, through the center of the Sun, and through the other focus. Using the Sun as the vertex, students will draw an angle out to the surface of the ellipse that encloses the point on the ellipse (the perihelion) where the planet is closest to the Sun. The angle should be equidistant on either side of the major axis. Students should count the number of graph squares inside the enclosed shape they have drawn.



The Law of Equal Areas (Kepler's Second Law) states that planets sweep through equal areas in equal time, so a second angle from the same vertex, but drawn to enclose the point on the ellipse farthest from the Sun (the aphelion), must enclose the same number of graph squares as the first. This will take some trial and error and some adjustments as partial graph squares must be estimated. Students will need to be reminded that the angle must be equidistant on either side of the major axis, but the number of squares in each enclosed shape should be close to the same. While each contains approximately the same number of graph squares, comparison of the two shapes reveals noticeable differences in shape.

How then can a planet travel so much farther along its orbital path in the same amount of time during the winter when it is closer to the Sun than it travels in the summer when it is further away from the Sun? Having made their observations, students will formulate a hypothesis that states the relationship between distance from orbital focus and orbital velocity. Students should be allowed to draw a second ellipse of different eccentricity (thumbtacks closer or farther apart) on a second sheet of graph paper to test their hypothesis and draw a conclusion about the velocities of other planets in our solar system as they orbit the Sun. Based upon the results of their additional experimentation, students should write and defend their conclusion based on the logical analysis of the experimental data they collected.

Activity 3: The Nebular Hypothesis (SI GLEs: 5, 8, 11, 13; ESS GLE: <u>16</u>)

Materials List: print and electronic resources; sheets of unlined paper and tape (enough for 2-3 meters per cooperative group); pencils, pens, markers for each group

In this activity, students will gain a historical perspective of how current scientific thinking has changed relative to the formation of our solar system. Individually or in small, cooperative groups, students will construct a timeline of the major theories of how our solar system came into being. They will use all available resources, including their textbook, the Internet, and library references to make an initial list of explanations and hypotheses and the timeframes of their introduction. They will then construct a timeline on lengths of paper (sheets taped together or sections of rolled paper). If available, computer software can be used to generate the timeline. The project will include the names of the persons who proposed the explanation, a description of the explanation with its strengths and weaknesses, the technology necessary to the explanation or hypothesis, and why it became outdated or scientifically unacceptable. Each explanation or hypothesis sheet will be placed on the timeline in the appropriate place for the project to be complete. Timelines will be displayed and shared with the entire class.

Activity 4: Our Planetary Neighbors (SI GLEs: 6, 7, ESS GLEs: <u>24</u>, 30)

Materials List: print and electronic resources, cardstock or heavy paper, pens, pencils, colored markers

This activity can be introduced as a *RAFT* (view literacy strategy descriptions) activity. The students are given the *RAFT* assignment:

*R*ole: advertising company representative
*A*udience: potential vacationers
*F*orm: travel brochure
*T*heme: interplanetary space travel

Working individually or in small, cooperative groups, students will participate in a role-playing activity. Students (or groups) will represent advertising companies hired to develop travel brochures for vacation packages to other planets in our solar system. The final product of their work will be a tri-fold travel brochure and poster advertising the vacation package. Students must use all available resources to research their planet and identify the vacation amenities it has to offer. They must use the authentic properties and environment of the planet to develop the brochure. For example, students could not offer snow skiing on the planet Venus as its temperature is much too hot, but offering sauna baths and hot tubs might be possible. They must work out the details, pricing, and other arrangements among themselves. In developing their brochure and poster, students will conduct research and include as much information as the brochure will permit. Several tasks are involved in this project, including those requiring creativity and artwork. This allows for a variety of learning preferences and skills, including use of available computer software to develop a multimedia presentation, so work in small groups is recommended. Upon completion of the project students should set up a display. Having other classes, faculty, or administrators view the display and allowing the students to take reservations from potential travelers can provide additional feedback to students.

Activity 5: How We Know What We Know About Stars (SI GLEs: 1, 5; ESS GLE: 25)

Materials List: text with Hertzsprung-Russell diagram and electromagnetic spectrum chart (or see online resources at the end of this unit for other choices); Hertzsprung-Russell Diagram such as http://zebu.uoregon.edu/~soper/Stars/hrdiagram.html (or a similar diagram), downloaded and printed for each student; index cards; colored pencils; print and online resources; Sample Vocabulary Card BLM

Students should construct *vocabulary cards* (view literacy strategy descriptions) that will enable them to learn the terms associated with stellar properties. *Vocabulary cards* (see Sample Vocabulary Card BLM) help students see connections between words, examples of the word, and critical attributes associated with the word. They also help students with their understanding of word meanings and key concepts by relating what they do not know with familiar concepts. Students should construct the first vocabulary card with the teacher's direction, and the remaining cards can be constructed independently. Pairs of students can compare and quiz one another on the information on their cards.

Students can be engaged in this activity by asking them to create a list of deep space objects and suggest questions that will address what can be learned from observing them. After a discussion of what properties all deep space objects have in common and what their differences are, students will use a Hertzsprung-Russell (H-R) Diagram (available in most Earth Science textbooks) as the basis for this activity. A review of how the observable temperatures and absolute magnitudes (or luminosities) of stars are plotted on the graph is recommended. Students should then use an electromagnetic spectrum chart (available in most Earth Science textbooks or see online resources at the end of this unit) to determine the colors associated with each of the temperature categories on the H-R diagram. When they have identified the colors for each temperature they should use colored pencils to lightly shade in the appropriate color bands on their printed copy of the Hertzsprung-Russell Diagram. Next, when given temperature and absolute magnitude (or luminosity) data for an unknown star, they should be able to plot it on the H-R diagram and identify its color. A discussion of the relationship between the temperature, light production, and the inferred size of just one group of stars on the H-R diagram should be enough to enable students to classify the five major groups: blue and blue/white giants, the red giants and super giants, the yellow normal stars, the white dwarf stars, and the red dwarf stars. When this information has been gathered, students will use all available resources to research the relationship between a star's size/color category and its life stage, with special emphasis on the relationship between the mass of a star and the eventual end of its life. Using all of the evidence they have collected, each student will write a summary essay that clearly describes these relationships and why the sun will never become a Black Hole star. They will identify deep space objects whose characteristics do not fall within H-R Diagram parameters such as pulsars, quasars, and even galaxies, and suggest alternative means of classifying them.

Activity 6: Investigating Stellar Spectra (SI GLEs: 6, 7; ESS GLE: 26)

Materials List: black construction paper, colored pencils, poster paper or other chart paper, colored markers, spectroscopes or diffraction grating

Caution: students should be reminded never to look directly at the Sun as one of their light sources.

Following a discussion of emission and absorption spectra small groups of students will use the website http://www.colorado.edu/physics/2000/quantumzone/index.html or other available resources, strips of black construction paper, and colored pencils to construct an emission spectrum for several of the following elements: hydrogen, helium, carbon, nitrogen, oxygen, neon, or iron. (On the referenced webpage students would scroll down to the white light spectrum menu and select from the list of individual element spectra the one they will draw.) Allowing the whole class to draw the same emission spectrum together as guided practice may be helpful to some students, followed by having each student select several spectra to draw individually. Other elements for independent practice include magnesium, silicon, calcium, and sulfur. Once the group has several spectra to use as a reference, they will use student spectroscopes or diffraction grating to compare their spectral diagrams (containing identified elements) with the spectra of available light sources such as incandescent bulbs, fluorescent bulbs, indirect sunlight, or any other convenient sources (containing unidentified elements). Using black construction paper strips and colored pencils, students should work together to draw those spectra and identify elements common to their reference spectra. Student groups will each develop a chart to display their findings.

