Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

A Project of the National Science Teachers Association

This project was suppported in part by the National Science Foundation.
Opinions expressed are those of the authors and not necessarily those of the Foundation.

Scope, Sequence & Coordination

SS&C Research and Development Center

Bill G. Aldridge, *Principal Investigator and Project Director**
Dorothy L. Gabel, *Co-Principal Investigator*
Erma M. Anderson, *Associate Project Director*
Nancy Erwin, *SS&C Project Editor*
Rick McGolerick, *Project Coordinator*

Evaluation Center

Frances Lawrenz, *Center Director*
Doug Huffman, *Associate Director*
Wayne Welch, *Consultant*
University of Minnesota, 612.625.2046

Houston SS&C Materials Development and Coordination Center

Linda W. Crow, *Center Director*
Godrej H. Sethna, *School Coordinator*
Martha S. Young, *Senior Production Editor*
Yerga Keflemariam, *Administrative Assistant*
Baylor College of Medicine, 713.798.6880

Houston School Sites and Lead Teachers
Jefferson Davis H.S., Lois Range
Lee H.S., Thomas Goldsbury
Jack Yates H.S., Diane Schranck

California Coordination Center

Tom Hinojosa, *Center Coordinator*
Santa Clara, Calif., 408.244.3080

California School Sites and Lead Teachers
Lowell H.S., Marian Gonzales
Sherman Indian H.S., Mary Yarger
Sacramento H.S., Brian Jacobs

Iowa Coordination Center

Robert Yager, *Center Director*
Keith Lippincott, *School Coordinator*
University of Iowa, 319.335.1189

Iowa School Sites and Lead Teachers
Pleasant Valley H.S., William Roberts
North Scott H.S., Mike Brown

North Carolina Coordination Center

Charles Coble, *Center Co-Director*
Jesse Jones, *Center Co-Director*
East Carolina University, 919.328.6172

North Carolina School Sites and Lead Teachers
Tarboro H.S., Ernestine Smith
Northside H.S., Glenda Burrus

Puerto Rico Coordination Center**

Manuel Gomez, *Center Co-Director*
Acenet Bernacet, *Center Co-Director*
University of Puerto Rico, 809.765.5170

Puerto Rico School Site
UPR Lab H.S.

Pilot Sites
Site Coordinator and Lead Teacher
Fox Lane H.S., New York, Arthur Eisenkraft
Georgetown Day School, Washington, D.C., William George
Flathead H.S., Montana, Gary Freebury
Clinton H.S., New York, John Laffan**

Advisory Board

* Western NSTA Office, 394 Discovery Court, Henderson, Nevada 89014, 702.436.6685
** Not part of the NSF-funded SS&C project.

> **National Science Education Standard—Earth and Space**
> **Energy in the Earth System**
> The outward transfer of Earth's internal heat drives convection circulation in the mantle that propels the crustal plates comprising Earth's surface across the face of the globe. Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

Teacher Materials

Learning Sequence Item:

948

Examples of Convection

March 1996
Adapted by: Patricia Allick

Convection in Earth's Mantle, Atmosphere, and Oceans: their Sources and Effects. Students should understand concepts of convection of large masses of material within Earth, and they should understand the same concepts in regard to air and water masses on Earth's surface. They must possess a working knowledge of radiation, conduction, evaporation, latent heat, density, climate, weather, water masses, basic kinematics, currents, salinity, heat capacity of water (heat reservoir-ocean), ecosystems, and habitats. A study of oceanic habitats and ecosystems could be done at this grade level. More than likely, some of this work has been done at the middle level. Wave tanks are easily used to simulate wave development and other coastal features. (*Earth and Space Sciences, A Framework for High School Science Education, p. 138.)*

Contents

This micro-unit was adapted by **Patricia Allick** (Kalispell Junior H.S., Kalispell, Mont.)

