The Ocean's Role in Weather and Climate

The ocean covers more than 70 pecent of the Earth's surface. The ocean plays a major role in regulating the weather and climate of the planet. These materials will help you understand the factors that impact the Earth's weather and climate, and how changes in temperature or air circulation are part of complex, long-term cycles. Understanding the influence of ocean conditions on the Earth's climate and monitoring changes in ocean conditions are key to predicting climate change.

Classroom Resources

This professional development section provides an understanding of the complex interactions between the ocean, weather, and climate. These resources present information on the water cycle, including real-time and animated data of surface and deep ocean currents. Activities and lesson plans explain the causes of ocean currents, and the interaction of ocean density, atmospheric winds, and Earth's rotation. Real-time weather and climate data show how meteorologists record and forecast the weather. Satellite and radar imagery provide a visual understanding of convection in the ocean, the atmosphere and their interrelatedness.

Teacher Tutorials

Global Climate Patterns	Global Precipitation and Energy	Global Circulation Patterns	Changing Climate

Click here for system requirements and how to access the tutorials
(pdf, 388Kb).

The tutorials, cooperatively developed by NOAA scientists and National Science Teachers Association (NSTA) pedagogic experts, are designed to help teachers understand ocean, climate and weather connections based on the science literacy goals in the National Standards. Each tutorial focuses on a key content idea, contains interactive simulations and embedded questions.

(top)

Media

Interactives

- Carbon Dioxide Emissions
- Climate Zones
- Create a Hurricane
- El Niño
- Evaporation in a Pot
- Hurricane Path
- Ocean and Wind Currents
- Ocean Circulation
- Land and Sea Breeze
- Specific Heat
- Water Cycle

Galleries

- NOAA Photo Library
- Ocean Explorer
- National Marine Sanctuaries

NSTA Partnership

Details

NSTA National Science Teachers Association

Web Seminar Archives

In collaboration with the NSTA, NOAA has presented a series of 90-minute, professional development experiences. Through the following link you can view Web seminar archives, download PowerPoint presentations, and access additional resources.

The Ocean's Role in Weather and Climate
http://learningcenter.nsta.org/products/symposia_seminars/fall06/oceans/webseminar.aspx

This link provides access to two Web seminar archives that focus on the connections among air, sea, and land; the processes by which energy is stored, released and transferred among them; and how our ability to understand and monitor ocean conditions is key to predicting climate change. The first seminar presents the influence of the Atlantic Ocean on climate, from hurricanes to African drought. The second seminar explains how changes in climate affect the Arctic sea ice.

(top)

Education HOME / Teachers: PD - Ocean & Climate

Ocean Basics

The ocean's waters are dynamic and these movements influence weather and climate, as well as living conditions in the sea and on land for plants and animals. The water cycle, also called the hydrologic cycle, is the continuous movement of water on, above, and beneath Earth's surface. Water can change from liquid, vapor, and ice at various stages in the water cycle. Ocean currents flow in complex patterns and are affected by wind, salinity, water temperature, bottom topography, and the Earth's rotation.

The Water Cycle

Links for Teachers | Links for Students

Since the water cycle is truly a "cycle," there is no beginning or end. Water can change states among liquid, vapor, and ice throughout in the water cycle. Water evaporates from the ocean and the Earth's surfaces, rises and cools as it moves higher in the atmosphere, condenses as rain or snow, and falls to the surface where it collects in lakes, ocean, soil, and underground.

Surface Ocean Currents

Links for Teachers | Links for Students

Water flows in a circular pattern – clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. Warm surface currents flow from the tropics to the higher latitudes, driven mainly by atmospheric winds, as well as the Earth's rotation. Cold surface currents come from polar and temperate latitudes. These currents tend to flow toward the equator.

Deep Ocean Currents

Links for Teachers | Links for Students

Currents flow in complex patterns affected by wind, salinity and water temperature, bottom topography, and the Earth's rotation. The density of ocean water causes deep ocean currents. Sea water that flows in polar regions will cool or freeze, becoming saltier and denser. Cold or salt water tends to sink.

(top)

Hot, Cold, Fresh and Salty

- Lesson Plan
- Case Study
- Sample of Student Work (pdf, 81Kb)

The Water Cycle: Links for Teachers

Effect of the Sun's Energy on the Ocean and Atmosphere

How does the Earth interact with the energy it receives from the sun? Is our planet in radioactive balance? Calculate the Earth's radioactive budget using satellite data collected by the National Aeronautics and Space Administration Earth Radiation Budget Experiment.
http://icp.giss.nasa.gov/education/radforce

Features: Hands-on Investigation, Lesson Ideas, Inquiry Materials

Dr. Art's Guide to Planet Earth—The Water Cycle

Beautifully written and composed web site. Interactive, well-presented, and consistent in its presentation.
http://www.planetguide.net/book/chapter_2/water_cycle.html

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia

National Estuarine Reserves Lesson Plan: For the Last 10,000 Years...

This lesson plan will show students how estuarine research reserves improve our understanding of interactions between human cultures and estuarine systems by using a case... study of the Tijuana River National Estuarine Research Reserves.
http://oceanservice.noaa.gov/education/classroom/lessons/14_estuaries_10000.pdf (pdf, 272 Kb)

Features: Lesson Ideas

The Water Cycle: Links for Students

The Hydrologic Cycle

Study the relationship between the hydrologic cycle and weather with this tutorial and animations.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/hyd/home.rxml

Features: Graphics/Multimedia

Thirstin's Question and Answer Game

The U.S. Environmental Protection Agency developed this 25-question quiz on water. The quiz is appropriate for students in grades 6-12.
http://www.epa.gov/safewater/kids/flash/flash_qagame.html

Features: Online Interactivity, Graphics/Multimedia, Assessment

Follow a Drop Through the Water Cycle

Students follow a drop of water through the water cycle via text and pictures on this U.S. Geological Survey Web page. Links to many activities and topics are readily available.
http://ga.water.usgs.gov/edu/followadrip.html

Features: Graphics/Multimedia, Data Sources, Inquiry Materials

Water Cycle Quiz

This quiz assesses student knowledge of water cycle vocabulary. Many other activities are also available with a single click.
http://www.enchantedlearning.com/classroom/quiz/watercycle.shtml

Features: Assessment

NOAA Learning Object - The Water Cycle

An audio and video description of the water cycle.
http://www.learningdemo.com/noaa/lesson07.html

Features: Graphics/Multimedia

(top)

Surface Ocean Currents: Links for Teachers

Ocean World: What Is a Current?

The National Aeronautics and Space Administration's Ocean World Project provides a comprehensive look at a number of oceanography topics including currents.
http://oceanworld.tamu.edu/students/currents/currents1.htm

Features: Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

Ocean Currents

Johns Hopkins's Applied Physics Laboratory presents three topics in ocean currents, "Gulf Stream," "Conveyor Belt," and "Mediterranean." The topics are readily understandable by middle and high school students.
http://fermi.jhuapl.edu/student/currents/index.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment

Science with NOAA Research: Ocean Currents

NOAA provides an interactive platform for students to research, gather, and analyze ocean current data. Extension activities are also available.
http://www.oar.noaa.gov/k12/html/oceancurrents2.html

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Data Sources, Inquiry Materials

The Gulf Stream Voyage: The Current Today

The Center for Innovation in Engineering and Science Education offers this research activity for students to better understand the Gulf Stream. Students capture data using a variety of techniques, analyze the data, and answer questions accordingly.
http://www.k12science.org/curriculum/gulfstream/studentcurrentnow.shtml

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

(top)

Surface Ocean Currents: Links for Students

Terra Measures Sea Surface Temperatures

The National Aeronautics and Space Administration describes the use of the Terra satellite to measure sea surface temperatures.
http://earthobservatory.nasa.gov/Newsroom/NasaNews/2002/200202147388.html

Features: Graphics/Multimedia, Data Sources

The Coriolis Effect Animations

This series of four animation sequences can help students understand the fundamentals and importance of the Coriolis effect.
http://www.uwf.edu/atc/projects/coriolis/main.swf

Features: Graphics/Multimedia, Assessment

Rip Currents: Nearshore Fundamentals

This Web site provides a unique look at the fundamentals of nearshore surface current dynamics, emphasizing rip currents. This Web site contains sophisticated animations throughout; download times may be a problem on slower computer systems. User registration is required to use the site, but is free.
http://meted.ucar.edu/marine/ripcurrents/NSF/

Features: Graphics/Multimedia, Assessment

NOAA Learning Objects - Ocean Currents

Through a narrated slide show with motion graphics, students learn about deep and surface ocean currents and their global impact on weather, climate, and human activities. The activity includes an online quiz.
http://www.learningdemo.com/noaa/lesson08.html

Features: Graphics/Multimedia, Assessment, Misconceptions

Science With NOAA Research: Ocean Temps

Find out how ocean temperatures vary with latitude and longitude and the effect they have on local residents. This is a research and investigation experience using online resources.
http://www.oar.noaa.gov/k12/html/oceantemps2.html

Features: Lesson Ideas, Assessment, Inquiry Materials, Misconceptions

How Can One Ocean Current Affect the Whole North Atlantic?

The Gulf Stream carries warm water from the Gulf of Mexico northward

along the eastern coast of the United States and across the Atlantic. You will see that the Gulf Stream affects the climate of coastal northern Europe and the fishing stocks of the Atlantic
http://www.classzone.com/books/earth_science/terc/content/investigations/es2403/es2403page01.cfm

Features: Lesson Ideas, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

(top)

Deep Ocean Currents : Links for Teachers

Ocean Exploration Lesson Plan

Students in grades 9–12 learn how scientists explore the mysteries of the ocean with new technologies and tools. The deep ocean provides artifacts, new plants and animals that benefit humans, and a chance to study plate tectonics.
http://oceanservice.noaa.gov/education/classroom/lessons/05_oe_explor.pdf

Features: Lesson Ideas

Ocean Currents

Johns Hopkins's Applied Physics Laboratory presents three topics in ocean currents, "Gulf Stream," "Conveyor Belt," and "Mediterranean." The topics are readily understandable by middle and high school students.
http://fermi.jhuapl.edu/student/currents/index.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment

Deep Ocean Currents: Links for Students

Variations in a Salty Ocean

This investigation explores how ocean water may or may not mix. The results may surprise you! This is a student-directed, self-paced investigation with numerous graphics.
http://www.classzone.com/books/earth_science/terc/content/investigations/

es2202/es2202page01.cfm?cha...

Features: Hands-on Investigation, Online Interactivity, Graphics/Multimedia, Inquiry Materials

Abrupt Climate Change: Are We on the Brink of a "New Little Ice Age?"

The Woods Hole Oceanographic Institute presents a comprehensive look at North Atlantic Ocean currents and how they might be related to "Ice Age" climate conditions.
http://www.whoi.edu/institutes/occi/currenttopics/
abruptclimate_joyce_keigwin.html

Features: Graphics/Multimedia

Thermohaline Circulation

Wikipedia is a collaborative effort of contributors. This site addresses thermohaline circulation and four important sub-topics: upwelling, downwelling, currents, and hydrothermal circulation.
http://en.wikipedia.org/wiki/Thermohaline_circulation

Features: Graphics/Multimedia, Misconceptions

Coastal Upwelling

Can upwelling occur on the New Jersey coast? Sure! View this animation and explanation of how upwelling occurs.
http://www.thecoolroom.org/education/upwelling.htm

Features: Graphics/Multimedia

NOAA Learning Objects - Ocean Currents

Through a narrated slide show with motion graphics, students learn about deep and surface ocean currents and their global impact on weather, climate, and human activities. The activity includes as online quiz.
http://www.learningdemo.com/noaa/lesson08.html

Features: Online Interactivity, Graphics/Multimedia, Core Content, Misconceptions

(top)

Lesson Plan: Hot, Cold, Fresh and Salty

This lesson plan was developed by NSTA master teacher Jerry D. Roth through NSTA's partnership with NOAA.

Grade Level:

9–12

Subject Area:

Primarily aimed at the geosciences, this is also valid with physical science and/or introductory chemistry.

