INVESTIGATION 3

Specific Heat *and* Climate

Lab

PURPOSE

- ➤ Determine the specific heat and the rates of heating of a soil sample, comparing them to those of water
- ➤ Relate specific heat findings to climatic phenomena

INTRODUCTION

The measure of the ability of a substance to change temperature is called **specific heat**. Some substances, such as air, change temperature with the addition of very little energy, while others need greater amounts of energy to change. The specific heat of a substance is defined as the heat needed to change the temperature of one gram of the substance one degree Celsius. For this exercise you will use the **Joule** (abbreviation **J**) as the unit of heat. (Other units of heat are the calorie and the BTU: one calorie is equal to 4.18 J and one BTU is equal to 1,055 J.) The more Joules needed for each degree change of a substance, the higher its specific heat.

Each substance has its own value for specific heat and these values can be found in many handbooks of science data. For example, iron has a value of 0.448 J/g °C. Many metals follow a general rule that their specific heat is approximately equal to 24.94/atomic weight. Ethanol, by contrast to iron, has a value of 2.43 J/g °C. So it takes about five times more energy to change the temperature of one gram of ethanol than to change the temperature of an equal mass of iron.

In this lab, you will determine the specific heat of a soil sample as compared to that of water. This difference has many ramifications regarding our climate, both local and global.

Materials

- 2 petri dishes
- soil
- water
- 2 thermometers
- heat lamp

Procedure

Step 1 In this lab, as in many of the investigations that follow, you will prepare tables to record and organize your experimental results. See **Fig. 3-2** on the following page for guidance in designing appropriate data tables for this lab.

Step 2 Record the mass of a petri dish and then add enough soil to fill it to the brim. Record the mass again. The difference is the mass of the soil sample.

Step 3 Record the mass of another petri dish and fill it with water. Record the mass again. The difference is the mass of the water.

Step 4 Place the thermometers so that the bulb of one is beneath the surface of the soil and the bulb of the other is under the water.

Step 5 Place both samples under a heat lamp, making sure the thermometers stay under the samples. Bring the lamp close to the petri dishes so that they are heated equally.

Step 6 Record the temperature of each thermometer every 30 seconds, for 10 minutes.

Step 7 Graph your temperature data on the same set of coordinates.

Fig. 3-1

MASS / TEMPERATURE DATA

	Soil	Water
Mass of Petri Dish and Material		
Mass of Petri Dish Empty		
Mass of Material		
Initial Temperature		
Final Temperature		

TEMPERATURE READINGS (Intervals of 30 Seconds)

	Temp.			Temp.	
#	Soil	Water	#	Soil	Water
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

Fig. 3-2: Data Tables

1a. Which sample showed the greater change in total temperature?

b. For each petri dish, calculate the change in temperature per gram of substance.

c. Which substance heated up faster? Which has the higher specific heat?

d. What do you think the results would be if the experiment were designed to measure the cooling behavior of each material?

2a. From your graph, what does the shape of the line tell you about rates of heating?

b. Describe how you could predict the temperature of the soil and water after 15 minutes of heating. What would each temperature be?

c. After 20 minutes of heating, what would be the temperature of each matter? How accurate would that prediction be? Why?

d. What would be the specific heat of each material after 15 minutes of heating? Why?

3a. The Earth is heated by the sun. Based on this investigation, how would land masses heat up compared to the sea at the same latitude? Explain.

b. If air over the warmer area rises, creating a lower atmospheric pressure, how would surrounding air move?

c. Explain how this factor causes cooling sea breezes on a sunny day on a coastal beach. How does this relate to large-scale atmospheric changes, such as the Asian Monsoon?

4a. Using the results of this lab, reason out why the yearly temperature ranges of interior regions of the United States are much larger than yearly coastal temperature ranges.

Analysis Problems Exercises **Questions**

Questions / Exercises / Problems / Analysis

b. Why is the average winter temperature in Anchorage, Alaska, similar to that of New York City (about 1,700 miles south; about 20° of latitude closer to the Equator), while Fairbanks, Alaska, just 300 miles north of Anchorage, is 20–50 degrees colder than Anchorage?

c. Compare temperatures for London, England, and Moscow, Russia, separated by about 4° of latitude. Explain how this difference could be explained partly by the same factors.

5a. If the specific heat of water is 4.18 J/g °C, calculate the heat gained by the water.

Heat = (mass of absorber substance)(change in temp.)(specific heat)

In symbolic form: $q = m \Delta t c$

b. If the total heat gained by the water is about the same as the heat gained by the soil, calculate the specific heat of the soil.

Heat gain by **water** = Heat gain by **soil**

$m \Delta t c = m \Delta t c$

c. How does the specific heat of the soil relate to your answers in question 4?