Finally students will use the spectrum of an unknown star, which can be found and downloaded ahead of time from http://www.learner.org/teacherslab/science/light/color/spectra/spectra_1.html or in most Earth Science text books, and identify the elements present in the unknown star with the aid of their element spectral diagrams.

Activity 7: Evidence for The Big Bang Theory (SI GLEs: 7, 9, 11; ESS GLEs: 23)

Materials List: print and electronic resources, 6-8 inch round balloons (enough for each group in each class to have a fresh one); markers; string; meter sticks or rulers; or cloth or paper measuring tape

In small cooperative groups students will use all available resources to research Hubble's Constant as the principle upon which expansion of the universe and the big bang theory are based. After a discussion of the principle and its implications for the universe, students will use (round) balloons, markers, string, and meter sticks or rulers to construct a model of expansion of the universe. Before inflating the balloon, students should draw several dots measuring one centimeter apart in a straight line on the surface of the balloon to serve as reference galaxies. They should also draw several other dots randomly on the balloon's surface to serve as experimental galaxies. They will observe and measure the distance between labeled dots (representing individual galaxies) as the balloon is inflated incrementally. No instructions should be given as to where on the balloon to draw. Each group will make its own decision. It is useful to label the dots, and using numbers for the reference dots and letters for the random dots will minimize confusion later. One student in each group should inflate the balloon incrementally, and measurements should be made of the changing distances between each pair of labeled dots during two or three partial levels of balloon inflation and then at full inflation. This data will enable students to explain the relationship between the measurements of distance for the reference galaxies and the scattered galaxies. Each group will collaborate to write a paragraph that uses their model to identify and explain uniform expansion of the universe as evidence for the big bang theory. Groups should share and discuss differences and similarities in their findings.

Sample Assessments

General Guidelines

Student participation should be monitored throughout all activities with the use of predetermined teacher observation checklist, and student journal entries. Student-developed products should be evaluated as the unit progresses and feedback delivered in a timely manner. Where a rubric is used for evaluation, students should participate in developing the criteria for the rubric.

General Assessments

- The student will engage problem-solving and performance-based assessments, including models, presentations, product development, discussions, and group participation/cooperation.
- The student will participate in reflective assessments, including journal entries, explanations of choices made during activities, report writing, group discussions and consensus, and defense of position taken.
- The student will complete traditional assessments, such as quizzes, pencil and paper tests containing multiple-choice items and constructed response items.

Activity-Specific Assessments

- Activity 1: The assessment for this activity should include a point value for the think-pair-share component of the activity, a second point value for the organization of information into the draft of their flow chart, and a third, and perhaps the largest point value of the three components, for the final poster presentation. One division of the three components would be to assign 25% of the points for the initial work, 25% for the draft and gallery walk, and 50% for the completed poster and the presentation. A 1 - 5 scale of student participation and student product can be used and students can be included in the process of establishing point values.

- Activity 3: The teacher will work with students before the project begins to develop a rubric for scoring each timeline and its related information. Components of the rubric can include the following:

  Quality of appropriate explanations and descriptions
  Quality of research and references
  Overall quality of timeline project
  Group member participation and cooperation

  Each of the components can be measured on a scale of 1 - 5 or whatever the teacher and the class decide is an appropriate total point value for the project

- Activity 4: Using a scoring scheme designed jointly by the teacher and students, one novel means of evaluating this project is to set up a "travel bureau" in an area accessible to teachers at the school. An "impartial jury" of teachers could then choose, based on the predetermined criteria, which "vacation" package they think is most attractive. Terms of confidentiality would have to be worked out with this selective target audience and names of students who created each brochure would have to be omitted from the brochures. Another means of identification, known only to the project teacher would have to be established. A portion of the overall project score (as determined by the project teacher) could be based on the number of "customers" signing up for each vacation package. It must be emphasized that a critical element to the brochure is accurate representation of the planet and its true environment. The inclusion of factual information about the planet should make up a portion of the assessment value.

Resources

- Animations of Kepler's Laws of Planetary Motion
  http://home.cvc.org/science/kepler.htm
  http://observe.arc.nasa.gov/nasa/education/reference/orbits/orbit_sim.html

- Visual of nebular hypothesis with explanation
  http://csep10.phys.utk.edu/astr161/lect/solarsys/nebular.html

- Multimedia tour of the solar system
  http://www.nineplanets.org/

- Hertzsprung-Russell (HR) Diagrams
  http://www.eso.org/public/outreach/eduoff/cas/cas2002/cas- projects/bulgaria comaber_1/hr_local.gif
  http://zebu.uoregon.edu/~soper/Stars/hrdiagram.html
  http://www.smv.org/jims/l6a.htm
  http://www.tim-thompson.com/hr.html

- Stars/elements and their spectra
  http://jersey.uoregon.edu/vlab/elements/Elements.html
  http://www.astro.uiuc.edu/~kaler/sow/spectra.html
  http://members.misty.com/don/spectra.gif
  http://www.colorado.edu/physics/2000/quantumzone/index.html
  http://www.learner.org/teacherslab/science/light/color/spectra/spectra_1.html

- Big bang theory
  http://liftoff.msfc.nasa.gov/academy/universe/b_bang.html
  http://map.gsfc.nasa.gov/m_uni/uni_101bbtest.html

The Earth Science
Unit 3: Earth's Atmosphere

Time Frame: 9 weeks

Unit Description

This unit examines one aspect of the relationship between our planet and its star, the Sun. Opportunities occur to analyze weather and climate patterns, the structure and composition of the envelope of air that we call the atmosphere, the ways heat is transferred at and near Earth's surface, and the differential heating of various Earth materials—all of which influence the weather.

Student Understandings

Students will develop an understanding that the influence of the Sun can be recognized in almost everything around us on Earth. They will be able to illustrate what happens to solar radiation received daily by Earth and describe how heat energy transferred through the processes in the water cycle drives the weather conditions they experience. They will be able to describe all of the layers of our atmosphere in terms of structure, composition, function, and temperature. As a result of their knowledge of the mechanisms that drive weather and climate, students will gain skill at using weather data to analyze and even generate short-term weather forecasts.

Guiding Questions

1. Can students illustrate what happens to almost 100% of the energy received from the Sun each day?
2. Can students identify the processes of the water cycle?
3. Can students trace the flow of heat through the processes of the water cycle?
4. Can students describe how convection, conduction, and radiation drive what we call weather?
5. Can students explain why almost all weather occurs in the troposphere?
6. Can students list and describe each of the layers in Earth's atmosphere?
7. Can students use weather data to generate short-term weather forecasts?

Unit 3 Grade-Level Expectations

GLE #	GLE Text and Benchmarks
Science as Inquiry	
The Abilities Necessary to Do Scientific Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
3.	Plan and record step-by-step procedures for a valid investigation, select equipment and materials, and identify variables and controls (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
10	Given a description of an experiment, identify appropriate safety measures (SI-H-A7)
Understanding Scientific Inquiry	
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
16.	Use the following rules of evidence to examine experimental results: (f) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability? (g) Has the technique or theory been subjected to peer review and publication? (h) What is the known or potential rate of error of the technique or theory when applied? (i) Were standards and controls applied and maintained? (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)
Earth Science	
1.	Describe what happens to the solar energy received by Earth every day (ESS-H-A1)
2.	Trace the flow of heat energy through the processes in the water cycle (ESS-H-A1)
3.	Describe the effect of natural insulation on energy transfer in a closed system (ESS-H-A1)
4.	Describe the relationship between seasonal changes in the angle of incoming solar radiation and its consequences to Earth’s temperature (e.g., direct vs. slanted rays) (ESS-H-A2)
5.	Explain how the process of fusion inside the Sun provides the external heat source for Earth (ESS-H-A3)