Standards Alignment-National Science Education Standards:

- Earth Science
  - Structure of the Earth system
    - The Ocean has a major effect on climate because water in the ocean holds a large amount of heat.

- Earth Science
  - Structure of the Earth system
    - Deep ocean currents are caused by the density of ocean water.

- Earth Science
  - Structure of the Earth system
    - The temperature, density, and color of ocean water varies.

- Earth Science
  - Structure of the Earth system
    - Thermohaline circulation is the flow of water induced by differences in temperature (thermo) and salinity (haline). These differences in water properties lead to density differences.

Time Required:

The time required to complete this lesson is two single 40-minute class periods or one lab period of 80 minutes if the students are well prepared and work in groups. If you find students need more time, an extra 40 minutes is optional.

Overall Lesson Goal:

The student will observe the effects of the layering of warm and cold water and water that is more or less saline than the normal.

Individual Learning Objectives:

1. The student will create saline solutions that mimic ocean salinity, are more saline than ocean water, and are less saline than ocean water.

2. The student will carefully pour different solutions into a basin that shows how the different solutions can model layering in the ocean.

3. The student will observe that waters of different temperatures can layer according to their respective temperature, with hot water rising above colder water.

4. The student will observe that waters with different salinity will layer according to their respective salinity with more saline water being more dense than that of lower salinity.

5. The student will recognize that the effects of salinity and temperature are the root cause of thermohaline layering in the ocean.

6. The student will combine the results of the two separate exercises and predict which of the conditions might prevail.

Prerequisite Knowledge; Misconceptions/Preconceptions:

Cool water is denser than warm water and will sink below the warmer water. Water that is more saline is also more dense than water with lower salinity and thus will sink below the water of lower salinity. Interestingly, water temperature has more of an effect on water movement than salinity. The student should have a good grasp of proper lab procedures.

Knowing about the effects of ocean temperature and salinity may help students have a better understanding of factors that influence weather and climate. Ocean currents have a major impact on climate, and a thorough explanation of surface currents can be found at "A CURRENT Is a CURRENT by Any Other Name, But What is a Current?", http://oceanworld.tamu.edu/students/currents/currents1.htm.

It is important to note that this activity addresses both parts of what is called the thermohaline circulation: temperature and salinity. A good reference to begin your investigation deals with a Web site about the Thermohaline Circulation. Another reference can be found at the JHU/APL Ocean Currents Web site, http://fermi.jhuapl.edu/student/currents/index.html. Sufficient background for the teacher and reference for the students is available in an easy-to-understand series of presentations.

A special note: Following instructions closely will result in usable results. If solutions are not carefully combined, results will be difficult to observe.

The students should mix their own solutions. I find it very important that students get practice, whenever possible to produce the solutions they use in a laboratory setting.

The concept of density is important for students. What appear to be minor changes with density differences caused by temperature and salinity may have a major impact in the oceans. Since the oceans do not have a constant temperature and a given area may be more saline than another, it is important for the student to understand factors that may contribute to observable layering and other differences within the oceans.

Procedures/Instructional Strategy:

Before beginning this lab, it is best to have enough materials for all students to work in groups of two. Larger groups can be used but clever students tend to double up the work and thus share the results, meaning they may have only a cursory understanding of each of the trials.

Materials and Equipment:

Materials and equipment shared by the entire class include triple–beam balances or other reasonably accurate scales, roughly a pound of table salt, and food dye in two colors. I recommend red or blue dye. Each pair of students should have a clear plastic shoebox. The plastic shoeboxes are readily available in most "Dollar Stores." They generally come with lids and I find them useful storage containers when not being used for this lab. Each pair of students also needs two 500 ml beakers for mixing and pouring their solutions. All students need a quantity of ice to chill their solutions and a source of hot water.

Step 1. Making the solutions:

Mix 2 liters of saltwater solution and pour into the shoebox for the temperature test. If your shoeboxes are smaller, use less solution.
The saltwater solution is made by dissolving 35 grams of NaCl into a liter of room-temperature

water. This roughly approximates the salinity of seawater at 3.5%. Additionally, each pair of students needs a minimum of one more liter of room–temperature solution for the experiment regarding water temperature.

Step 2. Temperature Test

(a) The first test involves having students create 500 ml of hot and 500 ml of cold seawater. The cold water can be made by chilling a beaker of the "seawater" in an ice bath for 10 to 15 minutes.

(b) The warm seawater can be made by warming the solution on a hot plate or using hot tap water to make the solution.

While the solutions are changing temperature, ask the students to predict which of the waters will rise or sink when gently poured into the room-temperature solution and record their prediction in their lab notebook. This test is fairly direct and most students may predict that the warm water will rise over the colder water.

(c): Once the solutions have reached temperature, add a few drops of different colored food coloring to each solution. I prefer red for hot and blue for cold.

(d): Have the students gently pour the contents of each of their beakers into the opposite ends of their shoebox. Allow time for the solutions to settle.

Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.

Once the students have finished observing the layering and made notations in their notebooks regarding their observations, have them discard the solutions in the drain and rinse their shoebox for the next test.

Ask the students to list where in the ocean sources of warm seawater and cold seawater arise.

Step 4. Salinity Test - The second test is a little more complicated to predict.

(a): Have all of the students make a liter of "regular" (35 grams NaCl per liter of water) seawater and pour it into their shoebox.

(b): Have half of your groups make seawater that is ¼ as salty as "normal" sea water by mixing 8.75 grams of salt per liter of water. I have students color this solution blue.

(c): Have the other half of the groups make seawater that is 4 times as salty by dissolving 120 grams of salt in a liter of water. Color this solution red.

(d): Ask the students to share half of their solutions with a group that has made the other solution. Make sure their solutions are clearly labeled.

Have the students record their predictions about which layer will rise to the top; the hypertonic (greater or more than) solution, the isotonic (same as) solution, or the hypotonic (under or less than) solution. Have the students record the reasoning for their prediction regarding their prior knowledge of density.

Step 5: Direct the students to carefully pour the contents of the beakers of hyper and hypotonic solutions into opposite ends of their isotonic shoebox and observe the layering.

Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.

Does the layering match the predictions? Have the students offer a reasonable explanation as to why their predictions where right or wrong.
Ask the students to record where in the ocean water that is more salty than seawater may exist and

where water that is less salty than "regular" seawater may exist.

Step 6: Finally the students should predict which is more important to the layering: temperature or salinity. Ask the students to propose a test that might determine which is more important. My recommendation is simple: Have the students test the temperature solutions with the solutions of different salinity. Ask them to report their results in a summary of the lab on the accompanying sheet.

Outcome / Assessment:

A straightforward assessment of this activity involves students explaining what they observed during the lab. A formal write-up may be acceptable but the important factors in this lab are:

1. How does salinity affect ocean layering?
2. How does temperature affect ocean layering?
3. Which has a greater impact on the oceans, salinity or temperature?

If you would like the students to complete a followup to the lab, they should look to the website listed in the extension section, which contains a tutorial regarding the concept.

Extension:

This lesson also directly applies to the theme regarding the sun and its effect on the ocean since it is primarily the sun that heats the oceans and not the Earth's internal temperature. Because warm water rises to the surface and currents are affected by wind and the Earth's rotation, the students should be able to see and perhaps understand the connection between deep ocean circulation and weather. Variations in a Salty Ocean contains an activity that allows the students to look at actual data and make their own predictions of the interactions of salinity and temperature.

Internet Resources:

Deep Ocean Currents, Surface Ocean Currents are the keywords and the urls include:

- A CURRENT is a CURRENT by ANY OTHER NAME, BUT WHAT is a CURRENT?
- Thermohaline Circulation
- Variations in a Salty Ocean
- JHU/APL Ocean Currents Website

Classroom Resources:

Provide a list of materials, consumables, and any physical equipment, including the total number of computers if using an entire lab, single computer station, LCD, speakers, etc., that a teacher looking to replicate your lesson would need. If your lesson also includes a hands-on component, please include all equipment necessary.

At least 4 scales to measure salt
1 plastic shoebox for each pair of students
1 lb of salt (table salt is adequate)
2 colors of food coloring for comparing the different solutions
One 1 l beaker and two 500 ml beakers per pair of students
Sufficient quantity of ice to cool solutions
Heat source to warm water or hot tap water.

Holt, Cold, Fresh, and Salty - Student Worksheet

Name_____________________ Date_______

1. Write your predictions for the hot and cold water test:

2. Did your prediction match the observed results of the test?

3. Describe your results in terms of the density of the solutions.

4. Record your predictions for the salinity water test:

5. Did your prediction match the observed results of the test?

6. Describe your results in terms of the density of the solutions.

7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.

(top)

Case Study: Hot, Cold, Fresh and Salty

Miss Sherwood wanted to review convection with her 9th grade earth science class. She had already taught convection in astronomy, meteorology, and geology. Reviewing convection made it really easy to demonstrate how temperature and density create ocean currents.

Using the online resources under "The Ocean's Role in Weather and Climate," she found an activity called “Hot, Cold, Fresh, Salty.” This activity was designed to demonstrate how temperature creates currents as well as how different densities create currents. Miss Sherwood used the worksheet that came with the activity. She did add two images – surface currents and the ocean conveyor system – to the worksheet so student could see the different types of currents.

The original activity called for small groups to complete the activity. Unfortunately, Miss Sherwood's class had to do the activity as a large group because many of the students are very clumsy and we have had major clean-ups after other liquid labs. Different solutions of salt water were created ahead of time due to shortened class times and different temperature solutions were created by storing solutions in the fridge or heating them during the experiment in a microwave using microwave-safe containers. Students themselves poured the solutions into the shoeboxes taking turns as they completed different steps and discussed what happened.

The students remembered convection in turns of hot and cold and knew that the cold blue water would sink to the bottom and the hot red water would rise to the top. Their experiment supported their hypothesis. They also remembered how denser substances sink and predicted that the red hypersaline solution would sink to the bottom while the blue hyposaline solution would rise to the top. Once again their experiment supported their hypothesis.

To further demonstrate temperature differences, students created four different temperature solutions of different colors. When poured into the shoeboxes, momentary differences could be seen, but mixing occurred to quickly. For future experiments, Miss Sherwood wants to try funnels to see if her class can control where the solutions end up.

For the final step of determining which was more important, temperature or salinity, Miss Sherwood had individuals think of different options and then discuss it with the person next to them. Volunteers then described their experiment and the class tried three of them. One group suggested trying to pour 2 hypersaline solutions of very hot and very cold. They mixed. A second group hypothesized using very cold water of hyposaline and hypersaline solutions. One again they mixed, but the blue hypersaline solution originally was on the bottom. Going from previous experiments, a final group hypothesized that hot hypersaline solution and a cold hyposaline solution would show which was more important. Their experiment worked and showed that salinity was more important since hot high saline water ended up below the colder low saline solution.

The NOS Education resources listed several Web sites that further explained the material for both teachers and students. Ocean World: What is a Current? is an excellent resource from TAMU and goes through many of the different types of currents and how they are formed. The Thermohaline Circulation website had a great animation showing the different parts of the ocean conveyor system.

Miss Sherwood looks forward to trying this experiment in the beginning of the year as a way to actually teach the concept since many students said that it helped to clarify convection.