948
Learning Sequence

Convection in Earth's Mantle, Atmosphere, and Oceans: their Sources and Effects. Students should understand concepts of convection of large masses of material within Earth, and they should understand the same concepts in regard to air and water masses on Earth's surface. They must possess a working knowledge of radiation, conduction, evaporation, latent heat, density, climate, weather, water masses, basic kinematics, currents, salinity, heat capacity of water (heat reservoir-ocean), ecosystems, and habitats. A study of oceanic habitats and ecosystems could be done at this grade level. More than likely, some of this work has been done at the middle level. Wave tanks are easily used to simulate wave development and other coastal features. (*Earth and Space Sciences, A Framework for High School Science Education, p. 138.)*

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
We Just Don't Mix **Activity 1**	Density Factor **Assessment 1**	Density Currents **Assessment 3**	
Soda Straw Float **Activity 2**	Convection in Air Masses—Weather 3 **Assessment 11**	Density Currents/Dynamic Equilibrium **Assessment 4**	
Look Ma, I Can Float! **Activity 3**	Geothermal Energy **Assessment 14**	Dynamic Equilibrium **Assessment 5**	
Currently, Deep in Thought **Activity 4**		Climate Causes **Assessment 7**	
Not Too Much, Not Too Little **Activity 5**		Convection in Air Masses—Weather 2 **Assessment 10**	
Liquid Density **Assessment 2**		Convection in Earth **Assessment 12**	
Energy & Heat **Assessment 6**		Kites in California **Assessment 16**	
Climate Causes **Assessment 7**			
Clouds in a Jar **Assessment 8**			
Convection in Air Masses—Weather 1 **Assessment 9**			
Convection in Air Masses—Weather2 **Assessment 10**			
Convection in Water **Assessment 13**			
Hot Air Balloon **Assessment 15**			
Salinity, Evaporation, Density **Assessment 17**			
Living Reefs, Living Oceans **Reading 1**			
Nature's Most Violent Storms **Reading 2**			
The Ocean/The Ocean: A Global View **Reading 3**			

Suggested Sequence of Events

Event # 1

Lab Activity

1. We Just Don't Mix (45 minutes)

Alternative or Additional Activities

2. Soda Straw Float (45 minutes)
3. Look Ma, I Can Float! (45 minutes)

Event #2

Lab Activity

4. Currently, Deep in Thought (30 minutes)

Event #3

Lab Activity

5. Not Too Much, Not Too Little (30 minutes)

Event #4

Readings from Inquiry, Science and Technology, Personal and Social Perspectives, and History of Science. Students select two or three from list.

Reading 1 Living Reefs, Living Oceans
Reading 2 Nature's Most Violent Storms
Reading 3 The Ocean/The Ocean: A Global View

The above readings can be found in the student version of this publication.

Assessment items can be found at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

We Just Don't Mix

How does density and salt concentration of salt water affect the formation of discrete layers?

Materials:

Per lab group:
four 50-mL beakers (3 for prepared solution)
3 eyedroppers (or plastic pipettes)
50-mL beaker

Per student:
clear plastic straw (length: 5 cm)
3-cm slice potato (or clay)

Solution preparation:
150 mL pickling salt (Kosher or ice cream salt)
food coloring (red, green, blue)
tap water
three 600-mL beakers (or jars)
500-mL graduated cylinder
100 mL graduated cylinder
3 plastic jugs with lids (save excess)

Procedure:

Prepare colored solutions prior to class. Pickling salt makes very clear saltwater. If you use Kosher salt you might want to increase the concentration.

Ocean water	Brackish water	River water
500 mL water	500 mL water	500 mL water
90mL salt	30mL salt	no salt
20 drops blue	20 drops red	20 drops green

Stir until salt dissolves. If making a day ahead of time, you can dissolve the salts faster by heating.

Have each student stick the plastic straw into the slice of potato, or clay, at an angle as shown in the figure. Do not stick straw all the way through the potato. Students are to add small amounts (about 1 cm) of each solution to the straw in the correct order until they produce three distinct layers that do not mix. Tell them that the solutions represent salt water, brackish water and fresh water. Their goal is to determine which colored solution corresponds to each. Before beginning the experiment, have students write a hypothesis as to the order in which the solutions should be added, and explain their hypothesis. If solutions mix, empty the straw into the waste container (fourth beaker). Students in the group will share the three solutions and eyedroppers. Do not contaminate solutions by switching eyedroppers in beakers. Once students have completed their tests, discuss any observations that they have. Be sure to discuss, why the solutions layer, why the solutions layer in the order they did, and what causes a fluid to become more dense.