GLE #	GLE Text and Benchmarks
7.	Analyze how radiant heat from the Sun is absorbed and transmitted by several different Earth materials (ESS-H-A5)
8.	Explain why weather only occurs in the tropospheric layer of Earth's atmosphere (ESS-H-A5)
9.	Compare the structure, composition, and function of the layers of Earth's atmosphere (ESS-H-A6)
10.	Analyze the mechanisms that drive weather and climate patterns and relate them to the three methods of heat transfer (ESS-H-A6)
13.	Explain how stable elements and atoms are recycled during natural geologic processes (ESS-H-B1)
15.	Identify the sun-driven processes that move substances at or near Earth's surface (ESS-H-B2)
22.	Analyze data related to a variety of natural processes to determine the time frame of the changes involved (e.g., formation of sedimentary rock layers, deposition of ash layers, fossilization of plant or animal species) (ESS-H-C5)
27.	Trace the movement and behavior of hydrogen atoms during the process of fusion as it occurs in stars like the Sun (ESS-H-D5)

Sample Activities

Activity 1: The Radiation Budget (SI GLEs: 6, 7; ESS GLEs: 1, 22)

Materials List: print and electronic resources, poster paper, markers, (optional) solar meter

As one part of their study of the relationship between our planet and its star, the Sun, students will develop an "energy budget" for Earth. The activity can be introduced with a *SPAWN* (view literacy strategy descriptions) prompt that generates discussion among students. For example, from the P or Problem Solving category from *SPAWN*, give students a prompt such as "Global warming is part of a budget out of balance. Explain how an excess of greenhouse gases in the atmosphere could upset the balance in the energy budget and cause an increase in global temperatures. Also propose possible solutions to the problem of excess greenhouse gases." The teacher may want to create another prompt similar to this example.

Students will use all available print and electronic resources to research the kinds and relative amounts of radiation reaching Earth every day and what happens to that energy at and near Earth's surface. The resulting product should demonstrate that students understand how incoming solar radiation is reflected or absorbed by various Earth materials and/or reradiated back into space and how changes in those Earth materials may alter or disrupt the balance of their budget. The product can be a poster or a model combined with a short presentation of the information to demonstrate understanding.

Having students begin with a "budget" of "100 units" of energy from the Sun with a goal of demonstrating how the energy is "spent" in the Earth system is one approach to the activity. If available, use of a "solar meter" would allow students to make authentic measurements of incoming solar radiation at various times during the school day. This activity also provides background for students to predict the effects of potential changes in the structure of the budget and long-term impacts on Earth such as global warming. An extension of this activity using an available solar meter would allow students to collect longer-term data over the entire school year. Students can record their responses to this and other *SPAWN* prompts in their *learning logs* (view literacy strategy descriptions). They can share them with a classmate or with the whole class. Students should listen for responses that are both accurate and logical.

Activity 2: The Hydrologic Cycle (SI GLEs: 3, 7, 10; ESS GLEs: 2, 13, 15)

Materials List: paint-roller trays with clear plastic cover or one-gallon pickle jars, light source, sand, water (warm and cool), ice, resealable plastic bags, tape, other similar materials as determined by availability, The Hydrologic Cycle Activity Assessment Rubric BLM

The safety considerations required when using an electrical light source should be emphasized before beginning the activity, and students should develop a list of all appropriate safety measures to be used in construction and operation of their models.

After a class discussion of the Sun-driven processes in the hydrologic (water) cycle and the role of heat in each of the processes, cooperative/collaborative groups of students will select from a teacher-made list of available materials to investigate and model the water cycle. The teacher-made list might include such items as paint-roller trays with clear plastic covers, one gallon glass pickle jars (which may be available from a school cafeteria or local restaurant), a light source, sand, water, ice, plastic zipper bags, tape, or other similar materials and equipment.

The model project should include a written explanation of water cycle processes, the movement of heat involved in each process, and the exchange of stable elements/atoms that occurs at or near Earth during each process. During the construction and testing phase of the project, students should be encouraged to select one variable in their model to change. They should predict the outcome of making that change and then observe the actual result of that change. A completed project should include a discussion of the role the oceans play in the transfer of heat in water cycle and the local inequities that sometimes occur within the larger global system. They should get approval from the teacher prior to demonstrating their models to insure that all safety issues have been addressed. Time should be allowed for each group to present its model, discuss and demonstrate the change they made and how that change affected water cycling processes.

Note: The Hydrologic Cycle Activity Assessment Rubric BLM can be used to assess this project.

Activity 3: The Effect of Natural Insulation on Energy Transfer in a Closed System (SI GLEs: 1, 3, 7, 9, 10; ESS GLE: 3)

Materials List: rigid plastic shoeboxes, thermometers, light source, thread or thin string, poly stuffing, available print and electronic resources

As part of a study of energy in the Earth system, small cooperative groups of students will use rigid plastic shoeboxes, thermometers, a light source, thread or thin string, and poly stuffing to construct a model of a closed system which they will use to investigate the insulating properties of cloud cover. Students will design and conduct multiple trials of an experiment in which varying thicknesses of the model cloud material (the poly stuffing) are suspended over open shoe boxes, a light source is directed onto the boxes, and temperatures inside the boxes are measured. Thread or thin string can be wrapped around the boxes several times across and down their lengths to form support grids for the simulated cloud cover. Students should use available resources to identify the basic cloud formations they use as their experimental degrees of cloud cover and be required to describe and set up a control for their experiment.

Their completed report should include the question their experiment addressed, with experimental variables clearly stated, the hypothesis they tested, a materials list, appropriate safety considerations, their step-by-step procedure, a completed data table, interpretations of the data they collected, and a conclusion which they can defend that either supports or refutes their initial hypothesis.

Groups should share their findings with the class and be encouraged to relate their mutual findings to the effect of cloud cover on Earth's daytime and nighttime surface temperatures.

Activity 4: Angle of "Insolation" (Incoming Solar Radiation) and Temperatures (SI GLEs: 5, 7, ESS GLEs: 4, 22)

Materials List: globe, flashlight, small-scale graph paper per group

This activity allows students to examine how the Sun's energy strikes different latitudes on Earth and its effects on temperatures at Earth's surface. Students should use a globe, a flashlight, and the smallest scale graph paper available for the activity. They should work in small, cooperative/collaborative groups or pairs, depending on availability of globes and flashlights. A review of latitude, the angle of the tilt of Earth's axis, the angle of the axis relative to the Sun during the four seasons of the year, and the parallelism of the axis during the year is recommended before students participate in the activity. They should also be reminded of the fixed amount of energy reaching Earth from the Sun each day and the energy budgets they constructed in Activity 1 of this unit. They should have an opportunity to model the revolution of Earth (the globe) around the Sun (the flashlight), and there should be a discussion of the limits of the model using a flashlight as the Sun. Once students have reviewed and understand the model, they are ready to explore how changes in the position of Earth relative to the Sun over the year influence changes in temperature at Earth's surface.

Students will arrange the globe and flashlight to represent the relative positions of Earth and Sun on the first day of winter. While one student holds the graph paper as flat against the globe as possible a partner or other group member will raise the flashlight, keeping it parallel to the table, until it shines directly on 0º latitude (the equator). The person holding the graph paper will draw a line enclosing the shape where the light strikes the paper. The shape will be labeled to identify the latitude and season. The number of squares the shape encloses should be counted and recorded. Counting the squares enables students to quantify how much surface area was covered by the incoming "solar" radiation at that latitude during that season. Students should create a table or chart in which to record their data.

The procedure should be repeated for 30º North Latitude, 60º North Latitude, and 90º North Latitude, taking care to keep the flashlight parallel to the table at all positions.

The entire process should be repeated for Earth in a relative position to the Sun during spring and summer. After completing the process for even one season, students should (and probably will on their own) begin to predict the outcomes before they proceed with the next season or latitude. Students should write a summary of what they think the data for autumn would look like and explain their reasoning. Collecting the autumn data can be used to verify or refute these predictions.