(top)

Name____________________ Date_______

Holt, Cold, Fresh, and Salty

1. Write your predictions for the hot and cold water test:

2. Did your prediction match the observed results of the test?

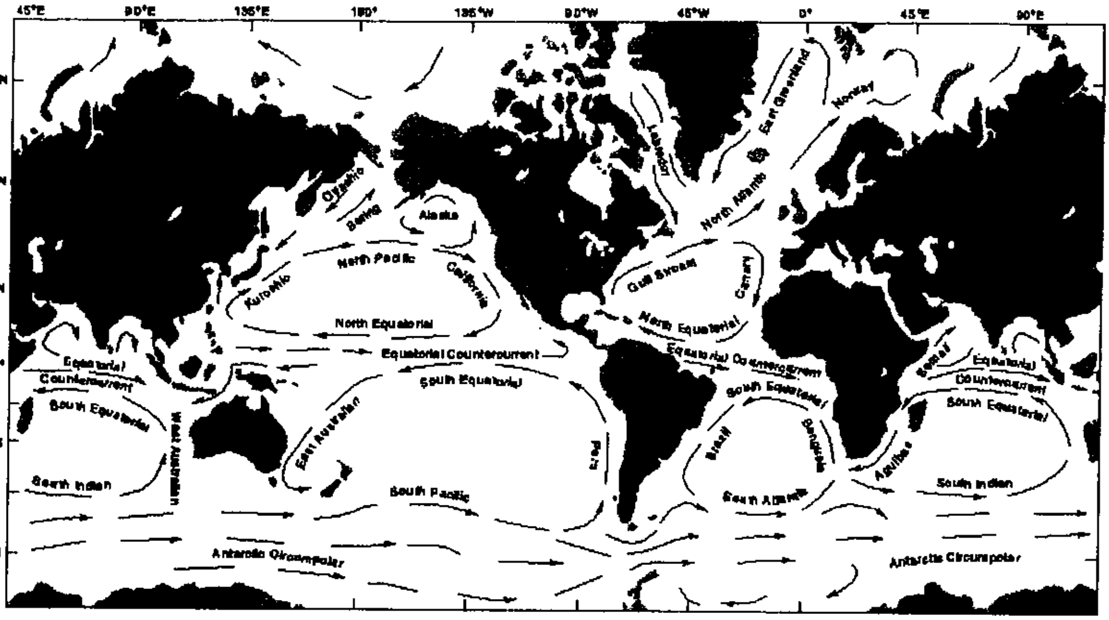
3. Describe your results in terms of the density of the solutions.

4. Record your predictions for the salinity water test:

5. Did your prediction match the observed results of the test?

6. Describe your results in terms of the density of the solutions.

7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.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Bering
Alaska
Kuroshio
North Pacific
California
North Equatorial
Equatorial Countercurrent
South Equatorial
East Australian
South Pacific
Peru
West Australian
Equatorial
Countercurrent
South Equatorial
South Indian
Antarctic Circumpolar
Labrador
East Greenland
Norway
North Atlantic
Gulf Stream
Canary
North Equatorial
Equatorial Countercurrent
South Equatorial
Brazil
Benguela
South Atlantic
Somali
Equatorial
Countercurrent
South Equatorial
Agulhas
South Indian
Antarctic Circumpolar

1. Write your predictions for the hot and cold water test:

The hot water will be red, The water will sink and the
The Cold water will be blue Cold water will be at the botton and the colom a the top and it will mix the souble

2. Did your prediction match the observed results of the test?

yes

3. Describe your results in terms of the density of the solutions.

I saw the blue Cold water sink on the botton, and the red hot water still on top, but at the end both mixed and form purple water.

4. Record your predictions for the salinity water test:

I think the red is more danser so is going to sink and the blue on top

5. Did your prediction match the observed results of the test?

yes it matched

.8 blue
.12 red

6. Describe your results in terms of the density of the solutions.

Well the danse water sink and the less danse / set on top

7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.

Top – Red
2 – green
Center – yellow – worm salty
bottom – blue – Cold less salinity

–The Salinity will have more impact

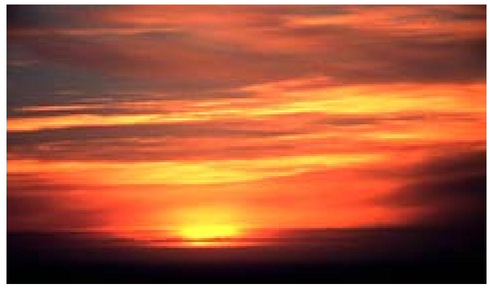
Holt, Cold, Fresh, and Salty

1. Write your predictions for the hot and cold water test:
   I think the salt might mix together, but then the colors will separate.
2. Did your prediction match the observed results of the test?
   No
3. Describe your results in terms of the density of the solutions.
   The hot water was on the top when the cold water was on the bottom, because warm rises and cold sinks. They also began to change purple as they began to mix together.
4. Record your predictions for the salinity water test:
   Blue will float
   Red will sink
   Blue will be over red
5. Did your prediction match the observed results of the test?
   Yes
6. Describe your results in terms of the density of the solutions.
   The blue was on the top while the red was on the bottom.
7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.

red
green
yellow
Blue

I think we should make both salinity the same and then test the hot and cold water.

Weather and Climate Basics



What is the difference between weather and climate? Weather is the air temperature, cloud cover, precipitation, wind, moisture content, and air pressure at any particular time in any particular place. Weather reflects the prevailing conditions of the air masses overlying the land and seas over the entire globe. Climate is the overall picture of weather during periods of seasons or years. Historical records (including geological and recorded history) show us how the climate of the Earth has changed throughout its history.

Earth's Energy Source

Links for Teachers | Links for Students

The Earth's main energy source is the sun. The sun causes convection within the atmosphere, which in turn affects weather and climate. Find resources here to help students use real-time data to learn about the relationship between the sun, weather, and climate.

Convection In the Atmosphere

Links for Teachers | Links for Students

The heating of the Earth's surface and atmosphere by the sun drives convection within the atmosphere and ocean, producing winds and ocean currents. Find resources here to help you better understand how convection impacts weather and climate, including some hands-on activities, lesson plans, real-time data and images.

Atmospheric Pressure and Winds

Links for Teachers | Links for Students

The heating of the Earth's surface and atmosphere by the sun drives convection within the atmosphere and ocean. This convection produces winds and ocean currents. The greater the pressure differences between a low-pressure area and a high-pressure area, the stronger the winds.

Weather Patterns

Links for Teachers | Links for Students

Air masses and accompanying fronts do not remain stationary for long. Their movements are never exactly the same and they do exhibit some patterns that help meteorologists and others predict the weather. Moving fronts indicate a change in the weather. Resources in this section direct

The Earth's Energy Budget

- Lesson Plan
- Case Study
- Sample of Student Work (pdf, 1.9 Mb)

students to real-time radar and satellite images to learn about weather patterns.

What Is Climate?

Links for Teachers | Links for Students

Climate is the weather in a location averaged over a long period of time. An old saying goes, "climate is what you expect, weather is what you get." Find out if our global climate is changing and what factors may be influencing these changes.

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Earth's Energy Source: Links for Teachers

SOHO Explore

This page contains lesson plans and activities to aid students in understanding the sun using data from the Solar and Heliospheric Observatory project. The newsroom link presents current scientific research.
http://sohowww.nascom.nasa.gov/

Features: Lesson Ideas, Graphics/Multimedia, Inquiry Materials

GLOBE Learning Activity – A Beginning Look at Photosynthesis

Photosynthesizing plants take carbon dioxide from the air, water from the soil, and use energy from the sun. This inquiry-based lesson emphasizes observation and inference and includes a “Skills of Science Assessment Checklist” and lesson grading rubric.
http://www.globe.gov/tctg/earth_la_seaphen_p4.pdf?sectionId=264

Features: Hands-on Investigation, Lesson Ideas, Assessment, Inquiry Materials

Earth's Energy Source: Links for Students

The Virtual Sun

Take a virtual tour of the sun and learn about its physical features. You will see images and animations of solar flares, sun spots, magnetic fields, and solar eclipses, as well as learn about the science behind the sun and its influence on the solar system.
http://www.michielb.nl/sun/kaft.htm

Features: Graphics/Multimedia, Data Sources, Inquiry Materials

A Multimedia Tour of the Solar System

Looking for a great place to start in your investigation of Earth's energy source, the Sun? This site is loaded with content, links, and more.
http://seds.lpl.arizona.edu/nineplanets/nineplanets/sol.html

Features: Graphics/Multimedia

Sun's Heat Powers Weather

How does the sun power our weather? This simple animation and description provide the answer to this critical concept in meteorology.
http://www.usatoday.com/weather/tg/wglobale/wglobale.htm

Features: Graphics/Multimedia

Science with NOAA Research: Solar Events

Solar events cause geomagnetic storms that can interfere with radio transmission, satellite reception, and airplane communications. Knowing about the storms, their effects, and how we can predict them, can help us in many ways worldwide.
http://www.oar.noaa.gov/k12/html/solarevents2.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment

(top)

Convection In the Atmosphere: Links for Teachers

Atmospheric Processes: Convection

In this two-part activity, students will study convective currents in water and observe the air as a fluid.
http://www.ucar.edu/learn/1_1_2_7t.htm

Features: Hands-on Investigation, Lesson Ideas

An Educator's Guide to Convection

The author explains why the physical process of convection is so important and addresses a number of instances in nature where convection can be observed. A link to a variety of fun puzzles is provided on the Web site.
http://www.solarviews.com//eng/edu/convect.htm

Features: Lesson Ideas, Graphics/Multimedia, Assessment

Getting Around the Coriolis Force

Teachers can enhance their understanding of the Coriolis effect without getting into overly detailed physics.
http://www.physics.ohio-state.edu/~dvandom/Edu/newcor.html

Features: Graphics/Multimedia

Mesoscale Circulation Modeling Visualizations

NOAA provides global visualizations of weather patterns as a resource for you and your students.
http://www.gfdl.noaa.gov/products/vis/gallery/mesoscale_dynamics/gmcm.html

Features: Graphics/Multimedia, Data Sources

Capturing Convection

"Sometimes a single physical process can explain a variety of events." Convection is explained simply with a focus on the sun. Its application to weather is equally important.
http://education.jpl.nasa.gov/educators/convection.html

Features: Data Sources

(top)

Convection In the Atmosphere: Links for Students

Remote Sensing Urban Heat Islands

Identify how cities heat up more than rural areas using this interactive Web application.
http://itg1.meteor.wisc.edu/wxwise/museum/a3/a3heatisl.html

Features: Online Interactivity, Graphics/Multimedia

Sea Breezes

See why a sea breeze occurs at the beach during a warm summer day. This Web site has an explanation with good graphics and links to information about land breezes.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/sea/htg.rxml

Features: Graphics/Multimedia

Forces and Winds: Online Meteorology

The purpose of this module is to introduce pressure, how it changes with height, and the importance of high-and low-pressure systems. In addition, this module introduces the pressure gradient, Coriolis forces, and their role in generating wind.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/home.rxml

Features: Graphics/Multimedia

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Observe How Air Pressure Affects a Rising Balloon

Try this interactive animation exploring how the height of a hot-air balloon influences both its volume and external air pressure.
http://www.classzone.com/books/earth_science/terc/content/visualizations/es1901/es1901page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia

The Atmosphere in Motion: Air Pressure, Forces, and Winds

An extensive introduction to atmospheric motion, this Web page is a set of animated lecture notes for a college meteorology class. Many concepts, along with embedded quiz questions, can be used by secondary school students and teachers.
http://apollo.lsc.vsc.edu/classes/met130/notes/chapter8/index.html

Features: Graphics/Multimedia, Assessment

Wind on Oahu: An Exploration

In this self-directed module, students analyze graphics, data, and animations to interpret wind and weather conditions on Oahu, an island in Hawaii. An excellent learning tool provided by TERC.
http://www.classzone.com/books/earth_science/terc/content/investigations/es1806/es1806page01.cfm?cha...

