**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 1. All students will describe the Earth's surface; describe and explain how the Earth's features change over time; and analyze effects of technology on the Earth's surface and resources. (Geosphere)

**Benchmark**
Explain the surface features of the Great Lakes region using the Ice Age theory (SCI.V.1.HS.1).

**Benchmark Clarification**
There is evidence to support the Ice Age theory. Students will:

- Explain moraines and till which are deposits of unsorted sediments
- Explain glacial scratches (striations) left on bedrock (*link to Glossary*)
- Explain kettle lakes: depressions in glacial deposits left by melting ice blocks, later filled with water
- Explain parallel arrangement of moraines and Great Lakes' shorelines
- Explain erratics: large boulders, mostly of igneous or metamorphic origin, which are deposited in areas of mostly sedimentary bedrock
- Hypothesize what climatic changes may have occurred to produce ice ages

**Bedrock:** the undisturbed solid rock generally found beneath loose surface material

**Key Concepts (voc.)**
Glacial processes:

- climate change
- snow changing to ice
- pressure
- moving (advance, retreat)
- melting

See Long-Term Climate Change *SCI.V.3.HS.1*.

Deposits:

- features: hills, lakes, Great Lakes

Tools:

- relief map
- topographic map
- elevation map
- geological maps

**Real-World Context**
Local examples in Michigan of glacial formations:

- moraines
- kettles
- drumlins

**Instructional Example SCI.V.1.HS.1**

**Benchmark Question:** What surface evidence found in the Great Lakes region supports Ice Age theory?
**Focus Question:** How does the location of moraines in the Great Lakes region support Ice Age theory?

The teacher will show evidence that morainal deposits are found all over the Great Lakes region, sometimes in the form of hills. By reviewing processes of erosion/deposition, students will infer that glaciers and mass wasting are the only common processes that leave unsorted deposits.
Mass wasting is eliminated, because these unsorted deposits are found on the tops of hills. Students will trace moraines on a topographical map and observe that moraines have a similar shape to Great Lake shorelines. (Shorelines and glacial deposits are created by very different processes) On the same map, students will identify the position and direction of major ice lobes.

**Constructing:** (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.3*), (*link to SCI.II.1.HS.4*).

**Resources/References:**

Webliography.
**http://mtn.merit.edu/mcf/SCI.V.1.HS.1.html**

Glacier Advance/Retreat Animation: The Michigan Department of Environmental Quality (DEQ) archives a number of maps dealing with Michigan's glacial history including a 850 K animation depicting glacial advance/retreat in the Great Lakes region. Note the evolving pattern of proglacial lakes and spillways captures the dynamic nature of the ice front.
http://www.deq.state.mi.us/gsd/freepaga.html#TOP

Glacier Home Page: basic information on the origin, location, and characteristics of glaciers.
**http://www.glacier.rice.edu/**

Glacier Landform Image Database: Images of erosional,subglacial,superglacial, ice-margin, glacial lakes, and proglacial environments.
**http://tvl1.geo.uc.edu/ice/Image/imageref.html**

The Great Ice Age: a PDF document from the USGS detailing the causes and characteristics of the ice advances during the Pleistocene Epoch.
**http://pubs.usgs.gov/gip/ice_age/**

All About Glaciers.
http://nsidc.org/glaciers/

Dorr & Eschman, *Geology of Michigan*. Ann Arbor Press, 1970.

Natural Processes of the Great Lakes.
http://www.on.ec.gc.ca/great-lakes-atlas/glat-chap2-e.html

*Jason: A Great Lakes Curriculum*. NSTA, 1990.

Weinle, Art, "Michigan Moraines." A classroom-ready worksheet with map.
Available from artweinle@home.com

Winters, H. *Uncovering Michigan*. A 35-slide glacial slide show. 1999.
Available from Michigan Earth Science Teachers Association ($28)

**Classroom Assessment Example SCI.V.1.HS.1**

Using as many examples as possible, each student will prepare and deliver a speech to convince an interested friend, who hasn't had Earth Science, that continental glaciers once covered Michigan.
Students may include a well-labeled illustration.

Five examples of evidence supporting Ice Age theory:

- The deposit of unsorted sediments (till) all over Michigan could only have been left behind by glaciers, since mass wasting cannot operate near hilltops.
- Parallel scratches on bedrock were created when glaciers dragged rock against rock.
- Kettle lakes are depressions formed in glacial deposits created by melting ice blocks.
- Moraine ridges are generally parallel to Great Lakes shorelines, suggesting that ice advanced out of lake basins
- Large boulders of igneous or metamorphic origin left in sedimentary regions (erratics) are too large and widespread to have been moved any other way.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.1.HS.1**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Explanation of relationships between surface feature and glaciation** | Explains the relationship for one to three examples of evidence. | Explains the relationship for four examples of evidence. | Explains the relationship for five examples of evidence. | Explains and illustrates the relationship for five examples of evidence. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 1. All students will describe the Earth's surface; describe and explain how the Earth's features change over time; and analyze effects of technology on the Earth's surface and resources. (Geosphere)

**Benchmark**
Use the plate tectonics theory to explain features of the Earth's surface and geological phenomena and describe evidence for the plate tectonics theory
(SCI.V.1.HS.2).

**Benchmark Clarification**
Scientists use the plate tectonics theory to explain surface and oceanic features of the Earth. Plate tectonics theory suggests that large sections, or plates, of the Earth's outer layer are moving at measurable rates in different directions.
Students will:

- Interpret the early evidence of continental movements, such as similarities across continents in existing animals, plants, fossils (*link to Glossary*), shoreline shapes, and rock layer sequences
- Illustrate how seafloor bedrock patterns and age (paleo-magnetism) (*link to Glossary)* provide convincing evidence of plate motions
- Differentiate between continents and plates (*link to Glossary*)
- Identify plate boundaries as lines of earthquakes on a world earthquake map
- Describe the causes of earthquakes as compression (plates moving together), tension (plates moving apart), or shearing (plates sliding sideways)

**Fossils:** any evidence of prehistoric life
**Paleo-magnetism:** magnetic orientations retained in rock
**Plates: a segment or section of** the Earth's lithosphere, or outer layer

**Key Concepts (voc.)**
Earth composition:

- crust
- mantle: upper part is able to flow very slowly
- core–interior at high temperature and pressure

See Temperature and Pressure *SCI.V.4.HS.3*.
See Earthquakes *SCI.IV.4.MS.6*.

Forces:

- tension
- compression
- shearing

Plates:

- continental crust
- oceanic crust

Features:

- faults
- trenches
- mid-ocean ridges
- folded mountains
- hot spots
- volcanoes

Related actions:

- earthquakes
- volcanic activity
- seafloor spreading
- mountain building
- convection in mantle

Evidence of “continental drift”:

- physical fit of continents
- fossil evidence
- glacial evidence
- measurements of movement
- rock layer sequence

**Real-World Context**

- recent patterns of earthquake and volcanic activities
- maps showing the direction and movement of major plates and associated earthquake and volcanic activity
- compressional boundaries: folded mountains, thrust faults, trenches (subduction zones), lines of volcanoes (e.g., Pacific “ring of fire”)
- tensional boundaries: mid-ocean ridges, rift valleys
- shearing boundaries: lateral movement producing faults (e.g., San Andreas Fault)

**Instructional Example SCI.V.1.HS.2**

**Benchmark Question:** What evidence is there that the Earth's outer layer is composed of large pieces that are moving?
**Focus Question:** How can the location of earthquakes be used to show plate boundaries?

The teacher will provide each student with a world map.
Students will research earthquake location data for a period of many years using the internet or other sources. The teacher will demonstrate how to plot epicenters by using a website that automatically plots them over a period of years. Working with a partner, students will plot epicenters on the map using latitude and longitude.

**Extension:** Students can distinguish the nature of plate boundaries based on earthquake magnitudes: compressional (larger magnitudes, shallow to deep hypocenters, subduction common) and tensional (smaller magnitudes, shallow hypocenters, rifting common.