Background:

Ocean water is not the same everywhere due to density differences. Density is affected by the amount of dissolved salts, (as more salts dissolve in water, the water becomes more dense) and by water temperature (as temperature decreases, density increases until it reaches a maximum of 4°C—below this temperature, the density begins to decrease). Ocean water contains 96% pure water, 3% NaCl, and a smaller amount of many other chemicals. River water or fresh water contains a tiny amount of dissolved salts, carried down from the continents as rainwater slowly dissolves rock. Brackish water, (found in estuaries, where river water flows into the ocean) has a higher concentration of dissolved salts than river water, but a lower concentration than ocean water. Besides layering, differences in density create density currents in the ocean. Ocean water at the Earth's poles is very cold and very salty (salts are not frozen in ice because there is not enough room in the molecular structure of ice to hold the salt atoms, therefore, salts increase in concentration in the remaining ocean water). The dense ocean water sinks and flows toward the equator along the ocean bottom. To replace the sinking water, warm, less dense water, at the equator, flows toward the poles creating a giant convection current.

Variations:

Have students assist in preparing solutions—this might help them understand concentrations.

Adapted from:

Ford, Brent A., and P. Sean Smith, *Project Earth Science: Physical Oceanography,* National Science Teachers Association, Arlington, Va., 1995.

alternative activity for Event 1

Teacher Sheet

Science as Inquiry

Soda Straw Float

How does density relate to the salinity of water?

Materials:

Per lab group:

- 2 L container (milk carton)
- soda straw
- masking tape
- waterproof marker
- 500-mL graduated cylinder
- metric ruler
- modeling clay
- pickling salt
- 5-mL metric measuring spoon (or balance)

Procedure:

Have the students obtain a piece of masking tape over 8cm long. At one end, they draw an 8-cm-long-line. Using the ruler and marker, they mark off each millimeter, making an extra long mark every five mm. Label the long marks 0, 5, 10, etc., up to 80mm (8.0 cm). Starting at one end of the straw, students wrap the tape as shown. They add a small ball of clay to the other end of the straw, making a water tight seal. Students fill the container with 1 L of water and float the straw in an upright position within the container. They create a table showing both the amount of salt, in grams, as well as the level of water on the straw, in mm. Students record their results for 0 g to 50 g of salt, in 10 gram increments. Have the students draw the graph of the relationship between density and salinity.

Background:

A hydrometer, or straw setup, measures relative density. In this activity students will see the relationship between density and salinity. Salt added to water increases the density of water. Water that contains dissolved salts has a greater density (mass per unit volume) than pure water. Salinity is a measure of the concentration of salt in water. It is measured in g per 1000 mL (not 100 mL) and its symbol is ‰. Ocean water has an average salinity of about 35‰ or 3.5%. The higher the salinity, the less water must be displaced by a floating object (as in a person floating in the Great Salt Lake).

Variations:

Have a salt concentration high enough to float an egg and then add fresh water to the solution and record the results (if done slowly enough, two layers will develop and the egg will float between the layers). Students can try using their home-made hydrometer with common household liquids to find the densities of these liquids.

Adapted from:
Earth Science Laboratory Manual, Prentice-Hall, 1987.

alternative activity for Event 1

Teacher Sheet

Science as Inquiry

Look Ma, I Can Float!

How does density relate to the salinity of water?

Materials:

Per lab group:

large beaker (or jar)
pickling salt
soup spoon (large enough to hold an egg)
100-mL graduated cylinder
hard boiled egg
5-mL metric measuring spoon
ruler (or straight-edge0
straw hydrometer

Procedure:

Create a chart that students can use to record their results. Have students fill the beaker 3/4 full with cool tap water and record the amount. They slowly lower the egg into the water and record their observations, then remove the egg. Students measure 10 mL of salt, add it to the beaker and stir until it has dissolved. They then put the egg back into the water and record observations. Students repeat the steps, adding the 10 mL of salt and recording their results until a change occurs (the egg floats). Using each groups' results, have students find the average salinity of the class. They should also solve salinity problems using the class average.