Features: Graphics/Multimedia, Assessment

Bad Coriolis (Bad Meteorology)

Learn about the Coriolis effect.
http://www.ems.psu.edu/~fraser/Bad/BadCoriolis.html

Features: Misconceptions

Science with NOAA Research: Forecasting

Weather forecasters help us plan and prepare for the weather.
http://www.oar.noaa.gov/k12/html/forecasting2.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

Hurricane Glossary

A glossary of commonly used hurricane terms.
http://www.nhc.noaa.gov/aboutgloss.shtml

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Features: Graphics/Multimedia

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http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/home.rxml

Features: Graphics/Multimedia

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Try this interactive animation exploring how the height of a hot-air balloon influences both its volume and external air pressure.
http://www.classzone.com/books/earth_science/terc/content/visualizations/es1901/es1901page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia

Wind: Small-Scale and Local Processes

An extensive introduction to atmospheric motion, this Web page is a set of animated lecture notes for a college meteorology class. Many concepts, along with embedded quiz questions, can be used by secondary school students and teachers.
http://apollo.lsc.vsc.edu/classes/met130/notes/chapter9/index.html

Features: Graphics/Multimedia, Assessment

Wind on Oahu: An Exploration

In this self-directed module, students analyze graphics, data, and animations to interpret wind and weather conditions on Oahu, an island in Hawaii.
http://www.classzone.com/books/earth_science/terc/content/investigations/es1806/es1806page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia, Assessment, Inquiry Materials

Science with NOAA Research: Forecasting

Weather forecasters help us plan and prepare for the weather.
http://www.oar.noaa.gov/k12/html/forecasting2.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

NOAA Learning Objects - Ocean Waves

Learn all about the anatomy of waves and the forces that cause them, especially wind. Find out what global impact waves have on coastlines and the possible development of wave energy to produce electricity.
http://www.learningdemo.com/noaa/lesson09.html

Features: Online Interactivity, Graphics/Multimedia, Assessment, Misconceptions

Historical Hurricane Tracks

Web visitors can capture hurricane tracks using NOAA's extensive database. Query tools are flexible and detailed graphics are included.
http://hurricane.csc.noaa.gov/hurricanes/index.htm

Features: Online Interactivity, Graphics/Multimedia, Data Sources

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Education HOME / Teachers: PD - Ocean & Climate / Weather & Climate Basics

Weather Patterns: Links for Teachers

Principles of Aeronautics: Atmosphere

The authors explain some of the mysteries of weather i.e.,(atmosphere, heat, wind, clouds) into manageable sections. Each section has dedicated activities and an online quiz.
http://wings.avkids.com/Book/Atmosphere/advanced/index.html

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia

GLOBE: Educators' Corner

This Web site gives teachers the ability to plan useful learning activities for their students. On this site you will find information on teacher workshops, teacher resources, learning activities, learning standards, and assessment.
http://www.globe.gov/fsl/html/templ.cgi?educorn

Features: Hands-on Investigation, Lesson Ideas, Assessment, Data Sources, Inquiry Materials

JetStream - Online School for Weather

This Web site contains links to the 11 topics and lessons related to weather, climate, and the ocean. A great teacher resource for inquiry-based activities.
http://www.srh.noaa.gov/jetstream/matrix.htm

Features: Hands-on Investigation Lesson Ideas, Graphics/Multimedia, Assessment, Inquiry Materials

Hurricane Education Materials

This site provides links to valuable hurricane education materials.
http://www.climate.noaa.gov/index.jsp?pg=./education/hurricanes/materials.jsp

Features: Hands-on Investigation, Assessment, Data Sources

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Weather Patterns: Links for Students

Air Masses and Fronts

This Web site discusses the formation of air masses that affect the weather. The section on air fronts describes warm fronts, cold fronts, occluded, and stationary fronts, as well as dry lines.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/af/home.rxml

Features: Graphics/Multimedia

Clouds and Precipitation

Explore the factors that determine the development of clouds and precipitation including convergence, convection, fronts, and relative humidity.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/cld/home.rxml

Features: Graphics/Multimedia

Forces and Winds: Online Meteorology

The purpose of this module is to introduce pressure, how it changes with height, and the importance of high-and low-pressure systems. In addition, this module introduces the pressure gradient and Coriolis forces and their role in generating wind.
http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/home.rxml

Features: Graphics/Multimedia

National Hurricane Center: Satellite Imagery

Obtain access to hundreds of NOAA weather satellite images through this Web portal. Although, this is not an educational Web site, the information presented strongly supports curriculum for meteorology.
http://www.nhc.noaa.gov/satellite.shtml

Features: Graphics/Multimedia, Data Sources

Land Breeze/Sea Breeze Animations

Use this online animation to learn how the land breeze/sea breeze cycle works.
http://www.classzone.com/books/earth_science/terc/content/visualizations/es1903/es1903page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia

How Does the Coriolis Effect Influence Wind Direction?

This Web-based animation demonstrates,using satellite imagery, the Coriolis effect on weather patterns.
http://www.classzone.com/books/earth_science/terc/content/

visualizations/es1905/es1905page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia

National Climatic Data Center: Data Access

NOAA's National Climatic Data Center provides easy access to an enormous amount of data, in a format that allows for easy access.
http://www.ncdc.noaa.gov/oa/mppsearch.html

Features: Data Sources

Hurricane Preparedness

History teaches us that a lack of hurricane awareness and preparation leads major hurricane disasters. This Web site provides information on hurricane hazards, the Saffir-Simpson Hurricane Scale, and emergency preparedness.
http://www.nhc.noaa.gov/HAW2/english/intro.shtml

Features: Graphics/Multimedia

Science with NOAA Research: Forecasting

Weather forecasters help us plan and prepare for the weather.
http://www.oar.noaa.gov/k12/html/forecasting2.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

Hurricane Glossary

A glossary of commonly used hurricane terms.
http://www.nhc.noaa.gov/aboutgloss.shtml

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What Is Climate: Links for Teachers

El Niño: Hot Air Over Hot Water

This Web site includes an introduction, activities, pictures, and interactive features on El Niño.
http://www.fi.edu/weather/nino/nino.html

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Data Sources

Online Trends of Global Change Data

The U.S. Department of Energy hosts this Web site, which provides a clearinghouse for information on climate research specifically related to carbon dioxide.
http://cdiac.esd.ornl.gov/trends/trends.htm

Features: Data Sources

What Is Climate?

Explore the fundamentals of climate in this comprehensive, interactive lesson.
http://www.classzone.com/books/earth_science/terc/content/investigations/es2101/es2101page01.cfm?cha...

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Inquiry Materials

What is Climate : Links for Students

Climate Timeline Information Tool

How has climate changed over the last hundred or thousand years? Learn about each time period with Overview, Science, History, and Resources sections. The Tutorial includes activities, and Data Access lets you search the numbers yourself.
http://www.ngdc.noaa.gov/paleo/ctl/index.html

Features: Graphics/Multimedia, Assessment, Data Sources

The Oceans' Role in Climate

The author argues that the role of the ocean in climate research has been underestimated, and needs to be better understood if we are to predict climate change in the future.
http://www.whoi.edu/institutes/occi/currenttopics/abruptclimate_schmitt_testim.html

Features: Misconceptions

Introduction to Paleoclimatology

How do we know what the Earth's climate was like before recorded history? There are clues, and they form the basis for a branch of meteorology called paleoclimatology. In studying climate change, understanding the Earth's cyclical past is essential.
http://www.ncdc.noaa.gov/paleo/proxies.html

Features: Graphics/Multimedia, Data Sources

Abrupt Climate Change

Several authors from Woods Hole Oceanographic Institute, proposes that climate change is not gradual, and that abrupt shifts may occur due to changes in ocean current patterns.
http://www.whoi.edu/page.do?pid=12455&tid=282&cid=9986

Features: Misconceptions

Crystal Ball – Climate Change

This article, developed by ABC News is a quick overview of the pressing issues and effects of climate change. The Pentagon's advisement that the largest threat to America is climate change was a driver for development of this story.
http://www.abc.net.au/science/features/climatechange/default.htm

Features: Graphics/Multimedia

Global Climate Modeling—The EdGCM Cooperative

Want to get your hands dirty working with Global Climate Modeling data? Generally not accessible or comprehensible by teachers, NASA developed EdGCM software to allow access to climate data. A comprehensive, powerful web site.
http://edgcm.columbia.edu/

Features: Hands-on Investigation, Online Interactivity, Graphics/Multimedia, Data Sources, Inquiry Materials

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Lesson Plan: The Earth's Energy Budget

This lesson plan was developed by NSTA master teacher Jerry D. Roth through NSTA's partnership with NOAA.

Grade Level: 9–12

Subject Area:
Primarily Geoscience, but the lesson can also be used for General Science that has an Earth Science component.

Standards Alignment-National Science Education Standards:

- Earth Science
  - Structure of the Earth system
    - Temperature differences in the atmosphere are a result of the way solar energy is absorbed as it moves through the atmosphere.

- Earth Science
  - Structure of the Earth system
    - Heat energy is transferred through the atmosphere by conduction and convection.

Time Required:
One class period will be needed to demonstrate the three types of heat transfer and the processes that light as radiation can undergo: reflection, absorption, and refraction. The actual tutorial will take two periods.

Overall Lesson Goal:
The student should come away from this lesson with an understanding of the Earth's energy budget; the flow of energy from the sun to the Earth, and the outward flow from the Earth.

Individual Learning Objectives:
Understand that energy flows from the sun to the Earth as radiation.
About 30% of the solar radiation that strikes the atmosphere is reflected or scattered.
Roughly 20% of the solar radiation is absorbed by the atmosphere.
The remaining radiation, approximately 50% is absorbed by the surface of the Earth.

Prerequisite Knowledge; Misconceptions/Preconceptions:
The total amount of radiation striking the Earth is equal to the total amount being radiated back into space. If more incoming radiation was absorbed, the Earth would get hotter. If more radiation was radiated back into space, the Earth would get cooler.

Ultimately, the sun is the source of all of our weather as it provides energy to drive other systems. Students understand that the sun makes them hot in the summer even though they may not understand the mechanism completely. Few really understand solar radiation or the lack of it is also what makes them cold in the winter.

The Earth rotates. This rotation puts one half of the Earth's surface in line for sunlight to strike it. The other half of the Earth is radiating radiation back into space.

The three ways to move heat are radiation, which can take place through a vacuum; conduction, which requires the direct contact of materials; and convection, which causes a heated material to flow as it is being replaced by a cooler material. Three preparatory activities addressing heat transfer, radiation, conduction, and convection, can be found at the University Corporation for Atmospheric Research's Web site Introduction to the Atmosphere. The activities are lower than recommended grade level and you may find they are too low for your students, but I've never had a group of students keep quiet when I pour carbon dioxide gas over a candle and extinguish it.

Once the students are comfortable with the types of heat transfer, they should move on to what may happen with radiation. Radiation can be reflected, refracted, or have its speed changed, or absorbed. All three of these happen in the atmosphere. Reflection occurs when radiation strikes an object and it bounces off. This happens in the atmosphere and on the surface of the Earth. Refraction, the changing of the speed of radiation as it energizes a substance it has entered is classically observed in rainbows, so we know it occurs in water molecules. Absorption is when the energy in the incoming radiation is passed from the electrons in the substance along to the nucleus of the atoms where it may be radiated back at a different wavelength, usually a lower frequency, longer wavelength wave. Reflection, refraction, and absorption are well explained at How Light Works.

We've got heat energy, electromagnetic radiation and the spinning Earth working together to produce weather and climate. What happens to solar radiation when it comes to the Earth's atmosphere is covered by the Solar Radiation Learning Module from the College of Alameda's Physical Geography Department. Access the learning module with your students and allow them to follow along as you lead them. Demonstrate how to navigate the site then allow them to go on their own. This module helps students understand the interaction of all of the factors above.

Procedures/Instructional Strategy:
All of the aspects of heat transfer and light processes can be demonstrated quickly and easily in one period. You need to set up everything in advance and turn on the heat sources as the students walk into class.

Step 1

(a): Place a 1000mL beaker filled with 800 mL water on a hot plate and turn the hot plate on hot to heat the liquid. Place another beaker with the 800 mL of water on another hot plate but do not turn this hot plate on.

(b): I would set up and turn on a heat lamp of 250 watts. Be sure to warn students that the lamp can get very hot!

(c): Point the heat lamp at a table about 2 ft away. Place two pieces of fabric, one black (I prefer heavy landscape fabric) and the other white, (a cotton t-shirt works well) flat on the table. Underneath each of the two pieces of fabric, place the bulb of a thermometer, and as much of a thermometer (range 0º to 100º C) as you can. As you turn the heat lamp on, have a student read both thermometers to get an initial temperature. Allow the lamp to heat the fabric for at least 10 minutes.