**Constructing:** (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*).

**Resources/References:**

Webliography.
**http://mtn.merit.edu/mcf/SCI.V.1.HS.2.html**

Plate Motion Calculator: determine the direction and speed of movement of earth's major geologic plates.
http://manbow.ori.u-tokyo.ac.jp/tamaki-html/nuvel1.html

USGS Explanation of Plate Tectonics: easy to digest discussion of the major types of plate boundaries with geographic examples.
http://pubs.usgs.gov/publications/text/understanding.html

Plate Tectonics and the Cause of Earthquakes: a well illustrated discussion of plate tectonics and the cause of earthquakes.
http://www.seismo.unr.edu/ftp/pub/louie/class/100/plate-tectonics.html

*CEEP (Crustal Evolution Education Project Modules*). National Association of Geology Teachers, 1996.
http://www.nagt.org/

Causes of earthquakes, volcanoes, and tsunamis with animations.
http://www.thirteen.org/savageearth/

Earthquakes.
http://www.thetech.org/hyper/quakes/intro/

Global Map of Earthquake Epicenters. MESTA, 98.02.
http://cires.colorado.edu/people/jones.craig/Eqimagemap/global.html

Landforms.
http://athena.wednet.edu/curric/land/landform/landform.html

Plate tectonics.
http://www.ucmp.berkeley.edu/geology/tectonics.html

Plate tectonics modules, hurricanes, El Nino, wind and ozone depletion. MESTA, 2000.1.
http://kids.earth.nasa.gov/

Seismological Laboratory.
http://www.seismo.unr.edu/htdoc/seismolab.html

Tectonics and ocean floor data. MESTA, 2000.1.
http://www.ngdc.noaa.gov/

Volcanoes.
http://volcano.und.nodak.edu/volcanoes.html

**Classroom Assessment Example SCI.V.1.HS.2**

Each student will be given a world map including epicenter locations along with magnitude and depth to hypocenter data. "Hypocenter" is a modern alternative to "focus," the place underground where the slippage actually began. The teacher will assign a particular plate to each student. The student will analyze that plate's boundaries and distinguish between tensional and compressional boundaries.

**Note:** A tensional plate boundary is characterized by shallow hypocenter, lower magnitude quakes. A compressional boundary involving an ocean plate is often a subduction zone where quakes are arranged in deepening bands under the continent and where magnitudes tend to be greater.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.1.HS.2**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Analysis of data** | Identifies one: either type of boundary, depth of hypocenters, or magnitudes. | Identifies two: boundary and either depth of hypocenters or magnitude. | Identifies all three: types of boundary, depth of hypocenters, and magnitude of quakes. | Identifies and explains with the aid of a diagram the relationships between type of boundary, depth of hypocenters, and magnitude of quakes. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 1. All students will describe the Earth's surface; describe and explain how the Earth's features change over time; and analyze effects of technology on the Earth's surface and resources. (Geosphere)

**Benchmark**
Explain how common objects are made from Earth materials and why Earth materials are conserved and recycled (SCI.V.1.HS.3).

**Benchmark Clarification**
Everything people make involves materials we have mined from the Earth. If people's livelihoods are dependent on the extraction of materials.(e.g., iron/copper mining in the UP and other ores in other parts of the world) then severe social and economic impacts are likely when these materials are depleted.

Students will:

- Investigate Earth's natural resources (*link to Glossary*), how they are used, and how they are limited
- Deduce the impacts when resources are depleted
- Explain how an individual's decisions involving consumption can have both a local and global impact

**Natural resources:** a useful material that is formed in nature without human involvement, includes non-renewable (i.e., used faster than natural rates of replacement, examples would be iron, coal, and aluminum) and renewable resources (used slower than natural rates of replacement, examples would be solar power, trees, and soils.

**Key Concepts (voc.)**
Valuable materials:

- minerals
- metallic ores
- iron
- copper
- aluminum
- fuels

Types of resources – renewable or non-renewable

Conservation
Limits
Recycling
Costs of developing more remote supplies

Manufacturing
Refining
Mining
Recycling Process

- melting
- shredding
- dissolving

**Real-World Context**

Manufacturing processes
Steel mills
Auto assembly lines
Paper making

Local recycling center for materials like

- glass
- plastic
- aluminum
- steel cans
- motor oil

Examples of technical and social means for slowing the depletion of Earth's resources such as developing more fuel-efficient cars, mandating their use; curbside recycling, tax on the use of fossil fuels, disposal in landfills and incinerators.

**Instructional Example SCI.V.1.HS.3**

**Benchmark Question:** How do we make things we use every day?
**Focus Question:** How is a common household or classroom object made? Include materials, processes, energy, and possible methods of recycling or conservation.

Each student will choose an object found in the classroom or the home. Students will do research using books, their local recycling center, local businesses, educational television, and/or videos **to determine how their object is made. Students will report their work in an oral, written, or visual (multimedia) format.**

**Constructing:** (*link to SCI.I.1.HS.4*), (*link to SCI.I.1.HS.5*).

**Reflecting:** (*link to SCI.II.1.HS.3*), (*link to SCI.II.1.HS.6*).

**Resources/References:**

Webliography.
**http://mtn.merit.edu/mcf/SCI.V.1.HS.3.html**

Journey of Garbage, from the Recycling Bin to the Store Shelf -
"Action packed show consisting of a series of demonstrations and activities that visually takes the audience on a journey of going through the processing of recyclables appropriate for use by high school students."
**http://www.muhs.edu/links/riverstudies/recycle.html**

Welcome to Recycle City-There's lots to do here - people and places to visit and plenty of ways to explore how the city's residents recycle, reduce, and reuse waste.
**http://www.epa.gov/recyclecity/mainmap.htm**

Municipal Solid Waste Factbook: U.S. EPA Student Center
**http://www.epa.gov/students/municipal_solid_waste_factbook.htm**

Garbage – How Can My Community Reduce Waste?
http://www.learner.org/exhibits/garbage/intro.html

Michigan Recycling Coalition.
http://www.Michiganrecycles.org

**Classroom Assessment Example SCI.V.1.HS.3**

Each student will create a written, oral, visual, or multimedia presentation including the following information:

1. How the chosen object is made from Earth materials
2. How the material is conserved and/or recycled
3. Location of mines
4. Chemical composition of resource
5. Physical form of ore (color, density of ore, and texture)

**(Give students rubric before activity.)**

**Scoring For Classroom Assessment Example SCI.V.1.HS.3**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Information on material** | Presents brief description of mine location(s) or form of material. | Describes mine location(s) or form of material. | Describes mine location(s) and in what form material is found. | Describes mine location(s), form of material, and geologic origin of ore. |
| **Processing of material** | Describes one: mining process, refining process, or forms of energy required. | Describes two: mining process, refining process, or forms of energy required. | Describes mining process, refining process, and forms of energy required. | Describes mining process, refining process, and forms of energy required at each step. |
| **Recycling/ conservation of material** | Describes methods of recycling or conservation. | Describes methods of recycling and conservation. | Describes methods of recycling, conservation, and alternative materials. | Describes methods and costs of recycling, conservation, and alternative materials. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 1. All students will describe the Earth's surface; describe and explain how the Earth's features change over time; and analyze effects of technology on the Earth's surface and resources. (Geosphere)

**Benchmark**
Evaluate alternative long-range plans for resource use and by-product disposal in terms of environmental and economic impact (SCI.V.1.HS.4).

**Benchmark Clarification**
Our knowledge is always limited and the long-term effects of the use of natural resources (*link to Glossary*) and their waste products on the environment may not be known at the time of use.

Students will:

- Research a natural resource:
  - the use of the natural resource
  - the disposal of by-products/wastes
- Assess the options involving the natural resource -their effect on the environment
- -their economic impact in the present
- -their economic impact in the future

**Key Concepts (voc.)**

- Understanding of limitations of knowledge and technology
- Side effects of resource use

See Technology *SCI.II.1.HS.2*.
See Risk/Benefit analysis *SCI.IV.1.HS.1*.
See New technologies *SCI.II.1.HS.5*.
See Air pollution *SCI.V.3.HS.4*.

**Real-World Context**
Industrial practices for mining, energy use, manufacturing, transportation, housing

Resources including fossil fuels, metals, wood, water

Pollution prevention and events:

- catalytic converters
- Love Canal
- tanning industry
- Superfund waste sites

**Instructional Example SCI.V.1.HS.4**

**Benchmark Question:** What is the long-range effect of the use and disposal of various natural resources?
**Focus Question:** What industries or practices are responsible for the production of hazardous wastes currently found in EPA Superfund sites in Michigan?