Background:

Salt added to water increases the density of water. Water that contains dissolved salts has a greater density (mass per unit volume) than pure water. Salinity is a measure of the concentration of salt in water. It is measured in g per 1000mL (not 100 mL) and its symbol is ‰. Ocean water has an average salinity of about 35‰ or 3.5%. The higher the salinity, the less water must be displaced by a floating object(as in a person floating in the Great Salt Lake).

Variations:

Students can make a hydrometer (measures relative density) so that they can take density measurements and add to the chart (use the straw hydrometer from Activity 2). Have a salt concentration high enough to float an egg and then add fresh water to the solution and record the results (if done slowly enough, two layers will develop and the egg will float between these layers.

Adapted from:

Ford, Brent A., and P. Sean Smith, *Project Earth Science: Physical Oceanography,* National Science Teachers Association, Arlington, Va., 1995.

Science as Inquiry

Currently, Deep in Thought

What is the relationship between density and the creation of currents?

Materials:

Per lab group: (or teacher demo)
4 narrow-necked bottles
pickling salt
blue food coloring
index card, cut in half
container for mixing

Procedure:

Fill three of the bottles with tap water (same temperature). Make a saturated salt solution and pour it into the fourth bottle. Add five drops of food coloring to the bottle of saltwater and five drops to one of the bottles of tap water. These two bottles of blue water will be inverted over the two bottles of clear water. Ask students for a hypothesis of what will happen. Put the index card over the bottle of blue tap water and invert. Carefully place this inverted bottle directly over one of the bottles of clear water and slowly remove the card. Repeat the inversion process with the bottle of blue salt water and the remaining bottle of clear water. Have students write down observations. Discuss where density currents can be found and their importance.

Background:

The greater density of salt water will cause the saltwater to sink to the lower bottle and the clear fresh water(less dense) will rise to the top bottle to replace the saltwater. These density currents occur in our oceans. Cold , dense saltwater at the poles sink (at a rate of 5 billion gallons per second) and move toward the warmer, less dense saltwater found at the equator. These currents bring nutrients from the bottom. The dense sinking saltwater carries huge amounts of carbon dioxide dissolved in at the surface ,which will be used by plankton in photosynthesis. The salt water is more dense at the poles because as water freezes the salt stays behind in the water. A concern is that global warming will cause the melting of the ice caps and dilute the saltwater at the poles, slowing or stopping the current.

Variations:

Use a clear tank with a removable divider—blue saltwater on one side and fresh tap water on the other side. Slowly remove the divider.

Adapted from:
Rosenthal, Dorothy B., and Richard Golden, *Global Warming Activities for High School Science Classes*, Climate Protection Institute, 1991.

Science as Inquiry

Not Too Much, Not Too Little

What is dynamic equilibrium and how does it relate to natural systems?

Materials:

Per lab group:

2 L plastic bottle (soda pop type)
electric drill with 1/4” bit (or phillip's screw driver)
sink (water supply and drain)
rubber hose

Procedure:

Prior to class, drill (or melt) 1/4” holes into the side of containers. Students draw a horizontal line on the side of their bottles above the holes. They then attach their bottles to a faucet with a rubber hose. Tell them that the goal is to keep the water level with this line. They should predict what will happen when the water is turned on. After turning on the water, students write down what they had to do to obtain the goal. They then plug-up a few of the holes, turn on the water, and write results. Students reduce the flow and write the results. Have students increase the flow and write the results. Discuss the students results and relate it to earth’s natural systems. Have students come up with as many natural systems, that are in dynamic equilibrium, as they can.

Background:

This demonstrates the “dynamic equilibrium” contained in many of earth’s natural systems. These systems are changing continuously—but seem to be stable. As long as conditions don’t change drastically in the system, the equilibrium will adjust. However, if conditions change too quickly, the system can collapse. This can be related to many natural systems: water cycle, sun’s energy, ozone layer, greenhouse gases, predator/prey relationship, etc., (mention recycling).

Variations:

To make a more accurate system, show the water being recycled.