Step 2

(a): The demonstration! Take a thermometer and hold it in the air above the black fabric and give the class an initial temperature reading. Allow five minutes in the path of the heat lamp and take the temperature reading again. Has the temperature changed? Why? Heat has traveled through the air to warm the thermometer. This is radiation.

(b): Compare the temperature readings in the two beakers. Why has the beaker in contact with a working heat source gotten hotter? Why hasn't the beaker over the hot plate that is not turned on gotten hotter? There is no added heat from the plate that is not turned on. The other beaker is getting warmer because it is in direct contact with the heat source. This is conduction-transfer by direct contact.

(c): As the water over the hot plate gets hot squeeze a drop of food coloring into it along one side. Watch as the drop settles and then begins to diffuse upward. This is convection: heat transfer by movement!

Step 3

(a): Hold up a mirror and have the students describe what they see. The image is reversed along the vertical plane. Reflection from a plane mirror!

(b): Take a temperature reading from the thermometers under the fabric. The black fabric has a higher reading because it has absorbed radiant energy from the light. The white fabric has reflected most of the energy. Absorption and reflection!

(c): Turn off all heat sources!

(d): Refraction can be demonstrated by using either a prism or a laser shown through a block of Lucite or clear gelatin. In a very dark room, light the laser and let the students note where the light enters the block at an angle that is not 90º. Note that the light appears to bend towards the center line (90º) as the light exits the block; it appears to bend away from the 90º line at the exit. This is textbook refraction. I have had success with this demonstration by holding the block on my whiteboard and having a student assist me by marking the entry and exit lines with an erasable marker.

On the second day, lead the students to the website from Alameda College's Solar Radiation Learning Module and have the students work through the very good tutorial found there. The module has three parts. If the students are thorough in their approach, they should complete the module's three parts in two days. What is particularly good about this module is that after demonstrating the methods of heat transfer and light processes, the students see firsthand how they impact the Earth's energy budget.

Outcome / Assessment:
When the three sections have been completed by the students, have them complete the Study Guide provided online at by writing the definitions of all of the key terms and writing answers to all of the questions listed in the objectives. There is a 10 question Online Quiz for the student that is reasonably well thought out. You may, of course, use the questions provided in your own test, but I have found the online quiz quite well done and use the results for a quiz grade.

Extensions:
Consider how your students might build on this lesson; offer suggestions for sharing what they have learned with their families and making it part of their world.

Internet Resources:
Keywords include: Energy In the Atmosphere. The specific URLs are:

- Earth's Energy Budget
- Introduction to the Atmosphere
- How Light Works
- Solar Radiation Learning Module
- Study Guide
- Online Quiz

Classroom Resources:
This lesson, really a tutorial, needs a classroom set of computers with Internet access, an LCD projector.

- 1 heat lamp
- White fabric and black fabric (about 1 square foot of each)
- 3 thermometers (range 0º to 100ºC)
- 2 hot plates
- 2 1000 mL beaker with 800 mL of water
- 1 bottle of red food coloring
- 1 pen-style laser
- 1 block of Lucite or gelatin

Alternately, to complete the heat transfer activities, go to the UCAR activities 5, 6, and 7 for materials and time (roughly three periods) The radiation experiment can double as the absorption demonstration.

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Case Study: Earth's Energy Budget

Independent study biology students in Ocala, Florida used these online resources to learn about the flow of energy from the sun to the Earth and from the Earth to the atmosphere. They used the extensive information from these educational Web sites to research energy heat transfer; aborption, reflection, and refraction; and solar radiation. After researching the Web sites, students' knowledge on the subject matter was assessed with worksheets and a quiz.

Ms. Kloepper first stressed to the students that the sun is the ultimate source of energy for our planet, as it provides energy necessary for the backbone of our food web. In addition to being ecologically important, the sun is also physically important to our planet, as it helps drive our weather patterns. Ms. Kloepper explained that as such, it is essential for students to understand how the energy from the sun reaches the Earth.

Ms. Kloepper visited the tutorial and created a worksheet that allowed students to individually collect necessary background information on the ways energy from the sun reaches the Earth, the physical processes that cause light energy to penetrate the atmosphere, and what happens to the solar radiation when it reaches the atmosphere. The students independently spent between one and three hours completing the assignment (depending on ability). The topics they researched included:

- Heat Transfer
- Radiation
- Conduction
- Convection
- Absorption
- Reflection
- Refraction
- Solar Radiation

After students individually collected information from the Web site, they completed a worksheet assessing their knowledge of the material. Some questions were taken verbatim from the Web site, other questions encouraged more broader thinking about the topics.

After the students submitted the worksheet, their knowledge on the material was reassessed with questions included on a test. Ms. Kloepper discussed the material with the students during their weekly meeting, and reinforced their understanding that the physical forces studied help drive the Coriolis effect.

Once the lesson was completed, it was evident that students had a firm understanding of how energy is transferred from the sun to the Earth. All students were able to fully explain the physical properties that cause light energy to enter our atmosphere and help drive our weather patterns. The online tutorial was instrumental in aiding students in their research, and provided a wealth of information on the Earth's energy, surpassing the information included in our textbook

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Name: [illegible]

The Earth's Energy Budget: Internet Assignment

The sun is the ultimate source of energy for our planet. The sun provides energy for physical processes such as wind and weather, but it also supplies energy needed for plants, which are the backbone of our food web. In this assignment, you will learn about the ways energy from the Sun reaches the Earth, the physical processes that cause the light energy to penetrate our atmosphere, and what happens to the solar radiation when it enters our atmosphere. To complete this assignment you need to read the attached printouts from various websites and answer the provided questions.

Heat Transfer, Radiation, Conduction, and Convection

Directions: Read the attached printout from The University Corporation for Atmospheric Research's website. Scan down to the section titled "Energy Heat Transfer". Read the rest of the information on the webpage and answer the following questions:

1. Practically all the energy that reaches the earth comes from what?

   the sun ✓

2. What are the three ways energy is transferred between the earth's surface and the atmosphere?

   Radiation, Conduction, and Convection ✓

3. What is conduction?

   the process by which heat energy is transmitted through contact with neighboring molecules ✓

4. What is Convection?

   transmits heat by transporting groups of molecules from place to place within a substance ✓

5. Explain how convection causes the Coriolis effect.

   Connection transmits heat by transporting groups of molecules from place to place within a substance, such as water or air which move freely, the rising and sinking of air masses distribute heat and moisture throughout the atmosphere column, forming 2 convection cells. The Earth's rotation causes deflection of the wind. ✓ great!

6. What is radiation?

   the transfer of heat energy without the involvement of a physical substance in the transmission ✓

Reflection, Refraction and Absorption

Directions: Read the attached printout from How Stuff Works's How Light Works website. You should view the pages titled "absorption, reflection, and refraction."

1. What are the four different things that can happen when light hits an object?
   1) The waves can be reflected or scattered off the object. ✓
   2) The waves can be absorbed by the object.
   3) The waves can be refracted through the object.
   4) The waves can pass through the object with no effect.
2. Explain what happens to atoms during absorption.
   They speed up, collide with other atoms in the material, and then give up as heat the energy they aquired from the vibrations ✓
3. Do light waves penetrate an object during reflection? Explain why or why not.
   No, because the light that hits the material bounces of electrons and are shot back, this is how you see your reflection ✓
4. Explain what refraction is.
   The turning or bending of any wave, such as a light or sound wave, when it passes from one medium into another of different optical density ✓
5. The angle of refraction depends on what?
   How much material slows down the light. ✓

Solar Radiation

Directions: Read the attached printout from the Physical Geography College of Alameda's website. Read the study guide and answer the "study objectives" questions and define the key terms on a separate piece of paper. Complete the "Earth's energy budget quiz".

Great Job on this!

STUDY OBJECTIVES

1) The fusion of hydrogen into helium. Visible light (41%), ultra violet, X rays, and gammarays (9%), and short wave infra red energy (50%) ✓

2) The balancing out of solar and earth radiation. Solar radiation heats Earth's surface while Earth radiation heats the atmosphere. ✓

3) The heat energy recieved by a surface perpendicular to the sun's rays, outside the atmosphere would be a relatively constant 1400 watts per square meter ✓

4) Insolation is incoming solar radiation. ✓
A) the angle of the sun's rays
B) the amount of time a place is exposed to the sun's rays
C) the amount of clouds, dust, and water vapor in the atmosphere

5) 50% of sunlight reaches Earth's surface. Reflection, Sattering, and Absorption ✓

6) Longwave radiation, sensible heat, and the release of latent heat. ✓

7) When radiation is temporarily retained in the lower atmosphere by carbon dioxide, and water vapor ✓

8) I low latitudes, more radiation is emited to [redacted] itself rather than space, while high latitudes emit more to space than itself. ✓

(9) Global radiation balance is maintained throgh the ocean current, and wind ✓

(10) By changing the chemistry of the atmosphere and the dustiness of the planet ✓

The Earth's Energy Budget Quiz

Directions: Pick one best answer for each question.

1. What is the source of the sun's energy?
   a. The fusion of helium into hydrogen
   b. The fusion of uranium
   c. The fusion of hydrogen into helium
   d. The fission of uranium

2. Solar energy is transferred to the earth's surface by:
   a. Shortwave radiation
   b. Convection
   c. Longwave radiation
   d. Conduction

3. What is insolation?
   a. Incoming Solar Radiation
   b. Energy radiated from the earth
   c. Wind speed
   d. Made mostly of asbestos

4. As a global average, what percentage of the solar radiation reaching the top of the atmosphere is reflected back to space?
   a. 10%
   b. 20%
   c. 30%
   d. 40%
   e. 50%

5. Which one of the following surfaces reflects the most solar radiation?
   a. Forests
   b. Sand
   c. Ocean surfaces
   d. Fresh snow
   e. Dark, moist soil

6. Atmospheric gases such as carbon dioxide and water vapor, absorb and reradiate longwave radiation from the earth. This process is called:
   a. The coriolis effect
   b. The greenhouse effect
   c. The thermal effect
   d. The scattering effect

7. The most important process in heating the atmosphere is:
   a. Heat release from volcanoes
   b. Absorption of shortwave solar radiation
   c. Absorption of longwave earth radiation
   d. Reflection off the surface of the earth

8. Which is NOT one of the ways in which the atmosphere is heated?
   a. Reflection off the surface of the earth
   b. Conduction
   c. Longwave radiation from the earth
   d. Convection

9. On average, how much of the sun's radiation is absorbed by the earth's surface?
   a. 30%
   b. 50%
   c. 70%
   d. 85%

10. Comparing earth radiation with solar radiation, solar radiation is:
   a. Cooler
   b. Less harmful
   c. Longer wavelength
   d. Shorter wavelength

Energy in the Ocean and Atmosphere

The ocean and atmosphere are connected. They work together to move heat and fresh water across the globe. Wind-driven and ocean-current circulations move warm water toward the poles and colder water toward the equator. The ocean can store much more heat than the land surfaces on the Earth. The majority of the thermal energy at the Earth's surface is stored in the ocean. Thus, the absorption and movement of energy on the Earth is related to the ocean-atmosphere system.

El Niño/La Niña

Links for Teachers | Links for Students

La Niña is characterized by unusually cold ocean temperatures in the Equatorial Pacific, compared to El Niño, which is characterized by unusually warm ocean temperatures in the same region. Consequences of El Niño or La Niña require scientists to make short-term climate predictions. To provide the necessary data, NOAA operates a network of buoys, which measure temperature, currents, and winds in the equatorial band. These buoys transmit data on daily basis, which are available to researchers and forecasters around the world in real time. Students can access this data to conduct research.

Energy in the Atmosphere

Links for Teachers | Links for Students

Temperature differences in the atmosphere are a result of the way solar energy is absorbed as it moves through the atmosphere. The transfer of heat energy within the atmosphere, hydrosphere, and the Earth's surface and interior occurs as a result of radiation, convection, and conduction. Ocean currents play a significant role in transferring this heat toward the poles. Major currents, such as the northward flowing Gulf Stream, transport tremendous amounts of heat to the poles and contribute to the development of many types of weather phenomena. Resources here include seven activities to help students better understand these concepts.