Each student will access the EPA website and determine the location, contents, cause, and economic impact of a specific site.
Each student will identify his or her Superfund site on a classroom map of Michigan and will share information about the site with the class as a whole.

**Note:** It is important for the teacher to help students realize that all disposal activities will have an impact, and that some practices currently considered "proper" may cause a problem for future generations.

**Constructing:** (*link to SCI.I.1.HS.1*).

**Reflecting:** (*link to SCI.II.1.HS.1*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.1.HS.4.html

HAZ-ED"Activities for grade levels 7-12 that focus on scientific, technical, and policy issues related to hazardous waste sites and Superfund."
http://www.epa.gov/superfund/students/clas_act/haz-ed/hazindex.htm

EPA Mapper of Toxic Release Sites: search the EPA's Toxic Release Inventory System (TRIS) by Zip Code.
http://maps.esri.com/esri/mapobjects/toxicweb/toxic.htm

EPA Office of Solid Waste information on recycling, reuse, and reduction strategies for reducing solid waste.
http://www.epa.gov/epaoswer/osw/

Sector Facility Indexing: EPA "information on compliance and inspection history, chemical releases and spills, demographics of the surrounding population and production for petroleum refining, iron and steel production, primary nonferrous metal refining and smelting, pulp manufacturing, and automobile assembly."
http://es.epa.gov/oeca/sfi/access.htm

Contaminated sites in Michigan.
http://www.deq.state.mi.us/erd/sites/misites.html

Great Lakes Areas of Concern.
http://www.great-lakes.net/teach/pollution/aoc/aoc.2.html

Great Lakes Information Network.
http://www.great-lakes.net/

Great Lakes National Program Office .
http://www.epa.gov/glnpo/us.epa/

**Classroom Assessment Example SCI.V.1.HS.4**

Each student will write a letter of inquiry to a local industry identified as a polluter on the EPA website and ask for information regarding pollution control methods they now employ to ensure compliance with EPA rules and regulations.

**Note:** It is suggested that the content portion of the rubric below be weighted at twice the value of the written or presentation portions.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.1.HS.4**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Effectiveness of presentation** | Explains topic with minimum understanding, little or no creativity, and no or poor visuals. | Explains topic with basic understanding, some creativity, and some visuals. | Explains topic with good understanding in a creative manner using visuals. | Explains topic with a thorough understanding in a creative manner using customized visuals. |
| **Content of presentation** | Meets one or two of the following accurately: identifies site, pollutant, pollution type, pollution control measures. | Meets any three of the following accurately: identifies site, pollutant, pollution type, pollution control measures. | Accurately identifies site, pollutant, pollution type, and pollution control measures. | Accurately identifies site, pollutant, pollution type, and explains pollution control measures. |
| **Correctness of letter (pass/fail)** | Uses correct grammar, business letter format, and clearly states request. | Uses correct grammar, business letter format, and clearly states request. | Uses correct grammar, business letter format, and clearly states request. | Uses correct grammar, business letter format, and clearly states request. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 2. All students will demonstrate where water is found on Earth; describe the characteristics of water and how water moves; and analyze the interaction of human activities with the hydrosphere . (Hydrosphere)

**Benchmark**
Identify and describe regional watersheds (SCI.V.2.HS.1).

**Benchmark Clarification**
Maps are commonly used to plan water management, evaluate potential disposal sites (*link to Glossary*), and analyze pollution events that concern both surface and ground water. Watersheds include many political jurisdictions such as counties, municipalities, and townships, which makes management difficult.

Students will:
- Outline local and regional drainage basins/ watersheds (*link to Glossary*) on maps
- Mark drainage divides on maps

**Disposal site:** a location where waste products can be stored with minimal risk of spreading through the environment

**Watershed**: an area of land, defined by a high point or drainage divide, that drains into a lower lying water body like a stream, river, lake, or ocean.

**Key Concepts (voc.)**
Drainage, basins, divides, reservoirs, tributaries, run-off.

Tools:
- maps

**Real-World Context**

Watershed examples:
- local and regional watersheds
- Great Lakes Basin
- Continental Divide

Activities:
- planning water management
- evaluating potential disposal sites
- analyzing pollution events that concern both surface and ground water

**Instructional Example SCI.V.2.HS.1**

**Benchmark Question:** What are the characteristics of the watershed in which you live?
**Focus Question:** On a map of your county, what are the major watershed(s)?

The teacher will provide each student with a map of their county. The class will identify the surface streams (rivers, creeks, etc.), lakes, and ponds.

Students will:

- Draw arrows on each stream indicating the direction of the flow of streams, lakes, and ponds
- Draw drainage divides (lines where water on either side of the divide line flows in different directions)
- Name watershed(s) according to the largest stream that flows out of the county
- Compare and contrast (using information from the internet) their watershed map with watersheds identified by the USGS database

**Suggestion:** Consider using Michigan county maps outside your district.

**Constructing:** (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.2.HS.1.html

Michigan Watershed Homepage
http://www.deq.state.mi.us/swq/watershd

Locate Your Watershed: discover watershed boundaries and water quality indicators for all of the United States.
http://www.epa.gov/surf2/

Surf Your Watershed.
http://www.epa.gov/students/surf_your_watershed.html

**Classroom Assessment Example SCI.V.2.HS.1**

Provided with a map of your county emphasizing the surface streams (rivers, creeks, etc.), lakes, and ponds, each student will complete the four tasks listed below:

1. Draw arrows on each stream indicating the direction of flow of streams, lakes, and ponds
2. Draw drainage divides (lines where water on either side of the divide line flows in different directions, to different watersheds)
3. Name watersheds according to the largest stream that flows out of the county
4. From the internet, compare/contrast your watershed map with watersheds identified by the USGS database

**Note:** A *stream* is a general name for all rivers, creeks, runs, tributaries, etc. A *tributary* is a stream that flows into another stream.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.2.HS.1**

**Note:** Because the map will be specific to the region, the total number of streams, drainage divides, and watersheds will vary. Therefore, specific numbers could not be indicated on the rubric but could be added at any time by a teacher to allow for adaptation to a specific area or region.

| Criteria | | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|---|
| **Completeness of contents** | | Meets one: identifies flow direction, divides, watersheds, matches USGS watershed boundaries. | Meets two: identifies flow direction, divides, watersheds, matches USGS watershed boundaries. | Meets three: identifies flow direction, divides, watersheds, matches USGS watershed boundaries. | Identifies flow direction, divides, watersheds, matches USGS watershed boundaries. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 2. All students will demonstrate where water is found on Earth; describe the characteristics of water and how water moves; and analyze the interaction of human activities with the hydrosphere . (Hydrosphere)

**Benchmark**
Describe how human activities affect the quality of water in the hydrosphere (SCI.V.2.HS.2).

**Benchmark Clarification**
Students will identify the activities (waste disposal, use of pesticides, herbicides, thermal pollution (*link to Glossary*) that often negatively affect groundwater, lakes, and streams. Using their awareness of water movement, students will:

- Predict how human activities at one location often have adverse affects on other locations
- Compare, contrast, and evaluate various methods of purifying water

**Thermal pollution:** increasing or decreasing temperature in an ecosystem, etc.

**Key Concepts (voc.)**
Human activities:

- agriculture
- fishing
- manufacturing
- energy production

Limits to natural resources

Quantity of water:

- rate of use
- urbanization

Oceans:

- oil spills
- garbage
- ocean life
- global warming
- marine life

Fresh water:
- industrial waste disposal
- agricultural run-off
- herbicides
- pesticides
- pollution
- sewage
- acid rain
- nutrient levels

Ground water:
- landfills
- leaching
- disposal of toxic wastes

Purification technology:
- filtering
- chlorination

**Real-World Context**
Examples of local and regional human activities that have measurable effects on water:
- farming
- industry
- sewage disposal
- toxic waste disposal

**Instructional Example SCI.V.2.HS.2**

**Benchmark Question:** How does water quality change as a stream flows from its headwaters through its watershed?
**Focus Question:** How does the water quality at the source of a stream compare to the water quality at the mouth of the stream?