Activity 5: Fusion In The Sun (SI GLEs: 6, 7; ESS GLEs: 5, 27)

Materials List: print and electronic resources, teacher-determined materials list as available

Students should work in small cooperative/collaborative groups to choose appropriate models and methods of illustrating the fusion of hydrogen nuclei into helium that takes place at the core of the Sun and the further fusion of helium nuclei into carbon that occurs at even higher temperatures. Students will use all available Internet and print resources in their research and may select construction materials from a teacher-made list or be encouraged to develop a fusion model in other ways such as role-playing or computer simulation. Within the scope of their research, students should obtain recent Sun Spot data and locate information related to any recent fluctuations in solar output that have affected global communications. The project should include a written explanation of the model that demonstrates understanding of the Sun as Earth's main external energy source and provides evidence of the effects of changes in incoming solar radiation on society during the year. The written document should describe the kind of investigation they undertook and compare it to the other forms investigations can take.

Activity 6: Radiant Heat At Earth's Surface (SI GLEs: 1, 3, 4, 5, 9, 10, 15, 16; ESS GLEs: 7, 15)

Materials List: light source; small containers of the same size and shape; Earth materials such as soil, sand, rocks, clear water, cloudy water; aluminum foil; samples of a single material, such as cloth or paper in several different colors and other similar choices as available

In this activity small groups of students will explore the relationship between the absorption and transmission of radiant heat from the Sun and different Earth materials. The teacher should provide a variety of Earth materials such as soil, sand, rocks, clear water, cloudy water; aluminum foil; samples of a single material in several colors; and similar choices; for students to observe and investigate. Students will select several Earth materials to investigate. They will select other items (such as a source of radiant heat energy) from a teacher-made list of available equipment and materials. Students will design and conduct an experiment to test the absorption and transmission rates of each of Earth materials they chose. The steps in the experimental design will include safety considerations and procedures, a hypothesis, a listing of dependent and independent variables, controlled variables and constants, steps to follow, data collection chart with quantitative data collected as multiple trials of the experiment were conducted, a conclusion which clearly states the relationship between the type of Earth material and its ability to absorb and transmit radiant energy and is defendable based on the experimental data collected, the rules of evidence, plus recommendations for further testing.

Activity 7: The Nature of Earth's Atmosphere (SI GLEs: 5, 7; ESS GLEs: 8, 9)

Materials List: print and electronic resources; lengths of white paper, sheets taped together, or rolls of "butcher" paper; meter sticks; rulers; markers

This activity can be introduced as an *SQPL* (view literacy strategy descriptions) lesson. In a *Student Questions for Purposeful Learning (SQPL)* lesson, student-generated questions about a topic or theme based upon an *SQPL* prompt can be used. The prompt for this lesson could be "There is no weather in most of Earth's atmosphere". Students should collaborate with a partner or small group to create a list of questions about the atmosphere based on the statement. All student questions should be recorded on chart paper or the chalkboard. Repeat questions should be marked to indicate their importance to the class. The teacher may contribute questions to the list as appropriate.

Students will use available resources to research the structure, composition, and functions of each of the layers of Earth's atmosphere. Each small group can be given a length of white paper (½ - 2 meters long by ½ meter wide, roughly). They will create a vertical poster illustrating the relative thickness of the layers of the atmosphere and the composition and unique properties of each. In addition, using temperature averages for each layer they will use the poster as a giant graph to construct a line graph of temperature changes that occur in the atmosphere with increasing altitude. Based upon the completed graph and their prior knowledge of convection, students will write an explanation for why almost all weather on earth takes place in the Troposphere. Students should pause in their work to determine which of their questions have been answered.

When this activity about the Earth's atmosphere is completed, all or most of the important repeat questions should be answered.

Activity 8: The Relationship Between Weather and Climate and Heat Transfer (SI GLEs: 1, 3, 4, 6, 10; ESS GLEs: 10, 22)

Materials List: print and electronic resources; available technology; weather instruments; all available materials, equipment, supplies for testing and experimentation; science learning logs

Following a review of both the three methods of heat transfer and a comparison between weather and climate, students will work in small, cooperative groups to investigate how conduction, convection, and radiation drive changes in atmospheric and sea surface temperatures, air pressure, moisture content, cloud formation, cloud cover, wind, precipitation and air mass dynamics. Groups should choose from among these weather factors the one they will investigate, use all available resources to research their factor, and develop a question that allows them to test the relationship between one or more of the methods of heat transfer and their weather component. Groups should formulate a hypothesis for their question, select appropriate materials and equipment from a teacher-made list of available supplies, write a procedure, list appropriate safety measures, and conduct multiple trials of their experiment. They should use any available technology (such as probes, meters, or computer-assisted devices) to collect data, record and interpret their data, and write a conclusion that supports or refutes their original hypothesis. Students should record daily weather data in their science *learning logs* (view literacy strategy descriptions) for later analysis. Their plan should identify appropriate safety measures. Further, student groups will follow up their initial investigation with a short summary of the effect of their weather factor on long-term climate and how this could cause existing scientific explanations to be supported, revised, or rejected. This may require increased research time using additional resources.

After having collected weather data for 3-4 weeks, students should be given an opportunity to analyze and form conclusions about the relationships among weather factors such as barometric pressure and relative humidity, or relative humidity and wind direction. They should write and defend one of their conclusions based upon logical analysis of their experimental data.

Sample Assessments

General Guidelines

Student participation should be monitored throughout all activities with the use of predetermined teacher observation checklist, and student journal entries. Student-developed products should be evaluated as the unit progresses and feedback delivered in a timely manner. Where a rubric is used for evaluation, students should participate in developing the criteria for the rubric.

General Assessments

- The student will engage problem-solving and performance-based assessments including models, presentations, product development, discussions, and group participation/cooperation
- The student will participate in reflective assessments including journal entries, explanations of choices made during activities, report writing, group discussions and consensus, and defense of position taken
- The student will complete traditional assessments such as quizzes and pencil and paper tests containing multiple-choice items and constructed response items

Activity-Specific Assessments:

- Activity 1: Student understanding of the concept of an energy "budget" can be assessed by introducing a change in some component of the budget and having students predict the outcomes of the change. For example, asking students to predict the results of increased cloud cover or increased reflective snow cover on the surface, or fewer molecules of water vapor in the air. Students should be able to explain in a paragraph or several sentences how these changes would affect the overall budgetary balance. They could also be asked to predict the outcomes of "unbalancing" the energy budget with more daily input of energy than Earth could use or less than it needs. Asking students to apply their knowledge of what happens to incoming solar radiation and predict how changes would impact the earth system can allow them to explore such real-world topics such as "global warming" and "global cooling" within a scientific context.

- Activity 2: The Water Cycle Models can be assessed using the Hydrologic Cycle Activity Assessment Rubric BLM provided at the end of this unit. It is based on a five-point scale, but multiples of 5 points can be used and would allow more flexibility in scoring.

- Activity 6: Assessment of the experimental design and the relationship among the variables in the experiment is recommended. Use of a rubric such as the *Lab Report: Rubric Training Mode*l found at http://rubistar.4teachers.org/index.php?screen=ShowRubric&rubric_id=704030& enables the teacher to organize assessment into the categories of experimental design, variables, data, participation, scientific concepts, components of the lab report, experimental hypothesis, components of the report, question/purpose, procedures, safety, appearance/organization, analysis, error analysis, and materials. Students can be assessed on any combination of these categories the teacher elects to emphasize.