Transfer of Energy from the Ocean to the Atmosphere

Links for Teachers | Links for Students

Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. Because water in the ocean holds a large amount of heat, the ocean has a major effect on climate.

The Coriolis Effect

- Lesson Plan
- Case Study
- Sample of Student Work (pdf, 63Kb)
- The Coriolis Effect: A Worksheet For Students (pdf, 10.3Kb)

When air in contact with the ocean is at a different temperature than the sea surface, heat transfer by conduction takes place. The ocean also absorbs and stores energy from the sun, and when precipitation falls, it releases heat energy into the atmosphere. Resources in this section include interactive online quizzes.

(top)

El Niño/La Niña: Links for Teachers

El Niño or El No-no: An Investigation

This web site allows students to predict future weather events. Use current data to build a predictive model for weather in your location.
http://www.powayschools.com/projects/elnino/

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Data Sources, History, Inquiry Materials

El Niño: A Web Quest

As an introduction to El Niño, consider using this web quest. Students learn about the phenomenon, find and interpret data, and report on El Niño's effects for a given geographic area.
http://projects.edtech.sandi.net/roosevelt/elnino/studentelnino.html

Features: Hands-on Investigation, Lesson Ideas, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

El Niño/La Niña: Links for Students

NOAA's El Niño Theme Page

Information, predictions, forecasts, analyses, and links are available on this award-winning Web site.
http://www.pmel.noaa.gov/tao/elnino/nino-home.html

Features: Graphics/Multimedia

USGS Information on El Niño

The United States Geological Survey provides a collection of information that discusses the effects of El Niño most relevant to USGS: landslides, floods, and coastal hazards.
http://walrus.wr.usgs.gov/elnino/

Features: Online Interactivity, Graphics/Multimedia, Data Sources

Tropical Atmosphere Ocean Project

This NOAA web site has El Niño data and graphics. Data and charts are available and presented in an accommodating format.
http://www.pmel.noaa.gov/tao/index.shtml

Features: Graphics/Multimedia, Data Sources

(top)

How Does El Niño Affect Infectious Diseases Worldwide?

In this brief report, get a sense of how El Niño affects weather and may also alter the incidence of infectious disease. The relevant information begins on page 4 of this document.
http://www.who.int/docstore/wer/pdf/1998/wer7320.pdf

El Niño Sea Level Rise Wreaks Havoc in California's San Francisco Bay Region

Discover the effects of El Niño in even a short period of time.
http://pubs.usgs.gov/fs/1999/fs175-99/

Features: Graphics/Multimedia

NOAA Learning Objects - Ocean Currents

Through a narrated slide show with motion graphics, students learn about deep and surface ocean currents and their global impact on weather, climate, and human activities. The activity includes an online quiz.
http://www.learningdemo.com/noaa/lesson08.html

Features: Online Interactivity, Graphics/Multimedia, Misconceptions

Can We Blame El Niño for Wild Weather?

When the Pacific is unusually warm near the beginning of the year, certain events are more likely to occur. How can such widespread phenomena in different parts of the world be connected to the same event? Find out more here.
http://www.classzone.com/books/earth_science/terc/content/investigations/esu601/esu601page01.cfm?cha...

Features: Lesson Ideas, Graphics/Multimedia, Data Sources Inquiry Materials, Misconceptions

(top)

Energy in the Atmosphere: Links for Teachers

Atmospheric Processes: Convection

In this two-part activity, students will study convective currents in water and observe the air as a fluid.
http://www.ucar.edu/learn/1_1_2_7t.htm

Features: Hands-on Investigation, Lesson Ideas

Climate Processes Over the Ocean

National Aeronautics and Space Administration's Goddard Space Flight Center developed the Earth Observing System to construct an integrated view of atmospheric climate over the ocean. Read about key research areas and access a data management tool.
http://eos.atmos.washington.edu/

Features: Data Sources

Energy in the Atmosphere: Links for Students

Global Surface Temperature Distribution

This resource is a brief primer on temperature distribution on Earth. It includes explanations of important concepts, including heat transfer, specific heat, and albedo.
http://www.physicalgeography.net/fundamentals/7m.html

Features: Graphics/Multimedia

Global Climate Animations

The University of Oregon provides this collection of animations in global energy balance, temperature, global water balance, atmospheric circulation, and more.
http://geography.uoregon.edu/envchange/clim_animations/

Features: Graphics/Multimedia

Surface Radiation Research

While the majority of information accessible from this NOAA Web site is rather technical, it does provide a student-friendly sunrise/sunset calculator and a solar position calculator.
http://www.srrb.noaa.gov/index.html

Features: Online Interactivity, Graphics/Multimedia, Data Sources

Examining Surface Temperatures Via Infrared Images

This animation allows the user to examine the changes in infrared radiation (heat) on Earth from 1990–1992.
http://www.classzone.com/books/earth_science/terc/content/visualizations/es1705/es1705page01.cfm?cha...

Features: Online Interactivity, Graphics/Multimedia

Variations in Global Temperature

Students can explore some of the variables that affect temperature in this multimedia lesson. The lesson is self directed, but it could serve as a basis for group discussion as well.
http://www.classzone.com/books/earth_science/terc/content/investigations/es1706/es1706page01.cfm?cha...

Features: Hands-on Investigation, Online Interactivity, Graphics/Multimedia, Assessment, Inquiry Materials

Heat in the Atmosphere: A Quiz

A brief online quiz on heat in the atmosphere.
http://wings.avkids.com/Activities/Atmosphere/advanced/heat-01.html

Features: Online Interactivity, Assessment

Earth's Energy Budget

Students can explore the concepts of balance and equilibrium as they relate to water resources in this activity. Expand their view of water in a bottle to water supply on Earth.
http://www.planetguide.net/book/chapter_3/energy_budget.html

Features: Hands-on Investigation, Assessment

The Oklahoma Meteorological Survey presents basic information on the Earth's energy budget. Follow the training materials link to case studies of severe weather events.
http://okfirst.ocs.ou.edu/train/meteorology/EnergyBudget.html

Features: Hands-on Investigation, Assessment, Data Sources, Inquiry Materials

A quick, graphics-intensive look at the Earth's energy budget.
http://csc.gallaudet.edu/soarhigh/SHMA31A.HTM

Features: Graphics/Multimedia

Solar Radiation Learning Module

This Web site includes a solar radiation learning module, study guides, PowerPoint presentations, tutorials, and practice quizzes to help you learn more about solar radiation.
http://members.aol.com/rhaberlin/srmod.htm

Features: Assessment

Understanding the Electromagnetic Spectrum and Blackbody Radiation

Rutgers University Institute of Marine and Coastal Sciences provides an introductory understanding of the electromagnetic spectrum and blackbody radiation.
http://marine.rutgers.edu/mrs/education/class/josh/em_spec.html

Features: Online Interactivity, Graphics/Multimedia, Data Sources

Solar Radiation Quiz

A quiz on solar radiation.
http://members.aol.com/rhaberlin/srquiz.htm

Features: Hands-on Investigation, Career Information

(top)

Transfer of Energy from the Ocean to the Atmosphere: Links for Teachers

Investigation of Climate Processes in the East Pacific

An in-depth look at how scientists research the interaction between the ocean and atmosphere. Due to complexity and length, this is recommended for advanced educators.
http://kestrel.nmt.edu/~raymond/epic2001/overview/overview.html

Features: Graphics/Multimedia

NOAA Climate Program Office

This Web site describes the purpose of NOAA's Climate Program, how it operates, and how to apply the data and information collected in an environmental setting.
http://www.climate.noaa.gov/index.jsp?pg./education/hurricanes/materilas.jsp

Features: Lesson Ideas, Data Sources, In the News

Transfer of Energy from the Ocean to the Atmosphere: Links for Students

The Ocean Atmosphere System

This Web site is a brief introduction on the ocean-atmosphere system. It serves as the basis for a teaching module for a Tulane University earth science course.
http://www.tulane.edu/~spaniels/geol204/oceanatmos.htm

Sunlight and the Earth

This Web site, developed by a retired National Aeronautics and Space Administration physicist, provides introductory information on the transfer of energy from the ocean to the atmosphere.
http://www-spof.gsfc.nasa.gov/stargaze/Sun1lite.htm

Features: Graphics/Multimedia

Hurricane Preparedness

History teaches us that a lack of hurricane awareness and preparation leads to major hurricane disasters. This Web site provides information on hurricane hazards, the Saffir - Simpson Hurricane Scale, and emergency preparedness.
http://www.nhc.noaa.gov/HAW2/english/intro.html

Features: Graphics/Multimedia

JetStream Online School for Weather: The Atmosphere

The JetStream (National Weather Service Online School for Weather) Web site is designed to help educators and students learn about weather and weather safety. Lesson, which can be easily adapted in the classroom, are include on the JetStream Web site.
http://www.srh.noaa.gov/jet stream/at mos/atmos_intro.htm

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Data Sources, Inquiry Materials

JetStream Online School for Weather: The Ocean

The JetStream (National Weather Service Online School for Weather) Web site provides complete lesson and plans for inquiry activities on the ocean and its role in weather and climate.
http://www.srh.noaa.gov/jet stream/ocean/oceans_intro.htm

Features: Hands-on Investigation, Lesson Ideas, Online Interactivity, Graphics/Multimedia, Assessment, Inquiry Materials, Misconceptions -->

Variations in a Salty Ocean

Students examine the relationship between temperature and salinity in

the ocean and how both of these qualities affect the density of sea water. Students estimate densities for water masses and predict how water mixes in the ocean.
http://www.classzone.com/books/earth_science/tierce/content/investigations/es2202/es2202page01.cfm

Features: Lesson Ideas, Data Sources, Inquiry Materials

(top)

Lesson Plan: Twisting the Air Away

Title:
Twisting the Air Away

Author:
Jerry D. Roth

Grade Level:
9-12

Subject Area:
Geoscience or General Science that has an Earth science component.

Standards Alignment-National Science Education Standards:

- Earth Science
  - Energy in the Earth system
    - Heating of the Earth's surface and atmosphere by the sun drives convection within the atmosphere and ocean, producing winds and ocean currents. (9-12)

- Earth Science
  - Energy in the Earth system
    - Global winds are part of a pattern of air circulation across the Earth and include the trade winds, westerlies and the polar easterlies.

Time Required:
The entire lesson requires about one-half hour from beginning to the end.

Overall Lesson Goal:
TLW understand that one of the effects of the Earth's rotation on the air and oceans is called the Coriolis Effect and it causes objects including air and water to move to the east in the Northern Hemisphere and to the west in the Southern Hemisphere.

Individual Learning Objectives:
The student should be able upon completion of the lesson to predict in which direction an object will move when being affected by the Coriolis effect.

Prerequisite Knowledge; Misconceptions/Preconceptions:
Most students have observed movies of the Earth rotating. Ask them if an area near the equator is rotating at the same speed as an area near the poles, and you may be surprised at their answer. All things have the same rotational velocity, but an object at the equator is traveling far faster than an object at the poles. This is not the case for all objects in the Solar System If you have access to the SOHO Web site you can see that the sun actually has something called differential rotation where the equator of the sun rotates with greater rotational velocity than the slower areas toward the poles.

Because the air and the ocean act as fluids they actually appear to drag behind the rotation of the planet. This causes the real direction of an object to be altered. A very good graphical representation of this is found at The Coriolis Effect. From Getting Around the Coriolis Force we can view in which direction the air is moved by the Coriolis effect. Objects in the Northern Hemisphere moving north actually show net movement to the east, and objects in the Southern Hemisphere moving south appear to move toward the west. The change in direction is called the Coriolis effect. It is a very small effect but the Earth is large and has been rotating for a long time. It has an impact on how winds and ocean currents move.

Please do not fall into the trap (no pun intended) regarding toilets and drains and the Coriolis effect. See the primary site listed for this lesson but also have a good read at Bad Coriolis to find what the Coriolis effect does not do. Just keep repeating to yourself… design issues cause this. I recommend reading down to the bottom of the Bad Science Web page and try some fakery yourself.