The teacher will review with students the standard techniques of water quality sampling and the meaning of each test. The teacher will choose a local stream that can be easily sampled in two or more places as far apart as possible.

Students will collect water samples and analyze them using standard water sampling techniques (water quality testing kits are commonly available).
Students will compare and contrast water quality data between sampling sites and develop reasonable hypotheses to account for their differences.

Note: Students need to know the difference between point and non point pollution (point pollution is a discernable source of water pollution like a pipe versus non point pollution which is a diffuse source of pollution where contaminants enter water bodies from thousands of different points. Examples of non-point pollution would be agricultural fields, building sites, and aerial deposition of contaminants) Environmental clean up efforts have been more successful with point sources of pollution because these sources are easily identified. It is more of a challenge to control agricultural runoff or stop an adjacent state from creating air pollution that will fall as acid rain.

Acid deposition includes rain as well as snow, sleet, dust, and hail, which are significant sources of acids in the environment

**Extension:** Students could also identify the human activities on the stream located between the sampling sites that could affect water quality changes.

**Constructing:** (*link to SCI.I.1.HS.1*).

**Reflecting:** (*link to SCI.II.1.HS.1*).

**Resources/References:**

Webliography.
**http://mtn.merit.edu/mcf/SCI.V.2.HS.2.html**

Locate Your Watershed: discover watershed boundaries and water quality indicators for all of the United States.
**http://www.epa.gov/surf2/**

National Water Quality Information Project: a summary of local water-quality issues and findings on nutrients, pesticides, volatile organic compounds, radon, and suspended sediment in ground water and surface water; and semivolatile organic compounds, organochlorine compounds, and trace elements in bed sediment and aquatic biota.
**http://water.usgs.gov/pubs/nawqasum/index.html**

Water Quality Conditions in the U.S.: 1998 Report to Congress: how much progress has the nation made in cleaning up its waters? Find out here. Fact sheets for individual states are also available.
**http://www.epa.gov/305b/98report/**

Lake Michigan Management Plan: from the EPA, how to preserve the integrity of the Lake Michigan ecosystem (Adobe Acrobat format).
http://www.epa.gov/grtlakes/lakemich/index.html

Amount and location of water, water use . MESTA, 2000.1 .
http://ga.water.usgs.gov/edu/

Everyone Is against Water Pollution.
http://www.geocities.com/RainForest/5161/water1.htm

Stapp, William. *Field Guide to Water Quality Testing*. Thomson-Shore Printers, 1990.

Surf Your Watershed.

http://www.epa.gov/student_your_watershed.html

**Classroom Assessment Example SCI.V.2.HS.2**

The teacher will provide each small group with a map of an unfamiliar watershed that notes industries, farms, and any other point sources of pollution. The students will be given the following scenario:

*Imagine that a large concentration of a single pollutant (e.g., DDT, mercury, liquid agricultural waste, etc.) is released into the environment at a single point in the watershed.*

What effects will the pollutant have?

Each group will trace the flow of pollutants, predict concentration levels, and describe the impact the pollutant might have on living things at different locations in the watershed. Each group will present this information to the class.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.2.HS.2**

| Criteria | | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|---|
| **Completeness of presentation** | | Explains all components, but all are incomplete: downstream flow, pollutant concentration downstream, and impact on living organisms downstream. | Explains one component, leaving two incomplete: downstream flow, pollutant concentration downstream, and impact on living organisms downstream. | Explains two components, leaving one incomplete: downstream flow, pollutant concentration downstream, and impact on living organisms downstream. | Explains all components: downstream flow, pollutant concentration downstream, and impact on living organisms downstream. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 3. All students will investigate and describe what makes up weather and how it changes from day to day, from season to season, and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere . (Atmosphere and Weather

**Benchmark**

Explain how interactions of the atmosphere, hydrosphere, and geosphere create climates and how climates change over time (SCI.V.3.HS.1).

**Benchmark Clarification**

Climate is the average condition of the atmosphere usually taken over ten or more years. Many factors influence climate (temperature, precipitation) and cause it to change over time. Students will:

- Explain how each of the following contributes to the creation of distinct regional climates:
    - the angle of the Sun's rays (which varies with latitude)
    - the uneven heating of the geosphere (*link to Glossary*), hydrosphere (*link to Glossary*), and atmosphere (*link to glossary*)
    - differences in global circulation of air and ocean currents
    - altitude and position of landforms

**Geosphere:** the portion of the Earth characterized by rocky material

**Hydrosphere:** the portion of the Earth characterized by liquid water

**Atmosphere:** the portion of the Earth characterized by a mixture of gases

**Key Concepts (voc.)**

- average yearly temperatures
- ice ages
- volcanic dust in atmosphere
- greenhouse effect
- global air circulation
- effects of latitude
- effects of mountain barriers
- effects of large bodies of land or water
- ocean currents

**Real-World Context**

Evidence of short-term climate changes:

- catastrophic volcanic eruptions
- impact sun spot activity

Evidence of long-term climate changes:

- ice ages
- global warming
- El Nino and La Nina

**Instructional Example SCI.V.3.HS.1**

**Benchmark Question:** What changes in the atmosphere, hydrosphere, and geosphere cause climates to change?
**Focus Question:** How does the altitude of the Sun and the length of the day affect regional climates (especially temperature)?

The teacher will review with students how to estimate the following information:

- the altitude of the Sun using one of the several methods (protractor/weight, transparent plastic dome, etc.)
- the length of the day

Twelve groups of students (arranged by month) will determine the length of the day and the Sun's altitude for four different locations (local, equatorial, Tropic of Capricorn, Tropic of Cancer) on the twenty-first day of each month. Students will plot the altitude and length of day calculations for the entire year on a classroom graph for each location. Each student will compare the graphs and predict how the altitude of the Sun and the length of the day each affect the climate.

(**Extension:** an area near the Arctic or Antarctic Circle could be used.)

**Constructing:** (*link to SCI.I.1.HS.1*), (*link to SCI.I.1.HS.4*), (*link to SCI.I.1.HS.5*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.3*).

**Resources/References:**
Webliography.
**http://mtn.merit.edu/mcf/SCI.V.3.HS.1.html**

Sunrise/Sunset Calculation Program-calculate the sunrise/sunset for anywhere in the world
**http://aa.usno.navy.mil/AA/data/**

Milankovich Cycles: "Milankovich cycles are cycles in the Earth's orbit that influence the amount of solar radiation striking different parts of the Earth at different times of year. He explained how these orbital cycles cause the advance and retreat of the polar ice caps.
**http://deschutes.gso.uri.edu/~rutherfo/milankovitch.html**

Athropolis: tabular display for  hours of daylight/twilight for Arctic locations.  Discover that there are over 2 hours of daylight at the Arctic Circle on Dec. 21, dispelling the misconception that there is 24 hours of darkness at all high latitudes.
http://www.athropolis.com/sun-fr.htm

*Climate Summaries of the Midwest*. MESTA, 98.5.
http://mcc.sws.uiuc.edu/Summary/index.html

*FAO World Climate Maps*. MESTA,.98.5.
http.www.fao.org/WAICENT/FAOINFO/sustdev/Eldirect/climate/Essptext.html

*For Kids Only – Earth Science Enterprise.* MESTA, 00.1.
http://kids.earth.nasa.gov/

Geosciences – atmosphere and  weather.
http://www.covis.nwu.edu/geosciences/resources/

*Hunter's Guide.* Michigan DNR,2000.

*NASA's Earth Observatory*. MESTA 1999.5, 1999.4.
http://earthobservatory.nasa.gov/

*National Climate Data*. National Climatic Data Center. Federal Building, Asheville, NC 28801.

*NOAA Paleo-Global Warming Page.* MESTA, 00.1.

*Photographers Almanac.*
http://www.ngdc.noaa.gov/paleo/globalwarming/sitemapgw.html

Regional climates.
http://faldo.atmos.uiuc.educ/w_unit/LESSSONS/regional.climates.html

Resources for Geography and Earth Science.
http://personal.cmich.edu/~Franc1m/homepage.htm

Weather Channel.