Resources

- Radiation energy budget information with diagram
  http://eosweb.larc.nasa.gov/EDDOCS/radiation_facts.html

- Hydrologic cycle
  http://observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro2.html
  http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/smry.rxml

- Insolation
  http://www.physicalgeography.net/fundamentals/6i.html
  http://ithacasciencezone.com/earthzone/lessons/07meteor/insolation.htm

- Solar fusion
  http://www.astro.ubc.ca/~scharein/a311/Sim/fusion/Fusion.html
  http://zebu.uoregon.edu/~soper/Light/fusion.html

- Temperature of atmospheric layers
  http://www.windows.ucar.edu/tour/link=/earth/images/profile_jpg_image.html
  http://www.physicalgeography.net/fundamentals/7b.html

- Climate factors
  http://vathena.arc.nasa.gov/curric/weather/adptcty/factors.html
  http://www.cartage.org.lb/en/kids/science/Geog/Climate/Climate.htm
  http://www.cartage.org.lb/en/kids/science/Geog/Climate/Factors.htm
  http://www.ecn.ac.uk/Education/factors_affecting_climate.htm

Earth Science
Unit 4: Plate Tectonics

Time Frame: 5 Weeks

Unit Description

The effects of lithospheric plate movements together with the energy required to drive these processes are explored. It is in this unit that the larger picture of Earth as a dynamic system comes into focus, connecting many separate geologic phenomena such as earthquakes and volcanoes, lithospheric plate movements, and mid-ocean ridges. With information and evidence from this unit, students begin to understand plate tectonics as a unifying theory for the geological sciences.

Student Understandings

Students will be able to relate the physical features and geologic events experienced world wide to the movement of lithospheric plates and the sources of energy needed to drive lithospheric plate movements. Students will be able to describe how plate tectonics brings together and provides coherence for much of what we know about the earth system. They will have a basic understanding of the scientific evidence supporting the plate tectonics theory as the unifying theory of the geological sciences.

Guiding Questions

1. Can students relate lithospheric plate movements to physical features found on Earth's surface and to other geologic phenomena?
2. Can students describe how Earth's internal energy sources drive lithospheric plate movements?
3. Can students give reasons why the theory of plate tectonics is the "unifying theory" of the geological sciences?

Unit 4 Grade Level Expectations

GLE #	Grade Level Expectation
Science as Inquiry	
The Abilities Necessary to Do Scientific Inquiry	
2.	Describe how investigations can be observation, description, literature survey classification, or experimentation (SI-H-A2)
4.	Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems

GLE #	Grade Level Expectation
	(SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-HA3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
12.	Cite evidence that scientific investigations are conducted for many different reasons (SI-H-B2)
13.	Identify scientific evidence that has caused modifications in previously accepted theories (SI-H-B2)
14.	Cite examples of scientific advances and emerging technologies and how they affect society (e.g., MRI, DNA in forensics) (SI-H-B3)
15.	Analyze the conclusion from an investigation by using data to determine its validity (SI-H-B4)
16.	Use the following rules of evidence to examine experimental results:
	(a) Can an expert's technique or theory be tested, has it been tested, or is it simply a subjective, conclusive approach that cannot be reasonably assessed for reliability? (b) Has the technique or theory been subjected to peer review and publication? (c) What is the known or potential rate of error of the technique or theory when applied? (d) Were standards and controls applied and maintained? (e) Has the technique or theory been generally accepted in the scientific community? (SI-H-B5) (SI-H-B1) (SI-H-B4)
Earth and Space Science	
6.	Discuss how heat energy is generated at the inner core-outer core boundary (ESS-H-A4)
11.	Describe the processes that drive lithospheric plate movements (i.e., radioactive decay, friction, convection) (ESS-H-A7) (ESS-H-A3) (ESS-H-A4)
12.	Relate lithospheric plate movements to the occurrences of earthquakes, volcanoes, mid-ocean ridge systems, and off-shore trenches found on Earth (ESS-H-A7)
22.	Analyze data related to a variety of natural processes to determine the time frame of the changes involved (e.g., formation of sedimentary rock layers, deposition of ash layers, fossilization of plant or animal species) (ESS-H-C5)

Sample Activities

Activity 1: Earth's Tectonic Processes (SI GLEs: 4, 5, 6, 9, 12, 14, 15; ESS GLEs: 12, 22)

Materials List: outline map of the world (see unit resources), colored pencils, print and electronic resources, laminated world map (optional)

Students will use near-real-time earthquake data and current volcanic eruption data to identify zones of tectonic activity and lithospheric plate boundaries. Accessing and retrieving data from the state-of-the-art technology of the United States Geological Quick Epicenter Determination website (see list of online resources at the end of this unit) or other similar resource and an outline map of the world, students will download, print, and plot the positions of earthquakes for any recent day of their choice. Students should plot earthquakes in pencil. The USGS site contains worldwide earthquake data over many years, so students may choose earthquakes that occurred on personally significant days, or the teacher may choose to assign the same date over a period of years or use some other plan, any of which will result in students discovering that there are zones on Earth where seismic activity is recurrent. Students will add sites of ongoing volcanic activity from data on the Volcano World website or other similar resource and mark each volcano location with a red triangle. When complete, individual maps should be labeled with the day, month, and year of the earthquake data and all of the maps should be displayed in chronological order. The class should view the maps in cooperative groups, noting and discussing patterns of occurrence and using colored pencils to shade areas of repetition on a fresh copy of the outline world map. Zones of volcanic activity can be shaded in red.

The cooperative groups should gather all available resources including physiographic maps from library atlases and Internet resources such as the NOAA world relief map. They will use these to find the physical Earth features that are formed where patterns of seismic and volcanic activity are recurrent over geologic time. Students should be able to recognize that the boundaries of the tectonic plates are outlined by earthquake and volcanic activity. They should be able to trace the mid-ocean ridge system as a spreading zone and identify offshore trenches as evidence of zones where subduction is taking place. They should be able to compare their data to the body of data already collected. Their data analysis should support or refute the established locations of plate boundaries as well as offer explanations for any discrepancies they identify. Further student research should include development of a written paragraph explaining how much of the technology that enabled scientists to discover these physical features of Earth was originally designed during World War II for military purposes. It should also explain that scientific investigations are undertaken for a variety of purposes that ultimately enable unexpected results. Students should include information about some of the scientists associated with the development of the concept of plate tectonics such as Harry Hess, Frederick Vine, Drummond Matthews, and J. Tuzo Wilson. The paragraph should trace the expansion of technologies used in the detection of tectonic activity and describe how one or more of these emerging technologies affect society, especially where large concentrations of the population live in zones of tectonic hazard. This project will take a minimum of several class periods, depending upon how many earthquake epicenters students plot, the thoroughness of their research, and the assessment method that is used.

Students can be part of an authentic, long-term research endeavor if each one is asked to plot a few current earthquakes on one large world map. Kept over a number of years with students from each successive year using a different color marker, the map becomes both a classroom legacy and an important piece of scientific evidence for the future. Using what they have learned during this project, students should be able to write and defend a logical analysis of their data and form a conclusion that supports or rejects the tectonic movement of lithospheric plates based on that data.

Activity 2: Changing Views of A Dynamic Planet (SI GLEs: 2, 7, 8, 11, 13, 14, 16; ESS GLEs: 11, 12, 22)

Materials List: Earth maps or globes, unlined paper, scissors, print and electronic reference materials

Students will use all available textbook, library, and Internet resources to create a timeline of evidence for a planet whose continents are in motion. Starting with tracings of the continents from any available map or globe, cut out and fit together to make a rough approximation of Pangaea, to the most timely and minute-by-minute laser measurements of lithospheric plate movements, students should lay out and examine all of the evidence for plate tectonics.

