EXPLORATIONS

Activity 21

Insulating Against the Cold

Objectives

- To test the insulating efficiency of different samples of fabric
- To develop an understanding of the properties which make a fabric a better insulator
- To develop an understanding of how animals are adapting (in the characteristic of skin covering) to their environment

Materials

- TI-73
- Unit-to-unit cable
- CBL 2™
- Temperature sensor
- Gloves made from a variety of fabrics
- Large beaker or container
- Two rubber gloves
- Water (37° C)
- Hot plate
- Stopwatch or 5-minute timer
- Data Collection and Analysis pages (p. 202 - 205)

In this activity you will

- Collect gloves made from a variety of fabrics.
- Use the CBL 2™ with a temperature sensor to see which glove material keeps hands the warmest.

Problem

Which glove material will keep your hands the warmest in a cold weather?

Introduction

Scientists who collect data or do research in extreme climates, such as the Arctic or Antarctic, face special challenges in order to stay warm in the cold temperatures. These sites have some of Earth's coldest temperatures. Scientists in these areas are constantly threatened with hypothermia where their body temperatures drop significantly below normal (93°F or below). In addition to the extremely cold temperatures, wind chill factor due to wind of 40 mph and above has a significant impact. Scientists who work aboard research vessels or dive also must battle the effects of getting wet.

The human body can lose heat in several ways:

- *Radiation* in which heat is transferred from the body to the atmosphere in the form of electromagnetic waves.
- *Conduction*, which is the transferal of heat from one body to the other by actual touching.
- *Convection* and *advection*, which transfer heat by means of currents.
- *Evaporation*, which transfers heat with the change of a liquid to a vapor.
- *Respiration*, which removes heat from the body when inhaling and exhaling.

Clothing only serves to conserve body heat through insulation; it cannot replace lost heat. Conservation of body heat is a critical survival tactic in the Arctic and Antarctic research sites.

Hypothesis

Before testing, complete the **Hypothesis** section on the **Data Collection and Analysis** page to predict which glove material will work best. Then complete the **Experimental Design** section on the **Data Collection and Analysis** page.

Procedure: Collecting the Data

1. Plug the temperature sensor into Channel 1 (**CH 1**) on the CBL 2™.
2. Start the DATAMATE program.
3. The Main Screen is displayed. If **CH 1:TEMP(C)** is displayed at the top of the screen, go to step 8. If **CH 1:TEMP(C)** is not displayed, go to step 4.
4. Select **1:SETUP**.
5. Select **CH1**. Select **1:TEMPERATURE**.
6. If you are using the TI stainless steel temperature sensor, select **4:STAINLESS TEMP(C)**. If you are using a different temperature sensor, select the appropriate item from the menu.
7. Select **1:OK** to return to the Main Screen.
8. Select **1:SETUP**. Select **MODE**, and then select **2:TIME GRAPH**.
9. The **TIME GRAPH SETTINGS** are displayed. If the screen shows **TIME INTERVAL: 30**, **NUMBER OF SAMPLES: 20**, and **EXPERIMENT LENGTH: 600**, go to step 12. If the settings are not correct, go to step 10.
10. Select **2:CHANGE TIME SETTINGS**. For **ENTER TIME BETWEEN SAMPLES IN SECONDS:**, enter **30**. For **ENTER NUMBER OF SAMPLES:**, enter **20**. The **TIME GRAPH SETTINGS** screen reappears, showing the new settings.
11. Select **1:OK** twice to return to the Main Screen.
12. Pick one type of glove from the samples provided by the teacher.
13. Place one rubber glove inside the glove you chose.

14. Pour 200 ml of 37°C water into the rubber glove.
15. Insert the temperature sensor into the water inside the glove.
16. When you are ready to begin, select **2:START**. The CBL 2™ beeps twice and displays a graph with the temperature in °C in the upper right-hand corner.
17. Continue to hold the temperature sensor in the water inside the glove. The CBL 2 beeps twice when it has finished collecting data.
18. The graph is displayed showing the data that was collected. Use ▶ and ◀ to move to each data point. Record the final temperature in the table on the **Data Collection and Analysis** page.
19. Press ENTER to return to the Main Screen.
20. Empty the rubber glove.
21. Pick a glove from the samples provided by your teacher.
22. Place the rubber glove inside the glove you chose.
23. Repeat steps 16 through 22 for each type of glove you are testing.
24. To exit from the DATAMATE program, press **6:QUIT** ENTER when the Main Screen is displayed.
25. To display the lists showing the results, press LIST. The times are stored in **L1**. The temperatures are stored in **L2**.

Data Analysis

After testing, answer the questions on the **Data Collection and Analysis** page to evaluate which glove material will keep your hands the warmest.