**Classroom Assessment Example SCI.V.3.HS.1**

The teacher will present the following scenario to the class:

*Assume that the Earth's rotational axis is tilted so that the North Pole always directly faces the Sun.*

Each student will write a list of predictions that describe the altitude of the Sun, the length of the day, seasonal changes, and temperature conditions that would result on such an Earth.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.3.HS.1**

| **Criteria** | | **Apprentice** | **Basic** | **Meets** | **Exceeds** |
|---|---|---|---|---|---|
| **Predictions of changes** | | Predicts one component: altitude of the Sun, length of the day, seasonal changes, and temperature conditions. | Predicts two components but leaves two incomplete: altitude of the Sun, length of the day, seasonal changes, and temperature conditions. | Predicts three components but leaves one incomplete: altitude of the Sun, length of the day, seasonal changes, and temperature conditions. | Predicts all four components: altitude of the Sun, length of the day, seasonal changes, and temperature conditions. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 3. All students will investigate and describe what makes up weather and how it changes from day to day, from season to season, and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere. (Atmosphere and Weather)

**Benchmark**
Describe patterns of air movement in the atmosphere and how they affect weather conditions (SCI.V.3.HS.2).

**Benchmark Clarification**
Patterns of air movement in the atmosphere affect weather conditions. Air motion is caused by differences in pressure, density, and temperature.
When air moves vertically, clouds may result.
Horizontal motion of air (wind) is altered by the rotation of the Earth/Coriolis Effect (*link to Glossary*). Fronts are often areas of storminess caused by the interaction of air masses.
Surface weather patterns are guided by the jet stream (an upper level wind moving across the U.S. from west to east).

Students will:
- Explain how changes in the weather result from the movement of air masses

**Coriolis Effect:** the apparent deflection of moving objects above the geosphere into curved paths caused by the rotation of the Earth

**Key Concepts (voc.)**
Air movement:
- air masses
- fronts
- pressure systems
- prevailing winds
- jet stream

**Real-World Context**
Reports of local weather patterns influenced by:
- jet stream
- prevailing winds

**Instructional Example SCI.V.3.HS.2**

**Benchmark Question:** How do horizontal motions of the air vary and contribute to the type of weather ?
**Focus Question:** How does the wind direction vary in your community?

The teacher will review with students that winds are named according to the direction from which they come. A north wind, for example, comes from the north!
Students will work with a partner and use a packet of wind data from the weather service to plot the data on a frequency graph e.g., a wind rose diagram (*link to Glossary*) to determine the general pattern.
Students will use weather map data from newspapers, the internet, or the weather channel to determine which direction large weather systems generally move across the United States.
In a paragraph, each student will explain how local wind data is related to the motion of large weather systems across the United States.

**Wind rose diagram:** a circular histogram showing how frequently wind comes from a given direction

**Constructing:** (*link to SCI.I.1.HS.3*), (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.3*).

**Resources/References*:***

Webliography.
http://mtn.merit.edu/mcf/SCI.V.3.HS.2.html

Michigan Weather Conditions: most current weather reports and forecasts from Michigan's weather stations.
http://www.wunderground.com/forecasts/MI.html

Surface Weather Map from Intellicast-see the location of pressure zones, fronts, precipitation, and isobars.
http://www.intellicast.com/LocalWeather/World/UnitedStates/SurfaceAnalysis/

U.S. Wind Statistics: where is the wind, on average blowing hardest in the U.S.? What is the mean direction? Find out here.
http://www.ems.psu.edu/wx/usstats/windstats.html

The Wind Air in Motion: succinct primer on the causes and characteristics of wind.
http://www.intellicast.com/DrDewpoint/wx101/1099Wind/

Coriolis Force:animation and explanation of the Coriolis force.
http://www.windpower.dk/tour/wres/coriolis.htm

U.S. Pressure Statistics: discover the highest and lowest atmospheric pressure currently reported in the U.S.
http://www.ems.psu.edu/wx/usstats/pressstats.html

Does Weather Happen Randomly?
http://169.207.3.68/~rlevine/Weathr20.html

Convection currents.
http://www.exploratorium.edu/snacks/convection_curents.html

Earth Science Dictionary
http://www.netcore.ca/~gibsonjs/dict1g.html

Nearest NOAA Weather Station for wind data.
University of Michigan Weather Underground.
http://groundhog.sprl.umich.edu/

Weather Channel.

**Classroom Assessment Example SCI.V.3.HS.2**

The teacher will present the following scenario to the class:
*A group of meteorology students has already completed a study in which they compare the wind direction and temperature of many cities before and after a cold front passes. They wish to display their wind direction data on a wind rose diagram.*

Each student will draw a likely wind rose diagram for all of those cities before the front passes and after the front passes. Each student will write a prediction of what changes in temperature might be expected due to a change in wind direction caused by the passage of the front.

**(Give students rubric before activity.)**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Identification of wind direction before and after the front** | Identifies change in wind direction with an incorrect compass direction(s). | Identifies wind direction before or after front passage. | Identifies wind direction before (S-SW) and after (NW-N) front passage. | Identifies wind direction before (S-SW) and after (NW-N) front passage. |
| **Drawing of wind rose diagram before and after the front passes** | Names compass direction. | Names compass direction and identifies wind direction. | Names compass direction and identifies wind direction and wind duration. | Names compass direction, identifies wind direction and duration, and explains effect of frontal speed on wind duration. |
| **Accuracy of predictions** | Associates either change in wind or change in temperature with frontal passage. | Associates change in wind direction with temperature change (incorrect association). | Associates change in wind direction with changes in temperature (S-SW = warmer, N-NW = cooler). | Associates change in the wind direction with changes in temperature and explains how speed of frontal movement alters changes in wind direction and temperature. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 3. All students will investigate and describe what makes up weather and how it changes from day to day, from season to season, and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere. (Atmosphere and Weather)

**Benchmark**
Explain general weather patterns and predict storms (SCI.V.3.HS.3).

**Benchmark Clarification**
Middle school focuses on measuring weather parameters (wind direction and speed, temperature, cloud cover, dew point, etc.) and discovering patterns. High school advances these concepts and explains the causes of weather phenomena.

Storms are related to rapidly rising air that is common along fronts but also occurs in other circumstances.

Students will:

- Explain air movements associated with fronts and pressure systems
- Explain that warm and cold fronts are part of larger air circulations
- Explain the relationship between weather variables and frontal speed to the degree of storminess

**Key Concepts (voc.)**
Weather patterns:

- cold front
- warm front
- stationary front
- air mass
- high and low pressure systems

See Buoyancy/Density *SCI.IV.1.MS.1*.
See Thermal expansion *SCI.IV.2.MS.1*.
See Satellite and radar monitoring *SCI.IV.4.HS.4*.

Storms:

- thunderstorms
    - lightning
    - thunder
- tornadoes
- hurricanes
- high winds and wind chill
- blizzards

Tools:

- weather maps
- thermometer
- hygrometer
- anemometer
- wind vane
- rain gauge
- satellite and radar monitoring

**Real-World Context**

Observable daily weather patterns:

- examples of weather reports from:
    - tv
    - radio
    - newspapers
    - world wide web
- representations on weather maps

Reports of local weather patterns influenced by the jet stream and prevailing winds

**Instructional Example SCI.V.3.HS.3**

**Benchmark Question:** How can weather and storms be explained using common features found on a weather map?
**Focus Question:** How does the location of "tornado alley" migrate during spring and summer months in North America?

The teacher should review the prior knowledge concepts of cold fronts, especially the rapid rising warm air at the leading edge of advancing colder air as a major cause of severe storms that could develop into tornadoes. The teacher should also discuss how variations in temperature, humidity, and mountain ranges orientations impact the frequency of tornadoeson each continent.

Students will work in pairs and use monthly tornado frequency maps to identify changes in the position of maximum tornado occurrence.

Students will observe average monthly temperature maps in the United States and note that the temperature gradient (change) is greater in the winter than it is in the summer. For example, the average monthly temperature of two selected cities (for example, Detroit and Dallas) could be compared during the year. Each student will explain the migration of tornado alley in a paragraph.. In a paragraph, each student will explain that mountain ranges and their orientations have a definite effect on the frequency of tornadoes on each continent.