During the research phase of the project, the *professor know-it-all* (*view literacy strategy descriptions*) strategy can be enacted. A student or small group can be assigned (or volunteer for) the role of Alfred Wegener and present Wegener's Continental Drift Hypothesis to fellow students who, in turn, take the roles of members of the Royal Geological Society. After having been presented with a clear idea of the early 20th century (World War I) context in which it was set, students can recreate the discussion, debate, and rebuttal that surrounded the evidence presented by Wegener, and then evaluate the strengths and weaknesses of his hypothesis. If this is their first experience with this format, the "professor(s) know-it-all" should be guided initially in how to respond to the questions of their peers. Typically, a brief huddle to consider how the question should be answered, followed by the answer given by the pre-selected speaker is appropriate. They should apply the rules of evidence to each element of Wegener's hypothesis as they examine his evidence. With no indication from the teacher of the final "answer" to the question of Wegener's ideas, students should continue their research until they have all of the major evidence which today's scientists use to support the modern Theory of Plate Tectonics. This information is available in Earth Science textbooks as well as in the online references in this unit.

Once again students should apply each of the rules of evidence to the modern discoveries, and as they add the pieces of evidence that came during and since World War II, especially the mechanisms that drive lithospheric displacements to happen, they will have investigated and recreated one of the most interesting and important scientific issues of our time. This activity will take a series of class periods or longer to complete. It should be divided into at least two distinct parts, one series of sessions for Wegener's original hypothesis and the evidence he offered in support and a second series of sessions to examine the evidence collected since World War II. As students analyze each piece of supporting evidence in the light of the research and experimentation involved in its development they should be able to form their own conclusion about both Wegener's Hypothesis and The Theory of Plate Tectonics. Their conclusion can take the form of a written statement with supporting evidence. From their own studies of this issue students should recognize and be able to describe the kind of investigation they have undertaken and compare it to the other forms scientific investigations can take.

Activity 3: What Drives The Lithospheric Plates (SI GLEs: 6, 7, 8, 11, 13; ESS GLE: 6, 11)

Materials List: print and electronic resources; presentation materials such as poster paper, markers, and/or computer with *PowerPoint*©; any available materials for construction of a model such as clay, foam board, or papier-mâché; Evaluating Student Presentations Rubric BLM

Students will work in small, cooperative groups to research the forces inside Earth that result in tectonic activity. Each group can be assigned one of the driving forces such as radioactive decay in the mantle, residual heat from the formation of Earth, friction between the inner and outer core layers, or convection in the mantle to study in depth. The group can construct a model, and make a group presentation using *PowerPoint*© or a similar method to inform and instruct the class. The presentation should outline the historical development of evidence and a description of the impact that these findings had on previously accepted theories causing them to be supported, revised, or rejected

As closure to this unit, students should be able to explain why plate tectonics has become the unifying theory of the Earth Sciences. The explanation can be part of their presentation or presented in written form.

The presentation can be assessed with the Evaluating Student Presentations Rubric BLM.

Sample Assessments

General Guidelines

Student participation should be monitored throughout all activities with the use of predetermined teacher observation checklist and student journal entries. Student-developed products should be evaluated as the unit progresses and feedback delivered in a timely manner. Where a rubric is used for evaluation, students should participate in developing the criteria for the rubric.

General Assessments

- The student will engage problem-solving and performance-based assessments including models, presentations, product development, discussions, and group participation/cooperation.
- The student will participate in reflective assessments including journal entries, explanations of choices made during activities, report writing, group discussions and consensus, and defense of position taken.
- The student will complete traditional assessments such as quizzes and pencil and paper tests containing multiple-choice items and constructed response items.

Activity-Specific Assessments

- <u>Activity 1</u>: Students should be active participants in monitoring one another's plotting of the data onto the world maps. They should work together in cooperative groups to check the accuracy of plotted points and should be accountable for the accuracy of points plotted for all members of their group. A percentage of the final assessment total, such as 30%, should be assigned to this portion of the project. The group notes and shaded pattern map should receive another percentage, such as 30%, and written explanation of the relationship between plate movements and tectonic activities can receive 40%. If students participate in the long-term research, points for participation can either be added to their score or the percentages listed above can be slightly modified.

- <u>Activity 2</u>: The teacher and students should work together to equitably divide the labor of researching the historical and modern evidence that has led to our current theory of plate tectonics. Each cooperative group should be assessed using a student-designed rubric for group projects similar to that found in units 1 and 3 of this curriculum.

  Components of the rubric can include

  Quality of appropriate explanations and descriptions
  Quality of research and references
  Overall quality of timeline project
  Group member participation and cooperation

  Each of the components can be measured on a scale of 1-5 or whatever the teacher and the class decide is an appropriate total point value for the project.

- Activity 3: The group presentation should be assessed using a rubric designed for that purpose (see Evaluating Student Presentations Rubric BLM). It can be modified according to the needs and requirements of the teacher and students.

Resources

- Current earthquake and volcanic activity
  http://earthquake.usgs.gov/recenteqsww/Quakes/quakes_all.html
  http://volcano.und.nodak.edu/vw.html

- World physiographic map
  http://www.ngdc.noaa.gov/mgg/image/relief_slides2.html
  http://www.nationalgeographic.com/xpeditions/atlas/world/world-dw.pdf
  http://www.worldatlas.com/aatlas/imageg.htm

- Overview of the hypothesis
  http://www.uwsp.edu/geo/faculty/ozsvath/lectures/Continental_Drift.htm
  http://www.hartrao.ac.za/geodesy/tectonics.html

- Continental drift/plate tectonics
  http://www.umich.edu/~gs265/tecpaper.htm#PDF
  http://visionlearning.com/library/module_viewer.php?mid=66&l=&c3

Earth Science
Unit 5: Earth's Biography

Time Frame: 5 Weeks

Unit Description

This unit explores the measurement of geologic time, both by relative and absolute means. The record of geologic history that is found in the rock exposed at the Earth's surface is examined and changes in the concentration of atmospheric oxygen based on fossil records are researched. Geologic dating principles are studied and applied to Louisiana geological history. The recent geologic history of the Mississippi River Delta is used to make predictions made about the future of the river and delta formation.

Student Understandings

Students will be able to explain the effect of changes in the concentration of atmospheric oxygen using fossil records. They will be able to read and interpret a geologic map as well as a geologic time scale. Students will understand how to interpret geologic cross-sections and block diagrams, and label the components chronologically. They will be able to describe briefly the geologic history of Louisiana and will apply the principles of geologic dating to the five most recent deltas of the Mississippi River.

Guiding Questions

1. Can students distinguish between relative and absolute dating techniques and recognize the functions and values of each?
2. Can students use fossil records to explain changes in the concentration of atmospheric oxygen over time?
3. Can students read and interpret a geologic map?
4. Can students interpret a geologic time scale?
5. Can students chronologically label a geologic profile or block diagram?
6. Can students briefly describe the geologic history of Louisiana?
7. Can students chronologically order the five most recent Mississippi River deltas and make reasonable predictions about the future of the river and its current delta?