Extension

- Repeat the activity, layering two or three of the fabrics which you think will be the most effective combined insulators. Compare your data with other lab groups that used other fabric combinations to determine the most effective insulation combination.
- List some other factors which become important when humans are considering the type of insulative clothing to wear.
- Many animals which live in cold climates rely on a layer of blubber as insulation. Repeat the activity, using a layer of lard surrounding your rubber glove. (This can be done by placing the glove in a resealable bag of lard so that the glove is surrounded by lard.) What does you data indicate?
- Repeat the activity, placing the gloves in a container of ice water instead of in front of a fan. What new factors are introduced in this scenario? What does your data indicate?

Data Collection and Analysis

Name _____

Date _____

Activity 21: Insulating Against the Cold

Problem

Which glove material will keep your hands warmest in cold weather?

Hypothesis

Before testing, complete the table below to predict the rank of each glove by how well it will keep your hands warm (1 = best).

Glove Material	**Predicted Rank** (Best Warming to Worst)

Experimental Design

1. Independent Variable: _____
2. Treatments: _____

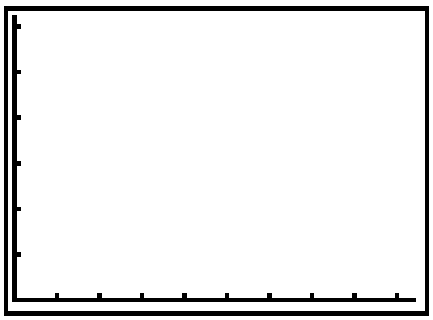
   _____
3. Dependent Variable: _____
4. Number of Trials: _____
5. Constants: _____
6. Control: _____

Data Collection

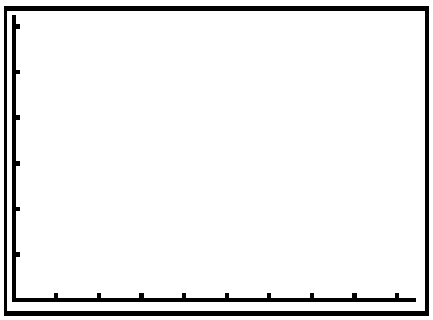
1. After you test each glove, record the final temperature of the water inside the glove in the table below. Then rank the gloves in order by how well they keep your hands warm.

Sample Number	**Glove Material**	**Temperature (°C)**	**Actual Rank** (Best Warming to Worst)
1			
2			
3			
4			
5			
6	Rubber Glove (uncovered)		

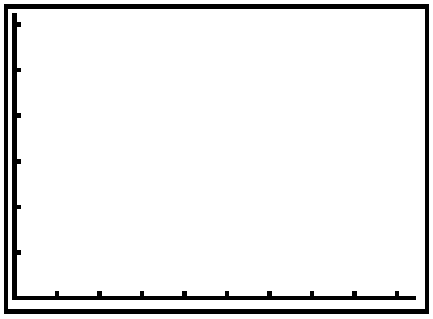
2. After you test each glove, sketch and label the graphs of the data below or print the graphs on the computer and attach them to this page.



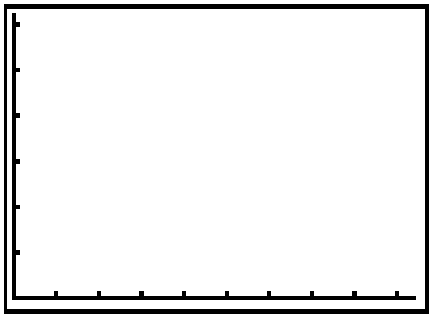
Glove 1



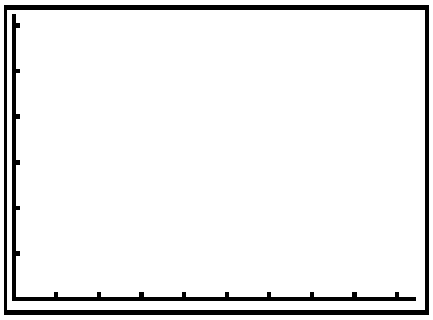
Glove 2



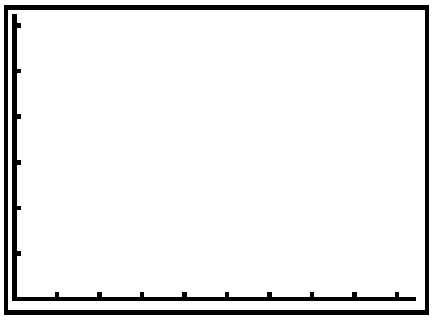
Glove 3



Glove 4



Glove 5



Glove 6

Data Analysis

1. Compare the actual rankings of how well the gloves worked to your predictions. Discuss any surprises or differences you find.

   _____

   _____

   _____

2. What does the slope of each represent?

   _____

   _____

   _____

3. What does the *y*-intercept represent?

   _____

   _____

   _____

4. Average your results with other lab groups in your class, and complete the table below.

Glove Material	**Average Temperature (°C)**	**Actual Rank** (Best Warming to Worst)

5. Compare your lab group's results to the class average. Discuss any surprises or differences that occurred.

_____

_____

_____

Conclusion

The gloves made from _____ will keep my hands warmest in cold weather.

