

Differential Heating and Cooling of Land and Ocean

Teacher Background

All you need to do on a sunny day is walk on a dry beach in the early afternoon to learn that the sand can get *very much* warmer than sea water. Water is a slow conductor of heat, thus it needs to gain more energy than the sand or dry land in order for its temperature to increase. On the other hand, soil loses its heat much faster. But your toasted toes would perhaps mislead your mind: Earth's oceans are far more important than the land as a source of the heat energy which drives the weather. Not only do the oceans cover more than 2/3 of the Earth's surface, they also absorb more sunlight and store more heat. Additionally the oceans retain heat longer. The Sun's rays also penetrate the oceans to a depth of many meters, but only heat up the top layer of the sand or soil. Water has to lose more energy than the sand (dry land) in order for the temperature to decrease.

During the summer the land is much warmer than the water. It's made up of many different materials which absorb the Sun's rays differently. Land covered in forests or snow warms and cools very differently from a city blanketed with asphalt streets and concrete buildings. Darker materials absorb more radiation than lighter materials. Texture also matters. Rougher and dryer materials absorb more radiation than smoother and wetter materials. If you have ever walked barefoot on a street or sidewalk you'll recall these are much hotter than the grass beside them.

This Activity can also be adapted to challenge older students to come up with their own experimental protocols to test some of these fundamental and important principles. As an extension, you can invite students to suggest various materials to test other than those specified here.

Objectives

- Students will research, compare and contrast temperature patterns around the country/world.
- Students will observe that soil both heats up and cools faster than water.
- Students will observe that different colors absorb different amounts of the Sun's radiation.

Vocabulary

differential

Engage

Provide temperature maps to each group of students. Allow time for them to study their maps and share observations with each other. Then ask each team to prepare 3-5 generalizations they have gathered from the maps. Prompt them to "Discuss the different temperature patterns you observe. Where are the highest temperatures located? Where are the lowest temperatures located? Compare coastal temperatures with temperatures further inland. Compare temperatures at different latitudes and elevations." Record these observations on an overhead transparency, chalkboard or large chart to facilitate whole class discussion, and then have students digest key observations in their journals.

Explain/Explore

Based on what they have observed on the temperature maps and from their existing knowledge, challenge students to form a hypothesis about whether soil or water will heat faster, and which will cool faster.

Materials

- reflector lamp with 100 watt bulb
- 2 x 250 ml beakers
- 150 ml of soil
- 150 ml of water
- 2 thermometers
- stopwatch
- temperature map (download current ones from the suggested URL below)
- Student Worksheet 1.2 (Side 1 supports the main Activity and Side 2 the "Sports Shirt" extension.)

Procedure

Distribute Student Worksheet 1.2 and review the procedure with students. Ensure each group has all the materials required and understands safety guidelines for the use of glassware and thermometers. Have students place 150 ml of soil in one beaker and 150 ml of water in the other beaker. They will then place a thermometer in each beaker and record the starting temperature. Ensure they position the lamp 10 cm from the beakers. Make sure that both beakers are equally distant from the lamp and that both receive an equal amount of light. Students should turn on the lamp and record temperatures every minute for 10 minutes. Turn off the lamp and record the temperature every minute for 10 minutes. Students should then graph their results. (The soil will heat up faster and also cool off faster. The water will warm up more slowly, but will then also cool off more slowly.)

Expand/Adapt/Connect

("The 'Cool' Sports Shirt Design Contest")

"Your challenge is to design a sports shirt for your soccer club which plays in the chilly fall, or for your baseball/softball team which plays in the summer heat. Choose your sport and season and come up with a color scheme that will make you and your team happiest--keeping as cool as possible in summer and as warm as possible in winter!"

Materials

- 4 thermometers
- construction paper (white, black, yellow and red or green)
- light source (this can be the Sun)

Have students form a hypothesis which ranks the four colors of construction paper beginning with the one that will *absorb* the most light (and therefore heat up most) and ending with the one which will *reflect* the most light (i.e. absorb the *least* light).

Students should cut pieces of construction paper 2 cm wide by 8 cm long. Have them fold each piece in half to form a pocket 2 cm wide by 4 cm long. Tape the sides to close the pocket. Note: If you are using wider thermometers students will need to make the pockets larger to fit the thermometers.

Students should place a thermometer inside each paper pocket. Have them position the four pockets with the thermometers equally distant from the heat source so they all receive the same amount of light. They should wait five minutes and record each temperature in their JOURNALS. "Was your hypothesis correct? Explain your results."

Challenge students to "Use what you learned from this experiment to explain why you would wear light clothing in the summer and dark clothing in the winter."

"Take what you learned one step further and form a hypothesis about what color and type of roof you would place on a house in the northern states and what color and type of roof you would place on a house in the southern states." Have students research roofs in the United States to discover what color and type are used most frequently. " Prepare a report proving your hypothesis. If your hypothesis was not accurate explain why it was incorrect in your report and write a new hypothesis based on your results."

To challenge older students, have them respond to the section above by devising their own experiment. They should develop a Materials list and set of procedures to prove or disprove their hypothesis. In this case, your role would be to facilitate the process as necessary.

Suggested URLs

Temperature map for this activity.

http://www.comet.ucar.edu/dstreme/images/sfc_temp.gif

<http://www.nssl.noaa.gov/edu/lessons/lesson3.html>

Simple explanation about why weather systems develop, due mainly to the non-uniform heating of the Earth.

http://www.oar.noaa.gov/k12/html/ocean_temps.html

NOAA Office of Oceanic and Atmospheric Research web page for students on ocean temperatures: includes good background information, activities and links to additional resources.

[http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/fw/sea/htg.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/sea/htg.rxml)

[http://ww2010.atmos.uiuc.edu/\(Gh\)/guides/mtr/fw/land/cls.rxml](http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/land/cls.rxml)

More advanced explanation of sea and land breezes, and the relationship to the uneven heating of land and oceans.