Adapted from:
Rosenthal, Dorothy B., and Richard Golden, *Global Warming Activities for High School Science Classes*, Climate Protection Institute, Calif., 1991.

Science and Technology

Density Factor

Item:

An ocean-going ship, with cargo, rides 15 meters below the surface of the water. The ship enters the Mississippi River—where depth in some places is only 16 meters. What will happen to this ship as it enters the river? Explain your answer.

Answer:

The ship floats higher on the dense salt water because it does not displace as much water as it would in fresh water. Therefore, as it enters the river the ship will not float as high in the less dense fresh water and will either hit bottom or come aground.

Science as Inquiry

Liquid Density

Item:

A container holds four different colored liquids. The liquids are layered from top to bottom: red, green, yellow, blue. Which of the following would be correct about the liquids' densities.

A. The yellow liquid is denser than the blue.
B. The blue liquid is denser the yellow.
C. The green liquid is denser than the yellow.
D. The red liquid is denser than the green.

Justification:

Draw a picture of the container and liquids. Then explain why your choice is better than the other three.

Answer:

B. The blue liquid is the most dense. The density of the liquids would have to increase from top to bottom, otherwise the liquids would mix.

Science in Personal and Social Perspectives

Density Currents

Item:

At the poles, the temperature of the ocean water is colder than at the equator. These ocean waters are also higher in salt concentration than at the equator. Describe or draw the currents created by these factors.

Justification:

Explain the reasoning behind your answer.

Answer:

Temperature and salt concentration determine density of the water. Cold, ocean water high in salt concentration will sink and move toward the equator. Warm, less concentrated salt water will stay on the surface and move toward the poles.

Science in Personal and Social Perspectives

Density Currents/Dynamic Equilibrium

Item:

Deep ocean currents travel from the poles to the equator. As the water warms and becomes less concentrated, it rises to the surface carrying with it nutrients from the bottom. What would happen to these currents if global warming causes the ice caps at the poles to melt? Explain your reasoning. What consequences would there be if this happens.

Answer:

Density is the driving force of these currents. The ice at the poles is made of fresh water that would dilute the concentration of salt water. The whole deep water circulation system would diminish. Several consequences could be stated, such as: less nutrients would mean less food for the fish, thus less food for people; carbon dioxide at the poles is carried down into the deep ocean to be used in photosynthesis—if it is not carried down, there might be a strengthening of the greenhouse effect.

Science as Inquiry/Science in Personal and Social Perspectives

Dynamic Equilibrium

Item:

Each year it is estimated that some four billion tons of dissolved salts and minerals are carried from the continents into the ocean. At the same time, water that evaporates from the ocean leaves its salts behind. What keeps the oceans from becoming too salty?

Answer:

The ongoing introduction of salts into the ocean is offset by fresh water continually entering the ocean by way of rivers and precipitation—at about the same rate as they're introduced. A balance or equilibrium is maintained even though the system is under constant change.

Science as Inquiry

Energy & Heat

Item:

Concept. Energy from the sun and heat capacity of water (heat reservoir—ocean).

Purpose. To show how water and land can store up energy and the effect they can have on weather and climate.

Procedure. Attach two clamps to a ring stand and then attach a thermometer to each clamp. Put one thermometer in a container of soil and the other thermometer in an equal-sized container of water. Immerse the thermometers one-inch into each container. Set a lamp one foot above the containers so that the light shines at a 90° angle on the containers and turn on the lamp. Record the date on the data table, as well as the temperature of the water and soil ever minute for 10 minutes. Repeat the experiment with the lamp set at a 45° angle. Turn the lamp off. Check the difference in soil and water temperature after half an hour and record the temperatures.

DATA TABLE

	Temperature °C	
Time (min.)	**Soil**	**Water**
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Questions:

1. At the end of 10 minutes, what was the difference in the temperature of the water and of the soil?

2. How do your observations in this experiment explain differences in temperature at the same longitude?

3. What two factors account for the low temperatures at the Poles?

4. What affect did changing the angle of the lamp have on the soil and water?

Answer:

Science as Inquiry/Science in Personal and Social Perspectives

Climate Causes

Item:

Is it better to live on an oceanic island or in the middle of a continent? If by better, we mean less temperature difference between night and day, you can answer that question.