Unit 5 Grade-Level Expectations

GLE #	GLE Text and Benchmarks
Science as Inquiry	
The Abilities Necessary to Do Scientific Inquiry	
1.	Write a testable question or hypothesis when given a topic (SI-H-A1)
5.	Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)
6.	Use technology when appropriate to enhance laboratory investigations and presentations of findings (SI-H-A3)
7.	Choose appropriate models to explain scientific knowledge or experimental results (e.g., objects, mathematical relationships, plans, schemes, examples, role-playing, computer simulations) (SI-H-A4)
8.	Give an example of how new scientific data can cause an existing scientific explanation to be supported, revised, or rejected (SI-H-A5)
9.	Write and defend a conclusion based on logical analysis of experimental data (SI-H-A6) (SI-H-A2)
Understanding Scientific Inquiry	
11.	Evaluate selected theories based on supporting scientific evidence (SI-H-B1)
Earth Science	
17.	Determine the relative ages of rock layers in a geologic profile or cross section (ESS-H-C2)
18.	Use data from radioactive dating techniques to estimate the age of earth materials (ESS-H-C2)
19.	Interpret geological maps of Louisiana to describe the state's geologic history (ESS-H-C3)
20.	Determine the chronological order of the five most recent major lobes of the Mississippi River delta in Louisiana (ESS-H-C3)
21.	Use fossil records to explain changes in the concentration of atmospheric oxygen over time (ESS-H-C4)
22.	Analyze data related to a variety of natural processes to determine the time frame of the changes involved (e.g., formation of sedimentary rock layers, deposition of ash layers, fossilization of plant or animal species) (ESS-H-C5)

Sample Activities

Activity 1: It's All Relative! (SI GLE: 7; ESS GLE: 17)

Materials List: sample diagrams of geologic cross sections from textbooks or online references (see online references in this unit), modeling clay in four different colors, newspaper to use as a work surface, paper for labels,

After a review of the principles of geologic dating using relative dating techniques and an opportunity for students to see examples of geologic cross sections, the teacher should provide small, cooperative groups of students with fist-sized pieces of at least four different colors of modeling clay. Each group will work together to sketch and then construct a model of each of the following relative dating principles using their "modeling rock" material:

- Superposition
- Original horizontality
- Cross-cutting relationships
- Angular unconformity
- Folding
- Faulting
- (Extension) Disconformity, Nonconformity, Inclusions, Intrusions

The sketches should contain labels identifying the rock family or type for each color of clay. The feature represented in the model should be identified on the sketches and the chronological order of the layers should be clearly identified with the oldest labeled 1 and younger layers labeled with successive numbers, but no indication of the chronology should be placed on the model itself. The models should only be identified with letters for discussion purposes. Upon completion, groups should swap model sets to see if other groups can recognize what they have constructed. Sketches and labels should be made for the swapped set. Finally, both groups should compare sketches and discuss differences and possible modifications that can be made. Time should be allowed for modifications and groups should swap sets with a second group. The same procedure should be followed until all groups have seen all other model sets and each group has had an opportunity to improve their own models. Structuring the swap as stations with groups moving in a predetermined order can prevent confusion and duplication of effort.

If time permits, students can use the sketch of their own model to construct a cross-section diagram of their model and again swap diagrams with other groups to check for accuracy in the diagram or, using the model of the feature it has previously worked with, each group can construct a three-dimensional block diagram, completing only the top view. Information and instructions for constructing and interpreting block diagrams can be found in the references for this unit. The blocks can be swapped and the receiving group can complete the other five faces of the block using the top view and the relative dating guidelines and the other sketches of the feature as a guide.

Activity 2: Radioactive Dating Simulation (SI GLEs: 5, 7; ESS GLEs: <u>18</u>, 22)

Materials List: print and electronic resources, any available rock samples to serve as "mystery rocks"

Following a discussion and guided practice using the absolute dating technique of calculating half-lives and parent-daughter ratios, students will engage in a simulated "rock dating" activity. Guided practice can include a period of modified q*uestion the author* (view literacy strategy descriptions) during which the students read a teacher-selected passage from their text or one of the online resources listed in this unit that contains information about absolute dating techniques, and then in teams of two, question one another on the concept of absolute dating and the skills needed to calculate the half-life of radioactive isotopes. This strategy provides an opportunity for students to read new content independently, digest information, ask relevant questions of a partner and the teacher, and use their own words to explain to a partner what they have learned. During *question the author,* each partner should have a turn as the questioner, and as the partner who answers. Asking questions such as “What information is needed in order to calculate half-life?”, “How did the author help us to check our calculations?”, or “How does calculating parent-daughter ratios help estimate the age of a rock sample?” will better enable students to take responsibility for constructing meaning from the text they are reading. A sample isotope such as Carbon 14 can serve as the practice isotope for all teams, and a subsequent whole-class discussion will provide a common body of knowledge for all students.

After the guided practice, small, cooperative groups of students are each assigned (or may draw by lot) one of the radioactive isotopes used in the dating of Earth materials. In addition to the ones mentioned above, other radioactive isotopes include Rubidium-87, Thorium-232, and Uranium-235. Groups will use all available resources to research their isotope, write a summary of their research, and construct a flow chart that illustrates the decay products that are intermediaries as well as its final decay product. Each group should construct a table of half-lives to establish the range of ages for which this isotope is useful. Students may take a few moments to review the sample (Carbon-14) sequence with their *question the author* partner at any time during the activity. This will make it easier for them to apply what they know to their group isotope. Groups will then post their isotope data on a bulletin board or wall where it is available to all of the class. A short “gallery walk” in which groups are able to view the posters created by their classmates will provide additional resources for the remainder of the activity.

Next, each group will then be given a “mystery rock.” (Any available rock samples can serve as “mystery rocks” for the purpose of the activity.) With each “mystery rock” comes an information profile that tells the percentages of parent isotope and daughter isotope present in the rock. It is the task of the group to use the available flowchart and half-life information to assign an approximate age to their rock. In addition to this direct approach, a twist can be added by giving the age information and asking students to provide the number of half-lives the rock has experienced. An accompanying explanation of how the answer was derived and a requirement that all calculations be shown is helpful to the teacher assessing the project. The table below lists several widely known radioactive isotopes that can be used by the teacher to develop a “profile” of parent-daughter information for each “mystery rock.” For example, if the isotope is Uranium-235 and the “mystery rock” contains 25% of its original U-235, using a half-life of 700 million years, the U-235 would have completed 2 half-lives. The “mystery rock” could be an estimated 1.4 billion years old. The teacher can make the “mystery rock” profiles as challenging as appropriate for the students. The completed project, including summary of research, flowchart, solution to “mystery rock” age, with the appropriate calculations and explanation of the solution can be assessed as a unit or in its individual components. Time should be allocated at the close of activities 1 and 2 to discuss with students the appropriate uses of absolute dating methods and relative dating techniques and how they work together to give scientists a clearer picture of Earth's history.

Parent Isotope	**Stable Daughter Product**	**Currently Accepted Half-Life Values**
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	700 million years
Thorium-232	Lead-208	14.0 billion years
Rubidium-87	Strontium-87	48.8 billion years
Potassium-40	Argon-40	1.25 billion years
Samarium-147	Neodymium-143	106 billion years

Activity 3: Formation of Earth's Atmosphere (SI GLEs: 1, 8, 11, ESS GLE: 21)

Materials List: Activity 3 Assessment Checklist BLM, print and electronic resources, geologic time scale from textbook or online source (see online references for this unit), graph paper

This activity should be prefaced by a thorough review of Earth's Geologic Timeline, using a textbook or online geologic time scale (see references at the end of this unit).

Small, cooperative groups of students will use all available resources including a geologic time scale and print and online resources to trace the changes in concentration of oxygen in Earth's atmosphere from the time of the formation of the planet until the latter part of the Pre-Cambrian Era. As a result of its research each group will develop an initial hypothesis that answers the question of the origin of the abundance of oxygen in the atmosphere. Once a group has agreed upon its hypothesis, group members will work together to construct a graph of changes in concentration of oxygen in the atmosphere over geologic time and use their geologic time scale to outline the parallel development of life forms over that time. Each group will write a summary conclusion that describes how its original hypothesis was supported or refuted by life form development evidence. Groups will present their hypotheses and findings to the class for their consideration. The project may be assessed with the Activity 3 Assessment Checklist BLM.