Procedures/Instructional Strategy:
Step 1: Ask the students to predict in which direction a straight line will turn when drawn from top to bottom on a page spinning clockwise.
Ask them to predict which direction the line will turn when drawn in the same direction if the paper is rotating in a counterclockwise direction. Have the students draw their predictions in their notebook.

Step 2: Break the class into groups of four students. Give each group a piece of poster board and two different colored markers-one for each side. I've tried this with photocopy paper but larger paper works better. Use paper that is clean on both sides. That way, when you reverse rotation you can work on the reverse side. Also, it really takes a little practice to get the procedure correct.

Step 2 (a): After the students have recorded their predictions, let them move to any available free wall or black/whiteboard.

Step 2 (b): One student should hold the paper at the center using either a finger or capped pen firmly enough so that it does not drop but loose enough so that another student can spin the paper around the center point on the paper.

Step 2 (c): Have the second student practice spinning the paper clockwise at a steady rate.

Step 2 (d): While the second student is turning the paper, have the third student practice drawing a line from top to bottom on the paper with the nonwriting end of the marker.

Step 3: After the students have synchronized their movements and are comfortable, have the student with the marker turn the marker to the writing position and while the paper is spinning, draw a line downwards from the top to the bottom of the paper.

Step 4: Have the fourth student label the sheet with the direction of travel and the start and end points of the line.

Step 5: Repeat **Step 1** through **Step 4** after turning the paper over and reversing the direction of spin. The only difference is the direction of the spin. All students should repeat their roles.

At the completion of the activity explain that the Coriolis effect causes an object to be deflected to the east (right), in the Northern Hemisphere and to the west (left) in the Southern Hemisphere. For your edification, the paper turning counterclockwise represented the Northern Hemispheric direction.

When this activity is completed, ask the students if their predictions agreed with their results. Ask the students to describe the lesson and write a paragraph or two describing how the procedure modeled the effect of the spin of the Earth on the ocean and air masses. Ask the students which of the two directions represented movement related to the Coriolis effect in the Northern Hemisphere.

Outcome/Assessment:
This lesson is fairly simple to assess. Once the students have mastered the turning and drawing, make sure their understanding has followed by reading through the Web sites and looking at their models to see how well they agree with the readings. The writing assignment need not be a major undertaking as long as the students are confident that they understand the direction things appear to move when related to the equator. Be very careful though, when the students use right and left in terms of the directions, it is better to have them use toward the east or toward the west relative to the equator.

Extension:
If the Coriolis effect causes air moving toward the poles to move to the east in the Northern Hemisphere and to the west in the Southern Hemisphere, how is it possible to explain to your classmates why the winds in the mid-latitudes of the Unites States are prevailing westerlies?

Internet Resources

Atmospheric Pressure and Winds are the keywords. The URLs include:

- SOHO Web site
- The Coriolis Effect
- Getting Around the Coriolis Force
- The Atmosphere in Motion: Air Pressure, Forces, and Winds: The Coriolis Force- An Introduction
- Bad Coriolis

Classroom Resources:
A large sheet of paper 18" by 24" or larger for each group of four students.
Wall space to work.
2 different colored markers, one for each side of the sheet of paper

(top)

Case Study: The Coriolis Effect

Miss Sherwood wanted to review the Coriolis effect with her 9th grade earth science class and a lower level earth science class and show how the ocean and air masses move on the planet. She had already taught the Coriolis effect during meteorology, but wanted to add how it affected the surface ocean currents.

Using the online resources under The Ocean's Role in Weather and Climate," she found an activity called "Twisting the Air Away." This activity was designed to be short (30 minutes) and demonstrate the Coriolis effect. Miss Sherwood created a worksheet based on the activity and started off with a simple question. If you got on a plane in New York City and wanted to fly to Miami, Fl., could you fly in a straight line to get there? Why or why not? This started discussions and divided the class in the lower level earth science class, while most of the upper level earth science class remembered that the Earth is rotating.

Miss Sherwood has very little wall space in her room, so she modified the activity since she has lots of table space. Instead of using paper, she used dry-erase boards which allowed students to erase mistakes and do the activity a couple of times. The lower level earth science students had quite a few problems, most of which were behavior and lack of interest. Many of them had trouble visualizing their line as the map was turned, much less writing their prediction down on paper. The activity itself was fairly easy since they could erase and do it over if they didn't do it correctly the first time.

The online resources also had some excellent Web sites that further explained the material for both teachers and students. The Coriolis Effect – Animations Web site through University of South Florida had a nice animation called "The Coriolis Effect Defined" as well as one called "Putting It All Together." "Getting Around the Coriolis Effect" was more for the instructor than for the students because it was a little more in depth than students needed. The "Bad Coriolis – Bad Meteorology" site had some interesting information for both teachers and students involving the misconceptions of toilets flowing in different directions.

As a follow up, Miss Sherwood used a writable globe and once again asked if students could fly from New York City to Miami, Fl. in a straight line. In order to demonstrate it, she had one student try to draw a line while another student turned the planet. This three-dimensional demonstration definitely put the final touches on the activity.

[(top)](#)

The Coriolis Effect

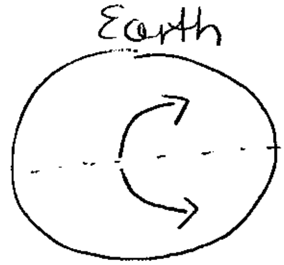
If you got on a plane in New York City and wanted to fly to Miami, could you fly in a straight line to get there? Why or why not? no

Earth rotates and if you are not attached to it, it spins under you.

→Does the Earth rotate @ the same speed @ N Pole & Equator? ⇒ fastest @ equator

Predict what direction you think the line will turn when paper is rotated clockwise and counterclockwise. Draw your prediction below.

CLOCKWISE Northern Hemis **COUNTERCLOCKWISE**



In the space below, draw the direction the line turned AFTER completing the rotations.

CLOCKWISE **COUNTERCLOCKWISE**

Did you predictions agree with your results? yes

Which way does the Coriolis Effect cause objects to be deflected in the Northern and Southern hemisphere?

Northern Hemisphere – objects are deflected to the east (right).

Southern Hemisphere – objects are deflected to the east (left).

How does the spin of the Earth affect the oceans and air masses?

ocean currents will travel clockwise in northern hemisphere but air mass will be counterclockwise

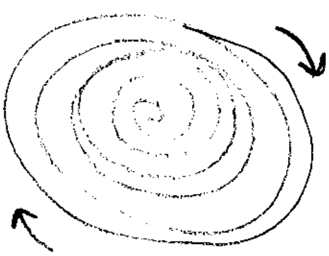
Sade P

The Coriolis Effect

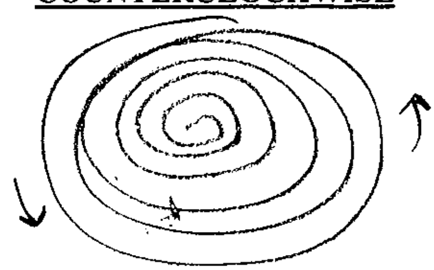
If you got on a plane in New York City and wanted to fly to Miami, could you fly in a straight line to get there? Why or why not? *No. Because of rotation of earth.*

Predict what direction you think the line will turn when paper is rotated clockwise and counterclockwise. Draw your prediction below.

CLOCKWISE

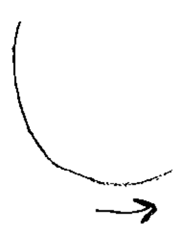


COUNTERCLOCKWISE



In the space below, draw the direction the line turned AFTER completing the rotations.

CLOCKWISE



southern hemisphere

COUNTERCLOCKWISE

northern hemisphere

Did you predictions agree with your results? *no*

Which way does the Coriolis Effect cause objects to be deflected in the Northern and Southern hemisphere?

Northern Hemisphere – objects are deflected to the *Right*.

Southern Hemisphere – objects are deflected to the *left*.

How does the spin of the Earth affect the oceans and air masses?

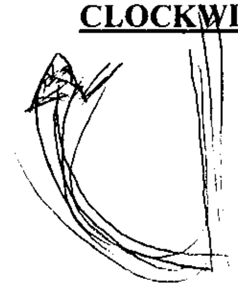
Quniaa S.

The Coriolis Effect

If you got on a plane in New York City and wanted to fly to Miami, could you fly in a straight line to get there? Why or why not? no because of the Rotation of the Earth.

Predict what direction you think the line will turn when paper is rotated clockwise and counterclockwise. Draw your prediction below.

CLOCKWISE



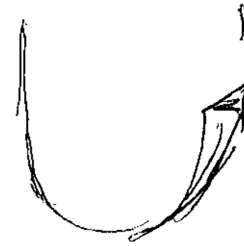
COUNTERCLOCKWISE

In the space below, draw the direction the line turned AFTER completing the rotations.

CLOCKWISE

COUNTERCLOCKWISE

Northern Hemispher



Did you predictions agree with your results?
No

Which way does the Coriolis Effect cause objects to be deflected in the Northern and Southern hemisphere?

Northern Hemisphere – objects are deflected to the East Right

Southern Hemisphere – objects are deflected to the left.

How does the spin of the Earth affect the oceans and air masses?
together.

The Coriolis Effect

If you got on a plane in New York City and wanted to fly to Miami, could you fly in a straight line to get there? Why or why not?

Predict what direction you think the line will turn when paper is rotated clockwise and counterclockwise. Draw your prediction below.

CLOCKWISE **COUNTERCLOCKWISE**

In the space below, draw the direction the line turned AFTER completing the rotations.

CLOCKWISE **COUNTERCLOCKWISE**

Did you predictions agree with your results?

Which way does the Coriolis Effect cause objects to be deflected in the Northern and Southern hemisphere?

Northern Hemisphere – objects are deflected to the ______________________.

Southern Hemisphere – objects are deflected to the ______________________.

How does the spin of the Earth affect the oceans and air masses?

Teacher Tutorials

Global Climate Patterns

http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/7/SCB-OCW.1.1

Click here for system requirements and how to access this tutorial
(pdf, 388Kb)

This tutorial explores global weather and climate patterns, focusing on why different conditions exist in specific areas. The Earth's weather patterns, which consist of different conditions of temperature, precipitation, humidity, wind, air pressure, etc., result in various climate zones across the globe. Weather and climate are the result of the transfer of energy from the sun at and near the surface of the Earth. Solar radiation heats land masses, the ocean, and air differently, resulting in the constant transfer of energy across the globe. Transfer of thermal energy at the boundaries between the atmosphere, land masses, and the ocean are influenced by dynamic processes such as cloud cover, and relatively static conditions such as the position of mountain ranges and the ocean. This transfer of thermal energy results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different density causes these layers to rise or fall, forming convection currents (cells). This circulation, influenced by the rotation of the Earth, produces winds and ocean currents.

Learning Outcomes:

- Explain why the temperature of the ocean does not generally fluctuate as dramatically as the temperature of the land.
- Describe the relationship between density of liquids and gases and their temperatures.
- Explain how a difference in density of different layers/portions of a fluid will cause internal currents (rising and falling of the fluid).
- Explain the cause of predictable wind patterns along the coastal regions of large land masses.
- Describe how the Coriolis effect determines the direction of the movement of air and water currents.
- List the major variables that affect the transfer of energy through the atmosphere.
- Provide an example showing how the transfer of energy affects weather and climate.
- Explain how convection relates to weather, including its role in the development of circulation patterns.

(top)

Global Precipitation and Energy

http://learningcenter.nsta.org/product_detail.aspx?

Click here for system requirements and how to access this tutorial

Media

Interactives

- Carbon Dioxide Emissions
- Climate Zones
- Create a Hurricane
- El Niño
- Evaporation in a Pot
- Hurricane Path
- Ocean and Wind Currents
- Ocean Circulation
- Land and Sea Breeze
- Specific Heat
- Water Cycle

Galleries

- NOAA Photo Library
- Ocean Explorer
- National Marine Sanctuaries

id=10.2505/7/SCB-OCW.1.2

(pdf, 388Kb)

This tutorial explores the distribution of water and energy on Earth. The cycling of water in and out of the atmosphere and ocean affects the Earth's climates by influencing patterns of precipitation and by transferring energy between the ocean and the atmosphere. As water moves through the water cycle, it evaporates from the Earth's surface, rises and cools, condenses into rain, snow, or ice, and falls back to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it eventually flows back into the ocean. The water cycle connects the ocean to all of the Earth's water reservoirs by evaporation and precipitation. The ocean loses thermal energy due to the evaporation of water. This energy transfer drives atmospheric circulation as water moves to the atmosphere as vapor and eventually condenses, releasing thermal energy to the surrounding air.