On a “map” of the Earth’s surface temperature, at different times of the day, you will notice that the continents and oceans warm up and cool differently. Perform the following experiment, to explore the original question.

Materials. 2 test tubes, beaker, 2 thermometers, water, sand, clay, timing device, hot plate or burner, heat lamp or spotlight, 2 pie pans.

Part 1. Fill one test tube half full with water and another half full with sand. Place the thermometers in the test tubes, using the clay to keep them upright. Place both tubes in a beaker of hot water and heat to approximately 70°C.

Remove the test tubes and record the drop in temperature every two minutes for 20 minutes. Graph the results.

Part 2. Fill one pie pan half full with water and the other half full with sand. Place both pans an equal distance from the heat source (lamp or spotlight). Place one thermometer flat on the sand, covering the thermometer bulb with 0.5 cm of sand. Obtain the surface temperature of the water by holding the other thermometer 0.5 cm below the surface. Record the surface temperature of each every two minutes for 20 minutes. (How did the temperature change with time?)

Questions:

1. In Part 1, why didn’t the exact temperature (heating the tubes to approximately 70°C) matter?

2. In Part 1, did the tubes cool at the same rate? What was the difference?

3. In Part 2, how did the temperature change with time?

4. How does this experiment model how continents and oceans warm and cool differently? Explain.

Science as Inquiry

Clouds in a Jar

Item:

Materials per lab group. Large jar with lid, 100-mL beaker, 50-mL beaker, matches, flashlight.

Materials per class. Crushed ice, water, two 1L beakers (or teakettle), hot plate (or burner).

Students work in pairs. Set up all work stations (level tables preferred) except for the ice and hot water. Have water boiling before students enter. Darken the room, but allow enough light so that students can comfortably read and write. Students will build a model of the atmosphere and observe what normally occurs on a very large scale.

Pour 100 mL of hot water into a jar. Students light a match and drop it (while still burning) into the jar. They quickly screw the lid on, then place a handful of ice on top of the lid. Students shine a flashlight through the jar, observe what occurs, and record their observations.

Questions:

1. Explain what is causing the phenomena your are observing.

2. How is this phenomena similar to what occurs in our atmosphere?

Answers:

- Evaporation of water into cool air form the hot water.
- Clouds consist of tiny water droplets.
- Droplets use smoke particles as “seeds.”
- Condensation of water droplets on the jar is similar to rain.
- Cooler air is denser than warmer air; circulation of air, with the cold air sinking.
- Dew point is the temperature at which water condenses into liquid.

Possible misconceptions to be found in answers:

- The water droplets are smoke.
- Water is leaking down from the ice.
- Clouds need boiling water and ice to form.
- Clouds are not made of water droplets.

Science as Inquiry

Convection in Air Masses—Weather 1

Item:

When cold air and warm air meet, as they often do over the central United States, we expect that:

A. The cold air will rise up and form clouds rapidly, making thunderstorms.
B. The cold and warm air will mix, giving rise to fine weather.
C. The warm air will be deflected back away from the cold air, causing high winds.
D. The warm air will rise up and form clouds rapidly, making thunderstorms.

Justification:

Briefly describe how clouds form.

Answer.

D. The warm air usually has moisture, but as it rises, it cools, and the water vapor content exceeds the limits. So, water droplets form as clouds and a thunderstorm develops.

Science as Inquiry, Science in Personal and Social Perspectives

Convection in Air Masses, Weather 2

Item:

In forecasting violent weather, so that people can be warned of impending problems, the following is the most useful data to obtain:

A. Current air temperature in the region.
B. Current humidity in the region.
C. Rate of change of barometric pressure in the region.
D. Rate of movement of nearby cold and warm air masses.

Justification:

Discuss how a weather forecaster uses information to predict weather on a daily basis.

Answer:

D. Because air masses with different densities don’t mix readily, but move above (hotter) and below (colder), this sets up vertical movements which are the source of much violent weather. Thus, tracking fronts is a major goal for weather forecasters.