This activity can achieve closure with the use of a *SPAWN* prompt (view literacy strategy descriptions). The teacher can encourage reflective thinking by asking a "what if" question related to oxygen levels in Earth's atmosphere such as "what if logging in the tropical rainforests were suddenly stopped…"or "what if an increase in rainfall over desert areas allowed increased vegetation growth…" or the teacher could encourage "problem solving" concerning the relationship between oxygen levels and worldwide vegetation losses, asking that students suggest possible mitigation strategies based upon what they have learned . Use of the *SPAWN* prompt will encourage students to broaden the applications of what they have learned to the real world in which they live and relate knowledge from other science courses to what they are currently learning.

Activity 4: Louisiana's Geologic Past (SI GLEs: 6, 9; ESS GLEs: 19, 22)

Materials List: copy of the geological map of Louisiana (see online references) for each student, geological time scale from textbook or online reference

Students will use all available resources, including a geologic time scale and resources available from the Louisiana Geological Survey to compare the geologic history of Louisiana to that of selected other states. A wall-sized geologic map of Louisiana, suitable for whole class instruction, is available from the LA Geological Survey. They also have 8.5 x 11 inch geological maps of Louisiana that can be used by individual students and small groups. The geological surveys of many states, including Louisiana, have posted geological maps of their states on their websites, or the maps can be ordered in hard copy from their offices.

Small, cooperative groups of students should have the opportunity to examine the geological map of Louisiana and engage in guided practice reading and interpreting the color-coded legend to determine the age of Earth materials at various locations around the state. Students should be encouraged to ask questions and discuss the maps during this phase of the activity.

When students have become familiar with the organization and interpretations of the geologic map of Louisiana, they will compare our geologic history with that of at least two other states. If possible, one state should be adjoining or near Louisiana, and the second state should be in another part of the United States. The teacher can assign states whose geologic maps are available online if necessary. Students will develop a table of data that will compare the three states on information such as oldest and/or youngest exposed rock, absence or presence of certain fossil organisms (like dinosaurs), age of river deposits, exposed rock of the same age/formations as those in Louisiana, state fossil, state mineral, and other questions of comparison that the teacher and students develop together. If circumstances allow, page-sized geologic maps of the selected states can be downloaded and printed. They can be displayed with the compared information and groups can view each other's completed project. Upon completion of the project, students will write a paragraph comparing the geologic history of Louisiana with other states' geologic history, offering information from the project as evidence for their conclusions.

If time permits students can use the geologic map Louisiana and the Louisiana Land Loss Map found at http://www.lacoast.gov/maps/2003landloss/landloss11X17.pdf to observe the geologic age of material being lost along our coast and predict changes that will have to be made to the geologic and coastal maps of Louisiana in 50 or 100 years.

Activity 5: The Mississippi River's Restless Delta (SI GLE: 7; ESS GLEs: 20, 22)

Materials List: outline map of Louisiana and copies of each of the five most recent deltas of the Mississippi River for each student, paste or glue, print and online resources, colored pencils (optional)

The teacher will use the referenced websites or other sources to download, print, and separately trace each of the five most recent lobes of delta material deposited by the Mississippi River. A copy of each delta will be given to each student together with a copy of an outline map of Louisiana drawn to the same scale as the deltaic lobes. Using references and any available resources and the geologic dating principle of Superposition, the student will reconstruct the chronology of the delta lobes from oldest to youngest. In their *learning log* (view literacy strategy descriptions), each student will write a paragraph in which they describe that chronology and predict the next probable route the river will take when it shifts from its present channel at some time in the future. They will list evidence to support their prediction, describe the part that subsidence has played in the process, and sketch their predicted route on an outline map of Louisiana. Upon completion of the activity, each student should be able to explain why the Chandeleur Barrier Island chain, which is directly south of the state of Mississippi is a part of the state of Louisiana. (*It is a remnant of the St. Bernard Delta of the Mississippi River, and the Mississippi River is a part of the state of Louisiana.)*

Sample Assessments

General Guidelines

Student participation should be monitored throughout all activities with the use of a predetermined teacher-observation checklist along with an inspection of the students' journal entries. Student-developed products should be evaluated as the unit progresses and feedback delivered in a timely manner. Where a rubric is used for evaluation, students should participate in developing the criteria for the rubric.

General Assessments

- The student will engage in problem-solving and performance-based assessments, including models, presentations, product development, discussions, and group participation/cooperation.
- The student will participate in reflective assessments, including journal entries, explanations of choices made during activities, report writing, group discussions and consensus, and defense of position taken.
- The student will complete traditional assessments such as quizzes, pencil and paper tests containing multiple-choice items and constructed response items.

Activity-Specific Assessments

- Activity 2: The inclusion of a self and peer evaluation component in an assessment of this activity makes students personally reflective about their own contribution to the group effort. The self and peer evaluation scores would be *in addition to the point score of the project products* themselves. The following rating scales can be 1-5 with 1 being the minimum and 5 the maximum score.

  Individual evaluation:
  1. Asking meaningful content questions
  2. Explaining content information to others
  3. Asking for help when needed
  4. Contributing content materials
  5. Following teacher's instructions
  6. Sharing responsibilities
  7. Respecting others
  8. Helping group stay on task
  9. Doing things on time
  10. Doing one's best

  A suggested group evaluation
  1. Contributing content ideas and information
  2. Explaining content to others
  3. Solving content and process problems within the group
  4. Staying on task and meeting deadlines
  5. Sharing responsibilities
  6. Respecting others
  7. Following teacher's instructions
  8. Producing a quality product

- Activity 3: An assessment for presentations can be used with this activity. A point value is assigned to each component of the presentation with a checklist available to students participating in the activity as they work. The points can be divided equally among the bulleted components, or the content can receive greater weight at the teacher's discretion. (See Activity 3 Assessment Checklist BLM.)

- Activity 5: Each student paragraph will be evaluated for accuracy of content related to the placement of deltas in correct chronological order on the model. In addition to accuracy of content, some consideration should be given to the quality of the written product. Such things as clarity of thought, appropriate use of vocabulary, sentence structure, capitalization, and punctuation should have a limited point value. The combined score of the completed model and the written explanation should determine the assessment value.

Resources

- Radiometric Dating
  http://earthsci.org/fossils/geotime/radate/radate.html
  http://www.gpc.edu/~pgore/geology/geo102/radio.htm
  http://pubs.usgs.gov/gip/geotime/radiometric.html
  http://www.astronomynotes.com/solfluf/s4.htm

- Geologic time
  http://www.geo.utexas.edu/courses/303/303_Lab/StructureLab303.html#blockdia (block diagrams)
  http://www2.nature.nps.gov/geology/usgsnps/gtime/gtime1.html
  http://www.carlwozniak.com/earth/Life.html
  http://www.ucmp.berkeley.edu/fosrec/BarBar.html#SETA
  http://www2.nature.nps.gov/geology/usgsnps/gtime/gtime2.html
  http://wrgis.wr.usgs.gov/docs/parks/gtime/radiom.html
  http://www.globalchange.umich.edu/globalchange1/current/lectures/first_billion_years/first_billion_years.html

- Geologic state maps
  http://www.lgs.lsu.edu/deploy/uploads/gengeomapla.pdf (color geologic map)
  http://www.lgs.lsu.edu/deploy/uploads/gengeolbw.pdf (black/white geologic map)
  http://lgs-moon.sece.lsu.edu/lagis/viewer.htm (interactive geologic map)
  http://www.consrv.ca.gov/CGS/information/publications/cgs_notes/note_17/note_17.pdf (geologic map of California for comparison)
  http://www.beg.utexas.edu/education/pubsforteach.htm
  http://www.deq.state.ms.us/MDEQ.nsf/page/Geology_maps_and_charts_publications?OpenDocument
  http://www.uni-mainz.de/FB/Geo/Geologie/GeoSurv.html (worldwide geologic information)

- River deltas
  http://geography.about.com/library/blank/blxusla.htm
  http://www.netstate.com/states/maps/la_maps.htm
  http://www.loyno.edu/lucec/images/anatomy.jpg