Learning Outcomes:

- Outline the basic steps in the water cycle in terms of density, energy of the water, and the relative molecular arrangement and motion in each phase.
- Describe how energy is transferred to the atmosphere by heating from the ocean and by the evaporation of water and its subsequent condensation.
- Identify the sun as the energy source that drives atmospheric circulation and the movement of masses of air and water from one place on Earth to another (through convection).
- List sources for the water cycle and identify the largest source.
- Explain the relationship between water, temperature, the amount of water evaporated into the atmosphere (and subsequently condensed), and the energy of the atmosphere at or near the location of evaporation.

(top)

Global Circulation Patterns

http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/7/SCB-OCW.1.3

Click here for system requirements and how to access this tutorial
(pdf, 388Kb)

This tutorial explores ocean circulation patterns and the effect that the ocean has on climate. Water in the ocean holds a lot of thermal energy (more than an equal amount of land). Throughout the ocean there is a global circulation system that transfers this thermal energy across the Earth. The shape of the ocean basins and adjacent land masses influence the path of circulation. As ocean currents transfer thermal energy to various locations, the temperature of the atmosphere above the ocean is affected. For example, the condensation of water that has been evaporated from warm seas provides the energy for hurricanes and cyclones. When the pattern of thermal energy released into the atmosphere changes, global weather patterns are affected. An example of a large-scale impact such as this is the El Niño Southern Oscillation, which changes the pattern of thermal energy released into the atmosphere in the Pacific.

Learning Outcomes:

- Explain how the ocean might influence and affect local weather and

climate, given a specific location (on the planet near the ocean) and the local ocean currents.
- Describe the cause of hurricanes and explain why they usually occur within specific regions during certain times of the year.
- Explain how changes in ocean temperatures (over a period of months) affect factors that influence weather patterns.
- List the major variables that affect the transfer of energy through the ocean.

(top)

Changing Climate

http://learningcenter.nsta.org/product_detail.aspx?id=10.2505/7/SCB-OCW.1.4

Click here for system requirements and how to access this tutorial *(pdf, 388Kb)*

This tutorial explores how Earth's climate has changed in the past and how it may change in the future. Climate change may occur as a result of changes in the Earth's surface, atmosphere, and ocean. Such changes may be abrupt (such as gas and dust from volcanic eruptions or asteroid impacts) or may occur over very long times (such as changes in landscape or increases in carbon dioxide levels in the atmosphere). Even relatively small changes in atmospheric or ocean content and/or temperature can have widespread effects on climate if the change lasts long enough. Since the industrial revolution, the concentration of greenhouse gases in the atmosphere has increased at an unprecedented rate. Though climate change and changes in the composition of the ocean and atmosphere are natural, present modifications far exceed natural rates.

Learning Outcomes:

- Explain the role that phenomena such as volcanic eruptions or asteroids have in changing climate.
- Describe the type of atmospheric conditions and weather-related data that can be obtained from ice core and deep-sea sediment records.
- Describe how a small change in the content of the ocean and atmosphere (such as a rise in carbon dioxide levels) can have significant impacts on global climate.
- Describe how human activity affects climate.

(top)

Save this page for future reference

System requirements to run NOAA/NSTA Teacher Tutorials:

Operating system

- Windows 98, 2000, or XP
- Mac OS 9 or OS X V10

Internet connectivity

- 56K modem minimum
- Broadband (recommended)

Browser (cookies and Java must be enabled)

- Windows
    i. Internet Explorer 5.5* or higher (recommended)
    ii. NetScape 6.2 or higher
- Mac
    i. Internet Explorer 5.2

Monitor

- Minimum 800x600 resolution

Sound card and speakers

Browser plug-ins

- Flash Player
- QuickTime

If you have additional questions, go to: http://learningcenter.nsta.org/help/faq.aspx

Accessing NOAA Teacher Tutorials

Teacher Tutorials on NOAA's National Ocean Service (NOS) Education Web site are available, through the National Science Teachers Association (NSTA) Online Learning Center - where they are called Science Objects. To use these materials, you must set up a library account at the NSTA Learning Center Web site and add the tutorials to your library. The Account is free, confidential, and only requires your name, email address and a password.

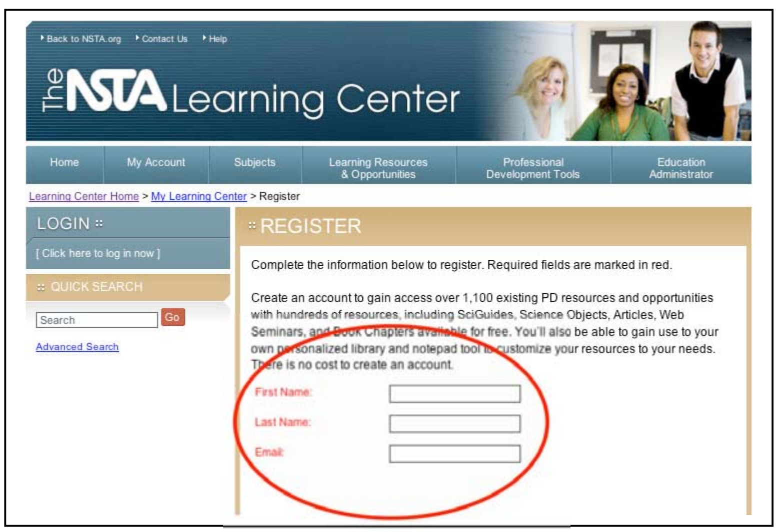
Setting up an NSTA Online Library Account and Adding A Teacher Tutorial

1. Make sure that your computer meets the minimum requirements for running the Teacher Tutorials (aka Science Objects).

2. Go to the NSTA Online Learning Center - http://learningcenter.nsta.org.

3. Roll your mouse over the "My Account" button on the upper left side of the page and click the "register" drop-down menu item.

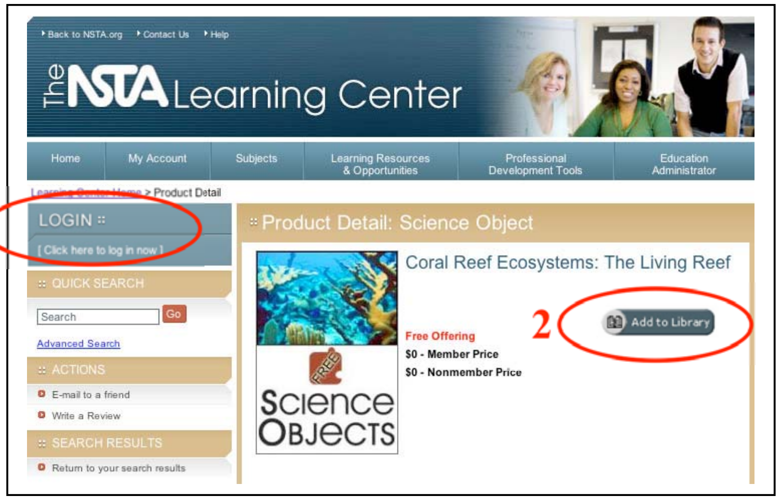
4. Fill in the required information fields (Name: First, Last; E-mail; Password - **at bottom of page**), and click the "submit" button at the bottom of the page.



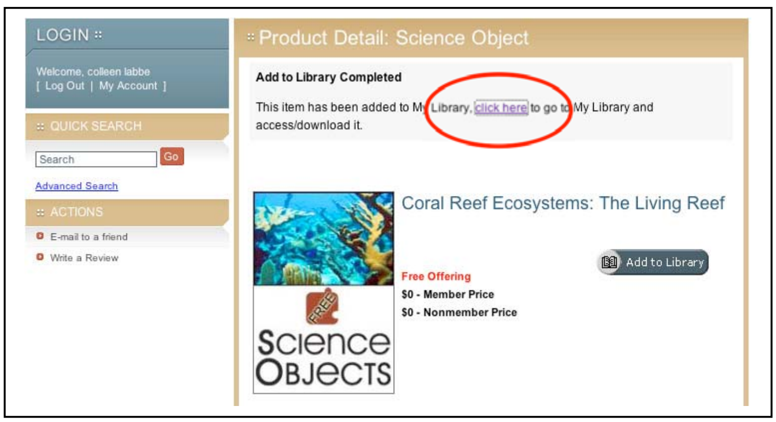
5. Go to the NOS Education Web site professional development subject area of your choice (i.e. http://oceanservice.noaa.gov/education/PD/oceans_weather_climate/) and click on the link to the Teacher Tutorial of your choice.

6. Click on the link to a Tutorial, and you will be taken back to the NSTA Online Learning Center Web site featuring that tutorial (Science Object).

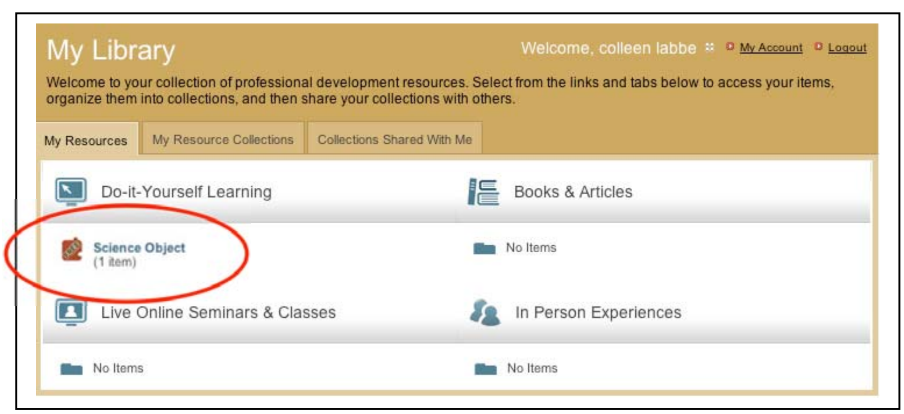
7. On the left hand side of the page you will be prompted to log in to your account. Once you do this, select the link "add to library" on the right side of the page. Note - You will not be able to add the resource without logging into your library.



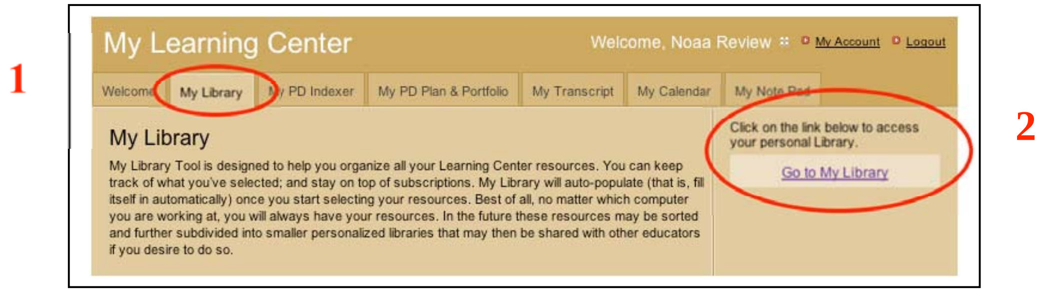
8. When the resource has been successfully added to your account, the NSTA Web site will prompt you to "click here" to access your library.



9. Once in your library, click on the Science Object to access it, then click on the title to activate and use it.



10. The next time you want to access any resource in your NSTA online library, log into your account at http://learningcenter.nsta.org., click on the "My Library" tab on the left side of the page, then click on the "Go To My Library" link on the left side of the page.



11. Click on the resource you would like to use.

To add and access additional teacher tutorials to your NSTA online library, repeat steps 5-9 above.

This document was created in August 2008.