Teacher Notes

Activity 21

Insulating Against the Cold

Objectives

- To test the insulating efficiency of different samples of fabric
- To develop an understanding of the properties which make a fabric a better insulator
- To develop an understanding of how animals are adapted (in the characteristic of skin covering) to their environment

NSES Standards

- Science as Inquiry: Abilities necessary to do scientific inquiry
- Science as Inquiry: Understanding about scientific inquiry
- Physical Science: Transfer of energy
- Life Science: Diversity and adaptations of organisms
- Science and Technology: Understanding about science and technology
- History and Nature of Science: Nature of science

Preparation

- A fan blowing over a container of ice water to cool the air hitting the gloves will amplify the results.
- Talk with students about clothing that will hold body heat and about windproof clothing. Have students give examples from personal experiences (for example, wool socks; down vests; and polypropylene long underwear needed for camping, fishing, or hunting). Students could examine scraps of material and discuss insulating and windproof qualities.
- Suggested types of gloves that will work well for this activity are: cotton, fur, wool, pile or fleece, polypropylene, rubber, neoprene, down, and space blanket material or aluminum foil.
- Students can select the fabrics they wish to test or groups can be assigned certain fabrics to test. Students can be encouraged to compare data from the different materials.
- In this experiment, the use of 37°C water represents human body temperature to create a more realistic model. This can be achieved using a hot plate on a low setting. If it is not possible to use water at 37°C, warm tap water can be substituted.

- Two gloves, the control with no covering and an experimental glove with a covering, can be tested simultaneously if there are two temperature sensors per student group. The sensors can be inserted into Channels 1 and 2 in the CBL 2™.
- This activity also can be done with beakers or baby food jars wrapped in different fabrics, if gloves are not available.

Management

- Assign these student jobs for this lab:
  - Materials/setup person (sets up samples, sensor)
  - Tech person (operates CBL 2 and TI-73)
  - Data recorder (reads temperatures from the TI-73 at each collection interval)
  - Runner (brings CBL 2 and TI-73 to the computer to print graphs with TI-GRAPH LINK™ or TI™ Connect and brings **Data Collection and Analysis** pages to the teacher)
- Clear covered plastic shoeboxes will hold the CBL 2, temperature sensors, and other equipment neatly at each station.
- Students can record data points in their lab journals as they are displayed on the TI-73. This keeps them engaged throughout the data collection period and if they lose the data/graph later, they can still write up their lab reports. Students can also access the data in the TI-73 lists after data collection. You can send lists to all students' calculators using [APPS] **1:Link**.

  a. Press [APPS].

  b. Press [ENTER] to select **1:Link.**

  c. Select **4:List** and press [ENTER].

  d. Press [▼] to move the ▸ beside the list you wish to send. Press [ENTER].

  e. Repeat step **d** for each list you wish to send.

  f. Set the receiving unit by pressing [APPS] [ENTER] [▶] to select **RECEIVE**. Press [ENTER]. **Waiting…** displays on the TI-73 screen.

  g. On the sending unit, press [▶] to select **TRANSMIT** and press [ENTER].

  For more permanent storage of data, use TI-GRAPH LINK or TI Connect to save the lists in a computer folder. However, students may inadvertently lose their data or overwrite it in the next trial, so recording data in journals is a good option.
- Students can assess each other using a teamwork rubric after the lab. Provide a checklist of positive and negative behaviors. Copy these on quarter sheets of paper.

- Have the students from each lab group complete the experiment for the control and one additional glove if there is not time to do all gloves in each group. To assure repeated trials, however, each glove should be done by at least two groups.
- You can enter data from each lab group into a class computer spreadsheet or manually record it on an overhead transparency. Have one student from each group responsible for recording the data during the period. Students will then have the opportunity of seeing data from all of the treatments.
- Students can print line graphs using TI-GRAPH LINK; label the horizontal axis time and the vertical axis cooling rate; and write an explanation analyzing their data. Students can also paste their graphs into a word processing document and write summaries.

Selected Answers

Experimental Design

1. Independent Variable: *fabric of gloves*
2. Treatments: *wool, cotton, rubber, polypropylene, neoprene, fleece*
3. Dependent Variable: *cooling rates*
4. Number of Trials: *varies*
5. Constants: *Initial temperature of water in gloves, amount of water in gloves, wind temperature and speed*
6. Control: *rubber glove without insulation*

Analysis Questions

1. Compare the actual rankings of how well the gloves worked to your predictions. Discuss any surprises or differences you find.

   Answers will vary with data.

2. What does the slope of each represent?

   Slopes of the graphs represent the cooling rates of the water inside the rubber gloves. Steeper slopes indicate a faster cooling rate.

3. What does the *y*-intercept represent?

   The y-intercepts represent the initial temperature of the water in the rubber gloves.

4. Average your results with other lab groups in your class, and complete the table below.

   Answers will vary with data.

5. Compare your lab group's results to the class average. Discuss any surprises or differences that occurred.

   Answers will vary with data.