**Constructing:** (*link to SCI.I.1.HS.1*), (*link to SCI.I.1.HS.3*).

**Reflecting:** (*link to SCI.II.1.HS.4*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.3.HS.3.html

National Severe Storms Laboratory: access current research efforts with Radar, Satellite, Software Development, Modeling, Tornadoes, Thunderstorms, Damaging Winds, Lightning, Hail,Winter Weather, Flooding.
http://www.nssl.noaa.gov/

Does Weather Happen Randomly?
http://169.207.3.68/~rlevine/Weathr20.html

Geosciences/Atmosphere.
http://www.covis.nwu.edu/geoscience/resources/

Michigan Forecast Center.
http://www.crh.noaa.gov/dtx/start.html

Tornado Alley.
http://www2010.atmos.uiuc.edu/(Gh)/guides/mtr/home.rxml

University of Michigan weather.
http://groundhog.sprl.umich.edu/

**Classroom Assessment Example SCI.V.3.HS.3**

Students should be grouped by continents and will view a world map showing major landforms. Each group will prepare a short speech explaining why there are fewer tornadoes on other continents than on the Great Plains of North America.

**(Give students rubric before activity.)**

## Scoring of Classroom Assessment Example SCI.V.3.HS.3

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Accuracy of interpretation** | Provides inadequate interpretation of the effect of east/west blocking mountains, suitable air mass source regions, movements of air masses, and degree of difference in air masses. | Provides basic interpretations of the effect of east/west blocking mountains, suitable air mass source regions, movements of air masses, and degree of difference in air masses. | Provides good interpretations of the effect of east/west blocking mountains, suitable air mass source regions, movements of air masses, and degree of difference in air masses. | Provides a thorough and accurate interpretation of the effect of east/west blocking mountains, suitable air mass source regions, movements of air masses, and degree of difference in air masses. |

**Strand:** V. Use Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 3. All students will investigate and describe what makes up weather and how it changes from day to day, from season to season, and over long periods of time; explain what causes different kinds of weather; and analyze the relationships between human activities and the atmosphere . (Atmosphere and Weather)

**Benchmark**
Explain the impact of human activities on the atmosphere and explain ways that individuals and society can reduce pollution (SCI.V.3.HS.4).

**Benchmark Clarification**
Air pollution comes from a variety of sources. Industrial emissions are a major factor. Students will:

- Identify those industries that are major contributors to air pollution
- Analyze the general impact that corrective measures would have on the polluting industry and the cost of their products
- Give examples of how their daily activities can both positively and negatively affect air quality
- Identify how their decisions impact air quality
-

**Note:** While outdoor air pollution is important and should be studied, there really needs to be more focus on the origin, characteristics, and health effects of indoor air pollution given that we spend 90% of our time indoors. See website under resources.

**Key Concepts (voc.)**
Air pollution:

- car exhaust
- industrial emissions
- smog

See Resource use *SCI.V.1.HS.4*.

Related effects:

- breathing problems
- acid rain
- enhanced global warming
- deforestation
- ozone depletion

**Real-World Context**

Examples of human activities that affect the atmosphere, including use of aerosol spray cans, discharge from smoke stacks, car exhaust, burning leaves and wood in stoves and fireplaces, climate change, global warming

Actions including:

- turning off lights
- turning down heat
- tuning up cars
- filling tires
- driving at consistent speeds
- mandating higher fuel efficiency
- energy saving from recycling

## Instructional Example SCI.V. 3. HS.4

**Benchmark Question:** What human activities produce pollution and how can we control air quality?

**Focus Question:** What industries in my area affect air quality? What are their effects on the environment?

After a discussion of various kinds of air pollution, each student will do the following:

- Use the internet or other resources to help identify local sources of air pollution.
- Determine the identity of the pollutants present and their effect on the environment.
- Propose possible remedies to the problem.
- Share their information with members of the class.

**Constructing:** (*link to SCI. I.1.HS.1*), (*link to SCI.I.1.HS.4*), (*link to SCI.I.1.HS.5*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.4*), (*link to SCI.II.1.HS.5*), (*link to II.1.HS.6*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.3.HS.4.html

Indoor Air Quality in Schools: describes the problem and outlines strategies for improving air quality. Links to radon pollution are also available.
http://www.epa.gov/iaq/schools/

EPA's national air quality trends: "This is the twenty-fourth annual report on air pollution trends in the United States issued by the U.S. Environmental Protection Agency."
**http://www.epa.gov/oar/aqtrnd96/general.html**

Deposition of Air Pollutants to the great lakes: in accordance with the Clean Air Act, the EPA "... focuses on research and activities in specific water bodies to further understand and promote reductions of overall contaminant loadings to the Great
Waters."
**http://www.epa.gov/oar/oaqps/gr8water/3rdrpt/**

EPA Air Web Page: access maps summarizing EPA air pollution data.
http://www.epa.gov/airsweb/mapview.htm

Causes and effects of climatic and environmental change through the use of satellite data.
MESTA,00.1
http://earthobservatory.nasa.gov/

Does Weather Happen Randomly?
http://169.207.3.68/~rlevine/Weathr20.html

Great Lakes Information Network.
http://www.great-lakes.net/

Model of the air pollution study.
http://edweb.sdsu.edu/webquest/

**Classroom Assessment Example SCI.V.3.HS.4**

The teacher will present the following scenario:

*A company that offers many jobs and other economic benefits makes a presentation to a community to get support to build a factory within that community. The factory will produce airborne pollutants (e.g., particulates, nitrogen oxides, sulfur oxides, ozone, etc.).*

Working in small groups, students will develop a list of pros and cons as to whether this industry is a viable addition to their community. Each pro and con listed must be described. Possible health effects of the pollutants must be described. Each group will provide a recommendation as to whether the factory should be allowed in their community and the reasons for the recommendation..

**Note:** Teachers may select one or more specific industries that may be realistically located in the students' community. Already developed realistic scenarios are available on the web.

**(Give students rubric before activity.)**

## Scoring of Classroom Assessment Example SCI.V.3.HS.4

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Correctness of pollutant identification** | Identifies pollutants and/or health effects poorly. | Identifies most pollutants and/or health effects correctly. | Identifies all pollutants and/or health effects correctly. | Identifies all pollutants and/or explains resulting health effects correctly. |
| **Correctness of positive aspects** | Identifies some pros. | Identifies most pros. | Identifies all pros. | Identifies and explains all pros. |
| **Correctness of negative aspects** | Identifies some cons. | Identifies most cons. | Identifies all cons. | Identifies and explains all cons. |
| **Completeness of recommendation** | Recommends a course of action without support. | Recommends a course of action with some support. | Recommends a course of action with good support. | Recommends a well-supported course of action. |

**Strand:** V. Using Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 4. All students will compare and contrast our planet and Sun to other planets and star systems; describe and explain how objects in the solar system move; explain scientific theories as to origin of the solar system; and explain how we learn about the universe. (Solar System, Galaxy, and Universe)

**Benchmark**
Compare our sun to other stars (SCI.V.4.HS.1).

**Benchmark Clarification**
Our Sun is just a small star in space. Scientists measure characteristics of stars: temperature, color, size, apparent brightness (*link to Glossary*), and absolute brightness (*link to Glossary*).

Students will:
- Explain why the Sun is a star
- Compare and contrast the Sun with other stars
- Deduce that the Sun is not an unusual star based on common star characteristics

**Apparent brightness:** the brightness of an object as it appears from Earth

**Absolute brightness:** how bright a star would be compared to other stars at a distance of 32.6 light years

**Key Concepts (voc.)**
Temperatures
Colors and sizes
Apparent and absolute brightness
Double stars

**Real-World Context**
Observing color and brightness of stars
Observing double stars

**Instructional Example SCI.V.4.HS.1**

**Benchmark Question:** How does our Sun rate as a star?
**Focus Question:** How are stars compared to each other?

The teacher should review with students the ideas of measuring a star's magnitude (brightness) and the relationship between temperature and a star's color. The teacher should provide students with a data table listing a minimum of twenty different stars of different types, with their brightness and temperature.

Each student should plot each star on a graph. There are many different ways to make such a graph, and students should have the opportunity to set it up their own way. Hertzsprung-Russell diagrams are commonly set up with magnitude (brightness) on the vertical axis and temperature on the horizontal with highest on the left. The Sun's position on the graph compared to other stars should be observed and discussed.