Science and Technology

Convection in Air Masses, Weather 3

Item:

Draw diagrams to show how air masses of different temperature meet in a front in a way which often results in thunderstorms. Explain briefly why the thunderstorms form.

Science in Personal and Social Perspectives

Convection in Earth

Item:

It has been suggested that highly toxic waste could be disposed of by placing it in holes drilled in the oceanic trenches where rocks are being slowly buried. Discuss what would happen to such wastes as a function of time. Create diagrams to help explain your answers. Would the wastes be safe to people?

Science as Inquiry

Convection in Water

Item:

Supposition: Take an empty aquarium tank, hang a small heater on one end, and fill the tank with water. After the water becomes very still, turn on the heater. Submerge water weed leaves in the water. Some of the water weed leaves will begin to move around. Use a drawing to predict how the leaves will move as long as the heater is on.

Science and Technology

Geothermal Energy

Item:

A geothermal well is a deep hole drilled into a water reservoir below ground. The Earth's mantle is unusually thin where the wells are drilled. When the water comes up the hole, it immediately and violently bursts into steam when it reaches the surface. The water remains liquid underground because:

A. The underground pressure is much higher than atmospheric pressure, which raises the boiling point.
B. The water reservoir is cool, the water gets heated by friction as it rises in the hole.
C. The water reservoir is cool, the water is heated by passing through the radioactive rocks as it rises.
D. The salts in the water are so concentrated, the water stays liquid.

Justification:

Automobiles have a warming printed on the radiator cap under the hood. If you remove the cap just after a long drive, the water may boil out of the radiator. Discuss how this phenomenon may be related to the geothermal well observation above.

Answer:

A. Increasing external pressure has a big effect on raising the boiling temperature of water. It is on an exponential curve.

Science as Inquiry

Hot Air Balloon

Item:

Your friend claims that the amount of a hot air balloon can lift, only depends on the size of the balloon. You claim that it also depends on the temperature of the air inside the balloon. You are to carry out an experiment to test your claim.

Materials. Crepe paper, sticks, glue, tape, construction paper, burner (sterno, propane torch or candle), matches, fuel, thermometer, spring scale (spring, indicator and calibration weights if building one)

You will need to construct a hot air balloon that will rise when heated against a spring scale tether (which enables you to measure the force of lift). Record data and plot a graph of lift vs. hot air temperature. Explain how the change in temperature affects the volume and pressure of a gas and how this results in the balloon rising.

Safety warning. This can be quite fire-hazardous (paper) if not carefully supervised. A wind-free out door area would be better than a classroom.

Answer:

Students will have difficulty controlling variables and deciding how to measure the air temperature inside the balloon and how to determine the size (volume) of the balloon. They should not be putting the thermometer in the flame. The spring scale needs to be fairly delicate (fishing scale?). The more ingenious should be able to work out most of the difficulties. Different groups could make balloons of various sizes and measure both effects as a class, then comparing global results. They should be thinking about what changes with temperature when the volume is fixed as it is in most home built paper hot air balloons.

Variation:

If a helium supply tank is available, students could do a very similar study with helium balloons vs. size (amount of helium inside). This is easier for those who don’t like the idea of flames. The quality (weight) of the rubber balloon could be a second variable.

Science in Personal and Social Perspectives

Kites in California

Item:

A beach town near the center of the California coastline is planning a kite-flying festival. The planners want to make sure there will be plenty of wind during the festival. Suggest a date and time of day for the festival and explain your reasoning.

Science as Inquiry

Salinity, Evaporation, Density

Item:

When you try to swim in different types of water, you find that floating is easier in some cases than in others. In which of the following will it be easiest to float?

A. Ocean water.
B. Water in the estuary of a large river.
C. Water in a lake in an area with a desert climate.
D. Water in a lake in an area with a high rainfall.

Justification:

Large boats have markings on their sides to show how deep in the water they are floating. What factors will affect how high in water a boat floats? Consider the boat in the different regions of water listed above.

Answer.

C. Water in lakes in a desert climate is likely to have the highest salt concentrations. There are famous examples—the Dead Sea, the Great Salt Lake. While the oceans are salty, they are not saturated. Constant evaporation of lakes in deserts leads to higher salt concentrations.