**Constructing:** (*link to SCI.I.1.HS.3*), (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.4*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.4.HS.1.html

Your Sky: a useful resource for obtaining sky maps for "any time and date, viewpoint, and observing location. Each map is accompanied by an ephemeris for the Sun, Moon, planets, and any tracked asteroid or comet. A control panel permits customization of for magnitudes, color, image size, and other parameters."
http://www.fourmilab.to/yoursky/

NASA's Photo Gallery: a valuable site attempting to bring all of NASA's still imagery into one site.
http://antwrp.gsfc.nasa.gov/apod/archivepix.html

NASA's JPL website & Mars education models.
http://marsnt3.jpl.nasa.gov/

NASA's Observatorium. MESTA, 99.3.
http://observe.ivv.nasa.gov/

Stanford Solar Center. MESTA, 98.2.
http://solar-center.stanford.edu/

Virtual Sun.
http://www.michielb.nl/sun/kaft.html

**Classroom Assessment Example SCI.V.4.HS.1**

The teacher will give each student a list of characteristics for five unnamed stars. The student will plot the position of each star on the H-R (Hertzsprung-Russell) diagram. The student will construct a data table and classify each according to size (dwarf, average, giant, supergiant) and color (white, yellow, red.) based on their location on the H-R diagram.

The student will write a prediction that answers the question, "Which of the stars is most likely to be the Sun?"

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.4.HS.1**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Correctness of diagram** | Plots one to two stars correctly. | Plots three stars correctly. | Plots four stars correctly. | Plots five stars correctly. |
| **Correctness of classification** | Classifies one to two stars. | Classifies three stars. | Classifies four stars. | Classifies five stars. |
| **Correctness of prediction** | Does not locate Sun on main sequence. | Locates Sun on main sequence with proper magnitude or temperature. | Locates Sun on main sequence with proper magnitude and temperature. | Locates Sun on main sequence with proper magnitude and temperature and compares its size and temperature to other stars on the diagram. |

**Strand:** V. Using Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 4. All students will compare and contrast our planet and Sun to other planets and star systems; describe and explain how objects in the solar system move; explain scientific theories as to origin of the solar system; and explain how we learn about the universe. (Solar System, Galaxy, and Universe)

**Benchmark**
Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe (SCI.V.4.HS.2).

**Benchmark Clarification**
Our solar system is located on one spiral arm of the slowly rotating Milky Way Galaxy, closer to the edge of the galaxy than the center. The universe consists of billions of galaxies. Like our solar system there is also structure and organization to our galaxy and the universe, but on a much larger scale with distances measured in light years.

Students will:
- Explain how spectral observations (red shift) have led to the theory of the big bang, which explains the origin and the age of the universe

**Key Concepts (voc.)**
Stars
Galaxies
Milky Way
Spiral structure
Speed of light
Light year
Travel miles
Big Bang
Red shift

Tools:
- telescopes
- binoculars
- spectroscopes

**Real-World Context**
Observations of other stars:
- star clusters
- nebulas
- galaxies
- potential planetary systems

Accounts of possible travel to other star systems

**Instructional Example SCI.V.4.HS.2**

**Benchmark Question:** Where are we?
**Focus Question:** How do scientists determine how objects are moving in space?

The teacher will review the Doppler Effect with students and one or more demonstrations using sound or water. The teacher will review a light spectrum and remind students that in the visible spectrum, red light is a longer wavelength and lower frequency.

The teacher will provide students with a reference spectrum of an element, which is available in most physics or astronomy texts.

Students will compare the wavelength of characteristic lines from the reference spectrum with those same lines in the spectrum of a star. With a partner, they will calculate the amount and direction of the wavelength shift in the star.

Students will determine the direction of relative movement by noting the direction of wavelength shift (red = moving away, blue = moving toward).

Students will determine the relative speed of the object by comparing the size of the wavelength shift (larger shift = faster moving).

**Constructing:** (*link to I.1.HS.1*), (*link to I.1.HS.3*), (*link to I.1.HS.4*), (*link to I.1.HS.5*).

**Reflecting:** (*link to II.1.HS.1*), (*link to II.1.HS.2*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.4.HS.2.html

Astronomy Picture of the Day Archive: features a new image daily and an accompanying description.
http://antwrp.gsfc.nasa.gov/apod/archivepix.html

Pictures from the Hubble Space Telescope: features many pictures of stellar bodies outside the solar system.
http://www.stsci.edu/pubinfo/Pictures.html

Education Constellation Quiz.
http://www.mtwilson.edu/Education/ConQuiz/

Hamilton, Calvin. *Views of the Solar System CD-ROM.* NSTA, 1996.

NASA's Observatorium . MESTA,1999.3.
http://www.observe.gsfc.nasa.gov/

NASA's Structure and Evolution of the Universe. MESTA, 1999.2.
http://www.universe.gsfc.nasa.gov/

*Project SPICA: A Teacher Resource To Enhance Astronomy Education.* Kendall/Hunt Publishing, 1995.

Solar system, Galaxy and Universe.
http://www.astro.wisc.edu/~doaln/constellations/constellations.html

University of Illinois- Cosmos in a Computer. MESTA,1999.2.
http://www.ncsa.uiuc.edu/Cyberia/EXPO.directoy.html

**Classroom Assessment Example SCI.V.4.HS.2**

A student in the future has just completed the Doppler shift lab in school and has rushed home to get on the family's spaceship to go away for the weekend. Shortly after departure, the student realizes that he or she may have left the sodium reference light on when leaving the lab. Upon aiming the spectroscope back toward school, the discovery is made that the sodium lamp is indeed on.

Given the drawing of the sodium reference spectrum that the student has just completed in the lab, how would the sodium spectrum observed from the rapidly moving spaceship compare? Explain. (Hint: Include a diagram in your explanation.)

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.4.HS.2**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Accuracy of diagram** | Proposes red shift. | Proposes red shift using a diagram. | Proposes red shift using a diagram and indicates that objects are moving away from each other. | Proposes red shift using a diagram, indicates that objects are moving away from each other, and explains the relationship between the amount of shift and the relative speed. |

**Strand:** V. Using Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 4. All students will compare and contrast our planet and Sun to other planets and star systems; describe and explain how objects in the solar system move; explain scientific theories as to origin of the solar system; and explain how we learn about the universe. (Solar System, Galaxy, and Universe)

**Benchmark**
Explain how stars and planetary systems form and how stars produce energy (SCI.V.4.HS.3).

**Benchmark Clarification**
Based on atomic theory, scientists have explained how stars and planetary systems formed. They have also explained how stars produce energy. Heavy elements are formed as a result of fusion during supernova explosions; a series of these explosions over time has spread heavy elements randomly throughout the universe. Fusion in our Sun, a stable- state, main-sequence star, could not have created the heavy elements found in the solar system.
Stars and planets may be formed by the random coalescence (accretion from collisions) of elements or by gravitational attraction.

Students will:

- Explain how the gravitational collapse (*link to Glossary*) of a cloud of gas and dust produces extreme pressure and temperature that triggers nuclear fusion
- Explain how smaller atoms combine to make larger ones during nuclear fusion, release large quantities of energy, and form a star
- Explain how heavy elements have been spread throughout the universe
- Explain how components of a solar system may be formed

**Gravitational collapse:** the contraction of a star or a cloud of dust or gas due to a stronger gravitational pull from the center of the contracting object

**Key Concepts (voc.)**
Processes of formation:

- coalescence from clouds of dust and gases by gravity
- explosions of stars producing heavy elements
- explosions of stars producing heavy elements:
    - hydrogen
    - helium

Production of energy
- fusion
- radiation

Planetary systems may form during this process
Heavy and light elements
Hot interiors of Earth-like planets

Age of the solar system

**Real-World Context**
Nebulas considered to be star-forming regions

Supernovas

Nuclear fusion research

**Instructional Example SCI.V.4.HS.3**

**Benchmark Question:** What star processes are responsible for generating both energy and planetary systems?
**Focus Question:** What happens to mass when hydrogen atoms combine to make helium?

The teacher should review with students the process of nuclear fusion, during which heavier elements are made from lighter ones. One form of fusion involves two protons (hydrogen nuclei) and two neutrons combining to make one helium atom, a process that takes place at very high temperatures in the cores of stars.

Mass of 1 proton = 1.01 amu (atomic mass units).
Mass of 1 neutron = 1.01 amu (atomic mass units).

Students will look up the atomic mass of helium on the periodic table (He = 4.00 amu).
Students will determine the number of hydrogen atoms that combine with two neutrons to make one helium atom.
By calculation, students will compare the mass of the two hydrogen atoms and two neutrons to the mass of a single helium atom.
Students should answer the question, “Where did that mass go?”

**Note:** Mass is converted to the energy that powers the star.

**Constructing:** (*link to SCI.I.1.HS.2*), (*link to SCI.I.1.HS.4*).

**Reflecting:** (*link to SCI.II.1.HS.1*).

**Resources/References:**

Webliography.
http://mtn.merit.edu/mcf/SCI.V.4.HS.3.html

Astronomy Picture of the Day Archive: features a new image daily and an accompanying description.
http://antwrp.gsfc.nasa.gov/apod/archivepix.html

Pictures from the Hubble Space Telescope: features many pictures of stellar bodies outside the solar system.
http://www.stsci.edu/pubinfo/Pictures.html

NASA- Observatorium . MESTA, 1999.3.
http://observe.ivv.nasa.gov/

Origin of the solar system.
http://hermes.astro.washington.edu/mirros/nineplanets/origin.html

Periodic Table.

Virtual Sun.
http://www.michielb.nl/sun/kaft.html

**Classroom Assessment Example SCI.V.4.HS.3**

The only known life in our universe is carbon-based. Carbon has an atomic mass of 12 amu. Each student will write an essay and answer the following questions:

- By what process could a larger atom-like carbon have formed?
- Which two combinations of lighter elements could explain the formation of carbon?

**(Give students rubric before activity.)**

### Scoring of Classroom Assessment Example SCI.V.4.HS.3

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Accuracy of description** | Describes fusion as a process that produces energy. | Describes fusion as a process that produces energy in stars. | Describes fusion as a process that produces energy in stars and forms heavier elements from lighter ones. | Describes fusion as a process that produces energy in stars and forms heavier elements from lighter ones with a loss in mass. |
| **Accuracy of data** | Selects mass numbers from the periodic table. | Selects a pair of atoms smaller than carbon. | Selects one pair of atoms whose atomic masses add up to 12 amu. | Selects two different pairs of atoms whose atomic masses add up to 12 amu. |

**Strand:** V. Using Scientific Knowledge from the Earth and Space Sciences in Real-World Contexts

**Content Standard:** 4. All students will compare and contrast our planet and Sun to other planets and star systems; describe and explain how objects in the solar system move; explain scientific theories as to origin of the solar system; and explain how we learn about the universe. (Solar System, Galaxy, and Universe)

**Benchmark**
Explain how technology and scientific inquiry have helped us learn about the universe (SCI.V.4.HS.4).

**Benchmark Clarification**
The remoteness of objects in the universe necessitates the use of sophisticated technologies to make even basic observations. Advancements in technology include radio, optical and other types of telescopes, space probes, satellites, computer imaging/modeling, spectroscopes, and charged-coupled devices (*link to Glossary*).

Students will:

- Explain how technological advances have allowed us to test our hypotheses and to expand our knowledge of the universe

**Charged-Coupled devices:** a postage stamp-sized device consisting of millions of light sensitive pixels that translate the light energy into a digital signal for computer enhancement

**Key Concepts (voc.)**
Information

- radiant energy
- radio waves
- light
- spectra
- color of stars
- Moon and meteor samples

Devices:

- radio
- optical and other types of telescopes
- space probes
- satellites
- computer imaging/modeling

See Computer imaging/modeling *SCI.IV.4.HS.4.*

Problems for investigation:

- geology and weather of planets and moons
- origins of extraterrestrial life

**Real-World Context**

- histories of discoveries
- stories of exploration
- visits to observatories and planetariums
- videos showing space exploration
- samples of space materials including Moon rocks and meteorites
- remote-sensing data
- SETL– Search for Extraterrestrial Life

**Instructional Example SCI.V.4.HS.4**

**Benchmark Question:** How do we study distant objects such as our Moon, other planets, the Sun, and other elements in the universe?
**Focus Question:** How have technological advancements changed our view of the sky?

Students will divide into small groups and each will investigate the historical development of several types of telescopes, including types of optical telescopes, infrared telescopes, radio telescopes, ultraviolet telescopes, microwave telescopes, and X-ray telescopes.
After placing these critical developments in chronological order (perhaps they could be displayed on a timeline), students will view slides of what our sky looks like in these same spectral bands in the same order.

Each student should sketch and compare the general characteristics of the sky in each of the spectral bands.

Each student will write an essay explaining how the Milky Way Galaxy appears in these views. And if it is indeed a spiral galaxy, why it appears as a thin line when viewed on its edge.

The teacher will present information about people of diverse cultures who have made significant contributions to science, because many of these contributions have not been recognized.

**Constructing:** (*link to SCI.I.1.HS.1*), (*link to SCI.I.1.HS.4*), (*link to SCI.I.1.HS.5*).

**Reflecting:** (*link to SCI.II.1.HS.1*), (*link to SCI.II.1.HS.2*), (*link to SCI.II.1.HS.4*), (*link to SCI.II.1.HS.7*).

**Resources/References***:*

Webliography.
http://mtn.merit.edu/mcf/SCI.V.4.HS.4.html

A Brief History of Astronomy.
http://www.bios.niu.edu/orion/history.html

Adler Planetarium - Weather Watch.
http://www.adlerplanetarium.org/

Bradford Robotic Telescope.
http://www.telescope.org/rti/

Culturally Relevant Materials for Science (Internal Link)

Current Information about Weather from Outer Space. MESTA, 2000.3.
http://www.windows.umich.edu/spaceweather/

Hubble Telescope Site – Science and Technology.
http://www.hubbles.stsci.edu/sci.d.tech/

News/entertainment to budding astronaut/astronomers
http://www.spacekids.com

NASA – human space flight
http://spaceflight.nasa.gov/index.html

NASA –Observatorium
http://observe.ivv.nasa.gov

NASA – Star Trails Society
http://www.startrails.com

http://space.jpl.nasa.gov

Space Telescope Science Institute – Instruments
http://stsci.edu/instruments/

*The Sky at Many Wavelengths*. Astronomical Society of the Pacific (slide show).

**Classroom Assessment Example SCI.V.4.HS.4**

The teacher will present the following scenario: Imagine that you are part of a team of scientists from a major university. You need to prepare a speech for a congressional hearing on funding for the space program. You have been asked to prepare answers to the following questions:

1. What is the advantage of putting telescopes of each type (radio, microwave, infrared, visible, ultraviolet, X-ray, gamma) in space rather than operating them from the bottom of the Earth's atmosphere?
2. Which types of telescopes are used effectively from the bottom of the atmosphere?
3. What are the advantages to scientific knowledge of using many different types of telescopes rather than just one?

Students will work as teams and research telescopes in order to prepare answers to these questions. One team will sit in the front of the room and act as congressional representatives while the other teams present their findings. The congressional representatives will evaluate each team on the persuasiveness of their arguments as well as the teams' understanding of telescopes.

Students should demonstrate their understanding of the following key concepts:

1. A telescope above the atmosphere is not hampered by atmospheric interference.
2. Radio telescopes can be effectively used at the bottom of the atmosphere, but other types are limited by interference.
3. Optical telescopes can be effectively used at the bottom of the atmosphere, but other types are limited by interference.
4. Combining data from different types of telescopes gives a more complete view of the universe.

**(Give students rubric before activity.)**

**Scoring of Classroom Assessment Example SCI.V.4.HS.4**

| Criteria | Apprentice | Basic | Meets | Exceeds |
|---|---|---|---|---|
| **Understanding of key concepts** | Shows understanding of one key concept. | Shows understanding of two key concepts. | Shows understanding of three key concepts | Shows understanding of four key concepts. |
| **Persuasiveness of argument** | Not very persuasive argument with little support and few logical reasons. | Somewhat persuasive argument supported by some logical reasons. | Quite persuasive argument supported by logical reasons. | Very persuasive argument supported by logical reasons. |